Aquatic Ecosystems

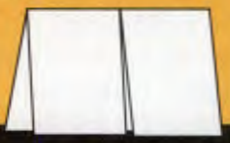
CHAPTER 7

PRE-READING ACTIVITY

FOLDNOTES

Two-Panel Flip Chart

Before you read this chapter, create the **FoldNote** entitled "Two-Panel Flip Chart" described in the Reading and Study Skills section of the Appendix. Label the flaps of the two-panel flip chart with "Freshwater Ecosystems" and "Marine Ecosystems." As you read the chapter, write information you learn about each category under the appropriate flap.



Manatees live in both freshwater and saltwater ecosystems. Manatees are herbivores and will eat at least 27 kg (60 lb) of aquatic plants per day.

SECTION 1

Freshwater Ecosystems

The types of organisms in an aquatic ecosystem are mainly determined by the water's *salinity*—the amount of dissolved salts the water contains. As a result, aquatic ecosystems are divided into freshwater ecosystems and marine ecosystems.

Freshwater ecosystems include the sluggish waters of lakes and ponds, such as the lake shown in **Figure 1,** and the moving waters of rivers and streams. They also include areas where land, known as a **wetland,** is periodically underwater. Marine ecosystems include the diverse coastal areas of marshes, swamps, and coral reefs as well as the deep, vast oceans.

Objectives

- Describe the factors that determine where an organism lives in an aquatic ecosystem.
- Describe the littoral zone and the benthic zone that make up a lake or pond.
- Describe two environmental functions of wetlands.
- Describe one threat against river ecosystems.

Key Terms

wetland
plankton
nekton
benthos
littoral zone
benthic zone
eutrophication

Characteristics of Aquatic Ecosystems

Factors such as temperature, sunlight, oxygen, and nutrients determine which organisms live in which areas of the water. For instance, sunlight reaches only a certain distance below the surface of the water, so most photosynthetic organisms live on or near the surface.

Aquatic ecosystems contain several types of organisms that are grouped by their location and by their adaptations. Three groups of aquatic organisms include plankton, nekton, and benthos. **Plankton** are the organisms that float near the surface of the water. Two types of plankton are microscopic plants called *phytoplankton,* and microscopic animals called *zooplankton.* Phytoplankton produce most of the food for an aquatic ecosystem. **Nekton** are free-swimming organisms, such as fish, turtles, and whales. **Benthos** are bottom-dwelling organisms, such as mussels, worms, and barnacles. Many benthic organisms live attached to hard surfaces. Decomposers, organisms that break down dead organisms, are also a type of aquatic organism.

Figure 1 ▶ Lake Louise in Alberta, Canada, is an example of a freshwater ecosystem.

Figure 2 ▶ Amphibians, such as this bull frog, live in or near lakes and ponds.

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Lakes and Ponds

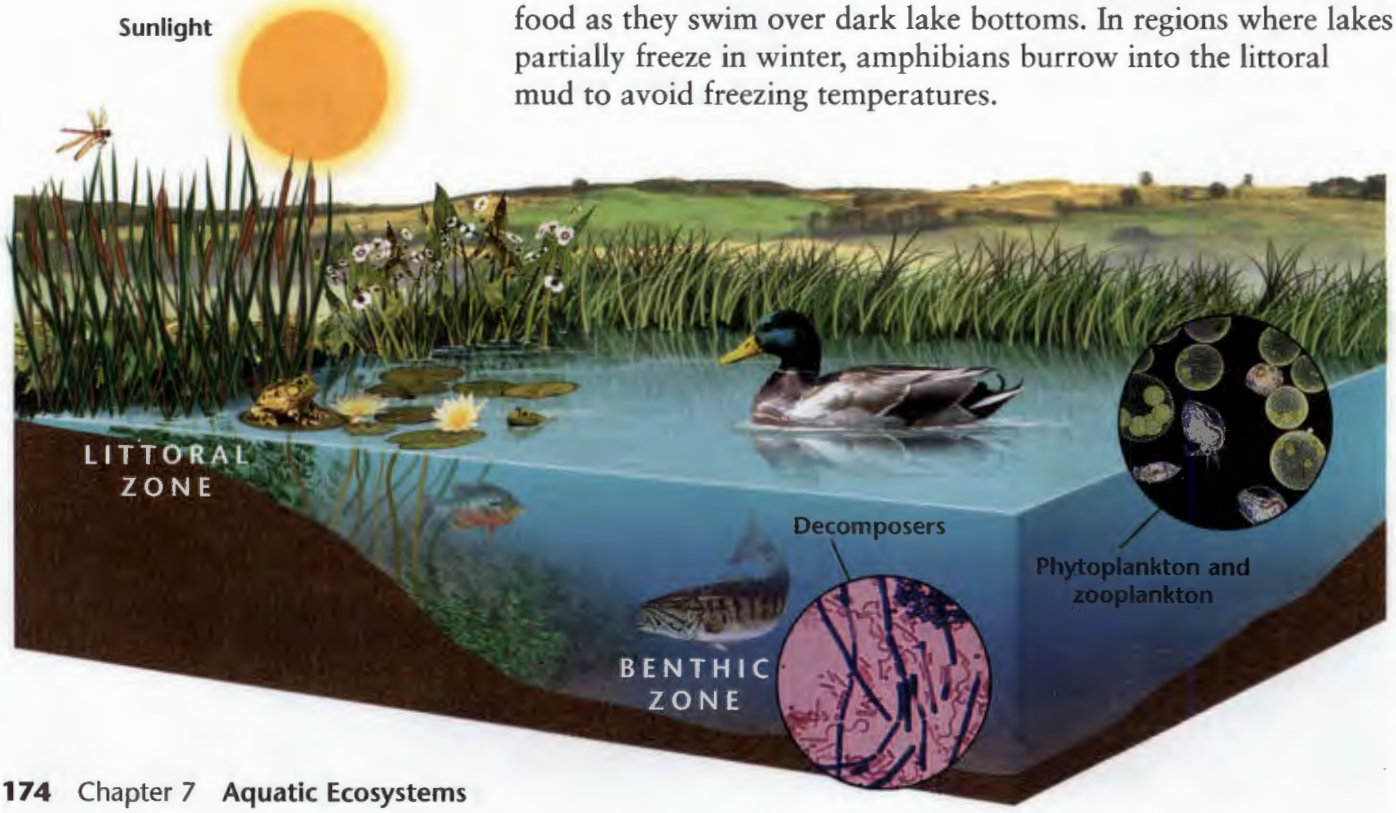
Lakes, ponds, wetlands, rivers, and streams make up the various types of freshwater ecosystems. Lakes, ponds, and wetlands can form naturally where groundwater reaches the Earth's surface. Beavers can also create ponds by damming up streams. Humans intentionally create artificial lakes by damming flowing rivers and streams to use them for power, irrigation, water storage, and recreation.

Life in a Lake Lakes and ponds can be structured into horizontal and vertical zones. In the nutrient-rich **littoral zone** near the shore, aquatic life is diverse and abundant. Plants, such as cattails and reeds, are rooted in the mud underwater, and their upper leaves and stems emerge above the water. Plants that have floating leaves, such as pond lilies, are rooted here also. Farther out from the shore, in the open water, plants, algae, and some bacteria capture solar energy to make their own food during *photosynthesis*. As shown in Figure 3, the types of organisms present in a pond or lake ecosystem depend on the amount of sunlight available.

Some bodies of fresh water have areas so deep that there is too little light for photosynthesis. Bacteria live in the deep areas of the fresh water to decompose dead plants and animals that drift down from the land and water above. Fish adapted to cooler, darker water also live there. Eventually, dead and decaying organisms reach the **benthic zone,** the bottom of a pond or lake, which is inhabited by decomposers, insect larvae, and clams.

Animals that live in lakes and ponds have adaptations that help them obtain what they need to survive. Water beetles use the hairs under their bodies to trap surface air so that they can breathe during their dives for food. Whiskers help catfish sense food as they swim over dark lake bottoms. In regions where lakes partially freeze in winter, amphibians burrow into the littoral mud to avoid freezing temperatures.

Figure 3 ▶ A pond or lake ecosystem is structured according to how much light is available. Tiny plants called *phytoplankton* and tiny animals called *zooplankton* live in open water, where more sunlight is available.



