

## Section 4–4

### 1 FOCUS

#### Objectives

- 4.4.1 Identify** the factors that govern aquatic ecosystems.
- 4.4.2 Identify** the two types of freshwater ecosystems.
- 4.4.3 Describe** the characteristics of the marine zones.

#### Guide for Reading

#### Vocabulary Preview

Point out the words *photic* and *aphotic* in the Vocabulary list on this page. Explain that *phot-* in these words means the same thing as the prefix *photo-* in words such as *photograph*. Ask: **What does the prefix *photo-* mean? (“Light”)** **What does the prefix *a-* in the word *aphotic* mean? (“Not” or “without”)** **What do you think the terms *photic* and *aphotic* mean? (“With light” and “without light”)** Tell students to check their predictions when they encounter these words in the text.

#### Reading Strategy

As with the biomes in Section 4–3, have students set up a table for recording the similarities and differences they find as they read about aquatic ecosystems. Suggest that they divide the “Marine Ecosystems” section of the table into two subsections so they can keep separate notes on the photic and aphotic zones.

## 2 INSTRUCT

### Freshwater Ecosystems

#### Use Community Sources

Have students consult road maps to find the locations and names of any freshwater ecosystems—lakes, ponds, rivers, or streams—in their area. If possible, arrange a trip to one of these locations so students can observe its characteristics and the types of organisms living there. **L2**

## 4–4 Aquatic Ecosystems

#### Guide for Reading

##### Key Concepts

- What are the main factors that govern aquatic ecosystems?
- What are the two types of freshwater ecosystems?
- What are the characteristics of the different marine zones?

##### Vocabulary

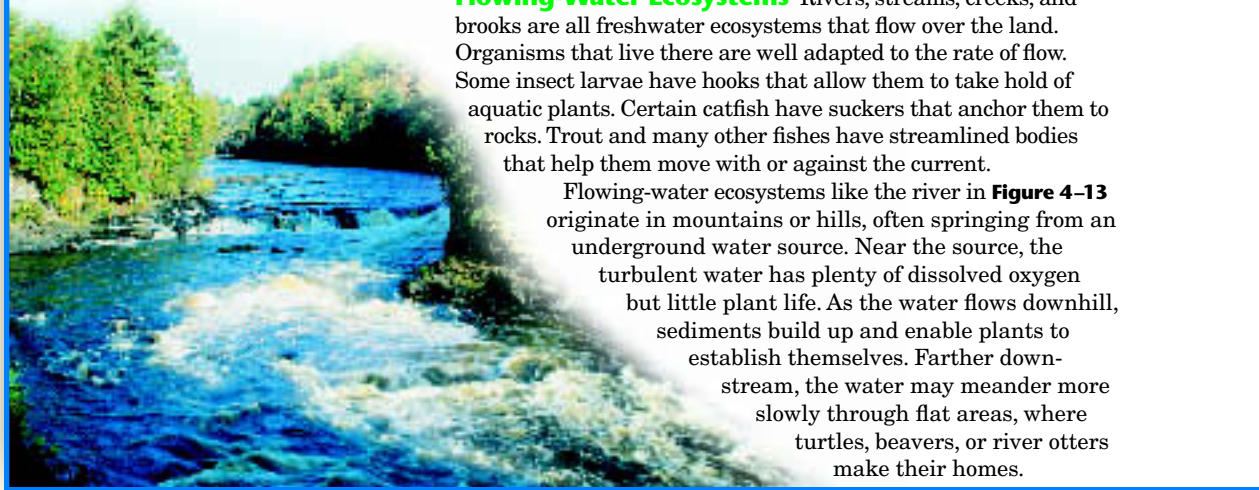
plankton • phytoplankton  
zooplankton • wetland  
estuary • detritus • salt marsh  
mangrove swamp  
photic zone • aphotic zone  
zonation • coastal ocean  
kelp forest • coral reef  
benthos

##### Reading Strategy:

##### Making Comparisons

As you read, write down statements about similarities and differences among the different types of aquatic ecosystems.

▼ **Figure 4–13** The Menominee River in Michigan is a flowing-water ecosystem. Like all aquatic ecosystems, this river’s communities are determined by the depth, flow, and chemistry of the water.



Nearly three fourths of Earth’s surface is covered with water, so it is not surprising that many organisms make their homes in aquatic habitats. Oceans, streams, lakes, and marshes—indeed, nearly any body of water—contain a wide variety of communities. These aquatic communities are governed by biotic and abiotic factors, including light, nutrient availability, and oxygen.

