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SIXTH EDITION

Invitation to

Oceanography

Chapter 11

The Dynamic Shoreline

Breaking waves provide the energy that changes the shape and texture of beach deposits

- As waves shoal (touch bottom) in shallow water:
  - wave speed decreases
  - wavelength decreases
  - wave height increases
  - waves refract
    - **Refraction** is the bending of waves towards shallower water so that they break almost parallel to the shore.
- Waves become unstable and break in very shallow water.
- Waves generate:
  - longshore currents that flow parallel to the beach
  - rip currents that flow perpendicular to the beach

Longshore Currents

transport sand grains (and swimmers) parallel to the shore

Figure 11.01a: Aerial view of oblique wave approach.

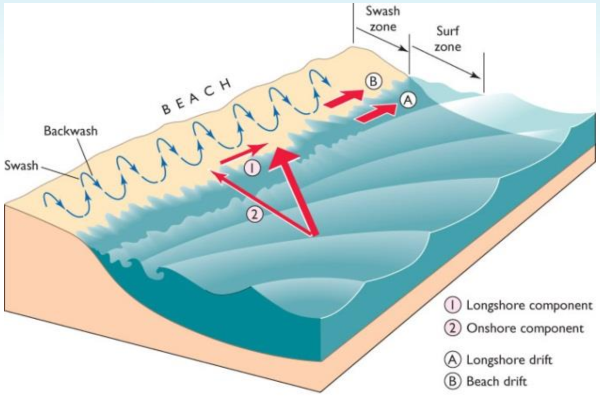


Figure 11.01b: waves that approach a beach at an angle produce a longshore drift of sand.

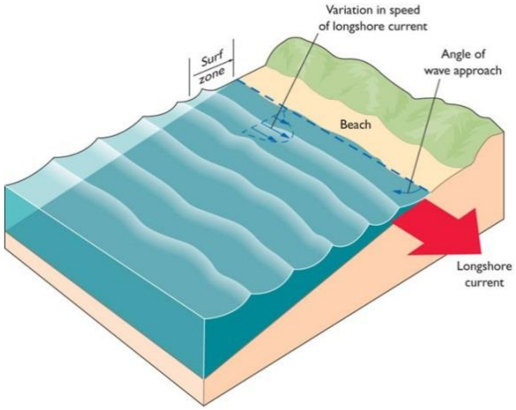


Figure 11.01c: Where waves approach a shoreline at an angle, a shore-parallel current called a longshore current is generated in the surf zone.

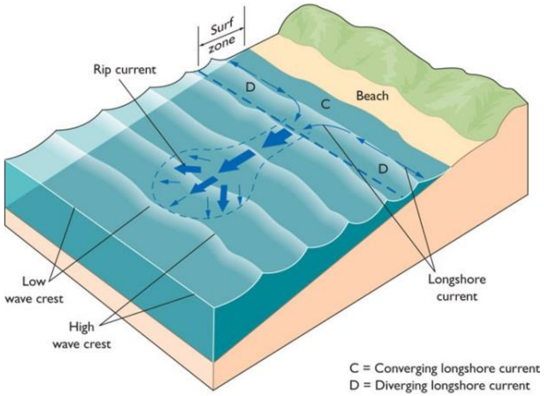


Figure 11.01d: Waves that are parallel to the beach can generate longshore currents, provided wave height varies along the waves' crest.

Longshore Currents

- Angle of wave approach is the acute angle (less than 90^{o}) between the wave crest and the beach.

- The direction of longshore current varies with the direction of wave approach.

- Longshore currents can also be generated by wave set-up.

- Where two opposing longshore currents collide, they form a swift, narrow, seaward rip current.

