Exam 2, Q34 Anthropogenic Climate

Where Sea Meets Land - Coastlines and Beaches

Coasts

Beaches

Reading:

5th Ed., Ch 12 Secs 2-9, 11, 13-14, 16-19, 30-34

Ch 6 Sec 20

6th Ed. Sec. 10.1-10.7, 10.15-10.19, 12.1-12.20, 12.28-12.30

Graphic: Beachfront property along North Carolina's outer banks following a Noreaster. Photographer, R.B.Mieremet, NOAA Senior Advisor. Courtesy of NOAA.

The Dynamic Coastline

Coasts are regions of constant and sometimes rapid change

39% of world population - within 100 km of a coast

25% of US population would be flooded by a 10 meter rise in sea level

Graphics: Underwater archaeological sites, wave-cut terraces, aerial view of the south end of Sapelo Island, Georgia. Courtesy of Sapelo Island National Estuarine Research Reserve.

Characteristics of Coasts – Global Influences

The <u>location of a coast depends on sea level</u>, which changes through time

- **global tectonic activity (are sea floors flat, or are there massive mid-ocean ridges?)**

- **volume of water in the ocean (how much water is stored on land in ice sheets? how warm are the oceans?**

Graphic: Garrison, Fig.12.2.

Characteristics of Coasts – Regional Influences

The <u>shape of a coast</u> depends on:

- uplift and subsidence due to the local effects of plate tectonic motion

- erosion

- can "fill in" coastal regions as material is moved from the land

- can reshape the coast due to coastal erosion

- redistribution of material in the coastal zone by sediment transport

Graphic: The coast of northern California, courtey of NASA.

U.S. Coasts

<u>Pacific Coast:</u>

Beaches interrupted by rocky headlands

Rivers are the main source of sand

<u>Atlantic Coast:</u>

Deep sediments offshore are the main source of sand

<u>Gulf Coast:</u>

Less wave energy and small tidal range

Large deltas and barrier islands

Graphic: Top: Otter Crest, Oregon Coast. Rear Adm. H.D. Nygren, photographer. Courtesy of NOAA. Bottom: Coast along the Gulf of Mexico, Florida. M.Folson, photographer. Courtesy of NOAA.

Processes that modify the coast

- Waves and currents

- Freeze/thaw

- Stream erosion

- Slumping

- Abrasion of wind-driven particles

Graphic: Islands eroded by waves, Garrison, 4th Ed., Fig. 12.12, pg 297, 5th Ed., Fig. 12.4, pg 279.

Waves provide much of the energy to modify the coast

Parts of a Wave

<u>Crest</u> -highest part of the wave

<u>Trough</u> - lowest part of the wave

<u>Wavelength</u> - distance between adjacent crests

<u>Wave height</u> -vertical distance from the trough to the crest

<u>Frequency</u> - number of wave crests passing by in a second

<u>Period</u> - time needed for the wave to move a distance of one wavelength

Graphic: Garrison, Fig. 10.2.

Deep vs Shallow Water Waves

<u>Shallow water waves:</u>

- elliptical orbits reach the bottom and flatten

- waves loose much energy due to friction (contact) with the bottom

Graphic: See Garrison, Fig. 10.6.

Deep water waves transport energy, not mass

In Shallow Water, Wave Energy Moves Mass

In shallow water, friction slows the bottom of the wave, but wave crests are not slowed as much

As the wave crests move ahead of the bottom of the wave, the wave curls or spills over and breaks

Wave breaking can move large amounts of material, such as sand

Graphics: Aerial view of the south end of Sapelo Island, Georgia. Courtesy of Sapelo Island National Estuarine Research Reserve.

Plunging and Spilling Breakers

Plunging breakers

- Hollow tube formed between the falling crest and the foot of the wave

- Form over steeply sloping bottoms

Spilling breakers:

- Breaking crest spills over the foot of the wave

- Form over gently sloping bottoms

Top: See Garrison, Fig. 10.18.

Features of a Beach

The shape of a beach is affected by alongshore and cross-shelf sediment transport

- Bars: underwater deposits, parallel to shoreline

- Beach scarp: steepest part of beach face

- Dunes: onshore sand deposits (if vegetated, can stabilize beach)

Graphic: Garrison, Fig. 12.14.

