COOPERATIVE INSTITUTE FOR GREAT LAKES RESEARCH 2021

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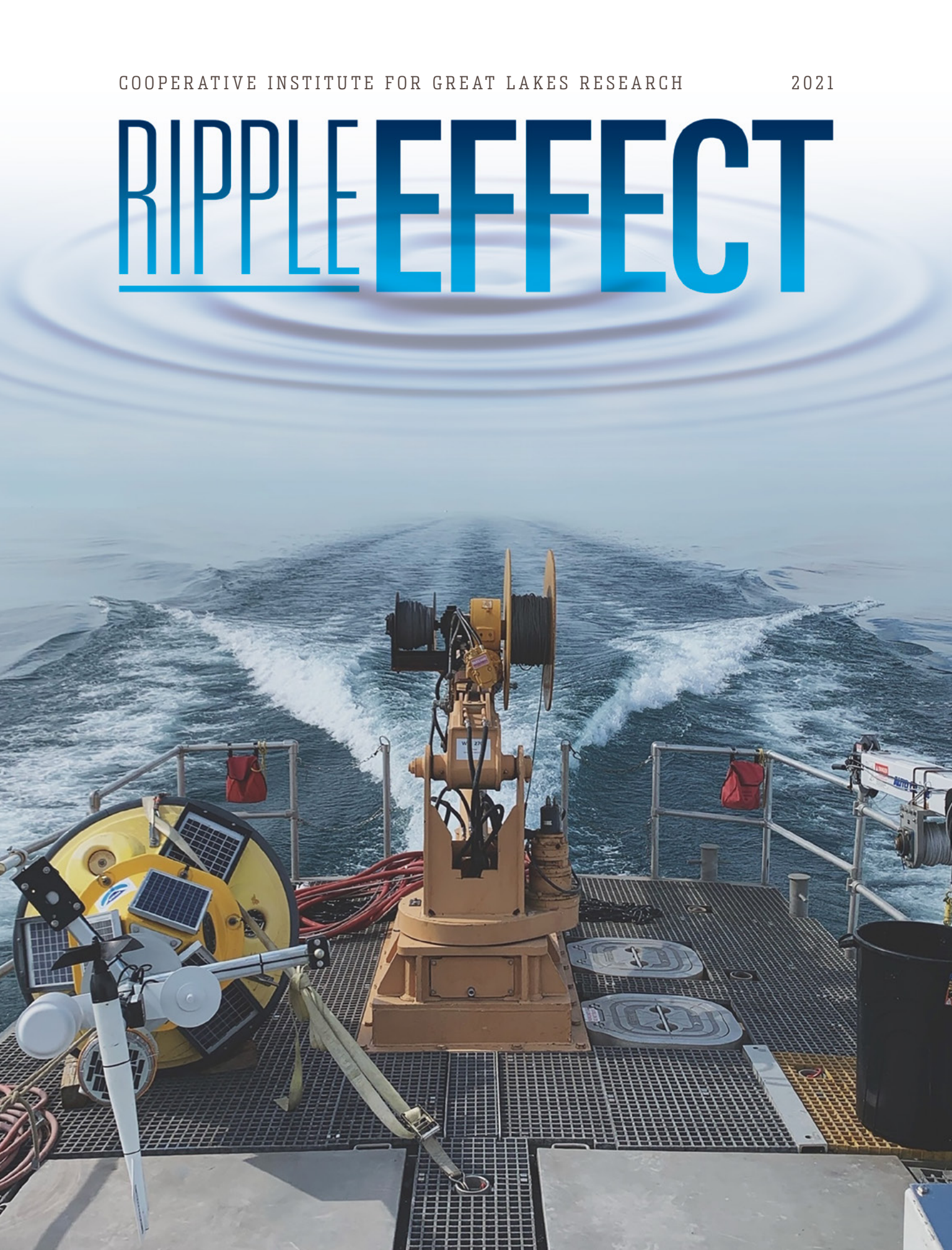

Mission Statement

As an 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.

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What's Inside

FIGURING OUT THE ELUSIVE AGE OF GROUNDWATER VENTING IN **Lake Huron's Sinkholes**

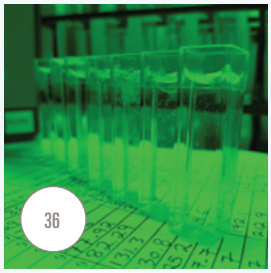

PHOTO CONTEST **Winners**

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Dear Friends and Colleagues,

I'm sure I am not alone in my feeling that I have been living under an alternate reality this past year. I'm still trying to decide, however, if that feeling is simply a reflection of the pandemic's ability to completely disrupt our schedules and routines, OR if I still can't believe that I have just spent the last 14 months trying to hold down three important jobs. Thank goodness, the job of serving as CIGLR's Acting Director is one that I held with the utmost reverence and one that never felt like an additional burden. It was truly a privilege and honor to come back and lead CIGLR, and to be able to work with so many career-long friends and colleagues over this past year. My only regret is that the interactions were not in person or to the extent they could have been without the restrictions of the pandemic.

But like all challenges, they are best faced as a team and with the goal of coming out of it better and stronger. To this point, I need to commend all of our CIGLR staff for their tremendous dedication and commitment to completing mission-critical work with our colleagues at NOAA GLERL, and for working every day to find creative ways to do their job to the best of their ability. The transition of our new permanent CIGLR Director also certainly scores well along those goals. I could not be happier or more confident about handing over the reins to Professor Greg Dick. I have had the personal pleasure of working with Greg for over a dozen years and have always been impressed with both his intellectual leadership and his ability to foster successful collaborations. During our candidate search, Greg clearly impressed all of us with his strong academic credentials, but more importantly, with his vision and passion for wanting to make CIGLR's work reach further and be more impactful. I hope you all share my excitement in watching this vision take shape over the coming years. I also look forward to working directly with Greg on his goal of furthering the collaborations of all of the University of Michigan Great Lakes programs, and strongly share that goal as the director of Michigan Sea Grant.

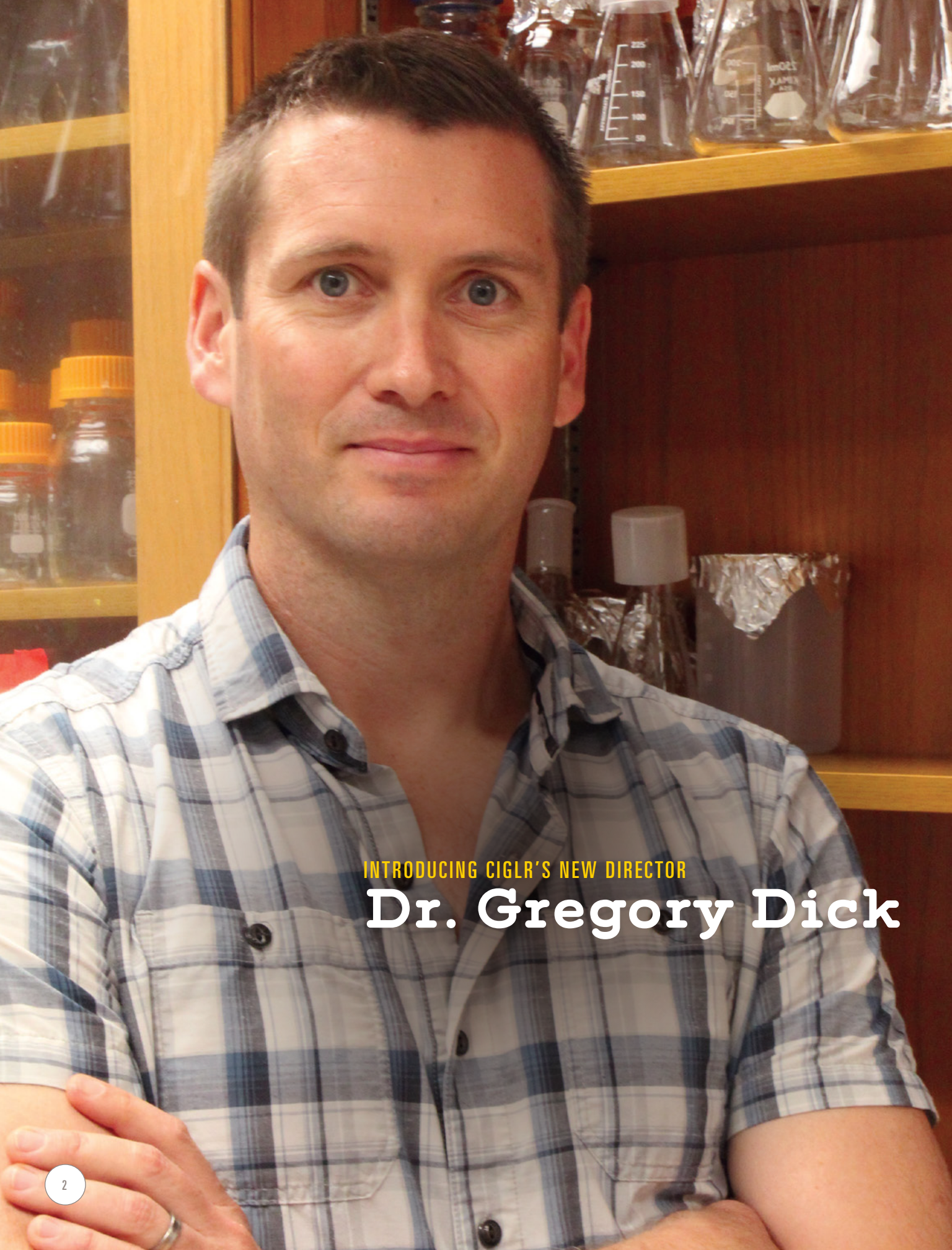
On a personal note, I am glad that as I step aside as director that I will still be able to work within CIGLR as a Research Scientist over the next two years while I finish up a few of my remaining research grants. It helps tremendously to know that I am not really leaving, just changing my role, AGAIN. And maybe this time I can really stick to the plan that ultimately lets me walk away, knowing how blessed I was to have a job that I looked forward to doing every day and that I believed made a positive difference in how we value and protect our amazing Great Lakes. Thank you all for helping provide me with that opportunity and privilege.

In closing, I have to express my sincerest gratitude and appreciation for the tireless and selfless contributions of our Program Manager, Mary Ogdahl. The job would have been almost undoable without her endless support and guidance. And for sure, it would have been a lot less fun.

