

Waves, Longshore Current, and Tides

The shoreline advances or retreats depending on the actions of the waves, currents, and tides and the availability of sediments. The changes in the location of the shoreline are of enormous importance to Texas. Shoreline erosion and retreat can cause millions of dollars in damages to homes, businesses, roads, pipelines and any other development that is lost or damaged by shoreline change.

Waves: Waves are a repeated movement in a body of water seen as an alternate rise and fall of the surface. Ocean waves may erode or deposit sediment on the beach. A ten-foot high wave is not uncommon during a major tropical storm or hurricane, and a few hours of big waves crashing on the coast can erode a lot of the beach—back to the dunes—or even farther. If the eroded sand is carried into deep water, the sediment is not available for the smaller waves to carry back to reconstruct the beach after the storm has passed. Unless additional sand is available, the post-storm shoreline will be established many feet inland of its former position before the storm.

A summary of waves

- There are 3 forces that form waves: wind, earthquakes (form tsunamis), and gravitational attractions between Earth, sun, and moon (form tides).
- Ocean waves are formed by the wind (friction between the wind and the waters surface).
- The size of a wave (fig. 1) depends upon the wind speed, length of time the wind blows in the same direction, and the distance over which the wind blows (fetch).
- Wind waves will continue as long as the wind is blowing. Once the wind stops the waves will continue until their energy is dissipated.
- Water particles in waves move in a nearly stationary circular motion (fig. 1).
- At the surface, the orbit of the water particles in a wave is about equal to the wave height. The orbits decrease in size downward through the water column to a depth of about one-half the wavelength ($L/2$)
- Breaking occurs when crest angle is less than 120° or steepness (H/L) greater than $1/7$.

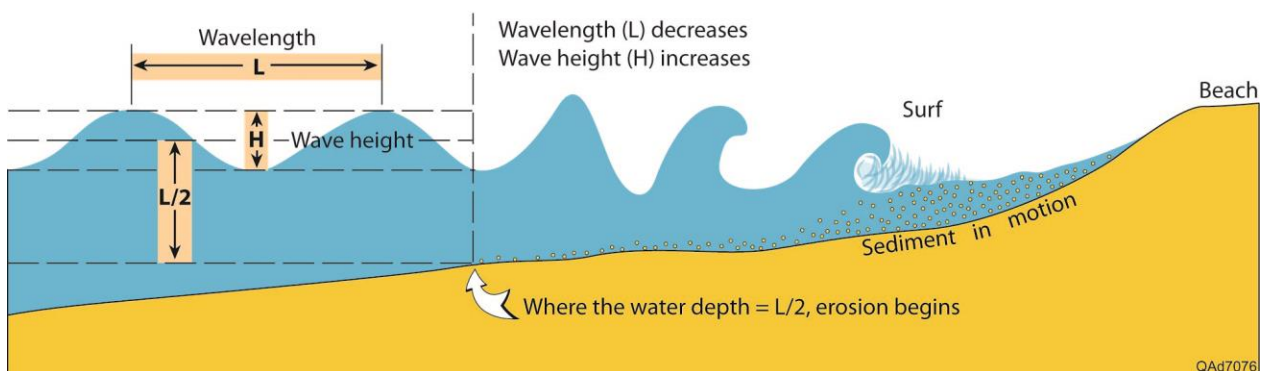


Figure 1. Ocean wave motion

Breaker Types: the slope of the lower beach depends on the type of waves (in beaches of uniform composition).

- Spilling Breaker: Gentle beach slope, waves break far from shore and surf gently rolls over the front of the wave.
- Plunging Breaker: Moderately steep beach slope, less steep wave, slightly longer period, wave curls over forming a tunnel until the wave breaks.
- Surging Breaker: Steep beach slope, low wave of long period, doesn't actually break, wave rolls onto the beach.

Longshore Current: Sand moves to and from the beach in an onshore-offshore direction, but it also moves along the shoreline ("longshore"). This longshore sand transport is referred to as *longshore drift* (fig. 2), and because of it, beaches have been called "rivers of sand".

