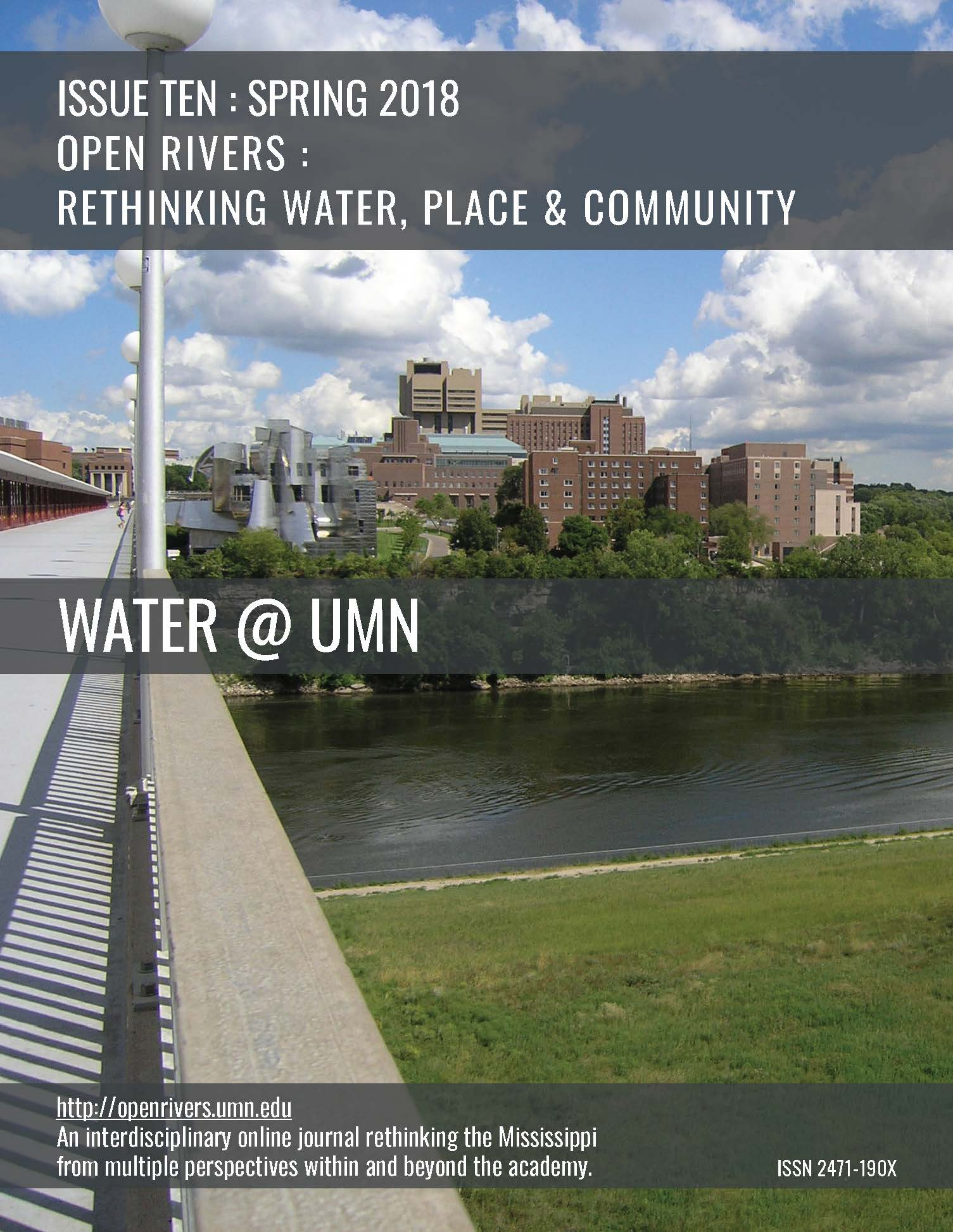

ISSUE TEN : SPRING 2018

OPEN RIVERS :
RETHINKING WATER, PLACE & COMMUNITY

WATER @ UMN

http://openrivers.umn.edu
An interdisciplinary online journal rethinking the Mississippi
from multiple perspectives within and beyond the academy.

ISSN 2471-190X

The cover image is of The East Bank of the Minneapolis campus of the University of Minnesota and the Mississippi River from the Washington Avenue Bridge. Image courtesy of Patrick Nunnally.

Open Rivers: Rethinking Water, Place & Community is produced by the University of Minnesota Libraries Publishing and the University of Minnesota Institute for Advanced Study.

