Disruptions in Ecosystems

Ecosystem Interactions, Energy, & Dynamics

Middle School Unit aligned with the Next Generation Science Standards

American Museum of Natural History
The Lawrence Hall of Science
University of California, Berkeley

Third Field Test Version
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You have learned in previous chapters that all organisms need resources to live and grow. For example, humans breathe oxygen, eat food, drink water, and do many other things that require resources of one type or another. Although some resources are available in large quantities, all are limited.

In this chapter you will investigate cause and effect relationships as you examine how resources are affected by populations of organisms. You will analyze and interpret data as you look at how populations are affected by the resources available to them. You will also learn about some ways that humans’ use of resources is managed to prevent overuse. Finally, you will construct arguments supported by evidence for how increases in the human population impact Earth’s systems.
Engage: Shopping for Fish

Sara and her mother were shopping for groceries one day. Sara had asked if they could have fish for dinner, because she knew fish was really good for her. They stopped by the fish counter to see what looked good. Sara was hoping they would have her favorite, orange roughy, but she hadn’t seen it for sale in the store in a really long time. They looked at the fish in the case and the first thing she noticed was that there was no orange roughy, so she started looking a little more carefully to see if there were any others she liked.

Once Sara started looking more carefully, she saw that a lot of the fish had colored labels. Some were red, some yellow, some green. Sara also noticed that some of the fish were pretty expensive, including the red snapper (another fish she likes). Some of the fish that were less expensive were ones she didn’t like as much. She wondered why one fish would cost so much more than another, and if it was worth it to pay more for the fish she really liked.

Over the last several decades, many fisheries have had problems with catching fewer and fewer fish. Many fish populations around the world have become overfished. If a fish population is overfished it means that so many are being caught that the population cannot reproduce fast enough to maintain its population. Fewer fish caught means fewer jobs for fishers, and less income for the fishers that are still fishing.

Guiding Question

What factors should you consider when purchasing fish to eat?
Process & Procedure

1. With your class, review what you already know about fishing.

2. With your partner, review the information in the table below.

<table>
<thead>
<tr>
<th>Fish Name</th>
<th>Cooking Notes</th>
<th>Cost per Pound</th>
<th>Label Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Snapper</td>
<td>Mild, “nutty,” sweet flavor, low in fat</td>
<td>$$</td>
<td>Yellow</td>
</tr>
<tr>
<td>Atlantic Salmon</td>
<td>Mild flavor, medium fat</td>
<td>$</td>
<td>Red</td>
</tr>
<tr>
<td>Coho Salmon</td>
<td>Medium-mild flavor, low to medium fat</td>
<td>$$$</td>
<td>Green</td>
</tr>
<tr>
<td>Albacore Tuna</td>
<td>Medium flavor, medium to high fat</td>
<td>$$</td>
<td>Red</td>
</tr>
</tbody>
</table>

3. With your partner discuss the following:
   a. Why do you think there are differences in the cost and label colors for the fish?
   b. What do you think the label colors mean?
   c. Based only on the information in the table, which fish would you buy?
   d. If you could get more information about the fish before deciding, what other questions would you have about the fish?

4. Discuss your answers to Step 3 with your class.

Analysis

1. How might the health of a fish population affect the ecosystem where the fish lives?

2. Is it important to monitor the health of fish populations? Why or why not?

3. What factors do you think are important to consider when deciding what fish to purchase? Explain your answer.
As you have learned, one major cause of ecosystem disruption is human activity. In aquatic ecosystems, one way that humans often disrupt the ecosystem is by overfishing. Preventing a resource, such as a fishery, from being overused is not always easy, and can involve making difficult decisions.

The resource in this activity is the fish in Blue Bay. Blue Bay is a marine ecosystem, with two main species of fish (orange and yellow). Many people fish in Blue Bay, both to feed their families and to earn a living. In this activity you will investigate fishing limits as a possible method to help prevent overfishing.

**Guiding Question**

Can fishing limits prevent the overuse of an ecosystem?
Materials

For each group of four students:
- 100 fish crackers (orange)
- 30 fish crackers (yellow or color other than orange)
- tray or dish
- set of 4 Game A Character Cards
- set of 4 Game B Character Cards
- set of 4 Ecosystem Disruptions Cards
- timer that beeps

For each student:
- Handout 3.2-1, “Populations Over Time”
- 1 pair of chopsticks
- cup
- paper towel

Process & Procedure

Part A: No Fishing Limits

1. Place 25 orange fish and 5 yellow fish in the tray in the center of your table. This represents Blue Bay and the fish in it. Each person will use a set of chopsticks to fish in the bay.

2. Use the flowchart on the next page for instructions on how to play the game.

3. In Game A you will have no fishing limits. Predict what you think will happen to the fish populations in Blue Bay. Write your prediction in your science notebook.

4. Begin playing. At the end of each round record your data for Game A on Handout 3.2-1, “Populations Over Time,” and then empty your cup onto your paper towel. After four rounds, stop, and finish recording the data for Game A on your student sheet.

⚠️ Safety

Don’t eat the crackers; many people have handled them. If you have any severe food allergies, such as a nut allergy, alert your teacher before handling the materials to ensure the materials will not harm you.
5. After the fourth round, discuss, as a group, what happened in Game A. Record your responses in your science notebook. Be sure to answer the following questions:

- How did your fishing limit affect your behavior?
- What is the condition of the fishing community (did everyone catch enough to survive, did everyone earn some extra money)?
- What is the condition of Blue Bay (are there fish left, will there be enough for the next generation)?
- Were your predictions from Step 3 correct?
- If the fishing limits were lower, do you think the fish populations in Blue Bay would be different at the end of the game? Why or why not?
Part B: Set Fishing Limits

6. Play the game again, following the same rules as before. Repeat Steps 3 - 5, using Character Cards for Game B. In Game B there are strict fishing limits.

Part C: Changing Ecosystem Disruptions

7. Play the game again, following the same rules as before, using Character Cards for Game B. Start with the same number of fish. Before you begin each round select an Ecosystem Disruptions Card and follow the instructions during that round. In Game C the limits are the same as Game B, but several ecosystem disruptions occur.

8. As a group, discuss what happened in your game. Record your responses in your science notebook. Be sure to include the following questions:
   - How did the conditions of the ecosystem change the results of the game as compared to Game B?
   - Were your predictions accurate?
   - How did each person do (did they catch enough to survive, did they earn extra money)?
   - What is the condition of the fishing community (did everyone catch enough to survive, did everyone earn some extra money)?
   - What is the condition of Blue Bay (are their fish left, will there be enough for the next generation)?

Analysis

1. Describe the three games and what happened to the two fish populations over time in each game.

2. How did the reproduction of the fish (adding one fish for every live fish at the end of each round) affect fish population levels? Explain.

3. How was the effect of humans modeled in this activity?

4. What is missing from this model?
**Activity 3.3**

**Explain: Three Fisheries**

In the previous activity, you saw how fishing limits and ecosystem conditions affect the health of a fish population and the fishery that catches those fish. The word “fishery” includes all the people and organizations that catch a certain species of fish to eat or sell. You tracked data on the fishery and the fish population, including reproduction. Often scientists do not have population data, but they do have other data such as how much of a particular fish is caught during the year. Scientists use this data to monitor the health of the fish populations. In this activity you will learn about three fisheries that have managed their fish populations in different ways.

These scientists are collecting data on a small, live shark. This data will help them monitor the health of the shark population and the ecosystem the shark lives in.

**Guiding Question**

What effect have humans had on the health of fisheries?

**Materials**

*For each student*

- Argument Tool

**Process & Procedure**

**Part A: Managing Different Fisheries**

1. With your partner, discuss what effect you think humans have had on the health of different fisheries. Discuss if you think the effect has been the same on all fisheries. Write down your ideas.
2. With your partner, examine the graph below. “Total catch” refers to all fish of that species caught by commercial fishers in that year. Discuss any patterns you see in the data.

**Catch Data, Species A**

3. Repeat Step 2 for fish species B using the graph below.

**Catch Data, Species B**

4. Repeat Step 2 for fish species C using the graph on the next page.
5. With your partner, read the three fisheries descriptions below. Decide which fishery you think matches the graphs above for fish species A, fish species B, and fish species C.

Three Fisheries

Pacific Halibut: A Healthy Fishery

The Pacific halibut fishery is known for maintaining a healthy population of Pacific halibut. The fishery is carefully monitored, and
each year scientists make new recommendations on where and how many fish can be caught. The entire fishery adopts these limits, and they are carefully enforced.

**Red Snapper: On the Rebound**

The red snapper has been fished in the Gulf of Mexico since at least the 1840’s. As fishing technology has improved, more and more snapper have been caught. By the 1990’s, up to 15 million pounds of red snapper were being caught in the Gulf of Mexico each year. The snapper population was being severely overfished. In 2007 fishers and the government worked together to set new regulations for the fishery. They used scientific studies of the snapper population levels to determine the number of fish each fisher is allowed to catch during the year. The limits are evaluated every year and changed as needed.

**Orange Roughy: Is It Too Late?**

The orange roughy was not fished for many years. They live on the bottom of the ocean, in very deep waters, and for a long time were rarely caught. That all changed with modern fishing techniques and equipment allowing fishers to find and catch fish more effectively, even deep on the bottom of the ocean. Because orange roughy tend to sit in groups on the ocean floor, they were easy targets for fishers. To
6. With your partner, based on what you have learned in previous activities and this activity, decide what level of health you think each of the fish species populations should be labeled: red, yellow, or green.

7. Follow your teacher’s instructions to discuss with your class how humans affect different fisheries.

**Part B: Pacific Halibut Fishery: More Information**

Different fisheries manage their populations differently. Some fisheries, such as the Pacific halibut fishery, collect more data than just the amount of fish caught.

8. The graph on the following page shows the average mass of male and female Pacific halibut at various ages. The data lines indicate the data for three years when data was collected: 1975, 1995, and 2014. With your group, examine the graph and answer the following:

a. What patterns do you notice in the data?

b. What do the patterns in the data tell you about the health of the fishery?
9. Using the Argument Tool, construct a scientific argument about the health of the Pacific halibut fishery in 2014. Use the list below to guide you as you use the Argument Tool.

- **Question**: Record the question “Was the Pacific halibut fishery healthy in 2014?”
- **Claim**: 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. Give two examples of criteria scientists might use to determine if the Pacific halibut fishery is healthy.

2. Why might scientists want to look at more than one type of data to determine the health of a fishery?
Humans can impact ecosystems in many ways. You have learned in previous activities about some ways that humans have affected aquatic ecosystems and fisheries. In this activity you will learn about an extreme case of human-influenced ecosystem disruption—dead zones.

In aquatic ecosystems around the world, scientists have recorded an increase in the number and size of dead zones. A dead zone is an area in a body of water where the water at the bottom has little or no dissolved oxygen. Scientists are concerned about the increase in dead zones because very few organisms can survive in dead zones.

One of the main causes of the increase in size and number of dead zones is fertilizer run-off. Fertilizer contains nutrients like nitrogen, which plants need to grow. Farmers apply fertilizer to plants to help them grow. If extra fertilizer is given to plants, when it rains the extra washes away into streams and rivers. This is called fertilizer run-off.

Dead zones happen when large amounts of nutrients are added to a body of water. If there is a lot of fertilizer run-off, the nutrients in the run-off help phytoplankton grow. Populations of phytoplankton increase quickly. When the plankton die and sink, they feed the bacteria (decomposers) on the bottom of the ocean. The bacteria population increases, and uses up the oxygen in the surrounding water, leaving no oxygen for other organisms. The organisms have to leave that part of the ecosystem or they die.
Guiding Question

How do humans affect the size of dead zones?

Materials

For each student:
- Explanation Tool

Process & Procedure

1. With your class, watch the video segment “The Gulf of Mexico Dead Zone.”
2. Discuss the video segment with your class.
3. With your group, examine the graph below. Discuss the following:
   - What patterns do you notice?
   - What do you think explains the patterns?
   - What pattern do you expect to see in the size of the dead zones in the Gulf of Mexico? Explain why you expect to see these patterns.