The Coastal Zone

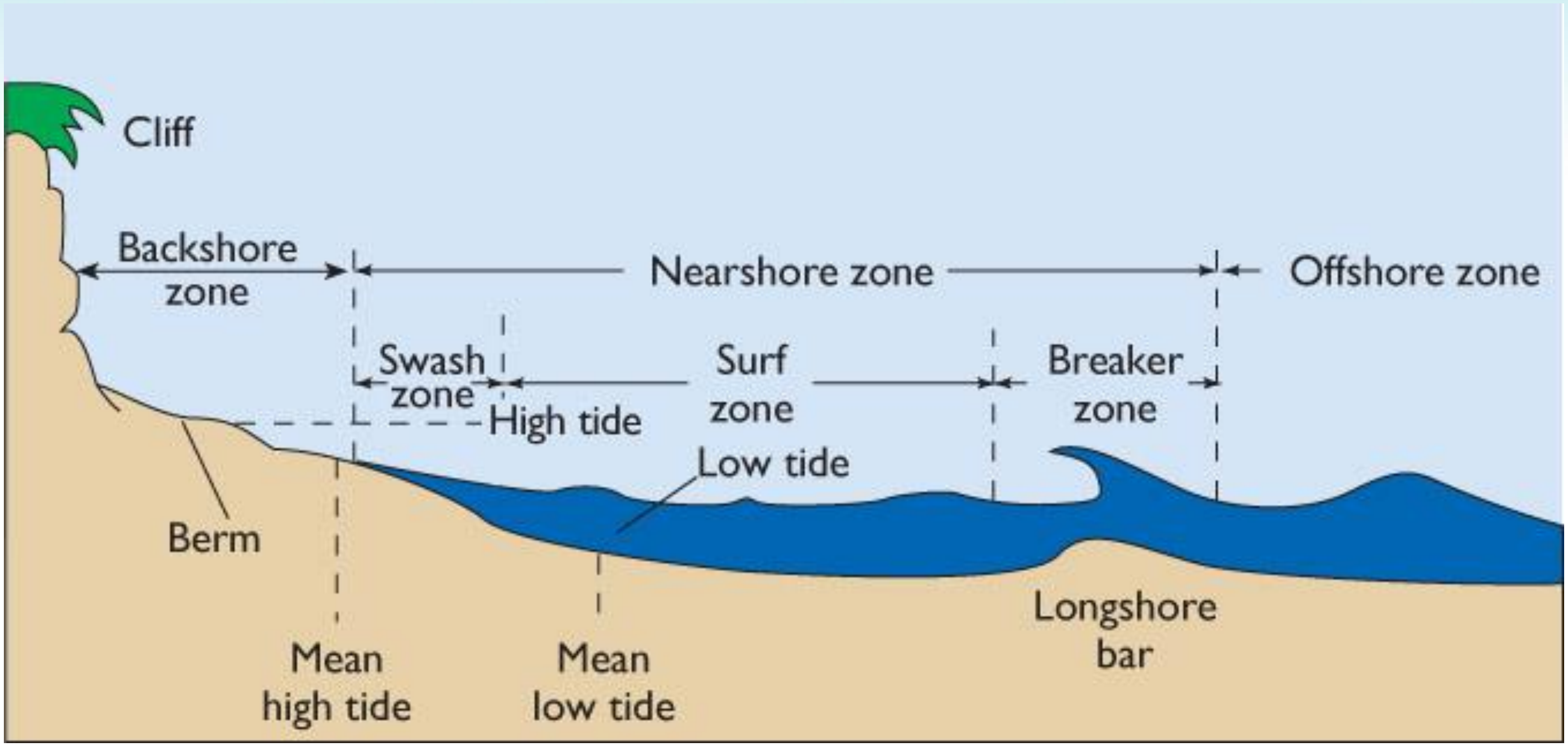


Figure 11.02: The nearshore zone is subdivided into breaker, surf, and swash zones.

- Waves generate:
  - longshore currents that flow parallel to the beach
  - rip currents that flow perpendicularly to the beach

