# Mussel Mania

*The pearls of Minnesota are freshwater mussels.*

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**Chapter 3 • Lesson 7**

Please note: Academic Standards are updated regularly and our alignments will be updated on the DNR Academic Standards Website at: www.mndnr.gov/education/teachers/edstandards_intro.html

# Mussel Mania

## Minnesota Academic Standards

◒ Lesson *introduces* this Benchmark.
◒ Lesson *partially* addresses this Benchmark.
● Lesson *fully* addresses this Benchmark..

### Language Arts

Grades 3, 4, 5
***I. Reading and Literature***
***B. Vocabulary Expansion:***
**Benchmark 1**—The student will acquire, understand and use new vocabulary through explicit instruction and independent reading. ◒
***III. Speaking, Listening and Viewing***
***A. Speaking and Listening:***
**Benchmark 2**—The student will demonstrate active listening and comprehension. ●

Grade 3
***III. Speaking, Listening and Viewing***
***A. Speaking and Listening:***
**Benchmark 3**—The student will follow multi-step oral directions. ●

Grade 4
***I. Reading and Literature***
***C. Comprehension:***
**Benchmark 4**—The student will summarize and paraphrase what is read. ●

### History and Social Studies

Grades 4-8
***II. Minnesota History***
***G. Post-World War II to the Present:***
**Benchmark 4**—Students will identify and describe significant land use changes in Minnesota, issues related to land use, and analyze the impact of those changes and issues. ◒

***IV. Historical Skills***
***A. Concepts of Time:***
**Benchmark 1**—Students will define and use terms for concepts of historical time. ◒ (Before zebra mussels, after zebra mussels are introduced, and long term impacts of zebra mussels.)
***V. Geography***
***D. Interconnections:***
**Benchmark 1**—Students will recognize changes over time in nearby landscapes, resulting from human occupation. ◒

### Science

Grade 3
***IV. Life Science***
***B. Diversity of Organisms:***
**Benchmark 1**—The student will describe the structures that serve different functions in growth, survival and reproduction for plants and animals. ●
***C. Interdependence of Life:***
**Benchmark 1**—The student will know that organisms interact with one another in various ways besides providing food. ●
**Benchmark 2**—The student will know that changes in a habitat can be beneficial or harmful to an organism. ●

Grade 4
***III. Earth and Space Science***
***A. Earth Structure and Processes:***
**Benchmark 1**—The student will identify and investigate environmental issues and potential solutions. ●

Grade 5
***IV. Life Science***
***E. Biological Populations Change Over Time:***
**Benchmark 2**—The student will recognize that extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival.
***F. Flow of Matter and Energy:***
**Benchmark 1**—The student will recognize that organisms need energy to stay alive and grow, and that this energy originates from the sun.
**Benchmark 2**—The student will use food webs to describe the relationships among producers, consumers, and decomposers in an ecosystem in Minnesota.
**Benchmark 3**—The student will recognize that organisms are growing, dying and decaying, and that their matter is recycled.

## Environmental Literacy Scope and Sequence

**Benchmarks**

- Social and natural systems are made of parts. (PreK-2)
- Social and natural systems may not continue to function if some of their parts are missing. (PreK-2)
- When the parts of social and natural systems are put together, they can do things they couldn't do by themselves. (PreK-2)
- In social and natural systems that consist of many parts, the parts usually influence one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched or misconnected. (3-5)

For the full Environmental Literacy Scope and Sequence, see:
**www.seek.state.mn.us/eemn_c.cfm**

**Chapter 3 • Lesson 7**

# Mussel Mania

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**Grade Level:** 3-5
**Activity Duration:** 20 to 30 minutes
**Group Size:** 15 to 35 participants
**Subject Areas:** Language Arts, Social Studies, Physical Education, Science
**Academic Skills:** kinesthetic concept development, large group skills, role-playing, simulation
**Setting:** large indoor or outdoor gathering area
**Vocabulary:** amphipods, carrying capacity, conglutinates, glochidia, invasive species, mollusk, native, substrate, veliger, zebra mussel
**Internet Search Words:** aquatic invasive species, zebra mussels

## Instructor's Background Information

Many people are unaware of the vast variety of animals that live under the surfaces of Minnesota waters. Mussels are one of these overlooked animals. Freshwater mussels inhabit the lakes and rivers in Minnesota, but they are found throughout the world, too, with North America supporting more species than any other continent.

Mussels are members of the second largest group of animals in the world, the **mollusks**. Mollusks are invertebrates whose soft, unsegmented bodies are usually enclosed by a shell. Mussels belong to the phylum Mollusca, and are closely related to other bivalves, such as marine mussels and clams, as well as to snails and octopuses.

Freshwater mussels have two shell halves, or valves. Inside the shell, a thin tissue—the mantle—surrounds the mussel's soft body. The mantle secretes the material that creates the shell. The valves, held together by an elastic-like hinge, close with the help of two strong muscles whenever the mussel senses a threat.

### Why Are Mussels Important?

Mussels are an important food source for several different kinds of animals, including river otters and raccoons, as well as several fish species. Mussel shells form an important **substrate** to which algae and insect larvae attach themselves. (A substrate is an underlying surface on which other organisms can grow—rocks, gravel, plants, woody debris, and mussel shells are all substrates). When present in large numbers, mussels can become a sort of underwater garden that attracts feeding fish, including their host fish. Mussels are filter feeders, and they eat

## Summary

Students become native mussels, invasive zebra mussels, perch, walleye, or "plankton movers" in a game designed to help them understand how harmful invasive species can affect the balance within aquatic ecosystems.

