CHAPTER

3

Interactions Between Populations and Resources

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.

Red snapper (left) and orange roughy (right) are two fish often sold in fish markets.

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.

Fish Name	Cooking Notes	Cost per Pound	Label Color
Red Snapper	Mild, "nutty," sweet flavor, low in fat	$$	Yellow
Atlantic Salmon	Mild flavor, medium fat	$	Red
Coho Salmon	Medium-mild flavor, low to medium fat	$$$	Green
Albacore Tuna	Medium flavor, medium to high fat	$$	Red

3. With your partner discuss the following:
   - **a.** Based only on the information in the table, which fish would you buy?
   - **b.** What do you think the label colors mean?
   - **c.** 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.

Explore: Going Fishin'

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 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 Conditions Cards
- timer that beeps

For each student:

- Handout 3.2-1, "Populations Over Time"
- 1 pair of chopsticks
- cup
- paper towel

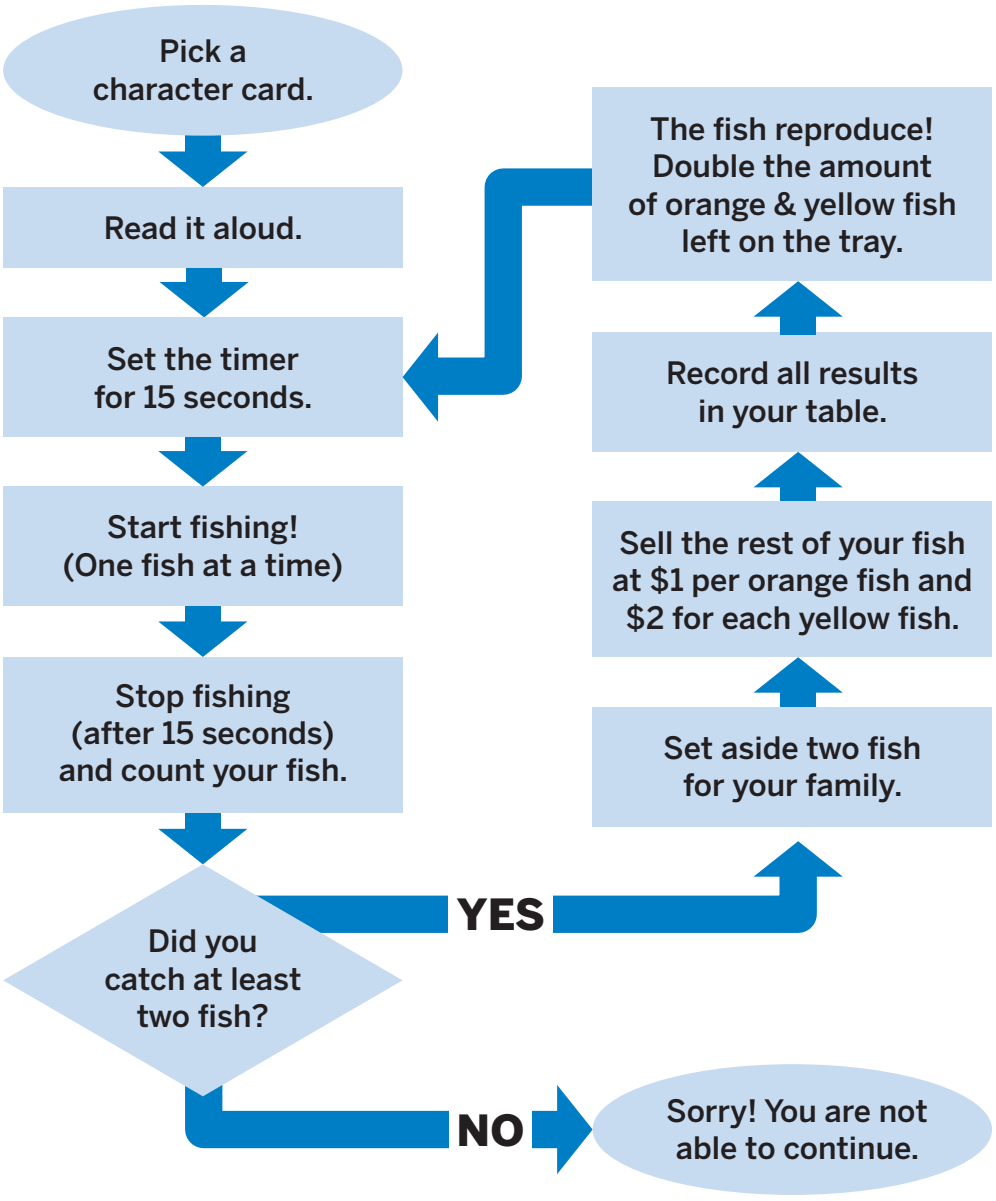
