IAGLR

LAKES Letter

OIL SPILL SCIENCE

Research networks

Hazards & risks

Response options & capabilities

Training the next generation of oil spill scientists

Oil spills under ice

FALL 2024, NO. 23

LAKES *Letter*
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iaglr.org/lakesletter

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EXECUTIVE DIRECTOR'S NOTE

We are pleased to share the latest issue of *Lakes Letter*, which centers on critical advancements in oil spill research within the Great Lakes basin. Oil remains a highly debated subject, with rising concerns about its usage, transportation, and the urgent need to reduce dependence on fossil fuels in the near future. Nonetheless, the demand for robust oil spill science is more vital than ever to ensure preparedness in the event of accidental releases into the environment. This need is especially pressing in freshwater systems, where comparatively less is known about oil's behavior, fate, and long-term impacts.

Reflecting on past milestones, a decade ago, I led Canada's first national ship-source spill risk assessment. This analysis demonstrated that, while no crude oil was being transported through the Great Lakes, the St. Lawrence River posed the highest spill risk for refined oil products in Canadian waters. Additional research with the Great Lakes Commission underscored the heightened sensitivity of lower Great Lakes regions to oil spills, particularly in urban centers like Chicago, which serve as transportation hubs for multiple oil transport modes.

In the realm of the International Association for Great Lakes Research, recent months have been dynamic. We convened the fall Board of Directors meeting, a key annual event where the budget for the upcoming fiscal year is solidified. As the year winds down, we encourage all members to renew their memberships, reinforcing our community's commitment to advancing Great Lakes science.

Preparations for our annual conference in Milwaukee are underway, with the abstract submission call opening earlier this month. Nearly 50 sessions have been proposed, signaling a robust and well-attended event on the horizon. Additionally, we extend a warm welcome to Dr. Margaret Docker, our new editor for the *Journal of Great Lakes Research*, as she transitions into her role. She will assume full responsibilities in January.

Thank you all for your continued engagement with our association. Together, we advance knowledge and resilience in Great Lakes research.

Best regards,
Jérôme Marty

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ASSOCIATION NEWS

Save the dates for two conferences in 2026

We're pleased to announce two conferences in the works for 2026.

- The **2026 IAGLR-SCAS Joint Meeting** will be held in Winnipeg, Manitoba, May 25-29, 2026. We're partnering with the Society of Canadian Aquatic Sciences to bring you this event.
- We're also planning a **conference in Arusha, Tanzania**, likely in February 2026. The event will be co-hosted with the African Center for Aquatic Research and Education. Jérôme Marty, IAGLR executive director, and Ted Lawrence, ACARE executive director, announced the 2026 conference in Tanzania last month at the Fisheries and Aquaculture Research for a Vibrant Blue Economy Conference, held in the same venue.

Season of Giving

December 3 kicks off a season of generosity with Giving Tuesday, a day when people around the world make a donation to the organizations and causes they hold dear. We invite you to join the community of members and friends who support IAGLR and make countless opportunities available to scientists and students from throughout the world. Together we can advance understanding of the world's large lake ecosystems to better manage and protect them for generations to come. To add your support, please view our giving opportunities and select the one that best fits your interests. Members, you can also make a donation when you renew or join.

- Support student scholarships
- Sign up for the Sustainers Circle Monthly Giving Program
- Make a one-time general donation
- Foster diversity, equity, and inclusion in the large lake research community
- Strengthen organizational sustainability with a contribution to the endowment fund

No matter the amount or the option you choose, we appreciate your support!

iaglr.org/giving

Let us put you in the spotlight!

Gain visibility at IAGLR 2025, scheduled for June 2–6 in Milwaukee, Wisconsin. Space is limited. Don't miss out on these opportunities to highlight your work and support large lake research:

- **Sponsor** the conference
- **Exhibit** at the conference
- Fund a specific event or item (e.g., registration waivers for Black and Indigenous attendees)
- Place an **ad** in the Program Book

Download the IAGLR 2025 Prospectus for details.

Great Lakes Benefactors

Become a Great Lakes Benefactor—Enjoy sponsor and exhibitor benefits and more! Great Lakes Benefactors value large lake research and demonstrate their commitment to IAGLR and the research community through a significant ongoing annual contribution. For their commitment, Great Lakes Benefactors receive multiple conference benefits as well as other promotional opportunities throughout the year. Join us to help advance understanding of the world's great lake ecosystems.

Travel support to attend IAGLR 2025

Did you know IAGLR offers support to attend the annual conference? Learn more about two opportunities for help getting to IAGLR 2025, We hope to see you there!

- **The International Travel Award** supports a master's or Ph.D. student or post-doctoral fellow from countries outside of Canada or the United States to present at the conference. **Apply by Feb. 10.**
- **Student Travel Awards** provide funds to IAGLR student members to help with travel costs. Conference registration will open in early March, and applicants are accepted through early bird registration. First come, first served as funds allow. Make sure to sign up for your 2025 membership to qualify!

Call for IAGLR award nominations

Each year, IAGLR recognizes excellence through its many awards. We invite you to nominate worthy candidates—it's your chance to recognize outstanding contributions in the large lake community.

Recent Lifetime Achievement Award winners at the 2024 conference, from left: Val Klump, Bob Hecky, Stephanie Guildford, and Pat Chow-Fraser.

Journal Awards

All are invited to nominate a notable paper from the *Journal of Great Lakes Research*, volume 50 (2024) for one of three awards given based on the career status of the lead author. Nominations are due **January 15**.

- Chandler-Misener Award
- JGLR/Elsevier Early Career Scientist Award
- JGLR/Elsevier Student Award

Professional Awards

IAGLR members can nominate people for our three professional awards. Nominations are due **February 1**.

- Lifetime Achievement Award
- Large Lake Champion Award
- John R. (Jack) Vallentyne Award

We invite you to nominate someone for an award this year. We encourage nominations of people from diverse identities, perspectives, and experiences.

Become a guest editor for *Lakes Letter*

This issue of *Lakes Letter* is our first that welcomed guest editors to guide its creation. We'd like to thank Kenneth Lee, of Kenneth Lee Research Inc., and Kelsey Prihoda, of the University of Minnesota Sea Grant College Program, for the time and energy they devoted to bringing you valuable information about oil spill science in the Great Lakes.

"Being a guest editor provided an opportunity to highlight the challenges in our field and to foster networking across various scientific disciplines to address our current and emerging issues of concern," notes Lee.

Prihoda adds, "I found the experience to be extremely collaborative and rewarding. For both guest editors and authors, the effort is less daunting than that of a traditional, peer-reviewed journal, while still providing the exciting challenge of telling a great, visually appealing story about the theme and its research. I also really appreciated the opportunity to highlight students and their research projects."

We'd like to invite you to consider being a guest editor of an upcoming issue. Although not required, it's a great opportunity to pair a senior scientist and student or early career researcher. Learn more on our website and consider submitting a proposal to serve!

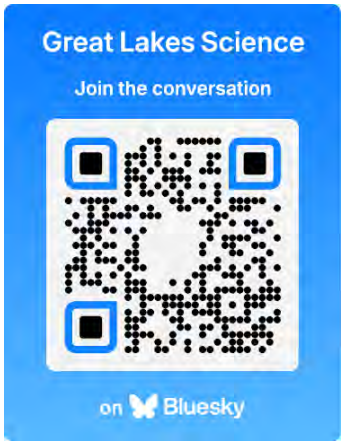
Share your perspective on STEM society culture

We're looking for participants for a research study conducted by ACCESS+. The research team is interested in understanding your individual experiences with and perspectives about your STEM professional society as well as the kinds of changes you would like to see. Your responses will help us better understand how members experience the society and make informed decisions about what improvements are needed. Participants must be a member of one of the 36 ACCESS+ STEM societies, which include IAGLR. For the past two years, IAGLR has participated in the ACCESS+ Community of Practice, which aims to accelerate the awareness, adoption, and adaptation of evidence-based, gender-related, diversity, equity, and inclusion policies, practices, and programs within and across STEM professional societies. We encourage you to take the survey by the end of December. Opt into a drawing for one of five $250 Amazon gift cards. Learn more!

Join IAGLR on Bluesky

As many of you make the jump to the friendly confines of Bluesky to connect with scientists on social media, don't forget to give IAGLR (@iaglr.bsky.social) a follow to keep up with all the latest Great Lakes science, as well as updates on the annual conference, the journal, and more.

To smooth the transition, we've created the Great Lakes Science starter pack to help you find other Great Lakes scientists and organizations that help advance understanding of the world's large lakes. We still have room to add people and organization to the list, so if you are interested, please contact us on Bluesky.



IAGLR 2025

JUNE 2-6 | MILWAUKEE

Creating Great Lakes Resilience

Enjoy a fantasic lineup of speakers

TUESDAY, JUNE 3

Steve Carpenter
Professor Emeritus, University of Wisconsin–Madison

WEDNESDAY, JUNE 4

Susan Chiblow
Canadian Commissioner, International Joint Commission & Assistant Professor, University of Guelph

THURSDAY, JUNE 5

Ismael Kimirei
Director General, Tanzania Fisheries Research Institute

CALL FOR ABSTRACTS

Deadline: Monday, December 16

Present your work at IAGLR's 68th Annual Conference on Great Lakes Research!

Abstract submission is now open for the conference, which will be held June 2–6, 2025, in Milwaukee, Wisconsin, as a hybrid event. Forty-seven sessions have been proposed to complement the theme *Creating Great Lakes Resilience.* We welcome abstract submissions for both oral and poster presentations.

iaglr.org/iaglr2025

MEMBER NEWS

Kudos

Congratulations to the following IAGLR members.

MICHAEL BACK (Kent State University) for receiving the NOAA Margaret A. Davidson Fellowship (2024–2026). Back will be conducting research on coastal wetland sediment nutrient cycling at the Old Woman Creek National Estuarine Research Reserve for the next two years.

EMILIE DEROCHIE (River Institute) for completing her Master of Education with a specialization in environmental and sustainability education at Lakehead University.

LAURA JOHNSON (Michigan Department of Agriculture and Rural Development) for her selection as chief science officer within the department's newly created Office of Agricultural Science and Research.

JAKE KIMMEL (Great Lakes Fishery Commission) for starting his new job as the commission's sea lamprey research program associate.

DEBORAH LEE (NOAA Great Lakes Environmental Research Laboratory) for receiving The Ohio State University College of Engineering 2024 Distinguished Alumni Award for Career Achievement.

ED RUTHERFORD (NOAA Great Lakes Environmental Research Laboratory) on his retirement. Throughout his esteemed career, Rutherford advanced our understanding of Great Lakes fish population dynamics, larval fish ecology, food web dynamics/modeling, and invasive species management.