## Student Objectives

The students will:

1. Explain why native freshwater mussels are important to ecosystems.
2. Identify the effects of zebra mussels on other aquatic organisms.
3. Describe three ways that zebra mussels can take over habitat in Minnesota waters.
4. List two ways in which human activity has introduced zebra mussels and two ways that people spread zebra mussels in Minnesota waters.
5. Describe the life cycle of a freshwater mussel, including how the larval forms of many mussel species require fish hosts during a stage of their development.

## Materials

- **Zebra Mussels Crash on Mississippi River Sheet**, one per student
- **Plankton Sheet**, one per student, or one transparency to project
- Tape, chalk, string, or rope for defining the lake boundary
- Two hula-hoops
- Newspaper or scrap paper crumpled into 100 or more tight balls, or 100 plastic golf balls, wiffle balls, or other substitute
- *Mussels of Minnesota* poster, available from the Minnesota DNR
- One legally collected native mussel shell (or other mollusk shell)
- *Field Guide to the Freshwater Mussels of Minnesota*, by Bernard E. Sietman (optional), available through the Minnesota DNR
- *Zebra Mussel Identification* cards, one per student (optional), available from the Minnesota DNR Information Center at 1-888-MINNDNR (646-6367)

small plants and animals known as plankton. Mussels also filter and clean the water by removing undesirable particles and chemicals as they feed.

Archeological digs in eastern North America have yielded shell materials used by native cultures as long ago as 8000 B.C. These cultures used mussels for food. They also used mussel shells to temper pottery and to make tools, utensils, and jewelry.

By the mid-1800s, European-Americans in the eastern United States were searching for natural pearls formed within mussel shells. Pearl hunting spread throughout the United States, and by the end of the century, "pearlers" were collecting mussels from as far west as the Mississippi River.

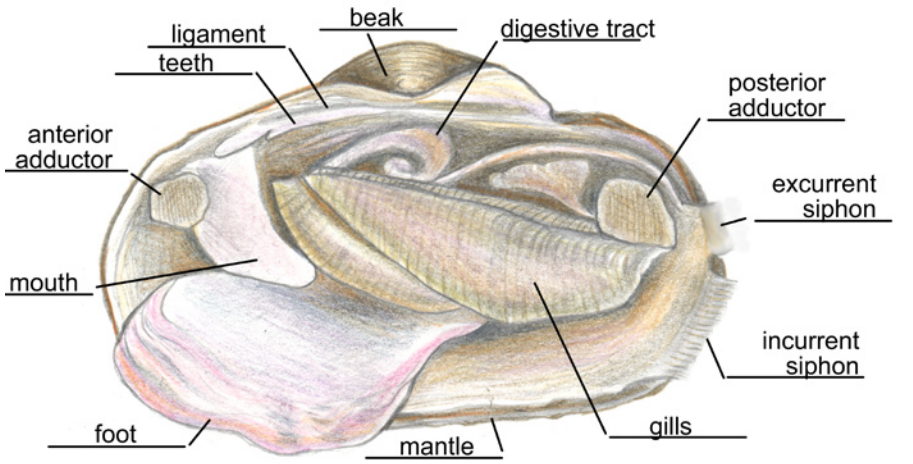
In the 1890s, mussel shells were first harvested and manufactured into pearl buttons. These early harvesters collected mussels by the ton from the Mississippi River and its major tributaries. Mussels were harvested for this multimillion-dollar industry until the 1940s, when plastic replaced pearl as a button material.

Freshwater mussels are presently harvested throughout much of their range for use in the cultured pearl industry. The shells are collected, ground into beads, and placed in live oysters, whose mantles then secrete a thin layer of mother of pearl upon the beads, forming a cultured pearl. These pearls are left inside the oyster for one to three years before they're removed, sorted, and sold. Most pearl industry practices now use synthetic materials instead of ground freshwater mussel shells to induce oysters to make pearls. Most states now have regulations prohibiting mussel harvest from their waters. In Minnesota, people who wish to harvest mussels from inland waters must have permits. But some freshwater mussel species are endangered, so permits haven't been issued for quite some time.

**How Do Mussels Live?**

Mussels spend most of their lives in a small area of a lake or streambed. They move using a muscular "foot," which they push into the sand or gravel to inch themselves along the bottom. This movement allows them to avoid fluctuating water levels and search for favorable habitats.

A mussel gathers food and oxygen by drawing water through an incurrent siphon. It removes the food and oxygen with its gills, and expels the water through an excurrent siphon. Tiny, hair-like cilia located on the gills sweep the food in the water—mostly plankton and organic matter—to the mussel's mouth.