Editors

Contact Us

Open Rivers
Institute for Advanced Study
University of Minnesota
Northrop
84 Church Street SE
Minneapolis, MN 55455

Telephone: (612) 626-5054
Fax: (612) 625-8583
E-mail: openrvrs@umn.edu
Web Site: http://openrivers.umn.edu

ISSN 2471-190X

Editorial Board

CONTENTS

FEATURE

EYES ON LARGE LAKES

By Erik Brown, Sergei Katsev, Sam Kelly, Ted Ozersky, Doug Ricketts, Kathryn Schreiner, Cody Sheik, Robert Sterner, and Lisa Sundberg

"A lake is a landscape's most beautiful and expressive feature. It is Earth's eye; looking into which the beholder measures the depth of his own nature." So said H.D. Thoreau in *Walden*, conjuring an image of human eyes peering intently into Earth's eyes, and learning something profound in the process. Indeed, who among us hasn't gazed into one of these watery eyes of Earth, into a lake's mysterious depths, and had their souls stirred, their curiosity piqued? How deep is it? How long has it been here? Where did the water come from and where does it go? What creatures live here? Is it safe to drink? On the western shore of Earth's largest lake, there is a

View of Duluth on the shores of Lake Superior, showing the Aerial Lift Bridge and the Great Lakes Aquarium.

century-old brick building, a former elementary school, where you can find a team of investigators whose job it is to be curious beholders of the largest of these "eyes" of Earth. Their studies of large lakes look into the past and help us project into the future. This story is about them and what they've done.

The Large Lakes Observatory (LLO) is a research unit at the University of Minnesota Duluth. It has a unique mission: to perform scientific study of the largest lakes of Earth. It is one of the largest water-centered research units at the university and its impact has been felt all over the world. The faculty, staff, and students of course use their human eyes to observe, but their senses also are extended in fascinating ways by the use of specialized observational platforms and techniques, some of which we will encounter here. Indeed, unusual skills and uncommon equipment often are needed to explore these large, sometimes remote, lake environments. Coordinated teams

Figure 1. The bottom of Lake Superior is below sea level! To measure certain parameters and to collect water from hundreds of meters below the surface, scientists can deploy this "CTD rosette." The gray vertical tubes are water sampling bottles that can be closed at chosen depths so that water from that location is brought back on board. Below the gray tubes is a package of instruments that measures such things as temperature, salinity, oxygen, and other parameters, giving LLO scientists a "vertical profile" of lake conditions. Photo credit: Blue Heron crew.

of investigators may take advantage of remote or autonomous sensors that extend their vision beyond what a single human alone can take in at a given moment. They use specialized equipment to make measurements of the chemistry, biology, and physics of large lakes. Such tools of the trade are not available everywhere, but they are central to the scientists of LLO.

Advancing human knowledge about large lakes isn't just fascinating for researchers; it has real value to society. Human welfare depends uniquely on these large lakes. It is sometimes said that clean freshwater is society's most valuable resource, something we can't live without. If you total it up, there is about 125,000 km3 of liquid, surface freshwater on Earth, covering about 9 million km2, roughly the area of Europe. Perhaps that seems like a lot of water. However, if all this freshwater was brought into a single spherical drop of liquid freshwater, its diameter would be only 62 km. This is really tiny on a global scale. One could barely see such a drop on an image of Earth from space, hardly what the iconic "blue marble" image of Earth or the nickname "the water planet" suggest. The lesson of this thought exercise is this: Only a small fraction of all the water on Earth is liquid and fresh, and it is spread thinly, with much greater breadth than depth, so the total volume is not impressive on a global scale. Just as remarkable and meaningful is where exactly this water is actually found on the planet. Just a handful of Earth's largest lakes hold a disproportionate amount of global freshwater. Lake Baikal, in Siberia, has 20 percent of the total, as do the five Laurentian Great Lakes

Figure 2. The university's 86' R/V Blue Heron is a critical piece of infrastructure, a floating field station, that provides scientific access to even the most remote parts of the Great Lakes. The Blue Heron is a Swiss Army knife of boats: it can be configured to perform a wide variety of scientific investigations. Image courtesy of the LLO.

(HOMES, or Huron, Ontario, Michigan, Erie, and Superior) together. These two lake systems thus hold four of every ten drops of liquid surface freshwater on Earth. Further, just five lakes (Baikal, Tanganyika, Superior, Malawi, and Vostok, in that order) hold more than half of this resource. Large lakes are significant reservoirs of freshwater. To sum up, we can't live without freshwater, there is a very limited supply, and it is very unevenly distributed on the planet. How valuable these reservoirs of freshwater, these large lakes of Earth, are! We clearly need to care for places that hold such huge percentages of one of society's most valuable resources. We care for them because future generations need us to. To do this, we need to understand how these lakes function, how they are changing, and how we can make use of them without jeopardizing them for future generations. And for that, we need a solid scientific foundation. That's where LLO comes in.

