Pennsylvania Invasive Mussel Monitoring Guide

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
COASTAL RESOURCES
MANAGEMENT PROGRAM

Sea Grant
Pennsylvania
www.seagrant.psu.edu

U.S. FISH & WILDLIFE SERVICE
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Why Monitor for Invasive Species?

Purple loosestrife
Lythrum salicaria

Aquatic invasive species (AIS) like round gobies, zebra mussels, and Eurasian watermilfoil are changing the health and natural diversity of watersheds across Pennsylvania. Aquatic invasive species compete with native plants and animals for habitat, prey on walleye and perch eggs, and may play a role in avian botulism causing bird deaths along Lake Erie. Aquatic invasive species are anticipated to be one of the leading causes of biodiversity loss and extinctions in the Great Lakes and North American freshwater ecosystems. In Pennsylvania, zebra mussels could potentially impact French Creek, a stream located in northwest Pennsylvania which has the largest diversity of native freshwater mussels in any Pennsylvania stream.

Flathead catfish
Pylodictis olivaris

Photo courtesy of the Philadelphia Water Department

Once established in a body of water, AIS are very difficult to eradicate, and are easily spread to uninfested waters through recreational boating and fishing, bait introductions, and aquaculture. AIS may also cause severe economic harm to water-based industries, tourism, and recreational fishing. From the collapse of the lake trout fishery due to sea lamprey invasions, to the costs incurred by municipal water treatment plants to control zebra mussels in intake pipes, scientists estimate the economic cost of invasive species to be $120 billion per year.

While many tools exist for minimizing the spread of invasive species, prevention and early detection of new invaders are the least expensive and most effective means to ensure the health of Pennsylvania's aquatic ecosystems. A statewide "Invasive Mussel Monitoring Network" comprised of volunteers, field biologists, and scientific experts can help achieve this goal through annual monitoring for invasive species.

Invasive species cost the U.S. approximately $120 billion per year.

As a Pennsylvania Invasive Mussel Monitoring Network volunteer, you are an important part of this statewide effort. This training guide will teach you how to identify zebra mussels and quagga mussels, how to choose a monitoring site, and how to record and report your data. The data you gather will help Pennsylvania Sea Grant advise future management and education efforts to minimize the spread and harmful impacts of aquatic invasive species.

Thank you for helping keep Pennsylvania's waters AIS-free!

