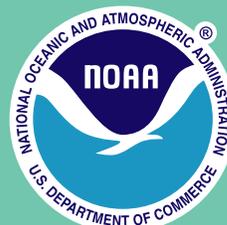




Pennsylvania Aquatic Invasive Species Monitoring Squad



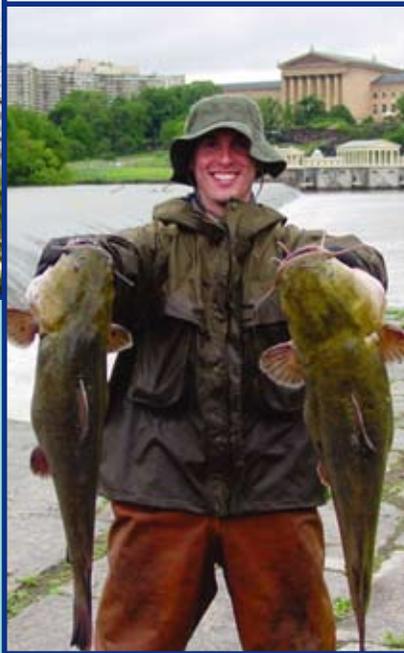
Why Monitor for Invasive Species?



Purple loosestrife
Lythrum salicaria

Flathead catfish
Pylodictis olivaris

Photo courtesy of the Philadelphia Water Department



Aquatic invasive species (AIS) like round gobies, zebra mussels, and Eurasian watermilfoil are changing the health and natural diversity of watersheds across Pennsylvania. Their impacts range from habitat competition with native plants and animals, to predation on walleye and perch eggs, to die-off of birds caused by avian botulism along Lake Erie. Aquatic invasive species are anticipated to be the leading cause of biodiversity loss in the Great Lakes in the 21st century and of extinctions in North American freshwater ecosystems. French Creek, having the largest diversity of native freshwater mussels in any Pennsylvania stream, may be heavily impacted by zebra mussel invasions.

Once established in a body of water, AIS are very difficult to eradicate, and are easily spread to uninfested waters through recreational boating, 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. That figure will grow more slowly if we all take a proactive role in preventing new introductions and minimizing the spread of existing AIS.

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 "Aquatic Invasive

Species Monitoring Squad" comprised of volunteers, field biologists, and scientific experts can help achieve this goal, through annual monitoring for invasive species.

As a Pennsylvania Aquatic Invasive Species Monitoring Squad volunteer, you are an important part of this statewide effort. This one-day workshop will teach you how to identify zebra mussels and quagga mussels, how to choose a monitoring site and record and report your data, and illustrate how your data will be uploaded in an interactive format using Google Earth or Google maps. 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.

**Welcome to the Pennsylvania Aquatic Invasive Species Monitoring Squad.
Thank you for helping keep Pennsylvania's waters AIS-free!**

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

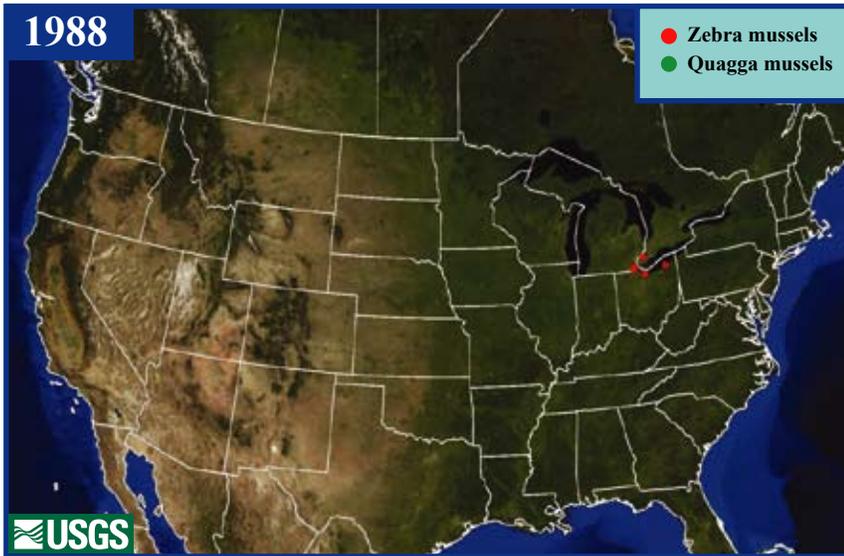
Water chestnut
Trapa natans

Photo courtesy of Vermont Department of Natural Resources



Early Detection = Prevention!