What is it like to work on large lakes? Some of the work at LLO takes place on the largest university-owned research vessel (R/V) in the Great Lakes, the *R/V Blue Heron*. The *Blue Heron*, owned by the university, is managed as part of the University National Oceanographic Laboratory System (UNOLS), and it is chartered by research scientists near and far to explore any of the Great Lakes. Built in 1985 for fishing on the Grand Banks, and closely resembling the *Andrea Gail* from the movie *The Perfect Storm*, the *Blue Heron* was purchased by the University of Minnesota in 1997, and converted into a limnological research vessel during the winter of 1997–98. The *Blue Heron* is outfitted with state-of-the-art instrumentation and is capable of up to three-week long expeditions to any of the Great Lakes when up to 11 scientists and crew eat, sleep, and work on board. She has supported work that has looked in detail at Lake Superior's bottom for clues about its past, work that has helped scientists better understand the cycling of carbon and nutrients in the Great Lakes, and helped government scientists keep an eye on the status of the fisheries.

See a three-minute video on the Blue Heron here.

LLO prides itself on its rich interdisciplinary atmosphere. Hardly any environmental investigation relies on a single academic subject. A physicist is needed to explain the currents and waves; understanding the water quality requires a chemist; and a biologist would find a lifetime of work studying the creatures big and small, from microscopic algae to fish. And understanding how the lakes evolve and respond to climate change is impossible without geologists and climate scientists. LLO brings all of these kinds of scientists together under one roof, serving as a long-standing, successful model of interdisciplinary scholarship. Its 12 faculty members all have roots in individual disciplines and teach in their respective departments, but they spend their research time at LLO. At LLO one can often see a biologist discussing science with a physicist, and both asking advice from a chemist. It is this interdisciplinary nature of the place that makes its science strong and relevant.

While the windows of LLO offer an impressive view of Lake Superior, the largest lake in the world and the headwaters of the Laurentian Great Lakes, the team often finds itself looking well beyond the region. LLO scientists have carried out major expeditions to the great lakes of the East African Rift Valley, Lake Baikal in Russia, Lake Nicaragua, Lake Issyk Kul in central Asia, Great Slave Lake in the Canadian Arctic, and many smaller lakes throughout the world. This global perspective, combined with an aptitude for carrying out large-scale oceanographic work, makes LLO unique among limnological research institutes in the world.

Today one may find LLO scientists and graduate students working on a dizzying array of tasks.

They operate autonomous underwater robots that are gliding for months on end in the depths of Lake Superior, study organisms under deep winter ice, trace different pollutants, and study the effects of invasive species. They investigate sediment cores that allow them to peek deep into the geologic history of lakes and the contemporary climate, and they look at some rare unusual modern lakes that may help unravel some mysteries in the Earth's ancient history. They also educate some of the next generation of scientists. Here are some of these stories, telling what LLO has learned by closely looking into the great eyes of Earth.

Figure 3. Children are always curious. Here, some LLO scientists working on Lake Malawi came to shore near a fishing market via a dinghy and attracted a crowd.
Photo credit: Sergei Katsev.

Peering into the Past

Earth's climate is changing. What that means for the future is still largely unknown, but knowledge of past climate helps us to understand ongoing and future climate change so we can better prepare and make effective plans to mitigate the social and economic impacts of a changing climate. Records from marine sediments and polar ice cores have yielded key information on global changes in climate. Lake sediments complement those records by providing sharper focus on local to regional histories that are directly relevant to places where people live. LLO researchers study sediments that have accumulated year after year on lake floors, faithfully recording chemical and biological signals of changing climate and environmental conditions. Unravelling the stories

Figure 4. Aerial view of the 160′ drilling barge Viphya on Lake Malawi, where 26 members of the drill team, science team, and ship's crew lived for six weeks. This fuel barge was converted to accommodate a 100 ton geotechnical drilling rig (capable of recovering sediment from >1 km below lake surface) and a dynamic positioning system to maintain the position of the drilling barge in waters too deep for anchoring. Photo credit: Isla Casteneda.

preserved in these archives provides knowledge of past climate change that forms a basis for evaluating impacts of ongoing and future climate change.

LLO research on paleoclimate archives has extended across the planet, with field programs on six continents. These range from coring operations using small inflatable rafts to major drilling operations taking advantage of technologies developed for the petroleum industry; from studies focused on sediments deposited over the past few thousand years to million-year long records; from drilling ancient lake beds now on land to recovering sediments from hundreds of meters of water depth. We highlight here two international collaborative projects where LLO scientists had leading roles, The Lake Malawi Drilling Project and MexiDrill: The Basin of Mexico Drilling Program.

