Objectives
After completing the lesson, students will be able to
A.3.2.1 Describe the causes and effects of red tides.
A.3.2.2 Describe the causes and effects of eutrophication.

Target Reading Skill
Comparing and Contrasting Explain that comparing and contrasting information shows how ideas, facts, and events are similar and different. The results of the comparison can have importance.

Answers
Saltwater blooms—Effects: Toxins concentrated in fish and shellfish that eat algae can cause illness to people and other large organisms when they consume the fish or shellfish. Freshwater blooms—Causes: Nutrients build up, causing a rapid increase in algae growth; Effect: Fishes and other organisms in the water die.

Discover Activity

How Can Algal Growth Affect Pond Life?
1. Pour water into a plastic petri dish until the dish is half full. The petri dish will represent a pond.
2. Sprinkle a spoonful of green paper punches into the water to represent green algae growing in a pond.
3. Sprinkle two more spoonfuls of paper punches into the water to represent one cycle of algae reproduction.
4. Sprinkle four more spoonfuls of paper punches into the water to represent the next reproduction cycle of the algae.

Think It Over
Predicting How might algae growing near the surface affect organisms living deep in a pond?

Over a five week period one year, the bodies of 14 humpback whales washed up along beaches on Cape Cod, Massachusetts. The whales showed no outward signs of sickness. Their stomachs were full of food. Their bodies contained plenty of blubber to insulate them from changes in water temperature. What caused such seemingly healthy animals to die?

When biologists examined the dead whales' tissues, they identified the cause of the puzzling deaths. The whales' cells contained a deadly toxin produced by dinoflagellates called Alexandrium tamarense. The population of these algae had grown rapidly in the ocean waters through which the whales were migrating. When the whales fed on the toxin-producing algae or on fish that had eaten the algae, the toxins reached a deadly level and killed the whales.

Algae are common in oceans, lakes, and ponds. They float near the surface of the waters and use sunlight to make food. The rapid growth of a population of algae is called an algal bloom. Algal blooms can occur in both saltwater and freshwater environments. In general, algal blooms occur when nutrients increase in the water.
Saltwater Blooms

In Figure 13, you see an algal bloom in ocean water. Saltwater algal blooms are commonly called red tides because the algae that grow rapidly often contain red pigments and turn the color of the water red. But red tides do not always look red. Some red tides are brown, green, or even colorless, depending on the species of algae that blooms. Dinoflagellates and diatoms are two algae that frequently bloom in red tides.

Causes of Red Tides

Scientists are not sure why some populations of saltwater algae increase rapidly at times. But red tides occur most often when there is an increase in nutrients in the water. Some red tides occur regularly in certain seasons. For example, the cold bottom layers of the ocean contain a lot of nutrients. When this cold water mixes with the surface waters, more nutrients become available to surface organisms. With greater concentrations of nutrients present in the surface waters, blooms of algae occur. Increases in ocean temperature due to climate changes also affect the occurrence of red tides.

Effects of Red Tides

Red tides are dangerous when the toxins that the algae produce become concentrated in the bodies of organisms that consume the algae. Shellfish, such as clams and mussels, feed on large numbers of the algae and store the toxins in their cells. Fishes may also feed on the algae and store the toxins. When people or other large organisms eat these shellfish and fishes, it may lead to severe illness or even death. Public health officials close beaches in areas of red tides to prevent people from fishing or gathering shellfish.

What determines the color of saltwater blooms?

Monitor Progress

Answers

Figure 13 Fish, other organisms in the water, and people

Pigments contained by the species of algae that bloom...
Freshwater Blooms

Teach Key Concepts

Examining Freshwater Blooms

Focus Ask students to observe the thick layer of algae in Figure 14.

Teach Define eutrophication and discuss how it can be harmful to bodies of water. Ask: When does eutrophication occur? (When excess nutrients build up, causing algae to grow) What human sources increase eutrophication? (Fertilizer runoff; sewage treatment wastewater) Why do pond organisms die with eutrophication? (Plants and algae beneath the surface can’t make food; they die and their decomposers use up oxygen needed by other organisms, such as fish.)

Apply Ask: How are saltwater and freshwater blooms similar? (Both occur when nutrients in water increase.)

learning modality: verbal

Monitor Progress

Answer Eutrophication

Assess

Reviewing Key Concepts

1. a. Rapid growth of a population of algae
   b. Ocean: increased nutrients, change in water temperatures; organisms that eat algae build up toxins harmful to organisms that eat them. Lake: increased nutrients from natural and human activities (fertilizer, sewage); organisms die from lack of food and oxygen.
   c. Freshwater blooms—smaller areas, easier to identify nutrient sources and measure effects.

Reteach

Sketch flow charts illustrating the processes that occur in both types of algal blooms.

