TEACHER LESSON PLAN

Mussel Quarantine Model

Grade
5th–8th grade

Length
One to two class periods

Subjects/strands (skills kids are developing)
use of technology as a tool, modeling, geography, mathematics, ecology, biology

Topics
AIS topics that are highlighted (prevention, pathways, stewardship)
Related to the subject: adaptations, resilience

LEARNING OBJECTIVES

Students will learn the life cycle of the zebra and quagga mussels, their impact on natural systems and the risk of transport through boaters' habits. Students will take the role of a boater to use a model for determining how long to quarantine their boats.

INTRODUCTION

Quagga and Zebra mussels were first introduced into the United States from Eurasia in the 1990s, most likely from ballast water. The pathway of introduction as they spread through freshwater bodies can be linked to boat traffic, fishing gear, and water-conveyance systems. These tiny mussels are ultimate invaders. They

- filter large volumes of water, eliminating plankton from the ecosystem and helping to support algal blooms
- grow rapidly, outcompeting native clams
- have few predators in the United States
- are very resilient—able to survive out of water for 20 days
- reproduce in large numbers
- foul and clog water pipes, treatment systems, and dam infrastructure
- have a planktonic stage that allows them to easily travel in water.

VOCABULARY

Aquatic nuisance species, humidity, lifecycle

BACKGROUND

Materials included: quagga and zebra mussel fact sheets (http://seagrant.oregonstate.edu/sites/default/files/invasive-species/toolkit/zebra-quagga-_mussels.pdf

MATERIALS NEEDED

Internet access, graph paper, *Zebra Quagga Mussel Primer* (http://seagrant.oregonstate.edu/sites/default/files/invasive-species/toolkit/zebra-quagga-_mussels.pdf)

PREPARATION

Understanding of the importance of biodiversity in a healthy ecosystem, the importance of plankton in the food web, understanding of percentage

PROCEDURE

1. Ask students if they have ever caught seeds on their hair or clothing after they have been outside. How do the seeds attach to the student? *Physical structures catch on clothing or hair.* Explain that in the water, microscopic life can attach to boats and equipment. When you take a boat out of the water, many organisms wash off with the water as it streams from the object, but others may remain attached. This is one way a tiny mussel can be spread from one location to another.

2. Have students review the zebra and quagga mussel primer.

3. Review discussion questions as a group.

   a. What are the incredible characteristics of zebra and quagga mussels that allow them to be introduced so easily into new environments? *(They can survive out of the water for over two weeks; can produce over 11 million eggs a year; can eat significant amounts of plankton, reducing biodiversity and competition; can hold on to one another with byssal threads; can colonize soft surfaces; few predators are found in new systems; and they can survive a great range of conditions.)*

b. Why are zebra and quagga mussels classified as an aquatic nuisance species? *(They change the health and dynamics of an environment by filtering massive amounts of plankton; they hold together, changing the substrate and clogging water intake systems, causing significant economic losses.)*

4. Introduce students to the importance of prevention. *(For example, to prevent cavities people brush their teeth; to prevent forest fires, campers make sure their campfire is completely out, to prevent overfishing there are fishing limits, etc.)* All of these examples are less costly to invest in as a prevention strategy than it is to try to correct the problem after the fact.

5. Share with students that researchers have studied the specific conditions that allow mussels to survive on a boat for a length of time and have used those results to create a predictive model to help recommend to boaters how long they need to leave their boat out of the water to ensure they don't spread the mussels from an infested lake or river to one that is not infested.

6. Introduce students to the 100th Meridian site (http://www.100thmeridian.org/). Because zebra and quagga mussel survival is dependent upon weather conditions as well as time out of the water, the 100th Meridian site has developed a model that uses temperature and humidity to predict how long a boat will need to be out of the water to prevent the spread of quagga and zebra mussels.

7. Have students use the 100th Meridian emersion estimator at http://100thmeridian.org/emersion.asp to complete their table. Ask them what patterns they observe as they explore the different states.

8. Using their results, have the students create a line graph showing temperature and humidity by location for each of the three months.

9. Have students share the relationship they observe between temperature and humidity.

CONCLUSION AND EVALUATION

As a class, brainstorm reasons to establish policies to protect habitats. *(For future generations, for biodiversity, for healthy economy, to preserve fishing opportunities, etc.)*

To assess for understanding and application, have the students

1. create a slogan for a T-shirt, advertisement, or billboard that will encourage boaters to clean and quarantine their boats between visits to different water bodies.

