The New England Region Cyanobacteria Monitoring Program: **A Pilot Study**

Hilary Snook

New England lakes, like many across the country, are experiencing an increase in cyanobacteria blooms. As a result, several communities have seen cyanobacteria-related warnings and advisories in recent years (Figure 1). Adding to the problem, financial resources for monitoring and forecasting bloom occurrences are limited, yet states are still facing increased pressure to develop monitoring programs to help understand and manage blooms and associated risks to the general public. Thus, coordinated efforts are needed between grassroots organizations, resource management agencies, and research institutions to regularly monitor for cyanobacteria and the nutrients that contribute to blooms.

In 2013, state agencies asked the EPA New England Regional Laboratory for better approaches to manage and monitor cyanobacteria and harmful algal blooms. By the middle of that year, the EPA New England Regional Laboratory began hosting cyanobacteria workshops. The workshops were well-attended and quickly evolved into a regional workgroup focused on developing consistent monitoring and sampling protocols across the region. The New England cyanobacteria workgroup represents a diverse community, including state water quality monitoring folks, researchers from EPA's Office of Research and Development, interstate NGOs, public water suppliers, lake and pond association members, public boards of health, watershed associations, the U.S. Geological Survey, academia, university

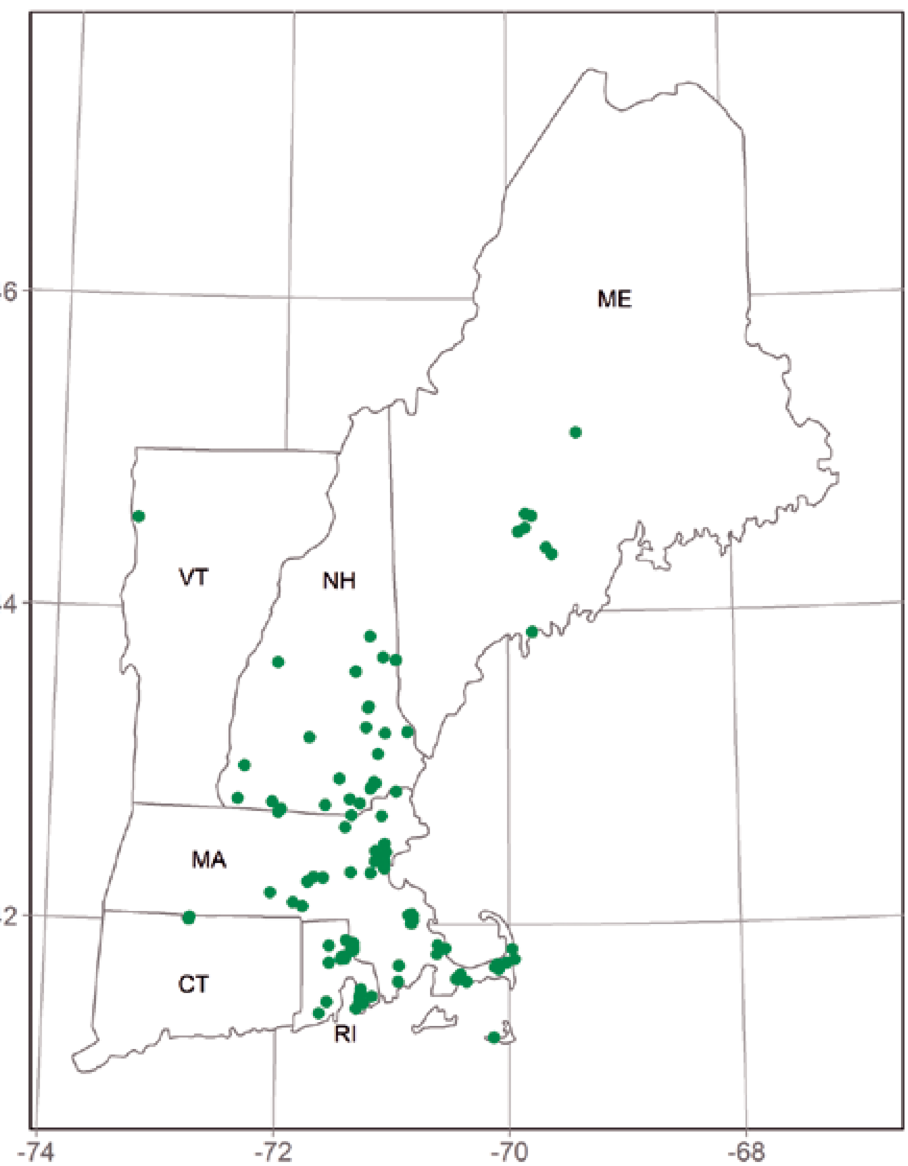


Figure 1. Map of New England lakes identified by state agencies as having cyanobacteria problems from 2009-2012.

