Oceanography, An Invitation to Marine Science | 9e
Tom Garrison

12

Coasts

Coasts Are Shaped by Marine and Terrestrial Processes

- The location of a coast depends on tectonic activity and the ocean's water volume
- The **shape** of a coast is a product of uplift and subsidence (wearing down of land by erosion) and redistribution by sediment transport and deposition

Shore – Where the ocean meets land

Coast - refers to the larger zone affected by the processes that occur at this boundary.

Changes of Sea Level

Eustatic change (global sea level)- 3 Factors

Amount of water in ocean varies

-Warmer periods, volcanic periods – more ocean, higher seas

Volume of Earth's ocean basins vary

-high rates of seafloor spreading increase sea level

-high rates of sedimentation

Water temperature

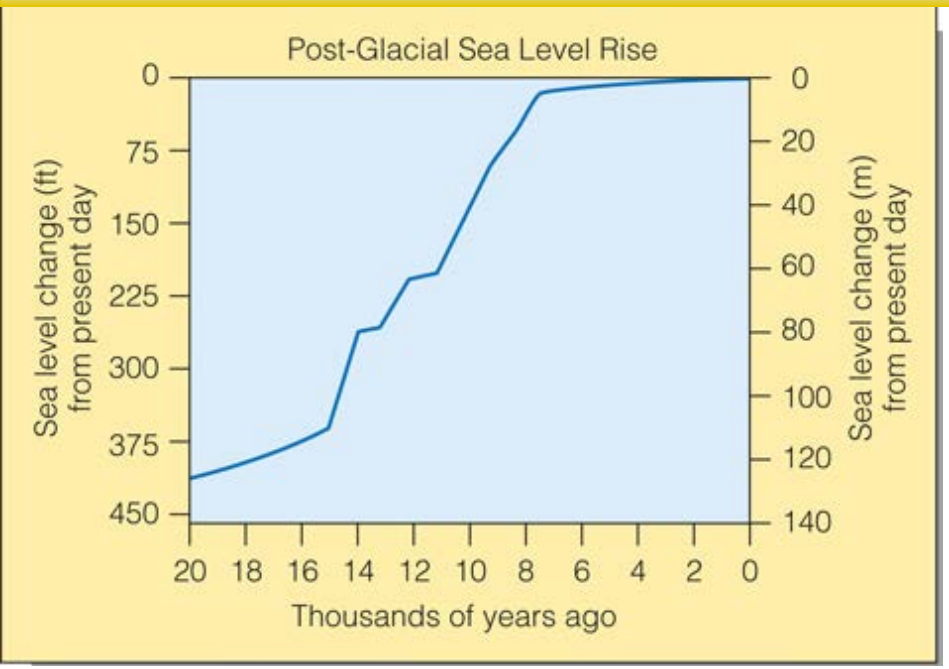
-Water can occupy more or less volume as temp rises or falls

-warm raises sea levels (expansion)

Local change-Tectonic and isostatic factors

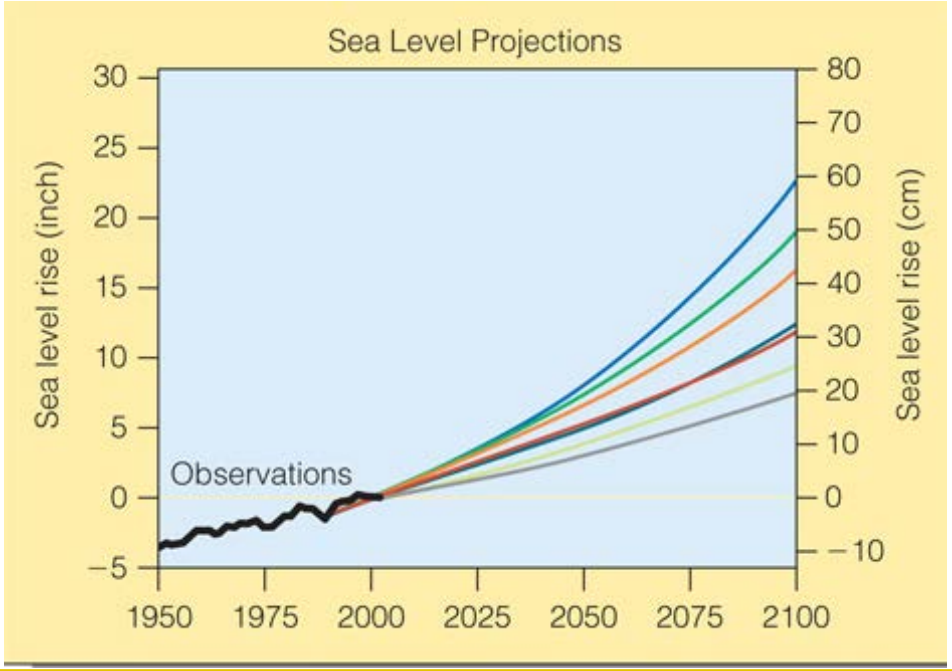
-Wind currents, seiches, storm surges, El Niño or La Niña, or other water in motion

Coasts Are Shaped by Marine and Terrestrial Processes



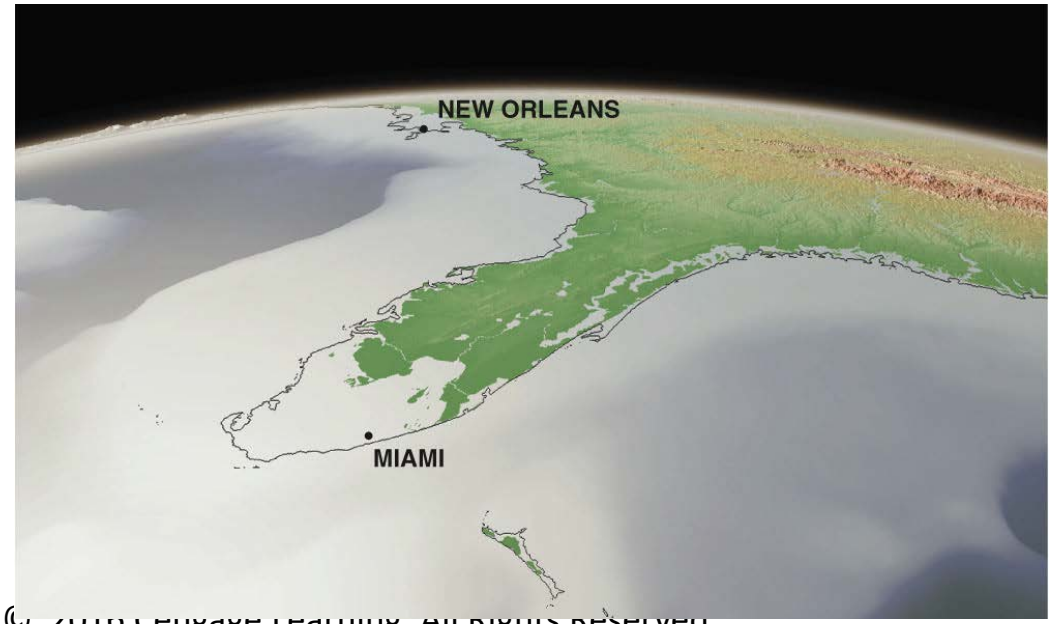
Sea level rose rapidly at the end of the last ice age as glaciers and ice caps melted and water returned to the ocean. The rate of rise has slowed over the past 4,000 years and is now about 3 millimeters per year.

