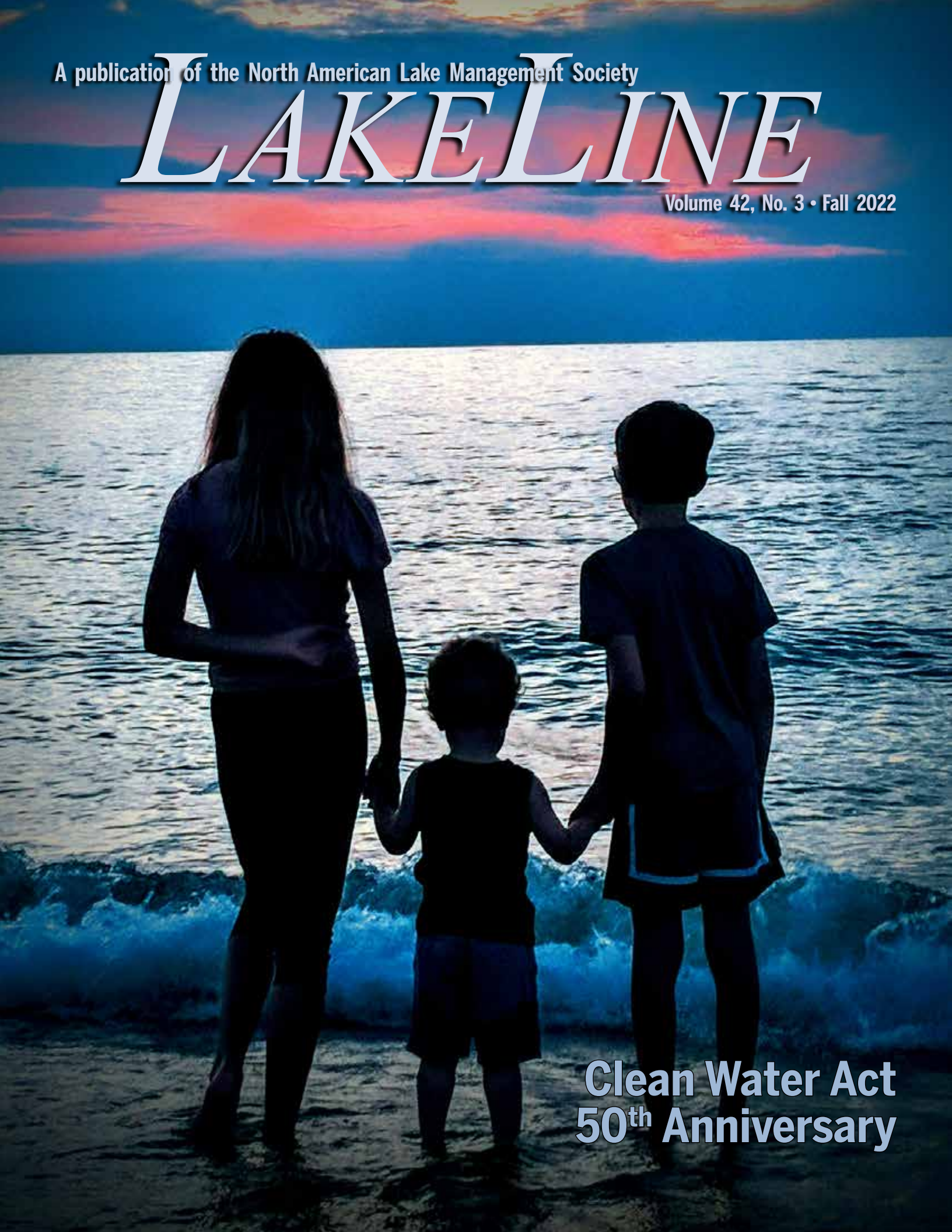
A publication of the North American Lake Management Society

LakeLine

Volume 42, No. 3 • Fall 2022



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42nd International Symposium of the North American Lake Management Society

Leveraging Experience to Manage Diverse Lakes, Landscapes, and People

November 14–17, 2022 • Minneapolis, Minnesota

Photo by Krivit Photography, Courtesy of Meet Minneapolis

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nalms.org/nalms2022

Leveraging Experience to Manage Diverse Lakes, Landscapes, and People

The Dakota (Sioux) homeland Mni Sóta Maḳoce means "land where the waters reflect the clouds." Nicknamed "Land of 10,000 Lakes," Minnesota really has almost 12,000 inland basins covering at least 10 acres, but across the state, they are mostly rural and rather diverse. Deep, oligotrophic waters are typical in northeastern boreal forests near Superior, the world's largest areal, freshwater lake. Shallow, hypereutrophic lakes predominate in southwestern agricultural plains.

With about 30 lakes and 700,000 residents within 64 square miles, the twin cities of Minneapolis and St. Paul reflect some of the challenges of managing Minnesota's urban landscapes. Generations of Dakota (Sioux) called the area's largest and deepest lake Bdé Makhá Ská, but since the 1820s, it had been called Lake Calhoun. In 2018, the federal government officially restored the name, but the Minnesota Court of Appeals in 2019 reversed the state's official designation of the indigenous name. Positioned in this nexus between Minnesota's rural-urban diversities and past-future legacies, Minneapolis hosts the 2022 symposium that focuses on NALMS' more than 40 years of experience.

Tentative Schedule

Monday, November 14
- Workshops
- Field Trips
- Welcome Event

Tuesday, November 15
- Opening Plenary Session
- Technical Sessions
- Exhibits Open
- NALMS Membership Meeting
- Exhibitors' Reception and Poster Session

Wednesday, November 16
- Technical Sessions
- Exhibits Open
- Clean Lakes Classic 5K
- NALMS Awards Reception

Thursday, November 17
- Technical Sessions
- Exhibits Open

#NALMS2022

nalms.org/nalms2022

Contact Information

General Conference, Registration, Exhibitor & Sponsorship Information
NALMS Office • nalms2022@nalms.org • 608-233-2836

NALMS Conference Coordinator
Sara Peel • speel@arionconsultants.com

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Workshops

We will be offering a variety of full- and half-day workshops on Monday, November 14. These workshops provide attendees the opportunity for a more in-depth focus on a topic of interest, and many will provide hands-on experience.

Photo: Todd Tietjen

Alum for Phosphorus Control in Lakes and Ponds
8:00 am – 5:00 pm | $215

Collection, Identification, Ecology, and Control of Freshwater Algae
8:00 am – 5:00 pm | $215

Development of HAB Management and Restoration Plans for Beaches and Marinas
8:00 am – 12:00 pm | $115

Ecology of Cyanobacteria
8:00 am – 5:00 pm | $215

Identification and Ecology of Aquatic Plants
1:00 pm – 5:00 pm | $115

Internal Phosphorus Loading and Cyanobacteria
8:00 am – 5:00 pm | $215

Introduction to R for Aquatic Research
8:00 am – 12:00 pm | $115

Intermediate R for Aquatic Research
1:00 pm – 5:00 pm | $115

The Role of Aeration/Oxygenation in Lake Management
8:00 am – 5:00 pm | $215

Sensor-based regional monitoring networks (RMNs)
8:00 am – 5:00 pm | $215

Stormwater Management for Lake Managers
1:00 pm – 5:00 pm | $115

Visit the conference website, www.nalms.org/nalms2022, for full details. Conference registration is not required to attend a workshop.

Technical Program

Photo: Todd Tietjen

The NALMS 2022 Program Committee has organized an excellent array of presentations on diverse aspects of lakes, ponds, reservoirs, their watersheds, and their many users and inhabitants. Below is a sample of session topics, but please check the symposium website regularly for up-to-date program information.

- Aquatic Invasive Species
- Aquatic Plant Management
- Carp Management
- Chloride
- Climate Change
- Harmful Algal Blooms (HABs)
- Human Dimensions and JEDI in Lake Management
- Lake Management at 40+
- National Lakes Assessment
- Nutrient Management
- Oxygen and DO Management
- Policy and Economics
- Remote Sensing
- Shallow Lakes
- Stormwater
- Urban Lakes
- Wild Rice

Registration Fees

Regular registration rates available until November 4. Add a 2023 membership to your registration and receive 20% off the membership!

NALMS Member: $555 regular / $645 on-site
Non-Member: $655 regular / $745 on-site
Student: $330 regular / $410 on-site
Single Day: $260 regular / $310 on-site
Guest: $290 regular / $360 on-site

Register online at nalms.org/nalms2022

Plenary Speaker

Lakes in a Warming World: Perspectives From Large to Small

Jay Austin
Large Lakes Observatory
University of Minnesota, Duluth

Jay Austin is a physical limnologist specializing in observational approaches to develop a better understanding of physical processes in deep lakes. He has wide-ranging interests across a broad range of temporal and spatial scales, including winter structure and processes, the role of ice, springtime convection, the response of large lakes to climate change, and the impact of physical processes on ecosystem function.

Field Trips

The NALMS 2022 local host committee has organized three field trips in the Minneapolils area on Monday, November 14 highlighting some of the work of local entities. Each workshop is 3 to 4 hours long. Visit the conference website for more details. Space is limited.

Minnesota Aquatic Invasive Species Research Center
8:30 am – 11:30 am | $45

Invasive Fish and Stormwater Pollution Management
1:00 pm – 5:00 pm | $45

St. Anthony Falls Laboratory
1:30 pm – 4:30 pm | $35

Clean Lakes Classic 5k Run/Walk

Photo: Lisa Borre

Need a little mid-symposium physical activity? Strap on your running/walking shoes for the 2022 Clean Lakes Classic 5K Run/Walk! Starting at mid-day on Wednesday, November 16, the 5-kilometer run or walk takes participants on a route along the Mississippi River. You need not be a runner to participate! We make no promises about the weather in Minneapolis in mid-November.

Student members of NALMS who participate in the Clean Lakes Classic are automatically eligible to receive $500 for use toward their education thanks to the **Kenneth H. Reckhow Scholarship Fund**. Visit the conference website for full details.

Photo by Krivit Photography, Courtesy of Meet Minneapolis

Hotel Information

Minneapolis Marriott City Center
30 South 7th Street
Minneapolis, Minnesota

- Room rates are $150/night for single or double occupancy (plus tax)
- Government rate rooms are available at the federal per diem rate.
- The sales tax rate is 8.025% and the lodging tax rate is 3%.
- Conference rates are available 3 days pre/post conference based on availability.
- The hotel does not offer airport shuttle service.
- Complimentary high-speed internet in guest rooms.
- Complimentary 24-hour fitness center access.
- Hotel check in is 4:00 pm and check out is 12:00 pm.
- You may cancel your reservation for no charge up to 2 days before arrival. Please note that the hotel will assess a fee of one night's room and tax charges if you must cancel after this deadline.
- On-site parking is available for $26/day.
- **The conference rate is available until Saturday, October 22, 2022.**

Visit the conference website to reserve your room at the discounted conference rate.

Transportation

The Minneapolis–Saint Paul International Airport (MSP) is served by 17 commercial airlines with non-stop connections to many markets throughout the US.

Airlines

Aer Lingus	Frontier Airlines
Air Canada	Icelandair
Air France	JetBlue
Alaska Airlines	KLM Royal Dutch Airlines
Allegiant Air	Southwest Airlines
American Airlines	Spirit Airlines
Condor	Sun Country Airlines
Delta Air Lines	United Airlines
Denver Air	

The Minneapolis Marriott City Center does not offer airport shuttle service. We recommend that attendees take the Metro Transit Blue Line light rail from MSP to the Nicolett Mall Station and take the short walk to the Minneapolis Marriott City Center.

We hope to see you in Minneapolis!

Photo by Krivit Photography, Courtesy of Meet Minneapolis

UPCOMING IN *LAKELINE*

WINTER 2022: Human-Made Ponds – Whether they were dug for animal watering holes, backyard swimming ponds, excavated out for their soil, or created for stormwater retention and treatment, small human-made ponds dot the landscape. Do you work with human-made ponds and have some data and pond management experiences to share? Please consider submitting an article related to your human-made pond experiences. **Draft articles for the winter issue are due by December 15th, for publication in mid-January.** Articles could cover pond creation, water quality management, plant management, algal management, functional values, and more.

SPRING 2023: Aquatic Invasive Species – This issue of *LakeLine* will highlight topics related to Aquatic Invasive Species (AIS). Articles could include overviews of new or emerging species on the move, evolving management strategies, long-term management projects, the elusiveness of eradication, or even eradication achieved, if there are success stories out there to share. **Articles for the spring issue are due by March 15, 2023, for publication in April 2023.**

SUMMER 2023: Harmful Algal Blooms – Every other summer we like to focus on Harmful Algal Blooms (HABs), and include a range of articles highlighting new data, activities, monitoring techniques, and reporting strategies, among other topics. If you are working on something now related to HABs, consider writing up your work for the summer 2023 issue of *LakeLine*. **Articles for summer 2023 are due June 15th, 2023, for publication in July, 2023.**

Please contact Amy Smagula, LakeLine Editor, with any questions, or to propose an article for one of the above-listed themes. Do you have a topic that doesn't match a theme? That's okay, we can include the article in any of these issues, or use it to build a themed issue. Amy can be reached at lakeline@nalms.org.

LakeLine

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On the cover:
"Familia." Photo submitted by Alex Bosovik, NALMS 2021 Photo Contest.

Advertisers Index

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From the Editor

Amy P. Smagula

In this issue we recognize and celebrate the 50th Anniversary of the Clean Water Act (CWA), which has been instrumental in protecting and improving the quality of the nation's waters since its enactment on October 18, 1972. This important Act provides the framework for regulating pollutant discharges, setting water quality standards, maintaining drinking water standards, providing funds for water infrastructure, and for monitoring, restoration and protection activities, among many other core elements.

For those of us who work in a field of water resources management, the Clean Water Act backs our day-to-day efforts to protect and rehabilitate these aquatic resources. For anyone who lives, recreates, drinks, bathes, or otherwise relies on clean water, the Clean Water Act safeguards our access to clean water. And, for all forms of wildlife that rely on a healthy aquatic environment in which to live or obtain water, the Clean Water Act is important.

The articles that were submitted for this issue cover some of the history of the Clean Water Act, as well as results of monitoring and restoration efforts under the Act. We also learn more about the NALMS 314 Workgroup, seeking to restore funding for an important section under the Clean Water Act.

Our opening article is provided by **Kerry Kuntz**, **Donald Benkendorf**, **Danielle Grunzke**, **Lareina Guenzel**, and **Sarah Lehmann** of the Environmental Protection Agency. In their article they provide a great overview of the milestones of lake monitoring programs under the Clean Water Act over the last 50 years and share an overview of the most recently released results of the 2017 National Lake Assessment.

Former NALMS President, **Matthew Scott**, from Maine, shares some stories of water quality concerns in Maine prior to the Clean Water Act, and talks about the very important role that a Maine congressman played in bringing about the Clean Water Act in 1972.

David Glaser, Elizabeth Moran, James R. Rhea, and **Christopher Gandino** share both the history and a success story on Onondaga Lake in New York, which they cite as having once been called one of the "the most polluted lakes in the United States." Their article discusses monitoring efforts and evaluates the sources of pollutants as well as the mitigation and restoration efforts that have been taking place in the lake over time, recognizing the requirements and values of the Clean Water Act in protecting our aquatic resources.

Kellie Merrell, from Vermont, contributed an article and coordinated a compilation of related pieces about the need for an enhanced Clean Lakes Program, with restored funding to support both diagnostic feasibility studies, as well as lake protection and preservation components. Sidebars from **Ralph Bednarz**, **Fred Lubnow**, **Kellie Merrell and Ginny Garrison**, and from **Tracy Lizotte** provide historic examples of the values of Section 314 funding for lakes and their watersheds. These authors are all members of the NALMS 314 Workgroup, doing a lot of behind-the-scenes work to help restore funding to the Section 314 Clean Lakes Program of the CWA.

Our "Student Corner" article is provided by **Lauren Knose**, who also happens to be the NALMS Student Director. Lauren has prepared a great article on all the benefits and opportunities that NALMS offers for student members in what is really a resource for new and existing student members.

Alexis Johnston, who is an undergraduate student at the University of Cincinnati, also contributes a student article about her work as the NALMS Justice, Equity, Diversity and Inclusion (JEDI) intern this past summer. Her work this summer focused on laying groundwork to ensure that NALMS provides a welcoming experience to all who wish to join and participate. Her article summarizes her work and interactions with the NALMS JEDI committee, and some of the projects she worked on.

Our NALMS President, **Chris Mikolajczyk**, provides some timely updates in his "President's Message," and talks about his experience with the Clean Lake Program in his work and personal life.

Finally, inside these pages you will find information about the upcoming NALMS Annual Symposium to be held in Minneapolis, Minnesota, in a few short weeks. There is also a plug for the NALMS Photo Contest, which will be judged at the conference. Entries are due by October 31, emailed to LLEditor@nalms.org. Finally, if you are someone who enjoys reading peer-reviewed literature and helping authors to hone manuscripts to a high level for publication, you might want to consider becoming the next Editor of *Lake and Reservoir Management*. An advertisement for the position is included in this issue.

Amy P. Smagula is a limnologist with the New Hampshire Department of Environmental Services, where she coordinates the Exotic Species Program and special studies of the state's lakes and ponds.

From Chris Mikolajczyk the President

Happy fall to us all! As the calendar now officially reads fall, Mother Nature really shows off her colors here in Colorado with the aspens achieving their annual golden hue. Soon we'll be skiing again as fall is only about two weeks long in the Rockies (or at least that what it seems like some years). As always, it's an amazing place to be as the animals and trees prepare for the winter with a fervor.

This issue of *LakeLine* highlights the 50th Anniversary of the Clean Water Act (CWA) on October 18th. As lake managers, residents, and overall advocates this Act has meant so much to the quality of the waterbodies of our nation. The Act was first written in 1942 as the Federal Water Pollution Control Act, but the amendments of 1972 overseen by the 1970 formation of the Environmental Protection Agency (EPA) are what we recognize to this day. The Act placed the chemical, physical, and biological integrity of the nation's waters into the hands of the individual states. As part of the Clean Water Act, the Clean Lakes Program was also established in 1972 as Section 314 of the Act, to provide financial and technical assistance to states in restoring publicly owned lakes. The program has funded a total of approximately $145 million of grant activities since 1976 to address lake problems, but there have been no appropriations for the program since 1994. The Section 314 Clean Lakes Program was reauthorized in September 2000 as part of the Estuaries and Clean Water Act of 2000, but no funds were appropriated. Section 319, established in 1987 to address non-point source pollution and develop non-point source management programs, has been the major source of funding with regards to lake and watershed management since. The NALMS 314 working group is currently seeking the restoration of funding specifically to Section 314 of the program to address in-lake concerns such as invasive species, harmful algal blooms, and the effects of climate change, along with the current Section 319 funding, which addresses non-point source watershed management.

The recently released results from the 2017 National Lakes Assessment support the need for an enhanced 314 Clean Lakes Program. The 2017 report indicates that nutrient pollution remains a widespread stressor with almost half of the nation's lakes in poor condition for elevated levels of nitrogen and phosphorus. Similarly, algal biomass, measured as chlorophyll-*a*, was rated poor in 45 percent of lakes, and excess algae associated with hypereutrophic conditions was observed in 24 percent of lakes. The algal toxin microcystin was detected in 21 percent of lakes, and 2 percent of lakes, or approximately 4,400 lakes, exceeded the EPA recreational water quality criterion for microcystin. Past-president Lisa Borre and myself, representing NALMS, were able to meet with the leadership of the EPA's Office of Water and Wetlands this past June to begin to discuss these issues.

The 314 working group has also been developing and implementing a survey or series of surveys to lake managers regarding existing financial resources and existing programs for in-lake management and assisting in the design of the advocacy campaign and developing supportive multi-media products. Multi-media products will include brochures, PowerPoint presentations, information kits, and a compilation of links to resources that will be useful to the campaign. The intent is for these products to be used by lake advocates across the country to campaign for restoring funding to, and enhancing, Section 314 of the CWA. As part of this, a review of the 2022 Government Accountability Office report also occurred and will be a factor in considerations related to those findings.