A Brief History of Invasive Mussels: 1988-Present



1988

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, stowing away in the ballast tanks of commercial ships.



1990

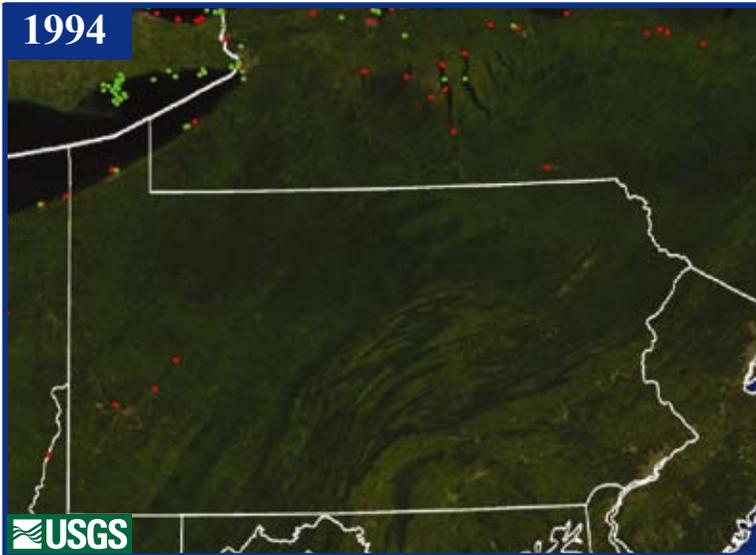
Zebra mussels rapidly spread across the Great Lakes via the movement of commercial ships to the west of Lake St. Clair and prevailing currents to the east. In 1989, quaggas (green dots) were first discovered in Lake Erie. Concerned about potential impacts of invasive mussels, Pennsylvania DEP began the Pennsylvania Zebra Mussel Monitoring Program in 1991. DEP biologists monitored key sites with assistance from water utilities, environmental consultants, DCNR State Parks staff, and the US Army Corps of Engineers.



1992

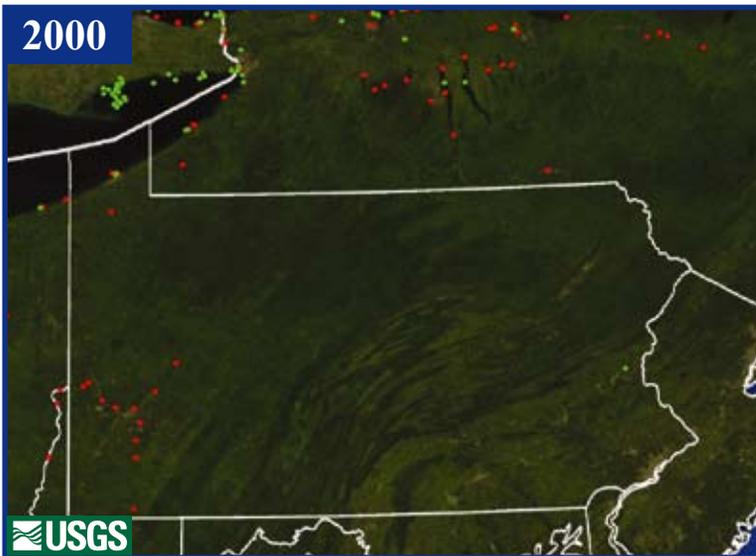
The next “wave” of mussels spread very quickly downstream, flowing out of Lake Michigan to the Mississippi and to other commercial shipping routes associated with the Great Lakes. Barge traffic carried the zebra mussels up several of the Mississippi’s tributaries. Recreational boating helped spread zebra 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



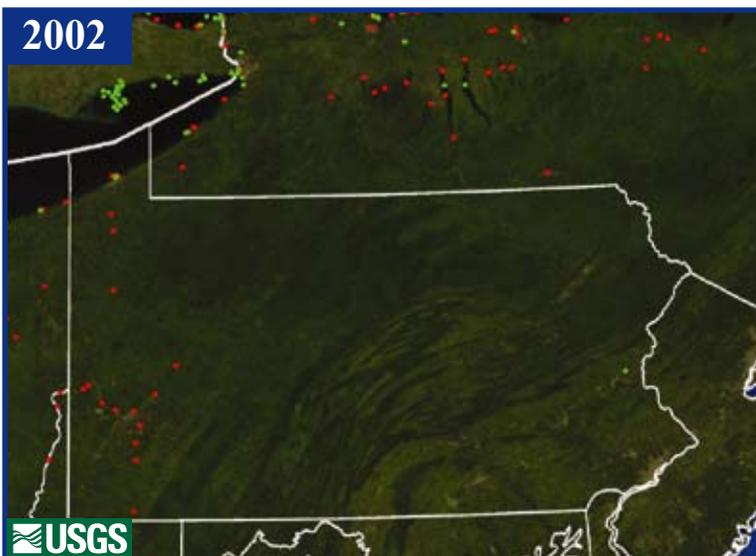
1994

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.



