



College of Letters & Science | University of Wisconsin-Madison
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Mendota

*A deep dive
into our
favorite
lake*



COLLEGE OF LETTERS & SCIENCE
UNIVERSITY OF WISCONSIN-MADISON

Lake Mendota

a scientific biography

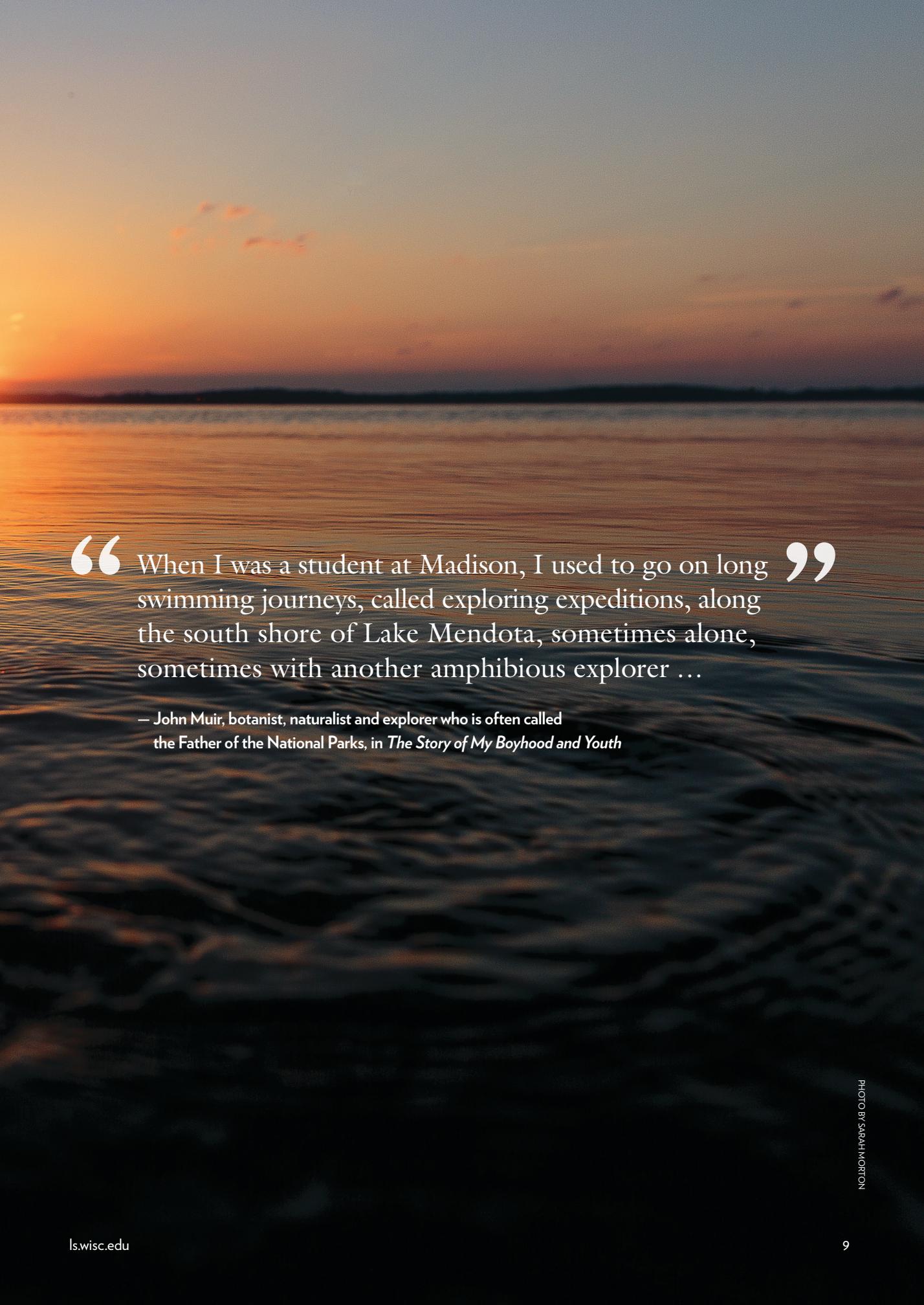
From the window of his second-story office overlooking Lake Mendota, Steve Carpenter can see the UW rowing team running drills. On a warmer day, he might glimpse yellow-hulled “tech” boats, piloted by amateur sailors, lurching around the buoys. And on an early autumn morning, a lone paddler might suggest the image of a traveller from long ago, navigating the waters in a birchbark canoe.