The Lake Malawi Drilling Project collected sediments at 600m water depth to recover a continuous record of past climate in the continental tropics over the past ~1.3 million years. This region over this time tells us about the conditions where and when humans evolved. Major findings include evidence that over the past million years, climate in this part of eastern Africa, in contrast to northern Africa, shifted from arid conditions with high-frequency variability to generally wetter conditions with more prolonged wet and dry intervals. This finding has significant implication for understanding the evolution and migration of early hominids in east Africa that we are beginning sort out as we obtain records from other areas on the continent.

Mexico City (then called Tenochtitlán) was established by the Aztecs in the 1300s on an island in the center of a closed-basin lake system, which at that time was shallow, marshy, and relatively saline. These lakes, which had existed for some 350,000 years, have been heavily modified through lowering of the water table to improve flood control, accommodate agricultural expansion, and provide water for urban development, and only a small remnant remains in the agricultural lands at the southern outskirts of Mexico City. However, the underlying sediments contain a rich record of past climate conditions. In 2016, LLO scientists were part of an international team (Mexico, Spain, Germany, UK) that drilled and recovered a sedimentary record, which we are now analyzing with the goal of recovering a 350,000 year record of environmental change directly relevant to the 25 million inhabitants of Mexico City.

Witnessing the Present

Large lakes sometimes change fast. As an example, consider how the introduction of new species may change the whole character of a lake ecosystem. Over the past two centuries, more than 180 invasive species have become established in the Laurentian Great Lakes and their watershed. Of those, among the most recognizable and damaging are two species of closely related bivalved mollusks (relatives of clams): the zebra and quagga mussels, together known as dreissenid mussels. After being accidentally introduced into Lakes Erie and St. Clair in the 1980s, dreissenids spread throughout all five of the Great Lakes and to numerous other water bodies in the U.S. and Canada, including many dozens of lakes and rivers in Minnesota.

The establishment of zebra and quagga mussels led to many changes in the functioning of aquatic systems and their ability to provide essential ecosystem services. As filter feeders, dreissenids can increase water clarity, stimulating growth of benthic (bottom-dwelling) plants and competing with zooplankton and the fish that rely on

Figure 5. Explosively growing dreissenid mussels have greatly altered lake environments. Here, a cluster of zebra mussels has encrusted a native, larger clam. Dreissenids affect lake environments in a variety of ways but those pathways are still being actively investigated. Photo credit: Ted Ozersky.

the zooplankton for food. These changes can result in modification of the food webs and fish communities of invaded systems. Dreissenids can also overgrow native mussels, leading to their localized extinction and to other changes in the diversity and abundance of benthic animals. Dreissenids attach not only to other mussels, but to artificial structures as well, including water intake pipes, boats, and buoys, leading to clean-up costs in the millions of dollars annually.

We know these invasive mussels have dramatically changed some large lakes, but we still don't understand well how they have done this. One aspect of zebra and quagga mussel impacts that is not well understood is the effect their establishment has on nutrient dynamics in invaded systems—that is, the cycling and distribution of phosphorus and nitrogen, elements that control the biological productivity of lakes and rivers. Changes to nutrient dynamics can lead to undesirable consequences such as excessive algal blooms, proliferation of toxin-producing cyanobacteria, or changes to the productivity of food webs, including abundances of commercially and recreationally important fish species. Researchers at LLO are conducting studies to better understand and predict the effects of invasive mussels on nutrient dynamics in both inland Minnesota lakes and in the Laurentian Great Lakes.

In the summers of 2014 and 2015, scientists from LLO sampled 10 dreissenid-invaded lakes throughout Minnesota, characterizing the distribution and biomass of mussels and making measurements on the turnover and storage of nutrients by the mussels. This was the most comprehensive study of the impacts of dreissenids on nutrient dynamics in lakes to date, and showed that invasive mussels can redirect large amounts of nutrients from the water to the bottom of lakes. Some of these nutrients become locked up in the soft tissues and shells of mussels, while another portion is returned to the water in dissolved form through metabolic excretion activity of the mussels. It appears that although dreissenids may be able to slightly alleviate the effects of excessive nutrient loading in some lakes by storing nutrients in their tissues, in unproductive lakes they may further reduce productivity and starve other organisms. This work lies at the interface of biology and chemistry, or "biogeochemistry."

LLO researchers are scaling up what they learned from work on small Minnesota lakes and are starting a research project to characterize the effects of dreissenids on nutrients in the entire Great Lakes ecosystem. Over the next three years, LLO researchers and students will sail aboard the *Blue Heron* and other research vessels to Lakes Superior, Michigan, Huron, and Erie; they will use a combination of field sampling, lab experiments, and mathematical models to study the effects of invasive mussels on the Great Lakes. These studies will help uncover the causes behind some poorly understood recent changes to the water chemistry of the Great Lakes and will enable researchers and ecosystem managers to better predict how the Great Lakes will respond to future changes in the abundances of dreissenid mussels, the loading of nutrients from the watershed, and the interaction of these processes with other environmental changes happening in the system.