7 research groups (represented here by colored lines) have estimated future sea level based on historical observations and climate models. The most conservative of these predictions estimates a 20-centimeter (8-inch) rise.



Coasts Are Shaped by Marine and Terrestrial Processes

Southeastern coast 18,000 years ago (last ice age). Lower sea level with gently sloping coast 200 km (125 miles) seaward from the present shoreline with much of the continental shelf exposed.



In the distant future, if the ocean were to expand and the polar ice caps were to melt because of climate change, sea level could rise 60 meters (200 feet), driving the coast inland as much as 250 kilometers (160 miles)

Classification of Coasts

Coasts classified as:

Erosional coasts -New Coasts in which the dominant processes are those that remove coastal material.

Depositional coasts-steady or growing because of their rate of sediment accumulation, or the action of living critters (like coral)

Erosional Processes Dominate Some Coasts

- Erosional Coasts

-Both land and marine erosion

-Depends upon rock type

- Sandstones – weather easily-fast
- Crystalline Rocks like granite – slow

High Energy– large waves, big fetches, rapid erosion

Along **eastern edges of continents**: prone to hurricanes West Wind Drift (Southern tips of Africa, S.A.)

Low Energy-Bay protected – Gulf of Mexico

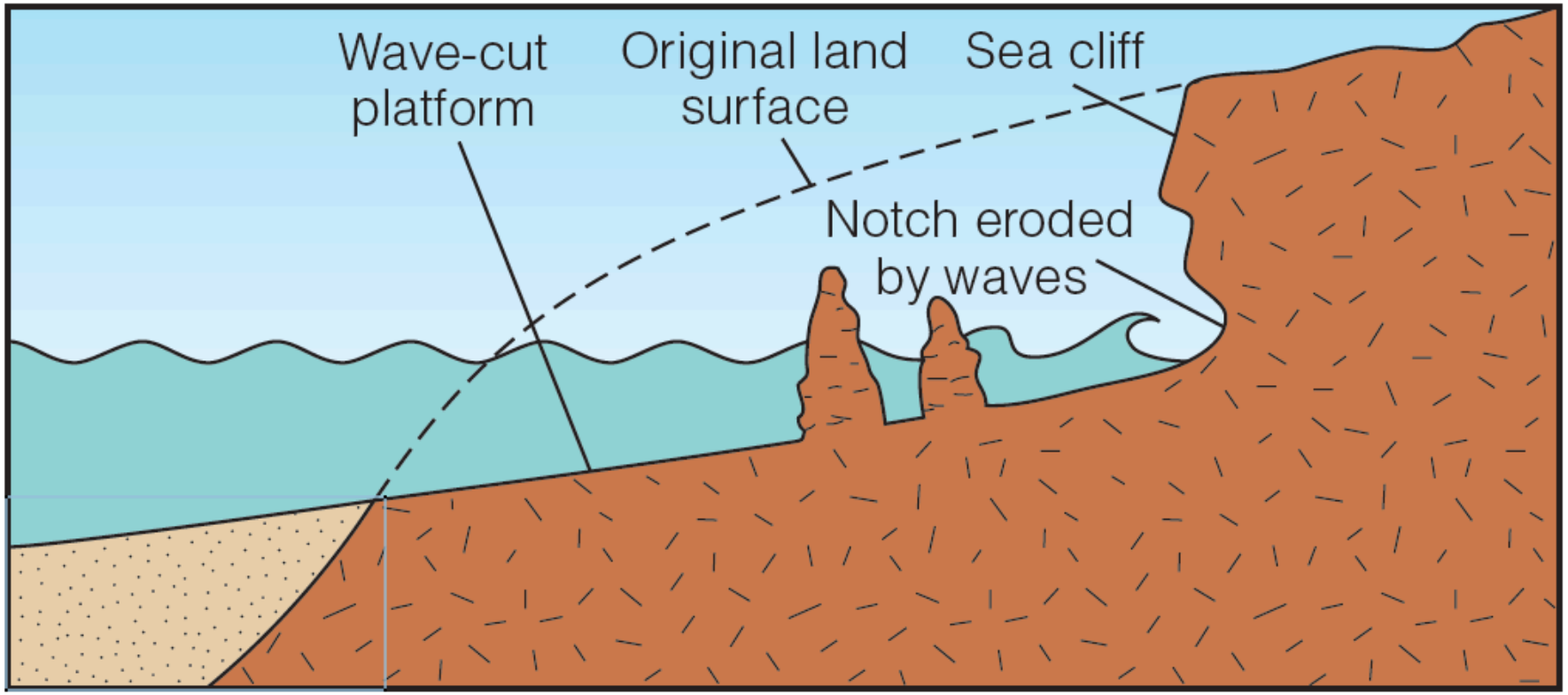
Results of Wave Action On a Coast

Complex features

Sea cliffs **Sea Stacks & Natural arches**

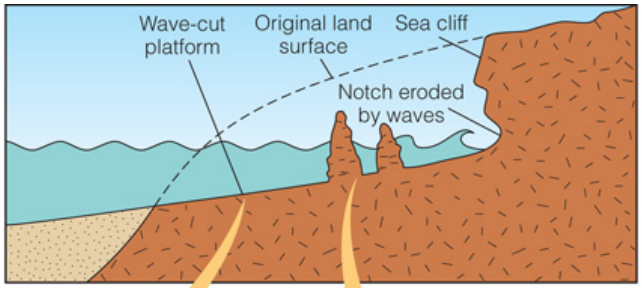
Sea caves-accessible in low tide

Wave-cut platforms (composed of rock)



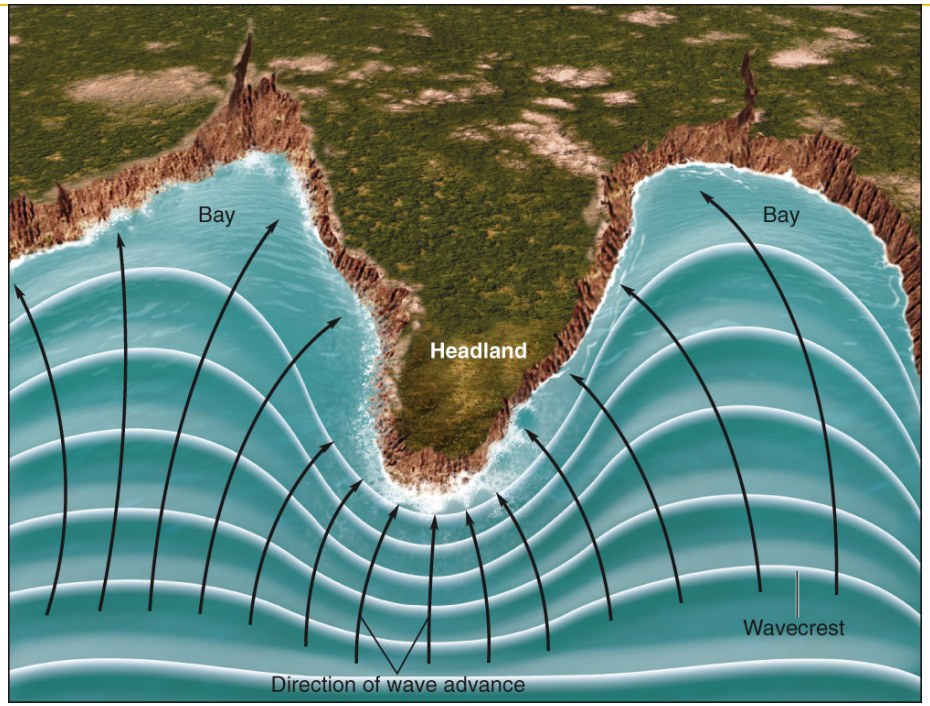
Wave erosion of a sea cliff produces a shelf-like, wave-cut platform visible at low tide. Remnants of the original cliff can protrude as sea stacks.