EMILY VARGA (University of Windsor) for successfully defending her Ph.D. Varga's research focused on the environmental drivers of phytoplankton community structure and cyanobacterial harmful algal blooms along the Thames River - Lake St. Clair continuum.

AL STEINMAN, the Allen and Helen Hunting Research Professor at Grand Valley State University's Annis Water Resources Institute, for receiving the Niles R. Kevern Lifetime Achievement Award at the Michigan Inland Lakes Convention, awarded by the Michigan chapter of the North American Lake Management Society, for "significant contributions to the advancement of the understanding of lakes, providing leadership in addressing key lake issues, and exhibiting excellence in promoting lake ecology and/or management."

STEVEN WILHELM (University of Tennessee) for his election as a fellow of the Royal Society of Canada Academy of Science. This recognition is the RSC's highest honor in areas of arts, social sciences, humanities, and science. In selecting Wilhelm, the society cited his research in advancing the study of microbes in aquatic systems, including the roles of viruses as drivers of marine and freshwater biogeochemistry, and his contributions in biogeochemistry, molecular ecology, oceanography, and limnology.

In memoriam

CHRIS VANDERGOOT, director of the Great Lakes Acoustic Telemetry Observation System since 2019, passed away unexpectedly in September while in Halifax, Nova Scotia, to attend a conference. Vandergoot, 48, was especially known for his infectious enthusiasm for acoustic telemetry projects and for faith, family, and friends. A tribute to Vandergoot aptly states, "His innovative approach and contribution to the field of fisheries management has made global impacts and his research is highly valued by scientists and anglers alike. Great Lakes anglers distinctly know more about the fish that they chase because of the work that Dr. Vandergoot so passionately pursued."

Welcome new members

The following members joined IAGLR between August and October 2024.

Chunjiang An

Noah Bohl

Timothy Calappi

Mercy Chepkirui

Sarah Dobie

Owen Donnelly

Sara Guiher

Alyssa Haram

Anna Hill

Meghan Jeske

Julie Kastanis

Susanna Keilig

Jake Kimmel

Jessy Lugya

Don Felix Otieno

Augustus Pendleton

Daxelle Sakubu

Rachel Smith

Drake Ssempijja

Jai Tiarks

Zanko Zandsalimi

Share your news

IAGLR members, we'd love to hear what you've been up to. Did you write a new book, finish your degree, get a new job, or retire? Maybe you've been a guest on a recent podcast, written a magazine article, or been featured in the media? We invite you to submit your news to be featured in the Kudos section.

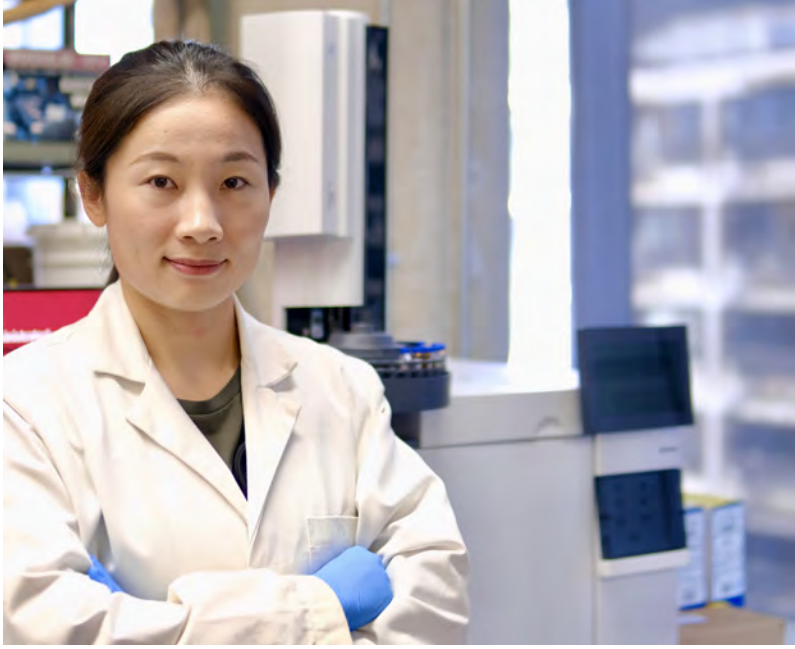
Also, if you're aware of a member who has passed recently, please let us know so that we can acknowledge them.

Please send your news to us at lakesletter@iaglr.org.

MEMBER SPOTLIGHT

Meet Huifang Bi

Master of Engineering & Ph.D. Candidate
Concordia University, Montréal



Describe your work or studies.

Spilled oil reaching shorelines can be highly weathered and hard to remove, and there is a need to develop an environmentally friendly, easy way to wash out the deposited oil, or even prevent the spilled oil from adhering on the shoreline. My research focuses on the development of green shoreline oiling prevention and treatment techniques to reduce the impacts of spilled oil in coastal regions. I am currently developing a biomass-derived coating with special wetting properties to reduce oil adhesion on sensitive shorelines and structures during emergency spill response. Meanwhile, I am also exploring whether this *functionalized coating* (one that has novel functions beyond its primary purpose) can enhance the biodegradation rates of the residual oil released into surrounding waters.

What inspired you to enter this work?

I grew up in a city by the shoreline, and I love the peaceful feeling of walking by the water. Since May 2019, as a master's student at Concordia University, I have participated in research projects related to shoreline cleanup during oil spill response, funded by the Multi-Partner Research Initiative (MPRI) under Canada's Oceans Protection Plan. As a core team member, I conducted extensive research on the use of surface washing agents for oil cleanup. In particular, I had the opportunity to work with many experts from academia, industry, and government in Canada, the United States, and Norway, and I received valuable suggestions from them. These experiences sparked my growing passion for this field, leading me to pursue a Ph.D. on this topic. As my research progressed, I continuously reflected on how to further reduce the impacts of spilled oil on the Canadian coastal environment and communities. In my opinion, using an environmentally friendly method to prevent the adhesion of spilled oil on shorelines is far superior to removing stranded oil. This led to the development of the idea of a functionalized coating for shoreline oiling prevention. Although still in the exploratory phase, my preliminary results showed that this method is both feasible and meaningful, with the potential to revolutionize oil spill response on shorelines.

What are your professional aspirations?

I hope to become a research scientist in the field of oil spill response, focusing on developing innovative solutions like functionalized coatings for shoreline oiling prevention. I aim to continue advancing this technology to minimize environmental disturbance while effectively protecting shorelines. In the long term, I aspire to lead a research team dedicated to transforming the developed technologies into practical applications for the oil spill response toolbox, helping responders protect coastal and freshwater ecosystems more sustainably.

What is something about yourself that you'd like to share with other IAGLR members?

In addition to my research, I actively participated in some forums, workshops, and conferences (e.g., IAGLR 2024) to share my research with a wider audience and engage with experts. These interactions provided me with valuable insights into the latest developments in oil spill science and response strategies, while also fostering collaborations that enhance the practical applications of my findings. I am deeply passionate about seeing my work transform into real-world solutions that protect shorelines.

Additionally, I am actively involved in event organization and knowledge dissemination, which gives me opportunities to demonstrate my leadership skills. For example, I led the promotion of International Oil Spill Science Conference 2022 through various channels and provided technical support for several online events, such as MPRI Student Research Forum 2021 and ITAC-MPRI Virtual Forum 2021. My contributions to shoreline cleanup research and my engagement with oil spill communities have been well recognized. For instance, I have published 21 papers in international journals. In recognition of my achievements, I was awarded the 2023 Vanier Canada Graduate Scholarship (the most prestigious of the doctoral scholarships offered by the Canadian federal government) and 2024 International Oil Spill Conference Scholarship.

What advice to you have for graduate students interested in pursuing oil spill science?

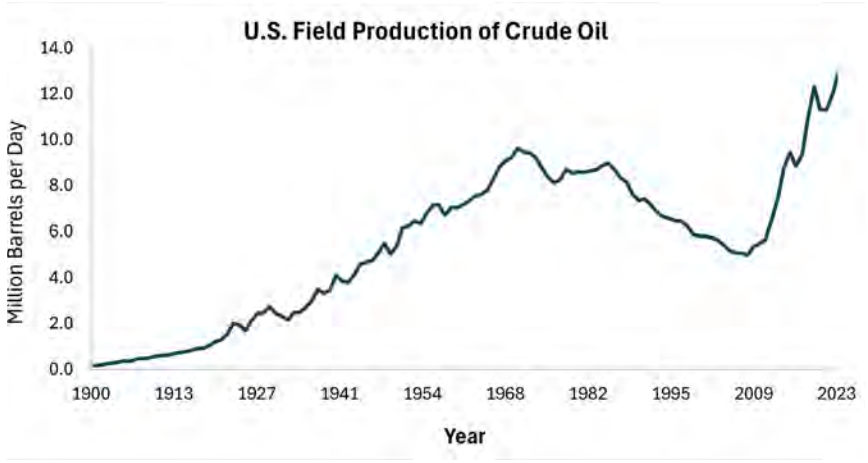
Don't hesitate to explore innovative solutions like nanotechnology or advanced materials, as these cutting-edge approaches may address complex challenges in oil spill prevention and cleanup. Innovation often leads to more efficient and sustainable outcomes, so keep an open mind and be willing to test new ideas.

