20 Years of Zebra & Quagga Mussel Research at NOAA's Great Lakes Environmental Research Laboratory

Zebra mussels (*Dreissena polymorpha*) are native to the Black, Caspian, and Azov Seas. By the early 19th century, zebra mussels had spread to almost all major drainages of Europe because of widespread construction of canal systems. They first appeared in Great Britain in 1824 where they are now well established. Since then, zebra mussels have expanded their range into Denmark, Sweden, Finland, Ireland, Italy, and the rest of western Europe. Zebra mussels were first discovered in North America in 1988 in the Great Lakes. The first account of an established population came from the Canadian waters of Lake St. Clair, a water body connecting Lake Huron and Lake Erie. By 1990, zebra mussels had been found in all the Great Lakes.

Quagga mussels (*Dreissena rostriformis bugensis*) are native to the Dneiper River drainage of Ukraine. Canals built in Europe allowed range expansion of this species, and it now occurs in almost all Dneiper reservoirs in the eastern and southern regions of Ukraine and deltas of the Dnieper River tributaries (Mills et al. 1996). The quagga mussel was first sighted in the Great Lakes in September 1989, when one was found near Port Colborne, Lake Erie. After confirmation that this mussel was not a variety of *Dreissena polymorpha*, the new species was named "quagga mussel" after the "quagga", an extinct African relative of the zebra. By 2005, quagga mussels had been found in all the Great Lakes.

Physical Alterations

The hydraulic flow regime of the Detroit River has changed since the arrival of zebra mussels in the late 1980's. Although the amount of change is difficult to quantify, GLERL analyses shows roughness and slope differences in the lower reach resulting in a change in the hydraulic regime after 1988.

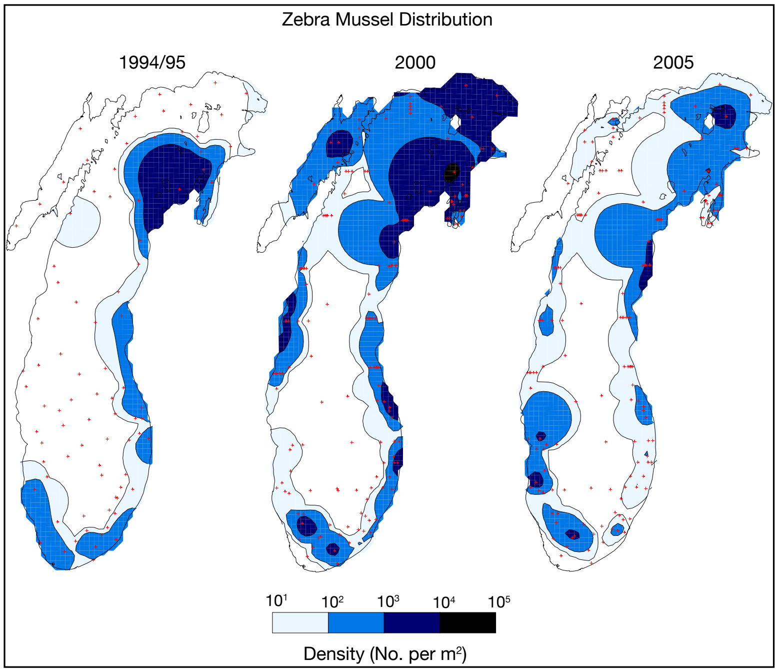
Zebra mussel "reefs" have dramatically alter the bottom contours of some lakes and rivers.