Coincidentally, in October of 1972, I was a two-year-old toddler, but my parents have told me the story of my first visit to the local park, Mindowaskin Park, located in Westfield, New Jersey. As the story goes, we got out of the family car and as soon as I saw the small waterbody present in the park, Mindowaskin Pond, I made a beeline straight toward it. I never stopped. I ran right off the small stone wall and straight into the water, where my mother proceeded to then rescue me. Word on the street is this is how the Clean Water Act was developed at the United States Environmental Protection Agency (USEPA).

In other NALMS news, the host committee for the annual symposium in Minneapolis is in overdrive for the annual meeting that's just a few weeks away now. Sponsorship and exhibitor opportunities are still available for the upcoming conference. This year's theme: "Leveraging Experience to Manage Diverse Lakes, Landscapes, and People." Early-bird registration has now closed, but registration remains open right up until conference time. There is also the opportunity for some excellent workshops, field trips, and, of course, the technical sessions. Full program and

(From the President, continued on p. 10 . . .)

(From the PRESIDENT, continued from p. 9 . . .)

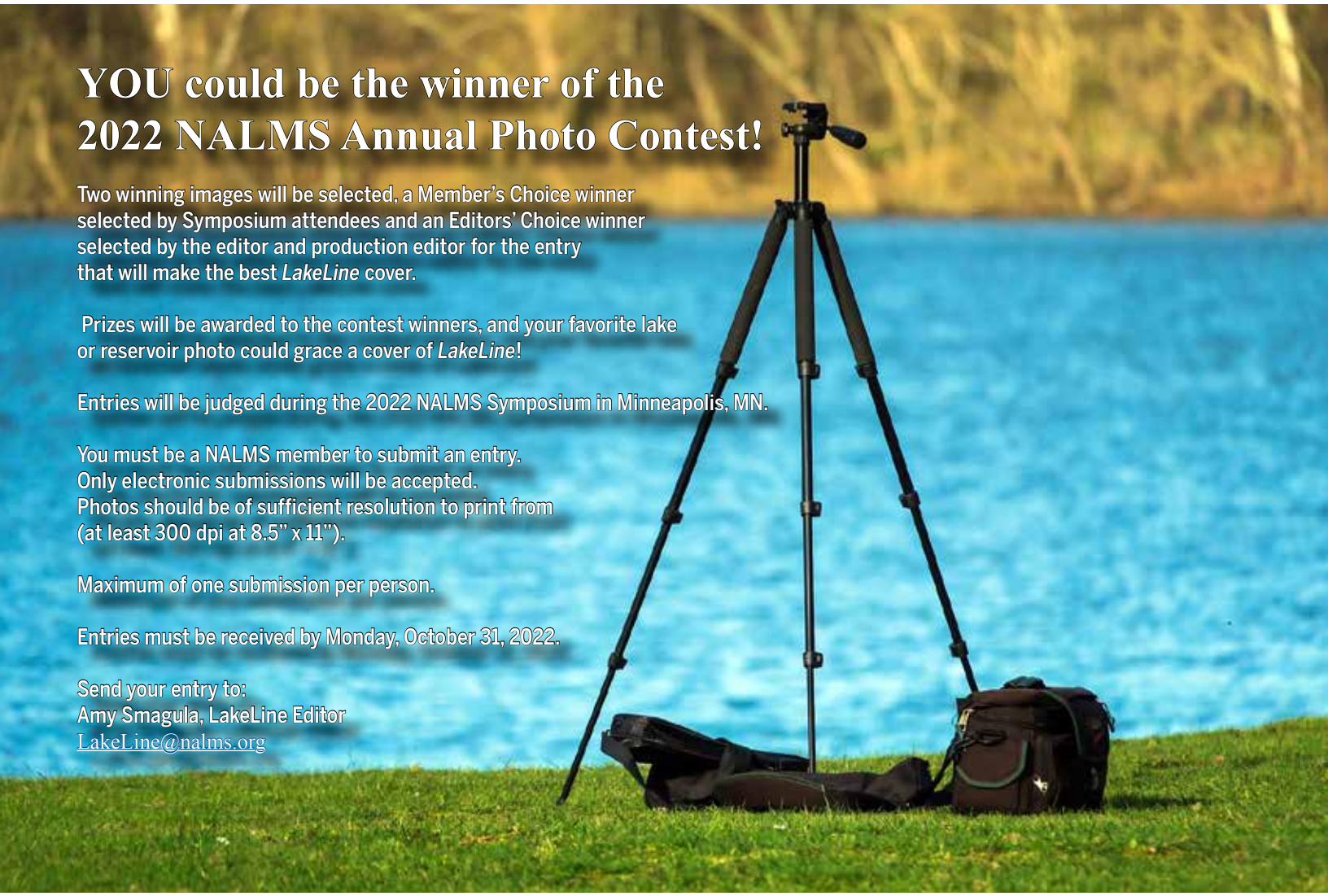
conference details are available on the conference website (https://www.nalms.org/nalms2022/). We are looking forward to welcoming as many of you as possible in Minneapolis.

A reminder to save the date! Please join us for the 13th National Monitoring Conference April 24–28, 2023, in Virginia Beach, Virginia, *and* in a limited virtual setting. This hybrid conference provides opportunities for water stakeholders – federal, state, tribal, and local water professionals; nonprofits, academia, water consultants, and industry; and volunteer and community scientists – to network, develop new skills and partnerships, and exchange information. Keep an eye on https://www.nalms.org/2023nmc/ for full details!

As we are all coming out of our busy field seasons, I wish you all a happy fall. I'm really looking forward to seeing many of you again in Minneapolis. It has been much too long. In fact, this picture of my sister and I was taken at the last in-person NALMS symposium. I'm kidding of course, but this picture does represent what the Clean Water Act has done for me

personally as this picture of two-year-old me was taken pre-Clean Water Act in a formerly heavily industrialized section of the Hudson River in Newton Hook, New York State. Today this section of river thrives with numerous migratory species and abundant mating pairs of bald eagles. To quote the Bandamanna Saga, a section of the Sagas of Icelanders, "*Wisdom is welcome wherever it comes from*" and I look forward to both talking and learning from you all again in November.

Christopher Mikolajczyk, CLM, is a senior project manager and certified lake manager for Princeton Hydro and conducts the management, oversight, and coordination of aquatic ecology and water resource projects in three main areas: aquatic resource restoration and management, aquatic ecosystem sampling and investigations, and stormwater quality modeling and management. Chris is the current president of NALMS.



YOU could be the winner of the 2022 NALMS Annual Photo Contest!

Two winning images will be selected, a Member's Choice winner selected by Symposium attendees and an Editors' Choice winner selected by the editor and production editor for the entry that will make the best *LakeLine* cover.

Prizes will be awarded to the contest winners, and your favorite lake or reservoir photo could grace a cover of *LakeLine*!

Entries will be judged during the 2022 NALMS Symposium in Minneapolis, MN.

You must be a NALMS member to submit an entry.
Only electronic submissions will be accepted.
Photos should be of sufficient resolution to print from (at least 300 dpi at 8.5" x 11").

Maximum of one submission per person.

Entries must be received by Monday, October 31, 2022.

Send your entry to:
Amy Smagula, LakeLine Editor
LakeLine@nalms.org

LAKE AND RESERVOIR MANAGEMENT

NALMS Seeks Editor-in-Chief for *Lake and Reservoir Management*

The Board of Directors of the North American Lake Management Society (NALMS) seeks letters of interest from individuals wishing to serve as the next Editor-in-Chief (EIC) of the society's peer-reviewed publication, *Lake and Reservoir Management* (LRM).

LRM publishes original, previously-unpublished studies relevant to lake and reservoir management. LRM addresses the management of lakes and reservoirs, their watersheds and tributaries, along with the limnological and ecological analyses needed for the sound management of such systems. LRM addresses scientific, economic, social, and regulatory aspects of water resource management. LRM also serves as a resource for lake managers, researchers and policy makers. Journal papers demonstrate strong relevance to lake management, integrate findings with current knowledge, apply sound study design and data analysis, and convey messages in a clear and concise manner. The EIC oversees all aspects of the publication process and works with an editorial board of approximately 25 highly-qualified associate editors that have expertise spanning all aspects of lake and reservoir management.

The duration of the assignment is negotiable, with a range of 3 to 5 years, commencing in January 2024, with training beginning several months earlier. NALMS offers a stipend for the position.

Interested individuals should:

- Possess a wide range of experience in lake management and the breadth of topics that come under the umbrella of LRM;
- Have experience with LRM, or a similar journal, as an associate editor or editor-in-chief, or an equivalent position;
- Be familiar with electronic manuscript management systems, such as ScholarOne or similar;
- Have participated in NALMS or a similar society as a member, officer, or volunteer;
- Possess tact and diplomacy;
- Recognize the importance of publishing high quality research from diverse researchers;
- Be aware of potential sources of biases in peer review and publication processes and best practices in how to minimize them;
- Demonstrate excellent project and schedule management skills, and attention to detail; and
- Have excellent scientific/technical English writing and editing skills.

Interested individuals should send an application package including a letter of interest, CV/resume, and a list of three references by Friday January 31, 2023 via email to:

Imad Hannoun; Ph.D., P.E.
NALMS Publications Committee Chair
President, Water Quality Solutions Incorporated
ihannoun@wqsinc.com
(phone) 1-540-421-2102

The letter should express the individual's interest in the position and outline how they meet the above qualifications. Application materials will be reviewed by the Publications committee and may be followed by an online interview.

If the responder has any questions, please do not hesitate to contact Dr. Hannoun.

50 Years of EPA Lake Monitoring Programs **Under the Clean Water Act**

Kerry Kuntz, Donald Benkendorf, Danielle Grunzke, Lareina Guenzel, and Sarah Lehmann

Five decades ago, Congress passed the Clean Water Act, which charted a new path for our nation's waters. Americans would no longer accept uncontrolled pollution and demanded the protection and restoration of these critical resources. The Clean Water Act put our nation's water bodies at the forefront to protect all Americans' right to clean water for fishing, and recreation. While anecdotal evidence supports that our waters have been cleaner since the Act passed 50 years ago, the question remains, how do we know if our waters are truly getting better nationwide?

The Clean Water Act and a growing need for monitoring efforts

When the Clean Water Act (CWA) was enacted in 1972, Congress explicitly acknowledged the importance of monitoring and assessing water quality to support the restoration of our waters. However, for several decades after the passage of the CWA, various organizations, including the United States Environmental Protection Agency (EPA) noted the lack of consistent, national data available to assess and report on the quality of our nation's waters.

To address this gap in monitoring and assessment efforts, federal agencies, states, and tribes began working on a number of monitoring efforts. In partnership with states and tribes, EPA began the National Aquatic Resource Surveys (NARS) to provide the public and decision-makers with consistent, statistically valid environmental information on the condition of the nation's waters. The NARS program is a partnership that aims to assess the long-term progress toward the CWA goal of making our waters "fishable and swimmable." NARS includes surveys of four waterbody types: lakes, coastal waters, rivers, streams and wetlands. NARS uses a randomized design and consistent methods for key indicators of the chemical, physical, and biological integrity of water resources. The goal of NARS is to determine:

- What is the condition of the nation's waters?
- What are the most widespread problems?
- Are conditions improving or getting worse?

The first official NARS survey was in the National Lakes Assessment (NLA) 2007. The NLA samples a wide array of lakes, from small ponds and prairie potholes to large lakes and human-made reservoirs, on federal, tribal, state, and private land. Repeated on a five-year cycle, additional surveys were conducted in 2012, 2017, and again this year. Results from the NLA and other NARS have established a national baseline of water quality and key stressors and are tracking changes over time.

An update on the quality of our nation's lakes

For the NLA 2017, 89 field crews collected data at 1005 randomly selected lakes; the results represent approximately 225,000 lakes across the conterminous United States. Trophic condition is a key indicator for lakes. Results of NLA 2017 indicate that hypereutrophic conditions, typically characterized by excess nutrients, high levels of algae growth, and low transparency, were observed in 24 percent of lakes. The percentage of lakes in mesotrophic condition declined from 27 percent to 20 percent from 2012 to 2017 (Figure 1).

In 2017, nutrient pollution was the most widespread stressor. Across the country, 45 percent of lakes were in poor condition with elevated phosphorus levels, and 46 percent were in poor condition with elevated nitrogen levels. Lakeshore disturbance, which reflects the extent and intensity of direct human alteration of the lakeshore itself, was the most widespread physical habitat indicator, with poor conditions in 29 percent of lakes across the country and fair conditions in 45 percent of lakes (Figure 2).

The NLA also includes three biological indicators: benthic macroinvertebrates, zooplankton, and chlorophyll-*a*. Based on benthic macroinvertebrates (e.g., insect larvae, snails, and clams living on the lake bottom), EPA found that 24 percent of lakes were in poor condition and 29 percent of lakes were in fair condition. Based on zooplankton (microscopic animals in the water column), results were similar: 22 percent of lakes were in poor condition, and 23 percent of lakes were in fair condition. The third biological indicator, chlorophyll-*a,* can provide an indication of the amount of microscopic algae and cyanobacteria present in a lake. With the application of ecoregional-based benchmarks, chlorophyll-*a* was at high levels and rated poor in 45 percent of lakes (Figure 2).

Additional analyses showed that poor biological condition was more likely when nutrient levels were high (rated poor). For example, in lakes where phosphorus was elevated, benthic macroinvertebrate communities were 2.3 times more likely to be in poor condition. In natural lakes (i.e., excluding human-made lakes), this risk increased to 6.9. Atrazine levels exceeded the EPA

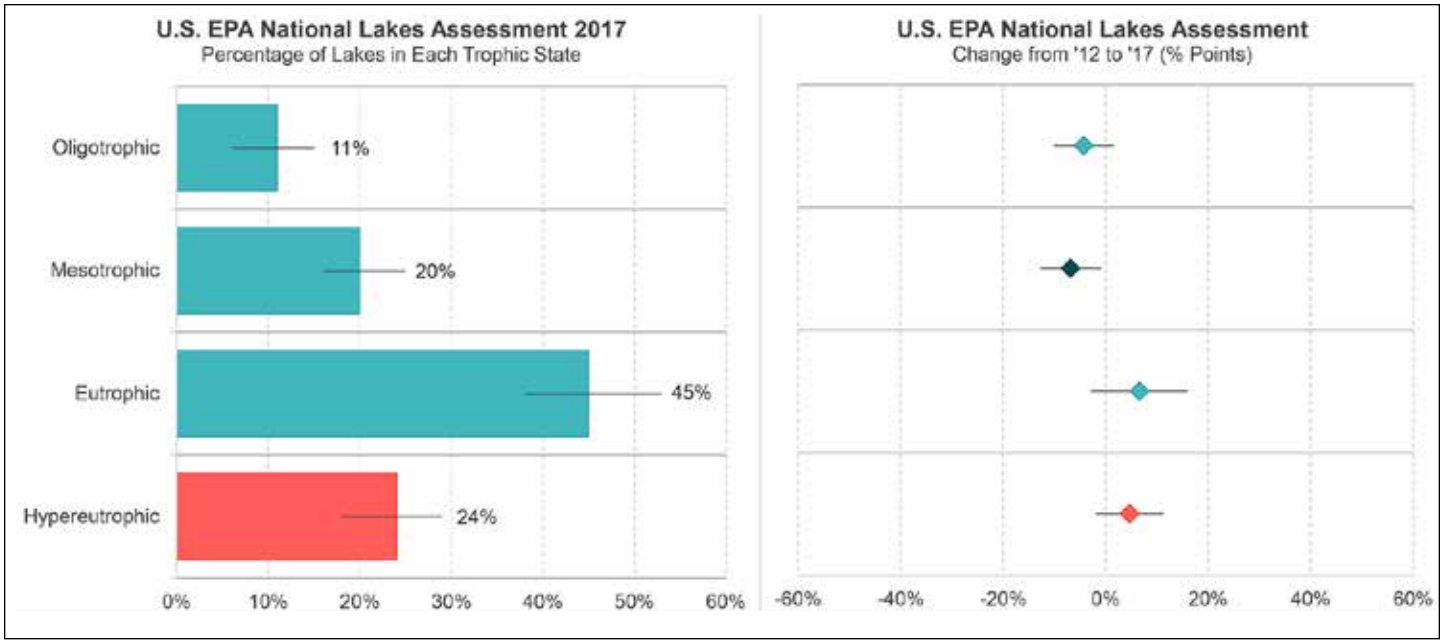


*Figure 1. U.S. EPA National Lakes Assessment results illustrating trophic state in 2017 and change in trophic state between 2012 and 2017 (percent points). *Indicates statistically significant difference (95 percent confidence) between time periods compared. Also represented by a darker-colored diamond in the right-hand column of figure.*

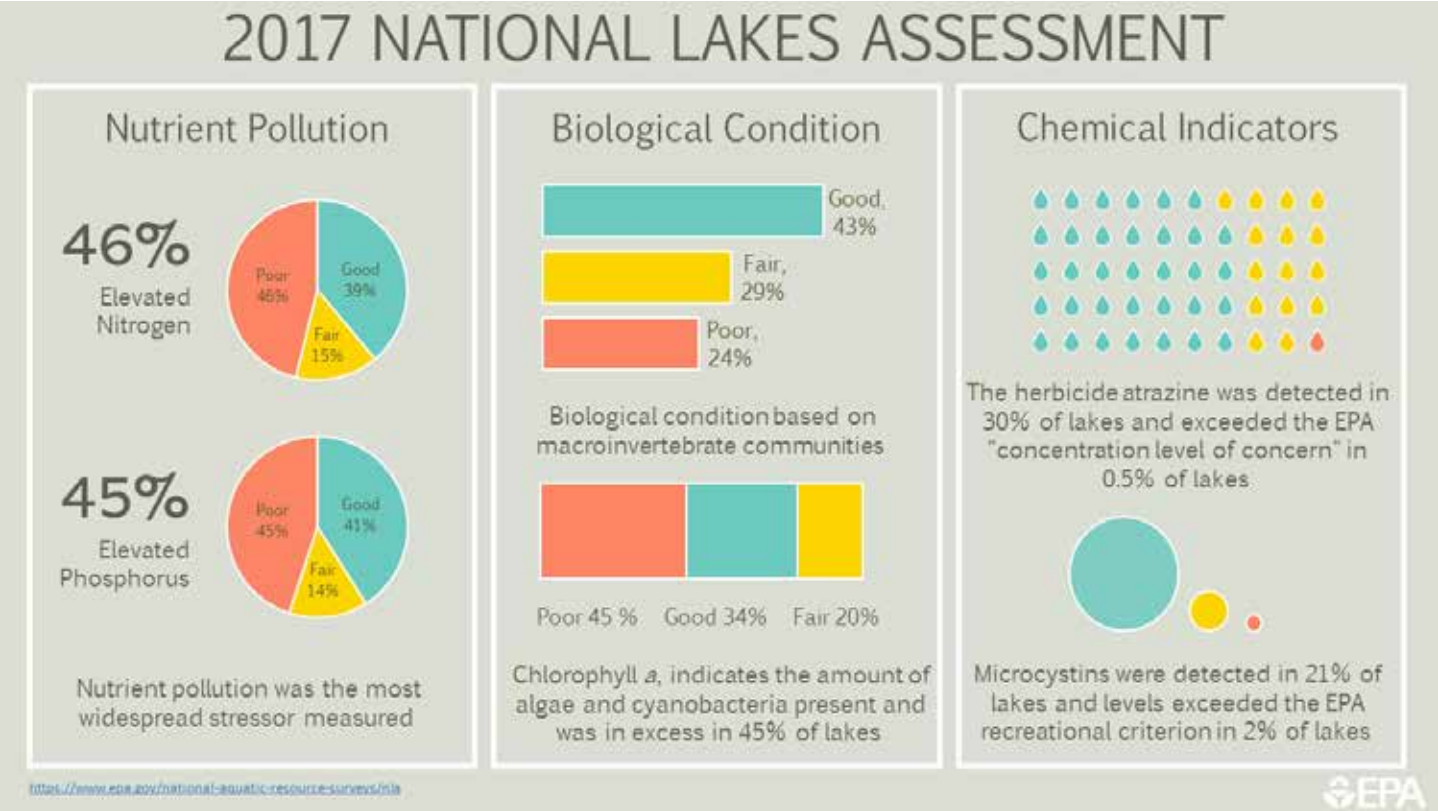


Figure 2. Infographic displaying some results of the 2017 National Lakes Assessment.

benchmark, the "concentration equivalent level of concern" for aquatic plant communities, in 0.5 percent of lakes, representing 1,200 lakes. In reservoirs (but not in natural lakes), poor biological condition was almost three times more likely for benthic macroinvertebrates when atrazine was detected (Figure 2). In terms of public health related indicators, the algal toxins known as microcystins were detected in 21 percent of lakes. Microcystins measured in the open waters exceeded the EPA recommended recreational water quality criterion in 2 percent of lakes, or approximately 4,400 lakes across the nation (EPA 2022b).