Safety ⚠

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.

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. 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.



4. 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)?
- 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

5. Play the game again, following the same rules as before. Repeat Steps 3 and 4, using Character Cards for Game B.

Part C: Changing Environmental Factors

6. 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 Conditions Card and follow the instructions during that round.

7. 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?
   - 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?

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

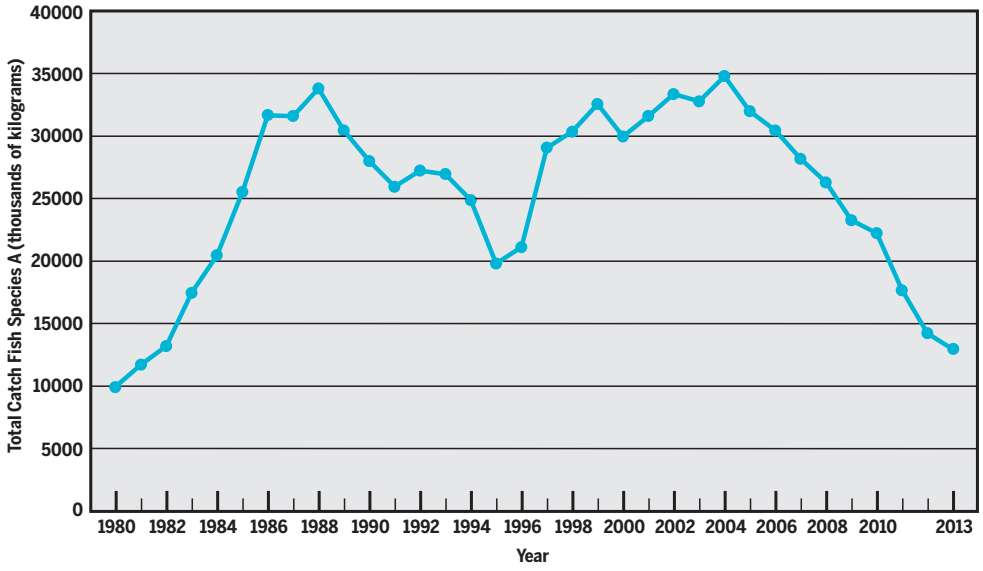
Process & Procedure

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.

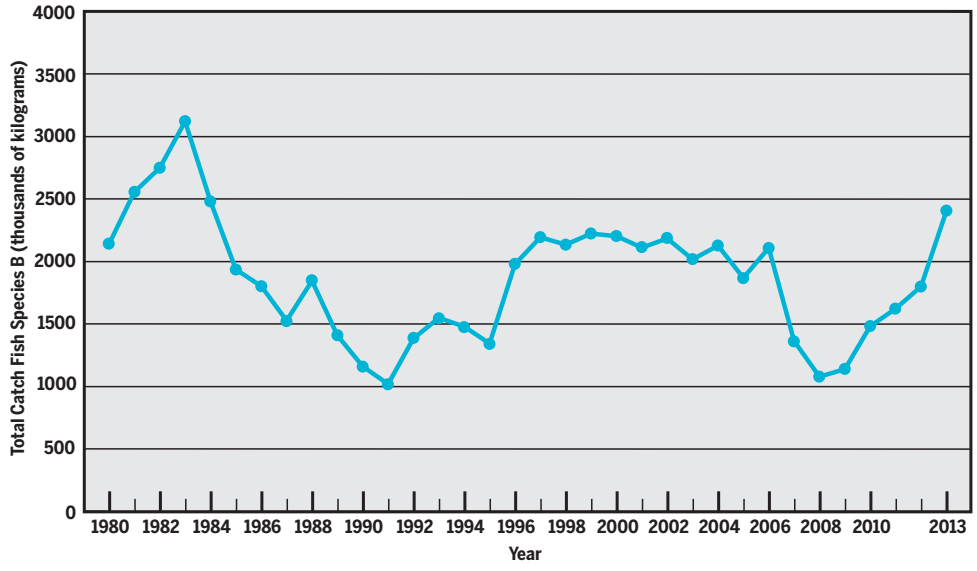
2. With your partner, examine the graph below. "Total catch" refers to all fish of that species caught by commercial fishers in that year. Discuss any patterns you see in the data.