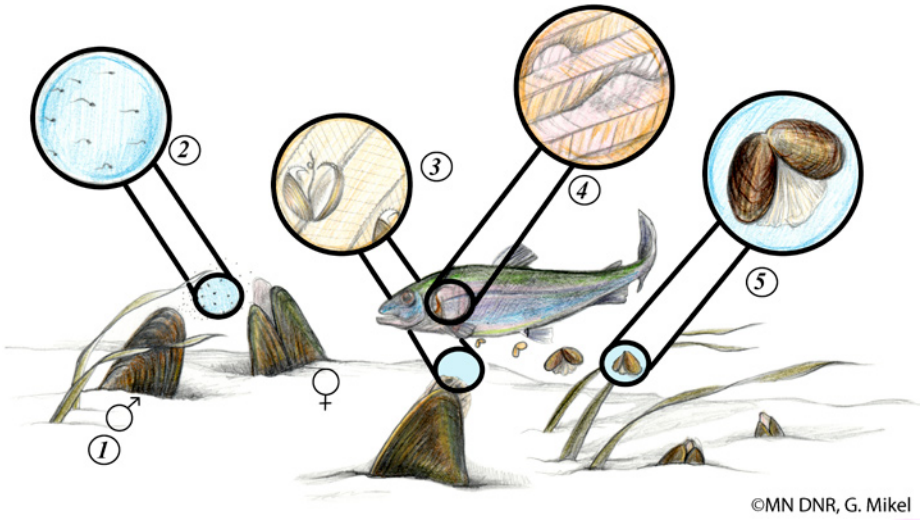





**Anatomy of a freshwater mussel.**

Freshwater mussels have a complex life history that links them closely to fish. During their larval, or **glochidial** stage, mussels must attach themselves to fish tissue as parasites. Zebra mussel larvae are called **veligers**. Veligers are free-swimming larvae. They don't require a fish host during any portion of their life cycle. Some freshwater mussels require one particular fish species as a host, but others use many species. One mussel species, the salamander mussel, is so specialized that it exclusively uses the gills of an amphibian, the mudpuppy, as its host. After being released by the female, the glochidia attach themselves to the host's skin or gills, where they grow for a month or more.

To improve the larvae's chances for survival, many mussel species have evolved elaborate means of luring fish to gravid (pregnant) females. For example, the pocketbook mussel has a modified mantle flap that resembles a minnow. Other mussel species package their developing glochidia into cases called **conglutinates**. These sometimes resemble the insects on which fish normally feed. When a fish attempts to eat this imposter insect, it becomes infected with the mussel's glochidia, which develop into juvenile mussels while attached to the host fish. They then detach from their host, fall to the lakebed or streambed, and begin their lives as free-living mussels. This method of reproduction is also the primary way that mussels are distributed throughout a water body, so mussel species distributions are directly related to the host fish's distribution.





**The life cycle of a freshwater mussel.**

1. The male flushes sperm into the water, where currents can carry them downstream toward a female. The female draws in sperm to fertilize her eggs. Unless males and females are near one another, odds for fertilization are slim.
2. The female broods the fertilized eggs inside of her, and then releases thousands of tiny larvae called glochidia. She must sense the presence of a fish, timing her release so the glochidia can "hitch a ride" on the fish. Many species release their glochidia in clumps shaped like small worms or other fish food. Fish feed on them and then expel them through their gills, where the glochidia of many species settle. When a nest-building fish stirs up the river bottom, glochidia from the bottom may also attach and hitch a ride.
3. When microscopic glochidia touch the tissue of a fish, they clamp or hook themselves onto the fish's scales, fins, or gills. Some glochidia need a certain species of host fish on which to grow.
4. The fish grows a layer of skin over the hitchhiker, forming a cyst. Depending on the species, young mussels stay on the fish for several days to a few months while they grow into juveniles. This doesn't harm or stress the fish.
5. The cyst breaks open, and the juvenile mussel drops off to start its adult life. With luck, it will land in good habitat and join other mussels in making a bed in the river bottom.

**Why Are Mussels in Trouble?**

Freshwater mussels filter oxygen and particles from the water, cleansing the water in the process and absorbing what they consume into their bodies and shells. For this reason, mussels are sensitive to changes in their environment, and serve as indicators of the health of lakes and rivers. Degradation of lakes and rivers from runoff of silt and chemicals—together with physical changes from damming, channelization, and dredging—has taken a toll on **native mussels** in North America. (A native organism is a species that naturally occurs in a particular environment.) As a result, conservation groups, such as the

American Fisheries Society and The Nature Conservancy, list mussels as one of North America's most endangered animal groups. Of the 297 known species and subspecies of freshwater mussels in North America, 213 are listed as either endangered, threatened, or of special concern. In Minnesota, 25 of our 48 native mussel species are listed as endangered, threatened, or of special concern. Two Minnesota species are believed to be extinct from the state.

Unregulated commercial harvest of mussels in the early part of the last century has also affected mussel communities. Experts believe that populations of mussels no longer legally collected may still be experiencing the impact of having been harvested during the early 1900s. The State of Minnesota does not allow the harvesting of mussels from inland waters, and allows only limited commercial harvest of a single species from the Mississippi River along the border with Wisconsin. A special permit is required to legally harvest mussels from this portion of the Mississippi River.


**Zebra mussels *(Dreissena polymorpha)* are small, with sharp edges and "zebra" stripes.**

More recently, mussels are especially threatened by the introduction of an **invasive** mussel species. **Zebra mussels** *(Dreissena polymorpha)*, are small clams, less than two inches in length, that attach to any solid object using tufts of fiber called byssal threads. Not native to North America, they were introduced from another part of the world. Zebra mussels are native to the Caspian Sea region of Asia and were brought from Europe into the Great Lakes in the late 1980s in the ballast water of transoceanic ships that discharged ballast water into Lake St. Clair, near Detroit. Tolerant of a wide range of environmental conditions, and having few natural predators in the U.S. to control their population, zebra mussels have extended their range to parts of all the Great Lakes and much of the Mississippi River. Zebra mussels were discovered in Minnesota in the Duluth Superior Harbor in 1989 and have since


**Note the shape of the zebra mussel.**

become established in the Mississippi River, the St. Croix River, Lake Zumbro (an inland lake north of Rochester), Lake Minnetonka (near the Twin Cities), and Lake Ossawinnamakee near Brainerd. Two zebra mussels were found in separate locations in Lake Mille Lacs on the northwest side of the lake in August 2005, during a routine dive survey for net locations by fisheries biologists from the Minnesota DNR. These were the first zebra mussels found in Mille Lacs. In 2005, an young angler found a zebra mussel in a minnow bucket attached to a dock on Rice Lake, near Brainerd. Subsequent investigation disclosed that the zebra mussel is established in Rice Lake.

