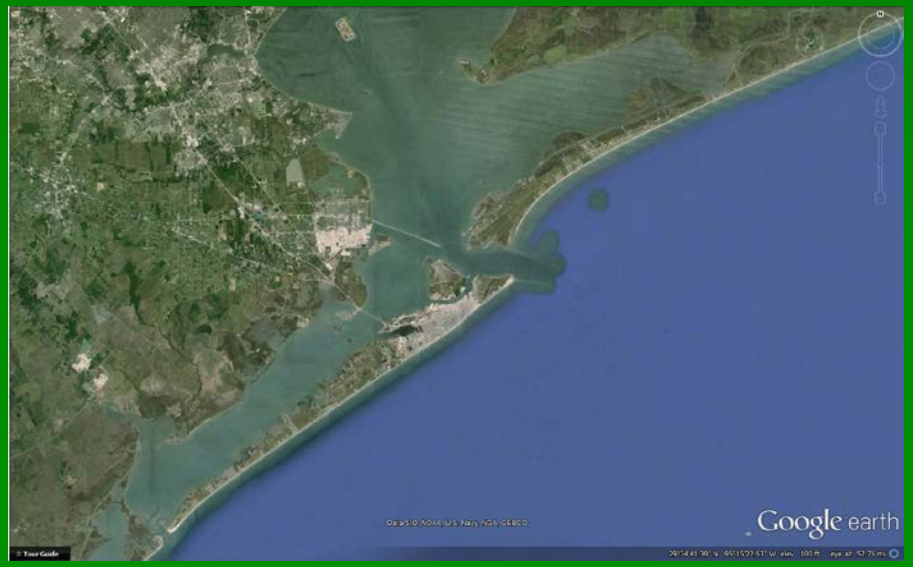
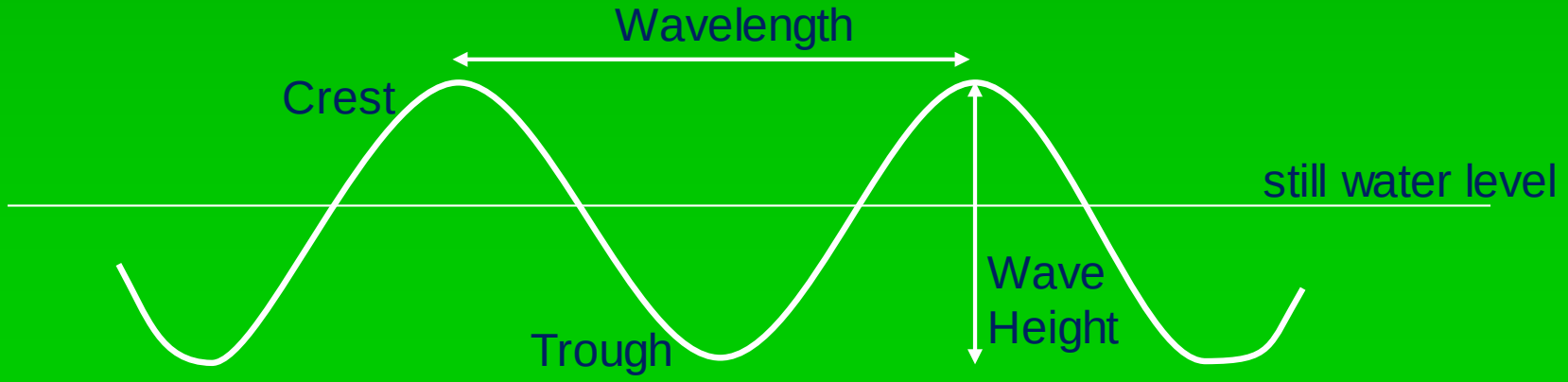
Coastal Processes and Barrier Islands

Presentation provided by:
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin



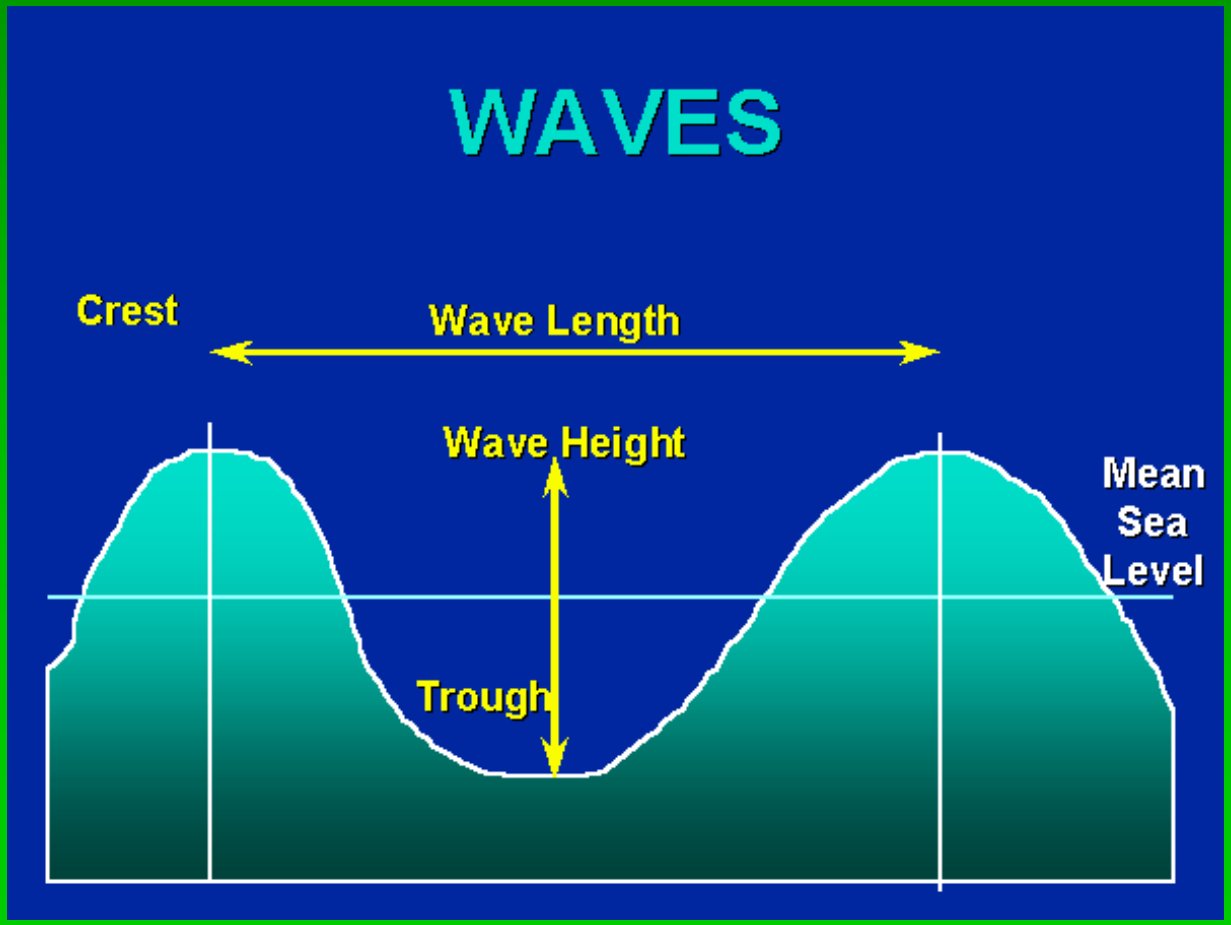
Shoreline Processes: Waves

- Waves are a repeated movement in a body of water seen as an alternate rise and fall of the surface.
- Wavelength – distance between successive wave crests or other equivalent points
- Wave Height – vertical distance between a wave's crest and trough