**Aquatic ecosystems are determined primarily by the depth, flow, temperature, and chemistry of the overlying water.** In contrast to land biomes, which are grouped geographically, aquatic ecosystems are often grouped according to the abiotic factors that affect them. One such factor is the depth of water, or distance from shore. The depth of water, in turn, determines the amount of light that organisms receive. Water chemistry refers primarily to the amount of dissolved chemicals—especially salts, nutrients, and oxygen—on which life depends. For example, communities of organisms found in shallow water close to shore can be very different from the communities that occur away from shore in deep water. One abiotic factor that is important both to biomes and aquatic ecosystems is latitude. Aquatic ecosystems in polar, temperate, and tropical oceans all have distinctive characteristics.

### Freshwater Ecosystems

It may surprise you to know that only 3 percent of the surface water on Earth is fresh water. **Freshwater ecosystems can be divided into two main types: flowing-water ecosystems and standing-water ecosystems.**

**Flowing-Water Ecosystems** Rivers, streams, creeks, and brooks are all freshwater ecosystems that flow over the land. Organisms that live there are well adapted to the rate of flow. Some insect larvae have hooks that allow them to take hold of aquatic plants. Certain catfish have suckers that anchor them to rocks. Trout and many other fishes have streamlined bodies that help them move with or against the current.

Flowing-water ecosystems like the river in **Figure 4–13** originate in mountains or hills, often springing from an underground water source. Near the source, the turbulent water has plenty of dissolved oxygen but little plant life. As the water flows downhill, sediments build up and enable plants to establish themselves. Farther downstream, the water may meander more slowly through flat areas, where turtles, beavers, or river otters make their homes.



#### SECTION RESOURCES

##### Print:

- **Teaching Resources**, Section Review 4–4
- **Reading and Study Workbook A**, Section 4–4
- **Adapted Reading and Study Workbook B**, Section 4–4
- **Lesson Plans**, Section 4–4

##### Technology:

- **iText**, Section 4–4
- **Transparencies Plus**, Section 4–4

**Standing-Water Ecosystems** Lakes and ponds are the most common standing-water ecosystems. In addition to the net flow of water in and out of these systems, there is usually water circulating within them. This circulation helps to distribute heat, oxygen, and nutrients throughout the ecosystem.

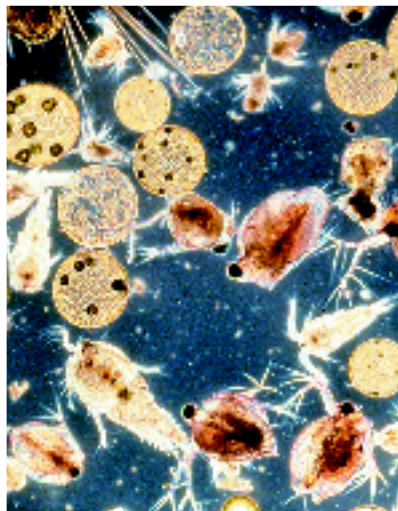
The relatively still waters of lakes and ponds provide habitats for many organisms, such as plankton, that would be quickly washed away in flowing water. **Plankton** is a general term for the tiny, free-floating organisms that live in both freshwater and saltwater environments. See **Figure 4-14** for examples. Unicellular algae, or **phytoplankton** (fyt-oh-PLANK-tun), are supported by nutrients in the water and form the base of many aquatic food webs. Planktonic animals, or **zooplankton** (zoh-oh-PLANK-tun), feed on the phytoplankton.

**CHECKPOINT** What are phytoplankton?

**Freshwater Wetlands** A **wetland** is an ecosystem in which water either covers the soil or is present at or near the surface of the soil for at least part of the year. The water in wetlands may be flowing or standing and fresh, salty, or brackish, which is a mixture of fresh and salt water. Many wetlands are very productive ecosystems that serve as breeding grounds for insects, fishes and other aquatic animals, amphibians, and migratory birds.

The three main types of freshwater wetlands are bogs, marshes, and swamps. Bogs, which are wetlands that are often dominated by sphagnum moss, typically form in depressions where water collects. The water in sphagnum bogs is often very acidic. Marshes are shallow wetlands along rivers. They may be underwater for all or part of the year. Marshes often contain cattails, rushes, and other tall, grasslike plants. Water flows slowly through swamps, which often look like flooded forests. The presence of trees and shrubs is what distinguishes a swamp from a marsh.

