CHAPTER 9 COASTS, ESTUARIES, AND ENVIRONMENTAL ISSUES

Key Concepts

Major Concept (I) *We can define the coast as being land that has been or is still being modified by marine processes.*

Related or supporting concepts:

- Coastal features are related to the tectonic history of the region.
- Coasts along divergent plate boundaries, such as the east coast of the United States, move away from the spreading center and become tectonically inactive. These coasts:
  a. change slowly with geologic time,
  b. have wide continental shelves, and
  c. may sink gradually as the crust ages and cools.
- Along a convergent plate boundary, such as the northwest coasts of the continental United States and Alaska, collision along a subduction zone can modify the coast by raising it or lowering it. Volcanism is associated with these coasts.
- The coast may include such landforms as cliffs, dunes, beaches, and other low-lying regions that have been influenced or modified by marine processes.
- Marine processes that affect the coast include tides, waves, winds, and currents.
- The coast can extend offshore to include nearby islands.
- The coastal zone includes both the land of the coast and the water regions found in bays and estuaries.
- The coastal zone's landward boundary is often defined as a specific distance (often 200 ft) from a fixed reference (usually high water). The seaward boundary is defined by state and federal laws.

Major Concept (II) *Coasts are often dynamic features, rising or falling relative to sea level. All coasts fall into one of two major categories, primary coasts and secondary coasts.*

Related or supporting concepts:

- Emergent coasts are rising relative to sea level. This may be due to:
  a. falling sea level (this occurs during glacial periods as water is trapped on land as ice),
  b. coastal uplift by tectonic forces (earthquake activity), or
  c. a decrease of weight on the coastal crust allowing it to rise (erosion or melting of ice sheets).
- Emergent coasts often have old beaches and shore features above sea level.
- Submergent coasts are falling relative to sea level. This may be due to:
  a. rising sea level (possibly due to melting of ice sheets),

b. coastal sinking caused by tectonic forces, or
c. an increase in crustal loading (for example, glacier deposits or river deposits).

- Along submergent coasts the water moves inland covering low-lying areas.
- Glacial and interglacial changes in sea level have been in excess of 100 m (300 ft).
- Table 9.1 lists characteristics and examples of different coastal types.
- Primary coasts are those that have not been significantly modified by marine processes following their formation.
- Secondary coasts are coasts whose shape or morphology has been influenced by marine processes.
- Further classification of coasts in these two categories is based on features found on the coast that have been created by different processes.
- Examples of primary coasts include:
    a. those formed by erosion such as:
        i. drowned river valleys, also called ria coasts (fig. 9.1a), and
        ii. fjords (fig. 9.1b),
    b. those formed by deposition such as:
        i. deltaic coasts (fig. 9.1c),
        ii. glacial moraine coasts, and
        iii. dune coasts (fig. 9.1d),
    c. those formed as a result of volcanism such as:
        i. lava coasts, and
        ii. cratered coasts (fig. 9.1e),
    d. and those formed by tectonism such as faulted coasts (fig. 9.1f).
- Examples of secondary coasts include:
    a. those formed by erosion such as cliffed coasts (fig. 9.2a and b).
    b. those formed by deposition such as:
        i. barrier island coasts (fig. 9.2c),
        ii. beach plains (fig. 9.2d), and
        iii. mud flats and salt marshes (fig. 9.2e),
    c. those formed by biological processes such as:
        i. coral reefs,
        ii. mangrove coasts (fig. 9.2f), and
        iii. marsh grass coasts(fig. 9.2g).

Major Concept (III) *The beach is an accumulation of sediment that moves along the coast under the influence of wave activity. The beach extends offshore and onshore above the high tide line.*

Related or supporting concepts:

- Despite day-to-day appearances of stability along most beaches, we must keep in mind that the beach is a dynamic feature. It is constantly in motion both perpendicular and parallel to the shoreline.

