TEACHER LESSON PLAN

How long can zebra mussels survive out of water? A math model!

Grade	Length	Subjects/strands	Topics
5th–8th grade	one to two class periods	Use of technology as a tool, modeling, geography, ecology, mathematics, biology	Trophic levels, food webs, natural selection, group problem solving

LEARNING OBJECTIVES

Students will learn the life cycle of 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 as a model for determining how long to quarantine their boats.

INTRODUCTION

Globalization has provided much greater access for the introduction of invasive species. Once invasives are introduced, unchecked recreational use of the waterways allows them to spread throughout North America. Some species are especially difficult to prevent from spreading, due to the microscopic planktonic stage of their lifecycle and their resilience under challenging circumstances. Scientists and water managers have developed procedures to limit the risk of invasion while still allowing access to infested waterbodies. This activity allows students to problem solve and use tools that help prevent the spread of quagga and zebra mussels.

MATERIALS NEEDED

Computer with Internet access, graph paper, Zebra and Quagga Mussels species guide.

VOCABULARY

Aquatic nuisance species, benthification, biodiversity, byssal threads, emersion, humidity, lifecycle, predictive model, quarantine, veliger

BACKGROUND

Zebra and quagga mussels were first introduced into the United States from Eurasia in the 1990s, most likely from ballast water from ships. 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 and able to survive out of water for 30 days;
- reproduce in large numbers;
- foul and clog water pipes, treatment systems, and dam infrastructure; and
- have a planktonic stage that allows them to easily travel in water.

Additional details are listed in the Zebra and Quagga Mussels species guide.

PREPARATION

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

PROCEDURE

1 **Ask students if they have ever found seeds on their hair or clothing after they have been outside. How do the seeds attach to the student?**

Some seeds are designed to catch on things.

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 Mussels* species guide.**

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 up to 30 days; can produce millions of eggs in a spawning season; 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?**

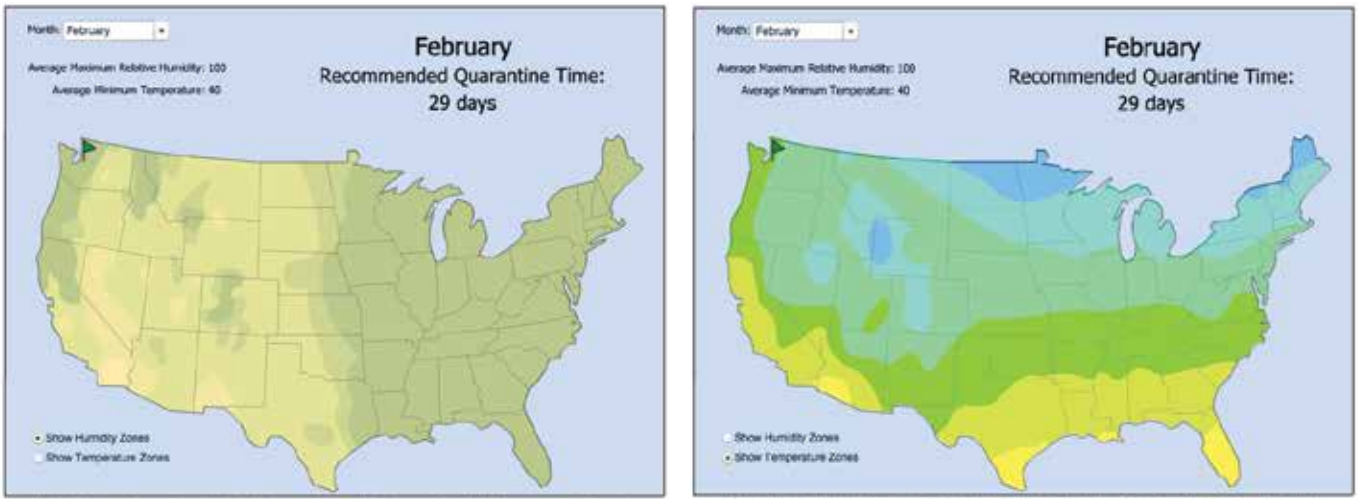
They change the health and dynamics of an environment by filtering massive amounts of plankton; they hold together, changing the substrate and clogging water intake systems, causing significant economic losses.

