Coastal Ecosystems—Estuaries, Salt Marshes, Mangrove Swamps, Seagrasses

High Productivity Marine Environments

Why are coastal ecosystems generally highly productive?

Why do human activities have wide-ranging potential effects on coastal ecosystems?

What is eutrophication*?*

Coastal ecosystems are generally highly productive ecosystems for several reasons. They benefit from nutrient-rich runoff from land. Because they're shallow, the benthic organisms in these ecosystems live in the upper photic zone, instead of the bottom as in the open sea. Salt-tolerant plants can grow in the well-lit shallows, providing shelter. These plants act as the foundation for several different types of ecosystems that cannot exist in the open ocean.

The combination of nutrients, ample light, and shelter make coastal ecosystems diverse and rich. While you don't commonly find large organisms here (though there are some), these ecosystems provide a haven for juveniles of open-ocean species. You may remember from Chapter 5 that mangrove swamps contribute to the health of coral reefs in this way.

Human activities have wide-ranging potential effects on coastal ecosystems.The effects are both varied and immediately at hand. Historically, people have always tended to live near water, putting humans in proximity with these ecosystems. This means that *many* of our activities potentially affect them, but it's not always obvious. Agriculture, for example, can alter these ecosystems when excess fertilizer washes seaward with rain runoff. The variety of human activities is so wide we can't always anticipate all the consequences to ecosystems.

Because the effects are immediately at hand, coastal ecosystems may experience the consequences more severely. Pollutants, for example, often reach coastal ecosystems in concentrated form. Open-ocean ecosystems, by contrast, benefit from a diluting effect. Some deep, open-ocean marine ecosystems are so far from human activities that human effects have been minimal (at least so far).

One particular concern with coastal ecosystems is *eutrophication*, which is an overabundance of nutrients that causes an ecological imbalance (from the Greek *eu* meaning *good*, and *trophos* meaning *feeding*). Eutrophication is a stimulus to some species and

STUDY QUESTIONS

Find the answers as you read.

1. Why are coastal ecosystems generally highly productive?
2. Why do human activities have wide-ranging potential effects on coastal ecosystems?
3. What is *eutrophication*?
4. What factors limit the productivity of estuary ecosystems?
5. For about what percentage of commercial fish species do estuary ecosystems serve as nurseries?
6. How do estuaries contribute to the productivity of surrounding marine ecosystems?
7. How do conditions differ in the upper marsh compared to the lower marsh of a salt marsh?
8. What adaptations allow halophytes to survive in salt water?
9. What two characteristics of mangrove trees make them the basis for mangrove ecosystems?
10. How do seagrasses differ from other halophytes?
11. How do seagrass ecosystems differ from other halophyte-based ecosystems?

a detriment to others. Fertilizer runoff can dump excess nutrients in the water, stimulating excessive algae growth or algae blooms. When the algae die, degradation of biomass consumes available oxygen. The depletion of oxygen kills fish and other sea life. Although there are other causes of harmful algae blooms (HABs), eutrophication is the most conspicuous.

Estuaries

What factors limit the productivity of estuary ecosystems?

For about what percentage of commercial fish species do estuary ecosystems serve as nurseries?

How do estuaries contribute to the productivity of surrounding marine ecosystems?

NOAA National Estuarine Research Reserve Collection

Figure 14-12a

NOAA National Estuarine Research Reserve Collection

Figure 14-12b

Where river meets sea.

Estuaries act as a dumping ground, filter, and absorber of nutrients (and pollutants). The continuous replenishment of nutrients results in ecosystems with high primary productivity. Estuaries can range from simple ecosystems such as a wide stretch of river entering the sea **(A)** to large, complex deltas with multiple inlets, lagoons, and islets **(B)**.

Estuaries existwhere the tides meet rivers. They're not found where all rivers enter the sea, but they're common where the tidal range is high. This allows high tide to push well up river, often flooding large land areas. Estuaries may be large, complex deltas with multiple inlets, lagoons, and islets or they may be simple wide stretches of river entering the sea.

Estuaries tend to trap and accumulate runoff sediments, so they're rich with nutrients and biologically productive. Most of the major North American rivers flowing into the Atlantic flow first into estuaries. This is why the North Atlantic doesn't have as much sediment flowing in to it as other ocean basins have with comparable rivers. The estuaries trap much of the sediment. Unfortunately, this also makes estuaries especially sensitive to eutrophication because the same process traps excess nutrients such as fertilizer runoff.

Estuaries act as a dumping ground, filter, and absorber of nutrients (and pollutants). Estuaries are the *kidneys* of the biosphere because of their cleansing function. The continuous replenishment of nutrients results in ecosystems with high primary productivity from algae and *halophytes*—saltwater plants (from the Greek *hals* meaning *salt*, and *phyton* meaning *plant*). These, in turn, support a large community of primary and secondary consumers.