Water chestnut
Trapa natans

Photo courtesy of Pennsylvania Sea Grant

A Brief History of Invasive Mussels Across the United States

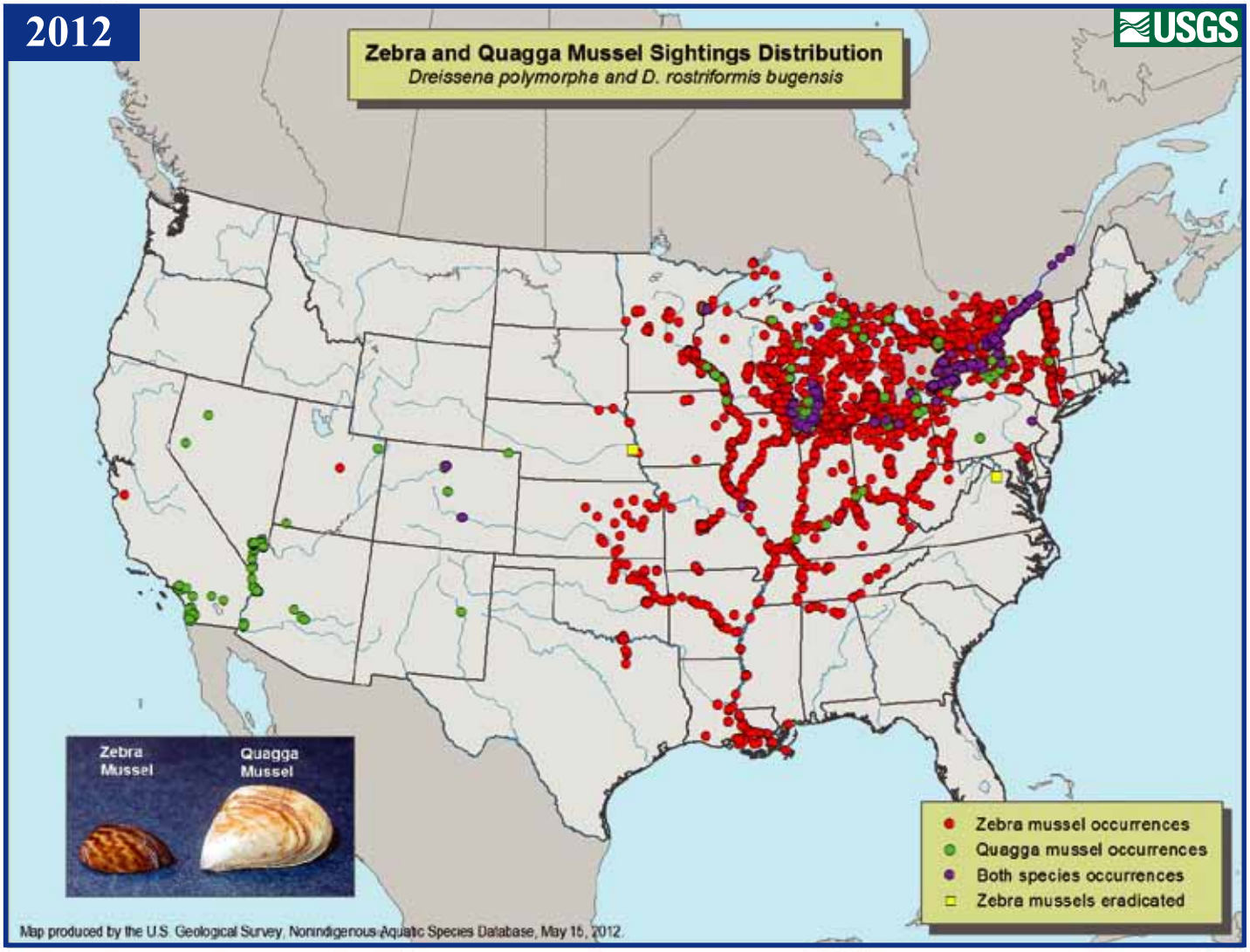
1989

Although zebra mussels were first discovered in Lake St. Clair in 1988, the large shell sizes indicated that they had already been present in the United States for several years. They probably traveled here from the Ponto-Caspian region of Eastern Europe, hitchhiking with the ballast water of commercial ships.

1998

The next “wave” of mussels spread very quickly, moving out of Lake Michigan to the Mississippi River and to other commercial shipping routes associated with the Great Lakes. Barge traffic carried zebra mussels up several of the Mississippi River’s tributaries. Recreational boating helped spread zebra mussels into inland lakes. In New York, zebra mussels began to colonize the Finger Lakes, the Hudson River, and the upper reaches of the Susquehanna River.

Zebra and quagga mussel data courtesy of United States Geological Survey

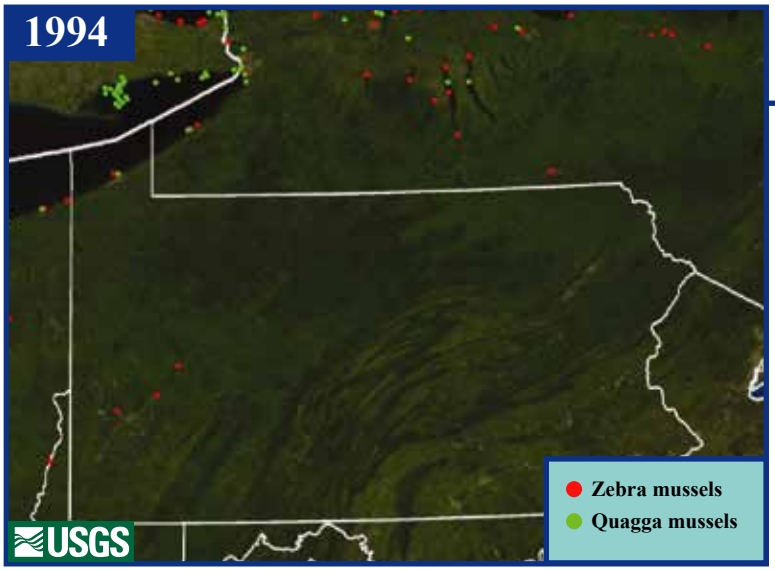


Present

In 2007, quagga mussels made their way to the western United States probably via recreational boat equipment. After they were found in Lake Mead, more quagga populations were found in California, Nevada, and Arizona, and since then zebra mussels have been found in California, Utah, and Colorado.

