Beaches, Shorelines and the Coast
Different kinds of beaches

They differ by the amount of energy, which results in either Erosion or Deposition

and also by where they form and whether they are

- wave-dominated
- tidal-dominated
- river-dominated
- current-dominated,
High energy

Erosion

Fig. 11-4, p. 249
Low energy

Deposition
Types of Coastlines

- Ria coast
- Fiord coast
- Barrier-island coast
- Delta coast
- Volcano coast (left)
- Coral-reef coast (right)
- Fault coast
Sydney Harbor
Australia
A drowned river system
A fjord, Alaska
Glacially eroded beach in Maine
An actively growing coastline, Hawaii
A collapsed caldera
Hawaii
A mangrove swamp
A Birdfoot Delta
Ganges-Brahmaputra Delta
Great Barrier Reef
Australia
Coral reef coastline in Florida
Transitional: Reef & Lagoon
In 1990, 50% of the U.S. population lived within 75 km of a coast.

By 2010, 75% of the U.S. population will live within 75 km of a coast.
What about changes in sea level?

*glacial/interglacial timescale*

Increase of ~120 meters
Florida coast during the last glacial maximum

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Florida coast after global warming
Tectonic uplift
Marine Terraces
Marine Terraces in California
Waves
Motion of water in a wave is circular

Motion of energy of the wave is forward
Frequency: Number of wave crests passing point A or point B each second

Period: Time required for wave crest at point A to reach point B

Direction of wave motion

Still water level

Crest

Wavelength

Trough

Height

Orbital path of individual water molecule at water surface
\[ y(t) = A \cdot \sin(\omega t + \theta) \]

\[ k = \frac{\omega}{c} = \frac{2\pi f}{c} = \frac{2\pi}{\lambda} \]
Waves are defined by their wavelength (L)

<table>
<thead>
<tr>
<th>Wave Type</th>
<th>Disturbing Force</th>
<th>Restoring Force</th>
<th>Typical Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capillary wave</td>
<td>Usually wind</td>
<td>Cohesion of water molecules</td>
<td>Up to 1.73 cm (0.68 in.)</td>
</tr>
<tr>
<td>Wind wave</td>
<td>Wind over ocean</td>
<td>Gravity</td>
<td>60–150 m (200–500 ft)</td>
</tr>
<tr>
<td>Seiche</td>
<td>Change in atmospheric pressure,</td>
<td>Gravity</td>
<td>Large, variable; a function</td>
</tr>
<tr>
<td>Seismic sea wave (tsunami)</td>
<td>Faulting of seafloor, volcanic eruption, landslide</td>
<td>Gravity</td>
<td>of ocean basin size</td>
</tr>
<tr>
<td>Tide</td>
<td>Gravitational attraction, rotation of</td>
<td>Gravity</td>
<td>Half Earth’s circumference</td>
</tr>
<tr>
<td></td>
<td>Earth</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Waves have are produced by a disturbing force and dissipated by a restoring force.

Table 9-1, p. 202
Waves may also be classified by defined by their frequency ($f$)
Bigger waves move faster and tend to group together (dispersion)

You will see the big waves from a storm first
Waves as tall as 36 ft are common
Coastal Erosion
Coastal Erosion

• Erosion is caused by the abrasive action of moving sand & gravel
  – Tectonics, rock type & land surface processes contribute to shaping a coast
  – Hydraulic pressure of breaking waves is a large contributor to mechanical erosion
Coastal Erosion

• Sea caves, arches, and stacks develop as refracted waves attack the coast
  – Refracted waves focus energy on headland sides
  – Zones of bedrock weakness allow preferential erosion
  – Caves form, evolve into arches and stacks
(a) Features of an erosional coast at low tide.
(b) Sea stacks off the coast of Australia. The large stack on the left fell in July 2005.
Coastal Erosion

• Sea cliffs & wave-cut platforms
  – Sea cliffs are produced by undercutting
    • Cliff retreats over time as cliff face collapses
    • Waves erode & remove debris
  – Wave-cut platforms develop
    • Flat surface commonly visible at low tide
    • Widening platform protects cliff
  – Beaches may develop on wide platforms
Wave erosion of a sea cliff produces a shelflike, wave-cut platform visible at low tide.
(d) A sea cliff and wave-cut platform.
Wave Refraction

• Waves are bent as a portion slows
  – Waves drag on the bottom & slow
  – Shoreline is uneven, some deeper areas
  – Wave is bent, becomes parallel to shore
  – Wave energy is:
    • concentrated on headlands
    • dissipated in bays
Selective erosion of the headlands tends to straighten a coast.
Highest point of the beach – where waves reach at high tide
Backshore
Windblown dunes, some vegetation
Foreshore
Active zone of the beach
Longshore troughs and bars
Below low tide;
Formed by waves, backwash and longshore currents
Beaches are temporary and can change with the seasons.
Wintertime beach
After Winter there is little sand left on the beach.