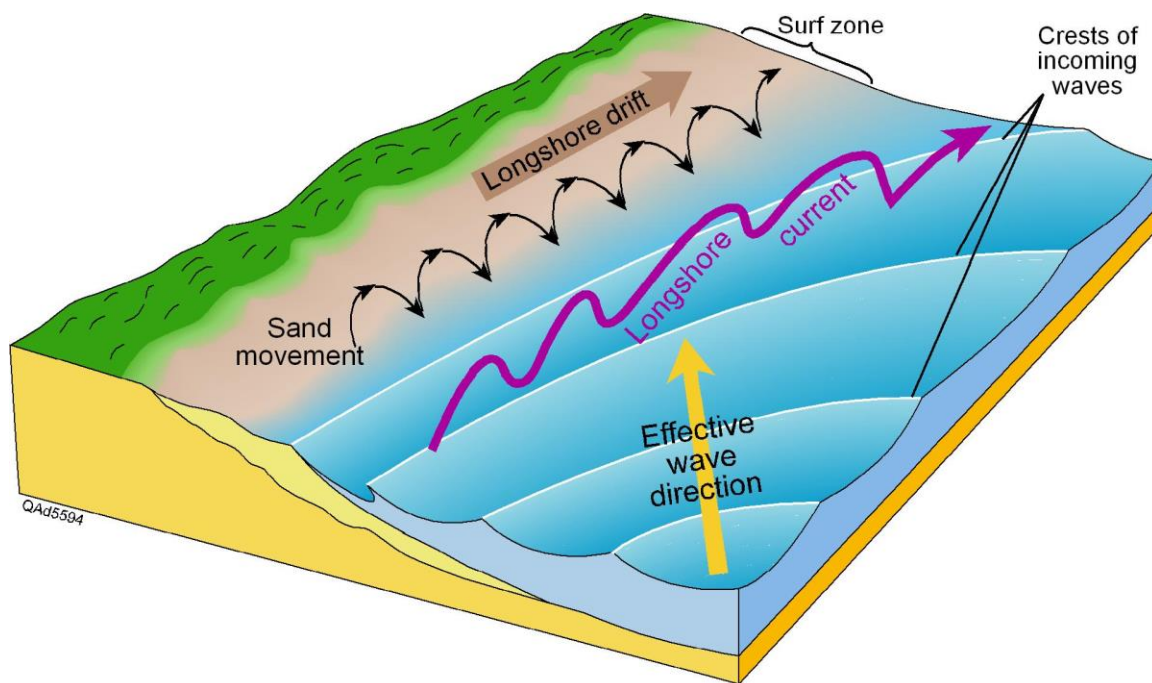


Figure 2. Schematic of longshore current.

The longshore current moves the sand along the beach. At a particular time, the longshore drift of the sand by the longshore current may be in either direction along the beach. Over the course of a year and at most locations, the volume of sand moved in one direction will exceed the amount moved in the opposite direction. The difference in the amounts of longshore drift between the two directions over a period of one year is called the annual net longshore drift. Knowing the annual net longshore drift is extremely important because the major source of sand for Texas beaches is from updrift beaches

The ultimate sources of the sand for our beaches are either new sand introduced to the coastal zone by rivers, or old sand reworked by the waves and currents from deposits in shallow offshore areas. Not much sand is added from the offshore because it is too deep, and little sand comes from the rivers because dams on the rivers trap the sand, and today most Texas rivers discharge

into bays where the sand is trapped. A not very satisfactory alternative is to dredge sand from deeper water in the Gulf of Mexico and pump it onto our beaches; dredging is expensive.

The longshore current, the movement of water along the shoreline, is caused by

- Waves approaching at an angle to the shoreline.
- Tidal currents.
- Wind pushing water along the beach.

Tides: *Tides* are the periodic rising and falling of ocean waters caused by the gravitational forces of the sun and moon (fig. 3). As the Earth rotates, the gravitational attraction of the moon and sun “pull” up a bulge of ocean waters when the ocean is facing the moon to create a high tide. There is a paired, high-tide bulge, on the “backside” of the Earth.

- Spring tides, the tides having the largest tidal ranges, occur when the Earth, sun, and moon line up (new and full moon or twice during the lunar month).
- Neap tides, the tides having the smallest tidal ranges, occur when the moon is in the first and third quarters.

As the water level rises and falls, it generates a *tidal current* that flows horizontally. Tidal currents caused by the dropping water level (as the tide "goes out") are called *ebb* currents. The rising tide generates *flood* currents. Tidal currents affect how sediments are transported along the Gulf shore and the near-shore environments in the bays. This is especially true for shores where the *tidal range*, the difference in elevation between high tide and low tide, is large. The tidal range in Texas is just a few feet, but this is enough to affect the shoreline environment.

In detail, tides are very complex and the tide height depends on many factors (such as winds, barometric pressure, rotation of the Earth, and the shape of the ocean basin). Texas’ tides are usually a few feet or less, but some places outside of Texas have enormous tides. The Bay of Fundy in eastern Canada, for example, has a tidal range of up to 16 m; that’s almost 53 feet!