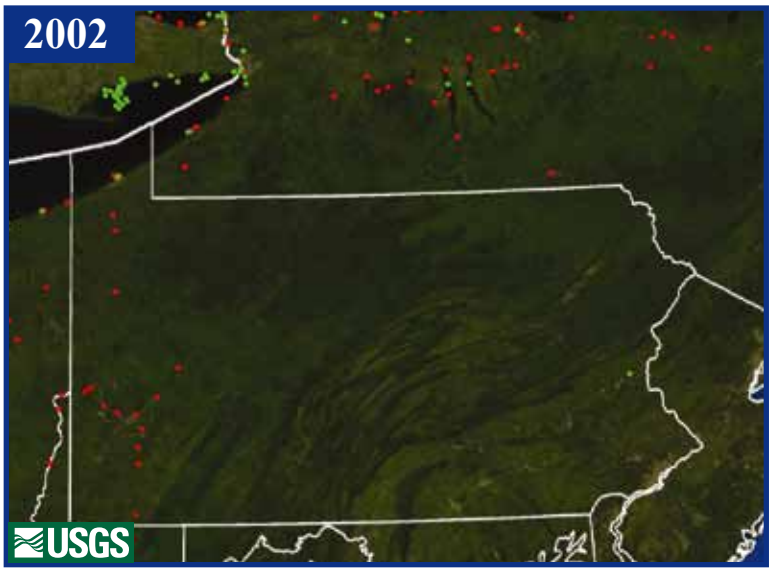
Zebra mussels on a stick.
Photo courtesy of David Jude, Center for Great Lakes Aquatic Sciences

A Brief History of Invasive Mussels in Pennsylvania



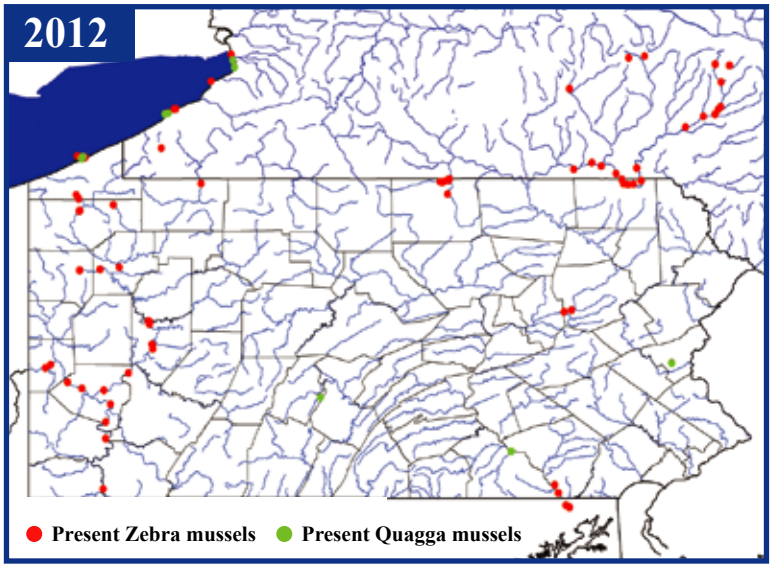
1994

Concerned about potential impacts of invasive mussels, Pennsylvania DEP started the Pennsylvania Zebra Mussel Monitoring Program in 1991. DEP biologists monitored key sites with assistance from water utilities, environmental consultants, DCNR State Parks, and the US Army Corps of Engineers. By 1994 zebra mussels made their way up the Ohio River to the Pittsburgh area, following the paths of barge traffic. From there, they further spread to the Allegheny River.



2002

Zebra mussels spread to the Monongahela River. After the initial range expansion along commercial shipping routes, the invasion moved more slowly into inland lakes and streams, primarily due to recreational boating and diving activities. The year 2000 marked the first year invasive mussels were documented in Pennsylvania's inland lakes: zebra mussels were found in Edinboro Lake and both species were found in a diving quarry near Bethlehem. In 2002, additional invasions were observed in northwest Pennsylvania in Sandy Lake and Creek, Conneauttee Creek, and upper French Creek.



Present

In 2007, zebra mussels were discovered in the Cowanesque Reservoir (Tioga County, near the New York border) and several places in the upper Susquehanna River. Zebra mussels were also found in Conewango Creek and the Upper Allegheny. Quagga mussels were also documented in a diving quarry near Williamsburg (central Pennsylvania). In 2008, zebra mussels were discovered at the Conowingo Dam in the lower Susquehanna River in Maryland, and at Muddy Run, a lower Susquehanna tributary just north of the Pennsylvania/Maryland state line. In 2012, zebra mussels were discovered in the Susquehanna River at Berwick, Pennsylvania.