Learn more about the National Lakes Assessment and view additional results:

- 2017 Web Report
- 2017 Key Findings
- Data Dashboard
- Lakes Context Tool

Changes in lake quality since 1972: Leveraging the NLA

Although the first to assess *all* lakes in the conterminous U.S., the NLA was not the first large-scale monitoring effort undertaken by EPA to look at lake water quality and condition. In 1972, EPA initiated an effort known as the National Eutrophication Survey (NES), to measure and report on lakes across the nation at risk of experiencing accelerated eutrophication from nutrient pollution (EPA 1972). Over 800 targeted lakes were assessed in the NES between 1972 and 1976 (Figure 3). EPA was concerned with the impacts of the amount of nutrients coming from wastewater treatment plants whose outflow flowed into lakes (EPA 1975, 1976). The NES measured chlorophyll-*a*, Secchi depth, total nitrogen and total phosphorus to assess the trophic state of the selected lakes (EPA 2009) (Figure 4).

As part of the NLA, EPA and its partners resampled a representative sample of the NES lakes to assess whether water quality conditions got better, got worse, or stayed the same in the NES

Figure 4. Crew sampling Lake Tahoe (Region 9), one of the lakes included in the National Eutrophication Survey.

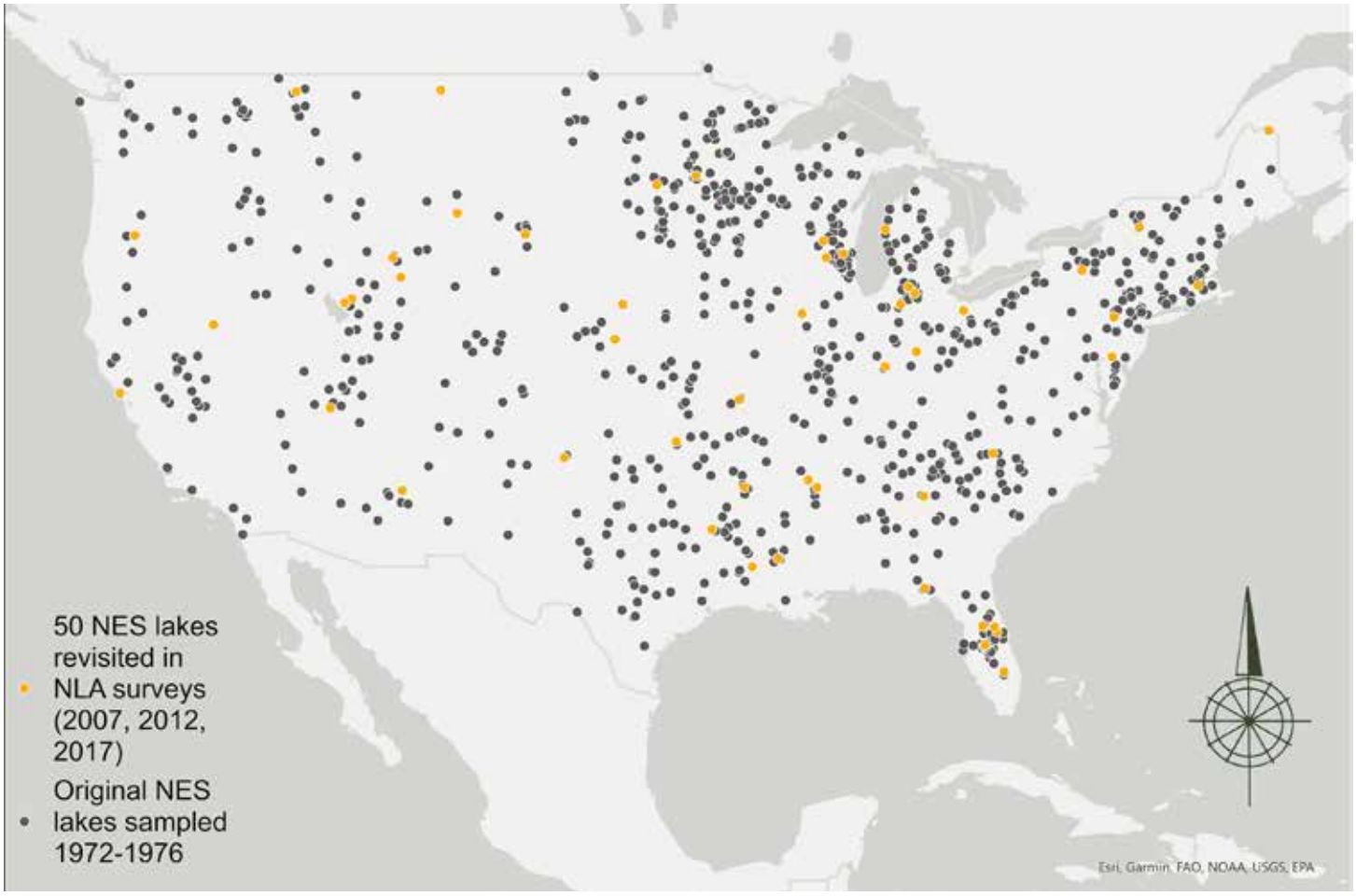


Figure 3. Map of original NES sites and sites sampled in the three NARS surveys.

lakes during the past 50 years. About 200 NES lakes were randomly selected from the original 800 and resampled in the 2007 NLA (Figures 5 and 6). When NES lakes were evaluated in 2007, trophic status based on chlorophyll-*a* had improved in one-quarter (26 percent) and remained stable in half (51 percent) of those lakes (EPA 2009). While the NLA 2022 data are not yet available, EPA has initiated an analysis to look back 50 years at whether this subset of lakes has changed. EPA's analysis will focus on questions such as the following:

- Has eutrophication status changed for the NES lakes since the 1970s?
- Are changes in certain environmental and anthropogenic variables associated with changes in lake eutrophication?
- Do we observe broad long-term trends in trophic state of lakes or are changes lake specific?

Since these surveys were conducted up to 50 years apart, field methods have differed slightly between the NES and NLA. In conducting this analysis, EPA is accounting for these differences to make the data comparable across surveys. The complete NES dataset was made publicly available by Stachelek et al. (2018). The NLA data are available on the EPA NARS website.

Advancements in the NLA

To provide consistent and comparable data and information on improving or declining lake conditions, most aspects of NLA have remained the same. However, new partnerships, priorities, and technological advancements fuel the need for change. Just as the NES applied novel approaches to collect data at lakes in the 1970s, NLA has continued to adopt new technologies and to support new science.

The 2022 field season presented several opportunities to leverage the NLA to address additional indicators and contaminants of concern (EPA 2022a). For the first time, crews documented visual observations of potentially harmful cyanobacterial (cyanoHABs) blooms on site. Observations were made at 12 locations in each lake and visible blooms were reported to state and local harmful algal bloom (HABs) coordinators using BloomWatch or other state-specific crowd sourcing apps. These observations supplement existing NLA analysis of microcystin, chlorophyll-*a*, and phytoplankton. NLA 2022 added the fecal indicator enterococci (consistent with other NARS surveys) and analysis of contaminants in fish tissue, including mercury, polychlorinated biphenyls, and per- and polyfluoroalkyl substances.

In addition to the more established indicators, the NLA supports other research efforts. For example, in 2017 dissolved gases were collected for the purpose of informing the EPA's research on the magnitude of methane, carbon dioxide, and nitrous oxide emission from lakes and reservoirs in the U.S. In the past two NLAs, water samples for environmental DNA (eDNA) have been collected to assess fish species presence with expanded sampling in 2022 to account for multiple habitat types. Discussions about potential research

Figure 5. EPA Region 4 crew member taking a water sample using an integrated sampler in Lake Okeechobee.

Figure 6. EPA Region 4 crew member lowering a Secchi disk to assess water clarity in Lake Okeechobee.

indicators for NLA 2027 will begin in 2024.

Under NARS, NLA has incorporated the use of electronic field forms for collecting data in the field, revised training to incorporate the use of videos that can be reviewed by field crews at any time, and implemented new automated quality checks of data. Additionally, innovative applications of NLA data and methodologies (e.g., EPA's numeric nutrient water quality criteria recommendations for lakes and reservoirs, cyanobacteria assessment network (CyAN)) expand our understanding of current conditions and support efforts to protect and restore the nation's lakes. Data and methodologies collected and developed during the NLA support research and contribute to a broader shared goal to better understand lakes. Some of these publications can be viewed on EPA's website.

Over the past 50 years, the CWA has significantly improved water quality. It established the National Pollutant Discharge Elimination System (NPDES) permitting program for discharges to navigable waters, required states to establish water quality standards for their waterbodies, required municipal facilities to meet secondary treatment standards, and required industrial facilities to meet technology standards. As work continues under the Act, monitoring and assessment efforts, including NLA, will be critical for helping to provide resource managers and decisionmakers with the information they need to continue to progress toward achieving the CWA goals.

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How Maine Evolved with the Clean Water Act

Matthew Scott

Maine has a motto, *Dirago*, meaning "I direct." This was the leadership position that United States Senator Edmund S. Muskie (Figure 1) took when he helped author amendments to the Federal Water Pollution Control Act of 1948, and then shepherded the amendments through the U.S. Senate in 1972, as the bill's lead sponsor. In supporting statements and debate on the bill, Muskie stated "This country was once famous for its rivers. In songs and poems and stories, Americans gloried in the now-quiet, now-roaring reaches of the river waters. A vigorous people, following their rivers to the oceans and beyond, built along the riverbanks a strong and productive economy. But today, the rivers of this country serve as little more than sewers to the seas. Wastes from cities and towns, from farms and forests, from mining and manufacturing, foul the streams, poison the estuaries, threaten the life of the ocean depths. The danger to health, the environmental damage, the economic loss can be anywhere."

Muskie knew what he was talking about. He grew up in the town of Rumford, on the banks of the Androscoggin River in Maine. Maine, along with much of the United States, has a lot of dirty water in its history, especially in our river systems that were serving as open sewers for all wastes being generated by our consuming populous. The Androscoggin River was one of the ten most dirty rivers in the United States. At one time the river had 16 pulp and paper processing mills discharging untreated wastes into the river. Muskie saw, smelled, and felt the ravages of pollution and always considered knowledge and data to be valuable for making good decisions. Maine's four major rivers have served as industrial working rivers like other rivers in the United States.

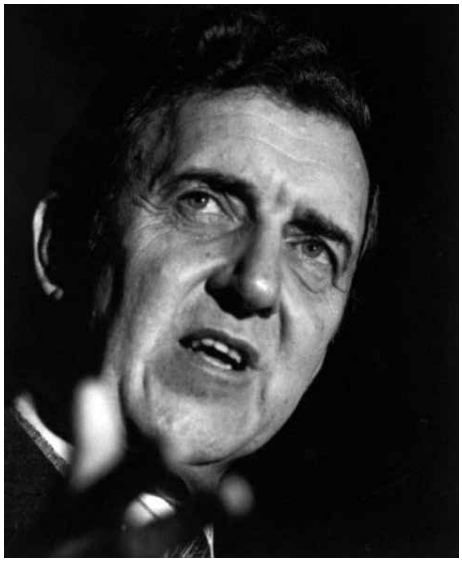

Figure 1. A photo of Edmund S. Muskie, former governor of the State of Maine, U.S. Senator, and U.S. Secretary of State. Graduate of Bates College and Cornell University.

Thus, the need to clean up our wastes was proposed via the Clean Water Act (CWA). This created a level playing field for all polluters, industrial and municipal, with no exceptions. The act had some unique features that were incorporated into law, including that we have swimmable and fishable water and that a national pollution discharge elimination system (NPDES) be established.

Fishable waters

Fishable waters are of interest to me as a former practicing fisheries biologist. Not only were fishable waters to be reclaimed under the CWA, the fisheries that were present were to be edible. Thus, consumption advisories were to be established.

The CWA has also been valuable for fisheries and dam removals where water quality is impacted or not meeting standards. Prior to the CWA there was a prominent Attorney from Waterville, Maine named Jerome Daviau, who authored a significant book titled *Maine's Life Blood*. He was ahead of his time as he advocated for fish passage and talked about the facts regarding the impact dams have made on our migratory fisheries in Maine. His focus was on dams of the Kennebec and Penobscot rivers. Hydro dams were present without fish passage. Daviau was a thorn in the side of Ed Muskie, then governor, and Roland Cobb, Commissioner of Inland Fisheries and Game Department in 1957. The focus on dams and how Maines's waterways are the lifeblood was his message. The very first dam on the Kennebec at Augusta was built in 1837 without fish passage. It set the pattern of dams for the future.

Daviau talked about the art of public deception and how the industrial lobby-controlled government, and the use of Maine's waterways with dams for hydropower and without fish passage. He specifically singled out the two largest producers of electricity in Maine at the time. He then focused on the polluters and water quality issues, often with references to Governor Muskie and Commissioner Cobb. His book makes for a good read.

Discharges into rivers in Maine

Author John Graham, in *Maine Heritage Magazine*, recorded his concerns of discharges into Prestile Stream and how it was impacted by a potato processor in Maine. The Prestile became a highly political issue regarding its water quality and use, degradation, and how it became an international issue for a short time. The situation of the potato farmer involved

their discharge of processed potato and sugar beet waste into the Prestile. The Maine Water Improvement Commission staff pointed out that the Prestile had very little assimilative capacity to accept production waste being discharged to it. The farmer continued to court the local legislators and political figures to the point that the declassification of the Prestile was necessary by our legislature so that its waste stream could continue emptying to Class D waters, the lowest water quality, a virtual sewer.

Graham pointed out the embarrassment that it was causing for the local citizenry of Maine and New Brunswick (NB) as the Prestile crosses the international border near Centerville, NB. Our Canadian neighbors had enough, and on July 9 1968, they built an earthen dam to stop the flow of waste. This caused an international stir all the way to Augusta, Maine, Washington, DC, and Ottawa, Canada. The local folks at Centerville, NB (population 1,200), made a point and created "the most international incident imaginable." They removed the dam the very next day, to the relief of all the politicians.

Clean water for Maine and the nation became the operative words for our future This one-day event sent a strong signal that our border province neighbor was not tolerating potato waste from Maine. James Ezra Briggs, the local House legislator, became involved and he saw to it that wastes had to be treated to clean up the Prestile.

These two activities in Maine (Daviau and Graham) preceded the CWA and rose to support the need for change. Governor Muskie was elected to the U.S. Senate from Maine after his term as governor of Maine. He saw the light and forged ahead to help solve the impacts of water pollution. Thus, the birth of the Clean Water Act.

A half-century to celebrate the Clean Water Act of 1972

It has been a long road and will continue to be so for all of humankind. Senator Edmund Muskie was an environmental leader and champion of the 1972 CWA and before that, the 1970 Clean Air Act. He was a native of Rumford, Maine; a graduate of Bates College and earned his law degree from Cornell University. He later was elected to the Maine legislature, House, and Senate, became governor and then onto the US Senate in 1958. He recognized pollution as a public health problem and became chairman of the Senate Subcommittee on Air and Water Pollution. He was a pioneer in creating these two environmental masterpieces. These two acts might very well or could have been called "Muskie Acts." However, he was recognized by the Senate and many non-government organizations as the "most important environmental leader" at that time. He maintained his devotion to environmental advocacy and knew how important it was to protect people's health and welfare from pollution. He also strongly felt that protecting the environment also protected the economy, and he retained that commitment even during his failed attempt for the presidential race in 1968. He was always prepared in his committee deliberations with Senate colleagues who became impressed with facts that Muskie knew.

Muskie wanted to solve problems by being an inclusive legislator and felt that technology could be used to reduce pollution and safeguard human health. He never felt that compromise was a dirty word and really understood the collaborative approach to reach consensus. This strong belief was so instilled with the Senate in his time that the CWA survived a Presidential veto by then-President Richard Nixon on October 17, 1972. Nixon finally signed the act into law the very next day on October 18, 1972, after congress voted 247-23 to override the veto. So may we conclude that Ed Muskie's work in the U.S. Congress represents the best legislative behavior of the time, and he was a giant in environmental law-making of the two fundamental acts. I am proud that he hailed from the State of Maine.

This year, on October 18, 2022, we celebrate 50 years of the CWA, which has improved and protected the quality of not only our Maine waters, but waters across the United States. The CWA is and has been a long road long lived, and a model of supreme effectiveness for all people. The road to recovery is long because environmental protection is forever. This year we continue our journey with the CWA – a cause for this 50-year celebration in this millennium. We raise our glasses in the name of the CLEAN WATER ACT. My best to all humankind and for the inarticulate organisms that cannot speak for themselves.

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Onondaga Lake: A Restoration Success Story

David Glaser, Elizabeth Moran, James R. Rhea, and Christopher Gandino

Introduction

The Clean Water Act has improved water quality across the nation. Among the many success stories is the restoration of New York's Onondaga Lake, once called "the most polluted lake in the U.S." The regulatory requirements and state and local funding included in the Act were fundamental to attainment of the lake's designated uses. Although the engineering successes and water quality improvements of the past decades are well described (Effler et al. 2013; Matthews et al. 2015, Murphy et al. 2015; Hurley and Gandino 2017; OCDWEP 2020a), we want to highlight the Onondaga Lake story from another perspective: the cascading impacts of nutrient reductions on the entire ecosystem. A central paradigm in lake management is the importance of controlling phosphorus and nitrogen inputs. The Onondaga Lake story illustrates the significance of considering the complex interplay between nutrient control and both top-down and bottom-up influences on ecosystem structure and function.

The Syracuse Metropolitan Wastewater Treatment Plant (Metro), an 85 million-gallons-per-day tertiary treatment facility, discharges to Onondaga Lake. Contravention of the New York State water quality guidance value of 20 micrograms per liter (µg/L) total phosphorus and the state standards for dissolved oxygen, ammonia, and nitrite led to an Amended Consent Judgment (ACJ) requiring advanced treatment of ammonia and phosphorus at Metro. In addition, Onondaga County was required to design and implement a comprehensive ambient monitoring program (AMP) to document the lake's response. The County constructed a biological treatment system to oxidize ammonia and a physical-chemical treatment system to remove phosphorus. The biologically activated filter (BAF) system for ammonia went online in 2004 and brought the lake into compliance with ammonia standards while substantially increasing water column nitrate concentrations. The high-rate flocculation settling (HRFS) system to treat phosphorus was completed in 2005. In 2009, the County initiated its *Save the Rain Program*, which includes green and gray infrastructure to reduce discharges from combined sewer overflows. Onondaga Lake responded to the reduced ammonia and phosphorus loadings with decreased water column productivity, decreased ammonia toxicity, and increased water transparency which promoted changes in the lake ecosystem.

Decades of intensive lake monitoring before and after the Metro upgrades have documented the ecosystem's response to these changes in the inputs and chemical forms of phosphorus and nitrogen. Onondaga County led an AMP to monitor changes in the lake's water quality, habitat, and biological resources (OCDWEP 2020b) and to provide insights into the effects of invasive species and a warming climate. The information presented here is supported by more than 50 published technical articles documenting the lake's restoration, including Effler (2013), Matthews (2015), and Murphy (2015).

Environmental setting

Onondaga Lake is in central New York State, northwest of Syracuse (Figure 1). It measures approximately 7.6 kilometers long, between 1 and 2 kilometers wide, and has a surface area of 11.7 square kilometers. The lake's maximum depth is 19.5 meters, and it averages 10.9 meters deep. Ambient data to track compliance and trends are collected at the lake's deepest point, South Deep. The Onondaga Lake watershed is highly urbanized compared with other lakes in the region, with approximately 20 percent urban, 40 percent forest, and 30 percent agricultural land cover.