2000

Zebra mussels spread to the Monongahela River. After the initial, rapid 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. Since then, quagga mussels have out-competed the zebras; the mussels in this diving quarry now appear to be solely quaggas.



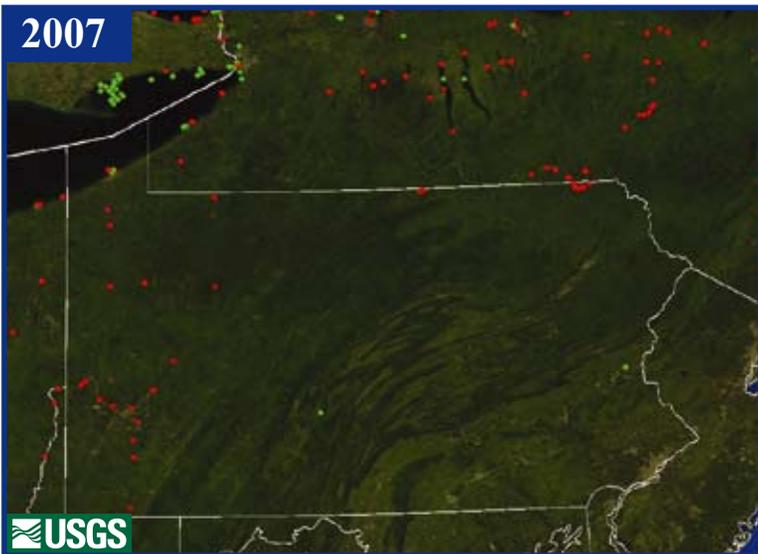
2002

Additional invasions were observed in northwest Pennsylvania in Sandy Lake and Creek, Conneauttee Creek, and French Creek.



2007

In 2007 quagga mussels made their way to the west coast of the United States probably via recreational boat equipment. After they were first found in Lake Mead, more quagga populations were found in California, Nevada, and Arizona.



2007

In Pennsylvania, zebra mussels were discovered in the Cowanesque Reservoir (Tioga County, near NY border) and several places in the upper Susquehanna. Zebra mussels were also found in Conewango Creek and the Upper Allegheny. Quagga mussels were also documented in a diving quarry near Williamsburg (central PA).



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

Monitoring for Invasive Mussels



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

Zebra 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 zebra and quagga mussels are so mobile and are transported in many ways, they have great potential to proliferate throughout Pennsylvania waters. We can help slow their spread by monitoring our rivers, streams, and lakes for new infestations. If mussels are identified at a new site, we can sound the alarm so appropriate steps can be taken, for example, to warn recreational boaters and water users 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 man-made 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 you and other Aquatic Invasive Species Monitoring Squad volunteers will be displayed on a Google Earth map at <http://seagrant.psu.edu/zm/>.

Choosing a Monitoring Site

Since recreational boating is the primary way that quagga and zebra 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.

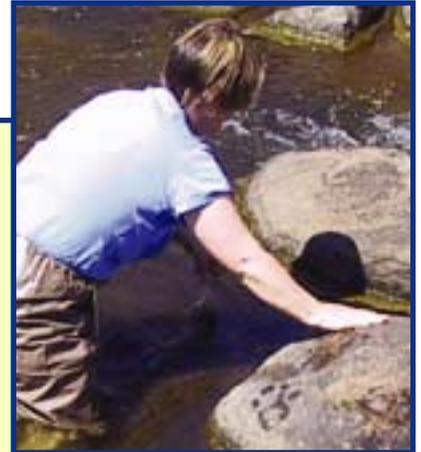
Searching for Zebra and Quagga Mussels

After you have picked your monitoring site, it's 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 your site, follow these steps to monitor for the presence or absence of zebra and quagga mussels:

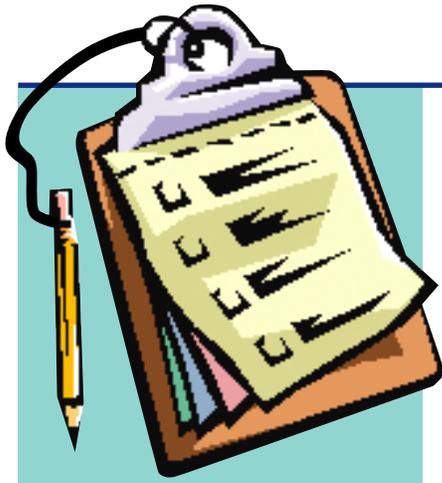
- Wear polarized sunglasses to reduce glare and improve vision into the water.
- Inspect all hard substrates. Both zebra and quagga mussels attach to hard surfaces, but quaggas are capable of colonizing soft sediments.
- Search objects located in dark, shaded areas and check underneath objects like driftwood, 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 a small pebble or sunflower seeds.
- Spend as much time as it takes to examine all hard-surfaced objects. Search until you're 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.



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



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



Recording and Reporting Monitoring Data

- Gather data monthly when the water temperature is warmer than 8°C (46°F).** 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 your 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	<input type="text"/>	pH	<input type="text"/>
Dissolved Oxygen (mg/l)	<input type="text"/>	Conductivity (umhos/cm3)	<input type="text"/>
Total Calcium (mg/l)	<input type="text"/>	Secchi Depth (m)	<input type="text"/>
Current Velocity (m/sec)	<input type="text"/>	Water Depth (m)	<input type="text"/>

- When you return home from your monitoring site, enter your data in digital form in the Excel spreadsheet.** Submit the document as an e-mail attachment to afaulds@psu.edu. The *Zebra & Quagga Mussel Survey Form* spreadsheet has been customized so that it will easily and accurately pool everyone's data into a common Microsoft Access database and Google Earth map. We will e-mail you to acknowledge that we've received your survey(s). You may send your 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:
Ann Faulds, 1350 Edgmont Avenue, Suite 2570, Chester, PA, 19013.

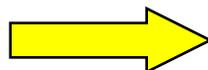
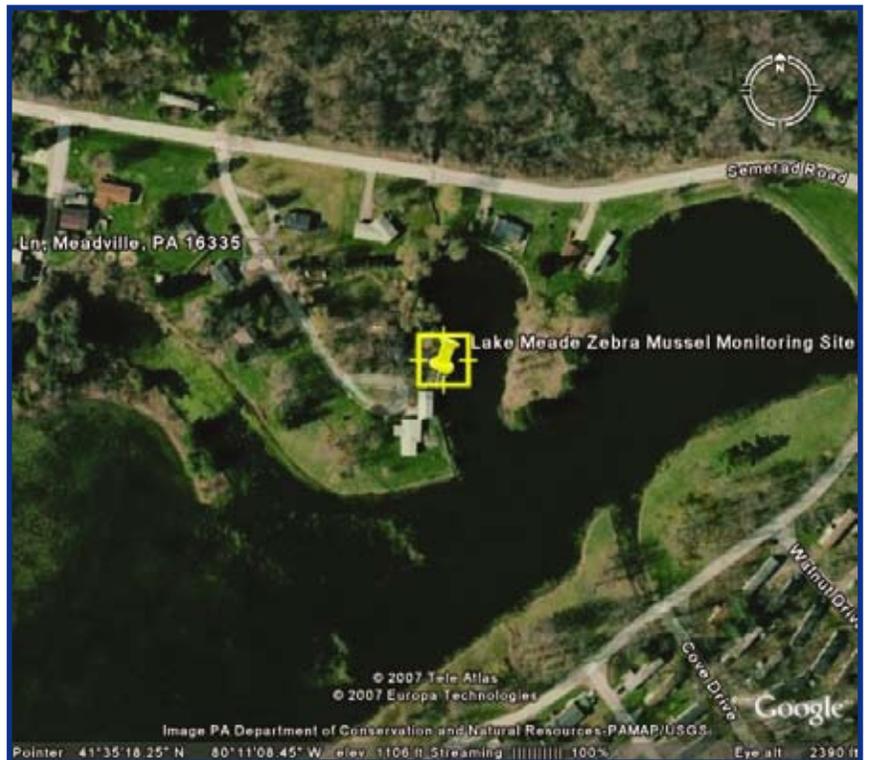


Zebra mussels on a golf ball.
Photo courtesy of Anthony Ricciardi,
McGill University