Shoreline Processes: Waves

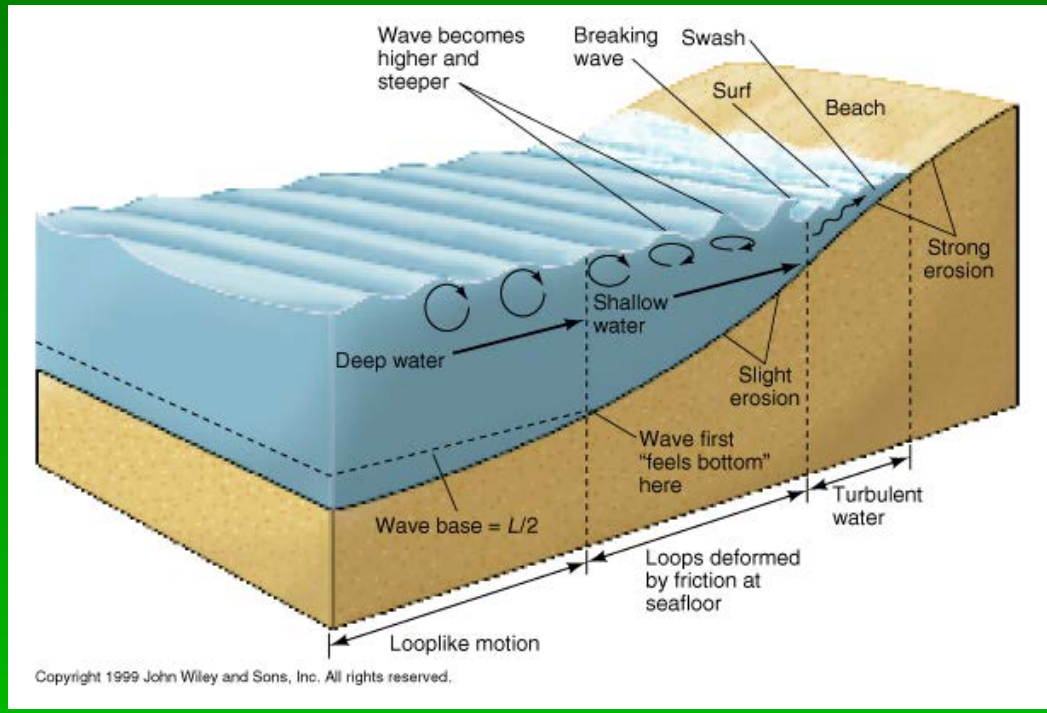
- Wave size determined by
  - Wind strength
  - Wind duration
  - Fetch (length of water surface exposed to wind)

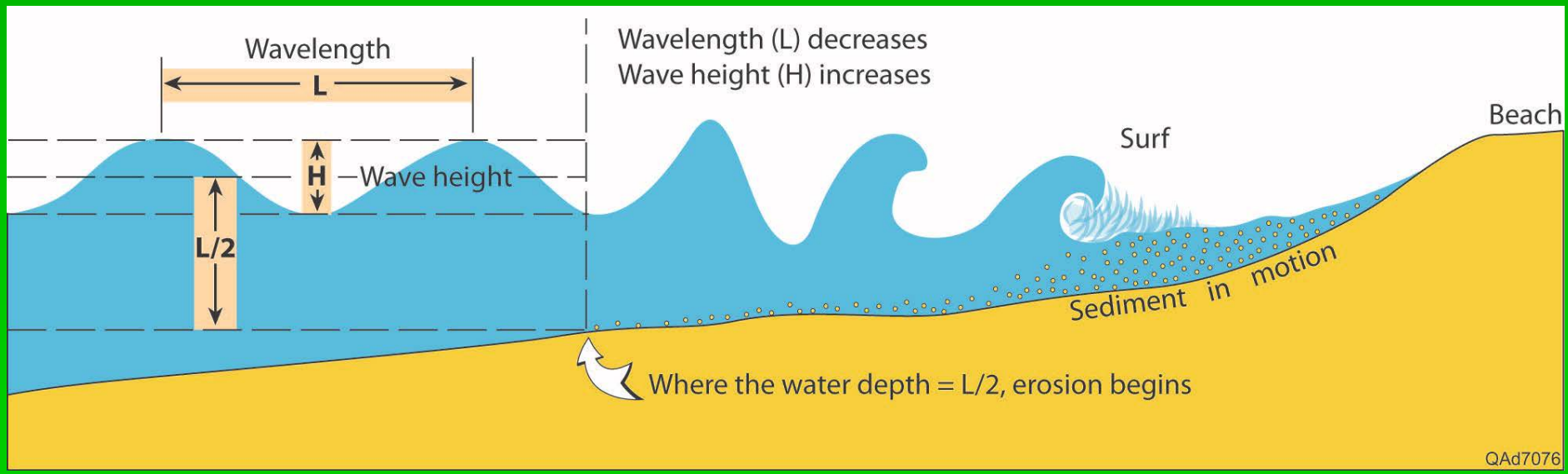


Shoreline Processes: Waves

- Waves slow down as they approach shore
- Waves closer together (wavelength decreases)
- Wave height increases
- Wave breaks

In water depths greater then half the wavelength, sediments on the seafloor are not disturbed.





Breaker Types

- 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 wave breaks
- Surging Breaker - steep beach slope, low wave of long period, doesn't actually break-wave rolls onto beach

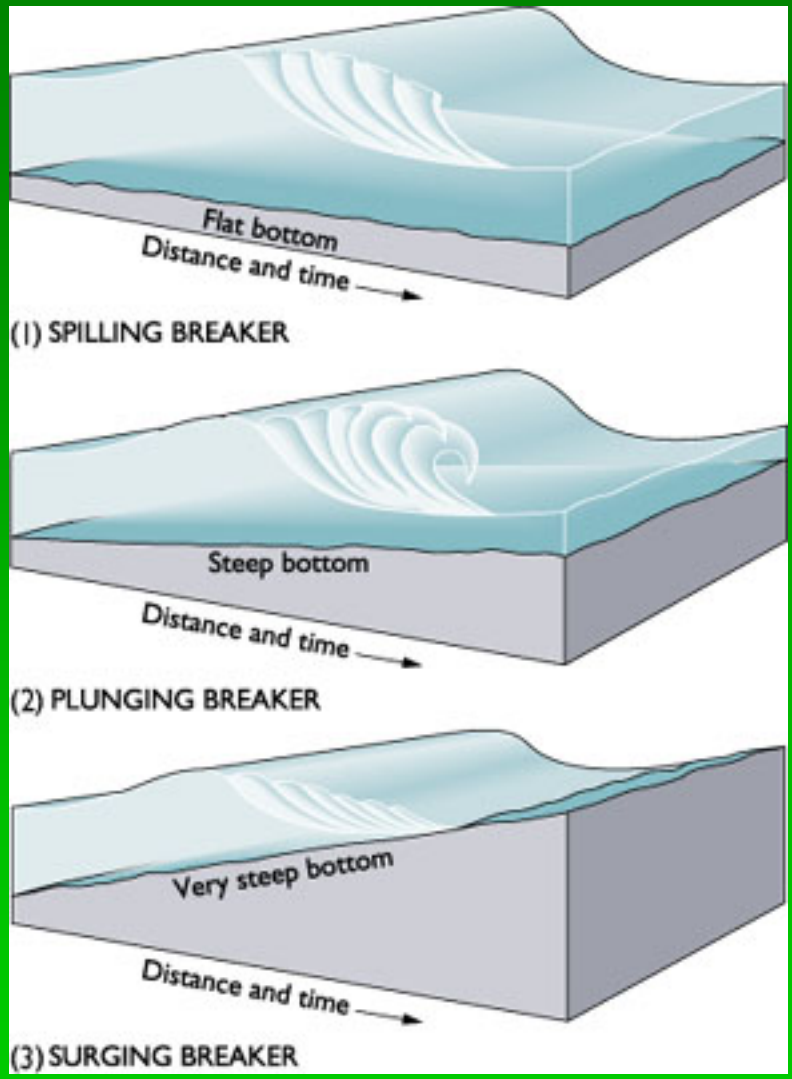
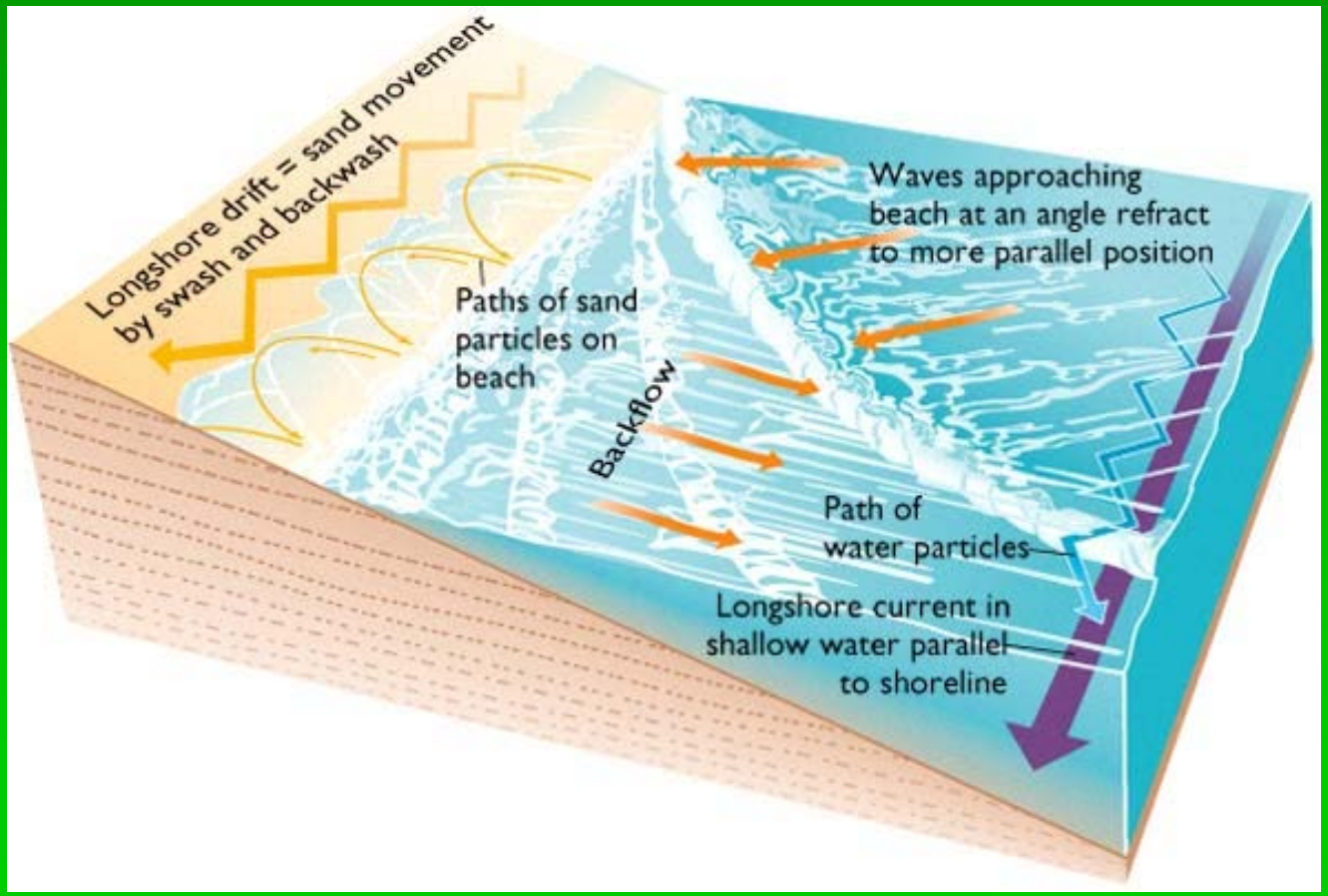


