from The New Book of Knowledge, 2006. Article on "Ocean".

*Left:* Water particles on the ocean's surface move in a circle as a wave passes. Despite appearances, they are not carried along with the wave. *Right:* A breaking wave advances toward shore where it is met by the backwash from a previous wave (a–c). After the wave breaks and washes onto land (d–f), it also becomes backwash and the cycle repeats.

## ▸ MOVEMENT OF OCEAN WATER

Ocean water is in continual motion. This water movement helps to provide a nearly constant environment for marine organisms. Water circulation helps disperse swimming and floating organisms, carries body wastes away from marine animals, and replenishes food, nutrients, and essential elements.

Movement of the upper layers of ocean water is usually caused by winds blowing steadily across the sea surface. Other causes include sudden shifts in the earth's crust and the gravitational pull of the moon and the sun.

### Waves and Currents

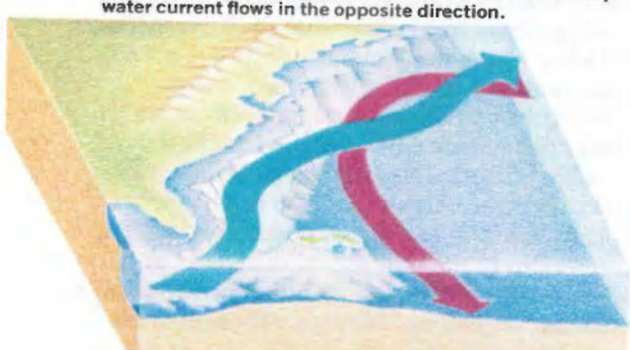
Creation of waves depends on the wind's speed, duration, and the size of the area over which the wind blows. Ocean waves range in height from fractions of an inch to almost 100 feet (30 meters) high.

Winds also produce surface currents. These are large-scale horizontal movements of surface waters caused by winds of constant direction and speed. As a result, these currents are semi-permanent features of the world's oceans.

Currents have a tremendous effect on the climate because they carry warm water into cold regions and cool water into tropical regions. This mix of temperatures creates many kinds of weather patterns. And without currents, the oceans would stagnate and could not support their great abundance of life.

Navigators rely on currents because the water movement helps ships speed along their paths. The Gulf Stream is a strong ocean current that was important to early travelers in exploring and settling the New World. (See the article GULF STREAM in Volume G.) Other strong currents include the Peru Current and the Japan Current in the Pacific Ocean as well as the Labrador Current and the Brazil Current in the Atlantic Ocean.

Winds known as the trade winds, westerlies, and polar easterlies help propel most ocean surface currents. (More information can be found in the article WINDS in Volume W-Z.) Below these surface currents are deeper, cool-water currents that flow in opposite directions to those above. Their movements result from changes in seawater density.

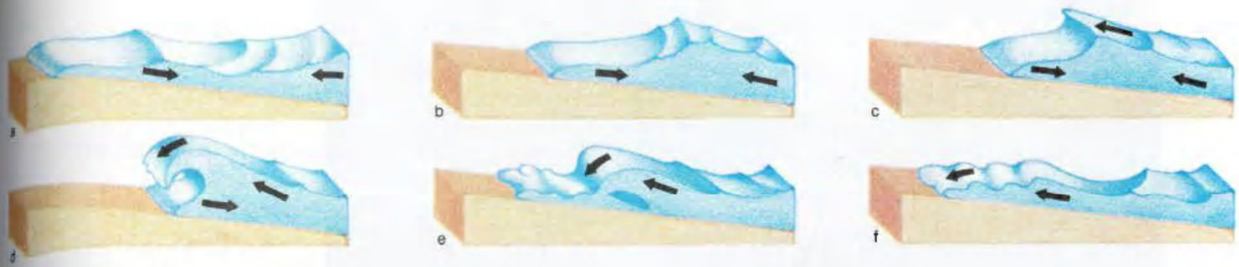


The Gulf Stream, a surface current, flows north along the eastern coast of the United States. Beneath it a deep-water current flows in the opposite direction.