Some factors limit productivity in estuaries. One is that organisms in this ecosystem must tolerate wide salinity ranges. The osmotic stress caused by the rising and falling tides mixing with fresh water proves fatal to many organisms. You may recall from Chapter 6 that organisms that tolerate wide salinity ranges are called euryhaline organisms. Therefore, variations in salinity tend to reduce the variety of species to only euryhaline.

Another productivity limit results from the tendency of decomposition to deplete the oxygen in the nutrient-rich sediments. This limits the benthic organisms that can thrive in estuaries. The rotten-eggs smell common to these areas comes from sulfides released by thriving anaerobic sulfur bacteria.

However, estuaries provide a region of shallow, sheltered water and nutrients, making them excellent nurseries. By providing a rich haven, larvae and juveniles of open-ocean species can elude predation and grow before venturing out to sea. Estimates show that estuary ecosystems serve as nurseries for more than 75% of commercial fish species.

Estuaries contribute to the productivity of adjacent marine ecosystems in at least two ways. First, surviving juveniles migrate from the estuaries as they grow and mature. The estuaries therefore contribute to productivity by increasing the number of individuals that survive the hazardous larval and juvenile stages. Second, estuaries provide a steady stream of nutrients to adjacent marine ecosystems, while trapping sediment and other materials in runoff from rain and storms. This contributes to productivity by providing the nutrients, while reducing eutrophication and other damage were the runoff to reach the open sea.

INTERNET PORTAL
SCiLINKS NSTA
Topic: Estuaries
Go To: www.scilinks.org
Code: LOP390

Salt Marshes

How do conditions differ in the upper marsh compared to the lower marsh of a salt marsh?

What adaptations allow halophytes to survive in salt water?

Salt marshes exist in estuaries and along the coasts. They grow where there's flat, gently sloping, nutrient-rich sediment washed by the tides. They're normally associated with estuaries because rivers provide a constant nutrient source.

Conditions within a salt marsh vary, which affects the types of organisms inhabiting different areas within the ecosystem. The upper marsh includes the areas only rarely flooded by the tides. The lower marsh, however, includes areas flooded by salt water as a regular part of the tidal cycle. In most areas, that means twice daily. Consequently, lower marsh organisms must tolerate significantly more osmotic stress than species with niches in the upper marsh.

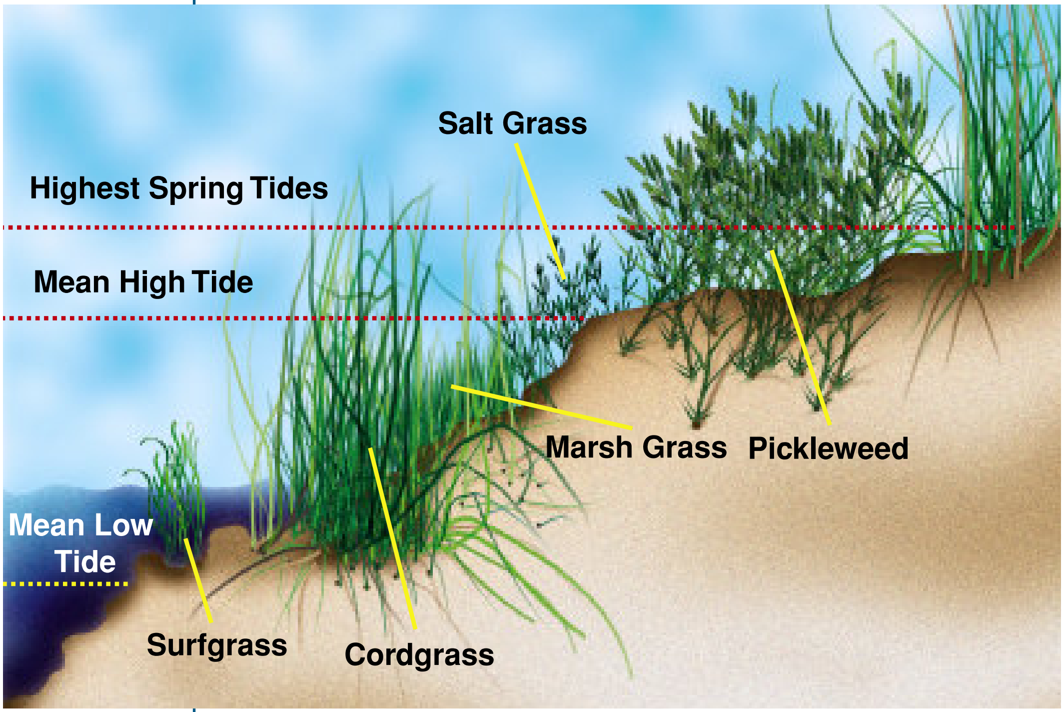


Figure 14-13

Salt marsh plant community.

A cross-section of a typical temperate salt marsh community along the US east coast, showing common submerged and emergent aquatic vegetation.

As you learned in Chapter 5, most plants can't live in seawater because osmosis dehydrates them. Halophytes, on the other hand, have adaptations that allow them to survive in salt water. Thanks to these adaptations, halophytes occupy a niche with little competition from other plants, and become the dominant species.

