



Zebra and Quagga Mussels

Use the case study, lesson plan, activities, assessment questions, and Aquatic Invader Investigator page to enhance student understanding of zebra and quagga mussels and connect these organisms to the community. Assign assessment questions as a homework assignment, or use the questions for classroom discussions or final evaluation.

LEARNING ACTIVITIES

- **Lesson:** *How Long Can Zebra Mussels Survive Out of Water? A Math Model!*
- **Article:** *Zebra Mussels Make New Rules*
- **Zebra and quagga mussel impact on food webs**
- **Game:** *Web of Life*
- **Research paper suggestions**
- **Assessment questions and answers**

CASE STUDY

Oregon Public Broadcasting coverage of quagga mussels: <http://www.opb.org/television/programs/ofg/segment/quagga-mussels/>

LESSON PLAN

How Long Can Zebra Mussels Survive Out of Water? A Math Model!

LEARNING ACTIVITIES

Article: Zebra Mussels Rule

Read this news article by Peter Kendall, environmental writer for the *Chicago Tribune* (link below). The article describes food chain impacts and provides an example of how to write about and share science with a more general audience.

Zebra and quagga mussel impact on food webs

- 1 Have students draw a diagram of a food web found in the Great Lakes region or in a typical aquatic ecosystem near your school. Each diagram should include energy (sunlight), producers (phytoplank-

ton), and consumers (zooplankton, fish, birds, and humans). Students can also learn about the Great Lakes food web from a website developed by Michigan Technological University (<http://techalive.mtu.edu/meecc/module08/FoodWeb.htm>). Also, the BBC website has a good activity that teaches about food chains (http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/foodchains/).

- 2 Ask students to redraw the food web with zebra mussels present. The main effect of the mussels will be a reduction of phytoplankton and the loss of native bivalves. How is the invaded food web different? Will some organisms benefit? Will some organisms be lost? Why?

Game: Web of Life

Students will demonstrate critical changes in a native river ecosystem, caused by the introduction of zebra mussels. This activity is from the *Zebra Mussel Mania Traveling Trunk*, by Illinois-Indiana Sea Grant, and is available at http://www.iisgcp.org/catalog/downloads_09/web_life_game.pdf

Research paper suggestions

- 1 **Position paper:** Zebra and quagga mussels impact ecosystems primarily by consuming large amounts of phytoplankton, thus clarifying the water. Have students write a position paper that answers this question: *Is water clarification "good" or "bad"?* Each student will address the impact of water clarification from the perspective of one of the players of the food web: phytoplankton, zooplankton, planktivorous fish, carnivorous fish, benthic fish, pelagic fish, native mussels, benthic macroinvertebrates, fish-eating birds, mussel-eating birds, plant-eating birds, humans, etc. Students then share their results in class and have a class discussion about how the impact can be viewed as positive or negative, depending on who/what you are and what your values are.
- 2 **Research project:** Most of our understanding about the impacts of zebra and quagga mussels comes from

Kendall article: http://articles.chicagotribune.com/1996-09-10/news/9609100221_1_zebra-mussels-striped-mollusk-lake-michigan

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research on the Great Lakes, and very little is known about how they would affect a lake in the Pacific Northwest, such as Lake Washington in Washington state. Write a report or research paper answering this question: If the zebra or quagga mussel does invade Lake Washington, what would be the impact? First, students need to gain a good understanding of the zebra mussel's life history, by reading the Zebra and Quagga Mussels species guide. Students can gain familiarity with lentic water (still waters, like the Great Lakes) ecosystems at http://en.wikipedia.org/wiki/Lake_ecosystem. Finally, students should read the article about Lake Washington ecosystems and recent problems (available at: <http://tinyurl.com/AIS-LakeWashington>), and then think about how the presence of zebra mussels will help or hinder Lake Washington's ecosystem. Feel free to substitute an aquatic ecosystem your students are more familiar with for Lake Washington. Students may address the following questions in their paper:

- a Would zebra or quagga mussels be able to survive in Lake Washington?

- b What physical characteristics (temperature, depth, nutrient levels, water quality, calcium levels, etc.) of Lake Washington would affect where zebra mussels could colonize?
 - c What organisms in Lake Washington would be hurt by (or benefit from) the presence of zebra or quagga mussels?
 - d According to the article, what problems are occurring at Lake Washington?
 - e Which of these problems could the zebra mussel help with? Make worse? Have no effect on?
- 3 Pretend you are the director of your state's Department of Fish and Wildlife (or Fish and Game, if you live in California). Your job is to prevent zebra and quagga mussels from entering and/or spreading in the state. How would you do this? List five or six strategies. These strategies can utilize life-history characteristics of the zebra and quagga mussel (which could be weak points that would allow control) and knowledge of its potential vectors. If you were on a limited budget and had to choose just one strategy, which one would you choose and why?

