CHAPTER

4

Zebra Mussels

Imagine you took a fish from the Amazon River in South America. If you let it go in the Hudson River, it would die because the Hudson is too cold. But what if you took a fish from another cold river in North America, like the Colorado River, and let it go in the Hudson. Could the fish survive? What would the fish need in its new environment in order to survive? How might the fish affect the other animals in its new environment?

In this chapter you will learn what happens when an organism that is native to one ecosystem is introduced to another ecosystem. You will analyze and interpret data as you investigate how ecosystems change when new organisms are introduced. You will develop explanations and construct arguments supported by evidence about how the introduction of new organisms affects ecosystems.

Engage: Introducing a New Species

There are many different ecosystems in the world. You have already learned about several, including the Gulf of Mexico. You have also learned about some of the challenges faced by ecosystems. One challenge is the introduction of new species to an ecosystem. If a new species survives and its population increases, it can disrupt the ecosystem. This can affect the health of the ecosystem. In this activity you will learn about the zebra mussel, a species that has been introduced to the ecosystems of the Great Lakes and the Hudson River. You will predict what effect the zebra mussel might have on the health of these ecosystems.

Guiding Question

How might the introduction of the zebra mussel affect the health of the Great Lakes and Hudson River ecosystems?

Materials

For each student:

- Handout 4.1-1, "Ecosystems Comparison"

Process & Procedure

Comparing Ecosystems

1. With your class, review what you already know about the Gulf of Mexico, Great Lakes, and Hudson River.
2. Watch the video clip, "The Problem."
3. Use the Read, Think, and Take Note strategy as you complete the following reading.

Read, Think, and Take Note: Guidelines

As you read, stop at least three times to write one of the following:

- Explain a thought or reaction to something you read.
- Note something in the reading that is confusing or unfamiliar.
- Identify a word that you do not know.
- Ask a question about the reading.
- Draw a diagram or picture of an idea.

4. As a group, based on the reading and the information your class has discussed, fill in as much as you can of Handout 4.1-1, "Ecosystems Comparison."
5. With your group, discuss what you still want to know about these ecosystems. In your science notebook, write down four of your group's questions.

An Unwelcome Newcomer

Invasion of the Zebra Mussels

The zebra mussel is a small freshwater animal with two shells like a clam. It is named for its striped shell. This tiny creature may look harmless, but it can cause big problems. The zebra mussel is not native to North America but arrived in this part of the world about thirty years ago.

The Great Lakes System includes Lakes Superior, Michigan, Huron, Erie, Ontario, and the smaller Lake St. Clair.

Zebra mussels cling to any hard surface—including native mussels and other animals with shells. This can cause these animals to die because they can't eat. Zebra mussels are filter feeders. They pump water through their gills and strain out microscopic animals and plants called plankton. Zebra mussels can quickly clear the plankton from huge bodies of water, leaving little food for the native mussels and other animals.

Zebra mussels can also cause millions of dollars in damage. The mussels clog water pipes to businesses and power plants. They damage boats, docks, and other structures.

The Great Lakes Invasion

The Great Lakes are a system of connected freshwater lakes and waterways in northeastern North America, between Canada and the United States. It is the largest group of freshwater lakes on Earth, and holds about 20% of the world's fresh water. In many places, if you stand on the shore of one of the Great Lakes you cannot see to the other side. Zebra mussels were first discovered in a small lake in the Great Lakes system, Lake St. Clair, in 1988. Scientists believe the mussel was introduced by one of the large ships that travel across the Atlantic Ocean carrying cargo between countries. Soon scientists were finding zebra mussels in other areas of the Great Lakes systems

and rivers connected to the Great Lakes, such as the Mississippi and Ohio Rivers. Even today, scientists continue to find new zebra mussel invasions in ecosystems as far away from the Great Lakes as Texas and California.


Zebra mussels

How do these mussels spread so quickly? A single female can produce up to one million eggs each year. The young mussels float along water currents and eventually attach themselves to hard surfaces like rocks on the riverbeds and the bottom of boats. They form dense colonies, with as many as 10,000 mussels in a single square foot.

The Hudson River Invasion

The Hudson River flows south through New York State, from the mountains to New York City. Because the river is connected to the Great Lakes, scientists predicted it would not be long before the zebra mussel would arrive in the Hudson.

The Hudson River's ecosystem is very different from the Great Lakes. Lake water settles into layers, with cool water near the bottom and warm, clear water above. In the Hudson River water flows from the mountains to the Atlantic Ocean. The last 150 miles of the Hudson River is significantly affected by water from the Atlantic Ocean. The salt water from the ocean mixes with fresh water from the river. The tides from the ocean mix the water from top to bottom. This area of mixed salt and fresh water is called an **estuary**. In the estuary, tides also stir up material from the riverbed, making the water cloudy. Little sunlight can pass through the water. Less sunlight means fewer plants and phytoplankton.

Scientists wondered how zebra mussels might affect the ecosystems of the Great Lakes and the Hudson River. They also wondered if different biotic and abiotic factors in the ecosystems might lead to different effects from the zebra mussels. Soon they would find out.

Analysis

1. Think about the differences and similarities between abiotic and biotic factors in the Hudson River, the Great Lakes, and the Gulf of Mexico. Do you think the zebra mussels will spread to the Gulf of Mexico? Explain why or why not.

