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.

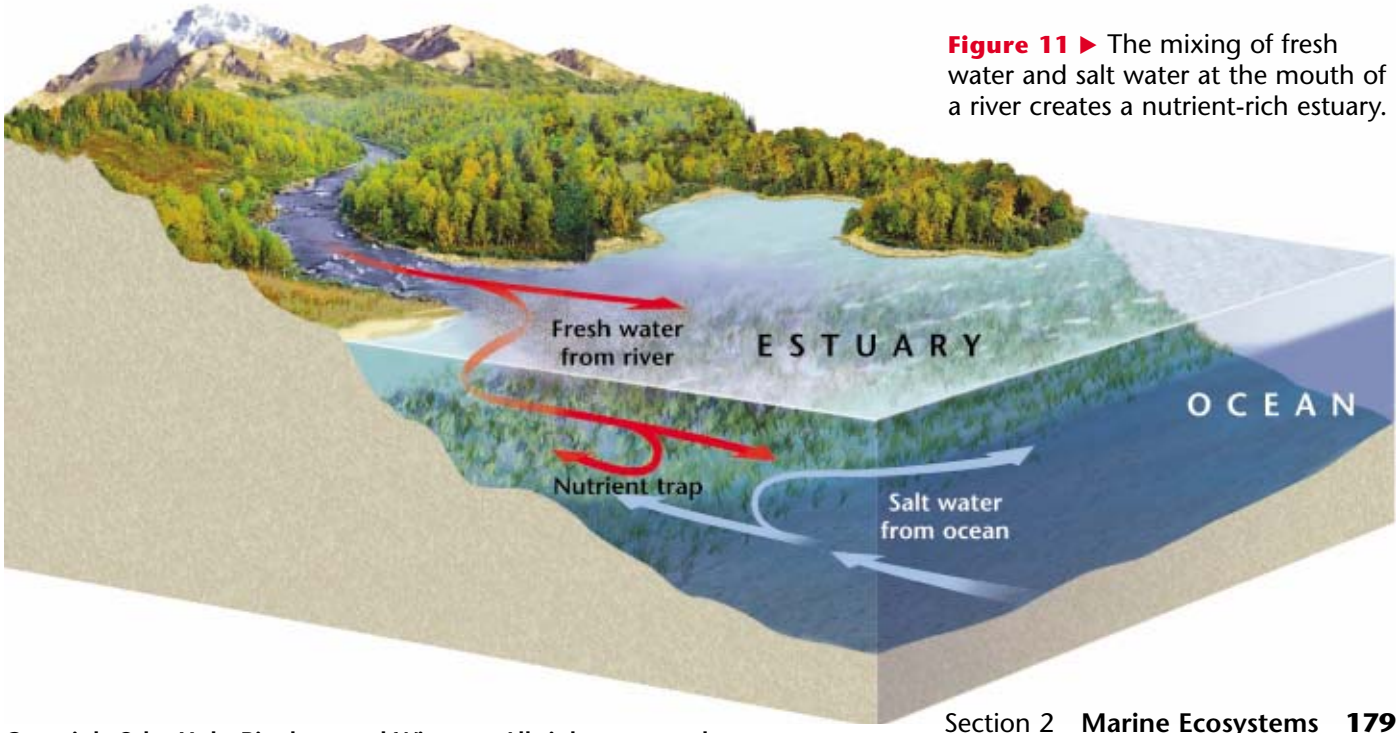

Figure 11 ▶ The mixing of fresh water and salt water at the mouth of a river creates a nutrient-rich estuary.

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 provides 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 were 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?

