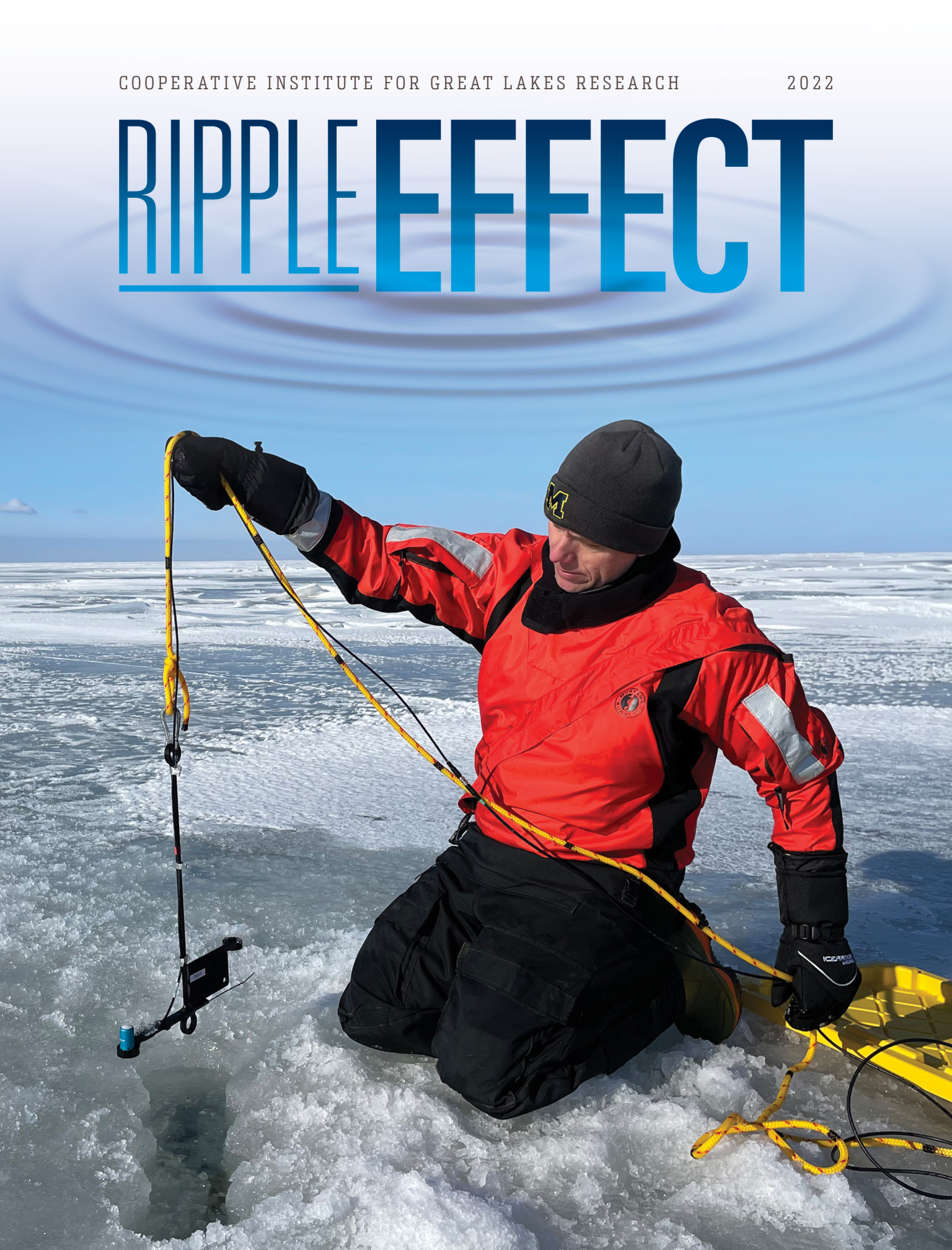
COOPERATIVE INSTITUTE FOR GREAT LAKES RESEARCH 2022

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.

The Local Match Conundrum

PHOTO CONTEST
Winners

@CIGLR.UMich
@CIGLR_UM
@ciglr_um
Cooperative Institute for Great Lakes Research
CIGLR um
Cooperative Institute for Great Lakes Research

ciglr.seas.umich.edu

Cover Photo: Michigan News

Produced by Michigan Creative, a unit of the University of Michigan Office of the Vice President for Communications. MC220263

Dear Friends and Colleagues,

Students in Ann Arbor and across the 10 university campuses in CIGLR's Consortium are rolling toward the end of their first semester. The height of the academic school year reminds me of the importance of CIGLR's educational mission and the opportunities that it brings. Through coursework and research experiences, thousands of students across the region will learn about the Great Lakes, their value, the threats that they face, and how we can study, protect, and manage them for a sustainable future. For some students, this represents a deepening of a life-long love of the Great Lakes. For others, an awakening to their existence and importance. Perhaps most inspiring to me is that some of these students will lead the future of Great Lakes research and conservation.

The onset of this semester marked the end of my first year as CIGLR's Director. And what a remarkable year it has been. One of the first major actions was to redefine our organizational structure. We retained our Theme Leads, thus continuing the highly successful model in which Casey Godwin (Invasive Species & Food Web Ecology), Ayumi Fujisaki-Manome (Hydrometeorological & Ecosystem Forecasting) and Russ Miller (Observing Systems & Advanced Technology) lead our research themes, coordinated with the NOAA GLERL branch chiefs. Further, we added an Associate Director with the hopes of using this position to broaden our expertise and strengthen connections between CIGLR and its host unit, the University of Michigan's School for Environment and Sustainability.

I am absolutely delighted that we were able to recruit Dr. Sara Hughes as Associate Director. Sara brings her expertise on water and climate policy and equity to CIGLR while leading the expansion of our footprint in social sciences more broadly (more about Sara on page 2). What does leadership and expansion of our social sciences really mean for CIGLR? To me, it is a commitment to communities and to society - working to ensure that our science is solutions oriented, and that those solutions are just, working for all Great Lakes citizens, especially those most vulnerable. Together with the revitalization of our stakeholder engagement program via the recent hires of Riley Ravary and Megan DiCocco, we are poised to meet our goal of co-designing research and research products with stakeholders.

In late May we learned that our proposal to renew CIGLR for the next 5 years was accepted (2022-2027). We will continue to collaborate with our NOAA colleagues on research to meet the challenges faced by the Great Lakes from climate change, invasive species, and pollution. Our funding ceiling of $53 million dollars over the next 5 years is more than twice the 2017 award ($20M). We are already seeing an increase in funding with grants starting this fall, especially new projects on improving predictions of changing Great Lakes water levels and coastal flooding, both funded through the Bipartisan Infrastructure Law.

With the renewal of CIGLR, we are also excited to welcome Lake Superior State University (LSSU) to the Regional Consortium. Located strategically at the nexus of three Great Lakes and on a connecting channel, LSSU brings unique expertise and facilities in fisheries, robotics, and geospatial science along with valuable partnerships with the Bay Mills Indian Community and the Sault Sainte Marie Tribe of Chippewa Indians. LSSU is a key partner in the establishment of the Great Lakes National Center of Expertise on oil spill research and response. CIGLR will work with NOAA GLERL, LSSU, and the United States Coast Guard to examine the impacts of oil spills in freshwater environments and develop effective methods for responding to oil spills in the Great Lakes.

Finally, with the growth of CIGLR's funding comes an expansion of our workforce. We have added 9 new full-time employees during my first year, and the pace of hiring is set to accelerate. Our staff are the foundation of all that we do; if we are successful, it is because they are successful. I am in awe of their performance, dedication, and enthusiasm. I can't wait to welcome new colleagues to the CIGLR family and to continue to build a strong CIGLR community and supportive culture of collaboration, inclusion, and excellence. As I get to know our long-time dedicated staff, our new arrivals, and the next generation of Great Lakes researchers in classrooms and laboratories on campus, I can't help but feel that the future of the Great Lakes is bright.

Sincerely,

Gregory J. Dick

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

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

WELCOME

Sara Hughes

SARA HUGHES, PhD, is an Associate Professor in the School for Environment and Sustainability (SEAS) , where she directs the Water and Climate Policy Laboratory. Professor Hughes recently joined CIGLR as Associate Director, expanding CIGLR's social science research footprint and thus amplifying the societal impact of our work. She has been a U-M faculty member since 2019 and has served as member of the SEAS PhD Program Committee; the SEAS Diversity, Equity, and Inclusion Communications and Diverse Voices Sub-committee; and as a member of the U-M Water Center's Steering Committee.

Prior to joining the faculty at Michigan, Professor Hughes was an Assistant Professor in the Department of Political Science at the University of Toronto, and a postdoctoral fellow at the U.S. Environmental Protection Agency and the National Center for Atmospheric Research. Her expertise in environmental policy and environmental justice complement CIGLR's strengths in natural science. She studies water and climate policymaking processes and outcomes, including both the drivers of policy (politics and incentives, organizational capacities and constraints, and environmental conditions) and the effects of policy (environmental outcomes, justice and equity, impacts at other levels of government). Her work has been supported by research grants from numerous agencies including the National Science Foundation and the Social Science and Humanities Research Council (Canada). Hughes said, "I am excited to work with the scientists at CIGLR and NOAA to identify opportunities to ask and answer meaningful research questions that incorporate social science perspectives. This kind of interdisciplinary research can forward our understanding of the drivers of environmental challenges in the Great Lakes and identify opportunities for effective and equitable solutions."

Hughes's leadership and expertise make her well-positioned for her role with CIGLR, which includes building research partnerships with Regional Consortium members, developing new research directions, identifying new funding opportunities, and mentoring postdocs and researchers. "My goal is to find opportunities to build social science capacities and insights that complement and support the great work already happening in CIGLR and NOAA, and to foster stronger connections between CIGLR science and policymakers at the local, state, regional, and national levels," said Hughes.

Together with Casey Godwin (CIGLR) and Mike Shriberg (NWF, a CIGLR Consortium member), Hughes is currently advising a CIGLR Postdoctoral Fellow (2022–23) focused on evaluating and developing recommendations for resilience and equity metrics that can be used to guide future investments in Great Lakes ecosystems and communities through the Great Lakes Restoration Initiative (GLRI). Other initial research focus areas include identifying effective and equitable financing models for Great Lakes infrastructure and communities; strengthening collaboration in HABs management and governance; and building coastal resilience and climate adaptation in the region.

Hughes also brings a strong interest in supporting CIGLR's DEI initiatives. "Building diversity, equity, and inclusion into everything CIGLR does — from hiring decisions to research priorities to training opportunities — will strengthen our science and relevance to society," said Hughes.

A Career of Leadership

IN GREAT LAKES RESEARCH

AFTER 31 YEARS SERVING THE GREAT LAKES COMMUNITY, WE CELEBRATE THE CAREER OF DR. THOMAS JOHENGEN AS HE RETIRES.

Tom Johengen has been a research scientist with the NOAA Cooperative Institute for Great Lakes Research (CIGLR, formerly the Cooperative Institute for Limnology and Ecosystems Research (CILER)) at the University of Michigan since 1991. He has also served as the Institute's Director (2000–05, 2020–21), Associate Director (2009–19), on numerous Great Lakes' advisory boards and panels, and most recently as the Michigan Sea Grant Director (2019–present).

Johengen holds degrees from Michigan State University (BS), Florida State University (MS), and the University of Michigan (PhD). His research has focused on a range of critical Great Lakes issues including harmful algal blooms, the impact of invasive species on lower food webs, ballast water management and the transfer of invasive species, and observing technologies.

Throughout his career, Johengen has led many exciting research projects and has mentored countless numbers of students, technicians, administrators, and scientists. His role as an advisor and Great Lakes science mentor has motivated, challenged, and afforded incredible experiences and opportunities to those lucky enough to work alongside him. His research has led to improved ballast water legislation to mitigate invasive species introductions, advanced our capacity to monitor Great Lakes water quality using emerging *in situ* technologies, and supported the development of ecological forecasting models to protect public health from the adverse effects of harmful algal blooms and hypoxia.

"Tom has been the ideal leader of our efforts to keep the Great Lakes great," said Dr. Jonathan Overpeck, Dean of the U-M School for Environment and Sustainability. "He understands the science and leveraged his knowledge to ensure the people and communities of the Great Lakes region continue to thrive for generations to come. This combination of perspectives gave him the ability to work with researchers and folks in society alike to create a compelling vision that made a real positive difference and impact. Thank you, Tom, for your endless efforts to research and protect our world's largest freshwater lake system."

"Tom has been a dedicated steward of the Great Lakes throughout his career, with substantial impact on protecting the health of the Great Lakes," said Deborah Lee, Director of the NOAA Great Lakes Environmental Research Laboratory (GLERL). "In his roles with the CIGLR and Michigan Sea Grant, he has been instrumental

in fulfilling NOAA's mission of Science, Service, and Stewardship in partnership with GLERL. He has been a leader in scientific thought as well as a leader of people. Tom will be greatly missed, but I wish him the best on his new adventures."

"From my first Great Lakes cruise in 2009 to our collaboration on the renewal of CIGLR in 2022, I have had a front-row view of Tom's outstanding work on the Great Lakes and, he had already been doing Great Lakes research for 18 years before that!" said Dr. Gregory Dick, Director of CIGLR. "Tom has been the bedrock of Great Lakes research at U-M for many years, and his research accomplishments are remarkable on their own. But, I will remember his exceptional passion for the work and care for his colleagues, the way he loved facilitating collaborative research, and especially his commitment to leadership and mentorship in service of others, including me. I will always be grateful for his leadership and guidance of CIGLR through a challenging transition. Thank you, Tom, and best wishes in your well-earned retirement!"