Image credit: Oceanlink
http://science.jbpub.com/oceanlink/c07f09.cfm?chapter=0

Shoreline Processes: Currents

- Longshore Current: A current that forms parallel to a beach as waves arrive at an angle to the shore; generated in the surf zone by wave action.
- Longshore Drift: Sediment that is transported by waves and currents along the shore.



Shoreline Processes: Currents

Longshore currents can move sediment from where it is introduced into the coastal ocean, usually by a stream, to beaches many miles away. Any interference in the longshore current can lead to exaggerated deposition of sediment in one area, and erosion in the down current direction.

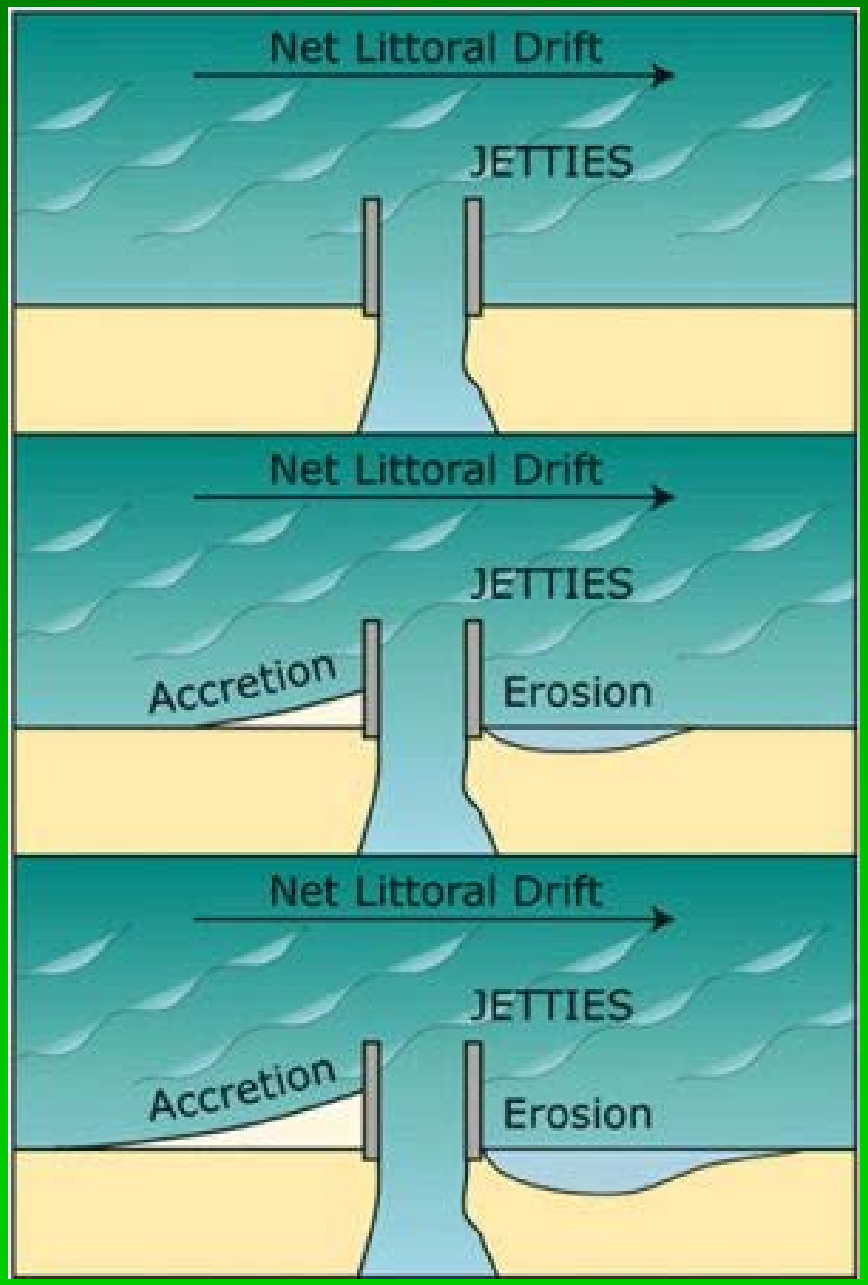
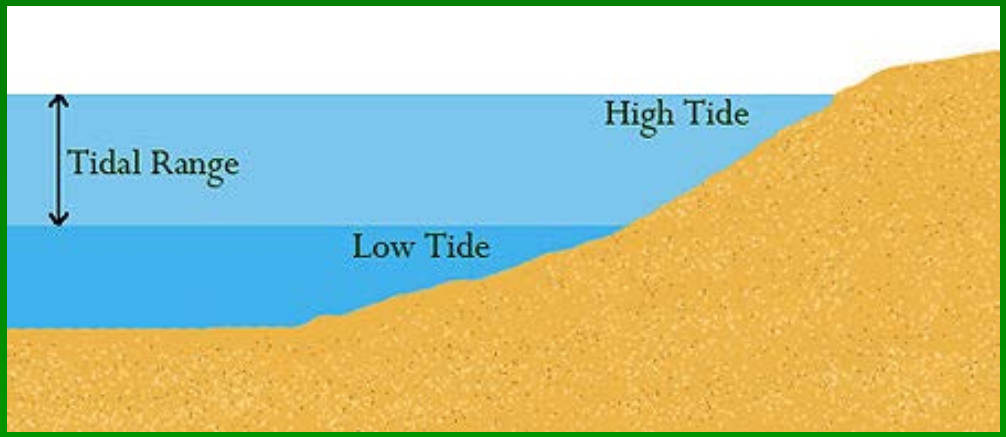