LLO scientists are always interested in discovering new things. In some cases this means studying something familiar in a new way. For example, the vast majority of lakes studies in seasonal environments have taken place in the ice-free season, especially in the summer. It is beginning to be recognized though that lakes remain active in the winter and we cannot understand what lakes do in the summer without understanding what they do in the winter. This means leaving the comfort of warm offices and venturing out on the ice. In other cases, new things are learned by applying brand new tools and techniques. An example of that is in unlocking the vast storehouse of information that is present in the genetic material in organisms in lakes. The majority of the genetic diversity found in lakes is in the

Figure 6. Scientists are discovering that lakes do not rest in the winter. Here, LLO faculty member Ted Ozersky is using a net to sample winter populations of zooplankton, small crustaceans (related to shrimp) that consume algae and in turn are consumed by fish.
Photo credit: Steve Kuchera, Duluth News Tribune.

microbial populations that we understand are key in nutrient cycles and which form critical links in aquatic food webs. Advanced genetic sequence techniques together with ever more powerful statistical tools are opening new windows into this biodiversity.

Other LLO studies of lakes as they exist today concern lake physics. The laws of physics govern the temperature and circulation of large lakes. In turn, these physical properties affect weather, fisheries, shipping, water quality, and coastal engineering. Physics "sets the table" for all other in-lake processes. Physical research at LLO spans a range of activities, from monitoring long-term trends and providing context for multidisciplinary projects, to investigating fundamental aspects of large-scale fluid dynamics.

Researchers at LLO provide a large amount of practical real-time data to the public and scientific community. As part of the Great Lakes Observing System, LLO maintains buoys in the western arm of Lake Superior that report air and water temperature, wind speed, and wave height. These measurements are not only viewed by anglers and hobbyists, but are also integrated into national weather forecast models. LLO also provides "nowcast" predictions of Lake Superior, using current weather data to estimate