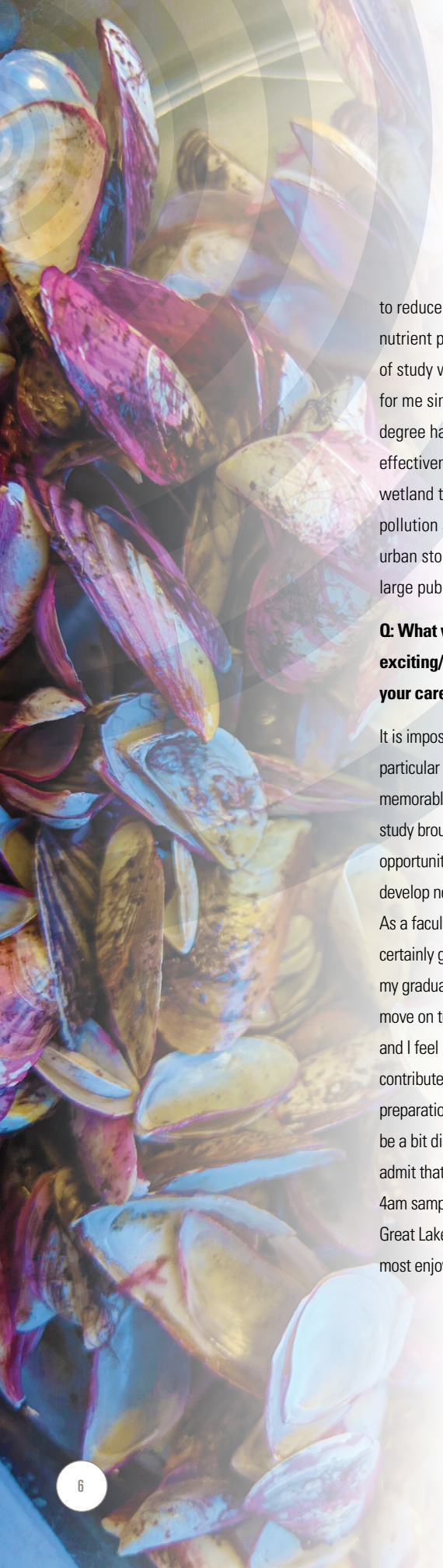
Q & A WITH TOM JOHENGEN

Q: What drew you to a career in Great Lakes research?

I grew up with a love of the outdoors and a deep connection to my time on the water, swimming, fishing, and boating at our family cottage in western New York. That connection, along with my preference for science subjects in college and the opportunity to work as a research assistant during my undergraduate studies, led me to pursue a master's degree in oceanography. While I tremendously enjoyed the opportunity of doing oceanic research and my time at Florida State, I knew that I always wanted to return to the Great Lakes region to pursue a career in academia.

Q: Why did you decide to come to U-M?

I had become very fond of Michigan during my undergraduate years at Michigan State and established a further connection to the state through my wife who grew up in Muskegon. Those personal connections, along with U-M's strong history as one of the foundational institutions that helped develop the field of Limnology, made Michigan one of my top choices when applying for PhD programs. I was very fortunate when U-M offered me a graduate student research assistantship to help conduct a study on the effectiveness of agricultural best management practices



to reduce nonpoint source nutrient pollution. That area of study was a natural fit for me since my master's degree had focused on the effectiveness of an artificial wetland to reduce nutrient pollution associated with urban stormwater runoff for a large public recreational lake.

Q: What was the most exciting/memorable part of your career?

It is impossible to pick any particular project as the most memorable because every new study brought so many exciting opportunities to learn and develop new collaborations. As a faculty member, it was certainly gratifying to watch my graduate student advisee's move on to successful careers and I feel proud to have contributed to their training and preparation. However, I would be a bit disingenuous if I did not admit that taking the 4pm to 4am sampling shifts out on the Great Lakes were some of the most enjoyable parts of the job.

Q: How do you think the position has evolved in your 31 years?

One of the things I love most about science and research is that it is constantly evolving. Certainly, technological advances in computing and instrumentation are some of the biggest drivers in our approaches and capacity to do research. I have spent a significant portion of my career helping to promote the development and application of new sensor technologies related to coastal water quality monitoring. The improvements in accuracy, sampling resolution, data management, and autonomous operations have been astonishing. However, probably the best and simplest answer to this question is that each new cohort of students and staff seems to be brighter and more skilled than the previous one. It certainly got harder and harder to keep up with them, and that helps me know that now is a good time to step aside and see just how far they can take us.

Q: What were some of your proudest moments?

I have always appreciated the fact that much of my research was directed at protecting the resources of the Great Lakes and serving public interests. I have had the opportunity to be part of a variety of applied research projects with outcomes directed at helping to solve pervasive management issues such as preventing the introduction of invasive species, or mitigating drinking water and public health concerns related to harmful algal blooms and hypoxia. While these beneficial societal outcomes were the underlying motivation of my research, it is of course the interactions with all my colleagues that made my job a true privilege and pleasure. It has been an honor to work with so many dedicated and passionate professionals across the basin, all directed toward making a positive impact within the Great Lakes community.

Q: What advice would you give to early career scientists?

For me, there were two key elements that helped lead to my successful career. The first was to build a strong set of collaborators with whom I could develop and implement my research program. Working within NOAA's Cooperative Institute for Great Lakes Research (CIGLR) and the Michigan Sea Grant program have been the absolute perfect environments for me and have provided such amazing and diverse teams of scientists to work with. The second was a willingness to explore many different opportunities and be willing to take on many new challenges. While this later approach is a little atypical for academia and can diminish how well established you become within your given field of specialization, I found each new project provided an opportunity to grow and expand the ways in which I could contribute to the improved management of our Great Lakes.

As I transitioned to more of a leadership position in the later part of my career, I similarly tried to live by the motto of never just saying no outright and approaching any new challenge or request with the attitude of 'well, let's just see how we can try to make that happen.'

Q: What do you hope to accomplish after retirement?

I purposely chose not to line up any immediate commitments or responsibilities. I have so many hobbies that I am looking forward to pursuing further and I know they will keep me busy. Plus, I can't wait for the opportunity to do an extensive amount of travel both within the United States and abroad. My wife and I have always enjoyed the opportunity to experience new places and cultures through our travels. It wasn't easy trying to fit in extended travel and vacations around my work schedule; now, it will be much easier! Lastly, I can only imagine how much larger our flower and vegetable gardens are going to become. I think the birds, bees, and butterflies at our house will be very happy.

Research Engineer Hayden Henderson (formerly CIGLR, currently Michigan Technological University) deploys instruments to measure temperature, dissolved oxygen, phytoplankton and other parameters under the ice in Saginaw Bay of Lake Huron.
Photo: Casey Godwin.

"One of the coolest things about the Winter Grab has been the opportunity to collaborate with so many Great Lakes researchers who are excited about winter. This enthusiasm tells me we are on the right track with this work."

— Ted Ozersky, PhD

OPENING THE

"Black Box"

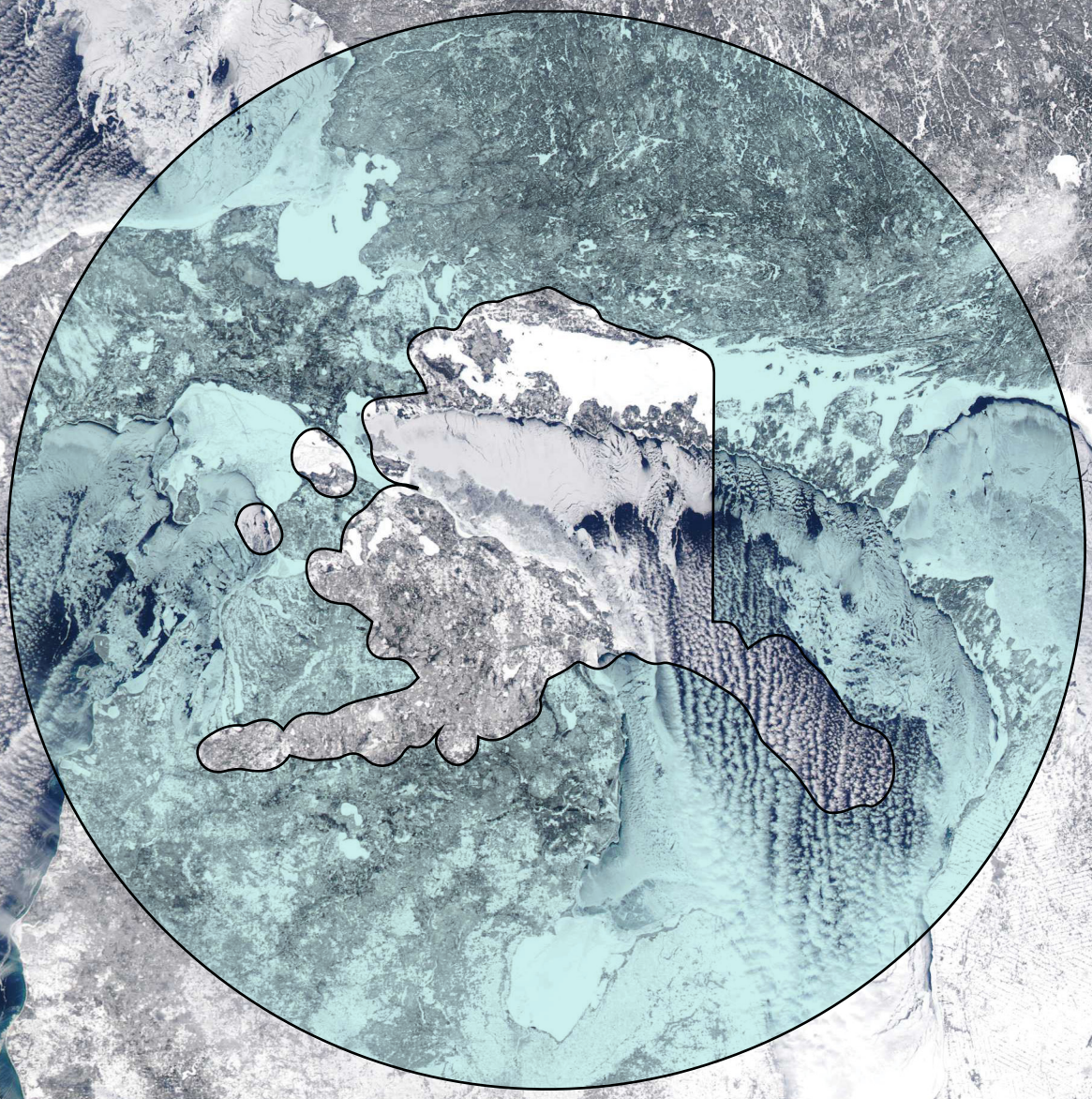
OF WINTER ON THE GREAT LAKES

WINTER is the season that is warming fastest due to climate change. On the Great Lakes, this means rising water temperatures, changing precipitation patterns, and decreasing ice cover. Unfortunately, understanding how these wintertime changes impact the Great Lakes ecosystem is difficult because very little is known about the behavior of the lakes during that time. One reason for this knowledge gap is the difficulty and danger of working on these large and dynamic systems during the winter season. Another reason is the implicit belief among some scientists that nothing important happens in the lakes during winter, and therefore, there is no need to study them during that time. However, our rapidly changing climate, along with the recent recognition that winter conditions can have important effects throughout the rest of the year, make it imperative to open the "black box" that is Great Lakes winter.

Last winter, lake biologist Ted Ozersky, PhD (University of Minnesota Duluth) initiated and led a first-of-its-kind coordinated campaign called the Winter Grab. Dozens of researchers from 19 organizations around the United States and Canada (and even some volunteer citizen scientists) participated in the event, visiting all five of the Great Lakes over a 10-day period in February. Participants recorded observations about ice and snow, measured light and temperature in the water, and took water chemistry and taxonomic samples to characterize the bacteria, phytoplankton, and zooplankton communities living in the icy, winter waters of the Great Lakes. At some of the sites, researchers also measured growth rates of phytoplankton and bacteria, which will help researchers understand how productive the Great Lakes ecosystem is during winter. With sampling at almost 50 stations, the Winter Grab is the most extensive winter-period study conducted on the Great Lakes to date, as well as one of the largest multi-institutional coordinated sampling efforts for the Great Lakes research community.

"Because of the long neglect, it will take us many years to learn as much about winter on the Great Lakes as we know about summer," said Ozersky. "But the tide is turning, and there is fast growing interest in winter among scientists, ecosystem managers, legislators, and the public. The Winter Grab project had two main goals: first, we wanted to start building a foundation of knowledge about how different parts of the Great Lakes work during winter; and second, was to use the Winter Grab as a catalyst for the Great Lakes science community, getting folks excited about winter science and helping create awareness of the need for this research."

Sample analysis from the Winter Grab is ongoing, but initial results show that there are dramatic differences in winter chemical and biological conditions across the Great Lakes. "This suggests that there is more happening with the Great Lakes ecosystem during winter than previously believed," said Ozersky. In addition to analyzing the samples and data, Winter Grab scientists are thinking about the "next steps" and ways to leverage this collaboration to make winter science a regular part of research on the Great Lakes. "The 2022 "Winter Grab" participants are broadly interested in repeating this sampling event in 2023 and are working on logistics and securing the appropriate funding," said Ozersky. "Better knowledge of winter and how it fits into the annual Great Lakes cycle will ultimately help improve our understanding of this important ecosystem and the services it provides."