Nitrogen Input and Water Flow from the Mississippi Basin to the Gulf of Mexico

This graph shows the amount of nitrogen input and water flow from the Mississippi Basin into the Gulf of Mexico from 1985 to 2014.
4. Using the Explanation Tool, construct a scientific explanation about the effect of water flow from the Mississippi Basin on the nitrogen input in the Gulf of Mexico. Use the steps below to guide you as you use the Explanation Tool.

- **Question:** Record the question “What is the effect of water flow from the Mississippi Basin on the total nitrogen input in the Gulf of Mexico?”
- **Evidence:** Examine the data in the graph and information from the introduction. What pattern do you notice in the nitrogen input and water flow data? 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.
- **Scientific 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 and on your scientific reasoning, state your claim about the effect of water flow from the Mississippi Basin on total nitrogen input in the Gulf of Mexico.

5. With your group, examine the graph below. Discuss the following:
   - a. What patterns do you notice?
   - b. Do the data in the graph match the prediction you made in Step 3 about patterns in the size of dead zones in the Gulf of Mexico?

**Size of Dead Zones in the Gulf of Mexico**

This graph shows the size of dead zones in the Gulf of Mexico between 1985 and 2014.

6. Complete the reading on the next page.
Gulf of Mexico Dead Zone

The Gulf of Mexico is one of the largest and most important areas for fisheries in the United States. The area where the Mississippi River drains into the Gulf waters is the location of the largest recorded dead zone in the United States. This dead zone reappears nearly every summer, and has been as large as 21,576 km² (8,400 mi²).

The Mississippi drains nearly 41% of the land in the United States, and a lot of the land is farmland where fertilizers are used. Scientists estimate that 65% of the nutrients that drain into the Gulf of Mexico come from farms and livestock production along the Mississippi.

<table>
<thead>
<tr>
<th>Source of Nitrogen</th>
<th>% Total Nitrogen from Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer &amp; treated soil</td>
<td>50</td>
</tr>
<tr>
<td>Animal manure</td>
<td>15</td>
</tr>
<tr>
<td>Other (atmosphere, ground water, erosion, runoff, etc.)</td>
<td>24</td>
</tr>
<tr>
<td>Factories and other buildings</td>
<td>11</td>
</tr>
</tbody>
</table>

Scientists are concerned about the effect of this increasing dead zone on the fisheries in the Gulf, especially because several of the fisheries are already considered overfished or in danger of becoming overfished.
7. With your class, debate the question “Should fertilizer use be limited to help prevent dead zones?”

Analysis

1. What are the abiotic and biotic factors that are affected in a dead zone? How do they differ from a healthy ecosystem?

2. How might an increase in the size of the dead zone in the Gulf of Mexico affect the red snapper fishery, or other fisheries in that area?

3. Draw a diagram with four panels showing the main stages in the creation of a dead zone. The panel below is an example of what the fourth panel in your diagram might look like. Include a caption for each panel that explains what is happening in the diagram.
**Evaluate: Chesapeake Bay Oysters**

Eastern Oysters are one of the most important organisms in the Chesapeake Bay ecosystem. The oysters are part of the food web, and they filter the water of the Bay. The oyster fishery is also very important to the area’s economy. One hundred years ago Chesapeake Bay was the world’s largest oyster-producing area, with fishers harvesting more oysters than all other countries combined. However, the oyster population has been overfished and the amount of oysters available to harvest has decreased dramatically. In this activity you will investigate how this has affected the Chesapeake Bay ecosystem.

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**Guiding Question**

How do increases in the human population affect the resources available to organisms?

**Materials**

For each student:
- Argument Tool
Process & Procedure

Part A: Oysters in Chesapeake Bay

1. With your partner, examine the graph below of the harvests of oysters in the Chesapeake Bay. Discuss what this information suggests about what has happened to the oyster population over time.

Oyster Harvests in Chesapeake Bay

2. Using the food web below, identify two organisms that compete with the Eastern Oyster for resources in the Chesapeake Bay ecosystem.
3. With your partner, discuss the following:
   - How might the changes in the oyster population affect other organisms in the ecosystem?
   - How might this affect the rest of the ecosystem?

4. Follow your teacher’s directions to share your discussion with your class.

**Part B: Changes in the Chesapeake Bay Ecosystem**

One of the important roles of the oysters is to filter the water in the Bay. As they filter the water they remove nutrients and other matter. One of the biggest challenges for the Chesapeake Bay ecosystem in recent years is the appearance of dead zones. There are farms surrounding the Bay, and the run-off from these farms is the primary source of nutrients that cause phytoplankton populations to increase. This can lead to an increase in the size of dead zones. In general, as the human population increases, so will the number of farms and the amount of fertilizer that becomes run-off.

5. With your partner, examine the following three graphs. For each graph identify and discuss any patterns or trends you see in the graphs.
Annual Nitrogen Run-off in Chesapeake Bay

Total Size of Dead Zones in Chesapeake Bay

Annual Oyster Harvests in Chesapeake Bay
6. Using the Argument Tool, construct a scientific argument about whether an increasing human population in the Chesapeake Bay area is affecting the number of oysters in the Bay. Use the list below to guide you as you use the Argument Tool.

- **Question**: Record the question “Is an increase in the human population in the Chesapeake Bay area affecting the number of oysters in the Bay?”
- **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. Suppose two species of fish that live in the Chesapeake Bay only reproduce during July. For the fish eggs to mature properly and hatch, there must be at least 2 mg/L of oxygen in the water. Based on the diagram below, answer the following:

- **a.** Which resources will the fish have to compete for in order to breed successfully?
- **b.** What effect might this competition have on the populations of the two fish, both long- and short-term?
CHARACTER CARD

Game

Activity 3.2
You captain an ocean trawler, which has no fishing limits.

Catch as many fish as you want to.
CHARACTER CARD

Game

Activity 3.2

CHARACTER CARD

Game

Activity 3.2
You are a line fisher (you catch with a long line with multiple hooks).

You may catch up to 3 fish, but only 1 yellow fish, each round.
Activity 3.2

Ecosystem Disruptions Card

Activity 3.2

Ecosystem Disruptions Card

Activity 3.2

Ecosystem Disruptions Card

Activity 3.2

Ecosystem Disruptions Card
Ecosystem conditions are normal.
Play this round following the regular rules.

Plankton die off occurs, not enough food for all fish to reproduce. At the end of this round instead of doubling the amount of fish only add one new fish for every two surviving fish.

Habitat loss occurs, so there is not enough space for all fish to lay eggs. At the end of this round instead of doubling the amount of fish only add one new fish for every two surviving fish.

Unusually warm weather causes Bay water temperature increases, and fish eggs die off. At the end of this round instead of doubling the amount of fish only add one new fish for every three surviving fish.

Plankton die off occurs, not enough food for all fish to reproduce. At the end of this round instead of doubling the amount of fish only add one new fish for every two surviving fish.
### Game A: What’s your fishing limit?

<table>
<thead>
<tr>
<th>Round #</th>
<th>Starting # of Fish in Blue Bay</th>
<th># of Fish You Caught</th>
<th>$ You Earned ($1 per extra orange fish caught, $2 per yellow fish)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Orange</td>
<td>Yellow</td>
<td>Orange</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
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</tr>
<tr>
<td>3</td>
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<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**End Result** (what’s going on in Blue Bay):

__________________________________________
### Game B: What’s your fishing limit?

<table>
<thead>
<tr>
<th>Round #</th>
<th>Starting # of Fish in Blue Bay</th>
<th># of Fish You Caught</th>
<th>$ You Earned ($1 per extra orange fish caught, $2 per yellow fish)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Orange</td>
<td>Yellow</td>
<td>Orange</td>
</tr>
<tr>
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<td>Total</td>
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### End Result (what’s going on in Blue Bay):


**Game C: What’s your fishing limit?**

<table>
<thead>
<tr>
<th>Round #</th>
<th>Starting # of Fish in Blue Bay</th>
<th># of Fish You Caught</th>
<th>$ You Earned ($1 per extra orange fish caught, $2 per yellow fish)</th>
<th>Ecosystem Conditions</th>
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<tr>
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<td>Total</td>
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</tbody>
</table>

**End Result** (what’s going on in Blue Bay):

________________________________________________________

________________________________________________________
**Game A:** What’s your fishing limit?  **No Limit**

<table>
<thead>
<tr>
<th>Round #</th>
<th>Starting # of Fish in Blue Bay</th>
<th># of Fish You Caught</th>
<th>$ You Earned ($1 per extra orange fish caught, $2 per yellow fish)</th>
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<tr>
<td><strong>Total</strong></td>
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<td></td>
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</tr>
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</table>

**End Result** (what’s going on in Blue Bay):

*There are no more fish.*
**Game B: What’s your fishing limit?**  
3 orange fish

<table>
<thead>
<tr>
<th>Round #</th>
<th>Starting # of Fish in Blue Bay</th>
<th># of Fish You Caught</th>
<th>$ You Earned ($1 per extra orange fish caught, $2 per yellow fish)</th>
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<td>Yellow</td>
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<tr>
<td><strong>Total</strong></td>
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<td>9</td>
</tr>
</tbody>
</table>

**End Result** (what’s going on in Blue Bay):

*Blue Bay is filled with fish, and we earned money.*
### Game C: What’s your fishing limit?

3 orange fish

<table>
<thead>
<tr>
<th>Round #</th>
<th>Starting # of Fish in Blue Bay</th>
<th># of Fish You Caught</th>
<th>$ You Earned ($1 per extra orange fish caught, $2 per yellow fish)</th>
<th>Ecosystem Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Orange</td>
<td>Yellow</td>
<td>Orange</td>
<td>Yellow</td>
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<tr>
<td>Total</td>
<td>9</td>
<td>0</td>
<td>9</td>
<td>0</td>
</tr>
</tbody>
</table>

**End Result** (what’s going on in Blue Bay):

*We had very few orange fish left in Round 4 and orange fish left at the end. The yellow fish population increased.*
## Argument Tool

### Question
What is the question that you are investigating?

<table>
<thead>
<tr>
<th>Claim A</th>
<th>Claim B</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is a claim you could argue?</td>
<td>What is a claim you could argue?</td>
</tr>
<tr>
<td>The evidence that supports this claim is . . .</td>
<td>The evidence that supports this claim is . . .</td>
</tr>
</tbody>
</table>

### Scientific Reasoning: Evaluating the Evidence and Claim
Critique the quality and strength of the evidence that supports this claim.  

Critique the quality and strength of the evidence that supports this claim.
Constructing a Scientific Argument

Decide which claim you think is best supported by the evidence and scientific reasoning. Using the criteria below and the information in the boxes you have completed, write a scientific argument that includes:

• The scientific question
• Your claim (that is best supported by evidence and reasoning)
• Relevant evidence that supports your claim
• Scientific reasoning that critiques the evidence and evaluates your claim

Scientific Argument

Critique of the Rebuttal

Other people might claim ______________ . I think the problem with this argument is ______________ .
## Argument Tool

### Question
What is the question that you are investigating?

*Was the Pacific halibut fishery healthy in 2014?*

### Claim A
What is a claim you could argue?

*The Pacific halibut fishery was healthy in 2014.*

**The evidence that supports this claim is . . .**
- amount of fish caught each year is monitored by scientists so that the population stays about the same
- catch limits go up and down, but change depending on how the population is doing

### Claim B
What is a claim you could argue?

*The Pacific halibut fishery was not healthy in 2014.*

**The evidence that supports this claim is . . .**
- the average mass of both female and male halibut is much lower in 2014 than in 1975 and 1995
- females average about 15kg in 2014, but were about 33kg average in 1975 and 20kg in 1996
- males average about 13kg in 1975, but were about 13kg average in 1975 and about 8kg in 1995.

