Earth Science

Chapter 21

Section 2 – Ocean Waves

E.Q.: ***How do waves form and affect coastlines?***

STANDARDS:

SES5. Students will investigate the interaction of insolation and Earth systems to produce weather and climate.

a. Explain how latitudinal variations in solar heating create atmospheric and ocean currents that redistribute heat globally.

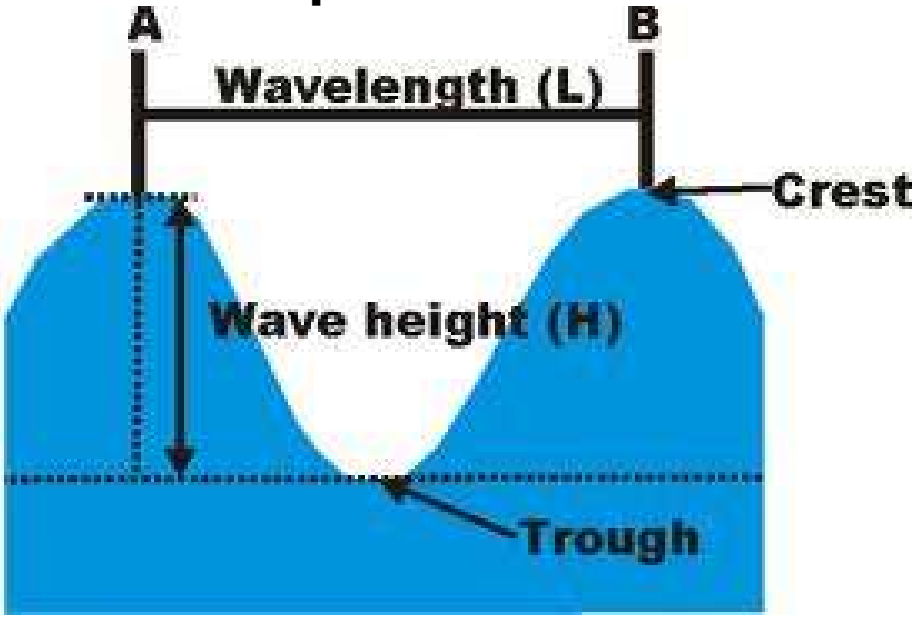
Objectives

- **Describe the formation of waves and the factors that affect wave size.**
- **Explain how waves interact with the coastline.**
- **Identify the cause of destructive ocean waves.**

OCEAN WAVES

wave **- a periodic disturbance in a solid, liquid, or gas as energy is transmitted through a medium**

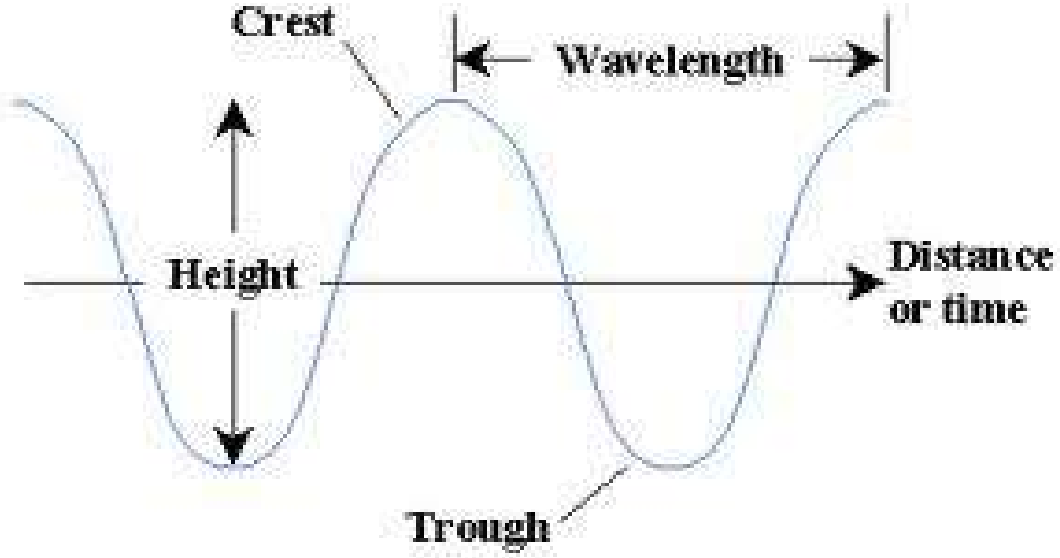
- **One kind of wave is described as the periodic up-and-down movement of water.**
- **Such a wave has two basic parts—a *crest* and a *trough*.**
- **The crest is the highest point of a wave. The trough is the lowest point between two crests.**



wave period **- the time required for two consecutive wave crests to pass a given point**