"Great Lakes' regional weather and climate are connected to conditions over the North Pacific. As year-to-year fluctuations become more extreme in the Great Lakes, it is critical to understand these global connections. Such understanding is important for producing accurate seasonal forecasts, anticipating future conditions in the Great Lakes, as well as how ice coverage, wind chills, waves and surge impact management and operational decisions."

— Ayumi Fujisaki-Manome, PhD

What's Alaska Got To Do With It?

UNDERSTANDING THE CHANGING PATTERNS AND GREAT LAKES ICE COVER

GREAT LAKES ICE cover and winter severity fluctuate notably from year to year, despite evidence of an overall warming trend. A January 2019 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. The subsequent 2019–20 winter was anomalously warm, with wet conditions covering the Great Lakes region. Such year-to-year fluctuations have substantial impacts on the surrounding population, economy, under-ice ecosystem, and biogeochemistry. Yuchun-Lin, PhD (formerly CIGLR, currently National Taiwan Ocean University) and Assistant Research Scientist Ayumi Fujisaki-Manome, PhD (University of Michigan, CIGLR) in collaboration with Jia Wang, PhD (NOAA GLERL) are researching the causes of high year-to-year fluctuations in Great Lakes winter severity and how they have changed over the past decades.

"Based on statistical analyses from 1980 to 2020, our team found that the Great Lakes experienced fewer freezing degree-days, a decrease of annual maximum ice cover [after the winter of 1997–98], and increased year-to-year fluctuations of annual maximum ice cover since 1993," said Fujisaki-Manome. "The team also found that before the winter of 1997–98, the annual maximum ice cover was significantly correlated with the well-known teleconnection patterns El Niño-Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO). Since then, the annual maximum ice cover has been significantly correlated with the Tropical/Northern Hemisphere (TNH) and Eastern Pacific Oscillation (EPO), but no longer with ENSO or NAO."

After the winter of 1997–98, the Great Lakes annual maximum ice cover started to correlate with a warm sea-surface temperature anomaly that developed in the northeast Pacific Ocean, in the Alaska region, where the atmospheric flow patterns are governed by the EPO. The EPO is an important driver of cold air over North America and has a large influence over our weather patterns. "This warm anomaly initiated a stationary Rossby wave, reaching far up into the upper troposphere and stratosphere," said Lin. Rossby waves are also known as planetary waves, as they are observed in the atmospheres and oceans of planets. Due to the planet's rotation, "this irregularity disrupted the polar vortex and was mirrored by the polar jet stream underneath, resulting in an eastward shift of the North American ridge-trough system," said Lin. When this shifted system develops, it can encase the Great Lakes region in Arctic air and, therefore, cause larger year-to-year fluctuations in ice cover.

"One of the most important topics for the Great Lakes community," said Fujisaki-Manome "is the seasonal forecasting of annual maximum ice cover and winter severity over the region. Better understanding of how Great Lakes winter weather connects to global atmospheric patterns, including the identified connection to the North Pacific, will advance our capability to forecast Great Lakes winter weather in the future."

"This interdisciplinary team seeks to gain better insight into the impacts of climate change on Lake Erie harmful algal blooms and if implementation of agricultural conservation practices would be an effective mitigation strategy."

— Michael Fraker, PhD

RAMPING UP AGRICULTURAL CONSERVATION PRACTICES TO

Combat the Impacts of Climate Change

CLIMATE CHANGE is projected to increase temperatures and spring precipitation in the Great Lakes region, affecting nutrient runoff from agricultural fields and influencing the size of harmful algal blooms (HABs) in Lake Erie.

Former CIGLR Assistant Research Scientist Michael Fraker, PhD, (currently Research Program Manager at Michigan Sea Grant) specializes in Great Lakes ecosystem dynamics research. He is working with scientists from The Ohio State University, The Nature Conservancy, Tusculum University, University of Guelph, University of Missouri, USDA, and USGS to use linked climate, agricultural land use, stream hydrology, and HAB models to explore how climate change may interact with the implementation of agricultural conservation practices. The team studied two climate scenarios: (1) a business-as-usual scenario that assumes that greenhouse gas emissions will continue at current rates and (2) a moderate-reduction scenario that assumes some emission mitigation policies will be enacted. Within each climate scenario, they studied four agricultural conservation practice scenarios: a baseline scenario that assumes that current land use practices will continue, and a series of scenarios that increase implementation of agricultural conservation practices best suited for each parcel of farmland, such as erosion control and nutrient management. The team's models predicted that nutrient runoff and annual HAB biomass will increase if current land use practices continue. However, sufficient implementation of additional agricultural conservation practices could offset the increase in nutrient delivery and HABs caused by climate change, and even potentially reduce HAB biomass below water quality target levels.

"Our study is valuable as an interdisciplinary collaboration with clear implications to the development of nutrient loading mitigation strategies that will be effective into the future," said Michael Fraker, PhD. "Our findings are specifically relevant to the western Lake Erie basin, and the methods and conclusions are relevant to all waterbodies impacted by agricultural land use in their watersheds. The next step is to better understand how climate change will influence HAB formation and development within the lake itself in order to develop complete land-to-lake models." The study is currently under peer review.

"Because suitable observations are essentially lacking, we know rather little about how waves and ice interact with each other in the Great Lakes."

— Dmitry Beletsky, PhD

NEW WINTER OBSERVATIONS TO

Improve Great Lakes Coastal Forecasts

PREDICTING LAKE CIRCULATION and other physical processes in the Great Lakes requires observations of actual ice, wave, and current interactions, which can be challenging to obtain during winter. The Great Lakes have amazingly complex geometry and topography and, due to their size, produce sea-like hydrodynamics, or movement of water. In turn, waves interacting with the formation and melting of ice on the Great Lakes directly modify these hydrodynamic processes. Open water waves generated by wind can penetrate into the lake's ice-covered region, impacting currents, water levels, and thermal structures.

Research Scientist Dmitry Beletsky, PhD (University of Michigan, CIGLR) and Jia Wang, PhD (NOAA GLERL) alongside collaborators Nathan Hawley (NOAA GLERL), Steve Constant (NOAA GLERL), Steve Ruberg (NOAA GLERL), and Ayumi Fujisaki-Manome, PhD (University of Michigan, CIGLR) are working to collect new, comprehensive data on wave parameters, ice thickness, and water currents in Lake Erie, which has the highest ice coverage among all five of the Great Lakes.

The team has expanded upon the 2020–21 observational winter campaign, when only two instruments were deployed in western Lake Erie due to the COVID-19 pandemic. The shallow water ice profiler (SWIP) and acoustic wave and current profiler (AWAC) provided a unique opportunity to observe the dynamic ice processes in Lake Erie's coastal areas, especially during the early stages of ice formation.

"In September 2021, six moorings were deployed in Lake Erie and successfully retrieved in May 2022," said Beletsky. "The six moorings include four SWIPs and two AWACs. The SWIP measures real-time ice thickness in shallow water environments with an upward-looking sonar device that is mounted on the lake floor. The AWAC measures wave height, wave direction, wave period, full current profile and ice thickness, as well."

"Currently, data analysis and mooring retrieval is ongoing, with the plans of a long-term Lake Erie observational study in the works," said Beletsky. "While this novel dataset will provide important information about ice-wave-current interactions and processes in Lake Erie, it will also be used for validation and calibration of a state-of-the-art coupled wave-ice-lake model for the Great Lakes developed at NOAA GLERL. Future plans include deployment of AWAC and SWIP instruments in a small lake, with a less dynamic ice environment than occurs in the Great Lakes, for inter-comparison. Our aim is to ultimately use the model results to improve predictions made by the Great Lakes Coastal Forecasting System (GLCFS)." The GLCFS is run operationally by NOAA's National Ocean Service under the name Great Lakes Operational Forecast System, which provides guidance for navigation, engineering, hazard warning, and regulatory actions in the Great Lakes.

"Our goal is to thoughtfully engage with and align local and regional parties in the Rouge and Detroit River watersheds to establish a clear and timely success path for sediment remediation."

— Jon W. Allan

The Local Match Conundrum

ACCELERATING RESTORATION OF THE ROUGE AND DETROIT RIVERS THROUGH PARTNERSHIPS

THE ROUGE AND DETROIT RIVERS comprise two of the Great Lakes region's Areas of Concern (AOC), with long histories of complex industrial use, municipal waste discharge, and the resultant legacy of sediment contamination. While significant progress under the Great Lakes Restoration Initiative (GLRI) has been made, considerable work in these two urban watersheds remain. A substantial portion of restoration efforts over the next decade will continue to address legacy contamination in the nearshore and offshore sediments of these two rivers.

"The problem is how to accomplish removal of a century of legacy contamination in the Rouge and Detroit Rivers that could cost well over a billion dollars in total," said Jon W. Allan, of the U-M School for Environment and Sustainability, a CIGLR Consortium institution. Allan leads the Detroit and Rouge River collaboration with Julie Simmons of NOAA Fisheries, along with partners from the Great Lakes National Program Office (GLNPO) of the US EPA and the State of Michigan. Although there is GLRI funding, administered by the US EPA, available to address sediment contamination under the Great Lakes Legacy Act (GLLA), this funding requires a significant local (non-federal) match for dollars expended on sediment management and removal. This represents a formidable hurdle to access GLLA funds.

"It is a good news/bad news story," said Allan. "The good news is that under GLLA funding, the Federal government could contribute up to 65% of the total restoration — roughly $650 million for a billion-dollar effort. The bad news is that the local match (from the community and a wide range of other non-federal participants) would be roughly 35% of the total cost — $350 million or more dollars. Historically, legal action against the 'potentially responsible parties (PRPs)' can take twenty or more years to wend through the regulatory and court systems, extending the restoration project timeline significantly."

A strategy that relies on legal action to force cleanup of the area could take two or more decades, leaving the restoration and revitalization of the communities and cities adjacent to the rivers at a standstill. "Finding new and innovative approaches and partnerships with governments, federal and state agencies, and private and corporate parties to craft the cleanup efforts and strategies may be a way to move forward together," said Allan. "There are efforts already underway by the Detroit Water and Sewerage Department (DWSD) and Great Lakes Water Authority (GLWA) to improve stormwater and municipal waste that city and regional residents are already paying for across the Rouge and Detroit River watersheds. If long range plans by the GLWA can be logically connected to the betterment of the rivers by reducing sediment and pollution loads, then some level of local match should be attributable to this effort."

Removing a century of historical contamination, including the effluents and waste from Detroit's profound role in WWII manufacturing efforts, is an immense and complex effort. "The essence of this work is to link local municipal and corporate partners and strategies together to try and craft cost effective and productive approaches to address the local match requirements," said Allan. "Finding ways to address a long history of harm from contamination through productive partnerships and by bringing people and groups together, united in common purpose, could shorten up the time for remediation, restoration, and revitalization by decades. If not now, when?"

"Our team is building a hyperspectral time machine that will show how the penetration of different wavelengths of light has likely changed over time, as a result of the Great Lakes mussel invasion."

— Casey M. Godwin, PhD

CIGLR SCIENTISTS

Turn Back the Clock on the Light Climate

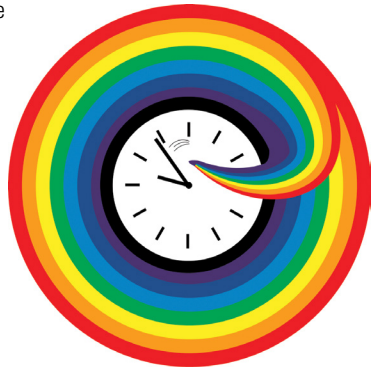
IN LAKES MICHIGAN AND HURON

VISIBLE AND ULTRAVIOLET LIGHT penetration through the Great Lakes water environment may have changed due to the rapid expansion of invasive *Dreissena* mussels, specifically zebra and quagga mussels. In contrast to zebra mussels, which had previously invaded nearshore areas, quagga mussels were able to proliferate in deeper water and in much greater numbers. *Dreissena* mussels consume large volumes of phytoplankton (microscopic algae) by filtering surrounding lake water, thus removing this important food source that forms the base of the Great Lakes food web and ultimately changing the light environment. Visible wavelengths are important for photosynthesis and animals that use light to find prey and avoid predators, whereas ultraviolet (UV) light is damaging to both phytoplankton and animals like larval fish. Although few measurements of UV light penetration were recorded prior to the mussel invasion, recent advances in spectrometry instrumentation are enabling researchers to measure effects of phytoplankton and other particles on light with resolution that was not previously possible.

Assistant Research Scientist Casey M. Godwin, PhD (University of Michigan, CIGLR) and his team are building a "hyperspectral time machine" that will show how the penetration of different wavelengths of light has likely changed over time as a result of the Great Lakes mussel invasion. Godwin explained, "Because we cannot go back in time and apply our modern hyperspectral techniques to the lakes before the quagga mussel expansion, we are instead measuring the optical properties of contemporary water and plankton in the lakes. We will use those data to model what the light climate would have been like with the phytoplankton community from the 1980s."

As part of a binational field effort called the Cooperative Science and Monitoring Initiative (CSMI), the CIGLR team worked alongside NOAA GLERL investigators Henry Vanderploeg, PhD, and Ed Rutherford, PhD, to measure how different sizes of phytoplankton and particles absorb and scatter light in Lakes Michigan and Huron. CIGLR Biogeochemistry Laboratory Analyst Christine Kitchens is part of this work and said, "These measurements are really challenging. We sequentially remove smaller and smaller particles from the water, measure the very tiny differences in light, and end up with huge datasets owing to the high resolution in terms of wavelengths."