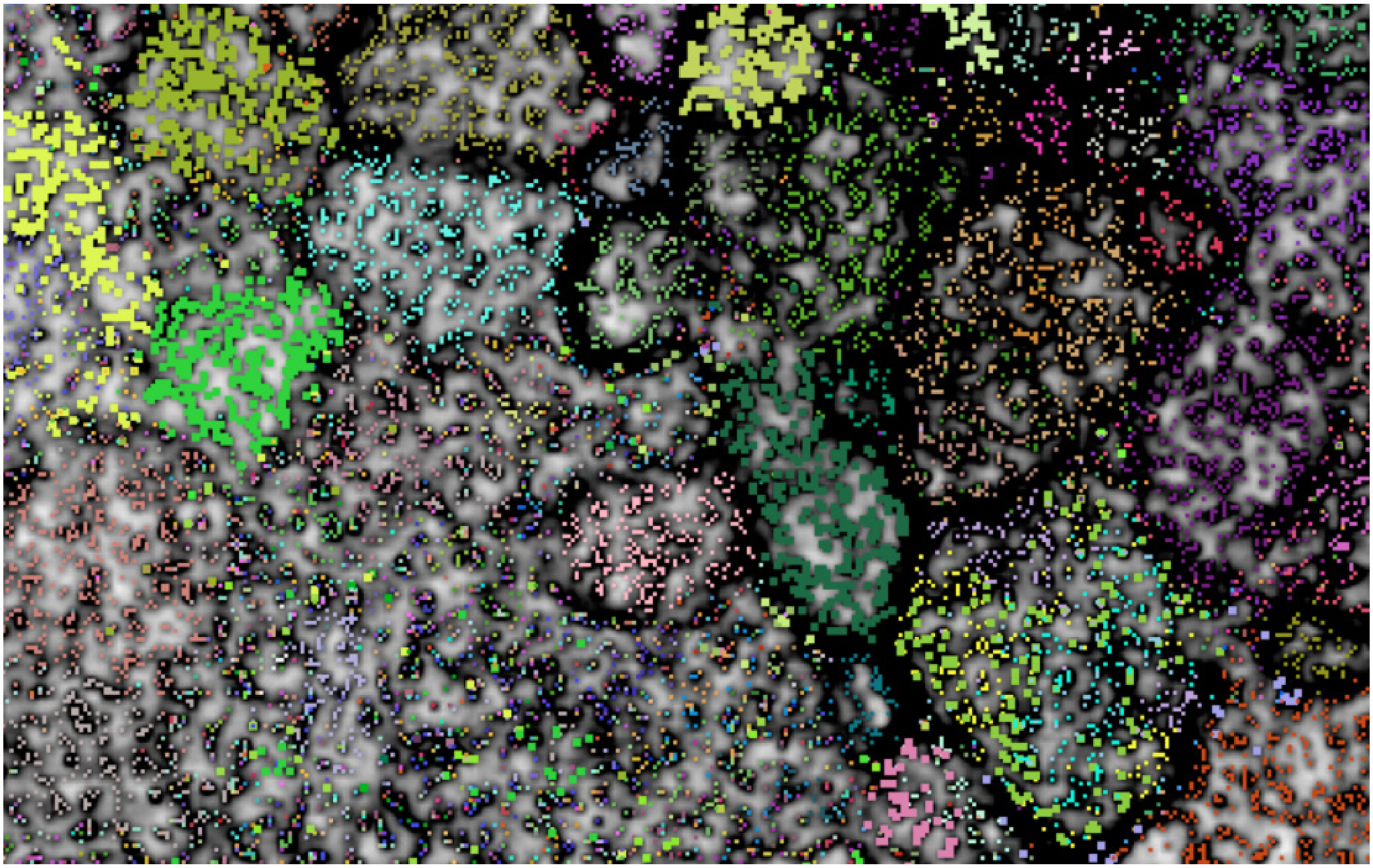

Figure 7. LLO scientists are using unique DNA fingerprints to discover new forms of biodiversity in large lakes. In this image, ESOM (Emergent Self Organizing Maps) shows the genetic relatedness of distinct microorganisms found in Lake Superior sediment using color and spatial position. Each point represents a DNA fragment which has been colored according to its taxonomy. Applying advanced genomic tools such as this can yield unique insight to cycling of elements like carbon and nitrogen in natural environments. Computer image by Cody Sheik.

the temperature, velocity, and water-level across Lake Superior.

Researchers are also collecting long-term records of Lake Superior. An array of sub-surface moorings have logged temperature and currents nearly continuously for the last 13 years. These moorings consist of a steel float 10 m below the surface (safe from ship propellers and the deepest projecting ice “keels”), which is tethered to an anchor by a steel rope. Instruments, which are attached to the rope every few meters, measure temperature and currents from top to bottom. These instruments can’t report real-time data because they are inaccessible, except when they are serviced once a year. However, over time these measurements have revealed subtle long-term warming trends and some surprising discoveries, such as an 11-m (36-ft) deep ice keel during the extremely cold winter of 2013–14.

For process-studies, which investigate specific aspects of fluid dynamics in detail, LLO researchers have also collected a diverse set of cutting-edge measurements from lakes around the world. These measurements have targeted processes, such as eddies tens of kilometers across, dye spreading, turbulence, and sound propagation. Most of the measurements were taken from research vessels, such as the *Blue Heron*, but others were collected using autonomous underwater vehicles, known as “gliders.” These gliders

Figure 8. One of LLO’s solar-powered buoys on a calm, sunny Lake Superior day, sending data concerning air and water conditions to shore. During the open water season, data from LLO's two buoys (LLO1 and LLO2) are available from http://d.umn.edu/buoys/. Photo credit: Jay Austin lab.

slowly move from the surface to the bottom and back again by increasing or decreasing their density. As they rise or fall, they glide horizontally toward programmed GPS coordinates. In a single deployment, these gliders can travel thousands of kilometers over the course of many weeks. These observational tools extend observable conditions greatly, providing data where and when direct human observation would be impractical or even impossible. Scientists have effectively developed "new eyes" in their pursuit of knowledge.

Looking to the Future: Preparing the Next Generation

At the Large Lakes Observatory, we combine our research mission with the education of graduate students and outreach to the local community. During scientific expeditions, generally half of the *R/V Blue Heron's* science party is made up of University of Minnesota Duluth undergraduate or graduate students, giving the students a full immersion in a field research experience. Along those lines, we at the LLO have embarked on a complete redesign of our graduate curriculum in order to better prepare our students for twenty-first century careers. Based on surveys of previous students and interviews with current employers, we defined some specific goals for our new curriculum. In order to succeed in their careers, they are required to have an interdisciplinary understanding of the field; an ability to work closely and converse with social scientists, policy makers, and the public; and an understanding of the professional skills required for their career. We have therefore redesigned our curriculum to include professional skills, field skills, and communication skills well integrated into the first-year graduate interdisciplinary scientific curriculum.

In the first half of this year, our students design a scientific project, carrying out a field campaign, sample analysis, data analysis, and writing up and presenting their results both individually and as a group at the end of the first semester. This allows the students to practice and implement designing a complete scientific project from start to finish, focusing on both the science they are most interested in carrying out and also working with other students in the course to design joint field campaigns and group papers. They must both complete a project from start to finish individually and also work to make sure they collaborate well with their colleagues.