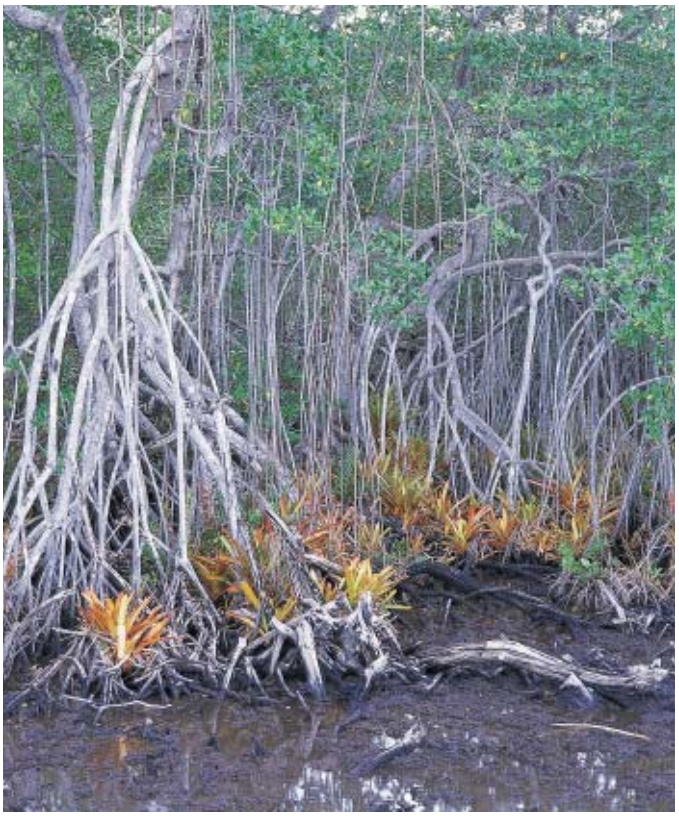

Figure 13 ▶ Mangrove swamps are found along warm, tropical coasts and are dominated by salt-tolerant mangrove trees.

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.

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.

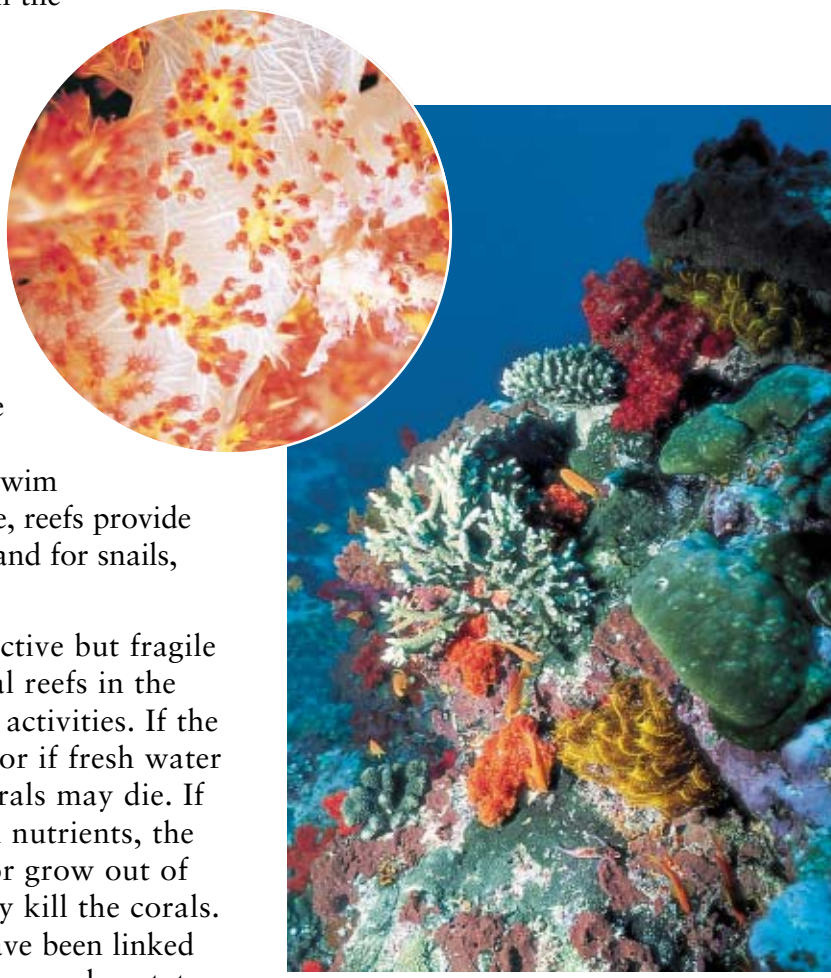

Figure 16 ▶ Coral reefs (bottom) are limestone ridges built by tiny coral animals. Coral animals have coral tentacles (top) that emerge from protective structures to capture food.