The study has shown that mussels grazing on phytoplankton had a proportionately larger effect on the penetration of visible wavelengths compared to UV. These results support the hypothesis that *Dreissena* invasion and expansion affected visible light proportionally more than UV. Though relatively small in magnitude, the changes in UV light penetration have likely caused important changes to zooplankton, larval fish, and photochemical reactions in the lakes.



The hyperspectral time machine as illustrated by CIGLR Aquatic Ecology Research Technician Christine Kitchens.

"An accurate rapid field kit for HAB toxin detection would be a game changer for Great Lakes resource managers, it is our goal to help advance MBio's efficiency and accuracy with this project."

—Thomas Johengen, PhD

PARTNERING WITH INDUSTRY TO DEVELOP

Rapid HAB Toxin Detection Technology

RAPID TOXIN DETECTION, including harmful algal bloom (HAB) toxin presence and concentration, is vital for ensuring public safety and environmental health. Efficiently measuring HAB toxins like microcystin (MC) and cylindrospermopsin (CYN) in freshwater systems requires technologies that are specific, accurate, and both time and cost effective. The cost and labor associated with standard laboratory-based toxin detection methods, such as the Liquid Chromatography-Mass Spectrometry (LC-MS) and Enzyme-Linked Immunosorbent Assay (ELISA), limit the number of samples that are analyzed and translate to significant time lags in data availability, making it difficult for resource managers to make timely and informed decisions to protect public health.

A CIGLR team led by Research Scientist Thomas Johengen, PhD (University of Michigan, CIGLR) and Engineer Heidi Purcell (University of Michigan, CIGLR) are working with partners at The Ohio State University, University of Toledo, and Bowling Green State University to evaluate a commercially-available field portable HAB Toxin MC/CYN System developed by industrial partner, MBio Diagnostics, Inc.. "The study is funded by the NOAA Monitoring and Event Response for Harmful Algal Blooms (MERHAB) program," said Johengen. "The primary goal is to fully validate and integrate a rapid, portable, quantitative, multiplexed cyanotoxin detection technology into routine monitoring programs, citizen science groups, recreational beach managers, and water treatment plants throughout western Lake Erie to provide water managers with on-the-spot testing of MC and CYN."

In 2020, the CIGLR team conducted comparative analysis of nine sampling events in western Lake Erie, covering four to five stations per trip. For each discrete sample, an analysis of both whole water toxin and dissolved toxin concentrations were measured and the accuracy of the portable MBio HAB Toxin field kit was evaluated against known certified standards. "In total, we conducted 693 comparative analyses from 2020 to 2022 against lab based ELISA methods," said Purcell. "A major finding from the field study was that the initial design of the MBio cartridge had a significant positive bias at low toxin concentration levels, including a substantial number of false positives. The company used these initial results to modify their assay and develop a new test. The 2021 comparative results showed significant improvement in the MBio tool accuracy and elimination of false positives."

The third and final study took place during the 2022 field season. "Our team focused on the efficacy and variability of the field portable cell-lysing method compared to the standard laboratory freeze-thaw method," said Purcell. "The MBio kit contains a cell-lyser that breaks down cells by rapidly stirring the sample along with glass beads for a period of ten minutes. The cell-lysing process is a vital step in toxin detection and happens when Microcystis cell walls are degraded and, within a matter of 20 minutes, release the microcystin toxin so it can be measured. In contrast, the laboratory ELISA analysis lyses the cell by freezing and thawing the sample multiple times and is a much more lengthy process. There remains a great deal of uncertainty in whether the variances between the rapid, field-generated, MBio results compared to the lab-standard ELISA measurements occurs during the bio-assay analysis or simply from the initial lysing step. MBio Diagnostics, Inc. made significant improvements in analytical accuracy and precision in 2021 and we look forward to working through the data we collect this year."

"This final analysis of the field-portable toxin methodology helped define technical specs, appropriate uses, and performance measures for this advanced technology. Our team's work will refine the development and guide the use of this promising new technology," said Johengen.

AN EXPERIMENTAL

Biophysical Modeling Forecast System

FOR LAKES MICHIGAN AND HURON

DECLINING OFFSHORE PRODUCTIVITY in Lakes Michigan and Huron has been a multi-decadal trend causing scientists to investigate and evaluate the importance of nearshore primary productivity in supporting the lakes' fisheries. However, the dynamic nature of the nearshore environment in the Great Lakes makes studying these areas inherently challenging. Strong and shifting currents, variable tributary nutrient inputs and flows, seiches, and upwellings/downwellings create a dynamic and patchy pattern of primary productivity "hotspots" in the nearshore that are difficult for field crews to locate and sample. These sampling challenges complicate the ability to collect environmental information that can support effective management strategies.

The Cooperative Science and Monitoring Initiative (CSMI) is a bi-national effort to coordinate research priorities and monitoring activities on one of the five Great Lakes each year. Research priorities guiding the CSMIs for Lake Michigan (2020-2021, COVID-19 disruption caused an extension into 2021) and Lake Huron (2022) included studying the importance of tributaries and nearshore areas to lake productivity and the need to focus sampling efforts on these productivity hotspots. To help address these objectives, project leader Mark Rowe, PhD (NOAA GLERL), Peter Alsip (University of Michigan, CIGLR), and Alex Kain (University of Michigan, CIGLR) developed an experimental biophysical modeling forecast system for Lakes Michigan and Huron.

"This model is part of a broader effort to explore our ability to use realtime biophysical models and forecasts to support field research," said Rowe. "If successful, field research guided by realtime models could provide new insights into localized and transient phenomena of ecological significance that are challenging to locate and sample."

Model-predicted chlorophyll-a and dissolved organic carbon (DOC) are generated daily and uploaded to a public website for field researchers to access. "Chlorophyll-a and DOC are used as indicators of the influence of rivers on primary productivity and as a tracer of river water as it disperses into the lake, respectively," said Alsip. "The variables are discharged into the lake model through 124 rivers in the Michigan-Huron domain [40 Michigan tributaries and 84 Huron tributaries], providing a way to identify river plumes. Identifying river plumes could help researchers who might be interested in measuring the effects of a large runoff event on the nearshore biophysical environment." Currently, the website focuses on Lake Huron, in support of its 2022 CSMI field year, and includes three products: 1) a daily nowcast-forecast; 2) a year-to-date animation; and 3) a comparison of nowcast chlorophyll and DOC to Visible Infrared Imaging Radiometer Suite (VIIRS) satellite images from NOAA CoastWatch. "The model shows spatial patterns, both recurrent and episodic, in simulated chlorophyll and DOC," said Alsip. "Some of the patterns simulated by the model include the movement of productive waters from Saginaw Bay, Lake Huron along Michigan's "thumb region," plumes of DOC near several North Channel tributaries, and elevated chlorophyll along Lake Huron's southeastern shoreline."

"The Lake Michigan-Huron experimental biophysical modeling forecast system is intended to help field researchers find transient features [e.g. river plumes, productivity hotspots] in dynamic nearshore areas, provide context to observations, and inform planning of future surveys."

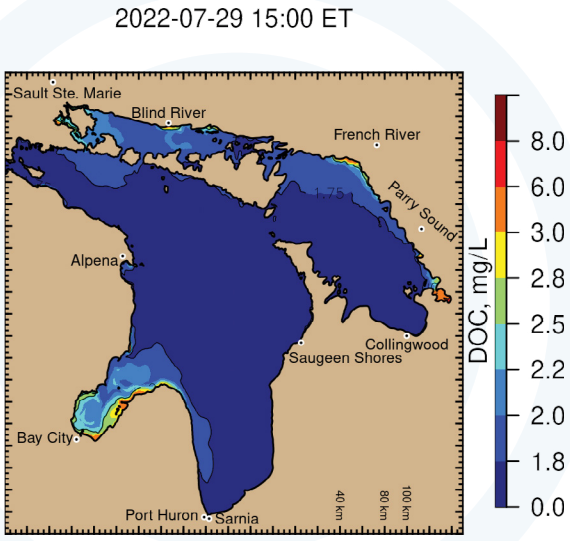
— Peter Alsip

"The model-satellite comparisons allow us to evaluate the model's performance throughout the field season," said Alsip. "Satellite data is not without bias, but agreement between the model and satellite is a good indication of reality and can give more confidence in the model. It's been really interesting to see spatial patterns emerge in the model and then be corroborated in the satellite imagery."

Lake Michigan was the focus of the 2020-2021 CSMI (archived model output) and the model performed reasonably well in its ability to simulate spatial/temporal patterns in chlorophyll/DOC associated with upwellings/downwellings and tributary loading. In 2020, a large runoff event in the eastern tributaries of Lake Michigan, including the Muskegon and Grand Rivers, produced a large plume of DOC near Grand Haven, MI. The model simulated this runoff event skillfully and demonstrates the model's utility at capturing short-lived events.

"Having a real-time forecast for these lakes has been great for executing field campaigns," said Research Scientist Casey Godwin, PhD (University of Michigan, CIGLR). "There are not many places in the world where the application of coupled physical and ecological modeling has advanced to this stage. These products allow us to optimize precious ship time and direct autonomous vehicles toward the conditions we are most interested to study - this could be revolutionary for how we do this kind of work."

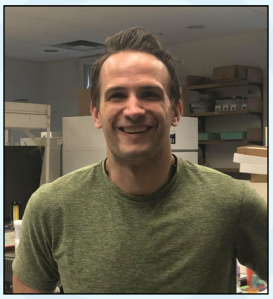
"Use of biophysical nowcast-forecasts and recent satellite imagery to support field research may lead to new insights on transient features, such as river plumes and productivity hotspots, in dynamic nearshore areas," said Rowe. The model will continue to run for the remainder of the 2022 Lake Huron field season. Progress by CIGLR and NOAA GLERL to develop ecological forecasts demonstrates how field and modeling research can complement one another, ultimately advancing shared goals and understanding of the Great Lakes ecosystem.



Postdoc Fellows

Cyanobacteria in a Changing World

HOW CLIMATE CHANGE AND NUTRIENTS INFLUENCE HARMFUL ALGAL BLOOMS IN THE GREAT LAKES



Cyanobacterial harmful algal blooms (HABs) are one of the most debilitating, widespread water quality problems in the Great Lakes. Determining how HABs respond to nutrients in tandem with climate change processes such as heat waves and elevated carbon dioxide levels is of critical importance. This is particularly true for HAB-prone areas in the Great Lakes, such as Lake Erie, Saginaw Bay in Lake Huron, and Green Bay in Lake Michigan, that supply municipal fresh water to millions of people. **Benjamin Kramer**, PhD (University of Minnesota Duluth) along with mentors Cody Sheik, PhD (University of Minnesota Duluth) and Reagan Errera, PhD (NOAA GLERL) are working to determine how cyanobacterial growth, toxin production, community composition, and ecosystem functions are influenced by changes brought on by anthropogenic stressors. "We collect water samples during bloom events, which we use to perform experiments and collect data that will help us understand how HABs respond to nutrients and climate change," said Kramer. "The samples are enriched with nutrients and subjected to conditions that reflect predicted 21st century lake temperature and carbon dioxide levels. Fluorometric and microscopic analyses are used to characterize cyanobacterial growth, while gas and liquid chromatography assays are used to measure nitrogen (N2) fixation rates and cyanotoxin levels, respectively." The team is using metagenomic and metatranscriptomic techniques to characterize community composition and ecosystem function within cyanobacterial blooms, with the goal to better understand how major

Environmental DNA Applications

FOR MONITORING KEY GREAT LAKES FISHES

Environmental DNA (eDNA) is genetic material extracted from any environmental sample, such as lake water, rather than directly from individual organisms. Thus, eDNA is usually a complex mixture of DNA from diverse taxa, including microorganisms, invertebrate and vertebrate animals, and even plant DNA. Extracting high-quality eDNA from various environmental samples (e.g., soil, water, gut content, fecal samples, etc.) can be challenging; however, there has been very active and focused research on effective eDNA-extraction methods. While challenges still exist, eDNA extraction from freshwater samples and fish fecal and stomach content samples is well established.

Matthew Yates, PhD (University of Windsor) along with mentors Daniel Heath, PhD (University of Windsor, Great Lakes Institute for Environmental Research (GLIER)), Subba Rao Chaganti, PhD (University of Michigan, CIGLR) and Ed Rutherford, PhD (NOAA GLERL) are applying eDNA methods to understand fish ecology and examine the utility of environmental RNA (eRNA) to non-invasively quantify the physiological status of progenitor (originator) organisms. "Part of our work will also investigate trophic interactions among top fish predators in Lake St. Clair using eDNA and stomach content DNA (scDNA)," said Yates. "eDNA will provide data on what species are present in an environment, and stomach content DNA will provide data on what species predators are actually consuming — i.e., are predators preferentially targeting certain prey species, or are they consuming whatever is present in the environment?"

These projects are building on the genomic network for fish identification, stress, and health called GENFISH. GENFISH is a Canada-funded research network dedicated to the development of

Graduate Research Fellows

eDNA as a Powerful Tool

FOR PREDICTING INVASIVE SPECIES ABUNDANCE

Understanding the impacts of invasive species and preventing their spread relies on the availability of dependable information on their distribution and abundance, which has been traditionally difficult to obtain. Advances in molecular techniques, in particular environmental DNA (eDNA) analysis, have given rise to their utility for censusing aquatic species due to improved sensitivity and efficiency compared with traditional sampling methods. While the use of eDNA for detecting species presence and biodiversity is well established, its use for predicting species abundance is relatively understudied, especially in natural systems. Efforts to correlate ambient eDNA concentration with species abundance have been met with moderate success, yet many questions and concerns about the accuracy and interpretation of these results remain, potentially hindering the application of this approach in practice.