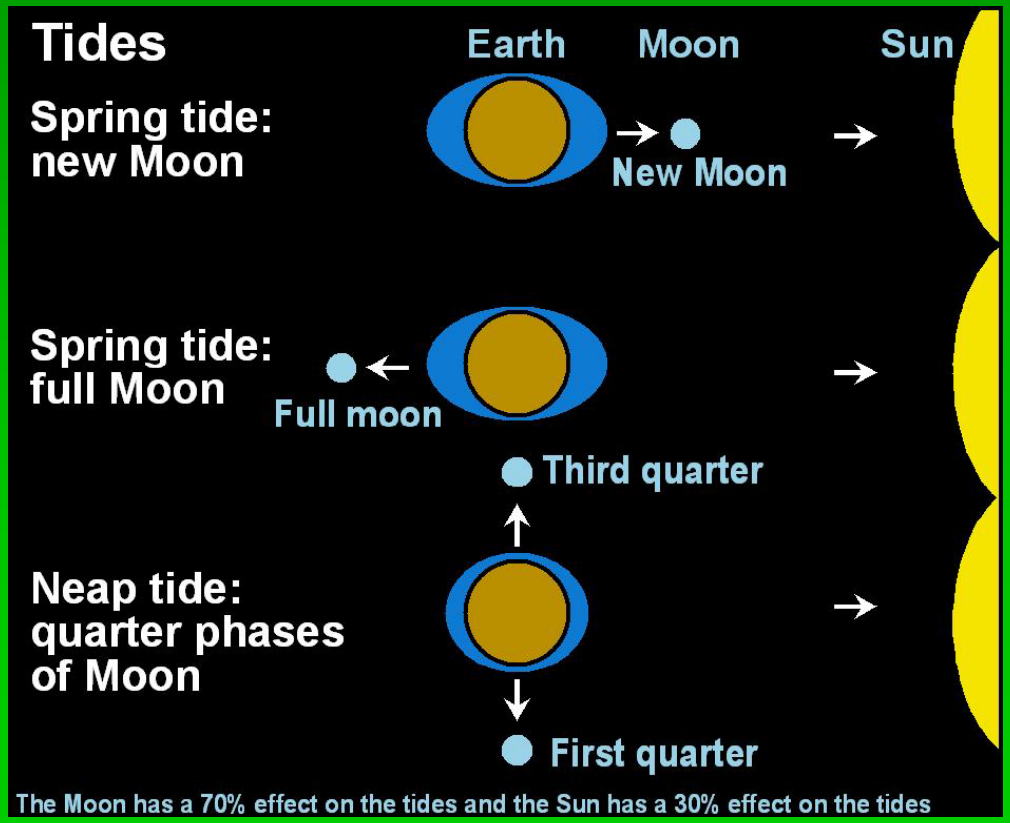
Image credit: Washington State Department of Ecology, 2004; modifications by U.S. Geological Survey.

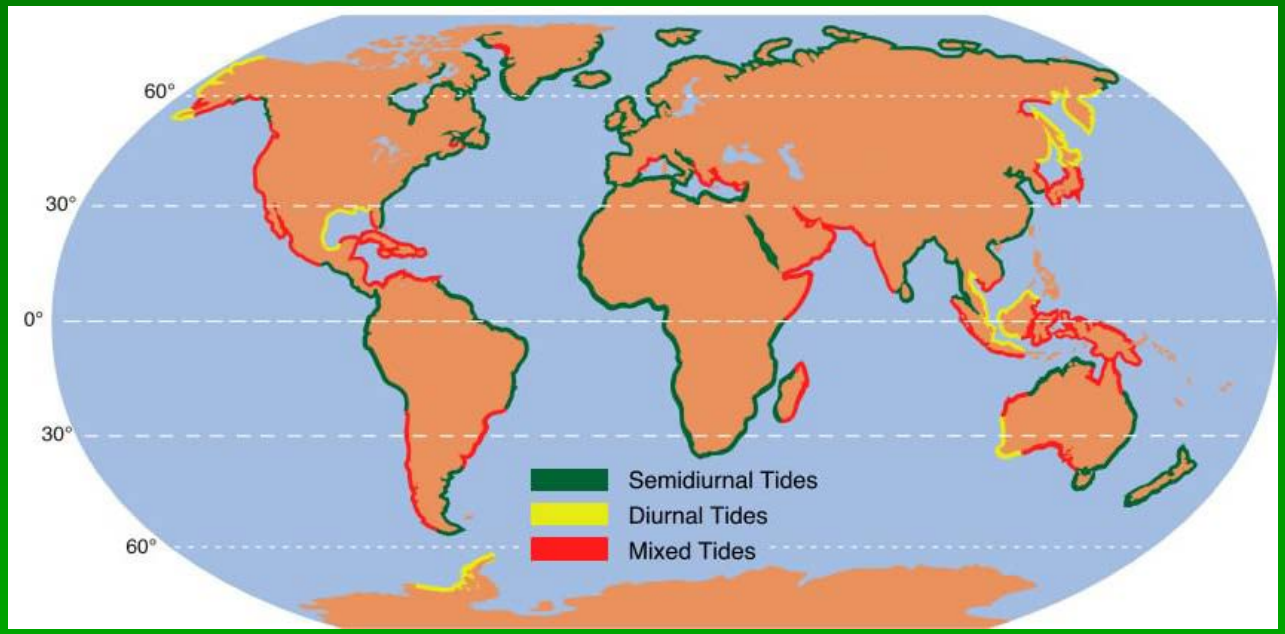
Tides

- They are the rhythmic, rise and fall of the surface of the ocean resulting from the gravitational forces of the moon and sun (a type of wave).
- Tides are caused by a relationship between the mass of the moon or sun as well as their distance from Earth.
- The moon orbits the Earth once every 27 days and 8 hours.
- The moon orbits the Earth in the same direction as the Earth rotates on its axis, takes the moon about 24 hours and 50 minutes to return to the same point in the sky. The tides move up 50 minutes every day.

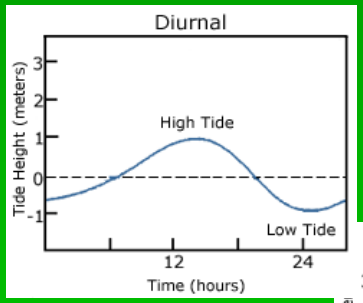
- **Tidal range:** vertical distance between high and low tides.
- **Spring tides** occur twice a lunar cycle (new and full moon) when the gravitational force of the sun combines with the moon creating larger than normal tidal range.
- **Neap tides** occur when at first and third quarters of the moon when the gravitational force of the sun opposes the moon creating a reduced tidal range.

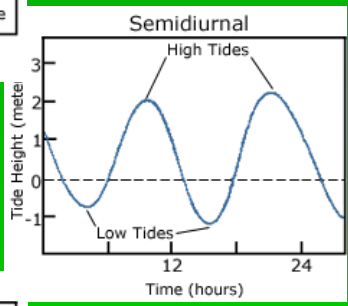


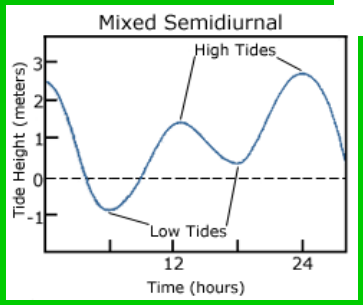




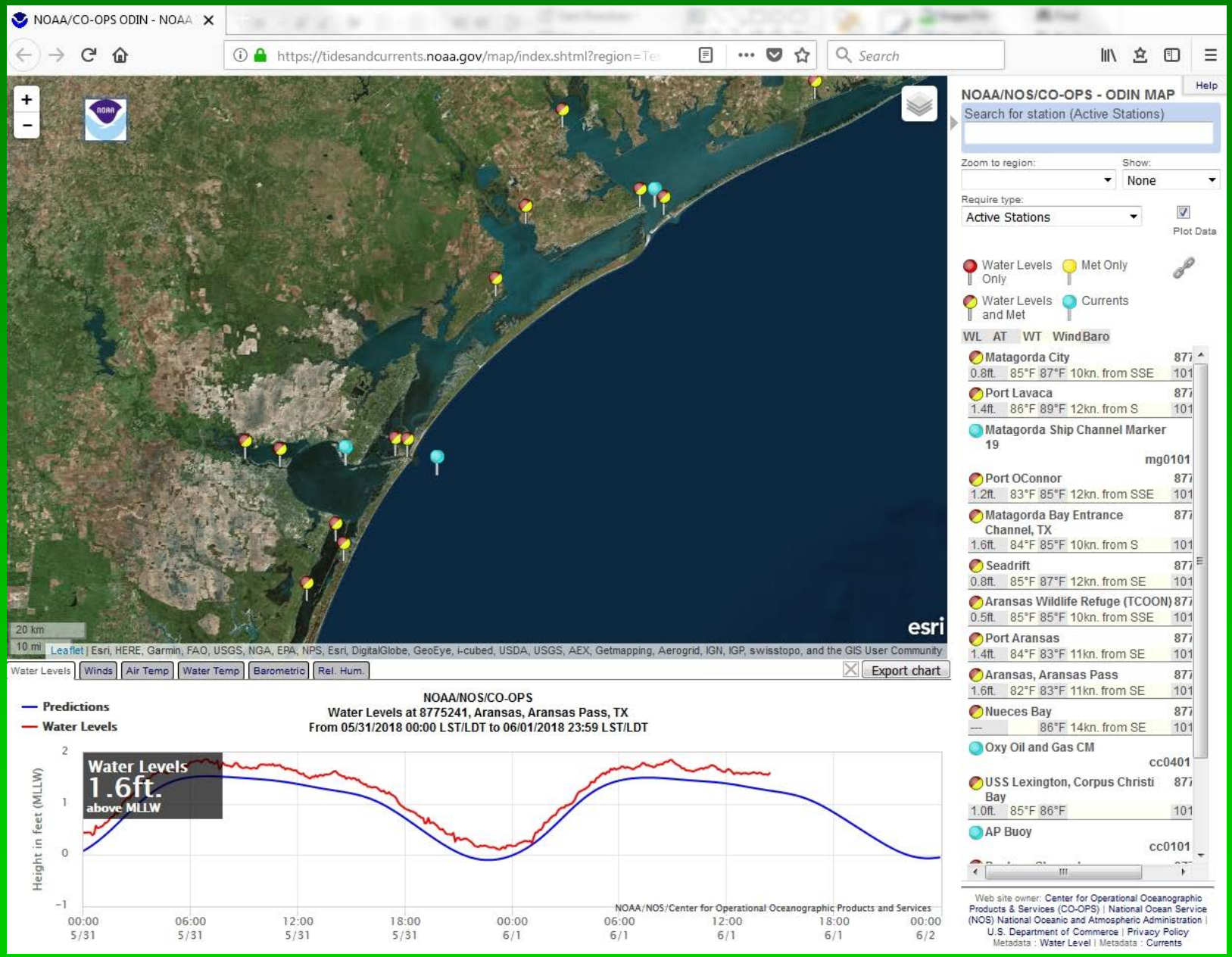
- Diurnal tide cycle: experiences one high and one low tide every lunar day
- Semidiurnal tide cycle: experiences two high and two low tides of approximately equal size every lunar day.
- Mixed Semidiurnal tide cycle: experiences two high and two low tides of different size every lunar day.







