Lecture Outlines

Physical Geology, 15/e

Plummer, Carlson & Hammersley

Waves, Beaches, and Coasts

Physical Geology 15/e, Chapter 14

Shoreline Dynamics

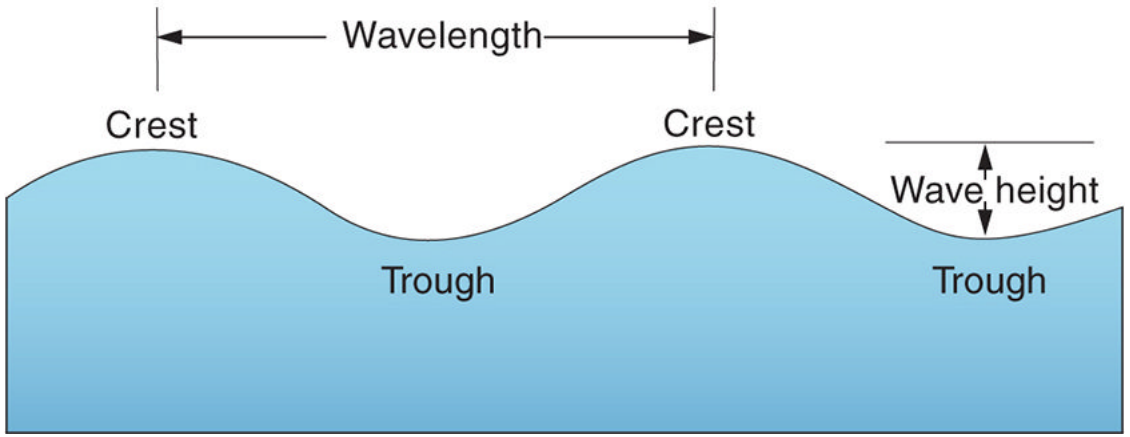
Ocean waves – created by **wind** blowing over the surface of the water

- when waves strike coastlines, wind energy is transferred to the rocks and sediments on beaches
- energy is available to erode coastlines and transport sediments
- beach erosion during storms increases greatly, and can undermine structures

Photo by AP Photo/Mike Groll

How Do Waves Form?

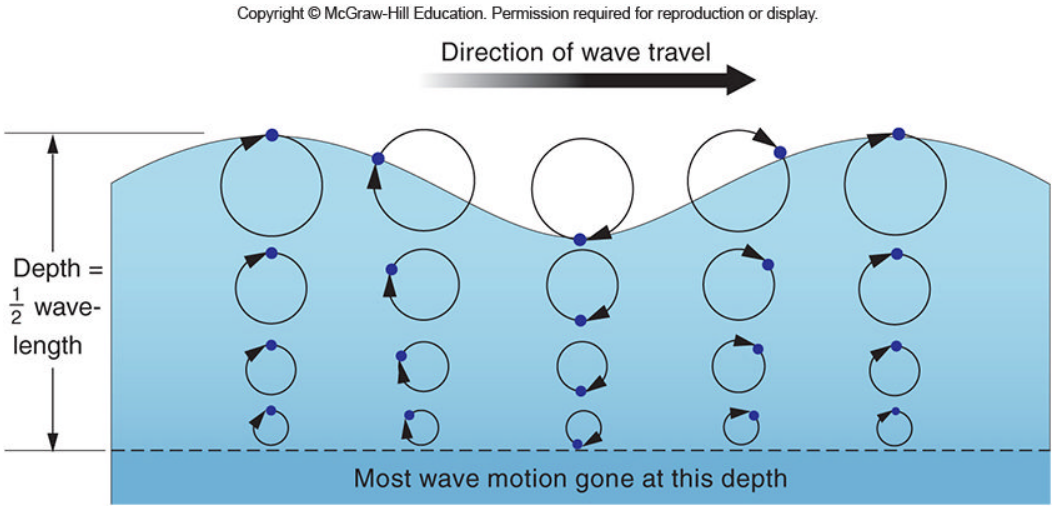
- Height, length and speed of water waves is determined by *wind speed*, *length of time* that wind blows, and *distance* wind blows over the water *(fetch)*
  - **wave height** – the vertical distance between the **crest** (top) and **trough** (bottom) of a wave
  - **wavelength** – the horizontal distance between two wave crests



How Do Waves Form?