Kara Andres, a PhD candidate at Cornell University and 2021–22 CIGLR Graduate Research Fellow is working with her advisor David Lodge, PhD (Cornell University), co-advisor Ed Rutherford, PhD (NOAA GLERL), and collaborator Peter Esselman, PhD (USGS Great Lakes Science Center) to develop novel eDNA-based metrics of species abundance. "My research focuses on the prolific Great Lakes invader, the round goby *(Neogobius melanostomus),"* said Andres. "Our team plans to carry out an intensive field sampling effort to compare and test the performance of image-based eDNA abundance estimates."

The round goby has impacted fisheries in the Great Lakes, where it competes with native fish and will even eat the eggs of some game fish species. When their numbers are low, the round goby can be difficult to find and collect because of their excellent camouflage with the lake bottom. "Being able to predict how many round goby individuals there are and possibly where they came from will be helpful if we hope to curtail new introductions at early stages," said Andres. "With the assistance of scientists from the USGS, I collected eDNA samples from nearshore areas of Lake Michigan and Lake Huron during the summer and fall of 2021. A USGS autonomous underwater vehicle (AUV) was simultaneously deployed at each site, capturing benthic images that will be used to estimate round goby numerical abundance for comparison to eDNA-based estimates."

While laboratory work and image assessments are still underway, preliminary results show reliable detection of genetic variation in eDNA samples. "Supporting the use of eDNA as a powerful tool for predicting species-specific abundance will be useful for assessing invasive species in natural systems," said Andres.

"Our goal is to improve eDNA-based estimates of population abundance, giving us a more reliable method to monitor species that are otherwise difficult to observe."

— Kara Andres, Cornell University

Graduate Research Fellows

Surveys and Habitat Modeling

FOR NATIVE AND INVASIVE MUSSELS IN TWO LARGE RIVERS OF THE LAURENTIAN GREAT LAKES

Ecosystem services of native freshwater mussels (Bivalvia: Unionidae; unionids) are numerous and include translocating nutrients through filter feeding, increasing habitat complexity, bioaccumulating toxins, providing sediment stability, and serving as food for other organisms. However, unionids are currently one of the most imperiled faunal groups in North America due to the combined negative effects of habitat degradation, historic commercial exploitation, and invasive species. In the Great Lakes, the unionid community declined sharply following the invasion of dreissenid mussels in the late 1980s. *Dreissena polymorpha and Dreissena rostriformis bugensis* (collectively dreissenid mussels) are considered among the most deleterious of freshwater invaders due to their often catastrophic economic and ecological impacts. One of the negative environmental impacts of dreissenids is their displacement of native unionids through competition for resources and fouling. Since the late 1990s, when unionids were seemingly pushed to the brink of extirpation from the St. Clair-Detroit River System (SCDRS), numerous and previously unknown refuges have been identified in many coastal and nearshore areas of the lower Great Lakes. However, remnant unionids and the potential for refuge habitats in the SCDRS remains poorly understood. As unionids are a globally imperiled faunal group, it has become increasingly important to find and protect remaining unionid populations.

Shay Keretz is an Earth and Ecosystem Science PhD candidate at Central Michigan University (CMU) and a 2020–21 CIGLR Graduate Research Fellow. Shay is working with her advisors David Zanatta, PhD (CMU) and Daelyn Woolnough, PhD (CMU) and her mentors Ashley Elgin, PhD (NOAA GLERL) and Todd Morris, PhD (Fisheries and Oceans Canada) to comprehensively survey the large, deep, and fast-flowing parts of the SCDRS for both unionid and dreissenid mussels. This project is a large collaborative effort between CMU and government agencies from both the United States and Canada: Fisheries and Oceans Canada, Environment and Climate Change Canada, Michigan Department of Natural Resources, U.S. Geological Survey, U.S. Fish and Wildlife Service, and the National Atmospheric and Oceanic Administration.

"In the summer of 2019, our team conducted a systematic survey of the Detroit River," said Keretz. "Of the 56 sites surveyed, only five had living unionids totaling 220 live animals representing 11 species. Additionally, over 2,000 unionid shells of 31 species were collected from 39 sites, confirming the large and diverse unionid assemblage that existed prior to the dreissenid invasion." Estimated dreissenid densities were highly variable with river location and ranged from 0 to 5,673 live individuals per m^2, with the highest densities concentrated in the upstream half of the River. They used the locations of live unionids in the Detroit River to create a unionid species distribution model in MaxEnt, a software program for modeling species niches and distributions by applying a machine-learning technique called maximum entropy modeling. "This model was then considered to select potential survey sites in the St. Clair River," said Keretz. "A systematic survey of the St. Clair River occurred in the summer of 2021 where we found a total of 14 live unionids representing 9 species across 7 of the 51 visited sites. Unfortunately, the model developed from the Detroit River dataset has failed to be predictive for unionid presence in the St. Clair River, since all 7 sites with live unionids were not model-selected sites." However, in 2022, the Detroit River model was successfully used to find live unionids at an additional 3 sites in the Detroit River. Since completing the SCDRS sampling in summer 2022, Keretz is focused on publishing their study results and finishing her dissertation.

2021 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 Great Lakes research project. These projects typically include computer-based modeling, marine engineering, field research, and laboratory analyses.

To help give the Fellows exposure to the many dynamic individuals in our collaborative, yet COVID-safe virtual environment, 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. Despite the less-than-ideal circumstances, the Fellows, mentors, and CIGLR ECO (Engagement, Career Training, and Outreach) team truly demonstrated just how much can be accomplished in a virtual fellowship. We applaud everyone involved for their flexibility, creativity, and positivity that helped shape a meaningful, career-building experience out of a challenging situation.

Meet the 2021 Great Lakes Summer Fellows:

Courtney Cameron

San Francisco State University

Courtney worked with Drs. Rochelle Sturtevant (Michigan Sea Grant), Ashley Elgin (NOAA GLERL), Lindsay Chadderton (Nature Conservancy), and Alisha Davidson (independent consultant) to expand the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS).

Sean Daly

St. Olaf College

Sean was mentored by Dr. Philip Chu (NOAA GLERL). He helped to develop an integrated data visualization and user interface for digital charting tables onboard research vessels.

Julie Dellick

University of Michigan

Julie worked with Lacey Mason (NOAA GLERL) and Drs. Hank Vanderploeg (NOAA GLERL), Ed Rutherford (NOAA GLERL), Doran Mason (NOAA GLERL), and Craig Stow (NOAA GLERL) to study the role of increased water clarity on fine-scale vertical distribution and density of macrozooplankton and fish larvae in Lakes Michigan and Huron.

Collin DeYoung

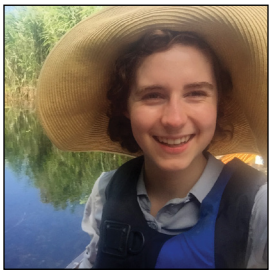
Central Michigan University

Collin worked with Drs. Brent Lofgren (formerly NOAA GLERL) and Jia Wang (NOAA GLERL) to analyze upper-level atmospheric circulation patterns associated with Great Lakes ice cover.

Jacob Fredrickson

University of Minnesota Duluth

Jacob worked with Dr. Mike Fraker (formerly CIGLR), Russ Miller (CIGLR), and Lauren Marshall (NOAA GLERL) to analyze fine-scale analysis of Lake Michigan glider data.



Mercedes Horn

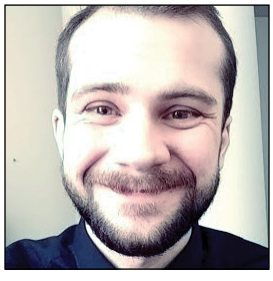
University of Vermont

Mercedes worked with Drs. Reagan Errera (NOAA GLERL) and James Hood (Ohio State University) to investigate plankton assemblage variations and identify shifts in the Kane's Index of plankton integrity in western Lake Erie.

Isabelle Horvath

Marquette University

Isabelle worked with Drs. Casey Godwin (CIGLR), Timothy Maguire (formerly CIGLR), Craig Stow (NOAA GLERL), and Sally Patrella (Friends of the Rouge) to expand and contribute to Detroit citizen science and water quality modeling.



Tyler Summers

University of Alaska Fairbanks

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

CONGRATULATIONS TO THE 2022 GREAT LAKES SUMMER FELLOWS COHORT

Maya Casey
Haverford College

Ryan Glassman
Valparaiso University

Shaun Laurinaitis
SUNY Oswego

Emilia Lepe
California State University, Monterey Bay

Marion Martyres
University of Michigan

David Rose
University of Michigan

Luke Skowronek
University of Michigan

Amy Van Zanen
University of Michigan

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

Summits, Rapid Response, & ECO Funding

The Benchmarks for Great Lakes Fish Habitat Restoration Summit was led by Karen Alofs, PhD, U-M SEAS. Photo: Aubrey Lashaway

CIGLR Summit:

Benchmarks for Great Lakes Fish Habitat Restoration

Great Lakes aquatic habitats and fish communities have changed drastically over the past two centuries due to a combination of persistent and ever-changing anthropogenic stressors. Coastal fish habitat restoration efforts in the Great Lakes would benefit from a critical examination of past and current approaches to planning and evaluating (i.e., benchmarking) restoration projects. To address this need, Karen Alofs, PhD (University of Michigan) led a 5-day working group meeting of 18 scientists with expertise in Great Lakes fish ecology and nearshore ecosystems to discuss approaches, information gaps, and data needs related to fish habitat restoration. Working group participants included representatives from multiple federal agencies, binational commissions, and universities. Steering committee members included Ed Rutherford, PhD (NOAA GLERL) and Andrew Miller, PhD (University of Michigan).

The group summarized the range of approaches used to guide restoration of nearshore fish habitat in the Great Lakes. They addressed the conceptual and data limitations of current approaches, such as data availability, quality, and sharing, and underrepresented species and life stages. Best practices were outlined for establishing benchmarks for future restoration projects under changing ecosystem conditions, with the goal of fostering a more unified and collaborative approach to coastal restoration projects in the Great Lakes.

CIGLR Summit:

Lake Erie Central Basin Hypoxia: State of the Science Review and Approaches to Track Future Progress

Hypoxia in Lake Erie's central basin has become one of the most widely-recognized symptoms of eutrophication and degraded water quality in the Great Lakes. Often referenced by the misnomer 'dead zone', seasonal hypoxia results from excess production of organic matter that accumulates in the hypolimnion and sediments and leads to rapid oxygen depletion during summer stratification. The resultant hypoxic zone routinely covers several thousand square kilometers. Low dissolved oxygen (DO) concentrations threaten drinking water quality by decreasing pH and causing sediments to release iron and manganese, reduce fishery habitat, and alter biogeochemical cycling of nutrients, contaminants, and greenhouse gases. In response to these impacts, under Annex 4 of the 2012 Great Lakes Water Quality Agreement (GLWQA), the US and Canada committed to "minimize the extent of hypoxic zones in the Waters of the Great Lakes associated with excessive phosphorus loading, with particular emphasis on Lake Erie" [Article 3(1)(b)(i)].

Summit lead Mike McKay, PhD (University of Windsor) and steering committee members Craig Stow, PhD (NOAA GLERL), Casey Godwin, PhD (University of Michigan, CIGLR) and Elizabeth Hinchey-Malloy, PhD (US EPA) organized interdisciplinary experts from the academic, private, and public sectors to (1) develop an approach to track progress in reducing hypoxia, in response to management actions that are underway to meet the recently updated phosphorus load targets; and (2) track interannual variability in hypoxic extent by identifying data requirements and gaps that should be addressed through enhanced monitoring programs. This includes reporting that emphasizes data delivery to end users at the resolution, timeframe, and formats necessary to support decision making and resource managers.

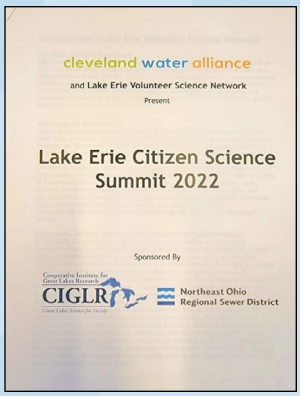
A publication to the Journal of Great Lakes Research, report to the Annex 4 subcommittee and summit white paper summarizing the summit's results and recommendations are being prepared as a result of this meeting.

CIGLR Summit:

Smart Lake Erie Citizen Science

States bordering Lake Erie are increasingly investing in solutions to reduce the nutrient pollution that drives harmful algal blooms (HABs), but often do not have enough information to know how to strategically locate these projects, evaluate their effectiveness, or optimize their performance. Further, budget reductions in some states are challenging the scope and sustainability of State agency water monitoring programs. Citizen science (volunteer monitoring by non-expert residents) represents an important opportunity to expand regional data collection capacity and address pressing water quality challenges like HABs. However, it is difficult for scientists and managers to leverage the full scope of Lake Erie's existing citizen science infrastructure to address their most pressing research and management needs.

A steering committee made up of individuals from The Ohio State University, Cleveland Water Alliance (CWA), Huron River Watershed Council, Heidelberg University, CIGLR, and NOAA GLERL led an interdisciplinary CIGLR summit to work toward building a framework for legitimizing water quality data collected by citizen scientists across the Lake Erie region. This summit was an outgrowth of CWA's Smart Citizen Science Initiative, which aims to build a network that coordinates volunteer monitoring groups across the Lake Erie basin. The outcomes of the summit will not only enable more consistent and reliable citizen-based monitoring across Lake Erie and its watersheds, but also open up a valuable regional data source capable of baselining advanced observing systems, feeding modeling tools, and serving as the basis for new data products that support sustainable water resource decision-making.