https://tidesandcurrents.noaa.gov/map/index.shtml?region=Texas

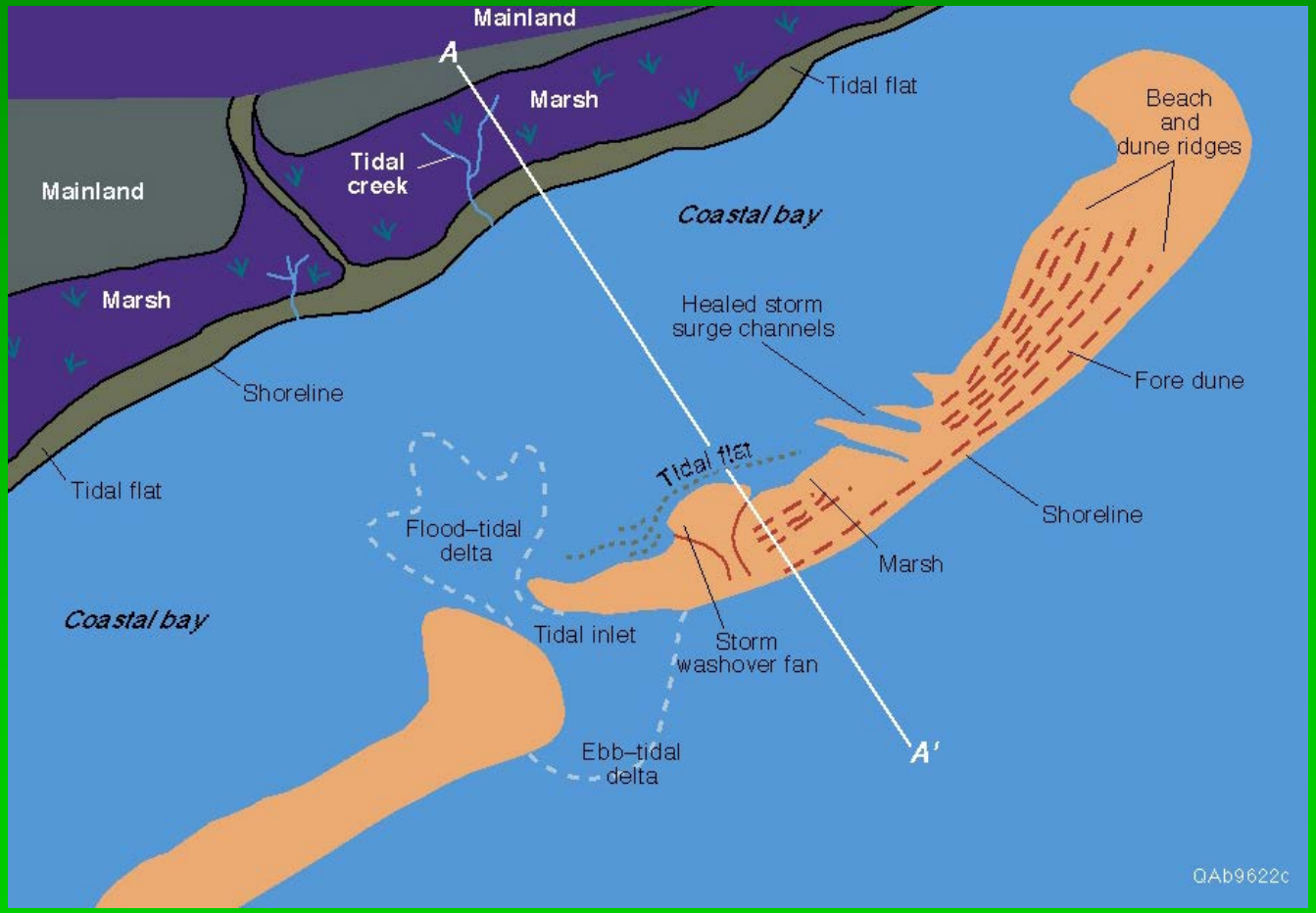


Ocean Currents

- http://oceanservice.noaa.gov/facts/current.html

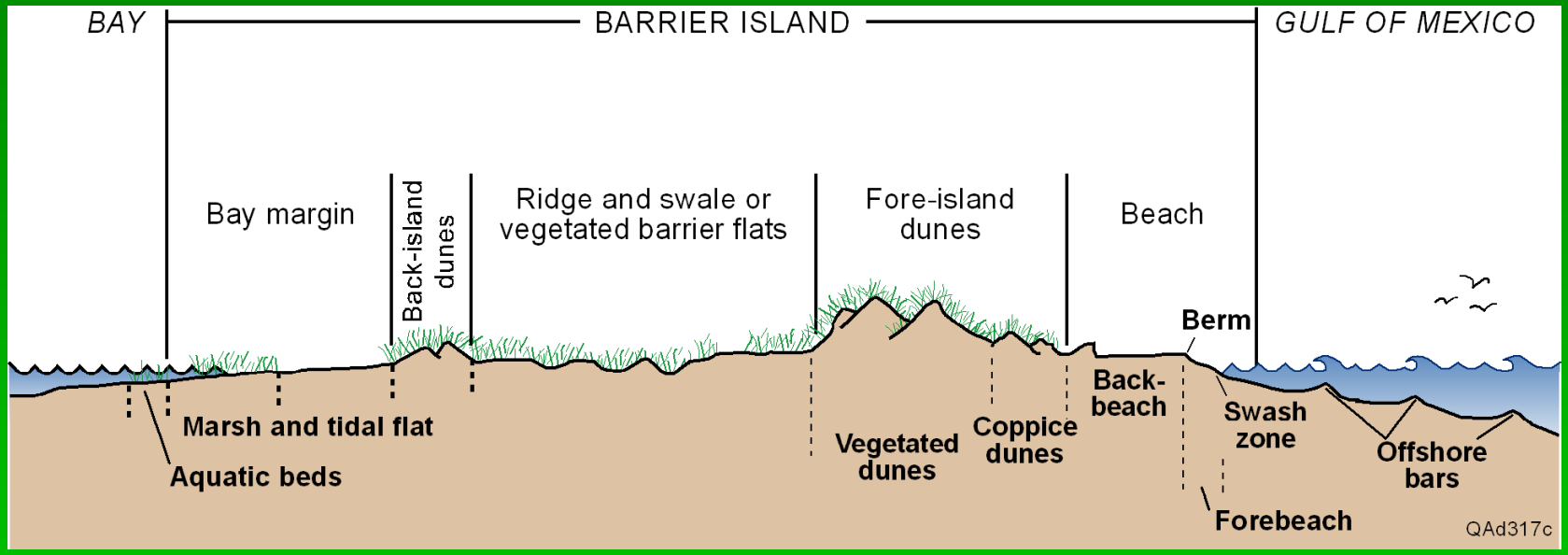
Shoreline Features: Barrier Islands

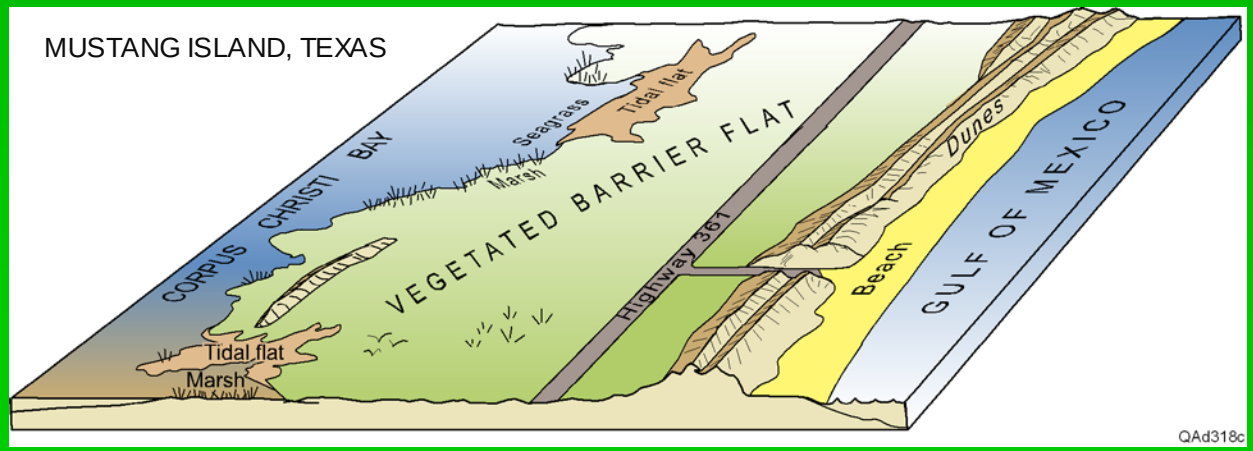
- Barrier islands are long narrow islands parallel to the coast that are built up by the deposition of sand. There is usually an estuary or lagoon between the barrier island and the mainland.



Anatomy of a Barrier Island

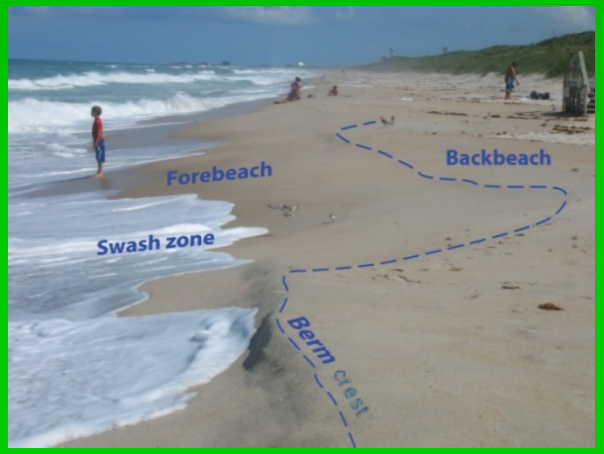
- primary components
  - beach, dune, barrier flat, bay margin

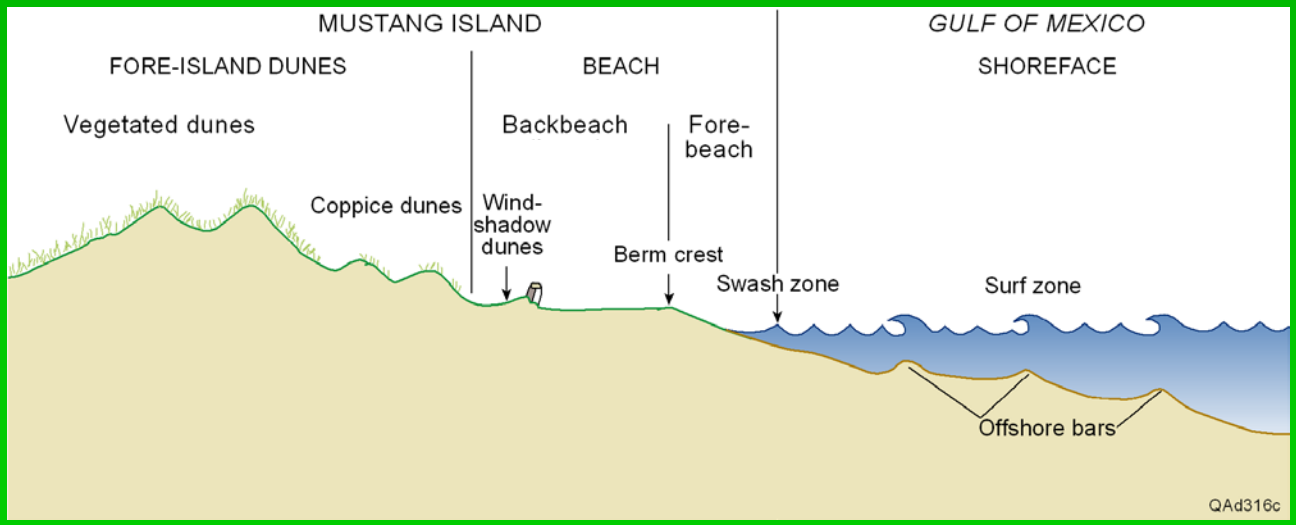




Beaches

- Beach lies between submerged upper shoreface (breaker & surf zone) and fore-island dunes
- Deposit of sediment where the ocean meets the land – unvegetated.