Catch Data, Species A



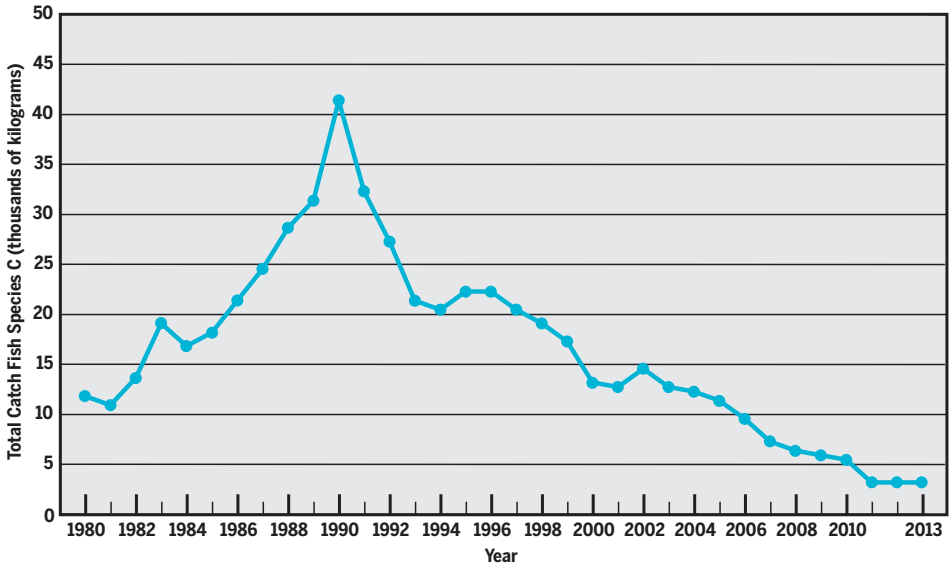
3. Repeat Step 2 fish species B using the graph below.

Catch Data, Species B



4. Repeat Step 2 for fish species C using the graph on the next page.

Catch Data, Species C



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

Pacific Hallibut

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

Red Snapper

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

Orange Roughy

sit in groups on the ocean floor, they were easy targets for fishers. To make matters worse, orange roughy grow and reproduce very slowly: they don't even start to reproduce until they are 20 years old! There were no limits on orange roughy catches until the mid-1990's, and only in some areas where the orange roughy is fished.