Wintertime storms remove sand from the beach and deposit offshore.

Calm conditions in the late Spring and Summer build up sand on the beach.
Coastal Deposition

- Shoreline systems receive sediment from a variety of sources
Coastal Deposition

• Shoreline systems receive sediment from a variety of sources
  – Much is land derived, river transported
Coastal Deposition

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  - Moved by longshore drift
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Coastal Deposition

- Shoreline systems receive sediment from a variety of sources
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  - Deposited in low energy areas
  - Shell and coral debris is common in tropical regions
Coastal Deposition

• Beaches
  – Shore built of unconsolidated sediments, usually sand sized particles
  – Shape & size of beach dependent on wave energy
  – Beach slope is often a function of particle size, coarser = steeper beach face
Longshore Drift

• One of the most important shoreline processes

• Occurs when waves hit the shore at angles other than 90°
  – Breakers push material up the beach at an angle
  – Backwash pulls material down perpendicular to shore
Geometry of longshore drift
Longshore Drift

• Repetition of this process moves material parallel to beach face
  – Beach drift & longshore currents are generated creating longshore drift
  – Large volumes of sand may move
  – Rip currents develop when large volumes of water accumulate onshore
Geometry of longshore drift

(a) A longshore current moves sediment along the shoreline between the surf zone and the upper limit of wave action.
(a) A longshore current moves sediment along the shoreline between the surf zone and the upper limit of wave action.

(b) 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 upcurrent sides. This view is toward the south, and south of the groins, on the downcurrent sides, sand is eroded.
General features of coastal cells. Sand is introduced by rivers, transported southward by the longshore drift, and trapped within the nearshore heads of submarine canyons.
Coastal cells in southern California. The yellow arrows show sand flowing toward the submarine canyons (shown in red).
Coastal Deposition

• **Spits**
  – Form by longshore drift of sediment
  – Extend across mouth of bays & estuaries

• **Tombolos**
  – Outward built beach connecting to an island
  – Island refracts waves away from beach
Longshore drift creates spits
Spits can create more beach
Coastal Deposition

• **Barrier islands**
  – *Offshore islands parallel to shoreline*
  – Common on gently sloping coasts
  – Separated from mainland by a lagoon
  – **Islands** may **migrate** by
    • Longshore drift parallel to coast
    • Toward/away from the coast by sea level change
Note about local geology

• The Rims around Billings are thought to have been formed in a barrier island dominated coast, so the next few slides show the kind of environment that existed here about 80 million years ago......
  • And now exists along the Texas coast in the Gulf of Mexico
Fig. 11-17, p. 257

Barrier islands

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Transitional: Barrier Islands
Cape Hatteras and the Chesapeake Bay
Barrier Islands change rapidly
Ocean City, Maryland, a developed barrier island. Host to 8 million visitors a year, this city (and others similarly situated) has no effective protection against flooding and damage from severe storms.
(a) The beach extending along the Matagorda Peninsula (Texas) barrier in September 1960.

(b) The same area 6 days after the passage of Hurricane Carla in September 1961. The beach and island have been breached, and washover deltas are clearly seen.

(c) Ocean City, Maryland, a developed barrier island. Host to 8 million visitors a year, this city (and others similarly situated) has no effective protection against flooding and damage from severe storms.
(a) Groin
Groins are structures that extend from the beach into the water. They help counter erosion by dissipating wave energy and by 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.

(b) Seawall
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 both the seawalls and the protected property.

(c) Importing sand
Importing sand to a beach is considered the best response to erosion. The new sand is often 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.
Fig. 9-29b, p. 222

TSUNAMI HAZARD ZONE

IN CASE OF EARTHQUAKE, GO TO HIGH GROUND OR INLAND
The Effect of the Wind on Land

18.23 Eye on the Landscape Dust storm A cloud of fine dust sweeps across this savanna plain in eastern Kenya. What else would the geographer see? ...Answers at the end of the chapter.
Aeolian crossbedding in rivers and deserts (aeolian)
Cross Beds
Zion National Park, UT