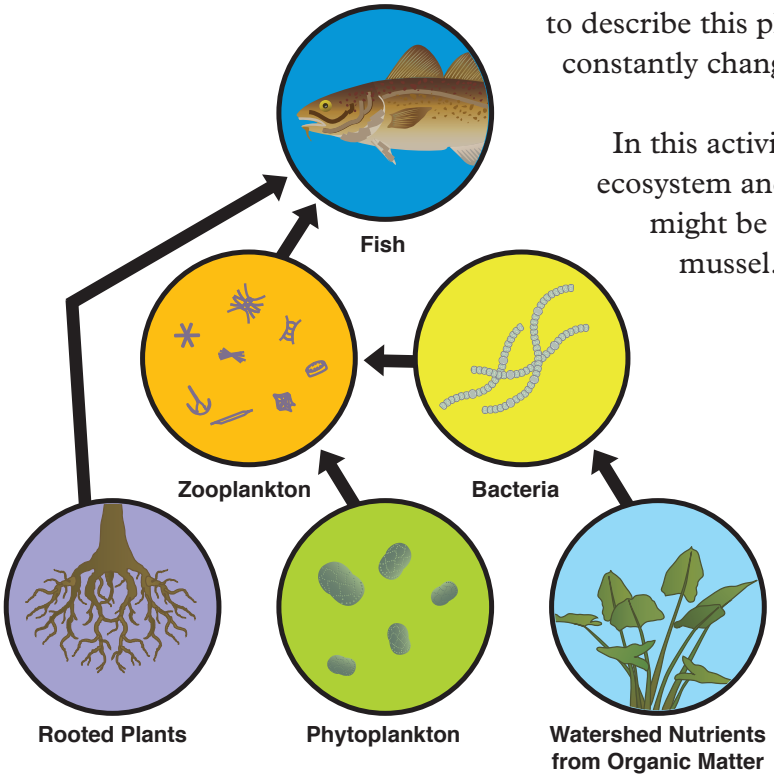
2. How do you think the zebra mussel will change the Hudson River ecosystem?

3. Suppose a group of scientists wants to monitor the effect of zebra mussels on an ecosystem. What data about the ecosystems might scientists collect to investigate this question?

Explore: Hudson River Ecosystem

When scientists realized that zebra mussels were likely to show up in the Hudson River, they were in a unique position to investigate the impact of the invasion. Scientists don't usually have data about a lake or river until after the new species appear. However, scientists began collecting data on the Hudson River's ecosystem in 1986. They started studying the whole Hudson River ecosystem to see how was changing. Ecosystems are constantly changing for many reasons. You have learned that ecosystems have many interactions between living organisms and between biotic and abiotic factors. These interactions can cause an ecosystem to change. Natural and human-caused disturbances can also cause changes in ecosystems. Scientists use the phrase **dynamic ecosystem** to describe this phenomenon because dynamic means constantly changing.

In this activity, you will explore the Hudson River ecosystem and predict how this dynamic ecosystem might be affected by the introduction of the zebra mussel.



Guiding Question

What biotic and abiotic factors are affected when a new species is introduced to an ecosystem?

Materials

For each pair of students:

- 1 set of 9 Hudson River Ecosystem cards
- 1 additional Hudson River Ecosystem card: Zebra Mussel

Process & Procedure

Exploring a Dynamic Ecosystem

1. Work with your group to examine the 9 Hudson River Ecosystem cards in your set.
2. Work with your group to create a food web using all of the cards in your set.
3. Record your food web in your science notebook. Use a full page of paper to draw your food web. Leave space around the name of each organism so that you have room to draw in arrows. Then draw in arrows from the eaten organism to the animal that eats it.
4. Discuss with your group the patterns of interaction among the organisms in your food web:
   - Which organisms play a similar role in the food web? Describe these roles.
   - What changes might occur in this dynamic ecosystem based on the patterns of interaction among the organisms?
   - What do you predict would happen to the food web if a new organism that consumes plankton was introduced?
5. Your teacher will give you another Hudson River Ecosystem card: Zebra Mussel.
6. Add the zebra mussel to your food web.
7. Discuss with your group how the introduction of this species might affect your food web.
8. With your class, watch the video clip, "Observation."
9. With your partner, review the abiotic factors in the table below. Choose one abiotic factor you think might be affected by the zebra mussels that you would like to investigate further.

Abiotic Factors

Water Temperature: Temperature affects an organism's metabolism—the internal chemical reactions that affect its health and growth.

Dissolved Oxygen: Oxygen dissolves in water. Both producers and consumers (like zebra mussels) take up oxygen during respiration. Producers also give off oxygen.

Water Clarity: Scientists use a Secchi disk to measure how clear water is. The disk is lowered into the water until the pattern on its surface can no longer be seen. The clearer the water, the deeper the pattern can be seen.

Suspended Solids: The solid particles suspended in water affect its clarity and quality. These particles can be both biotic (like phytoplankton) and abiotic (like silt and clay). Zebra mussels consume huge amounts of biotic suspended solids, clearing large bodies of water.

10. With your partner, choose two organisms (biotic factors) from your food web that you think might be affected by the zebra mussels that you would like to investigate further. Have your teacher approve your choice of factors.

11. Following your teacher's directions, develop a testable question and a prediction for how each factor you selected will change after the zebra mussels' arrival in the river. Write down why you chose these factors and your prediction for each factor.

Analysis

1. Explain how the Hudson River is an example of a dynamic ecosystem. Use observations from the activity to support your answer.