Halophytes in the lower marsh deal with constant osmotic stress. The hollow reed *Spartina* sp., called cordgrass, is a good example of halophyte adaptation to this part of the ecosystem. Cordgrass has *stomata*, which are pores in its leaves through which it breathes (singular *stoma*, from the Greek *stomachos* meaning *mouth*). The stomata allow *Spartina* to draw oxygen into its submerged parts, some of it oxygenating the anaerobic mud. Additionally, *Spartina* concentrates salts in its roots, so that the salt concentration exceeds that of seawater. This causes water to diffuse *into* the roots instead of out. Salt glands on the leaves and stem excrete excess salt.

Plants in the upper marsh don't have to deal with seawater twice daily. In addition, the inflow of fresh water dilutes salt water, reducing osmotic stress. Organisms thriving in this part of the ecosystem adapt differently. One example is *Salicornia* sp., or pickleweed. Pickleweed handles excess salt by storing it in sacrificial leaves. When the salt load accumulates to a certain point, the leaf drops away, taking the salt with it. *Salicornia* grows another leaf to take its place.

Halophytes dominate the salt marsh, yet they are not food for many organisms. Salt marsh plants are tough and salty, making them unsuitable for most herbivores. Their root systems hold sediment, which, along with the accumulation of dead halophytes, creates dense mats of *humus*. Humus is any mass of partially decomposed organic matter that makes up a portion of soil or sediments. In the salt marsh, humus provides habitats for huge communities of invertebrates, water birds, juvenile fish, larva, eggs, and other organisms.sea.

NOAA Restoration Center, SE Region, Mark Sramek

Figure 14-14

Estuarine plants.

Spartina sp., known commonly as cordgrass, is wide-ranging. A true halophyte (salt lover), it concentrates salts in its roots so that the concentration exceeds that of seawater. This causes water to diffuse into the roots instead of out. Salt glands on the leaves and stem excrete excess salt.

Mangrove Swamps

What two characteristics of mangrove trees make them the basis for mangrove ecosystems?

In Chapter 5, you read about mangrove swamps (also called mangrove forests or just mangroves for short) and their important role in the marine environment, especially coral reefs. Mangrove trees are not a single species, but actually a group of more than 50 species from several families of halophytic trees and shrubs.

In many respects, mangroves occupy similar niches as the halophytes that characterize salt marshes, but they're bigger, tougher, and found in tropical climates. Mangrove species have various adaptations that allow them to live in salt water and anaerobic mud.

Red mangroves, *Rhizopora* sp., grow above the waterline on stilt-like roots. This allows oxygen to reach the roots. *Rhizopora* obtains fresh water by filtering seawater through its adapted roots, which exclude the salt. This is an example of *reverse osmosis*, which is the process of transporting water through a semipermeable membrane against the natural osmotic pressure gradient. This is a form of active transport, which is the process of a cell moving materials from areas of low concentration to areas of high concentration.

Mangroves of the genus *Avicennia* (black mangroves) have roots that grow in the sediment below the waterline. These mangroves

NOAA Restoration Center, Louise Kane

Figure 14-15

Estuarine plants.

Salicornia, commonly known as pickleweed, deals with excess salt by storing it in sacrificial leaves. These salt-laden leaves drop off, taking the salt with them. Another leaf then grows to take its place.

OAR/NURP/NOAA

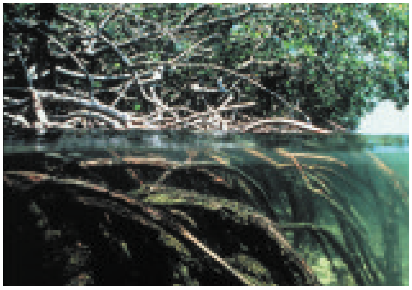


Figure 14-16

Red mangroves.

Red mangroves (*Rhizopora mangale*) grow above the waterline on stilt-like roots. They obtain fresh water by a form of reverse osmosis, excluding seawater through their adapted roots.

aerate their roots with snorkel-like tubes called *pneumatophores*, which carry air from above the surface to the roots. Some *Avicennia* eliminate salt through sacrificial leaves, like the pickleweed. Others have special salt glands in their leaves.

White mangroves, such as *Laguncularia* sp., lack such specialized adaptations. They're very saltwater tolerant, but thrive high on the tideline where they don't need special root adaptations. These mangroves receive sufficient freshwater runoff to survive.

Regardless of species or adaptations, mangroves share two important characteristics that make them the basis of mangrove ecosystems. First, they have strong, tangled roots that provide habitats for juvenile fish and invertebrates. As in salt marshes, this provides a nursery for nearby marine ecosystems, particularly coral reefs. Second, because they're large plants (compared to most halophytes), mangroves hold the soil well, protecting the habitat and coast from erosion from storm surges, waves, and weather. This is especially important in a tropical setting where violent storms are frequent. Without the strong mangrove root systems, tropical storms would quickly wash away many tropical islands and beaches.