### Scientific Reasoning: Evaluating the Evidence and Claim

Critique the quality and strength of the evidence that supports this claim.

*This evidence is strong in terms of the population size, if the statements about fishing limits are accurate. This evidence does not support the claim in terms of individual organisms.*

Critique the quality and strength of the evidence that supports this claim.

*This evidence is strong in terms of individual organisms, if smaller average mass is a sign that the population is less healthy. It does not support the claim in terms of population size.*
Constructing a Scientific Argument

Decide which claim you think is best supported by the evidence and scientific reasoning. Using the criteria below and the information in the boxes you have completed, write a scientific argument that includes:

- The scientific question
- Your claim (that is best supported by evidence and reasoning)
- Relevant evidence that supports your claim
- Scientific reasoning that critiques the evidence and evaluates your claim

Scientific Argument

Was the Pacific halibut fishery healthy in 2014?

The Pacific halibut fishery was healthy in 2014. The data shows that over time the population numbers are fairly stable. The average mass of the individual organisms is decreasing, but we do not have any data about how average mass of individual fish affects the population. If the population numbers are stable, it indicates that the fish are not being overfished and that the fishery is healthy, otherwise the population size would have decreased.

Critique of the Rebuttal

Other people might claim ______________. I think the problem with this argument is ______________.

Other people might claim that the Pacific halibut fishery was not healthy in 2014 because the average mass of the fish is declining. However, we have no evidence indicating if this is good or bad, or if it matters at all.
# Argument Tool Rubric

<table>
<thead>
<tr>
<th>Component</th>
<th>Level 3 Proflcient</th>
<th>Level 2 Developing</th>
<th>Level 1 Beginning</th>
<th>Not Evident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>Claim answers the question completely.</td>
<td>Claim partially answers the question.</td>
<td>Claim does not answer the question.</td>
<td>Does not make a claim.</td>
</tr>
<tr>
<td>Evidence</td>
<td>Provides appropriate evidence to support the claim.</td>
<td>Provides evidence that actually supports a different claim, but not the one selected or is missing some evidence.</td>
<td>Provides inappropriate evidence (evidence does not support the claim selected or a counter claim).</td>
<td>Does not provide evidence.</td>
</tr>
<tr>
<td>Scientific Reasoning</td>
<td>Appropriately uses relevant science concepts to thoroughly evaluate the evidence provided and support the selected claim.</td>
<td>Uses inappropriate science concepts to evaluate the evidence provided or is missing some science concepts.</td>
<td>Evaluates the evidence provided without mention of science concepts. For example, states evidence is good but does not explain why.</td>
<td>Does not evaluate the evidence.</td>
</tr>
<tr>
<td>Rebuttal</td>
<td>Student identifies an alternative claim AND Student provides a critique of the alternative claim (e.g. the alternative claim is not supported by evidence because . . ., the evidence that supports this alternative claim is not good because . . .)</td>
<td>Student identifies an alternative claim AND Attempts to critique the alternative claim, but the critique is not accurate or is not specific (e.g. “that idea does not make sense,” or “there’s no evidence for that claim”)</td>
<td>Student provides an alternative claim (it can be weak or not plausible) BUT Does not provide a critique or the critique does not make sense</td>
<td>Student does not identify an alternative claim or provide a critique.</td>
</tr>
</tbody>
</table>
# Explanation Tool

**Question**
What is the scientific question you are investigating?

<table>
<thead>
<tr>
<th>Evidence</th>
<th>Science Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the science observations or data that address your question?</td>
<td>What science concepts are connected to the evidence and might help answer the question?</td>
</tr>
</tbody>
</table>

**Scientific Reasoning**
How do the science concepts connect to the evidence and to the question you are trying to answer?

**Claim**
What claim can you make based on the evidence and reasoning?
Construct a Scientific Explanation

Using the information in the boxes you have completed, write a scientific explanation that includes:

• The scientific question
• Your claim
• Relevant evidence that supports your claim
• Science concepts that are connected to the evidence
• Scientific reasoning that links the evidence and science concepts to the claim

Scientific Explanation
### Question
What is the scientific question you are investigating?

*What is the effect of water flow from the Mississippi Basin on the total nitrogen input in the Gulf of Mexico?*

### Evidence
What are the science observations or data that address your question?

- The graph shows that generally when water flow is increased the nitrogen input is also increased
- There are lots of farms in the Mississippi Basin
- The streams and rivers in the Mississippi watershed empty into the Gulf of Mexico

### Science Concepts
What science concepts are connected to the evidence and might help answer the question?

- Cause and effect
- Extra fertilizer in farms can be washed away into streams and rivers

### Scientific Reasoning
How do the science concepts connect to the evidence and to the question you are trying to answer?

- If there is more water falling on more farms that will cause more nitrogen to be washed from the Basin into the Gulf

### Claim
What claim can you make based on the evidence and reasoning?

*An increase in water flow in the Mississippi Basin will lead to an increase in nitrogen flowing into the Gulf of Mexico.*
Construct a Scientific Explanation

Using the information in the boxes you have completed, write a scientific explanation that includes:

• The scientific question
• Your claim
• Relevant evidence that supports your claim
• Science concepts that are connected to the evidence
• Scientific reasoning that links the evidence and science concepts to the claim

Scientific Explanation

What is the effect of water flow from the Mississippi Basin on the total nitrogen input in the Gulf of Mexico?

An increase in water flow in the Mississippi Basin will lead to an increase in nitrogen flowing into the Gulf of Mexico. Data shows that in most years when there is increased water flow in the Basin there is higher nitrogen input into the Gulf. There are many farms surrounding the rivers and streams in the Basin, and excess fertilizer used on those farms can be washed into the waterways causing an increase in nitrogen. An increase in water flow will cause an increase in nitrogen input because it is washing away more fertilizer.
## Explanation Tool Rubric

<table>
<thead>
<tr>
<th>Component</th>
<th>Level 3 Proficient</th>
<th>Level 2 Developing</th>
<th>Level 1 Emerging</th>
<th>Level 0 Not Evident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>Claim answers the question, is accurate, and is complete. Completely describes the trend in the relationship between two variables.</td>
<td>Claim does answer the question but it is inaccurate or incomplete.</td>
<td>Claim does not answer the question.</td>
<td>Does not make a claim.</td>
</tr>
<tr>
<td>Evidence</td>
<td>Provides appropriate and sufficient evidence to support the claim.</td>
<td>Provides appropriate, but insufficient evidence to support the claim. May include some inappropriate evidence.</td>
<td>Evidence does not support the claim; only provides inappropriate evidence.</td>
<td>Does not provide evidence.</td>
</tr>
<tr>
<td>Science Concepts</td>
<td>Includes explanation of science concepts that link evidence to the claim (concepts are appropriate), and science concepts are sufficient (no omission of key concepts) and are clearly stated and accurate.</td>
<td>Includes explanation of some science concepts that link evidence to the claim, but are insufficient (one or more concepts that should have been included are not included) or some are inappropriate.</td>
<td>Restates evidence and does not include explanation of science concepts.</td>
<td>Does not include science concepts.</td>
</tr>
<tr>
<td>Scientific Reasoning</td>
<td>Includes logic statements that link the claim, evidence and science concepts (including words such as ‘because...’ ‘therefore...) that clearly demonstrates logical reasoning.</td>
<td>Attempts to include a logic statement that links the evidence to the claim but does not adequately link the evidence to the claim.</td>
<td>Restates evidence or claim and does not include a logic statement that links the evidence to the claim.</td>
<td>Does not include scientific reasoning.</td>
</tr>
</tbody>
</table>
Argument Tool

Question
What is the question that you are investigating?

Is an increase in the human population in the Chesapeake Bay area affecting the number of oysters in the Bay?

Claim A
What is a claim you could argue?

The increase in human population is affecting the number of oysters.

The evidence that supports this claim is . . .
- there is more nitrogen run-off with more people because there are more farms to grow more food
- there are larger dead zones when there is more nitrogen run-off
- oyster harvests usually decrease when dead zones increase

Claim B
What is a claim you could argue?

The increase in human population is not affecting the number of oysters.

The evidence that supports this claim is . . .
- humans are catching a lot fewer oysters now than in previous decades

Scientific Reasoning: Evaluating the Evidence and Claim

Critique the quality and strength of the evidence that supports this claim.

This evidence is strong and there is a lot of evidence.

Critique the quality and strength of the evidence that supports this claim.

This evidence is not strong because the lower oyster catch could just be because there are fewer oysters because they have been overfished. We have no evidence that the lower catch means more oysters are being left in the Bay.
**Constructing a Scientific Argument**

Decide which claim you think is best supported by the evidence and scientific reasoning. Using the criteria below and the information in the boxes you have completed, write a scientific argument that includes:

- The scientific question
- Your claim (that is best supported by evidence and reasoning)
- Relevant evidence that supports your claim
- Scientific reasoning that critiques the evidence and evaluates your claim

**Scientific Argument**

*Is an increase in the human population in the Chesapeake Bay area affecting the number of oysters in the Bay?*

The increase in the human population in the Chesapeake Bay area is affecting the number of oysters in the Bay. An increase in the human population means that there need to be more farms to grow food for more people. If there are more farms then there is more nitrogen run-off, which leads to larger dead zones. When the dead zones increase, the oyster harvests decrease, likely because there are fewer oysters to catch. Overall, this means that more people in the area leads to fewer oysters.

**Critique of the Rebuttal**

Other people might claim _____________. I think the problem with this argument is ________________.

Other people might claim that the increase in human population in the Chesapeake Bay area does not affect the number of oysters in the Bay. I think the problem with this argument is that the only data that might support this is that fewer oysters are being caught than in previous decades, but that could just be because the oysters have been overfished by humans.
1. The table below shows the population of deer in a grassland ecosystem over a period of fifteen years. Use the information below and the table to help you answer the questions that follow.

- At the end of Year 4, 80% of the grassland is converted to farmland and fenced to keep the deer out.
- People do not hunt the deer.
- In Year 11, there is a very harsh winter and the deer have very little access to food.

<table>
<thead>
<tr>
<th>Year</th>
<th>Deer Population</th>
<th>Average Mass (kg)</th>
<th>Number of deer births</th>
<th>% malnourished (severely underweight) deer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>30</td>
<td>30</td>
<td>5</td>
</tr>
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<td>26</td>
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<tr>
<td>14</td>
<td>48</td>
<td>21</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>15</td>
<td>53</td>
<td>21</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>
1a. Use the data to describe the effect of the grassland being converted to farmland in Year 4 on the deer population.

1b. Use the data to describe the effect of the harsh winter in Year 11 on the deer population.

2a. Construct a scientific argument that argues the question: "Should the farmland be converted back to grassland?"

Your argument should include the following:

- The scientific question
- Your claim (which is best supported by evidence and reasoning)
- The relevant evidence that supports your claim
- Scientific reasoning that critiques the evidence and evaluates your claim
Chapter 3 Assessment
Continued

2b. Imagine that you have a classmate who disagrees with your claim. What claim might your classmate make?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2c. What is the problem with your classmate’s claim or the argument based on that claim?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
1. The table below shows the population of deer in a grassland ecosystem over a period of fifteen years. Use the information below and the table to help you answer the questions that follow.

- At the end of Year 4, 80% of the grassland is converted to farmland and fenced to keep the deer out.
- People do not hunt the deer.
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</tr>
</tbody>
</table>
1a. Use the data to describe the effect of the grassland being converted to farmland in Year 4 on the deer population.

The population decreases. It goes from 105 in Year 4 to 83 in Year 5 and then to 57 in Year 6 and then stays relatively stable until Year 10.

1b. Use the data to describe the effect of the harsh winter in Year 11 on the deer population.

The population decreases. It goes from 58 in Year 10 to 35 in Year 11.

2a. Construct a scientific argument that argues the question:

“Should the farmland be converted back to grassland?”