### Upwelling and El Niño

Ocean water masses can also move vertically in a process called **upwelling.** As winds blow warm surface water away from a coastline, cold water—rich in nutrients—moves up from the ocean depths. Upwelling brings nutrients and food to shallow ocean areas. As a result, areas of upwelling such as the Pacific coast of North America have rich fishing grounds.

Sometimes winds weaken so much that upwelling cannot take place. For example, when westward-blowing trade winds over the Pacific Ocean diminish near the equator, warm water surges eastward and stops upwelling along the northwestern coast of South America. This phenomenon, called **El Niño,** can have catastrophic consequences. Large populations of fish can die, and weather patterns can be disrupted around the world. (See the Wonder Question, What is El Niño? in the article WEATHER in Volume W-Z.)




## Tides

Ocean waters can also be put into motion by tides. These are very long waves that cause a rise and fall of the ocean surface. The maximum height of this rise is called a high tide and is followed by a fall in sea level known as the low tide. As many as two high and two low tides may occur along a coastline in each 24-hour period.

Tides that result from the gravitational pull of the moon are called **lunar tides.** Strong gravitational pull on the side of the earth facing the moon causes the ocean to rise up or bulge. This produces a high tide. On the opposite side of the earth, the gravitational pull of the moon on the water is weak. However, the earth mass is still attracted toward the moon, leaving the oceans on the far side of the earth slightly behind. The result is the same—a high tide.

The gravitational pull of the sun (in addition to that of the moon) produces solar tides known as **spring tides** and **neap tides.** A spring tide occurs during the full and new moons when the sun, moon, and earth are in a straight line. This combined gravitational pull of the sun and moon causes extra-high high tides and very-low low tides.

A neap tide happens when the sun and moon are at right angles to one another. The gravitational pull is not very strong, so these tides are not very high or very low. Two sets of spring and neap tides occur each month.

## Tsunamis

The highest ocean waves are caused not by powerful winds but rather by sudden movements in the earth's crust. These waves are called **tsunamis.** Although sometimes called tidal waves, they have nothing to do with tides. Instead, they happen as a result of earthquakes, volcanic eruptions, and underwater landslides. Though rare, they occur most commonly in the Pacific Ocean. The huge waves of tsunamis move across the ocean very rapidly and can destroy entire coastal communities.

## Effects of Ocean Movements

Waves, currents, and tides may influence marine plants and animals and their habitats. Waves, especially those created by storms, may cause the erosion of land masses, move-

Ocean shorelines are constantly changing, sometimes causing damage to coastal communities. This California roadway was washed away by the pounding of ocean waves.

Surtsey (*left*) is a volcanic island that formed off the southwest coast of Iceland in the 1960's. It is one of the few places where features of the ocean floor (*diagramed below*) project above the water's surface.


**Features of an ocean floor**

ment of large volumes of ocean-floor sediment, and the relocation or destruction of marine life. The movement of sediment during coastline erosion may build up sandbars along the shore and fill harbors with sand and mud, thus preventing the passage of ships. Sediments carried by currents may bury feeding areas and spawning grounds important to the survival of marine organisms.

[redacted]

Many of the [redacted] of the [redacted] along the ocean floor. One of [redacted] describing the [redacted] to begin with its [redacted] and proceed seaward to [redacted] the deep [redacted]

and Arctic—have similar features and can be [redacted]

## The Continental Shelf

The [redacted] as a shallow under-[redacted] This seaward extension is known as the [redacted] **shelf** because of its [redacted] The [redacted] flat and is covered with [redacted] land.

Most continental shelves [redacted] ward [redacted] 400 to 650 feet [redacted] meters). The width of con-[redacted] few miles off the Pacific coast of North America [redacted] than 250 miles [redacted] part of the seafloor accounts for 7 to [redacted] sixth of the [redacted]