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

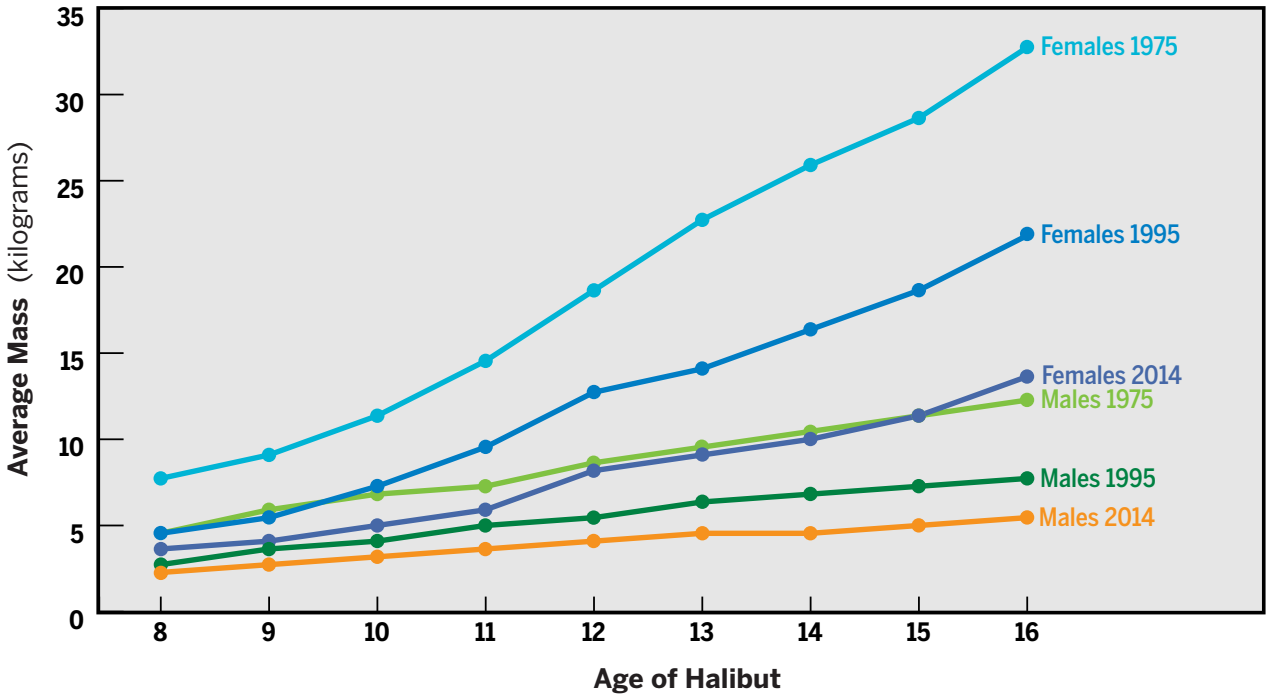
Different fisheries manage their populations differently. Some fisheries, such as the Pacific halibut fishery, collect more data than just the amount of fish caught.

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?

Average Mass of Male and Female Halibut Over Time



9. Using the Argument Tool, construct a scientific argument about the heath 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. Why might scientists want to look at more than one type of data to determine the health of a fishery?

Elaborate: 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.

All of the streams and rivers in the Mississippi Watershed (the green shaded area) connect to the Mississippi river. One area that has a very large dead zone is the Gulf of Mexico, where the Mississippi river ends.

Guiding Question

How do humans affect the size of dead zones?

Materials

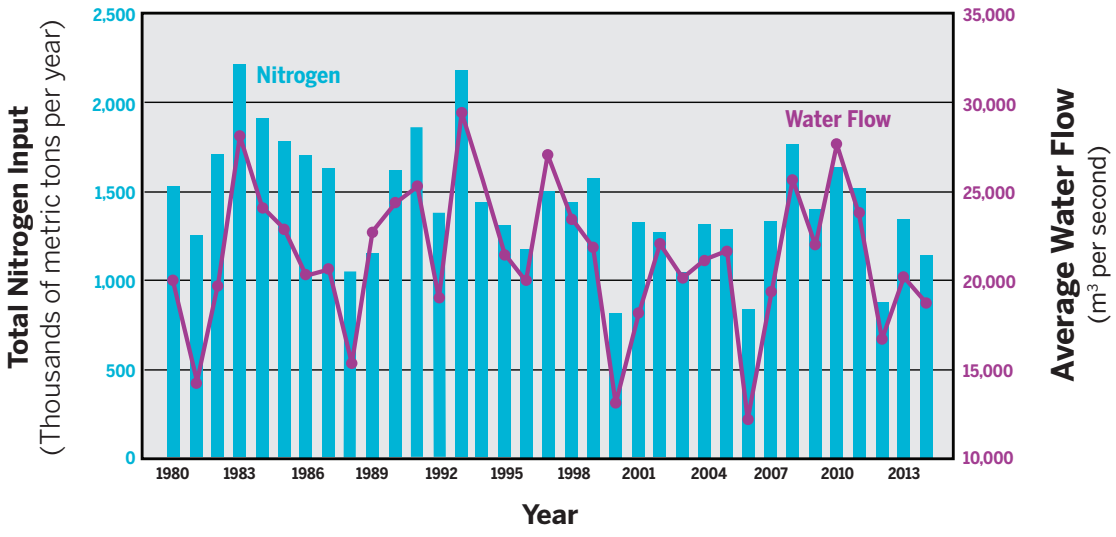
For each student:

- 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.

