Answer Key

Answers to Study Questions

1. *Wave height* refers to the vertical distance separating the wave crest (the highest point) and the wave trough (the lowest point). The wave height and speed of water waves depend on the speed of the wind that generates the waves as well as the time duration over which the wind blows. Wave height also depends on the horizontal distance over which the wind blows over the water.

2. The *wavelength* of a water wave is equivalent to the distance separating two successive wave crests or troughs.

3. As a wave travels through water, water particles move in circular orbital paths. At the surface, the orbital paths have diameters equal to the wave height. With depth, however, the orbitals become progressively smaller until the motion disappears. As waves travel closer to the coast, the shallow ocean floor begins to interfere with the orbital motion. The circular paths of the orbitals flatten out and the wavelength decreases, but the wave height increases significantly. Nonetheless, the wave period remains the same. As a wave approaches the coast, the wave becomes steeper and steeper until it breaks by toppling over onto the beach. The breaker washes up onto the beach, dissipating its energy in the process. *Surf* is a collective term referring to a group of breakers.

4. *Wave refraction*, or bending of a wave, occurs when a wave approaches a coastline at an angle. The oblique approach results in one end of the approaching wave reaching the shallow part of the ocean floor first. This retards the wave. The trailing end of the wave travels faster until it also hits the shallow part. As a result, the wave crest rotates to become parallel with the coastline. This turning effect is called *refraction*.

5. A *longshore current* describes a water current that moves parallel to the coastline. Such currents arise when waves that strike the shoreline at an angle move water up the beach face at an angle to the coastline. When the water comes to a standstill on shore and the wave's energy is dissipated, the water flows back seaward perpendicular to the coast. If this action is repeated successively with each approaching wave front, the water develops a zigzag path with a net transfer of water parallel to the coast.

6. *Rip currents* are narrow sections of water in the surf zone that flow seaward from the shore, bringing back water after the waves' energy is dissipated. Rip currents usually form in sections of the shoreline where the wave height is low, often where channels occur on the sea floor.

7. A *beach* is the gently sloping part of the coastline extending from the low water line landwards to a cliff or line of fixed vegetation. Beaches usually comprise sand or gravel material, and incoming waves break on the beach. The steepest part of the beach is the beach face, whereas the upper landward section, which has a lower slope, is the *berm*. The beach face is routinely subjected to wave action, especially at high tide. The berm, on the other hand, is usually dry, and is only submerged during storms.

8. Longshore drift occurs when water waves reach the coastline at an angle. The water moves sediment landward at an angle to the shoreline until the water stops (swashes). However, when the water flows back as backwash, the sediment is moved back perpendicular to the coastline. Successive wavefronts move the sediment back and forth in a zig-zag pattern that transfers the sediment progressively parallel to the coastline. Sand is moved in this manner both on the beach face and in the surf zone.

9. Sand transported by longshore drift can move down the shoreline until it reaches a point where the shoreline curves or forms an embayment. In such circumstances, the sand deposition can continue along the original trajectory to build a finger-like projection of sediment termed a *spit*.

   A *baymouth bar* forms in front of a bay in a similar manner to a spit, but it continues along its original trajectory until it encloses the bay completely.

10. *Tombolos* form in areas where longshore drift occurs along a coastline that has an island just offshore. The island forms an obstacle in the path of waves approaching the coastline. Waves are then refracted by the island and converge in the space between the island and the shoreline. As the waves converge, they move sediment along, constructing a ridge called a *tombolo* that ultimately links the island to the mainland.

11. Jetties and groins are engineering structures that are erected perpendicular to the coast to interrupt the longshore drift of sand. While these structures can be effective in protecting parts of the coastline for a time, sand tends to accumulate on the upstream side of the longshore current, while further downstream the coastline becomes starved of sand. In essence, sands removed downstream from the jetty or groin are not replaced, leading to an increase in coastal erosion.

12. A major proportion of the sand transported by rivers ends up on the beach because sediment transport by longshore drift moves it parallel to the shoreline.

13. Irregular shorelines with headlands interspaced with bays can be shaped by wave erosion until they are straight. As waves approach the coastline, wave refraction concentrates the energy of the waves on projecting sections of the coastline. With time, these erode until the coastline is straightened. The sediment removed from the headlands is deposited in the calmer embayments.

14. *Sea caves* are cavities that are sometimes carved into susceptible rock by water waves at the bottoms of coastal sea cliffs.

15. Barrier islands are mounds of sand that protrude from the sea floor and are aligned parallel to the coastline. The zone between the barrier island and the coastline is sheltered from the sea, which may provide protected areas for mooring boats. Barrier islands may form when longshore drift forms extended spits. They may also form when water waves erode sand from deeper offshore and deposit it in shallower waters parallel to the shoreline.

16. *Drowned coasts* form when coastal zones become submerged by water. This can occur when the sea level rises. The last 2.5 million years of the geological history (the Pleistocene Epoch) have been characterized by recurrent ice ages during which the polar ice caps grew, ice sheets covered parts of continents, and the sea level fell by more than 100 m. During periods of low sea level, shorelines were further into the sea. When the climate warmed and sea level rose, former coastlines drowned. The process of global warming that is currently taking place is also believed to be threatening to submerge low-lying coastal zones by causing a rise in sea level due to the melting of polar ice caps.

17. When reefs from corals or algae grow on the continental shelf close to the shoreline, they act as protective barriers that shield the coastline from excessive erosion of strong waves. A reef may also provide carbonate sands that replenish the beach with sediment.

18. *Mangroves* are vegetation (trees and shrubs) that grow in the saline coastal waters in the tropics. The branching root structures of such vegetation attenuate the movement of waves and ocean currents, providing a calm environment to shelter larvae of marine organisms. Decaying mangroves can also form peat deposits on some coastal plains.

19. The catastrophic flood of New Orleans following Hurricane Katrina was the result of a combination of events related to the rise of the sea level and the subsidence of the Mississippi Delta. Large-scale subsidence of the Mississippi Delta began in the 1930s following the

construction of levees along the Mississippi River, built to defend the city of New Orleans against seasonal flooding. The reduction in annual flooding and the lack of additional sediment resulted in subsidence as the ground compacted. The sediment compaction is also believed to have triggered a fault beneath the city that led to additional subsidence. The extraction of natural gas and petroleum from the region contributed to yet further subsidence. The cumulative effect of these processes is that the ground level in New Orleans has sunk by an equivalent of 74 cm over the last 100 years, which is three times greater than the global rate.

At the same time, the sea level was also rising. Melting of Pleistocene glaciers that began 15,000 years ago combined with the global warming trend that followed the industrial revolution to cause a rise in sea level.