Research Networks

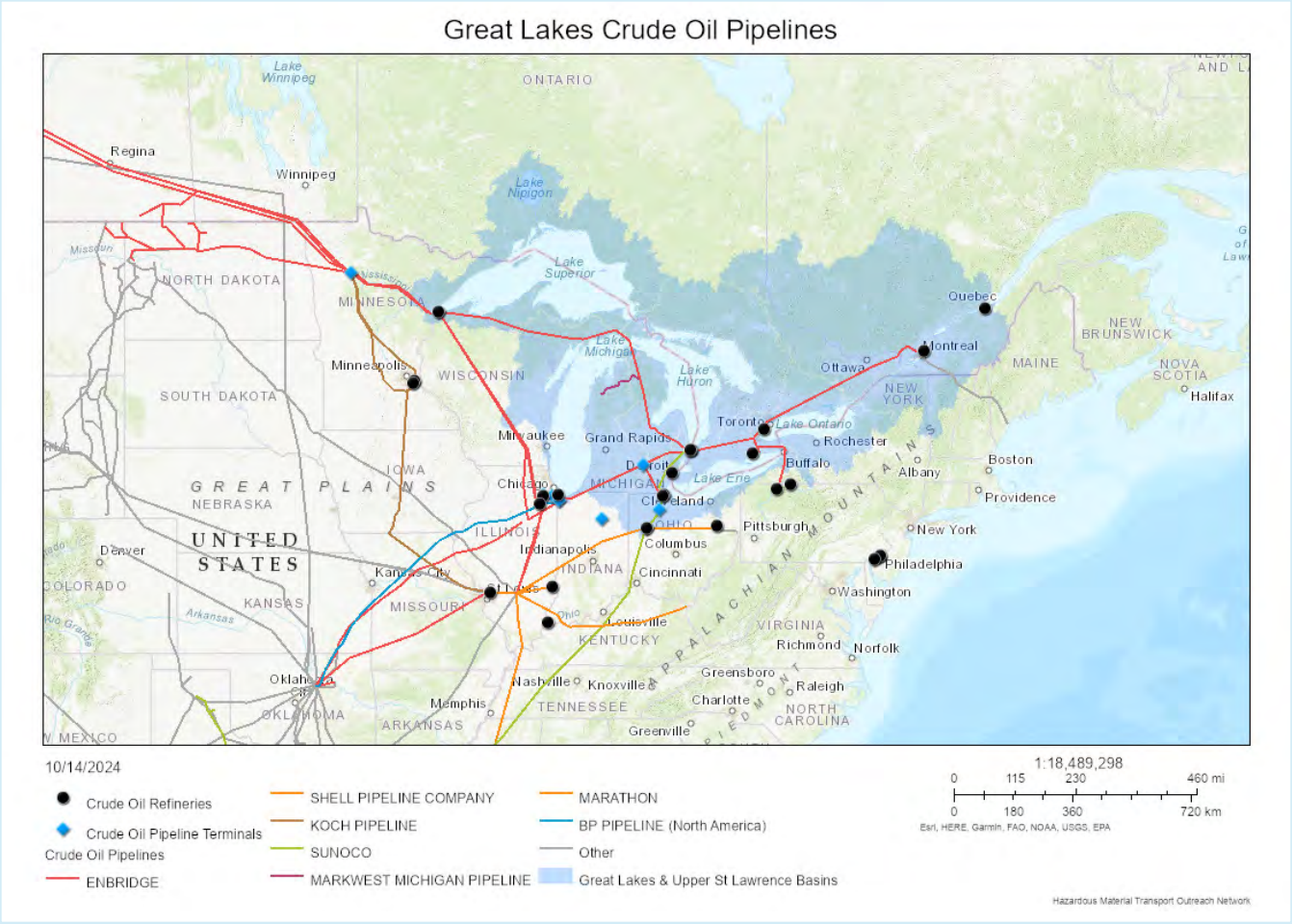
Advancing Great Lakes oil spill preparedness, response, and recovery through collaboration

BY KELSEY PRIHODA & KENNETH LEE
GUEST EDITORS

THE HEADLINE of a recent analysis by the U.S. Energy Information Administration on global production of crude oil reads "United States produces more crude oil than any country, ever." Domestic production of crude oil in the U.S. has been increasing since 2010 (see figure below) in part due to technological advances (hydraulic fracturing and horizontal drilling) that have allowed the extraction of unconventional crude oil from oil and shale sands. A similar trend is also apparent in Canada, where crude oil production has increased by 41% since 2013. In 2023, Canada was ranked as the fourth largest producer of crude oil in the world, producing 5.1 million barrels per day (MMb/d). Together in 2023, the U.S. and Canada were responsible for producing over 21% of the world's crude oil.



Annual field production of crude oil, measured in millions of barrels per day, in the United States from 1900 to 2023. Credit: Kelsey Prihoda, Minnesota Sea Grant, with data provided by the U.S. Energy Information Administration.



Major crude oil pipelines in the Great Lakes region, the location of crude oil pipeline terminals, and the location of active refineries. Data sources: U.S. Department of Homeland Security, U.S. Energy Information Administration. Credit: Hazardous Material Transport Outreach Network.

In 2023, Canada exported an average of 4.0 MMb/d (nearly 80% of its total crude production) with the majority going to the U.S. There are numerous refineries in the Great Lakes–St. Lawrence River region. Pipelines, which transport about 90% of the petroleum hydrocarbons within North America, are located adjacent to, and underneath, the Great Lakes and the region's major tributaries (see figure above).

Spills of petroleum hydrocarbons within the Great Lakes–St. Lawrence River region have become a concern due to their extensive use in power generation, manufacturing, and chemical industries. From 2013 to 2019, approximately 1,300 oil and petroleum product spills occurred in the Great Lakes region according to a recent analysis of U.S. National Response Center data. The St. Lawrence Seaway is a major transport route that permits oceangoing vessels to travel from the Atlantic Ocean to reach ports in all five of the Great Lakes. In 2020, Transport Canada reported that over 4.1 million tonnes of oil products, or the equivalent of approximately 33 million barrels of oil products annually, were moved from 29 marine facilities in and out of ports in the Great Lakes–St. Lawrence Seaway. Despite advances in technology and safety protocols, the public remains concerned over the risk and impacts from accidental releases of petroleum hydrocarbons into the Great Lakes–St. Lawrence Seaway System.

The Great Lakes are the world's largest source of freshwater. They provide a source of drinking water for 40 million people, support a robust blue economy, and are a place of cultural significance for many Indigenous peoples. The Great Lakes are a dynamic system with strong currents, wind, and wave energy; rapid changes in ice cover; and tributaries with fast-moving water. The Great Lakes–St. Lawrence River region faces significant challenges with respect to oil spill preparedness, response, and recovery, including (Great Lakes Commission, 2015, and Lee et al., 2015):

- Early warning systems and predictive models for oil fate and transport in the dynamic Great Lakes system.
- Oil spill detection under ice and response in ice-covered environments.
- Limited knowledge and research on the impacts of oil spills in freshwater, cold-climate ecosystems.

Within the Laurentian Great Lakes region, several collaborative research networks have been established recently to improve our ability to predict, prepare for, respond to, and recover from oil spills.

- Development of effective oil spill countermeasures for use in freshwaters.
- Lack of awareness among Great Lakes communities about oil spill response planning and preparedness efforts.

RESEARCH NETWORKS

Within the Laurentian Great Lakes region, several collaborative research networks have been established recently to improve our ability to predict, prepare for, respond to, and recover from oil spills. Teams of multidisciplinary partners benefit from recent funding available through Natural Resources Canada's Multi-Partner Research Initiative, the U.S. Coast Guard Great Lakes Oil Spill Center of Expertise (GLCOE), and the National Oceanic and Atmospheric Administration's Office of Response and Restoration. Examples include the following:

Concordia Oil Spill Research Group

Led by Concordia University, this research group is dedicated to addressing the challenges of oil spills in freshwater shoreline environments. Its work focuses on three main areas: sensitivity and risk assessment, fate and transport of oil along shorelines, and shoreline spill response.

International Consortium of Oil Research–Our Waters of the North

This collaboration led by the Center for Freshwater Research and Education at Lake Superior State University (LSSU) and Algoma University is building capacity for detection of and response to oil spills under ice by developing drone and autonomous underwater vehicle systems. It is also working across 12 organizations and among 24 scientists to examine the effects of oil spills in freshwater ecosystems and to advance bioremediation strategies for the Great Lakes to enhance habitat recovery.

Great Lakes Oil Spill Center of Expertise

Established by the U.S. Coast Guard, the GLCOE is conducting research, development, testing, and evaluation for freshwater oil spill response equipment, technologies, and techniques to mitigate and respond to oil spills in the Great Lakes with a number of partners.

Hazardous Material Transport Outreach Network

This network is led by Minnesota Sea Grant and is supported by all the Great Lakes Sea Grant Network programs. Through education and outreach, it is working to translate research findings into actionable information for emergency managers, policy makers, and Great Lakes communities.

Oil Spills Under Ice Working Group

The working group is led by Michigan State University and includes researchers from the Cooperative Institute for Great Lakes Research, Michigan Technological University, and LSSU. It is working to identify current gaps in our knowledge of oil fate and transport under ice, available technologies for timely detection of oil under ice, and response strategies to safely remediate oil spills in ice-covered environments.

Smart Lake Erie Watershed Initiative

Led by Cleveland Water Alliance, the initiative is being used as a testbed for hydrocarbon sensors developed by LimnoTech, LSSU, and the GLCOE that could one day be the foundation of an early warning system for petroleum hydrocarbons in the Great Lakes.

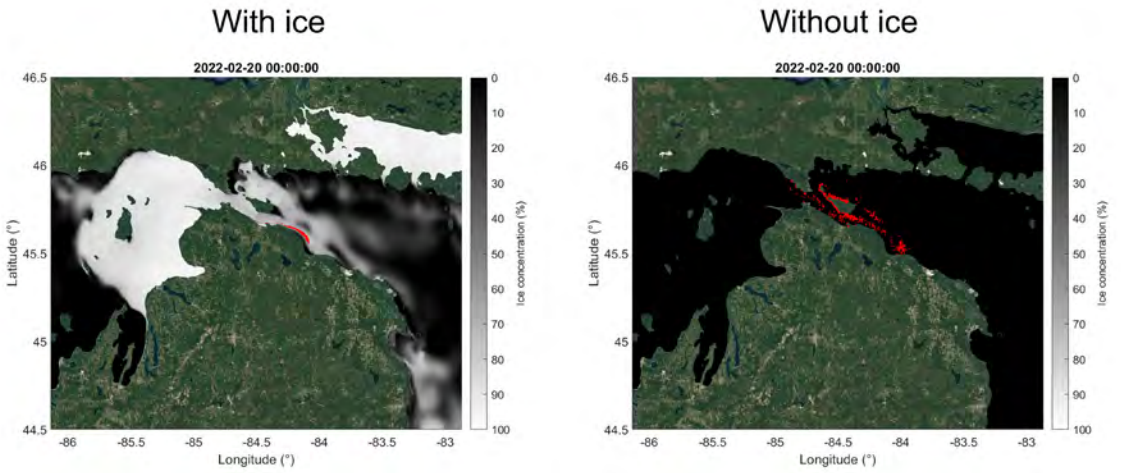
Oil spill preparedness and response exercises that incorporate the application of new knowledge and technologies from these new research and outreach collaborations—not to mention the attention and efforts of hundreds of researchers and other participants across government, industry, academia, regulatory agencies, response organizations, Indigenous Nations, and coastal communities in multiple countries—offer hope for Great Lakes ecosystems, communities, and economies who may be impacted by future oil spills. We invite you to learn more about many of their efforts in this issue.

Kelsey Prihoda, MSc, is the Great Lakes transportation extension educator with the University of Minnesota Sea Grant College Program, and regional coordinator of the Hazardous Material Transport Outreach Network. Kenneth Lee, Ph.D., is the director of Kenneth Lee Research Inc. and chair of the Advisory and Technical Advisory Committees for Phase II of the Multi-Partner Research Initiative for Oil Spill Research managed by Natural Resources Canada under Canada's Ocean Protection Plan. Prihoda and Lee served as guest editors for this issue of *Lakes Letter*.