Map courtesy of Pennsylvania Sea Grant

Monitoring for Invasive Mussels

Zebra mussels on a buoy.
Photo courtesy of JT Carlton,
West Coast Ballast Outreach Program

Zebra mussels and quagga mussels can compete with native mussels for food and space, disrupting aquatic food chains, and clogging utility pipes and industrial water intakes. Because these mussels are transported in many ways, they have great potential to proliferate throughout Pennsylvania waters. While prevention is the first step in AIS management, monitoring Pennsylvania's rivers, streams and lakes for new infestations can aid early detection and response efforts. If mussels are identified at a new site, steps can be taken to warn water users and recreational boaters about an infested location. At some sites, early warning may be useful for developing control measures.

This monitoring protocol was designed to provide practical and efficient techniques to track the population dynamics and ranges of invasive mussels in Pennsylvania watersheds. The method relies on observing natural and artificial habitats in lakes, rivers, and streams. Zebra mussels are more likely to be found in lakes and larger, slow-moving streams than swift, small streams. Data submitted by Pennsylvania Invasive Mussel Monitoring Network volunteers will be displayed using GIS at the Pennsylvania Invasive Mussel Monitoring Network website.

Choosing a Monitoring Site

Since recreational boating is the primary way that zebra and quagga mussels are spread in Pennsylvania waters, boat ramps and public access areas along waterways are the most likely places for mussels to inhabit. Hence, inland lakes, large ponds, and reservoirs are very important areas to monitor. Choose a monitoring site near a boat ramp, dock, marina, or under a bridge. Another important place to survey is downstream from a known population of mussels, for example, below an infested quarry or reservoir. Mussels have also been spread to Pennsylvania scuba diving quarries through recreational diving activities, so freshwater diving locations are also key areas to monitor.

Zebra and quagga mussels prefer water bodies that yield enough algae to support their nutritional needs for growth and shell production. They prefer larger water bodies such as lakes, rivers, and slow-moving streams. If monitoring time is limited it is important to inspect habitats near boat and fishing access areas or habitat downstream from water bodies with existing populations of invasive mussels.

This is an excellent site to look for signs of invasive mussels because it is located near a public boat launch, the dock provides shade, and there are several hard surfaces, such as pilings, rip-rap, and groins for zebra mussels to colonize.
Photo courtesy of Pennsylvania Sea Grant

Searching for Zebra and Quagga Mussels

After you have picked a monitoring site, it is time to get your hands and feet wet. As you search for signs of zebra and quagga mussels, remember:

- Mussels are often found in dark crevices.
- They are typically found in water deeper than 15 to 30 cm.
- Mussels can be attached to a wide variety of objects such as:
  - – pilings and dock floats,
  - – buoys, mooring lines, or cables,
  - – rocks and concrete,
  - – logs or driftwood,
  - – vegetation,
  - – or anything that has been in the water for a long time.

When you arrive at the site, follow these steps to monitor for the presence or absence of zebra and quagga mussels:

- Wear polarized sunglasses to reduce glare and improve vision into the water.
- Inspect all hard substrates. Both zebra and quagga mussels attach to hard surfaces, but quaggas are capable of colonizing soft sediments.
- Search objects located in dark, shaded areas and check underneath objects like driftwood, or in the dark crevices between rocks.
- Slowly run your fingers over smooth surfaces checking for mussels too tiny to see easily. Newly-settled mussels feel like the grit on sandpaper. Larger mussels will feel coarser, like small pebbles or sunflower seeds.
- Spend as much time as it takes to examine all hard-surfaced objects. Search until you are confident that no mussels occur at the site. You are searching adequately if you are finding small snails.
- Record your findings on the *Zebra Mussel and Quagga Mussel Survey Form*, including the amount of time you spent searching for mussels.
- Be sure to clean your own sampling gear and boots before proceeding to the next site to eliminate the possibility of personally moving invasive species through your monitoring efforts. See page 11, ***Prevention and Control*** paragraph for information on how to clean your gear.