Some wetlands, such as the swamp shown in **Figure 4-15**, are wet year-round. Other kinds of wetlands, however, may not always be covered in standing water. Such areas may be classified as wetlands because they have certain kinds of soils and are wet enough to support a specific community of water-loving plants and animals.



▲ **Figure 4-14** Both freshwater and saltwater ecosystems often include plankton. This photograph shows phytoplankton, zooplankton, and larger animals called water fleas. **Predicting** What might happen to an aquatic food web if phytoplankton were removed from the ecosystem?

▼ **Figure 4-15** Freshwater ecosystems can be divided into two main types: flowing-water ecosystems and standing-water ecosystems. Although this swamp along the Loxahatchee River in Florida appears stagnant, water actually flows through it slowly. The swamp is home to turtles, otters, alligators, and herons that live among the baldcypress trees.



**Build Science Skills**

**Comparing and Contrasting**

As suggested for biomes, guide students through the information in this section by having them focus on one factor at a time—temperature range, light, oxygen and nutrient availability, and characteristic organisms—across all the aquatic ecosystems. Discuss any unfamiliar organisms, and provide field guides so students can do further research. Also, encourage students to share any personal experiences they have had with different aquatic biomes. **L2**

**Demonstration**

Collect several different types of freshwater plants and animals to set up a classroom aquarium. Also collect some abiotic elements—water, rocks, mud, sand, and the like—so the organisms will have as natural an environment as possible. Make sure you or students return all organisms to their original location at the end of this unit. **L1 L2**

**Use Community Resources**

Emphasize that a particular area of land is classified as a wetland not by whether it has water on it at any particular time of the year but by its soil type and the plants found there. In fact, many freshwater wetlands are dry for a good part of the year, so people may not even recognize them as wetlands. If a wetland exists near the school, take the class to observe it. Caution students to be very careful walking in the area, as many wetland plants are fragile and the soil, if damp, can be easily compacted. Do not allow students to collect any plants, animals, or abiotic materials. **L2 L3**

**Differentiated**

**Instruction Solutions for All Learners**

**Less Proficient Readers**

Few students will have observed any marine ecosystems beyond the intertidal zone. To help students comprehend the text description of marine zones, provide a wide variety of visual resources—photographic books, nature magazines, videotapes, and CD-ROMs—so students can see what the different zones and their organisms look like. **L1 L2**

**Advanced Learners**

Students who need an additional challenge might enjoy researching and reading about Sylvia Earle, a marine biologist who earned international recognition for her pioneering studies of hydrothermal vents and the unique organisms found there. Encourage students to share their findings in posters, oral reports, mock radio shows, or skits. **L3**

**Answers to . . .**

**CHECKPOINT** Single-celled algae

**Figure 4-14** The consumers would die off because there would be no more producers to sustain them.

## Estuaries

### Word Origins

A detritivore is an organism that eats detritus. **L2**

### Build Science Skills

#### Comparing and Contrasting

Have students describe similarities and differences between the types of organisms found in freshwater ecosystems and those found in estuaries. Then, ask: **Do the same species of aquatic organisms live in both ecosystems? (No) Why not? (Estuaries are saltwater ecosystems. Species usually are adapted to live in either a saltwater environment or a freshwater environment, not both.)**

**L1 L2**

## Marine Ecosystems

### Build Science Skills

**Predicting** Draw a horizontal line on the chalkboard to represent the surface of the ocean. Then, draw a diagonal line slanting downward, and mark it to indicate ocean depths of 50 meters, 100 meters, 200 meters, 1000 meters, 2000 meters, and 10,000 meters. Invite students to relate what they already know about marine organisms. Then, ask: **What factors do you think determine the types of organisms that live at different depths in the ocean? (Most students will realize that available light is a major factor. Accept all responses without comment at this time.)** **L2**

### Word Origins

**Detritus** is a Latin word meaning “worn away.” In ecology, detritus refers to particles that have worn away from decaying organic material. **If the Latin word *vorare* means “to devour,” what is a detritivore?**

## Estuaries

**Estuaries** (ES-tyoo-ehr-eez) are wetlands formed where rivers meet the sea. Estuaries thus contain a mixture of fresh water and salt water, and are affected by the rise and fall of ocean tides. Many are shallow, so sufficient sunlight reaches the bottom to power photosynthesis. Primary producers include plants, algae, and both photosynthetic and chemosynthetic bacteria. Estuary food webs differ from those of more familiar ecosystems because most primary production is not consumed by herbivores. Instead, much of that organic material enters the food web as detritus. **Detritus** is made up of tiny pieces of organic material that provide food for organisms at the base of the estuary’s food web. Organisms that feed on detritus include clams, worms, and sponges.