2. How do you predict the introduction of the zebra mussel will affect each of the following in the Hudson River ecosystem:

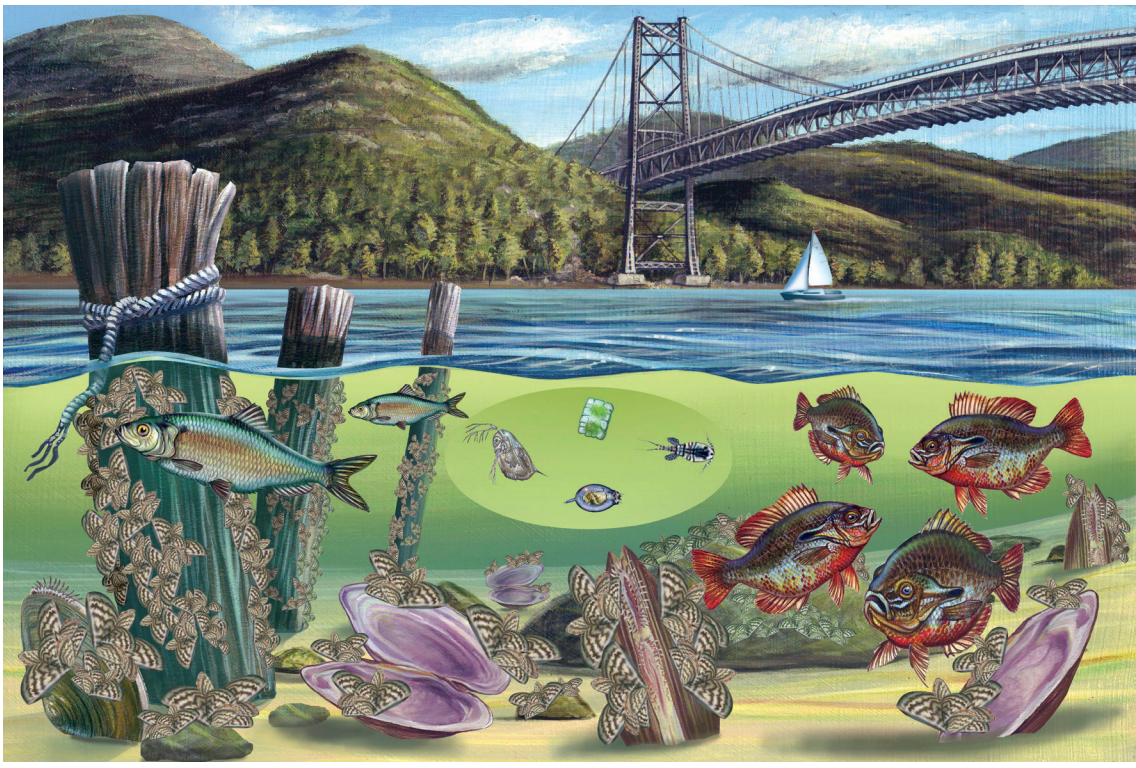
a. the flow of energy.

b. the location and cycling of matter.

Explain: Changing Ecosystems

In May 1991, a few years after they were first found in the Great Lakes, zebra mussels appeared in the Hudson River. Within a year scientists estimated the zebra mussel population had reached 500 billion! If you had a huge balance and put zebra mussels on one side, they would outweigh all the other consumers in the ecosystem combined: all the fish, zooplankton, worms, shellfish, and bacteria. Scientists wondered how the zebra mussels would affect the river ecosystem.

One measurement scientists use to monitor ecosystem health is the biodiversity in the ecosystem. **Biodiversity** is the diversity of life at every level, including variation within a species, variation between species, and variation between populations of species. For example, if an area has many healthy populations of a range of organisms scientists say it has more biodiversity than a region with a smaller number of healthy populations of organisms. The biodiversity of an ecosystem is affected by biotic and abiotic factors. Over time, the biodiversity of a particular ecosystem may change depending on the health of the ecosystem.



To measure the biodiversity of the Hudson River ecosystem scientists count the number of different species and how large their populations are.

In the previous activity, you chose three factors to investigate further. In this activity you will compare data for those factors collected by scientists in the years before and after the arrival of the zebra mussel. From the data and a reading you will learn more about how the ecosystem health and biodiversity of the Hudson River in the first eight years after its arrival.

Guiding Question

How did the zebra mussel initially affect the health and biodiversity of the Hudson River ecosystem?

Materials

For each pair of students:

- computer with Internet access

For each student:

- Handout 4.1-1, "Ecosystems Comparison" (from Activity 4.1)

Process & Procedure

Investigating Zebra Mussel Impact

1. With your partner, review the testable questions and predictions you developed for your three chosen factors from the previous activity.
2. With your partner, go to the "Overview" page of the "Graph the Data" section of the River Ecology website:
   http://www.amnh.org/education/hudsonriver
3. You will examine data from the Kingston location. Select "Over Time" and use the map to choose the Kingston location.

4. Set the first parameter to "Zebra mussel" and set the second parameter to one of the factors that you chose in the previous activity. Use the table below to determine which parameter matches with the factors you chose.

Factor	Graph Parameter
Alosa: Fish	Alosa (pelagic fish)
Bacteria	Bacterial abundance
Centrarchidae: Fish	Centrarchidae (littoral fish)
Cladocera: Zooplankton	Cladocera
Copepods: Zooplankton	Copepods
Dissolved Oxygen	Dissolved oxygen
Phytoplankton	Chlorophyll a
Rotifers: Zooplankton	Rotifers
Sphaeriidae: Freshwater Mollusks	Sphaeriidae
Suspended Solids	Total suspended solids
Unionidae: Freshwater Mollusks	Unionidae
Water Clarity	Secchi depth
Water Temperature	Temperature

5. Examine the section of the graph from 1988 to 1996. Look for any patterns and record your observations.
6. Repeat Procedure Steps 4 and 5 for each of the other two factors you chose.
7. With your class, watch the video segment "Results."
8. Return to your Handout 4.1-1, "Ecosystems Comparison," from Activity 4.1 and add any new information you have learned.
9. Complete the reading on the next page, following your teacher's instructions to answer the "Stop to Think" questions.

