IAGLR
LAKES Letter

Listening to the lakes: A look at the emerging use of acoustic monitoring in large lakes.

CONTENTS

AN ADDITION TO THE LIMNOLOGISTS' TOOLKIT

Passive acoustic monitoring of freshwater ecosystems

by Toby Gifford, Leah Barclay, and Simon Linke

LAKES AND RIVERS ARE SURPRISINGLY NOISY under the surface, if you know how to listen. Human ears are not well adapted to hear underwater sounds unaided, but using a hydrophone (underwater microphone) reveals a rich soundscape in many freshwater environments. Numerous taxa emit myriad sounds, including many species of fish.

Environmental change in freshwater ecosystems can be difficult to track, yet freshwater species are three times more endangered than terrestrial species, so monitoring is important. Passive acoustic monitoring is an emerging approach that uses computer analysis of underwater audio recordings to mark changes in the composition and behavior of freshwater biota.

Passive acoustic monitoring addresses three problems with more traditional sampling methods:

- **Risks to fish health and habitat integrity.** Classic techniques like netting and electrofishing can cause injury or even death in fish. This is inappropriate for sensitive or threatened species.
- **Bias.** While all sampling methods are biased to varying degrees, a key source of bias is the act of sampling itself. It often causes fright responses of the target fish, making detection difficult.
- **Temporal variation.** Usually single survey events are used to estimate ecosystem health and monitor population. This can deliver only a snapshot of the population at a single sampling time.

Apart from mitigating sampling-induced risk of damage to species and ecosystems as well as certain sampling biases, acoustic monitoring can autonomously detect continuous environmental change in an ecosystem. This is a significant improvement on classic sampling techniques, which frequently employ only annual or quarterly sampling.

Freshwater acoustic recordings also provide a powerful tool for community engagement with river and lake health, and an accessible platform for public participation in science. Soundscape recordings provide a conduit to an otherwise obscure world that can help create meaningful emotional connections for people with these environments, and the steadily increasing affordability of underwater recording equipment is seeing an explosion in community-based monitoring.

For more on this topic, see the authors' "Freshwater Ecoacoustics—A New Addition to the Limnologists' Methods Toolkit" (2022).

Toby Gifford and Leah Barclay are lecturers in design at the University of the Sunshine Coast, Australia. Simon Linke is a senior research fellow with the Australian Rivers Institute, Griffith University, Australia.

A NOTE FROM THE EXECUTIVE DIRECTOR

These last few months kept the entire IAGLR team busy as we had to relearn the making of our annual conference, with the first in-person event organized since 2019. The 2023 conference would not have been possible without the support of many people volunteering with the program, the local logistics, the student judging process (for over 300 students!) and the numerous sponsors. It also would not have been possible without your participation. It felt great welcoming close to 700 participants and hearing that being at the conference was like being back home within the Great Lakes community. This resonated strongly with the participants of the Indigenous symposium—the most attended session of the week.

With the conference behind us, working on key strategic initiatives will be our main focus. This includes releasing our annual report, launching the new membership portal, and revising our strategic plan to include outcomes for each of the IAGLR values. We were also invited by elected officials to develop a brief about Great Lakes science priorities. This will be an opportunity for IAGLR to contribute to knowledge sharing with decision makers.

I invite you to read this new issue of Lakes Letter and enjoy the stories and learn about diverse topics on the Great Lakes. Please join me in welcoming our new members, our newly elected board members and your new president!

In the Great Lakes Spirit,

Jérôme Marty

IAGLR 2024: Save the date

The 67th Annual Conference on Great Lakes Research will be held May 20–24, 2024, in Windsor, Ontario. This marks the fifth time we've held the conference in Windsor, most recently in 2006.

"We are thrilled to be hosting IAGLR 2024 in Windsor, *where Canada begins*," says Mike McKay, director of the University of Windsor's Great Lakes Institute for Environmental Research

Centrally located within the basin, Windsor offers a unique opportunity for both the science and local communities to share about the health of the Great Lakes. The conference will take advantage of this opportunity through the theme *Shared Lakes: One Water, One Health.*

"*Safeguarding Healthy Great Lakes* and *Building Healthy Communities* are strategic pillars that have guided scholarship at the University of Windsor for decades. The COVID-19 pandemic disrupted lives and derailed the economy, yet it also brought opportunity by reinforcing the interconnectedness of these pillars," notes McKay. "The conference theme highlights the important intersections between environmental and public health in the context of large lakes, often shared across borders, and the communities impacted by them."

IAGLR is looking forward to working with the local site team to bring you a great conference next year. Save the date—we hope to see you there. Look for the Call for Sessions in a few months!

JGLR call for papers on Lake Superior

You're invited to submit a paper for a special section of the *Journal of Great Lakes Researc*h titled "Lake Superior: Current conditions, trends, and emerging threats." This issue will feature a wide range of research, capturing the status of Lake Superior and providing insight to current and future stressors. Further, this issue will include results from the 2021 Lake Superior Cooperative Science and Monitoring Initiative field season and other collaborative efforts to better understand and protect Lake Superior. Submissions will be accepted July 1, 2023–January 30, 2024. View the Call for Papers for details.

Congratulations IAGLR award and scholarship winners

Hazem Abdelhady (Purdue University) received the **2023 IAGLR Scholarship** for research on "Great Lakes shoreline changes in response to rapid water level fluctuation."

Andrew Bramburger (Environment and Climate Change Canada) received the **IAGLR Board of Directors Appreciate Award** upon completion of his term of service.

Mary Ginnebaugh (retired, Wisconsin Department of Natural Resources) received the **IAGLR Committee Chair Appreciation Award** for concluding her service as Conference Committee co-chair and Financial Strategy Committee chair.

Craig Hebert (Environment and Climate Change Canada) received the ***Journal of Great Lakes Research* Outgoing Associate Editor's Appreciation Award**.

Calvin Hitch (Toronto and Region Conservation Authority) received the **IAGLR Conference Appreciation Award** for his service as IAGLR 2023 Conference Site Chair.

Sabrina Jaffe (University of Toledo) received the 2023 **David M. Dolan Scholarship** for research on "Application of Bayesian hierarchical models in grass carp and harmful algal bloom management."

Nicholas Johnson (Great Lakes Science Center Hammond Bay Biological Station) received the ***Journal of Great Lakes Research* Outgoing Associate Editor's Appreciation Award**.

Tim Johnson (Ontario MNRF, Glenora Fisheries Station) received the **IAGLR Conference Appreciation Award** for his outstanding service as IAGLR 2023 Program Chair.

Alexander Koeberle (Cornell University) received a 2023 **Norman S. Baldwin Fishery Science Scholarship** for research on "Modeling native fish restoration in the Great Lakes basin via a unique inland lake."

Patricia Chow-Fraser (McMaster University) celebrates receiving the **IAGLR Lifetime Achievement Award at the annual conference earlier this month** with her husband, Noel Fraser, (in back), friends, and former students. Chow-Fraser is a leading coastal wetlands scientist noted for her influential research, innovative uses of technology, and mentorship of the next generation of Great Lake scientists. As the 18th recipient of IAGLR's Lifetime Achievement Award, Chow-Fraser is the first woman to receive it. She is a long-time member and former president of IAGLR. For more about Chow-Fraser and her impact, please read the news release. What an inspiration!

Scott Koenigbauer (Purdue University) received a 2023 **Norman S. Baldwin Fishery Science Scholarship** for research on "Surveying spawning utilization of a restored reef in Saginaw Bay, Lake Huron."