Game fish have not yet shown impacts from zebra mussels in the Mississippi River, Lake Superior, or other Minnesota lakes where they've been discovered. The effects of zebra mussels, however, are difficult to predict. They're known to foul beaches, clog water intakes, harm native mussels, and possibly interfere in lake food chains.

A single zebra mussel female can produce more than 30,000 eggs, and the generations mature rapidly, making them difficult to control. A body of water with no detectable zebra mussels one year may have its bottom covered with them the next. Colonies can have from 70,000 zebra mussels per square yard—as in portions of Lake Erie—to the incredible 700,000 mussels per square yard that have been found in some utility water intake pipes. Zebra mussels feed by extracting microscopic plant life (phytoplankton) from the water, robbing native organisms of much-needed food sources. A single adult zebra mussel can filter a full liter of water daily for every day of its life. Zebra mussels live an average of about five years, so the mussel can filter 482 gallons (1825 liters) over its lifetime.

Large numbers of zebra mussels can filter *all* of the water in a lake or stream, removing plankton (tiny plants and animals) that serves as food for juvenile fish—and for native mussels. When zebra mussel populations peaked in Lake Erie, it was estimated that the entire volume of the Erie basin was filtered through zebra mussels every single day. When zebra mussels filter so much plankton, a link in the food chain is broken, causing severe damage to native species. Zebra mussels also affect native mussels by attaching in large numbers to any exposed areas of the native mussel's shell. This leads to increased vulnerability to parasitism, interference with movement, suffocation, starvation, and death.

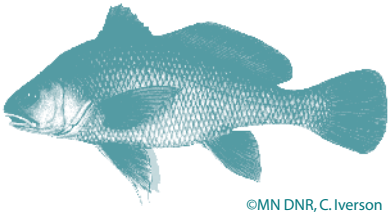
Zebra mussels can form colonies so dense that they carpet the lake or river bottom in a layer several inches thick, eliminating the habitat required by native mussels and other bottom-dwelling animals and reducing the **carrying capacity** of the habitat for native mussel species. Carrying capacity is the maximum number of individuals or inhabitants that a given environment can support without detrimental effects to the habitat or to the organisms. Any firm surface that is not toxic can

be colonized by zebra mussels, including boat hulls and motors, trailers, docks, anchors, and rocky beaches. In times of low water, a band of zebra mussels a few inches thick can be seen along the shores in areas of the Mississippi River.

Recent studies have shown that zebra mussels may move toxic materials from the sediments into the food chain in two ways. When they filter algae that have absorbed toxic materials, they ingest those toxins. The toxins can accumulate in the mussel's fatty tissue and be passed on to fish, ducks, or other predators. Or the mussels can release the toxins back into the food chain as waste, which is grazed upon by **amphipods** (small crustaceans, similar to tiny shrimp), which are then eaten by fish.

**Commercial Effects**

Power plants and water treatment plants located on Lake Erie have experienced 20 to 30 percent reductions in their pumping ability due to zebra mussels clogging the intake pipes. The utilities have spent up to one million dollars annually on controlling and researching the zebra mussel.



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Commercial fishermen and clammers are beginning to feel the effects of dense infestations of zebra mussels on native clam beds and fish spawning areas. Several formerly productive beds have already been severely damaged by zebra mussel growth.

**Recreational Effects**

Zebra mussels attach to boat docks and boat hulls. They plug water intake ports, causing outboard motors to overheat. Huge deposits of dead zebra mussels can wash up on beaches, causing foul odors and cutting swimmers' feet with their sharp shells. In Lake St. Clair (located between Lake Huron and Lake Erie), the filtering action of zebra mussels has caused clearer water, allowing more sunlight to reach the bottom, which causes more vegetation to grow. Walleye are being replaced by other fish and are having difficulty reproducing successfully. Other formerly productive Great Lakes area fisheries are also in decline due to loss of food sources and spawning grounds caused by zebra mussel infestation.

Lake- or river-wide control of zebra mussels isn't feasible at this time. Europeans have been unable to find a control after two centuries of infestation. In the Great Lakes, no chemical toxicant has been developed that is both feasible for widespread use and nontoxic to other aquatic species. In North America, the species that are most likely to prey on relatively deep beds of zebra mussels are duck species like scaup, canvasback, and oldsquaw. Freshwater drum (also known as sheepshead) have also been observed feeding on the mussels, and yellow perch have been seen feeding on juveniles, mainly when the young mussels are detached and drifting.


**Prevent the Spread of Invasive Zebra Mussels**

If you are a water recreationist—a boater, angler, water-skier, sailor, or canoeist—there are some important things you can do to help prevent the spread of zebra mussels to non-infested waters. It is illegal in many states and provinces to transport **invasive species—**those species or types of organisms that are not native and that have been introduced through intentional or accidental means to a place where they weren't originally living.

- Carefully remove all aquatic plants from watercraft, trailers, and equipment.
- Completely drain all water from your boat, motor, and trailer, including live wells, bilges, and bait buckets before leaving an access site. Empty your bait bucket on land—never into the water. Microscopic zebra mussel larvae (veligers) can live in the water for many days.
- Wash everything using water heated to at least 140°F; pressure washers with hot water are most effective.
- Dry boats and trailers thoroughly in the sun for at least five days before using them in other waters.
- Never dip your bait or minnow bucket into one lake if it contains water from another lake.