Erosional Processes Dominate Some Coasts



Cengage Learning; photo left: Tom Garrison; photo right: Radius Images/Corbis

Shorelines Can Be Straightened by Selective Erosion



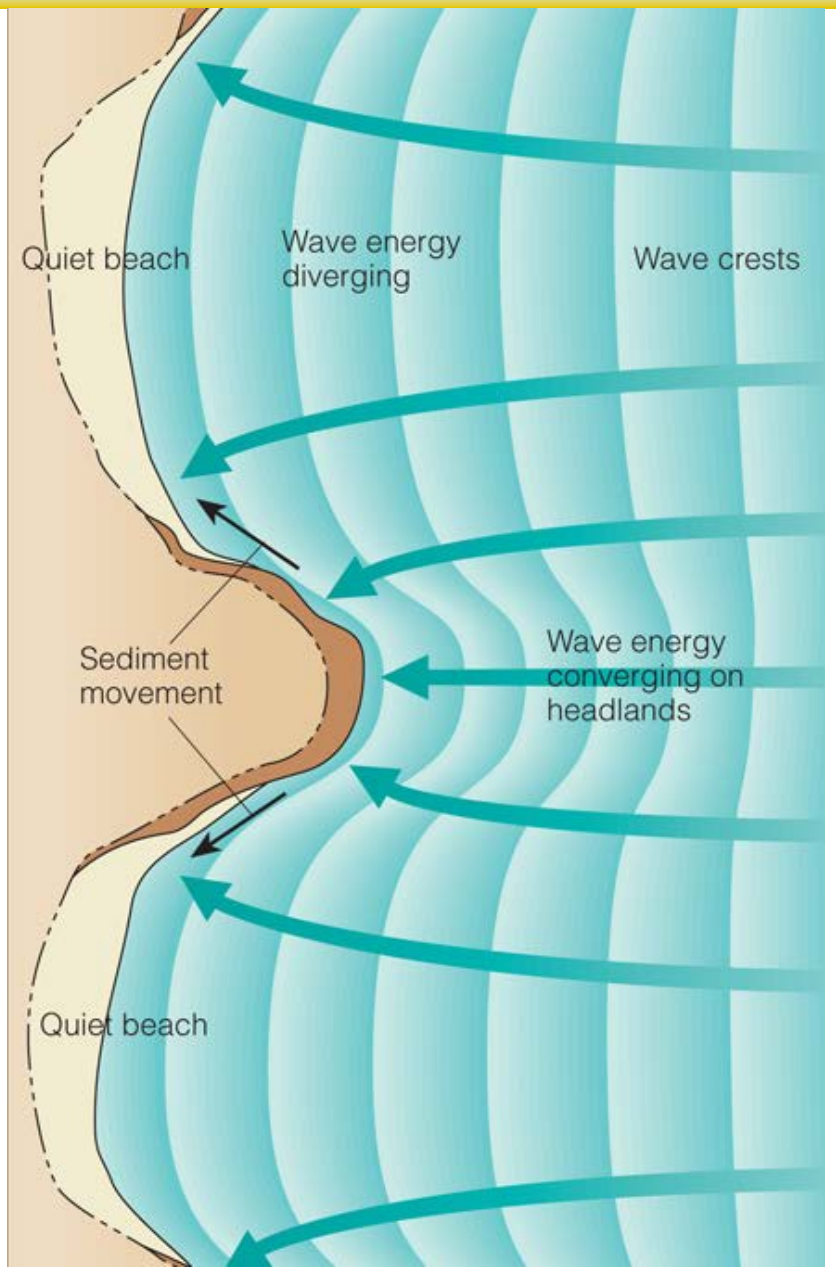
Wave energy converges on headlands and diverges in the adjoining bays. The accumulation of sediment derived from the headland in the tranquil bays eventually smoothens the contours of the shore.

- Marine erosion is usually most rapid on ***high-energy coasts***, areas frequently battered by large waves.
- ***Low-energy coasts*** are only infrequently attacked by large waves.

Wave Energy

Wave energy converges on headlands and diverges in the adjoining bays.

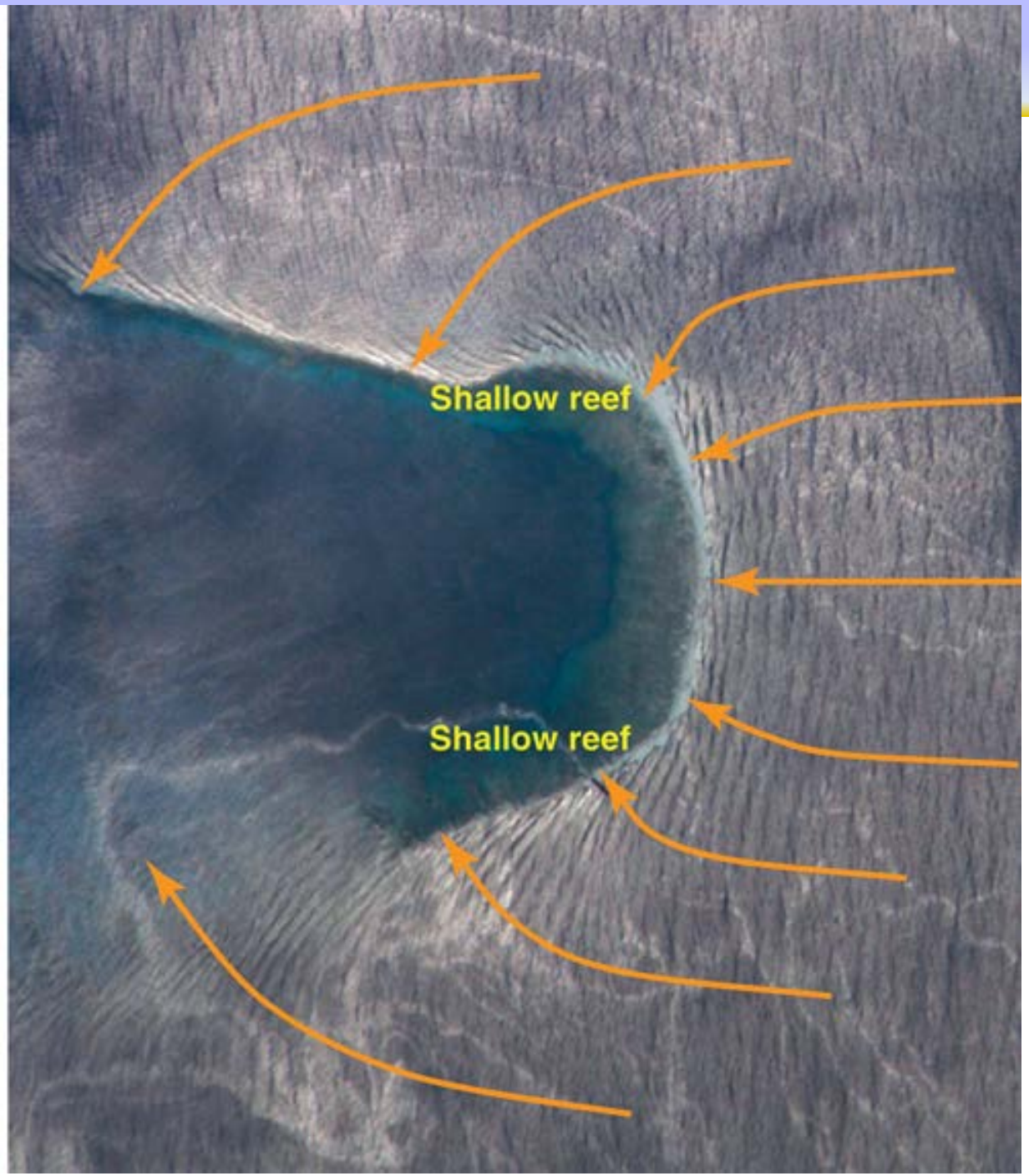
The concentrated forces shape the headland into platforms and stacks. The accumulation of sediment from the headland in the tranquil bays eventually forms beaches and straightens the contours of the shore.