Yuli Liu (Nanjing University of Information Science and Technology, Nanjing, China, and University of Wisconsin-Madison) received the **Elsevier Student Author Award** for the article "Rip currents near coastal structures in Lake Michigan: Characterization and assessment for warnings," *Journal of Great Lakes Research* 48(3), 1645-658. This award recognizes a student scientist who is first author on a top-ranked article in the journal. Co-authored with Chin Wu.

Gabriella Lükő (Budapest University of Technology and Economics) received IAGLR's 2023 **International Travel Award** for the presentation titled "Comprehensive analysis of model parameters and wind forcing for simulating hydrodynamics of a large shallow lake" at this year's Conference on Great Lakes Research.

Noribeth Mariscal (Wayne State University) received IAGLR's inaugural **IDEA+ Presenter Scholarship** for the presentation titled "Evaluation of Model Simulated Ozone and its Precursors Using High-Resolution Model Simulations during the Michigan-Ontario Ozone Source Experiment (MOOSE)" at this year's Conference on Great Lakes Research.

Carol Waldmann Rosenbaum (Michigan State University) received IAGLR's inaugural **IDEA+ Research Scholarship** for the presentation titled "*Dolichospermum* in the Great Lakes: a comparison of trait and genetic diversity across Lakes" at this year's Conference on Great Lakes Research.

Awards continued

Staff from the **River Institute** (above), led by Executive Director **Jeff Ridal**, accept the **John R. (Jack) Vallentyne Award** from former IAGLR President Paul Sibley (right). The award recognizes the institute's valuable education and outreach efforts that engage and excite researchers, communities, and educators about many aspects of the St. Lawrence River and the Great Lakes. Located in Cornwall, Ontario, the institute was established as a unique community partnership among governments, educators, business and industry, and the Mohawks of Akwesasne. It is the first time the Vallentyne Award has gone to an organization rather than an individual.

Jason Stockwell (University of Vermont) received the *Journal of Great Lakes Research* **Outgoing Associate Editor's Appreciation Award.**

Joshua Tellier (Michigan Department of Environment, Great Lakes, and Energy) received the **Elsevier Early Career Scientist Award** for the article "Widespread prevalence of hypoxia and the classification of hypoxic conditions in the Laurentian Great Lakes," *Journal of Great Lakes Research* 48 (1):13-23. Co-authors include Nicholas Kalejs, Benjamin Leonhardt, David Cannon, Tomas Hook, and Paris Collingsworth.

Anett Trebitz (U.S. EPA Duluth) received the **Best Associate Editor 2022 Award** for outstanding support of the review process for the *Journal of Great Lakes Research*.

Paul van Zwieten (Wageningen University, the Netherlands) received the **Best Reviewer 2022 Award** for outstanding support of the review process for the *Journal of Great Lakes Research*.

Edward Verhamme (LimnoTech, above right) received the **Anderson-Everett Award** in recognition of his service to IAGLR. Verhamme is a recent past president and navigated IAGLR through a challenging move to virtual conferences during the pandemic. He's been a voice of support for the association's diversity initiatives and a leader in creating IAGLR's new executive director position. This award recognizes important and continued contributions to the association over a period of years and honors the efforts of David Anderson and Margaret Everett for their significant early contributions to the association and the Great Lakes.

Cody Sheik, Kaela Natwora, Elizabeth Alexson, Jake Callaghan, Austin Sailer, Kathryn Schreiner, Byron Steinman, Matthew Finkenbinder, Christopher Filstrup, and **Andrew Bramburger** received the **Chandler-Misener Award** for their paper "*Dolichospermum* blooms in Lake Superior: DNA-based approach provides insight to the past, present and future of blooms," published in the *Journal of Great Lakes Research* 48(5):1191-1205 (2022).

Meet the new members and leadership of the IAGLR Board

Welcome new members and leadership to the IAGLR Board of Directors! Newly elected members include Suzanne Gray and Sabina Rakhimbekova. Alex Duncan was reelected to a second term. The new presidential lineup includes Neil Rooney (president), Donna Kashian (vice president), and Jean Adams (past president). In addition, IAGLR members approved a bylaws change for the IAGLR executive director, Jérôme Marty, to serve on the board as an *ex officio* non-voting member. Thanks to all for your commitment and service to IAGLR and large lake science!

Suzanne Gray
The Ohio State University
U.S. Regular Member

Sabina Rakhimbekova
University of Western Ontario
Canadian Regular Member

Alex Duncan
University of British Columbia
Canadian Student Member

Neil Rooney
University of Guelph
Board President

Donna Kashian
Wayne State University
Board Vice President

Jean Adams
USGS, retired
Board Past President

Jérôme Marty
IAGLR Executive Director
Ex officio, non-voting member

IAGLR 2023 TORONTO

Adapting to Climate Change

Recordings available

If you missed a session or want to rewatch one, make sure to visit the Meeting App. Recordings are now available for registrants. Check out the Virtual Access Instructions if you need help logging in. The following recordings are freely available for all to view from the Meeting App's Public Webinars page: all three plenaries, the Valuing Indigenous Ways of Knowing, Being, Doing, and Connecting in an Era of Climate Change, Crisis, and Uncertainty session and the Science Strategy Town Hall. If you haven't had a chance yet, you're invited to fill out the science strategy survey mentioned during the town hall.

Conference survey

If you participated in IAGLR 2023, please keep an eye out for an invitation to share your feedback. We sent a link for a conference survey to the emails used for registration on Friday, May 19. Reminders will go out to folks who haven't yet filled it out by the **May 31 deadline.**

Conference highlights

We had a fantastic time seeing everyone in Toronto earlier this month for the 66th Annual Conference on Great Lakes Research—our first in-person conference since 2019. More than 750 people registered for either in-person or virtual attendance to enjoy 600+ presentations and three plenaries.

Updating a toast

From left to right, IAGLR board members Alex Duncan, Neil Rooney (president), Alfred Achieng, and Jean Adams (past president) make a toast at the awards dinner.

In a break with tradition, board members toasted not only Canadian and U.S. leadership, but Indigenous and African leaders as well. Following toasts from Jean Adams to the U.S. president and Neil Rooney to the Canadian prime minister, Alfred Achieng (international board member) raised a glass to the presidents of the 54 countries of Africa, and Alex Duncan (Canadian student board member) toasted the chiefs who preside over the many First Nations and Tribal communities across the Great Lakes, and the Anishinaabekweg, the Indigenous women who bear the sacred responsibility to care for and protect our waters.

Participants in the session titled Valuing Indigenous Ways of Knowing, Being, Doing, and Connecting in an Era of Climate Change, Crisis, and Uncertainty

Bridging knowledge systems

More than 130 in-person and virtual particpants enjoyed an all-day discussion on embracing Indidgenous knowledge systems in efforts to understand and care for large lakes. Presenters shared their experiences from the Great Lakes-St. Lawrence basin, Africa, Alaska, and Lake Nipigon. Thanks to the Great Lakes Fishery Commission and the Great Lakes Indian Fish & Wildlife Commission for supporting Indigenous participation at the conference.

Many thanks to photographer Stephany Hildebrand for providing the photos on this and the following page.