**What Does the Future Hold for Minnesota's Native Mussels?**

The Minnesota DNR has initiated a statewide mussel survey project. Information gained about the distribution and abundance of mussels will be used to protect remaining areas where mussels and the water resources that sustain them are healthy, and to target areas where conditions indicate that improvements are needed. Because zebra mussels can rapidly colonize new habitats, it's important for people to recognize this invader so they don't inadvertently spread it throughout the state. To prevent the spread of zebra mussels and other invasive species, the DNR will continue its sustained public awareness campaign, urging boaters and others to carefully remove all aquatic plants from their watercraft, trailers, and equipment. By conserving native mussel habitats, we can maintain the health of the lakes and rivers that are an integral part of Minnesota's quality of life.

**Harvest Regulations**

No live mussels may be collected in Minnesota without a special permit. No live or dead mussels may be collected in National Park Services units, including the St. Croix River. If you pick up a live mussel, return it to the water immediately: carefully place its foot end in the lake or stream bottom so that about two-thirds of the shell is buried. Currently, a person with a fishing license may possess up to 24 whole or 48 half shells of dead mussels, collected from waters in the open season where fishing is allowed. It's illegal, however, to collect state-listed threatened species.

## Procedure

**Preparation**

1. Collect the materials.
2. Crumple sheets of newspaper or scrap paper to make at least 100 balls (or use 100 plastic golf balls, wiffle balls, or other lightweight substitute).
3. Mark a circle, 20 feet in diameter, with tape, chalk, string, or rope. This area represents a portion of a lake or stream system.
4. In this circle, randomly place two hula-hoops to represent the native mussels' habitat, a soft lake bottom. The rest of the area in the lake is a hard bottom.
5. Within each of the two hula-hoops, stick a small piece of masking tape.

## Activity

**Warm-up**


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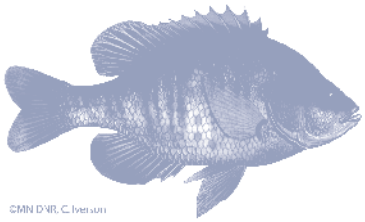
1. Ask students to list the organisms that live underneath the surface of lakes and rivers in Minnesota. Keep adding to the list until freshwater mussels (or clams) are noted. Discuss with students that Minnesota does have many different kinds of native mussel species. Bring out a copy of the *Mussels of Minnesota* poster, the *Field Guide to the Freshwater Mussels of Minnesota,* by Bernard E. Sietman (available through the Minnesota DNR), and a legally collected native mussel shell (or some other mollusk shell). Have fun noting the colorful, descriptive names of many native mussel species, such as the monkeyface, washboard, winged mapleleaf, ebonyshell, purple wartyback, fawnsfoot, flat floater, threeridge, fatmucket, elktoe and hickorynut. Ask students to discuss why they think each type of mussel was given its name.
2. Discuss the life cycle of the freshwater mussel with students. Make sure to talk about the veliger, which is the free-swimming larval form of the immature zebra mussels. Discuss how mussel glochidia use fish as hosts during a stage of their development. Just as the host of a party provides for the well-being of guests, the fish provides the glochidia (which attach themselves to the fish's gills or other tissues) an opportunity to travel, obtain food, and grow enough to eventually drop off of the fish and fend for themselves in the place where they land.
3. Explain to students the ways in which native mussels benefit Minnesota aquatic ecosystems, including filtering water as they feed, and providing food for other animals, including many types of fish.
4. Have students read, and summarize the newspaper article in the **"Zebra Mussels Crash on Mississippi River" Sheet**. Have students choose four main ideas from the article about the impacts of zebra mussels in Minnesota, and paraphrase those main concepts in a way that their best friend would understand. (To paraphrase



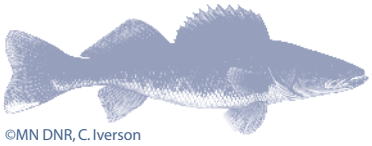

means to generate a new way to explain the main ideas.)

5. Ask students how a mussel called "zebra mussel" might have gotten its name. Show students an illustration of a zebra mussel. Discuss how aquatic species like the zebra mussel aren't native to Minnesota, and how the zebra mussel was transported to Minnesota.
6. Review the four components of habitat with the group: food, water, cover, and space. A body of water has limits on how much of each of these it can provide. The number of animals and plants that can be supported by a habitat without being detrimental is called the carrying capacity. If an invasive species like the zebra mussel in introduced to a Minnesota lake or river and has few, if any, predators, they can thrive and reproduce, creating a large population of the invader in the ecosystem. How might this impact native species in the lake or river?
7. Ask students if they can describe some ways that zebra mussels harm the Minnesota aquatic ecosystems and businesses noted in the newspaper article. Further discuss how invasive or non-native species have been harmful to Minnesota native species and ecosystems.
8. Describe the role of plankton as producers. Hand a copy of the **Plankton Sheet** to each student, or show a projection made from the **Plankton Sheet** to show students illustrations of some different types of freshwater plankton.
9. Tell the students that they will play a game. Each student will be a native mussel, yellow perch, walleye, or zebra mussel trying to meet its habitat needs.

**Lesson**

1. Have the students gather inside the circle and mill around. Tell them that they are baby native mussels, called glochidia, trying to find a great place to live. They have been traveling around the water body attached to the gills of a host fish and have grown enough to strike out on their own so they're ready to drop off the fish's gills. They'll be asked to mill around to represent drifting in the current after leaving the host fish. Tell students that the circle marks the boundary of an area of a stream, lake, or river.
2. Have the students begin wandering around the circle, drifting in the currents after dropping off the gills of a host fish. Call out "Stop!" Some students will be inside or touching the hula-hoops. Inform students that anyone not standing in a hula-hoop must leave the circle. Explain that native mussels live in muddy or sandy bottoms, which are only represented by the hula-hoops. Still, some remaining immature mussels will not survive to reach maturity.
3. The person nearest the small piece of tape inside the hula-hoop has found the very best spot for good mussel survival and can sit down. Others do not survive (they can't attach well where they landed, they get eaten by a fish or other animal, they don't get enough food, and so forth) and must leave the lake.