Wave Energy

Waves approaching a shallow Caribbean reef refract around it.

Energy is clearly concentrated on the headland.



Land Erosion and Sea-Level Change

First Effect of Marine Erosion → intensity irregularity

-Then coast is smoothed through time

Drowned River Mouths – Rivers erode coast during glacial times, later during higher sea level, coast is flooded

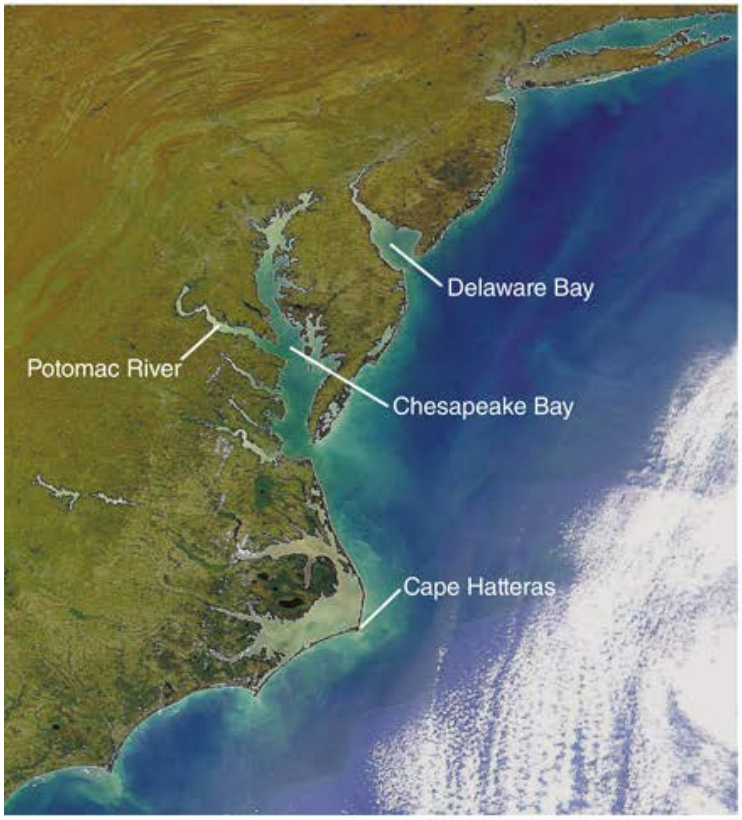
Glaciers do the eroding – Fjord or fiords

Volcanic Coasts –Pillow lava's

Faulted Coasts – uplifted during earthquake

Land Erosion and Sea-Level Change

Drowned river valleys: submerging coasts that filled with water as the last ice age ended.



Volcanism and Tectonism

Lava flowing seaward from an eruption on the island of Hawai'i forms a fresh coast exposed to erosion for the first time.

Two volcanic cones on the southeastern coast of the Hawai'ian island of O'ahu. One of the volcanoes has collapsed, and its crater has filled with seawater.

Depositional Coasts

- Composed of sediments rather than rock
- Can evolve from an erosional coast

Most common form – Beach

Zone of loose particles on the shore

Constant state of change

Composition of Beaches

- Ranges in size, but mostly sand
- Black Sand – Lava (Basalt)
- Cobble beaches (Greece)

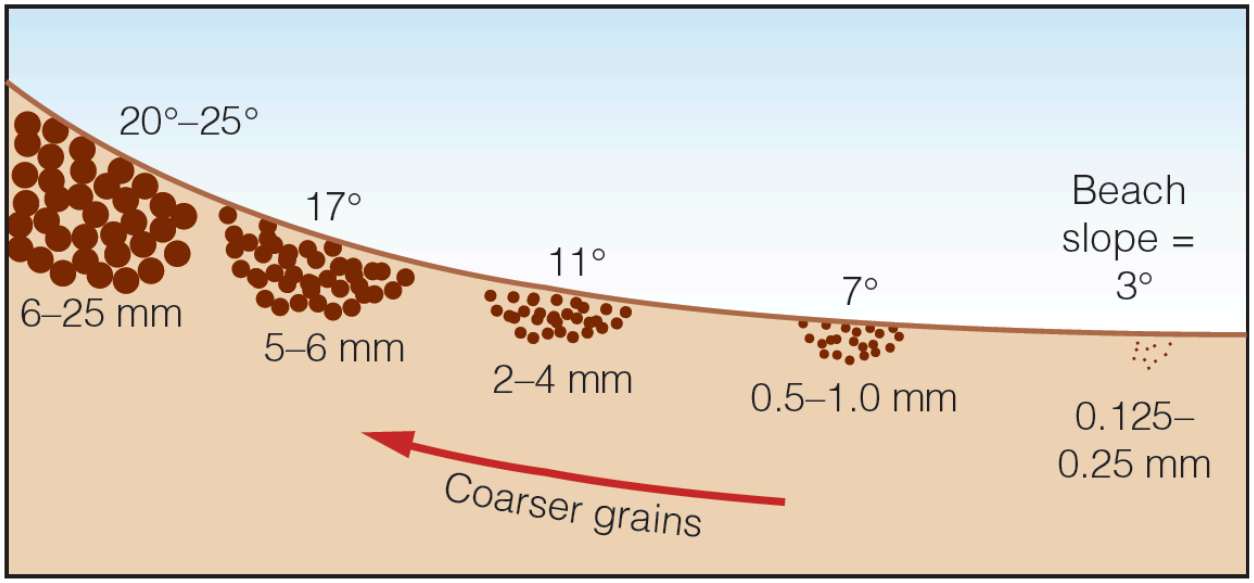
Depositional Coasts

- Beach – loose particles
- Wave action, particle size, and permeability
  - Swash – carries particles onshore
  - Backwash – carries particles offshore