Program Participants: Linda Bacon, Joanie Beskenis, Shane Bradt, Sonya Carlson, Elisabeth Cianciola, James Coles, Charles Culbertson, Roger Fryemire, Linda Green, James Haney, Elizabeth Herron, Guy Hoffman, Jeffrey Hollister, Hillary Kenyon, Betty Kreakie, Kitty Lane, Daniel Leonard, Tracy Lizotte, Bryan Milstead, Amanda Murby, David Neils, Dan Peckham, Angela Shambaugh, Toby Stover, Paul Susca, Urena Vuarnelle, George Zoto extension services, and individual citizen scientists wanting to learn more and participate in the program.

Sampling Approach and Methods

The workgroup's initial responsibility was to develop a sampling strategy that provided regionally consistent and useful data while fostering local citizen participation. The collected information would contain useful data for the prediction, identification, and management of algal blooms, while providing a mechanism for the tracking of bloom occurrences and cyanobacteria levels in regional waterbodies. Additionally, an organizing principle for the monitoring effort was to accommodate all levels of participation, while maintaining consistent data collection practices.

The workgroup also understood that it was important to provide mechanisms for educating the public, the principal users of the resources, and provide data that would be useful to public health agencies and water resource officials. Thus, the effort will include data from both citizen scientists, whose only available monitoring tool might be a smartphone, as well as data from large municipal water suppliers with sophisticated sampling and monitoring equipment. This would allow both types of groups and all gradations in between to make contributions to a regional database for sharing and displaying information on regional harmful cyanobacteria bloom (cyanoHABs) occurrences and ambient cyanobacteria concentrations.

To monitor for blooms, field crews used hand-held, field fluorometers as the principal monitoring tool to quantify overall phytoplankton (chlorophyll) and cyanobacteria concentrations (phycocyanin). All blooms are not necessarily toxic, nor are they always cyanobacteria and it is rare to be able to distinguish this visually (Figure 2). The fluorometers allow one to discriminate between ambient phytoplankton, and the presence of cyanobacteria blooms or ambient water column concentrations that have the potential to be toxic.

To collect lake water for analysis, the sampling equipment was made up of varying lengths of inexpensive tubing, which allowed for integrated sampling down through the water column. Regional concerns are focused on tracking the onset of CyanoHABs in the water column and the potential effects these may have to human and animal health in near shore areas and swimming beaches. For these reasons, samples were collected at both offshore and near-shore locations. For the offshore sites, integrated samples were taken to a depth of three meters to capture the principal area where light can penetrate and induce photosynthesis, which is the area where cyanobacteria are the most likely to reside during the summer months. Sampling throughout this entire zone is critical, as cyanobacteria, as well as algae, may reside in discrete layers at specific depths depending on conditions (Figure 3). In addition, integrated samples

Figure 2. The non-toxic golden algae Botryococcus overlying the potentially toxic cyanobacteria Woronichinia. Image credit: J. Haney.