Estuaries support an astonishing amount of biomass, although they usually contain fewer species than freshwater or marine ecosystems. Estuaries serve as spawning and nursery grounds for commercially important fishes and for shellfish such as shrimps and crabs. Many young animals feed and grow in estuaries, then head out to sea to mature, and return to reproduce. Many waterfowl use estuaries for nesting, feeding, and resting during migrations.

**Salt marshes** are temperate-zone estuaries dominated by salt-tolerant grasses above the low-tide line, and by seagrasses under water. Salt marshes like the one shown in **Figure 4-16** (left) are (or were once) found along great stretches of eastern North America from southern Maine to Georgia. One of the largest systems of connected salt marshes in America surrounds the Chesapeake Bay estuary in Maryland.

**Mangrove swamps**, shown in **Figure 4-16** (right), are coastal wetlands that are widespread across tropical regions, including southern Florida and Hawaii. Here, the dominant plants are several species of salt-tolerant trees, collectively called mangroves. Seagrasses are also common below the low-tide line. Like salt marshes, mangrove swamps are valuable nurseries for fish and shellfish. The largest mangrove area in the continental United States is within Florida’s Everglades National Park.

**Figure 4-16** Salt marshes occur in estuaries along seacoasts in the temperate zone. Salt-tolerant grasses are the dominant plants in this salt marsh (left) along the coast of Mount Desert Island in Maine. Mangrove swamps (right) occur in bays and estuaries along tropical coasts. The stiltlike roots of mangrove trees trap sediment that accumulates as mud behind the trees. This allows other plants to take root and helps to build the mangrove forest out from the shoreline. **Predicting** *Would you expect to find mangrove swamps or salt marshes on a coast exposed to large ocean waves? Explain.*

