History of Quagga Mussels

By Christine Moskell WS '08

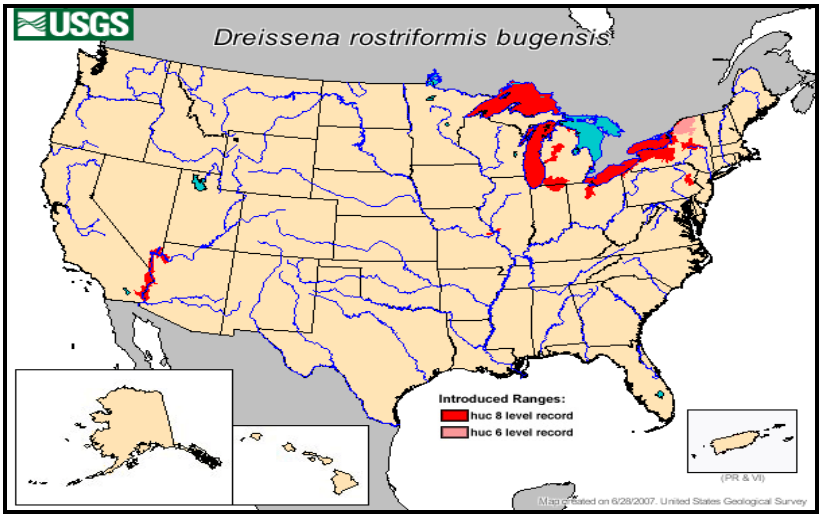
Zebra mussels (*Dreissena polymorpha*) have long been the poster child of invasive species in Seneca Lake. Most people don't even realize there are other varieties of mussels inhabiting the lake. Today, the tide is changing for zebra mussels in Seneca Lake, as another invasive mussel species has displaced the zebra mussels. Meet the quagga mussel.

A close relative to zebra mussels, Quagga mussels (*Dreissena bugensis*) invaded the Finger Lakes in the same way as zebra mussels. Native to Ukraine, quagga mussels were first transported to the United States when foreign ships unknowingly carrying microscopic quagga larvae discharged their ballast water into the Great Lakes. Quagga mussels were first observed in the United States in the Great Lakes in September 1989, but were not at first considered a different species from zebra mussels.[1] In 1991 during a zebra mussel survey near Palmyra, New York, researchers Dr. Bernie May of Cornell University and Dr. Ellen Marsden of the Illinois Natural Survey discovered a mussel with a different genotype than the zebra mussels.[2] Genetic tests confirmed that this unique mussel was indeed a different species of *Dreissena*.

The mussel was named "quagga" after an extinct African relative of the zebra. [3] Like zebra mussels, quagga mussels spread to the Finger Lakes via the waterways connected to the Great Lakes. The quagga mussel first arrived in Seneca Lake in 2000.[4]

Since their arrival to the United States, quagga mussels have expanded their populations throughout the country. Quagga mussels have been established in four of the five Great Lakes; Lake Michigan, Lake Huron, Lake Erie and Lake Ontario. The only Great Lake without a quagga mussel population is Lake Superior, but researchers expect the quagga mussel population to establish soon, having found the first quagga mussel there in 2005. Quagga mussels also inhabit Lake St. Clair, Saginaw Bay, and the St. Lawrence River north to Quebec City as well as throughout the Finger Lakes and in inland bodies of water in Ohio, Michigan and Pennsylvania.[5]

Quagga mussels have even expanded to US regions far from the Great Lakes. In the early 1990s, quagga mussel larvae were transported down the Mississippi River and discovered between St. Louis, Missouri and Alton, Illinois in 1995. Quagga's have also been discovered as far west as Lake Mead near Boulder City, Nevada and in Lake Havasu and Lake Mohave on the California/Arizona border.[6]



Populations of Quagga Mussels in the United States,
USGS Map, created on 6/28/2007

Competition Between Quagga and Zebra Mussels: Who's the Better Competitor?

