

## CHAPTER 14 The Movement of Ocean Water

## SECTION

## 3

## Waves

**BEFORE YOU READ**

After you read this section, you should be able to answer these questions:

- How do waves form?
- What are the parts of a wave?
- How do waves move?

**National Science Education Standards**  
ES 1b

**How Do Ocean Waves Form?**

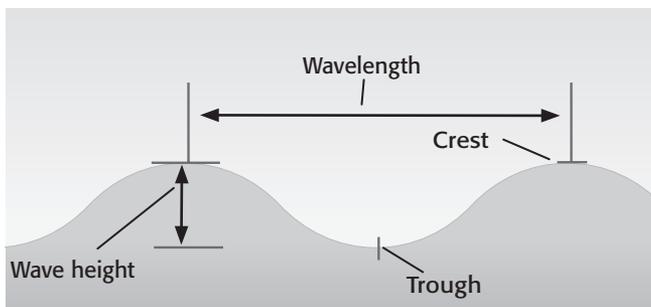
A *wave* is any disturbance that carries energy through matter or empty space. Waves in the ocean carry energy through water.

Ocean waves form when energy is transferred from a source to the ocean water. The source of energy for most ocean waves is the wind. Most ocean waves form as wind blows across the water's surface. However, the energy for some waves comes from earthquakes or meteorite impacts. ✓

Ocean waves can travel at different speeds. They can be very small or extremely large. The size and speed of a wave depend on the amount of energy the wave carries.

**PARTS OF A WAVE**

Waves are made up of two main parts: crests and troughs. A *crest* is the highest point of the wave. A *trough* is the lowest point of the wave. The distance between one crest and the next, or between one trough and the next, is the *wavelength*. The distance in height between the crest and the trough is called the *wave height*.

**Parts of a Wave****STUDY TIP**

**Summarize** As you read, underline the main ideas in each paragraph. When you finish reading, write a short summary of the section using the ideas you underlined.

**READING CHECK**

**1. Identify** Give two sources of energy that can cause ocean waves.

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**TAKE A LOOK**

**2. Define** Write your own definition for *wavelength*.

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**SECTION 3** Waves *continued*

### Critical Thinking

**3. Predict Consequences**  
 People who own boats often leave the boats anchored a short distance away from the shore. The boats stay in about the same place over many days. What would happen to these boats if waves caused water to move horizontally?

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### TAKE A LOOK

**4. Describe** What is the shape of the path that the bottle takes as the wave passes by it?

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### Math Focus

**5. Calculate** A water wave has a speed of 5 m/s. If its wavelength is 50 m, what is its wave period? Show your work.

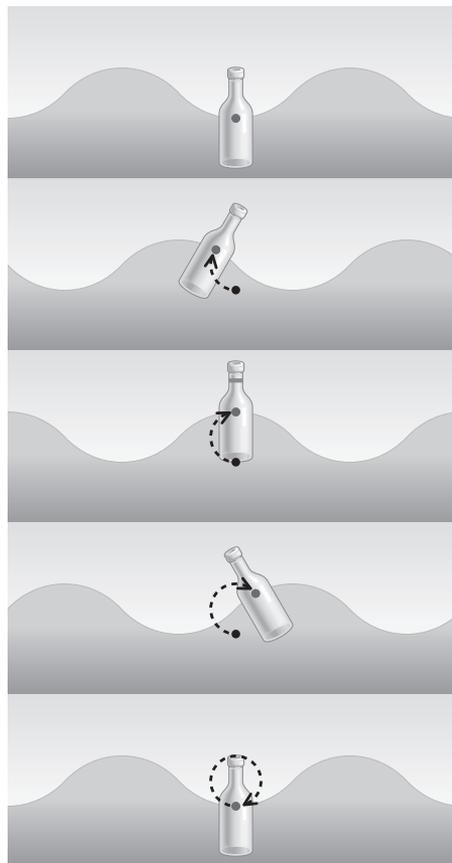
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### MOVEMENT OF WAVES

If you have ever watched ocean waves, you may have noticed that water seems to move across the ocean's surface. However, this movement is only an illusion. The energy in the wave causes the water to rise and fall in circular movements. The water does not move horizontally very much. The figure below shows how waves can move energy without moving water horizontally.



The bottle shows the circular motion of matter when a wave moves in the ocean. The energy in the wave makes matter near the surface move in circular motions. The matter does not move horizontally.