NOAA Restoration Center

Figure 14-17

Black mangroves.

The roots of the black mangrove (*Avicennia germinans*) grow in the sediment below the waterline. Tubes called pneumnatophores act as snorkels to provide air to the roots in the muck. The trees eliminate salt through special glands in their leaves.

NOAA National Estuarine Research Reserve Collection

Figure 14-18

White mangroves.

White mangroves (*Laguncularia racemosa*) lack specialized adaptations. They're very saltwater tolerant, but thrive high on the tideline where they don't need special root adaptations.

You may remember from Chapter 5 that mangroves trap nutrients, much as estuaries do, helping to protect coral reefs and other nearby marine ecosystems. However, because they're swampy, sulfide-smelling mosquito havens, until relatively recently people viewed them as wastelands. Today we know they're ecosystems crucial to the global ecosystem, but mangroves continue to vanish. This is because of social pressures you'll read about in the next few chapters.

Mr. Ben Mieremet, Senior Advisor OSD, NOAA

Figure 14-19

Coastal sentinels.

Mangroves are crucial ecosystems in the subtropics and tropics. In addition to their ecosystem function, they protect coastlines from storm damage and erosion.

Seagrasses

How do seagrasses differ from other halophytes?

How do seagrass ecosystems differ from other halophyte-based ecosystems?

Seagrass ecosystems are similar to other halophyte-based ecosystems in that they stabilize sediments and provide shelter and habitats for other organisms. However, seagrasses differ from other halophytes in several important ways that make them and their ecosystems distinct.

Seagrasses are the only submergent plants, meaning they live entirely under water except during rare, very low tides. Some species live as deep as 30 meters (98.4 feet). You may find seagrasses growing as members of a mangrove or salt marsh ecosystem. More commonly, though, seagrass grows in colonies spread across the bottom like underwater pastures. Their root systems intertwine, forming a mat below the sediment. Seagrasses extract oxygen from the water and have internal air canals. Most species even release pollen into the current to reproduce, much like terrestrial plants release pollen into the wind.

They do not need to have a freshwater source. Unlike most halophytes, seagrasses have no means of extracting fresh water from seawater. Seagrasses have an internal salinity the same as seawater, eliminating any need for it. The water surrounding them provides an endless supply of all they need.

Because of these differences, seagrass ecosystems differ from other halophyte-based ecosystems. They do not need to have a freshwater source and they can exist in deep water. Unlike most halophytes, seagrasses are edible and provide food for ecosystem inhabitants. They are heavily grazed by microbes, invertebrates, fish, turtles, and even manatees and dugongs.

Heather Dine/Florida Keys National Marine Sanctuary/NOAA

Figure 14-20

Seagrasses.

Seagrasses grow in underwater pastures, sometimes spreading across vast areas of the sea bottom. Their root systems intertwine, forming a mat that helps to retain and stabilize the sediment. Most species release pollen into the current to reproduce, much like terrestrial plants release pollen into the wind.

ARE YOU LEARNING?

1. Coastal ecosystems are generally highly productive because (choose all that apply)

A. they benefit from nutrient-rich runoff from land.

B. benthic organisms can live in the upper photic zone.

C. plants provide shelter.

D. large organisms typically dominate them.

2. Human activities have wide-ranging potential effects on coastal ecosystems because (choose all that apply)

A. people dislike coastal ecosystems.

B. we can't anticipate all the consequences of our many activities.

C. the effects are immediately at hand with coastal ecosystems.

D. trophic pyramids are unstable in coastal ecosystems.

3. Eutrophication is

A. the trophic pyramid common to European estuaries.

B. pollution that results from dumping toxins into the ocean.

C. pollution that results from excess nutrients in the ocean.

D. none of the above

4. Factors that limit the productivity of estuary ecosystems include (choose all that apply)

A. a lack of seawater.

B. the need to survive osmotic stress.

C. the depletion of the oxygen in the sediments.

D. excessive growth of benthic organisms.

5. Estuary ecosystems act as nurseries for about _______% of commercial fish species.

A. 25

B. 50

C. 75

D. 100

6. Estuaries contribute to the productivity of surrounding marine ecosystems by (choose all that apply)

A. providing a nursery for juveniles of many species.

B. providing a steady stream of nutrients.

C. allowing all sediment from storm runoff to reach them.

D. encouraging eutrophication.

7. In the __________ marsh of a salt water marsh, organisms must deal with salt water as a regular part of the tidal cycle. The ________ marsh, by contrast, includes areas rarely flooded by tides.