How Nutrients Affect Lakes Eutrophication is an increase in the amount of nutrients in an aquatic ecosystem. A lake that has a large amount of plant growth due to nutrients, as shown in **Figure 4**, is known as a *eutrophic lake*. As the amount of plants and algae grows, the number of bacteria feeding on the decaying organisms also grows. These bacteria use the oxygen dissolved in the lake's waters. Eventually, the reduced amount of oxygen kills oxygen-loving organisms. Lakes naturally become eutrophic over a long period of time. However, eutrophication can be accelerated by runoff. Runoff is precipitation, such as rain, that can carry sewage, fertilizers, or animal wastes from land into bodies of water.

Freshwater Wetlands

Freshwater wetlands are areas of land that are covered with fresh water for at least part of the year. The two main types of freshwater wetlands are marshes and swamps. *Marshes* contain non-woody plants, such as cattails, while *swamps* are dominated by woody plants, such as trees and shrubs.

Wetlands perform several important environmental functions, as shown in **Table 1.** Wetlands act as filters or sponges because they absorb and remove pollutants from the water that flows through them. Therefore, wetlands improve the water quality of lakes, rivers, and reservoirs downstream. Wetlands also control flooding by absorbing extra water when rivers overflow, which protects farms and urban and residential areas from damage. Many of the freshwater game fish caught in the United States each year use the wetlands for feeding and spawning. In addition, these areas provide a home for native and migratory wildlife, including the blue herons shown in **Figure 5.** Wetland vegetation also traps carbon that would otherwise be released as carbon dioxide, which may be linked to rising atmospheric temperatures. Some wetlands are used to produce many commercially important products, such as cranberries.

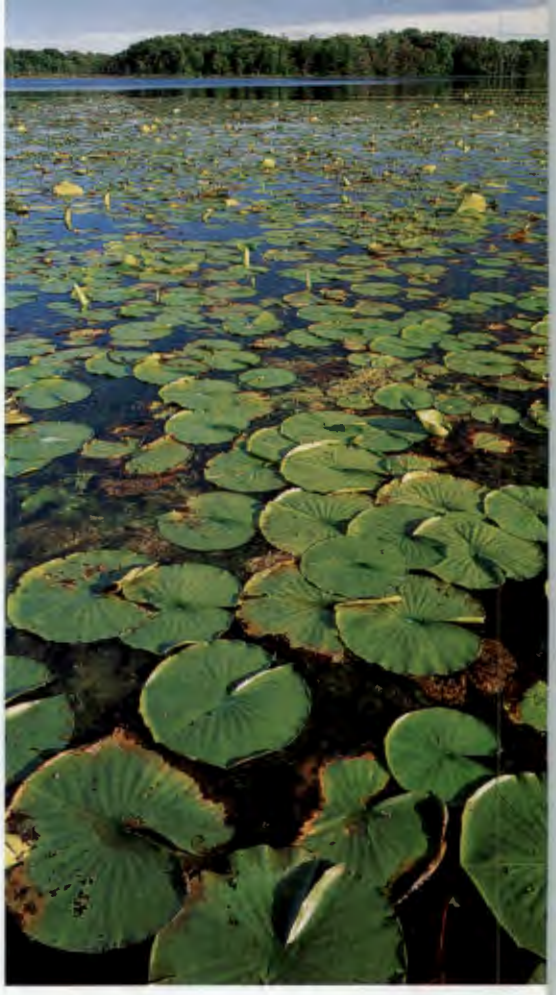


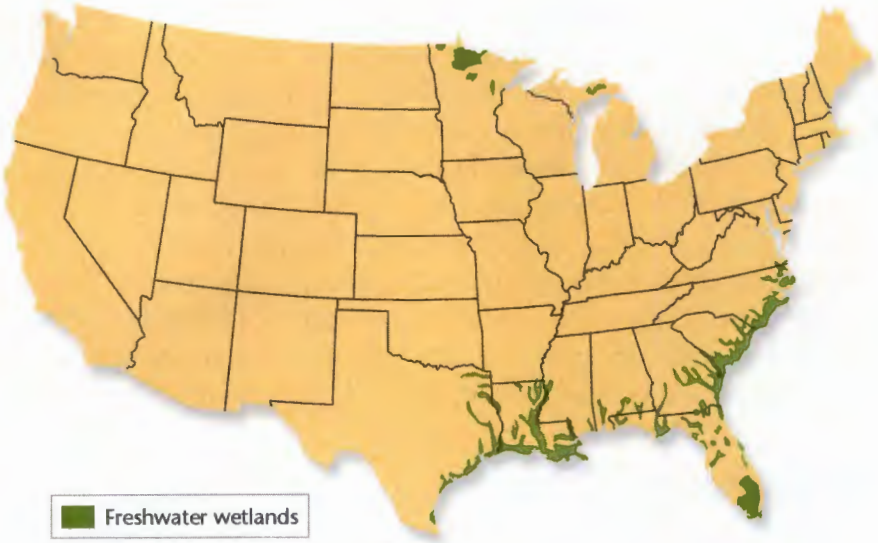
Figure 4 ▶ A eutrophic lake, like the one above, contains large amounts of plants as a result of high levels of nutrients.

Figure 5 ▶ Wetlands provide habitat for many plants and animals, including the blue herons shown below.

Table 1 ▼

Environmental Functions of Wetlands
• trapping and filtering sediments, nutrients, and pollutants, which keep these materials from entering lakes, reservoirs, and oceans
• reducing the likelihood of a flood, protecting agriculture, roads, buildings, and human health and safety
• buffering shorelines against erosion
• providing spawning grounds and habitat for commercially important fish and shellfish
• providing habitat for rare, threatened, and endangered plants and animals
• providing recreational areas for activities such as fishing, bird-watching, hiking, canoeing, photography, and painting

Figure 6 ▶ This map shows the locations of large freshwater wetlands in the United States.



Connection to History

The Florida Everglades Because of the work of many writers, conservationists, and naturalists, former U.S. President Truman dedicated the Everglades National Park in 1947. The park was established to protect the wildlife and habitat of the Florida Everglades. The Florida Everglades is one of only three sites on Earth declared an International Biosphere Reserve, a World Heritage Site, and a Wetland of International Importance. The other two sites are located in Tunisia and Bulgaria.

Marshes As shown in **Figure 6**, most freshwater wetlands are located in the southeastern United States. The Florida Everglades is the largest freshwater wetland in the United States. Freshwater marshes tend to occur on low, flat lands and have little water movement. In shallow waters, plants such as reeds, rushes, and cattails root themselves in the rich bottom sediments. As shown in **Figure 7**, the leaves of these and other plants stick out above the surface of the water year-round.

The benthic zones of marshes are nutrient rich and contain plants, numerous types of decomposers, and scavengers. Waterfowl, such as grebes and ducks, have flat beaks adapted for sifting through the water for fish and insects. Water birds, such as herons, have spearlike beaks that they use to grasp small fish and to probe for frogs buried in the mud. Marshes also attract many migratory birds from temperate and tropical habitats.

There are several kinds of marshes, each of which is characterized by its salinity. Brackish marshes have slightly salty water, while salt marshes contain saltier water. In each marsh type, organisms are adapted to live within the ecosystem's range of salinity.

Figure 7 ▶ A marsh is a type of wetland that contains nonwoody plants.

Figure 8 ▶ The American alligator is a common reptile that lives in marshes and swamps.

Swamps Swamps occur on flat, poorly drained land, often near streams. Swamps are dominated by woody shrubs or water-loving trees, depending on the latitude and climate in which the swamps are located. Mangrove swamps occur in warm climates near the ocean, so their water is salty. Freshwater swamps are the ideal habitat for many amphibians, such as frogs and salamanders, because of the continuously moist environment. Swamps also attract birds, such as wood ducks, that nest in hollow trees near or over the water. Reptiles, such as the American alligator in **Figure 8**, are the predators of swamps and will eat almost any organism that crosses their path.

Human Impact on Wetlands Wetlands were previously considered to be wastelands that provide breeding grounds for insects. Therefore, many have been drained, filled, and cleared for farms or residential and commercial development, as shown in **Figure 9.** For example, the Florida Everglades once covered 8 million acres of south Florida but it now covers less than 2 million acres. The important role of wetlands as purifiers of wastewater and in flood prevention is now recognized. Wetlands are vitally important as habitats for wildlife. Law and the federal government protect many wetlands, and most states now prohibit the destruction of certain wetlands.