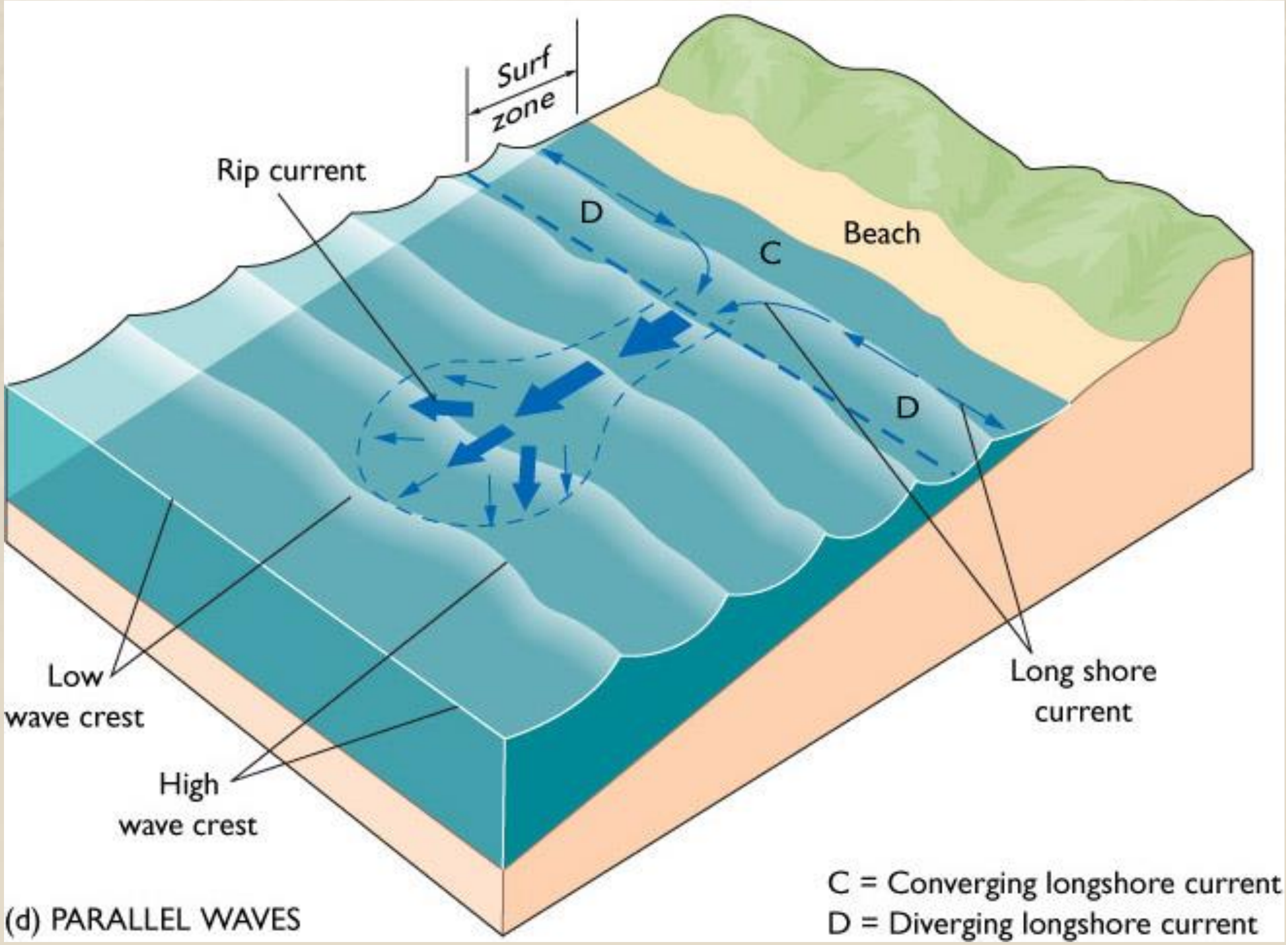
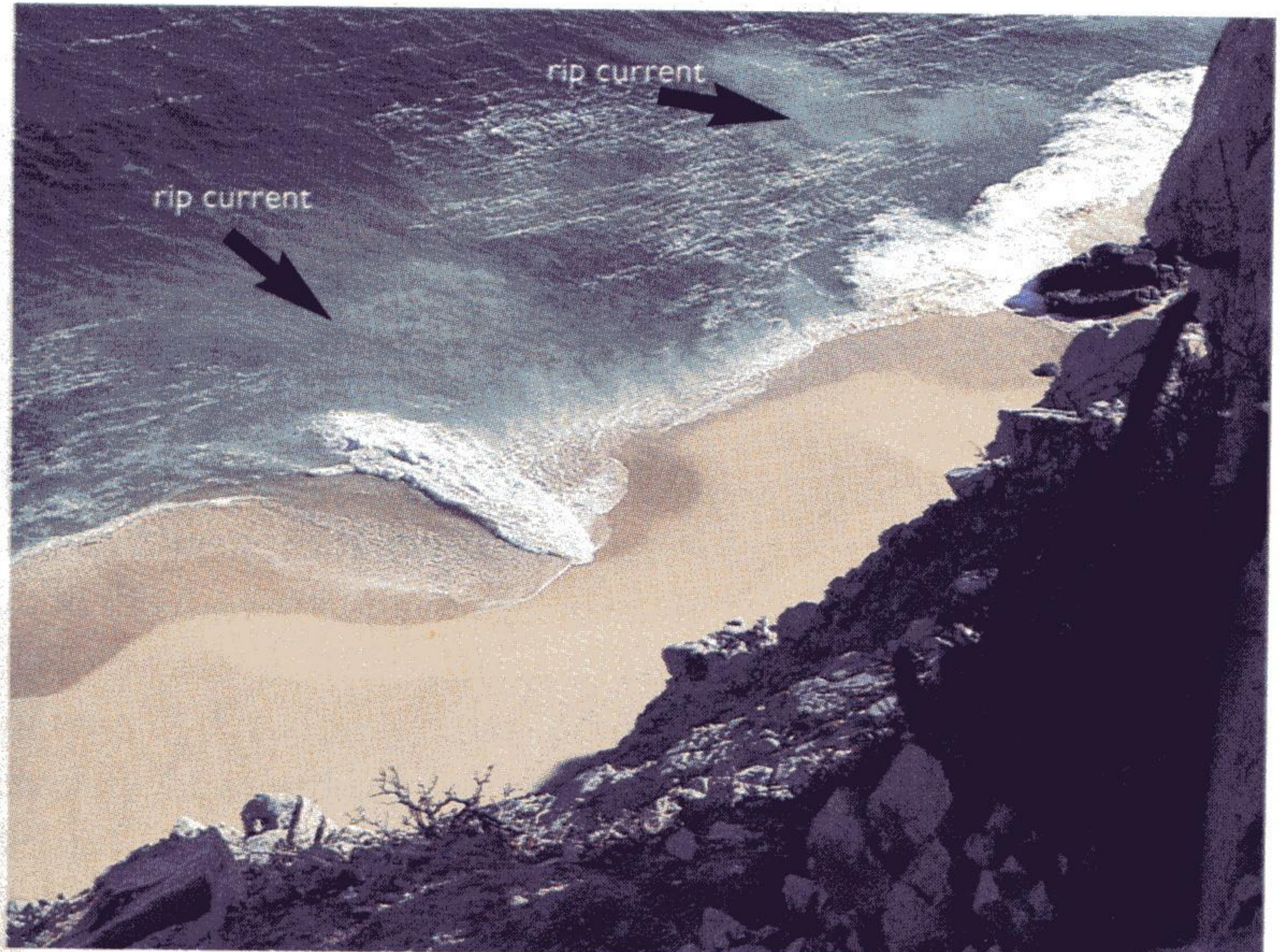


Figure 11-1d Parallel Waves

11-1 Coastal Water Movement



(d) RIP CURRENTS

- A **storm profile** displays erosion of the berm and a broad flat intertidal beach face, often with a submarine bar.