- Figure 9.3 illustrates all of the different segments of beach that may be present. Any specific beach may have all or only some of these different features.
- A beach can be divided into two major sections, the foreshore and the backshore.
- The foreshore extends from a point seaward of the low tide line to the high tide line. Parts of the foreshore are always submerged while other parts are routinely submerged and exposed with the flood and ebb tides.
- The backshore usually remains dry. It is inundated with seawater only during severe storms or the highest spring tides.
- The region of the sea floor that extends from the outer edge of the foreshore to the deepest point where the bottom is still affected by wave action is called the offshore.
- Wave activity will construct berms where the foreshore and backshore meet (see fig. 9.4). Berms may have flat tops or rounded berm crests.
- Stronger winter waves will build a winter berm high on the backshore that will generally remain throughout the year. A seasonal summer berm will form closer to the foreshore due to a decrease in wave energy during the spring, summer, and fall.
- At the high tide line on the edge of the foreshore, there is often a steep change in the slope of the beach called a scarp (see fig. 9.5). A scarp is caused by erosional cutting of the waves at normal high tide.
- The beach face is the intertidal region. It is generally fairly smooth with some low regions called runnels bounded by higher areas called ridges. Runnels are generally just a few inches deep.
- Scarps and berms do not form on the beach face because of the constant wave action between low and high tide.
- Evenly spaced, crescent-shaped inundations in the beach face are known as cusps (see fig. 9.6). Cusps are thought to form as a result of interaction between waves and the beach slope but we do not know how this occurs.
- The foreshore below the low tide water level is a flat region called the low tide terrace.
- In the offshore region there may be ridges of sediment that have accumulated as strong winter waves erode material from the beach and carry it offshore. Low regions between ridges are called troughs.
- Not all coasts have beaches.

Major Concept (IV) *There are numerous ways to categorize beaches. They may be grouped according to shape, composition, particle size, or color.*

Related or supporting concepts:

- Different types of beaches based on shape include:
    a. spits that extend away from the shore for a short distance and then parallel it (see fig. 9.7),
    b. hooks (see fig. 9.9), that are curved spits, and
    c. tombolos that are spits that extend outward connecting an island with the land

(see fig. 9.8).

- When offshore bars accumulate enough sediment to break the surface they create barrier islands parallel to the shore.
- Barrier islands are stabilized by the growth of vegetation that anchors the sediment and traps additional sediment so that the island grows in size. Some are large enough to encourage building and recreation (see fig. 9.2c)
- Barrier islands protect the mainland from the worst of the wave erosion and damage that can occur along unprotected coastlines.
- Beaches are composed of whatever loose material is present. Different types of beaches include:
    a. shell beaches,
    b. coral beaches,
    c. rock beaches, and
    d. lava beaches.
- One special type of rock beach is the shingle beach. Shingles are flat rocks that have been worn flat by sliding back and forth with the waves.
- The particles that form the beach can be categorized by size. Size terms for sedimentary particles include boulder, cobble, pebble, sand, and mud.
- Beaches can have different colors depending on the materials found in the beach. Shell beaches may be white or pink, coral beaches are generally white, sand beaches are often brown, volcanic beaches can be black, and beaches with either olivine or glauconite in large quantities can have a green hue.

Major Concept (V) *Beaches are constantly being modified. Those beaches that appear to remain unchanged with time are actually in equilibrium with the amount of material removed, balanced by the amount of new material added to the beach.*

Related or supporting concepts:

- Seasonal changes in wave conditions will transport sand onto and off the face of the beach. Large, energetic winter waves will strip sand from the beach and deposit it in offshore bars. The lower energy summer waves will gradually drive the offshore bars back onto the beach to replenish the supply of sand. A classic example of this is shown in figure 9.12.
- Wave crests usually approach the shore at an angle.
- Movement of the waves toward the shore creates an onshore current in the surf zone that carries sediment with it onto the beach and back again in a zig-zag fashion in what is called the swash zone (see fig. 9.13).
- Because the waves are not parallel to the shore there is another current that flows along the shore called the longshore current.
- The longshore current flows along the beach in the general direction of wave travel.
- As waves break in the surf zone they will resuspend sediment. This resuspended

sediment is transported by the longshore current in a process called longshore transport.
- The dominant longshore transport on both coasts of the United States is to the south.

Major Concept (VI) *Sediment is carried to the coast from the land. Once it reaches the coast it will be transported along the beach until some process results in offshore deposition. The area from the point of introduction to the point of deposition is called a coastal circulation cell (see fig. 9.15).*

Related or supporting concepts:
- Water is piled onto the face of the beach by the onshore current.
- The water that accumulates on the beach often returns offshore in a narrow, concentrated flow called a rip current (see fig. 9.14).
- Rip currents are often strips of water with a distinct color change caused by suspended sediment.
- The rip current will dissipate offshore and some of the sediment will be deposited while some of it returns to the beach by the onshore current.
- The head of a submarine canyon can trap the sediment moving by longshore transport and prevent it from re-entering the longshore current. When this happens, the beach may suddenly disappear for a distance downshore until a new sediment supply can build it once again.
- At the end of a coastal circulation cell, the longshore current is deflected away from the beach, and the sand transported in the current is directed offshore.
- The end of a coastal circulation cell is often marked by an offshore submarine canyon that channels sediment to the deep seafloor.