MATHPRACTICE

Wetland Conversion
From 1982 to 1992, approximately 1.6 million acres of wetlands on nonfederal lands in the United States were converted for other uses. Fifty-seven percent of the wetlands were converted into land for development. Twenty percent of the wetlands were converted into land for agriculture. How many acres of land were converted into land for development? How many acres of land were converted into land for agriculture?

Figure 9 ▶ The wetland above has been drained for agricultural purposes. Wetlands such as the one above typically serve as breeding areas for ducks. The oil rig on the left is located in a marsh off the coast of Louisiana.

Rivers

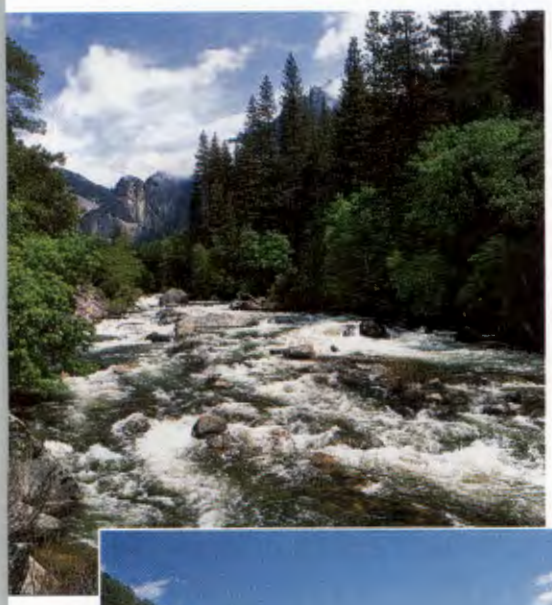


Figure 10 ▶ The water flow of a river slows and the habitat changes as narrow headwaters give way to wide channels downstream.

Many rivers originate from snow melt in mountains. At its headwaters, a river is usually cold and full of oxygen and runs swiftly through a shallow riverbed. As a river flows down a mountain, a river may broaden, become warmer, wider, and slower, and decrease in oxygen. **Figure 10** compares the water flow of two sections of two different rivers. A river changes with the land and the climate through which it flows. Runoff, for example, may wash nutrients and sediment from the surrounding land into a river. These materials affect the growth and health of the organisms in the river.

Life in a River Near the churning headwaters, mosses anchor themselves to rocks by using rootlike structures called *rhizoids*. Plankton do not live in the headwaters because the current is too strong for them to float. However, trout and minnows are adapted to the cold, oxygen-rich headwaters. Trout are powerful swimmers and have streamlined bodies that present little resistance to the strong current. Farther downstream, plankton can float in the warmer, calmer waters. Other plants, such as the crowfoot, set roots down in the river's rich sediment. The leaves of some plants, such as the arrowhead, will vary in shape according to the strength of a river's current. Fish such as catfish and carp also live in the calmer waters.

Rivers in Danger Industries use river water in manufacturing processes and as receptacles for waste. For many years, people have used rivers to dispose of their sewage and garbage. These practices have polluted rivers with toxins, which have killed river organisms and made river fish inedible. Today, runoff from the land puts pesticides and other poisons into rivers and coats riverbeds with toxic sediments. Dams also alter the ecosystems in and around a river.

SECTION 1 Review

1. **List** two factors that determine where an organism lives in an aquatic ecosystem.
2. **Compare** the littoral zone of a lake with the benthic zone of a lake.
3. **List** two environmental functions that wetlands provide. How do these functions affect you?
4. **Describe** one threat against river ecosystems.

CRITICAL THINKING

5. **Identifying Relationships** A piece of garbage that is thrown into a stream may end up in a river or an ocean. What effects might one piece of garbage have on an aquatic ecosystem? What effects might 100 pieces of garbage have on an aquatic ecosystem?
6. **Analyzing Processes** Write a short paragraph that explains how fertilizing your yard and applying pesticides can affect the health of a river ecosystem.
WRITING SKILLS

SECTION 2

Marine Ecosystems

Marine ecosystems of the world are made up of a wide variety of plant and animal communities. Marine ecosystems are located mainly in coastal areas and in the open ocean. Organisms that live in coastal areas adapt to changes in water level and salinity. Organisms that live in the open ocean adapt to changes in temperature and the amount of sunlight and nutrients available.

Objectives

- Explain why an estuary is a very productive ecosystem.
- Compare salt marshes and mangrove swamps.
- Describe two threats to coral reefs.
- Describe two threats to ocean organisms.

Key Terms

estuary
salt marsh
mangrove swamp
barrier island
coral reef

Coastal Wetlands

Coastal land areas that are covered by salt water for all or part of the time are known as *coastal wetlands*. Coastal wetlands provide habitat and nesting areas for many fish and wildlife. Coastal wetlands also absorb excess rain, which protects areas from flooding, they filter out pollutants and sediments, and they provide recreational areas for boating, fishing, and hunting.

Estuaries Many coastal wetlands form in estuaries. An estuary is an area in which fresh water from a river mixes with salt water from the ocean. As the two bodies of water meet, currents form and cause mineral-rich mud and other nutrients to fall to the bottom. **Figure 11** illustrates how the waters mix in such a way that the estuary becomes a nutrient trap. These nutrients then become available to producers, and in some shallow areas, marsh grass will grow in the mud. Estuaries are very productive ecosystems because they constantly receive fresh nutrients from the river and from the ocean. The surrounding land, such as the mainland or a peninsula, protects estuaries from the harsh force of ocean waves.

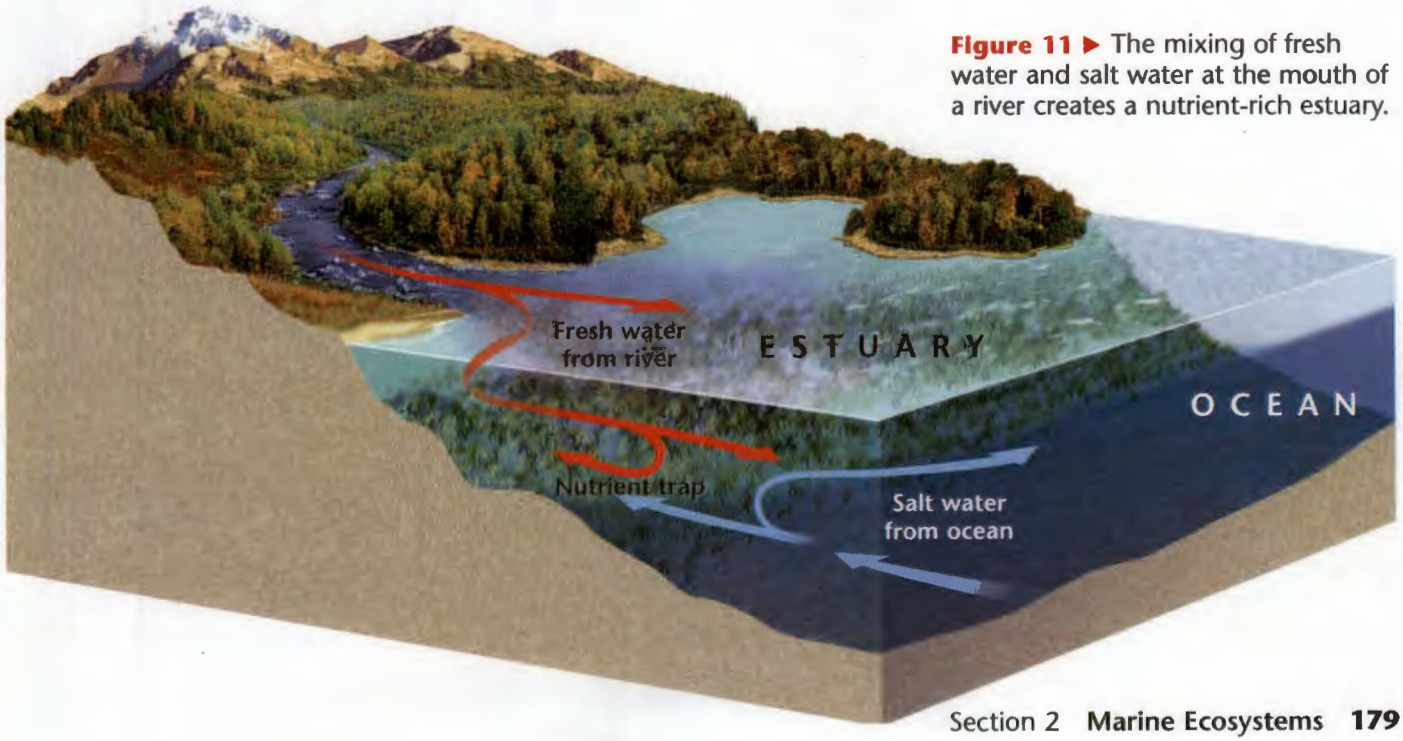


Figure 11 ▶ The mixing of fresh water and salt water at the mouth of a river creates a nutrient-rich estuary.