Orbital Motion – particles of water move in a nearly circular path to allow the advance of the wave energy much like the way wheat in a field moves as wind blows across it.

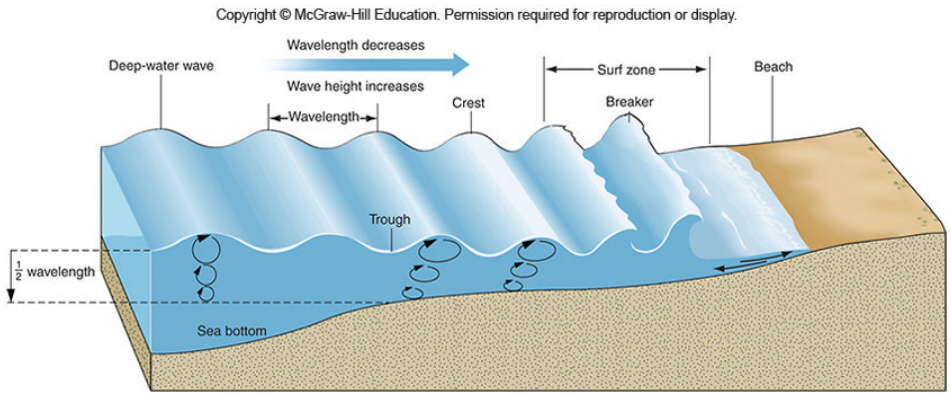
- energy advances with the wave, but the water does not
- orbital motion in waves decreases with depth until it is essentially gone at a depth of half the wavelength



How Do Waves Form?

Surf

- As waves move into more shallow water the waves are first affected by the ocean bottom which flattens the orbitals into ovals
- The waves slow; wavelength decreases and the wave height increases until the wave breaks
- *Breaker* – wave that has become so steep that the crest of the waves topples forward. Breakers are collectively called **surf.**



What Happens When Waves Reach the Shore?

Wave refraction – waves hitting the shoreline at an angle bend and change direction to become more nearly parallel to the shoreline

Longshore current– refracted waves hitting the coastline at a slight angle, pushing water and sediments parallel to the coastline

A

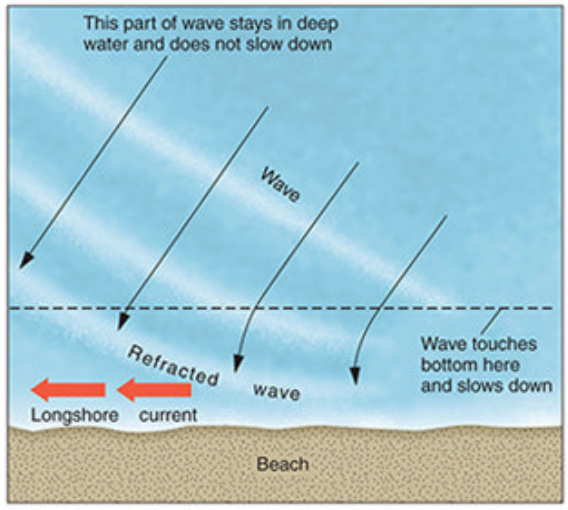


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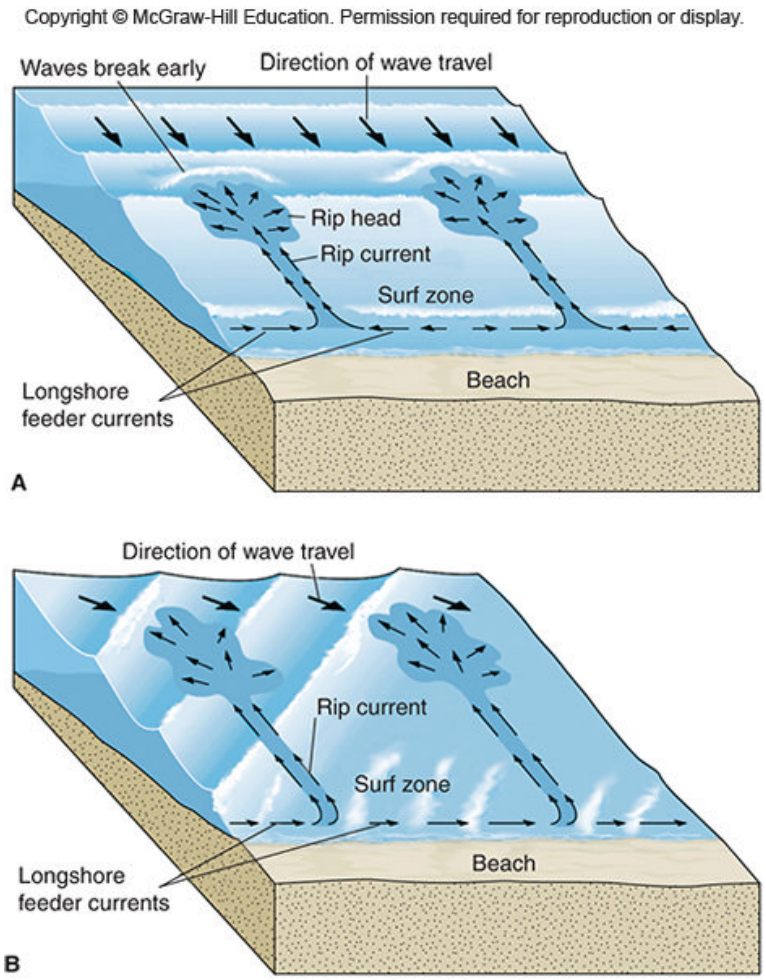
Photo by David McGeary