Oil Spill Modeling

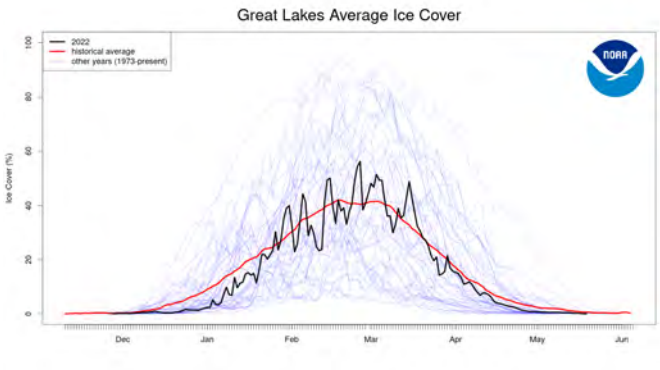
The critical impact of ice cover in the Great Lakes

BY YANG SONG, AYUMI FUJISAKI-MANOME, CHRISTOPHER H. BARKER, AMY MACFADYEN, DAN TITZE, DAVID M. WRIGHT, JAMES KESSLER & JIA WANG



Comparison of a hypothetical oil spill spread at the Straits of Mackinac in Lake Michigan-Huron, with and without ice cover.

THE RISK OF OIL SPILLS in the Laurentian Great Lakes is a growing concern due to frequent ship traffic and aging submerged pipelines at the Straits of Mackinac in Lake Michigan-Huron. Freshwater oil spills are known to cause severe environmental damage—from the death of local wildlife to contamination of drinking water supplies—yet they have been studied less extensively than marine oil spills. To address this issue, high-fidelity oil spill models are being developed and used for oil spill preparedness and response in the Great Lakes. Meanwhile, although ice cover is a regular occurrence in this region (see figures, this page), it has not been rigorously incorporated into these models. This lack of research could notably reduce the accuracy of oil spill movement simulations and decrease response effectiveness, posing serious threats to the water environment and ecology.

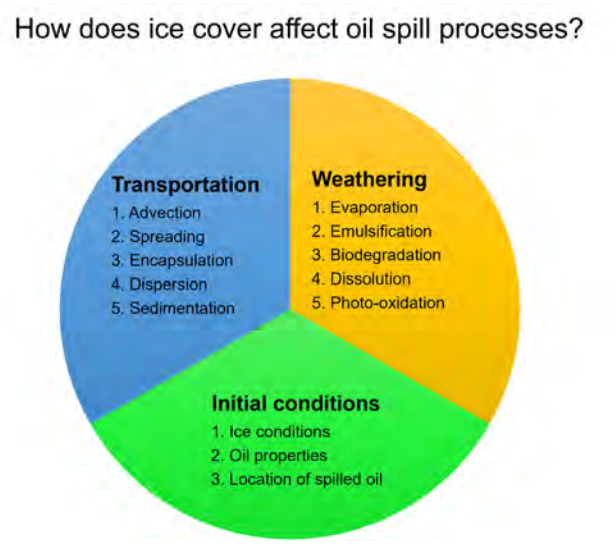


Historical ice cover for the Great Lakes. Credit: National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory.

For the Great Lakes, we created a computer model looking at hypothetical oil spills at the Straits of Mackinac to help predict what would happen if oil were accidentally released there. The model explored how spills might spread across the water's surface and interact with ice. It focused on the prominent oil *advection* process, specifically the movement of oil due to currents, winds, and ice. The results demonstrated that ice cover can limit oil movement and reduce the extent of oil-affected open water areas (see previous page, top figure). While this may initially seem like a positive outcome of ice cover, oil can actually move beneath the ice cover or become trapped and locked in ice, which is known as *oil encapsulation* or an *oil-ice sandwich*. Furthermore, oil trapped under ice is difficult to detect and clean up, making it even more crucial to predict its movement. These complex interactions between oil and ice are not fully understood or effectively represented in oil spill modeling, adding to the uncertainty in predictions.

In general, ice cover affects oil spills through both transportation and weathering aspects (see figure at right). In terms of oil transport, ice cover can affect oil spill movement by forming barriers that reduce oil advection and spreading. This *spreading* is the thinning process of an oil slick caused by the interaction between viscosity, gravity, buoyancy, and surface tension. Moreover, ice cover can influence oil transport in other less-studied ways. These processes include 1) *encapsulation*, which is specific to ice-covered waters and is poorly understood; 2) *dispersion*, where breaking waves force oil droplets into subsurface water; ice cover can prevent this process; and 3) *sedimentation*, which refers to the adhesion of oil to suspended sediments and is the least studied of the transportation aspect.

Oil weathering refers to the changes in the physical and chemical properties of spilled oil, including processes such as evaporation, emulsification, biodegradation, dissolution, and photo-oxidation. Ice cover weakens evaporation by lowering the ambient temperature and thickening the oil slick, and it can even stop evaporation altogether if the oil is under ice, with no exposure to the atmosphere. *Emulsification* is the process in which small droplets of water are mixed into oil to form a stable emulsion due to waves and turbulence; ice has been reported to slow this process. *Biodegradation*, often considered the final fate of weathered oil, refers to the breakdown of petroleum hydrocarbons into simpler components, such as water and carbon dioxide, by microorganisms like bacteria and fungi. Ice cover can reduce this process due to the higher viscosity of oil, the lower evaporation rate, and the slower microbial activity compared to open water. *Dissolution* is the process where the soluble portion of oil breaks into individual molecules, blending with water to create a uniform mixture; it occurs much more slowly than evaporation, and oil could dissolve more readily in ice-covered water due to greater contact with the liquid phase. *Photo-oxidation* occurs when oil is exposed to oxygen and light, causing it to degrade into new oxygenated products; this process is the least studied of the weathering aspect, and the impacts of ice cover are largely unknown.



The initial location of the oil spill, such as whether the oil is on the ice, beneath the ice, within leads, on snow, or absorbed by snow, must be considered for emergency responders, as it can directly determine how ice cover affects oil transportation and weathering, the modeling of these processes, and the mitigation and cleanup strategies. It is also worth noting that the type of ice—such as land-fast ice, pack ice, and broken ice—and ice duration, as well as the properties of oil—such as oil type, viscosity, components, and volatility—also influence oil transportation and weathering, adding another two layers of complexity.

In summary, ice cover exerts unignorable impacts on oil spill movement and greatly complicates the oil spil process. Ice cover generally slows oil transportation and weathering and complicates modeling and cleanup efforts. To date, modeling oil behavior in ice remains in its initial stages, lacking a sufficient understanding of the influencing mechanisms and valid mathematical algorithms. Additionally, most research on oil-ice interaction has focused on sea ice; the differences with freshwater ice, like that in the Great Lakes, are not well understood. To improve the predictive accuracy of oil spills under icy conditions and ensure effective responses, future research should focus on quantifying oil-ice interactions to ensure their adequate representation in the models.

Yang Song, Cooperative Institute for Great Lakes Research (CIGLR), School for Environment and Sustainability, University of Michigan (UM); Ayumi Fujisaki-Manome, CIGLR and Climate & Space Sciences and Engineering, UM; Christopher H. Barker and Amy MacFadyen, NOAA Office of Response and Restoration; Dan Titze, David M. Wright, James Kessler, and Jia Wang, NOAA Great Lakes Environmental Research Laboratory.

Straits of Mackinac in Lake Michigan-Huron.

A New Focus on an Old Issue

The International Consortium of Oil Research builds scientific capacity in the Great Lakes to understand oil spills

BY MICHAEL TWISS & ASHLEY MOERKE

Summer research assistants setting up the 24 treatment vessels containing St. Marys River water, sediment, and a variety of aquatic plants.

OIL IS AN INTEGRAL PART of the economy in the Great Lakes-St. Lawrence River system. It fuels shipping and is moved by pipelines that cross the basin and pass underneath many of its connecting waters, including the Straits of Mackinac. Major oil spills have occurred in the region before. In June 1976, a barge ran aground in the Upper St. Lawrence River and spilled 1,100 m^3 of crude oil that was poorly contained and spread along an 80-mile(130-kilometer) reach of the river, contaminating shoreline marshes and killing innumerable fish, fowl, and wildlife. It was one of the largest oil spills in the U.S. until 2010 when a pipeline buried beneath the Kalamazoo River, a tributary of Lake Michigan in southwest Michigan, ruptured and at least 840,000 gallons (3,180 m^3) of crude oil spread along a 38-mile (61-kilometer) reach of this river.

As academic scientists, our responsibilities are to provide unbiased research findings to both the public and government scientists.

More recently, residents of the Great Lakes have been reminded that the risk remains. Currently, a 65-year-old oil pipeline traverses the Straits of Mackinac on the floor of this critical waterway. There is a proposal to bury the pipeline in a tunnel to prevent potential catastrophes such as the event on April 1, 2018, when a tugboat anchor dragged along the lakebed through the Straits of Mackinac severing submerged electrical cables that spilled 608 gallons (2.3 m^3) of mineral oil insulation fluid. The same incident also dented the submerged oil pipeline, risking a major oil spill during the winter shipping period when response and containment would have been very difficult, if not impossible.

Where do our responsibilities lie? Natural Resources Canada (NRCan) has recently stimulated research on the impacts of oil spills in the Great Lakes system and additional support is provided by the U.S. Coast Guard Great Lakes Center of Expertise. There has been some excellent research conducted on freshwater oil spills in inland lakes, notably at the IISD-Experimental Lakes Area research facility in northwestern Ontario. However, impacts of oil on freshwater ecosystems are far less understood than in marine systems and comparatively little research has been conducted on how oil spills will adversely affect Great Lakes ecosystems and food webs in winter and warmer seasons.

As academic scientists, our responsibilities are to provide unbiased research findings to both the public and government scientists. Understanding the impacts oil spills will have on the Great Lakes will help the public, managers, and responders implement science-based decision making regarding oil transport across and under the Great Lakes.

To this end, the International Consortium of Oil Research (ICOR) was funded by NRCan for a five-year project to examine biological impacts, oil fate and transport processes, and oil detection in the Great Lakes. Directed by Ashley Moerke and Michael Twiss, ICOR has three research networks involving over 20 international researchers. These networks include Biological Impacts of Oil, Oil Particle Interactions, and Monitoring and Detection of Oil in Our Waters of the North, all under the focus of Our Waters of the North. The goals are to advance understanding of oil spill detection, impacts, and response in Great Lakes water by building infrastructure, training early career professionals, and increasing the science available to guide decision making.

Some examples of current collaborative research efforts include construction of an outdoor experimental tank facility at the Center for Freshwater Research and Education at Lake Superior State University to conduct food web experiments (see photo, previous page); ecotoxicology experiments of fish exposed to oil and measured at realistic conditions using sensitive physiological parameters (olfaction, behavior, and cortisol expression) at Algoma University; measurements of microbial community composition and function when exposed to oil at the Great Lakes Institute for Environmental Research, University of Windsor (see page 26); studies of oil aggregate formation and the microbiome of oil-degrading microbes at Memorial University of Newfoundland and United States Geological Survey; and autonomous vehicle and sensor development for oil detection under ice at the University of Windsor, NOAA, and Limnotech.