- **The *wave height* is the vertical distance between the crest and the trough of a wave.**
- **The *wavelength* is the horizontal distance between two consecutive crests or between two consecutive troughs.**

wave speed = wave length / wave period



Wave Energy

- **The longer that wind blows from a given direction, the more energy is transferred from wind to water and the larger the wave becomes.**
- **Because of their large surface area, larger waves receive more energy from the wind than smaller waves do.**
- **Thus, larger waves grow larger, and smaller waves die out.**

http://www.youtube.com/watch?v=7nS_aR8XX_U

Water Movement in a Wave

- **Although the energy of a wave moves from water molecule to water molecule in the direction of the wave, the water itself moves very little.**
- **As a wave moves across the surface of the ocean, only energy of the wave, not the water, moves in the direction of the wave.**
- **The water molecule within the wave move in a circular motion. During a single wave period, each water particle moves in one complete circle.**
- **As a wave passes a given point, the circle traced by a water particle on the ocean surface has a diameter that is equal to the height of the wave.**
- **Because waves receive their energy from wind pushing against the surface of the ocean, the energy received decreases as the depth of the water increases.**
- **Thus, the diameter of a water molecule's circular path decreases as water depth increases. Below a depth of about one-half the wavelength, there is almost no circular motion of water molecules.**

READING CHECK

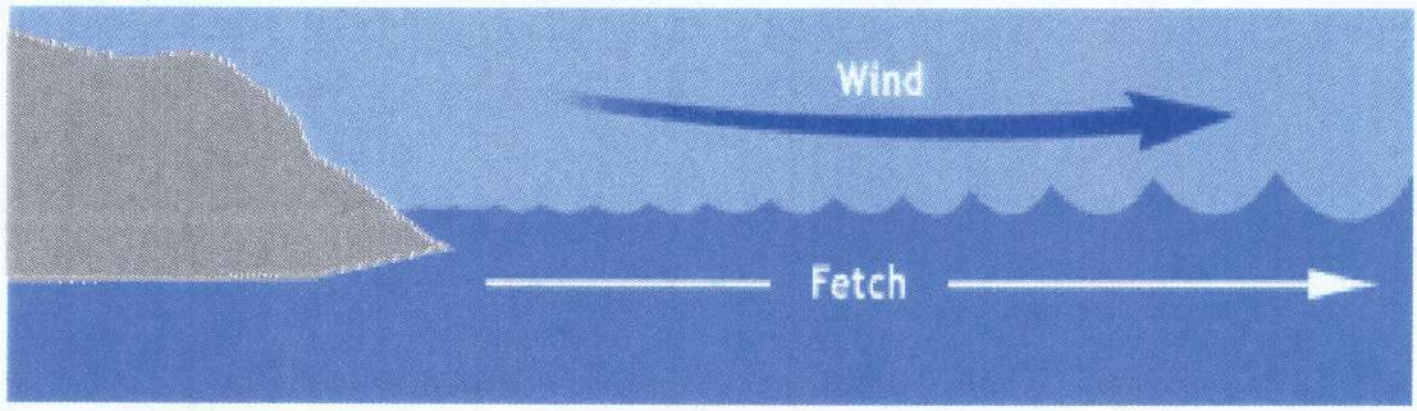
Why does the diameter of a water molecule's circular path in a wave decrease as depth increases?

Because waves receive energy from wind that pushes against the surface of the water, the amount of energy decreases as the depth of water increases. As a result, the diameter of the water molecules' circular path also decreases.