Seasonal Changes in Beach Shape

Changes in onshore-offshore sediment transport from summer to winter can change the shape of the beach

Summer (top photo) – gentle waves move sand from offshore bars onto the beach, building the beach

Winter (bottom photo) – stronger winter storm waves erode sand from the beach

Graphic: Garrison, Fig. 12.15.

Sediment Transport via Longshore Drift

Sand moves along

beaches within the surf

zone due to wave action

Graphic: (top) Garrison, Fig. 12.16,

(bottom) impact of longshore transport

on a coastal zone, see Garrison,

Fig. 12.16b, (animations)

Along-Shore Drift – An Example

Sand accumulates "upstream" of the barrier

Sand is depleted and erosion is accelerated "downstream" of the barrier

Graphic: Jetties at the entrance to the Port Mansfield Channel, Texas. M. Beaver, Photography Plus, photographer. Courtesy of NOAA.

(animations)

Waves Straighten Shorelines Over Time

Refraction causes wave energy to:

- converge on headlands

- diverge in bays

This tends to straighten shorelines over time

Graphic: Garrison Fig. 12.5.   (animation)

Coastal Erosion

- hardness and resistance of rock

- wave action

- local range of tides

FEMA: 25% of structures within 500 ft of coast will fall victim to erosion within 60 years

Costs to property owners: $530 million per year

Graphic: Coastal developments, Impact of erosion, Garrison, Fig. 12.38.

Depositional Coasts

- **Usually composed of sand (not rock)**
- **Waves, currents and tides shape depositional coasts by transporting sand**
- **Less energy is needed to move smaller particles – fine-grained shorelines are more easily changed than shorelines with larger particles**

Graphic: Garrison, Fig. 12.12.

Waves and Currents Shape Depositional Shorelines by Moving Sediment

Along-shore drift – moves sand along the shore due to ocean waves and currents

Cross-shore drift – moves sand between the beach and offshore zone due to the action of waves and tides

Graphic: Aerial view of the south end of Sapelo Island, Georgia. Courtesy of Sapelo Island National Estuarine Research Reserve.

Wave Refraction at the Shore

If waves approach shore from an angle:

- the part of the wave closest to the shore will slow down due to friction with the bottom

- the part of the wave offshore will maintain its speed

Waves bend to become more parallel to the shore

Graphic: Garrison, Fig. 10.19.

Processes that Shape Erosional Coasts

Shaped by the removal of material from the coast by the action of streams, wind-driven grit, freeze and thaw cycles, plant roots, glacial activity, soil motion, …

Graphic: Glacial fjords, courtesy of NASA visible Earth, formation of a new coast via volcanism.

Barrier Islands -

Vulnerable to Erosion

Graphics: Garrison, Figs. 12.23c, 12.22, 12.21

Land and Sea: Lower Mississippi Delta

Coastal regions and wetlands protect inland regions from hurricanes by:

- absorbing storm surge

- **separating inland regions from the sea**

Erosion removes this zone of separation, leaving inland areas vulnerable

Land loss in the Miss. River delta is estimated at 2 acres per hour

Graphic: (top) Mississippi River Delta, courtesy of NASA, (bottom) close up of a bird foot delta, courtesy of NOAA., see Garrison Fig. 12.24.

Sea Level Rise,
Coastal Erosion and Climate Change

According to all IPCC climate change scenarios, sea level will rise in the coming decades

- a small change in sea level, coupled with increases in storms can require expensive erosion-control strategies

- a small change in sea level can flood large areas in relatively flat regions

Graphics: (top) Courtesy of NOAA, (bottom) Courtesy of Maine.gov

Shore Stabilization Strategies can be "Hard" or "Soft"

Hard: Riprap - irregular rocky structures are placed over surfaces that are susceptible to erosion. These structures absorb or reflect wave energy

Soft: Vegetation and wind fences reduce beach erosion by reducing movement of sand

Graphic: Top: Riprap erosion mitigation structure, Baltimore Harbor. M. Hollinger (NODC), photographer

Bottom: Wind fences, Tybee Island Georgia. W.Folsom, photographer.

Courtesy of NOAA.

Shoreline Stabilization

Other strategies for stabilizing coasts and beaches include:

Groins - walls perpendicular to the shore reduce along-shore drift

Seawalls - "armoring" the shore

Sand replenishment – importing sand from elsewhere and placing it on the beach

Mechanical Energy from the Ocean