Strategy Development
IAGLR
Conference on
Great Lakes Research

MEMBER PROFILE

Emilie DeRochie

River Strategy Coordinator, River Institute & M.Ed. Student, Lakehead University

About my work

Currently, I am an educator and the coordinator for the St. Lawrence River Strategy. For the River Strategy, I work closely with colleagues at the Mohawk Council of Akwesasne and groups along the Upper St. Lawrence River to develop a framework for inclusive and equitable communication and collaboration on shared goals related to the river. As an educator, I teach Biology for St. Lawrence College's Environmental Technician program and develop education materials for the Great River Rapport. I am also currently an M.Ed. student at Lakehead University in Environmental and Sustainability Education.

Inspiration for this work

I was inspired to enter this type of work because I grew up on the St. Lawrence River and I have always loved river. During my undergraduate degree, I also worked at the River Institute in the summers where I supported the education team and Ph.D. Candidate (UQAM) Cristina Charette's fieldwork. Through these experiences I became passionate about environmental education and freshwater ecology.

Something else about myself

Outside of work and school, I love to spend time on the water and in wetlands collecting and pressing plants. I particularly enjoy the challenge of pressing macrophytes!

Why I joined IAGLR

I joined IAGLR to stay up to date on the latest research and news pertaining to the Great Lakes-St. Lawrence River Basin and to expand my network.

MEMBER PROFILE

Ali Reza Shahvaran

M.Sc. Student, Earth Science (Water), University of Waterloo

About my work

My research focuses on modeling and monitoring algal blooms using remote sensing data for western Lake Ontario, including satellite and drone imagery. I develop remote sensing-derived Chlorophyll-a (Chl-a) models by training them with in-situ matchups. Chl-a, a green pigment in phytoplankton, is the most common parameter for detecting eutrophication in aquatic remote sensing. After training the models and preprocessing the images, I generate Chl-a concentration maps that aid in understanding algal bloom patterns. The outcomes of my research help characterize the spatial and temporal dynamics of algal blooms in the western basin of Lake Ontario over the last 20 years, informing decision-making and nutrient management plans, especially in the Greater Toronto Area.

Inspiration for this work

The awe-inspiring beauty of Earth, as seen from space, has always been a source of motivation for me. Transforming raw images of our planet into meaningful information for environmental stewardship is a rewarding and fascinating experience.

Something else about myself

In my free time, I appreciate cinema as an art form, enjoy reading fantasy novels, and aspire to explore acrylic painting when time permits.

Why I joined IAGLR

Joining IAGLR as an early-career researcher with a background in environmental engineering offers me an ideal scientific community

for networking and learning. IAGLR presents opportunities to present my research at annual international conferences, publish my work in the *Journal of Great Lakes Research*, and collaborate with like-minded researchers on projects contributing to the sustainable management of the Great Lakes ecosystem.

Welcome New Members

The following members joined the association between February and April 2023. We're glad you're here!

Laya Ahmadi
Razegheh Akhbarizadeh
Quinn Allamby
Zane Almquist
Karen Alofs
Dana Arends
Paige Arieno
Mahatub Khan Badhon
Adellia Baker
Vanessa Baker
Anna Barnard
Aman Basu
Evan Batte
Karen Baumann
Sam Beck-Andersen
Timothy Becker
Jordanna Bergman
Hannah Blair
Valerie Blakely
Emma Bloomfield
Georgia Bock
Jose Bonilla-Gomez
Britney Bourdages
Mary-Claire Buell
Cal Buelo
Lu Buller
Stuart Carlton
Jake Carman
Megan Casler
Yu-Ting Chen
Keoni Chong
Jeanne Coffin-Schmitt
Travis Cole
Greg Crawford
Sophie Crevecoeur
Alex Curwin
Prasad Daggupati
Lindsay Day
Mikela Dean
Michele Dell'Aquila
Emilie DeRochie
Yvonne Drebert
Zhongzhao Duan
Hilary Dugan
Kianna Durston
Peri Dworatzek
Michael Edwards
Elvita Eglite
Mona Farhani
Alex Fields
Hugo Flavio
Shane Flinn
Brenna Friday
Karl Friesen-Hughes
Meagan Froeba
Nicole Fuller
Katherine Gaudreau
Natalie Gervasi
Don Goodyear
Luc Goulet
Megan Gunn
Joshua Habib
Charlotte Hagelstam-Renshaw
Lauren Halliwell
Julia Harig
Claire Harvey
Eden Hataley
Karina Heim
Taylor Herne
Jade Hill
Tim Hollinger
Madison Holm
Kaitlyn Horton
Jacob Hosen
Xiuli Hou
Kelly Hoyer
Ryan Hutchins
Abby Hutson
Emily Johnson
Ashley Jones
Maria Jordao
Naomie Kayitesi
Elizabeth Kazmierczak
Ben Keen
Nusrat Khan
Karen Kidd
Sandra Klemet-N'Guessan
Carolina Koebel
Jennifer Korosi
Christopher Kotalik
Alicia Krause
Jayson Kucharek
Harris Kuemmerle
Robert Ladwig
Nicole Latulippe
Sarah Lavoie-Bernstein
Sarah Lawhun
Lauren Lawson
Timothy Lewis
Jingjing Li
Nell Libera
Juliana Lisuk
Jinliang Liu
Aislin Livingstone
Michael Lowe
Al Lu
Yifan Luo
Kelly McCabe
Lauren McElroy
Luke McGill
Meghan McLeod
Rachel McNamee
Laura McNeill
Zach Melnick
Andrew Miller
Kristie Mitchell
Dejana Mitrovic
Garrett Moots
Spencer Myers
Miye Nakashima
Vivian Nguyen
Elizabeth Nyboer
Olivia Nyffeler
Brooke Odstrchel
Erick Ogello
Alex Okolocha
Jason Olsthoorn
Evance Pakuwal
Alison Palmer
Catherine Paquette
Gabrielle Parent-Doliner
April Patterson
Paige Penningroth
Brittany Perrotta
Fritz Petersen
Alycia Peterson
Sarah Peterson
Sally Petrella
Nhu Pham
Rhiannon Pinkerton
Basia (Barbara) Pioro
Lindsay Platt
James Polidori
Hannah Postma
Logan Potter
Cameron Proctor
Ryan Prosser
Samira Rifat Prova
Maria Ramirez
Kaitlyn Read
Jessica Reid
Emily Robson
Madison Rodman
Connor Roessler
David Rose
James Roy
Mica Rumbach
Gianna Saarenvirta
Monika Sadler
Ratnajit Saha
Halima Salah
Chelsea Salter
Paris Schofield
Bailey Schwenk
Ryan Scott
Ronald Semyalo
Ali Reza Shahvaran
Wei Shi
Rohit Shukla
Krystal Siebert
Stephanie Slowinski
Marisa Smedsrud
Claire Stevens
Elizabeth Striano
Pamela Strong
Madison Summers
Kayla Sunday
Laura Swatridge
Joshua Tellier
Sebastian Theis
John Thibeau
Bridget Thornburg
Sebestyen Torok
Lara Treemore-Spears
Yoji Uno
Joris Van Zeghbroeck
Jacqueline Vinden
Alexander Waldie
Barbara Wall
Gloria Wang
Lifei Wang
Jamie Ward
Colleen Wardlaw
Meredith Watson
Caroline Weidner
Olivia Williams
Jeff Wright
Jiankang Yang
Ysabelle Yrad
Hayden Zavareei
Barbara Zeeb