Zebra mussels colonizing on a native clam.
Photo courtesy of Fred Snyder, Ohio Sea Grant

Photo courtesy of R. Griffith,
Ontario Minisitry of Natural Resources

Recording and Reporting Monitoring Data

Zebra mussels on a golf ball.
Photo courtesy of Anthony Ricciardi, McGill University

- **Gather data monthly when the water temperature is warmer than 8ºC (46ºF).** For most areas of Pennsylvania, this period falls between April and October. While monthly sampling is recommended, any monitoring observations are valuable, particularly from lakes, rivers, streams, and quarries. If you know you will be doing field work near a high risk area like a boat ramp or marina, please take a quick look around and report to us if mussels are present. If you have limited time, we recommend that you survey after August when young-of-the-year are larger and easier to observe.

- **Print a copy of the Excel datasheet entitled *Zebra & Quagga Mussel Survey Form* for each of your monitoring sites.** The data sheet is available on the website *http://seagrant.psu.edu/zm/monitor/monitor.htm*. Take a copy with you to record your observations in the field.

- **After you finish searching for mussels at the monitoring site, record all the data requested, along with any other relevant information, on the Excel datasheet entitled *Zebra & Quagga Mussel Survey Form*.** Record your field observations in pencil or indelible pen (e.g., a sharpie marker). Complete one datasheet for each monitoring site. Since the general habitat requirements for zebra and quagga mussels are well-described in the literature, recording the following water quality information on your data sheets is optional:

Temperature C		pH	
Dissolved Oxygen (mg/l)		Conductivity (umhos/cm3)	
Total Calcium (mg/l)		Secchi Depth (m)	
Current Velocity (m/sec)		Water Depth (m)	

- **When you return home from the monitoring site, enter your data in digital form in the Excel spreadsheet.** Submit the document as an e-mail attachment to *invasivespecies@psu.edu*. We will e-mail you to acknowledge that we have received your survey(s). You may send surveys as often as you like, and you may send multiple worksheets in the same workbook if you like. Please indicate in the body of your e-mail how many surveys you have attached. Please retain your original field records in your files as a back-up. If you do not have access to a computer, please mail your completed forms to: Invasive Species, Pennsylvania Sea Grant, P.O. Box 67000, Harrisburg, PA 17106-7000.

This protocol was adapted from procedures from the Pennsylvania DEP, the Virginia Department of Game and Inland Fisheries, *http://www.dgif.state.va.us/wildlife/zebramussels.asp*, the Missouri Stream Team, *www.mostreamteam.org/pdfs/zebra.pdf*, and the California Department of Fish and Game, *http://www.dfg.ca.gov/quaggamussel*.

Finding Latitude/Longitude for Your Monitoring Sites

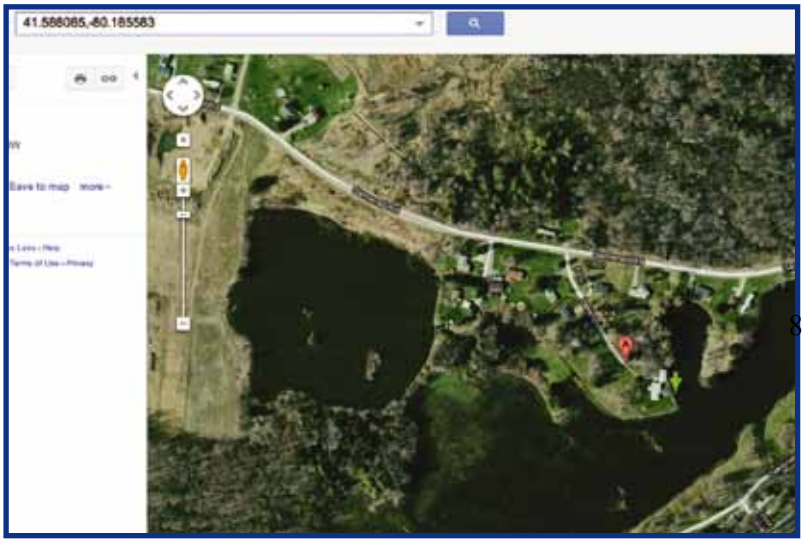
1. Open Google Maps.

2. In the location search box at the top of the page, type your location (e.g., Lake Lane, Meadville, Pennsylvania).

3. Right click on the monitoring location on the map, and select "What's here?".

4. The coordinates will automatically pop up in the search box.

4.



Reporting a New Sighting

If you think you have found zebra mussels or quagga mussels in a new location, please report it immediately. Early detection and action can help prevent the spread of these mussels, so report new sightings as quickly as possible.