The general relationship between grain size and beach **slope.**

Finer grained beaches – gentle slope

Gravel – steeper



A Typical Beach Profile

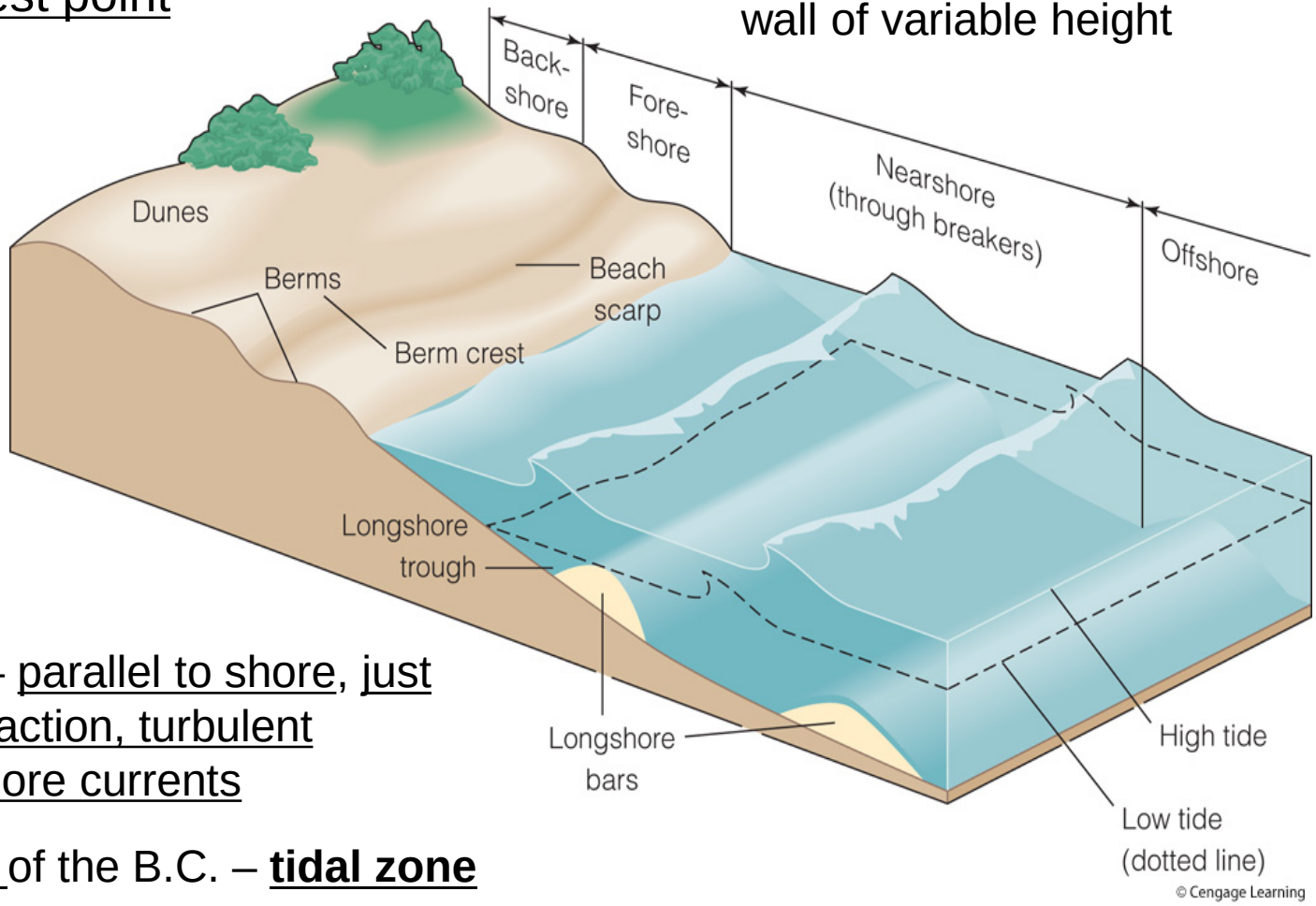
Berm - an accumulation of sediment that runs parallel to shore and marks the normal limit of sand deposition by wave action.

Berm Crest – highest point on the beach

Backshore – inland of B.C., extending to the farthest point where beach sand has been deposited

Sandbars – hidden ridges of sand offshore

Beach Scarp - vertical wall of variable height

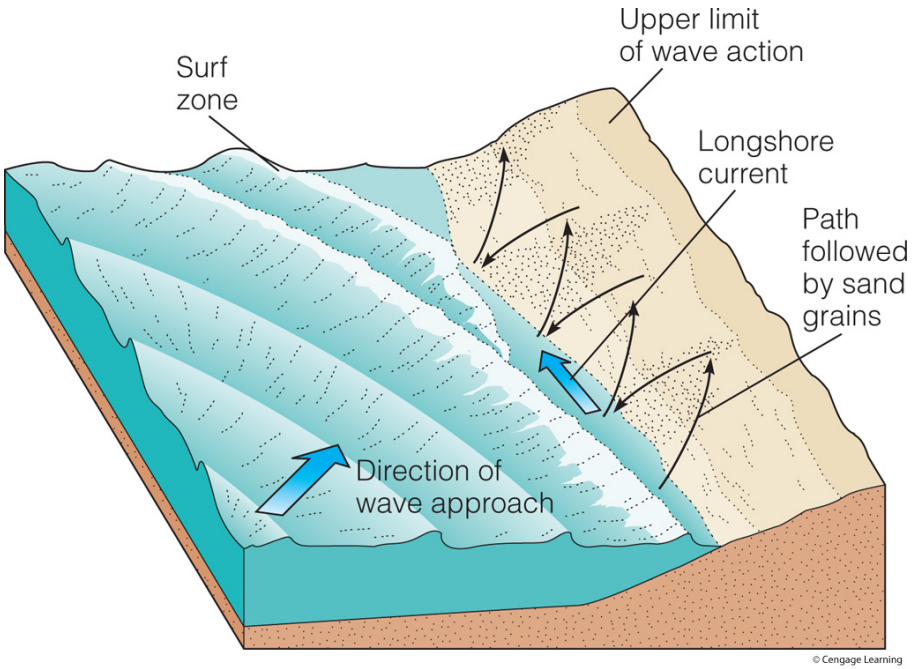


Longshore Trough – parallel to shore, just offshore cut by wave action, turbulent backwash and longshore currents

Foreshore – seaward of the B.C. – **tidal zone**

Waves Transport Beach Sediment

A **longshore current moves sediment along the shoreline** between the surf zone and the upper limit of wave action. It is driven by wave action.

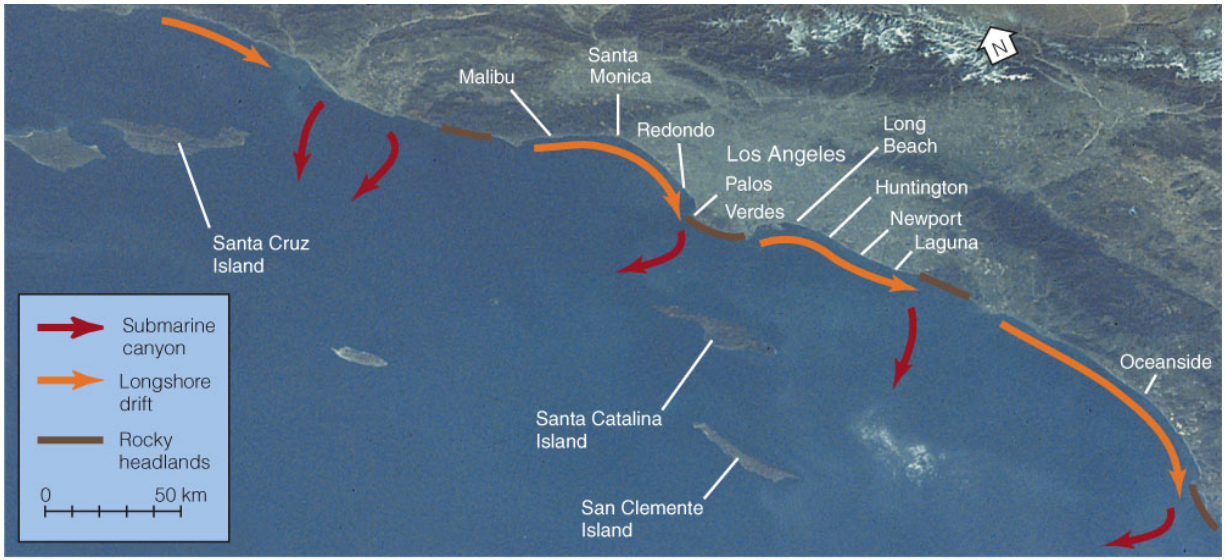



University of Washington Libraries, Special Collections, John Shelton Collection, kcs2-26