Wave Size

fetch **- the distance that wind blows across an area of the sea to generate waves**

- **Three factors determine the size of a wave. These factors are the speed of the wind, the length of time the wind blows, and fetch.**
- **The size of a wave will increase to only a certain height-to-length ratio before the wave collapses.**



Whitecaps

- **When winds blow the crest of a wave off, *whitecaps* form.**
- **Because whitecaps reflect solar radiation, they allow less radiation to reach the ocean.**
- **Scientists have been studying how this characteristic may affect climate.**

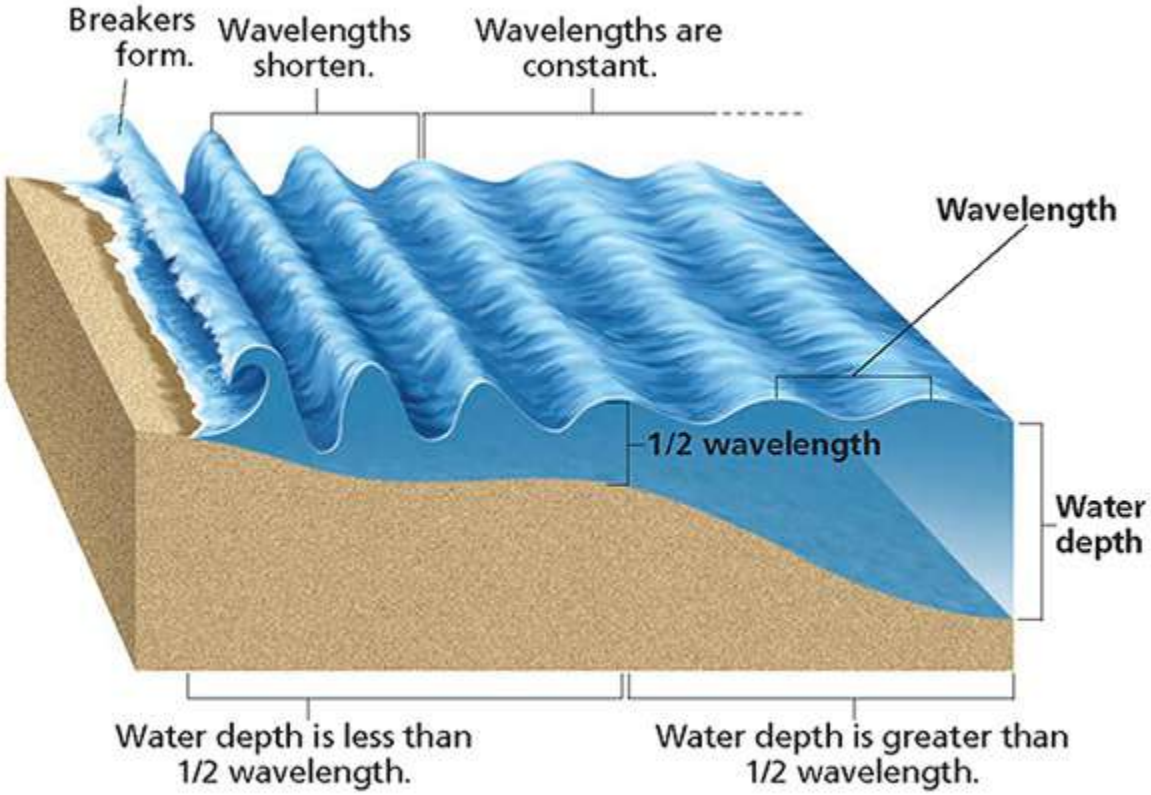
Waves and the Coastline

- **In shallow water near the coastline, the bottom of a wave touches the ocean floor.**
- **A wave touches the ocean bottom where the depth of the water is about half the wavelength.**

Breakers

- **The height of a wave changes as the wave approaches the coastline.**
- **As the wave moves into shallow water, the bottom of the wave is slowed by friction. The top of the wave, however, continues to move at its original speed.**
- **Finally, the top of the wave topples over and forms a *breaker,* a foamy mass of water that washes onto the coastline.**

The diagram below shows how breakers form.