In addition to inflows from four major and several minor tributaries that direct runoff from the 642-square-kilometer watershed, the lake receives treated effluent from Metro that originates both inside and outside the basin. Metro effluent contributes about 20 percent of the total lake inflow in an average hydrologic year, and about 50 percent in summer. Because of the lake's large watershed, inputs of water from outside the watershed via Metro, and small volume, lake water residence time is short, about three to four months. The lake discharges into the Seneca River, which flows into Lake Ontario. Due to downstream flow control and associated changes in surface water elevation, the Seneca River periodically backflows into Onondaga Lake, ecologically linking the two systems.

The lake's narrow littoral zone, where light reaches the sediment surface, typically extends a few hundred meters out from the shoreline to a water depth of approximately six meters.

Onondaga Lake undergoes thermal stratification each summer when the dissolved oxygen (DO) of the cooler lower water is depleted, restricting the biological community to the warmer upper water. The lake mixes each fall, entraining cooler low-DO hypolimnetic water with the surface water. Although portions of the lake freeze in the winter, total ice cover is rare.

Nutrient reduction

Phosphorus

Treated wastewater contributed 40 percent to 60 percent of Onondaga Lake's external total phosphorus (TP) load in the

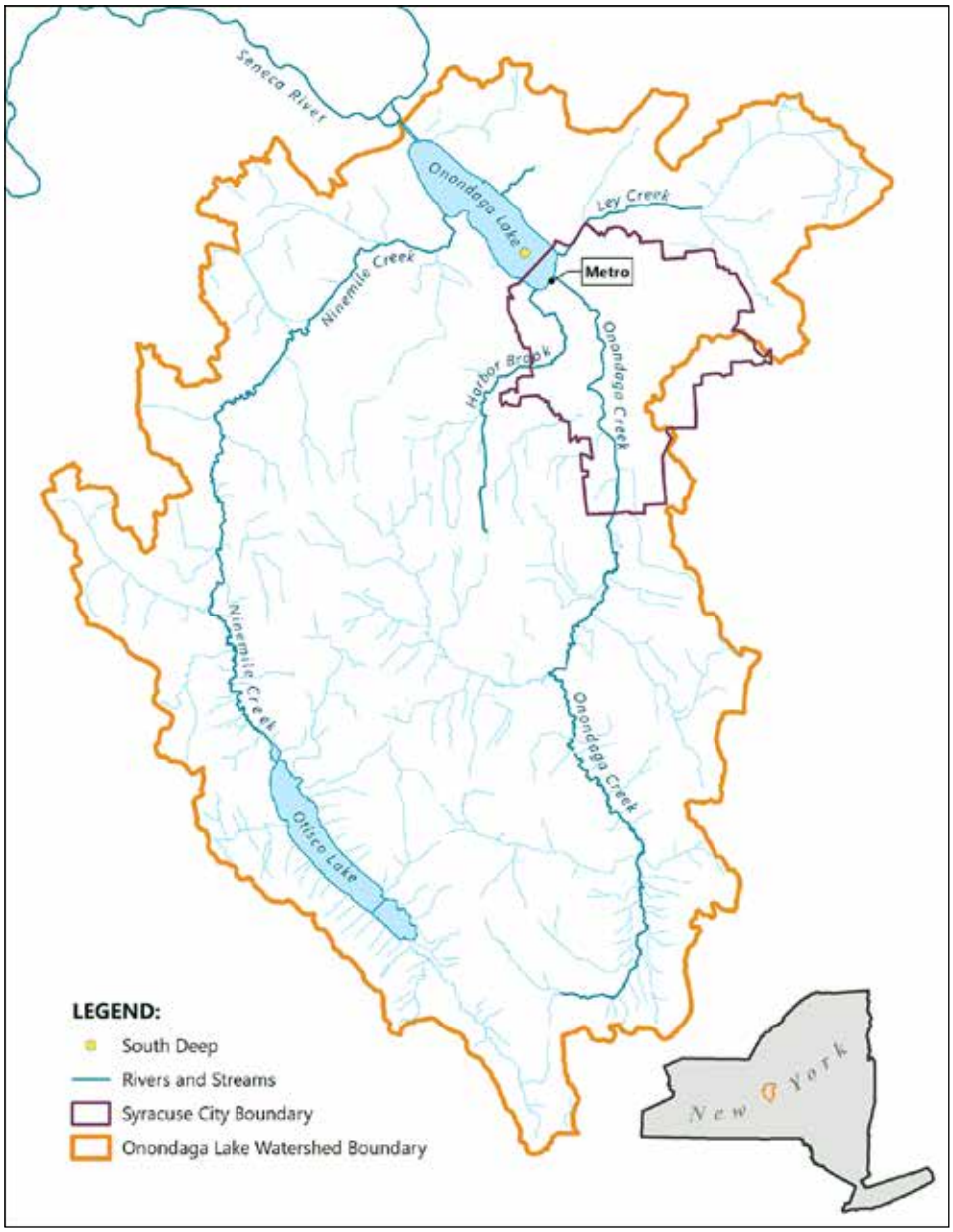

Figure 1. Onondaga Lake and its watershed.

1990s. Metro's contribution was especially significant during the summer, when inflows from the tributaries were low. The result was hypereutrophic conditions: elevated phosphorus and chlorophyll, low Secchi disk transparency, cyanobacteria dominance of the phytoplankton community, rapid DO loss, and accumulation of reduced species such as hydrogen sulfide in the hypolimnion during the summer. When the lake cooled and mixed in the fall, DO levels throughout the water column fell as the reduced species were entrained and oxidized.

Tertiary phosphorus removal using HRFS began in 2004 (Figure 2) and had a rapid, positive impact on the lake's trophic state. Since 2007, average summer TP concentrations have been close to meeting the state's regulatory guidance value of 20 µg/L for recreational waters (Figure 3). With Metro's HRFS system producing consistently low effluent TP, the year-to-year variability in lake phosphorus levels largely reflects changes in weather (the tributaries deliver more phosphorus during wet years) and food web structure.

Nitrogen and its Forms

Historically, Onondaga Lake was impaired by elevated concentrations of ammonia-N (NH3-N). About 90 percent of the external ammonia load came from Metro. Concentrations of this potentially harmful form of nitrogen exceeded the ambient water quality standard for protection of aquatic life. The County upgraded aeration treatment at Metro in the 1990s and in 2004 implemented BAF technology, which converts ammonia to nitrate year-round in a process known as nitrification (Figure 4). Ammonia-N concentrations in the upper waters of the lake were reduced significantly (Figure 5), and in 2008 the lake was removed from New York State's 303(d) list of impaired waterbodies for this water quality parameter. The lake remains in full compliance with this ambient water quality standard.

Efficient year-round nitrification at Metro resulted in increased nitrate (NO3-N) concentrations in Onondaga Lake. Essentially, NH3-N and nitrite (NO2-N) were replaced by NO3-N, leaving the concentration of total nitrogen (TN) approximately the same (Figure 5). This led to diminished releases of

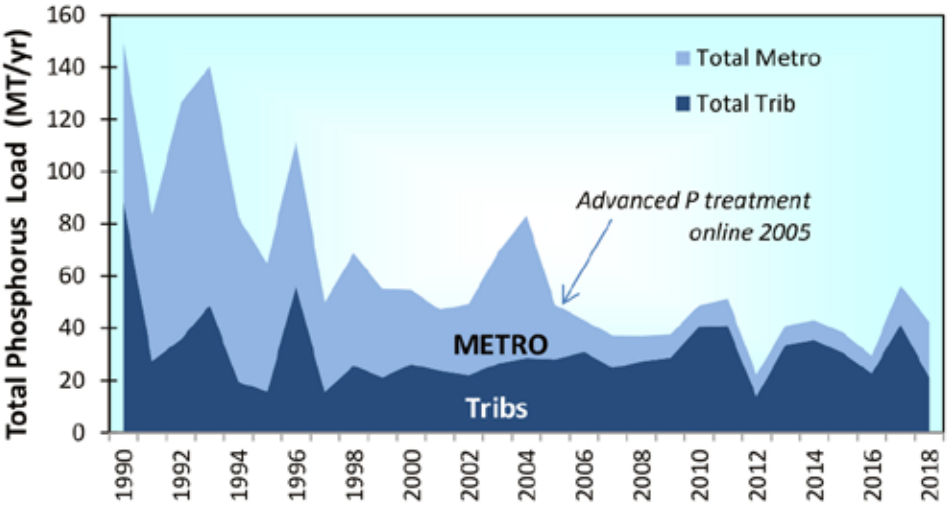

Figure 2. Annual discharge of total phosphorus (TP) to Onondaga Lake from metro and tributaries, 1990-2018.

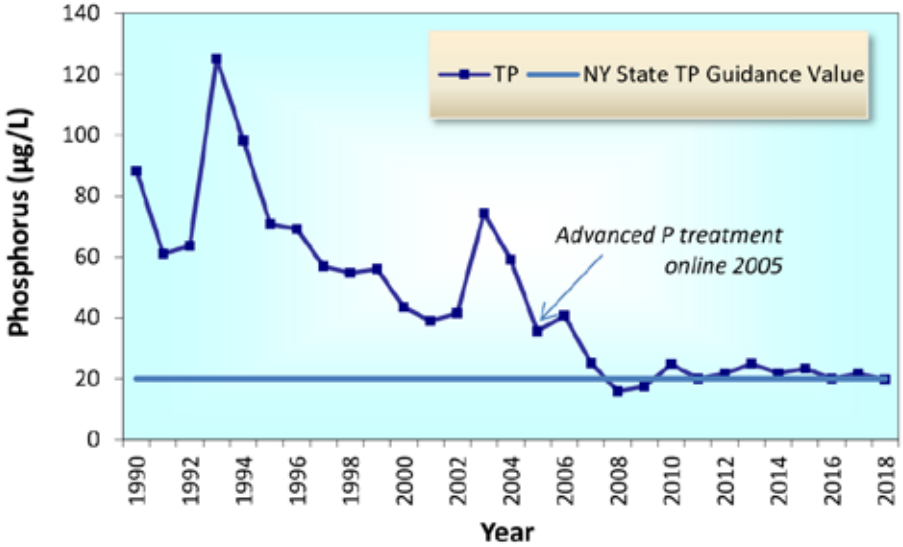

Figure 3. Summer average total phosphorus concentrations in the upper waters, 1990-2018.

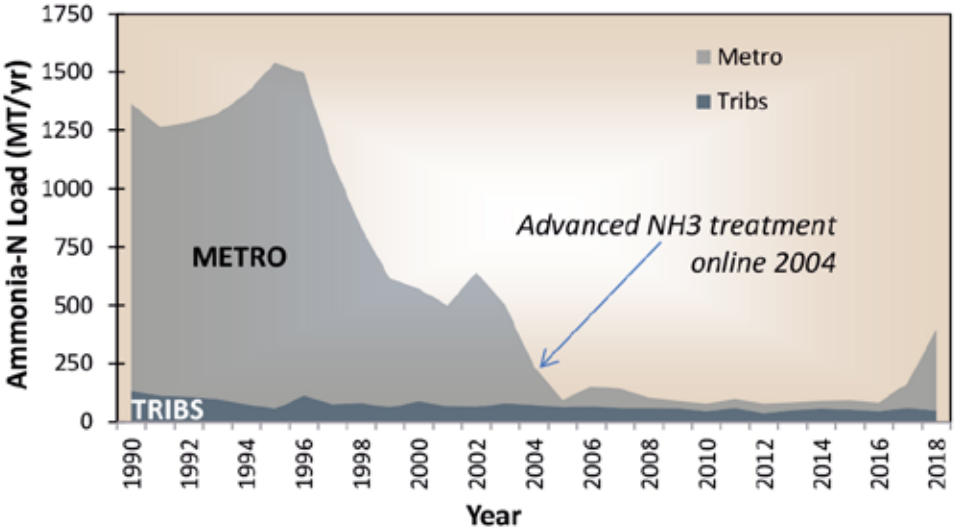

Figure 4. Annual discharge of Ammonia-N (NH_3-N) to Onondaga Lake from metro and tributaries, 1990-2018

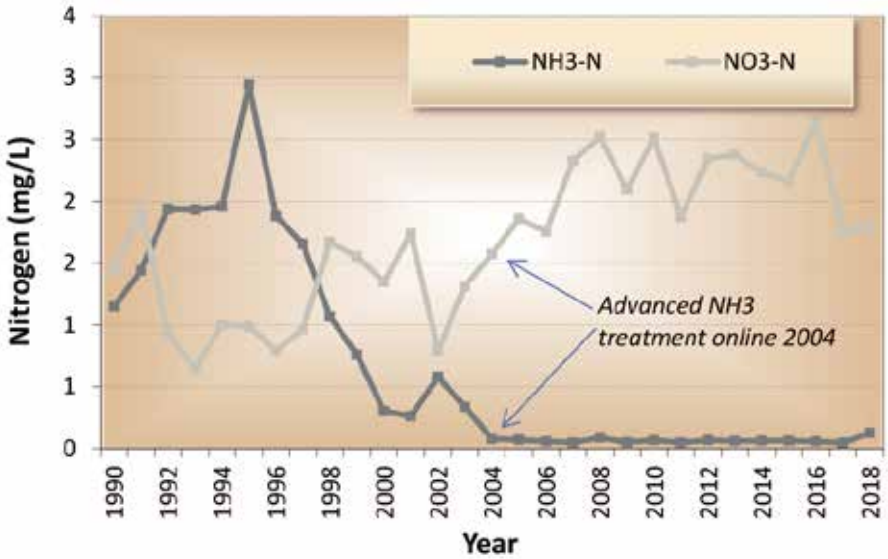

Figure 5. Summer average ammonia and nitrate concentrations in the upper waters, 1990-2018.

phosphorus and mercury from the sediments during intervals of anoxia (Matthews et al. 2013). As part of an effort under Superfund to further abate sediment releases of methylmercury, nitrate has been added to the lake in summer since 2011 (Matthews et al. 2013).

Ecosystem response

Primary Producers: Phytoplankton and Macrophytes

The supply of the major plant nutrients nitrogen and phosphorus is an important determinant of phytoplankton community composition and the risk of cyanobacterial blooms.

Maintaining high nitrogen-to-phosphorus ratios in the upper waters of Onondaga Lake has long been a strategy to reduce the risk of cyanobacterial blooms. As reported by Smith (1983), data from a wide range of temperate lakes suggest that a total N to total P ratio (TN:TP) of 29:1 (by mass) differentiates lakes with cyanobacteria dominance (TN:TP<29:1) from lakes without such dominance (TN:TP>29:1).

The time series of the summer average (June 1 to September 30) TN:TP ratio for the lake's upper waters from 1995 to 2018 is shown in Figure 6. The TN:TP ratio has remained above the literature N:P threshold for increased risk of cyanobacteria dominance since 1995. The higher values after 2007 reflect systematic decreases in total phosphorus loading from Metro, with mostly unchanging TN concentrations.

Recent literature also emphasizes the importance of the form of nitrogen in controlling phytoplankton populations, community structure, and the potential toxicity of cyanobacterial blooms (Glibert et al. 2014).

Summer average concentrations of chlorophyll-*a* (Chl-a) in Onondaga Lake have declined substantially since the early 2000s, particularly in response to the HRFS upgrade at Metro (Figure 7). Chl-*a* concentrations, which commonly exceeded a summer average of 15 µg/L from 1990 to 2004, have remained below 12 µg/L since 2007. Summer data (June to September) are used to track the lake's suitability for recreational uses. The New York State Department of Environmental Conservation (NYSDEC) defines suitable Chl-a thresholds for recreational use as follows: above 8 µg/L recreational uses are stressed; above 12 µg/L they are

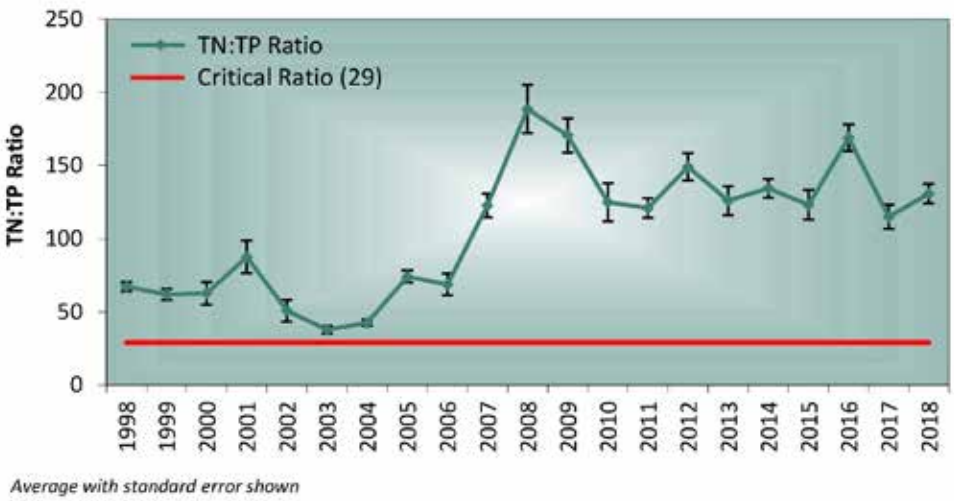

Figure 6. Summer average total nitrogen to total phosphorus (TN:TP) ratio in the upper waters, 1998-2018.

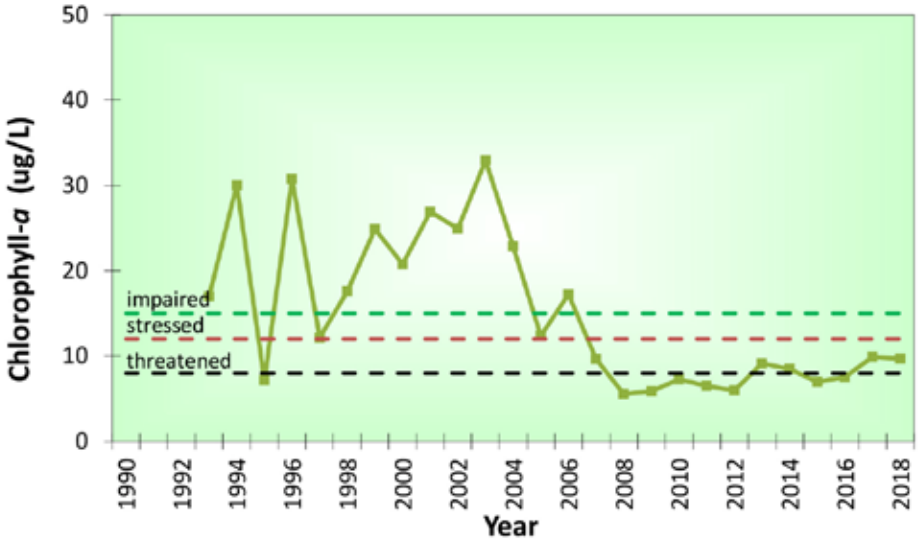

Figure 7. Summer average chlorophyll-a concentrations in the upper waters, 1990-2018.

threatened; and above 15 µg/L the uses are impaired. Thus, the lake has improved from "impaired" prior to 2004, past "threatened," to "stressed" in 2008; in some recent years, the summer average was below 8 µg/L. As shown in Figure 7, there may be a slow upward trend in Chl-*a* since about 2008. Whether this trend is real is not yet known, but the County is not resting on its laurels; as described below, additional nutrient reduction programs are in place.

Algal blooms have also declined since 2004. In the absence of state or federal criteria, the AMP has used subjective thresholds of 15 µg/L and 30 µg/L to represent minor blooms (impaired conditions) and major blooms (noxious conditions). According to these criteria, 2005 saw the last major blooms and minor blooms have declined greatly; some recent years have seen no blooms at all.

Summer blooms of filamentous cyanobacteria were once common in the lake, but in recent years, cyanobacteria have not been an important component of the phytoplankton community. Lower P levels, higher N:P ratios, and nitrogen predominantly in the form of nitrate all contribute to this observed suppression of cyanobacteria. There is evidence of a modest increase in cyanobacteria in recent years, however, which may be related to changes in climate (notably, warmer temperatures and increased frequency of calm winds).

Macrophyte populations, including submerged, emergent, and floating species, are an important component of a healthy lake ecosystem. They support an active benthic population and are strongly correlated with the diversity and productivity of fish stocks. For decades, macrophytes were scarce in Onondaga Lake. Aquatic plants were present in only about 11 percent of the littoral zone in 2000 (OCDWEP 2020b). Sediment instability, low sediment fertility, elevated salinity, poor light availability, and elevated ammonia concentrations may have contributed to the lack of vegetation in the past. Conditions have improved dramatically; in 2018 macrophytes covered 50 percent of the lake littoral zone. This change was facilitated by the increased water clarity due to the reduction in phytoplankton brought about by the reduction in phosphorus input from Metro.