Like all lakes, this one holds the past, present and even the future in its depths.

“Lakes reflect the land around them,” Carpenter says. “They also reflect the ways that humans use that land, and the ways we use the water.”

Often called “the most studied lake in the world,” Mendota is the birthplace of the field of limnology, the scientific study of inland waters. Thanks to a trove of long-term data gathered over more than 100 years by UW scientists like Steve Carpenter, the connection between Mendota and the humans who have interacted with it over time is unusually well understood.

This data offers a glimpse of the lake’s future — one that Carpenter and his colleagues are eager for us to realize that we are responsible for writing.



“ When I was a student at Madison, I used to go on long swimming journeys, called exploring expeditions, along the south shore of Lake Mendota, sometimes alone, sometimes with another amphibious explorer ... ”

— John Muir, botanist, naturalist and explorer who is often called the Father of the National Parks, in *The Story of My Boyhood and Youth*

The early years

In the dog days of summer, it may be hard for Memorial Union Terrace loungers to imagine a lake without the murky water and smelly algae blooms that are as much a part of the experience as stunning sunsets. But from the first written accounts, penned by European settlers in the early 1800s, we know that Mendota – formed by the retreat of glaciers some 10,000 years before – once boasted white sand beaches and, through clear water, an equally sandy bottom. That “sand” was actually calcite/calcium carbonate, a byproduct of the watershed’s gypsum stores. It looked, Carpenter says, “as if the bottom of the lake were covered in crushed-up Tums.”

But just a few decades after Madison was settled, those white sands had disappeared. The Tenney Locks, constructed in 1849 to help boats navigate the isthmus, drowned the beaches under four feet of water. And by 1870, according to sediment samples, the lake’s bottom was covered with rich, black prairie soil – runoff from surrounding shoreline and farmlands that had been broken by oxen and plow.

This new base, replete with phosphorus from soil and manure, became the welcoming habitat for new plant and animal life. As Madison’s

population grew to the tens of thousands by the turn of the century, the lake was made even more fecund by sewage and human waste.

So disruptive was the phosphorus input, in fact, that the young scientist E. A. Birge documented the lake’s consequent first toxic blooms of cyanobacteria, or blue-green algae, back in 1882. Birge would go on to serve as the inaugural dean of the College of Letters & Science and, later, a UW president. But long after he had assumed these leadership positions, he continued the data collection in Lake Mendota that he had championed as chair of the zoology department.

For more than five decades, Birge would record meticulous descriptions of the lake’s changes and of the samplings he observed through his microscopes. His colleague Chancey Juday was often by his side in this “living lab.” The two were committed to letting patterns emerge from the data itself.

Birge and Juday laid the foundation for the long-term research studies that offer such a nuanced understanding of the lake today.

Arthur D. Hasler, a former student of Juday, returned to work alongside them in 1937. Hasler

would later secure funds from the National Science Foundation, or NSF, for the lakeshore building that carries his name and houses the UW-Madison Center for Limnology, UW's hub for freshwater research. In the 1980s, John Magnuson, the Center's first director, drew NSF support for the Long-Term Ecological Research (LTER) project, designed specifically to study how the world's lakes operate and change over time.

"Long-term funding for long-term research is so important because it's the only way we can know when some change is unusual," says Emily Stanley, professor of zoology, who heads the LTER project today. Ice records recorded at Mendota since 1855, for example, give us insight into climate trends that individual occurrences cannot reveal. And Stanley says that the decades of record-keeping following Birge's first documentation of cyanobacteria help establish a link between phosphorus inputs and algae growth.

"We are now trying to understand where the phosphorous is coming from and how land use practices around the watershed end up affecting the lake," says Stanley.

20th-century growing pains

By the 1930s, native fish were dying off as compromised water quality diminished the "weed beds" (full of native water flora), their essential habitat. Meanwhile, new fish were moving in. As early as 1890, immigrants had introduced

carp to the lake with an eye to selling them via New York's short-lived gefilte fish market. (Carp's destructive habit of rooting through the lake's bottom disturbs the weed beds to this day.)

Then, during the Dust Bowl's "fish rescue operations," residents introduced more new fish in an effort to save them from nearby waters succumbing to drought.

Meanwhile, sewage and farm runoff increased, as Madison's population grew from 35,000 in 1920 to more than 170,000 by the 1980s. The city stopped dumping sewage directly into the lakes in the early 20th century, but waste was still dumped into its tributaries as late as 1971.