READING CHECK

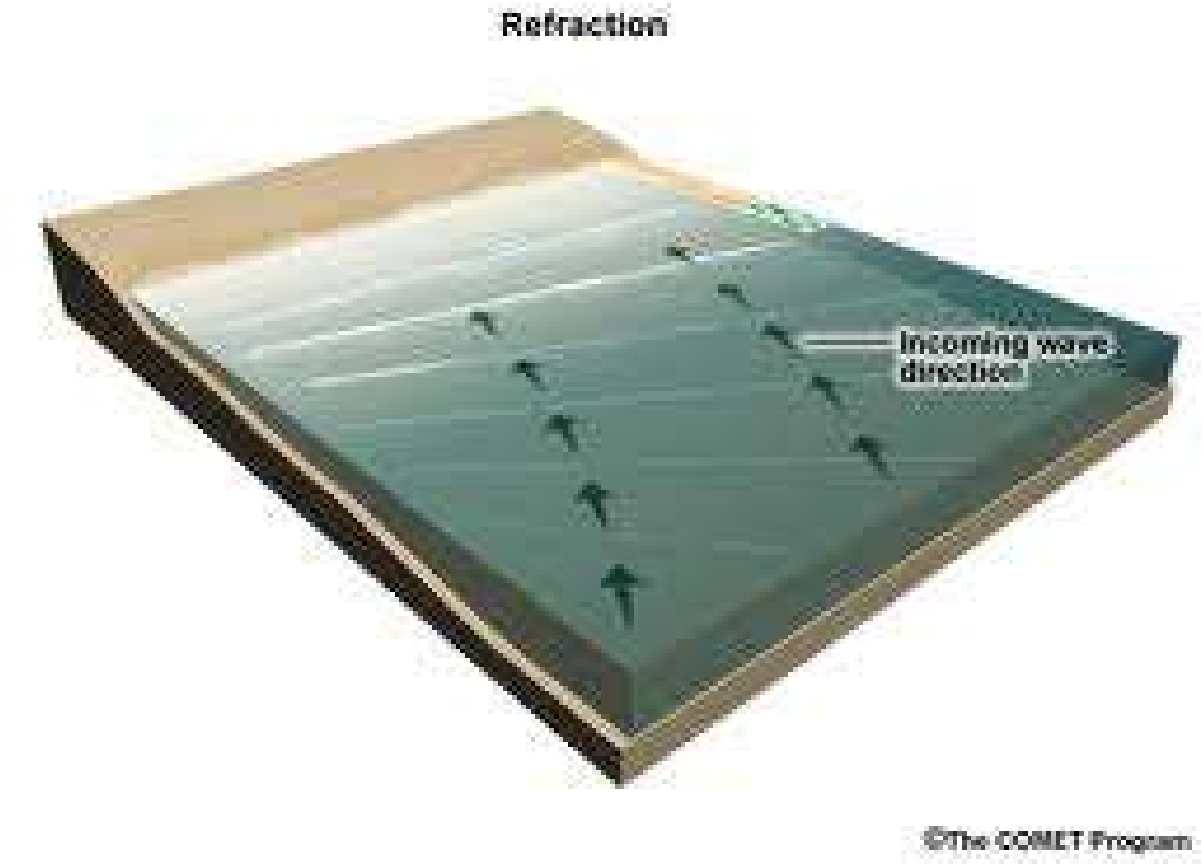
As a wave moves into shallow water, what causes the top of the wave to break and topple over?

Contact with the ocean floor causes friction, which slows down the bottom of the wave but not the top of the wave. Because of the difference in speed between the top and bottom of the wave, the top gets farther ahead of the bottom until the wave becomes unstable and falls over.