The International Consortium of Oil Research is an international group of aquatic ecologists, limnologists, ecotoxicologists, microbial ecologists, physiological ecologists, and mechanical and environmental engineers examining the potential impact of oil spills in the Great Lakes region, seen here at an ICOR workshop in March 2024.

Ultimately, this research will support discussions of the risk inherent with economic activity on the lakes that involve oil. These important discussions will depend on data collection and analysis, knowledge of risk and its mitigation, foresight to recognize threats well before their impact, and ways to alert our responders and communities so correct actions can take place.

Michael Twiss is a professor of biology at Algoma University. Ashley Moerke is the dean of the College of Great Lakes Ecology and Education and executive director of the Center for Freshwater Research and Education at Lake Superior State University.

Leading Response Research

The U.S. Coast Guard Great Lakes Oil Spill Center of Expertise

BY ALISON GATES & ALLISON SNIDER

THE U.S. COAST GUARD Great Lakes Oil Spill Center of Expertise (GLCOE) stands at the forefront of oil spill research in the Great Lakes, bridging the gap between scientific innovation and practical application and playing a pivotal role in safeguarding these vital freshwater resources. The GLCOE was established through the Frank LoBiondo Coast Guard Authorization Act of 2018. This legislative mandate tasked the GLCOE, a non-operational unit, with conducting vital research and training focused on oil spill response in freshwater and ice-laden environments.

Cadets Maddie Greene and Jacey Tippman reviewed Shoreline Cleanup Assessment Technique protocol and learned about spill response with GLCOE's Chief Warrant Officer Joe Torcivia.

The GLCOE has two primary objectives: 1) **Scientific Leadership**: to serve as a hub of scientific expertise that transitions cutting-edge research and technology into practical field applications; and 2) **Knowledge Repository**: to function as a knowledge base and research coordinator that addresses gaps in oil spill response knowledge specific to the Great Lakes region.

Housed at Lake Superior State University (LSSU) in Sault Ste. Marie, Michigan, and the National Oceanic and Atmospheric Administration's (NOAA) Great Lakes Environmental Research Laboratory in Ann Arbor, Michigan, the GLCOE benefits from its co-location with these prominent institutions. This strategic positioning fosters collaboration with regional partners and a diverse network of researchers.

Achievements & Collaborations

One of the first tasks the GLCOE completed was to charter a comprehensive analysis of oil spill risks and response capabilities in the Great Lakes region, conducted by RAND (see page 20). Since the GLCOE's founding and the completion of this report, the unit has made significant strides:

- Collaborated with over 20 principal investigators across various disciplines
- Engaged with five countries and 26 states
- Trained more than 40 regional responders
- Acquired multiple unmanned aerial systems and remotely operated vehicles for real-world exercises and responses
- Funded over 30 research projects, allocating more than US$4 million to initiatives involving academia, industry, non-profits, and federal and international partners

Annual Funding Opportunities

Each spring, the GLCOE announces its funding opportunities, allocating approximately US$2 million for various research projects, with individual proposals capped at US$250,000. Recent research themes have included freshwater oil spill preparedness, freshwater oil spill response, application of alternative response measures in freshwater environments, and fundamental research on freshwater oil spill science and response technology. Each project undergoes a rigorous peer and scientific review process before being submitted to the Project Selection Committee for final approval.

Innovative Research Projects

The GLCOE supports a diverse range of research initiatives, from foundational science to advanced, near-deployable technologies. Notable projects include:

- **Oil Detection Methods**: Exploring techniques such as oil detection canines, electromagnetic interference, and acoustic monitoring
- **Oil Weathering Studies**: Investigating how oil behaves and degrades in freshwater environments
- **Responder Training Tools**: Developing resources like short-range uncrewed aerial systems training protocols and response guides for icy conditions

Community Engagement and Education

In addition to research, the GLCOE is committed to outreach and educational initiatives. Efforts include interactive oil spill education games during the Soo Locks Engineers Day and classroom outreach to regional high school and college students. Looking ahead, the GLCOE plans to host regional community oil spill response workshops twice a year.

The center has initiated a U.S. Coast Guard Academy (USCGA) cadet summer internship program at LSSU for the past two years. These internships aim to enhance cadets' education while fostering collaboration with researchers across academia, government, and nonprofit sectors.

Recent Projects and Future Directions

This past summer, USCGA cadets collaborated with LSSU researchers on a molecular ecology project investigating the impacts of marine diesel on native microbial communities in the sediments of St. Marys River. This project serves as a precursor to a larger-scale mesocosm study at LSSU's Center for Freshwater Research and Education. Funded by the Canadian Multi-Partner Research Initiative, the forthcoming project will simulate Great Lakes wetlands in mesocosm tanks, enabling researchers to study various ecological responses to oil contamination.

Cadets Jacey Tippman (front) and Maddie Green (back) prepare sediment jars and oil to test the impacts of marine diesel on microbial communities.

The cadet-led project provided critical insights into sediment microbiomes and their responses to diesel, laying the groundwork for the larger mesocosm research and informing future oil spill response strategies.

Preliminary analysis shows that some taxa decrease in abundance after diesel exposure, while others appear to thrive despite the contamination. The research team is especially interested in groups that have previously been documented to break down hydrocarbons, such as *Pseudomonas*, *Aquabacterium*, and *Novosphigobium*, which were detected in the sediment samples and seemed undeterred by diesel.

Ongoing analyses aim to link this bacteria community response with the chemical profile of the oil throughout the experiment, which was measured by LSSU researchers during the project.

For more information about the GLCOE, including future funding opportunities and ongoing projects, please visit our website.

Lieutenant Alison Gates is the executive officer of the GLCOE in the Ann Arbor, Michigan, office. Allison Snider is a civilian research scientist in the GLCOE's Sault Ste. Marie office.

Innovating Environmental Solutions for a Cleaner Future

Concordia Oil Spill Research Group responds to oil spills and protects freshwater ecosystems

BY CHUNJIANG AN & ZHENG WANG

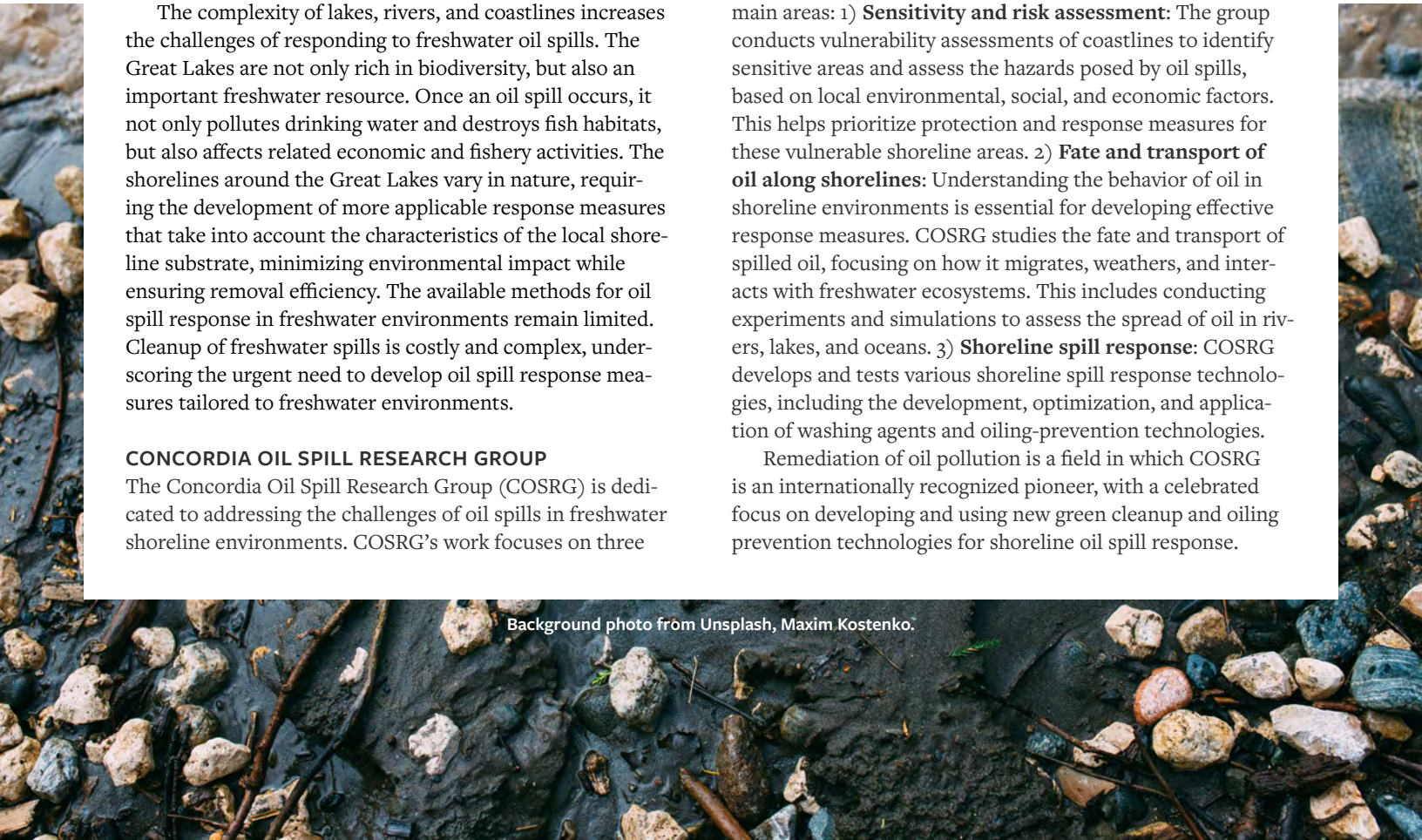
THE RISK OF OIL SPILLS is increasing with the rise in oil-related activity. Canada and the United States have extensive oil pipelines and shipping routes, including those that pass through the Great Lakes and surrounding freshwater environments, putting the Great Lakes ecosystem at risk of oil spills. The 2010 Kalamazoo River oil spill in Michigan was one of the largest inland oil spills in U.S. history, with more than 840,000 gallons (3,180 m^3) of crude oil flowing into Talmadge Creek and subsequently into the Kalamazoo River. The spill contaminated at least 35 miles (56 km) downstream on the river, as well as floodplain and upland areas, causing significant damage to local ecosystems.