QuickLAB

Estuaries

Procedure

1. Place a few drops of **red food coloring** in a **test tube** filled with **water.**
2. In a separate **test tube,** add **salt water** and a few drops of **yellow food coloring.**
3. Gently place some of the fresh water solution on top of the salt water solution.

Analysis

1. How do fresh water and salt water interact in an estuary?

Plants and Animals of Estuaries For a week each spring, horseshoe crabs, shown in **Figure 12,** crawl out of the ocean and onto the beaches of Delaware Bay. In the shallow areas along the shore, the crabs mate and lay billions of eggs. Many migrating shorebirds depend on these eggs for food.

Estuaries support many marine organisms because estuaries receive plenty of light for photosynthesis and plenty of nutrients for plants and animals. Rivers supply nutrients that have been washed from the land, and because the water is shallow, sunlight can reach all the way to the bottom of the estuary. The light and nutrients support large populations of rooted plants as well as plankton. The plankton in turn provide food for larger animals, such as fish. Dolphins, manatees, seals, and other mammals often feed on fish and plants in estuaries. Oysters, barnacles, and clams live anchored to marsh grass or rocks and feed by filtering plankton out of the water. Organisms that live in estuaries are able to tolerate variations in salinity because the salt content of the water varies as fresh water and salt water mix when tides go in and out.

CASE STUDY

Restoration of the Chesapeake Bay

The Chesapeake Bay is the largest estuary in the United States. The bay produces large amounts of seafood each year, supports many species of wildlife, and provides recreation for millions of people.

However, the ecosystems of the bay are threatened by several environmental problems. For example, pollution builds up because the tide flushes pollutants out of the bay very slowly. Pollution builds up because only a very narrow opening joins the bay and the ocean. By 1980, the Chesapeake Bay was severely polluted with toxic industrial chemicals. Pesticides as well as excess nutrients ran into the bay from housing developments, farms, and wastewater (including sewage). Marsh grasses and plankton were dying, and fish, oysters, and crabs were disappearing. Birds of prey, such as bald eagles, had almost vanished. Therefore, fishers, environmentalists, and residents became alarmed and launched campaigns to save the bay.

Restoring Chesapeake Bay habitats and water quality is not easy. Maryland and Virginia, the main bordering states of the bay, have different environmental laws. Also, the bay's watershed covers parts of four other states. Interested groups would have to work together if they were to restore the bay. The Chesapeake Bay Program was set up as a partnership between the Environmental Protection Agency, the District of Columbia, Maryland, Pennsylvania, Virginia, and citizen advisory groups. Goals included reducing chemical pollution, removing dams that prevented fish from migrating, and reforesting river banks to reduce soil erosion.

▶ The Chesapeake Bay forms where the Potomac, Rappahannock, and other rivers meet the Atlantic Ocean.

Remarkable progress has been made in the last 20 years. About half of the wastewater flowing into

Estuaries provide protected harbors, access to the ocean, and connection to a river. As a result, many of the world's major ports are built on estuaries. Of the 10 largest urban areas in the world, 6 were built on estuaries. These 6 cities are Tokyo, New York, Shanghai, Buenos Aires, Rio de Janeiro, and Bombay.

Threats to Estuaries Estuaries that exist in populated areas were often used as places to dump waste. Estuaries that are filled with waste can be developed and used as building sites. This practice occurred extensively in California, which now has plans to restore some of its estuary wetlands. The pollutants that damage estuaries are the same ones that pollute lakes, rivers, and the oceans: sewage, industrial waste containing toxic chemicals, and agricultural runoff of soil containing pesticides and fertilizers. Most of these pollutants break down over time, but estuaries cannot cope with the amounts produced by dense human populations.

Figure 12 ▶ Horseshoe crabs go to the Delaware Bay, an estuary between New Jersey and Delaware, to lay their eggs.

▶ This great egret lives in one of the estuaries that borders the Chesapeake Bay.

the bay is now biologically treated to remove pollutants and excess nutrients. Bald eagles are back, and industry has reduced the chemical pollutants released into the bay by nearly 70 percent. Planting trees has restored forested buffers to about 60 percent of the river banks, and populations of fish, such as striped bass, are increasing.

However, the number of people in the bay area is increasing and the number of miles these people drive each year has increased even faster. In the last 30 years, miles traveled by vehicles increased four times as fast as the population. This has led to runoff from streets and lawns and pollution from vehicle exhaust, all of which harm the bay. The oyster harvest has decreased and the forested part of the bay's watershed is still decreasing.

You can help save your local watershed in the following ways: by reducing the number of miles you drive, trying to conserve electricity and water, planting native vegetation, using only a small amount of fertilizer or water on your lawn or garden, and properly disposing of hazardous wastes such as motor oil, antifreeze, and cleaning fluids. You can help by picking up trash that others leave behind. You can also join a citizens group to help preserve estuaries.

CRITICAL THINKING

1. Predicting Consequences If the Chesapeake Bay Program had never been founded, what might have happened to the Chesapeake Bay? Explain how one organism may have been affected.

2. Identifying Relationships How may the use of less fertilizer on plants and lawns help the Chesapeake Bay and other estuaries?

Figure 13 ▶ Mangrove swamps are found along warm, tropical coasts and are dominated by salt-tolerant mangrove trees.

Salt Marshes Marsh grasses dominate much of the shoreline of the Gulf of Mexico and the Atlantic Coast of the United States. These **salt marshes** develop in estuaries where rivers deposit their load of mineral-rich mud. Here, thousands of acres of salt marsh support a community of clams, fish, and aquatic birds. The marsh also acts as a nursery in which many species of shrimps, crabs, and fishes find protection when they are small. As they grow to maturity and migrate to the sea, they are eaten by larger fish or caught by commercial fisheries. Salt marshes, like other wetlands, absorb pollutants and protect inland areas.

Mangrove Swamps Swamps located along coastal areas of tropical and subtropical zones are called **mangrove swamps.** Plants called mangrove trees dominate mangrove swamps. Mangrove trees, such as those shown in **Figure 13,** grow partly submerged in the warm, shallow, and protected salt water of mangrove swamps. The swamps help protect the coastline from erosion and reduce the damage from storms. They provide the breeding and feeding grounds for about 2,000 animal species. Like salt marshes, mangrove swamps have been filled with waste and destroyed in many parts of the world.

Rocky and Sandy Shores Rocky shores have many more plants and animals than sandy shores do. The rocks provide anchorage for seaweed and the many animals that live on them, such as sea anemones, mussels, and sponges. Sandy shores dry out when the tide goes out, and many of the tiny organisms that live between the sand grains eat the plankton that are stranded on the sand. These organisms are the main food for a number of shorebirds. **Barrier islands,** such as the one in **Figure 14,** typically run parallel to the shore. These long, thin islands help protect the mainland and the coastal wetlands.

Mangrove Swamps Mangroves cover 180 billion square meters of tropical coastlines around the world. The largest single mangrove swamp is 5.7 billion square meters, located in the Sundarbans of Bangladesh. This single mangrove swamp provides habitat for the Bengal tiger and helps supply approximately 300,000 people with food, fuel, building materials, and medicines.

Figure 14 ▶ This barrier island is located off the coast of Long Island, New York. Barrier islands are separated from the mainland and help protect the shore of the mainland from erosion.

Figure 15 ▶ Coral reefs are found in warm, shallow waters, where there is enough light for photosynthesis. Coral reefs support a great diversity of species.

Graphic Organizer **Cause-and-Effect Map**

Create the **Graphic Organizer** entitled "Cause-and-Effect Map" described in the Appendix. Label the effect with "Disappearing Coral Reefs." Then, fill in the map with causes of disappearing coral reefs and details about the causes and effects.

Coral Reefs

Coral reefs are limestone ridges built by tiny coral animals called *coral polyps*. Coral polyps secrete skeletons of limestone (calcium carbonate), which slowly accumulate and form coral reefs. Thousands of species of plants and animals live in the cracks and crevices of coral reefs, which makes coral reefs among the most diverse ecosystems on Earth.