Your argument should include the following:

- The scientific question
- Your claim (which is best supported by evidence and reasoning)
- The relevant evidence that supports your claim
- Scientific reasoning that critiques the evidence and evaluates your claim

The question my argument answers is, “Should the farmland be converted back to grassland?” My claim is that the farmland should be converted back to grassland. The evidence that supports my claim is that after the grassland was converted to farmland and fenced in Year 4 there was an increase in malnourished deer from 3% to 46%. The average mass of deer fell steadily from 31 kg in Year 4 to 15 kg in Year 11. After this year the number of deer births also dropped from 15 to 5 and stayed below 8 for the rest of the years when data was collected. The overall population decreased from around 100 in years 1-4 to around 40-50 in Years 6-15. This evidence all shows that the conversion of grassland to farmland has had a negative effect on the deer population, because it has restricted their access to resources.
2b. Imagine that you have a classmate who disagrees with your claim. What claim might your classmate make?

_The classmate would say the farmland should not be converted back to grassland because humans need to farm to have food. Without farmland, humans might not have enough food._

2c. What is the problem with your classmate’s claim or the argument based on that claim?

_The problem with this argument is that if the deer population dies out, then the whole ecosystem might collapse because the organisms that eat deer would suffer, and the plants that deer eat would become too numerous. Farmland is important, but if an entire ecosystem collapses, then this could even put the farmland at risk because the environment would change._
Chapter 3 Assessment
Student Checklist

1a. □ I have included data from the table that shows what happens to the deer population after Year 4

1b. □ I have included data from the table that shows what happens to the deer population after Year 11

2a. □ Claim
    □ Evidence (numbers or trends from graphs or tables)
    □ Reasoning

2b. □ I have written a claim that is different than my initial claim

2c. □ I have pointed out a problem with the hypothetical classmate’s claim or argument
# Scoring guide for Chapter 3 Assessment

Note: The rubrics below are drafts. They are intended as guides for assessing whether your students are achieving learning goals. We encourage you to use a scoring system that works in your classroom context and that is appropriate for the level of your students. So, for example, students may be able to earn a “full credit” score for a “Level 2: Developing” response.

## 1a. Use the data to describe the effect of the grassland being converted to farmland in Year 4 on the deer population.

<table>
<thead>
<tr>
<th>Level 4: Advanced</th>
<th>Level 3: Proficient</th>
<th>Level 2: Developing</th>
<th>Level 1: Beginning</th>
<th>Level 0: Not evident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student states that the population decreases AND Provides sufficient data from the table to support their answer (e.g. “the population decreases: it goes from 105 in year 4 to 83 in year 5 and then to 57 in Year 6 and then stays relatively stable until year 10”)</td>
<td>Student states that the population decreases or that the population is negatively affected AND Provides some data from the data table to support their answer</td>
<td>Student states that the population is affected, but is not specific about the relationship</td>
<td>Student offers an idea related to the data table but does not address the question of what happens to the deer population.</td>
<td>Student does not discuss the deer population</td>
</tr>
</tbody>
</table>

## 1b. Use the data to describe the effect of the harsh winter in Year 11 on the deer population.

<table>
<thead>
<tr>
<th>Level 4: Advanced</th>
<th>Level 3: Proficient</th>
<th>Level 2: Developing</th>
<th>Level 1: Beginning</th>
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</thead>
<tbody>
<tr>
<td>Student states that the population decreases AND Provides sufficient data from the table to support their answer (e.g. “the population decreases: it goes from 58 in year 10 to 35 in year 11.”)</td>
<td>Student states that the population decreases or that the population is negatively affected AND Provides some data from the data table to support their answer</td>
<td>Student states that the population is affected, but is not specific about the relationship</td>
<td>Student offers an idea related to the data table but does not address the question of what happens to the deer population.</td>
<td>Student does not discuss the deer population</td>
</tr>
</tbody>
</table>
2a. Construct a scientific argument that argues the question “Should the farmland be converted back to grassland?”

<table>
<thead>
<tr>
<th>Component</th>
<th>Level 4: Advanced</th>
<th>Level 3: Proficient</th>
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<th>Level 0: Not evident</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Claim</strong></td>
<td>Provides evidence to support the claim.</td>
<td>Claim completely answers the question e.g. “The farmland should be converted back to grassland” or “The farmland should not be converted back to grassland”</td>
<td>Claim partially answers the question e.g. “Things should stay the way they are”</td>
<td>Claim does not answer the question e.g. “More grasslands would help the deer”</td>
<td>Does not make a claim</td>
</tr>
<tr>
<td><strong>Evidence</strong></td>
<td>Provides evidence to support the claim. May include some inappropriate evidence.</td>
<td>“The evidence that supports my claim is that after the grassland was converted to farmland and fenced in Year 4 there was an increase in malnourished deer from 3% to 46%. After this year the number of deer births also dropped from 15 to 5 and stayed below 8 for the rest of the years when data was collected. The overall population decreased from around 100 in Years 1-4 to around 40-50 in Years 6-15.”</td>
<td>Provides evidence that actually supports a different claim, but not the one selected.</td>
<td>Provides inappropriate evidence (evidence does not support the claim selected or a counter claim).</td>
<td>Does not provide evidence</td>
</tr>
</tbody>
</table>
## Scientific Reasoning

**Level 4: Advanced**
Appropriately uses relevant science concepts to thoroughly evaluate the evidence provided and support the selected claim.  
*e.g.,* a student connecting the claim that farmlands should be converted back to grassland to evidence: “This evidence all shows that the conversion of grassland to farmland has had a negative effect on the deer population, because it has restricted their access to resources (food).”

**Level 3: Proficient**
Uses science concepts to evaluate the evidence provided to support the selected claim. May include some additional or inappropriate evidence and/or science concepts.

**Level 2: Developing**
Uses inappropriate science concepts to evaluate the evidence provided.

**Level 1: Beginning**
Evaluates the evidence provided without mention of science concepts. For example, states evidence is good but does not explain why.

**Level 0: Not evident**
Does not evaluate the evidence.

### 2b.

<table>
<thead>
<tr>
<th><strong>Level 4: Advanced</strong></th>
<th><strong>Level 3: Proficient</strong></th>
<th><strong>Level 2: Developing</strong></th>
<th><strong>Level 1: Beginning</strong></th>
<th><strong>Level 0: Not evident</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CounterClaim</strong></td>
<td>N/A</td>
<td>Student writes a claim for the classmate that is not the same as the student’s original claim.</td>
<td>Student attempts to write a claim that is not the same as the student’s original claim, but the claim is either not clear or is not a true counter-claim</td>
<td>Student offers something other than a counter-claim</td>
</tr>
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</table>

### 2c.

<table>
<thead>
<tr>
<th><strong>Level 4: Advanced</strong></th>
<th><strong>Level 3: Proficient</strong></th>
<th><strong>Level 2: Developing</strong></th>
<th><strong>Level 1: Beginning</strong></th>
<th><strong>Level 0: Not evident</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Critique</strong></td>
<td></td>
<td>Student identifies a problem with the claim, the evidence that would support that claim, or the reasoning connecting claim and evidence and offers full justification</td>
<td>Student identifies a problem with the counter-claim, the evidence that would support that claim, or the reasoning, but the critique or the justification is not clear</td>
<td>Student attempts to identify a problem with the counter-claim, but is not successful in identifying a problem or providing justification</td>
</tr>
</tbody>
</table>
Disruptions in Ecosystems

Ecosystem Interactions, Energy, & Dynamics

Middle School Unit aligned with the Next Generation Science Standards

Teacher Materials
Third Field Test Version
Disruptions in Ecosystems
Ecosystem Interactions, Energy, & Dynamics

Third Field Test Version
Middle School Unit aligned with the Next Generation Science Standards

This material is based upon work supported by the National Science Foundation under Grant # NSF DRL 1418235. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Interactions Between Populations and Resources

CHAPTER 3

Activity 3.1 Engage What factors should you consider when purchasing fish to eat?
Students begin the chapter thinking about fishing as an example of human use of natural resources. Students start considering how the health of one population might affect the ecosystem it lives in.

Activity 3.2 Explore Can fishing limits prevent the overuse of an ecosystem?
Students explore how fishing limits can change the effect of human natural resource use, and examine how changes to the surrounding ecosystem can be a compounding factor. This allows students to investigate their initial ideas about natural resource use and about how multiple factors can affect populations.

Activity 3.3 Explain What effect have humans had on the health of fisheries?
Students transition from analyzing their own data about a fictitious fishery to an analysis of long-term data from three real fisheries. Students use this analysis to develop an initial explanation about humans’ effect on fisheries and a formal argument about the health of one fishery.

Activity 3.4 Elaborate How do humans affect the size of dead zones?
Students expand on their understanding of human disruption of ecosystems by looking at a more complex problem: the creation and expansion of dead zones. Students use their analysis of a variety of data to inform a debate on limiting human use of fertilizers to prevent dead zones.

Activity 3.5 Evaluate How do increases in the human population affect the resources available to organisms?
Students conclude the chapter with an investigation that examines the effects of fishing and dead zones on the Chesapeake Bay Oyster fishery. This allows for the evaluation of students’ understanding of the effects of resource availability on organisms and populations of organisms as well as how increases in the human population impact the Earth’s systems. This also prepares them to investigate another complex ecosystem disruption, invasive species, in the next chapter.
Chapter 3 Overview

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<td>3.1 Shopping for Fish</td>
<td>MS LS2.A.1 Cause &amp; Effect Science Knowledge Describes Consequences</td>
<td>Analyzing &amp; Interpreting Data</td>
<td>overfished</td>
<td>1</td>
</tr>
<tr>
<td>Guiding Question: What factors should you consider when purchasing fish to eat?</td>
<td>In this activity, students analyze data about purchasing fish in a grocery store. They use this data to decide what fish they would buy, and what other information they would want to have before making their decision. The class discusses the factors they think are important to consider when deciding what fish to purchase.</td>
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<tr>
<td>Explore</td>
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<tr>
<td>3.2 Gone Fishin’</td>
<td>MS LS2.A.1 Cause &amp; Effect</td>
<td>Analyzing &amp; Interpreting Data</td>
<td>overfished</td>
<td>1-2</td>
</tr>
<tr>
<td>Guiding Question: Can fishing limits prevent the overuse of an ecosystem?</td>
<td>Students model resource consumption and overuse through a game that models fisheries. In the first game students are able to overfish the available fish populations. In the second game the fishing limits are set such that the fish populations are able to survive and increase. In the third game students model the effect of changes in ecosystem conditions.</td>
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<tr>
<td>Explain</td>
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<tr>
<td>3.3 Three Fisheries</td>
<td>MS LS2.A.2 MS ESS3.C.2 Consequences of Human Activity</td>
<td>Analyzing &amp; Interpreting Data</td>
<td>overfished</td>
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</tr>
<tr>
<td>Guiding Question: What effect have humans had on the health of fisheries?</td>
<td>Students analyze data about three fisheries. They then use the data to try and identify the fisheries based on short text passages that describe each fishery, their historical and current fishing limits and practices, and key regulation dates. Students use their analysis to construct an argument about the health of a fishery.</td>
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</tbody>
</table>
### Elaborate

#### 3.4 Dead Zones

**Guiding Question:** How do humans affect the size of dead zones?

Students analyze data about nitrogen input, streamflow, and the size of dead zones. They use this data and additional evidence from a video to construct an explanation about the effect of these factors on the size of the dead zone in the Gulf of Mexico. They then gather additional evidence from a short reading to inform a debate on fertilizer use and dead zones.

<table>
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<td>MS ESS3.C.2</td>
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<td>Consequences of Human Activity</td>
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<td>Describes</td>
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<td></td>
<td>Consequences</td>
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</tbody>
</table>

### Evaluate

#### 3.5 Chesapeake Bay Oysters

**Guiding Question:** How do increases in the human population affect the resources available to organisms?

Students learn about the Chesapeake Bay ecosystem and the oyster harvests in the Bay. They analyze and interpret data about the nitrogen run-off, dead zone size, and oyster harvests to develop an argument about the effect of the human population on the Chesapeake Bay oysters.