Major Concept (VII) *Sea level does not remain constant with time but rises and falls in response to global climate variations. Sea level has been rising since the last glacial period, but recently the rate at which it is rising has increased markedly.*

Related or supporting concepts:
- Over the last 100 years sea level has risen by about 15 cm (6 in).
- In recent years it appears that the rate at which sea level is rising has increased.
- Global warming has contributed to greater melting of land ice as well as an expansion of the water in the ocean basins due to an overall rise in temperature of the seas.
- While it is difficult to predict what will happen in the future in the case of something as complicated as global warming, some people believe that sea level could rise by another 30 cm in the next 50 years.

- A rise of 30 cm would inundate large regions of low-lying coastline, increase coastal erosion, and increase the destructive effects of major coastal storms.
- The greenhouse effect is due to an increase in the amount of CO_2 in the atmosphere. Some scientists believe that the concentration of CO_2 may double in the next century, resulting in an increase in the average surface temperature of seawater of 2 - 4°C.
- Increasing temperature would raise sea level both by melting land ice and by the expansion of sea water at higher temperatures.
- The rise in sea level caused by melting land ice is estimated at 31 - 110 cm (1 - 3.5 ft) over the next century.
- Sea water expansion could raise sea level by as much as 60 cm (24 in) for each increase in average ocean temperature of one degree.
- The greatest change in temperature would occur at high latitudes where there is a lot of land ice that could melt.
- Barrier islands are particularly susceptible to erosion and damage during severe storms. They are even more vulnerable with an increase in sea level.
- Recognizing the foolishness of extensive development on barrier islands, the federal government passed the Coastal Barrier Resources Act in 1982, prohibiting the allocation of federal money for repairs to roads, bridges, and piers, as well as flood insurance for homes built after 1983.

Major Concept (VIII) *Semi-isolated bodies of seawater that receive a supply of fresh water from continental runoff are called estuaries.*

Related or supporting concepts:

- The mixing of fresh and salt water in an estuary is controlled by:
    a. the nature of the tides,
    b. the amount of fresh water supplied, and
    c. the shape of the inlet.
- There are four basic types of estuaries based on differences in mixing and circulation of the water. These include:
    a. the salt wedge estuary,
    b. the well-mixed estuary,
    c. the partially-mixed estuary, and
    d. the fjord.
- The mouth of the estuary is where seawater flows into it and the head of the estuary is where the freshwater input is.
- Table 9.2 lists the characteristics of each type and provides examples. Figures 9.17*a-d* illustrate the type of mixing and circulation found in each.
- The amount of mixing and strength of stratification in an estuary varies with the speed of tidal currents and freshwater inflow, the roughness of the bottom and its effect on mixing and turbulence, and the average depth.

- Salt wedge estuaries occur where major rivers introduce large volumes of fresh water directly into the ocean. There is little mixing of fresh and salt water. The fresh water flows over a wedge of denser salt water below. The interface between fresh and salt water can move up the river with the flood tide and down it during the ebb tide. The flow of water is inward at depth and outward at the surface.
- Well-mixed estuaries have salinities that decrease from the mouth of the estuary to the head. At any given location, the salinity is fairly constant vertically. The flow of water is toward the mouth at all depths. Tidal processes are usually much stronger than the freshwater input.
- Partially-mixed estuaries are a little deeper than well-mixed estuaries. The influences of tidal and freshwater flow are about equal. There is a net flow inward at depth and outward at the surface with mixing at intermediate depths between the two water types.
- Fjords are drowned valleys that were carved out by glaciers. They are very deep, have U-shaped cross-sections, and often have a sill of glacial material near the mouth that reduces the depth. The deep water has constant salinity while a layer of fresh water flows out at the surface. The sill at the mouth can trap deep water and inhibit mixing.
- In general, there is a net flow of water outward at the surface and inward at depth in estuarine environments.
- Surface flow carries pollutants and debris out to sea. It also disperses marine organisms that live in estuaries as juveniles and spend their adult lives in the ocean.
- Inward flow at depth carries nutrients to the estuary.
- Mixing is primarily due to tidal currents.