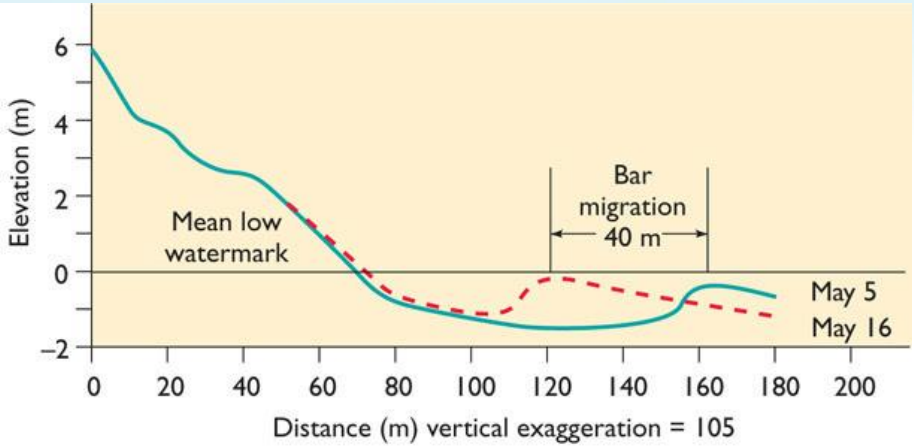


Figure 11.03c: Following a storm, the eroded beach tends to undergo accretion.

- The **sand budget** is the balance between sediment added to and sediment eroded from the beach.

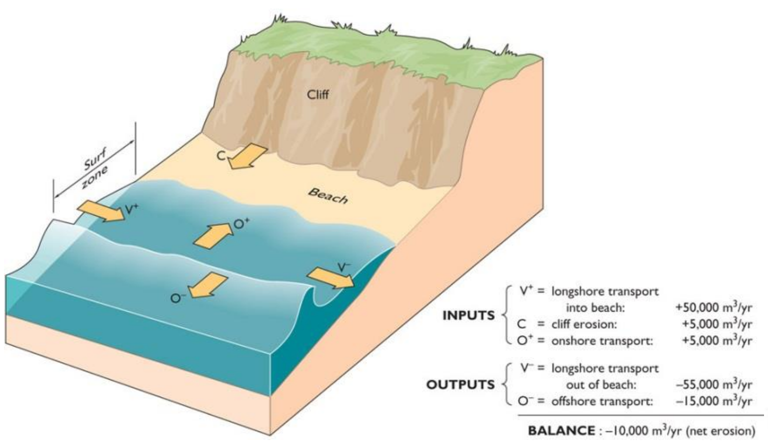


Figure 11.04b: In this example of a hypothetical sand budget, sand inputs are less than sand outputs.

Coastal Cells

- The formation of a coastal cell:
  - Sand is input from river.
  - Longshore drift carries the sand down the shoreline.
  - Sand drifts into the head of a submarine canyon.
  - It is swept down the canyon into the deep-sea basin.

Sand Dunes (Continued)

- Wave erosion of dunes:
  - supplies sand to the offshore
  - creates a steep **scarp** at the base of the dune

- Dunes act as a natural barrier and prevent or reduce inland flooding.
  - Rooted plants that grow on dunes stabilize them and prevent dune erosion.
- Human activity that damages vegetation leads to dune destruction by blowouts and washover by storm waves.

Figure 11.09: A steep scarp has been cut into a large dune, exposing its internal cross-bedded structure.

Figure 11.10: Wooden foot ramps are used to direct foot traffic through dunes in order to minimize damage to grasses and shrubs.

The Origin of Barrier Islands

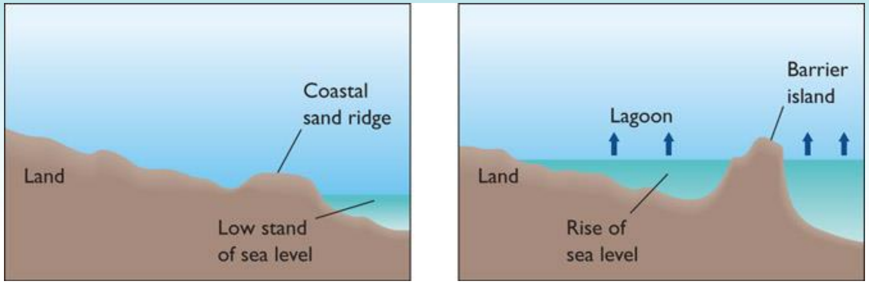


Figure 11.12a: A coastal sand ridge develops when sea level is reasonably stable.

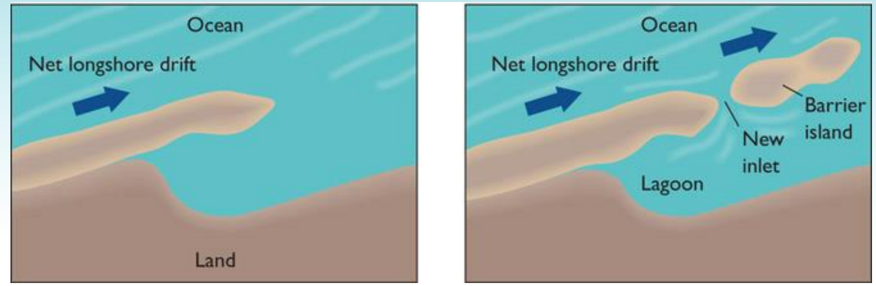


Figure 11.12b: The rapid longshore drift of sand promotes split growth.