Zebra Mussels Invade

What Makes a Good Invader?

There are many characteristics of the zebra mussel that help them thrive in North American lakes and rivers. Zebra mussels can reproduce when they are less than a year old. Just one female can lay up to 1 million eggs every year. Zebra mussels will eat most types of plankton and will attach to nearly any hard surface. They can grow in water as cold as 3°C and as warm as 30°C.

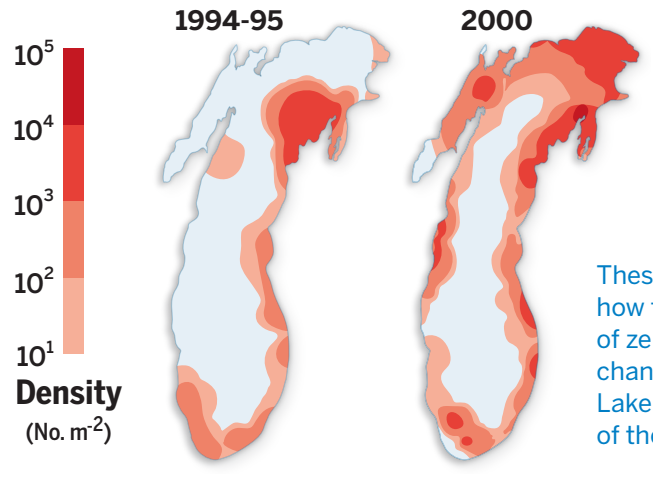
Zebra mussels are sensitive to several abiotic factors, which limit their spread. They can only live in fresh water or water that has very little salt (less than 0.4%). They cannot survive in water with low oxygen levels. They also are not found in water that moves faster than about two meters per second, so you won't find them in fast-moving streams or rivers. They will only reproduce if the water is 14-16°C or warmer.

Stop to Think

What characteristics of zebra mussels make them likely to live in a variety of river ecosystems?

In the Hudson River and Great Lakes, the conditions for a zebra mussel invasion were just right. There were lots of plankton for the zebra mussels to eat, many hard surfaces for the mussels to attach to, and in spring and summer the temperatures were just right for zebra mussels to reproduce. This means that once the zebra mussels were introduced, it was easy for them to spread out.

Lake Michigan Zebra Mussel Density



These maps show how the distribution of zebra mussels changed over time in Lake Michigan, one of the Great Lakes.

Stop to Think

What do the patterns in the data on the map tell you about the density of zebra mussels in Lake Michigan between 1994-95 and 2000?

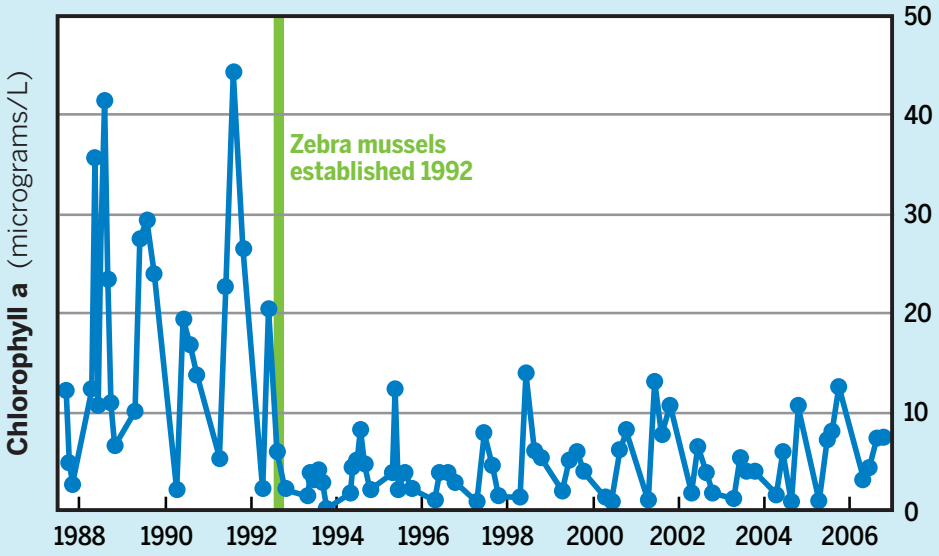
Changes Caused by Zebra Mussels

By 1992, there were so many zebra mussels in the Hudson River that scientists estimate they were filtering a volume of water equal to all of the water in the estuary every 1-4 days during the summer. In the years right after their arrival, phytoplankton fell by 80-90 percent. Zooplankton (which eat phytoplankton) declined by half.

The plankton populations in the Great Lakes also dropped dramatically. Some research showed the zebra mussels were rejecting certain types of harmful blue-green algae as food. This meant the blue-green algae population increased, while other plankton decreased, causing changes in the biodiversity and the food availability for other filter feeders.

Hudson River Chlorophyll Levels Over Time

(Sampled from Kingston, NY)



In both locations the populations of native mussels, also filter feeders, shrank dramatically. Native mussels could not compete with the zebra mussels, and their populations dropped as the plankton populations dropped. In the Hudson, native mussel populations fell from more than one billion to almost none. Many fish species also eat plankton. With the decline in plankton populations, there were fewer—and smaller—fish in the open river as well as the open lakes. The biodiversity of the Hudson was changing.