Corals live only in clear and warm salt water where there is enough light for photosynthesis, so coral reefs are found in shallow, tropical seas, as shown in **Figure 15.** Only the outer layer of a reef contains living corals, which build their rock homes with the help of photosynthetic algae. Corals, such as those shown in **Figure 16,** are predators that never chase their prey. They use stinging tentacles to capture small animals, such as zooplankton, that float or swim close to the reef. Because of their convoluted shape, reefs provide habitats for a magnificent variety of tropical fish, and for snails, clams, and sponges.

Figure 16 ▶ Coral reefs (bottom) are limestone ridges built by tiny coral animals. Coral animals have coral tentacles (top) that emerge from protective structures to capture food.

Disappearing Coral Reefs Coral reefs are productive but fragile ecosystems. An estimated 27 percent of the coral reefs in the world are in danger of destruction from human activities. If the water surrounding a reef is too hot or too cold or if fresh water drains into the water surrounding a reef, the corals may die. If the water is too muddy, polluted, or too high in nutrients, the algae that live within the corals will either die or grow out of control. If the algae grows out of control, it may kill the corals.

Oil spills, sewage, pesticide, and silt runoff have been linked to coral-reef destruction. Furthermore, overfishing can devastate fish populations and upset the balance of a reef's ecosystem. Because coral reefs grow slowly, a reef may not be able to repair itself after chunks of coral are destroyed by careless divers, fisheries, shipwrecks, ships dropping anchor, or people breaking off pieces of it for decorative items or building materials.

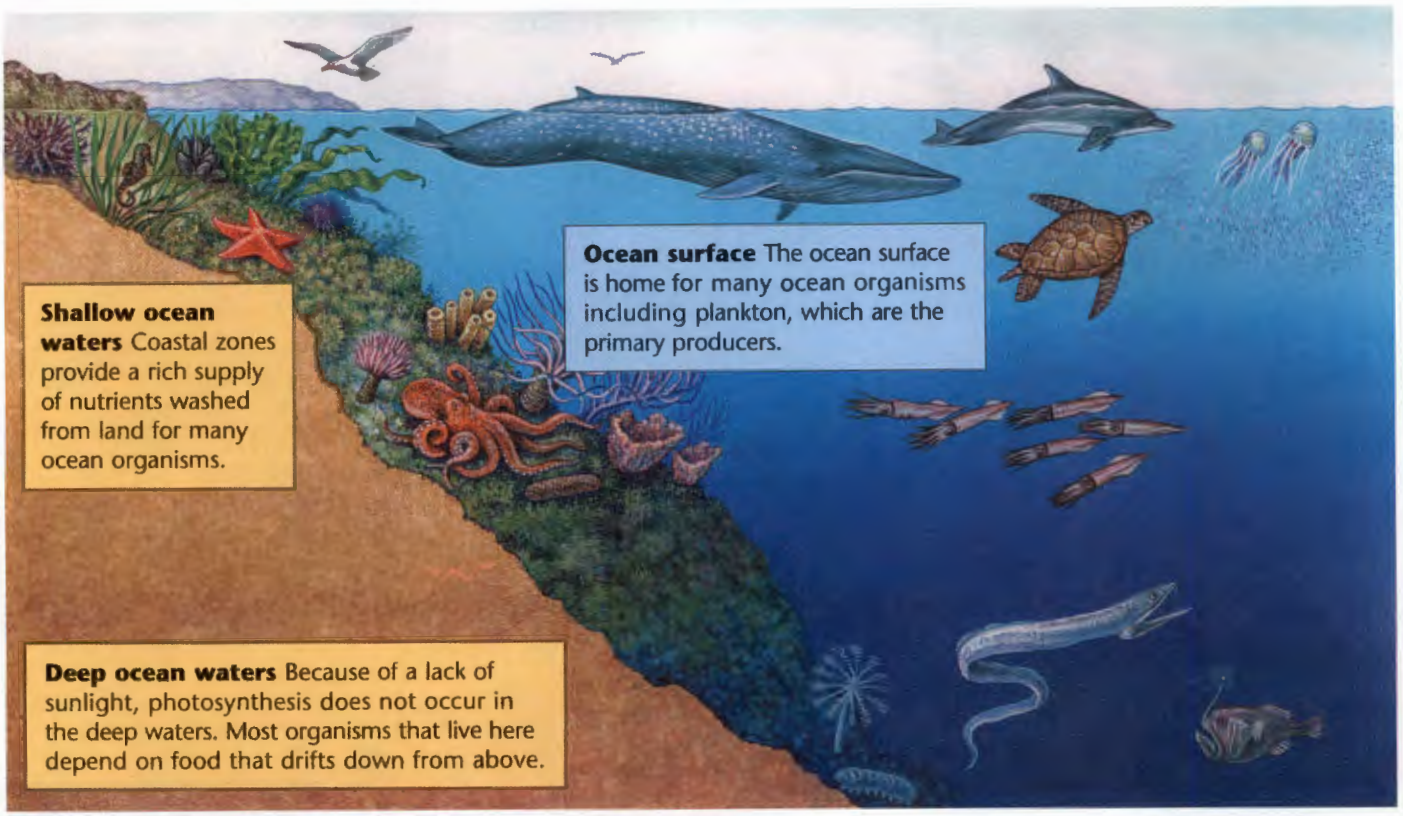


Figure 17 ▶ The amount of sunlight available determines which organisms can live in each layer of the ocean.

FIELD ACTIVITY

Make a Miniature Aquatic Ecosystem Make your own aquarium by collecting organisms from an aquatic ecosystem near your home or school. Be sure to collect some water from the aquatic ecosystem. Bring your collection back to school and set up an aquarium. If necessary, research the Internet to find out the special care that your ecosystem may require. Examine a few drops of your collected water under the microscope. Be sure to look for algae or other forms of life. Record and draw your observations in your ***EcoLog***. Observe and record the changes you see in your aquarium over the next 3 weeks. What conditions are needed to keep your miniature ecosystem healthy?

Oceans

Because water absorbs light, sunlight that is usable by plants for photosynthesis penetrates only about 100 m (330 ft) into the ocean before all of the sunlight is absorbed. As a result, much of the ocean's life is concentrated in the shallow, coastal waters. Here, sunlight penetrates to the bottom and rivers wash nutrients from the land. Seaweed and algae grow anchored to rocks, and phytoplankton drift on the surface. Invertebrates and fish that feed on these plants are also concentrated near the shore.

Plants and Animals of Oceans In the open ocean, phytoplankton grow only in areas where there is enough light and nutrients. As a result, the open ocean is one of the least productive of all ecosystems. Phytoplankton have buoyancy devices, such as whip-like flagella, that prevent them from sinking into deep water, which is too dark for photosynthesis. The sea's smallest herbivores are the zooplankton, which live near the surface with the phytoplankton they eat. The zooplankton include jellyfish, tiny shrimp, and the larvae of fish and bottom-dwelling animals, such as oysters and lobsters. Fish feed on the plankton as do marine mammals such as whales.

The depths of the ocean are perpetually dark, so most food at the ocean floor consists of dead organisms that fall from the surface. Decomposers, filter feeders, and the organisms that eat them live in the deep areas of the ocean. **Figure 17** illustrates the types of organisms that may be found in the layers of the ocean at various depths, depending on available sunlight.

Threats to the Oceans Although oceans are huge, they are steadily becoming more polluted. Most ocean pollution arises from activities on land. For example, plant nutrients washing off the land as runoff from fertilized fields may cause algal blooms, some of which are poisonous. Industrial waste and sewage discharged into rivers is the biggest source of coastal pollution in the United States.

Overfishing and certain fishing methods are also destroying some fish populations. Immense trawl nets can entangle organisms that are larger than the net holes. Marine mammals such as dolphins, which must breathe air, can drown in the nets. Although it is against the law, some ships discard fishing lines into the ocean, where they can strangle and kill fish and seals. The sea lion in **Figure 18** was strangled by a net off the coast of California.

Figure 18 ▶ This sea lion was strangled by a fishing net.

Arctic and Antarctic Ecosystems The arctic ecosystems at the North and South Poles depend on marine ecosystems because nearly all the food comes from the ocean.

The Arctic Ocean is rich in nutrients from the surrounding landmasses, and it supports large populations of plankton which feed a rich diversity of fish in the open water and under the ice. The fish are food for ocean birds, whales, and seals. Beluga whales, shown in **Figure 19,** feed on nearly 100 different arctic organisms. Fish and seals also provide food for polar bears and people on land.