<table>
<thead>
<tr>
<th>Activities</th>
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<td>MS LS2.A.3</td>
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<td>MS ESS3.C.2</td>
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# Assessment Overview

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<td>MS LS2.A.1*</td>
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<td>P&amp;P 4, 5, 7</td>
<td>P&amp;P 7</td>
<td>P&amp;P 4, Analysis 1 &amp; 2</td>
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<tr>
<td>MS LS2.A.2*</td>
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<td>P&amp;P 9</td>
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<tr>
<td>MS LS2.A.3*</td>
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<tr>
<td>DMS ESS3.C.2**</td>
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<td><strong>Science and Engineering Practices (SEP)</strong></td>
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<td>Constructing Explanations and Designing Solutions</td>
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<tr>
<td>Engaging in Argument from Evidence*</td>
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<td>P&amp;P 9</td>
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<td>P&amp;P 7</td>
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<tr>
<td>Analyzing and Interpreting Data</td>
<td>P&amp;P 4, 5, 7</td>
<td>P&amp;P 2-6 Analysis 1</td>
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<td><strong>Crosscutting Concepts (CCC)</strong></td>
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<td>Cause and Effect*</td>
<td>Analysis 3</td>
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<td>P&amp;P 3 &amp; 4 Analysis 1</td>
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<td>Connections to Engineering, Technology and Applications of Science**</td>
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<td>P&amp;P 7 &amp; 9 Analysis 1</td>
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<tr>
<td>Connections to Nature of Science**</td>
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<td>P&amp;P 7</td>
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* Primary PE and supporting elements  
**Secondary PE and supporting elements
## Embedded Formative Assessment

<table>
<thead>
<tr>
<th>Performance Expectations (PE)</th>
<th>Activity 1 Engage</th>
<th>Activity 2 Explore</th>
<th>Activity 3 Explain</th>
<th>Activity 4 Elaborate</th>
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<tr>
<td>LS2-1*</td>
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<td>P&amp;P Analysis 1</td>
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<td>ESS3-4**</td>
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<td>P&amp;P 6</td>
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<td><strong>CCSS ELA</strong></td>
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<td>RST.6-8.1</td>
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<td>Analysis 3</td>
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<td>WHST6-8.1</td>
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<td></td>
<td>Analysis 1</td>
</tr>
<tr>
<td>WHST6-8.9</td>
<td></td>
<td></td>
<td></td>
<td>P&amp;P 5 &amp; 6</td>
<td>P&amp;P 6</td>
</tr>
</tbody>
</table>

* Primary PE and supporting elements  **Secondary PE and supporting elements

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### PE

**LS2-1**: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

**ESS3-4**: Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

---

### DCI

**LS2.A.1**: Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.

**LS2.A.2**: In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.

**LS2.A.3**: Growth of organisms and population increases are limited by access to resources.

**ESS3.C**: Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.
<table>
<thead>
<tr>
<th>SEP</th>
<th>EAE: Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AID: Analyze and interpret data to provide evidence for phenomena.</td>
</tr>
<tr>
<td>CCC</td>
<td>C&amp;E: Cause and effect relationships may be used to predict phenomena in natural or designed systems.</td>
</tr>
<tr>
<td></td>
<td>(CET&amp;S): All human activity draws on natural resources and has both short- and long-term consequences, positive as well as negative, for the health of people and the natural environment.</td>
</tr>
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<td></td>
<td>(CNoS): Science knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.</td>
</tr>
<tr>
<td>CCSS ELA</td>
<td>RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.</td>
</tr>
<tr>
<td></td>
<td>RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).</td>
</tr>
<tr>
<td></td>
<td>WHST.6-8.1: Write arguments focused on discipline-specific content.</td>
</tr>
<tr>
<td></td>
<td>WHST.6-8.9: Draw evidence from informational texts to support analysis, reflection, and research.</td>
</tr>
</tbody>
</table>
What factors should you consider when purchasing fish to eat?

Students begin the chapter thinking about fishing as an example of human use of natural resources. Students start considering how the health of one population might affect the ecosystem it lives in.

Rationale and NGSS Integration

This activity is designed to pique students’ curiosity about the use, and potential overuse, of fish as a resource. Commercial fishing, as an example of human natural resource use and management, will be the focus of the storyline in this chapter. The questions initiated in this activity will be addressed in the activities that follow. Overall, the science practices developed in this chapter are analyzing and interpreting data, constructing explanations and designing solutions, and engaging in argument from evidence. In this activity students begin to engage in the practice of analyzing and interpreting data using simple data about purchasing fish. Class discussion around the students’ data analysis will begin to frame students’ thoughts about human use of natural resources. Students will also begin thinking about the crosscutting concept of cause and effect in terms of human use of resources, as well as the concept that science knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes, a connection to the nature of science.

Review the chapter overview and assessment chart to see how the three dimensions of the NGSS are woven together throughout this chapter, and how they are assessed in each activity. Decide in advance which assessments you plan to emphasize.
Activity Overview

In this Engage activity, students analyze data about purchasing fish in a grocery store. They use this data to decide what fish they would buy, and what other information they would want to have before making their decision. The class discusses the factors they think are important to consider when deciding what fish to purchase.

Key Vocabulary

overfished

Teaching Summary

Getting Started

1. Facilitate a class discussion to determine what the students know about fishing.

Doing the Activity

2. Students analyze information about purchasing fish.

Follow-Up

3. The class discusses factors to consider when purchasing fish.
4. Preview the chapter and revisit the Guiding Question.

Teaching Suggestions

Getting Started

1. Facilitate a class discussion to determine what the students know about fishing. (15 minutes)
   a. Have students read the introduction as a class read aloud or in pairs.

This activity introduces the concept that people have many reasons for choosing which fish to eat, and introduces a criterion that may be new to many, if not most, of the students—the environmental impact of the fishery.
Students will need to understand the key term, overfished, which is defined in the introduction as: so many fish being caught that the population cannot reproduce fast enough to maintain its population. Note that the Guiding Question could be used as a written warm up at the beginning of the class session.

For the class discussion in Step 1, focus on what students know about fish, fishing, fisheries, overfishing, and any related topics. Encourage students to discuss what connections people have to fish, for example as a food source, tourism and recreation, industry, etc. Be sure students discuss connections that are not about the consumption of fish, e.g. aquariums, snorkeling, etc. This conversation will begin to frame the chapter focus, looking at resource use and human disruption of ecosystems.

**Doing the Activity**

2. **Students analyze information about purchasing fish.** (20 minutes)
   
a. Have the students complete the Procedure.

   Note that there is no “best” or “correct” choice, rather the students should be able to rationalize their choice based on the evidence from the chart.

   Students may not initially conclude that the label colors on the fish indicate the health of the fishery. During the class discussion in Step 4 first give students the opportunity to offer up their ideas about the color-coding system. As part of this discussion, have the students discuss what biotic and abiotic factors might affect fisheries, and what role humans might have in controlling (or not controlling) their effect on fisheries. Then explain to them that for the past several decades, scientists, fishers, and concerned citizens have been working together to develop systems that rate the health status of a fish population. Once they determine a rating, that information is shared with the public so that people who are buying fish to cook at home or in restaurants know if they are buying fish that are coming from a healthy population. One method for categorizing the health of a fish population is to label the fish red, yellow, and green, just like the colors on a traffic light. If a fish population is in the red category it is being overfished, yellow means the fish population is doing ok but there are still some concerns, and green means the size of the fish population is healthy. The red snapper that Sara looked at in the grocery store used to be categorized as red, because the population was severely overfished. In 2013 the red snapper was moved into the yellow category. Students will learn more about this, in particular for the Pacific halibut, red snapper, and orange roughy fisheries, in the activities that follow.
Follow-Up

3. **The class discusses factors to consider when purchasing fish.** (15 minutes)

   a. Conclude the class with a class discussion about the Analysis questions.

   Analysis question 3 examines what factors to consider when deciding what fish to purchase. Consider closing class with a discussion of all of the Analysis questions, or just Analysis question 3, as time permits. This is a good point to introduce the term criteria, which will be used in subsequent activities and chapters. In this activity, the criteria concern the health of the fishery. For example, scientists might consider a fishery healthy if it meets the criteria of not decreasing more than 5% from a target population level. Another example of criteria for determining the health of the population might be that the geographic range of where the fish are found does not decrease more than 3% year to year. If student responses to the question focus primarily on choosing fish based on taste, encourage them to discuss other factors that might be relevant such as cost and the current state of the fishery. This is also a good point to have them add the term overfished to the class word wall.

4. **Preview the chapter and revisit the Guiding Question.** (10 minutes)

   a. Preview the chapter with the students.

   Use the Chapter Overview to guide you as you preview the rest of the chapter with the class. Tell students the guiding question for the chapter, “How do environments change when resources are used up?” Write this question on chart paper, a board, or some other location where it can be seen by the students as the class works through the rest of the chapter. Be sure to refer back to the question at appropriate points in subsequent activities. Briefly preview the content they will be learning including the disciplinary core ideas, crosscutting concepts, and science and engineering practices they will use to build conceptual understanding.

   Explain to the students that they have two main learning goals for this chapter:

   1. to investigate how human fishing is affecting the resource availability for other organisms and populations of organisms in ecosystems through the scientific practices of analyzing and interpreting data, and,

   2. constructing an argument supported by scientific evidence. In order to develop their arguments they will also be engaging in the scientific practice of constructing explanations.

   The guiding question, “What factors should you consider when purchasing fish to eat?” is the same as Analysis question 3.
1. **How might the health of a fish population affect the ecosystem where the fish lives?**

   An unhealthy fish population might have a negative effect on the food web for that ecosystem. For example, if the fish is a prey species for a shark, the sharks wouldn’t have as much food to eat so the shark population would decrease. It might also mean that whatever the fish eats, like plankton, would increase.

2. **Is it important to monitor the health of fish populations? Why or why not?**

   It is important to monitor the health of fish populations because they are part of the ecosystem and food web. If one population in a food web is unhealthy it can affect the whole food web.

3. **What factors do you think are important to consider when deciding what fish to purchase? Explain your answer.**

   **Assessment – CNOS**
   Use this question as an initial, informal assessment on students’ ideas about the connection to the nature of science, science knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.

   When you are deciding what fish to purchase, it is important to consider how much it costs, how healthy the fish is for you, and if you like the flavor of that fish. These three factors are about your personal needs and preferences. It may also be important to consider if the population of that fish is being overfished, because that can lead to bigger problems in the ecosystem that the fish lives in.
More Information

Key Vocabulary

When words are formally defined in an activity, they appear in bold type in the Key Vocabulary list in the Teacher’s Guide and in the Student Book. During informal and formal discussions listen for these words to see if students are applying them correctly. Encourage students to use these words when they speak in class and when answering the Analysis questions. Decide how you will support students’ understanding of the vocabulary—perhaps with a student glossary or setting up a word wall in the classroom. Whenever appropriate, discuss familiar words with similar roots. For ELLs, and even native English speakers, explore how scientific meanings of words such as compete and host may be different from their everyday meanings. If you have many Spanish-speaking students, ask them to help point out roots of words or words that have the same or similar spelling and meaning in both English and Spanish.

Other relevant scientific words that are not considered key vocabulary for this chapter aren’t related to the primary learning goals, but you might need to clarify them for students. In this activity, you might need to explain that a species is a specific type of organism, such as a wolf or a coyote, without going into the complete definition of species.
Activity 3.1

Engage: Shopping for Fish

Teaching Summary

Getting Started

1. Facilitate a class discussion to determine what the students know about fishing. (15 minutes)
   a. Have students read the introduction as a class read aloud or in pairs.

Doing the Activity

2. Students analyze information about purchasing fish. (20 minutes)
   a. Have the students complete the Procedure.

Follow-Up

3. The class discusses factors to consider when purchasing fish. (5 minutes)
   a. Conclude the class with a class discussion about the Analysis questions.