Sincerely,

Thomas H. Johengen

Thomas Johengen
Director
Cooperative Institute for Great Lakes Research
Michigan Sea Grant



INTRODUCING CIGLR'S NEW DIRECTOR

Dr. Gregory Dick

GREGORY DICK, PhD, is a professor in the Department of Earth and Environmental Sciences in the College of Literature, Science, and the Arts (LSA) at the University of Michigan. He has been on the U-M faculty since 2008, served as Associate Chair for Curriculum and Undergraduate Studies from 2016–2021, holds a dry appointment in the Department of Ecology and Evolutionary Biology (LSA), and is affiliated with the Center for Computational Medicine and Biology (Medical School). Dick now joins the School for Environment and Sustainability (SEAS) faculty as CIGLR Director with a 50% appointment.

During his 13 years on the faculty at Michigan, Dick's research has evolved from oceanography to geobiology to its current focus on the Great Lakes. His early work at Michigan focused on microbial ecosystems at deep-sea vents, studying how these organisms thrive in extreme environments and in turn influence the flux of bio-essential elements from vents to the ocean. The discovery of sinkholes in Lake Huron that harbor chemosynthetic communities similar to those at deep-sea vents piqued his interest in the Great Lakes. In fact, CIGLR (then CILER) was a gateway to Great Lakes research and ultimately proved to be critical in his transition from oceanography to freshwater research. "From the very beginning of my time at Michigan, CIGLR played a key role in my evolution as a scientist," said Dick. "Soon after I arrived in 2008, Tom Johengen and Bopi Biddanda [Grand Valley State University] generously brought me along on a sinkhole expedition. While I didn't find the iron and manganese I was looking for, I fell in love with sinkhole cyanobacteria. The rest is history."

That initial sinkhole research – combined with an appreciation of cyanobacteria's crucial role in Earth's chemistry and biology gained through teaching undergraduate geobiology – spurred an interest in cyanobacteria that drives his current work, which focuses on answering critical questions about the causes of cyanobacterial bloom toxicity using cutting-edge omics techniques. Increasingly, this work has involved collaborations with CIGLR and NOAA GLERL scientists.

Having gained a first-hand view of the synergism between NOAA GLERL, CIGLR, and regional consortium partners, he now joins CIGLR as the 7th Director in the 32-year history of NOAA Cooperative Institutes at the University of Michigan. "I am excited to join and lead CIGLR and I look forward to building on the foundation of excellence that has been established by previous CIGLR Directors as well as Research Scientists, staff, and our NOAA GLERL partners," said Dick. "I deeply appreciate all that Tom Johengen, Brad Cardinale, and others have done to build CIGLR into the successful operation that we have today."

Dick says that there are several aspects that attract him to working with CIGLR and NOAA. "First, I am particularly interested in the interface between science and society. To this point of my career I've been mostly generating knowledge through scientific research; I'm excited to do more to put that knowledge to use for forecasts, management, and policy. Second, I look forward to promoting the Great Lakes as a world-class natural laboratory for studying interactions between humans and water and between terrestrial and aquatic ecosystems. While it is an honor and a privilege to work to understand, manage, and protect the greatest freshwater system on Earth, our work does not end with the Great Lakes. I like to think of the Great Lakes as a model system for understanding the processes that operate in lakes around the world. As a leader in water research, what we learn in the Great Lakes should be relevant to ecosystems and water resources globally. Third, I am delighted to have the chance to work with the fantastic scientists and staff at CIGLR, NOAA GLERL, and our partner institutions."

While acknowledging that he still has a lot to learn about CIGLR's strengths and areas with room for improvement, he does have some initial goals and ideas about new directions and opportunities. "First, I'd like to more deeply engage faculty and professionals at our partner institutions, especially in molecular and climate sciences, engineering, chemistry, and public health," said Dick. "Second, I want to leverage the geography of CIGLR's regional consortium to understand and tackle cross-basin challenges such as climate change. Third, I want to make diversity, equity, and inclusion [DEI] a priority. Rather than viewing DEI as a side project, I see it as a mission-critical objective that permeates everything that we do internally [student recruiting, hiring, promotion, mentoring, research, education] and externally [grantsmanship, outreach, interactions with stakeholders, promoting environmental justice]. We will infuse evidence-based best practices into CIGLR, drawing on the impressive expertise of our partners."

CIGLR COMPLETES

Program Review

APRIL 12–14, 2021

Cooperative Institute for Great Lakes Research

CIGLR

Great Lakes Science for Society

THE COOPERATIVE INSTITUTE FOR GREAT LAKES RESEARCH (CIGLR) is hosted by the University of Michigan and funded by the National Oceanic and Atmospheric Administration (NOAA). CIGLR's five-year, $30 million cooperative agreement was awarded by NOAA on May 16, 2017 to form a research institute and regional consortium focused on sustainable management of the Great Lakes. Since that time, researchers from CIGLR, the NOAA Great Lakes Environmental Research Laboratory (NOAA GLERL), nine universities across the Great Lakes region, as well as multiple nongovernmental organizations and private businesses have worked together to study the most pressing issues in the Great Lakes, including weather and climate, invasive species, harmful algal blooms, and protection of ecosystem services.

To maintain a long-term collaborative partnership with a Cooperative Institute (CI) beyond its initial five-year award period, NOAA requires that CIs undergo an extensive review during the fourth year of the award. Based on the results of the review, NOAA may choose to issue a new non-competitive award to CIGLR for an additional five years beyond the initial five-year award. CIGLR's fourth year review took place virtually and was conducted in two parts: a science review and an administrative review.

The science review (April 12–13, 2021) evaluated the quality of CIGLR's research and consisted of presentations from CIGLR research scientists and consortium partners that highlighted successful, ongoing research projects and thriving collaborations between CIGLR and NOAA researchers. Presentations highlighted CIGLR's research on Great Lakes harmful algal blooms (HABs), hypoxia, climate and weather modeling, observing systems, hydrodynamic and ecosystem modeling, invasive species, ecological 'omics, human dimensions, and stakeholder engagement. The science review chair was Dr. Michael Donahue, Vice President and Director of National Coastal and Ecosystem Restoration Practice with AECOM.

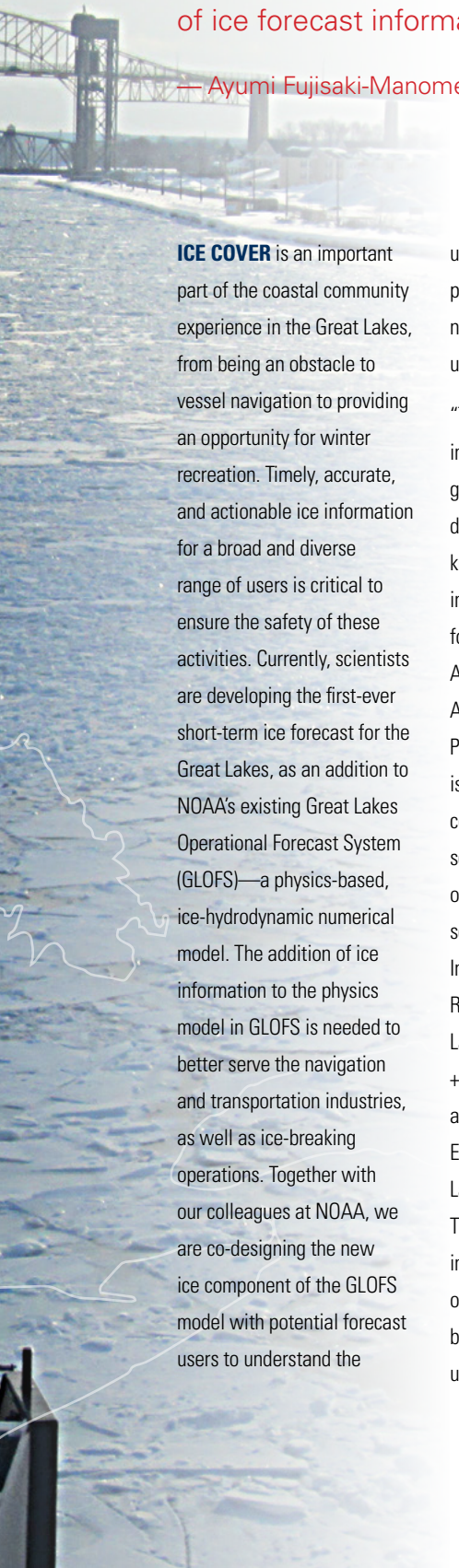
The administrative review (April 14, 2021) examined the procedures associated with grants management at CIGLR and the University of Michigan. The panel evaluated CIGLR's accomplishments since the last review, and reviewed processes and procedures for both pre- and post-award compliance of grant policies. The administrative review chair was Deborah Lee, Director of the NOAA Great Lakes Environmental Research Laboratory (NOAA GLERL).

CIGLR is thrilled to have received an "Outstanding" rating for "...scientific excellence, productivity, focus on critical issues, and collaborative nature" in the preliminary science review report. According to NOAA, an Outstanding rating is given when "the CI has consistently demonstrated superior achievement of all initially agreed upon goals, as well as evidence of an ongoing resource commitment that enhances NOAA's resources to support collaborative research." NOAA will evaluate results from the science and administrative reviews to determine whether to approve a five-year non-competitive renewal for CIGLR for the period 2022–2027.

PARTNERING WITH STAKEHOLDERS TO CO-DESIGN THE

Great Lakes Ice Forecast

USER EXPERIENCE



"The creation and design of the Great Lakes ice forecast is critical for supporting decision making of the Great Lakes shipping community, and any potential users of ice forecast information."

— Ayumi Fujisaki-Manome, PhD

ICE COVER is an important part of the coastal community experience in the Great Lakes, from being an obstacle to vessel navigation to providing an opportunity for winter recreation. Timely, accurate, and actionable ice information for a broad and diverse range of users is critical to ensure the safety of these activities. Currently, scientists are developing the first-ever short-term ice forecast for the Great Lakes, as an addition to NOAA's existing Great Lakes Operational Forecast System (GLOFS)—a physics-based, ice-hydrodynamic numerical model. The addition of ice information to the physics model in GLOFS is needed to better serve the navigation and transportation industries, as well as ice-breaking operations. Together with our colleagues at NOAA, we are co-designing the new ice component of the GLOFS model with potential forecast users to understand the usability of existing ice data products, user information needs, and preferences for the user interface.

"Through systematic interactions with stakeholder groups, this project demonstrates the value of knowledge co-production in our Great Lakes ice forecast product," said CIGLR Assistant Research Scientist Ayumi Fujisaki-Manome, PhD. "This project team is highly interdisciplinary, consisting of both natural scientists [engineer, physical oceanographer] and social scientists from the Cooperative Institute for Great Lakes Research [CIGLR], Great Lakes Integrated Sciences + Assessments [GLISA], and NOAA's Great Lakes Environmental Research Laboratory [NOAA GLERL]. Through workshops, interviews, and focus groups, our project team seeks to better understand how users perceive and interpret uncertainty in ice forecast information to inform how to best present the data."

