The Nature of Waves

Anatomy of a Wave

What is a wave?

What are the three types of progressive wave?

What are the crest, trough, height, wavelength, period, *and* frequency *of a wave?*

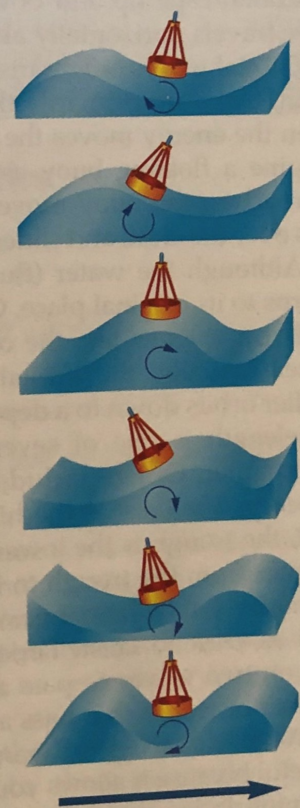
How do wavelength and period relate to a wave's speed?

Before we can look at what waves do in the sea and how they affect life there, it's useful to know something about waves themselves. They're more complex than they appear. By understanding the basic principles of waves, you'll understand how different types produce different effects in the marine environment.

A *wave* is the transmission of energy through matter. When energy moves through matter as a wave, the matter moves back and forth or rotates, but then it returns to its original position. It transmits the energy to adjacent matter, allowing the energy to continue. For instance, imagine dropping a stone in a pond. Waves ripple away from the splash. The water doesn't move away, only the energy.

As you watch the rippling, you can see the energy move as a series of waves away from the disturbance as a *progressive wave*. It's called a progressive wave because you can see the energy progress from one point to another. There are three types of progressive wave—*longitudinal, transverse,* and *orbital*.

A longitudinal wave occurs when the matter moves back and forth in the same direction that the energy travels. This type of wave can move through



STUDY QUESTIONS

Find the answers as you read.

1. What is a wave?
2. What are the three types of *progressive wave*?
3. What are the *crest, trough, height, wavelength, period,* and *frequency* of a wave?
4. How do wavelength and period relate to a wave's speed?
5. What *disturbing forces* cause waves?
6. What *restoring forces* resist waves?
7. What are the differences between deepwater waves and shallow-water waves?
8. What three factors affect the maximum wave size?
9. How can a fully developed sea have waves that are bigger or smaller than the maximum theoretical size?
10. What causes *internal waves*?

Figure 10-1

Orbital wave motion.

As the wave approaches, the buoy moves forward on the wave face. It rises, goes over the crest, and slides backward down the rear of the wave. Individual particles of water move in circular patterns (shown by curved arrow) as the wave's energy moves through the water.

all states of matter, transmitted through the compression and decompression of particles, much like a spring. Sound is a longitudinal wave.

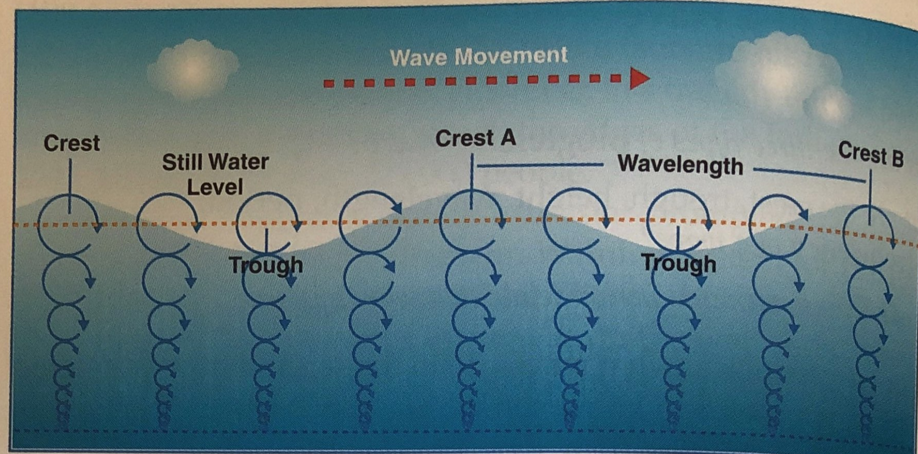


Figure 10-2

Major wave components and orbital pattern. The wavelength is the horizontal distance between the identical points on two waves—in this illustration the horizontal distance from A to B. The crest is the highest wave point above the average water level. The trough is the lowest point, and the height is the vertical measurement from the trough to the crest. Period is the time it takes for the same spot on two waves to pass a single point, while frequency is the number of waves that pass a fixed point in one second. Note the orbital wave pattern tapering in intensity down to a depth equal to one half the wave's wavelength.

When transverse waves occur in matter, the motion of the matter is perpendicular to the direction in which the wave as a whole is moving. For example, when you shake one end of a taut, horizontal rope up and down, the rope moves vertically, but the wave travels horizontally along the length of the rope.

Orbital waves only transmit through fluids. With respect to the ocean, these are primarily the waves that concern us. They occur when the energy moves the fluid in a circular motion as it passes. Imagine a floating buoy as shown in Figure 10-1. As the wave approaches, the buoy moves forward on the wave face. It rises, goes over the crest, and slides backward down the rear of the wave.

Although the water (fluid) travels through orbital motion, it returns to its original place. Only the energy moves on. Looking at the buoy, it looks like the orbital motion occurs only in a single plane. Actually, the orbital motion continues in progressively smaller orbits down to a depth of about half the wave's *wavelength*. Wavelength is one of several terms that we'll use throughout this chapter. Others include the *crest, trough, height, period,* and *frequency*. The crest is the highest point above the average water level, the trough is the lowest point, and the height is the vertical distance from the trough to the crest. You measure wavelength as the horizontal distance between the identical point on two waves, such as crest to crest. Period is the time it takes for the same spot on two waves to pass a single point, while frequency is the number of waves that pass a fixed point in one second.

Wave characteristics can be expressed mathematically. This is useful because it allows you to calculate wave behaviors based on the information you have. H:L is the ratio of the wave height to wavelength. Later, you'll see how we use this to determine when a wave will break.

If you know the wavelength (L: depth in meters) and the period (T: time in seconds), you can determine the speed of ideal deepwater waves (S: speed in meters per second):

speed = wavelength ÷ period

This is sometimes abbreviated:

$$S = L \div T$$

Note that various factors can cause actual deepwater wave speed to differ from that calculated using this equation. The equation for the speed of a shallow-water wave is given later in this chapter.

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Normal wind wave:

Example 1	T = 5 s	L = 100 m	S = 100 m ÷ 5 s = 20 m/s
Example 2	T = 20 s	L = 200 m	S = 200 m ÷ 20 s = 10 m/s
Example 3	T = 10 s	L = 150 m	S = 150 m ÷ 10 s = 15 m/s

Tsunami:

Example 1	T = 10 min	L = 500 km	**convert to seconds and meters**
	T = 600 s	L = 500,000 m	S = 500,000 m ÷ 600 s = 830 m/s
Example 2	T = 120 min	L = 500 km	
	T = 7,200 s	L = 500,000 m	S = 500,000 m ÷ 7,200 s = 69 m/s