Stop to Think

Why did the introduction of one species, the zebra mussel, cause changes to so many of the other populations in the Great Lakes and Hudson River?

But some populations in the Hudson River increased—likely due to the change in the river's water clarity. With far less phytoplankton, the water got clearer. During the summer, visibility went from 3-4 to 4-8 feet from the surface. Since sunlight reached deeper into the water, rooted aquatic plants increased by up to 40 percent. Populations of fish living in these shallow weeds increased, and they were also found further upriver than before the invasion. Another surprising result was that dissolved oxygen in the river fell by about 15 percent. Scientists think the enormous zebra mussel populations were consuming a lot of oxygen very quickly. At the same time, the mussels were removing the phytoplankton that produce oxygen.

In the Great Lakes, most of the species that increased after the zebra mussel invasion were considered "nuisance" or even harmful species, like the blue-green algae. The zebra mussel increase also seemed to cause an increase in the bacteria that produces botulism toxin, and more than 52,000 waterbird deaths due to botulism toxin occurred between 2002 and 2006.

Stop to Think

What are some of the biotic and abiotic factors that were affected by the zebra mussels in the Great Lakes and Hudson River?

Effect on Ecosystem Services

The organisms living in the Hudson River and the Great Lakes are not the only organisms depending on those ecosystems. Humans depend on, and benefit from, these two ecosystems in many ways. When humans benefit from an ecosystem, scientists call these benefits ecosystem services. For example, a lake might provide people with drinking water, fish to eat, and a place to go sailing and relax. All of these benefits are **ecosystem services**. When scientists study the effect of a non-native species, like the zebra mussel, they study how it affects the ecosystem in all ways, including how it affects ecosystem services.

In both the Great Lakes and the Hudson River, the zebra mussels have affected many ecosystem services. One effect has been on power plants and water treatment facilities built on the shores of large lakes and rivers. These facilities have large pipes to take in and release water. The zebra mussels attach to the pipes and other equipment. The number of mussels that attach to the pipes is so great that the pipes become clogged, causing large increases in maintenance and repair costs. Another effect is that the blue-green algae that increased

after the zebra mussel invasion releases harmful toxins into the water in the Great Lakes, causing beaches to be closed and preventing people from going swimming. Also, several fisheries, including the Lake Whitefish, have declined dramatically due to the zebra mussel invasion, causing people to lose income and jobs. However, some fisheries on the Hudson River that rely on littoral fish have increased.

The Hudson River provides many ecosystem services to the nearby communities, including a place for recreation.

Stop to Think

Why might people be concerned about the effects of zebra mussels on ecosystem services?

Questions about the long-term impact

Once scientists had a clear picture of the invasion's immediate impact, they started to wonder about long-term effects the zebra mussels might cause in these two ecosystems. Would the systems continue to change, or would they recover? Would native species eventually tolerate or even feed on the zebra mussel? Perhaps another species might arrive that would change the effects of the invasion? Should people try to control the zebra mussel invasion or see if the ecosystem would eventually stabilize? Only continued studies would allow scientists to determine how the zebra mussel might change these ecosystems in the long term.

10. With your group, update the information on Handout 4.1-1, "Ecosystems Comparison."

11. Follow your teacher's directions to debate the question "Has the zebra mussel had a positive or negative effect on the Hudson river ecosystem?" Use words from the class word wall to help you form your discussions during the debate.

Analysis

1. For each factor you examined, do the data show stability or change in the Hudson River ecosystem? Explain your answers.

2. In Activity 4.2, Hudson River Ecosystem, you made predictions about how each of the three factors would be affected by the introduction of the zebra mussels. Describe whether the data supported your predictions.

3. Your observations covered data that spanned from a few years before to a few years after the zebra mussels arrived in the Hudson River. Predict what the data might show about the biodiversity and health of the Hudson River ecosystem 20 years or more after the introduction of the zebra mussels. Explain the reasons for your prediction.

4. An invasive species is a species that is brought from its native area to a new place where it causes harm to the environment, the economy, or human health. Scientists consider the zebra mussel an invasive species in North America. What evidence supports this?

Elaborate: The Zebra Mussel Problem: 20 Years of Data

Ecosystems are dynamic places that can change over time. The introduction of zebra mussels changed the Great Lakes and Hudson River ecosystems by altering their food webs. Over time, further changes occurred in both ecosystems. Sometimes an ecosystem can recover from a change and return to a stable state similar to before the change, or a new stable state. Other times the changes are too great.

In the last two activities, you learned how the zebra mussel affected the ecosystem in the Hudson River. The data you investigated covered a period of eight years. When scientists monitor ecosystem health, this amount of time is considered short-term. Looking at short-term data can give scientists important information about the early effects of a change. In this activity, you will look at the same factors you investigated before, but you will analyze the data in terms of long-term ecosystem health.

Scientists want to understand what happens when ecosystems, such as the Hudson River, have a new species introduced.

Guiding Question

What are the long-term effects of the zebra mussel invasion of the Hudson River?

Materials

For each pair of students:

- Computer with Internet access

For each student:

- Explanation Tool
- Argument Tool

Process & Procedure

Part A: Constructing Another Explanation of the Impact

1. In this activity you will examine long-term data for the same factors you studied in Activity 4.3. With your partner, review your predictions from activity 4.3. Decide with your partner if you want to change your prediction or keep it the same.