What Happens When Waves Reach the Shore?

Rip currents – narrow currents that flow straight out to sea through the surf zone

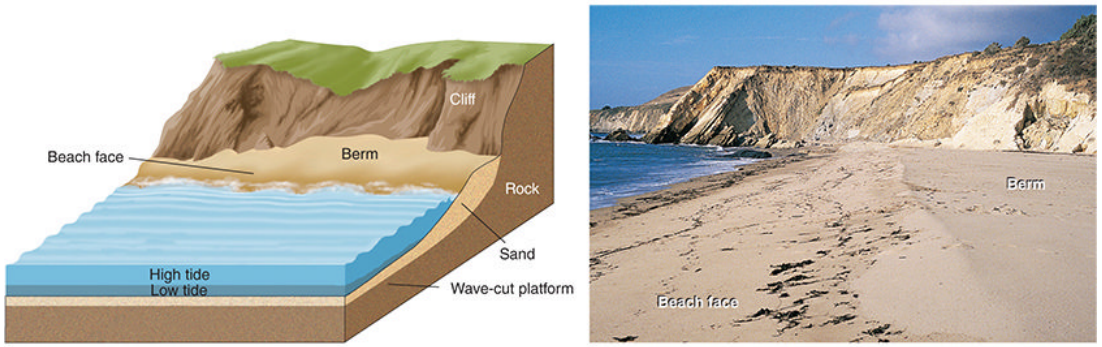
- rip currents fed by water in surf zone, where backflow gets localized
- located where waves in the surf zone are lowered by underwater channels or wave interference patterns
- die out quickly with depth and end just outside the surf zone



How Do Beaches Develop?

Beach – a strip of sediment (usually sand or gravel) from the low-water line inland to a cliff or zone of permanent vegetation

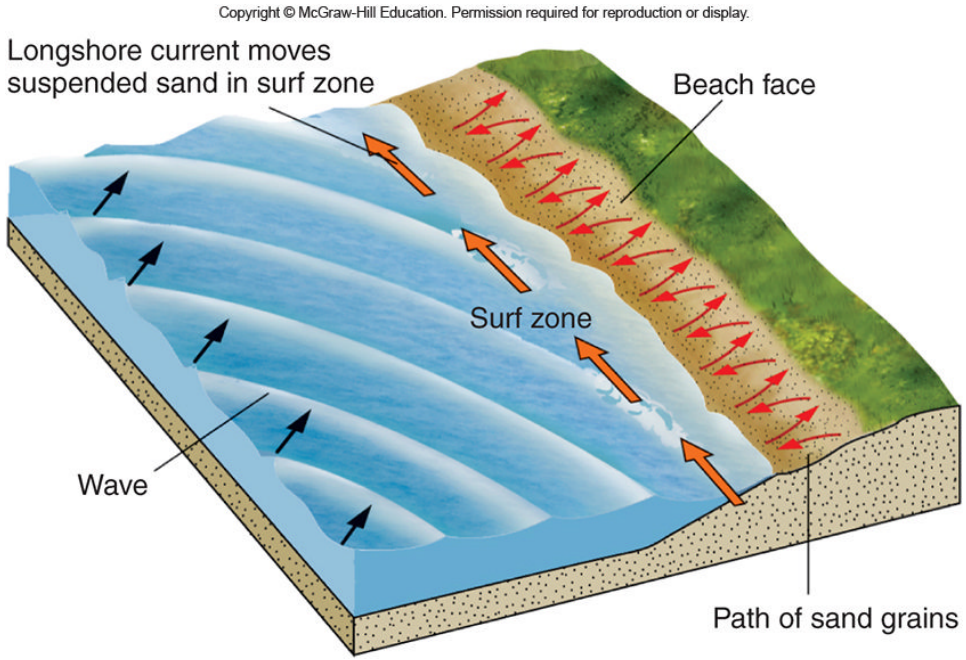
- **beach face**– steepest part of a beach, up which water sloshes as waves are breaking
- **berm** – a flat or gently inland-sloping platform above and landward of the beach face
- berms narrowed by wave erosion during stormy season and rebuilt by gentler waves in calm weather
- **marine terrace** – a broad, gently sloping platform of rock or sediment just offshore from the beach face



