



Lake Michigan Mysteries: Sleeping Bear Dunes

Looking out from shore, Lake Michigan can seem enormous and immutable, but beneath its sparkling surface a thousand changes are unfolding. The lake is adjusting to a wave of bold new invaders from Europe and Asia, including quagga mussels and round gobies. These creatures, though individually small and unassuming, have overwhelmed and transformed Lake Michigan's food web, shifting it in ways we are only beginning to understand.

Signs of Distress

Quagga mussels (*photo 1*) arrived in the Great Lakes in 1989 and quickly established themselves. By filtering water to obtain food, quaggas increase water clarity while also depriving fish of their plankton food source. Clearer water allows the sun to penetrate deeper into the lake, and this extra light, along with the fertilizing waste produced by the mussels, fuels the growth of bottom-dwelling algae.

By the early 2000s, **mats of overgrown algae** began washing up on Sleeping Bear's beaches along with the shells of dead mussels (*photo 2*), which smell foul and create a hazard for barefooted beach walkers.



Lake Michigan from the high bluffs of Sleeping Bear Dunes National Lakeshore.

Making matters worse, the decay of **dead algae and quagga mussels** on the bottom of the lake (*photo 3*) consumes most of the available oxygen and generates huge amounts of nutrients—conditions conducive to the production of botulism toxin.

The **botulism toxin** then makes its way into the lake food web, assisted by invasive quagga mussels and round gobies (*photo 4*), and ultimately affects a wide variety of fish and waterbirds.

In 2006, large numbers of dead birds began washing ashore, victims of **type-E botulism poisoning**. Since then, botulism outbreaks have affected thousands of birds in Lake Michigan, including hundreds of state-threatened common loons (*photo 5*) and several federally endangered piping plovers.

While the arrival of quagga mussels and the growth of algae occurred largely out of sight, the bird deaths caused by botulism poisoning presented a clear signal that the Lake Michigan ecosystem is in distress. We are responding to that alarm.

What We've Learned

- *Quagga mussels promote nuisance algal growth.* Sleeping Bear Dunes has provided a

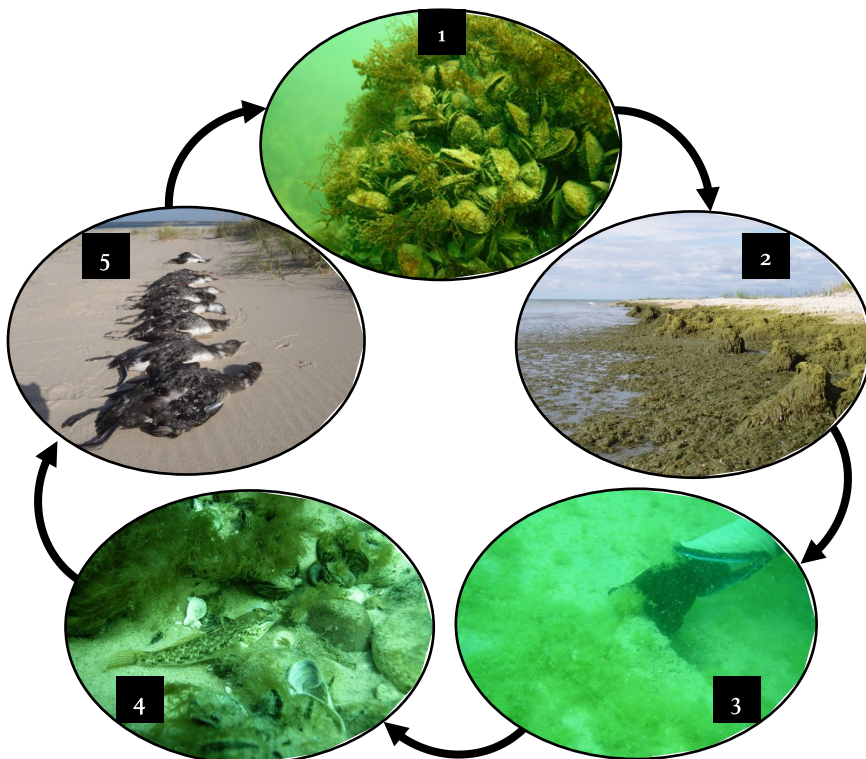


Photo credits: National Park Service staff, Volunteers-In-Parks, and Harvey Bootsma (University of Wisconsin-Milwaukee).

natural laboratory for researchers seeking to understand what's driving nuisance algal growth in the Great Lakes. Lake Michigan waters are not directly affected by nutrient inputs from large rivers, but they are heavily infested with quagga mussels, and our research shows that quagga mussels are fueling the growth of nuisance algae.