The complexity of lakes, rivers, and coastlines increases the challenges of responding to freshwater oil spills. The Great Lakes are not only rich in biodiversity, but also an important freshwater resource. Once an oil spill occurs, it not only pollutes drinking water and destroys fish habitats, but also affects related economic and fishery activities. The shorelines around the Great Lakes vary in nature, requiring the development of more applicable response measures that take into account the characteristics of the local shoreline substrate, minimizing environmental impact while ensuring removal efficiency. The available methods for oil spill response in freshwater environments remain limited. Cleanup of freshwater spills is costly and complex, underscoring the urgent need to develop oil spill response measures tailored to freshwater environments.

CONCORDIA OIL SPILL RESEARCH GROUP

The Concordia Oil Spill Research Group (COSRG) is dedicated to addressing the challenges of oil spills in freshwater shoreline environments. COSRG's work focuses on three main areas: 1) **Sensitivity and risk assessment**: The group conducts vulnerability assessments of coastlines to identify sensitive areas and assess the hazards posed by oil spills, based on local environmental, social, and economic factors. This helps prioritize protection and response measures for these vulnerable shoreline areas. 2) **Fate and transport of oil along shorelines**: Understanding the behavior of oil in shoreline environments is essential for developing effective response measures. COSRG studies the fate and transport of spilled oil, focusing on how it migrates, weathers, and interacts with freshwater ecosystems. This includes conducting experiments and simulations to assess the spread of oil in rivers, lakes, and oceans. 3) **Shoreline spill response**: COSRG develops and tests various shoreline spill response technologies, including the development, optimization, and application of washing agents and oiling-prevention technologies.

Remediation of oil pollution is a field in which COSRG is an internationally recognized pioneer, with a celebrated focus on developing and using new green cleanup and oiling prevention technologies for shoreline oil spill response.



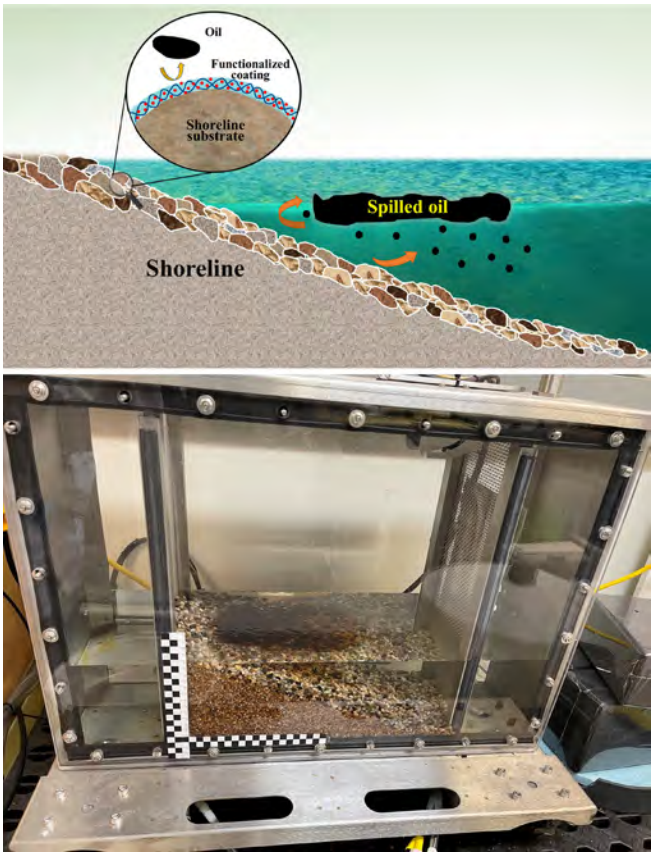
Background photo from Unsplash, Maxim Kostenko.

COSRG is an internationally recognized pioneer, with a celebrated focus on developing and using new green cleanup and oiling prevention technologies for shoreline oil spill response.

These agents are made from biodegradable, low-toxicity, and environmentally friendly materials. Our comprehensive framework for selecting washing agents systematically considers multiple critical environmental and technical factors related to shoreline oil spill response. Our laboratory protocol for testing surface washing agents facilitates interlaboratory comparison, and our invited policy brief in *The Hill Times* outlines new directions for the future development of oil spill response technologies.

In a recent study, COSRG developed a bio-based coating technique using calcium alginate and cellulose nanocrystals for oil spill emergency response and oiling prevention, minimizing the impacts of spilled oil in coastal areas. This eco-friendly, biodegradable method imparts special wetting properties to shoreline substrates to improve oil pollution control. Additionally, a shoreline tank system was set up in the lab to assess the performance of coated gravel (see figure at right and page 8). The results demonstrated that the coating technique caused more stranded oil to float on the water's surface, reduced oil retention on the shoreline, and minimized subsurface disturbance. The proposed coating method is suitable for shorelines with large substrates and low permeability (e.g., bedrock shorelines). Additionally, it can be applied to a variety of surfaces such as docks, ports, and concrete structures. Shoreline cleanup is expected to become much easier and more effective once this method is deployed, reducing the need for heavy machinery and toxic chemicals.

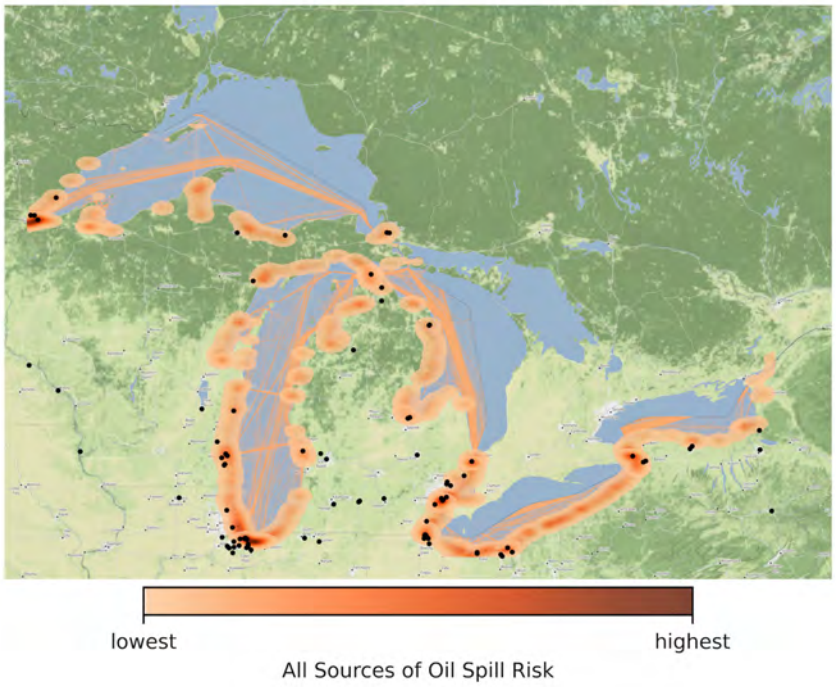
COSRG currently comprises five faculty members, three postdoctoral fellows/research associates, one laboratory technician, and more than 20 graduate students. The COSRG laboratory is equipped with state-of-the-art analytical instruments and pilot-scale equipment. COSRG's research covers a variety of areas related to oil spills, including spill response, pollution control, hazardous waste treatment, pollutant transport, environmental risk assessment, and sustainable solutions. Its projects are funded by major federal and provincial agencies and are carried out in collaboration with over 30 national and international institutions and industrial partners. For example, COSRG is currently leading projects funded by the Multi-Partner Research Initiative under Canada's Oceans Protection Plan, which fosters collaboration among leading experts to identify research gaps and priorities, improve our understanding of aquatic oil spills and their impact on aquatic organisms, develop new technologies and protocols for cleanup, and support science-based decisions that minimize environmental impacts and aid habitat recovery.



Top: Schematic diagram of bio-based coating on shoreline substrate for oiling prevention. Bottom: Shoreline simulation tank test showing the release of stranded oil from coated gravel after immersion in water. Photo by Huifang Bi.

In the past five years, COSRG has published over 280 journal articles and trained more than 70 highly qualified personnel. In 2022, COSRG organized the International Oil Spill Science Conference in Halifax, in collaboration with Fisheries and Oceans Canada, which brought together global experts to discuss oil spill science and technology. COSRG also emphasizes equity, diversity, and inclusion in its research and collaborates with Indigenous communities, such as the Snuneymuxw and Simpcw First Nations, to address their spill response concerns.

Chunjiang An is an associate professor in the Department of Building, Civil, and Environmental Engineering at Concordia University, and Concordia University Research Chair in Spill Response and Remediation. Zheng Wang is a postdoctoral fellow at Concordia University.



Heatmap of possible oil spill risk sources showing oil and petroleum product sources within five miles of the coast of the Great Lakes. The dots represent approximate locations of oil spill response organizations.

Oil Spill Risks & Response Capabilities

An overview of the Great Lakes region

BY ALEXIS LEVEDAHL & JO CAULKINS

OIL AND PETROLEUM PRODUCTS are both sourced from and moved through the Great Lakes region, presenting an ever-present risk of oil spills. While the Coast Guard and private companies are well positioned to respond to spills, updated response strategies focusing on enhanced communication and public education could lessen potential impacts.

The Great Lakes, which cover more than 95,000 square miles across the U.S. and Canada, are a hub of commercial and recreational activity and a major source of freshwater for both countries. The Great Lakes Oil Spill Center of Expertise (GLCOE), within the U.S. Coast Guard (USCG) Office of Marine Environmental Response Policy, was established in 2022 to conduct research and training activities relevant to oil spills in freshwater and ice-laden environments. To support its mission, the GLCOE asked RAND's Homeland Security Operational Analysis Center to assess the risk of oil spills in the Great Lakes region and to examine oil spill response capabilities to identify any preparedness gaps. Our report focused on U.S.-based risks and U.S.-based preparedness.

At left, an ice cutter chainsaw sled creating a space for oil to collect. At right, oil between the water and ice collects in the trench for easier clean-up. Source: ECRC, Cold Weather Training Document, provided to authors, 2023.

Oil spills are less frequent in the Great Lakes region than in other coastal U.S. locations. Data from the USCG's National Response Center show that approximately 1,300 oil and petroleum product spills occurred in the Great Lakes area between 2013 and 2019. There are many sources of oil spill risk throughout the region, including oil and petroleum products moved via pipelines, railcars, vessels, and tanker trucks. The region is also home to numerous petroleum refineries and oil wells (see figure on previous page).

Three primary techniques are available to track and respond to oil spills: monitoring using technology such as remote sensing equipment or unmanned aerial vehicles, mechanical techniques like the use of skimmers or sorbents, and non-mechanical techniques like in-situ burning and using chemical agents. The Great Lakes are at a disadvantage regarding oil spill response techniques because much of the available research is focused on the saltwater environment. As a result, some knowledge gaps exist about the impacts and effectiveness of freshwater oil spill cleanup techniques.