Why Does Sand Move Along A Shoreline?

Longshore drift – movement of sediment parallel to shoreline when waves strike it at an angle

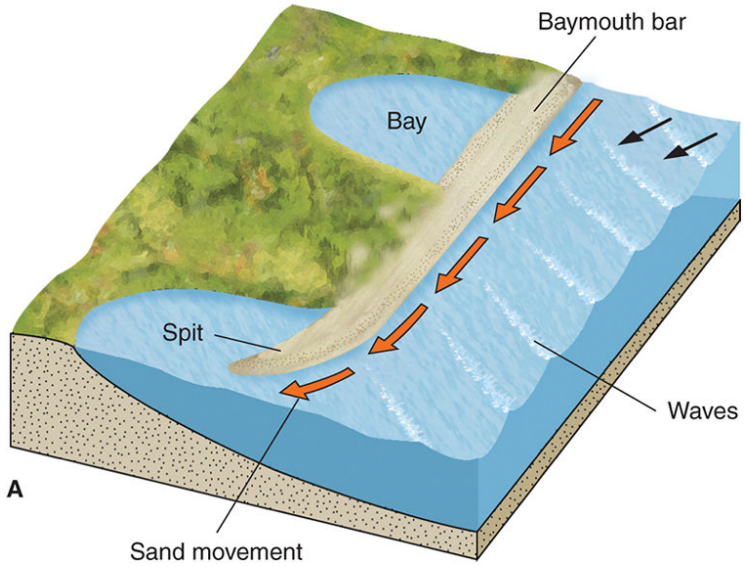
- some sediment is transported along the shoreline as waves wash up on the **beach face**
- most sediment is transported by **longshore current** in the more energetic **surf zone**



Why Does Sand Move Along A Shoreline?

Longshore drift can deposit sediments in **spits**, **baymouth bars**, and **tombolos**

Spits – build out into the open water off a point of land



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(b) Photo by D. A. Rahm, courtesy Rahm Memorial Collection, Western Washington University
(c) Photo by Diane Carlson

Why Does Sand Move Along A Shoreline?

Baymouth bars – ridges of sediments that cut bays off from the ocean

Tombolo – a bar of sediment connecting a former island (generally bedrock) to the shore