Secondary Producers: Macroinvertebrates and Dreissenids

Benthic macroinvertebrates are an important component of the aquatic food web, facilitating the cycling of energy and nutrients between the sediment and the water column. Like many components of the lake ecosystem, the macroinvertebrate community has shown signs of improvement over the past two decades. The NYSDEC Biological Assessment Profile (BAP) scores at the lake's five sampling sites have improved since 2000. By 2017, four of the five sites were either "slightly impacted" or on the line between "slightly" and "moderately" impacted. Even the site near the Metro outfall has improved from 2000, when it was characterized as "severely impacted," to 2017, when it was characterized as "moderately impacted."

The improvements in the benthic macroinvertebrate community are due, in part, to decreased nutrient loading from Metro, which has led to decreased phytoplankton growth and increased macrophyte abundance and coverage. Invasive zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis,* collectively referred to as dreissenids) may also have played a role by directing nutrients from the water column to the sediments via their pseudofeces, improving water clarity and modifying the nature of the benthic substrate. These invasive filter-feeders have been prolific in the Seneca River drainage basin since the early 1990s. The Seneca River flows past and exchanges water with Onondaga

Lake. Both mussel species were first found in Onondaga Lake in 1992. They remained rare in the lake prior to 1998 and increased once ammonia concentrations fell below levels of concern to aquatic life (Figure 8). Their populations have decreased since 2014, possibly due to the invasion of the lake by the round goby (*Neogobius melanostomus*), which consume dreissenids, in 2011.

In contrast to their muted impact on Onondaga Lake, dreissenid mussels had a profound impact on water quality in the adjacent Seneca River. They heavily colonized the hard substrate of the riverbed, effectively stymied phytoplankton production through their filtering activities, and reduced DO so much the river could not assimilate effluent Metro proposed to divert from the lake to the river (Glaser et al. 2009).

Thus, reduced NH3-N and TP inputs from Metro have resulted in bottom-up impacts (reduced primary production), top-down impacts (increased dreissenid herbivory on phytoplankton due to reduced NH3-N loads from Metro), and processes that have bottom-up and top-down components (consumption of phytoplankton by dreissenids leading to the transfer of pelagic organic matter to the sediment bed, where it feeds benthic invertebrates).

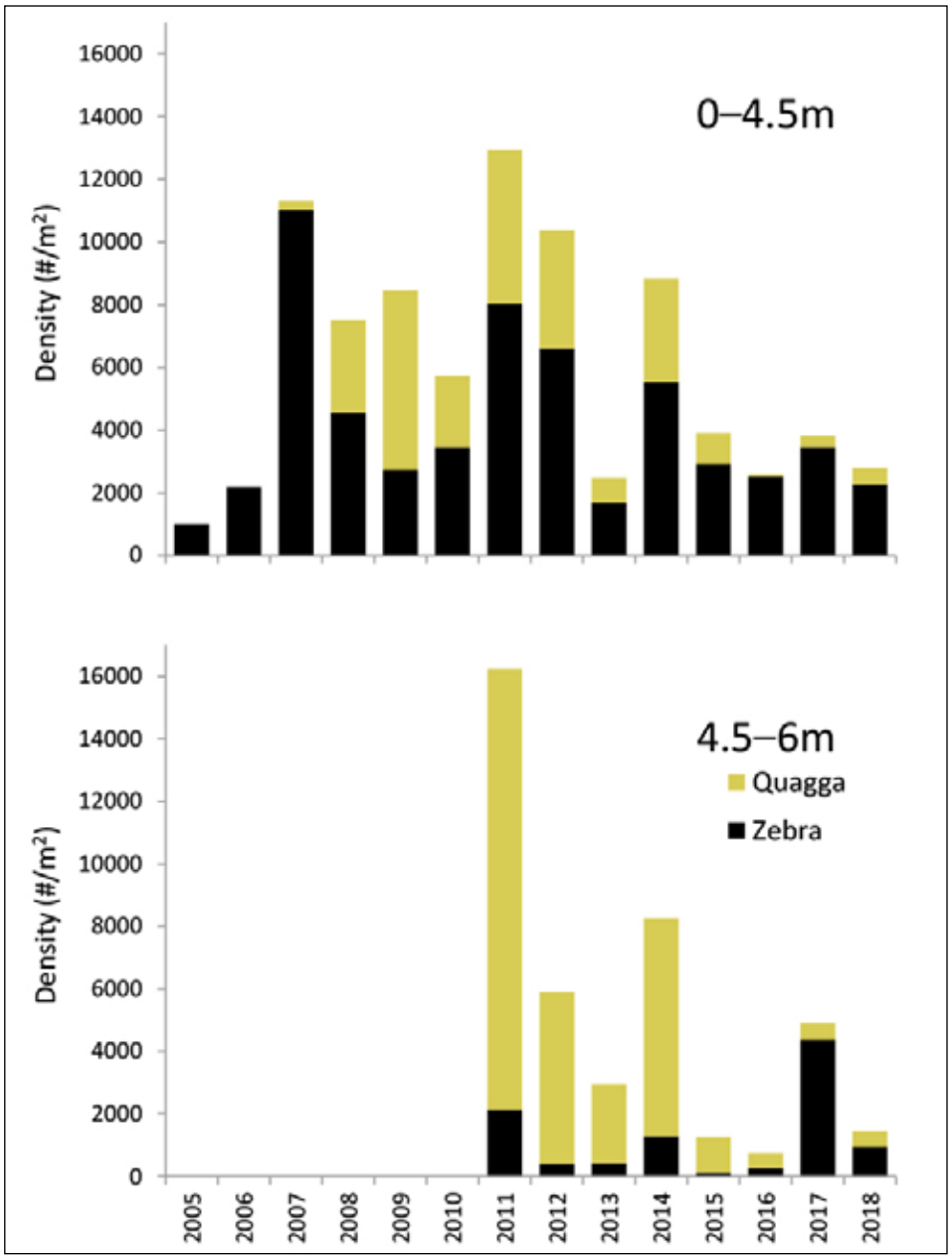

Figure 8. Average density of dreissenid mussels, 2005-2018.

Fish community

Nutrient reduction has improved fish habitat. In the past, many fish would swim from the lake during fall turnover to escape low DO concentrations. Since that time, conditions for ammonia-sensitive aquatic invertebrates and early life stages of fish have improved due to Metro's nitrogen treatment upgrades. Moreover, the expansion and diversification of the aquatic macrophyte community has provided habitat for a variety of fish species.

One of the most notable results of nutrient reductions has been the increase in water clarity and the subsequent increase in aquatic macrophytes. Numerous species of fish depend on aquatic vegetation for their survival (Valley et al. 2004). Species such as Pumpkinseed *(Lepomis gibbosus),* Bluegill *(Lepomis macrochirus)*, Largemouth Bass, and Northern Pike *(Esox Lucius)*, depend on submersed aquatic vegetation for food and shelter. Other non-game species such as Brook Silverside *(Labidesthes sicculus)* and Banded Killifish *(Fundulus diaphanus)* depend primarily on nearshore emergent and submersed vegetation for much of their life history.

In response to improved habitat, the fish community has increased in diversity and abundance comparable to other regional lakes. Noble and Forney (1969) encountered 14 species and deemed the lake a warm water fish community. In the early 1990s, Ringler et al. (1996) sampled about 40 species of fish annually. The lake-wide biomonitoring conducted by the Onondaga County Department of Water Environment Protection has recorded since 2000, 53 species of fish. Combining all other studies since 1927, 66 species of fish have been identified in Onondaga Lake.

The fish community is affected by many factors interacting in complex ways, notably invasive species. For example, the invasion of the lake by alewife (*Alosa pseudoharengus*) has changed the species composition and average size of the zooplankton community. Alewife prey on the larger zooplankton, and the smaller species that remain are less efficient grazers of phytoplankton. The round goby affects the population of dreissenids (also invasive) by direct predation and may also have other impacts on the ecosystem.

Discussion

Onondaga Lake is a Clean Water Act success story. Investment in advanced nutrient controls has returned the lake to a mesotrophic condition. With phosphorus and Chl-*a* concentrations comparable to those of many neighboring lakes, Onondaga Lake appears to be less susceptible to the cyanobacterial blooms that have become prevalent in recent years. The high N:P ratio in the lake water, and the near absence of ammonia, benefit the plankton community by helping suppress mercury releases from legacy contamination. The benthic and fish communities are responding to the improved habitat quality of the littoral zone.

The Onondaga Lake story also contributes to our scientific understanding of lake eutrophication. The complex interplay of bottom-up forces (nutrient reduction) and top-down forces (invasive species) shows how lakes are affected by both targeted management actions and factors beyond our control. As illustrated in Figure 9, nutrient reduction affects all trophic levels of the ecosystem, including the lake's open waters and littoral zone. Water quality improvements and the Superfund cleanup intersect at NO3, with its impact on both phosphorus and mercury releases from sediments.

Over the past 10 years, the lake water quality has remained remarkably stable with little change in TP (Figure 3), NH3 (Figure 4), NO3 (Figure 5), and Chl-*a* (Figure 7) and the absence of major algal blooms. This stability prevails despite considerable variation in upper trophic level dynamics. For example, the density of the dreissenid community has varied considerably from year to year, and the species composition has changed; after being largely replaced by quagga mussels, zebra mussels returned to dominance, making Onondaga Lake the first system in which this change was documented (Strayer et al. 2018; Figure 8). Alewives, with their striking impacts on plankton populations, have varied dramatically year to year (OCDWEP 2020b).

Nonetheless, in recent years average Chl-a concentrations (Figure 7) and the frequency of blooms have appeared to trend slightly upwards. Cyanobacterial populations have also increased recently (although not to levels seen in the past). Whether these trends are statistically significant is not yet clear. Also, the potential causes are not known because TP remains low and the TN:TP ratio remains high but contributing factors may include year-to-year variation in precipitation, trends in temperature due to climate change, or complex processes involving upper trophic levels.

The County's attention is now focused on the tributary sub-watersheds to track nonpoint sources and ensure the hard-won gains in water quality, benthic habitat, and aquatic species diversity and abundance continue. County, state, and federal partners plus a diverse array of community stakeholders have worked closely over the past 20 years to realize these substantial improvements in the Onondaga Lake ecosystem. The effective partnerships among resource managers, municipalities, local universities, and the research community will help sustain the progress and facilitate adaptive management to emerging issues of invasive species and climate change.

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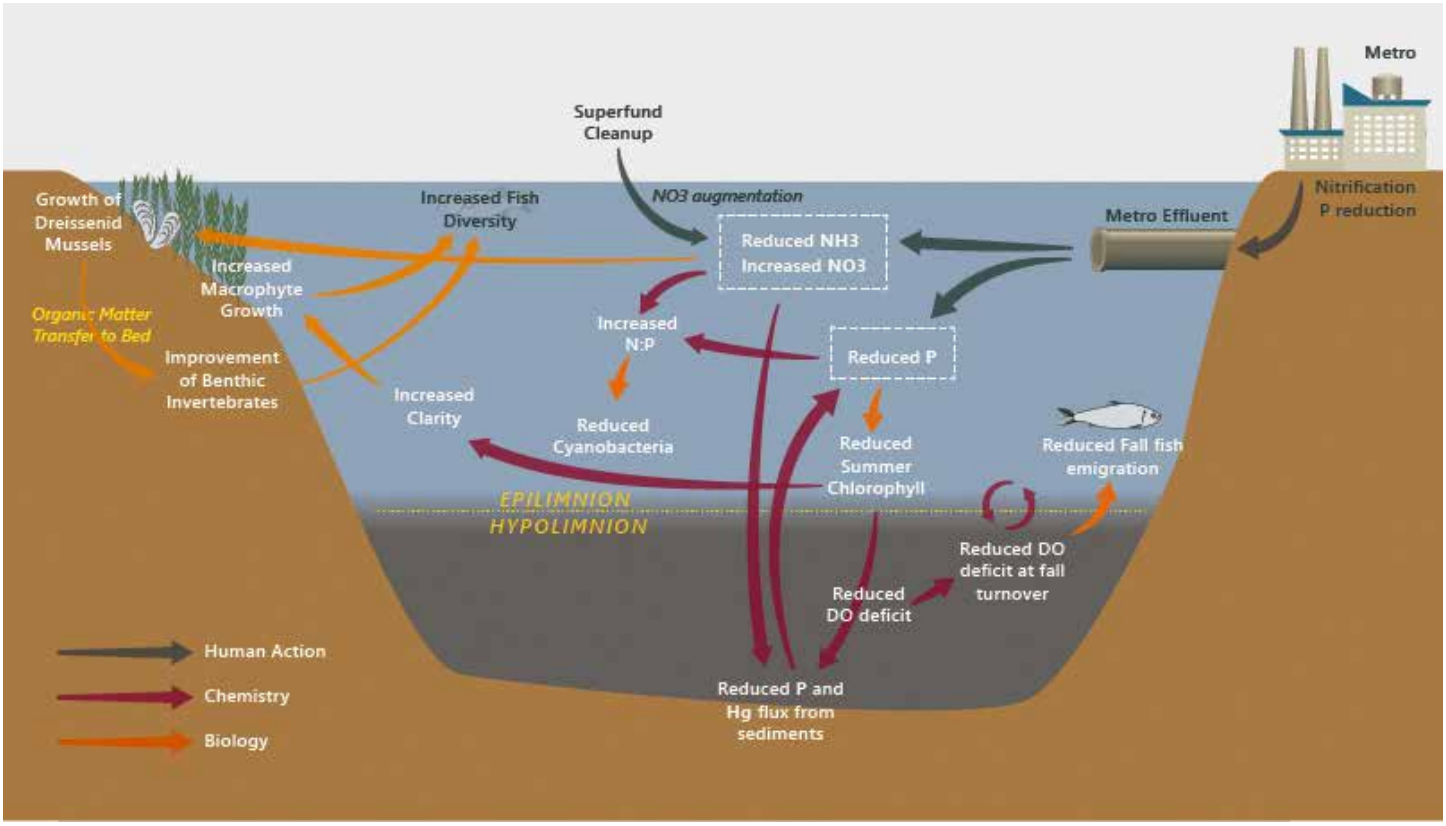

Figure 9. Conceptual model of the impacts of Metro improvements on the lake ecosystem.

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David Glaser, Ph.D., is an environmental scientist with more than 30 years of experience. He works at Anchor QEA, a science and engineering firm, where he was a founding partner. He participated with a team of scientists and engineers in developing a water quality model of the Seneca River and Onondaga Lake, to support Onondaga County Department of Water Environment Protection (OCDWEP) in meeting the goals of the phosphorus TMDL for the lake. His particular contribution was the development of a bioenergetics-based model of zebra mussels and their impacts on the aquatic environment. You can contact him at dglaser@anchorqea.com.

James R. Rhea, Ph.D., a founding member of Anchor QEA, LLC, has over 30 years of experience in the assessment and mitigation of water quality problems under CWA, CERCLA, and RCRA. He was the principal investigator for the development and application of a water quality modeling framework for the Onondaga Lake and Seneca River that guided the mitigation strategies for the system. He also served on the Onondaga Lake Technical Advisory Committee that oversaw the execution of the Ambient Monitoring Program that produced the physical, chemical, and biological database used to assess the impact of advanced tertiary treatment on the water quality of Onondaga Lake and its attainment of water quality standards. Jim Rhea can be reached at jrhea@anchorqea.com.

Elizabeth Moran, Ph.D., is an aquatic scientist specializing in lake and watershed management. She is a principal scientist at EcoLogic LLC, in Cazenovia New York. Liz has collaborated with this team of environmental engineers and scientists for decades on the Onondaga Lake restoration project. She has served on the Onondaga Lake Technical Advisory Committee to the Onondaga County Department of Water Environment Protection since 1996 and helped develop the metrics used to track the ecosystem response to point and nonpoint source controls. You can contact her at LMoran@EcoLogicLLC.com.

Christopher Gandino, is a sanitary engineer II with the Onondaga County Department of Water Environment Protection. His work for the last 35 years has focused on the biological communities of Onondaga Lake in response to water quality improvements. You can contact him at chrisgandino@ongov.net.

Honoring Our Waters: Tribal Investment

Nancy Schuldt

The Fond du Lac Band of Lake Superior Chippewa has been delegated regulatory authorities (Water Quality Standards [WQS}, §401 certification) and non-regulatory authorities (monitoring, nonpoint source management) under the Clean Water Act. The tribe's considerable investment in protecting our water resources is grounded in both a cultural worldview *(water is sacred; we human beings are in relationship with the natural world, not in dominion over it)* and a clear focus on protecting the high-quality water resources (Figure 1) of the reservation and ceded territories of the upper Great Lakes region. Our water quality monitoring program (Figures 2-4) has, since 1998, built a comprehensive database of physical, chemical, and biological data which we have used to inform the development of new approved water quality criteria (lake-specific numeric nutrient criteria, a specific conductance aquatic life use criterion, biological thresholds for streams).

Figure 1. Protecting high quality waters in undisturbed watersheds (Lac Lake).

Figure 2. Monitoring in the headwaters of Otter Creek.

Figure 4. Restoring lake sturgeon to the upper St. Louis River.

< Figure 3. Summer intern opportunities: stream fish electroshocking surveys.

Along with refining our WQS, monitoring data also provides the scientific basis for many of the conditions we impose through §401 certification of federal permits. As the foundation for our water quality program, monitoring has directly and indirectly affected critical decision-making, including during emergency response and industrial permitting actions. For instance, in February 2019, a train loaded with coal derailed on the Fond du Lac Reservation in northeastern Minnesota, sending 40 cars off the tracks and spilling over 4,600 tons of coal across the site and onto the frozen St. Louis River. With pressure from tribal leadership and legal staff, the rail company came to recognize tribal authorities and staff capacity for shaping incident response, determining short-term cleanup objectives, and defining longer-term ecological recovery. More recently, when petroleum pipeline construction activities caused the breach of an artesian aquifer, sending millions of gallons of groundwater into the watershed upstream of the Band's wild rice lakes, our monitoring data, standards and §401 certification authorities all came into play as the company coordinated remedial actions with the Band and state agencies.

Nancy Schuldt has served as the Fond du Lac Band of Lake Superior Chippewa's water projects coordinator since 1997. She developed the Band's water quality standards and long-term monitoring program, including recently approved numeric nutrient criteria for lakes and biological criteria for streams on the reservation, located in northeastern Minnesota. She has directed research into fish contaminants and sediment chemistry to characterize mercury impacts to Fond du Lac Band members, collaborated on research into wild rice ecology and toxicity, as well as watershed hydrologic modeling to inform management and restoration efforts. She participates in numerous local, regional, national, and binational working groups to ensure the tribal perspective is represented and initiated a cooperative wastewater management project with the non-tribal community to service a heavily developed lake on the Reservation. She initiated the tribe's nonpoint source management program and leads the Band's environmental review of mining and energy industry impacts to treaty-protected resources. Nancy has a degree in biology from the University of Dayton, and a master's degree in aquatic ecology from the University of Kansas.

The Clean Water Act
Needs an "Enhanced" Clean Lakes Program

Kellie Merrell

The 50th anniversary of the Clean Water Act (CWA) is a great opportunity to reflect on the many accomplishments that states, tribes, local communities, and nonprofit organizations such as NALMS and lake associations have made to protect and restore our lakes and streams. It is also a time to reflect on the many challenges that remain as well as the new ones that emerge for protecting and restoring our waters – and especially lakes. The CWA is a multifaceted act that addresses a wide range of water pollution issues including lake water quality. For those who want a refresher or an introduction to the CWA, please visit EPA's Watershed Academy and you'll find several training modules on the Act.

The federal CWA has many different sections to address varied aspects of water pollution. Section 314 Clean Lakes Program is one of the sections and it was originally established in 1972 under the Federal Water Pollution Control Act Amendments (P.L. 92-500) to address lakes and was initially funded in 1976. The final year of Clean Lakes Program funding was in 1995; a total of $145 million of Section 314 funds was awarded by Congress over a 20-year period, though $380 million was originally authorized from 1973-1980.

