Surface processes: Defending our beaches

Coastal population

85% of U.S. population is in the 30 coastal states. Half of these live in coastal counties.
Sculpting a coastline

Controlling factors:
1. Tectonic setting
2. Geological materials and their supply
3. Energy: wave and tidal processes

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U.S. tectonics

Passive margin
Active margin

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Vertical movement

**Earthquakes:**
Prince William Sound was uplifted 3 m by the 1964 Alaskan earthquake.

**Loading and unloading**
The weight of the Mississippi delta is causing gradual subsidence.
Scandinavia is rebounding from the ice age at 2 cm/yr.

Tides – Moon

The Earth rotates while the tidal bulge remains fixed.
Tides – Moon and Sun

When sun and moon aligned the tides are strongest: spring tides.

Neap tides are when the attraction of the sun and moon are perpendicular.

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Sediments

The coastline is a major depositional environment

We’ll return to the sediment balance...

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Wave action

Wave refraction

Refraction:
Wave crests bent toward the coastline.
Refraction around a headland

This process acts to straighten coastlines.
Longshore drift and current
Barrier islands

The sediment budget

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediments eroded from backshore cliffs by waves</td>
<td>Sediments transported to backshore dunes by offshore winds</td>
</tr>
<tr>
<td>Sediments eroded from upcurrent beach by longshore drift and current</td>
<td>Sediments transported downcurrent by longshore drift and current</td>
</tr>
<tr>
<td>Sediments brought in by rivers</td>
<td>Sediments transported to deep water by tidal currents and waves</td>
</tr>
</tbody>
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Dynamic process: changing one of the components will effect all the others...
Sediment loss

Westhampton, NY
Beach level dropped 4 m

Fire Island, NY

Coastal “stabilization”
Sand replenishment

Sand lost from beaches is replaced by pumping sand from offshore or trucking it to the beach.

Miami beach, FL
- 10 miles by 300 ft replaced in 1970s
- Cost: $65 mill

Ocean City, NY
- $5.2 mill to replenish beach in 1982
- Lasted 2 ½ month!

...a temporary solution
Coastal “stabilization”
Groins and jetties

Obstacles perpendicular to shore to slow longshore drift
• Deposition “upstream” of groin/jetty
• Erosion “downstream” due to sediment starvation

Miami, FL
...problems can be passed along

Coastal “stabilization”
Seawalls and breakwaters

FIGURE 9.22
Hard stabilization of a shoreline: seawalls and breakwaters. A. Structures such as seawalls and breakwaters are built parallel to the shoreline to intercept the force of the waves. B. Breakwaters constructed offshore from Tel Aviv, Israel, protect the beach zone from incoming waves. Sediment builds up behind each breakwater, creating a scalloped coastline. Meanwhile wave action at the base of such structures can hasten erosion and erode the beach on the ocean side.

...a temporary solution
Coastal “stabilization”
Cliff erosion

Walls or boulders (rip rap) used to protect cliff.
But, erosion continues around barrier.

El Granada, CA

...a temporary solution

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Storms

High water + strong currents = rapid coastal erosion

Hurricane Gorges takes homes of the Florida Keys

Beach level dropped 4 m in one storm in Westhampton, NY

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Sea level change

Sea level is on the rise...

- 1 ft per century due to continued melting of polar ice since the last ice age
- 1 ft vertically means 10s to 100s m horizontally

Increases in greenhouse gases will increase the rate at which polar ice melts.
Some estimates suggest a sea level rise of 1 m by 2100.

Coastal erosion can only get worse...