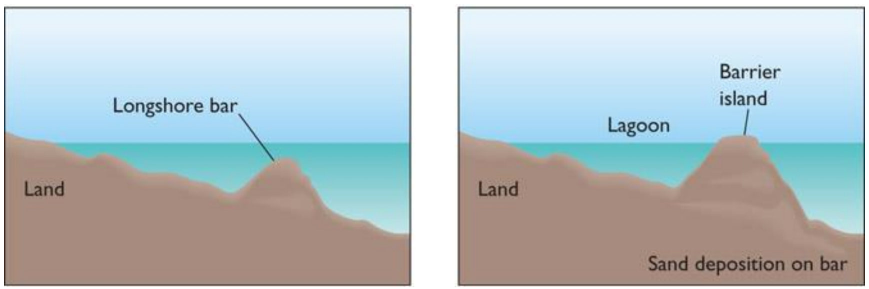


Figure 11.12c: A longshore bar is built upward to sea level.

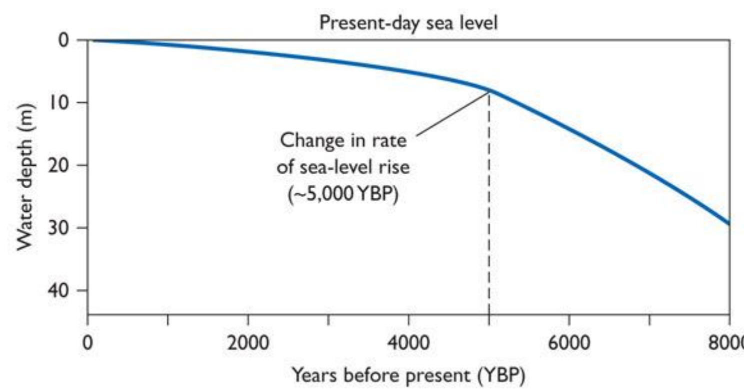


Figure 11.12d: Sea level has risen continually since the last glaciation, a worldwide event known as the Holocene sea-level rise.

Storm Modifications of Barrier Islands

Figure 11.15a: Arial view of a barrier island with recently formed washover fans that carried sand into the salt marsh. Arrows indicate large washover fans.

Figure 11.15b: This tidal inlet formed when part of the barrier island was breached during a recent storm.

Figure 11.15c: Storm waves are eroding the beach and shore-front property.

Figure 11.15d: Wave attack has undercut this coastal road.

The wave-cut platform is the gentle sloping area in front of the sea cliff that was produced by sea-cliff retreat

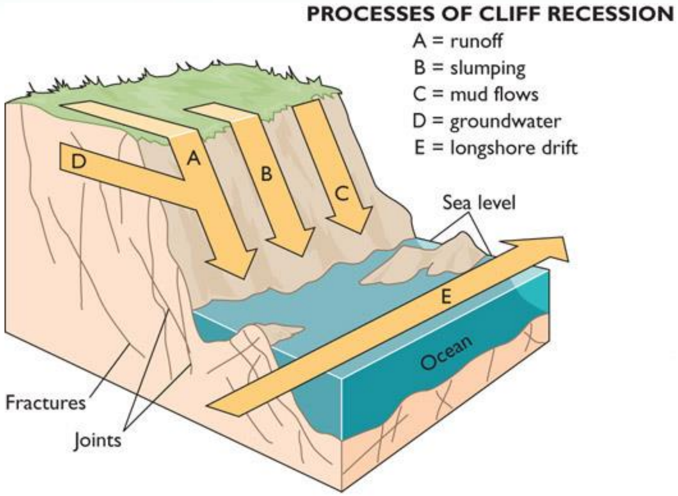


Figure 11.16a: Surface runoff, slumping, mud flows, and groundwater seepage all erode cliffs, as waves destabilize the cliff face by undercutting its base.

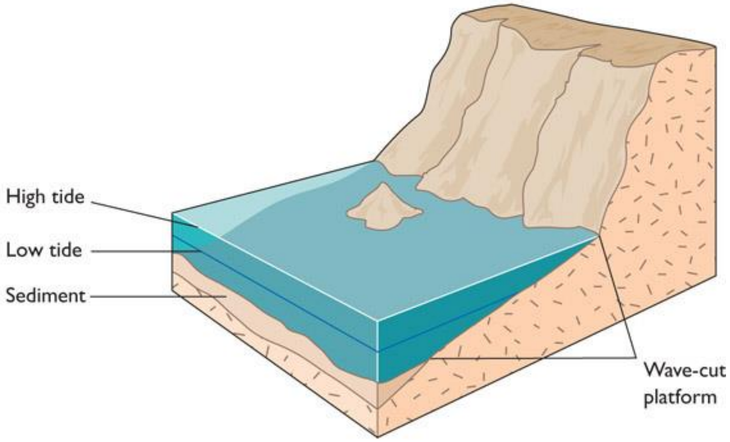


Figure 11.16c: If sea level is stable for a time, waves will erode a wave-cut platform as the cliff face retreats landward.

