INSTITUTE PROFILE

The Center for Limnology, University of Wisconsin–Madison

Adam Hinterthuer, and M. Jake Vander Zanden

INTRODUCTION

In 1895, Edward A. Birge launched a rowboat into the waters of Lake Mendota along the University of Wisconsin–Madison (UW–Madison) shoreline in hopes of learning more about the zooplankton that called the lake home. It marked the beginning of one of the first limnological field studies in North America and of an illustrious career. Birge, along with collaborator Chancey Juday, would go on to make foundational observations of the chemistry, physics, and ecology of Wisconsin's lakes as he pioneered the science of limnology.

Today, the Center for Limnology (CFL) continues this tradition of research on inland waters in Wisconsin and around the world.

As a research center in the UW–Madison's College of Letters and Science, the CFL conducts the bulk of its work from our two research facilities. The Hasler Laboratory of Limnology (Fig. 1) in Madison is situated in an agricultural and urban-dominated watershed in the southern part of Wisconsin, whereas Trout Lake Station (Fig. 2) sits in the lake-rich and heavily forested northern region of Wisconsin.

FACILITIES

Hasler Laboratory of Limnology (Figs. 1, 3) is nestled into a hillside along UW–Madison's campus lakefront and offers researchers direct access to 39.4 km^2 Lake Mendota, one of the best-studied lakes in the world. UW–Madison is an internationally ranked research university with an enrollment of 50,000 students and research expenditures surpassing $1.5 billion annually. Hasler Lab is home to six full-time faculty members, several emeritus faculty, numerous affiliated researchers, around two-dozen graduate students and postdoctoral researchers, and a large team of research specialists and administrative staff. There are multiple lab spaces in the building, as well as office space, a conference room, a multipurpose library space with common-use computers and meeting space, and the "Fika" room, where weekly all-lab coffee breaks are held. Two Boston Whalers sit in the basement boat slip, and researchers can reach Lake Mendota by simply raising the boat slip door. During the open-water field season, the Limnos II, a 25-ft tritoon boat, sits in a lift off of the dock ready for research expeditions or science outreach trips. In addition, there is a fleet of other boats available for use. Meanwhile, "David Buoy," the CFL's primary instrumented buoy, has spent each open-water season since 2006 collecting data from where it is anchored out at Lake Mendota's deepest point. The CFL also runs an aquatic experimental facility in the adjacent campus building. This 1700-sq ft flow-through aquarium facility is comprised of five experimental rooms and offers a wide range of aquaria and tanks to work with.

A little more than 200 miles to the north, Trout Lake Station (Figs. 2, 4) sits on 77 acres of forested land on the southern shore of 16.1 km^2 Trout Lake, surrounded by a canopy of pine and birch trees. A team of researchers, technicians, and administrators keep the lab and assorted research projects running year-round, but the busiest time of the year is our summer field season, when more than four dozen people can be found living and working on station. Trout Lake Station boasts a fleet of flat-bottomed Jon boats, an amphibious vehicle for studying lakes during spring and fall "shoulder" seasons. The 10,000-sq ft main research lab includes a wide selection of lab space, offices, a library, a large conference room, common-use computers and high-speed, fiber optic Internet that lets researchers collaborate virtually even in the remote Northwoods. A new, heated facility offering workshop and maker spaces will soon let researchers engineer new scientific instruments and fix their existing gear year-round. Ten cabins tucked into the woods house scientists and students who come to the station for either active research projects, retreats and workshops, or limnology class field trips. Trout Lake Station routinely welcomes visiting researchers from universities across the country, as well as scientists from state and federal agencies and Tribal Nations.

FIG. 1. The Hasler Laboratory of Limnology in Madison, Wisconsin, offers researchers access to Lake Mendota. Photo: A. Hinterthuer.

RESEARCH

Despite its relatively small size, the CFL has contributed a vast amount of literature to the freshwater sciences over the years. From field-based studies, to research in the lab, to big data-driven computer models, CFL research aims to understand the drivers and timing of potentially harmful algae blooms, the impacts of warming waters on freshwater fish species, how top-down disturbances can lead to

FIG. 2. Trout Lake Station is located on the shores of Trout Lake near Boulder Junction, Wisconsin, and provides access to the thousands of lakes in the region. Photo: S. Carpenter.