Follow these simple steps to report your sighting:

1. At the monitoring site, collect a sample of the mussels you suspect are invasive species. Please collect a range of shell sizes if they are present, to help determine if this is a new infestation or an established colony.

2. Place 10-15 specimens in a tightly sealed jar of rubbing alcohol — you may freeze the sample temporarily before placing in alcohol. PLEASE CONTACT US BEFORE SHIPPING A SAMPLE.

3. Using a pencil or waterproof pen, label the mussel specimens using the following template:

> Site: Crooked Creek
> Date: 7/12/08
> Species: Zebra (or Quagga) Mussel
> Name: Joe Volunteer
> Phone: 814-123-4567
> Preserved in alcohol

4. Contact Sarah Whitney to make arrangements to confirm the specimen's identity. Call 610-304-8753, or email *invasivespecies@psu.edu* to provide your name, phone number, and location of the sighting.

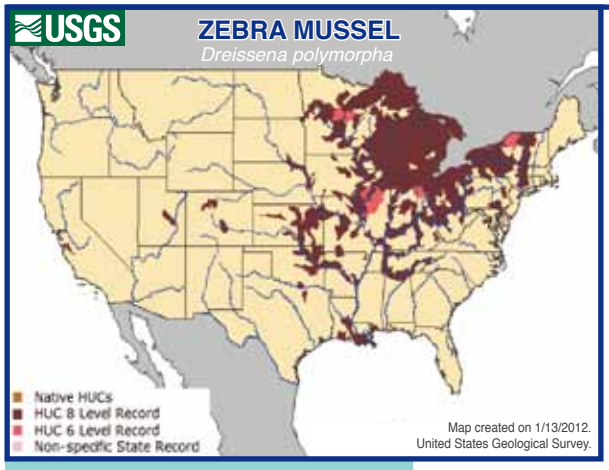
5. To verify the identification, send the mussel sample to:
   Sara Grise, Pennsylvania Sea Grant
   Tom Ridge Environmental Center
   301 Peninsula Dr., Suite 3
   Erie, PA 16505
   Phone: 814-602-4383
   E-mail: invasivespecies@psu.edu

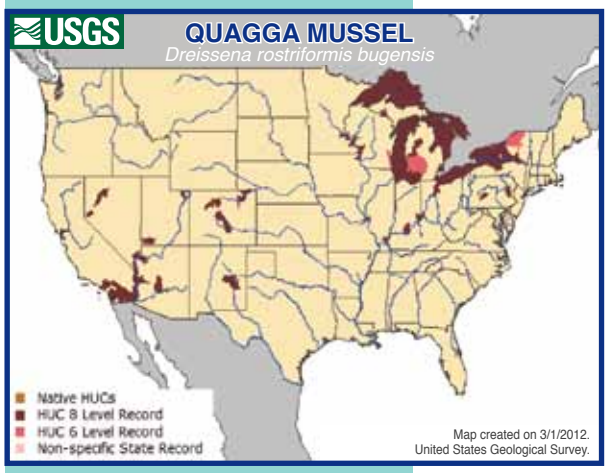
In 1893, Henry Kew, an English naturalist, described Dreissenid mussels as one of the most successful groups of aquatic colonists in the world.

Photo courtesy of David Brenner, Michigan Sea Grant

Zebra Mussel & Quagga Mussel

Dreissena polymorpha & Dreissena rostriformis bugensis





Zebra and quagga mussels are fingernail-sized, freshwater mollusks that attach to objects and other organisms. Since their discovery in the Great Lakes region, zebra and quagga mussels quickly spread to become the most intrusive, prolific, and costly aquatic invaders in North America.

Species Description

Zebra and quagga mussel shells generally have alternating light and dark bands, but may be entirely light or dark. Zebra mussels have a "D" shaped shell which allows them to sit flat on their sides. They are rarely found at depths greater than 50 feet. Quagga mussels are rounder in shape, and may topple over if placed on their sides. Compared to zebra mussels, quagga mussel populations can tolerate cooler water temperatures, lower dissolved oxygen content, and are commonly found as deep as 100 feet or more; however, they are not limited to deep water habitats.

Native & Introduced Ranges

Native to eastern Europe and western Asia in the Black, Azov, and Caspian Sea drainages, zebra mussels first appeared in the Great Lakes in Lake St. Clair in 1988, and quagga mussels were discovered in Lake Erie in 1989. Both species were likely transported to the Great Lakes in the ballast water of ships.