Major Concept (IX) *Some semi-isolated bodies of water may become very saline due to low precipitation and high evaporation. These are sometimes called inverse estuaries.*

Related or supporting concepts:

- In dry climates near 30°N and S, bodies of water with little freshwater input and limited mixing with the ocean can develop a circulation pattern opposite that of an estuary (see fig. 9.18).
- High evaporation and low precipitation will increase surface salinity, and hence density, causing the surface water to sink and flow outward at depth.
- Inward flow at the surface replaces the higher density water flowing to the ocean at depth.
- Examples of this type of behavior include the Mediterranean Sea and the Red Sea.

Major Concept (X) *The amount of time required for an estuary to exchange its entire volume of water with the ocean is called the flushing time.*

Related or supporting concepts:

- The flushing time of an estuary is a function of the rate of net flow of water out of the estuary and the size of the estuary.
- Flushing time can be calculated by dividing the volume by the net seaward flow.
- Estuaries with rapid flushing times have high carrying capacities for wastes since they tend to be removed in short order.
- Estuaries with slow flushing times are particularly susceptible to damage from pollutants and waste material.
- Where there is no freshwater input to an embayment, the flushing is accomplished by tidal action. It may take several tidal cycles to completely replace the water. Some of the polluted water may even be returned to the bay with the next flood tide if offshore currents do not transport it down the coast away from the mouth of the bay.
- Flushing time can also be lengthened in partially-mixed estuaries when some of the surface water is mixed downward into the seawater flowing in at depth.

Major Concept (XI) *Beaches are dynamic features. When people interfere with natural marine processes by building structures along or on the beach, they can upset the natural equilibrium of the beach system.*

Related or supporting concepts:

- Construction projects along the beach or on rivers supplying sediment to the beach can radically alter the characteristics of the beach.
- The sediment that the beach is composed of comes from the erosion and transport of particles from the land.
- The construction of a dam on a river supplying sediment to the coast will trap the sediment behind the dam. Cutting off the supply of sediment will eventually result in the disappearance of the beach as the sand particles that are transported down the beach are no longer replaced.
- Other construction projects may include breakwaters and jetties to protect harbors. Sediment moving in the longshore current will commonly settle out behind these features in the relatively low energy environment they create. This will cause shoaling of the water, thus reducing its utility as a mooring location for boats, and it will cut off the natural supply of sediment for beaches down the coast.
- Groins are short walls built perpendicular to the beach to trap sediment being carried by the longshore current in an effort to widen the beach (see fig. 9.19). Sediment accumulates on the up-current side and is eroded on the down-current side.
- In some areas where beach erosion is a major problem, sand and gravel is hauled to the beach and dumped to maintain the beach. This material may be mined from offshore bars, inland gravel pits, or less populated regions along the coast.
- The mouths of harbors can close due to sedimentation if nothing is done to prevent it. Sediment in the longshore current settles out at the mouths of harbors and in their interior as waves are diffracted and move into the embayment. Santa Barbara,

California is an excellent example of a location where the harbor must be constantly dredged (see fig. 9.20).

- As a rule of thumb, it is often safe to say that structures built to "solve" one coastal problem often create other problems related to excess erosion or deposition.
- With the exception of Alaska, 43 percent of our coastlines are losing sediment faster than it is being replaced.

Major Concept (XII) *Wetlands are extremely important to many different marine and land organisms. Wetlands include freshwater and saltwater marshes and swamps that provide nutrients, shelter, and breeding areas for organisms.*

Related or supporting concepts:

- Many marine organisms, including varieties that are harvested commercially, rely on wetlands for food and shelter. These include crabs, shrimp, oysters, clams, and many different fish.
- In tropical and subtropical regions mangrove trees line the shore of lagoons and estuaries. The trees protect the shore from wave and storm damage and their large root systems provide habitats for fish.
- In recent years mangrove trees have been harvested for timber, wood chips, and fuel. Mangrove swamps are increasingly being cleared and filled to provide more land for development.
- Over 50 percent of the world's mangroves are now gone.
- The long-term environmental importance of these wetlands has often been ignored in the past. This has resulted in their destruction by filling them in for new land in populated areas and the indiscriminate dredging of channels through them for access to harbors (see fig. 9.21).
- San Francisco bay is the most extensively modified estuary in the country. Large areas have been filled for agricultural, residential, and industrial development. In addition, vast amounts of the original freshwater runoff into the estuary have been diverted for irrigation and municipal water needs.
- The conversion of estuarine environment to dry land in San Francisco has reduced the total tidal marsh environment from 2200 km^2 (860 mi^2) to only 125 km^2 (49 mi^2).
- The Mississippi River delta has less sediment carried to it because of the building of levees, dams, and other flood-control efforts. This results in a reduction of the amount of Mississippi River wetland marsh of 100 - 150 km^2 (40 - 60 mi^2) each year.
- Between the mid-1950s and the mid-1980s the United States lost approximately 20,000 acres of coastal wetlands each year. Over half of the country's coastal wetlands have been destroyed.
- With steadily increasing numbers of people living near coastal regions, the danger of harming wetlands is greater than ever. Fortunately there are federal and state regulations that govern the development of wetlands but we still need to be alert to prevent further destruction.