Our students interact with local professional limnologists and environmental scientists in smaller venues throughout the year, and in a more in-depth way through an end-of-the-year Capstone project. This Capstone project is led by a local professional, either in a private consulting company or governmental lab. Previous organizations we have partnered with for the Capstone project include TetraTech consulting, LimnoTech consulting, and the Duluth Environmental Protection Agency laboratory. Through these Capstone relationships, student groups are given an authentic problem, work through a data set, and prepare and lead a presentation for industry professionals and interested stakeholders at the end of the project. They gain a professional network, meet potential employers, and practice important professional skills like project management, time management, and scientific communication. Our Capstone partner organizations have the opportunity to train potential new employees and have low-cost but educated students dedicated to their projects for

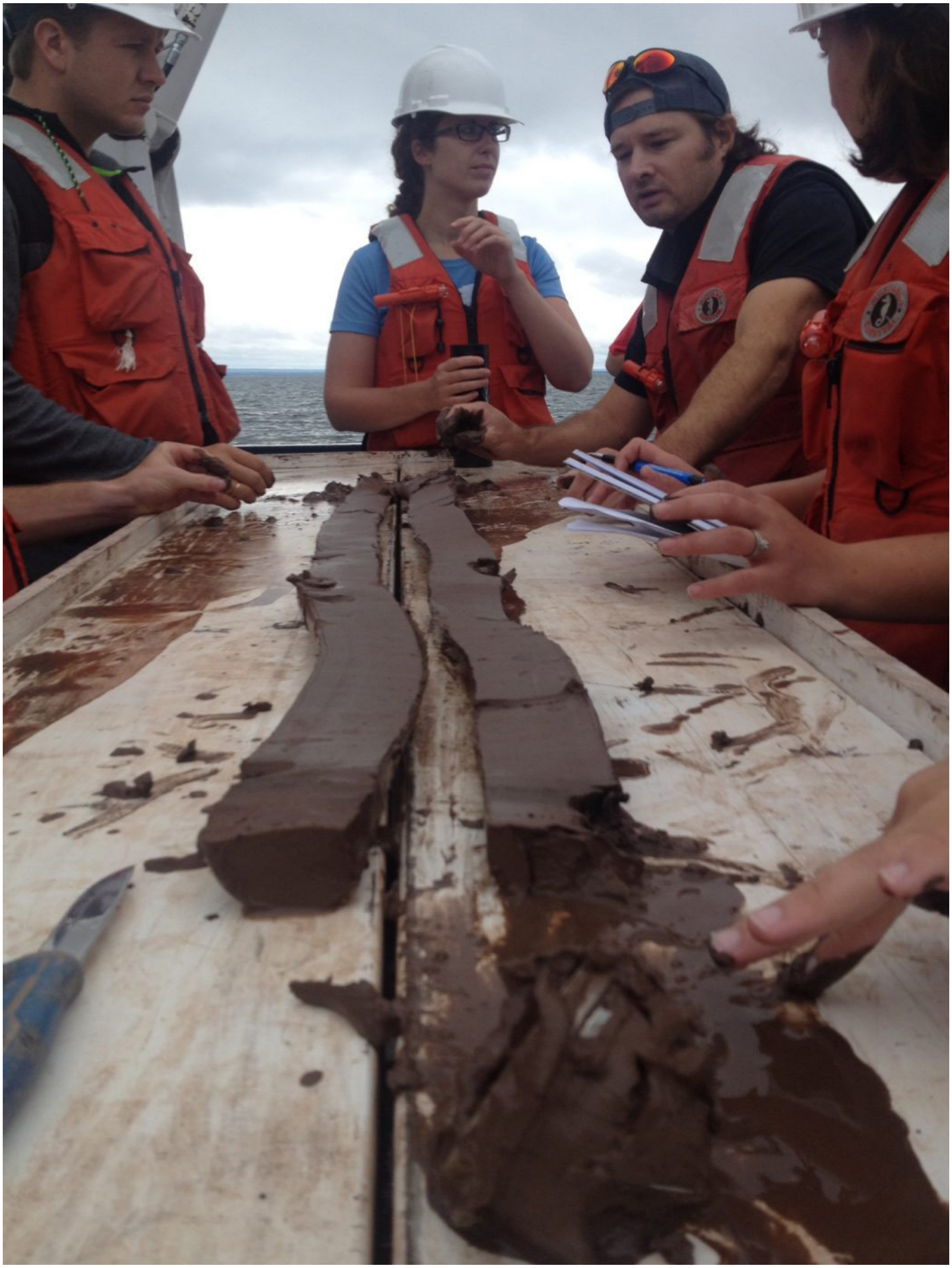

Figure 9. LLO professors and students gather around a sample of Lake Superior mud, which was collected using a coring device and then split into two halves. Lake sediments like this are a time machine, giving us insight into conditions well before scientific records began. Photo credit: Sergei Katsev.

weeks every year. Our group is always open and looking for new Capstone partners in the Duluth and Twin Cities area for our student projects, and our goal is to keep expanding our list of partner organizations.