Several characteristics of the Great Lakes region make oil spill response unique and challenging. The Great Lakes are freshwater, a source of drinking water, and contain numerous unique and sensitive habitats for wildlife, including aquatic, forest, marsh, wetland, and dune ecosystems. Techniques such as in-situ burning or the use of chemical agents are not currently permitted or regarded as viable techniques, both because of the limited research about their use in freshwater systems and the impacts they could have on these sensitive environments. The ostensibly enclosed environment of the Great Lakes also means that oil and petroleum products could take many years to dissipate naturally.

The USCG's approaches to oil spill response have largely focused on oil spills that occur in saltwater. This has some benefits; for example, their preparedness to cover ocean distances means that they can easily cover distances required in the Great Lakes. However, this also means they have focused on what occurs at sea rather than on other scenarios that may occur in the Great Lakes region.

Another challenge is in understanding how to respond to oil spills in icy conditions. While Canadian response organizations are prepared and practiced in oil spill response on ice (see photos above), U.S. response organizations have fewer ice response capabilities. Finally, many oil-spill scenarios developed as part of oil spill response planning include both Canadian and U.S. response organizations. While clear plans are in place for international coordination, an international response is still more complicated than a domestic response.

Despite the numerous risks and gaps outlined above, we found the USCG and U.S.-based oil spill response organizations (OSROs)—private companies that are overseen by the USCG and own and operate the majority of oil spill response equipment in the Great Lakes region—are very well prepared and positioned to respond to oil spills in most Great Lakes area locations (see figure on previous page). In addition, we found that given their current resources and the breadth of their responsibilities, overall the USCG is well prepared to respond to a spill.

Even though preparedness measures are in place, an oil spill in the Great Lakes region would still be a significant problem, both because of the potential direct impact to the environment, and because of public perceptions surrounding that impact. There are a few things the response community could do to improve their ability to respond to future spills.

Developing response scenarios collaboratively and systematically within the response community could help identify additional gaps in response capability and capacity. We also suggest the response community focus on improving communication and information sharing across stakeholders and educating the public on oil spill response approaches and procedures. As the GLCOE matures, it could play a key role in facilitating public communications and collaboration among stakeholders.

Alexis Levedahl and Jo Caulkins are technical analysts at RAND, a nonprofit, nonpartisan research institution. Both authors contributed to RAND's report *Great Lakes Oil Spill Response Capabilities Evaluation*.

The Impact of Regulation on Oil Spill Response

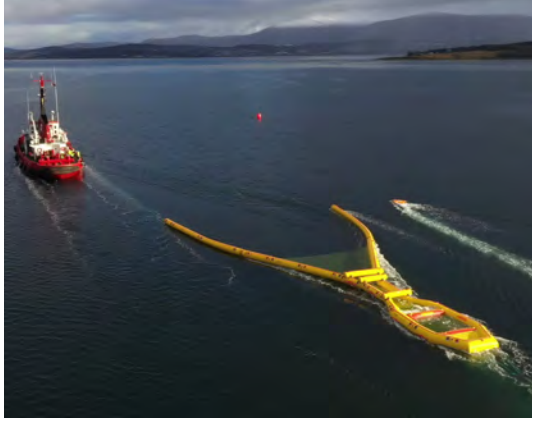
A perspective from an oil spill removal organization

BY JOSH CLIFFORD

IN RECENT DECADES, the landscape of oil spill response in the United States has undergone significant transformation, largely shaped by regulatory frameworks designed to minimize environmental damage. The U.S. Oil Pollution Act of 1990 stands out as a pivotal piece of legislation, catalyzing improvements in spill prevention and response capabilities. While these regulations have undoubtedly led to a reduction in the frequency and severity of oil spills, they also have presented new challenges, particularly in terms of workforce qualifications and the retention of institutional knowledge within oil spill removal organizations (OSROs).

The Oil Pollution Act was a direct response to the *Exxon Valdez* disaster of 1989 and was designed to enhance the nation's ability to prevent and respond to oil spills. The legislation instituted stricter regulations on oil spill preparedness and response, requiring facilities and vessels to develop and implement spill response plans. This framework has fostered a culture of compliance and accountability, ultimately resulting in fewer spills nationwide.

Oil spill response in Silver Bay, Minnesota. The response took place beginning May 29, 2024, at the Silver Bay Marina. Nearly 400 gallons of diesel was spilled into Lake Superior during fueling operations (fuel transfer).


Modern spill response technologies: At left, the heavy-duty Sea Sentry Oil Containment Boom is resilient to oils, chemicals, UV light, weathering, and abrasion and is used by the largest oil spill response organizations around the world as well as the U.S. Navy and Coast Guard. The NOFI Current Buster High Speed Oil Containment system (center) has the unique ability to contain, collect, decant, and store oil collected from the water surface into a smaller holding area, known as the separator. This results in a thicker layer of oil that can be more efficiently pumped on board vessels or into storage tanks. This system has a higher rate of oil recovery than other boom systems, as it can be towed at speeds up to 5 knots. At right, the Foilex Twin Disc Screw Technology can effectively recover a wide range of products from the lightest diesel fuel to extremely high-viscosity crude oils, even when mixed with debris.

In the Great Lakes, the Great Lakes Geographic Annex (CANUSLAK Plan) plays a pivotal role to ensure effective spill response in this unique ecosystem—a vital ecological and economic resource that faces unique challenges in oil spill response. The five lakes and their watersheds represent one of the largest freshwater ecosystems in the world, essential for biodiversity and the livelihoods of millions. Yet much of its infrastructure is aging, and the vessels navigating these waters are generally not equipped with the latest spill response technologies. In addition, although encouraging, the reduction in spill frequency has led to concerns over the experience and preparedness of response personnel, making the need for enhanced training and skill retention particularly acute.

These realities underscore the need for robust preparedness and cross-border cooperation. The CANSULAK framework guides cooperation between the U.S. and Canada, recognizing the need for a coordinated response to incidents that could impact both nations. The plan outlines clear protocols for resource sharing and operational collaboration, essential for managing spills that do not recognize political boundaries.

The effectiveness of this proactive, collaborative, cross-border approach relies heavily on qualified regional oil spill removal organizations (OSROs) equipped with state-of-the-art technology. Operating companies are stepping up to meet these challenges through substantial investments in these modern spill response technologies (see photos above). Innovations such as NOFI Current Busters (a high-speed containment system developed for the North Sea in Norway), Foilex skimmers (a viscous oil skimmer and pump system), and Sea Sentry booms (an open-ocean class oil containment boom) are being deployed to protect critical areas such as the Straits of Mackinac in Lake Michigan-Huron and the Twin Ports in Lake Superior. These technologies enhance the ability to contain and recover spilled oil, providing a crucial line of defense in the event of a spill.

As companies invest in advanced spill response solutions, the role of qualified regional OSROs becomes increasingly vital. These local organizations are integral to the infrastructure for oil spill response in the Great Lakes. OSROs must possess not only the necessary expertise but also the local knowledge required to navigate the unique challenges posed by this vast ecosystem. Their understanding of regional dynamics, environmental sensitivities, and logistical considerations enhances their ability to respond swiftly and effectively to incidents. OSROs must operate at a level of preparedness that not only meets but exceeds industry standards.

As spill incidents become less frequent, the need for a well-trained and experienced workforce remains critical. OSROs in the Great Lakes region must prioritize comprehensive training programs that not only comply with regulations but also simulate real-world exercises with conditions specific to the Great Lakes—such as weather variability, ice cover, and varying depths—to better prepare responders for actual events. This includes using advanced technologies, which help personnel become proficient in their operation and maximize response efficiency.

In addition to technical training, industry partners, OSROs, and other stakeholders should collaborate to implement mentorship programs that facilitate knowledge transfer from seasoned responders to newer responders. Retaining institutional knowledge is vital for maintaining a high level of operational readiness, especially in a region where environmental conditions can vary dramatically.

As we look toward the future of oil spill response in the Great Lakes, the role of qualified regional OSROs cannot be overstated. Their expertise, combined with investments in state-of-the-art technology, positions them to effectively protect this vital ecosystem. By fostering collaboration, enhancing training programs, and retaining institutional knowledge, we can ensure that the Great Lakes remain safeguarded for generations to come.

Josh Clifford is vice president of emergency response at QT Environmental, Inc., a global response organization headquartered in Watertown, Minnesota, with regional bases around the Great Lakes.

A Look Back

A chronology of oil spills in the Great Lakes basin

THE WATERS OF THE GREAT LAKES BASIN supported the growth of North America's industrial heartland throughout the 19th and 20th centuries. Its rivers served as "working rivers for commerce and industrial manufacturing" (Hartig 2010), and pollution was seen as "an acceptable sign of progress" (Adler 2002). The 1948 Detroit River and 1952 Cuyahoga River photos below illustrate this time in our history.

Jonathon Adler paints a compelling picture of this era in his account of the Cuyahoga River. With 20 refineries in the Cleveland area by the mid-1800s, large volumes of the unusable fraction of refined crude were often dumped into the river. He quotes John D. Rockefeller, who owned one of the refineries, as stating, "We used to burn it for fuel in distilling the oil, and thousands and hundreds of thousands of barrels of it floated down the creeks and rivers, and the ground was saturated with it, in the constant effort to get rid of it."

The river caught fire multiple times between the mid-1800s through 1969. Although not the only river to catch fire in the basin (see Hartig's Burning Rivers), nor the largest fire on the Cuyahoga (that was the 1952 fire pictured here), the 1969 fire gained national attention from an article in *Time* magazine and is credited with helping to launch the environmental movement.

Concerns over extensive pollution led to the passage of multiple state, provincial, and federal laws over time. These include the Clean Water Act and the U.S.-Canada Great Lakes Water Quality Agreement in the 1970s, and the Oil Pollution Act of 1990 (OPA 90).

The *NEPCO 140* grounding, pictured below, right, helped to make the case for passage of OPA 90. The U.S. Congress passed the legislation in response to the *Exxon Valdez* oil spill in 1989 as an amendment to the Clean Water Act of 1972. As stated in a case study by the U.S. Coast Guard, "The need to reduce the affected area should be paramount to all other considerations in a spill such as this. The problems encountered in this spill should clearly motivate both government agencies and private concerns to plan for and provide all that is necessary to be as prepared as possible for an incident of this nature."

AN ERA OF "WORKING RIVERS"

Credit: Bentley Historical Collection, Jack Van Covering Papers.

DETROIT RIVER 1948

In 1948, much of the river froze over during a particularly cold winter, driving over-wintering birds to spots of open water filled with oil from industries lining the shores. As a result, 11,000 ducks and geese died from the oil pollution. (Hartig 2010). A Michigan conservation officer is shown here with oil-soaked ducks from the river.

Credit: Cleveland State University. Michael Schwartz Library. Special Collections.