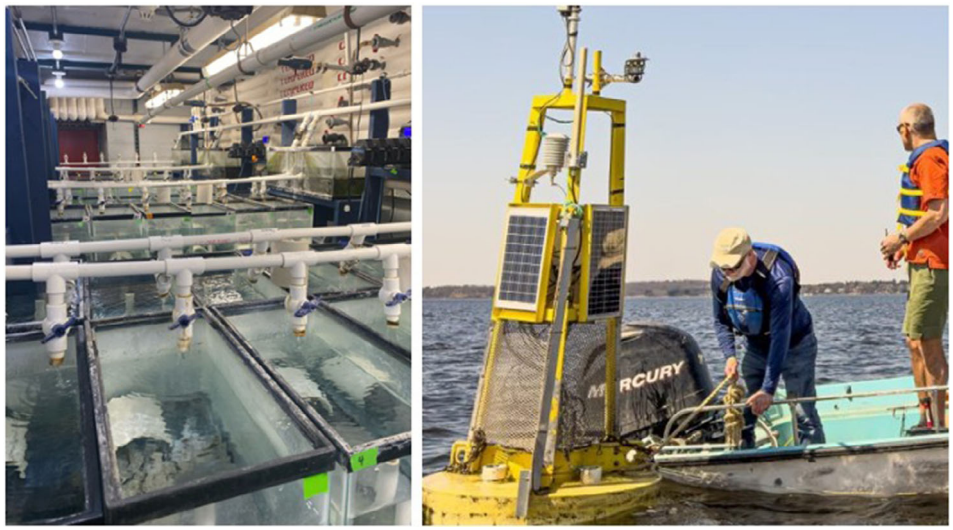

FIG. 3. Example of facilities available at the Hasler Laboratory of Limnology: (**a**) aquatic experimental facility, (**b**) instrumented bouy (David Bouy). Photos: A. Hinterthuer.

cascading disruptions to food webs, and the role lakes play in greenhouse gas emissions (Fig. 5).

Research topics continue to evolve over time. Our winter limnology program aims to fill in the gaps in understanding of lake dynamics during cold-weather months and highlight the potential physical, chemical, and ecological impacts of less lake ice and shorter winters. A related study is exploring how increasing phenological extremes, like the spring thaw, impacts the timing of important ecological processes and how organisms that evolved to respond to these cues are scrambling to keep up. Research on the microbial communities of lakes is pointing to their importance in lake ecology and how they can impact phenomena like algae blooms and anoxia.

We also conduct research on all seven continents. For example, current CFL-led projects involve Mongolian freshwater fisheries, hypersaline Antarctic lakes, and methane fluxes in polar wetlands.

LONG-TERM ECOLOGICAL RESEARCH

The largest research project at the CFL is the National Science Foundation-funded North Temperate Lakes Long-Term Ecological Research (NTL-LTER) program. The NTL-LTER has monitored 11 lakes—4 in southern Wisconsin and 7 up north, since 1982. LTER crews are out on these lakes year-round compiling datasets on everything from water chemistry to fish populations to ice cover. LTER data allow researchers to ask—and answer—big questions about how temperate lakes are responding to a warming world, changes in land use and more. LTER data are open and accessible to researchers everywhere thanks to the CFL-led Environmental Data Initiative (https://edirepository.org/).

A LONG HISTORY OF APPLIED SCIENCE

Since the early days of research on Wisconsin's waters, limnology at UW–Madison has illustrated how human activities on land have impacts in the surrounding waters. Our unique positioning in both urban and agricultural watersheds and less developed, forested watersheds, has allowed CFL researchers to study lakes of all types, and better understand the forces at work behind eutrophication and anoxia, as well as the effects of invasive species and shoreline development. We are also committed to putting that science to use. Among other things, CFL research has helped inform fisheries management decisions at the Wisconsin Department of Natural Resources (DNR), agricultural conservation practices in southern Wisconsin watersheds, and invasive species management efforts around the state.