Like zebra mussels, quagga mussels are excellent filter feeders and can filter more than 1 liter of water each day.[7] Zebra mussels are generally found in shallower water up to 50 feet. On the other hand, quagga mussels are able to inhabit deeper waters up to 98 feet. [8] Additionally, quagga mussels are competing with zebra mussels to settle on hard surfaces like rocks and water intake pipes. Quagga mussels also compete with zebra mussels (and zooplankton) for food, as both species prey on phytoplankton. Since quagga and zebra mussels share a similar habitat, lifestyle and diet, they are occupying the same niche. Gause's principal of competitive exclusion explains that two species overlapping the same niche can not coexist.[9] Recent studies have demonstrated that Gause's principle may be playing out between quagga and zebra mussels. Quagga mussels have been displacing zebra mussels in the Great Lakes, suggesting that quagga mussels must possess some characteristic that gives them a competitive advantage over zebra mussels.[10] Since the habitat shared by quagga and zebra mussels is so similar, researcher Anne Stoeckmann believes that this advantage is manifested in the biology and physiology of quagga mussels. In a study conducted between 1998 and 2001, Stoeckmann measured respiration, shell growth, body mass and reproduction in Lake Erie populations of zebra and quagga mussels inhabiting the same area. She reported no difference in the percentage of spawning mussels within each species. Differences between

the species were observed in quagga mussels having a lower respiration rate than zebra mussels. Their ability to reproduce at the same rate as zebra mussels, while having a greater body size, all at a lower respiration rate, suggests that they have more energy available to devote to growth. Quagga mussel body mass which isn't devoted to reproduction represents energy reserves, which the quagga mussel uses when food is less available during the summer months. Since zebra mussels devote a higher percentage of their energy toward reproduction, they do not have as much stored energy available during the summer months and thus, experience a higher occurrence of death.[11]

The lower respiration rate represents the quagga mussel's ability to survive in conditions in which zebra mussels falter. A lower respiration rate means quagga mussels can exist in waters with less dissolved oxygen, which may explain why quagga mussels are able to live at greater depths than zebras.

Lake Michigan: Quagga Domination

Unlike zebra mussels, quagga mussels are able to thrive in a wide range of temperatures. Zebra mussels are tolerant of warm water, but quagga mussels can survive in both warm and cold waters. An example of quaggas temperature tolerance is evident in Lake Michigan. There, zebra mussels have inhabited the rocky shore, because of warmer water temperatures. Additionally, zebra mussels can only establish on hard surfaces. The quagga mussels, tolerant of colder temperatures and able to establish on both hard and soft surfaces, have flourished in the deeper waters. In fact, quaggas were collected at a depth of 540

feet! Lake Michigan is 307 miles long and 118 miles wide, providing a huge area of sand, clay and pebbles on the lake bottom on which only quagga mussels can survive. Tom Nalepa, a researcher at the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory, reported that a recent survey of 160 sites across Lake Michigan represented quagga's domination. When the survey was first conducted in 2000, 899 zebra mussels per square meter of lake bottom were collected. In the 2006 survey, 7,790 quagga mussels were collected on average per square meter of lake bottom.[12] Quagga mussels have been present in Lake Michigan since 1997, three years earlier than in Seneca Lake, but quaggas may soon dominate Seneca Lake. Preliminary research conducted by Bin Zhu of the Finger Lakes Institute in the summer of 2007 is showing predominately more quagga mussels in samples taken in Seneca Lake.[13]

Outlook for the Future

In 1999, Mills et al. hypothesized that quagga mussels will take over areas where zebra mussels have already established. Surveys of zebra and quagga mussel shell size and biomass increased for both species from 1992 to 1995 in Southern Lake Ontario, but the increase was greater for quagga mussels, who conquered the area where zebra mussels once dominated by 1999.[14] Student researchers Meredith Eppers WS '08 and Joe Sullivan H'08 are currently researching zebra and quagga mussel populations in Seneca Lake under the direction of Bin Zhu. During the summer of 2007, Eppers and Sullivan, sampled

for zebra and quagga mussels in Seneca Lake. In classifying the mussels in each sample, the pair has observed far more quagga mussels than zebra mussels. Sullivan reported that the ratio of quagga to zebra mussels found was greater than 2 to 1. In shallower waters, more zebra mussels were collected. Their research suggests that what has happened in Lake Michigan may well already be happening in Seneca Lake.[15]