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.

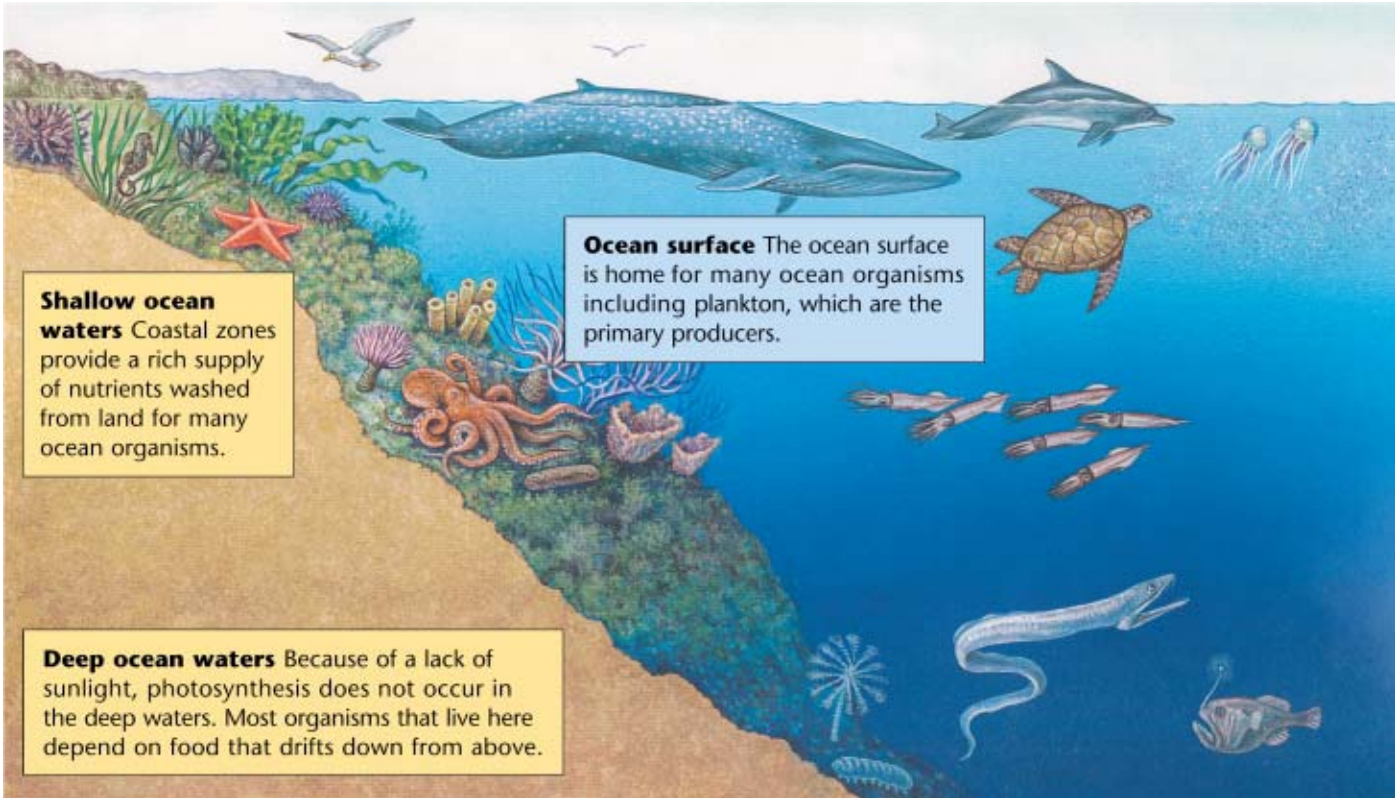

Figure 17 ▶ The amount of sunlight available determines which organisms can live in each layer of the ocean.

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