3–4 class sessions

The Zebra Mussel Problem: 20 Years of Data

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

Students transition to looking at long-term data on the effects of the zebra mussel. This allows them to deepen their understanding of dynamic ecosystems, and the importance of looking at disruption of ecosystems in both the short- and long-term.

Rationale & NGSS Integration

Students use this Elaborate activity to continue to deepen their understanding of the core ideas of dynamic ecosystems and competition for resources. Students analyze data to investigate the long-term effects of zebra mussels on the Hudson River ecosystem. This provides an opportunity to further explore stability and change and the relationships in the ecosystem. They also continue to apply the scientific practices of developing explanations and constructing arguments and analyzing and interpreting data to their understanding of the dynamic Hudson River ecosystem.

Activity Overview

In this Elaborate activity, students investigate the long-term data on the factors they investigated in Activity 4.3, and use that data to develop an explanation for the long-term effect of zebra mussels. Students also watch a video clip and complete a short reading about scientists' interpretation of the long-term data and what effects the zebra mussel invasion is having on the Hudson River ecosystem. The activity concludes with students constructing an argument about whether the zebra mussel has had a positive or negative effect on the Hudson River ecosystem.

Materials and Advance Preparation

For the teacher

- ☐ Scoring Guide: Constructing Explanations
- ☐ Scoring Guide: Developing Arguments
- ☐ Access to computer with Internet connection
  The video clip can be downloaded prior to class. Note that in this activity you are only showing the final video clip, "Going Further." The other clips have already been used earlier in the chapter. The link to the segment follows.
  http://www.amnh.org/education/resources/rfl/web/riverecology/watch.html
- ☐ 1 large computer monitor or projector

For each pair of students

- ☐ Access to computer with Internet connection

For each student

- ☐ Explanation Tool
- ☐ Argument Tool

Teaching Summary

Getting Started

1. Hold a class discussion about students' predictions for the long-term data.

Doing the Activity

2. Students investigate the data on the long-term effect of the zebra mussel.
3. Students develop an explanation.
4. Students read about the long-term effects of the zebra mussel and revise their explanations.

Follow-Up

5. Students construct an argument about the effect of the zebra mussel on the Hudson River ecosystem.
6. Revisit the Guiding Question.

Teaching Suggestions

Getting Started

1. **Hold a class discussion about students' predictions for the long-term data.** (15 minutes)

   a. Have a brief discussion with the class about why they think scientists might want to look at data on the Hudson River ecosystem over a long period of time instead of just a few years.

   Students will likely suggest the idea that there might be changes over the long term in the ecosystem that would not be apparent in the first few years of data collection, therefore looking at long-term data can give the scientists a more accurate picture of the whole story.

   b. Have student pairs read the introduction to the activity.

Doing the Activity

2. **Students investigate the data on the long-term effect of the zebra mussel.** (30 minutes)

   a. Have students use the River Ecology graphing tool to examine the long-term data for the factors they investigated in Activity 4.3, "Hudson River Ecosystem."

   Note that the data in this activity will show as bar graphs, not line graphs, showing the average over each time period. This presentation of the data makes it easier to see any long-term trends. You may want to model for your students how to interpret a bar graph, compared to the line graphs they were interpreting in the previous activity.

   The general effects of the zebra mussel on the factors are shown in the table on the following page. Note that the first time frame in the graph, 1973 to 1990, was before the zebra mussel was introduced, so it can be considered baseline data.

   b. Show students the video clip "Going Further."

   Have students focus on the reasons scientists give for monitoring long term, and what long-term changes they saw in the zebra mussel population of the Hudson River ecosystem.

   Before or after this step is a good point to conclude the first class session.