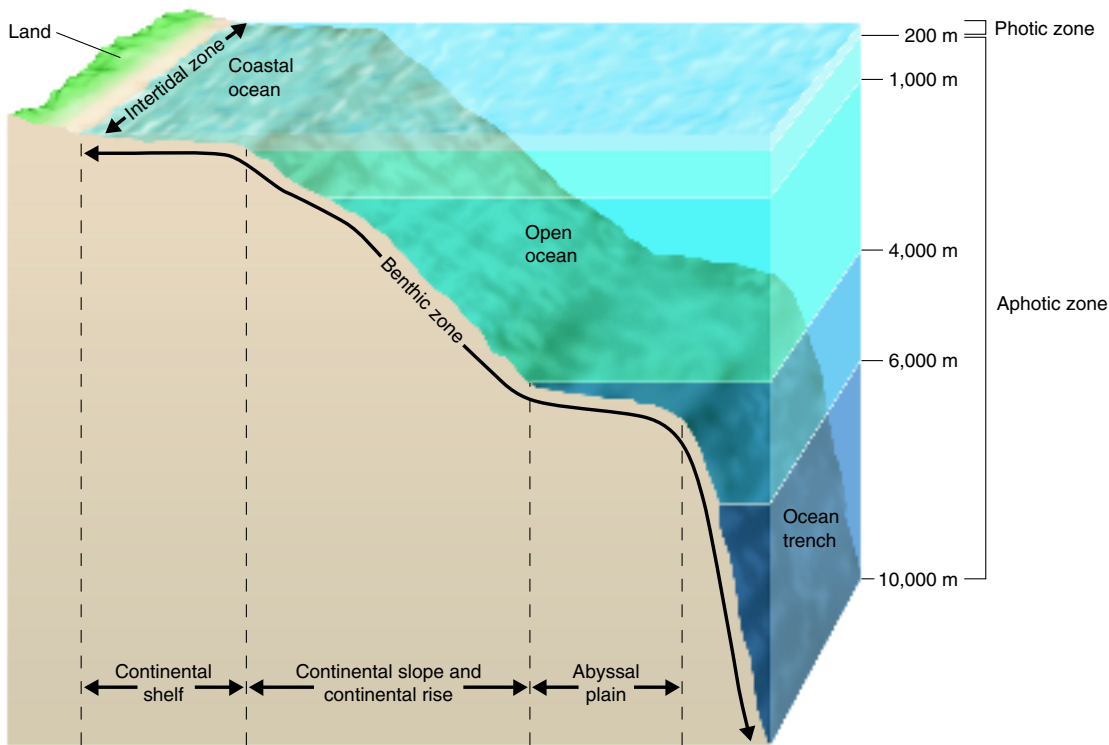


### FACTS AND FIGURES

#### Bottoms up!

A problem that occurs in aquatic ecosystems is that nutrients tend to sink below the photic zone so organisms cannot use them. In lakes, strong winds usually mix the water. In oceans, deep nutrient-rich water rises to the photic zone in a process called upwelling. In upwelling, winds carry surface water away from land.

Bottom water with valuable nutrients is pulled up into the photic zone to replace the surface water that has been moved out to sea. These nutrients support vigorous and rapid growth of phytoplankton, which provide the basis for marine food webs. Upwelling is common along the coastal margins of continents, where winds carry surface currents toward the open ocean.



## Build Science Skills

**Problem Solving** Explain that three main factors determine the types of marine organisms that live at different depths: available sunlight, water temperature, and water pressure. Ask: **At what depth do you think sunlight is most abundant?** (Near the surface) **How does this factor affect where organisms live?** (Organisms that conduct photosynthesis live near the surface, as do many animals that depend on those organisms for food.) **At what depth would you expect water temperatures to be the warmest? Why?** (Near the surface, because sunlight warms the water there) **How do you think water pressure changes with ocean depth?** (Pressure increases as depth increases.) **How would this factor affect where organisms live?** (Most organisms cannot withstand great pressure on their bodies, so they must live near the surface.) **L2**

## Use Visuals

**Figure 4-17** Have students locate the intertidal zone, coastal ocean, open ocean, and benthic zone on the figure and identify the characteristic organisms pictured for each of the four zones. Ask: **What are the abiotic characteristics of each zone?** (Intertidal zone: extreme changes in conditions from being submerged in sea water to being exposed to air, sunlight, and heat; subject to waves and currents. Coastal ocean: receives sunlight. Open ocean: surface receives sunlight; deep ocean has high pressure, frigid temperatures, and total darkness. Benthic zone: includes ocean floor, various ocean depths, and deep-sea vents.) **L1 L2**

## Marine Ecosystems

Unless you are an avid diver or snorkeler, it takes some imagination to picture what life is like in the vast, three-dimensional ocean. Sunlight penetrates only a relatively short distance through the surface of the water. Photosynthesis is limited to this well-lit upper layer known as the **photic** (FOH-tik) **zone**. Only in this relatively thin surface layer—typically down to a depth of about 200 meters—can algae and other producers grow. Below the photic zone is the **aphotic** (ay-FOH-tik) **zone**, which is permanently dark. Chemosynthetic autotrophs are the only producers that can survive in the aphotic zone.

There are several different classification systems that scientists use to describe marine ecosystems. **In addition to the division between the photic and aphotic zones, marine biologists divide the ocean into zones based on the depth and distance from shore: the intertidal zone, the coastal ocean, and the open ocean.** Each of these zones supports distinct ecological communities. The benthic zone covers the ocean floor and is, therefore, not exclusive to any of the other marine zones. **Figure 4-17** shows a generalized diagram of the marine zones.

**CHECKPOINT** What factor is absent in the aphotic zone?

**▲ Figure 4-17** The ocean can be divided into zones based on light penetration and into zones based on depth and the distance from shore. Each zone contains a characteristic assemblage of organisms.

**Go Online**  
 NSTA SciLINKS  
 For: Links on aquatic ecosystems  
 Visit: [www.SciLinks.org](http://www.SciLinks.org)  
 Web Code: cbn-2044

**Go Online**  
 NSTA SciLINKS  
 Download a worksheet on aquatic ecosystems for students to complete, and find additional teacher support from NSTA SciLinks.

## Answers to . . .

**CHECKPOINT** Sunlight

**Figure 4-16** No, because large ocean waves would make it impossible for the roots of salt marsh grasses or mangrove trees to remain anchored.

## 4-4 (continued)

### Build Science Skills

**Classifying** To reinforce students' understanding of which organisms live in which zone, provide a variety of once-living ocean organisms for students to examine. Possibilities include dried sea stars and sea urchins, seashells, crab and lobster shells, dried kelp and other seaweed, pieces of coral, and dried, pickled, or fresh squid or octopus. Challenge students to sort the objects into groups based on the zones in which the living organisms are found.