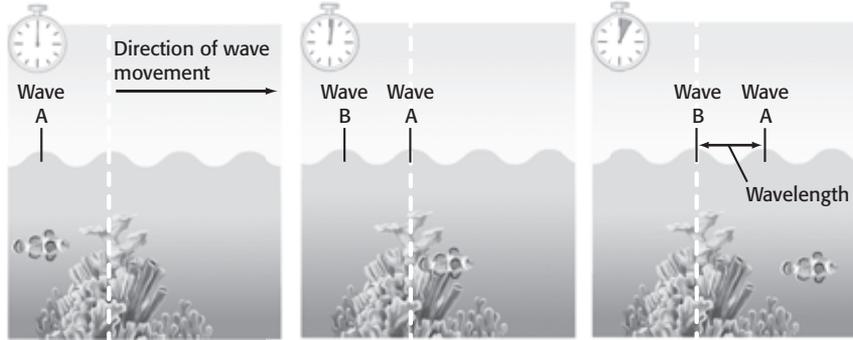
### WAVE SPEED

Waves travel at different speeds. To calculate wave speed, scientists must know the wavelength and the wave period. *Wave period* is the time between the passage of two wave crests or troughs at a fixed point. Dividing wavelength by wave period gives wave speed, as shown below.

$$\frac{\text{wavelength (m)}}{\text{wave period (s)}} = \text{wave speed (m/s)}$$

Increasing the wave period decreases the wave speed. Decreasing the wave period increases the wave speed. The figure on the top of the next page shows how the period of a wave can be measured.

**SECTION 3** Waves *continued*



1. The waves are moving from left to right. The reef is a fixed point because it is not moving. The dotted line marks the center of the reef.

2. The timer begins running as the crest of Wave A passes the center of the reef.

3. The timer stops when the crest of Wave B passes the center of the reef. The time that the timer recorded, 5 s, is the wave period.

**TAKE A LOOK**

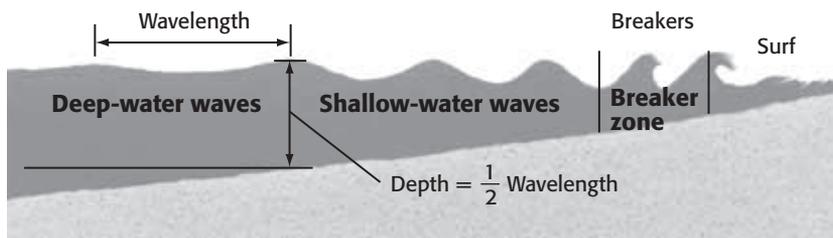
**6. Identify** What part of Wave B is passing the reef when the timer is stopped?

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**DEEP-WATER WAVES AND SHALLOW-WATER WAVES**

You may have seen ocean waves get taller as they move toward the shore. This happens because the depth of the water affects the size and shape of the waves. *Deep-water waves* are waves that move in water deeper than one-half their wavelength. When waves reach water shallower than one-half their wavelength, they begin to interact with the ocean floor. This produces *shallow-water waves*.

As waves begin to touch the ocean floor, they transfer energy from the water to the ocean floor. As a result, the water at the bottom of the waves slows down. However, the water at the top of the wave continues to travel at the original speed. Eventually, the wave crest crashes onto the shore as a *breaker*. The area where breakers start to form is called the *breaker zone*. The area between the breaker zone and the shore is called the *surf*.



Deep-water waves become shallow-water waves when they reach depths of less than half of their wavelength.

*Critical Thinking*

**7. Apply Concepts** An ocean wave has a wavelength of 60 m. It is traveling through water that is 40 m deep. Is it a shallow-water wave or a deep-water wave?

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**TAKE A LOOK**

**8. Describe** What are breakers?

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**SECTION 3** Waves *continued*

*Critical Thinking*

**9. Compare** How are whitecaps different from swells? Give two ways.

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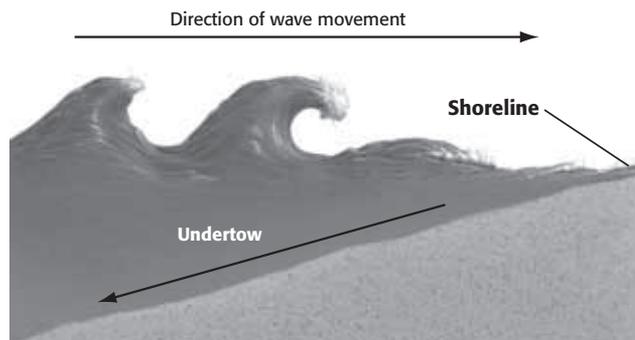
**OPEN-OCEAN WAVES**

Sometimes waves called whitecaps form in the open ocean. **Whitecaps** are white, foaming waves with steep crests. These waves break in the open ocean before they get close to shore. They usually form in stormy weather, and most do not last very long.

Winds that are far from shore can form waves called swells. **Swells** are rolling waves that move steadily across the ocean. They have longer wavelengths than whitecaps. Swells can travel for thousands of kilometers.

**What Are Some Effects of Waves?**

After waves crash on the beach, the water glides back to the ocean. It flows underneath the incoming waves. This kind of water movement produces a current called **undertow**. Undertow carries sand and pieces of rock away from the shore.