Long-term Effects of Zebra Mussels on Factors in the Hudson River Ecosystem

Factor	Time Frame 2 (1990-2000)	Time Frame 3 (2000-2010)
Alosa	significant decrease	continued decrease, not as dramatic
Bacterial Abundance	slight increase	slight decrease from Time Frame 2
Bacterial Production	significant increase	Slight decrease from Time Frame 2
Centrarchidae	significant increase	major decrease, far below pre-zebra levels
Chlorophyll	significant decrease	continued decrease, not as dramatic
Cladocera	significant decrease	continued decrease, not as dramatic
Copepod nauplii	significant decrease	significant increase but not to pre-zebra level
Copepods	slight decrease	increase to above pre-zebra levels
Dissolved Oxygen	no change	no change
Oxygen Saturation	no change	no change
Rotifers	significant decrease	slight increase from Time Frame 2
Secchi Depth	slight increase	return to pre-zebra level
Sphaeriidae	significant decrease	increased some, but not dramatically
Temperature	no change	no change
Total Suspended Solids	slight decrease	increase, not completely to pre-zebra level
Unionidae	no data*	no data*

*There is no data for Unionidae with the split dates used in this activity because scientists did not start collecting data on Unionidae until 1991.

3. **Students develop an explanation.** (30 minutes)

   a. Have students develop explanations about the long-term effect of zebra mussels on one of the factors they chose.

      Because student responses may vary widely, depending on the factors they chose, have a class discussion after students construct their explanations.

Alternatively, instead of written explanations you may wish to have the students provide their explanations orally, either as individual answers or to develop a group/whole-class explanation. This would be particularly appropriate if you are working with English language learners or students with special needs, in order to reduce the overall amount of writing in the chapter.

Step 11 provides an opportunity to check students' understanding of the core ideas of the dynamic nature of ecosystems and resource competition, and can also be used to informally evaluate students on constructing explanations, as can Step 13 after they revise their explanations to add new information from the reading. See the More Information section for additional details about the Explanation Tool. A sample answer is provided in the Handouts section of the Teacher's Guide.

Conclude the second class session after this step, or preview the reading with the class if time permits.

4. **Students read about the long-term effects of the zebra mussel and revise their explanations.** (40 minutes)

   a. Have students complete the reading alone or in pairs.

   The Stop to Think question can be used to check students' understanding of the crosscutting concept of cause and effect relationships. A sample answer is provided below.

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

   The smaller and younger zebra mussels would probably eat less plankton than the larger ones. This might mean more plankton would be available for other filter feeders like the native mussels, allowing their population to increase.

   b. Have students revise their explanations.

   Conclude the third class session after this step.

Follow-Up

5. **Students construct an argument about the effect of the zebra mussel on the Hudson River ecosystem.** (30 minutes)

   a. Have students construct an argument around the question "Has the zebra mussel had a positive or negative effect on the Hudson River ecosystem?"

A sample answer is provided in the Handouts section of the Teacher's Guide. Student responses may be scored using the Argument rubric. As appropriate, have students use a copy of the rubric for peer or self evaluation of a draft response, then revise their response as needed. See the More Information section for additional details about the Argument Tool.

6. **Revisit the Guiding Question** (10 minutes)

   a. Briefly review the long-term effects of the zebra mussel on the Hudson River ecosystem.

   Have students share what factors they examined and what the data showed. Ask the students how relating the effects of the zebra mussel to crosscutting concepts such as cause and effect and stability and change helps scientists (and students) think about and explain the impact of zebra mussels on ecosystems. Then have the students add to the KWL chart based on what they learned from the long term data, and add any new questions that have arisen for them.

Suggested Answers To Analysis

1. **Explain why it is important to monitor ecosystems over long periods of time.**

   It is important to monitor ecosystems over long periods of time because ecosystems are dynamic and they can change significantly over time. For example, when the zebra mussel first arrived in the Hudson River ecosystem it spread quickly and ate most of the zooplankton and phytoplankton. However, recently the zebra mussel population has decreased – they are physically smaller and are not living as long. This means they aren't eating as much zooplankton, so the zooplankton population is increasing. The ecosystem might eventually become more stable, or might keep changing, but we only know if we have long-term data to analyze.