4 **Introduce students to the importance of prevention.**

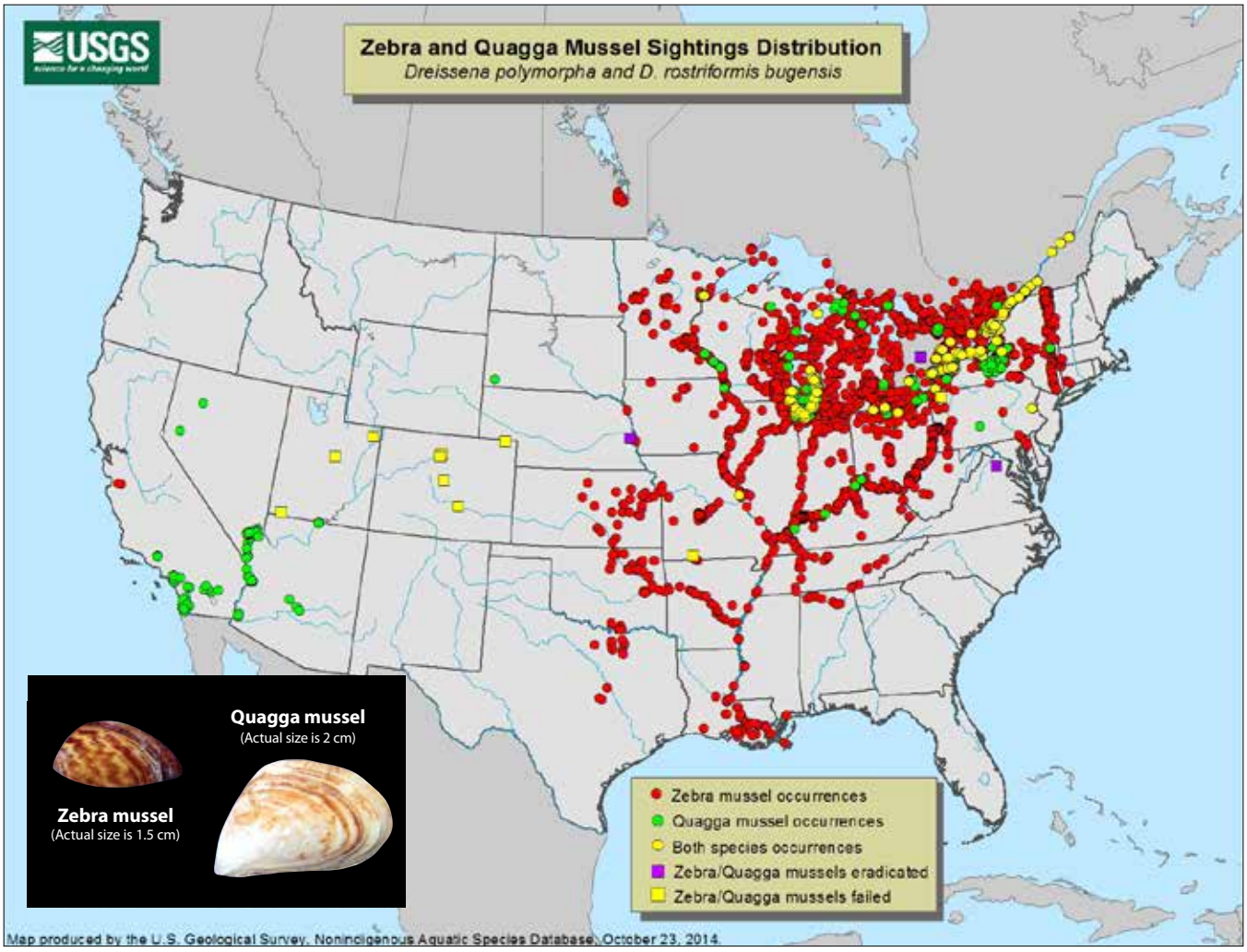
For example, to prevent cavities, people brush their teeth; to prevent forest fires, campers make sure their campfire is completely out; to prevent overfishing, there are fishing limits, etc.