"We interviewed ship captains and operations managers that have spent decades navigating the Great Lakes," said CIGLR Stakeholder Engagement Specialist Devin Gill. "The captains consider many factors when choosing their navigation routes. When the information they need is not available, they make informed predictions based on their years of experience. It is so complicated and impressive! Our research team has benefited greatly from their experiential knowledge. We built a better forecast because of their involvement."

Early project results indicate that there is a need for a short-term ice forecast consisting of ice thickness, concentration, and predicted movement, capable of providing location-specific information in key geographical areas like bays and connecting channels. "Our findings will be incorporated into a final report that includes recommendations to the user interface of GLOFS ice forecast guidance and will be provided to the National Ocean Service and the National Ice Center," said Fujisaki-Manome. The forecast guidance will be used by operational forecasters to determine whether to issue an ice warning and advisory to the shipping community, the U.S. and Canadian Coast Guards, and other end user groups. "The findings will also guide long-term future research and development work pertaining to GLOFS," said Fujisaki-Manome. "Our project will not only advance the usability of this specific Great Lakes ice forecast product, but also will demonstrate the importance of participation by social scientists through our unique collaboration among GLISA, CIGLR, and NOAA GLERL."

FIGURING OUT THE ELUSIVE AGE OF

Groundwater Venting IN Lake Huron's Sinkholes

"This collaborative project seeks to determine the age of groundwater venting from submerged sinkholes in Lake Huron for gaining insights on its origin, residence time, and impacts."

— Bopaiah Biddanda, PhD

GREAT LAKES SINKHOLES are hard to find and scientists know little about the abundance, distribution, and composition of these submerged karst ecosystems. Lake Huron, the third largest of the Laurentian Great Lakes, is underlain by 400-million-year-old Paleozoic limestone bedrock that formed when shallow seas covered these continental areas. The gradual dissolution of this limestone has led to caves, cracks, and fissures called karst formations. When underground karst formations collapse, they form sinkholes. Some of these sinkholes can be found on land, while others are located under the surface of Lake Huron. In Lake Huron's recently discovered submerged sinkholes, dense groundwater rich in sulfur but poor in oxygen flows through underwater springs onto the lake floor.

An intriguing aspect of these sinkholes is that they support colorful microbial mat communities bearing close resemblance to life in the Proterozoic seas (~3 billion years ago) and deep-sea vent ecosystems. "Whereas we have preliminary information about the communities inhabiting the sinkholes and basic chemistry of the vent water that fuels this life, we have no idea of the origin or age of this water," said Professor Bopi Biddanda, PhD, of Grand Valley State University's Annis Water Resources Institute, a CIGLR Consortium institution. Biddanda leads CIGLR's sinkhole research in collaboration with Steve Ruberg of NOAA GLERL. "In addition to the shallow, sunlit submerged sinkhole ecosystems we have been studying in Lake Huron, we now have several strong lines of evidence based on water chemistry, multi-beam mapping, and remotely operated vehicle (ROV) footage suggesting that numerous submerged sinkholes with actively venting water exist in deeper, offshore waters. The resulting emergent features, high-sulfur and low-oxygen, appear to fuel the microbial life in Lake Huron's sinkholes, mimicking benthic microbial communities that prevailed on early Earth during the long period of carbon fixation and oxygen evolution."

Relative to our knowledge of surface water hydrology, our understanding of groundwater dynamics remains a black box. Knowledge of the age of venting groundwater is essential for identifying the source and estimating timescale of recharge of the aquifers. "Currently, we are working on this collaborative project with Steve Ruberg of NOAA GLERL to collect and determine the age of the groundwater venting in an extensive field of newly discovered (2016) and mapped (2017) sinkholes in the offshore karst areas of Lake Huron," said Biddanda. "Specifically, we are conducting organized sonar and ROV surveys and sampling in shallow and deepwater sinkholes during field expeditions in 2021 and 2022. We will use sulfur hexafluoride [SF6] analysis for short-term age determination (a 0–30 year age window) and if the findings warrant, follow up with noble gas isotope ratio analyses for longer-term age determination. These analyses will reveal the timestamp reflecting the atmospheric composition at the time of groundwater origin. At this time, our working hypothesis is that groundwater emerging at deeper, offshore sinkholes will be older than ones venting at shallow, nearshore ones."

Reliable knowledge of the age of groundwater venting at submerged sinkholes can shed light on their spatio-temporal origins and provide a working idea of groundwater residence time in the aquifer, enabling quantification of its impacts on sinkhole ecosystems and Great Lakes water quality and quantity. For example, improved knowledge of both the age and residence time of groundwater in the aquifer will be valuable for taking conservation measures to identify and protect groundwater recharge areas on land—crucial to protecting the unique life found in submerged sinkhole refugia.

"Extant extreme ecosystems such as the mat worlds found in Lake Huron's submerged sinkholes not only provide a valuable time portal for peering into the early biosphere, when similar mats in the Proterozoic produced organic carbon and released oxygen," said Biddanda, "but they also contribute to Earth's biodiversity and physiologic potential today."

(Photo: Phil Hartmeyer, NOAA Thunder Bay National Marine Sanctuary).

Observing Lake Michigan

USING AN AUTONOMOUS UNDERWATER GLIDER

"Glider observations help support Lake Michigan food web research and provide a foundation for management and conservation efforts aimed at maintaining critical ecosystem services."

— Michael Fraker, PhD

GLIDERS provide information on key weather, water, hydrodynamic, and biological variables throughout all of the Great Lakes. Gliders are able to traverse from one side of a Great Lake to another and collect data from the surface to the deepest depths. They provide researchers with wider horizontal coverage than do ships and buoys, and better vertical coverage below the depths observable by satellites.

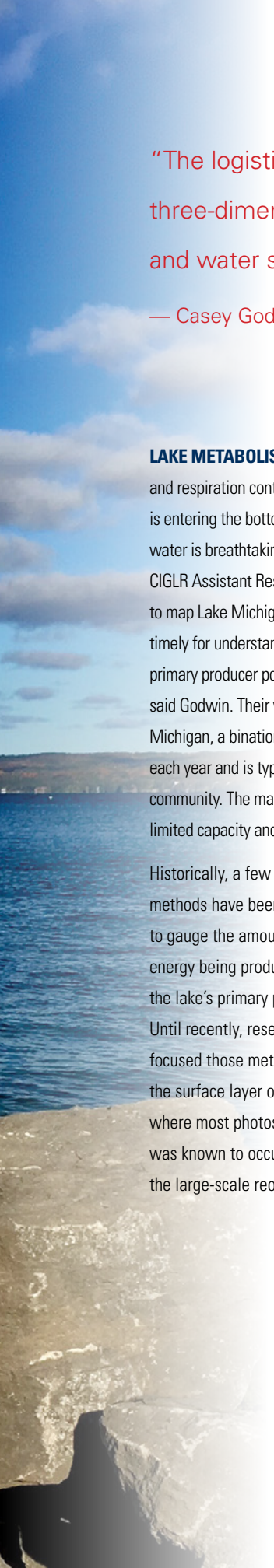
Michigan Sea Grant's Research Program Manager and former CIGLR Assistant Research Scientist Michael Fraker, PhD, specializes in Great Lakes ecosystem dynamics research. He is working with mechanical engineers Russ Miller (CIGLR) and Lauren Marshall (NOAA Affiliate), and CIGLR Great Lakes Summer Fellows Anisha Shrestha (2020, Grand Valley State University) and Jake Fredrickson (2021, University of Minnesota Duluth) to analyze and process an extensive limnological dataset collected by a Slocum glider in southern Lake Michigan. "The Slocum glider moves slowly across the lake in an up-and-down trajectory and is equipped with several sensors to measure water conditions, including temperature, light, and chlorophyll," said Fraker. "Its deployments last several weeks at a time, and it makes several passes back and forth across the lake, often from near Muskegon, Michigan to Milwaukee, Wisconsin.

"Shrestha and Fredrickson are focused on analyzing the Slocum glider observations, which will help describe variation in the spatial and temporal scales of key limnological variables," Fraker continued. "The goal of this research is to understand how patchy the lake environment is, and how it changes seasonally and spatially within the lake. This glider data analysis will help us understand how representative a sample is from each location and how far away you can move from a sampling site before the conditions are likely to be different."

The Lake Michigan ecosystem has undergone substantial change in recent decades due to a variety of factors, including nutrient management and the introduction of invasive dreissenid mussels. As a result, nutrient concentrations and water clarity, among other water quality characteristics, are different. "In response, the Lake Michigan food web, from the phytoplankton and zooplankton all the way up to the fish, has changed," said Fraker. "Information from the glider observations will help support Lake Michigan food web research by describing some of the physical and lower food web characteristics that influence the distribution and interactions of species." In combination, this work will help Great Lakes researchers understand more about how the Lake Michigan food web functions and provide the foundation for management and conservation efforts aimed at maintaining critical ecosystem services, such as the vital Lake Michigan fishery.

MAPPING

Lake Michigan's Metabolism



"The logistics of these missions are especially tricky. We're choreographing a three-dimensional rendezvous of two gliders, numerous shipboard instruments, and water sampling to support laboratory experiments."

— Casey Godwin, PhD

LAKE METABOLISM is measured by scientists to understand how key processes like photosynthesis and respiration control oxygen concentrations in the lake and, ultimately, the amount of energy that is entering the bottom of the food chain. Visitors to the upper Great Lakes often remark that the blue water is breathtaking, but did you know that the water in the lakes is actually breathing? In 2021, CIGLR Assistant Research Scientist Casey Godwin, PhD, and his colleagues are executing a project to map Lake Michigan's breaths by measuring its metabolism with new technologies. This work is timely for understanding changes in the lake's ecosystem. "During the last decade, we have watched primary producer populations and their metabolism decline and also redistribute throughout the lake," said Godwin. Their work is part of the Cooperative Science and Monitoring Initiative (CSMI) for Lake Michigan, a binational program that coordinates fieldwork and research efforts in a different Great Lake each year and is typically focused on key issues that are identified by the research and management community. The main campaign was delayed by a year due to the pandemic, but work has resumed with limited capacity and extensive safety preparations.