Major Concept (XIII) *The coastal regions of the United States are becoming increasingly densely populated. This is putting increasing pressure on this environment as pollution and waste material build up. We must carefully manage growth and protect the environment from further harm.*

Related or supporting concepts:

- Over one-half the population of the United States lives within 70 km of a coast, including the Great Lakes region.
- Recent major environmental disasters in coastal regions have demonstrated how fragile the environment is and how serious our concerns for preserving it must be.
- The need and desire to protect the environment are often balanced by the cost of implementing environmentally sound programs.
- Water quality is a major concern. Legislation and awareness of the problem have essentially halted the deliberate dumping of chemicals into the water. Unfortunately, some materials that were routinely dumped in the past have very long lives.
- A major water quality problem in some areas is the introduction of pesticides and nutrients into the water by surface runoff from agricultural lands. The pesticides can poison organisms. A surplus of nutrients in the water can spur plant growth. When large amounts of plant material die and decay they can strip oxygen out of the water, thus killing other organisms.
- Surface water runoff from cities introduces a wide range of pollutants to the oceans including oil, leaded gasoline, industrial waste, and animal waste.
- Even chlorine added to drinking water can combine with organic compounds to produce chlorinated hydrocarbons toxic to marine organisms.
- Each year a large low-oxygen area can be found in the Gulf of Mexico adjacent to the Louisiana coast. This is called a dead zone because oxygen levels in the water are too low to support life.
- The Gulf of Mexico dead zone is caused by the introduction of nitrogen-based fertilizers washed into the Mississippi River. High levels of nitrate stimulates small plant plankton growth in the water. When the plankton die they drop to the bottom and bacterial decomposition consumes the dissolved oxygen in the water.
- The enormous number of pollutants entering the oceans makes it extremely difficult to solve the problem.
- Many pollutants do not remain in the water but are adsorbed onto clay and organic particles that then settle out of the water column and are deposited in the bottom sediment.
- Marine organisms can concentrate these pollutants in their tissue by feeding on organic material in the sediment. These pollutants are then passed up the food chain. Shellfish concentrate heavy metals such as mercury and cadmium thousands of times higher than the water.
- A particularly dangerous waste material deposited in the oceans is plastic. Plastic is a

popular packaging material because it is light and durable. Unfortunately, these are the very characteristics that make it an environmental hazard. Plastic has a very long life span.

- New, biodegradable plastics break down in sunlight. These plastics may not be much of an improvement in the water, however, because sunlight is attenuated rapidly, the water will keep the plastic cool, and materials in water are quickly covered by a thin film of organisms.
- It is estimated that a plastic six-pack ring may last as long as 450 years in the oceans.
- Plastics kill when organisms become entangled in them and drown, swallow them and choke, or eat them (see fig. 9.23).
- Plastics are thought to be as deadly in terms of numbers of organisms killed as oil spills, toxic waste, and heavy metals.
- It is now against federal law to dump plastic waste in the oceans. Enforcement outside of United States harbors is very difficult however.
- Oil spills are a continuous threat with the constant transport of oil and oil products at sea (see fig. 9.24).
- There have been multiple recent, large oil spills from tankers including:
    a. the Amoco Cadiz in 1978 on the French coast, and
    b. the Exxon Valdez in 1989 on the Alaska coast.
- In large oil spills along the coast some of the oil may:
    a. be partially cleaned up with a high cost in dollars and time,
    b. evaporate,
    c. penetrate deep into the beach and be cleaned gradually over a long time by wave action,
    d. sink to the sea floor, or
    c. dissolve in the water.
- It is clear from past experience that we do not have the necessary technology to handle large oil spills at sea. The average amount of oil recovered from spills is only 15 percent.
- Oil is recovered from the water with the use of booms that contain the spill and skimmers that lift the oil off the surface of the water.
- Major oil spills can also occur when offshore wells develop problems or as a result of bombing and sabotage in war.
- In general, refined oil products such as gasoline and diesel fuel are more hazardous to life, but they evaporate and spread out quickly. Crude oil is not as hazardous, but it is difficult to recover and may sink to the bottom and remain in the sediment for long periods of time.