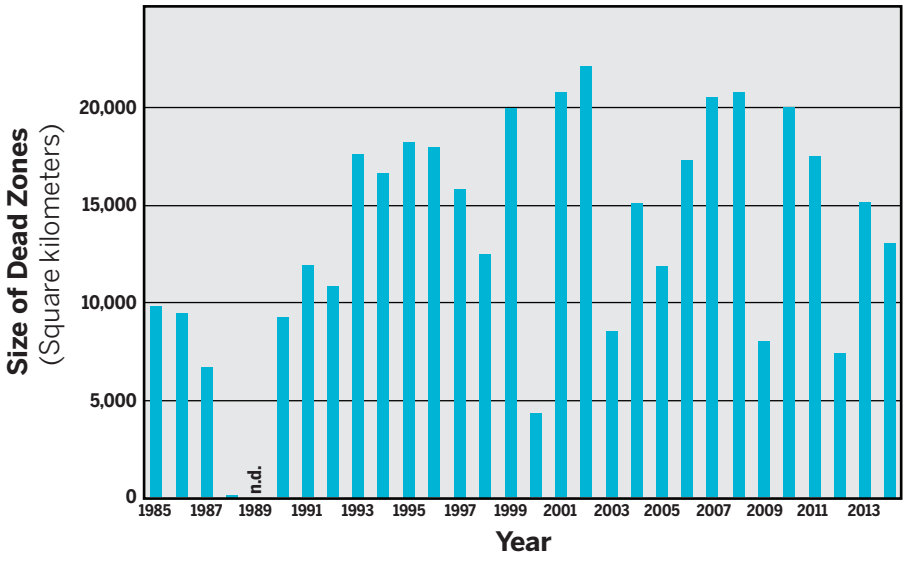
5. With your group, examine the graph below. Discuss the following:

   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?

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

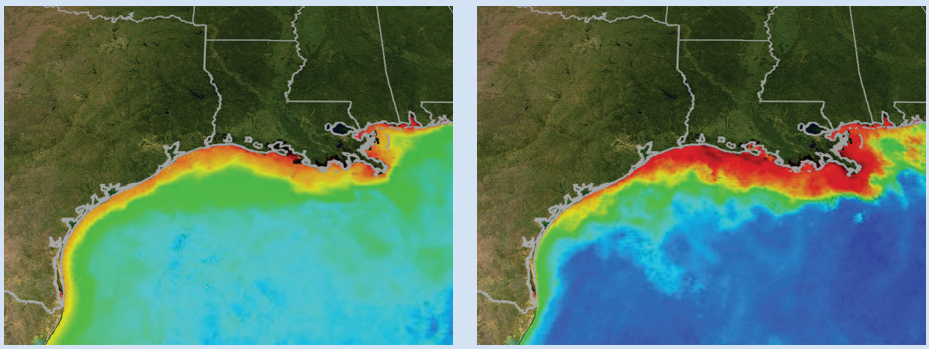
Size of Dead Zones in the Gulf of Mexico



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 km^2 (8,400 mi^2).



These maps show the dead zone in the Gulf of Mexico in winter (left) and summer (right). The colors indicate how much plankton is present. Red represents high levels of plankton. Orange is slightly less plankton, yellow is less than orange, etc..

The Mississippi drains nearly 41% of the land in the United States, and a lot of the land is farmland where fertilizers are used. There are also many sewage treatment plants along the river that discharge treated waste that is very high in nitrogen. Scientists estimate that 65% of the nutrients that drain into the Gulf of Mexico come from farms and livestock production along the Mississippi.

Source of Nitrogen	% Total Nitrogen from Source
Fertilizer & treated soil	50
Animal manure	15
Other (atmosphere, ground water, erosion, runoff, etc.)	24
Factories and other buildings	11

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.

