

# 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

- Like a Mussel out of Water
- "Zebra Mussels Rule"
- Zebra and quagga mussel impact on food webs
- "Web of Life" game
- Research paper suggestions

## CASE STUDY

Oregon Public Broadcasting coverage of quagga mussels:  
[www.opb.org/programs/ofg/episodes/view/1901](http://www.opb.org/programs/ofg/episodes/view/1901)

## LESSON PLAN

Invasive Species Research Symposium

## LEARNING ACTIVITIES

### Like a Mussel out of Water

Students use an online quarantine estimator to determine how long zebra mussels can survive out of water. This activity incorporates geography with climate, biology, and mathematics to help students learn about models. By varying the settings, such as location in country and month of the year, students can observe how the time needed to dry a boat is related to the time of year and the local climate (humidity and temperature). Ask students to answer the questions below as they explore the model. The model is available at <http://100thmeridian.org/emersion.asp>

1. Have students compare the results from the model for a northern and southern location, such as Seattle and San Diego. Repeat the procedure for Maine and

Florida for several months in the year (e.g., May, August, December).

2. Why does it take longer for the mussels to die in Maine than in southern California? (Because Maine is colder and wetter!)
3. Is it likely you will actually have to quarantine your boat for 181 days in Maine? (No. Because conditions are likely to be freezing, boaters can quarantine their boats for as little as three days.)
4. What is the best time of year for zebra mussel survival out of water? Why? (Winter, because it is cold and wet.)
5. Is it likely people will be using their boats in the winter? (No.)
6. Do zebra mussels survive out of water better in low or high relative humidity? Why? (High, because the mussels will dry more slowly at high relative humidity.)
7. Do zebra mussels survive better out of water in cold or warm temperatures? (Cold, because the mussels will dry more slowly at cooler temperatures.)
8. Compare the quarantine time in January to the quarantine time in August for western Oregon. (In January it is 7 days; in August it is 29 days.) Is this due primarily to a change in temperature or a change in relative humidity? (Temperature. The average temperature for January is 40°F; in August it is 70°F, while the relative humidity stays the same, at 100%.)
9. Compare the quarantine time in northern Nevada, near the Oregon border, to the quarantine time in Pennsylvania during the month of July. (In northern Nevada, it is three days; in Pennsylvania it is seven days.) Is this due primarily to a change in temperature or to a change in relative humidity? (Humidity. The average relative humidity in northern Nevada in July is 20 percent and in Pennsylvania it is 100%, while the relative humidity stays the same, at 70°F.)
10. Would you say zebra mussel survival time is more affected by temperature or by humidity? (The two

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examples above suggest that temperature plays a larger role, since changes in temperature have a larger effect on survival time.)

11. You and your family live in San Francisco, California. Every July, the whole family piles into the truck and hauls the boat to Lake Mead, Nevada, for a one-week bass-fishing trip. At the boat dock, a ranger warns you that you will need to thoroughly wash your boat before driving home to San Francisco. You argue that any mussels attached to your boat will die before you get home. Use the quarantine calculator and a travel Web site to determine whether you are correct. (It is a nine-hour drive from Las Vegas to San Francisco, based on Google Maps. The quarantine calculator indicates three to five days of drying is needed to quarantine your boat, so the ranger is right that you must wash your boat or let it dry for at least five days. Be on the safe side: wash and dry.)
12. Repeat the above exercise. This time, you will travel from Seattle, Washington. Is the driving time from Las Vegas to Seattle sufficient for the mussels to die in the month of July, or will additional time be needed? (It takes 18 hours, or 3 days of driving, assuming you drive 6 hours a day, to get from Las Vegas to Seattle. The quarantine calculator indicates 3 to 19 days of drying time are needed to quarantine your boat. As you move north from Las Vegas, the time needed to dry increases. So, again, you should wash the boat before you leave Lake Mead and continue to dry your boat when you get to Seattle before you use it in a local water body. However, considering wind-drying that occurs while you are driving, it is probably safe to use your boat once you arrive as long as you are certain there are no quagga mussels and the boat is thoroughly dry, including live wells and engine compartments.)

### “Zebra Mussels Rule”

Read this news article by Peter Kendall of the Chicago Tribune. (The PDF is available on the resource CD and online at [www.csd509j.net/cvhs/staff/cornelp/APES/Readings/Chapters%2011-13/zebra%20mussels%20rule.pdf](http://www.csd509j.net/cvhs/staff/cornelp/APES/Readings/Chapters%2011-13/zebra%20mussels%20rule.pdf).) The article describes food chain impacts and provides an example of how to write and share science with a more general audience.

### Zebra and quagga mussel impact on food webs

- a. 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 (phytoplankton), and consumers (zooplankton, fish, birds, and humans). Students can also learn about the Great Lakes food web from this Web site developed by Michigan Technological University: <http://techalive.mtu.edu/meec/module08/FoodWeb.htm>. Also, the BBC Web site has a good activity that teaches about food chains. [www.bbc.co.uk/schools/revisewise/science/living/03b\\_act.shtml](http://www.bbc.co.uk/schools/revisewise/science/living/03b_act.shtml)
- b. Ask students to re-draw the food web with zebra mussels present. The main effect of the mussels will be reduction of phytoplankton and loss of native bivalves. How is the invaded food web different? Will some organisms benefit? Will some organisms be lost? Why?

### “Web of Life” game

Students will demonstrate critical changes in a native river ecosystem, caused by the introduction of zebra mussels (activity is from the Zebra Mussel Mania Travelling Trunk, available from: [www.iisgcp.org/edk-12/mania/mania.htm](http://www.iisgcp.org/edk-12/mania/mania.htm)).

### Research paper suggestions

1. Position paper: Zebra and quagga mussels impact ecosystems primarily by consuming large amounts of phytoplankton and 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 research on the Great Lakes; 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 Resource Guide. Students can gain familiarity with lentic water (still waters, like the Great Lakes) ecosystems at [http://en.wikipedia.org/wiki/Lentic\\_System\\_Ecology](http://en.wikipedia.org/wiki/Lentic_System_Ecology). Finally, students should read the attached article about Lake Washington ecosystems and recent problems, and then think about how the presence of zebra mussels will help or hinder Lake Washington's ecosystem. Feel free to substitute for Lake Washington an aquatic ecosystem your students are more familiar with.

Students may address the following questions in their paper:

- i. Would zebra or quagga mussels be able to survive in Lake Washington?
  - ii. What physical characteristics (temperature, depth, nutrient levels, water quality, calcium levels, etc.) of Lake Washington would affect where zebra mussels could colonize?
  - iii. What organisms in Lake Washington would be hurt by (or benefit from) the presence of zebra or quagga mussels?
  - iv. According to the article, what problems are occurring at Lake Washington?
  - v. 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?

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## ASSESSMENT QUESTIONS

(with answers following)

- 1 How could 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.
- 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. Includes 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. 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 re-polluting 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. Economy: commercially important pelagic fish, such as walleye, can be negatively impacted by zebra and quagga mussels.
- 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?** 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.
- 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.



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## WHAT DO YOU KNOW?

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- 5 How do the mussels spread through water?
- 6 How do the mussels spread over land?
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- 8 How have zebra mussels changed the Great Lakes ecosystem? List three ways. Do you think these changes are good or bad? Why?
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