L1 L2



▲ **Figure 4-18** ● The main divisions in the ocean based on depth and distance from shore are the **intertidal zone**, the **coastal ocean**, and the **open ocean**. Along the coast of Vancouver Island in Canada, low tide reveals sea stars, seaweed, and other organisms adapted to life in the intertidal zone.

**Intertidal Zone** Organisms that live in the intertidal zone are exposed to regular and extreme changes in their surroundings. Once or twice a day, they are submerged in sea water. The remainder of the time, they are exposed to air, sunlight, and temperature changes. Often, organisms in this zone are battered by waves and sometimes by strong currents.

There are many different types of intertidal communities. One of the most interesting is the rocky intertidal, shown in **Figure 4-18**, which exists in temperate regions where exposed rocks line the shore. There, barnacles and seaweed permanently attach themselves to the rocks. Other organisms, such as snails, sea urchins, and sea stars, cling to the rocks by their feet or suckers.

Competition among organisms in the rocky intertidal zone often leads to zonation (zoh-NAY-shun). **Zonation** is the prominent horizontal banding of organisms that live in a particular habitat. In the rocky intertidal zone, each band can be distinguished by differences in color or shape of the major organisms. For example, a band of black algae might grow at the highest high-tide line, followed by encrusting barnacles. Lower down, clusters of blue mussels might stick out amid clumps of green algae. This zonation is similar to the pattern that you might observe as you climb up a mountain. In the intertidal zone, however, zonation exists on a smaller vertical scale—just a few meters compared to the kilometers you would ascend on a mountain.



**Coastal Ocean** The **coastal ocean** extends from the low-tide mark to the outer edge of the continental shelf, the relatively shallow border that surrounds the continents. The continental shelf is often shallow enough to fall mostly or entirely within the photic zone, so photosynthesis can usually occur throughout its depth. As a result, the coastal ocean is often rich in plankton and many other organisms.

One of the most productive coastal ocean communities is the kelp forest. **Kelp forests** are named for their dominant organism: a giant brown alga that can grow at extraordinary rates—as much as 50 centimeters a day. Huge forests of this seaweed are found in cold-temperate seas around the world, including those along the coasts of California and the Pacific Northwest. Kelp forests, like the one shown in **Figure 4-19**, support a complex food web that includes snails, sea urchins, sea otters, a variety of fishes, seals, and whales.

**Check Your Understanding** What is the coastal ocean?

◀ **Figure 4-19** Kelp forests are ecosystems that occur in coastal oceans. The long strands of kelp create a habitat that shelters a variety of organisms. This kelp forest off the coast of California is part of a larger zone of kelp forests found along the western coast of North America from Alaska to Mexico. **Comparing and Contrasting** How is a kelp forest like a forest on land?



### BACKGROUND

#### **The ocean floor**

The benthic zone, or ocean floor, extends from the high-tide mark to the deepest part of the ocean. Life in this zone consists of sessile and motile organisms. These organisms are distributed from near the shore to the depths of the ocean and they play an important role in the ocean's food chain. Plants found in the benthic zone can live only in the photic zone, or area where sunlight can penetrate (30 to 200 meters below the ocean's surface). The portion of the benthic zone

that is between 2000 meters and 6000 meters deep is known as the abyssal zone. The floor of the abyssal zone is covered with mud and organic debris. For the most part, food is in short supply. However, there are fishes (rattails), echinoderms, mollusks, and burrowing worms. In areas around hydrothermal vents (volcanic hot springs), clumps of bacteria growing on rocks use the hydrogen sulfide as an energy source. Living on these bacteria are filter-feeding animals such as giant clams and giant tube worms (up to 3.7 meters long).

**Coral Reefs** In the warm, shallow water of tropical coastal oceans are coral reefs, among the most diverse and productive environments on Earth. **Coral reefs** are named for the coral animals whose hard, calcium carbonate skeletons make up their primary structure. As you can see in **Figure 4–20**, an extraordinary diversity of organisms flourishes in these spectacular habitats.

Coral animals are tiny relatives of jellyfish that live together in vast numbers. Most coral animals are the size of your fingernail, or even smaller. Each one looks like a small sack with a mouth surrounded by tentacles. These animals use their tentacles to capture and eat microscopic creatures that float by. Coral animals cannot grow in cold water or water that is low in salt.