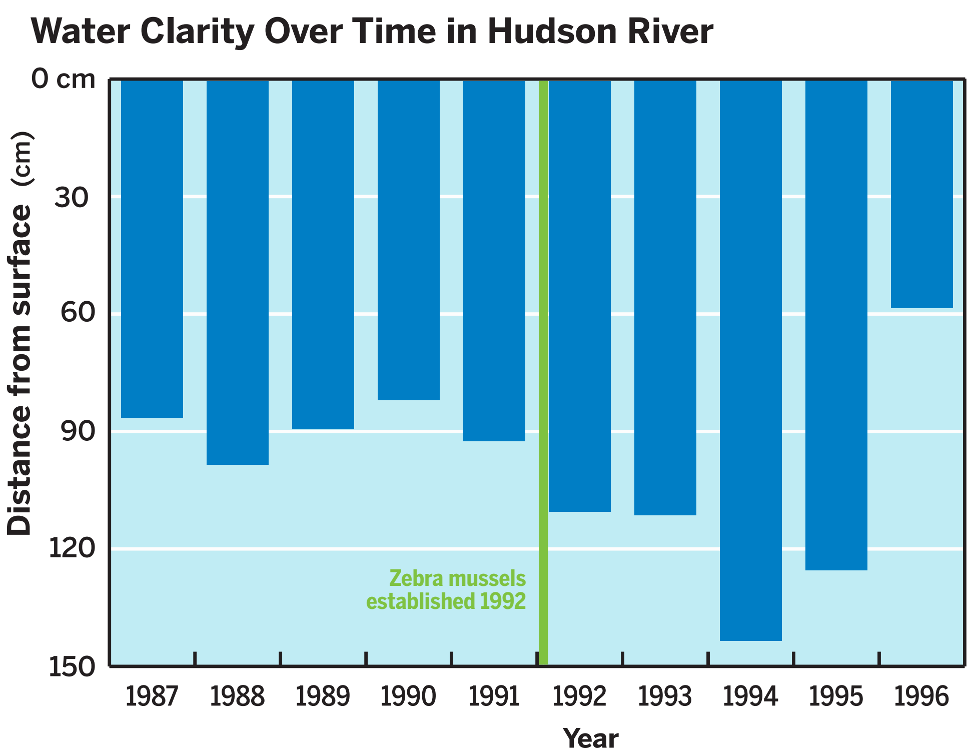
2. **How do the effects of zebra mussels in the Hudson River relate to stability and change in ecosystems?**

   > **Assessment – CCC - Cause and Effect**
   > This question assesses students' ability to relate the concepts of stability and change and cause and effect (CCC) to an ecological phenomenon they have now studied in some depth.

   The zebra mussels in the Hudson River show that a small change, the introduction of just one organism, can cause a big effect on the stability of *an ecosystem. In the short-term the zebra mussels caused many factors in the Hudson River ecosystem to change, such as large decreases in the phytoplankton, zooplankton, and native mussel populations. Over the long-term some of the factors that changed seem to be getting more stable and recovering, like the zooplankton population.*

3. **The graph below shows water clarity over time in the Hudson River. What do the patterns in the data tell you about the effect of zebra mussels on water clarity?**

This question introduces students to a style of bar graph that they will be analyzing in the Evaluate activity of this chapter. Make sure students understand the layout of the graph, and that the y-axis is in negative numbers. This style of graph is used to help visualize how deep in the water the secchi disc is visible. The longer the bar, the deeper the disc is visible, indicating higher water clarity.



The patterns on the graph show that after zebra mussels were introduced in 1992 the water was much clearer. Before 1992 the water clarity went from 82 to 98 cm. After 1992, when the zebra mussel was introduced, the water clarity ranged from 110 to 143 cm, except in 1996 when it is only 58 cm. Maybe in 1996 there were a lot of storms or something making the water really cloudy.