2. With your partner, go to the "Overview" page of the "Graph the Data" section of the website.

   http://www.amnh.org/education/hudsonriver

3. Select "Over Time" and use the map to choose the Kingston location to study.

4. In the box below the map, select "Split Date."

5. Use the pop-up calendar to set Split Date #1 to August 15, 1990. This represents average data from before the zebra mussels arrived in the Hudson River.

6. Set Split Date #2 to August 15, 2000. This will split the remaining data into two periods—one soon after the zebra mussels arrived and the other more recent.

7. Set the first parameter to "Zebra mussel" and set the second parameter to the first factor you investigated in Activity 4.3.

8. Examine the three pairs of bar graphs that are produced. Look for any patterns and record your observations.

9. Repeat Procedure Steps 6 and 7 for the second and third factors you investigated in Activity 4.3. Make sure the first parameter is always "zebra mussel."

10. With your class, watch the video clip, "Going Further."

11. Using the Explanation Tool, construct a scientific explanation about the long-term interactions between zebra mussels and the biotic or abiotic factor you chose. Use the steps below to guide you as you use the Explanation Tool.

- **Question:** Record the question "What is the long-term effect of zebra mussels on the factor you chose?"
- **Evidence:** Examine the data in the graphs you created. What pattern do you notice in the zebra mussels over time? What pattern do you notice in the factor you chose over time? Describe these patterns. Include data (with units) as evidence from the graph to support your description.
- **Science Concepts:** List any science concepts that are connected to the evidence and might help answer the question.
- **Science Reasoning:** Describe the scientific reasoning that connects the evidence and science concepts to the question you are trying to answer.
- **Claim:** Based on the evidence of patterns in the data, state a claim about the relationship between the zebra mussels and the factor you chose.

12. Complete the reading below, following your teacher's instructions to answer the "Stop to Think" question.

Long Term Changes

In 2005, 14 years after the first sighting of zebra mussels in the Hudson River, Cary Institute scientists noticed an unexpected change in the river: zooplankton had returned to the same levels as before the invasion. The scientists also observed a change in the zebra mussels they were collecting from the river. Scientists group zebra mussels by three sizes: small (less than 10 mm), medium (10–20 mm), and large (more than 20 mm). While there were still many zebra mussels in the Hudson River, they were on average much smaller. Populations of the largest—or oldest— mussels were in decline. Zebra mussels can live six or seven years, but now it seemed that most were dying after only one or two years. If there were fewer older and larger zebra mussels, it made sense that there was more zooplankton. That's because large zebra mussels feed on bigger food particles like zooplankton. Smaller zebra mussels can eat only smaller particles like phytoplankton and bacteria.

Stop to Think

What effect do you think the smaller and younger zebra mussel population might have on the rest of the food web?

These changes started to affect the rest of the food web. As zooplankton increased, so did native mussels and clams. Scientists anticipated some fish species would increase too as their food supply increased. Scientists didn't know all the factors that caused the decline in large zebra mussels, but they did know blue crabs were starting to eat the zebra mussels.

Over time, blue crabs have developed a taste for zebra mussels and are one significant factor in the decrease of zebra mussels.

By monitoring several aspects of the Hudson River over many years, Cary Institute scientists are beginning to answer their original question: How might a zebra mussel invasion affect the Hudson River ecosystem? Early on during the invasion, zebra mussels thrived and had a huge impact on the ecosystem's food web—just as scientists had predicted. However, about 20 years later the number of zebra mussels has greatly declined. Parts of the ecosystem, such as the number of zooplankton, native mussels, and clams, have started to increase. But is this the end of the story? Or have we just seen the first two stages of an invasion that might have three, four, or more stages?

As their data sets grow, the scientists are able to track changes in the river—whether from pollution, weather, invasive species, or human activity—and to pose new questions. This broad approach puts scientists in a unique position to investigate future changes to the Hudson River ecosystem.

13. Review your Explanation Tool from Procedure Step 11. Revise or add to your student sheet as needed, based on the passage you just read.

14. Using the Argument Tool, construct a scientific argument about whether the zebra mussel has had a positive or negative effect on the Hudson River ecosystem. Use the list below to guide you as you use the Argument Tool.

■ **Question:** Record the question "Has the zebra mussel had a positive or negative effect on the Hudson River ecosystem?"

■ **Claims:** Record the two possible claims that could be made in response to the question.