Ecological Impact of Quagga Mussels

Water clarity in Seneca Lake greatly improved when zebra mussels were introduced into the lake in 1995.[16] With both zebra and quagga mussels filtering the water, Seneca Lake's water is experiencing a high level of water clarity. With more light infiltrating the water, more aquatic plants will be able to grow. Unfortunately, the introduction of quagga mussels has further depleted food sources for other native mussels, fish larvae and zooplankton. In filtering phytoplankton and sediment out of the water, quagga mussels are putting large amounts of pseudofeces, or waste, into the water column. The decomposition of the waste results in decreased oxygen and increased pH, leaving the entire ecological community vulnerable to significant environmental changes.[17]

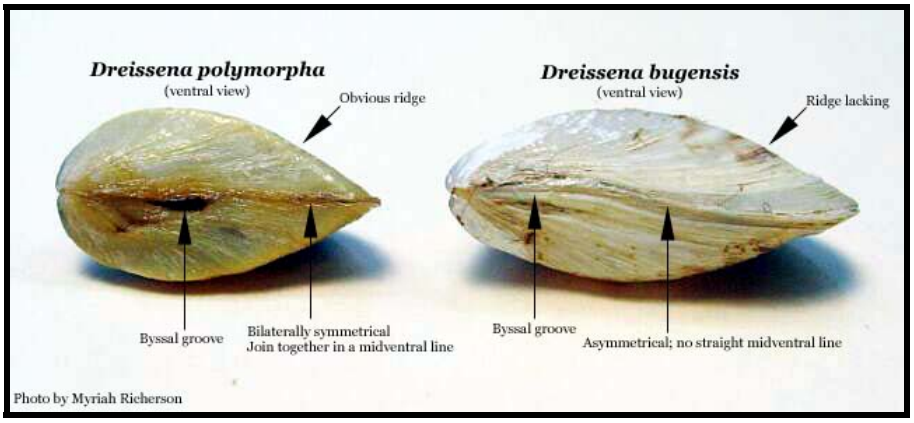
Quagga mussels also threaten local industries. Like zebra mussels, quagga mussels can colonize on hard surfaces, including those built by humans. Quagga colonies can form on water intake structures, which decreasing the efficiency of pumping for water utilities and increases their costs. Quagga mussels can also form on docks, break walls, buoys, boats and beaches and so

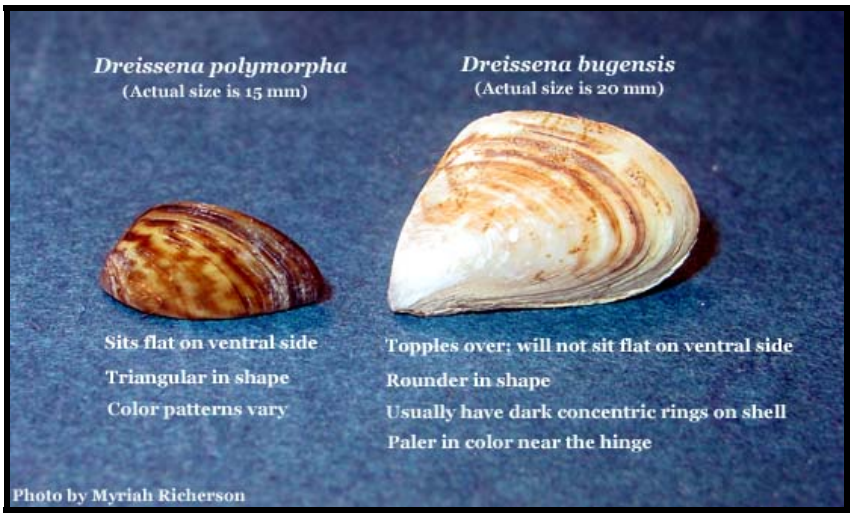
can ruin recreational activities for tourists in the Finger Lakes.[18] Since quagga mussels were introduced later than zebra mussels, their future ecological impact is hard to predict.

Morphological Differences Between Quagga and Zebra Mussels

	Shell Shape	Color	Valves	Size
Zebra	Angle between ventral and dorsal shells. Ventral side flattened. Triangular in shape.	Variable, but usually darker than quagga's. Dark stripes	Equal in size	2-3 cm
Quagga	Smooth, rounded between ventral and dorsal shells. Ventral side convex. Round in shape.	Pale near the hinge, dark concentric rings.	Unequal in size	Up to 4 cm

Identification Hint: When the shell is placed upright on its ventral side, a zebra mussel will stand up and a quagga mussel will fall over. [19]





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