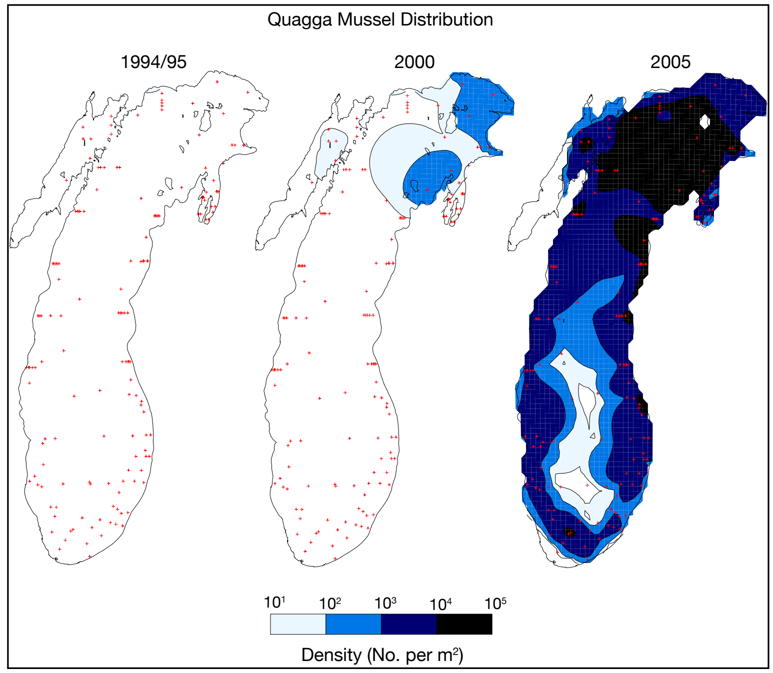
Declining Fish Health

While many species of fish will readily eat *Diporeia* (see right), few species can use zebra and quagga mussels efficiently for food. Moreover, even if a fish species does eat these mussels, the loss of *Diporeia* has left many of them with food choices much lower in nutrition than *Diporeia*. In Lake Erie, a severe decrease in smelt stocks was seen in the 1990s. Estimates of the slimy sculpin and lake trout populations in Lake Ontario showed a 95% decline between the late 1980s and 1996. In Lake Michigan, many fish populations are now sacrificing health to feed off zebra mussels. Whitefish, for example, shifted from a diet of 25-75% *Diporeia* to a diet of zebra mussels. During their first 2 weeks of life, larval bluegill reared in the presence of mussels grew 24% slower than fish reared alone. Alewife energy density was 23% lower during 2002-2004 (post zebra mussel invasion) compared to 1979-1981 (pre zebra mussel invasion). As a result, a Chinook salmon now needs to eat 22% more alewives to attain an ideal body weight by age 4.

Diporeia Declines

Diporeia, a tiny shrimp-like organism, was the dominant benthic invertebrate in most offshore areas of the Great Lakes since the glaciers receded ~10,000 years ago. *Diporeia* have a high lipid (fat) content, with lipids often exceeding 30% of its total weight. As a result, it is rich in calories and a good source of energy for fish. Since the early 1990s population densities of *Diporeia* in all the lower Great Lakes have dropped dramatically. "Exact mechanisms are unclear, but the decline of *Diporeia* is related to the introduction and expansion of the zebra and quagga mussels," says Tom Nalepa, a GLERL biologist who has been sampling Lake Michigan sediments since the early 1980s.





Native Mussels Eliminated

Zebra mussels attach to the shells of native mussels and alter normal life-sustaining activities such as feeding, breathing, and eliminating waste products. In addition, large populations of zebra mussels substantially reduce the amount of food available to the native mussels. NOAA's Great Lakes Environmental Research Laboratory (GLERL) has monitored populations of native mussels in Lake St. Clair periodically since 1986. Based on surveys between 1986 and 1997, it can be stated that native mussels have been completely eliminated from the open waters of Lake St. Clair.

Altered Contaminant Cycling

Zebra and Quagga mussels have the potential to change contaminant cycling in the Great Lakes by rerouting dissolved and particulate-bound contaminants into mussel food chains, with possible biomagnifications in mussel predators and transfer into upper trophic levels. Selective predation on small, pre-spawning (high lipid) mussels may present a greater hazard than predation on larger mussels.

Benthic Algae Promoted

Zebra mussels altered inner Saginaw Bay from a pelagic-dominated system to a benthic/pelagic system, which will have long-term effects on food web structure and productivity at higher trophic levels. They are very effective filter feeders. Because of their population densities, zebra mussels remove much of the particulate matter from the water column, leaving the water very clear and allowing increased light penetration. This produced a significant increase in productivity of bottom plants and the amount of bottom area covered with plants.

Algae growth causes muck accumulation along the shoreline.

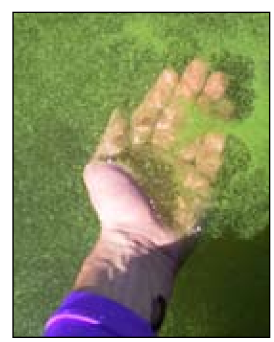
Selected Publications List from 20 Years of GLERL Dreissenid Research

www.glerl.noaa.gov/pubs/brochures/20dreissenidrefs.pdf

Harmful Algal Blooms

Nuisance blooms of the toxic blue-green alga *Microcystis* have returned to many portions of the Great Lakes since 1992. These recent blooms started a few years after the invasion of zebra mussels and their cousins the quagga mussels in the Great Lakes.

Using special video equipment, NOAA's Great Lakes Environmental Research Laboratory (GLERL) showed that mussels reject *Microcystis* but eat other algae. Thus, the competitors of *Microcystis* are removed. At the same time, the mussels are excreting nutrients (phosphate and ammonia) derived from the phytoplankton they eat. These nutrients, in turn, serve to fertilize further growth of *Microcystis*.



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