OR

2. design a device that could be installed to clean and dry boats as they are pulled out of lakes before they enter another lake, or that help reduce the risk of introduction of quagga and zebra mussels. Students must explain the technology necessary in the design to ensure success.

EXTENSION

1. Have students research whether invasive zebra or quagga mussels exist in their local water body, and if so, what policies are in place to prevent their spread.
2. Interview local boaters to see how they handle their equipment when they haul out their boats. Have students share their knowledge with boaters.

STANDARDS

National and State Education Standards

Science Core Concepts:

LS2.C: Ecosystem Dynamics, Functioning, and Resilience—Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health.

LS4.D: Biodiversity and Humans—Biodiversity is the wide range of existing life forms that have adapted to the variety of conditions on Earth, from terrestrial to marine ecosystems. Changes in biodiversity can influence humans' resources, such as food, energy, and

medicines, as well as services humans rely on—for example, water purification and recycling.

ESS2.D: Weather and Climate—Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can be predicted only probabilistically.

The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

ESS3.A: Natural Resources—Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geological processes.

Mathematics 6.RP.3. Use ratio and rate reasoning to solve real-world and mathematical problems—for example, by reasoning about tables of equivalent ratios, tape diagrams, double-number line diagrams, or equations.

7.RP.2. Recognize and represent proportional relationships between quantities.

Decide whether two quantities are in a proportional relationship—for example, by testing for equivalent ratios in a table or graphing on a coordinate plane and observing whether the graph is a straight line through the origin.

Ocean Literacy Standards (relates to ocean and Great Lakes, and watersheds that lead into them)

- Great Lakes and Ocean Literacy Principle #5: The Great Lakes and ocean support a great diversity of life and ecosystems.
- Great Lakes and Ocean Literacy Principle #6: The Great Lakes, ocean, and humans are inextricably interconnected.
- Great Lakes Literacy Principle #8: The Great Lakes are socially, economically, and environmentally significant to the region, the nation, and the planet.

"Reflecting on Science Practices"

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)

Oregon Department of Education Standards by Design: Fifth, Sixth, Seventh and Eighth Grade for Science:

5.1 Structure and Function: Living and non-living things are composed of related parts that function together to form systems.

5.2 Interaction and Change: Force, energy, matter, and organisms interact within living and non-living systems.

6.4 Engineering Design: Engineering design is a process of identifying needs, defining problems, developing solutions, and evaluating proposed solutions.

7.1 Structure and Function: Living and non-living systems are composed of components which affect the characteristics and properties of the system.

7.2 Interaction and Change: The components and processes within a system interact.

7.4 Engineering Design: Engineering design is a process of identifying needs, defining problems, identifying constraints, developing solutions, and evaluating proposed solutions.

8.2 Interaction and Change: Systems interact with other systems.

8.4 Engineering Design: Engineering design is a process of identifying needs, defining problems, identifying design criteria and constraints, developing solutions, and evaluating proposed solutions.

LIKE A MUSSEL OUT OF WATER

Use an online quarantine estimator to determine how long zebra mussels can survive out of water. This model helps to predict how long a boat would need to be out of the water to ensure zebra and quagga mussels are not spread to new bodies of water. By varying the settings, such as location in country and month of the year, you can observe how the time needed to dry a boat is related to the time of year and the local weather (humidity and temperature). Answer the questions below as you 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 181 days in Maine in the winter?** No, because conditions are likely to be freezing, boaters can quarantine their boats for only 3 days.

4 **What is the best time of year for zebra mussel survival out of water? Why?** Winter, because it is cold and wet.