- Beach can be divided into 2 zones
  - Forebeach - slopes seaward & is subjected to daily swash of waves (swash zone)
  - Backbeach - horizontal or gently landward sloping and only flooded during unusually high water levels
- Berm crest- most seaward component of backbeach, separates backbeach from forebeach, formed by sediments deposited at high tide





Dunes

- Dunes piles of sand deposited by the wind that (fore-island dunes) are located landward of backbeach and seaward of barrier flat
- Consist of wind-blown sand
  - active dunes can be free of vegetation, sand is easily redistributed by the wind.
  - stabilized dunes have abundant vegetation
- Coppice dunes are small mounds of sand formed by the accumulation of windblown sand just seaward of the fore-island dunes.

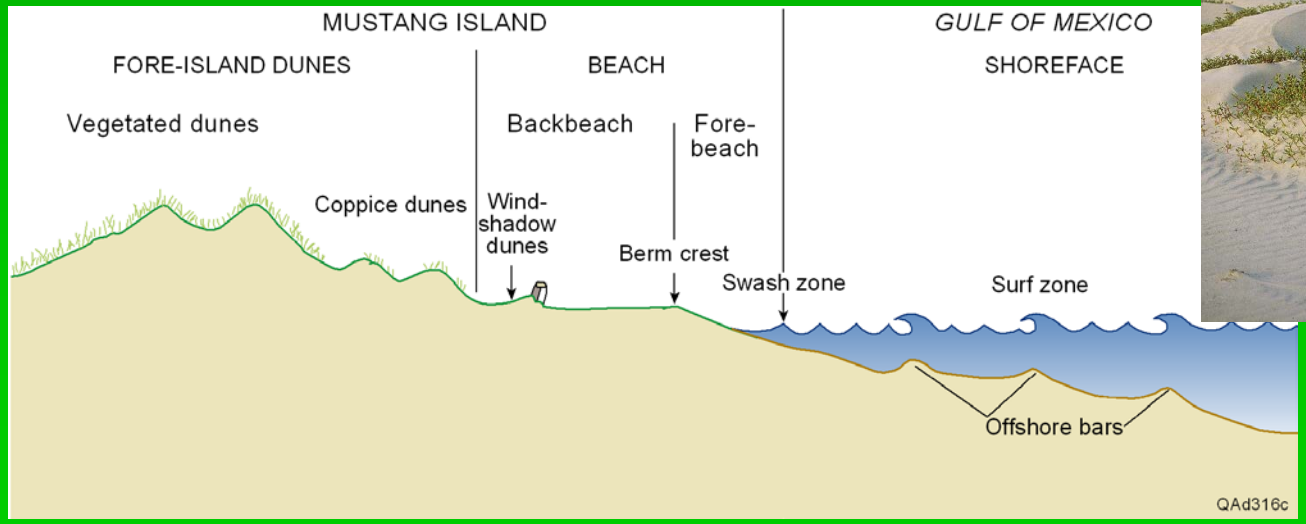
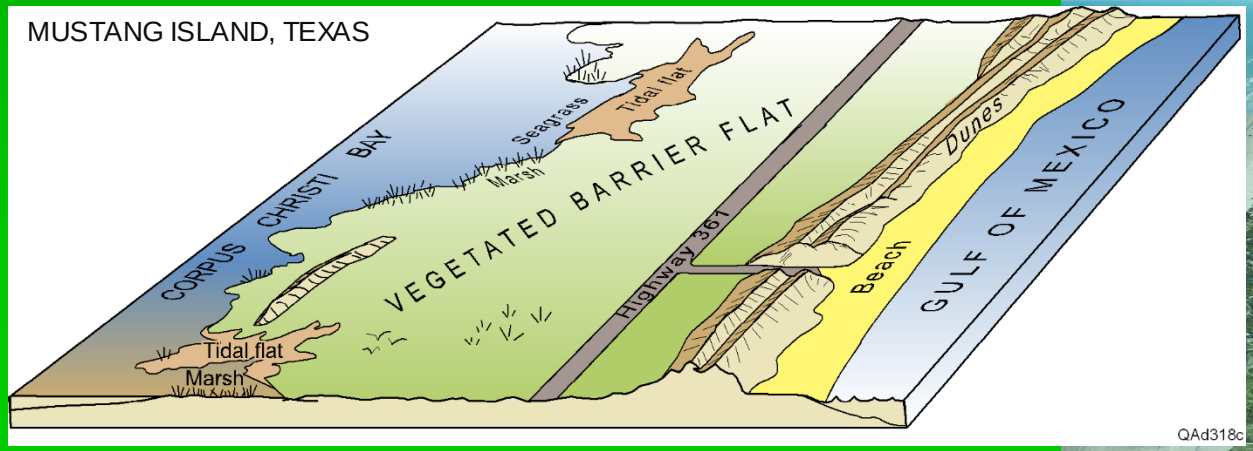