Section 314 Clean Lakes Program

In 1980, when NALMS was formed, there were many foundational lakes activities that were happening that were driven in large part by funding under the Section 314 Clean Lakes Program. This voluntary Clean Lakes Program helped states, tribes and local communities manage their lake resources with financial and technical assistance. Most Section 314 funds went to the implementation of projects to help locals restore their lakes. EPA also funded $35 million in research and development grants from 1975 to 1979 to advance the science of lake restoration and demonstrate the effectiveness of several types of lake management techniques.

Many key lessons were learned in these early efforts and provided an important foundational understanding of lakes and reservoirs and how to manage them to protect and restore their water quality. Responding to these lessons, EPA promulgated Clean Lakes Program regulations in 1980 (40 CFR Part 35, Subpart H). The 1980 regulations set up a program to award four types of grants under this program to states and tribes:

1. **Lake Classification Survey/Water Quality Assessments –** grants to assess the water quality of lakes across a state or reservation.
2. **Phase I – Diagnostic/Feasibility Studies** – grants to determine the causes of pollution to a specific lake and recommend the restoration methods.
3. **Phase II – Restoration and Protection Implementation Projects** – grants to fund implementation of Phase I recommendations.
4. **Phase III – Post-Restoration Monitoring Studies** – grants to support post-restoration monitoring and evaluation of completed Phase II projects.

More details on the Clean Lakes Program can be found in the actual Clean Lakes Program regulations, on an archived EPA lakes website: https://archive.epa.gov/water/archive/web/html/onlndocs.html and a *LakeLine* article at: https://www.nalms.org/wp-content/uploads/2018/09/30-3-5.pdf. Importantly, the Clean Lakes Program successfully supported the restoration of several lakes across the country – a few of which are highlighted in the "sidebars" associated with this article.

Section 319 Nonpoint Source Program

Another important section of the CWA is the Section 319 Nonpoint Source Program that was established in the 1987 Amendments to the CWA. Since 1990, EPA has been providing financial support to states and tribes through Section 319 grants to implement their nonpoint source management programs. EPA has encouraged states and tribes to use Section 319 funds to support the Clean Lakes work previously funded under the Section 314 Clean Lakes Program. EPA issued a set of questions and answers on the relationship between 319 and 314 – this guidance can be found via the link listed above. At the 2019 NALMS conference, Curtis and Flaherty reported that 19 percent of 319 funds are used annually to fund lakes-related projects, but it's use for that purpose varies widely by state and tribe.

National Lakes Assessment

In addition to awarding grants to support lakes work, EPA has been funding a series of National Lakes Assessments (NLA) with the first one in 2007 and subsequent ones in 2012, 2017, and 2022. These assessments provide an unbiased estimate of the condition of natural and man-made freshwater lakes, ponds, and reservoirs across the country. The opening article in this issue was written by EPA and summarizes the history of data collected through the NLA.

Readers are encouraged to visit EPA's NLA Website at https://www.epa.gov/national-aquatic-resource-surveys/nla to read about the detailed findings of these assessments. But suffice it to say, the

trends and the findings are not good. For example, the surveys found the proportion of lakes in the nation that are eutrophic and hypereutrophic jumped from half to 69 percent in just the five-year period between the 2012 and 2017 surveys. As of 2017, only 11 percent of the nation's lakes remain oligotrophic.

NALMS 314 Workgroup

While the NLA and the Section 319 programs are good, they are not sufficient to address the water quality issues of lakes across the country today. Given this, NALMS established a workgroup in 2021 to try to increase funding for lake restoration and protection including reestablishing an enhanced Section 314 Clean Lakes Program. I have had the privilege to co-chair this NALMS workgroup and we have developed a policy statement calling for more funding for lakes restoration and protection. This policy statement was adopted by the NALMS board and it is posted on the Web at: https://www.nalms.org/nalms-position-papers/enhanced-314-clean-lakes-program-position-statement/. We are also currently working on developing outreach materials to share with legislatures and others to raise awareness for the need for greater funding for lakes restoration and protection.

The following sidebars highlight some of the great work that the 314 Clean Lakes Program fostered:

Section 314 Clean Lakes Program Financial Assistance:
A Catalyst for Inland Lakes Monitoring in Michigan

Ralph Bednarz

Michigan is a lake rich state with approximately 3,300 miles of Great Lakes shoreline and over 11,000 inland lakes. Michigan's history of lakes management dates back to the early 1900s along with fisheries management and the desire to culture and stock fish in Michigan lakes and streams (Latta 2006). However, prior to the passage of the Federal Water Pollution Control Act in 1972 and the implementation of the Clean Water Act Sec. 314 Clean Lakes Program in 1976, few water-chemistry data had been collected on Michigan lakes, which hampered understanding and documentation of status and trends in lake water quality.

Michigan initiated a systematic effort in 1973 to monitor the quality of its inland lakes (Walterhouse 2015). It was expected that the "significant" lakes, defined as public lakes 50 acres or larger in surface area, could be sampled every 5 years. These included 656 lakes with public access facilities out of the approximately 2,000 Michigan inland lakes of that size. By 1979, only 300 of the significant lakes had been sampled due to budget and personnel constraints. A more robust lake monitoring program was needed to fulfill the lake classification requirement of the Clean Lakes Program in Michigan.

Additional Clean Lakes Program funding became available to the states as one-time grants in 1980 for inventorying and classifying publically owned freshwater lakes according to trophic condition. Michigan was awarded a lake classification grant in 1980 and continued and completed the water quality monitoring and assessment for the 656 significant public lakes (Massey 1982).

In addition to the lake classification grant support, Michigan was awarded 16 individual project grants: seven Diagnostic-Feasibility Studies (Phase I) awards, eight Restoration and Protection Implementation Projects (Phase II) awards, and one Post-Restoration Monitoring Studies (Phase III) award, during the time period of the Section 314 Clean Lakes Program financial assistance.

Michigan also initiated a volunteer lakes monitoring program, the Self-Help program, in 1974. Now known as the Cooperative Lakes Monitoring Program (CLMP) under the Michigan Clean Water Corps (MiCorps), the CLMP is the second-oldest volunteer lakes monitoring program in the nation (https://micorps.net/).

Congress eliminated funding for the Clean Lakes Program in 1995. Michigan continued its lake water quality assessment monitoring program in partnership with the U.S. Geological Survey (USGS) with support from the Clean Michigan Initiative bond fund, passed by the citizens of Michigan in 1998. From 2001-2010, 729 public access inland lakes greater than 25 acres in size were monitored for baseline water quality conditions and trophic status (Fuller and Taricska 2011).

In 2002, Michigan initiated a statewide Status and Trend Program with a statistically based design and standardized sampling methods for public inland lakes ten acres and larger (Wehrly et al. 2011). The lakes are stratified by size and fisheries management unit, which allows for statewide and regional watershed assessments of fisheries, lake habitat, and water chemistry. The number of lakes surveyed per year varies depending upon individual management unit priorities, but typically about 25 lakes per year. Approximately 600 lakes have been surveyed with the status and trend protocols to date.

Michigan participates in the National Lakes Assessment every five years, from 2007 to present. A minimum of 50 lakes are sampled to provide for a state-scale assessment. In 2022, Michigan also participated in the Northern Lakes and Forest Ecoregion intensification project, which included approximately 65 Michigan lakes (https://www.fs.usda.gov/detail/hiawatha/news-events/?cid=FSEPRD1057366).

Section 314 Clean Lakes Program support was the catalyst that launched Michigan's inland lakes water quality monitoring and assessment programs. Restored funding for an enhanced Section 314 Clean Lakes Program would assist Michigan, and all the states, in expanding its lake monitoring and management programs for the preservation and protection of lake resources in Michigan and across the nation.

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Ralph Bednarz is a retired limnologist after a 35-year career in environmental protection and water resources management with the Michigan Department of Environmental Quality. Ralph managed the Michigan's inland lakes water quality monitoring programs. He was responsible for the implementation of the 2007 and 2012 National Lakes Assessment (NLA) in Michigan and he served as a national trainer for the 2012 NLA. Ralph coordinated the development and implementation of the Michigan Clean Water Corps (MiCorps) volunteer water monitoring network, including the Cooperative Lakes Monitoring Program (CLMP). Ralph holds a BS in biology/chemistry from the University of Illinois and an MS in limnology from Michigan State University.

Studying and Rehabilitating **Harveys Lake**

Fred Lubnow

In response to cancelling an annual triathlon event due to issues associated with water quality problems in Harveys Lake, the Borough of Harvey's Lake submitted for and was awarded funding through the Clean Lakes Program (Section 314) in 1993 to conduct a Phase I Diagnostic / Feasibility study of the lake and watershed. The resulting Management Plan was used to obtain funds for the implementation of a variety of watershed and in-lake management measures to reduce the lake's annual total phosphorus (TP) load. Most of the funds for these projects focused on stormwater management and originated from the Non-Point Source (Section 319) program as well as Pennsylvania's Growing Greener grant program.

The original management plan developed through the Section 314 funding served as the foundation for both the development of the lake's total maximum daily load (TMDL) for total phosphorus (TP) as well as it's Watershed Implementation Plan. In turn, the subsequent implementation efforts resulted in the lake attaining 75 to 80 percent compliance with the TMDL and being in compliance with the targeted mean TP Trophic State Index of 50 or lower over eleven of the last 12 years. As a result of these conditions, the Pennsylvania Department of Environmental Protection has taken Harveys Lake off the impaired list.

While the use of 314 and 319 funds resulted in an improvement in the overall water quality of Harveys Lake, the lake is still an excellent example of why funds should be reinstituted into the Clean Lakes Program. Although improvements in water quality were realized with each of the nutrient control actions, hydrilla ended up entering the lake, more than likely via the public boat launch. The Borough and State have been working on getting the hydrilla under control in the lake; however, additional funds are needed if it is to be eradicated and additional proactive protection measures are to be implemented to prevent this and other invasive species from entering the lake.

Re-funding Section 314 of the Clean Lakes Program could provide the potential funds needed to address these long-term measurements of management and protection for this highly valuable recreational resource.

Fred S. Lubnow is the senior technical director of the Ecological Services at Princeton Hydro, and the office manager of the Exton, Pennsylvania office. Dr. Lubnow received his Bachelor of Science in biology from Susquehanna University (1988), his Master's degree in environmental sciences (1992) from the University of California Davis, and his Ph.D. in limnology (1994) from the University of California Davis. Dr. Lubnow has been an environmental consultant for 30 years and has worked on a variety of ecosystems throughout the Mid-Atlantic States. Dr. Lubnow is also an adjunct professor at Delaware Valley University, Doylestown, PA, where he teaches a course and laboratory on Watershed Management.

Clean Water Act Section 314
Funding to Vermont

Kellie Merrell and Virginia Garrison

From 1977 to 1994, Vermont received over one and a half million dollars in Clean Water Act Section 314 grant funding. NALMS life member Virginia (Ginny) Garrison, who retired in 2008 after 35 years with the Department of Environmental Conservation managing and protecting Vermont's lakes recounted some examples of projects that were funded by 314.

- Starting in 1977, before the three-part 314 grant program was established in 1980, Vermont received $74,640 to investigate the potential to permanently remove nutrients through aquatic plant harvesting on Lake Bomoseen.
- From 1979–1980 Vermont received $100,000 to conduct a statewide Lake Classification Survey.
- In 1980 Vermont received over $200,000 to conduct Phase I Diagnostic Feasibility Studies on Harvey's Lake and Lake Morey.
- In 1982, Vermont received over $100,000 for a Phase I Diagnostic Feasibility Study on Lake Iroquois (Figure 1).
- In 1989, Vermont received over $100,000 to conduct a Phase I Diagnostic Feasibility Study on Lake Champlain.
- In 1986, using the findings from the Phase I Diagnostic Study on Lake Morey, an alum treatment was successfully conducted with funding from a Phase II Restoration Project Grant (Figure 2 and Figure 3).
- In 1990, Vermont received over half a million dollars to conduct a Phase II Demonstration Project Grant on Lake Bomoseen to investigate the use of weevils to control Eurasian Watermilfoil.
- In 1990, 1993 and 1994, Vermont received Lake Water Quality Assessment Grants each for roughly $50,000 and possibly more.

According to the 1996 Vermont Lake Water Quality Report, for the four lakes that received 314 Phase I Diagnostic Feasibility Study grants "In every case, causes have been determined and recommendations for management or restorative action have resulted from the studies."

If we look at Vermont's long-term data from the Vermont Lake Score Card for the three inland lakes that used 314 funding to conduct Phase I Diagnostic Feasibility Studies; Harvey's Lake (1980) shown in Figure 4, Lake Morey (1980) shown in Figure 5, and Lake Iroquois (1982) shown in Figure 6, it seems 314 has left its legacy for all to see etched in the improving water quality trends on these three Vermont lakes.

The importance of the CWA Section 314 Phase I diagnostic feasibility studies cannot be understated for these three Vermont Lakes. Those studies allowed lake managers to

Figure 1. Photo of Lake Iroquois, Vermont.

Figure 2. Photo of Lake Morey, Vermont.

Figure 3. Photo of inlet to Lake Morey, Vermont.

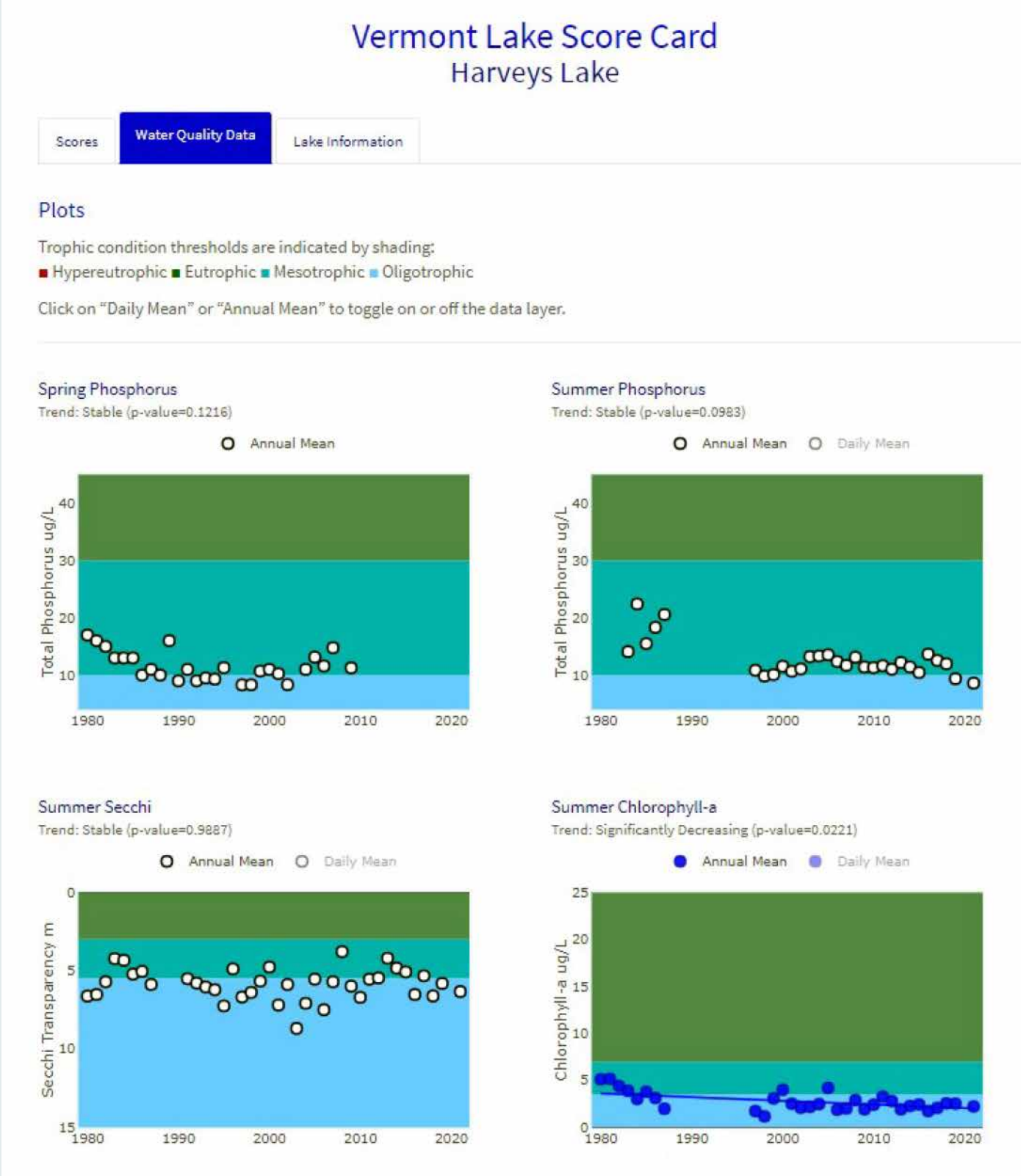

Figure 4. Harvey's Lake long-term water qualitiy trends. VTDEC received a 314 Phase I Diagnostic Grant for Harvey's Lake in 1980.

make decisions in the management of these lakes that have led to lasting improvements in lake water quality. Remarkably, almost four decades later, Lake Morey is only now showing signs the benefits of its alum treatment may be beginning to wane. Sadly, this time around there is not a 314 grant funding source to fund another Phase I diagnostic feasibility study and

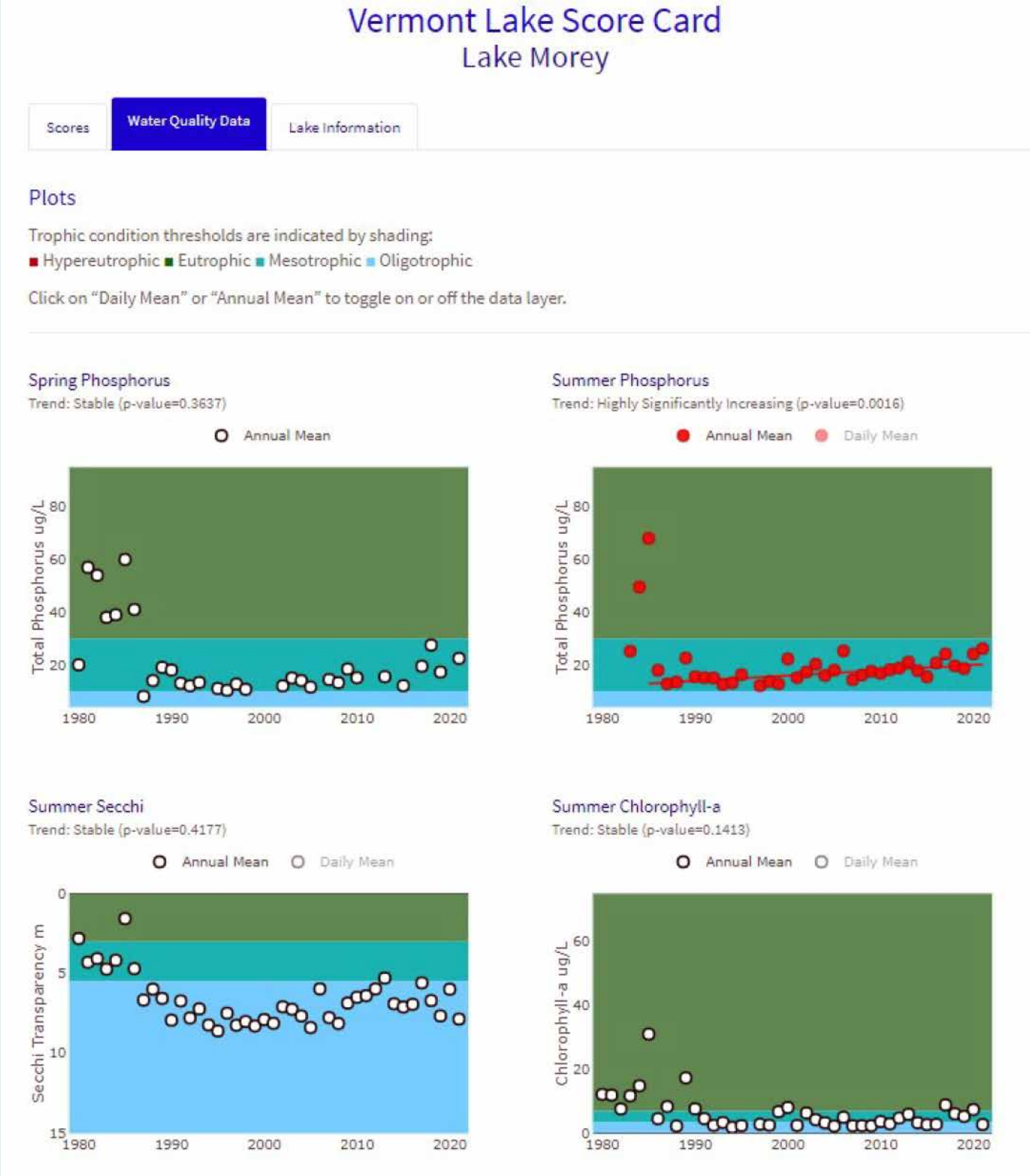

Figure 5. Lake Morey's long-term water qualitiy trends. VTDEC received a 314 Phase I Diagnostic Grant in 1980 and Phase II Restoration Grant in 1986 to implement an alum treatment..

phase II restoration grant to determine if the increasing phosphorus trends in recent years is due to internal loading and to fund another alum treatment to restore the lake if that is determined to be the best lake management approach.