Historically, a few different methods have been used to gauge the amount of energy being produced by the lake's primary producers. Until recently, researchers focused those methods on the surface layer of the lake, where most photosynthesis was known to occur. But with the large-scale reorganization of the lake's food web, there is a need to start mapping photosynthesis throughout the depth of the lake and also in nearshore regions where primary producers are now most abundant. To do this, Godwin and colleagues will leverage new technologies and approaches. Among those are autonomous vehicles—called gliders, due to their undulating movement in the water—that can precisely measure small changes in temperature, oxygen, and light that collectively influence the balance of photosynthesis and respiration in the lake. The gliders are capable of making these measurements continuously as they travel not only up and down through the depth of the lake, but also in pre-programmed "flight paths" across the lake. For the 2021 campaign, Godwin is partnering with CIGLR's Research Engineer Russ Miller and CIGLR consortium partner Hunter Carrick, PhD (Central Michigan University) to bring classical metabolism techniques together with advanced glider technology to get an apples-to-apples comparison of their results. From this work, Godwin and colleagues hope to get an unprecedented level of detail about where oxygen production and respiration occur in different zones of the lake.

WHAT DOES

Successful Shoreline Restoration

LOOK LIKE?

"Monitoring and evaluating Great Lakes restoration projects from the last decade helps us measure fish habitat successes and refine restoration methods."

— Karen Alofs, PhD

SHORELINE RESTORATION AND ENHANCEMENT is a relatively common practice throughout the Great Lakes region. A significant portion of the Great Lakes work overseen by the National Oceanic and Atmospheric Administration (NOAA) Restoration Center (RC) focuses on using Great Lakes Restoration Initiative (GLRI) funds to implement shoreline and nearshore habitat restoration, protection, and enhancement projects in areas that have been damaged and/or compromised by historical activity. To gauge restoration success and support proper adaptive management, NOAA is interested in understanding the ecological and physical outcomes of these efforts and developing a robust and consistent method of evaluating these projects. A CIGLR team led by Karen Alofs, PhD, based at the University of Michigan School for Environment and Sustainability (SEAS), and Bradley Cardinale, PhD (Pennsylvania State University) is working with the NOAA RC to investigate past restoration projects and improve future efforts.

"A fundamental question that lies at the heart of all ecological restoration initiatives is: how can restoration projects be evaluated for success?" said Alofs. To address this question, University of Michigan graduate student Kia Billings is working with NOAA RC to better understand the outcomes from restoration efforts along Great Lakes coastal shorelines. Recent restoration projects have focused on enhancing habitat for native fish and wildlife, improving measures of ecological communities and target species (abundance, diversity, biomass), increasing stability at the land-water interface (improved shoreline slopes and reduced erosion), and resilience to climate variability.

Billings is assessing the characteristics of successful restoration projects by surveying contacts from previously funded NOAA restoration projects across the Great Lakes region. "The survey collects information on the project's design and implementation, including involvement by stakeholders and community members. This work also examines the monitoring measures and techniques used for evaluating each project," said Alofs. The research team is evaluating the effectiveness of restoration efforts based on survey results that demonstrate (i) clearly stated and achievable goals and objectives, (ii) completion of an ecological assessment, and (iii) a monitoring program that can demonstrate ecological improvements post-restoration.

"Another focus of this research is to inform future shoreline restoration and associated monitoring projects through the identification of high-quality reference sites, or benchmarks," said Alofs. "These reference sites are helpful for evaluating restoration success because they provide appropriate comparisons for ecosystem conditions (e.g., fish community composition) before and after habitat restoration." To identify these sites, postdoctoral researcher Andrew Miller, PhD, is mapping the distribution of several Great Lakes fishes that are common targets of habitat restoration, including walleye, yellow perch, smallmouth bass, lake sturgeon, northern pike, and white sucker. "Data are being compiled from a number of state, provincial, tribal, and academic partners and will be used to identify the habitat characteristics where each of these species thrives," said Alofs. "Benchmarks can be used to identify appropriate sites for fish community monitoring and site comparisons to inform restoration planning and evaluation."

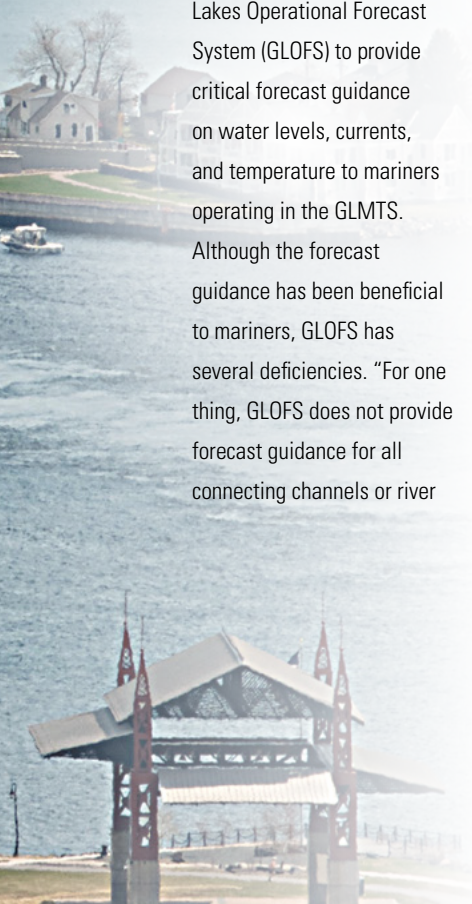
"This study will help NOAA identify potential bottlenecks to restoration of Great Lakes shorelines, and help maximize the effectiveness of future funding allocated to restoration efforts," said Billings. "The results of this study will both appraise the effectiveness and impacts of past restoration projects and inform how future restoration projects should be conducted to increase adaptive management within the Great Lakes." Ultimately, this project will provide tools that improve the assessment of shoreline restoration project "success," in turn, guiding more cost-effective and productive shoreline restoration actions in the Great Lakes.

CONNECTING THE GREAT LAKES AND RIVERS FOR A

Better Navigational Forecast

"In this project, we will address the gaps in navigational support by focusing on the interaction between the land and lake models at key Great Lakes ports."

— Dmitry Beletsky, PhD



GREAT LAKES WATERWAYS provide a crucial marine transportation system that supports $35 billion dollars in economic activity between the United States and Canada. The Great Lakes Marine Transportation System (GLMTS) consists of canals, channels, straits, locks, and rivers (e.g., Detroit River) that connect the lakes together to form one of the busiest shipping areas in the world. Over 150 tons of cargo move over the Great Lakes each year. The GLMTS serves 15 major international ports and some 50 regional ports on both sides of the U.S.-Canada border, including the twin ports of Duluth, Minnesota and Superior, Wisconsin. "The Port of Duluth is the largest and furthest-inland freshwater port in America and allows passage to ocean-traveling vessels, so it is important to have up-to-date information and forecasts of lake levels and conditions," said CIGLR Research Scientist Dmitry Beletsky, PhD.

Through a collaborative effort, NOAA developed and implemented the Great Lakes Operational Forecast System (GLOFS) to provide critical forecast guidance on water levels, currents, and temperature to mariners operating in the GLMTS. Although the forecast guidance has been beneficial to mariners, GLOFS has several deficiencies. "For one thing, GLOFS does not provide forecast guidance for all connecting channels or river inflows, such as near harbors, where it is most needed," said CIGLR Hydrological Modeler Lindsay Fitzpatrick.

CIGLR has teamed up with Eric Anderson, PhD (formerly NOAA GLERL, currently Colorado School of Mines) and John Kelley, PhD (NOAA National Ocean Service) to expand our coastal forecasting capabilities. "The goal is to address gaps in navigational support by focusing on the interaction between the hydrologic model that gives us information about river inflows and the coastal hydrodynamic model that allows us to predict lake conditions. We are doing this at key navigational points, such as the Port of Duluth, which are not resolved in the existing NOAA models," said Fitzpatrick. "To do this, we performed upstream expansion of the hydrodynamic Finite-Volume Community Ocean Model (FVCOM) grid, which is used in GLOFS. After testing the FVCOM grid to make sure it was stable and resolved the shoreline correctly, we coupled the model with the hydrological National Water Model (NWM) to account for the inflows to the lake."

The next steps will be to test the models' performance during different flooding events including lake-based floods (e.g., storm surges), precipitation-driven floods, and compound flooding events. Once the flood simulation capability of the model framework is evaluated, the team will develop a workflow of suggested approaches to operational implementations of the NWM and GLOFS.

NEW

Genomic Tools Advance Science

IN THE GREAT LAKES

"We have developed a new methodology that uses eDNA and eRNA to accurately detect species presence and estimate relative abundance."

— Subba Rao Chaganti, PhD

GENOMIC TOOLS developed by CIGLR in partnership with NOAA GLERL offer a new, robust technique to advance conservation biology and biodiversity management in the Great Lakes. Nathaniel Marshall, PhD (formerly CIGLR, currently Stantec), Henry Vanderploeg, PhD (NOAA GLERL), and Subba Rao Chaganti, PhD (University of Michigan, CIGLR) recently published an article in *Scientific Reports* describing a new methodology they developed that uses environmental DNA and RNA (eDNA and eRNA) to accurately detect and distinguish the presence of living organisms and improve estimates of their relative abundances. eDNA and eRNA refer to genetic material naturally released from an organism into the environment through feces/urine, mucus, gametes, skin/tissue, carcasses, and so on. It can be collected from an environment (such as lake water), rather than directly from an organism, and analyzed to identify the species present.

For successful management of bio-invasions and monitoring the reintroduction of threatened or endangered species in the Great Lakes and elsewhere, managers and stakeholders need timely and accurate scientific information. Traditionally, scientists have used conventional approaches such as visual surveys to measure species presence, but low rates of detection can increase the cost and labor required for this approach. During the last decade, eDNA has become a powerful tool used to collect species information from aquatic habitats. eDNA methodology is cost effective and easier to collect compared to traditional sampling, and has improved the management and assessment of species distribution. eDNA analysis has been incorporated into Great Lakes monitoring programs for detection of a wide range of organisms, including species that are endangered/threatened, invasive, or economically important.

Although eDNA is a rapid and robust methodology, some concerns still exist in current eDNA protocols. False positives (i.e., detection of species not actually present) are sometimes a concern with eDNA results. False positives occur when eDNA is naturally transported from one environment to another, such as with currents, natural dispersion within the water column, or from predator- and/or human-mediated movement. False positives can obscure species' spatial patterns and prevent true understanding of community assemblages. These drawbacks often raise major concerns for stakeholders and environmental managers working toward resource mitigation.

To address these concerns, Marshall, Vanderploeg, and Chaganti developed a new methodology that uses eDNA and eRNA to accurately detect species presence and estimate relative abundance. Because the concentration of eRNA degrades much faster than the eDNA, it provides a more accurate time marker for estimating when genomic material was released from an organism into the environment, thus improving estimates of community composition at any given location and time. "This new method is easily modified and can be applied to monitoring different species within the Great Lakes and elsewhere in the world," said Chaganti. "It is a powerful technique that will enhance the confidence of rapid decision-making by environmental managers and expand monitoring of ecosystem health."