Deltas

- In cross section, a delta's deposits can be divided into three sets of beds:
  - topset beds (under delta plain)
  - foreset beds (deposited on the delta front)
  - bottomset beds (deposited on the flat seafloor)

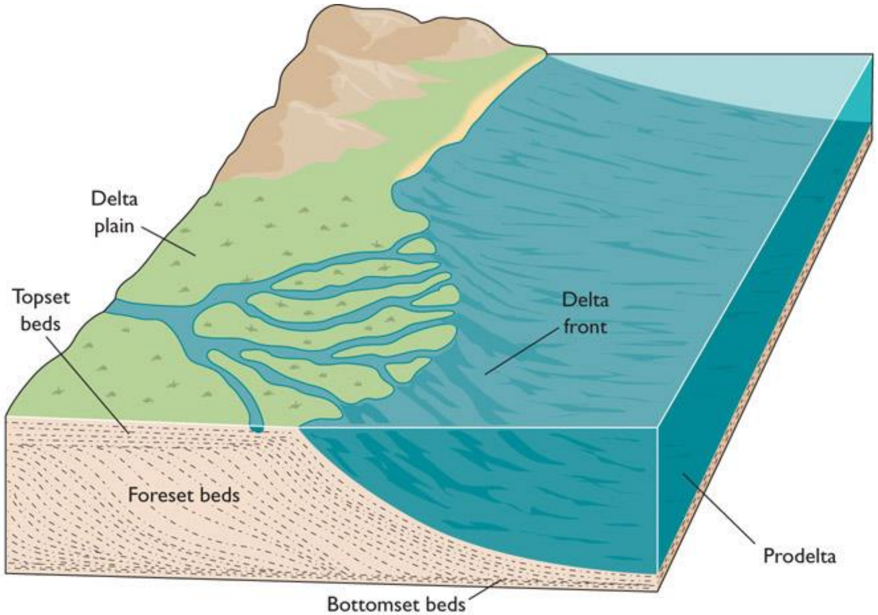


Figure 11.17a: Where river-supplied sediments are abundant, a delta grows seaward. Typically, the delta consists of a delta plain, a delta front, and a prodelta.

Coastal Environment determines Delta shape.

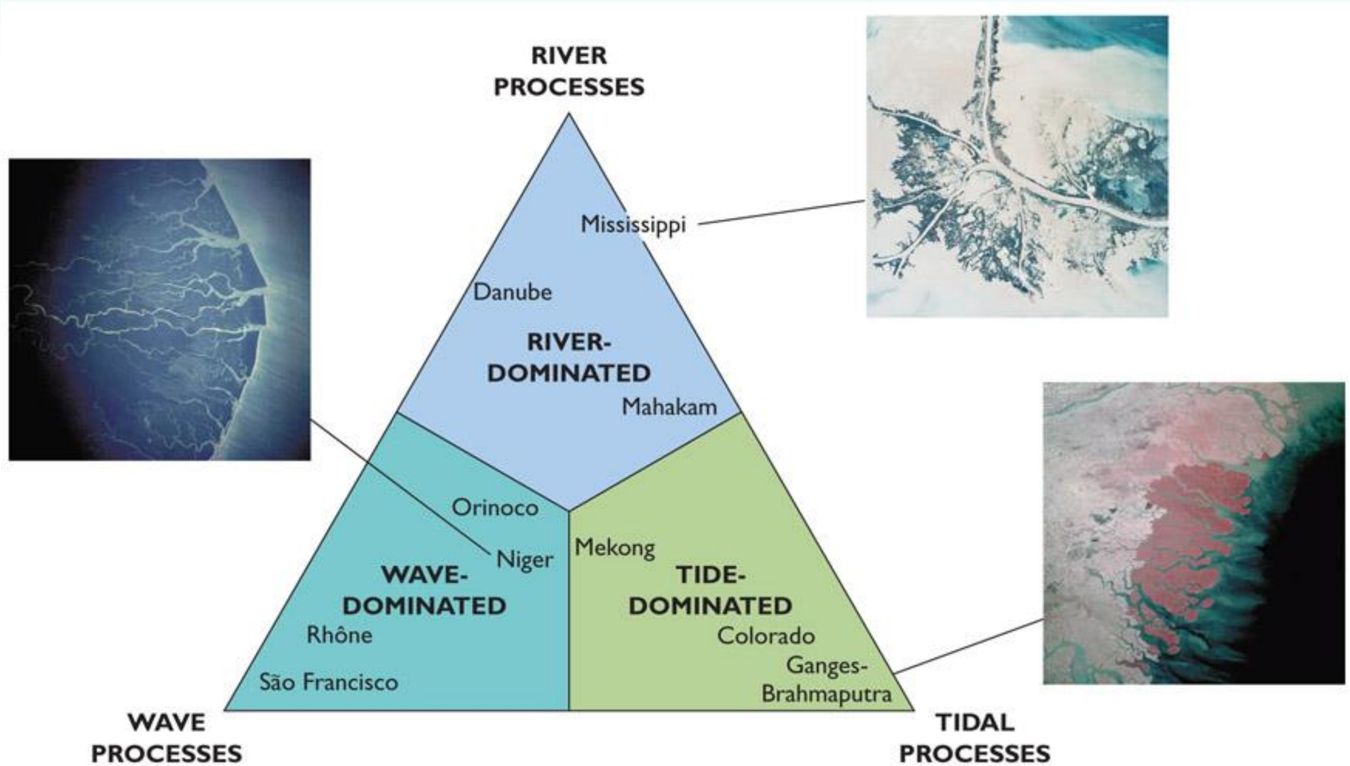


Figure 11.17b: Depending on the relative effects of river, waves, and tides, deltas assume a variety of shapes.