Over the last four years, LLO has conducted a “Chief Scientist” training program where graduate students, postdoctoral fellows, and first-year faculty members from outside the University of Minnesota system have participated in a workshop and multi-day research expedition using the *R/V Blue Heron*. Thirty individuals have participated in this program, representing 20 institutions from across the country. The participants not only learned how to plan and execute their own research voyage but also were able to collect samples and data for their own work, learn more about the University of Minnesota and the Large Lakes Observatory, and experience how exciting work on the Great Lakes can be. This program helps bring Great Lakes science to the attention of future scholars from all over the country.

LLO is committed to insuring open channels of communication with the public. The scientists and staff of UMD’s Large Lakes Observatory have been diligently and enthusiastically organizing monthly events during the spring, summer, and fall since 2013. During each LLO Science on Deck event, the *R/V Blue Heron* ties up near the Great Lakes Aquarium and extends the gangway so the public can come aboard from noon to 4:00 p.m. Tours are provided by scientists, crew, and students for an overview of the *R/V Blue Heron’s* layout and research capabilities. A variety of scientists prepare and present results of large lakes studies under a canopy on deck at each event, as well. Each scientist will answer questions on a related topic and share photos, graphs,

Figure 10. What better place to learn about lakes than aboard a big boat? Here, a party hears about some of the Blue Heron’s scientific adventures while the boat is tied up in Duluth harbor at a Science on Deck event. Photo credit: UMD News Service.

equipment, and samples. During the upcoming summer (2018), the *Blue Heron* will stop in Milwaukee and Chicago for Science on Deck events, inviting the public there to visit the vessel and learn about the Great Lakes ecosystem.

Conclusion

LLO works hard to fill a large void in understanding. Though large lakes are important, fascinating, and valuable, our understanding of how they work is very incomplete. Indeed, basic research on the large lakes of the world lags behind its counterpart on the oceans. Our nation's freshwater inland seas, as well as those on others continents, are invaluable resources and are in need of major research initiatives. LLO frequently advocates for increasing attention on these huge "eyes" of Earth.

The research of the Large Lakes Observatory provides more than the wonder of discovery. It serves as the basis for assessing human impact on large-lake ecosystems, and for developing sound policy for protecting these invaluable bodies of freshwater as our global environment evolves.

Figure 11. LLO scientists sometimes find themselves hundreds of miles away from any other persons, with nothing but water as far as the eye can see. This is one of the many rewards of doing scientific research on Earth's largest freshwater bodies. Photo credit: Blue Heron crew.

Judgment can be recognized as a scientific tool. Much of the judgment, knowledge, and skill needed to make good decisions in science is learned through basic research, designed to help us fill in the white space of knowledge, to understand how separate pieces come together to make a functioning whole, and to assess how human actions alter the natural world around us. LLO undertakes with pride and dedication interdisciplinary studies that include biology, chemistry, physics, and geology in order to improve our understanding of these globally significant resources and provide society with knowledge needed to manage them sustainably for future generations.

For More Information:

LLO Social Media feeds:

- Instagram – LLOInstagram
- Twitter – @UMDLLO
- Facebook – UMDLLO, LLOScienceOnDeck

Further reading

Sterner, Robert, Steve Colman, and Thomas Johnson. "Institute profile: The large lakes observatory and the scientific study of the large lakes of earth." *Limnology and Oceanography Bulletin* 26, no. 1 (2017): 11-13.

Recommended Citation

Brown, Erik, Sergei Katsev, Sam Kelly, Ted Ozersky, Doug Ricketts, Kathryn Schreiner, Cody Sheik, Robert Sterner, and Lisa Sundberg. 2018. "Eyes on Large Lakes." *Open Rivers: Rethinking Water, Place & Community*, no. 10. http://editions.lib.umn.edu/openrivers/article/eyes-on-large-lakes/.

About the Authors

The authors are among the scientists and staff of the Large Lakes Observatory, University of Minnesota Duluth, and they have worked on small and large lakes in Africa, Asia, in the Arctic, as well as in our own backyard in the largest lake on Earth. You may meet some of them at a Science on Deck event, held some summer Fridays on Duluth's waterfront (see our Facebook page "LLO Science On Deck").