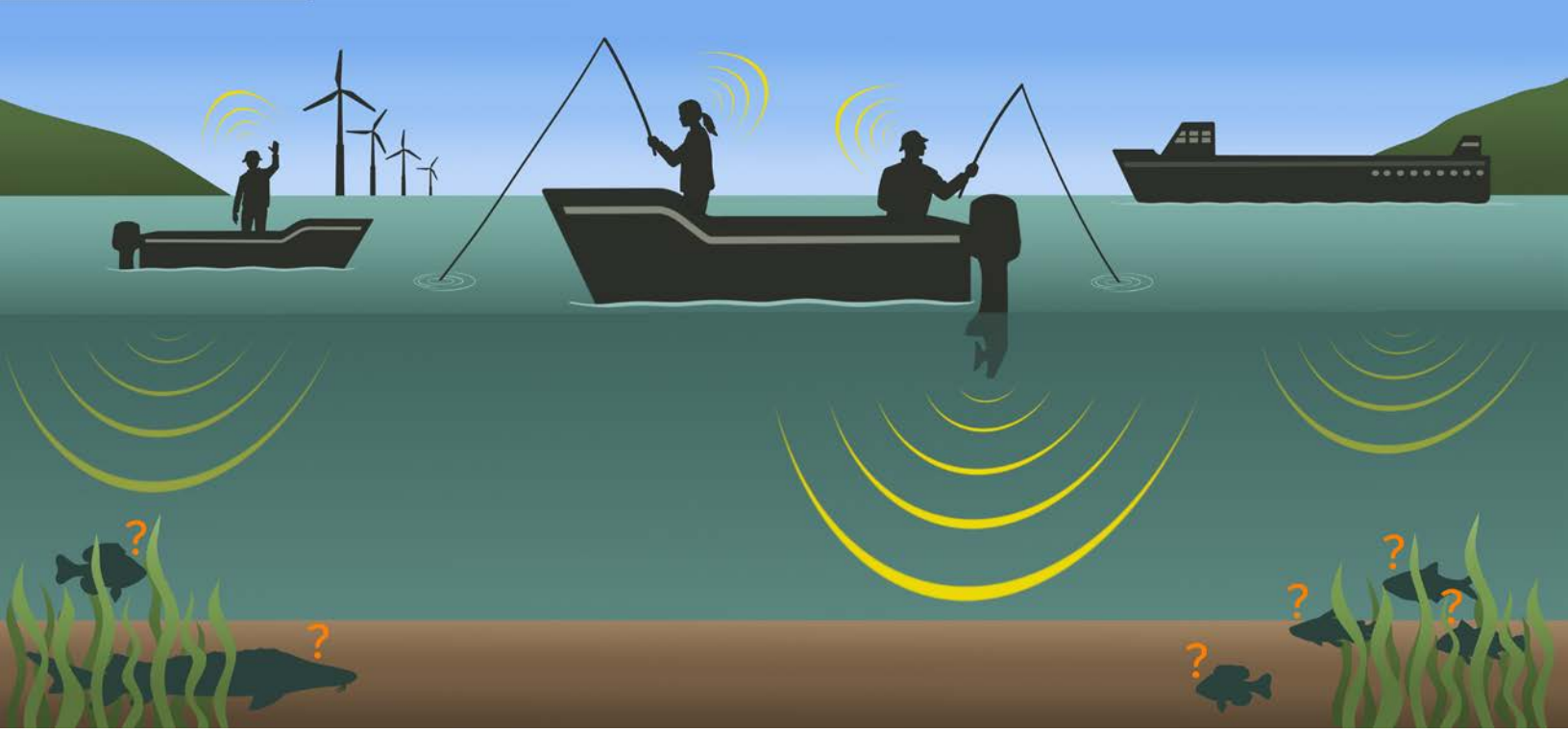
KUDOS

Congratulations to the following IAGLR members for their accomplishments!

DONNA KASHIAN (Wayne State University) for being named director of the of the new United Nations Regional Centre of Expertise on Education for Sustainable Development on behalf of Wayne State University. This new center is a joint designation via the UN to Wayne State and the University of Windsor for sustainable development in the Detroit-Windsor region.

JOHN LENTERS recently began a research scientist position with the University of Michigan Biological Station, where he will be managing the AmeriFlux tower at the field station, as well as remote sites that comprise the Great Lakes Evaporation Network.

MICHAEL TWISS (Algoma University) has been named professor emeritus for 20 years of service to Clarkson University.



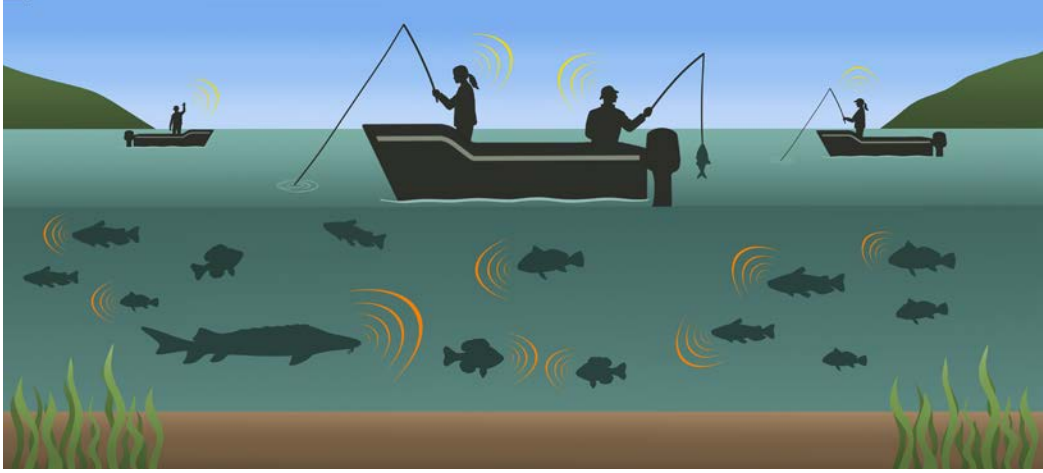
The Great Lakes are important waterways for a range of human activities — from boating to shipping and even commercial wind farms. These activities increase the levels of underwater sound that can negatively impact aquatic organisms. Illustration by Grace Dycha.

The environmental stressor you never *hear* about

by Rachel H. Pieniazek, Grace M. Dycha, Riley K. Beach, and Dennis M. Higgs

Speeding across Lake Erie in your treasured fishing boat, you and your friends have visions of landing your walleye limit in no time. Switching off the outboard motor and settling in, you observe many other boats looking for their lucky spots, appreciating that they stay a respectful distance so as not to foul your lines. You all sit quietly as you fish because you once heard that your voices could scare them off and don't want to risk it on this beautiful day. Although you enjoy the morning, the gang doesn't catch much and notices no one else has any luck either. You power up to head home and wonder why the catch seems to be lower on days with heavier boat traffic. Is it just the nature of fishing?

Now put yourself in the place of the fish. Awakening for your morning meal you listen for prey when a deafening roar sounds overhead as a monster seems to tear through the waves. Every time you relax again, and it's quiet enough to hunt, a new beast passes. You relentlessly swim back and forth to hide from the deafening giants above. This continuous noise and the subsequent stress means your heart races, you can't think straight, and you're still famished.



Reducing our inputs of underwater sound and establishing quiet zones of refuge may reduce fish stress and increase the overall health of the environment. Illustration by Grace Dycha.

The above scenarios are a common feature of our Great Lakes watershed and waters around the world. The Great Lakes face many challenges from human influences and many of these (e.g., increased nutrient runoff, invasive species, long-lasting chemical pollutants) have received a large amount of attention, policy scrutiny, and research dollars. While these threats are of course important, a lesser-known but growing concern is the intensifying levels of anthropogenic noise. Construction, resource exploration, and, more recently, offshore wind farms are some examples of noise-producing activities, but one of the most common sources of global underwater noise pollution comes from shipping vessels and recreational boats. In recent years, there have been calls for noise regulation in marine waters, since such pollutants have been shown to have great potential to harm ecosystems, but consideration for this problem in freshwater ecosystems remains minimal.