Groins built at right angles to the shore at Cape May, New Jersey, to slow the migration of sand. The groins interrupt the flow of longshore currents, **so sand is trapped on their up-current sides, south of the groins, on the down-current sides, sand is eroded.**

Rip currents form when a group of incoming waves pile excess water on the landward side of the surf zone faster then the longshore current can carry it

Sand Input and Outflow Are Balanced in Coastal Cells

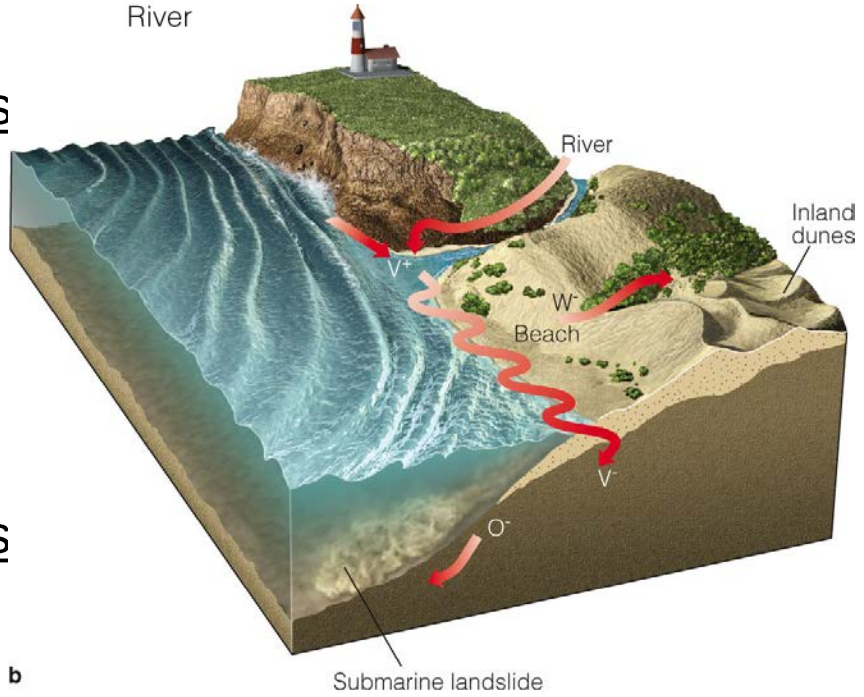


a

Coastal cells. Sand is introduced by rivers, transported southward by the longshore drift, and trapped within the nearshore heads of submarine canyons.

Sand budget. If sediment gains and losses are approximately equal, the nearshore system is in equilibrium. If losses exceed gains, as shown here, the beaches within the cell will shrink and possibly disappear.

Sections of coast in which sand input and sand output are balanced are referred to as **coastal cells.**



b

Other Features

Sand Spits – form where the longshore current slows as it clears a headland and approaches a quiet bay

Baymouth Bar – forms when sand spit closes off a bay by attaching to a headland adjacent to the bay. → **Protects bay**

Inlet - natural passage cut by tides

Barrier Island – narrow, exposed sandbars that are parallel to, **but separated from land**. 13% coasts

Lagoon – long shallow body of seawater isolated from the ocean–

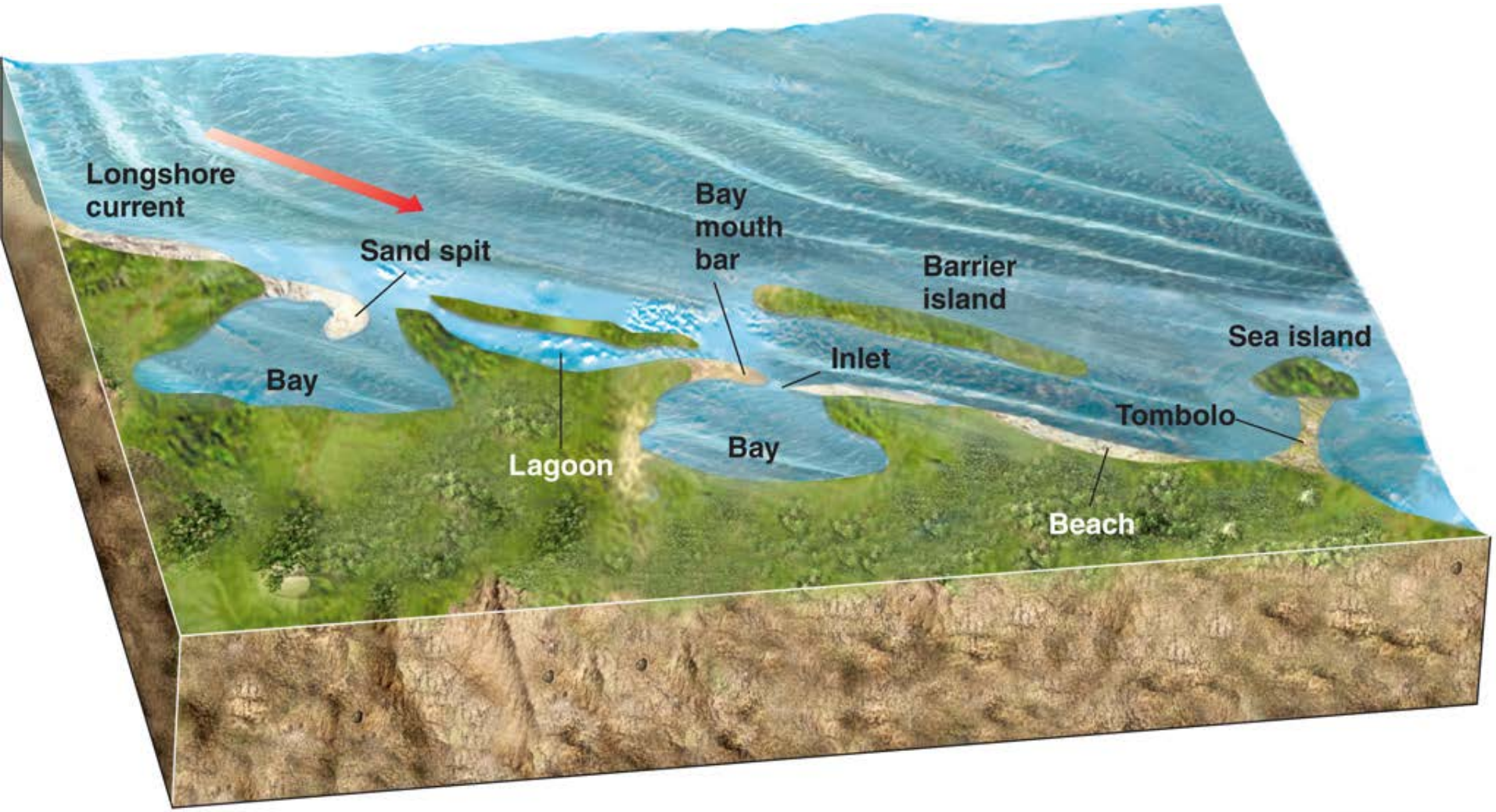
Barrier Islands → start out as coastal dunes, then a sea level rise, and migration of the island westward, Atlantic City, Ocean City, Miami Palm Beach, Galveston