Postdoc Fellows

SYNTHESIZING THE GREAT LAKES RESTORATION INITIATIVE'S Funding Efforts

Since 2010, the Great Lakes Restoration Initiative (GLRI) has funded thousands of projects to protect and restore the largest system of fresh water in the world. These projects have been implemented by hundreds of local, municipal, state, and federal entities and span a wide range of goals and objectives. After a decade of GLRI-funded work, there is a need to compile and synthesize these efforts. Matthew Jurjonas, PhD, joined The Nature Conservancy and CIGLR as a Baily Conservation Postdoctoral Research Fellow, where he will broadly assess the efforts of GLRI using the Open Standards for Conservation Action Framework, a local project manager survey, and interviews with coastal restoration project managers. Using the Open Standards of Conservation, Jurjonas will categorize GLRI funding efforts in order to compare planning efforts to implementation actions according to the target species, contaminants, and ecosystems. In addition, Jurjonas will conduct survey research to measure how restoration and remediation project managers considered equity in project design, what level of monitoring was performed for ecological and human well-being indicators, and what benefits were documented. His results will help guide future GLRI actions.

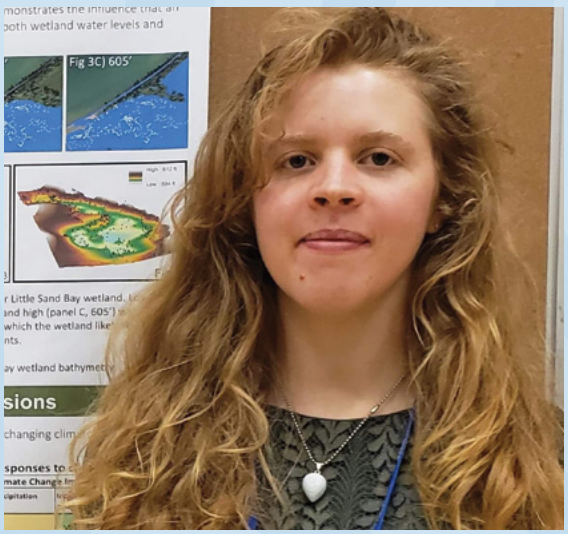
UNCOVERING LAKE ERIE'S Harmful Algal Bloom PARTNERS AND INTERACTIONS

Cyanobacterial harmful algal blooms (HABs) are increasing in magnitude and frequency worldwide and pose major economic, human health, and ecological threats in the Great Lakes. The main culprit in Lake Erie HABs is *Microcystis*, a cyanobacterium that produces multiple toxins, known as microcystins, that can cause liver damage in humans. Previous studies have shown that *Microcystis* does not live alone, but has potentially many bacterial partners. Sara R. Rivera, PhD, and her advisor Gregory Dick, PhD (University of Michigan), are recipients of a 2020 CIGLR Postdoctoral Fellowship award. They are working to identify the microbial partners of both toxin producing *Microcystis* and non-toxin-producing *Microcystis* to isolate and understand these partnerships. Rivera firmly believes that to better understand bloom dynamics, we must understand the "conversations" taking place at the molecular level between *Microcystis* and its bacterial partners. "Knowing who participates in and changes these conversations could impact the way we think about and predict harmful algal blooms," said Rivera. "Small changes can have large impacts when the message is passed along throughout the western Lake Erie basin." Ultimately, this research may help us to better understand why some blooms are bigger or more toxic than others.

Graduate Research Fellows

The Influence of Extreme Water Levels
ON COASTAL WETLAND EXTENT ACROSS THE LAURENTIAN GREAT LAKES

Great Lakes coastal wetlands (GLCW) are immensely productive ecosystems that provide many ecosystem services, such as water filtration and flood protection, through robust plant communities. Changes in the hydrologic regime of the Great Lakes in recent years are causing concern for these wetland plant communities. The concern is not simply a rise from low to high water, but a shift in the frequency and magnitude of fluctuations away from historic patterns. Olivia Anderson, a biology master's student at Central Michigan University and a 2020 CIGLR Graduate Research Fellowship recipient, along with her advisor Donald Uzarski, PhD (Central Michigan University), co-mentor Casey Godwin, PhD (University of Michigan, CIGLR), and committee members Anna Harrison, PhD (Central Michigan University), and Benjamin Heumann, PhD (Central Michigan University), have developed a study to better understand how GLCWs shift with extreme changes in water levels. Although wetlands can migrate to moderate the impact of water level changes, it is possible that water levels could change faster than wetlands can migrate. This could result in decreases to wetland extent and integrity, subsequently diminishing the ability of GLCWs to provide ecosystem services. This research will provide insight on how water levels may influence GLCW size and, as a result, GLCW ecosystem services, providing further support for coastal wetland protection and restoration in the Great Lakes region.



"I intend to improve understanding of how Great Lakes coastal wetlands have shifted with water level rise and lay a foundation for continuing to track trends in how wetland extent is affected by changes in long-term water levels across the Great Lakes."

— Olivia Anderson

Graduate Research Fellows

"Even as practiced scientists, we all bring biases to our work. The goal of my work is to blend climate science with social science to understand how the design and application of quantification methods like vulnerability assessments can affect the environmental health, livelihoods, and well-being of communities in the Great Lakes region."

— Sarah Dobie

Improving Coastal Resilience Planning

FOR GREAT LAKES COMMUNITIES

Michigan's coastal communities are facing a time of reckoning, as coastal erosion, record high water levels, and nearshore flooding are responsible for extensive coastal damage and the disruption of regional economies. In response, communities have begun to implement coastal resilience plans to mitigate these hazards and build adaptive capacity. Vulnerability and fiscal impact assessments are common tools used by planners and policymakers to prioritize coastal ocean resilience actions. However, little research has been conducted to explore how well these methods perform in Great Lakes coastal settings and to understand their practical implications for planning and policymaking. Sarah Dobie, PhD student at the University of Michigan and 2020 CIGLR Graduate Research Fellow, along with her advisors Philip Chu, PhD (NOAA GLERL) and Richard Norton, PhD (University of Michigan), conducted a study to investigate the applicability of these methods for use in Great Lakes coastal settings. They also simulated a property buyout program in four communities to compare the planning and policy implications. "Our study examined five quantification methods including a coastal [biophysical] vulnerability assessment, social vulnerability assessment, integrated social-biophysical vulnerability assessment, fiscal impact analysis, and fiscal impact analysis containing a contingent valuation of ecosystem services," said Dobie. "Our study tentatively suggests that current methods are not appropriate for application to the Michigan Great Lakes setting, due to its unique biophysical, socioeconomic, and institutional attributes, and we suggest ways to modify the methods. We also found that application of the methods for prioritizing coastal buyout assets produced very different spatial distributions, which suggests that the method communities use for planning and policymaking affects fiscal impact, social equity, and environmental health."

DEEP-WATER QUAGGA MUSSEL

Nutrient Cycling

IN THE GREAT LAKES

Over the past few decades, invasive zebra and quagga (dreissenid) mussels have become the dominant organism inhabiting the bottom of all the Great Lakes except for Lake Superior. By removing phytoplankton from the water, excreting nutrients, and changing bottom-dwelling communities, dreissenids have dramatically altered nutrient cycling regimes in the lakes. A lack of information on the bioenergetics and physiology of deep-water quagga mussels has resulted in a gap in understanding the impacts of dreissenids on the Great Lakes ecosystem. Audrey Huff is a PhD student at the University of Minnesota Duluth Large Lakes Observatory (UMD LLO) and a 2020–2021 CIGLR Graduate Research Fellow, working with advisor Ted Ozersky, PhD (UMD LLO) and co-advisor Mark Rowe, PhD (NOAA GLERL). "We are working to determine how deepwater dreissenid populations alter carbon, nitrogen, and phosphorus cycles in the Great Lakes, and to model individual deepwater quagga mussel metabolism and nutrient cycling," said Huff. "Results from this research will help us understand the trajectory of nutrient budgets and assist in the design of more effective management practices in the Great Lakes and other dreissenid-impacted ecosystems."

Graduate Research Fellows

FORECASTS TO IMPROVE
Multi-Objective Water Level Management
ON LAKE ONTARIO

Outflows from Lake Ontario are regulated by the International Joint Commission (IJC) at the Moses Saunders Dam on the St. Lawrence River. In 2017, the IJC implemented Plan 2014, with the goal of reintroducing natural variability in lake levels to promote wetland health and services while maintaining or improving other system objectives, such as flood control, navigation, hydropower, and recreation. However, Lake Ontario experienced its worst flood event on record soon after Plan 2014 was implemented. The precipitation record for 2017 was broken during the summer of 2019.

Kenji Doering is a 2020–2021 CIGLR graduate student at Cornell University working with fellow graduate student Kyla Semmendinger (Cornell University), advisor Scott Steinschneider, PhD (Cornell University), and co-advisors Lauren Fry, PhD (NOAA GLERL) and Deborah Lee (NOAA GLERL) to advance the use of subseasonal-to-seasonal hydroclimate forecasts in lake level management. Hydroclimate forecasting on subseasonal-to-seasonal timescales (two weeks to three months) is emerging as a new frontier at the intersection of climate, hydrology, and water resources management. Subseasonal-to-seasonal forecasts could be particularly useful for managing Lake Ontario water levels, as it provides information at critical times of year needed to balance tradeoffs between wetland inundation and flood risk. "By improving Lake Ontario flood forecast information, we hope to minimize the impacts of future flood events while preserving the services and benefits of the entire ecosystem," said Doering.

GREAT LAKES WATER LEVEL CHANGES:
Using Satellites for Lake Forecasting Studies

Changing water levels have altered the Great Lakes shoreline, causing severe damage to structures and creating hazardous conditions. Accurately characterizing Great Lakes-wide water mass changes can help us forecast climate-stressed lake conditions and improve weather forecasts. Chaoyang Zhang, an Ohio State University Geodetic Science PhD student and 2020 CIGLR Graduate Research Fellow recipient, his advisor C.K. Shum, PhD (Ohio State University) and co-mentor Philip Chu, PhD (NOAA GLERL), used two satellite-based techniques to continuously monitor and collect data on changes in Great Lakes water mass from 2002–2020. The team used satellite altimetry to collect observations of lake height variation and satellite gravimetry to measure lake mass change. Merging lake mass change estimates from the two different geodetic data sets can improve assimilative Great Lakes forecasting.