To understand the potential threat of these underwater noise sources to our freshwater fauna, it is useful to first think about how sound travels in water. Since water is much denser than air, sound can travel much further from the source, causing aquatic impact zones to be much larger than those in terrestrial environments. As commercial freighters navigate through deep channels, their engines and propellers produce low-frequency sounds that can be detected by fish up to a kilometre away. Recreational boats dart across shallower inlets emitting high-frequency sounds that can still be detected by fish at an appreciable distance. While you were happy to see other boaters avoid tangling your lines, their boat motor noise may have traveled beneath you without much dissipation. In contrast, your friends' voices likely bounced off the surface without reaching the fish's ears.

Wait, fish have ears? You don't see any external ears when you catch a fish, however all fish do have well-developed internal ears that can hear a broad range of sounds. Different fish species hear different frequency ranges, but all fish can hear lower frequencies like those dominant in boat noise. And some of our local species, like gizzard shad, even have hearing ranges that exceed our own. Many fish, including sturgeon, freshwater drum, sunfish, and catfish, produce sounds to attract mates, guard territories, and sometimes scare predators. Increases in background noises can mask these sounds, thus impacting the communication space of local species. Fish are constantly using their auditory system to detect vocalizations and movements from other organisms and assess environmental conditions. Added background noise from boats can conceal sensory information, interfere with sensory detection, and act as a general stressor. This can lead to fish having reduced communication spaces, interruptions in feeding, changes in swimming patterns, elevated stress hormones, and overall decreased fish presence, which may explain your unsuccessful fishing trip.

Shipping and boating will always be important activities in our Great Lakes watershed, but with careful management, it can be possible to mitigate their impacts. There are upwards of 20 underwater preserves or protected areas in the Great Lakes, but none of them have guidelines regarding underwater noise levels. As we move forward to develop policies, it is essential for Canadian and U.S. government agencies to properly assess the noise levels and impacts of both shipping and recreational boating in our waters. Well-defined regulations that reduce speed limits and prevent vessels from disturbing critical spawning habitats are just some ways this could be accomplished. In the meantime, next time you're out, look for quiet spots and reduce your speed on approach to maximize your chances of keeping hungry fish in the area.

"There are upwards of 20 underwater preserves or protected areas in the Great Lakes, but none of them have guidelines regarding underwater noise levels. As we move forward to develop policies, it is essential for Canadian and U.S. government agencies to properly assess the noise levels and impacts of both shipping and recreational boating in our waters."

Rachel H. Pieniazek, Grace M. Dycha, Riley K. Beach, & Dennis M. Higgs are all part of the Aquatic Sensory Ecology Lab ("Higgs Lab") at the University of Windsor.

Listening
to Great Lakes fishes

by Aaron N. Rice and Rebecca E. Cohen

Aaron Rice on the St. Lawrence listening for Lake Sturgeon.

WITH NEARLY 200 SPECIES inhabiting the Laurentian Great Lakes and their associated watersheds, fishes are vital to the ecology, economics, and recreation of the region. Additionally, changes in Great Lakes fish populations due to climate change, invasive species, and habitat impacts have made understanding their ecology more important than ever for ensuring sustainable and effective management. Increasing awareness of the importance of both hearing and acoustic communication for fishes opens opportunities to use underwater acoustic recording instruments for studying Great Lakes fishes. While underwater acoustics has been essential for studying whales and dolphins, the technology has only just begun to be applied for listening to fishes, and there are many emerging opportunities to use bioacoustics to gain a better understanding of behavior, ecology, population dynamics, and more.

Sound production in fishes has been known to science for centuries, but it wasn't until just after WWII that advances in underwater sound recording and analysis allowed for studying fish sounds. Since then, a few hundred fish species have been recorded and identified, but acoustic communication is likely far more widespread than is currently documented. Fish produce sounds in similar behavioral contexts as other vertebrates: finding mates and defending resources. Reproductive sounds are one of the best studied examples, where males call to attract females, whether individually or as part of a larger school. Territorial fishes use sounds to chase away possible intruders, and catfishes use sounds as a defensive tactic to scare predators. Fish sounds are relatively simple, particularly when compared to bird song or human speech, but still convey important behavioral information.

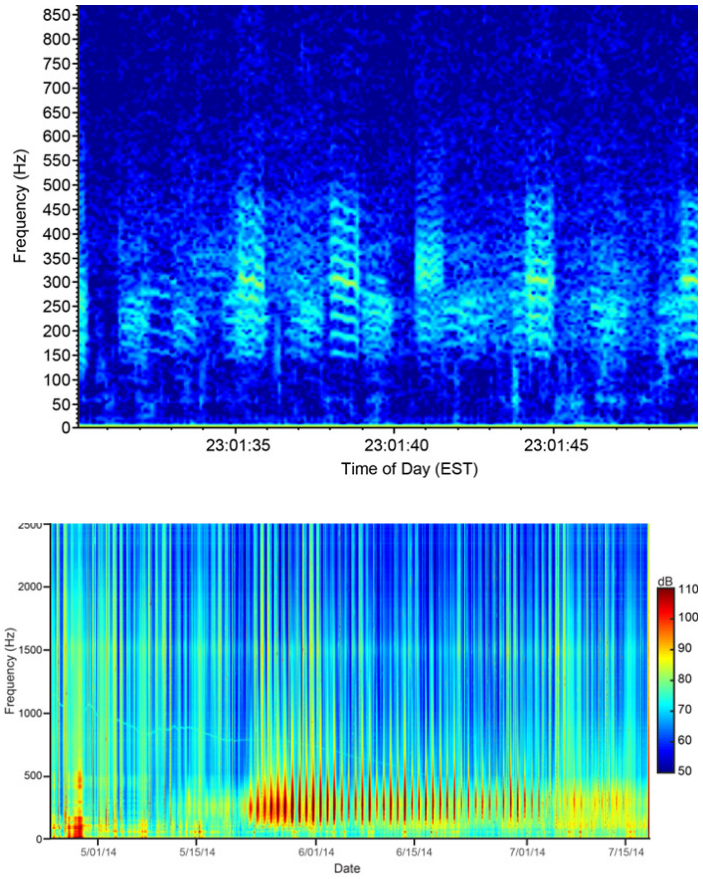
All fish have two inner ears in their head, and their best hearing is in lower frequency ranges (<1000 Hz). This range overlaps with the frequency range of most fish sounds, but also with noise from weather (e.g., wind, waves, and even rain) and passing ships. Vessel

traffic exposes many fish to noise pollution, increasing fish stress levels and making communication sounds more difficult for other fish to hear (a phenomenon known as "acoustic masking").

Based on a few species that have been studied, Great Lakes fishes produce a wide variety of sounds. Most fish calls can be classified into a few broad categories such as grunts, croaks, and pulsed calls, but the particular call characteristics are often species-specific. Freshwater drum produce low-frequency grunts and are most likely the loudest species in the Great Lakes. During their peak spawning periods, aggregations of males produce a loud chorus that can last for multiple hours every night (see figure). Lake sturgeon produce a very low-frequency "rumble," which can last up to several seconds. Round gobies and darters produce a series of pulses when males are calling to attract females for spawning. The ability to identify species by sounds enables studying many aspects of fish biology and ecology using acoustic data, either alone or in combination with other data types.