Migration – Hatteras (originally 1500 ft from ocean) in 1870, by 1997 only 120 feet

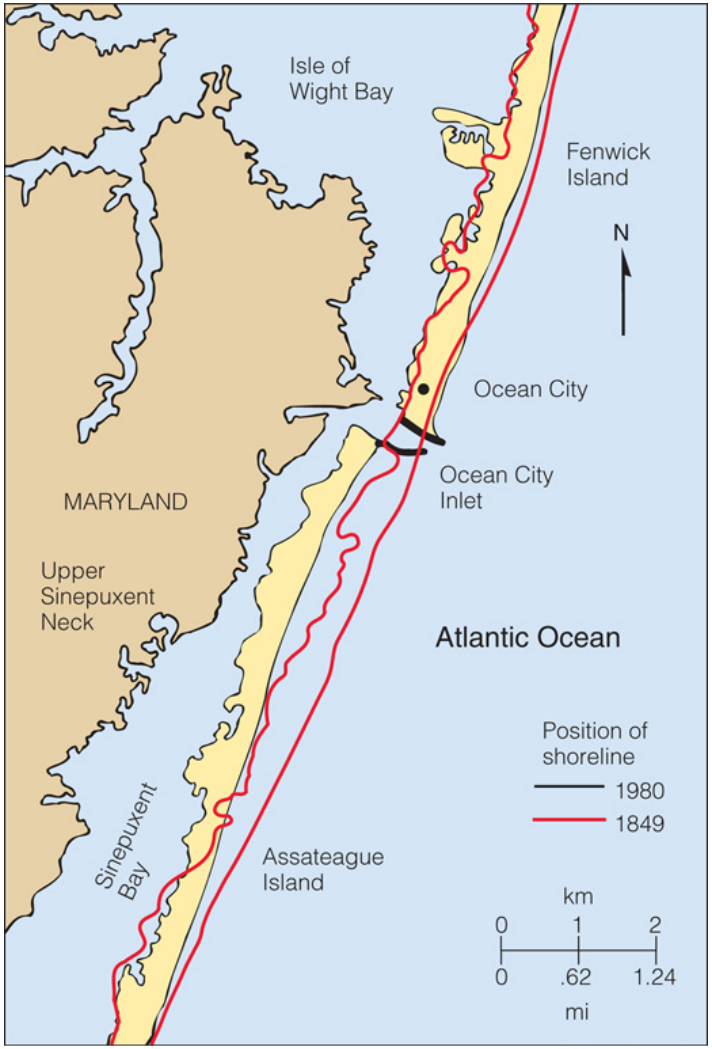
Sea Island – contain continental core material

Tombolo may connect to it – sand

Other Features Accumulate on Depositional Coasts



Barrier Islands



Jetties constructed in the 1930s to protect the inlet.

The jetties disrupt the north-to-south longshore current.

As a result, Assateague Island has been starved of sediment and has migrated about 500 meters (1,640 feet) westward.

Deltas

River opens into ocean (not always) - needs a good shelf for deposition
Biggest ones empty into stable seas/ Gulfs (Nile, Mississippi)

Combine effects of waves, tides, and river flow determine the shape of a delta

1. **River dominated** – strong flow of freshwater – protected from distributaries – Bird's foot of Mississippi

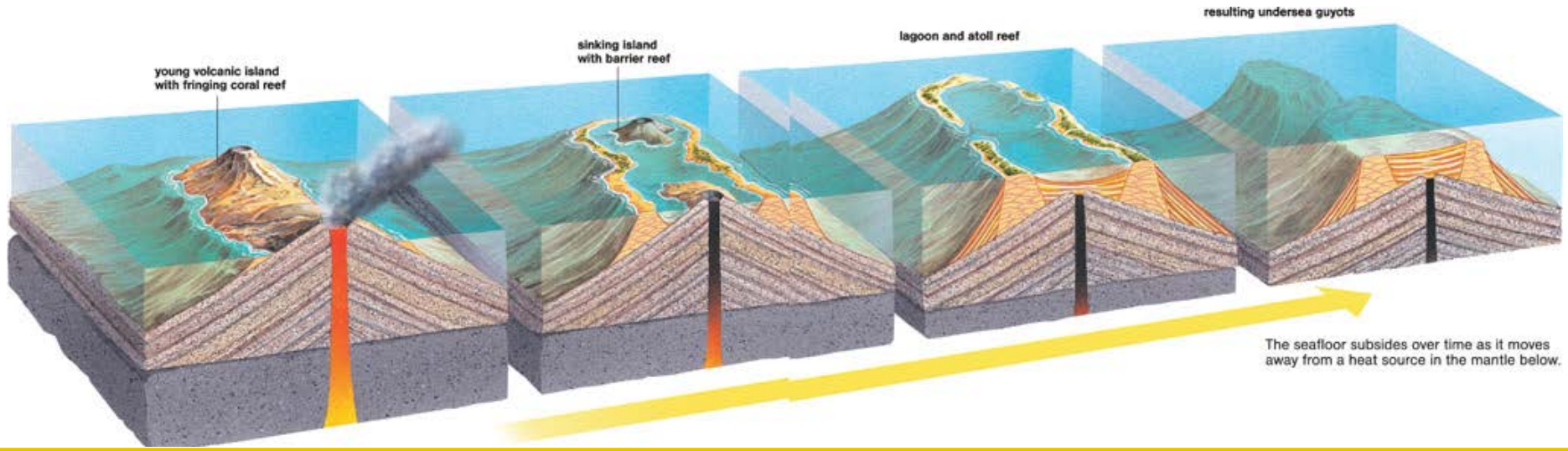
2. **Tide Dominated** – freshwater discharge is overpowered by tidal currents that mold sediments into long islands parallel to the river flow and perpendicular to the trend of the coast Ganges – Bay of Bengal

3. **Wave dominated** – generally smallest - smooth shorelines punctuated by beaches and sand dunes and has a primary exit channel

Glaciers also built coastlines in New England - drumlins, moraines

Biological Activity Forms and Modifies Coasts

- Coral reefs
  - **Fringing reefs** – cling to the margin of land
  - **Barrier reefs** – separated by a lagoon
  - **Atolls**- **ring – shaped island** of coral reefs and coral debris enclosing or almost enclosing a shallow lagoon from which no land protrudes



Freshwater Meets the Ocean in Estuaries

- Body of water partially surrounded by land
- Mixing fresh and salt water
- Estuaries classified by origin
- Characteristics influenced by water density and flow

Types of Estuaries

1**. Drowned River Mouths** – from last sea level rise, very common, Atlantic Coast

2. **Fjords-** steep glacially eroded u-shaped troughs (1000 – 1300 feet deep)

3. **Bar- built Estuaries-** form when a barrier island or a barrier spit is built parallel to the coast above sea level Tidal action is limited – small inlet Chincoteaque, MD