A. upper, lower

B. inner, upper

C. lower, upper

D. outer, lower

8. Adaptations that allow halophytes to survive in salt water include (choose all that apply)

A. vegetative gills.

B. stomata.

C. sacrificial leaves.

D. salt glands.

9. The two characteristics that make mangroves the basis for mangrove ecosystems include (choose all that apply)

A. strong, tangled roots that provide habitats.

B. the ability to hold soil in storm surges, waves, and weather.

C. the ability to live entirely underwater.

D. special sap that repels large predators.

10. Seagrasses differ from other halophytes because (choose all that apply)

A. they live entirely under water.

B. they can live in deep water.

C. they have the same internal salinity as seawater.

D. they release pollen under water.

11. Seagrass ecosystems differ from other halophyte-based ecosystems because (choose all that apply)

A. they don't require a freshwater source.

B. they can exist in deep water.

C. the seagrasses provide food for ecosystem inhabitants.

D. they don't require sunlight.

Check it out.

1. A, B, C **2.** B, C **3.** C **4.** B, C **5.** C **6.** A, B **7.** C **8.** B, C, D
9. A, B **10.** A, B, C, D **11.** A, B, C

Miss any? Got it right but you're not sure you understand? Go back and reread the material until you're clear about it before moving on.

Coastal Ecosystems—Intertidal Zones, Beaches, Kelp and Seaweed, Coral Reefs

Intertidal Zones

What are the greatest challenges to life in supralittoral ecosystems?

What conditions challenge organisms in littoral ecosystems?

When we think of coastal ecosystems, we tend to think of mangroves, estuaries, and similar ecosystems. The numerous complex organisms make their productivity conspicuous. However, in *every* place the ocean touches land, you'll find a coastal ecosystem with rich communities.

Ecosystems in the world's intertidal zones exist in areas that may be above the waterline at times. Other portions of intertidal zones reach depths of about 10 meters (32.8 feet).

The supralittoral zone, you remember from Chapter 3, is the area only submerged during the highest tides. The greatest challenges facing organisms that live in supralittoral ecosystems are drying and thermal stress. A constant spray of seawater that evaporates also results in high salt levels.

Organisms with habitats in the supralittoral zone have adaptations that help them retain moisture. Unlike many marine organisms, they can either obtain oxygen from the air or store sufficient oxygen in their tissues to endure many hours out of the water. Additionally, they need to be hardy enough to withstand periodic

STUDY QUESTIONS

Find the answers as you read.

1. What are the greatest challenges to life in supralittoral ecosystems?
2. What conditions challenge organisms in littoral ecosystems?
3. How do beaches affect other marine ecosystems?
4. How has human hunting of sea otters disrupted the ecological balance of kelp forest ecosystems?
5. What marine ecosystem is thought by most scientists to be the most taxinomically diverse?
6. Why do coral ecosystems require water that is in moderate motion and free of nutrients?
7. Why is eutrophication one of the biggest threats to coral ecosystems?
8. What other threats do coral ecosystems face?

Nancy Sefton, Earthwise Media

Figure 14-21a

Capt. Albert E. Theberge, NOAA Corps.

Figure 14-21b

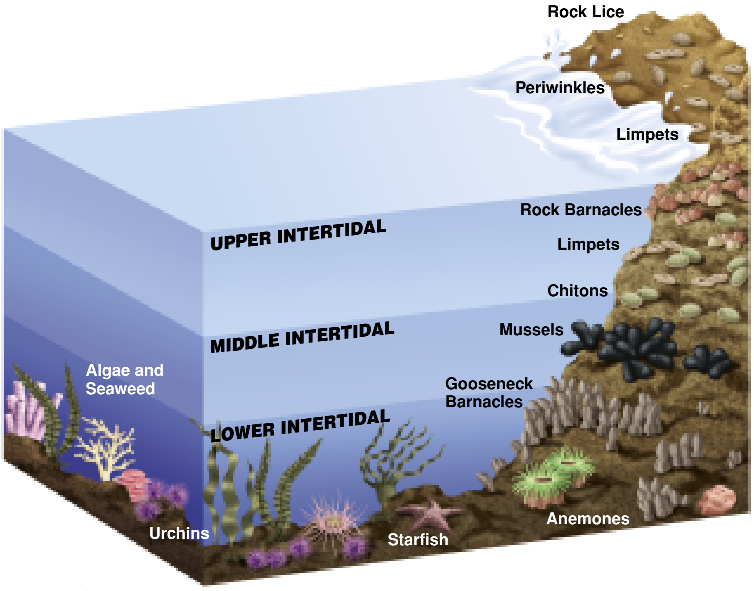
The supralittoral zone.

Organisms in the supralittoral zone have adaptations that help them retain moisture. They can either obtain oxygen from the air or store sufficient oxygen in their tissues to endure many hours out of the water. They're also hardy enough to withstand drying and thermal stress.

motion and pounding by waves. Barnacles, periwinkles, and limpets are examples of organisms adapted to life in the supralitttoral zone.

The rest of the littoral zone (the area between high and low tide) faces similar challenges. However, life here isn't left above the surface for extended periods like the supralittoral zone. Organisms in littoral ecosystems also face the challenges of drying out, thermal stress, and water motion. Progressing seaward, the environment becomes less stressful with respect to drying out and thermal stress, though waves and surge remain challenges. Many supralittoral organisms also thrive here, along with seaweeds, anemones, and mussels.