The Antarctic is the only continent never colonized by humans. It is governed by an international commission and is used mainly for research. Even during the summer, only a few plants grow at the rocky edges of the continent. As in the Arctic, plankton form the basis of the Antarctic food web. The plankton nourish large numbers of fish, whales, and birds such as penguins, which cannot fly because their wings have evolved for swimming.

Figure 19 ▶ Beluga whales inhabit the Arctic Ocean.

SECTION 2 Review

1. **Explain** why estuaries are very productive ecosystems. Why are estuaries vulnerable to the effects of pollution?
2. **Compare** salt marshes with mangrove swamps.
3. **Describe** two factors that can damage coral reefs.
4. **List** two ways in which animals of the oceans are threatened.

CRITICAL THINKING

5. **Predicting Consequences** Suppose the sea level were suddenly to rise by 100 m. What would happen to the world's coral reefs? Explain.
6. **Analyzing Processes** Read the description of estuaries in this section and explain why cities are often built on estuaries. How would building a city on an estuary affect the plants and animals living in an estuary? READING SKILLS

CHAPTER 7

Highlights

1 Freshwater Ecosystems

Key Terms

wetland, 173
plankton, 173
nekton, 173
benthos, 173
littoral zone, 174
benthic zone, 174
eutrophication, 175

Main Ideas

- Aquatic ecosystems can be classified as freshwater ecosystems or marine ecosystems. The plants and animals in aquatic ecosystems are adapted to specific environmental conditions.
- Freshwater ecosystems include lakes, ponds, freshwater wetlands, rivers, and streams. The types of freshwater ecosystems are classified by the depth of the water, the speed of the water flow, and the availability of minerals, sunlight, and oxygen.
- Freshwater wetlands serve many functions within ecosystems. They trap and filter sediments and pollutants; reduce the likelihood of a flood; and buffer shorelines against erosion.

2 Marine Ecosystems

estuary, 179
salt marsh, 182
mangrove swamp, 182
barrier island, 182
coral reef, 183

- Marine ecosystems are identified by the presence of salt water and include coastal wetlands, coral reefs, oceans, and polar ecosystems.
- Estuaries are among the most productive of ecosystems because they constantly receive fresh nutrients from a river and from an ocean. Estuaries provide habitat for a multitude of plants and animals.
- Coral reefs are susceptible to destruction because they must remain at tropical temperatures and they must receive a large amount of sunlight. Coral reefs provide habitat for approximately one-fourth of all marine organisms.
- Almost every person has an impact on aquatic ecosystems. Through understanding how we affect aquatic ecosystems, we can reduce the negative effects we have on them.

CHAPTER 7 Review

Using Key Terms

Use each of the following terms in a separate sentence.

1. *wetland*
2. *mangrove swamp*
3. *estuary*
4. *eutrophication*
5. *benthos*

For each pair of terms, explain how the meanings of the terms differ.

6. *littoral zone* and *benthic zone*
7. *plankton* and *nekton*
8. *salt marsh* and *barrier island*
9. *wetland* and *coral reef*

STUDY TIP

Graph Skills Taking the following steps when reading a graph will help you correctly interpret the information. Be sure to read the title so that you understand what the graph represents. If the graph has axes, read the titles of both the *x*- and the *y*-axis. Examine the range of values on both the *x*- and the *y*-axis. Finally, examine the data on the graph, reading them from left to right, and put into words what you think the graph represents.

Understanding Key Ideas

10. Wetlands are important to fisheries in the United States because
    a. wetlands are the easiest place to catch fish.
    b. wetlands are the breeding grounds for insects that are eaten by fish.
    c. wetlands provide the most desirable species of fishes.
    d. many of the fish caught each year use wetlands for feeding and spawning.
11. Animals that live in estuaries
    a. tend to produce few offspring.
    b. are usually found in unpolluted environments.
    c. must be adapted to varying levels of salinity.
    d. are adapted to cold-water conditions.
12. Bacteria can kill organisms in eutrophic lakes by
    a. feeding on decaying plants and animals.
    b. reducing oxygen dissolved in the water.
    c. Both (a) and (b)
    d. Neither (a) nor (b)
13. Arctic ecosystems are considered marine ecosystems because
    a. arctic ecosystems contain an enormous amount of frozen sea water.
    b. arctic ecosystems are inhabited by few organisms.
    c. sunlight is limited.
    d. phytoplankton form the basis of arctic food webs.
14. Which of the following statements does *not* describe a function of wetlands?
    a. Wetlands buffer shorelines against erosion.
    b. Wetlands provide spawning grounds for commercially important fish and shellfish.
    c. Wetlands filter pollutants.
    d. Wetlands make good hazardous waste dumpsites.
15. Tiny animals, called *coral polyps*, that excrete limestone create
    a. barrier islands.
    b. coral reefs.
    c. swamps.
    d. salt marshes.
16. Mangrove trees grow
    a. along riverbanks.
    b. in freshwater wetlands.
    c. in tropical areas and in subtropical areas.
    d. in the benthic zones of lakes.
17. The Florida Everglades
    a. is the largest freshwater marsh in the United States.
    b. protects threatened and endangered wildlife.
    c. provides habitat for migratory birds.
    d. All of the above
18. Which of the following actions is an example of how humans affect wetlands?
    a. draining a wetland to create farmland
    b. clearing a wetland to build a housing development
    c. using a wetland as a landfill
    d. all of the above

CHAPTER 7 Review

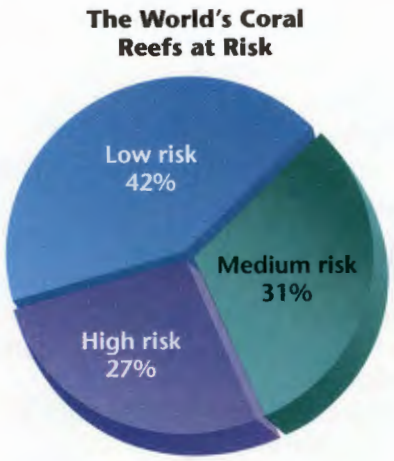
Short Answer

19. How does the phrase "best of both worlds" relate to an estuary?
20. Explain the difference between the types of organisms that make up these classes: plankton, nekton, and benthos.
21. List three functions of wetlands.
22. Describe what happens when a lake is considered to be eutrophic.
23. What type of vegetation dominates mangrove swamps?

Interpreting Graphics

The pie graph below shows the percentage of coral reefs at risk in the world. Use the pie graph to answer questions 24–26.

24. If there is a total of 255,300 km² of coral reefs in the world, how many square kilometers of coral reefs are at a high risk of being destroyed?
25. Where would you expect to find coral reefs that are at a low risk of being destroyed?
26. Where would you expect to find coral reefs that are at a high risk of being destroyed?



Source: World Resources Institute.

Concept Mapping

27. Use the following terms to create a concept map: *lakes, estuaries, aquatic ecosystems, coral reefs, freshwater wetlands, freshwater ecosystems, rivers, oceans, marshes, marine ecosystems, swamps, coastal ecosystems,* and *mangrove swamps.*

Critical Thinking

28. **Analyzing Relationships** Write a short paragraph that explains the relationship between the speed of a river and the oxygen content of a river. WRITING SKILLS
29. **Determining Cause and Effect** Explain what may happen if the use of fertilizer on farms and lawns around an estuary is not controlled.
30. **Making Comparisons** Read the paragraph under the heading "Threats to Estuaries" in this chapter. How do these threats compare to those described under the heading, "Threats to the Oceans?" READING SKILLS
31. **Analyzing Relationships** Explain why planting trees along a riverbank might benefit a river ecosystem.

Cross-Disciplinary Connection

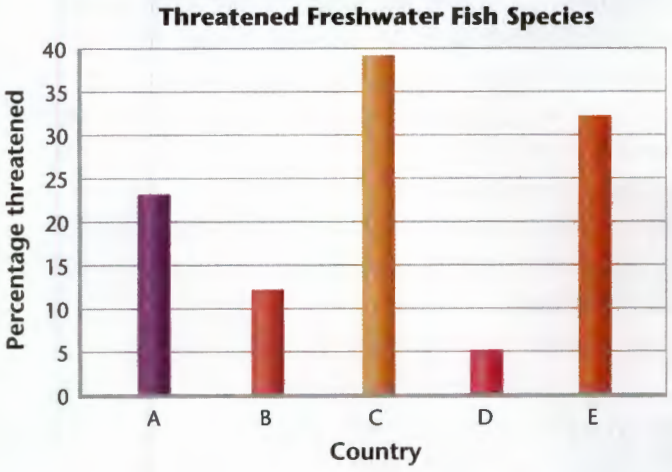
32. **Demography** Six out of 10 of the largest urban areas were built on estuaries. Three of these cities are Tokyo, New York, and Rio de Janeiro. Research the populations of each of these cities, and predict what may happen if population numbers continue to increase.