In Pennsylvania, zebra and quagga mussels have been found in Lake Erie, as well as several inland lakes and rivers in Pennsylvania including Edinboro and Sandy lakes; Conneauttee, Conewango, and French creeks; and the upper Allegheny River. Zebra mussels have also been found in the lower Allegheny and Monongahela rivers, the upper Ohio River, and the upper and lower reaches of the Susquehanna River. In addition, quagga mussels have been found in diving quarries in Bethlehem and near Williamsburg, PA.

ZEBRA & QUAGGA MUSSELS

Biology & Spread

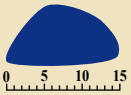
The reproductive cycles of these invasive mussels allow for successful and rapid infestation. Fertilization takes place externally and one female can produce up to one million eggs. Each fertilized egg develops into a free-swimming veliger, which can float in the water column for three to four weeks before settling on a hard surface where it develops a shell and begins to colonize with other mussels. Both mussels can survive out of water for up to five days, making it easy for them to be carried from lake to lake on recreational boating and fishing gear. Adult mussels can attach to boat hulls, trailers, motors, vegetation, and equipment using sticky fibers called byssal threads. Immature mussels, called veligers, are microscopic larvae that can float undetected in the water of bait buckets, live wells, and bilges.

Photo courtesy of S. van Mechelen

Zebra Mussel *(Dreissena polymorpha)*

Photo courtesy of U.S. Geological Survey

- D-shaped shell
- Sits flat on its ventral side
- Color patterns vary, but it has obvious striping



Actual size is 15 mm

Quagga Mussel *(Dreissena bugensis)*

Photo courtesy of U.S. Geological Survey

- Rounder in shape
- Does not sit flat on its ventral side
- Usually has dark, concentric rings
- Paler in color near the hinge

Actual size is 20 mm

Zebra mussels covering a shopping cart.
Photo courtesy of U.S. Geological Survey

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Penn State is an affirmative action, equal opportunity university.

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
COASTAL RESOURCES MANAGEMENT PROGRAM

Funded in part by PA DEP
Coastal Resources Management Program

Habitat

While zebra mussels are found mainly on hard substrates such as rock, wood, concrete, and steel, quagga mussels can survive on both hard and soft sediment in the deep waters of Lake Erie and Ontario.

Impacts

Threat to Biodiversity

Efficient filter feeders, zebra and quagga mussels are capable of straining one liter of water per day to consume the microscopic plants and animals, called plankton, found in it. The removal of plankton, in turn, reduces the amount of food available for other organisms. Zebra and quagga mussels selectively filter for certain types of green and brown algae, while they reject blue-green algae. This results in higher concentrations of blue-green algae in the algal community, which can become toxic to aquatic life and cause taste and odor problems for drinking water supplies. Filtering of the water also allows sunlight to penetrate deeper into the water column, causing an overgrowth of aquatic plants. Native species of mussels and clams are also impacted as invasvie mussels form colonies on their shells, hindering their ability to feed and breathe.

Economic Costs

Zebra and quagga mussels attach themselves in large clumps on hard surfaces such as boat hulls, docks, and buoys. They foul water intake pipes for waterside industries such as power and water facilities, and are very expensive to remove and control. Each year the economic impact to the United States and Canada is about $140 million in damage and control costs.

Health Risks

Because they are filter feeders, zebra and quagga mussels can build up contaminants such as PCBs, heavy metals, and toxins in their tissues. These chemical contaminants can then be passed up the food chain into larger fish and birds. Scientists also suspect they can concentrate harmful bacteria, including the species that causes Type E Botulism, a disease that has caused large die-offs of birds and fish in the Great Lakes.

Prevention & Control

To prevent the spread of zebra and quagga mussels to new locations, check for and remove any plants, mud, and aquatic life from your boat and equipment before transporting to a new area. Drain all water from your boat, including bilges, live wells, bait buckets, and coolers. Thoroughly wash your boat and all equipment with hot water (140°F or above), or if washing is not possible, boats and trailers should be dried for five days before moving to a new water body. Once established in a water body, control of zebra mussels is difficult. Chemical control has only been feasible in isolated ponds and lakes where there is no discharge to nearby streams. In Pennsylvania, it is unlawful to possess, sell, purchase or transport zebra and quagga mussels.

ZEBRA & QUAGGA MUSSEL
sightings in Pennsylvania
(2012 and earlier)

References:

Benson, A., and Raikow, D. 2006. *Dreissena polymorpha*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. <http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=5>.