4. Preview the chapter and revisit the Guiding Question. (10 minutes)
   a. Preview the chapter with the students.
Going Fishin’

Can fishing limits prevent the overuse of an ecosystem?

Students explore how fishing limits can change the effect of human natural resource use, and examine how changes to the surrounding ecosystem can be a compounding factor. This allows students to investigate their initial ideas about natural resource use and about how multiple factors can affect populations.

Rationale and NGSS Integration

This activity provides students with an opportunity to engage in the science and engineering practice of analyzing and interpreting data that they have generated via their investigation. The activity looks at overfishing, which ties back to the introduction of the concept in the Engage activity they just completed. The crosscutting concepts of cause and effect and the consequences of human activity are embedded throughout the activity, as are the disciplinary core ideas of the dependence of populations on environmental interactions, and the impact of increasing human populations on the Earth. Ideas and concepts that students develop in this activity will lead into the next where they will analyze data from actual fisheries.

Activity Overview

In this Explore activity, students model natural resource consumption and overuse through a game that models fisheries. Each round of the game has different fishing limits. In the first game students are able to overfish the available fish populations. In the second game the fishing limits are set such that the fish populations are able to survive and increase. In the third game students model the effect of changes in ecosystem conditions.
Materials and Advance Preparation

For each group of four students

- 100 fish crackers (orange)
- 30 fish crackers (yellow or color other than orange)
- tray or dish
- set of 4 Game A Character Cards
- set of 4 Game B Character Cards
- set of 4 Ecosystem Disruptions Cards
- timer that beeps

Count the fish crackers into plastic zip-top bags ahead of time. If students have access to smart phones with a stopwatch feature that can be set to beep when an allotted time has been reached, they may be used for this activity. Otherwise, provide timers that beep when the allotted time has been reached.

For each student

- Handout 3.2-1, “Populations Over Time”
- 1 pair of chopsticks**
  (**You may want to have some plastic spoons available for activity modification. See Teaching Suggestions, Doing the Activity, for more information.)
- cup
- paper towel

Safety Note

Make sure students do not consume the fish crackers. Check with your students in advance to see if any of them have severe food allergies, such as a nut allergy, to be sure the food products being used will not cause any allergic reactions.
Teaching Summary

Getting Started

1. Introduce the game to the students.

Doing the Activity

2. Students play four rounds each of Game A, Game B and Game C.

Follow-Up

3. Facilitate a class discussion about the game as a model of fisheries.
4. Revisit the Guiding Question.

Teaching Suggestions

Getting Started

1. **Introduce the game to the students.** (10 minutes)
   a. Read the brief introduction aloud to the whole class.

   Review the materials for the activity and the flow chart with the instructions for the game. Show students one model round, and how to make fish reproduce at the end of each round (if there are any fish left). Make sure students understand how to record their data on Handout 3.2-1, “Populations Over Time”. Make sure students also understand that after four rounds of Game A they reset the entire game (go back to 100 orange fish and 30 yellow fish) before they begin Game B.

   You may wish to only pass out the Character Cards for Game A initially, reserving the Game B cards until students show you their completed data tables for Game A and that they have properly reset the game for Game B, and the same for Game C.

Doing the Activity

2. **(Assessment) Students play four rounds each of Game A, Game B and Game C.** (25 minutes)
a. Have students play Game A.

The game is designed to work with four students. If there are five students per group have one student act as the group timer and data recorder. Try to maximize the number of four-person groups in the class. Groups of three will likely not have the desired outcomes for the game. Note that each game focuses on the following:

<table>
<thead>
<tr>
<th>Game</th>
<th>Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Effects of no fishing limits</td>
</tr>
<tr>
<td>B</td>
<td>Effects of sustainable fishing limits</td>
</tr>
<tr>
<td>C</td>
<td>Effects of environmental disruptions on fisheries with “sustainable” fishing limits</td>
</tr>
</tbody>
</table>

For more suggestions on group work, see the More Information section that follows the Suggested Answers to Analysis Questions at the end of this activity.

As they are working, observe each group to make sure the students who are not as well-practiced with chopsticks are engaged. If students have not caught enough fish to continue in Game A, they can practice with their chopsticks on the side, or they can serve as the group data recorder. If necessary, explain to students that having varying abilities with the chopsticks is a good model of fishing. Some fishers have the most modern equipment in top condition that allows them to catch as many fish as are available, while others may have older equipment. If you have students who are extremely frustrated, or who have trouble with fine motor skills, you may wish to provide them with a plastic spoon in place of the chopsticks, but this should be in very limited circumstances and these students should still only be allowed to use the spoon (and not the cup or their fingers) to catch one fish at a time.

b. Check student results and have them move to Games B and C.

When students finish Game A be sure they fill out their data tables and discuss the questions in Step 5 before proceeding to Game B. Results will vary by group, but most groups will run out of fish in Game A. If Game B is played according to the instructions there should be more yellow and orange fish at the end of the game than at the beginning. See the sample student response for Handout 3.2-1, “Populations Over Time” at the end of this Activity. The results for Game C should vary significantly
Activity 3.2

depending on which cards are drawn. Some groups may see very little effect from changes in the environment, while others may see dramatic changes in their fish populations.

Depending on how quickly students are able to complete the Games, you may wish to teach this activity over two class periods. If so, conclude the first period after students have completed at least one full game. Do not stop in the middle of a Game.

Use the students’ answers to the questions at the end of each game (Steps 5, 6, and 8) to informally assess their analysis and interpretation of the data from the games, their initial understanding of the core idea of the dependence of populations on environmental interactions, and cause and effect relationships. This is also a good point to have students reflect on what they learned in previous chapters about ecosystem interactions and how those interactions come into play when humans are using a natural resource, such as fish.

Follow-Up

3. Facilitate a class discussion about the game as a model of fisheries. (10 minutes)
   a. Have a class discussion about what happened in the three games.

   Have student groups share the results of the three games, including what Ecosystem Disruptions Cards they drew and how it affected their fisheries. Have them discuss if their predictions for each game were accurate. In order to prevent groups repeating similar findings, consider having one group share and then other groups add new or different findings if they had them. Have students discuss how these games modeled fisheries, and what limitations there were with the models. Students will expand on these points in the Analysis questions. Analysis questions 3 and 4 provide opportunities to connect back to Chapter 2 where students engaged in the practices of developing models to predict and/or describe phenomena and to describe unobservable mechanisms.

4. Revisit the Guiding Question (5 minutes)
   a. Conclude the class with a discussion about the Guiding Question, “Can fishing limits prevent the overuse of an ecosystem?” based on the data students gathered in the activity.

   This discussion will segue into the next activity where students will be looking at data and text passages about three fisheries with different approaches to fishing limits. Have students add to the crosscutting
concepts poster for cause and effect, which relates to the core of this activity. Ask the students how scientists might think about the challenges fisheries face in terms of cause and effect. Students will likely suggest that the limits humans set on fisheries can affect the health of the fish populations in an ecosystem. They will also likely bring up that external factors, such as changes in the ecosystem like a plankton die-off, can also affect the health of the fish populations.

Suggested Answers To Analysis

1. **Describe the three games and what happened to the two fish populations over time in each game.**

   In Game A, we had no fishing limits on anyone. Even though Sam only caught one fish in Round 1 and couldn’t keep fishing, the rest of us caught so many fish that the fish were all gone by the end of Round 2. In Game B we all had a fishing limit of 3 orange fish per round. Everyone caught enough fish to survive and at the end of the game there were more orange and yellow fish than there were at the beginning. In Game C we had a plankton die-off and unusual warm weather, both of which meant fewer fish, and by the end of Round 4 we had almost no fish in Blue Bay.

2. **How did the reproduction of the fish (adding one fish for every live fish at the end of each round) affect fish population levels? Explain.**

   In Game B, when we weren’t catching too many fish, the reproduction of the fish meant that the fish we did catch got replaced, and the population even grew. But in Game A we had no limits and the fish did not reproduce fast enough to make up for the fishing so the populations disappeared. In Game C we had two ecosystem disruptions that limited reproduction of our fish, which meant we had almost no fish left by the end of Round 4.

3. **How was the effect of humans modeled in this activity?**

   The effect of humans was modeled in this activity by us pretending to be fishermen that were catching the fish and by us setting and following fishing limits.

4. **What is missing from this model?**

   This model was missing other abiotic and biotic factors affecting the fish populations, like pollution or predators and prey in the ecosystem.
More Information

Group Work

This unit assumes that students work in pairs and small groups (usually four students) to engage in the practices of science. You may wish to explain your expectations for working together as a group and emphasize the role of collaboration in science and engineering. If you wish to model productive group interactions (both agreement and constructive disagreement), the Group Interaction Student Sheet 1, “Developing Communication Skills,” provides sentence starters you can model and students can use to facilitate discussion. This Student Sheet is in the Teacher Resources section.
Activity 3.2

Explore: Going Fishin’

Materials and Advance Preparation

For each group of four students

- 100 fish crackers (orange)
- 30 fish crackers (yellow or color other than orange)
- tray or dish
- set of 4 Game A Character Cards
- set of 4 Game B Character Cards
- set of 4 Ecosystem Disruptions Cards
- timer that beeps

Count the fish crackers into plastic zip-top bags ahead of time. If students have access to smart phones with a stopwatch feature that can be set to beep when an allotted time has been reached, they may be used for this activity. Otherwise, provide timers that beep when the allotted time has been reached.

For each student

- Handout 3.2-1, “Populations Over Time”
- 1 pair of chopsticks**
  (**You may want to have some plastic spoons available for activity modification. See Teaching Suggestions, Doing the Activity, for more information.)
- cup
- paper towel

Safety Note

Make sure students do not consume the fish crackers. Check with your students in advance to see if any of them have severe food allergies, such as a nut allergy, to be sure the food products being used will not cause any allergic reactions.
Teaching Suggestions

Getting Started

1. Introduce the game to the students. (10 minutes)
   a. Read the brief introduction aloud to the whole class.

Doing the Activity

2. (Assessment) Students play four rounds each of Game A, Game B and Game C. (25 minutes)
   a. Have students play Game A.
   b. Check student results and have them move to Games B and C.

3. Facilitate a class discussion about the game as a model of fisheries. (10 minutes)
   a. Have a class discussion about what happened in the three games.

4. Revisit the Guiding Question. (5 minutes)
   a. Conclude the class with a discussion about the Guiding Question, “Can fishing limits prevent the overuse of an ecosystem?” based on the data students gathered in the activity.
Three Fisheries

What effect have humans had on the health of fisheries?

Students transition from analyzing their own data about a fictitious fishery to an analysis of long-term data from three real fisheries. Students use this analysis to develop an initial explanation about humans’ effect on fisheries and a formal argument about the health of one fishery.

Rationale and NGSS Integration

Students analyze and interpret data in order to investigate the effect of humans on three fisheries. Students use this analysis to develop a general, preliminary explanation of human effects on fisheries as a natural resource. Students then move into constructing a formal argument about the health of one fishery at a specific point in time. Interpreting the long-term, real-life data in this activity provides students with a deeper understanding of the core ideas of competition for resources within ecosystems and how human populations can impact Earth’s resources if actions are not engineered otherwise. This helps to deepen their understanding of natural resource use and overuse, building on what they have learned in the two previous activities. It also prepares them to transfer this knowledge into a new setting with a different challenge in the next activity.

Activity Overview

In this Explain activity, students analyze data about three fisheries. They then use the data to try and identify the fisheries based on short text passages that describe each fishery, including their historical and current fishing limits and practices, and key regulation dates. Students use their analysis to construct an argument about the health of a fishery.
Activity 3.3

Materials and Advance Preparation

For the teacher
- Scoring Rubric: Developing Arguments

For each student
- Argument Tool

Teaching Summary

Getting Started
1. Student pairs discuss the effects of humans on fishery health.

Doing the Activity
2. Student pairs analyze data on fisheries and match the data with text descriptions.
3. The class develops a preliminary explanation of human effects on fisheries.