4. Over the course of many years, the two surviving young native mussels have grown into adult mussels. Emphasize that finding the right kind of lake or river bottom (space) is very important for the native mussels, and this habitat need limits their numbers.
5. Identify two students as plankton movers. They are the currents moving the plankton (food) into the area. They should sit outside the circle, facing away from the "lake." They will toss plankton (paper balls) at random over their shoulders into the circle. Explain to students that plankton are very small plants and animals that float or swim in the water. Hold up the **Plankton Sheet** to give students a visual image of plankton.
6. The native mussels must catch the plankton in the air to simulate feeding, remaining seated within the hula-hoops as they play. Anything missed stays on the ground until the end of the round.
7. Assign two scavengers to pick up the plankton and return it to the movers. (Later in the game, they'll also return plankton to the movers after retrieving it from the tagged perch.)
8. Tell students that other animals live in balance in the ecosystem with mussels and plankton. Select three students to be yellow perch and add them to the lake. Perch feed on plankton. They move around inside the circle and try to catch plankton in the air. They must catch the plankton without overtly interfering with or blocking the native mussels' feeding. Perch can also feed from the bottom (by picking up stray paper plankton balls).
9. After a few minutes, select two students to be walleye and add them to the lake. The walleye eat the perch. They can move around the outside of the circle, reaching in to eat the perch. Tagged perch must leave the circle and give their plankton to scavengers to return to the movers. As perch are eaten, add more, trying to maintain at least one perch in the circle at all times.
10. The rest of the students are zebra mussels. Begin to add zebra mussels to the lake three at a time. Explain that zebra mussels compete with native mussels for *food* and *space*. Zebra mussels can't live in the soft bottom like the native mussels, but must live on hard surfaces, like rocks, represented by the area outside the hula-hoops. The zebra mussels filter-feed and eat plankton from the water, just as native mussels do.
11. Gradually add more zebra mussels. Explain that, unlike the perch, zebra mussels have very few predators that will feed on them. This allows the zebra mussel population to expand to the limits of their food supply. As it gets crowded, tell the group that, because zebra mussels can stick to hard surfaces, they can sit or stand in the hoops as long as they're either touching each other or a native mussel. Continue until all the native mussels are smothered with zebra mussels or until everyone has had a chance to get back into the game.
12. End the game.


©MN DNR, C. Iverson

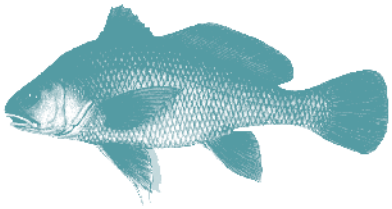
**Wrap-up**

After the game, discuss the following questions:

1. What happened to the fish and native mussels as more zebra mussels were added to the lake? (Space became increasingly scarce while food became harder to find. Some of the fish and native mussels may have even starved because they couldn't get any food. The carrying capacity of the lake for fish and native mussels decreased as more and more zebra mussels were introduced.)
2. Why are native mussels important? What is their role in the ecosystem? (They're an important food source for many animals, including river otters, raccoons, and several species of fish. Mussels filter or clean the water during their feeding process. They also provide a surface to which bacteria and algae can attach, providing food for even more species that eat these organisms.)
3. How could zebra mussels impact facilities such as water treatment plants (water intake pipes), boat docks, motors, and boat hulls? (Because zebra mussels adhere to hard surfaces, they often clog intake pipes, build up on boat docks, motors, and boat hulls. It costs thousands of dollars remove them, and they just build up again over time.)
4. Why should anglers and recreational boaters always drain the water from their boats, minnow pails, and live wells? (To prevent the spread of harmful invasive aquatic species.)
5. Remind students that zebra mussels start out as free-swimming veligers, unlike native freshwater mussels, and they'll swim off into the next lake if they're allowed to survive the trip in standing water.
6. Discuss how nonnative species are intentionally introduced into an ecosystem. For example, brown trout and rainbow trout have been intentionally introduced as a management tool in some Minnesota cold water streams to provide trout fishing opportunities for anglers. Minnesota's only native stream trout species is the brook trout. As many cold water streams were degraded by human activities ranging from agriculture to logging to land development, many streams no longer supported populations of brook trout. Rainbow trout and brown trout are less sensitive than brook trout. They can survive conditions in some streams that no longer support brook trout.

## Assessment Options

1. Have students complete a written summary of the newspaper article about zebra mussels. Evaluate each summary for inclusion of the definition of invasive species, how zebra mussels were introduced to Minnesota waters, and three harmful effects of zebra mussels, including how they impact native species.
2. Have students paraphrase the main concepts in the news paper article in a way that younger students (first graders, for example) might understand, by creating a different way to express the same concepts about impacts of zebra mussels in Minnesota waters. They could express the concepts by creating a play, a picture book, a zebra mussel game, and so forth.
3. Create and perform a skit on how zebra mussels affect other aquatic organisms. Include the characteristics and behaviors that allow zebra mussels to take over Minnesota water habitats and overtake or out-compete native aquatic organisms.
4. Draw or describe the life cycle of a freshwater mussel. Include three reasons why native freshwater mussels are important parts of the aquatic ecosystem.
5. Assessment options include the Checklist and Rubric on the following pages.