Head-on waves create an undertow.

**TAKE A LOOK**

**10. Identify** Does an undertow current move toward the shore or away from the shore?

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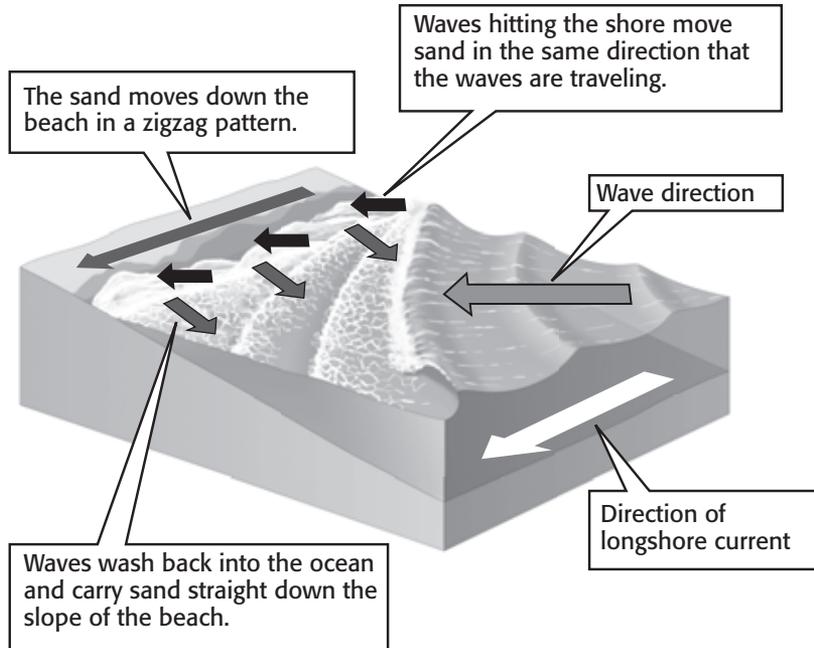
**LONGSHORE CURRENTS**

Sometimes, water moves in a current parallel to the shoreline, close to the shore. This is a **longshore current**.

Longshore currents form when waves hit the shore at an angle instead of head-on. The waves wash sand onto the shore at the same angle that the waves are moving. However, when the waves wash back into the ocean, they move sand directly down the slope of the beach. This causes the sand to move in a zigzag pattern. The figure on the next page shows how longshore currents form.

Longshore currents transport most of the sediment on beaches. This movement of sand erodes and builds up the coastline. Longshore currents can also carry and spread trash and pollution along the shore.

**SECTION 3** Waves *continued*



**TAKE A LOOK**

**11. Infer** Why don't longshore currents form in places where waves hit the shore head-on?

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**TSUNAMIS**

**Tsunamis** are waves that form when a large volume of ocean water suddenly moves. Most tsunamis are caused by movement from underwater earthquakes. However, a volcanic eruption, a landslide, an explosion, or a meteorite impact can also cause a tsunami. Most tsunamis occur in the Pacific Ocean because of the many earthquakes there.

**STORM SURGES**

Severe storms, such as hurricanes, can blow ocean water into a large "pile" near the shore. This causes sea level to rise in the area near the storm. The local rise in sea level near the shore is called a **storm surge**. As the storm moves onto shore, so does the giant mass of water beneath it. This huge amount of water can cause serious flooding. A storm surge can be the most destructive part of a hurricane.

Storm surges contain a lot of energy and can reach about 8 m in height. That is as tall as a two-story building! Storm surges often disappear as quickly as they form. This makes them difficult to study.

*Critical Thinking*

**12. Apply Concepts** Do most tsunamis probably form near plate boundaries or far from them? Explain your answer.

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# Section 3 Review

## SECTION VOCABULARY

<p><b>longshore current</b> a water current that travels near and parallel to the shoreline</p> <p><b>storm surge</b> a local rise in sea level near the shore that is caused by strong winds from a storm, such as those from a hurricane</p> <p><b>swell</b> one of a group of long ocean waves that have steadily traveled a great distance from their point of generation</p>	<p><b>tsunami</b> a giant ocean wave that forms after a volcanic eruption, submarine earthquake, or landslide</p> <p><b>undertow</b> a subsurface current that is near shore and that pulls objects out to sea</p> <p><b>whitecap</b> the bubbles in the crest of a breaking wave</p>
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**1. Describe** How do ocean waves form?

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**2. Compare** How is an undertow current different from a longshore current?

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**3. Calculate** A wave has a wave period of 20 s and a wavelength of 100 m. What is its speed? How would the speed change if the wave period increased?

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**4. List** Name five events that can cause a tsunami.

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**5. Summarize** What is a storm surge? Why are storm surges difficult to study?

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