The everyday movement of tidal currents is an important factor in transporting sediments along a beach or through tidal channels. But there are also instances when the height of the tides can enhance the impact of storms or the opposite can be true. During a major storm, like a tropical storm or hurricane, waves will be significantly bigger. There is also the threat from the *storm surge*, which is simply water that is pushed toward the shore by the force of the winds swirling around the storm. Now imagine the difference in impact between this storm surge arriving during a spring high tide or neap low tide.

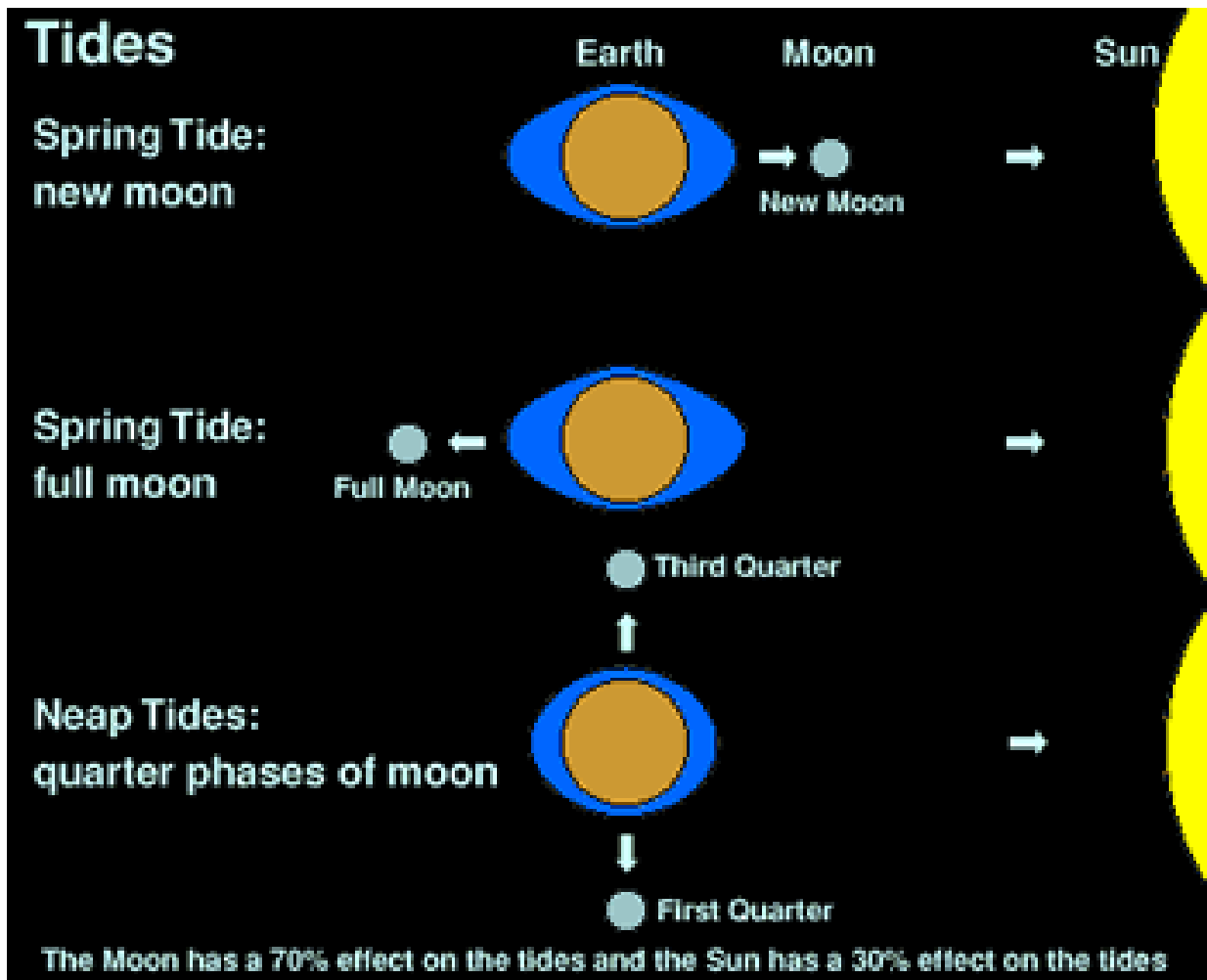


Figure 3. Earth, moon, and sun alignment during Spring and Neap tides.