Pelee Island Magic Sand:

TRACKING MICROBIAL GENE EXPRESSION AND METABOLITES DURING MICROCYSTIN DEGRADATION IN LAKE ERIE SEDIMENT

Microcystin (MC) hepatotoxins released during cyanobacterial blooms pose a human health risk in freshwater lakes worldwide. As natural resource managers seek strategies to reduce the severity and impact of cyanobacterial blooms, there is a need to better understand the ecological processes that influence the presence of MC toxins. There is evidence that MC toxins are removed through microbial degradation, but the mechanism by which this occurs is not well understood in Lake Erie.

Chelsea Salter, a 2020 CIGLR Graduate Research Fellow and master's student at the Great Lakes Institute for Environmental Research (GLIER) at the University of Windsor, aims to gain a comprehensive understanding of the degradation process by studying the microbial community in sand from Pelee Island, located in the western basin of Lake Erie. "Municipal monitoring of public well water on Pelee Island has shown an absence of MC toxins during bloom events," said Salter. "This groundwater is sourced from the surrounding lake but passes through sand trenches on the shores of the island, indicating biological degradation is occurring in the sand." Salter and her advisor, Chris Weisener, PhD (University of Windsor, GLIER), have partnered with Judy Westrick, PhD (Wayne State University) and Subba Rao Chaganti, PhD (University of Michigan, CIGLR) to investigate which bacterial species are involved, which genes are being expressed, and how MC toxins are degrading. "Our team is monitoring the changes that occur within the microbial community during exposure to MC variants," said Salter. "Cyanobacteria blooms are becoming more widespread and it is imperative that we understand more about how to safely and effectively remove prevalent toxins from Lake Erie and other freshwater sources."

"Lake Erie is an incredibly important resource, but its utility is threatened due to the toxins released from algal blooms that occur each year. My work with CIGLR is providing me the opportunity to help tackle this challenge by utilizing bacteria to degrade microcystin toxins."

— Chelsea Salter

2020 Great Lakes Summer Fellows

In partnership with NOAA GLERL, the Great Lakes Summer Fellows Program is the cornerstone of our 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. Translating this hands-on research to our new hands-off world was the monumental task given to the 21 mentors from CIGLR, NOAA GLERL, and The Ohio State University (a CIGLR Consortium institution) who volunteered to guide the eight students accepted to the 2020 fellowship program. Over the course of a few short weeks, these dedicated mentors adapted their research projects to a virtual format by developing new and relevant research questions, overcoming critical IT obstacles, and preparing for remote interaction.

While the fellowship mentors made adjustments to their research plans, the CIGLR ECO (Engagement, Career Training, and Outreach) team translated the career preparation and team-building aspects of the program to a virtual format. In a typical year, these activities include weekly seminars on career development topics and many opportunities for networking, both as a Fellows cohort and more broadly with the staff and students of CIGLR, NOAA GLERL, and other in-house partners working at the laboratory. Moving the seminars to a virtual platform was an easy modification, but replicating the social aspects of the program, which are always reported among the most valuable parts of Fellows' experiences, proved to be a greater challenge. To help give the Fellows exposure to the many dynamic individuals in our collaborative environment, the weekly virtual career development seminars were complemented by weekly virtual research discussions, where Fellows had the opportunity to hear from CIGLR and NOAA GLERL scientists about their work and their own career paths. The Fellows also participated in virtual social hour gatherings, trivia nights, and a book club focused on diversity and inclusion topics.

Despite the less-than-ideal circumstances, the Fellows, mentors, and ECO team truly demonstrated just how much can be accomplished in a virtual fellowship. We applaud everyone involved for their flexibility, creativity, and positivity that shaped a meaningful, career-building experience out of a challenging situation.

The 2020 Great Lakes Summer Fellows comprised:

Brenna Friday

Wayne State University

Brenna worked with Michael Fraker (formerly CIGLR, currently Michigan Sea Grant) to identify climatic influences on antipredator phenotypic plasticity in larval amphibians to clarify how the structure and function of many ecosystems will be impacted by future aquatic conditions.

Chanse Ford

Michigan State University

Chanse was mentored by Lacey Mason (NOAA GLERL), Lindsay Fitzpatrick (CIGLR), Brent Lofgren (NOAA GLERL), Lauren Fry (NOAA GLERL), and Yao Hu (formerly CIGLR, currently University of Delaware). He evaluated the next generation runoff risk tools that will help farmers determine the best time to apply fertilizers based on weather forecasts and soil moisture conditions.

Kaylin Jones

University of Michigan

Kaylin worked with Yi Hong (CIGLR) and Eric Anderson (formerly NOAA GLERL, currently Colorado School of Mines) to study flood resilience in Great Lakes coastal regions by using numerical models to predict flood risks in different zones under climate change.

Lorrayne Miralha

Arizona State University

Lorrayne was mentored by Regan Errera (NOAA GLERL) and James Hood (The Ohio State University). She investigated the environmental mechanisms influencing seasonal progression of phytoplankton in the western basin of Lake Erie from spring to fall 2019.

Drew Reiser

University of Illinois at Urbana-Champaign

Drew worked with Jia Wang (NOAA GLERL), Philip Chu (NOAA GLERL), and Ayumi Fujisaki-Manome (CIGLR) to analyze and predict ice cover and thickness in the Great Lakes and the Arctic in response to a changing climate on seasonal, interannual, and decadal time scales.

Kaitlyn Rivers

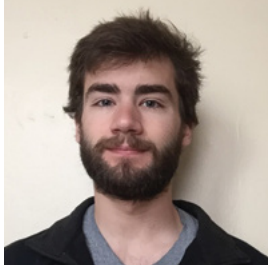
Oberlin College

Kaitlyn was mentored by David Wells (formerly CIGLR, currently U.S. Department of Defense), Doran Mason (NOAA GLERL), Ed Rutherford (NOAA GLERL), and Hank Vanderploeg (NOAA GLERL) to investigate bottlenecks to fish larvae growth, survival, and potential recruitment in Lake Michigan.

Anisha Shrestha

Grand Valley State University

Anisha worked with Russ Miller (CIGLR) and Michael Fraker (formerly CIGLR, currently Michigan Sea Grant) to identify patterns in Great Lakes environmental data collected by an underwater glider.



Kaelan Weiss

University of Minnesota Duluth

Kaelan was mentored by James Kessler (NOAA GLERL), Dmitry Beletsky (CIGLR), and Dan Titze (CIGLR). He helped improve water level forecasts in the Lake Champlain basin by assessing the accuracy, or skill, of operational atmospheric models that are critical for improving water level predictions in the basin.

CONGRATULATIONS TO THE 2021 GREAT LAKES SUMMER FELLOWS COHORT

Courtney Cameron
San Francisco State University

Sean Daly
St. Olaf College

Julie Dellick
University of Michigan

Collin DeYoung
Central Michigan University

Jacob Fredrickson
University of Minnesota Duluth

Mercedes Horn
University of Vermont

Isabelle Horvath
Marquette University

Tyler Summers
University of Alaska-Fairbanks

Hear about the program from the Fellows themselves! Scan for Fellows profile videos.

Summits, Rapid Response, & ECO Funding

The Great Lakes Indicator Summit was led by the National Wildlife Federation (NWF) Great Lakes Regional Center. It was the first CIGLR summit to be held virtually.

CIGLR Summit:

Great Lakes Indicators: Exploring Alternative Approaches through Stakeholder Input

Environmental indicators have been used for decades to track the status of multiple aspects of the Great Lakes ecosystem. However, it is not clear to what extent the broader policymaking and nongovernmental organization (NGO) communities closely track and utilize the current indicators. To address this need, Michael Murray, PhD, of the National Wildlife Federation Great Lakes Regional Center, led a summit of 25 experts from the natural and social sciences, policymaking and policy analysis, and NGO and business communities. Steering committee members included John Bratton, PhD (Limnotech), Ashley Elgin, PhD (NOAA GLERL), Casey Godwin, PhD (University of Michgan, CIGLR), and Catherine Riseng, PhD (University of Michigan, Michigan Sea Grant). The group gathered virtually with a goal of identifying alternative approaches to indicator development and implementation that are science-based, that link management and ecosystem outcomes, and that are of greater NGO and other stakeholder interest. A report summarizing the summit's results and recommendations is in preparation.

The Great Lakes Groundwater Summit was led by Grand Valley State University. It was the second CIGLR summit to be held virtually.

CIGLR Summit:

Groundwater in Crisis? Addressing Groundwater Challenges in Michigan as a Template for the Great Lakes

Groundwater is a critical but understudied and underappreciated natural resource, both nationally and in the Great Lakes basin. Given its importance, and given the increasing pressures being placed on groundwater, issues have arisen in recent decades around both groundwater quantity and quality in the Great Lakes. A summit led by Alan Steinman, PhD (Grand Valley State University) was convened to address key groundwater issues. A group of 29 experts participated from the academic, private, and public sectors, including steering committee members Philip Chu, PhD (NOAA GLERL), Patrick Doran, PhD (The Nature Conservancy), Carol Miller, PhD (Wayne State University), Don Uzarski, PhD (Central Michigan University), and Tom Zimnicki (Michigan Environmental Council). The summit specifically focused on Michigan groundwater, which is in the midst of several critical issues, in terms of both quality (e.g. PFAS) and quantity (e.g. declining static water levels, bottled water withdrawals). This summit aimed to inventory the key challenges facing groundwater in Michigan; identify the knowledge gaps, scientific needs, and policy recommendations associated with these challenges; construct a set of conceptual models; and develop a list of next steps that can be taken to address these groundwater challenges. The group plans to produce a white paper focused on policy implications and recommendations, and at least one peer-reviewed manuscript based on summit findings.