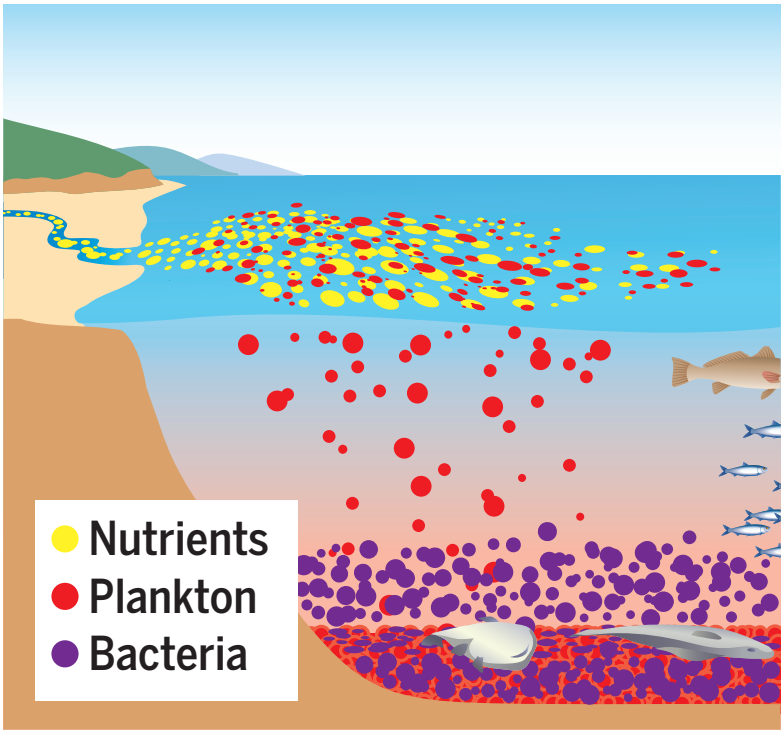
7. With your class, debate the question "Should fertilizer use be limited to help prevent dead zones?"

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.

Guiding Question

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

Materials

For each student:

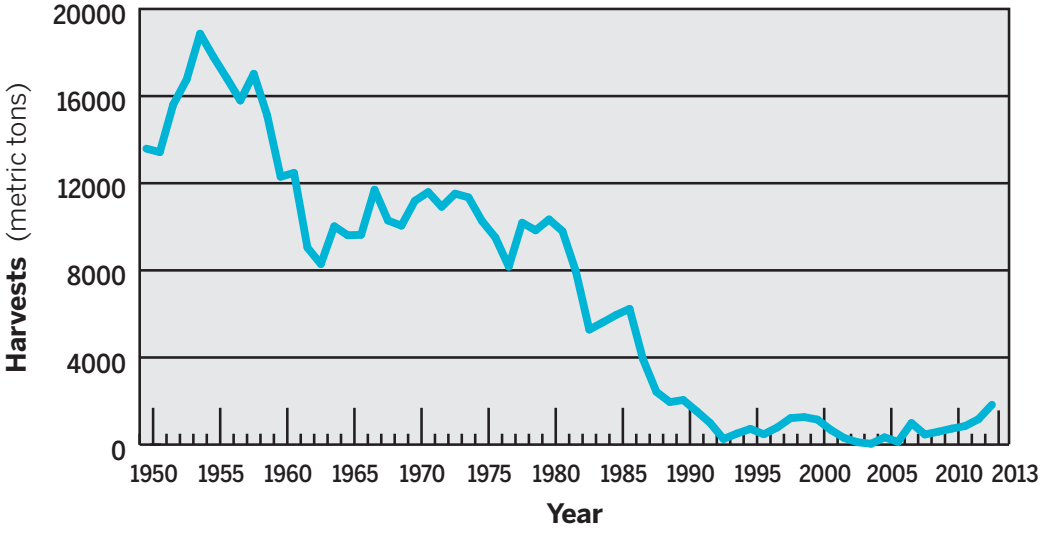
- Argument Tool

Process & Procedure

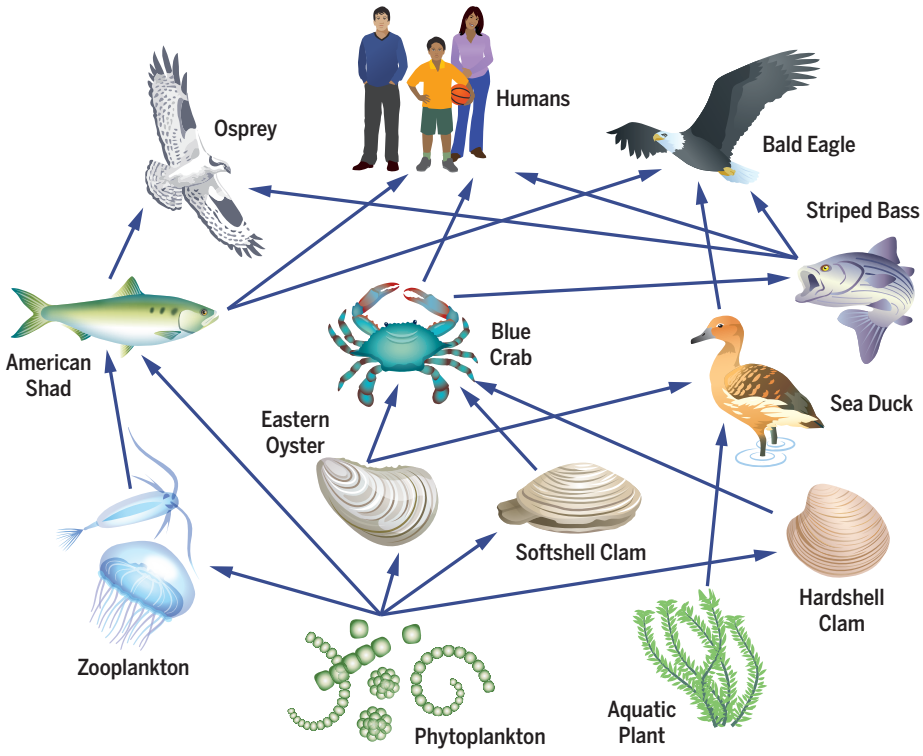
Part A: Oysters in Chesapeake Bay

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.



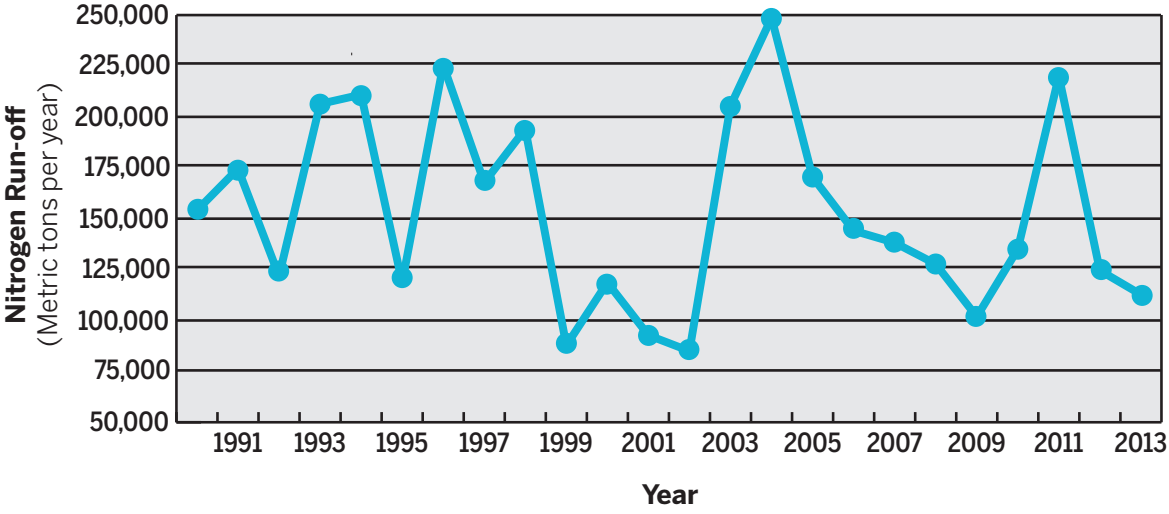
3. With your partner, discuss the following:
    - How might the changes in the oyster population affect other organisms in the ecosystem?
    - How might this affect the rest of the ecosystem?
4. Follow your teacher's directions to share your discussion with your class.