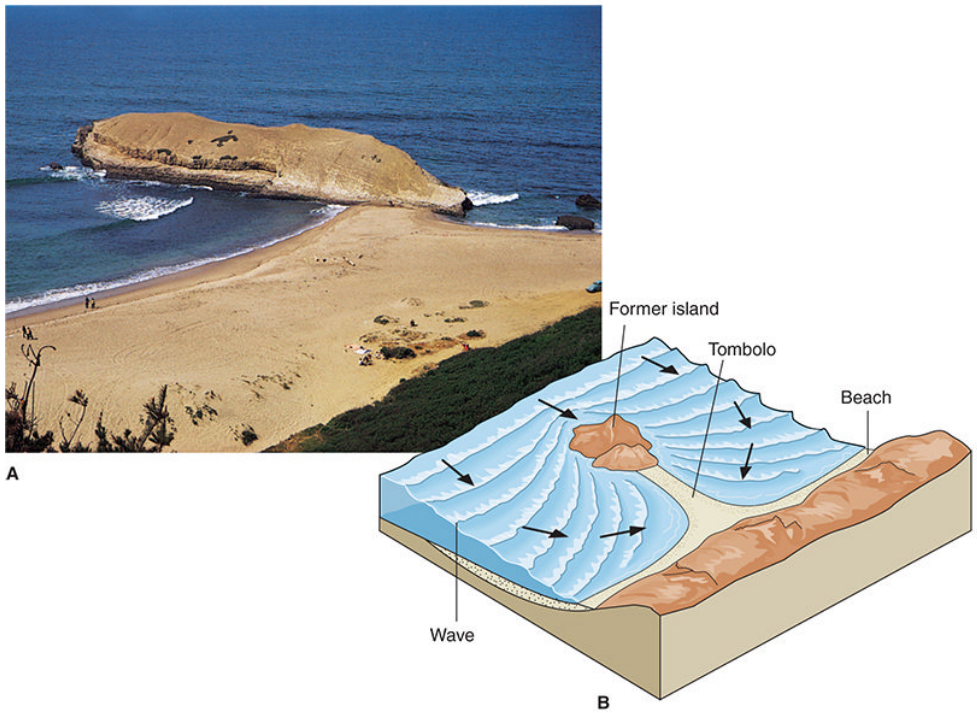
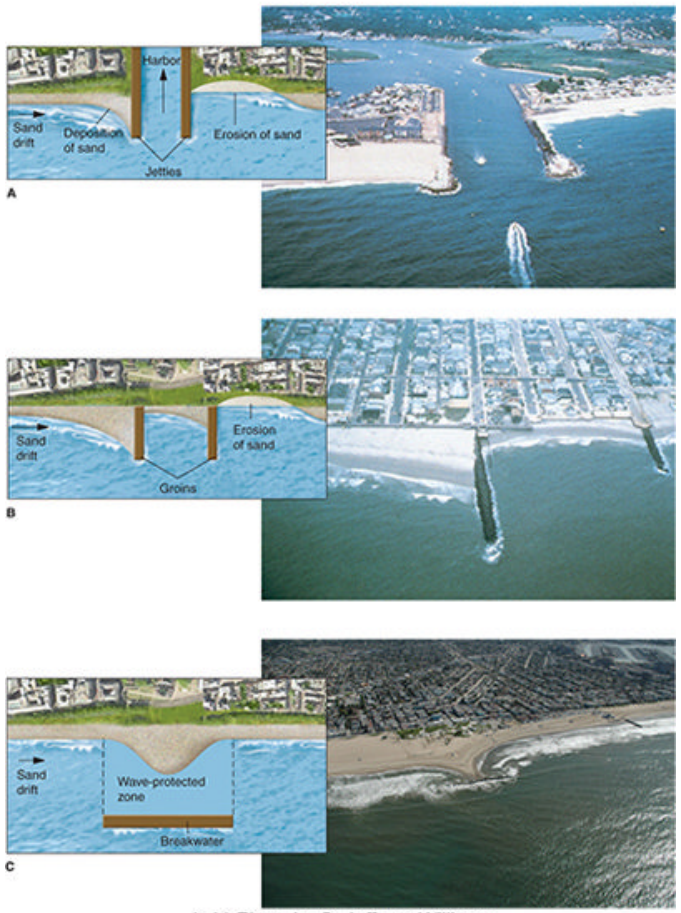


Photo by David McGeary

Why Does Sand Move Along A Shoreline?



(a,b) Photo by S. Jeffress Williams
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Human Interference with Sand Drift

- **Jetties** – rock walls designed to prevent the entrance of a harbor from filling with sand
- **Groins** – short walls perpendicular to shore built to trap sand and widen a beach
- **Breakwaters** – offshore structures, typically parallel to the shoreline, built to absorb the force of large breakers and provide quiet water near shore

Why Does Sand Move Along A Shoreline?