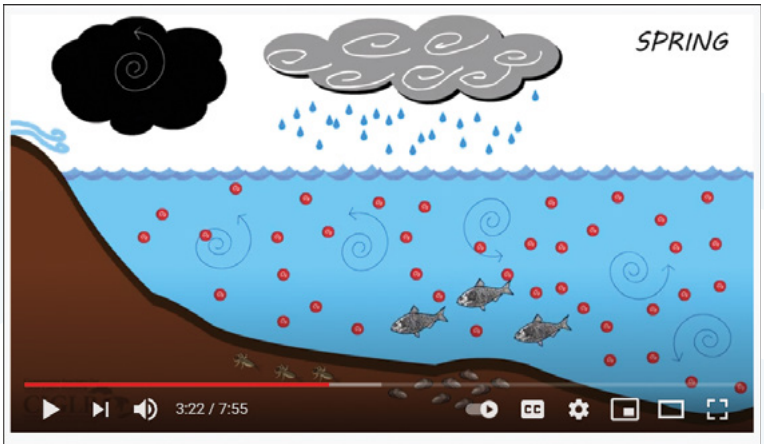
CIGLR Summit:

Oil Spills Under Ice — Challenges and Solutions

Oil spills can lead to disastrous outcomes for all natural waters, but spills in icy conditions pose a special challenge for an emergency response team. Current methods for locating oil spilled under ice are based on an experimental "guess-and-check" approach, wherein holes are cut through the ice in strategic locations with the hope of revealing oil. New methods of oil detection under ice must be developed to effectively decrease detection and response times. As there is an increased risk of an oil spill or leak due to shipping and aging infrastructure in the Great Lakes, awareness, preparation, and having the most effective methods for detection and recovery will lead to the greatest success in protecting the environment. Furthermore, such techniques can be valuable tools for scientists, communities near potentially affected areas, and legislators concerned about oil transport and related risks within the Great Lakes region. Summit lead Volodymyr Tarabara, PhD (Michigan State University) and steering committee members Ayumi Fujisaki-Manome, PhD (University of Michigan, CIGLR), Melissa Baird, PhD (Michigan Technological University), Edoardo Sarda (Lake Superior State University), and John Lenters, PhD (Michigan Technological University) are organizing interdisciplinary experts from the academic, private, and public sectors to explore a broad set of issues related to oil spills under Great Lakes ice. A virtual pre-meeting planning session among 22 of the working group affiliates was held in May 2020 to discuss the underlying science, technical solutions, and social impacts. The working group anticipates holding an in-person summit with the goal of further building a framework to address the challenge of oil spills in icy conditions within the Great Lakes region. A publication summarizing the summit's results and recommendations and grant proposal to further this work will be prepared as a result of this meeting.

Virtual Outreach Offers an Expanded Audience

Each year, the Cooperative Institute for Great Lakes Research (CIGLR) joins forces with NOAA's Great Lakes Environmental Research Laboratory (NOAA GLERL) to participate in approximately 10 local and regional outreach events. Michele Wensman (former CIGLR Outreach Specialist) and Communications Specialist Aubrey Lashaway create an engaging setup that includes hands-on activities and informational materials that translate CIGLR and NOAA GLERL research for the public. In 2019, they reached approximately 19,000 people during public outreach events.



An animated, educational video about hypoxia was a product of CIGLR's 2020 virtual outreach campaign. CIGLR Aquatic Ecology Research Technician Christine Kitchens produced the video.

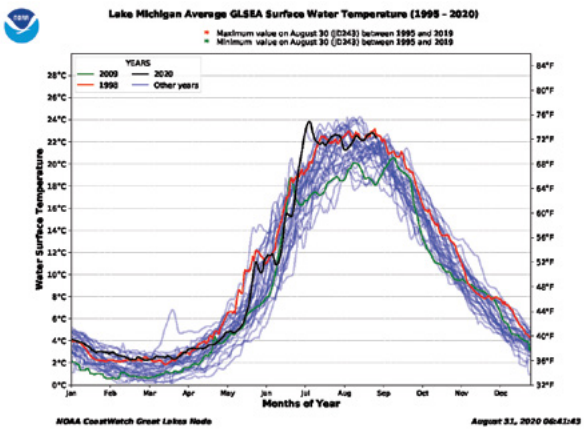
However, 2020 was a different year entirely, as COVID-19 upended the way we interact as humans. CIGLR planned to kick off their 2020 outreach events by traveling to Michigan Technological University (MTU) to participate in their Annual National World Water Day event. However, in early March 2020, MTU cancelled the in-person event due to COVID-19. Shortly thereafter, one by one, each outreach event on CIGLR's calendar was cancelled.

"So, what do you do when you can't reach the public in person?" asked Wensman. "We completely switched gears and created virtual programming, recognizing that teachers still had their classrooms and parents were looking for ways to connect their children to engaging science. We created and shared activities on Asian carp, Great Lakes food webs, Great Lakes trivia, and questions about fish otoliths. CIGLR's outreach campaign on Twitter included puzzles on invasive dreissenid mussels, word-finds, and coloring pages of Great Lakes fishes. We shared photos of research and online publications. One of CIGLR's research technicians created a video on hypoxia. We even posted fun science jokes!"

The most rewarding outcome was virtually connecting with over 797,000 people from April to June, 2020 and watching them share and promote CIGLR programs with others.

"CIGLR misses that human connection with people all across the Great Lakes region," said Wensman. "We miss stories that parents and children share about a favorite Great Lake, and concerns about the importance of taking care of these most precious waters. Although there is no replacement for in-person events, we know that virtual programs help enhance our connection, until we can meet again."

Scan to watch video



New NOAA CoastWatch Product Compares Great Lakes Water Temperatures

Exceptionally hot weather patterns in July 2020 pushed surface water temperatures in most of the Great Lakes to their highest level on record. In a typical year, surface temperatures usually peak in August. "In response to the extremely warm water temperatures, the NOAA CoastWatch Great Lakes team received many inquires from the community about the current and historical Great Lakes water temperatures," said Songzhi Liu, CIGLR Programmer/Analyst and research assistant for Great Lakes CoastWatch. "To answer these questions, we created a **new product** that displays the Great Lakes current, maximum, and minimum average surface water temperatures in one graph." This new product uses the **Great lakes Surface Environmental Analysis (GLSEA)** and is updated daily to reflect the most up-to-date information on changes in temperature.

2021 Winners

CIGLR AWARDS $260,000 IN 2021 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, and respond to emergencies and other time-sensitive needs in the Great Lakes. The recipients of the 2021 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

- **Daniel Heath, PhD, University of Windsor:** Environmental DNA Applications in Diet/Trophic Analyses for Key Great Lakes Fishes
- **Cody Sheik, PhD, University of Minnesota Duluth:** The Effects of Climate Change and Eutrophication on Cyanobacterial Diazotrophs in the Great Lakes

GRADUATE RESEARCH FELLOWSHIP AWARDS

- **David Lodge and Jose Andres, PhDs, Cornell University:** A Comparison of Novel Environmental DNA Approaches and Benthic Video Surveys to Quantify Round Goby Abundance in Lake Michigan
- **Daelyn Woolnough and David Zanatta, PhDs, Central Michigan University:** Surveys and Habitat Modelling for Both Unionids and Dreissenids in Two Large Rivers of the Laurentian Great Lakes

SUMMIT AND WORKING GROUP (SWG) AWARDS

- **Karen Alofs, PhD, University of Michigan:** Benchmarks for Great Lakes Fish Habitat Restoration
- **Mike McKay, PhD, University of Windsor:** Lake Erie Central Basin Hypoxia: State of the Science Review and Approaches to Track Future Progress
- **Chris Winslow, PhD, Ohio State University:** Smart Lake Erie Citizen Science Summit

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J. Val Klump
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Dennis McCauley
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Mike Murray
Staff Scientist, National Wildlife Federation Great Lakes Regional Center

Steve Ruberg
Group Leader, Marine Instrumentation Lab, NOAA GLERL

Lars Rudstam
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Alan Steinman
Director, Annis Water Resources Institute, Grand Valley State University

Robert W. Sterner
Director, Large Lakes Observatory, University of Minnesota Duluth

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

Hank Vanderploeg
Research Ecologist, NOAA GLERL

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

CIGLR welcomes a new member to our team!

Abby Hutson, PhD, is a CIGLR Postdoctoral Research Fellow collaborating with Ayumi Fujisaki-Manome, PhD, and the climate modeling team at NOAA GLERL to improve the simulation of precipitation within the Great Lakes region and advance our understanding of its potential impact in a changing climate. Prior to working with CIGLR and NOAA GLERL, Hutson studied storm-scale dynamics within supercell thunderstorms, using both observations and numerical modeling to identify outflow characteristics associated with tornado formation.

Peer-Reviewed Publications

Abdalla, S., Y. Jia, C.K. Shum and others. 2021. Altimetry for the future, building on 25 years of progress. *Advances in Space Research.* (DOI:10.1016/j.asr.2021.01.022, 2021).

Alsip, P.J., H. Zhang, M.D. Rowe, E. Rutherford, D.M. Mason, C. Riseng and Z. Su. 2020. Modeling the interactive effects of nutrient loads, meteorology, and invasive mussels on suitable habitat for Bighead and Silver Carp in Lake Michigan. *Biological Invasions.* 22:2763–2785. (DOI:10.1007/s10530-020-02296-4).

Anderson, H.S., T.H. Johengen, C.M. Godwin, H. Purcell, P.J. Alsip, S.A. Ruberg and L.A. Mason. 2021. Continuous in situ nutrient analyzers pinpoint the onset and rate of internal P Loading under anoxia in Lake Erie's central basin. *Environmental Science & Technology: Water.* 1(4):774–781. (DOI:10.1021/acsestwater.0c00138).

Bai, P., J. Wang, P. Chu, N. Hawley, A. Fujisaki-Manome, J. Kessler, B.M. Lofgren, D. Beletsky, E.J. Anderson and Y. Li. 2020. Modeling the ice-attenuated waves in the Great Lakes. *Ocean Dynamics.* 70:991–1003. (DOI:10.1007/s10236-020-01379-z).

Binding C.E., R.P. Stumpf, R.A. Shuchman and M.J. Sayers. 2020. Advances in remote sensing of Great Lakes algal blooms. *Contaminants of the Great Lakes, ed. J. Crossman and C. Weisener.* pp:217–232. (DOI:10.1007/698_2020_589).

Cai, Q., J. Wang, D. Beletsky, J. Overland, M. Ikeda and L. Wan. 2021. Accelerated decline of summer Arctic sea ice during 1850–2017 and the amplified Arctic warming during the recent decades. *Environmental Research Letters.* 16(3). (DOI:10.1088/1748-9326/abdb5f).

Chen, X., R.G. Nystrom, C.A. Davis and C. Zarzycki. 2021. Dynamical structures of cross-domain forecast error covariance of a simulated tropical cyclone in a convection-permitting coupled atmosphere-ocean, model. *Monthly Weather Review.* pp:41–63. (DOI:10.1175/MWR-D-20-0116.1).

Do, H.X., J.P. Smith, L.M. Fry and A.D. Gronewold. 2020. Seventy-year long record of monthly water balance estimates for Earth's largest lake system. *Scientific Data.* 7(276). (DOI:s41597-020-00613-z).

Evans, J.T. and V.J. Denef. 2020. To dereplicate or not to dereplicate? *mSphere.* 5(4):e00971-19. (DOI:10.1128/mSphere.00971-19).

Fujisaki-Manome, A., E.J. Anderson, J.A. Kessler, P.Y. Chu, J. Wang and A.D. Gronewold. 2020. Simulating impacts of precipitation on ice cover and surface water temperature across large lakes. *Journal of Geophysical Research: Oceans.* 125(5):e2019JC015950. (DOI:10.1029/2019JC015950).