By the time the Eurasian watermilfoil – a cousin to the native milfoil plant, but more aggressive – found its way to Mendota on boats that had shared waters with cargo ships in the Great Lakes, conditions were ideal for its takeover. Throughout the 1970s and '80s, the interloper thrived.

"The public hated it," says Carpenter, "but the fish made the real sacrifice." Because of the plant's ability to reach the top of murky water and then grow laterally along the lake's surface, Eurasian watermilfoil shaded the lake beds below, and Mendota's native plants, which had provided a much better habitat for the fish, all but disappeared.

During this time, the field of limnology was undergoing its own evolution. UW's limnologists

Below: Steve Carpenter holds native pondweed, an important fish habitat common in the early 1900s and almost lost by 1980 that is now making a comeback. (Photo by Jeff Miller)

Water Warrior: Steve Carpenter

Considered one of the world's most-cited ecologists and known in the scientific community for his creativity and enthusiasm, Steve Carpenter also holds one of the greatest honors for water-related work. In 2011, he received the Stockholm Water Prize, which identifies individuals and organizations that contribute to the conservation and protection of water resources.

Carpenter, director of the Center for Limnology and the Stephen Alfred Forbes Professor of Zoology at UW-Madison, is an international authority on lakes and freshwater ecosystems. His groundbreaking research has illuminated how lake ecosystems are impacted by humans and the surrounding landscape, and his collaborations both within and outside of academia have led to policies and practices on managing lakes.



began to embrace models that rejected the idea of the lake as a microcosm (one unit of the environment), and instead saw it as part of a larger ecosystem. Hasler took this approach to Trout Lake Station, a UW research outpost in Boulder Junction, Wisconsin, where scientists began to carry out “whole lake manipulations,” rather than just sampling and data-gathering, in order to better understand cause and effect at the ecosystem level.

The fish experiment of the century

It was during the height of Mendota’s Eurasian watermilfoil invasion that Professor James Kitchell and then-visiting professor Steve Carpenter posited that a disruption in the lake’s natural food chain could be responsible for an explosion of algae. They suggested that the loss of large predator fish had allowed smaller fish to thrive. The growing population of smaller fish, in turn, consumed a greater number of the lake’s zooplankton. Which meant fewer zooplankton to consume their food source—algae—which meant a lake choked with the stinky stuff that swimmers and boaters love to hate.

In an experiment that would influence fishery managers around the world, the Center for Limnology, in partnership with the Wisconsin Department of Natural Resources, launched the Biomanipulation Project in 1987. Mendota was stocked with walleye and northern perch and new fishing regulations were enforced to ensure their protection.

The program was wildly successful. The large fish thrived. The algae blooms and invasive plants diminished. Even many of the native plants made a comeback. For two decades, Carpenter says, “it produced the single greatest improvement in Lake Mendota’s water clarity.”

That is, until 2009, when undergraduate students, collecting samples along with professor of zoology Jake Vander Zanden, made a startling discovery. Spiny water fleas, an invasive zooplankton previously believed to be suited only to cooler lakes, had turned up in their nets.

New invaders signal a murky future

These crustaceous zooplankton, inedible to small fish because of the spine hanging off their tail, had begun to devour the lake’s *Daphnia pulex*, a native species of zooplankton that feasted on algae. By 2014, just five years after the discovery, the *Daphnia pulex* had been so diminished by the spiny water flea that their numbers failed to keep the algae in check.