Refraction

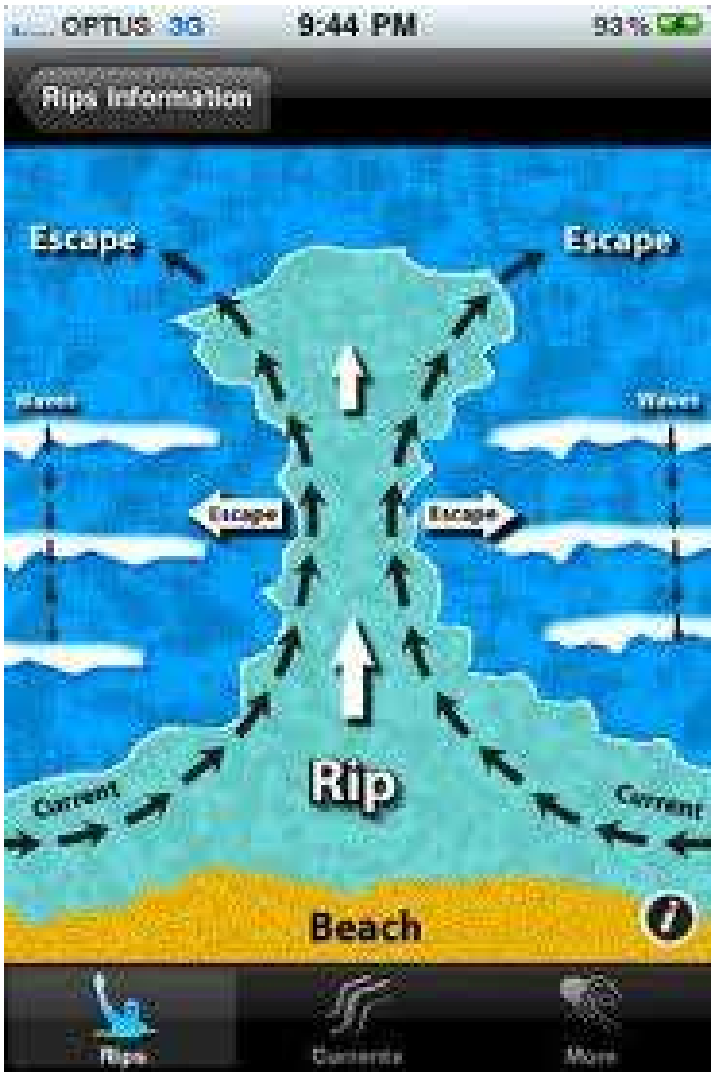
refraction **- the process by which ocean waves bend directly toward the coastline as they approach shallow water, the part of the wave that is traveling in shallow water travels more slowly than the part of the wave that is still advancing in deeper water.**