Bioacoustic studies typically involve deploying acoustic recorders at one or more study locations to capture the calls of a species of interest as they move through their habitats. The acoustic data can be used to investigate the spatial occurrence of a given species or the timing of various life history events, such as migration or spawning, which can be inferred from spatial and temporal patterns when detecting sounds of interest. By combining acoustic data with other fisheries survey methods such as visual observations, netting, and tagging efforts, we can start to understand the biology and behaviors underlying acoustic behaviors, spawning, characterize population structures, and even estimate stock sizes based on call rates. Once a baseline understanding of acoustic behavior and habitat use has been established, it becomes possible to quantify how environmental changes may alter species' distributions, population sizes, or behaviors strongly linked to particular conditions. There is also a need to better understand how anthropogenic sound pollution, such as vessel traffic noise, dredging and trenching activities, and resource extraction, affects these species' abilities to carry out their normal life histories. All of these varied insights are essential to the management of healthy populations and resilient ecosystems, and will better equip fisheries managers to design and implement effective conservation strategies.

Despite advances in studying fish sounds, one of the biggest challenges is that for most species, we still don't know which fish make which sounds (see Rountree et al. 2019). Even in intensively studied lakes, the overwhelming majority of biological sounds cannot be attributed to a particular species. This knowledge gap greatly limits the utility of using passive acoustics for studying freshwater fishes. However, with increasing availability of low-cost, consumer-grade hydrophones, there is



Spectrograms of freshwater drum calls recorded in Lake Erie (a spectrogram is a visualization of sound showing frequency versus time, and the louder sounds have warmer colors). Top: A closeup of several overlapping freshwater drum calls. Bottom: A seasonal depiction of freshwater drum nightly chorusing (red vertical bars seen between late May through mid-July), revealing that they are one of the louder sounds in the Lake Erie underwater soundscape (decibels [dB] are referenced to 1 µPa). These data were collected as part of a collaboration with the Ohio Department of Natural Resources.

an enormous opportunity for scientists, fishers, and the public to explore and help us understand Great Lakes underwater soundscapes, and enable continued use of underwater listening for monitoring important fish and habitats.

Aaron Rice is principal ecologist and Rebecca Cohen a postdoctoral research associate with the K. Lisa Yang Center for Conservation Bioacoustics, Cornell Lab of Ornithology, Cornell University.

Further Reading

Looby, A., K. Cox, S. Bravo, R. Rountree, F. Juanes, L. K. Reynolds, C. W. Martin. 2022. A quantitative inventory of global soniferous fish diversity. Reviews in Fish Biology and Fisheries 32:581-595.

Rice, A. N., S. C. Farina, A. J. Makowski, I. M. Kaatz, P. S. Lobel, W. E. Bemis, A. H. Bass. 2022. Evolutionary patterns in sound production across fishes. Ichthyology and Herpetology 110:1-12.

Rountree, R. A., M. Bolgan, F. Juanes. 2019. How can we understand freshwater soundscapes without fish sound descriptions? Fisheries 44:137-143.

Great Lakes science helps shape green energy revolution:

A case study of offshore wind in Lake Erie

by Ed Verhamme

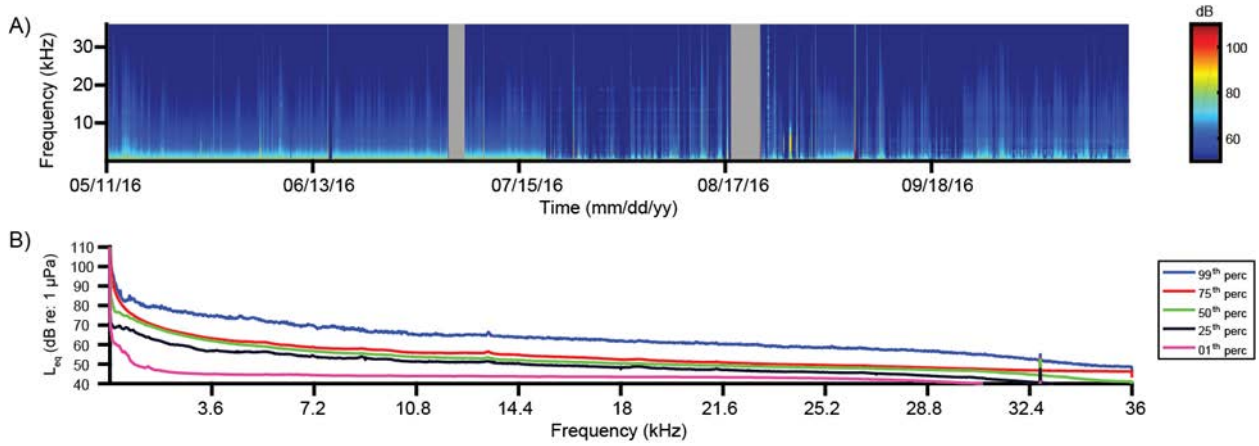
Within the last five years, many large electric utilities in the Great Lakes region have announced the closure and sunsetting of nearly every large coal-fired power plant. The repowering of our communities with renewable (and carbonless) energy presents a once-in-a-lifetime opportunity for Great Lakes scientists to weigh in on the various pros and cons of proposed projects and energy sources. Providing solid scientific research and evidence-based studies helps regulators, developers, and local community leaders make better decisions to minimize or eliminate potential impacts.

One such example is the evaluation of a demonstration offshore wind energy project near Cleveland, Ohio. Between 2017 and 2020, LimnoTech worked on behalf of a Cleveland-based nonprofit (LEEDCo) with funding from the U.S. Department of Energy to evaluate environmental impacts from the installation, operation, and removal of six wind turbines in the offshore waters of Lake Erie.

A portion of this monitoring included the deployment of passive audio/acoustic recording devices in the offshore waters of Lake Erie. This is one of the first uses of this technology in the offshore waters to understand the present "soundscape" and use it to evaluate potential impacts from future construction and operation activities of an offshore wind project. In addition to the microphones, the project site was also equipped with fish telemetry technology that can precisely map the presence and location of already tagged fish. The pairing of microphones and fish trackers allows for an unprecedented *in-situ* evaluation of construction and operation activities on freshwater fish. Other monitoring equipment deployed at the site measured currents, temperature, oxygen, and turbidity, which supports comparative and behaviorial analysis to describe current conditions and make comparisons after construction. This four-year pre-construction study offers a model for how future energy projects can collaborate across the often separate research, regulatory, and private sectors in the Great Lakes region while using cutting-edge technology.

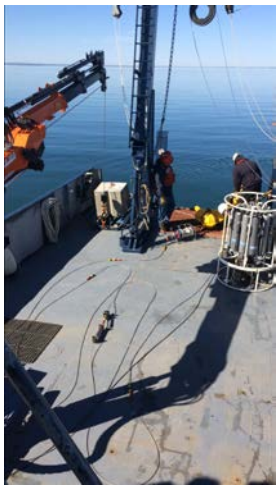
Deploying passive acoustic recording devices in Lake Erie. Photo courtesy of LimnoTech.

Ed Verhamme is a principal and senior engineer with LimnoTech and a former president of IAGLR.