Coastal Engineering Structures

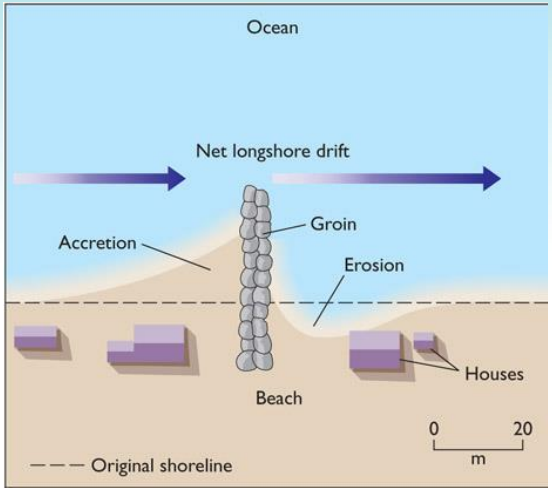


Figure 11.18a: Groins

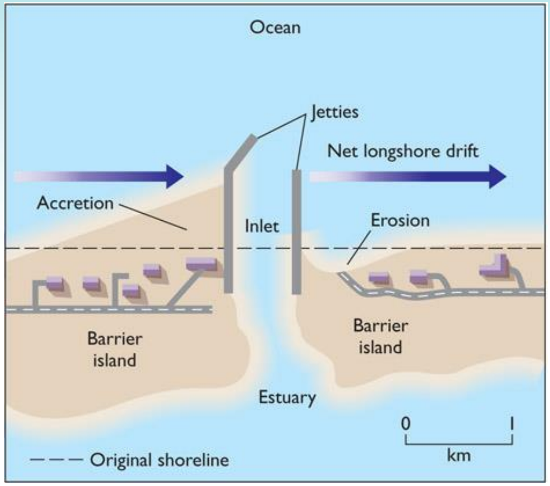


Figure 11.18b: Jetties

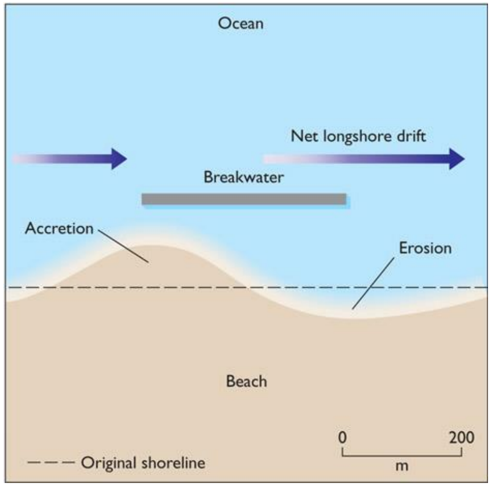


Figure 11.18c: Breakwaters

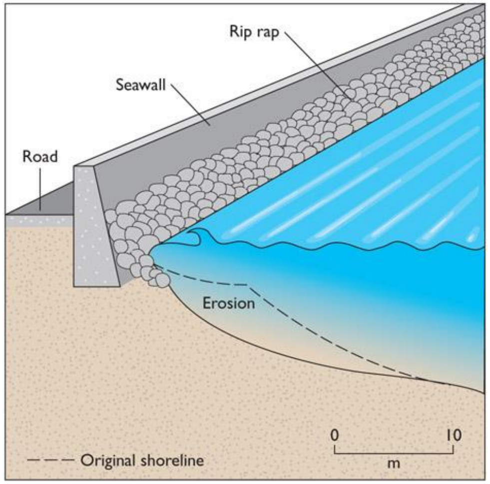


Figure 11.18d: Seawalls

Coastal Engineering (Continued)

- In 1934-35, jetties were built to stabilize the inlet between Ocean City, Maryland, on Fenwick Island, and Assateague Island.

- Beaches along Ocean City accreted as sand was trapped on the updrift side of the northern jetty.

- Assateague Island, denied its sand supply from longshore drift from the north, rapidly eroded (about 40 feet/year).

This attempt to control erosion lead to greater erosion… many other examples indicate a serious problem with this approach.

Figure B11.07a: This is an aerial view of Ocean City looking south. The eroding Assateague Island can be seen in the extreme upper right corner of the photo.