Photo credit: Tiffany Caudle

Barrier Flats

- Barrier flats
  - gently sloping areas of lower elevation than the dunes
  - located landward of dunes and seaward of lagoon or estuary
- Sediment deposition by
  - wind-blown sediment from dunes
  - sediment washed across the island during major storms in a storm surge (storm-derived bulge of water)
- Stable barrier flats commonly are vegetated



Bay Margin

- Bay margin is a low relief area where land gently merges with shallow waters of a bay that is influenced by tidal waters.
- Environments: salt marshes and tidal flats.

Photo credit: Tiffany Caudle

Salt Marsh

- Salt Marsh is a saturated, poorly drained area, intermittently or permanently flooded with saltwater having aquatic and grass-like vegetation.
- Texas salt marsh plants: Cordgrass (salt-marsh, salt-meadow, and gulf), saltwort, glasswort, sea purslane, mangroves
  - Plants specifically adapted to survive in an environment that has salt water and very little oxygen in the soil
- Plants are important part of ecosystem of the bay. The plants help stabilize the shore and trap sediments.

Photo credit: William White

Tidal Flat

- Tidal flat – nearly horizontal barren area adjacent to bay that is alternately covered and uncovered by the tide, consisting of unconsolidated sediment.
- Wind tidal flat - wind (rather than tides) cause the flat to be flooded or exposed. Occurs at irregular intervals
- Sometimes covered by layer of algae called Algal Mats

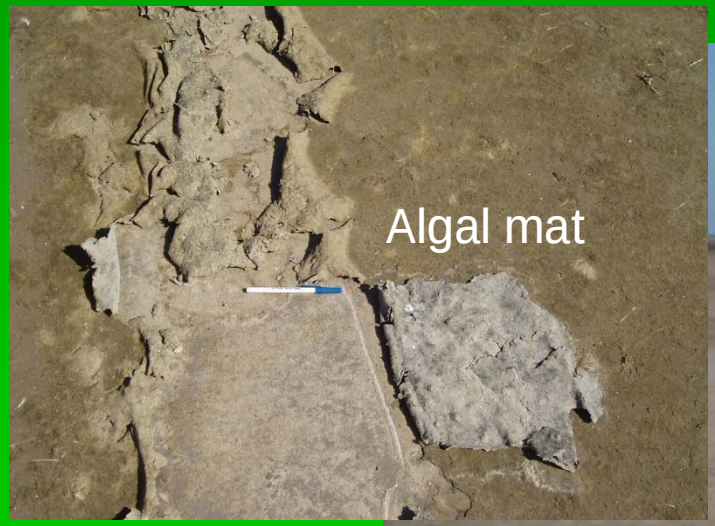
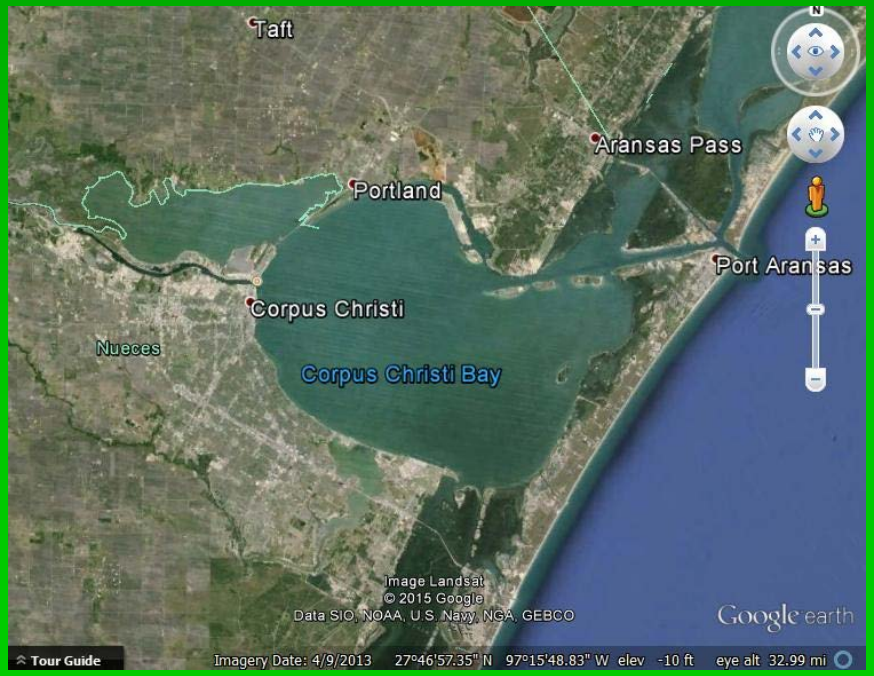


Photo credit: William White

Estuaries

- Estuary - body of water partly enclosed by land, where freshwater from streams and rivers mixes with seawater
  - http://oceanservice.noaa.gov/facts/estuary.html
- Corpus Christi Bay – large Texas estuary fed by freshwater from Nueces River. Mustang Island is barrier between the bay and the Gulf of Mexico. Marine waters enter the bay through Aransas Pass and Packery Channel.



Importance of Estuaries

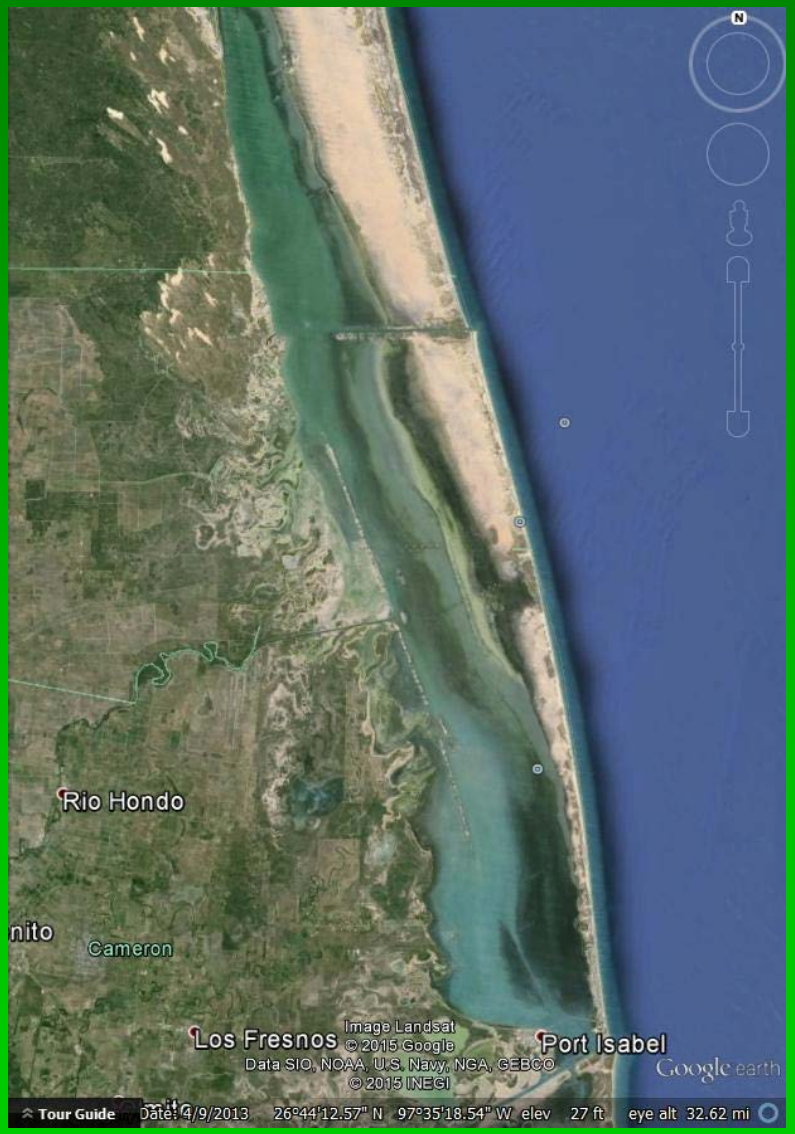
- Humans rely on estuaries for food, recreation, jobs, and coastal protection. Of the 32 largest cities in the world, 22 are located on estuaries!
- Estuaries serve as sponges. As water flows from the land to the ocean, the water is filtered by the vegetation, and silt is trapped. Estuaries can also filter small amounts of pollution out of the water before it reaches the ocean.
- Estuaries serve as important natural buffers, protecting upland areas from erosion and natural storm surge.