The lowest part of the littoral zone is rarely exposed to air—only at extremely low tides. With ample water, nutrients, and sunlight, this is a highly productive region in most coastal ecosystems. One challenge to life here, therefore, is massive competition.



igure 14-22

ocky shore community.

Beaches

How do beaches affect other marine ecosystems?

To the untrained eye, the typical sandy beach appears nearly devoid of life. It looks almost like a desert, with only an occasional shell or starfish. The reality is that beaches are rich and productive ecosystems. They also have important roles that affect other marine ecosystems.

In Chapter 13, you learned that sand results from the energy of waves weathering the coast and washing it into the sea with river runoff. Scientists think that the sands on the world's beaches may have migrated thousands of years before washing ashore. In addition to minerals, living and dead organic material accumulates into the sand mix.

Sand protects the coastline. As a wave comes ashore, it picks up sand. Each sand grain dissipates a miniscule portion of wave energy. That portion times billions and billions of sand grains reduces the forces that wear away the coastline. This is the first way that beaches affect ecosystems. They reduce sedimentation caused by coastal erosion.

Beach ecosystems are rich in organisms living on the organic material in the sand mix. Complex organisms, including worms, mollusks, and fish live in the submerged beach sand. The *meiofauna*—benthic organisms that live in the spaces between sand grains—are so diverse that the community of a single beach ecosystem could take years to catalog. About a third of all known animal phyla have representatives in the meiofauna. Additionally, algae and other nonanimal organisms live among the sand grains.

The interaction between water motion and the meiofauna provides the second way that beaches affect other marine ecosystems. The physical and organic processes in the beach ecosystem break down organic and inorganic materials. This makes the beach a giant filter that processes compounds from runoff to the sea or washed up from the sea.

Ken Kurtis

Figure 14-23

Beach dwellers.
One of the largest infauna found on sandy beaches are the mole crabs (*Emerita* sp.), also know as sand crabs. They can be found quickly borrowing back into the sand as waves wash back to sea.

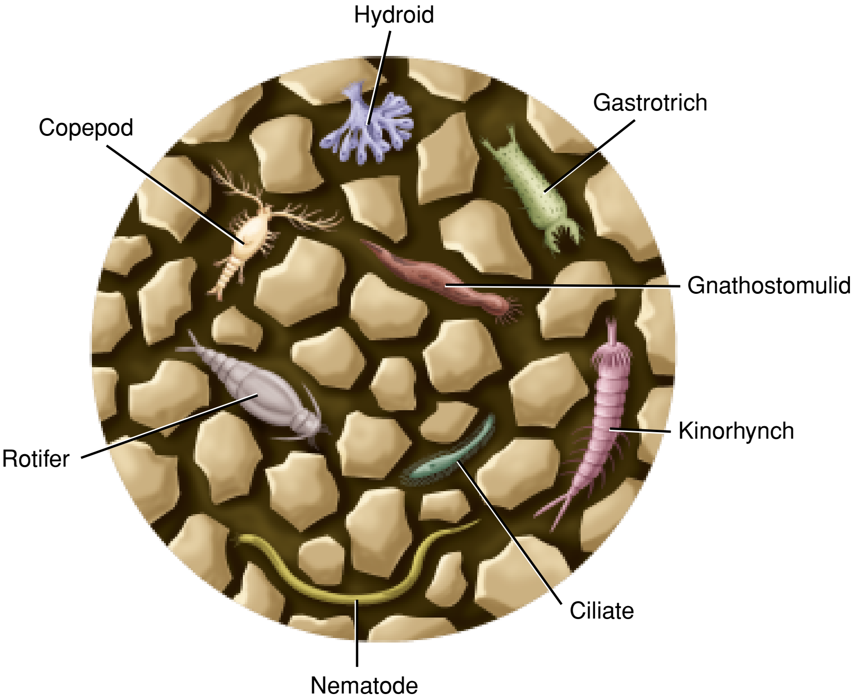


Figure 14-24

Life at the beach.
Beach ecosystems include worms, mollusks, and fish that live in the submerged beach sand. The organisms living among the sand grains, while tiny, are so diverse that about a third of all known animal phyla have representatives in the meiofauna.

INTERNET PORTAL
SCILINKS NSTA
Topic: Kelp Forests
Go To: www.scilinks.org
Code: LOP395

Kelp and Seaweed Ecosystems

How has human hunting of sea otters disrupted the ecological balance of kelp forest ecosystems?

In Chapter 5, you learned that seaweed refers to a diverse group of red, green, and brown algae. All of these provide the bases for ecosystems among their stipes, holdfasts, and blades. Among these, kelp ecosystems are probably the most diverse.

You find kelp forests globally in cool water. This is because they require the nutrients found in cool oceans. The richest and most productive kelp ecosystems exist in coastal waters with upwellings. In clear water with ample sunlight and nutrients, giant kelp (*Macrocystis pyrifera*) can reach 60 meters (196.8 feet) long, providing habitats for a substantial ecosystem. Kelp forests and other seaweed-based ecosystems are among the most biologically productive ecosystems. Their primary production exceeds the primary productivity of terrestrial forests and is almost equal to the productivity of coral reefs.