Checklists are tools for students and instructors. Checklists involve students in managing their own learning. They help students understand and set learning goals before the lesson begins, and help them monitor their progress during the lesson, ensuring that they meet learning goals and objectives by the end of the lesson. Students can also use checklists to discover areas that may need improvement. Checklists help instructors monitor each student's progress throughout the lesson, facilitating appropriate adjustment of instruction to ensure learning by the end of the lesson. The instructor may wish to have students add several of their own learning goals to the checklist to personalize it, and to accommodate varied learning needs and styles.

**Grade**

**30-33 points = A**
Excellent. Work is above expectations.

**26-29 points = B**
Good. Work meets expectations.

**21-25 points = C**
Work is generally good. Some areas are better developed than others.

**17-20 points = D**
Work does not meet expectations; it's not clear that student understands objectives.

**0-16 points = F**
Work is unacceptable.

# Mussel Mania Checklist

| Possible Points | Points Earned Student | Points Earned Instructor | |
|---|---|---|---|
| 3 | _____ | _____ | Student faces the audience and speaks clearly and loudly enough for audience to understand presentation. |
| 2 | _____ | _____ | Student can explain that zebra mussels are not native to Minnesota waters. |
| 3 | _____ | _____ | Student can define *native species*, *invasive species*, and *harmful invasive species*. |
| 3 | _____ | _____ | Student can describe how zebra mussels are harmful to native species and to people. |
| 3 | _____ | _____ | Student can describe how zebra mussels came to Minnesota waters. |
| 3 | _____ | _____ | Student understands how zebra mussels spread as veligers. |
| 3 | _____ | _____ | Student can describe three other ways that zebra mussels spread to uninfected waters. |
| 6 | _____ | _____ | Student can describe multiple effects of zebra mussels on other aquatic organisms and the characteristics that enable that effect. |
| 4 | _____ | _____ | Student can describe the life cycle of mussels and explain how the life cycle is connected to fish. |
| 3 | _____ | _____ | Student can describe three ways in which native mussels are important to an ecosystem. |
| **Total Points** | | | |
| **33** | _____ | _____ | **Score** _____ |

# Mussel Mania Scoring Rubric

| Performance Criteria | 4 Excellent | 3 Good | 2 Fair | 1 Poor | 0 Unacceptable |
|---|---|---|---|---|---|
| **Presentation** | Faces the audience and speaks clearly and loudly enough for audience to understand presentation. | Speaks clearly and loudly enough for audience to understand, but didn't face audience. | Hard to understand due to lack of volume, body position, and speech clarity. | Not at all understandable. | Didn't present to audience. |
| **Invasive zebra mussels** | Can explain that zebra mussels are not native to Minnesota waters; can describe how they're harmful to native species and to people; can describe how they came to Minnesota waters. | Can explain why zebra mussels are considered an invasive species in Minnesota, and that they're harmful to native species. | Can identify that zebra mussels are considered an invasive species in Minnesota waters. | Can't identify zebra mussels as an invasive species in Minnesota waters. | Doesn't understand invasive species concept. |
| **Spread of zebra mussels** | Understands how zebra mussels spread as veligers; can describe three other ways that zebra mussels spread to uninfected waters. | Understands that zebra mussels spread widely; can describe two ways that zebra mussels spread. | Understands that zebra mussels spread widely and can give one reason why. | Has little understanding of how zebra mussels spread. | Has no understanding of how zebra mussels spread. |
| **Impacts of zebra mussels on other aquatic organisms** | Describes multiple effects on other aquatic organisms and the characteristics of zebra mussels that enable those effects. | Describes one effect on other aquatic organisms and the characteristics of zebra mussels that enable that effect. | Describes one effect on other aquatic organisms but doesn't understand that characteristics of zebra mussels can enable this effect (or vice versa). | Can't accurately describe any effects on other aquatic organisms or characteristics of zebra mussels. | Doesn't describe any effects on other aquatic organisms or characteristics of zebra mussels. |
| **Life cycle and importance of native mussels** | Accurately draws or describes the life cycle of a freshwater mussel, including how its life cycle is connected to fish; explains three reasons why native freshwater mussels are an important part of the aquatic ecosystem. | Accurately draws or describes the life cycle of a freshwater mussel and explains two reasons why native freshwater mussels are an important part of the aquatic ecosystem. | Can define life cycle; knows that freshwater mussels progress through life stages in their life cycle as they mature; can explain one reason that native freshwater mussels are and important parts of the aquatic ecosystem. | Can define life cycle; can explain one reason why native freshwater mussels are an important part of the aquatic ecosystem. | Can't define life cycle and doesn't know why fresh water mussels are important. |