Teaching Resources

• Section Summary: Algal Blooms
• Review and Reinforce: Algal Blooms
• Enrich: Algal Blooms

Freshwater Blooms

Have you ever seen a pond or lake that looked as if it was coated with a layer of green paint or scum? The green layer usually consists of huge numbers of green algae. Lakes and ponds undergo natural processes of change over time. Eutrophication (you troh fih KAY shun) is a process in which nutrients, such as nitrogen and phosphorus, build up in a lake or pond over time, causing an increase in algae growth.

Causes of Eutrophication

Certain natural events and human activities can increase the rate of eutrophication. For example, when farmers and homeowners spread fertilizers on fields and lawns, some of the nutrients can run off into nearby lakes and ponds. Sewage treatment plants can leak wastewater into the soil. The nutrients in the wastewater make their way from the soil into water that leads into lakes and ponds. These events cause a rapid increase in algae growth. If the nutrient sources can be eliminated and the nutrients used up, eutrophication slows to its natural rate.

Effects of Eutrophication

Eutrophication triggers a series of events with serious consequences. First, the layer of algae prevents sunlight from reaching plants and other algae beneath the surface. Those organisms die and sink to the bottom. Then decomposers, such as bacteria, which break down the bodies of the dead organisms, increase in number. Soon the bacteria use up the oxygen in the water. Without oxygen, fishes and other organisms in the water die. About the only organisms that survive are the algae on the surface.

FIGURE 14 Eutrophication The thick layer of algae on the surface of a pond can threaten other organisms in the water.

Section 2 Assessment

Target Reading Skill Comparing and Contrasting Use the information in your table about algal blooms to help you answer the questions below.

Reviewing Key Concepts

1. a. Defining What is an algal bloom?
   b. Comparing and Contrasting What might cause an algal bloom to occur in an ocean? In a lake?
   c. Predicting Would it be easier to control saltwater or freshwater blooms? Explain.

Chapter Project

Keep Students on Track By now, your teacher should have approved your plan, and you should have started growing your mushrooms. Make careful observations of growth daily, including appropriate sketches and measurements. Use a table to organize the data you collect. (HINT: As you make your observations, be careful not to disturb the experiment or introduce any new variables.)

Writing in Science

Writing Mode Description

Scoring Rubric

4 Includes definition of eutrophication, explains causes and effects; tone is clear and engaging.
3 Includes all criteria; writing not engaging
2 Minimally covers criteria
1 Includes inaccurate or incomplete information
An Explosion of Life

Skills Lab

Problem
How does the amount of fertilizer affect algae growth?

Skills Focus
controlling variables, drawing conclusions, predicting

Materials
• 4 glass jars with lids
• marking pen
• aged tap water
• aquarium water
• graduated cylinder
• liquid fertilizer

Procedure
1. Read through the steps in the procedure. Then write a prediction describing what you think will happen in each of the four jars.
2. Copy the data table into your notebook. Be sure to allow enough lines to make entries for a two-week period.
3. Label four jars A, B, C, and D. Fill each jar half full with aged tap water.
4. Add aquarium water to each jar until the jar is three-fourths full.
5. Add 3 mL of liquid fertilizer to jar B, 6 mL to jar C, and 12 mL to jar D. Do not add any fertilizer to jar A. Loosely screw the lid on each jar. Place all the jars in a sunny location where they will receive the same amount of direct sunlight.

6. Observe the jars every day for two weeks. Compare the color of the water in the four jars. Record your observations.

Analyze and Conclude
1. Observing How did the color in the four jars compare at the end of the two-week period? Did your observations match your prediction?
2. Controlling Variables What was the purpose of jar A? Explain.
3. Drawing Conclusions How can you account for any color differences among the four jars? What process and organisms were responsible for causing that color change?
4. Predicting Predict what would have happened if you placed the four jars in a dark location instead of in sunlight. Explain your prediction.
5. Communicating Write a warning label to be placed on a bag of fertilizer. On the label, explain what might happen to fish and other organisms if the fertilizer gets into a body of fresh water. Also, outline steps consumers can take to prevent these problems.

Design an Experiment
Some detergents contain phosphates, which are also found in many kinds of fertilizer. Design an experiment to compare how regular detergent and low-phosphate detergent affect the growth of algae. Obtain your teacher’s permission before carrying out your investigation.

Data Table

<table>
<thead>
<tr>
<th>Day</th>
<th>Jar A (no fertilizer)</th>
<th>Jar B (3 mL of fertilizer)</th>
<th>Jar C (6 mL of fertilizer)</th>
<th>Jar D (12 mL of fertilizer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 2</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Analyze and Conclude
1. Jar D was the darkest green, with jars C and B increasingly lighter, and jar A the lightest. Answers regarding predictions will vary.
2. Jar A served as the control.
3. The difference: fertilizer input. Eutrophication—increased nutrients causing rapid algal growth—caused the color changes.
4. Without light for algae to make food, jars would stay the same as the first day.
5. Labels should explain that fertilizer runoff speeds up algal growth, which eventually kills pond plants and animals. Consumers can prevent fertilizer runoff by using appropriate amounts, applying according to directions, and ensuring runoff is contained.

Expected Outcome
Algae will grow fastest in jar D and slowest in jar A.