Because of its dependence on sunlight, cool water, and nutrients, kelp responds noticeably to environmental changes. During ENSO events, for example, the coastal water temperatures in Southern California rise. This often causes massive die-offs of kelp, disrupting the local ecosystems for a year or more.

Kelp provides a clear example of why it's important to study ecology, not simply individual organisms. Until protected, in some areas the sea otter was hunted nearly to extinction. Amazingly, in these areas the kelp began to die off rapidly.

Bob Wohlers

Figure 14-25

Underwater forests.

The fastest growing algae known, giant kelp (*Macrocystis pyrifera*) can reach 60 meters (196.8 feet) in length. It provides a lush habitat and supports or is an integral part of one of the most biologically productive ecosystems.

It turns out that while few organisms eat kelp, one that does is the sea urchin. These echinoderms graze on the rubbery holdfasts that anchor the kelp. Sea urchins are also one of the sea otter's primary foods. The energy required by a mammal living in cool seawater is considerable, so the average sea otter eats a substantial number of sea urchins.

Killing the sea otters disrupted the kelp forest's ecological balance by removing the sea urchin's chief predator. This allowed the sea urchin population to rise relatively unchecked. More sea urchins meant more grazing on kelp holdfasts. In the end, the sea urchins ate the kelp faster than it could grow. This is an excellent example of the interdependence that exists within an ecosystem. It shows that each organism contributes to a balance that allows life to thrive there.

Coral Reefs

What marine ecosystem is thought by most scientists to be the most taxinomically diverse?

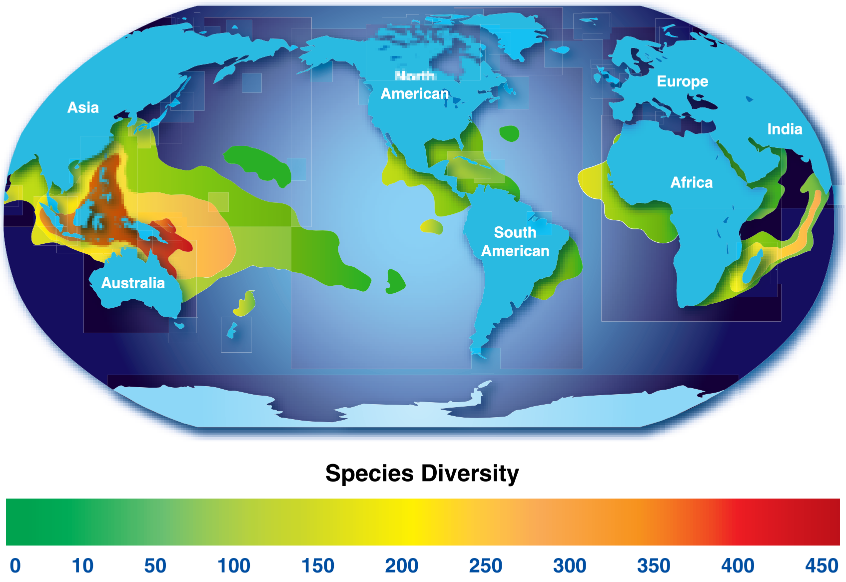
Why do coral ecosystems require water that is in moderate motion and free of nutrients?

Why is eutrophication one of the biggest threats to coral ecosystems?

What other threats do coral ecosystems face?

Of all the Earth's ecosystems, few compare to the coral reef. Most scientists believe they are the most taxonomically diverse ecosystems in the ocean. The Indo-West Pacific area between Papua New Guinea and the Sulu and Celebes Seas has the world's highest marine species diversity. More than 2,000 species of fish are known, with new species discovered every year. Scientists think corals and coral reefs originated here because the further you go from this area, the less diversity you find.

While supporting immense diversity, coral reef ecosystems are also fragile. For a couple of decades now, scientists, divers, and others familiar with coral have been worried about the health of



Commander John Bortniak, NOAA Corps.

Figure 14-26

Upsetting the balance. Killing sea otters disrupted kelp forest ecology by removing the sea urchin's chief predator. Without predators, sea urchins can eat kelp faster than it can grow, denuding vast areas of once lush coastal habitat.

INTERNET PORTAL
SCILINKS NSTA
Topic: Coral Reefs
Go To: www.scilinks.org
Code: LOP405

Figure 14-27

Coral diversity. The Indo-West Pacific area between Papua New Guinea and the Sulu and Celebes Seas has the world's highest marine species diversity. More than 500 species of coral are known. Diversity declines the further you go from this area.

these ecosystems. The conditions coral requires for life are narrow and specific. It lives in clear water so that dinoflagellates (zooxanthellae) coexisting in the polyps have light for photosynthesis. It also needs water that's in moderate motion to prevent sediments from accumulating on the polyps. Particulate matter can clog and smother the polyps. It also reduces the light reaching the algae inside.