2022 Smart Lake Erie Citizen Science Summit program. Photo: Ed Verhamme

Rapid Funding:

Lake Superior Cyanobacterial Blooms

Cyanobacterial blooms have become an increasing concern in the western arm of Lake Superior, and little is currently known about the species present in the bloom, their origin, or their potential toxicity. With a CIGLR Rapid Fund award, University of Minnesota Duluth (UMD) investigator Cody Sheik, PhD, is using shotgun metagenomics to generate a DNA sequencing library for samples collected from Lake Superior algal blooms. "Spurred by several small *Dolicospermum sp.* blooms in the Duluth, MN area in July and August 2022, we aim to recover the cyanobacterial genomes that are present," said Sheik. Furthermore, in collaboration with Matt Hudson, PhD (Northland College) and Bob Sterner, PhD (UMD), Sheik's team is sequencing select samples from a spatial and temporal transect from summer 2022. "Cyanobacterial blooms have initiated earlier and to a greater extent across the western arm of Lake Superior," said Sheik. "We aim to recover *D. lemmermmannii* genomes and compare them with the genome from a similar bloom that occurred in 2018 to elucidate where these organisms are being sourced (i.e., watershed or within Lake Superior) and ultimately assess whether the genotype is capable of producing toxins."

2021 Cyanobacterial bloom at Park Point in Duluth, MN along the Lake Superior shoreline. Photo: Cody Sheik

Water intake crib off the coast of Lake Erie in Cleveland, Ohio. LimnoTech's genomic testing will help drinking water plant managers be prepared to adjust their treatment as needed. Photo: Public Domain

Rapid Funding:

Genomic Testing Near Lake Erie Drinking Water Intakes

With a CIGLR Rapid Award, LimnoTech is laying the foundation for the future development of an RNA/DNA surveillance network that blends the capabilities of public research and private enterprise to meet the needs of public water utilities. LimnoTech is working with the Environmental Quality Operations (EQO: **eqo.life)** company to develop and produce primer/probe sets for use in quantitative real-time polymerase chain reaction (qPCR) assays. The probes will analyze the expression level of toxin-related cyanobacteria genes of interest, including the microcystin family of genes (mcyA through mcyE) as well as the most common genes associated with anatoxin-a and saxitoxin production. The Rapid Award funds were specifically used to isolate RNA and DNA from preserved Lake Erie water intake samples and perform whole-microbiome analysis using the proprietary PhyloChip microarray platform. The information collected from this process is intended to support determination of toxic event severity risk and serve as a proof-of-concept study to be expanded upon for development of a prevention forecast model. LimnoTech's eventual goal is to expand the collection of preserved RNA/DNA samples that can either be analyzed rapidly (days) or on an as-needed retroactive basis using a cache of preserved samples. This will help water facility operators determine how to rapidly adjust treatment approaches to changing raw water conditions, thus protecting public health

Kirill Shchapov, PhD (University of Minnesota Duluth) collects zooplankton samples and other data from below the ice on Lake Michigan's Green Bay. This work is part of a Great Lakes region-wide effort to find out more about the lake ecosystems in winter. Photo: Audrey Huff

Rapid Funding:

Winter Grab: A Multi-Institutional Great Lakes Winter Sampling Campaign

Led by University of Minnesota Duluth lake biologist Ted Ozersky, PhD, a CIGLR Rapid Award helped support a multi-institutional coordinated winter sampling campaign across all of the Great Lakes. A network of Great Lakes researchers (Great Lakes Winter Network; GLWiN) coalesced around a common interest in winter conditions and a set of priority research questions. This network of more than a dozen U.S. and Canadian institutions braved the elements to sample at 35 sites on all five Great Lakes during the "Winter Grab," a first-of-its-kind coordinated winter sampling campaign. Their sampling efforts aimed to fill key knowledge gaps on winter dynamics in the lakes, including ice properties (thickness and light attenuation), water column physical and chemical conditions (temperature, clarity, conductivity, oxygen, nutrients, etc.), and biological patterns and processes (plankton biomass and community structure, primary and bacterial production rates). "Winter is rapidly changing on the Great Lakes and the current scarcity of winter research impedes our ability to predict and manage the consequences of these changes," said Ozersky. "The formation of GLWiN and the initiation of this first coordinated winter sampling event is an important step toward better preparing the Great Lakes region for future climate scenarios." GLWiN members are working to secure proper funding and are hopeful for another "Winter Grab" event in the future.

ECO Funding:

Communicating the Impact of Road Salt Pollution in the Great Lakes

In snowy climates road salts are applied to keep roads safe, but they end up in waterways where chloride (a chemical compound found in road salts) permanently pollutes freshwater and can be harmful to aquatic organisms. However, not much is fully understood about the long-term impacts of chloride in freshwater environments. Lexi Passante, a graduate student in Sandra McLellan's, PhD, laboratory at the University of Wisconsin Milwaukee (UWM) School of Freshwater Sciences took a microbiological approach to investigate these impacts. For her Master's degree research, Passante sampled sediment at riverine sites located in a Lake Michigan drainage basin and discovered widespread halophile populations. Halophiles, or salt-loving bacteria, generally require the presence of high salt concentrations to survive and can be found in places like the oceans. "Our findings were very surprising!" said Passante. "We thought it would be difficult to find halophiles sustained in freshwater—so, we definitely wanted to share our results with the hope of educating others about chloride pollution." With support from a CIGLR ECO Award, Passante teamed up with Wisconsin Salt Wise, Oconomowoc High School, Waukesha County, and the UWM Film Department to create educational materials through *Data Nuggets* and a video series that documented Passante's research. "The data we collected were incorporated into the Data Nuggets educational page for students to learn how to work with environmental datasets," explained Passante. "Ultimately, we hope that our work has raised awareness of the impacts of chloride pollution and set the foundation for developing a biological indicator to assess chloride-impacted freshwaters as halophilic bacteria thrive under high salt conditions."

Scan for *Data Nuggets*

University of Wisconsin Milwaukee (UWM) School of Freshwater Sciences graduate student Lexi Passante collecting water samples at an urban sampling site along the Kinnickinnic River.
Photo: Lexi Passante

2022 Winners

CIGLR AWARDS $302,000 IN 2022 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 2022 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

- **Jeremy Bricker, PhD, University of Michigan:** Coupling FVCOM-Ice Output with a Forcing and Response Model for Wind Turbines in Lake Erie
- **Timothy James, PhD, University of Michigan:** Flow of Cyanotoxins Through the Food Web Mediated by Chytrid Fungi Infections

GRADUATE RESEARCH FELLOWSHIP AWARDS

- **Elizabeth Minor, PhD, University of Minnesota Duluth:** $CaCO_3$ Saturation State as a Predictor of Dreissenid Habitat in the Laurentian Great Lakes
- **C.K. Shum, PhD, Ohio State University:** Machine-Learning Aided Detection of Great Lakes Meteotsunamis Using Satellite Geodetic Observations

SUMMIT AND WORKING GROUP (SWG) AWARDS

- **Alan Steinman, PhD, Grand Valley State University:** Coordinated Experiments Across the Great Lakes Basin: Great Lakes Integrated Mesocosm Research (GLIMR)
- **Chris Winslow, PhD, Ohio State University:** Defining Baseline Ecosystem Conditions in Dynamic Great Lakes Ecosystems

ECO AWARDS

- **Sandra McLellan, PhD, University of Wisconsin-Milwaukee**
- **David Poulson, Michigan State University:** Great Lakes Echo Reporting

RAPID AWARDS

- **Ted Ozersky, PhD, University of Minnesota Duluth:** Winter Grab: A Multi-Institutional Great Lakes Winter Sampling Campaign
- **Cody Sheik, PhD, University of Minnesota Duluth:** DNA Analysis of Lake Superior Cyanobacterial Blooms
- **Edward Verhamme, LimnoTech:** Rapid Funds Proposal for RNA/DNA Processing of Samples Collected Near Lake Erie Drinking Water Intakes of Toledo and Cleveland
- **Edward Verhamme, LimnoTech:** Rapid Funds to Respond to St. Mary's River Oil Spill

Staff & Governance

ADMINISTRATION

Gregory Dick
Director
Sara Hughes
Associate Director
Mary Ogdahl
Program Manager
Ayumi Fujisaki-Manome
Modeling & Forecasting Theme Lead
Casey Godwin
Ecosystem Dynamics Theme Lead
Russ Miller
Observing Systems Theme Lead
Aubrey Lashaway
Communications Specialist
*Michele Wensman
Outreach Specialist

RESEARCH INSTITUTE

Research Scientists

Dmitry Beletsky
Research Scientist
S. Rao Chaganti
Assistant Research Scientist
*Michael Fraker
Assistant Research Scientist
Ayumi Fujisaki-Manome
Assistant Research Scientist
Casey Godwin
Assistant Research Scientist
Sara Hughes
Research Scientist
Thomas Johengen
Research Scientist

Research Staff

Peter Alsip
Ecological Modeling Data Analyst
Raisa Beletsky
Research Associate
Anna Boegehold
Algal Toxin & Ecology Research Specialist
Ashley Burtner
Research Lab Specialist Associate
Andrew Camilleri
Benthic Ecology Research Technician
*Charlie Carter
Research Assistant
Glenn Carter
Benthic Ecology Research Technician
*Santhi Davedu
Research Assistant
*Paul Den Uyl
Aquatic Ecology Research Technician
Megan DiCocco
Stakeholder Engagement Specialist Associate
Daniel Dominique
Research Assistant
Briana Ellis
Research Assistant
Katy Frank
Hydrological Modeler
Lindsay Fitzpatrick
Hydrological Modeler
*Adam Friedman
Research Assistant
*Devin Gill
Stakeholder Engagement Specialist
Connor Gluck
Research Assistant
*Hayden Henderson
Observing Systems Engineer
Haoguo Hu
Ice Modeler
Alex Kain
Model Data Analyst
*Holly Kelchner
Aquatic Ecology Research Analyst
Christine Kitchens
Aquatic Ecology Research Technician
Linfeng Li
Research Assistant
*Lian Liu
Research Assistant
Songzhi Liu
General Programmer/Analyst Lead
Jasmine Mancuso
Aquatic Ecology Research Assistant
Melissa Mattwig
Research Assistant
Kelly McCabe
Biogeochemistry Laboratory Analyst
Russ Miller
Mechanical Technician Intermediate
Miye Nakashima
Research Assistant
*Daniel Peters
Research Assistant
Heidi Purcell
Research Area Specialist Intermediate
Riley Ravary
Stakeholder Engagement Specialist Intermediate
*Connor Roessler
B-Wet Program Assistant
Paris Schofield
Aquatic Ecology Laboratory Technician
*Daniel Titze
Hydrodynamic/Wave Modeler
Madeline Tomczak
Food Web Laboratory Analyst
Lucas Vanderbilt
Research Assistant
*Michele Wensman
Research Associate

Postdoctoral Research Fellows

David Cannon
Yi Hong
Abby Hutson
*Yuchun (Yoyo) Lin
*Timothy Maguire
Kristie Mitchell

EXECUTIVE BOARD

Gregory Dick
Director, CIGLR, University of Michigan
(Ex Officio)
Carl Gouldman
Director, U.S. IOOS Office, NOAA National Ocean Service
Deborah Lee
Director, NOAA GLERL
(Ex Officio)
Brad Orr
Associate VP for Research, Natural Sciences and Engineering, University of Michigan
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)

COUNCIL OF FELLOWS

Gregory Dick
Director, CIGLR, University of Michigan
Sara Hughes
Associate Director, CIGLR, University of Michigan
John Bratton
Senior Scientist, LimnoTech
Philip Chu
Physical Scientist, NOAA GLERL
Patrick Doran
Associate State Director for Michigan, The Nature Conservancy
Aaron Fisk
Professor, Great Lakes Institute for Environmental Research, University of Windsor

Steve Fondriest
President, Fondriest Environmental
Ayumi Fujisaki-Manome
Assistant Research Scientist, CIGLR, University of Michigan
Rebecca Klaper
Associate Dean/Professor, School of Freshwater Sciences & Director, Great Lakes Genomics Center, University of Wisconsin Milwaukee
Phanikumar Mantha
Professor/Associate Chair for Graduate Studies, Michigan State University
Dennis McCauley
President and Principal Research Scientist, Great Lakes Environmental Center
Ashley Moerke
Professor/Director of the Center for Freshwater Research and Education, Lake Superior State University
Steve Ruberg
Group Leader, Marine Instrumentation Lab, NOAA GLERL
Lars Rudstam
Director, Shackelton Point Field Station, Cornell University
Mike Shriberg
Regional Executive Director, National Wildlife Federation Great Lakes Regional Center
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

*Indicates research institute staff transitions

2022
INTERNATIONAL WORKSHOP ON
Modeling the Ocean

The 12th International Workshop on Modeling the Ocean (IWMO) was held in Ann Arbor, Michigan, USA from June 28, 2022 through July 1, 2022. The workshop maximized international participation by successfully adopting a hybrid format, with 60 participants from across the globe attending either at the University of Michigan or online. Drs. Dmitry Beletsky (University of Michigan, CIGLR) and Jia Wang (NOAA GLERL) co-chaired the IWMO local organizing committee.

Hosted annually at a different international location, the IWMO focuses on all aspects of ocean modeling, including process studies, prediction, interactions among air, wave, ice, currents, and sediments using coupled model systems. This year's sessions included one dedicated to Great Lakes System Modeling and Forecasting and featured an Outstanding Young Scientist Awards competition.