The types of corals that build reefs grow with the help of algae that live symbiotically within their tissues. These algae carry out photosynthesis using the coral animals' wastes as nutrients. In turn, the algae provide their coral hosts with certain essential carbon compounds. Because their algae require strong sunlight, most reef-building corals thrive only in brightly lit areas within 40 meters of the surface.



► **Figure 4–20** This coral reef off the island of New Britain in the Pacific Ocean supports a dazzling variety of corals and fishes. Reefs are most abundant around islands and along the eastern coasts of continents. In the United States, only the coasts of southern Florida and Hawaii have coral reefs. **Applying Concepts** *In what types of community interactions are coral animals involved?*

### Analyzing Data

Before students graph the data, have them review the characteristics of the listed types of ecosystems. **L2 L3**

1. Students should choose a scale for the axis of the graph representing average primary productivity that is large enough to enable them to graph the data accurately.
2. Coral reef ecosystems are the most productive. Students may infer that reefs are so productive because they are near the top of the photic zone.
3. The area of the open ocean far exceeds the area occupied by all the other ecosystems put together.
4. Latitude and precipitation are both factors that affect the productivity of the land ecosystems in the table. Ecosystems that are drier (tropical savanna) or closer to the polar zones (tundra) are less productive.

### Analyzing Data

#### Ecosystem Productivity

The data table on the right compares the primary productivity of some of the world's ecosystems. Use the data table to answer the following questions:

1. **Using Tables and Graphs** Construct a bar graph to display the data. Use different colors to distinguish aquatic and land ecosystems.
2. **Using Tables and Graphs** According to your graph, which ecosystem is most productive? Use what you know to explain that fact.
3. **Inferring** Although the open ocean is among the least productive ecosystems, it contributes greatly to the overall productivity of the biosphere. How can this situation be explained?
4. **Applying Concepts** What are two abiotic factors that might account for the differences in productivity among the land ecosystems in the table? (*Hint: Review the relevant biomes on pages 100–104.*)

#### Productivity of Aquatic and Land Ecosystems

Ecosystem	Average Primary Productivity (grams of organic matter produced per square meter per year)
<b>Aquatic Ecosystems:</b>	
Coral reef	2500
Estuary	1800
Lake	500
Open ocean	125
<b>Land Ecosystems:</b>	
Tropical rain forest	2200
Temperate forest	1250
Tropical savanna	900
Tundra	90

### Build Science Skills

**Using Analogies** Direct students to consider what they learned about mountains when they studied biomes in the previous section. Then, ask: **How is the benthic zone like an upside-down mountain?** (*Sample answer: As you go up a mountain, temperatures become colder and precipitation increases, producing different conditions at different elevations. Similarly, as you go farther down in the ocean and the water depth increases, pressure also increases, available sunlight decreases, and temperatures become colder, producing different zones along the ocean floor.*) **L2**

### Answers to . . .

**CHECKPOINT** *The part of the ocean that extends from the low-tide mark to the outer edge of the continental shelf*

**Figure 4–19** *Students' comparisons should include the idea that the producers in a kelp forest ecosystem—giant kelp—have a function similar to the producers in a forest on land.*

**Figure 4–20** *Coral animals are involved in predation both as predators and as prey. They are also involved in a mutualistic symbiotic relationship with algae. Students might also infer that corals are involved in competition and are affected by parasitism and disease.*

## 4–4 (continued)

### Use Visuals

**Figure 4–21** Focus students' attention on the photo of the octopus, and ask: **Since this animal lives mainly on the ocean floor, can it be classified as a benthos organism?** (Yes, but not exclusively so. Some octopi live in the depths of oceans, but others live in shallow coastal waters.) Point out that marine animals can adapt to different environments, just as land animals can. **L1 L2**

## 3 ASSESS

### Evaluate Understanding

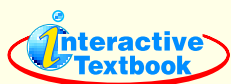
As you did with biomes in the previous section, describe various aquatic ecosystems and ocean zones, and call on students at random to identify each one. Limit your descriptions to the information contained in this section.