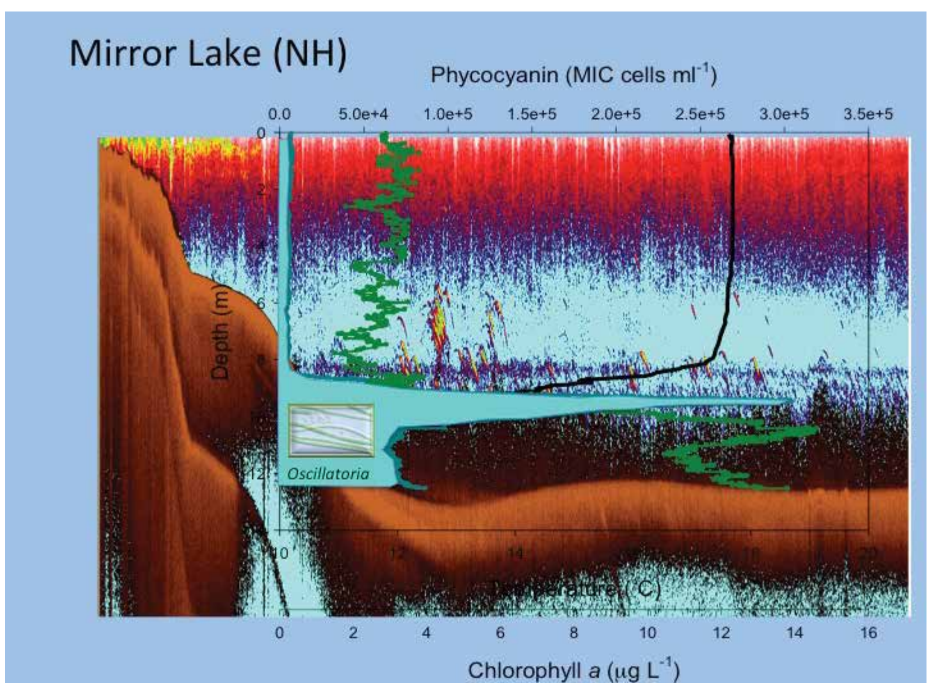


Figure 3. A New England lake profile showing the distinct stratification of the cyanobacteria Oscillatoria (light blue) and a green algae (green line) in relation to the lake temperature (black line). Image credit: J. Haney.

were collected at a minimum of three offshore locations around the water body in order to provide insights to the horizontal phytoplankton heterogeneity. One-meter integrated samples were collected in the near-shore areas where recreational swimmers and pets are the most likely to spend their time in the water. This is also where local and state boards of health routinely collect their samples.

Once samples are collected from a lake, they are then analyzed using the hand-held fluorometers, which provide immediate results on phycocyanin and chlorophyll pigment concentrations. These fluorometers are relatively inexpensive and designed for in-field use, making them ideal for small or large budget monitoring efforts with easy portability. This simple approach provides the capability for tracking cyanobacteria concentrations and impending bloom conditions on a daily or more frequent basis.

Data Collection

In the summer of 2014, a pilot project began with all workgroup member associations participating, and resulted in more than 100 water bodies being sampled over the three-month period. A minimum sampling frequency per water body was established at twice per month, but no upper limit was set. This enabled those that wanted to track phytoplankton concentrations or bloom forming conditions more closely the oppor,tunity to do so. By the end of the pilot summer, over 5,000 data points were collected across the six New England states from the northernmost points of Maine to the urban waters of Connecticut. Most of the data were collected by volunteer monitoring citizen scientists.

Datasets were subsequently sent to EPA's Atlantic Ecology Division for compilation into a single database. Core sampling measurements included phycocyanin, chlorophyll, sampling locations, and sample date(s). In addition to these core measurements, the database includes additional information from sampling events that will allow more detailed questions to be answered in the future as more data are collected. These additional data include local weather observations, lake surface conditions, GPS sampling locations, sampling depths, and the freezing of samples for later analysis.

Preliminary Results

After aggregating the pilot year data, the next step was conducting some preliminary analysis. Post-calibration checks were made on all the instruments utilizing secondary standards that validated the accuracy of the chlorophyll and phycocyanin values from the fluorometers. The second goal was determining baseline conditions seen across the region. Although data are still being processed for Maine and Connecticut, the other four New England states median sensor-measured chlorophyll was 1.07 μg/L and median sensor-measured phycocyanin was 0.55 μg/L with mean values of 1.6 μg/L and 19.6 μg/L for chlorophyll and phycocyanin, respectively. There was variation across the region with only a few lakes at significantly higher concentrations of both chlorophyll and phycocyanin (Figure 4). As future sampling takes place, a much clearer picture will begin to emerge for cyanobacteria levels within individual waterbodies, as well as regional trends across New England.

Lessons Learned

Through the course of the workgroup meetings, planning, sampling, data collection, and analysis, many lessons were learned that will provide returns as we continue building our monitoring efforts. One of the most important realizations of our pilot study is that the benefits of more intensive and focused sampling efforts are great. Unlike larger national efforts, regional monitoring allows us to make repeated samples in the same lake throughout the summer months and beyond. Collection of multiple data points within lakes and across lakes allows one to make assessments on lake condition and trends, and helps us begin to understand the temporal and spatial dynamics of cyanobacteria across the region and across waterbodies.

The pilot demonstrated that there is a tremendous amount of interest and enthusiasm in learning and becoming more involved in the issue of cyanobacteria within the region. The educational component that is intentionally tied into the effort reinforces monitoring and continues to build capacity in the region. When combined with affordable and easy to use monitoring equipment, the door is wide open for almost anyone to learn and participate in the program, providing valuable data to support a better understanding of the problem.