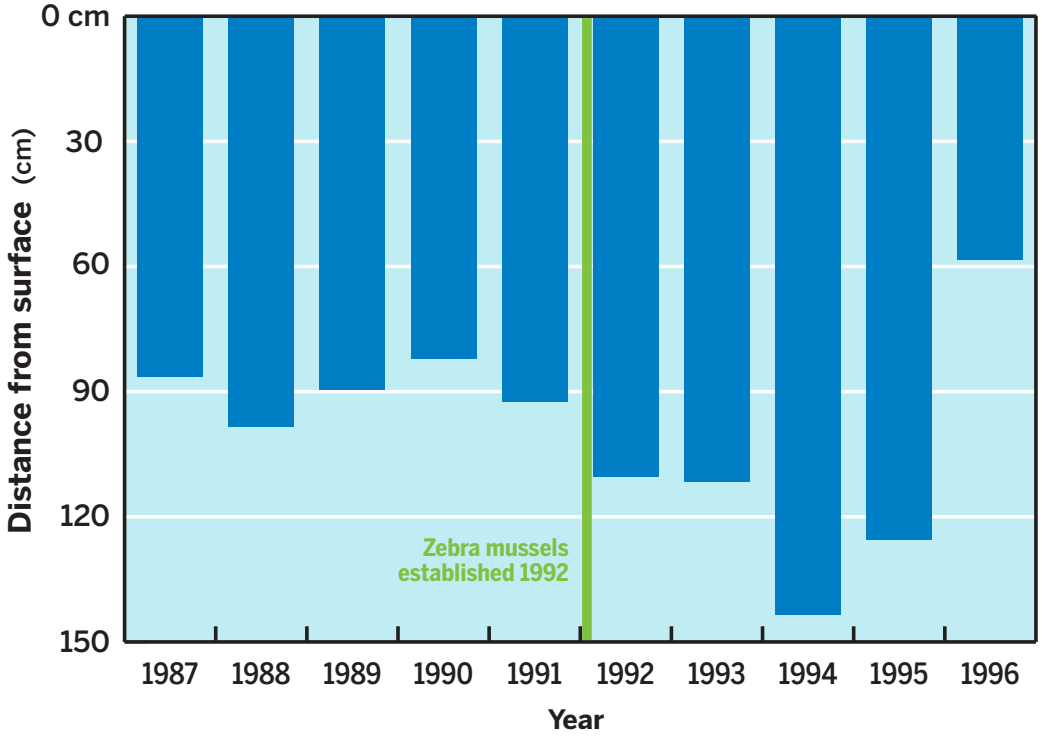
■ **Evidence:** What evidence supports each of the two claims?

■ **Science Reasoning:** For each claim, critique the quality and strength of evidence that supports the claim.

Analysis

1. Explain why it is important to monitor ecosystems over long periods of time.
2. How do the effects of zebra mussels in the Hudson River relate to stability and change in ecosystems?
3. The graph below shows water clarity over time in the Hudson River. The bars indicate how far scientists are able to see into the river from the surface of the water. What do the patterns in the data tell you about the effect of zebra mussels on water clarity?

Water Clarity Over Time in Hudson River



4. Consider the statement: "A small change to one factor can lead to large changes in an ecosystem." If the introduction of one species is considered a "small change," do you think this statement is accurate? Explain your answer.

Evaluate: A New Mussel in Town

Quagga mussels are an invasive species closely related to the zebra mussel. They arrived in the Great Lakes region a few years after the zebra mussels. Quagga mussels are now found in all of the Great Lakes.

In this activity you will examine data on the spread of the quagga mussel and compare it to data on the zebra mussel populations in one of the Great Lakes, Lake Michigan. You will compare this information to other data about biotic and abiotic factors in Lake Michigan and how those factors have changed as the quagga mussel has spread.

Guiding Question

Has the quagga mussel had a positive or negative effect on the Lake Michigan ecosystem?

Materials

For each student:

- Argument Tool

Process & Procedure

Constructing an Argument

1. Using data from the information items that follow, the concepts you have learned in this chapter, and the Argument Tool, construct a scientific argument about whether the quagga mussel has had a positive or negative effect on the Lake Michigan ecosystem. Use the list below to guide you as you use the Argument Tool.

- **Question:** Record the question "Has the quagga mussel had a positive or negative effect on the Lake Michigan ecosystem?"
- **Claims:** Record the two possible claims that could be made in response to the question.
- **Evidence:** What evidence supports each of the two claims?
- **Science Reasoning:** For each claim, critique the quality and strength of evidence that supports the claim.

Information Item 1

The Next Invasion: Quagga Mussels

Quagga mussels and zebra mussels share many characteristics, but they also have important differences. They are both filter feeders, and can filter up to a liter of water per day. Both species produce up to a million eggs per mussel per year. Both species will attach to hard surfaces, and can clog water pipes and equipment at water treatment and power generation facilities. Zebra mussels can survive being out of water for longer than quagga mussels. However, quagga mussels can also live on sandy and muddy

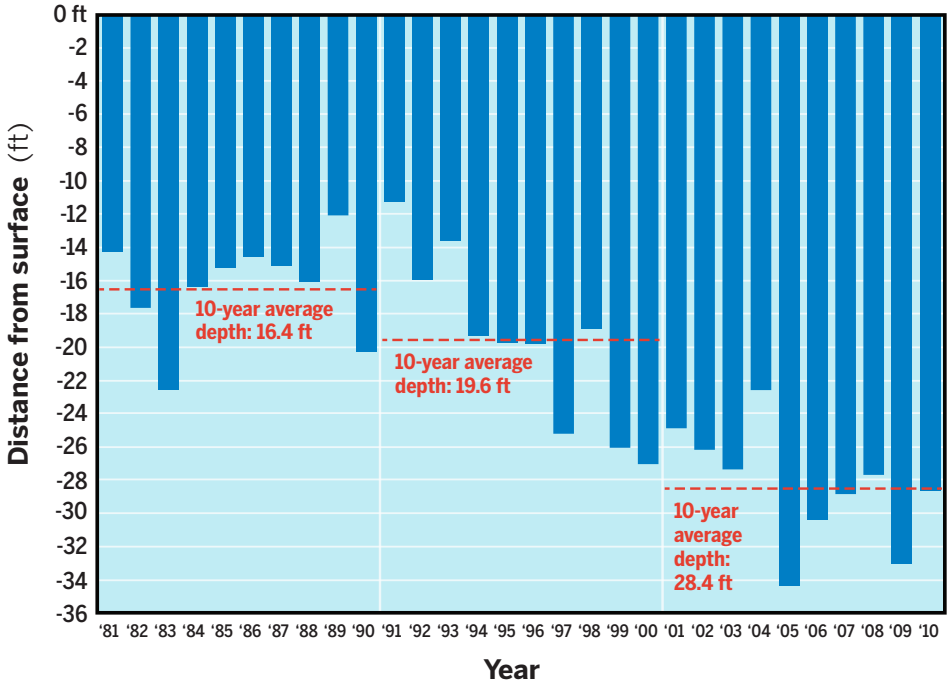
river and lake bottoms. They can live in deeper water and in a much wider temperature range than zebra mussels.