Part B: Changes in the Chesapeake Bay Ecosystem

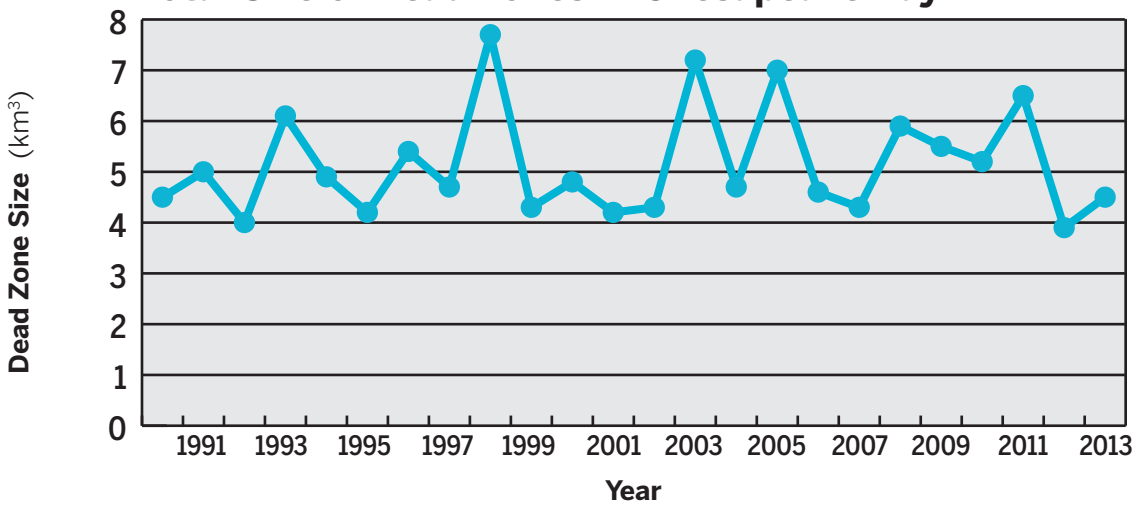
One of the important roles of the oysters is to filter the water in the Bay. As they filter the water they remove nutrients and other matter. One of the biggest challenges for the Chesapeake Bay ecosystem in recent years is the appearance of dead zones. There are farms surrounding the Bay, and the run-off 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.

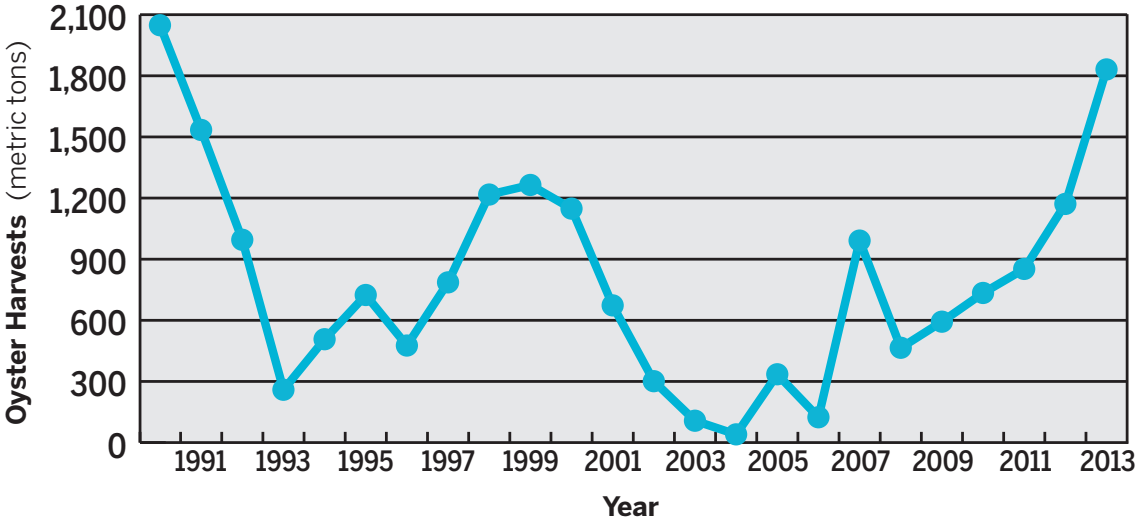
Annual Nitrogen Run-off in Chesapeake Bay



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?