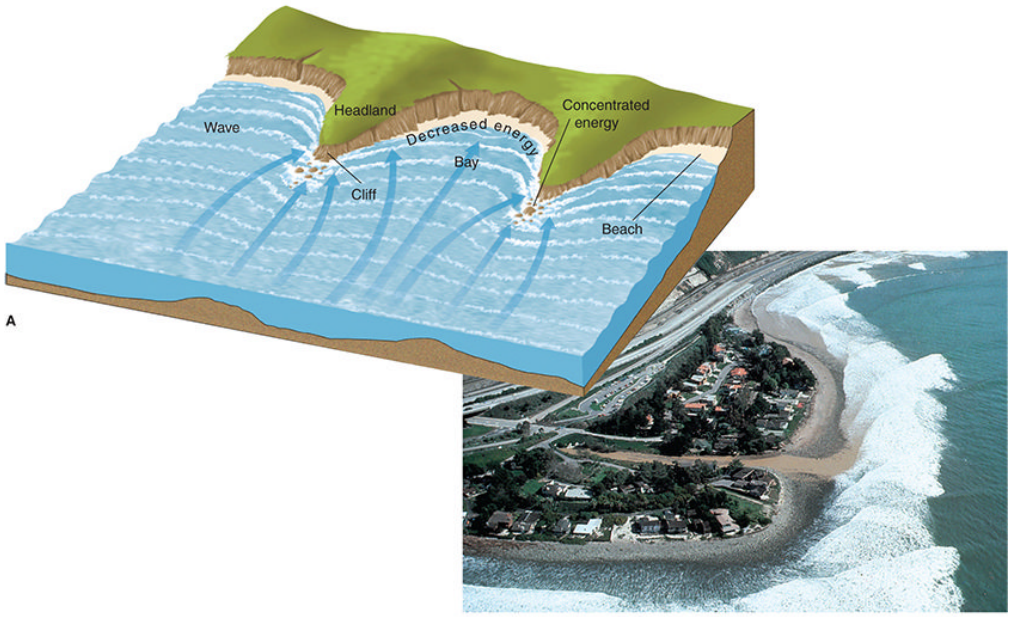
Sources of Sand on Beaches

- Erosion of local rock
- Replenishment from sand stored seaward of the surf zone
- Carbonate remains of shelled marine organisms
- River sediment brought down to the ocean
  - river sediment is the largest sand source for most beaches
  - building of dams to produce reservoirs upstream cuts off the river sand supply and leads to severe beach erosion
  - some coastal communities with eroding beaches move sand to the coastline by pipeline or truck

Why Are There Different Types of Coasts?

Coasts – all the land near the sea, including beach and land just inland

- can be rocky, mountainous or broad, gentle plains
- can be erosional, depositional, drowned, or emergent



Why Are There Different Types of Coasts?

Erosional Coasts

Common where **bays** are separated by irregular rocky **headlands** jutting out into the ocean

- *Coastal straightening* will occur, with wave erosion of headlands and wave deposition of sediments in bays
- *Sea Cliffs* – steep cliffs that retreat inland due to wave erosion of headlands

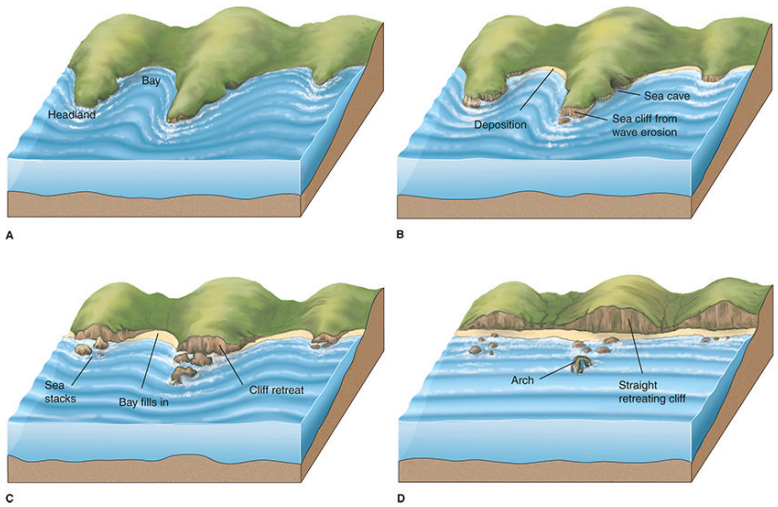


Photo by David McGeary

Why Are There Different Types of Coasts?

Erosional Coasts

- *Wave-cut platform (terraces)* – horizontal bench of rock formed by wave erosion beneath the surf zone.
- *Stacks*- erosional remnants of headlands
- *Sea arches* – bridges of rock left above openings eroded into headlands or stacks.