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

> **Assessment – DCI - MS LS2.C.1, CCC - Stability and Change**
> Use this question to assess students' understanding that ecosystems are dynamic in nature (DCI - MS LS2.C.1) and as an example of cause and effect relationship as well as stability and change (CCC). A sample answer follows.

I think this statement is accurate because the zebra mussel is only one species, but when it was introduced to the Hudson River and Great Lakes ecosystems it caused a lot of changes in the biodiversity and other factors like water clarity. It also caused changes to the ecosystem services, like decreasing fish populations that fishermen rely on and increasing harmful algae so the water was not safe to swim in. This is an example of a cause and effect relationship.

More Information

The Explanation Tool

Students should use the first side of the tool as a note-taking space. They do not need to write in complete sentences until they reach the second side of the tool where they construct their complete scientific explanation. Students begin by filling in the Question before they obtain more evidence from the activity.

Decide whether to have students read and review any text, graphs, or other evidence as a class, in their groups, or individually. As students complete the bulleted steps for completing the first parts of the Explanation tool, you might need to clarify some terms. Students may already be familiar with the concept of evidence. Discuss their ideas about evidence and explain that evidence is factual information or data that supports or refutes a conclusion. Have students use the information in the student book to record evidence that addresses the question being considered.

Students are then asked to record what science concepts are connected to the evidence and might help answer the question. Encourage them to note any concepts they think might be relevant. As they develop their reasoning in the next section, they note how the concepts connect to the evidence. At this point they may find that some concepts are not appropriate for inclusion with their final scientific explanation.

The last box on the first side of the tool is where students state a claim. Define a scientific claim as a conclusion for a question or problem. Science focuses on claims that can be supported or refuted by using evidence and logical reasoning.

Ask students to respond to the initial Question by stating a claim based on the evidence they have recorded and their scientific reasoning.

The last section of the Tool guides students to construct a scientific explanation utilizing the previous components of the tool. The tool contains a series of five components that students should include to create a complete paragraph that provides a clear and logical explanation.

The Argument Tool

As in the Explanation Tool, the first sets of boxes provide a space for students to think through and record their ideas before they move on to a formal argument on the second page of the tool.

Students record the question there are investigating, then two possible claims that could be argued. They then record under each claim what, if any, evidence supports that claim. Students then critique the quality and amount of the evidence. Students may need assistance when they first begin critiquing evidence.

Students then use their ideas to construct a formal paragraph that clearly sets forth their argument. They also complete a short critique of one of the alternative claims. Students may need assistance when they first begin critiquing alternative claims (rebuttals). Model developing a simple critique of an alternative claim using the sentence starters provided in the tool. For example: Other people might claim *that the zebra mussel has had a positive effect on the Hudson River ecosystem*. I think the problem with this argument is *that the only data that could be considered positive is increased water clarity*. *Everything else is negative.*

Activity 4.4

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Elaborate: The Zebra Mussel Problem: 20 Years of Data

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For each pair of students

- ☐ Access to computer with Internet connection

For each student

- ☐ Argument Tool

Teaching Suggestions

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   a. Have a brief discussion with the class about why they think scientists might want to look at data on the Hudson River ecosystem over a long period of time instead of just a few years.

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Doing the Activity

2. **Students investigate the data on the long-term effect of the zebra mussel.** (30 minutes)

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    a. Have students complete the reading alone or in pairs.

    b. Have students revise their explanations.

Follow-Up

5. **Students construct an argument about the effect of the zebra mussel on the Hudson River ecosystem.** (30 minutes)
   Have students construct an argument around the question "Has the zebra mussel had a positive or negative effect on the Hudson River ecosystem?"

6. **Revisit the Guiding Question.** (10 minutes)
   Briefly review of the long-term effects of the zebra mussel on the Hudson River ecosystem.