4. **Tectonic**- constant indentations formed by faulting and local subsidence

Three factors determine the characteristics

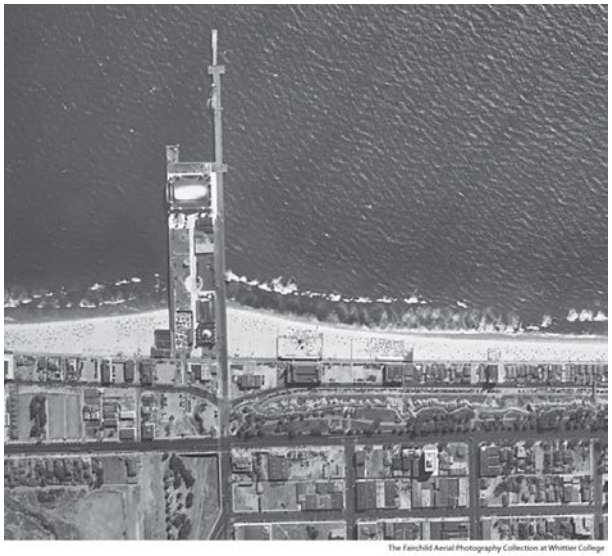
1. **Shape** of the Estuary
2. **Volume of river flow** at the head of the estuary
3. **Range of tides** in the mouth

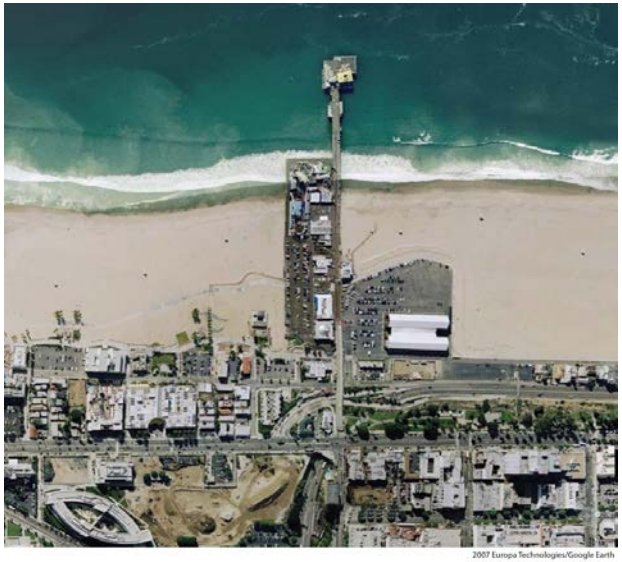
The Characteristics of U.S. Coasts

- Pacific
  - Actively rising
  - Recent tectonic activity
- Atlantic
  - Passive margin
- Gulf coast
  - Smaller wave size
  - Smaller tidal range

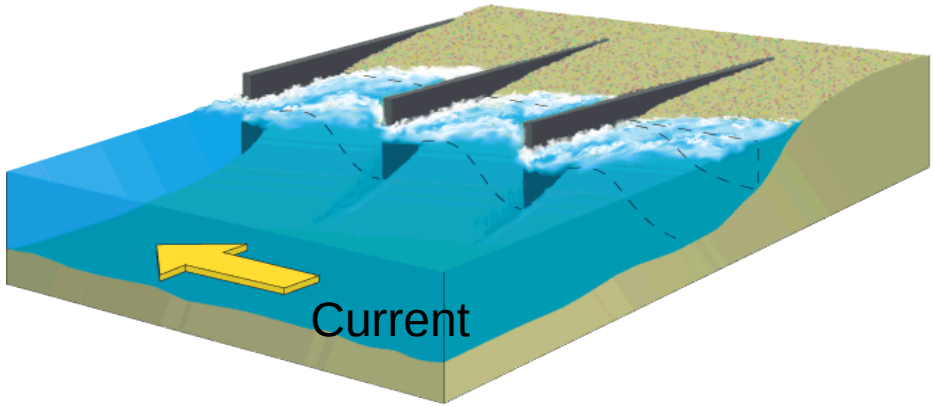
Humans Interfere in Coastal Processes

- Engineering to prevent/slow erosion

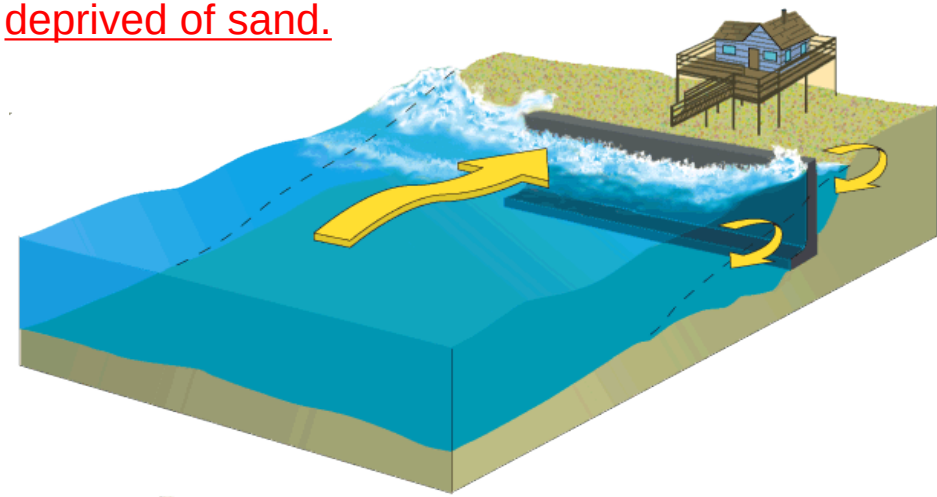




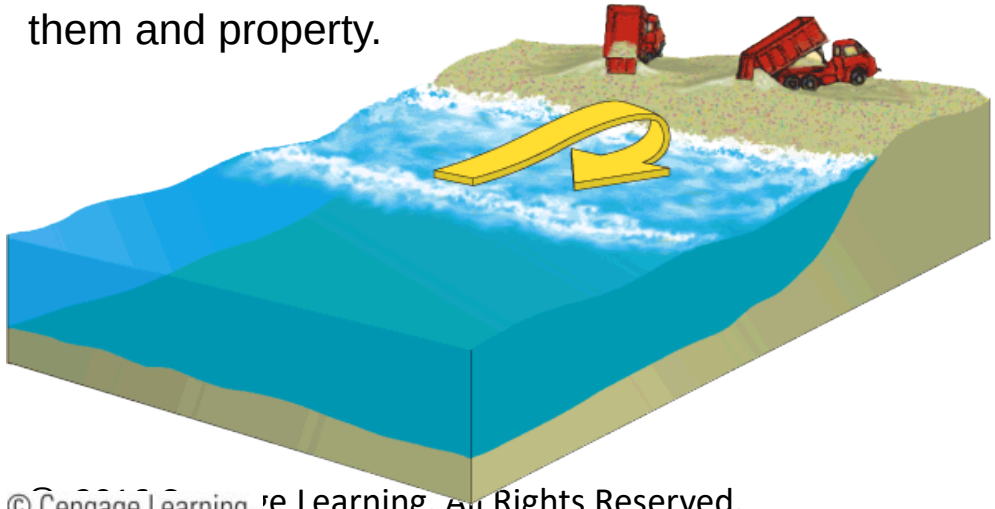
Some Measures Taken to Slow Beach Erosion



Groin -extend from the beach into the water, trapping sand from the current. Groins accumulate sand on their updrift side, but erosion is worse on the downdrift side, which is deprived of sand.



Seawalls-protect property temporarily, but they also increase beach erosion by deflecting wave energy onto the sand in front of and beside them. High waves can wash over seawalls and destroy them and property.



Importing sand to a beach is considered the best response to erosion. New sand often is dredged from offshore, can cost tens of millions of dollars, and can disturb aquatic biodiversity. Because it is often finer than beach sand, dredged sand erodes more quickly.

Stepped Art

Figure 12-34 p379