The quagga mussel's ability to live in deeper water allows them to filter the plankton from the water at the bottom of deep lakes. Scientists believe that the quagga mussels are competing for food with another species, diporeia. Diporeia are a small, shrimp-like organism that used to cover the bottom of many of the Great Lakes. Scientists used to find up to 20,000 diporeia per meter on the bottom of Lake Michigan. Now in some areas there are almost no diporeia left. Diporeia are an important food source for many fish in the Great Lakes, including the Whitefish, chubs, and smelt. Chubs and smelt are prey for trout and salmon. Trout, salmon, and Whitefish fisheries are important sources of income for many people.

Information Item 2

The graph below shows how the water clarity has changed over time in Lake Michigan. The bars indicate how far scientists are able to see into the lake from the surface of the water.

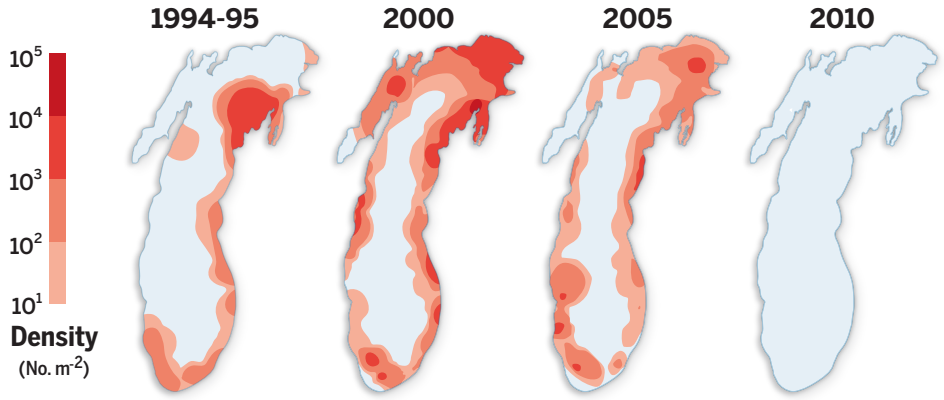
Water Clarity Over Time in Lake Michigan



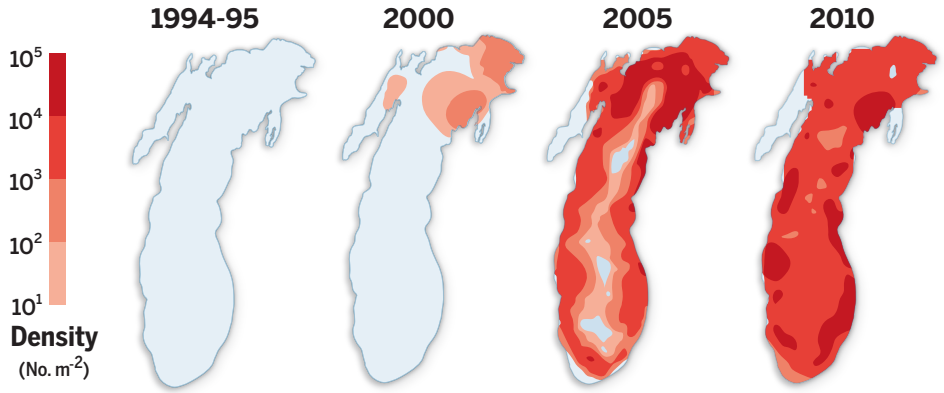
Information Item 3

The maps below show how the distribution of zebra mussels, quagga mussels, and diporeia has changed over time in Lake Michigan, one of the Great Lakes.

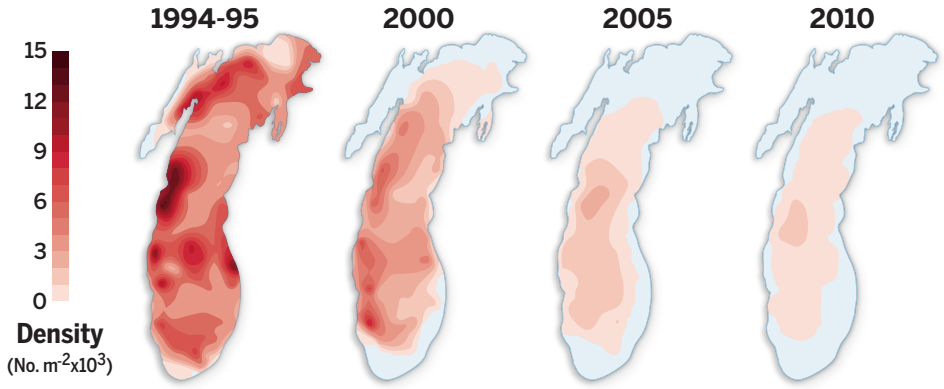
Lake Michigan Zebra Mussel Density



Lake Michigan Quagga Mussel Density



Lake Michigan Diporeia Density



Analysis

1. What additional information would have been useful to know in developing your argument?

2. Compare the change in distribution of the zebra mussels in Lake Michigan to that in the Hudson River over the last 20 years. Do you think that the changes have occurred because of the same reasons? Explain.