The 12th International Workshop on Modeling the Ocean (IWMO) was held in Ann Arbor, Michigan, USA at the University of Michigan and online from June 28, 2022 through July 1, 2022. Photo: Mary Ogdahl

CIGLR welcomes new members to our team!

Anna Boegehold is an Algal Toxin and Ecology Research Specialist working with Casey Godwin, PhD (CIGLR) and the harmful algal bloom (HAB) monitoring team to investigate the dynamic ways in which cyanobacteria blooms interact with the surrounding ecosystem and impact environmental and community health in the Great Lakes.

David Cannon, PhD, is a Postdoctoral Research Fellow working with Ayumi Fujisaki-Manome, PhD (CIGLR) and the climate modeling team at NOAA GLERL to improve climate change simulations in the Great Lakes region, with a specific focus on the coupled ice-lake model.

Megan DiCocco is a Stakeholder Engagement Specialist in CIGLR's ECO program and facilitates connections between stakeholders and scientists at CIGLR and NOAA GLERL to co-design research from project development to product distribution.

Kaitlyn (Katy) Frank is an Applications Programmer working under Russ Miller (CIGLR) and with the NOAA GLERL Observing Systems and Ecosystem Dynamics teams to facilitate data management and develop and maintain web interfaces for data products.

Alexander (Alex) Kain is a Modeling Data Analyst working with Casey Godwin, PhD (CIGLR) to develop experimental ecological forecasts linked to the hydrodynamic models of the Great Lakes Operational Forecast System.

Kristie Mitchell, PhD, is a Postdoctoral Research Fellow focused on microbial ecology, with a research interest in zooplankton predator-prey dynamics. She is working with S. Rao Chaganti, PhD (CIGLR) to evaluate the gut contents of zooplankton in the Great Lakes using metagenomics.

Riley Ravary, PhD, is a Stakeholder Engagement Specialist Intermediate supporting ongoing efforts to facilitate connections between CIGLR scientists and stakeholder communities in the Great Lakes region.

Paris Schofield is an Aquatic Ecology Laboratory Technician working with Casey Godwin, PhD (CIGLR) on aquatic ecology and harmful algal bloom (HABs) research in the Great Lakes.

CIGLR Energizes Great Lakes Partnerships

WITH VIRTUAL 5TH ALL PARTNERS MEETING

Madeline (Maddie) Tomczak is a Food Web Laboratory Analyst working with Casey Godwin, PhD (CIGLR), Ed Rutherford, PhD (NOAA GLERL) and Doran Mason, PhD (NOAA GLERL) to assess Great Lakes larval fish and food web dynamics, as well as fisheries acoustics.

Each year, the Cooperative Institute for Great Lakes Research (CIGLR) hosts a 2-day meeting that aims to coordinate research goals and foster new research partnerships between NOAA GLERL and members of CIGLR's Regional Consortium. The 2021 meeting was held virtually from November 4-5, with more than 100 scientists from the CIGLR Research Institute, CIGLR Regional Consortium, and NOAA in attendance.

The meeting started with welcome presentations by NOAA GLERL Director Deborah Lee and CIGLR Director Gregory Dick, who provided overviews of NOAA GLERL/CIGLR and laid out pathways to collaboration. Meeting sessions included presentations by CIGLR, NOAA GLERL, and Regional Consortium investigators on social science and policy development; research co-development with nongovernmental organizations (NGOs); and future research directions in observing systems and advanced technology, modeling and forecasting, and ecosystem dynamics. A virtual poster session gave attendees the opportunity to showcase their research successes and engage in one-on-one discussions. Facilitated breakout sessions provided opportunities for investigators from the CIGLR Regional Consortium, CIGLR Research Institute, and NOAA GLERL to identify and prioritize opportunities for collaboration, including strategies for pursuing new research directions.

The 2021 CIGLR All Partners Meeting included a virtual poster session.

In the Media

CI UPDATES

- U-M awarded $53M to expand federally funded Great Lakes research institute over next 5 years, Michigan News
- NOAA doubles five-year grant to $53 million for Great Lakes researchers at U-M, Michigan Radio
- Funding for Great Lakes research institute to expand work in Detroit, Bridge Detroit
- Research consortium gets $53M to expand study of the Great Lakes, MLive
- U-M research group receives more funding to study Great Lakes, WEMU 89.1
- Feds double grant for U-M's Great Lakes research center to $53M, The Detroit News
- U-M gets $53 million federal deal that will expand Great Lakes research, Crain's Detroit Business
- Sara Hughes named CIGLR's associate director, University of Michigan School for Environment and Sustainability News

WINTER GRAB

- Winter Grab: U-M team bores through Saginaw Bay ice to glimpse Great Lakes life below, Michigan News
- Scientists take rare look under Great Lakes' frozen surfaces, Great Lakes Now
- Great Lakes scientists initiate 'Winter Grab' in efforts to boost knowledge of ecosystems frozen over, Fox 2 Detroit
- What happens to the Great Lakes in winter? Scientists want to know, Wood TV 8
- Scratching the surface: Regional research groups explore winter conditions of Green Bay, Great Lakes, Great Lakes Now
- On the Great Lakes, scientists are making a 'Winter Grab' of rare data, Science
- What happens under Great Lakes ice? Scientists want to know before it's too late, The Detroit News
- What is the 'Winter Grab' along the Great Lakes?, Newsy
- Michigan Tech University conducts winter research of Lake Superior, Upper Michigan Source
- Researchers to study the winter mysteries of the Great Lakes ecosystem, CTV Windsor News
- Climate change brings thinner, more unstable ice to the Great Lakes, Grist
- Coolest job ever? These scientists ride snowmobiles to study ice on the Great Lakes, WBEZ Chicago
- Trent University joins rare winter sampling of the Great Lakes, PTBO Canada
- Dozens of Great Lakes scientists participating in region's first coordinated 'Winter Grab', The Toledo Blade
- Four ways Great Lakes winters are changing as scientists search for clues, Bridge Michigan
- Researchers to study the Great Lakes during our ever-changing winters, Fox 9 News Minneapolis
- Scientists prepare for first-of-its-kind study of the Great Lakes, WXYX Detroit
- Equipped with snowmobiles, sleds and ice picks, scientists to launch rare winter study of the Great Lakes, Chicago Tribune
- Scientists to gather winter data across all five Great Lakes, Finger Lakes Times
- Scientists embark on 'Winter Grab' to gather data on warming Great Lakes, MLive
- Scientists to hit the ice for Great Lakes winter research project, Windsor Star
- Winter Grab: Dozens of Great Lakes scientists join rare February sampling campaign to study 'the changing face of winter', Michigan News
- Scientists race to gather winter data on warming Great Lakes, AP News

HARMFUL ALGAL BLOOMS

- **Plastic Oceans International and Great Lakes Outreach Media complete production on the Erie Situation**, Plastic Oceans
- **Meet postdoctoral research fellow Sara R. Rivera**, NOAA Research Newsletter
- **Great Lakes scientists start harmful algal bloom sampling**, NOAA Research Newsletter

ICE, WATER LEVELS & INVASIVE SPECIES

- **Bridge's next Lunch Break will discuss Great Lakes invasive species**, Bridge Michigan
- **Shrinking Winter – Great Lakes Now – Episode 2202 – Segment 1**, Great Lakes Now
- **Cold Cover: Great Lakes ice forms after initial low percentage**, Great Lakes Now
- **Looking at the impacts of changing water levels in the Great Lakes**, NOAA Research Newsletter
- **Environmental DNA advances science in the Great Lakes**, NOAA Research Newsletter

OTHER STORIES

- **State of the Strait Conferences: Lessons from 24 years of advancing ecosystem-based management**, Great Lakes Connection Connexion Grands Lacs
- **Video, board games keep research technician connected**, The University Record
- **CIGLR staff member feels at home on the water**, The University Record
- **This is what a Great Lakes scientist looks like: Christine Kitchens**, Upwellings
- **Gregory Dick named CIGLR's new director**, University of Michigan School for Environment and Sustainability News
- **Congratulations to the following IAGLR members on their accomplishments (pg 14)**, IAGLR Lakes Letter

Stay up to date on CIGLR news! Subscribe to our quarterly eNewsletter: **ciglr.seas.umich.edu/resources/latest-news/**

Read our stories

Peer-Reviewed Publications

Anderson, H.S.; T.H. Johengen; R. Miller; C.M. Godwin. 2021. Accelerated sediment phosphorus release in Lake Erie's central basin during seasonal anoxia. *Limnology and Oceanography*. 66(9): 3582-3595. (DOI:10.1002/lno.11900).

Benjamin, S.G.; T.G. Smirnova; E.P. James; E.J. Anderson; A. Fujisaki-Manome; J.G.W. Kelley; G.E. Mann; A.D. Gronewold; P. Chu; S.G.T. Kelley. 2022. Inland lake temperature initialization via cycling with atmospheric data assimilation. *Geoscientific Model Development*. 15:6659-6676. (DOI:10.5194/gmd-15-6659-2022).

Berrang-Ford, L; A.R. Siders; A. Lesnikowski; M. Jurjonas; et al. 2021. A systematic global stocktake of evidence on human adaptation to climate change. *Nature Climate Change*. 11:989-1000. (DOI:10.1038/s41558-021-01170-y).

Biddanda, B.; D. Dila; A. Weinke; J. Mancuso; M. Villar-Argaiz; J.M. Medina-Sánchez; J.M. González-Olalla; P. Carrillo. 2022. Housekeeping in the hydrosphere: Microbial cooking, cleaning, and control under stress. *Life*. 11(2):152. (DOI:10.3390/life11020152).

Biddanda, B.; A. Weinke; I. Stone; S. Kendall; P. Hartmeyer; W. Lusardi; S. Gandulla; J. Bright; S. Ruberg. 2021. Extant earthly microbial mats and microbialites as models for exploration of life in extraterrestrial mat worlds. *Life*. 11(9):883. (DOI:10.3390/life11090883).

Cai, Q.; D. Beletsky; J. Wang; R. Lei. 2021. Interannual and decadal variability of Arctic summer sea ice associated with atmospheric teleconnection patterns during 1850-2017. *Journal of Climate*. 34(24):9931-9955. (DOI:10.1175/JCLI-D-20-0330.1).

Den Uyl, P.A.; S.B. Harrison; C.M. Godwin; M.D. Rowe; J.R. Strickler; H.A. Vanderploeg. 2021. Comparative analysis of Microcystis buoyancy in western Lake Erie and Saginaw Bay of Lake Huron. *Harmful Algae*. 108. (DOI:10.1016/j.hal.2021.102102).

Dick, G.J.; M.B. Duhaime; J.T. Evans; R.M. Errera; C.M. Godwin; J.J. Kharbush; H.S. Nitschky; M.A. Powers; H.A. Vanderploeg; K.C. Schmidt; D.J. Smith; C.E. Yancey; C.C. Zwiers; V.J. Denef. 2021. The genetic and ecophysiological diversity of Microcystis. *Environmental Microbiology*. 23(12):7278-7313. (DOI:10.1111/1462-2920.15615).

Evans, T.M.; Z.S. Feiner; L.G. Rudstam; D.M. Mason; J.M. Watkins; E.D. Reavie; A.E. Scofield; L.E. Burlakova; A.Y. Karatayev; W.G. Sprules. 2021. Size spectra analysis of a decade of Laurentian Great Lakes data. *Canadian Journal of Fisheries and Aquatic Sciences*. 79(1). (DOI:10.1139/cjfas-2020-0144).

Fraker, M.E.; A. Shrestha; L. Marshall; L. Mason; R. Miller. 2021. Seasonal variation in light penetration and subsurface chlorophyll-*a* in southern Lake Michigan observed by a glider. *Journal of Great Lakes Research*. 47(4):1228-1234. (DOI:10.1016/j.jglr.2021.04.007).

Fraker; M.E.; J.S. Sinclair; K.T. Frank; J.M. Hood; S.A. Ludsin. 2022. Temporal scope influences ecosystem driver-response relationships: A case study of Lake Erie with implications for ecosystem-based management. *Science of the Total Environment*. 813. (DOI:10.1016/j.scitotenv.2021.152473).

Fujisaki-Manome, A.; D.M. Wright; G.E. Mann; E.J. Anderson; P. Chu; C. Jablonowski; S.G. Benjamin. 2022. Forecasting lake-/sea-effect snowstorms, advancement, and challenges. *WIREs Water*. 9(4):E1594. (DOI:10.1002/wat2.1594).

Grim, S.L.; A.A. Voorhies; B.A. Biddanda; S. Jain; S.C. Nold; R. Green; G.J. Dick. 2021. Omics-inferred partitioning and expression of diverse biogeochemical functions in a low O_2 cyanobacterial mat community. *mSystems*. 6(6):e01042-21. (DOI:10.1128/mSystems.01042-21).

Hong, Y.; H.X. Do; J. Kessler; L. Fry; L. Read; A.R. Nasab; A.D. Gronewold; L. Mason; E.J. Anderson. 2022. Evaluation of gridded precipitation datasets over international basins and large lakes. *Journal of Hydrology*. 607:127507. (DOI:10.1016/j.jhydrol.2022.127507).

Hu, Y.; L. Fitzpatrick; L.M. Fry; L. Mason; L.K Read; D.C. Goering. 2021. Edge-of-field runoff prediction by a hybrid modeling approach using causal inference. *Environmental Research Communications*. 3:075003. (DOI:10.1088/2515-7620/ac0d0a/meta).

Hu, H.; A.J. van der Westhuysen; P. Chu; A. Fujisaki-Manome. 2021. Predicting Lake Erie wave heights and periods using XGBoost and LSTM. *Ocean Modelling*. 164:101832.(DOI:10.1016/j.ocemod.2021.101832).