### Reteach

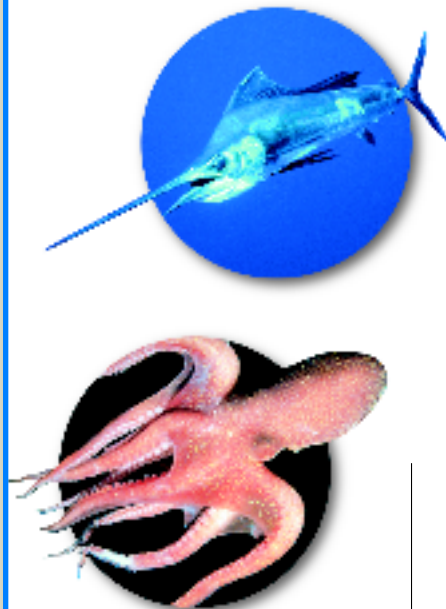
Have students work cooperatively to construct a bulletin board display showing the different kinds of aquatic ecosystems and ocean zones discussed in this section, using pictures they have drawn themselves or photocopied. Have students label the names of the aquatic ecosystems and ocean zones, their major characteristics, and the types of organisms found in each.

### Writing in Science

Answers may vary. Students might select any plants and animals from three of the aquatic ecosystems discussed in this section. In their comparisons, they should describe how specific adaptations of the organisms help them live in their environments



If your class subscribes to the iText, use it to review the Key Concepts in Section 4–4.



**▲ Figure 4–21** In the open ocean, the swordfish (top) can sometimes be seen swimming near the surface, yet these fish can also dive to more than 600 meters to prey on fishes of the deep ocean. Some types of octopus (bottom) live in the depths of the open ocean, although other types live in shallow coastal waters.

**Open Ocean** The open ocean, often referred to as the oceanic zone, begins at the edge of the continental shelf and extends outward. It is the largest marine zone, covering more than 90 percent of the surface area of the world's oceans. The open ocean ranges from about 500 meters deep along continental slopes to more than 11,000 meters at the deepest ocean trench. Organisms in the deep ocean are exposed to high pressure, frigid temperatures, and total darkness.

Typically, the open ocean has very low levels of nutrients and supports only the smallest producers. Productivity is generally low. Still, because of the enormous area, most of the photosynthetic activity on Earth occurs in the part of the open ocean within the photic zone. Fishes of all shapes and sizes dominate the open ocean. The swordfish and the octopus in **Figure 4–21** are just two examples of the organisms found in this zone. Marine mammals such as dolphins and whales also live there but must stay close to the surface to breathe.

**Benthic Zone** The ocean floor contains organisms that live attached to or near the bottom, such as sea stars, anemones, and marine worms. Scientists refer to these organisms as the **benthos**. That is why the ocean floor is called the benthic zone. This zone extends horizontally along the ocean floor from the coastal ocean through the open ocean.

Benthic ecosystems often depend on food from organisms that grow in the photic zone, particularly the producers. Animals that are attached to the bottom or do not move around much, such as clams and sea cucumbers, feed on pieces of dead organic material, or detritus, that drift down from the surface waters. Near deep-sea vents, where superheated water boils out of cracks on the ocean floor, dwell chemosynthetic primary producers that support life without light and photosynthesis.

## 4–4 Section Assessment

- Key Concept** List three characteristics that determine the structure of aquatic ecosystems.
- Key Concept** Compare standing-water ecosystems to flowing-water ecosystems. How are they alike? How are they different?
- Key Concept** List six distinct ecological zones that can be found in the ocean. Give two abiotic factors for each zone.
- Define the terms *wetland* and *estuary*. Give at least one example of a freshwater wetland and of an estuary.
- Critical Thinking Predicting** How might the damming of a river affect an estuary at the river's mouth?

### Writing in Science

#### Comparing and Contrasting

Choose three different aquatic ecosystems. From each of these ecosystems, select a plant and an animal and describe how the organisms are adapted to their environments. Show comparisons. *Hint:* Create a table to organize your ideas.

## 4–4 Section Assessment

- Any three of these four: depth, flow, temperature, and chemistry of overlying water
- Alike: freshwater ecosystems; water contains oxygen and nutrients. Different: Water in a flowing-water ecosystem moves rapidly near the source and slows near the mouth. Water in a standing-water ecosystem has little net flow but circulates within the system.
- Photic zone, aphotic zone, intertidal zone, coastal ocean, open ocean, benthic zone; and the abiotic factors for each.
- A wetland is an ecosystem in which water either covers the soil or is present at or near the surface of the soil for some of the year. An estuary is a wetland where a river meets the sea. Check students' examples.
- Without fresh water from the river, the brackish estuary water would become saltier, changing the kinds of organisms that could survive in that ecosystem.