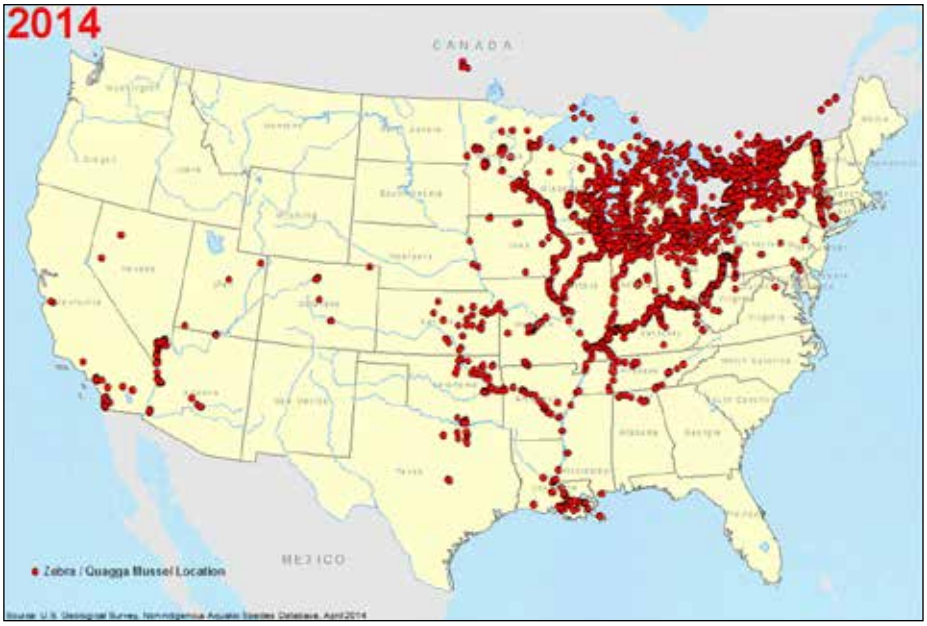
5 **Is it likely people will be using their boats in the winter?** No.

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, and in August it is 29 days. **Is this primarily due to a change in temperature or a change in relative humidity?** Temperature. 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 3 days, and in Pennsylvania it is 7 days. **Is this primarily due to a change in temperature or a change in relative humidity?** Humidity. The average relative humidity in northern Nevada in July is 20 percent, and in Pennsylvania it is 100 percent, while the relative temperature is the same at 70°F.



Zebra and quagga mussels are spreading rapidly across the United States. Only recently (in 2007) were they discovered on the west coast. The quarantine calculator used in this activity will help students learn about modeling while they help prevent the spread by determining how long to dry a boat before launching.

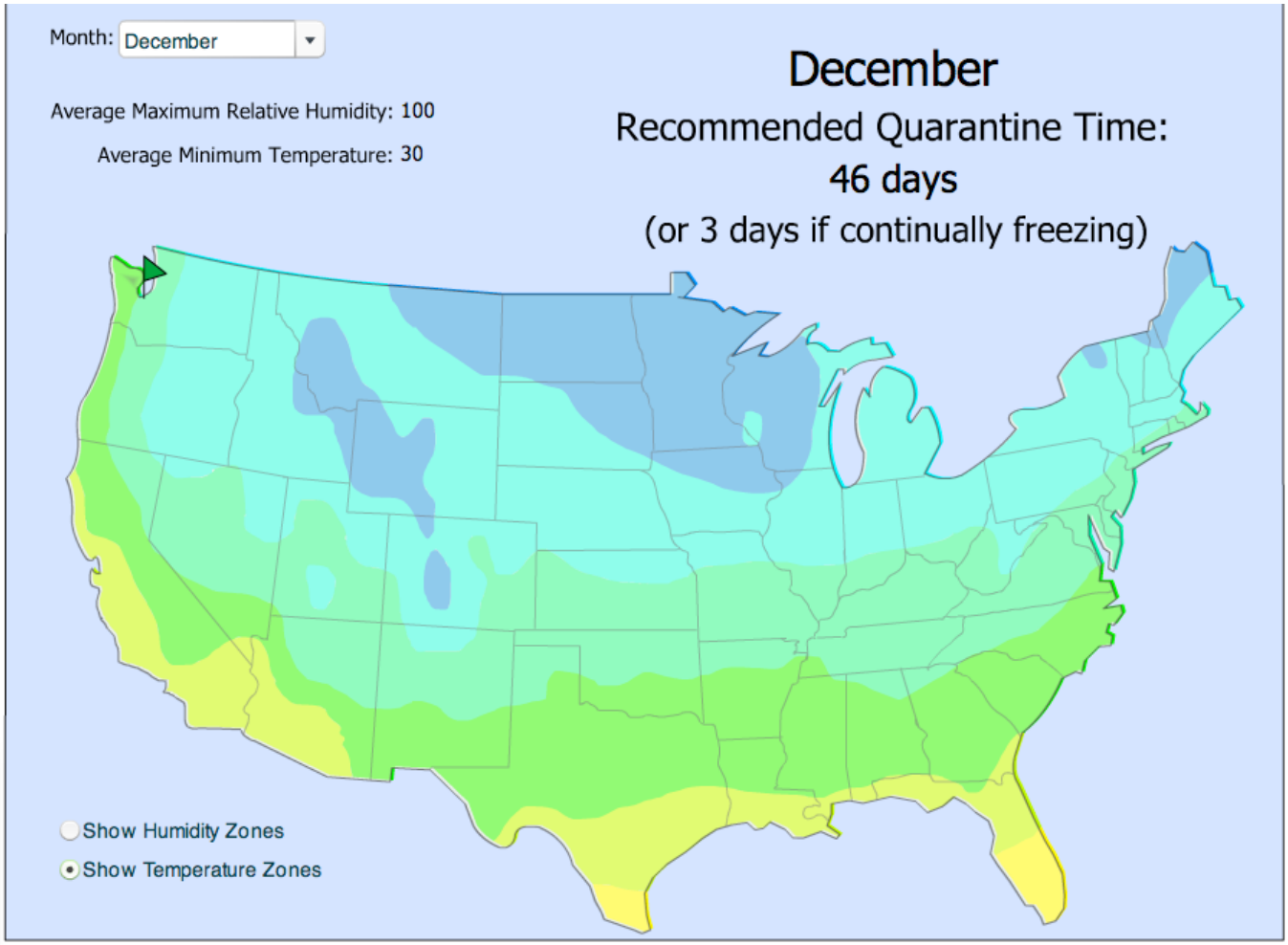
10 **Would you say zebra mussel survival time is affected more by temperature or humidity?** The two examples above suggest that temperature plays a larger role, since changes in temperature have a larger effect on survival time.