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 Earth.
If you haven't downloaded it previously, you can download a free copy from <http://earth.google.com>.
2. In the Search Tab, type your location (e.g. Lake Meade, Pennsylvania) in the "fly to" box.
3. In the Layers tab, located in the left hand tool bar, turn on the roads layer by checking the box. This will provide points of reference for your location.
4. Pan or zoom to the point nearest your site using the slider bars in the upper right corner of the map. Use buildings or streets as a point of reference. Position the hand print (your cursor) as close to your monitoring site as possible.
5. The latitude and longitude will be displayed at the bottom of the screen (see the yellow arrow). For the Lake Meade monitoring site, the latitude is: 41°35'18.25" N and the longitude is: 80°11'08.45" W. Note: If the pointer is not visible, go to the top left tool bar. Click "View", then click "Status Bar" to see the pointer.



Reporting a New Sighting



If you think you have found a zebra or quagga mussel 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. Call us from your monitoring site if you can.

Follow these simple steps to report your sighting:

1. At your 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 us 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 DON'T SHIP A SAMPLE BEFORE CONTACTING US!
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 Ann Faulds to make arrangements to have the specimen's identity confirmed. Call (215-806-0894), fax (206-984-9617), or e-mail (afaulds@psu.edu) Ann and provide her with your name, phone number, and the location of the sighting.
5. To verify the identification, send the mussel sample to:
Eric Obert, Pennsylvania Sea Grant
Tom Ridge Environmental Center
301 Peninsula Dr., Suite 3
Erie, PA 16505
Phone: 814-217-9018
E-mail: eco1@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.**

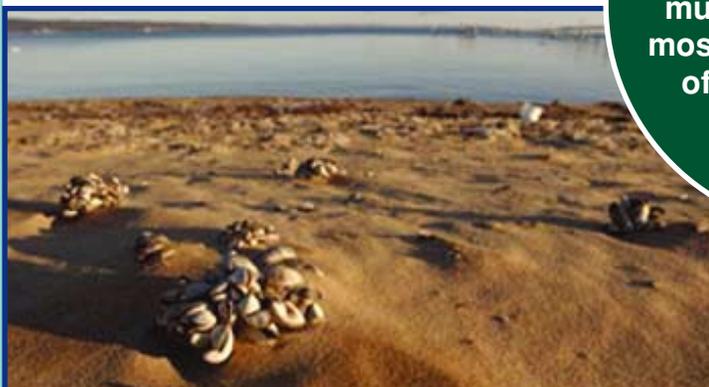


Photo courtesy of David Brenner,
Michigan Sea Grant.



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.

NATIVE & INTRODUCED RANGES

Zebra and quagga mussels are 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 northwestern 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 in a diving quarry in Bethlehem. In addition, quagga mussels have been found in a diving quarry near Williamsburg.

SPREAD

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.

IMPACTS

Threat to Biodiversity

Zebra and quagga mussels are efficient filter feeders, capable of straining one liter of water per day to consume the microscopic plants and animals, called plankton, found in it. This removal of plankton, in turn, reduces the amount of food available for other organisms. Zebra and quagga mussels prefer certain types of green and brown algae while they dislike blue green algae. Filtering by the mussels upsets the balance of algae communities and results in higher concentrations of blue green algae. Blue green algae can become toxic to aquatic life and cause taste and odor problems for drinking water supplies. Filter feeding by the mussels also clears the water, allowing sunlight to penetrate deeper, which can increase the growth of aquatic plants. Zebra mussels, which like to colonize on hard surfaces, can also kill native mussels and clams by using their tough byssal threads to build thick colonies over them, hindering their ability to feed.

ZEBRA &
 QUAGGA
 MUSSELS

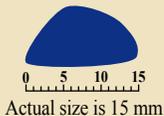
Photo courtesy of
 S. van Mechelen.

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

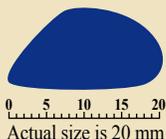


Quagga Mussel (*Dreissena bugensis*)



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



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

Sea Grant
Pennsylvania
www.seagrants.psu.edu

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Sea Grant is a partnership of
The Pennsylvania State University,
The Commonwealth of Pennsylvania,
and NOAA.