According to Ginny Garrison, retired Vermont Lakes Program Chief, besides the projects funded in Vermont "many of these grants funded new positions, long-term temporary positions that were eventually able to change to full-time. The

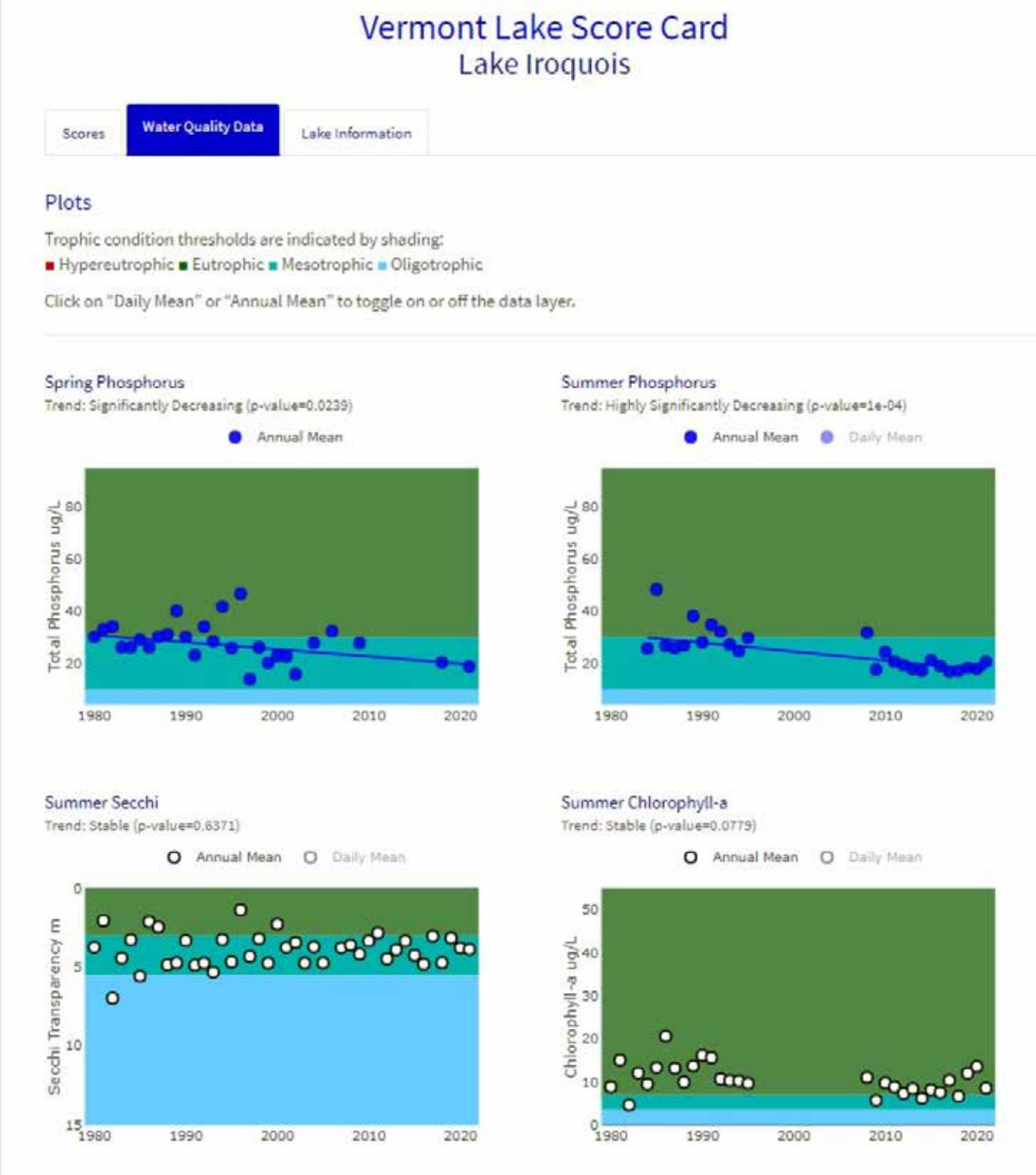

Figure 6. Lake Iroquois' long-term water qualitiy trends. VTDEC received a 314 Phase I Diagnostic Grant for Lake Iroquois in 1982.

funds made it possible for the Lakes Program to learn a lot about Vermont's lakes and do innovative work to manage and protect them. The 314 focus on lakes and their watersheds, separate from the large river watersheds in Vermont that are funded under 319, was important. The switch to 319 funding for lakes was a real loss for lakes, both in Vermont and nationally."

Kellie Merrell is a program scientist with the Vermont Lakes and Ponds Management Program, and currently serves as the Region 1 NALMS Director.

Virginia Garrison is retired from the Vermont Lakes and Ponds Management and Protection Program, where she served as manager of the program for 35 years.

Reflections on Additional Benefits to the 314 Clean Lakes Program

Tracy Lizotte

Now that retirement is on the horizon, I often find myself reflecting on what got me started in the field of environmental science and into water resource management. I believe some of my interest was initially started by my parents who are what I call Long Island Sound beach bums. In my early years, they were living in Atlanta, Georgia, and the place they found to fill their need to be on the water was Lake Lanier. There were many weekends spent learning to waterski and fish that gave me my love of the water, however, the key point that sent me on my career path was a high school internship that started with the CT Department of Environmental Protection (CT DEP) Water Compliance Unit in 1978. At that time, I did not even know about the Clean Water Act and how new many of the programs were. One such program was the 314 Clean Lakes Program which was established in 1972 and funded to 1995.

It turns out that this program was foundational to Connecticut's water monitoring program by (1) enhancing the technical ability of staff to assess lake water quality for status and trends; (2) conducting Phase 1 Diagnostic Feasibility studies to determine cause of pollution and evaluate potential controls and recommend the most feasible and cost-effective lake restoration methods; and (3) building the capacity to manage projects and implement lake restoration techniques that were referred to as Phase II projects. There was work done on important public recreational lakes like Lake Waramaug, Bantam Lake, and Candlewood Lakes as part of the Phase 2 project. During that time, I cannot say I knew how foundational this program would be to myself or the State of Connecticut lakes.

My personal foundation was started with CT DEP when I was placed in the water monitoring lab. My first jobs were not so great; I had to clean out a lot of old smelly fish and bug specimens that had been stored way too long. Looking back now, my persistence of not giving up paid off and I got asked to go out on a Lake Classification Water Quality Assessment Survey (Figure 1). This is where things started to click for me and I could now find a use and application for biology (looking at phytoplanktonic communities), chemistry (looking at nutrient concentration in various lakes and their affects), earth science (looking at different lake types), physics (temperature and stratification effects), math (performing dissolved oxygen analysis with Winkler method), and technology (understanding how a pH or dissolved oxygen meter worked) that I was learning in school at the time. There were so many important things I was learning while doing these surveys. It was not just about the science, as there were other important life skills learned – such as working together as a team, especially on a small boat,

Figure 1. Lake survey crew from the 1980s: Joe Nestico, Tom Haze, and Guy Hoffman. These were my mentors and the crew developing the survey method that CT still uses to today.

planning skills to perform a survey, and learning to communicate this information to the public. As I went onto college and studied environmental studies and worked over my 35-year career I kept calling on the skills I learned on the water quality assessment surveys back at CT DEP in my early career, all in part to the 314 Clean Lakes Program.

Over my long working career and going to NALMS meetings I have heard others talk about similar experiences and getting their start from the 314 Clean Lake program. Just this summer we took out our student research assistant and I could see that same light bulb going off in their mind as the questions were rolling out. As our country's lakes are facing many new challenges such as global climate change, harmful algae blooms, nutrient enrichment, and invasive species, it is a good time to re-fund the 314 Clean Lakes Program to meet these challenges, and I believe in doing so we will see additional benefits for STEM Education and turning the next bright minds on to finding solutions.

Tracy Lizotte is an environmental analyst in the Water Monitoring and Assessment Program with the Connecticut Department of Energy and Environmental Protection. Tracy works on a variety of projects that include the beach program, lake, and cyanobacteria monitoring, as well as statewide monitoring for Clean Water Act assessments.

So, in closing, let's celebrate all the great work done under the CWA over the past 50 years and especially under the Section 314 Clean Lakes Program for lakes. And let's recommit to establishing an "enhanced" Section 314 Clean Lakes Program. By "enhanced," we recommend revising the implementation of the Clean Lakes Program by adding a Healthy Lakes component to protect high quality lakes and prioritize lakes with significant cultural heritage value and lakes in communities where there are environmental justice concerns. The "enhanced" 314 Clean Lakes Program will also need to discuss how Section 314 of the CWA can be fully integrated with the other important CWA tools such as the Section 319 Nonpoint Source Program, TMDLs and the ongoing NLAs.

~ Kellie Merrell

Values of the Clean Water Act (CWA) -

Clean Lakes Program (CLP) – Section 314 Funding

Feedback from various program coordinators of these projects over the years:

"I was fortunate to work on lakes in several states under the Clean Lakes Program. The Section 314 diagnostic-feasibility studies brought a focus to lake water quality issues, and potential solutions, that did not exist in many areas until those studies were conducted. Subsequent restoration efforts under both Sections 314 and 319 provided valuable information on the effectiveness, and in some cases lack thereof, of various restoration alternatives."

– **Chris Holdren, *Environmental Consultant in Colorado, and Past President of NALMS***

"Turns out that the original Clean Lakes concept in the Clean Water Act really did work, the guidelines and EPA's various lake assessment publications provided very good techniques for both effective BMPs and ways to document improvement. In fact, PA DEP through the years adapted much of the Clean Lakes concept for our watershed assessment, implementation and restoration projects. Seems that good things come around again; I think the Clean Lakes Program concepts are timeless and so well thought out that lake assessment and restoration projects will benefit from a higher profile funding avenue from EPA."

– **Barbara Lathrop, *retired from the Pennsylvania Department of Environmental Protection (PA DEP)***

"The passage of the Clean Water Act and Clean Lakes Program were quite literally watershed events for lakes across the country. Much of what New York state learned about lake management and assessments came from Section 314 Clean Lakes program demonstration projects, Phase I diagnostic studies, Phase II implementation projects, water quality assessment grants, and management conferences. More importantly, these projects managed and restored critically important water resources throughout the state, particularly urban lakes serving environmental justice communities. The loss of the Clean Lakes program funding in 1994 led to some states to allocate scarce Section 319 funding for these activities, but in New York and many other states, most of these Clean Lakes needs will continue to be unmet until the Clean Lakes program funding is reappropriated. I strongly urge Congress to restore Clean Lakes funding for EPA."

– **Scott Kishbaugh, *retired from the New York State Department of Environmental Conservation (NYS DEC)***

"The Clean Lakes Program at the federal level provided the most complete framework for assessing lakes and determining a logical course of remedial or protective action. The CLP was adopted by many states with minor adjustments to guide lake programs across the USA. Those of us fortunate to have worked on projects under those programs both gained and contributed to a wealth of lake and watershed management knowledge that is the foundation of what we do today. The defunding of the federal program and gradual dismantling of many state programs has left lake management a fractured discipline in most areas. Approaches like Total Maximum Daily Loads and Watershed Based Plans, and Sec 319 projects are useful but represent only a portion of a complete program. We would do well to return to the complete assessment approach embodied in the original CLP, preferably with federal and state funding support."

– **Ken Wagner, *Water Resources Services, Wilbraham, Massachusetts, Water resource consultant, former NALMS President, and former editor in chief of* Lake and Reservoir Management**

"While the association I have worked for my entire career was not a direct recipient of Clean Lakes Program funding, the Section 314 program was instrumental in raising the regional and national awareness of the importance clean lakes. The assessments and demonstration projects showed many – professionals, citizens, and decisionmakers alike, the possibilities of applying science to improve our nation's water resources. For me, the many projects funded and completed through the Clean Lakes Program showcased the possibilities that I and many other lake managers could replicate with our own resources."

– **Larry Butler, *Reston Association, Reston, Virginia, and past president of NALMS***

"I had the opportunity to work with local units of government, consultants, and USEPA on several Clean Lakes Program projects. The diagnostic-feasibility study, which served as the scientific basis for management decisions, remains a standard approach for lake and watershed assessments in local and state-run projects as well. Another very valuable facet of CLP was demonstration projects. These demonstrations became the basis for developing and refining in-lake and watershed approaches that are now routinely used across the country to improve water quality."

– **Steven Heiskary, *research scientist (retired), Minnesota Pollution Control Agency, and former NALMS president***

Lauren Knose

Student Corner

NALMS Supports Students!

Five years ago, I was attending the first scientific conference of my graduate career (Global Lake Ecological Observatory Network, or GLEON), where I met Lisa Borre, whom I call the unofficial ambassador for NALMS. For those few of you yet to meet Lisa, she is an incredibly welcoming individual, with an accomplished career, and an incredible commitment to engaging and supporting students. After hearing about my interests, Lisa was quick to recommend that I join NALMS and attend the annual Symposium held that upcoming year in Cincinnati, Ohio. Since 2018, I have attended every Symposium and have served as the Student Director for two years. My persistence with this organization should be telling enough how valuable NALMS is, and I cannot express how much NALMS has empowered me as a student and as a professional.

Although my participation in NALMS has been very rewarding, it is my understanding that the full scale of benefits available to student members is not well-known. Some opportunities have been around for many years, whereas others are brand new. I would like to raise awareness of the many ways NALMS supports students, through recognition, funding, engagement, and mentoring. Further, I submit a call to action for students to capitalize on these opportunities and further engage in NALMS and thank NALMS members and leadership for their continued support of students.

Gaining a better understanding of student membership through the Student Story Map

In April 2022, Student Programs launched the Student Story Map webpage (Figure 1) to highlight the students of NALMS. The goals of the Story Map were to increase visibility of students to

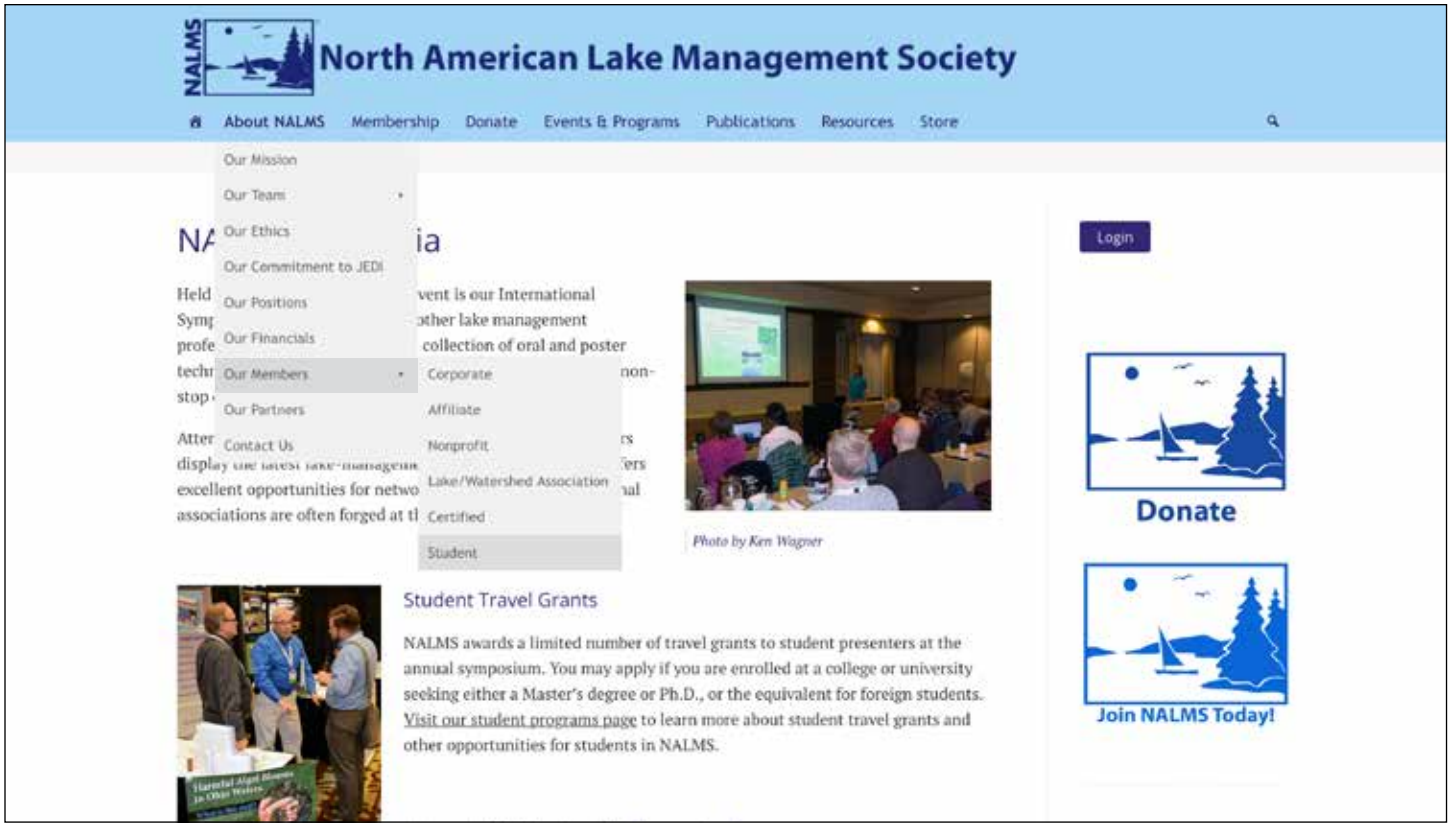

Figure 1. Screenshot of navigating to the NALMS Student Member webpage. The Student Member webpage can be located through the NALMS website (nalms.org) by selecting the "About NALMS," "Our Members," and "Student" tabs.

potential graduate programs and/or employers, increase the awareness of programs across the United States (U.S.) where students are studying lake science and management, and to improve equity in recruitment and representation. The Story Map includes an interactive heat map (Figure 2) showcasing where students are studying lake science and management, updates on Student Programs activities, a slideshow showcasing the latest accomplishments of NALMS students, and links to the Student Survey, membership, and donation pages. Users can zoom through the interactive map to specific regions and select the data points to see the academic institution highlighted. The Story Map was developed using the ESRI Story Maps platform and is updated quarterly by the Student Director. If you would like to nominate a student or yourself to be highlighted, send an email to the student director (student@nalms.org).

Student members come from all over the world, with greater representation in the U.S. and Canada. NALMS students are spearheading the effort to improve diversity and inclusion among members and to ensure NALMS is a welcoming and safe environment through the Justice, Equity, Diversity, and Inclusion (JEDI) Program. You can view a summary of the JEDI efforts in NALMS presented at JASM 2022 by students Sarah Burnett and Keiko Wilkins. Of the 101 historically black colleges and universities (HBCUs) in the U.S., 100 are located within five miles of a lake or reservoir (spatial analysis performed in ArcGIS Pro 2.9.0 using Environmental Protection Agency (EPA) NHDPlus waterbody data and IES National Center for Educational Statistics, HBCU data). Thirty-four HBCUs are located within walking distance (0.5 miles) to a lake or reservoir, which means those students, who are generally under-represented in NALMS membership, are more likely to be influenced and affected by lakes. Student Programs uses the map to determine where students are less represented and where outreach and support may improve student engagement.