11 **Imagine that 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. Your friends say that any mussels attached to your boat will die before you get home. Use the quarantine calculator and a travel website to determine which recommendation is correct.** It is a 9-hour drive from Las Vegas to San Francisco, based on Google Maps. The quarantine calculator indicates 3 to 5 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 5 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 is 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.

Name_____Date_____

The on-line quarantine estimator allows you to determine how long a zebra mussel will survive out of water. The map output below shows that in December in Seattle, a zebra mussel would survive for **46 days** out of water!



Note: both layers (temperature and humidity) are used in the estimation regardless of which one is currently showing.

Recommendations are based on U.S. Army Corps of Engineers Contract Report EL-93-1, June 1993, "Use of Emersion as a Zebra Mussel Control Method" by Robert F. McMahon, Thomas A. Ussery, and Michael Clarke, The University of Texas at Arlington.

LIKE A MUSSEL OUT OF WATER

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Location	Month	Temperature	Humidity	Days of Quarantine
Seattle	May			
Seattle	August			
Seattle	December			
San Diego	May			
San Diego	August			
San Diego	December			
Maine	May			
Maine	August			
Maine	December			
Florida	May			
Florida	August			
Florida	December			

1 How would you describe the variation in results from the model for northern and southern locations such as Seattle and San Diego? How about Maine and Florida?

2 Why does it take longer for the mussels to die in Maine than in southern California?

3 Is it likely you will actually have to quarantine your boat 181 days in Maine in the winter?

4 What is the best time of year for zebra mussel survival out of water? Why?

5 Is it likely people will be using their boats in the winter?

6 Do zebra mussels survive better out of water in low or high relative humidity? Why?

7 Do zebra mussels survive better out of water in cold or warm temperatures?

8 Compare the quarantine time in January to the quarantine time in August for western Oregon. Is this difference primarily due to a change in temperature or a change in relative humidity?

9 Compare the quarantine time in northern Nevada, near the Oregon border, to the quarantine time in Pennsylvania during the month of July. Is this primarily due to a change in temperature or a change in relative humidity?

10 Would you say zebra mussel survival time is more affected by temperature or humidity?

11 Pretend that you and your family live in San Francisco, California, and 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. Friends told you that any mussels attached to your boat will die before you get home. Use the quarantine calculator and a travel website to determine which recommendation is correct.

12 Repeat the above exercise, traveling from Seattle, Washington, to Las Vegas. 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?