**Score _____ (Calculate score by dividing total points by number of criteria.)**

## Diving Deeper

### Extensions

1. Make an informational poster about a harmful invasive aquatic species (plant or animal) in Minnesota. Examples include purple loosestrife, Eurasian water milfoil, curly leaf pondweed, yellow iris, flowering rush, Eurasian ruffe, round goby, spiny water flea, sea lamprey, rusty crayfish, white perch, and Asian carp. Display the posters throughout the community (at places such as bait shops, boat sales shops, and gas stations) or otherwise share them with people outside of class. See the Minnesota DNR website for information on aquatic invasive species.
2. Invite a local resource person to talk with your class about managing a lake or stream that is infested with a harmful invasive species. An *Aquatic Invasives* learning trunk is available through the Minnesota DNR MinnAqua Program.
3. Check the Minnesota DNR website and the Minnesota Sea Grant website for suggestions on how to help stop the spread of other harmful invasive species such as Eurasian water milfoil and purple loosestrife (plants), and Eurasian ruffe, Asian carp, and round goby (fish).
4. Have students identify other harmful invasive species and discuss how they may have moved from their native areas of the world to North America. Trace their paths to North America on a map. Was the introduction of this species a result of human activity? How did it happen? Was the introduction accidental or intentional? Discuss preventative measures that people should take to slow the spread of these invasive species. Have students design a method to stop the future unintentional introduction of invasive species to Minnesota waters.
5. Have your class write and perform an informational skit about a harmful invasive species and how it impacts native species. Include the preventive measures people should take to stop the spread of these invaders to uninfested Minnesota waters. Title possibilities include *Zeroing in on the Zebra Mussel, Losing Loosestrife, Sending the Sea Lamprey Packing, Flex Your Muscle Against Zebra Mussels, Foiling Eurasian Milfoil,* or *See Ya, Sea Lampreys*. Videotape the skit. Perform the skit, or show the video program of the skit to your local city council.



**For the Small Fry**

## K-2 Option

1. Play the Mussel Mania game. Emphasize how the amount of available food can affect the number of organisms that live in a lake or river, and discuss the impact of a harmful invasive species on an ecosystem.
2. Instead of the Mussel Mania game, have students play the tag game in **Lesson 1:2—Food Chain Tag** to learn the concept that food is a limiting resource for aquatic organisms such as fish.



**STUDENT COPY**

## "Zebra Mussels Crash on Mississippi River" Sheet

August 7, 2003
By **John Weiss**; Reprinted with permission from *The Post-Bulletin*, Rochester, Minnesota

The feared zebra mussel, an invasive species that invaded the Mississippi River and Lake Pepin in this region about a decade ago, crashed nearly two years ago and shows no sign of returning.

The only remaining evidence of the tiny striped mussels on the lake, a large natural reservoir of the river, are piles of fading shells littering the shore.

They are not showing up on boat hulls, on metal debris in the lake, nowhere on the lake or in the river, said John Hoxmeier, Department of Natural Resources large-lake specialist.

In the late 1990s, the DNR would find the mussels attached to any metal object, such as old bait buckets, it pulled up when trawling as part of studies. But this year, none were found, he said. "It took us completely by surprise," he said.

One theory is that the hot weather warmed the water in late 2001 and they were killed off, he said. Another thought is that, like other invading species, their numbers exploded when they entered a new ecosystem. That overtaxed the new environment and the population was killed off. Invasive species often come back, but not in such large numbers as they began with, he said.

*(continued)*

*(continued)*

Zebra mussels exploded in such huge numbers that they would stack up inches thick on native mussels and kill them. Mike Davis, who monitors native mussels for the DNR, said he has noticed a significant reduction in zebra mussels on native mussels.

At the Lake City Marina, boats that were in the harbor but not used for a few months, would often develop engine problems because the zebra mussels would get into water intakes and clog them, said harbormaster Mark Lutjen. They were more of a nuisance than a serious headache, he said.

Helen Coffman, owner of Wabasha Marina in Wabasha, has seen the same thing. They would attach to docks and other hard surfaces. Like Hoxmeier, she has noticed a huge dropoff in their numbers beginning last fall when they took boats out of the water and didn't see the small mussels.

While the death of the zebras has been welcome, Davis said he's not celebrating. "We're not out of the woods yet," he said. If hot weather did kill them, some could have survived and they could recolonize the lake and river, he said.

While the zebra mussels died back in the Mississippi system, they have shown no sign of disappearing from Lake Zumbro, north of Rochester, said Joe Hensel, environmental specialist with Rochester Public Utilities. RPU owns the dam that created the lake on the Zumbro River.

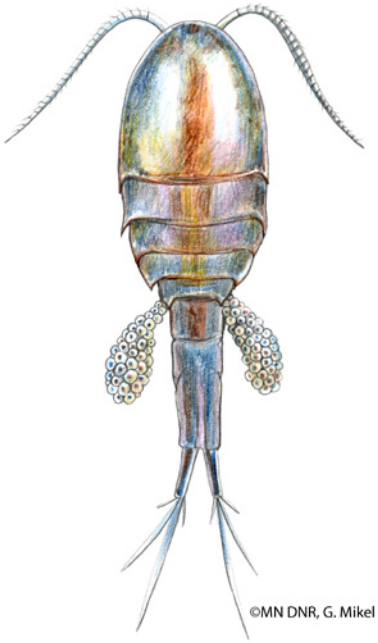
"Lake Zumbro is still loaded," he said.

If the same thing happens on Lake Zumbro as is happening on the Mississippi, "that would be a great turn of events," he said.

**STUDENT COPY**

## Plankton Sheet

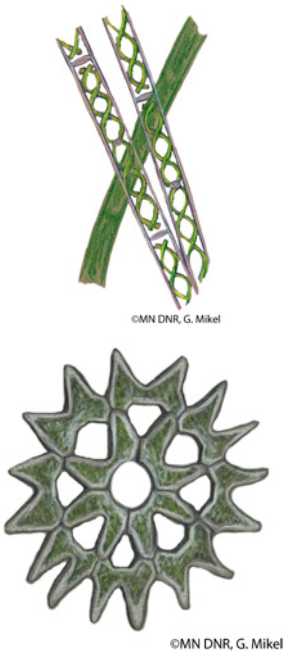
Plankton are tiny organisms. Many float freely (or drift) in the water, and are eaten by mussels and fish.




Cyclops
(Copepod)


Rotifer


Water Flea or Daphnia




Spirogyra and Pediastrum
(Green Algae)


Anabaena
(Blue-Green Algae)


Diatoms

# Mussel Mania Playing Field Set-up