The processed sound data shows that the offshore waters of Lake Erie are very quiet; however, there were some interesting recordings of the freshwater drum, which make "noise" during mating season. These chirps and spikes of sound are uniquely identifiable offshore. The data also revealed low frequency noise from nearby cities (e.g., Cleveland) and passing ships and the impact of the thermocline on isolating soundwaves. Figure A shows long-term spectral average and B shows statistical distribution of power spectra (in Leq) at ICE4 from May 11 through October 19, 2016, for the entire available frequency bandwidth of 0-36 kHz. Spectrogram was created with FFT=512 points and 1 hour integration time. Grey boxes show periods of time with missing data.

What can we hear in freshwater lakes?

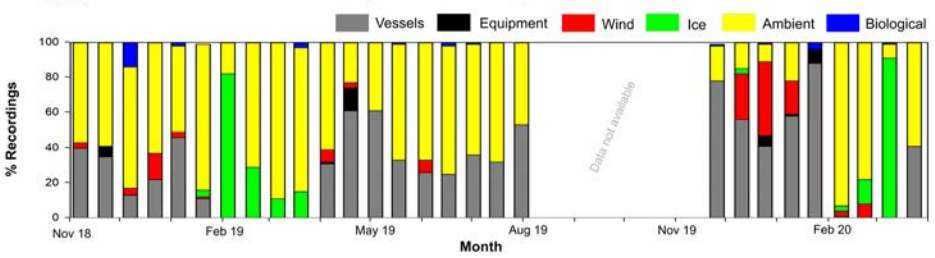


Underwater sound is used by aquatic animals to communicate, find prey, avoid predators, and navigate. Yet despite lakes and rivers being home to a diverse array of wildlife and a place for both recreational and commercial activities, little is known about the underwater soundscape of freshwater environments. To address this need, researchers at the University of Minnesota Duluth and the Large Lakes Observatory put an underwater microphone out in Lake Superior for 15 months (between November 2018 and March 2020) to explore the different sounds we can hear and compare seasonal trends (deployment pictured above).

Sound levels were much lower during the winter and spring months coinciding with ice cover and the annual closure of the nearby Twin Ports of Duluth and Superior. As shown in the figure, recordings also provided an insight into the diversity of sounds that are found in the freshwater soundscape with ice cracking, snow mobiles, ice augers and fish vocalisations identified in the winter. Whereas, in summer boat traffic dominated the soundscape, masking the detection of other sounds (Putland et al. 2022).

There is increasing concern about the effect of noise pollution from human activities on sound sensitive species and potential physiological and behavioural changes. Climate change is also expected to reduce ice cover and thickness potentially increasing the shipping season into the Twin Ports. Continued efforts to record baseline sound levels in freshwater environments and determining when, where and how often different animals are producing sound allows managers to prioritize acoustically sensitive times and areas and mitigate potential effects.

By Rosalyn Putland, Bioacoustician, Centre for Environment, Fisheries and Aquaculture Science, UK.

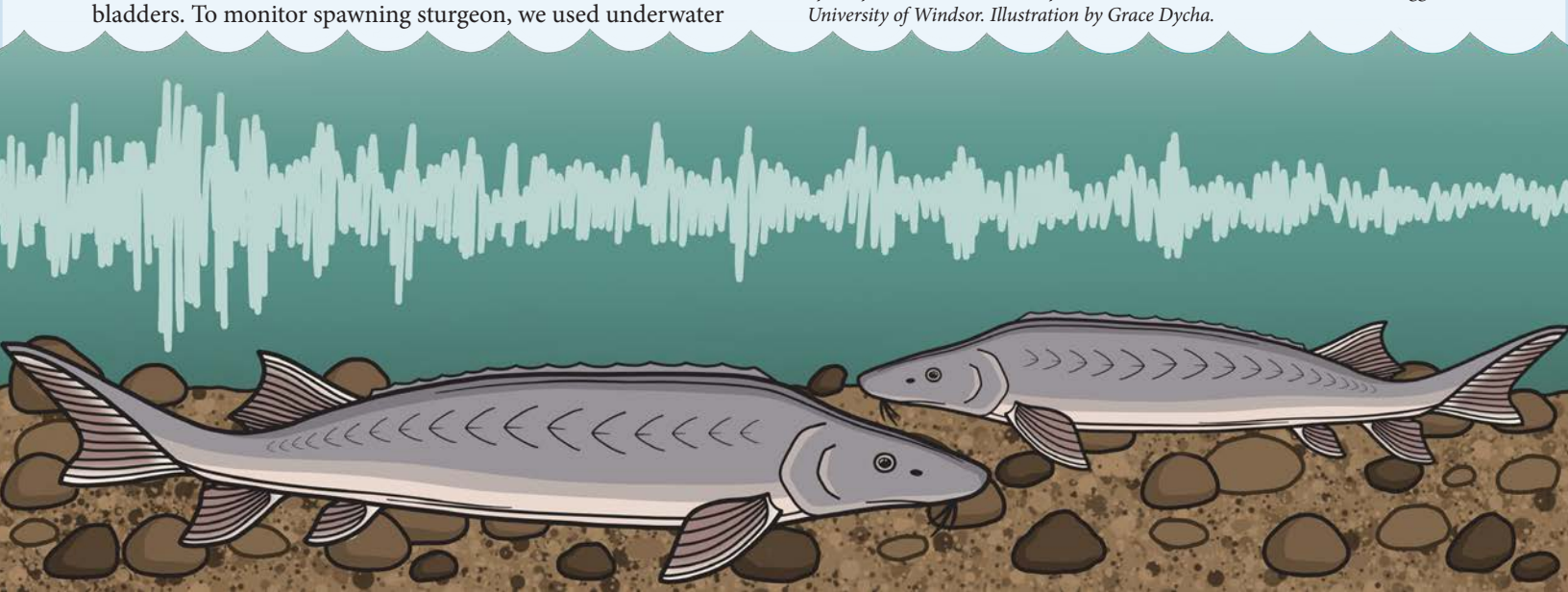


Thunderstruck: Using passive acoustics to eavesdrop on sturgeon spawning vocalizations

Lake sturgeon (*Acipenser fulvescens*) were once abundant in the Laurentian Great Lakes, but overfishing and habitat destruction led to dramatic declines in their population. Individuals of this keystone species are known for living up to 100 years, but these long life spans have kept their numbers low. Another obstacle to their recovery is their need for clean gravel substrates and fast currents for spawning beds, a habitat that is becoming harder to find. There have been encouraging efforts to improve water quality and establish new spawning beds in the Great Lakes, but it can still be difficult to tell where sturgeon might be breeding, especially in deeper waters.

Sturgeon use sound to communicate when spawning and male sturgeon produce what has been termed a "thunder" sound, a low-frequency rumble caused by vibrating their swim bladders. To monitor spawning sturgeon, we used underwater microphones (called hydrophones) to "eavesdrop" on sturgeon in the Detroit River (Higgs and Beach 2021). Our spawning bed was relatively quiet until water temperatures reached 15°C, after which there was an explosion of calling fish, with up to 45 fish calls/hour. The fish also seemed to prefer calling only during the day, going quiet each night. Interestingly, the fish also seemed to go quiet when a large ship passed overhead, highlighting the impact that increasing levels of sounds from human activity can have on our local fishes. There are many fish species that can vocalize, and their sounds can get picked up with consumer-grade hydrophones available for a reasonable price. Even GoPro cameras can pick up fish sounds. We encourage all fishers to bend an ear to our underwater world!

By Riley K. Beach, Grace M. Dycha, Rachel H. Pieniazek, and Dennis M. Higgs, University of Windsor. Illustration by Grace Dycha.