The regularly scheduled workgroup meetings proved to be a critical component to making certain that appropriate training on methods, protocols, and instruments took place, and assisted in providing regional

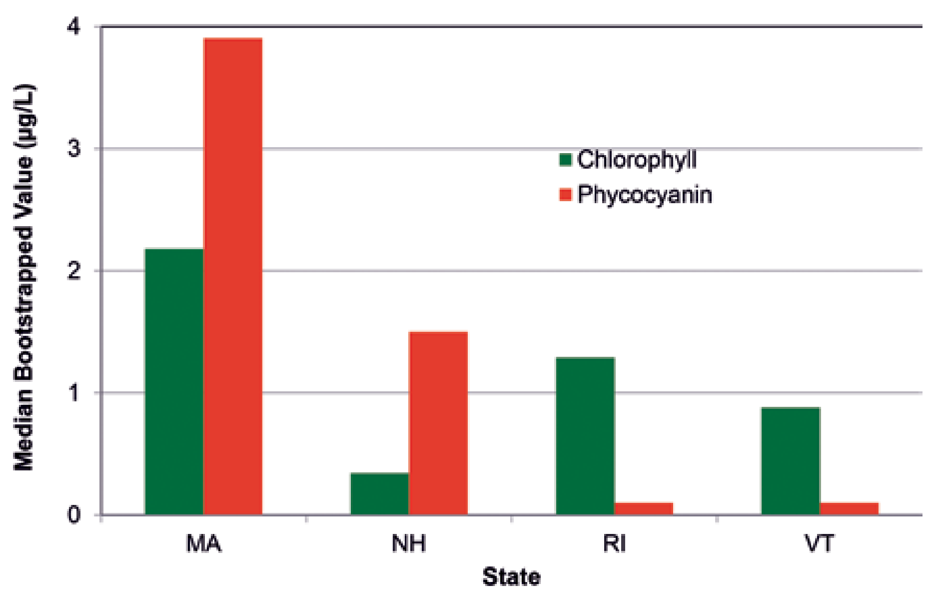


Figure 4. Median phycocyanin and chlorophyll in New England states for summer of 2014.

consistency in data collection efforts and data integrity. With the diversity of the workgroup displaying many levels of expertise and experience, it was essential not only to ingrain the details of the sampling and analysis protocols, but also to convey why the data were being collected in the way they were. This type of discourse at workgroup meetings provided deeper understandings of cyanobacteria and how they interact and behave in the environment. The pilot year was essential for working out the kinks, and the end result will be a more robust program where sampling will be more streamlined, data collection easier, and the resultant data of increasingly exceptional quality. Without the pilot year implementation, this would have been a significant challenge.

Project Developments

As the project matures in 2015 and beyond, the program will be expanding with increasing participation and inclusion of an ever-increasing number of waterbodies selected for sampling. A key part of this successful expansion is the program's flexibility, allowing participants to provide data at the most basic level (i.e., just core measurements) or to expand their efforts and provide more extensive data, such as toxin concentrations and phytoplankton species identifications, whichever budgets and time allow. The database architecture is nearing final completion, and the program will continue to evolve as the workgroup continues to work with new participants who will add additional information on an ad-hoc program basis.

To take advantage of the lessons learned over the first year, scheduling training sessions will take place prior to the "sampling season" every year. Training ensures that instruments are uniformly calibrated, that groups are well trained in sample collection techniques, and that any new tools are fully understood, vetted, and demonstrated.

New tools in development that will be usable for the summer of 2015 include a smart phone application for ease of data collection and transmission. These electronic phone app data entry forms will feed a back-end database from either a smartphone application or a web interface. Another component in development for use in 2015 is the addition of a citizen science component (aka "Bloom Watch") that will allow users to send images of possible blooms taken from a smart phone directly to a database accompanied by locational information. In addition, some of our collaborating partners with the University of New Hampshire Center for Freshwater Biology have developed a "Dirty Dozen" image based cyanobacteria key (Figure 5) to be used as a quick reference with the program. Our current efforts will link to the "Dirty Dozen" key through optics adapters for smartphones to serve as a field "microscope" (Figure 6). High-resolution images will be able to be taken from the field, sent to the database, allow for algae identifications, and relay potential species related toxin information back to the user.