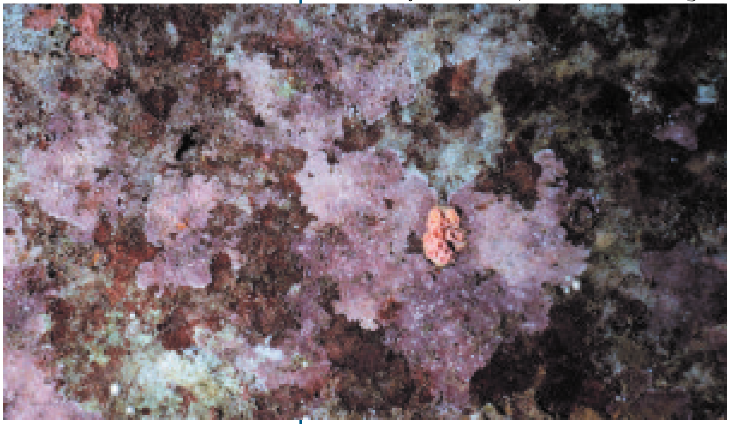
Coral ecosystems also require water that's relatively free of nutrients. This may seem odd considering the high productivity of this ecosystem. However, coral ecosystems efficiently pass on and preserve organic material. The lack of nutrients in the water actually protects coral from competitive organisms.

This is why eutrophication is one of the biggest threats to coral ecosystems. A rise in water nutrient levels allows competitive algae to overgrow and smother coral colonies. It also allows plankton to grow, reducing water clarity and the amount of sunlight reaching the polyps. To some extent, these are natural processes, but over the last several decades eutrophication levels have been rising. Correspondingly, many reefs once dominated by corals now have algae overgrowing them.

Besides eutrophication, thermal stress threatens coral reef ecosystems. A concern is that global warming may raise temperatures above coral's survival threshold. Another threat comes from sedimentation resulting from coastal dredging and construction. This causes sediment to accumulate on the polyps more quickly than water motion can remove it. Coral diseases seem to be more common. These are "attacks" by fungi, cyanophytes, bacteria, and other competitive algae damaging and displacing corals. Scientists are still determining the likely sources and causes for many of these.

You'll read more about threats to the world's coral reefs in Chapter 16. Regardless of the specific threat, it's important to apply the principles of ecology to the overall picture. The concern isn't for the coral alone, but the entire coral ecosystem. Just as the loss of sea otters threatens kelp, the loss of the corals threatens other organisms in the ecosystem.

Parrotfish, for example, feed on coral. If the coral dies, the parrotfish will dwindle as they lose their primary food source. Predators



Dr. James P. McVey, NOAA Sea Grant Program

Figure 14-28

Coral versus algae.

A rise in nutrient levels allows algae to grow, displacing coral colonies. Today, many reefs once dominated by corals are now covered with mats of algae.

that feed on the parrotfish may similarly suffer. Other organisms will not survive because the competitive algae don't provide the same habitat as a coral reef. The decline of coral is likely to have a domino effect throughout not just the coral ecosystem but the entire marine ecosystem. Ultimately, that means the loss of coral will affect the global ecosystem in ways that ecologists are still trying to determine.

ARE YOU LEARNING?

1. The greatest challenges to life in supralittoral ecosystems are

A. drying out and thermal stress.
B. predators and pollution.
C. drowning and flooding.
D. none of the above

2. Conditions that challenge organisms in littoral ecosystems include (choose all that apply)

A. drying out.
B. thermal stress.
C. water motion.
D. drowning.

3. Beaches affect other marine ecosystems by (choose all that apply)

A. accelerating coastal erosion.
B. reducing sedimentation caused by coastal erosion.
C. acting as a lifeless haven for vulnerable organisms.
D. acting as a filter that processes compounds entering the sea.

4. Hunting sea otters disrupted the kelp forest ecological balance because

A. sea otters eat kelp, so the kelp overpopulated.
B. sea otters eat sea urchins, which eat kelp.
C. stray bullets hit and killed kelp.
D. none of the above

5. The most diverse marine ecosystems on Earth are

A. terrestrial forests.
B. kelp forests.
C. neuston ecosystems.
D. none of the above

6. Coral ecosystems require water that is in moderate motion and free of nutrients because

A. water motion keeps sediments from accumulating on the coral.
B. the presence of nutrients allows plankton to grow.
C. the presence of nutrients allows competitive algae to grow.
D. all of the above

7. One reason eutrophication is one of the biggest threats to coral ecosystems is that it provides nutrients that allow plankton growth, depriving coral of sunlight.

A. true
B. false

8. Threats facing coral ecosystems include (choose all that apply)

A. global warming.
B. sedimentation.
C. coral disease.
D. competitive algae.

Check it out.

1. A **2.** A, B, C **3.** B, D **4.** B **5.** D **6.** D **7.** A **8.** A, B, C, D

Miss any? Got it right but you're not sure you understand? Go back and reread the material until you're clear about it before moving on.