Follow-Up
4. Students construct a scientific argument about the health of one fishery.
5. Revisit the Guiding Question.

References
Teaching Suggestions

Getting Started

1. **Student pairs discuss the effect of humans on fishery health.** (10 minutes)
   
   a. Have students share ideas on what a “healthy” fishery is.

   Briefly have students offer suggestions for what it mean to be a “healthy” fishery. Encourage them to consider what they have learned in the previous activities. Record their ideas to revisit later in the activity.

   b. Have student pairs read the introduction and Guiding Question, then complete Step 1.

   Do not have a class discussion at this point, as students will use their discussion with their partners from this step to frame the rest of the activity and their explanations at the end of the activity.

Doing the Activity

2. **(Assessment) Student pairs analyze data on fisheries and match the data with text descriptions.** (30 minutes)
   
   a. Have the students work in pairs to analyze the graphs.

   Depending on their level of comfort with analyzing line graphs, students may need support to analyze the data. Remind students to look for patterns in the data, to look at when the line changes direction and if it goes up, down, or stays relatively flat. You may also want to point out that while the x-axes (year) are all the same, the y-axes (total catch) have different scales. The total catch for Species A is much smaller (between 2 and 42 thousands of kilograms) per year and over time than the other two species. If appropriate, review one graph as a class, and then have students continue the analysis working in pairs.

   b. Have student pairs match graphs to text descriptions.

   If students are unable to match the graph with the fishery, have them use the process of elimination with the three graphs and the text descriptions. They should be able to easily identify the orange roughy graph (Species A), as the catch for this species has dropped dramatically with no sign of recovery. To help them distinguish between the Pacific halibut (Species B) and red snapper (Species C), encourage them to look
at which population seems to have stayed steady, as the Pacific halibut fishery is described in the text, and which has decreased but seems to be recovering toward the end of the graph, as one would expect with the new regulations for the red snapper that were instituted in 2007.

Note that students’ answers may differ for Step 6 based on what they think defines a healthy fishery. As long as the students’ reasoning is sound and consistent, accept their answers. Generally, the Pacific halibut fishery is considered a healthy (green label/category) fishery by scientists and industry. The red snapper has recently been moved from the yellow label/category to the green label/category by most organizations that analyze the fisheries, due to the stricter fishing regulations and apparent beginning of the recovery of the fishery. Orange roughy is considered a red label/category fish by all organizations that analyze fisheries, due to the population crash and lack of regulations on the fishery.

Steps 2 – 5 provide an opportunity to assess students’ analysis and interpretation of the data in the activity. Step 6 can be used to assess the students’ understanding of connections to engineering, technology and applications of science.

3. **(Assessment) The class develops a preliminary explanation of human effects on fisheries.** (10 minutes)

a. The class discusses how humans affect different fisheries.

This step provides the students the opportunity to develop a general, informal explanation of how humans affect different fisheries. Students should be able to explain that the effects differ depending on the fishery, limits enforced by the fishers, and by other factors such as how long it takes the fish to reproduce. This is a good opportunity to informally assess students’ current level of skill with developing explanations. Students will use this informal explanation to support their construction of a scientific argument in Step 9.

This is a good point to conclude the first class session.

b. Students analyze more data on the Pacific halibut fishery.

Part B has students analyze data on the average mass of Pacific halibut during three years. Students may need support in their initial analysis of the graph. If necessary, point out that the graph shows the average mass per fish, not whole catch. Have students pick one age and one sex to analyze first. For example, have them look only at 14-year-old female halibut. Students should notice that these halibut were, on average,
much smaller in 2014 than in previous years. This trend is true for both sexes and all ages on the graph, although it is less pronounced in males and younger females. Scientists generally consider this to be a possible sign of pressure from fishing, as larger fish are often more “desirable” catch, although other factors may be causing, or influencing, this trend.

Follow-Up

4. (Assessment) Students construct a scientific argument about the health of one fishery. (40 minutes)

   a. Introduce and use the Argument Tool

   Show students the Argument Tool and discuss the various sections of the tool. Because this is the first time the students have used the tool, you may want to do the first few sections as a class, have the students complete the tool in pairs, or provide other support as needed. See the More Information section at the end of this activity for more details about using this tool.

   You may wish to use this as an opportunity to assess students’ developing skills with analyzing and interpreting data. You can also use this as a point for an informal, baseline assessment of their skills with constructing a scientific argument, a practice they will be utilizing throughout the rest of the chapter. A sample answer for this argument is provided in the Handouts section of the Teacher’s Guide.

5. Revisit the Guiding Question. (10 minutes)

   a. The guiding question, What effect have humans had on the health of fisheries? is the focus of the informal explanation students develop in Step 7, however, students’ opinions may have changed after completing the argument in Step 9.

   Have students share their thoughts and opinions. At this point in the chapter, students should have a basic understanding of the idea that the effect humans have on the health of fisheries depends largely on how those fisheries are regulated. Have the class review their ideas of what makes a healthy fishery from the beginning of the activity, and adjust the list if applicable. Students may wish to add to the crosscutting concept poster for cause and effect, depending on how much their ideas have changed from the previous chapter.
Suggested Answers To Analysis

1. Give two examples of criteria scientists might use to determine if the Pacific halibut fishery is healthy.

   Scientists might consider the size of the fish population. They might also consider the average size of fish and if that is decreasing or staying the same.

2. Why might scientists want to look at more than one type of data to determine the health of the fishery?

   Scientists should look at more than one type of data to determine the health of the fishery because it gives them a better overall picture of how healthy the fish population is. For example, if they only looked at how many fish were caught and that number stayed the same it might seem like the fish population was healthy even if over time all of the older, larger fish were being caught and only small, young fish were left.

More Information

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 they 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 orange roughy fishery is healthy. I think the problem with this argument is that the data clearly shows that the orange roughy population has decreased to almost zero and there are no data showing any positive changes.
Activity 3.3

*Explain: Three Fisheries*

**Materials and Advance Preparation**

**For the teacher**

- Scoring Rubric: Developing Arguments

**For each student**

- Argument Tool

**Teaching Suggestions**

**Getting Started**

1. **Student pairs discuss the effect of humans on fishery health.** (10 minutes)
   
   a. Have students share ideas on what a “healthy” fishery is.
   
   b. Have student pairs read the introduction and Guiding Question, then complete Step 1.

**Doing the Activity**

2. **(Assessment) Student pairs analyze data on fisheries and match the data with text descriptions.** (30 minutes)
   
   a. Have the students work in pairs to analyze the graphs.
   
   b. Have student pairs match graphs to text descriptions.

3. **(Assessment) The class develops a preliminary explanation of human effects on fisheries.** (10 minutes)
   
   a. The class discusses how humans affect different fisheries.
   
   b. Students analyze more data on the Pacific halibut fishery.
Follow-Up

4. (Assessment) Students construct a scientific argument about the health of one fishery. (40 minutes)
   a. Introduce and use the Argument Tool

5. Revisit the Guiding Question. (10 minutes)
Dead Zones

How do humans affect the size of dead zones?

Students expand on their understanding of human disruption of ecosystems by looking at a more complex problem: the creation and expansion of dead zones. Students use their analysis of a variety of data to inform a debate on limiting human use of fertilizers to prevent dead zones.

Rationale and NGSS Integration

This Elaborate activity challenges students to apply their understanding of the core ideas of population dynamics and resource use, as well as human impacts on Earth, to the issue of dead zones. Students use what they have learned in the previous activities about population limits in ecosystems to analyze a more complex situation where both biotic and abiotic factors are being changed. This provides students an opportunity to expand their understanding of the complexity of stability and change, how that concept relates to the interactions and relationships in an ecosystem, and how they can be affected by changes in abiotic and biotic factors.

Activity Overview

In this Elaborate activity, students analyze data about nitrogen input, streamflow, and the size of dead zones. They use this data and additional evidence from a video to construct an explanation about the effect of these factors on the size of the dead zone in the Gulf of Mexico. They then gather additional evidence from a short reading to inform a debate on fertilizer use and dead zones.
Key Vocabulary

dead zone

Materials and Advance Preparation

For the teacher

- Access to computer with Internet connection

  The video clip, “Big River: A King Corn Companion | Agricultural Runoff and the Gulf of Mexico Dead Zone,” is available from PBS Learning Media. You may need to register for a free account to access the video. A direct link to the segment follows.

  http://ca.pbslearningmedia.org/asset/envh10_vid_deadzone/

- 1 large computer monitor or projector

For each student

- Explanation Tool

Teaching Summary

Getting Started

1. Introduce the concept of dead zones.

Doing the Activity

2. Students investigate the effects of abiotic factors on the size of dead zones.

3. Students construct an explanation for the effect of water flow on nitrogen input.

Follow-Up

4. Facilitate a class debate about fertilizer use and dead zones.

5. Revisit the Guiding Question.
References


Teaching Suggestions

Getting Started

1. **Introduce the concept of dead zones.** (10 minutes)

   a. Have students read the introduction independently, in pairs, or as a class.

   Review the map of the Mississippi Watershed with the students, making sure they understand that the entire watershed, including all of the fertilizer run-off from all of the farms, drains into the Gulf of Mexico (because water flows downhill). You may need to explain to students that most organisms that live under water get their oxygen from the dissolved oxygen in the water (not from the air). Note that the key vocabulary term, dead zone, is defined in the introduction as an area in a body of water where the water at the bottom has little or no dissolved oxygen. Have a short class discussion about how dead zones are created, based on the information given in the introduction. Students will learn more about this in the activity.
**Activity 3.4**

**Doing the Activity**

2. **Students investigate the effects of abiotic factors on the size of dead zones.** (25 minutes)
   
a. Show the students the video segment on the dead zone in the Gulf of Mexico.

   Ask the students to list any new information they have learned from the video, listing the students’ answers on the board for them to reference.

   
b. Have students work in groups of four to analyze and interpret the graph in Step 3.

   You may need to work with individual groups, or the class as a whole, to help them understand the graph in Step 3 with two y-axes. Students should come to the conclusion that nitrogen input and water flow from the Mississippi Basin to the Gulf of Mexico are fairly closely correlated. Ask students why they think the correlation is not perfect. Students should be able to suggest additional factors affecting nitrogen input such as changes in fertilizer use by farmers upstream, storms and other weather conditions affecting when and how much water flows at different times of year, etc.

3. **Students construct an explanation for the effect of water flow on nitrogen input.** (15 minutes)
   
a. Have students use the Explanation Tool to construct their explanations.

   Depending on the class, you may wish to encourage students to try constructing their explanations without the scaffolding of the Explanation Tool, or to give individual students that option.

   This is a good point to conclude the first class period for the activity.

**Follow-Up**

4. **Facilitate a class debate about fertilizer use and dead zones.** (40 minutes)
   
a. Have the students analyze data on dead zone size.

   Assist students as needed with analysis of the graph on the size of dead zones in the Gulf of Mexico. Students should notice that the size of the dead zone does not necessarily have a direct correlation to the nitrogen input and water flow data from the previous graph. If necessary, have a short class discussion about other factors that might affect the dead zone size (changes in temperature, currents in the Gulf of Mexico, storms or other weather events that affect the Gulf, etc).
b. Have students complete the reading on the Gulf of Mexico dead zone.

Have students complete the reading in pairs or groups. Students should note from the data table in the reading that a majority of the nitrogen input in the Gulf of Mexico is from human-made sources.

c. Have the class conduct a Walking Debate to debate the question “Should fertilizer use be limited to help prevent dead zones?”

See the More Information section at the end of this activity for more details on how to conduct a Walking Debate. Designate one area of the room as “limit fertilizer use” and a second area as “do not limit fertilizer use.” If students are not relatively equally distributed at the beginning of the debate you may choose to assign them a viewpoint. For example, you could assign half the class to take the position they think a fisher would take, and half to take a farmer’s position. This debate provides an opportunity to evaluate students understanding of the connection to the nature of science crosscutting concept, science knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. This is also a good time to briefly introduce the idea of constraints on potential solutions, an important concept in Chapter 5. Have student suggest possible solutions to the problem of dead zones, then ask what the limitations, or constraints, are on those solutions. For example, the solution of not using any fertilizer means farmers will not be able to grow as many crops and will make less money.