SPECIES GUIDE ASSESSMENT QUESTIONS AND ANSWERS

1 How can you tell the difference between a zebra and quagga mussel?

The zebra mussel is triangular in shape, with one flat edge that allows it to stand on its ventral side without falling over; the quagga mussel is rounder in shape and will topple over if placed on its ventral side.

2 How many different forms do quagga and zebra mussels take throughout their life cycles?

Two: they are larvae as juveniles and bivalve mussels as adults.

3 How were the zebra and quagga mussels introduced to North America?

Ballast water discharge from ships.

4 What characteristics of zebra and quagga mussels make them so good at invading?

Rapid reproduction; byssal threads allow attachment to many surfaces. Also, the mussels can disperse during all life stages. Passive drift of large

numbers of pelagic larval veligers allows invasion downstream. Yearlings are able to detach and drift for short distances. Adults routinely attach to boat hulls and floating objects and are thus anthropogenically transported to new locations. Transporting recreational boats disperse mussels between inland lakes.

5 How do the mussels spread through water?

Passive drift of veligers. Adults get rides on boats, debris, or vegetation.

6 How do the mussels spread over land?

As veligers or adults in water holding tanks on boats and as adults attached to boat hulls.

7 What main life history characteristics of zebra and quagga mussels explain their dramatic impacts on ecosystems?

Enormous but selective filtering capacity, and rapid colonization.

- 8 How have zebra mussels changed the Great Lakes ecosystem? List three ways.**

Answers include increased number of algae blooms, increased water clarity, bioaccumulation, loss of native bivalves.

Do you think these changes are good or bad? Why?

Answer depends on value systems. People usually like clear water, but dislike toxic algae blooms, etc.

- 9 Explain how zebra and quagga mussels' ability to filter large amounts of phytoplankton can affect fish. Will this impact all fish the same?**

Planktonic fish will experience loss of food resources; fish that are visual predators will benefit; fish that can find refuge in the increased number of benthic plants will benefit.

- 10 Why do zebra mussels increase the number of cyanobacteria toxic blooms?**

They are able to selectively avoid filtering cyanobacteria that are toxic. This gives the cyanobacteria an advantage over other algae, making them more likely to experience a population explosion.

- 11 Quagga mussels are replacing zebra mussels in Lake Michigan, and their populations are growing to levels far higher than those of zebra mussels. What are some characteristics of quagga mussels that might explain this?**

The quagga mussel can reproduce at cooler temperatures than the zebra mussel, which means it can reproduce more often and produce more offspring per year than the zebra mussel. Also, the quagga mussel can attach to more substrates and invade more habitats, including the soft, sandy bottom, where the zebra mussel can't attach. It is thought that exploding quagga mussel populations will make a bad problem worse by magnifying the impacts of the zebra. It may also have different impacts, as it can invade new habitats and thus affect different species.

- 12 How do zebra and quagga mussels impact our economy?**

Large costs of cleaning fouled surfaces, and loss of recreational fisheries.

- 13 Explain how the invasion and impact of zebra and quagga mussels provide an example of how human health and economy depend on healthy ecosystems.**

The main examples are bioaccumulation and loss of important fisheries. By filtering at the benthic level, zebra mussels are repolluting the lake and its food webs by accessing sediments that have been buried for decades. Polluted water and fish have a negative effect on human health. Commercially important pelagic fish, such as walleye, can be negatively impacted by zebra and quagga mussels and can have a significant effect on the economy.

- 14 Is it possible to eliminate zebra and quagga mussels once they get established?**

Not without harming other species in the environment.

- 15 What is the main problem with current zebra and quagga mussel control methods?**

Most are only for localized control and have negative impacts on other organisms and water quality.

- 16 Why has the spread of zebra mussels been primarily north-south and not east-west?**

The spread has followed major river drainages such as the Mississippi River, as veligers float downstream and establish in calm backwaters.

- 17 Why haven't quagga mussels invaded rivers?**

While zebra mussels can establish in very slow moving rivers, quagga mussel byssal threads are not strong enough to keep the mussels attached in flowing water.

- 18 How did the zebra and quagga mussel spread west of the Rockies into southwestern states and California?**

By hitching a ride on trailered boats. They could have been attached to the boat hulls as adult mussels, or they may have been transported as larvae in bilge water or other standing water left on the boat.

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- 19 Why is overland transport necessary for dispersal of zebra mussels to the west coast?**

There are no major east-west river systems, due to the Rocky Mountains.

- 20 What is the best strategy for controlling zebra mussels?**

Preventing their spread, and public education.

- 21 Think of some ways your classroom could help prevent the spread of zebra mussels.**

Students could make posters or T-shirts, write letters to public officials, present their research to boaters' clubs, etc.