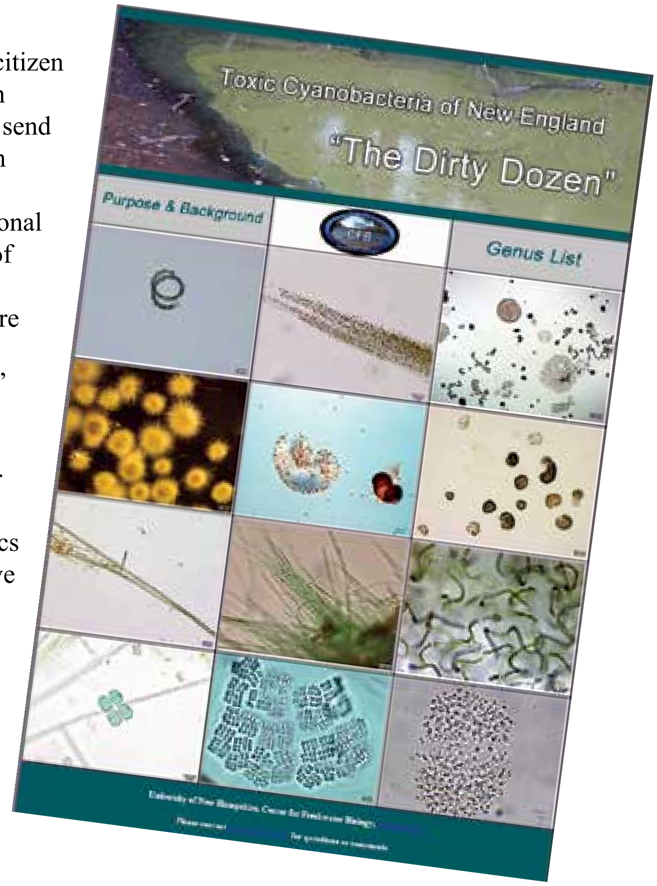


Figure 5. The home page for the University of New Hampshire Center for Freshwater Biology depicting the top "Dirty Dozen" cyanobacteria groupings in New England. This is an image based key with accompanying ecological notes. Image credit: A. Murby.

Summary

Starting in 2013, the efforts of many people (see page 36 for participant list) have resulted in a fledgling New England Regional Cyanobacteria Monitoring program. As a result, the program has

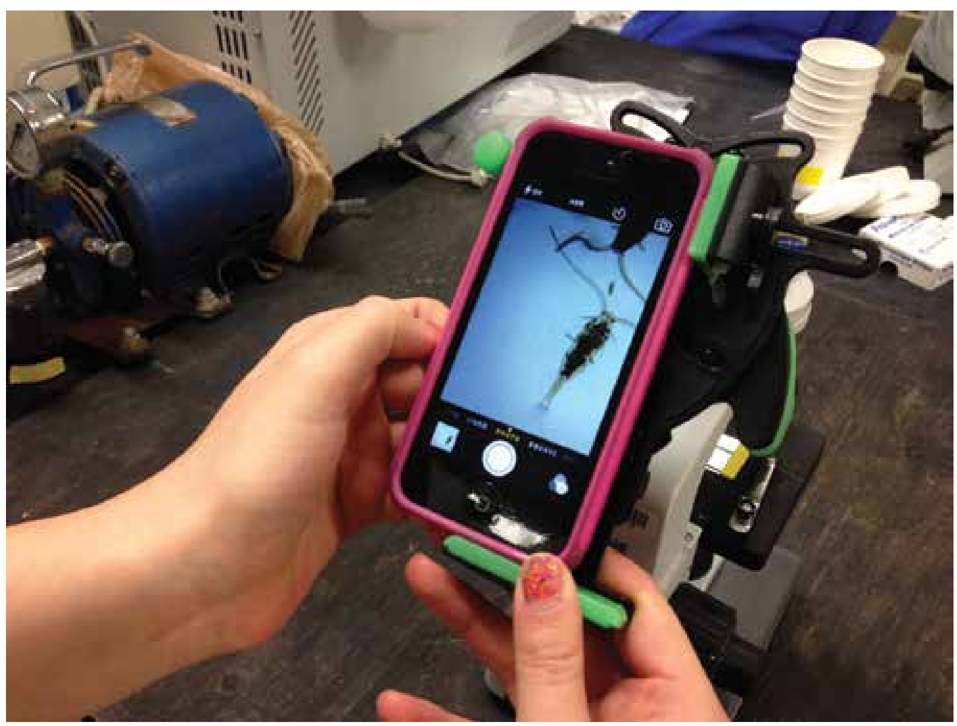
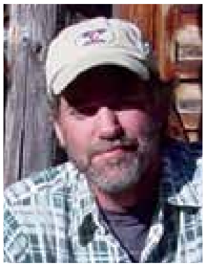