Note that for Analysis question 3, students may need some scaffolding to construct their answers. You may wish to draw a template on the board for students, with four numbered panels. Note the sample student response in the Suggested Answers to Analysis section.

5. Revisit the Guiding Question. (5 minutes)

a. Revisit the guiding question, how do humans affect the size of dead zones?

At this point students should understand that the effect of humans on the size of dead zones is not entirely straightforward, but that there clearly is an effect due to human use of fertilizers. Have students add this example to the crosscutting poster for cause and effect if they have not done so already, as well as the phrase “dead zone” to the class word wall.
Suggested Answers To Analysis

1. What are the abiotic and biotic factors that are affected in a dead zone? How do they differ from a healthy ecosystem?

   Assessment – DCI and CCC
   Use this question to assess students’ understanding of the core idea of population dependence on environmental interactions (DCI – MS LS2.A.1) and cause and effect (CCC).

   In a dead zone abiotic factors that are affected include oxygen levels and the amount of nitrogen. The oxygen levels are much lower than in a healthy ecosystem and the nitrogen levels are much higher. The biotic factors that are affected are the amount of plankton, bacteria, and fish and other organisms. The plankton increase because of the higher nitrogen levels. When the plankton die they feed the bacteria, which increase and consume more oxygen. This causes the fish and other organisms to either die or leave the ecosystem. When nitrogen levels are lower, plankton remain at lower level, oxygen levels increase, and fish populations increase.

2. How might an increase in the size of the dead zone in the Gulf of Mexico affect the red snapper fishery, or other fisheries?

   Assessment – DCI and CCC
   Use this question to assess students’ understanding of the core ideas of population dependence on environmental interactions and how the increase of human populations affects the Earth (DCI MS ESS3.C.2) and cause and effect (CCC).

   An increase in the dead zones might cause a decrease in the red snapper fishery, or other fisheries in the Gulf of Mexico, because there would not be enough oxygen for the fish to survive. This would mean fewer fish, and that the fishermen would not have as much to catch so they would make less money.
3. Draw a diagram with four panels showing the main stages in the creation of a dead zone. The panel below[see student book] is an example of what the fourth panel in your diagram might look like. Include a caption for each panel that explains what is happening in the diagram.

Panel 1: Nutrients in the water, like nitrogen, increase from runoff from farms

Panel 2: Plankton population increases. As they die they sink to the bottom.

Panel 3: An increase in dead plankton causes an increase in bacteria (decomposers).

Panel 4: Increased bacteria populations use up the oxygen, causing fish and other organisms to die or leave the ecosystem.

More Information

Walking Debate

A walking debate allows students to express their opinions about an issue by moving from one area of the room to another. Each area represents a certain side of an issue. Students select an area to stand in based on the side of an issue they agree with. The “sides” then discuss the issue and present their arguments to the other groups. Students can opt to change their location if the presentations given change their opinions about the issue.

In asking students to choose a position and stand in the corresponding area of the room, the Walking Debate requires students to physically commit to a position. This serves several purposes. First, it requires that students take a position. Secondly, students will more clearly see the distribution of thoughts, ideas, or opinions among their classmates. Walking Debate allows students yet another way to practice identifying evidence and reasoning in a group setting, which is an important component of scientific argumentation.

Begin by identifying the question or issue that is being debated, and designate different parts of the classroom as representing certain points of view. For example, for the question “Has the zebra mussel had a positive or negative effect
on the Hudson River ecosystem?" one area of the room would be designated as the “positive” area and another the “negative” area. Students walk to the area that best represents their point of view and talk within that group to come up with a convincing argument to bring people from other areas to their own area. The groups make their presentations, students ask questions of the other groups, and those who change their minds move to the area that represents their final position. Over the course of one activity, several activities, or a unit, the class may encounter more evidence related to the debate issue. If the first Walking Debate was successful, the teacher might give students a chance to repeat the debate and decide if they will change positions. It is helpful to have students keep a record of the evidence they will consider for the Walking Debate, especially when they are new to the strategy. Have students record their evidence on an index card to which they can easily refer during the debate. Students might do this in pairs when they are becoming familiar with the strategy.
Activity 3.4

Elaborate: Dead Zones

Materials and Advance Preparation

For the teacher

- Access to computer with Internet connection
  
  The video clip, “Big River: A King Corn Companion | Agricultural Runoff and the Gulf of Mexico Dead Zone,” is available from PBS Learning Media. You may need to register for a free account to access the video. A direct link to the segment follows.
  
  http://ca.pbslearningmedia.org/asset/envh10_vid_deadzone/

- 1 large computer monitor or projector

For each student

- Explanation Tool

Teaching Suggestions

Getting Started

1. Introduce the concept of dead zones. (10 minutes)
   
   a. Have students read the introduction independently, in pairs, or as a class.

Doing the Activity

2. Students investigate the effects of abiotic factors on the size of dead zones. (25 minutes)
   
   a. Show the students the video segment on the dead zone in the Gulf of Mexico.

   b. Have students work in groups of four to analyze and interpret the graph in Step 3.

3. Students construct an explanation for the effect of water flow on nitrogen input. (15 minutes)
   
   a. Have students use the Explanation Tool to construct their explanations.
Follow-Up

4. Facilitate a class debate about fertilizer use and dead zones. (40 minutes)
   a. Have the students analyze data on dead zone size.
   b. Have students complete the reading on the Gulf of Mexico dead zone.
   c. Have the class conduct a Walking Debate to debate the question “Should fertilizer use be limited to help prevent dead zones?”

5. Revisit the Guiding Question. (5 minutes)
   a. Revisit the guiding question, how do humans affect the size of dead zones?
Chesapeake Bay Oysters

How do increases in the human population affect the resources available to organisms?

Students conclude the chapter with an investigation that examines the effects of fishing and dead zones on the Chesapeake Bay Oyster fishery. This allows for the evaluation of students’ understanding of the effects of resource availability on organisms and populations of organisms as well as how increases in the human population impact the Earth’s systems. This also prepares them to investigate another complex ecosystem disruption, invasive species, in the next chapter.

Rationale and NGSS Integration

This Evaluate activity concludes the chapter with an investigation of data on the Chesapeake Bay oyster fishery, which has been affected by both overfishing and dead zones. Students analyze and interpret data to provide evidence for an argument focused on if the increase in the human population in the Chesapeake Bay area is affecting the oysters in the Bay. This allows students to bring together multiple practices and crosscutting concepts while demonstrating their understanding of content and performance expectations for the chapter.

This Evaluate activity draws together the three dimensions of the NGSS that support the two performance expectations that are the focus of this chapter.

Activity Overview

In this activity, students learn about the Chesapeake Bay ecosystem and the oyster harvests in the Bay. They analyze and interpret data about the nitrogen run-off, dead zone size, and oyster harvests to develop an argument about the effect of the human population on the Chesapeake Bay oysters.
Activity 3.5

Materials and Advance Preparation

For the teacher

☐ Scoring Rubric: Developing Arguments

For each student

☐ Argument Tool

Teaching Summary

Getting Started

1. Students learn about the ecosystem and oyster fishery in Chesapeake Bay.

Doing the Activity

2. Students analyze data on dead zones in Chesapeake Bay.

Follow-Up

3. Students develop an argument about the effect of increasing human populations on the Chesapeake Bay oyster harvest.

4. Revisit the Guiding Question.

References


Teaching Suggestions

Getting Started

1. **Students learn about the ecosystem and oyster fishery in Chesapeake Bay.** (20 minutes)
   a. Have student pairs read the introduction and complete Steps 1 through 3.
      Be sure students review the map, and that they understand the graph in Step 1.
   b. Have a class discussion about students’ predictions.
      Discuss students’ predictions of how the oyster population change might affect other organisms in the ecosystem. Student responses will vary depending on which organisms they chose to focus on in Step 2, but ultimately all students should conclude that as the oyster population decreases there is less competition for organisms similar to the oyster, but also that there will be increased pressure from predators on those organisms. For example, the food web shows two predators of the eastern oyster – the blue crab and sea ducks. With fewer eastern oysters available the pressure on the softshell and hardshell clams will be increased as the blue crab utilizes more of an alternative food source. Similarly the pressure on aquatic plants will be increased from sea ducks.

Doing the Activity

2. **Students analyze data on dead zones in Chesapeake Bay.** (20 minutes)
   a. Have student pairs analyze the graphs in Part B.
      Students should notice a clearer correlation between increased nitrogen and increased dead zone size than in the previous activity. They should also notice that increases in the dead zone correlate with decreases in the oyster harvest. If needed, point out to students that the graph in this section only shows data from 1990 to 2013, while the graph in the introduction shows data beginning in 1950. This means the graphs are on a different scale, so the fluctuations in the population levels in this graph do not necessarily indicate that the population is returning to historic levels.
      This is a good point to conclude the first class period for this activity.
Follow-Up

3. **Students develop an argument about the effect of increasing human populations on the Chesapeake Bay oyster harvest.** (25 minutes)

   a. Students develop a scientific argument around the question “Is an increasing human population in the Chesapeake Bay area affecting the number of oysters in the Bay?”

   As this is an Evaluate activity, students should construct their arguments independently, not in pairs or groups. Their arguments can also be used to assess the performance expectation “Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations in an ecosystem” and “Construct an argument supported by evidence for how increases in human population...impact Earth’s systems.” See the sample student response 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.

4. **Revisit the Guiding Question.** (15 minutes)

   a. Return to the Guiding Question, “How do increases in the human population affect the resources available to organisms?”

   It is a generalized version of the question that students use to develop their arguments in this activity. To conclude this chapter, have a brief class discussion about this question after students have completed writing their arguments.
Suggested Answers To Analysis

1. Suppose two species of fish that live in the Chesapeake Bay only reproduce during July. For the fish eggs to mature properly and hatch, there must be at least 2 mg/L of oxygen in the water. Based on the diagram below [see student book], answer the following:

   **Assessment – PE LS2-1**
   Use this question to assess students understanding of the performance expectation “Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.”

   a. **Which resources will the fish have to compete for in order to breed successfully?**
      
      *The fish will have to compete for space and for water with enough oxygen for their eggs to mature and hatch.*

   b. **What effect might this competition have on the populations of the two fish, both long- and short-term?**
      
      *In the short term this competition might mean that some fish in both populations have fewer or no offspring, depending on where they lay their eggs. In the long term it will probably affect fish species 2 the most, because their breeding zone is lower in the water where there is less oxygen. Their population will probably decrease. Fish species 1 will probably not decrease very much because only a very small portion of their breeding zone is in the area with not enough oxygen to support their eggs.*
Activity 3.5

Evaluate: Chesapeake Bay Oysters

Materials and Advance Preparation

For the teacher

☐ Scoring Rubric: Developing Arguments

For each student

☐ Argument Tool

Teaching Suggestions

Getting Started

1. Students learn about the ecosystem and oyster fishery in Chesapeake Bay. (20 minutes)
   a. Have student pairs read the introduction and complete Steps 1 through 3.
   b. Have a class discussion about students’ predictions.

Doing the Activity

2. Students analyze data on dead zones in Chesapeake Bay. (20 minutes)
   a. Have student pairs analyze the graphs in Part B.

Follow-Up

3. Students develop an argument about the effect of increasing human populations on the Chesapeake Bay oyster harvest. (25 minutes)
   a. Students develop a scientific argument around the question “Is an increasing human population in the Chesapeake Bay area affecting the number of oysters in the Bay?”

4. Revisit the Guiding Question. (15 minutes)
   a. Return to the Guiding Question, “How do increases in the human population affect the resources available to organisms?”
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