- **The wave gradually bends toward the beach and strikes the shore head-on.**

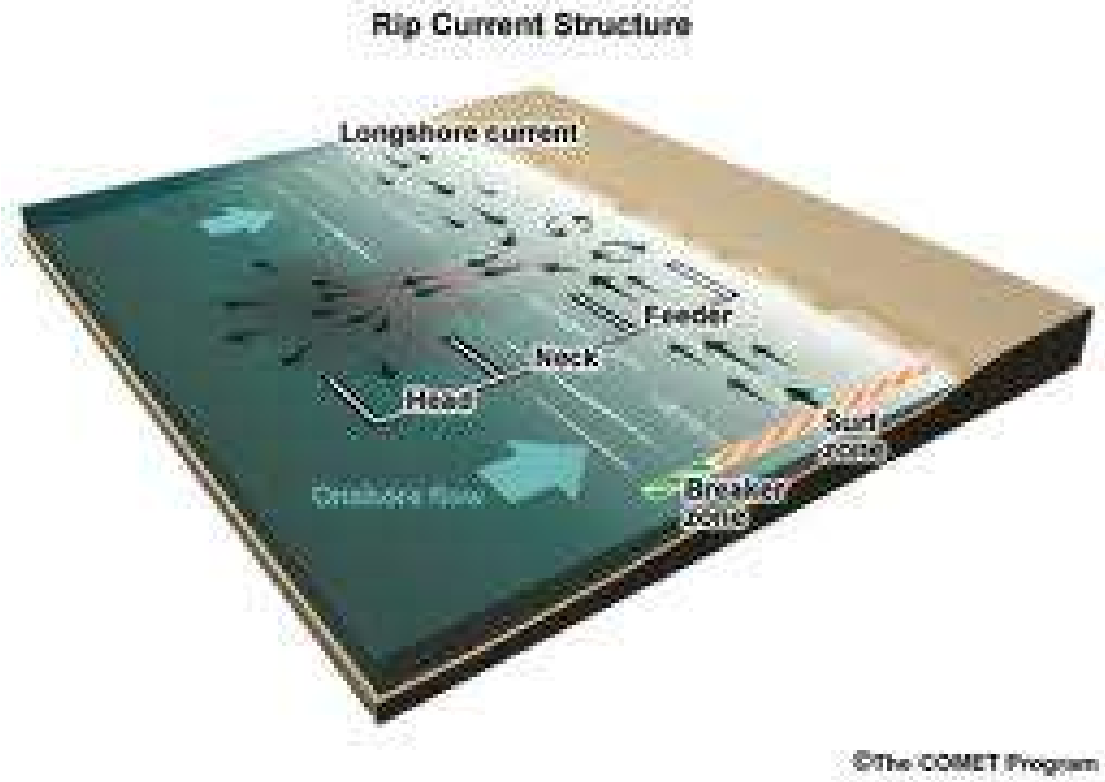


Undertows and Rip Currents

- **Water carried onto a beach by breaking waves is pulled back into deeper water by gravity. This motion forms an irregular current called an *undertow.***
- **The generally weak undertow is often confused with the more dangerous *rip current*.**
- **Rip currents form when water from larger breakers returns to the ocean through channels that cut through underwater sandbars that are parallel to the beach.**

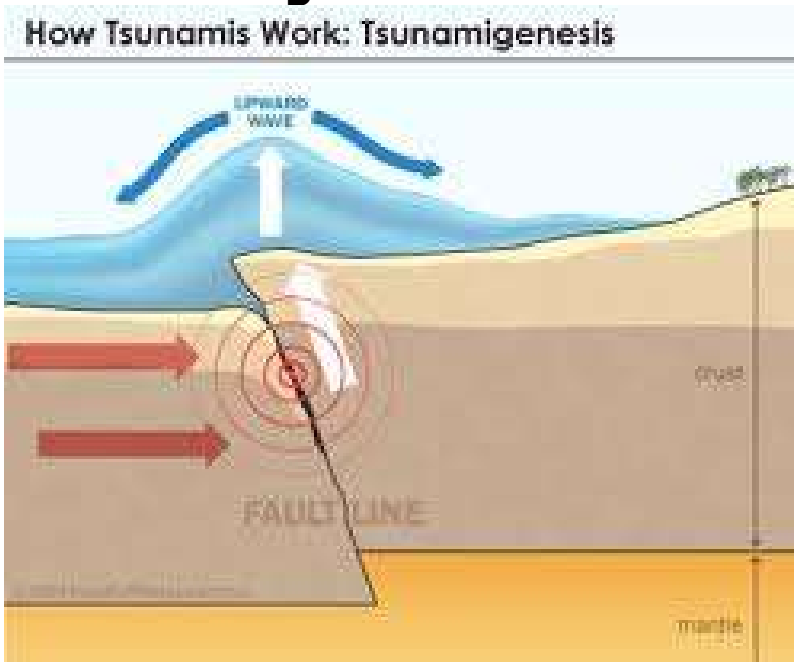


- **<u>Longshore Currents</u>**
- ***Longshore currents*** **form when waves approach the beach at an angle.**
- **Longshore currents flow parallel to the shore. Great quantities of sand are carried by longshore currents.**
- **These sand deposits form low ridges of sand called *sandbars*.**



Tsunamis

- ***Tsunamis*** **are giant seismic ocean waves.**
- **Most tsunamis are caused by earthquakes on the ocean floor, but some can be caused by volcanic eruptions and underwater landslides.**
- **Tsunamis are commonly called *tidal waves*, which is misleading because tsunamis are not caused by tides.**



Tsunami as a Destructive Force

- **A tsunami has a tremendous amount of energy.**
- **All of the energy of this mass of water is released against the shore and causes a great deal of destruction.**
- **The arrival of a tsunami may be signaled by the sudden pulling back of the water along the shore.**

Houses are swept by a tsunami in Natori City in northeastern Japan March 11, 2011. A massive 8.9 magnitude quake hit northeast Japan on Friday, causing many injuries, fires and a ten-metre (33-ft) tsunami along parts of the country's coastline. There were several strong aftershocks and a warning of a 10-metre tsunami following the quake, which also caused buildings to shake violently in the capital Tokyo. (Reuters)

Houses swallowed by tsunami waves burn in Natori, Miyagi Prefecture (state) after Japan was struck by a strong earthquake off its northeastern coast Friday, March 11. (Kyodo News/Associated Press)