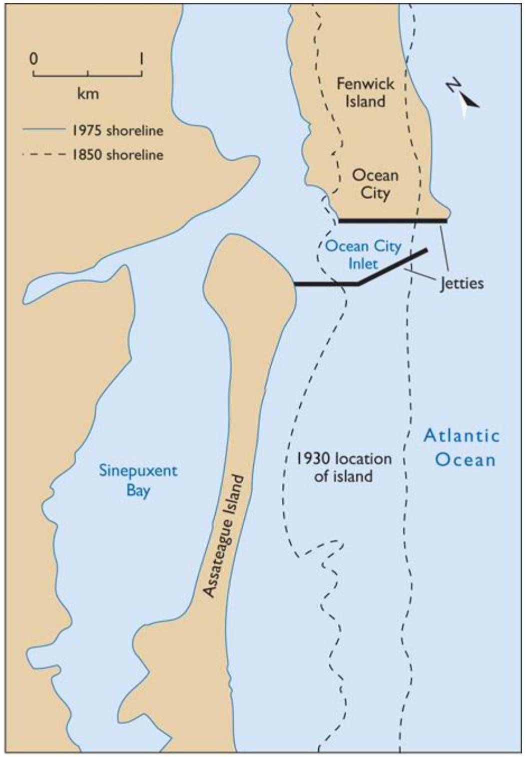


Figure B11.07b: Jetties which were constructed shortly after a hurricane opened Ocean City Inlet in 1933 interfered with the southerly longshore drift of sand.

The Ocean Sciences: Katrina Drowns New Orleans

- Experts have long known the city's system of levees and canals were inadequate to protect the city from a category-5 hurricane.

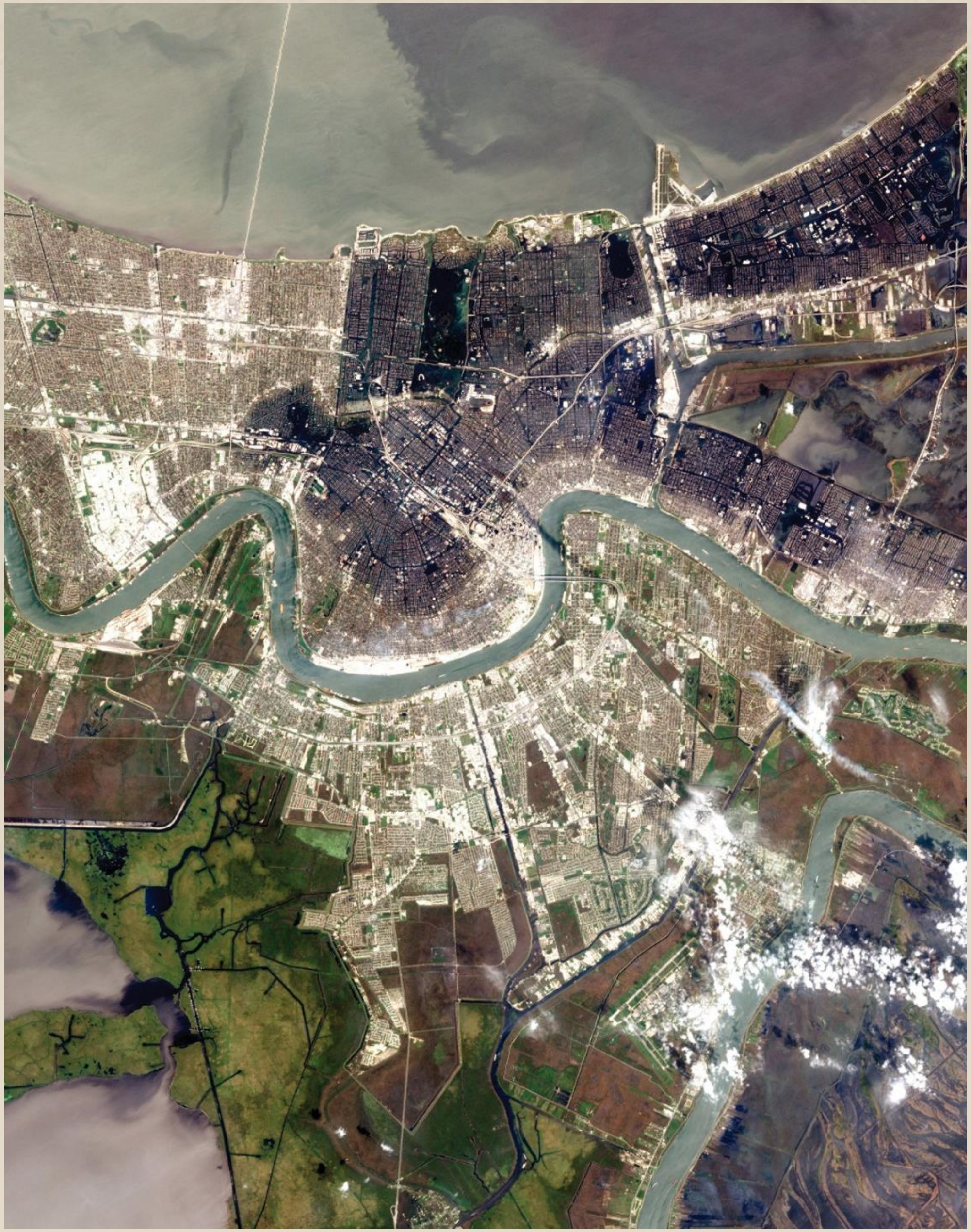


Figure B11-9 Dark blue indicates flooded areas.

- Protecting the city against future storms requires:
  - Strengthening and raising the levees
  - Establishing a long-term management strategy to restore barrier islands and marshlands
  - Add sand to the barrier islands' long shore currents
  - Find ways to increase the sediment load to the mouth of the Mississippi River

Figure B11-8b