Importance of Estuaries

- Estuaries provide a safe haven and protective nursery for small fish, shellfish, migrating birds, and coastal shore animals.
  - In the U.S., estuaries are nurseries to over 75% of all fish and shellfish harvested.
- Estuarine environments protect our health and well-being by:
  - improving water quality
  - reducing flooding and erosion
  - supporting commercially important fish and wildlife

Lagoon

- Lagoon – shallow body of water that is separated from the open ocean by a barrier (land, reef, or other obstruction) that prevents wave attack and inhibits tidal circulation.
  - no perennial source of freshwater input (rain only)
  - salinity in lagoon can be high
  - low energy conditions with deposition of finer grained sediments
- Example: Laguna Madre, landward of Padre Island, Texas.



Tidal Inlet

- A tidal inlet (or pass) is a channel that carries water and sediment into or out of a bay as water levels change due to the rise and fall of the tides.

- Flood Tidal Delta
  - A fan-shaped sediment body that accumulates on the landward end of tidal inlets
  - Rising tide, water flows from ocean to bay
- Ebb Tidal Delta
  - A fan-shaped sediment body that accumulates on seaward end of tidal inlets
  - Falling tide, water flows from bay to ocean

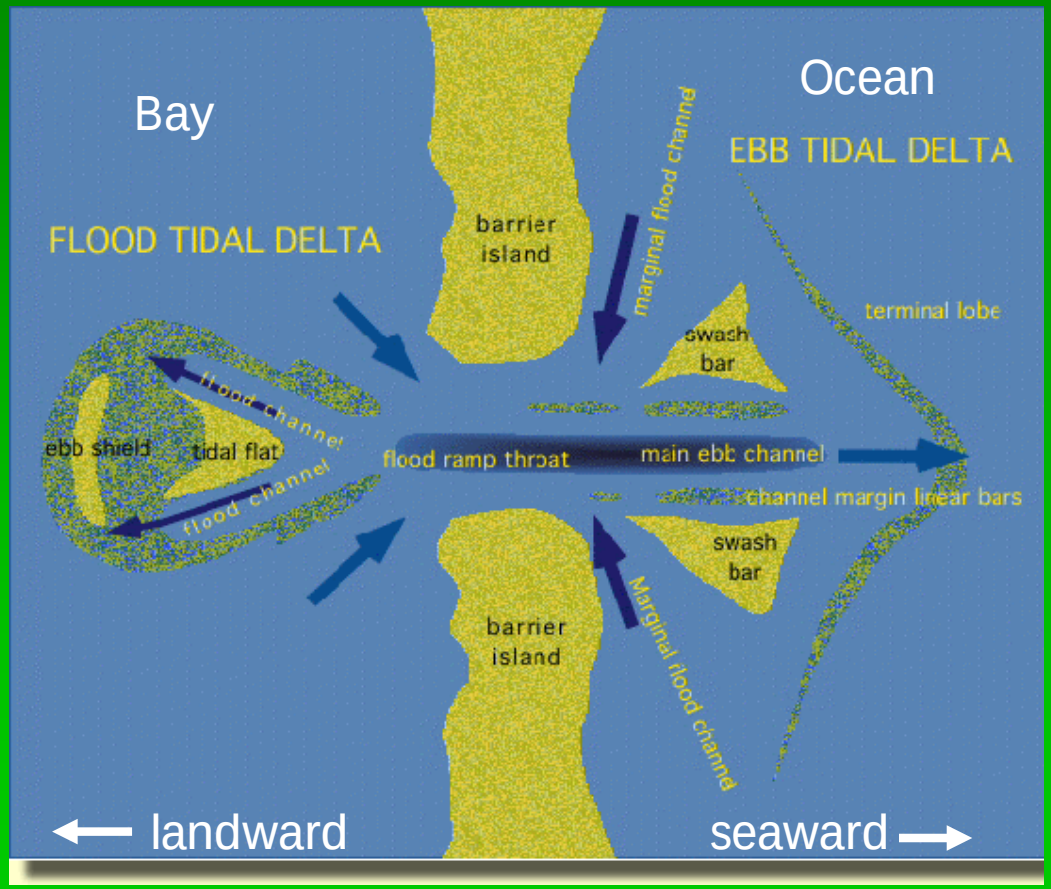


Image credit: Salem State University
http://w3.salemstate.edu/~lhanson/gls214/gls214_inlets.htm

Tidal Inlets

Importance of Barrier Islands

- Protect the mainland from waves and storm surge
- Create estuaries that provide critical habitat for wildlife, including commercially important fish and shellfish (nursery)
- Teach us about sedimentary processes of erosion, transportation, and deposition of sediments

Dynamics of Barrier Islands

Standard Processes - wave action, longshore drift, wind action constantly move sediment around and re-arrange features

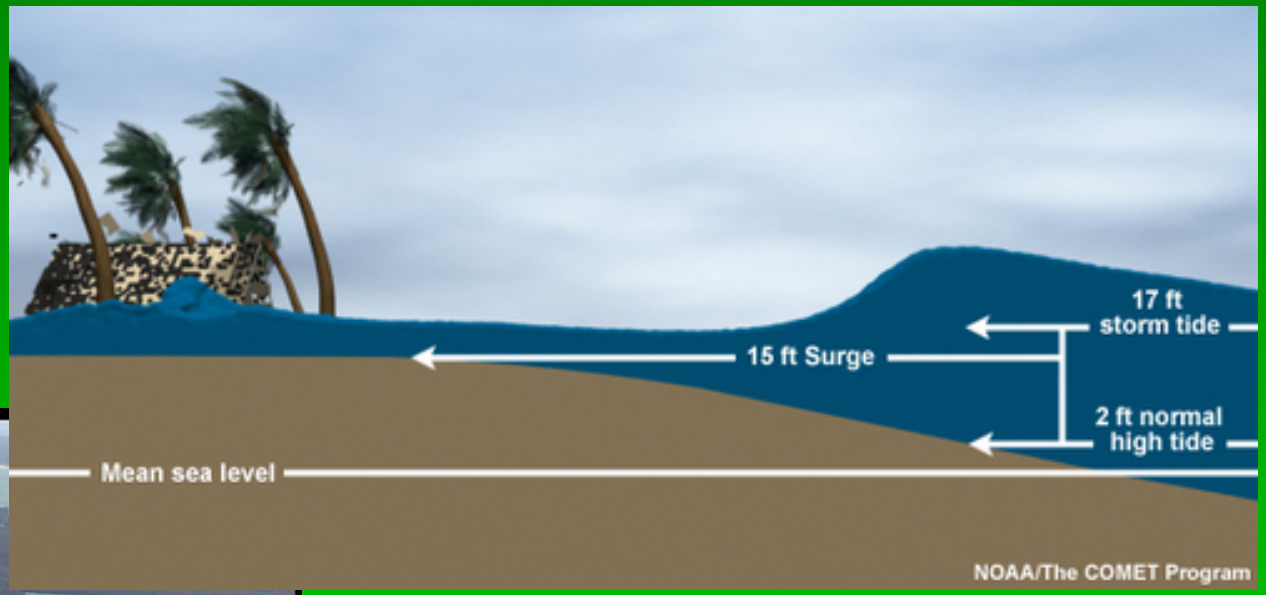
Storm Events - storms and/or hurricanes are abrupt geologic agents that drastically impact barrier islands by destroying some parts of the island, but creating new features through the action of wind and water

Galveston Island State Park

Photo credit: Tiffany Caudle, Bureau of Economic Geology

Storm Impacts on Barrier Islands

Storm surge – abnormal rise in sea level (over and above predicted astronomical tides) pushed toward shore by the winds of a storm.



http://www.nhc.noaa.gov/surge/

Washover Features

Washover channel - storm generated channel that erodes the beach and dunes and connects the ocean directly to the lagoon or estuary. Often this channel is filled by sediment as the storm recedes, but can remain open

Washover fan - fan-shaped layer of sediment deposited landward of the beach and foredune by storm action. Important for the growth and building of barrier islands

Corpus Christi Pass after Hurricane Allen 1980. Photo credit: William White.

Photo credit: USGS.