Britton, D. 2006. Zebra Mussel (*Dreissena polymorpha*). ANS Taskforce Web site. <http://www.anstaskforce.gov/spoc/zebra_mussels.php>.

Virginia Department of Game and Inland Fisheries (VDGIF). 2006. Millbrook Quarry Zebra Mussel Eradication. <http://www.dgif.virginia.gov/zebramussels/>.

Internet Resources

Pennsylvania's Invaders

Pennsylvania Sea Grant
http://seagrant.psu.edu/publications/ais.htm
http://www.pserie.psu.edu/seagrant/ais/index.htm

Pennsylvania Fish and Boat Commission
http://fishandboat.com/ais.htm

Zebra and Quagga Mussels

Pennsylvania Zebra and Quagga Mussel Monitoring Network
http://seagrant.psu.edu/zm/

Zebra Mussel Species Profile: National Invasive Species Information Center
http://www.invasivespeciesinfo.gov/aquatics/zebramussel.shtml

Zebra Mussel and Quagga Mussel Information Page (USGS)
http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/

Zebra Mussels in the Chesapeake Watershed (Maryland Sea Grant)
http://www.mdsg.umd.edu/issues/restoration/non-natives/workshop/zebra_mussel.html

The 100th Meridian Initiative
http://www.100thmeridian.org/zebras.asp

Aquatic Invasive Plants

Center for Aquatic and Invasive Plants
http://plants.ifas.ufl.edu/

Maine Volunteer Lake Monitoring Program
Center for Invasive Aquatic Plants
http://www.mainevlmp.org/wp/?page_id=186

Minnesota Department of Natural Resources
Invasive Aquatic Plants
http://www.dnr.state.mn.us/invasives/aquaticplants/index.html

Purple Pages – Purple Loosestrife Project (Michigan State University)
http://www.miseagrant.umich.edu/pp/index.html

Eurasian watermilfoil
Myriophyllum spicatum
Photo courtesy of Ann Murray,
University of Florida
IFAS Center for Aquatic and Invasive Plants

Bighead carp
Hypopthalmichthys nobilis
Photo courtesy of David Riecks,
UIUC/IL-IN Sea Grant

Internet Resources

Round Goby
Neogobius melanostomus
Photo courtesy of David Jude,
Center for Great Lakes Aquatic Sciences

Regional and National Resources

Aquatic Nuisance Species Task Force
http://www.anstaskforce.gov/

Exotic Species in the Chesapeake (Maryland Sea Grant)
http://www.mdsg.umd.edu/issues/restoration/non-natives/

Great Lakes Aquatic Invasive Species Research (GLERL)
http://www.glerl.noaa.gov/res/Programs/ais/

Great Lakes Panel on Aquatic Nuisance Species
http://glc.org/ans/panel.html

Invasive Species in the Great Lakes Region (Great Lakes Information Network)
http://www.great-lakes.net/envt/flora-fauna/invasive/invasive.html

Mid Atlantic Panel on Aquatic Invasive Species
http://www.midatlanticpanel.org/

National Invasive Species Information Center (NISC)
http://www.invasivespeciesinfo.gov/

National Aquatic Nuisance Species Clearinghouse
http://www.aquaticinvaders.org/

Nonindigenous Species Alert System
http://nas.er.usgs.gov/AlertSystem/register.asp

Protect Your Waters – Stop Aquatic Hitchhikers Campaign
http://www.protectyourwaters.net/

US Army Corps of Engineers Aquatic Nuisance Species Research Program
http://el.erdc.usace.army.mil/ansrp/

USEPA Invasive Species Website
http://www.epa.gov/owow/invasive_species/

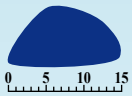
USFWS Invasive Species Website
http://www.fws.gov/invasives/

USGS Nonindigenous Aquatic Species Information Resource
http://nas.er.usgs.gov/

Zebra Mussel *(Dreissena polymorpha)*

Photo courtesy of U.S. Geological Survey

- D-shaped shell
- Sits flat on its ventral side
- Color patterns vary, but it has obvious striping

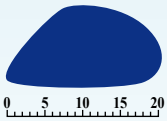


Actual size is 15 mm

Quagga Mussel *(Dreissena bugensis)*

Photo courtesy of U.S. Geological Survey

- Rounder in shape
- Does not sit flat on its ventral side
- Usually has dark, concentric rings
- Paler in color near the hinge



Actual size is 20 mm

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