Fujisaki-Manome, A., G.E. Mann, E.J. Anderson, P.Y. Chu, L.E. Fitzpatrick., S.G. Benjamin, E.P. James, T.G. Smirnova, C.R. Alexander and D.M. Wright. 2020. Improvements to lake-effect snow forecasts using a one-way air-lake model coupling approach. *Journal of Hydrometeorology.* 1–50. (DOI:10.1175/JHM-D-20-0079.1).

Godwin, C.M., J.R. Zehnpfennig and D.R. Learman. 2020. Biotic and abiotic mechanisms of manganese (II) oxidation in Lake Erie. *Frontiers in Environmental Science.* 8:57. (DOI:10.3389/fenvs.2020.00057).

Guo, T., V. Campbell-Arvai and B.J. Cardinale. 2021. Why does the public support or oppose agricultural nutrient runoff regulations? The effects of political orientation, environmental worldview, and policy specific beliefs. *Journal of Environmental Management.* 279. (DOI:10.1016/j.jenvman.2020.111708).

Guo, T., R.C. Graydon and R.S. Bejankiwar. 2020. Informing public engagement strategies to motivate the public to protect the Great Lakes: Lessons learned from the 2018 Great Lakes Basin Binational Poll. *Environmental Management.* 66:733–741. (DOI:10.1007/s00267-020-01364-8).

Li, J., V. Ianaiev, A. Huff, J. Zalusky, T. Ozersky and S. Katsev. 2021. Benthic invaders control the phosphorus cycle in the world's largest freshwater ecosystem. *Proceedings of the National Academy of Sciences.* 118(6). (DOI:10.1073/pnas.2008223118).

Liu, Q., M.D Rowe, E.J. Anderson, C.A. Stow, R.P. Stumpf and T.H. Johengen. 2020. Probabilistic forecast of microcystin toxin using satellite remote sensing, in situ observations and numerical modeling. *Environmental Modelling and Software.* 128:104705. (DOI:10.1016/j.envsoft.2020.104705).

Lower, E., R. Sturtevant and D. Gill. 2020. Sharing feedback, sharing screens: Videoconferencing as a tool for stakeholder-driven web design. *Journal of Extension.* 58(3):v58-3tt1. (tigerprints.clemson.edu/joe/vol58/iss3/8).

Marshall, N.T., H.A. Vanderploeg and S.R. Chaganti. 2021. Environmental (e)RNA advances the reliability of eDNA by predicting its age. *Scientific Reports.* 11:2769. (DOI:10.1038/s41598-021-82205-4).

Robinson, K.F., P.J. Alsip, A.R. Drake, Y.C. Kao, M.A. Koops, D.M. Mason, E.S. Rutherford and H. Zhang. 2021. Reviewing uncertainty in bioenergetics and food web models to project invasion impacts: Four major Chinese carps in the Great Lakes. *Journal of Great Lakes Research.* 47(1):83–95. (DOI:10.1016/j.jglr.2020.11.003).

Rowland, F.E., C.A. Stow, L.T. Johnson and R.M. Hirsch. 2021. Lake Erie tributary nutrient trend evaluation: Normalizing concentrations and loads to reduce flow variability. *Ecological Indicators.* 125. (DOI:10.1016/j.ecolind.2021.107601).

Schmidt, K.C., S.L. Jackrel, D.J. Smith, G.J. Dick and V.J. Denef. 2020. Genotype and host microbiome alter competitive interactions between *Microcystis aeruginosa and Chlorella sorokiniana. Harmful Algae.* 99. (DOI:10.1016/j.hal.2020.101939).

Steiner, A.L., A. Amiri-Farahani, N. Olson, D. Neubauer, B. Roozitalab and A.P. Ault. 2021. Lake spray aerosol emissions alter nitrate partitioning in the Great Lakes region. *Geophysical Research Letters.* (DOI:10.1002/essoar.10505990.1).

Vasquez, A.A., B.A. Kabalan, J.L. Ram and C.J. Miller. 2020. The biodiversity of water mites that prey on and parasitize mosquitoes. *Diversity.* 12(6):226. (DOI:10.3390/d12060226).

Yang, T.Y., J. Kessler, L. Mason, P.Y. Chu and J. Wang. 2020. A consistent Great Lakes ice cover digital data set for winters 1973–2019. *Scientific Data.* 7(250). (DOI: s41597-020-00603-1).

Non-Peer-Reviewed Publications:

Lower, E., N. Boucher, A. Davidson, A. Elgin and R. Sturtevant. 2020. 2019 Update to "A risk assessment of potential Great Lakes aquatic invaders." *NOAA Technical Memorandum GLERL-169c.* (DOI:10.25923/w9vp-bk86).

Lower, E., N. Boucher, R. Sturtevant and A. Elgin. 2020. 2019 Update To "An Impact Assessment of Great Lakes Aquatic Nonindigenous Species." *NOAA Technical Memorandum GLERL-161c.* (DOI:10.25923/zpeq-c616).

In the Media

HARMFUL ALGAL BLOOMS

- **U-M CIGLR's Research Staff Provide Critical Information on Lake Erie's Harmful Algal Blooms During COVID-19 Pandemic,** University of Michigan School for Environment and Sustainability News

HYPOXIA

- **Release of nutrients from lake-bottom sediments worsens Lake Erie's annual 'dead zone,' could intensify as climate warms,** Michigan News
- **Release of nutrients from lake-bottom sediments worsens Lake Erie's annual 'dead zone',** Science Bulletin
- **U-M team makes discovery about Lake Erie dead zone,** Michigan Radio

METEOTSUNAMIS & WATER LEVELS

- **Researchers Aim to Improve Coastal Storm Surge Forecasting,** The Cordova Times

OTHER STORIES

- **E.E.S. Student Secures CIGLR Fellowship,** Central Michigan University Beyond the Headlines
- **Thirty-five years of restoring Great Lakes Areas of Concern has a hopeful future,** Great Lakes Echo

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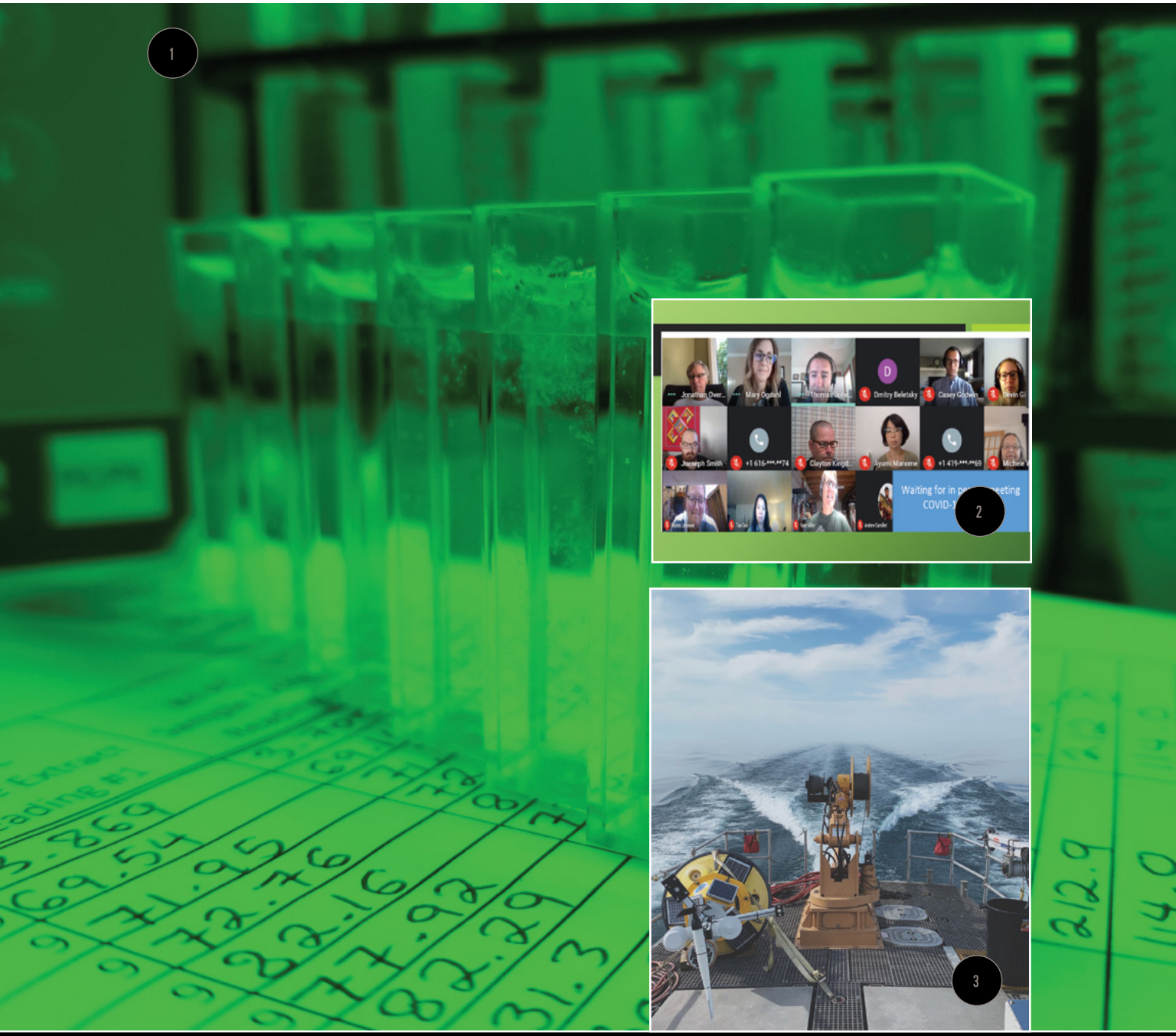
Annual Photo Contest Winners

CIGLR IN ACTION



With a universal 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 fourth year in a row, the CIGLR Photo Contest entries feature images that inform, inspire, and amaze.

1st place: *Phycocyanin Days,* Christine Kitchens

2nd place: *Zoom Meeting Congratulating Tom Johengen,* Subba Rao Chaganti

3rd place: *CIGLR Ludington Buoy Deployment,* Hayden Henderson

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: *Lake Superior Corgi,* Aubrey Lashaway

2nd place (2a): *Lake Michigan Ice,* Holly Kelchner

2nd place (2b): *Sugarloaf Superior Splendor,* Aubrey Lashaway

2nd place (2c): *Pictured Perfect,* Aubrey Lashaway

2nd place (2d): *Manganese Manifold,* Christine Kitchens

Explore more photos.

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