All of these examples represent a smaller investment than trying 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 they have used those results to create a predictive model. This model forms the basis for recommendtions to boaters as to how long they should leave their boat out of water to minimize the risk of spreading mussels from an infested lake or river to one that is not infested.**



Screenshots from the 100th Meridian website (http://100thmeridian.org/emersion.asp) showing recommended drying time in the Seattle area for zebra/quagga mussel–contaminated boats. Note that both humidity and temperature are taken into account when making these estimates. To change location, click on desired area to move flag.



Zebra and quagga mussels are spreading rapidly across the United States. Only recently (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. Map produced by the U.S. Geological Survey, Nonindigenous Aquatic Species Database, October 23, 2014.

6 **Introduce students to the 100th Meridian site. Because zebra and quagga mussel survival is dependent upon weather conditions as well as time out of the water, 100th Meridian 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. By varying the settings, such as location in the country (click on desired location to move flag) and month of the year, students can observe how the time needed to dry a boat is related to the local weather (temperature and humidity). Have students answer the questions below as they explore the model.**

7 **Pass out the student pages and ask students to complete the table and questions.**

8 **Have students use the 100th Meridian emersion estimator at: http://100thmeridian.org/emersion.asp to complete their table and explore the relationship between temperature, humidity, and survival time. Ask them what patterns they observe as they explore the different states.**

9 **Using their results, have the students create a line graph for each location that shows temperature and humidity by location for each of the three months.**

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

LESSON QUESTIONS AND ANSWERS

1 **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.**

For example, May, August, and 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 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 29 days, and in August it is seven days.

Is this primarily due to a change in temperature or a change in relative humidity?

Temperature. Average temperature for January is 40 degrees F (4.5 degrees C); in August it is 70 degrees F (21 degrees C), while the relative humidity stays the same, at 100 percent.

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, and in Pennsylvania it is seven 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 degrees F (21 degrees C).

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 near Las Vegas, 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 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 exercise. This time, you will travel from Lake Mead to 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 three days of driving, assuming you drive six hours a day, to get from Las Vegas to Seattle. The quarantine calculator indicates three 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.

EXTENSION AND COMMUNITY STEWARDSHIP

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.**

CONCLUSIONS AND EVALUATION

1 **As a class, brainstorm reasons to establish policies to protect habitats.**

For future generations, for biodiversity, for healthy economy, to preserve fishing opportunities, etc.

2 **To assess for understanding and application, have the students**

- a **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.**
- b **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 introducing zebra and quagga mussels. Students must explain the technology necessary in the design to ensure success.**

STANDARDS

Common Core

Reading for Informational Text:
- Key Ideas and Details: 5.1-3, 6.1-3, 7.1, 8.1
- Craft and Structure: 5.4, 6.4, 7.4, 8.4
- Integration of Knowledge and Ideas: 5.7, 6.7

Writing:
- Research to Build and Present Knowledge: 5.7, 6.7, 7.7, 8.7* (extension activity)

Speaking and Listening:
- Comprehension and Collaboration: 5.1, 5.2, 6.1, 6.2, 7.1, 7.2, 8.1
- Presentation of Knowledge and Ideas: 5.4, 6.4, 7.4, 8.4

Mathematics:
- 6.RP.3, 7.RP2

Next Generation Science Standards:

Ecosystems: Interactions, Energy, & Dynamics:
- 5-LS2-1, MS-LS2-4, MS-LS2-5

Earth's Systems:
- MS-ESS2-5

Earth and Human Activity:
- 5-ESS3-1, MS-ESS3-3, MS-ESS3-4

Engineering Design:
- 3-5-ETS1-1, MS-ETS1-1