Huang, C.; E. Anderson; Y. Liu; G. Ma; G. Mann; P. Xue. 2021. Evaluating essential processes and forecast requirements for meteotsunami-induced coastal flooding. *Natural Hazards*. 110:1693-1718. (DOI:10.1007/s11069-021-05007-x).

Jurjonas, M.; C.A. May; B.J. Cardinale; S. Kyriakakis; D.R. Pearsall; P.J. Dorana. 2022. A synthesis of the Great Lakes Restoration Initiative according to the open standards for the practice of conservation. *Journal of Great Lakes Research*. (DOI:10.1016/j.jglr.2022.01.008).

Kravtsov, S.; P. Roebber; T.M. Hamill; J. Brown. 2022. Objective methods for thinning the frequency of reforecasts while meeting post-processing and model validation needs. *Weather and Forecasting*. 37(5):727-748. (DOI:10.1175/WAF-D-21-0162.1).

Li, Y.; D. Beletsky; J. Wang; J. Austin; J. Kessler; A. Fujisaki-Manome; P. Bai. 2021. Modeling a large coastal upwelling event in Lake Superior. *JGR Oceans*. 126(5):e2020JC016512. (DOI:10.1029/2020JC016512).

Lin, Y-C.; A. Fujisaki-Manome; J. Wang. 2022. Recently amplified interannual variability of the Great Lakes ice cover in response to changing teleconnections. *Journal of Climate*. 35(19):2683-2700. (DOI:10.1175/JCLI-D-21-0448.1).

Maguire, T.; C. Stow; C. Godwin. 2021. Spatially referenced Bayesian state-space model of total phosphorus in western Lake Erie. *Hydrology and Earth System Sciences*. 26(8):1993-2017. (DOI:10.5194/hess-26-1993-2022).

Mancuso, J.L.; A.D. Weinke; I.P. Stone; S.E. Hamsher; M.M. Woller-Skar; E.B. Snyder; B.A. Biddanda. 2021. Bloom and bust: Historical trends of harmful algal blooms in Muskegon Lake, Michigan, a Great Lakes estuary. *Freshwater Science*. 40(3):463-477. (DOI:10.1086/716236).

Mancuso, J.L.; A.D. Weinke; I.P. Stone; S.E. Hamsher; M. Villar-Argaiz; B.A. Biddanda. 2021. Cold and wet: Diatoms dominate the phytoplankton community during a year of anomalous weather in a Great Lakes estuary. *Journal of Great Lakes Research*. 47(5):1305-1315. (DOI:10.1016/j.jglr.2021.07.003).

Ozersky, T.; A.J. Bramburger; A.K. Elgin; H.A. Vanderploeg; J. Wang; J.A. Austin; H.J. Carrick; L. Chavarie; D.C. Depew; A.T. Fisk; S.E. Hampton; E.K. Hinchey; R.L. North; M.G. Wells; M.A. Xenopoulos; M.L. Coleman; M.B. Duhaime; A. Fujisaki-Manome; R.M. McKay; G.A. Meadows; M.D. Rowe; S. Sharma; M.R. Twiss; A. Zastepa. 2021. The changing face of winter: Lessons and questions from the Laurentian Great Lakes. *JGR Biogeoscience*. 126(6):e2021JG006247. (DOI:10.1029/2021JG006247).

Passante, E.K.; L.E.Dechant; C.J.Paradis; S.L.McLellan. 2022. Halophilic bacteria in a Lake Michigan drainage basin as potential biological indicators of chloride-impacted freshwaters. *Science of the Total Environment*. 846:(157458). (DOI:10.1016/j.scitotenv.2022.157458).

Qian, S.S.; C.A. Stow; F.E. Rowland; Q. Liu; M.D. Rowe; E.J. Anderson; R.P. Stumpf; T.H. Johengen. 2021. Chlorophyll a as an indicator of microcystin: Short-term forecasting and risk assessment in Lake Erie. *Ecological Indicators*. 130:108055. (DOI:10.1016/j.ecolind.2021.108055).

Rowland, F.E.; C.A. Stow; L.T. Johnson; R.M. Hirsch. 2021. Lake Erie tributary nutrient trend evaluation: Normalizing concentrations and loads to reduce flow variability. *Ecological Indicators*. 125:107601. (DOI:10.1016/j.ecolind.2021.107601).

Shahraki, A.H.; S.R. Chaganti; D. Heath. 2021. Spatio-temporal dynamics of bacterial communities in the shoreline of Laurentian great Lake Erie and Lake St. Clair's large freshwater ecosystems. *BMC Microbiology*. 21:253. (DOI:10.1186/s12866-021-02306-y).

Sinclair, J.S.; M.E. Fraker; J.M. Hood; K.T. Frank; M.R. DuFour; A.M. Gorman; S.A. Ludsin. 2021. Functional traits reveal the dominant drivers of long-term community change across a North American Great Lake. *Global Change Biology*. 27(23):6232-6251. (DOI:10.1111/gcb.15902).

Smith, D.J.; J.Y. Tan; M.A. Powers; X.N. Lin; T.W. Davis; G.J. Dick. 2021. Individual Microcystis colonies harbour distinct bacterial communities that differ by Microcystis oligotype and with time. *Environmental Microbiology*. 23(9):5652-5657. (DOI:10.1111/1462-2920.15772).

Steinman, A.D.; D.G. Uzarski; D.P. Lusch; C. Miller; P. Doran; T. Zimnicki; P. Chu; J. Allan; J. Asher; J. Bratton; D. Carpenter; D. Dempsey; C. Drummond; J. Esch; A. Garwood; A. Harrison; L.D. Lemke; J. Nicholas; W. Ogilvie; B. O'Leary; P. Sachs; P. Seelbach; T. Seidel; A. Suchy; J. Yellich. 2022. Groundwater in crisis? Addressing groundwater challenges in Michigan (USA) as a template for the Great Lakes. *Sustainability*. 14(5):3008. (DOI:10.3390/su14053008).

Vasquez, A.A.; O. Mohiddin; Z. Li; B.L. Bonnici; K. Gurdziel; J.L. Ram. 2021. Molecular diet studies of water mites reveal prey biodiversity. *PLOS One*. 16(7):e0254598. (DOI:10.1371/journal.pone.0254598).

Peer-Reviewed Publications

Yancey, C.E.; D.J. Smith; P.A. Den Uyl; O.G. Mohamed; F. Yu; S.A. Ruberg; J.D. Chaffin; K.D. Goodwin; A. Tripathi; D.H. Sherman; G.J. Dick. 2022. Metagenomic and metatranscriptomic insights into population diversity of Microcystis blooms: Spatial and temporal dynamics of mcy genotypes, including a partial operon that can be abundant and expressed. *Environmental Microbiology*. (DOI:10.1128/aem.02464-21).

Zhang, Y.; S.B. Sieron; Y. Lu; X. Chen; R.G. Nystrom; M. Minamide; M.Y. Chan; C.M. Hartman; Z. Yao; J.H. Ruppert Jr.; A. Okazaki; S.J. Greybush; E.E. Clothiaux; F. Zhan. 2021. Ensemble-Based assimilation of satellite all-sky microwave radiances improves intensity and rainfall predictions for Hurricane Harvey (2017). *Geophysical Research Letters*. 48(24):e2021GL096410. (DOI:10.1029/2021GL096410).

Non-Peer-Reviewed Publications:

Biddanda, B.; S. Kendall. 2021. Hidden life of giant microbialites in Laguna Bacalar, Yucatan Peninsula, Mexico. Postcards from the Field. *Eos, American Geophysical Union*. 102(10):48.

Biddanda, B.; S. Kendall; A. Weinke; I. Stone; N. Dugener; S. Ruberg; J. Leidig; E. Smith; M. Berg. G. Wolffe. 2021. Muskegon Lake Observatory Buoy Data: Muskegon Lake, Michigan: 2011-2019 ver 1. Environmental Data Initiative.

Biddanda, B.; T. Roetman; A. Yagiela; D. Burlingame. 2021. Reeling in a Great Lakes Observing Science Buoy. Postcards from the Field. *Eos, American Geophysical Union*.

Biddanda, B.; I. Stone; N. Dugener; A. Weinke; R. Rediske; J. Mancuso; A. Parker; L. Marshall; A. VanderWoude; S. Ruberg. 2021. Like lawn on a lake: Nuisance blooms plague a Great Lakes estuary. Postcards from the Field. *Eos, American Geophysical Union*.

Biddanda, B.; A. Weinke; I. Stone; S. Kendall; P. Hartmeyer; W. Lusardi; S. Gandulla; J. Bright; S. Ruberg. 2021. Microbial mats: Extraterrestrial life models. Encyclopedia.

Billings, K. 2021. Great Lakes shoreline restoration: Evaluation and benchmarks. Deep Blue Documents. (DOI:10.7302/3789).

Briley, L.; J. Jorns. 2021. 2021 Great Lakes Climate Modeling Workshop Report. Ann Arbor, MI. Available at: glisa.umich.edu/publication/2021-great-lakes-climate-modeling-workshop

Cameron, K.; A. Kaczmarek; A. Paine; H. Paulson; E. Soderberg. 2022. A user-facing report: An assessment of coastal resilience in Great Lakes communities: Basinwide resources and local efforts in response to a changing coastline. Deep Blue Documents.

Cohn, D.; S. Davedu; L. Liu; M. Nakashima; I. Peng. 2021. Great Lakes ice cover: Enriching database and improving forecast. Deep Blue Documents. (DOI:10.7302/1050).

Cook, J.; C. Catanese; B. Biddanda. 2021. A just and delightful tantrum: Sophia's call for climate action. Connections for the STEM Classroom.

Dusicska, E.; S.R. Green; C.W. Rosenbaum; K. Sun; X. Wu. 2021. Assessing nutrient management strategies to control harmful algal blooms in Lake Erie. Deep Blue Documents. (DOI:10.7302/967).

Environment and Climate Change Canada and the U.S. National Oceanic and Atmospheric Administration. 2021. 2020 Annual climate trends and impacts summary for the Great Lakes Basin. Available at binational.net.

Kaczmarek, A.; K. Cameron; A. Paine; H. Paulson; E. Soderberg. 2022. A project final report: An assessment of coastal resilience in Great Lakes communities: Basinwide resources and local efforts in response to a changing coastline. Deep Blue Documents. (DOI:10.7302/4334).

Thompson, L.R.; S.R. Anderson; P.A. Den Uyl; N.V. Patin; S.J. Lim; G. Sanderson, K.D. Goodwin. 2022. Tourmaline: a containerized workflow for rapid and iterable amplicon sequence analysis using QIIME 2 and Snakemake. bioRXiv: The Preprint Server for Biology. (DOI:10.1101/2021.09.15.460495v2.full).

Murray, M.; J. Bratton; A. Elgin; C. Godwin; C. Riseng. 2021. Great Lakes indicators –Exploring alternative approaches through stakeholder input: A white paper. National Wildlife Federation, Great Lakes Regional Center, Ann Arbor, MI.

Steinman, A.D.; D.G. Uzarski; D. Lusch; C. Miller; P. Doran; T. Zimnicki; P. Chu; J. Allan; J. Asher; J. Bratton; D. Carpenter; D. Dempsey; C. Drummond; J. Esch; A. Garwood; A. Harrison; L.D. Lemke; J. Nicholas; W. Ogilvie; B. O'Leary; P. Sachs; P. Seelbach; T. Seidel; A. Suchy; J. Yellich. 2021. Groundwater in Crisis? Addressing groundwater challenges in Michigan as a template for the Great Lakes. A White Paper for the Cooperative Institute for Great Lakes Research, University of Michigan, Ann Arbor, MI

Stone, I.; A. Weinke; N. Dugener; J. Cook; B. Biddanda. 2021. Anchor truth to power: The battle for Earth. Interchange, Connections for the STEM Classroom.

Wang, J.; M. Trumper; H. Zhang; J. Kessler; M. Rowe; P. Chu; T.Y. Yang; B. Lofgren. 2022. Development of multiple-variable, non-linear, regression models linking Lake Erie water quality to environmental and climate teleconnection forcings, 1970s-2010s. *NOAA Technical Memorandum GLERL-177*. (DOI:10.25923/d9mk-jn08).

Weiskerger, C. 2022. Use of Lagrangian methods to simulate heavy storm-induced river plume dynamics and recreational water quality impacts in the nearshore region of southwestern Lake Michigan. (Doctoral dissertation, Michigan State University).

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

1st place: *Kelly McCabe on Deck,* Holly Kelchner

2nd place (2a): *Glider Guys,* Heidi Purcell

2nd place (2b): *Glenn Moving Incubator,* Holly Kelchner

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: *Ice,* Holly Kelchner

2nd place (2a): *Sleeping Bear Sunset,* Mary Ogdahl

2nd place (2b): *CIGLR after Work,* Andrew Camilleri

2nd place (2c): *Field Season 2021,* Christine Kitchens

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

Cooperative Institute for Great Lakes Research
University of Michigan
Dana Building, Room 4040
440 Church Street
Ann Arbor, MI 48109-1041

NON-PROFIT
ORGANIZATION
U.S. POSTAGE PAID
ANN ARBOR, MI
PERMIT #144

Great Lakes Science for Society

Make a Donation

The Great Lakes are the most critically important freshwater resource on the planet. They support the fourth-largest economy in the world and offer clean drinking water to more than 35 million people. CIGLR leads exciting new research, trains the next generation of scientists, and turns research into action for safe and healthy Great Lakes communities. To "Take Action" and support our Great Lakes, consider a donation today.