Figure 6. A field microscope and smartphone in use with the optics adapter, capturing a microscopic image. Direct transfer to the regional database is in development.

seen the development of a fast-growing community focused on cyanobacteria education and monitoring, developed a sampling protocol, planned and executed a field sampling program, collected data, begun initial analysis, and made plans for the growth and sustainability of the program. This is a noteworthy accomplishment, and one that suggests that the program will continue to move forward. Without these kinds of diverse collaborative efforts and the resulting data that they collect, it will prove very difficult to understand the full extent of the problem or to manage our resources appropriately. This is imperative if we desire to mitigate the potential health and economic impacts of cyanobacteria. A willingness to share knowledge, experience and expertise, and provide the time and effort to investigate a looming environmental issue through regional collaboration is a testament unto itself as to the success of this project. We look forward to learning more about cyanobacteria so that we can move closer to appropriately managing our precious water resources.



Hilary Snook is a scientist for USEPA's New England Regional Laboratory. His work involves the coordination and management of water quality and aquatic biological monitoring surveys for the region, and provides a supporting role for national aquatic resource surveys presently being initiated by the EPA. He has implemented ecological assessments of condition for wadeable streams, large rivers, lakes and ponds, and near coastal waters for the past 20 years with a focus on development of biological indicators for assessing aquatic resource condition, emerging contaminants, and the transport of contaminants through food webs and the environment. He has spent the past 25 years working on water quality and other hydrologic issues and problems.

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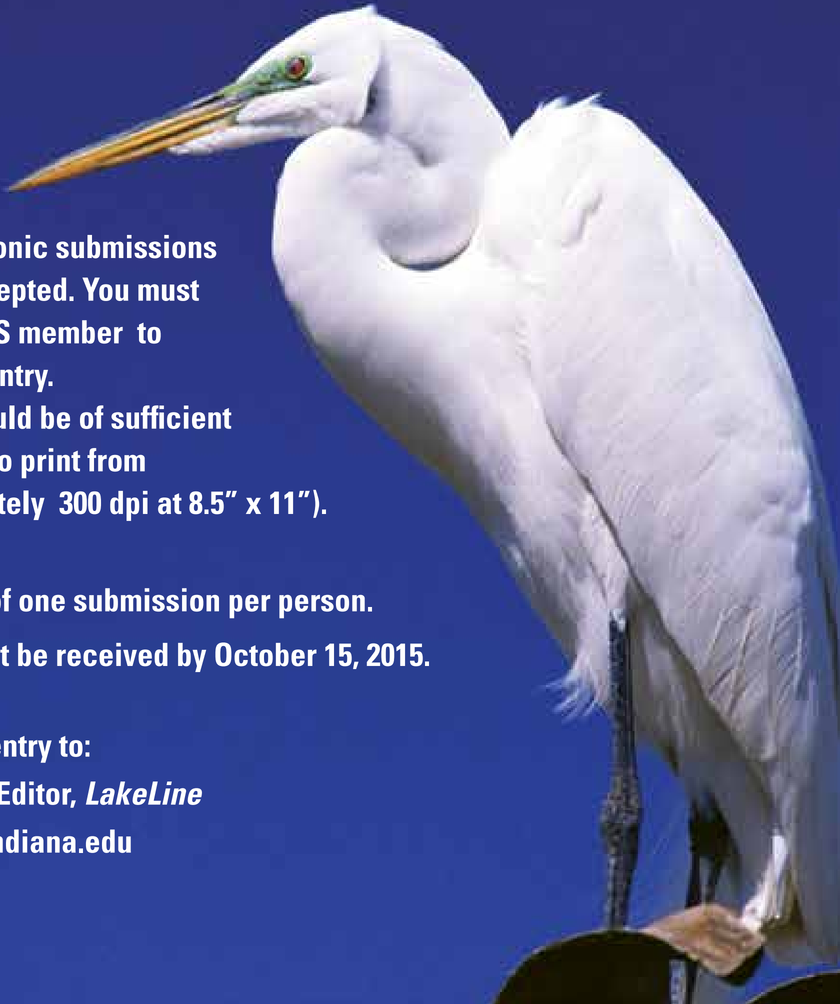

Only electronic submissions will be accepted. You must be a NALMS member to submit an entry.
Photos should be of sufficient resolution to print from (approximately 300 dpi at 8.5" x 11").

Maximum of one submission per person.

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