Key Terms and Related Major Concepts

At the back of the chapter in your book there are a number of key terms. You should be able to find the following terms referenced in the major concept indicated in parentheses.

coast(I)
coastal zone(I)
beach(III)
trough(III)
bar(III)
backshore(III)
foreshore(III)
offshore(III)
berm(III)
berm crest(III)
scarp(III)
low tide terrace(III)
beach face(III)
spit(IV)
tombolo(IV)
barrier island (IV)
onshore current(V)
longshore current (V)
longshore transport(V)
rip current(VI)
coastal circulation cell(VI)
estuary(VIII)
salt wedge(VIII)
fjord(VIII)
flushing time(VIII)
wetlands(XII)

Test Your Understanding With The Following Questions:

FILL IN THE BLANK

1. _____ are drowned valleys that were carved out by glaciers.
2. Water flows off the beach in concentrated flows called _____ currents.
3. A beach that extends offshore and connects to an island is called a _____.
4. Flat, smooth stones found on beaches are called _____.
5. Sediment is transported parallel to the beach by the _____ current.
6. A semi-isolated body of water with freshwater input is called an _____.
7. The time required for an estuary to exchange its water with the ocean is the _____ time.
8. A cliff coast is an example of a _____ coast.
9. An accumulation of sediment along the coast is called a _____.
10. The dry region of the beach is called the _____.

TRUE - FALSE

1. Along some beaches the sand is stripped from the beach and deposited in offshore bars in the winter.
2. Wave-cut scarps form on the low tide terrace.
3. The summer berm is a permanent feature.
4. A large amount of shell material in a beach can color it pink.
5. Groins are structures built just offshore parallel to the beach to reduce wave energy.
6. The melting of sea ice would not raise sea level.
7. An excessive amount of nutrients entering an estuary can be bad for organisms living there.
8. Over one-half of the population of the United States lives within 70 km of a coast.

9. Present technology is inadequate to handle major marine oil spills.
10. The sediment making up a beach remains in the same place on the beach except during severe storms.

MULTIPLE CHOICE

1. The circulation in inverse estuaries is characterized by:
    a. outward flow at the surface and inward flow at depth
    b. outward flow at all depths
    c. inward flow at the surface and outward flow at depth
    d. inward flow at all depths
    e. none of the above
2. Beaches can be categorized by:
    a. color
    b. particle size
    c. shape
    d. composition
    e. all of the above
3. Examples of primary coasts include:
    a. barrier coasts
    b. fjords
    c. dune coasts
    d. a and b
    e. b and c
4. The greenhouse effect:
    a. is caused by an increase in the amount of incoming solar radiation
    b. is caused by an increase in CO_2
    c. will increase the surface water temperature by about 10°C
    d. will not have much of an impact on coastal regions
    e. a and b
5. In which estuary is the circulation dominated by tidal processes?
    a. well-mixed estuary
    b. salt wedge estuary
    c. partially-mixed estuary
    d. fjord
    e. b and e
6. In which estuary is the circulation dominated by river flow?
    a. well-mixed estuary
    b. fjord
    c. partially-mixed estuary
    d. salt wedge estuary
    e. none of the above
7. Wetlands are important because they:

a. provide nutrients to estuaries
b. are a source for food for marine organisms
c. provide shelter for organisms
d. serve as spawning grounds for some organisms
e. all of the above

8. The estimated life span of a plastic six-pack ring in the oceans is about:
a. 3 weeks
b. 50 years
c. 450 years
d. 120 years
e. 8 months

9. Oil spilled at sea may:
a. evaporate
b. sink into the beach
c. sink to the sea floor
d. dissolve in the water
e. all of the above

10. The greenhouse effect could cause rising sea level because:
a. sea ice would melt
b. land ice would melt
c. the seawater would expand with increasing surface temperature
d. all of the above
e. b and c

Answer Key for 'Key Terms' and 'Test Your Understanding'

FILL IN THE BLANK

1. fjords
2. rip
3. tombolo
4. shingles
5. longshore
6. estuary
7. flushing
8. secondary
9. beach
10. backshore

TRUE - FALSE

1.T 2.F 3.F 4.T 5.F 6.T 7.T 8.T 9.T 10.F

MULTIPLE CHOICE

1.c 2.e 3.e 4.b 5.a 6.d 7.e 8.c 9.e 10.e