Penn State is an affirmative action, equal
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Lake Erie Office
814-217-9011
sng121@psu.edu

Delaware Estuary Office
215-806-0894
afaulds@psu.edu



Funded in part by PA DEP Coastal Zone Management

Economic Costs

Zebra and quagga mussels attach themselves in large clumps on hard surfaces such as boat hulls, docks, and buoys. They can also clog water intake pipes for power and water facilities. Zebra and quagga mussels are 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 in their tissues. These chemical contaminants can then be passed up the food chain to the fish that feed on the mussels and then to larger fish. Scientists also suspect that they can concentrate harmful bacteria such as 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, drain all water from your boat, including bilges, live wells, bait buckets, and coolers. Since mussels can cling to vegetation, be sure to check your boat each time you take it out of the water and remove any plants. Thoroughly wash your boat and all equipment with hot water (140°F or above). 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, or purchase or transport zebra and quagga mussels.

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.

HABITAT & BIOLOGY

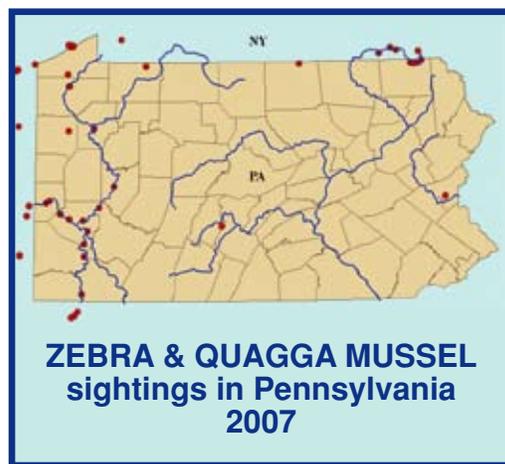
While zebra mussels are found mainly on hard substrates, such as rock, wood, concrete, and steel, quagga mussels can survive in soft sediment in the deep waters of Lake Erie and Ontario. The zebra and quagga mussel reproductive cycle is the key to their rapid infestation. Fertilization takes place externally and one female can produce up to one million eggs. Each fertilized egg develops into a free swimming veliger. Veligers can float freely in the water for three to four weeks before settling on a hard surface where it develops a shell and begins to colonize with other mussels.

References:

Benson, A., and Raikow, D. *Dreissena polymorpha*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. 2006. Revised: 4/24/2006 <<http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=5>> (Accessed November 10, 2006).

Britton, David. *Zebra Mussel (Dreissena polymorpha)*. ANS Taskforce Web site. 2006. <http://www.anstaskforce.gov/spoc/zebra_mussels.php> (Accessed November 13, 2006).

Millbrook Quarry Zebra Mussel Eradication. Virginia Department of Game and Inland Fisheries (VDGIF). 2006. <<http://www.dgif.virginia.gov/zebramussels/>> (Accessed November 13, 2006).



Internet Resources

Pennsylvania's Invaders

Aquatic Invasive Species (Pennsylvania Sea Grant)

<http://www.pserie.psu.edu/seagrant/ais/index.htm>

<http://seagrant.psu.edu/extension/ais.htm>

<http://seagrant.psu.edu/publications/ais.htm>

Aquatic Nuisance Species (Pennsylvania Fish and Boat Commission)

<http://www.fish.state.pa.us/ans.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://aquat1.ifas.ufl.edu/ie6/index.html>

Control of Invasive Non-Native Plants:

A Guide for Gardeners and Homeowners in the Mid-Atlantic Region

<http://www.mdflora.org/publications/invasives>

Non-Native Invasive Aquatic and Wetland Plants in the United States

<http://plants.ifas.ufl.edu/seagrant/aquinv.html>

Purple Pages – Purple Loosestrife Project (Michigan State University)

<http://www.miseagrant.umich.edu/pp/index.html>

Continued on next page...



Eurasian watermilfoil

Myriophyllum spicatum

Photo courtesy of Ann Murray,

University of Florida

IFAS Center for Aquatic and Invasive Plants



Bighead carp

Hypophthalmichthys 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



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Funded in part by PA DEP Coastal Zone Management

Regional and National Resources

Aquatic Nuisance Species Task Force

<http://www.anstaskforce.gov/>

Biological Pollution: Reducing Aquatic Invasive Species Introductions (Northeast Midwest Institute)

<http://www.nemw.org/biopollute.htm#laws>

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/>

Invasive Species in the Great Lakes Region (Great Lakes Information Network)

<http://www.great-lakes.net/envt/flora-fauna/invasive/invasive.html>

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/>

Sea Grant Nonindigenous Species Site

<http://www.sgnis.org/>

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/contaminants/ANS/ANSSpecies.cfm>

USGS Nonindigenous Aquatic Species Information Resource

<http://nas.er.usgs.gov/>