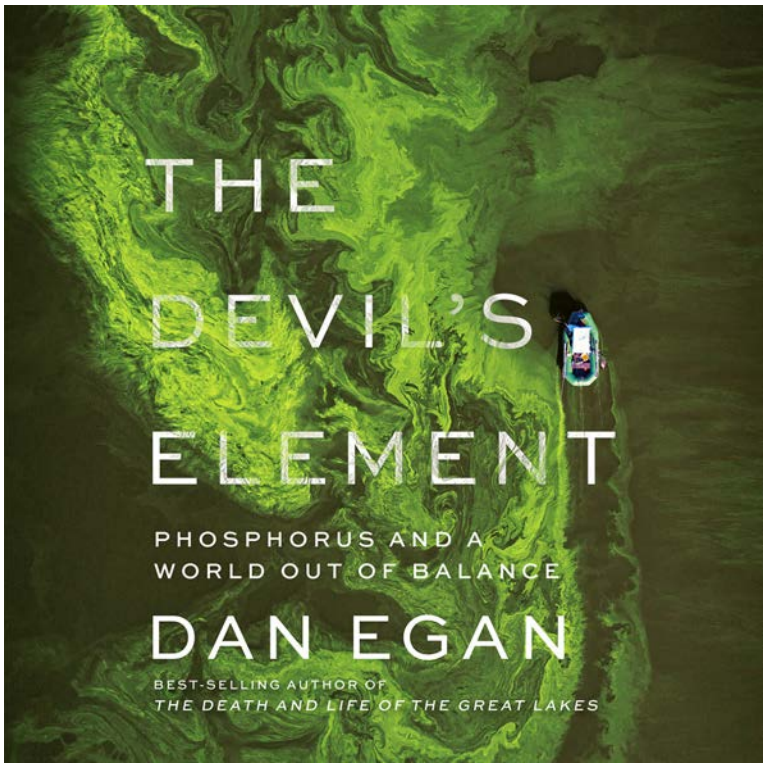
BOOK REVIEW

Too little and too much: Humanity's phosphorus paradox

by **Bopi Biddanda, Nate Dugener, and Steve Ruberg**

IN *THE DEVIL'S ELEMENT,* Dan Egan traces humanity's love-hate relationship with the 15th element in the periodic table, phosphorus (P). One of six macroelements required for life (CHONPS), P is an essential building block of life (nucleic acids) and its energy currency (adenosine triphosphate). Life can neither take shape nor fire up its engine without P.

Unlike elements CHONS, P is neither abundant on Earth's surface (CHO) nor biologically fixable (CNS). Consequently, availability of P is mostly regulated by Earth's slow rock cycle and often limits growth. Egan examines the dual role of P as a boon and curse: critically needed as fertilizer for our ever-intensifying agriculture and a pollutant degrading water quality and habitat downstream. Too little P limits plant growth at the base of aquatic food webs, whereas too much P fuels excessive plant growth (eutrophication) often triggering the formation of harmful algal blooms and bottom water hypoxia.



The Devil's Element: Phosphorus and a World Out of Balance, by Dan Egan (Norton & Co., New York, 2023, p. 256, ~$24).

Geologic and anthropogenic forces have created a paradox of scarcity and excess P across our modern world. There are only two sources of bioavailable P (phosphate, PO_4): minable phosphate-rich rocks (mostly in Western Sahara) and onshore deposits of guano (marine bird poop). With human activity having doubled the flow of P in the environment relative to the pre-industrial baseline, the latter is now all but exhausted, and the former is in precipitous decline. Indeed, Earth's P reserves are projected to last only about 100 years, endangering global food security. At the same time, excessive P from agricultural and sewage runoff is degrading water quality and endangering aquatic and human health.

How we manage the "devil's element" will reshape our civilization's future just as fossil fuels have. Egan elegantly states the problem of a world in serious P-imbalance given current unsustainable agricultural and animal waste disposal practices, but does not provide concrete solutions for the required balancing act: having enough P to grow our food while maintaining healthier ecosystems downstream. That is now up to us.

Bopi Biddanda and Nate Dugener are at the Annis Water Resources Institute, Grand Valley state University; Steve Ruberg is at the NOAA-Great Lakes Environmental Research Laboratory.

Lakes Letter is published quarterly by the International Association for Great Lakes Research, a scientific organization made up of researchers studying the Laurentian Great Lakes, other large lakes of the world, and their watersheds, as well as those with an interest in such research.

Lakes Letter is edited by IAGLR Communication Director Paula McIntyre with assistance from Alex Duncan and Jessica Ives, members of the *Lakes Letter* editorial team.

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A NOTE FROM THE PRESIDENT

Weaving Indigenous Knowledge and western science, engaging with policy makers, and strengthening community bonds

by Neil Rooney

It is my great honour to write this column as the incoming president of IAGLR. I would first like to reflect on the wonderfully successful IAGLR 2023. The breadth and depth of the material presented there were amazing to witness. We also celebrated our commitment to incorporating Indigenous perspectives in addressing environmental issues faced by Great Lakes ecosystems. The participation of Indigenous youth was particularly exciting and insightful. It was heartening to witness the genuine exchange of knowledge and the strengthening of relationships among knowledge holders of all backgrounds and approaches. Perspectives shared by all participants shed light on the intricate web of relationships surrounding Great Lakes ecosystems and emphasized the importance of weaving knowledge systems to help understand the complex local and global issues facing great lakes around the world.

Research in the pursuit of knowledge is a noble pursuit, but of course we cannot stop there. As we move forward, it is crucial for IAGLR to engage with policy makers. Our collective knowledge and expertise can greatly contribute to the development of effective policies that protect and restore the health of Great Lakes. In the coming year, we will actively seek opportunities to meet with policy makers, ensuring our voices are heard. I encourage all members to continue to provide valuable input while our executive director and board seek to ensure that the importance of Great Lake ecosystems is acknowledged by policy makers. Together, we can advocate for evidence-based decision making and promote policies that prioritize the preservation of our beloved lakes.

Being a food web ecologist, I cannot help but comment on future research directions that take an integrative approach to studying Great Lake ecosystems. While we celebrate the recent success of securing funding and carrying out research on the restoration of nearshore habitats damaged by land-based human activities, it is essential to maintain a holistic view of lake ecosystems. In the face of global stressors (such as climate change) that endanger more than shoreline habitats, we must now shift our focus back to the threatened pelagic zone to integrate these two energy channels to "put the lake back together" (with a nod to the classic *BioScience* paper by Yvonne Vadeboncoeur and colleagues from 2002). By understanding the interdependencies between nearshore and open water habitats, we can achieve a more comprehensive understanding of the lakes' ecosystem functioning. This integrated approach will guide us in implementing protective and restoration efforts that consider the entire lake environment.

Finally, engaging local communities (Indigenous and non-Indigenous) has become a core priority for IAGLR. The collaboration between researchers and communities is invaluable in ensuring the relevance and applicability of our work. By actively involving local stakeholders, we strengthen our understanding of the lakes' unique challenges and empower communities to take ownership of their natural resources. Let us continue to foster these partnerships, promoting co-learning and co-creation, as we strive for a sustainable future for the Great Lakes of the world.

I invite you all to join me in celebrating the successes we have achieved while recognizing the work that lies ahead. Let us continue to build bridges, bringing together diverse perspectives to enhance our understanding and conservation efforts. Our commitment to science, Indigenous knowledge, policy engagement, and community involvement will undoubtedly lead us to a brighter future for the Great Lakes.

Thank you for your continued dedication and support.