Portfolio Project

33. **Research a Local Aquatic Ecosystem** Observe an aquatic ecosystem near your school or home. This ecosystem can be as simple as a pond or stream or as complex as a lake or estuary. Observe the types of plants and animals in the aquatic ecosystem. Record any interactions among these organisms that you observe. When you have recorded all of your data and observations, write a one-page report on the aquatic ecosystem.

MATH SKILLS

Use the graph below to answer questions 34–35.



34. **Analyzing Data** The graph below illustrates the percentage of freshwater fish species that are threatened in specific countries. What percentage of freshwater fish species are threatened in country B? in country D?

35. **Evaluating Data** If the number of freshwater fish species in country C totals 599 different species, how many of these species are threatened?

WRITING SKILLS

36. **Communicating Main Ideas** What effect does overfishing have on estuaries? What effect does overfishing have on oceans?

37. **Writing from Research** Research endangered marine mammals of ocean and polar ecosystems. Write a one-page report on the factors that have caused these mammals to become endangered.

STANDARDIZED TEST PREP

For extra practice with questions formatted to represent the standardized test you may be asked to take at the end of your school year, turn to the sample test for this chapter in the Appendix.

READING SKILLS

Read the passage below, and then answer the questions that follow.

In the United States during the last 200 years, over 99 percent of native prairies have been replaced with farmland or urban development and most of the old-growth forests have been cut. Loss of so many of these habitats has resulted in losses of biodiversity.

A new discipline, called *conservation biology,* seeks to identify and maintain natural areas. In areas where human influence is greater, such as agricultural areas, former strip mines, and drained wetlands, biologists may have to reverse major changes and replace missing ecosystem components. For example, returning a strip-mined area to grassland may require contouring the land surface, introducing bacteria to the soil, planting grass and shrub seedlings, and even using periodic fires to manage the growth of vegetation. Restoring an area to its natural state is called *restoration ecology.*

1. Which of the following phrases describes a likely task of a restoration ecologist?
   - **a.** raising funds needed to create a national park
   - **b.** returning missing ecosystem components to a drained wetland
   - **c.** educating citizens about the need to protect a local habitat
   - **d.** both (a) and (b)

2. According to the passage, which of the following statements is true?
   - **a.** Former strip mines tend to have a high level of biodiversity.
   - **b.** A conservation biologist would most likely oppose the development of areas around the Grand Canyon.
   - **c.** Periodic fires in some ecosystems do not help manage excess growth of vegetation.
   - **d.** Most prairie ecosystems located in the United States have been preserved.

CHAPTER 7

Skills Practice Lab: OBSERVATION

Objectives

- **USING SCIENTIFIC METHODS** **Observe** the effects of nitrates and phosphates on an aquatic ecosystem.
- **Compare** the growth of organisms in different levels of nutrients.
- **Predict** possible effects nitrates and phosphates would have on an aquatic ecosystem in your area.

Materials

distilled water
eyedropper
fertilizer, household use
fluorescent lamp
graduated cylinder
guide to pond life identification
jars, 1 qt (3)
microscope
microscope slides with coverslips
plastic wrap
pond water that contains viable organisms
stirring rod
wax pencil

▶ **Step 5** Observe a drop of pond water under the microscope.

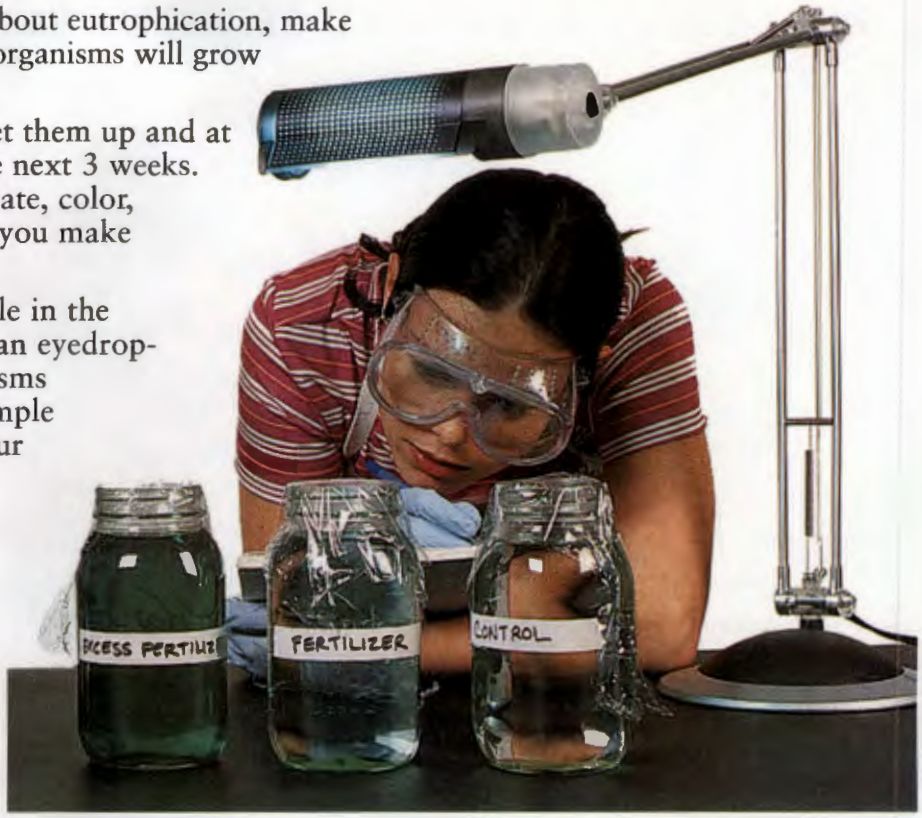
Eutrophication: Too Much of a Good Thing?

Plants depend on nutrients such as phosphates and nitrates to survive. However, when people release large amounts of these nutrients into rivers and lakes, *artificial eutrophication* can occur. In artificial eutrophication, nutrients cause algae and plant life to grow rapidly and then die off and decay. When microorganisms decompose the algae and plant matter, they use up oxygen in the water, which causes the death of fish and other animals that depend on oxygen for survival. Eutrophication is commonly caused by phosphates, which are often found in detergents, and by nitrates, which are found in animal wastes and fertilizers. In this lab, you will observe artificial eutrophication in an aquatic ecosystem.

Procedure

1. Working with your team, use a wax pencil to label one jar "Control," a second jar "Fertilizer," and a third jar "Excess fertilizer."
2. Put 750 mL of distilled water in each of the three jars. Read the label on the fertilizer container to determine the recommended dilution of fertilizer for watering plants. To the "Fertilizer" jar, add the amount of fertilizer recommended for a quart of water. To the "Excess fertilizer" jar, add 10 times this amount of fertilizer. Stir the contents of each jar thoroughly to dissolve the fertilizer.
3. Obtain a sample of pond water. Stir it gently but thoroughly to ensure that the organisms in it are evenly distributed. Measure 100 mL of pond water into each of the three jars.
4. Cover each jar loosely with plastic wrap. Place all three jars about 20 cm from a fluorescent lamp. (Do not place the jars in direct sunlight, as this may cause them to heat up too much.)
5. Observe a drop of pond water from your sample, under the microscope. On a sheet of paper, draw at least four different organisms that you see. Determine whether the organisms are algae (usually green) or consumers (usually able to move). Describe the total number and type of organisms that you see.

6. Based on what you have learned about eutrophication, make a prediction about how the pond organisms will grow in each of the three jars.
7. Observe the jars when you first set them up and at least once every three days for the next 3 weeks. Make a data table to record the date, color, odor, and any other observations you make for each jar.
8. When life-forms begin to be visible in the jars (probably after a week), use an eyedropper to remove a sample of organisms from each jar and observe the sample under the microscope. Record your observations.
9. At the end of your 3-week observation period, again remove a sample from each jar and observe it under the microscope. Draw at least four of the most abundant organisms that you see, and describe how the number and type of organisms have changed.