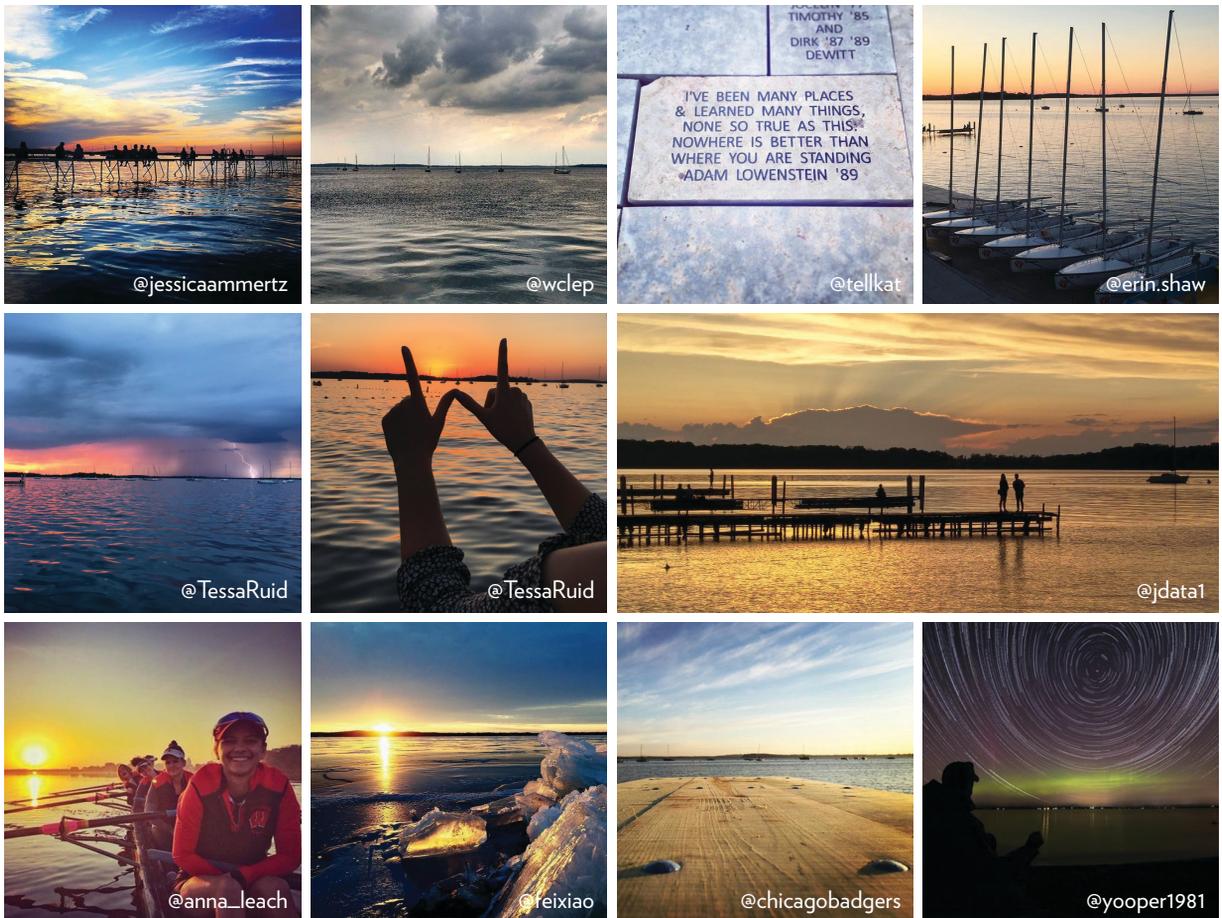
“*Daphnia* were these unsung heroes of water quality,” says doctoral student Jake Walsh, whose thesis examines the spiny water flea invasion.

“They gave us three feet of extra water visibility when they were abundant.” A recent study published by Walsh estimates the damages caused by the invader at between \$87 and \$163 million – with no end in sight.

Below: Jake Walsh (right), graduate researcher for the Center for Limnology, and undergraduate Carly Broshat use plankton nets to collect water samples from Lake Mendota. (Photo by Bryce Richter)



#MendotaMemories on Instagram and Twitter



“The spiny are still in control,” says Carpenter. “It’s going to take some catastrophe for them to disappear.” Adding to Mendota’s woes, in 2015 students in Vander Zanden’s course discovered Zebra mussels, another Eurasian traveler hailing from the Great Lakes.

These new challenges demand new solutions, some behavioral (such as cleaning boats from lake to lake) and some research-driven (for example, identifying a natural predator for the invasive species). Other challenges, such as the general warming of Mendota’s waters, present even more inscrutable outcomes.

This is where the LTER project lends a hand, Stanley says. “No one can predict the future, but long-term data allow us to make predictive models that help the community make informed decisions.”

And one of those decisions, everyone agrees, will have to be about land use management.

“Agriculture is the 800-pound gorilla in the room,” Carpenter says. “As a society, we have to do something about phosphorus runoff and manure.” To that end, he points to a handful of innovative programs, including manure processing sites and the Yahara Pride Program, in which farmers work together to keep runoff out of the watershed.

One thing is for certain: solutions arrive from the same tradition of interdisciplinary collaboration, community partnerships, and public engagement that mark limnology’s first 100 years. After all, as Carpenter says, “solving the problem begins with caring about the lake.”

— Story by Masarah Van Eyck



For more about how the Center for Limnology is partnering with farmers in the watershed through The Yahara Pride Project, watch “Yahara Watershed: A Place of Change,” airing early this fall on wpt.org.