Working to better serve student members through the Student Survey and Dashboard

In April 2022, Student Programs launched the Student Survey (Figure 3) aimed at better serving student members, by identifying students who have yet to receive funding support, connecting students with potential mentors, and providing greater opportunities for placement with future graduate programs, internships, and employment. Students can answer questions related to their focus of interest/research, academic level,

Figure 3. QR code to access the NALMS Student Survey. Students (members and non-members) are encouraged to scan the QR code (or visit the webpage) with a mobile device or computer and fill out the survey.

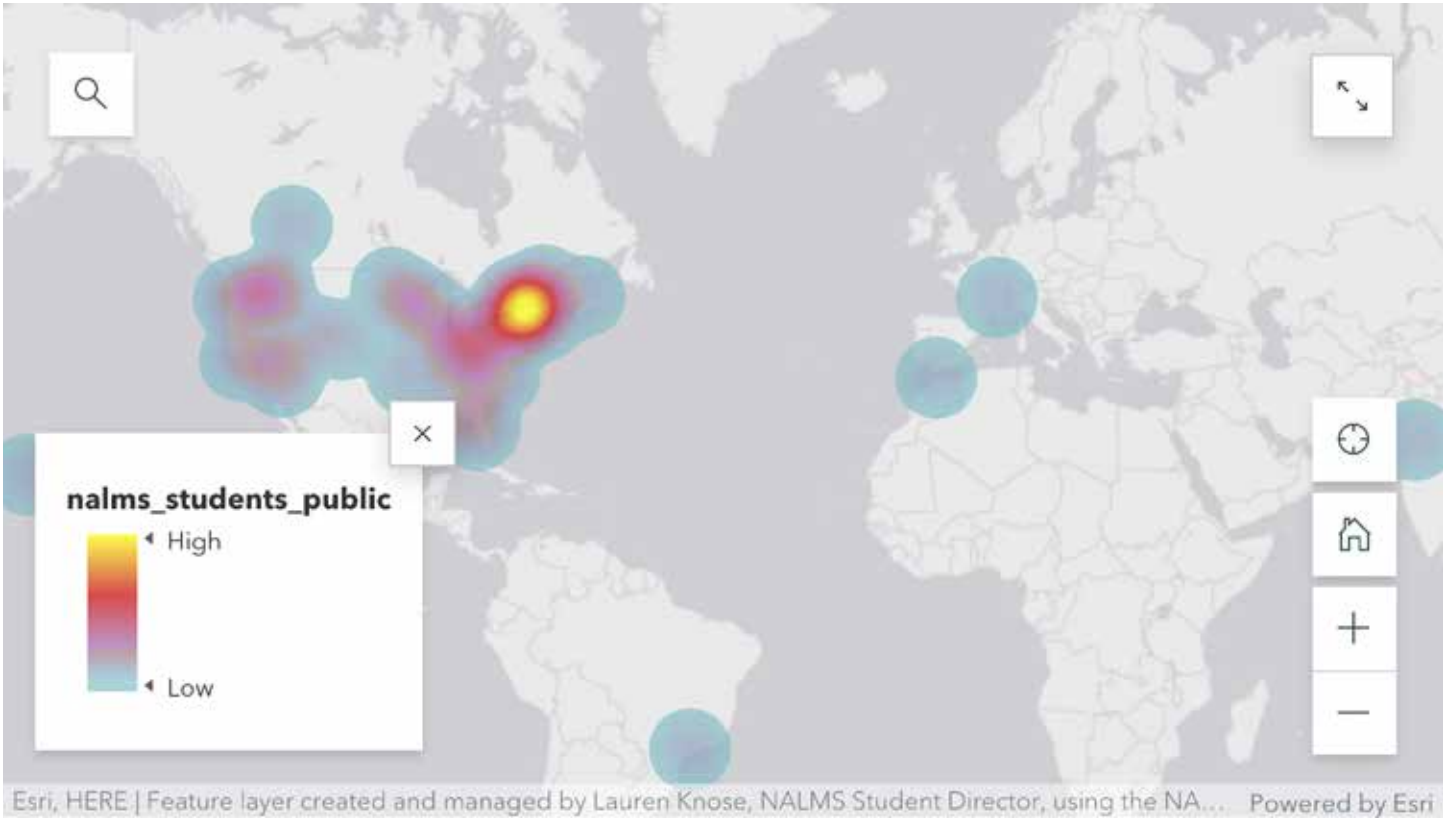

Figure 2. Heat map displaying the relative number of NALMS student members, located by academic institution. The density of student members in a region are displayed across a color scale of blue (low) to yellow (high).

membership status, anticipated graduation date, and any previous support received. The data collected by the survey are displayed through an interactive Dashboard (Figure 4), which is available only to NALMS members.

Each section of the Dashboard can act as a filter, simply by clicking on the information of interest. For example, if you are an employer and looking for a Masters-level student, who studies invasive species, and will be graduating soon, you can filter the list of students within a specific NALMS region, academic level, type of employment wanted, or by topic of interest, and the list of student members who fit those criteria will auto-populate. Likewise, if you are a student looking for a peer-mentor in a program related to a topic of interest, you can query the dashboard to find potential graduate programs and students to contact. The dashboard is auto populated by the data entered into the Student Survey. The survey and dashboard were developed using the ESRI survey123 and Dashboard platforms and is updated quarterly by the Student Director.

Opportunities for student engagement and benefit

NALMS supports students in many ways and through several programs, in addition to providing reduced rates for membership and conference registration. The following list includes the many opportunities for student members to participate and receive support from NALMS.

NALMS Programs and Committees

There are many programs and committees that are welcoming to student participation and engagement. For example, the Student Programs Planning Team, which meets quarterly to discuss and plan activities and support for students, is actively seeking current students to participate. The Planning Team generally consists of the Student Director, past student directors, current student members, and student mentors. If you are interested in serving on the Planning Team for Student Programs, please reach out to the student Director at student@nalms.org.

Student Video Series contests

Last year, NALMS offered three video competitions with prizes for first-, second-, and third-place winners. Participants were asked to make either an eight-minute video or short clip (140 sec) related to a lake management initiative. The guidelines for the video were posted on the student video series webpage. The winners of the video contest were Ben Cuppett and Jess Casey, students at SUNY Oneonta Lake Management Program. They received a $500 gift card to support their research and a free membership to NALMS. You can watch the winning video on YouTube, titled "Clean Lake Initiative 314."

Jody Connor Student Awards

Each year select NALMS members review poster and oral presentations given by students at the annual Symposium. The winner(s) receive awards and special recognition by the NALMS Awards Committee.

Kenneth H. Reckhow Scholarship Fund

Every year, a graduate student is randomly selected to receive $500 to use toward education and research, provided through a generous donation from life-time member Kenneth H. Reckhow. To qualify for this scholarship, graduate students must register and participate in the Clean Lakes Classic 5K Run/Walk (held during Symposium), be enrolled in a lake management-related graduate program, and be a current member of NALMS.

Student Internships

This year, NALMS is hosting two paid internships, through the Clean Water Act (CWA) 314 Working Group and JEDI program. Sky Embry is an undergraduate student at Trinity College Public Policy and Law program and is serving as the intern for the CWA 314 Working Group. Alexis Johnston is an undergraduate

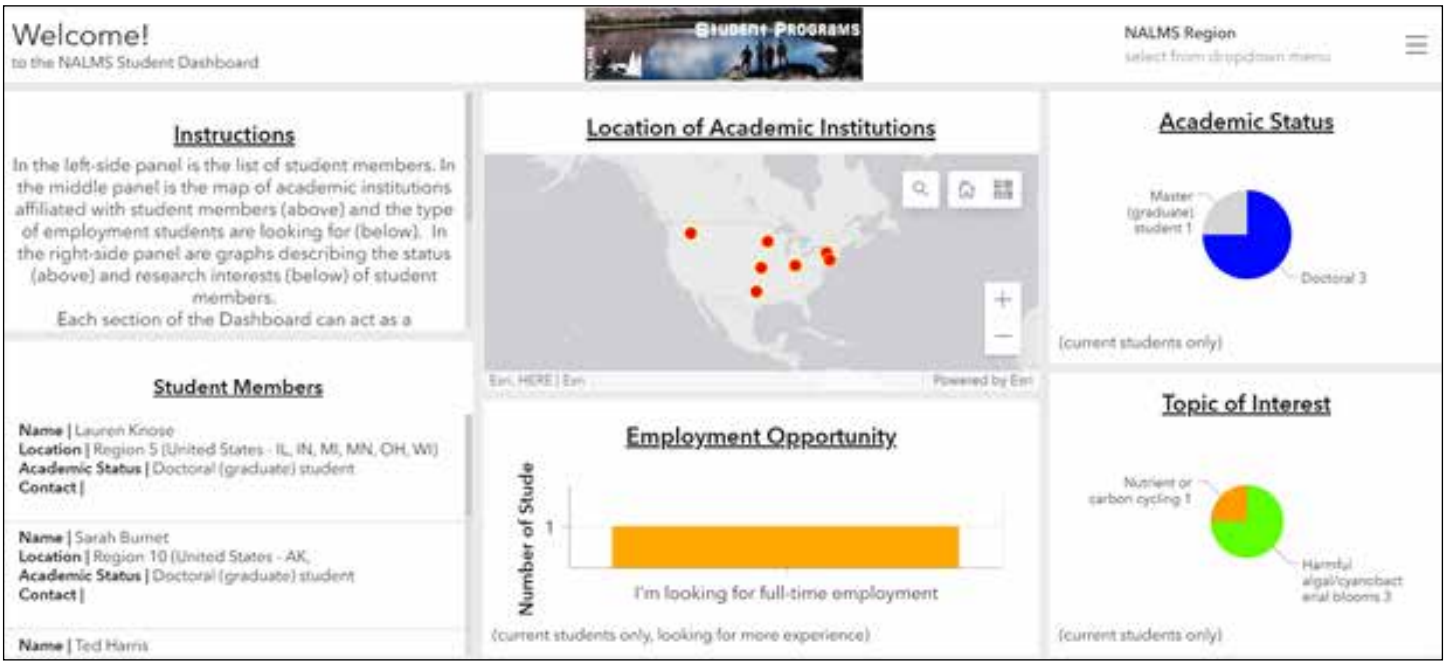

Figure 4. Screenshot of the NALMS Student Dashboard beta version (not showing current membership data).

student at the University of Cincinnati Law and Society program and is serving as the intern for the Justice, Equity, Diversity, and Inclusion (JEDI) program. Welcome to these amazing undergrads!

Student Travel Grants

NALMS offers grants to help cover the cost to travel (hotel, air, or auto transport) and attend the annual Symposium for students who are presenting. Students can apply through the application portal on the Student Travel Grant Application webpage.

Student Mentorship Program

NALMS is a unique community where researchers, practitioners, and industry leaders come together to collaborate, discuss ideas, and share experiences. Students can benefit from a diverse field of mentors, with over half (58.2 percent) of the membership employed in the private sector, 15.1 percent in academia, 13.4 percent in non-profits, 10.8 percent in government, and 2.6 percent in utilities. Student Programs pairs students with experienced mentors willing to help guide students towards greater success in different fields and sectors.

Sponsored Student Program

A portion of NALMS member donations go towards providing free memberships to students. Students can apply through a simple GoogleForm on the Sponsored Student Program webpage.

Resume and Interview Workshop/Session at Symposium

In 2021, Student Programs offered a résumé and interview workshop at the virtual Symposium. The workshop, led by Ryan O'Hanlon (Stonefly Aquatic Nursery), provided a panel of experts from different fields to offer guidance on developing resumes and interviewing skills. During the activity portions of the workshop, students were paired with mentors and received valuable feedback on their résumés and mock interviews. At the 2022 Symposium in Minneapolis, MN, the résumé and interview workshop will be held as a session after the student lunch on Tuesday.

Student Lunch and Home Room at Symposium

At in-person meetings, NALMS hosts a lunch for student members, where they get to meet members of the Board of Directors and leadership for the various programs and committees. Participants can talk about the many ways to participate in NALMS, find mentors, and share ideas and experiences. At the 2022 Symposium in Minneapolis, MN, there will be a Home Room for students to meet, work, or rest.

Student Silent Auction

Every year during the annual Symposium Student Programs holds a silent auction, from which 100 percent of the proceeds go toward supporting student programs, including, but not limited to, student memberships, travel grants, and awards.

Opportunities for supporting students

The students of NALMS are diverse, driven, and devoted to the advocacy, monitoring, and management of lakes and their watersheds. NALMS is devoted to supporting students. If you would like to contribute to supporting students of NALMS, please visit www.nalms.org/donate-to-nalms. If you would like to sponsor a student or donate to the Student Silent Auction, please contact the Student Director (student@nalms.org). If you are a student and not yet a member of NALMS, please visit www.nalms.org/nalms-memberships and sign up!

Lauren Knose is a Ph.D. candidate in ecology, evolution, and environmental biology (EEEB) from Miami University (Oxford, OH). She serves as the NALMS Student Director, Chair of Student Programs, and participates in the Inland HABs Program and Clean Water Act (CWA) 314 Working Group. She was recently awarded a fellowship through the Oak Ridge Institute of Science and Education (ORISE) at the U.S. Environmental Protection Agency (EPA) Office of Research and Development, in the Environmental Decision and Analytics Branch.

"Get to Know a NALMS Intern"

My Experience as a NALMS JEDI Intern

Alexis Johnston

Hello, my name is Alexis Johnston, and I am an undergraduate student at the University of Cincinnati, studying political science and law and society. My field of study primarily focuses on political thought, behavior, and outcomes, especially as they pertain to the law.

My background in political and legal studies was extremely useful for the work I did with the North American Lake Management Society's JEDI Program. This is because political ideologies usually directly coincide with how people view marginalized communities and what they are entitled to, as well as how people react to change in general.

Over the summer, and into this fall I had the pleasure of working directly with the NALMS "JEDI" committee as their intern. "JEDI," is an acronym for Justice, Equity, Diversity, and Inclusion. Coming into the internship, I was under the impression that assistance was needed with general outreach to underrepresented communities and with amplifying underrepresented voices. While this much was accurate, there were many other things that needed to be done, and still need to be done to make NALMS a better environment for everyone.

The JEDI committee for my internship was made up of four incredible co-chairs who are all experts in their

respective fields of lake management or aquatic science. Aside from this, the committee was made up of individuals who saw that NALMS was in desperate need of diversity, education, and outreach initiatives directed at underprivileged individuals and communities. I quickly realized that while a lot of people saw the lack of diversity in many categories as an issue, many people didn't and still don't. I realized that I had my work cut out for me very quickly, before I even began my work for the internship.

My first task during my internship was analyzing voluntary survey data that focused on the demographic representation of the NALMS membership. (I'll display the data from this survey during my talk on divisive concepts during the November 2022 NALMS Symposium). I was immediately overwhelmed with the findings, but not particularly surprised. I was mainly overwhelmed with the level of ignorance that I simply did not anticipate. With the understanding that "ignorance" entails the lack of knowledge or education, I knew that my focus should be on diversity, equity, and inclusion education.

After establishing a foundation of education, the next step would be to work on both sympathizing for and attempting to empathize with the groups of people who are underrepresented and mistreated. I was also confused on why people in this professional sphere didn't know the difference between race, ethnicity, and nationality. Or the difference between sex and gender. While my assumptions are based on survey results, and there may very well have been people that responded in a questionable way on purpose, I truly think there are a lot of individuals who just need to become more knowledgeable on the topics.

I also had an interesting realization that most of the people responding to these questions fall into majority categories. They most likely felt uncomfortable answering these questions. Even though there was nothing at stake based on how people answered the demographic questions in the survey, there was a certain level of defensiveness in some of the written responses, for most of which a written response was not required for the question. I would challenge those people to imagine how people who have identities that are outside of what is respected and rewarded feel about potentially not getting a job based on the information they do or don't include in their application or resume. The work I did with this survey data set the tone for my internship and further ignited my interest in bettering this organization for marginalized and underrepresented communities.

In my role, I also did research to supplement diversity education, analyzed data that outline the existing society demographics and opinions about diversity, and created a presentation that breaks down conflating and confusing terminology that exists within JEDI efforts (which will be shown at the NALMS Symposium).

Most of my intern projects were research projects, data analysis, and or initiating outreach. My favorite part of working as a JEDI intern is being able to use my passion for advocating for marginalized communities in my projects. Aside from the work I did with the survey data, I think the most important thing I have done with this internship and my projects is provide a good foundation for future JEDI interns. This will in turn lead to a better and more inclusive environment in the NALMS community.

My favorite part of working as a JEDI intern is being able to use my passion for advocating for marginalized communities in my projects.

I chose to focus on confusing terminology or divisive terms for my symposium presentation because they often lead to opposition from individuals who do not fit into a marginalized category. This is generally because individuals who experience privilege in an unwavering fashion begin to view equality for others as oppression toward them. This type of research is important because plainly there is an obvious lack of diversity and representation within NALMS. I feel that it is imperative that all members are educated on what "divisive" terms mean and why they matter. This type of education is incredibly important so that NALMS as an organization is accessible to everyone, especially people from marginalized and disadvantaged backgrounds.

To be successful in JEDI efforts, there needs to be a society-wide effort to learn and accept the changes that foster an environment that is conducive to more groups of people. Such changes help to ensure more contribution and advancement in fields such as lake management and aquatic science.

The most important thing I've had reaffirmed for me during this internship is that it's incredibly important to have perspective. The ability to view things from a lens unlike your own is absolutely essential in today's society. Empathy has far-reaching impacts on so many groups of people and everyone can benefit from it. In all honesty, at the heart of my talk for the NALMS symposium is a lesson in empathy and compassion. Overall, the inability to fully empathize with someone isn't a reason to invalidate or ignore their experiences. Therefore, the amplification of marginalized and minority voices is at the heart of JEDI efforts. I have gained so much insight from my JEDI experience and I cannot express how excited I am to present at the North American Lake Management Society Symposium this November.

My name is **Alexis Johnston**, and I am an undergraduate student at the University of Cincinnati studying political science and law. I had the pleasure of working directly with the NALMS "JEDI" committee as an intern – "JEDI," being an acronym for Justice, Equity, Diversity, and Inclusion. In my role, I researched supplemental diversity education, analyzed data that outline the existing society demographics and opinions about diversity, and created a presentation that breaks down conflating and confusing terminology that exists within JEDI efforts. I also engaged with several other research projects, data analysis, and outreach opportunities. My favorite part of working as a JEDI intern was being able to use my passion for advocating for marginalized communities in my projects.

NALMS Membership Form

Mailing address

Name

Company

Address

City ST/Prov. Postal Code

Country

Phone

Email

Billing address ❑ check if same as above

Name

Company

Address

City ST/Prov. Postal Code

Country

Phone

Email

I am ...

❑ ... a New Member ❑... a Renewing Member ❑... purchasing a gift

Individual

- ❑ College Student $45
- ❑ Early Career* $85
- ❑ Professional $140
- ❑ Lake Leader $75
- ❑ Emeritus** $75

*For individuals with less than 5 years in the field - the stepping stone to the Professional level!
**For individuals who are retired, over the age of sixty, and have maintained a membership for five years.

Organization

- ❑ Affiliate $330
- ❑ Lake/Watershed Association*** $165
- ❑ Non-Profit****..... $330
- ❑ Corporate $650

*** For organizations with a yearly budget of under $50K
****For organizations with a yearly budget of over $50K

Do you want to help protect lakes? A donation will help ensure that NALMS' mission to foster the management and protection of lakes continues.

Eberhardt Memorial Student Fund ..... $_____

G. Dennis Cooke Symposium Fund ..... $_____

Lake Givers Club (for general donations) ..... $_____

Payment Information

☐ Check or money order enclosed in the amount of US$_____

☐ Charge the amount of US$ _____ to the following credit card: ☐ VISA ☐ MasterCard | Is this a business card? ☐ Yes ☐ No

Card Number Exp. Date V-code*

PRINT Card Holder's Name

X_____
Card Holder's Signature

**The 3-digit verification code is located on the back of your card in the signature box.*

Mail application and payment in US funds to:

NALMS, PO Box 5443, Madison, WI 53705

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