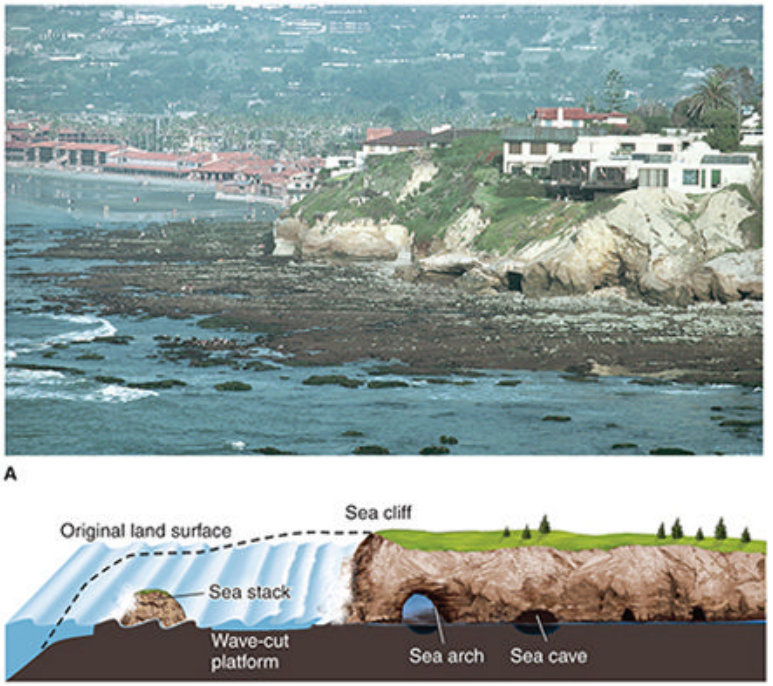


Photo by David McGeary

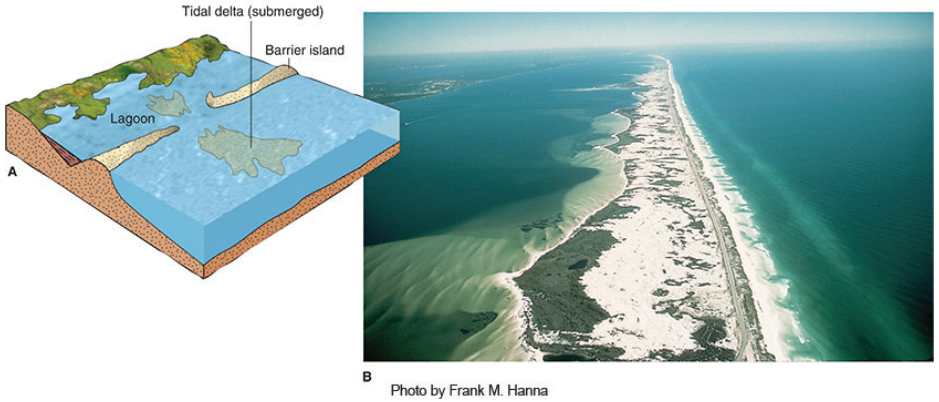
Sea walls are sometimes constructed to protect retreating shorelines, but eventually are undermined by the wave energy they reflect toward their bases

Why Are There Different Types of Coasts?

Depositional coasts – typically exhibit gently sloping plains showing few effects of erosion; shaped primarily by sediment deposition, particularly by longshore drift

•**Barrier islands** – ridges of sand that parallel the shore, are common on depositional coasts

- protected lagoons separate barrier islands from the mainland
- barrier islands are **dynamic**, with rapid erosion and deposition in various areas
- heavy population on some barrier islands has led *to* ***property loss*** from rapid, localized erosion



Why Are There Different Types of Coasts?

Drowned (submergent) Coasts

– common today because sea level has been rising for 15,000 years since end of last ice age. Average sea-level during the Pleistocene was 130 meters lower than today.

Estuaries – (drowned river mouths) and **fiords** (drowned glacially cut valleys) common along coastlines today

- quiet waters of estuaries rich in marine life
- cities and factories have badly polluted some estuaries

EROS Center, U.S. Geological Survey

Why Are There Different Types of Coasts?

Uplifted (Emergent) Coasts –
elevated by deep-seated tectonic forces

- uplift has occurred more rapidly than rise in sea level
- **uplifted marine terraces** (originally formed just offshore from the beach face) are exposed along the tectonically active western coast of North America

Photo by David McGeary

The Biosphere and Coasts

- Mangroves
- Coral and algal reefs
  - Provide protection and sediment for beaches

End of Chapter 14