In addition, being housed at an internationally ranked research institution in a state's capital city allows for collaborations across scientific disciplines and organizations. The CFL is involved in research projects with colleagues from UW–Madison Departments like Microbiology and Civil and Environmental Engineering, as well as governmental agencies like the Wisconsin DNR and U.S. Geological Survey. We also frequently partner in international, team-based science, with CFL faculty playing important roles in projects like the Global Lakes Ecological Observatory Network (https://gleon.org/) and the RAM Legacy database of global fishery stock assessments.

The CFL has also been involved in the development of new scientific instruments, like the Fast Limnological Automated Measurement system, a tool that lets researchers take real-time measurements on a lake as a boat is speeding through the water.

EDUCATION

In addition to being a leader in limnological research, the Center for Limnology is committed to training the next generation of aquatic researchers. As professors in the Department of

FIG. 4. Examples of facilities available at Trout Lake Station: (**a**) boats and view of Trout Lake Station, (**b**) research lab. Photos: A. Hinterthuer.

FIG. 5. The Center for Limnology conducts research on waters across Wisconsin and the world. Research explores a variety of topics in the freshwater sciences. For example, (clockwise from left) freshwater microbial communities and their impact on algae blooms, long-term fishery population trends and predator–prey dynamics, and addressing gaps in knowledge about urban waterways and winter limnology. Photos: Jeff Miller, Riley Steinbrenner, Adrianna Gorsky.

Integrative Biology, CFL faculty teach numerous undergraduate courses at UW–Madison. Examples include "Limnology: Conservation of Aquatic Resources" and "Ecology of Fishes." Both courses have robust lab components that involve field-based training on Lake Mendota, Trout Lake, and other surrounding bodies of water. "Limnology: Conservation of Aquatic Resources" is the nation's largest and longest-running undergraduate limnology course. It enrolls around 150 students and has been running since 1908. In addition to classroom and lab-based educational opportunities, the CFL provides dozens of undergraduate students hands-on, in-the-field training through summer job opportunities and fellowships each year.

Graduate students at the CFL are typically affiliated with the Freshwater and Marine Sciences Graduate Program (http://fms.wisc.edu/), an interdisciplinary graduate training program that offers M.S. and Ph.D. degrees to students interested in the science of freshwater and marine ecosystems. Throughout the year, graduate students are offered CFL-specific graduate-level seminars and courses like Zoology 750, the legendary Sapelo Island (Georgia) field course, which has been a rite of passage for CFL graduate students for over 50 years.

COMMUNITY ENGAGEMENT

At the Center for Limnology, there is a strong emphasis on sharing science with non-scientific audiences. We have a strong commitment to community engagement and outreach and a number of dedicated programs that stem from this commitment. CFL researchers serve on science advisory boards for local non-governmental organizations and are often asked to speak to policymakers about lake conservation efforts. Our Science on Tap-Minocqua science cafe series in northern Wisconsin has been drawing standing-room only crowds to local establishments to hear about ecological research for more than a decade. Trout Lake Station hosts a handful of artists-in-residence throughout the year, including "Drawing Water," a traveling exhibit of art created through a collaboration with our North Temperate Lakes Long-Term Ecological Research program and regional artists interested in new ways of sharing our science with broader audiences. Throughout the year, CFL researchers give presentations for local school groups, community organizations, and lake associations and, each summer, we provide field trips out on Lake Mendota for summer camp groups and others. We also host annual open houses at both of our labs, where we open the doors to the public for an afternoon each summer. Both open-house events average 300–400 visitors each year.

For more information on pursuing graduate studies at or collaborating with the Center for Limnology, please visit https://limnology.wisc.edu/.

Adam Hinterthuer, Center for Limnology, University of Wisconsin–Madison, Madison, WI

M. Jake Vander Zanden, Center for Limnology, University of Wisconsin–Madison, Madison, WI; mjvanderzand@wisc.edu