CUYAHOGA RIVER 1952

That year saw the largest fire on the Cuyahoga River in Cleveland, Ohio. A two-inch thick oil slick on the river ignited near a shipyard, resulting in an estimated US$1.5 million of damage to boats, a riverfront office building, and the Jefferson Avenue bridge (Adler 2002).

Photo courtesy of Save The River.

ST. LAWRENCE RIVER 1976

In June 1976, the tug barge *NEPCO 140* ran aground in the Upper St. Lawrence River, spilling 300,000 gallons (1,135 m^3) of crude oil that was poorly contained and spread along 80 miles (130 kilometers) of the river, contaminating shoreline marshes and killing innumerable fish, birds, and wildlife. It is one of the largest oil spills in the United States. The photo shows the barge spilling oil off Mason Point in the Thousand Islands.

OPA 90 holds polluters responsible for cleaning up oil spills and restoring the environment. It fundamentally changed oil spill response, with companies that move or store large volumes of petroleum products improving their measures to prevent oil spills and developing emergency plans that include routine training exercises.

More recently in the Great Lakes, the focus has shifted to understand the risk from spills in inland waters and to develop strategies and tools that will mitigate that risk in freshwater environments.

While inland oil spills typically receive less attention than those in marine environments, they are common, with more than 2,000 on average taking place each year in the continental United States, according to an expert panel report on oil spills (Lee et al., 2015). "Although freshwater spills tend to be smaller volumes than their marine counterparts, they can have a greater potential to pose risks to the environment because of the greater likelihood that they occur within populated areas close to waterbodies with much less dilution and dispersion capacity and involve shorelines that are often immediately adjacent to or directly impacted by the spill."

There are many practical lessons learned from historical case studies. Oil spill science is a rapidly developing field with many unanswered questions, as the articles in this issue of *Lakes Letter* attest. Current multi-disciplinary research studies (e.g., toxicology, chemistry, hydrodynamics, genomics, environmental engineering, etc.) and the development of predictive models will improve our understanding of natural recovery, the long-term impacts of oil spills, and the effectiveness and/or detrimental effects of active remedial strategies in freshwater environments. This integrated approach will provide the scientific evidence needed to support site- and time-specific decisions to select the most appropriate oil spill response strategy to apply to protect our waters and its living resources.

KALAMAZOO RIVER 2010

In July 2010, a pipe carrying heavy crude oil ruptured, releasing oil into Talmadge Creek, which feeds into the Kalamazoo River. At least 840,000 gallons (3,180 m^3) of crude oil spread along 38 miles (61 kilometers) of this Lake Michigan tributary in southwest Michigan, making this one of the largest inland oil spills in the United States. More than 1,560 acres of shoreline habitat, as well as floodplain and upland areas were affected, injuring birds, mammals, reptiles, and other wildlife. Sections of the river remained closed for several years. The spill cost Enbridge, the company that operates the pipeline, more than US$1.2 billion to clean up. This collection of photos from the Environmental Protection Agency's album EPA's Response to the Enbridge Oil Spill in Michigan captures some of the impacts of the spill. The photos, from top to bottom, show 1) Oiled vegetation upstream of Ceresco Dam; 2) Cleanup crews removing oil and contaminated materials from the Talmadge Creek stream bank near Marshall, Michigan; 3) A volunteer preparing to clean oil from the feathers of a heavily-oiled Canada goose at the Wildlife Rehabilitation Center in Marshall; and, 4) Oil-stained grass in a wetland area of the Kalamazoo River.

SMALLER SPILLS ADD UP

We've come a long way since the days when oil pollution was considered an acceptable price to pay for economic progress. As these photos illustrate, small spills still occur in the Great Lakes and can impact the environment, communities, and economies. The photo at far right shows the tug *Ann-Marie* sinking in the Saginaw River in Bay City, Michigan (December 2010), and the adjacent photo shows the Suncor Energy Sarnia Refinery diesel spill response in the St. Clair River (August 2022). Spills such as these may go unnoticed to all but the community that is directly impacted, and efforts are underway in the Great Lakes to strengthen community preparedness through education and outreach.

Photos courtesy of QT Environmental, Inc.

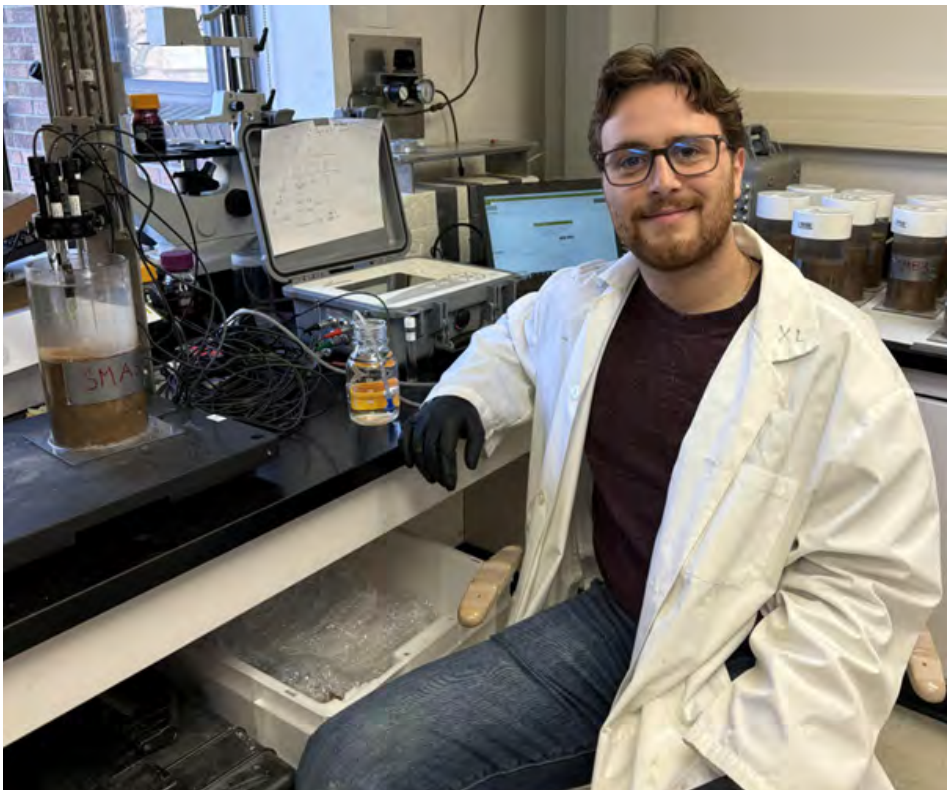
RESEARCH BRIEFS

Can freshwater microbes help clean up oil contamination in the Great Lakes?

RESEARCHERS AT THE UNIVERSITY OF WINDSOR are exploring the role of freshwater microbes in the growing threat of large-scale oil contamination within the Great Lakes. Peter Jobin, an environmental science graduate student at the University of Windsor's Great Lakes Institute of Environmental Research (GLIER) is investigating the hydrocarbon-degrading potential of natural microbial communities across freshwater Great Lakes habitats and tributaries and cataloguing the impacts on critical biogeochemical cycles (e.g., nitrogen, carbon, and phosphorus) that constitute these environments.

Funded by Natural Resources Canada and working with Chris Weisener and Mike McKay of GLIER, Jobin is part of a transnational group of researchers led by Ashley Moerke, dean of the College of Great Lakes Ecology and Education and executive director of the Center for Freshwater Research and Education at Lake Superior State University, and Michael Twiss, biology professor at Algoma University (see page 14). The group includes additional partners from Memorial University, the U.S. Coast Guard Great Lakes Oil Spill Center of Expertise, and the Bay Mills Indian Community.

The natural defense against oil spills and complex hydrocarbon organic compounds (e.g., naphthalene and polycyclic aromatic hydrocarbons) is often attributed to the metabolic potential of local communities of oil-degrading microorganisms found within the water and underlying sediment. Research will focus on the microbial functional potential for species capable of metabolizing hydrocarbons and will apply omics-based approaches (metagenomics and metatranscriptomics) and novel microsensor techniques. The Weisener group will characterize novel gene pathways during hydrocarbon degradation (alkB), as well as monitor changes to key genes within the nitrogen cycle (amoA) across these various Great Lakes waterways. This research has implications for policy makers and the public, helping to guide decisions on oil spill response and pollution control in the Great Lakes.



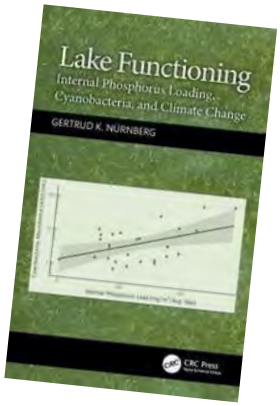
Graduate student Peter Jobin in the lab at the University of Windsor, Great Lakes Institute of Environmental Research.

By Chris Weisner, professor of geomicrobiology and environmental chemistry, and Peter Jobin, environmental science MSc candidate, at the University of Windsor, Great Lakes Institute of Environmental Research.

This research has implications for policy makers and the public, helping to guide decisions on oil spill response and pollution control in the Great Lakes.

New book looks at phosophorus, cyanobacteria, and climate change

Lake Functioning: Internal Phosphorus Loading, Cyanobacteria, and Climate Change explores the interconnections of internal phosphorus loading, cyanobacteria, and climate change and their role in determining water quality in freshwater. The book, by Gertrud K. Nürnberg, explains the sometimes elusive process of internal phosphorus loading with its chemical and biological roots.



A primer in cyanobacteria ("blue-greens") provides the background to investigate connections and causal relationships. Reviewing recent observations on present and future climate change, the book explores its effects on lake functioning. Quantitative and theoretical evidence support the hypothesis that a major contributing factor to the recent increase in cyanobacteria bloom expansion and frequency is the initiation and persistence of internal P loading as intensified by climate change. The final chapter addresses the abatement and prevention of cyanobacteria proliferation using techniques that address internal P loading. Academic teachers can get an evaluation copy. Others can use code AFLY04 for 20% off when ordering directly from the publisher through March 31, 2025.

An environmental history of Lake Ontario

The Lives of Lake Ontario: An Environmental History by Daniel Macfarlane details the lake's relationship with the Indigenous nations, settler cultures, and modern countries that have occupied its shores. He examines the myriad ways Canada and the U.S. have used and abused this resource: through dams and canals, drinking water and sewage, trash and pollution, fish and foreign species, industry and manufacturing, urbanization and infrastructure, population growth and biodiversity loss. Serving as both bridge and buffer between the two countries, Lake Ontario came to host Canada's largest megalopolis. Yet its transborder exploitation exacted a tremendous ecological cost, leading people to abandon the lake. Innovative regulations in the later 20th century, such as the Great Lakes Water Quality Agreements, have partially improved Lake Ontario's health. McFarlane is an associate professor in the School of Environment, Geography, and Sustainability at Western Michigan University.

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