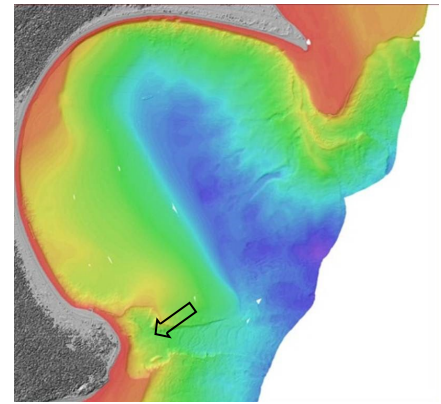
- ***The Sleeping Bear Dunes region features a complex lake bottom with underwater “pits.”*** These pits are abundant in the northeastern part of the lake and have become collection points for decomposing algae and mussels, thus providing the low-oxygen conditions needed for the botulism bacteria to grow.
- ***Nearshore food webs and botulism toxin pathways are dominated by invasive species.*** Loons and other waterbirds in Lake Michigan are now feeding primarily on the round goby, an invasive fish from eastern Europe and western Asia. Round gobies consume a wide variety of bottom-dwelling organisms, including quagga mussels. Quaggas, other bottom-dwelling invertebrates, and round gobies are prime suspects for transferring botulism toxin to loons and other waterbirds.
- ***Botulism outbreaks are linked to ecosystem stress.*** Both historic and modern avian botulism outbreaks have occurred during times of ecosystem upheaval. Common threads include non-native species invasions and food web disruption, nuisance algal growth, and climatic factors like warm waters and low or falling lake levels.

What We're Doing Now

- ***Experimentally removing quagga mussels.*** Lake-wide quagga mussel control is currently unfeasible, but removing quaggas from key habitats like Good Harbor Reef could yield ecological benefits. We have observed that rocks scraped clean of mussels are not readily recolonized by quaggas. So in 2016, we began to systematically remove quagga mussels from a section of Good Harbor Reef. We are monitoring the responses of algae, invertebrates, and the fish community to these control methods, and evaluating their effectiveness and potential for broader applications.
- ***Engaging park visitors and citizens.*** Since 2007, the National Park Service and a team of citizen scientists have routinely surveyed park beaches to count and identify botulism-affected birds, then bury them to prevent the spread of the disease. In 2014, we convened a group of citizen SCUBA divers to assist with maintenance of our nearshore monitoring station in Good Harbor Bay. Additionally, National Park Service rangers are spreading the word by including information gained from these monitoring and research activities in their park interpretive programs and in an increasing range of community and school outreach events.
- ***Strengthening local partnerships.*** We are working with local educational institutions to create internships and initiate joint monitoring activities. We are looking to expand collaborations with local, tribal, and state management agencies, and to explore joint adaptive management efforts that address these challenging Lake Michigan issues.

Through all of these efforts, we are gaining a clearer picture of Lake Michigan's changing ecosystem and helping to shape a healthier future for the lake and all life that depends on it. ●

This work was made possible by funding from the Great Lakes Restoration Initiative and the National Parks Conservation Association, and was conducted in cooperation with local citizens and key partners from the University of Wisconsin-Milwaukee School of Freshwater Sciences, the U.S. Geological Survey, Northwestern Michigan College, Northern Michigan University, and the Inland Seas Education Association.



A nearshore depression, or “pit,” off the southeastern shore of South Manitou Island, Sleeping Bear Dunes National Lakeshore.



A diver removes quagga mussels from an experimental plot on a high quality fish spawning reef in Good Harbor.



Citizen volunteers identify and bury dead birds, improving estimates of bird mortality and preventing disease spread.



A diver conducts routine maintenance on the monitoring station in Good Harbor Bay.