▶ **Step 7** Record your observations of the jars every 3 days for 3 weeks.

Analysis

1. **Describing Events** After three weeks, which jar shows the most abundant growth of algae? What may have caused this growth?
2. **Analyzing Data** Did you observe any effects on organisms other than algae in the jar that had the most abundant algae growth? Explain.

Conclusions

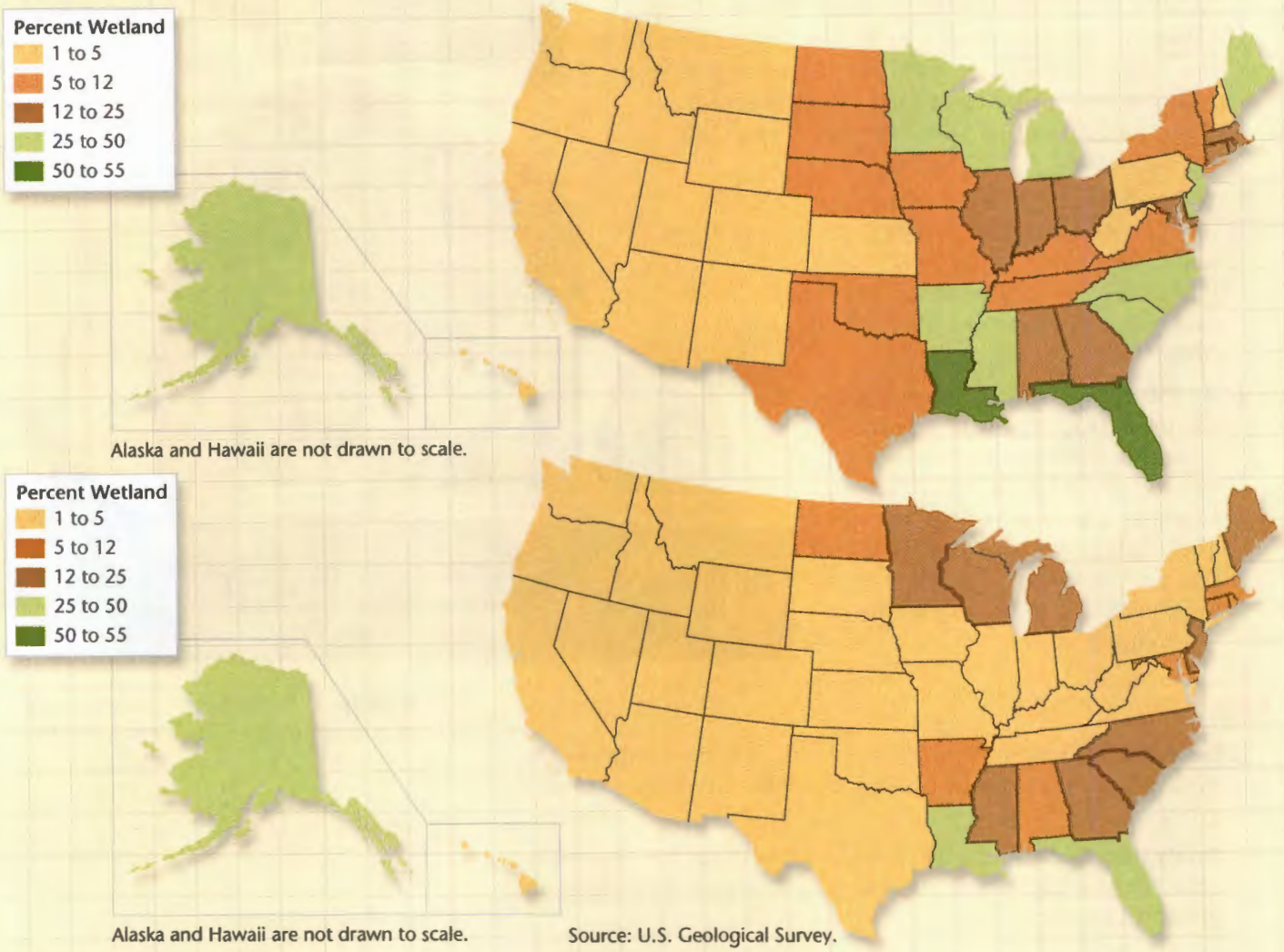
3. **Applying Conclusions** Did your observations match your predictions? Explain.
4. **Drawing Conclusions** How can artificial eutrophication be prevented in natural water bodies?

Extension

1. **Designing Experiments** Modify the experiment by using household dishwashing detergent instead of household fertilizer. Are the results different?
2. **Research and Communications** Research the watersheds that are located close to your area. How might activities such as farming and building affect watersheds?

MAPS in action

WETLANDS IN THE UNITED STATES, 1780s Vs. 1980s



Source: U.S. Geological Survey.

MAP SKILLS

Use the maps of wetland loss in the United States to answer the questions below.

1. **Using a Key** Use the key to determine how many states had a decrease in wetland distribution from 5 to 12 percent to 1 to 5 percent.
2. **Analyzing Data** Is there any state on the map of wetland distribution in the 1980s that has the same percentage of wetland distribution as it did in the 1780s? If so, how many?
3. **Analyzing Data** Which states have had the greatest decrease in wetland distribution since the 1780s?
4. **Making Inferences** What might have caused Florida's and Louisiana's wetlands to decrease in distribution?
5. **Using a Key** Use the key to determine how many states had a decrease in wetland distribution from 25 to 50 percent to 12 to 25 percent.
6. **Identifying Trends** If these trends of wetland loss continue, what might a map of wetland distribution of the United States look like circa 2040?

SCIENCE & TECHNOLOGY

CREATING ARTIFICIAL REEFS

Hundreds of years ago, people found that the fishing is often good over a sunken ship. The fishing is especially good if the wreck is in a protected area, where it will not be broken up by heavy surf or covered with silt from a river.

The reason fishing is often good under these conditions is because many marine organisms, such as seaweed, corals, and oysters live only where they can attach to a hard surface in clear water. So, the rocky shores of New England and of the West Coast support many more species than sandy areas do.

The Formation of a Reef

Organisms that attach to a hard bottom attract other species and eventually form a reef community. When seaweed grows on a rock, snails and crustaceans that eat the seaweed will join the community, as will sea anemones, which feed on the eggs, larvae, and waste produced by other organisms. Corals may settle on the bottom and add their hard skeletons to the reef. Then, fish arrive to feed on the reef organisms and to reproduce in the cracks and crevices of the reef that protect them from predators. If the reef is in a relatively calm area, it will become a diverse community that fishermen and scuba divers can enjoy.

In recent years, many communities have created artificial reefs by sinking various objects in the ocean. Barges full of broken up concrete are a common choice. The San Diego Oceans Foundation sank a decommissioned Canadian warship to create an artificial reef off Mission Beach, California. The warship was sunk to attract tourists who are recreational divers. A nonprofit group is working to bring the decommissioned USAF's *General Hoyt S. Vandenburg* to Key West to be sunk as a diving reef that will enhance the Florida Keys National Marine Sanctuary. A reef foundation in Georgia produces objects called reef balls. Reef balls are hollow, concrete balls that have holes in them. They have legs that "stick" out to prevent them from rolling around on the ocean floor. The balls come in various sizes and can be towed behind even a small boat to where they will be sunk. Reef balls are used to provide additional hard surfaces for restoring damaged coral reefs as well as to create new fishing and diving reefs.

▶ The gun turret (below) and the aircraft (left) are examples of objects used to create artificial reefs.

Safe Artificial Reefs

Sinking artificial reefs is not problem free. Obviously, the reef must be deep enough so that it does not interfere with the movement of ships. But we cannot be sure what depth of water the ships of the future will need or that shipping channels will be in the same places. In addition, if the object is to attract divers, any parts that might trap or entangle a diver must be removed. Also, the reef must not pollute the water or fall apart and leave debris drifting in the sea. In the case of ships that are used to create artificial reefs, stripping out all the hazardous materials, such as plastics, insulation, and oil, is necessary.

What Do You Think?

What are the benefits to creating artificial reefs? How are most artificial reefs created? Are there any disadvantages to creating artificial reefs? Explain why creating artificial reefs may be helpful in aquatic ecosystems other than the ocean. Research the Internet to find out if there are any artificial reefs in your community.