

Sea level and Climate

Lower Sea-Level

expansions of ice sheets at expense of sea level
great quantities of water locked up in glaciers.

Today there are two main ice sheets:

- 1) Greenland; and
- 2) **Antarctica** - contains 3/4 of the worlds' freshwater
changes in Antarctica critical to sea level.

During the Ice Age ice sheets grew and contracted depending on climate:

glacial maxima at 18,000; 75,000; and 130,000 years.

glacial maxima at 18,000 years.
water contained within ice sheets
sea level 120 m lower
exposed the continental shelf

Global Warming and Sea-level Rise

As ice melted (Maximum ~18,000 years), sea level began to rise
Sea-level is rising about 2mm/year.
important for shoreline erosion and planning.

Predicted that temperatures will rise over next century - CO₂ rise.

Burning of fossil fuels for 200 years increases input of CO₂.

Greenhouse effect - increased CO₂ levels absorb invisible infrared rays and reflect heat back to earth.

Project Temp increase of 1.5 - 4.5° for mid 21 century.
Result - global sea level rise of 70 cm.

Can cause rise in sea-level due to:

- 1) increased melting of ice;
- 2) increase in ocean volume due to thermal expansion.

What Causes Climatic Changes?

changes in Earth's relationship with sun caused these oscillations.

Variations in Earth's orbit control incoming solar radiation - **Insolation**.
affects amount and duration of sunlight at Earth's poles.

Milankovitch (1941) - minor variations in earth's orbit controlled insolation variations;
occur with distinct beat of 21,000, 41,000, and 100,000 years.

1) **Tilt** of Earth's axis of rotation.

Earth's axis of rotation inclined (tilted) relative to plane of sun. angle of tilt oscillates through time - periodicity of ~ **41,000 years**.

Controls timing of maximum sunlight and solar heating at poles.

tilt varies by a few degrees from the present 23.5° (21.5° - 24.5°). shallow tilt - more snow can accumulate as sun's rays strike less of the polar regions in the winter.
steep tilt - more of the polar snow melts in summer.

2) **Eccentricity**:

Earth's orbit slightly elliptical varying from 0 - 6% eccentricity at **100,000 year** cycles. 100,000 years for Earth's orbit to change from circular to slightly more elliptical.

A more elliptical orbit puts the earth further away from the sun's heat during the summer; not all the previous winter's ice can melt.

3) **Precession, or wobble**:

fastest of the cycles. Earth's axis wobbles; moves through a conical path every **21,000 - 23,000** years. Depending on how wobble moves polar regions during summer and winter, the precession cycle can cause the earth to receive either more or less sunlight on its icecaps.

Beaches

Beaches form where:

- land and sea meet
- sediment is available
- site available for sediment accumulation

33% of North American shorelines have beaches.

Best developed beaches:

low-lying coasts - large quantities of sediment available.

Geometry of beaches

- long and narrow features
- barrier islands
 - continuous for hundreds of kilometers
 - broken by inlets

Atlantic and Gulf Coastal Plains

- relatively flat and slope seaward
- highest features - sand dunes; maximum 5-10 m.
- Lagoons separate barriers from land.

Sources of sediment

- 1) Rivers - locally derived material
- 2) Erosion of coasts
 - bedrock headlands
 - Wave-Cut Cliffs and Platforms
 - surf erodes base of coastal land.

cliff retreats.

- 3) Erosion/reworking of shallow marine deposits
landward movement of sediment

Processes

- 1) Tides

periodic changes in the elevation of the ocean surface
caused by gravitational attraction of earth and moon, and sun to
a lesser extent.
every 24 hours - 2 high and 2 low tides.

Spring tide - sun + moon in alignment; greater range

Neap tides - sun, moon - 90° out of alignment
offset each other
subdued tidal range

- 1a) Tidal effects

alternately expose and cover portions of the beach
inlets, estuaries, marshes.
flood and ebb tidal deltas

- 2) Winds

generally effective during storm conditions
modifies backbeach zones
produces a storm surge and water level changes
cause of property damage

- 3) Waves

undulations of the water surface;
derive their energy and motion from the wind.

characteristics: T-85

crests - top of wave separated by troughs.
wave height - vertical distance between trough and crest.
wavelength - horizontal distance separating successive crests.

water particles move in circular path.

When water is part of crest - moves forward.

When water is part of trough - moves backward.

Beneath surface, circular motion diminishes until depth = 1/2 the
wavelength - movement becomes negligible.

In deep water, wave size depends on

- 1) wind speed;
- 2) length of time the wind has blow; and
- 3) fetch - distance the wind has traveled across open water.

ocean breakers (**whitecaps**) gradually change to **swells**

lower and longer
carry a waves energy to distant shores.

Nearshore - wave feels bottom $\sim 1/2$ its wavelength.
water depth/wavelength $< 1/2$
Bottom friction slows advance.
speed and length of wave diminishes, wave grows higher.
steep wave front collapses - breaks.
Water advances up the shore.

Turbulent water created by breaking waves - surf.
swash and backwash.
considerable amounts of sediment placed in suspension and
later transported by currents.

storm waves - produce considerable erosion
suspend sediment
seaward movement of bars

4) Currents

originate by wind and wave action

Wave refraction - the bending of waves
waves move toward shore at angle.
bend and parallel to shore in shallower water
some vector component of energy is given off parallel

longshore currents
parallel to shore
transport large amounts of sediment

Due to refraction:

- 1) wave impact is concentrated against sides and ends of headlands projecting into the water; - headland eroded.
 - 2) wave attacks are weakened in bays - receive sediment (beaches).
- Over time, shoreline is straightened as headlands erode faster -T-87

beach drift
swash is oblique.
backwash perpendicular to beach.
zigzag pattern across beach transports sand and pebbles
hundreds of meters per day.

rip currents
where opposing longshore currents meet
move sediment offshore

Sediment moved by beach drift and longshore current can be large. At e.g. Sandy Hook, NJ, quantity of sand transported along shore over a 50-year period averaged 750,000 tons per year.

Morphology - shoreline-to-shallow-marine depositional system

foreshore

beach - portion above low tide line
dominated by swash and backwash

shoreface

lies below low tide level
day-to-day sand transport above fair weather wave base
5-15 m water

offshore zone

mud dominated
below wave base

Shoreline Features - longshore drift

Spits and Bars

Spits - elongated ridges of sand
project from the land into the mouth of an adjacent bay

e.g. Sandy Hook

baymouth bar - a sand bar that completely crosses a bay,
sealing it off from the open ocean.

Shoreline Erosion Problems

engineering approaches to protecting the beaches.

Jetties

development and maintenance of harbors.

usually built in pairs

extend into ocean at entrances to rivers and harbors.

keep sand in motion and prevent deposition in the channel.

produce changes in beach depending on longshore current.

Groins

constructed to maintain or widen beaches that are losing sand.

barrier built at a right angle to the beach

trap sand moving parallel to shore.

Result in irregular wider beach

stacking of sand on upcurrent side;

depletion of sand downcurrent.

Breakwaters

structures constructed parallel to shoreline to protect boats from
the force of large breaking waves

creating a quiet zone near the shore.

Reduced wave activity along behind the structure allows sand to accumulate.

marina fills in with sand; downstream beach erodes, retreats.

Seawalls

massive barriers preventing waves from reaching areas behind the wall.

Built to protect property from breaking waves.

Act to diminish force of waves.

Beach on seaward side of wall experiences significant erosion.

With reduced beach, wall is subject to intense pounding.

Beach Nourishment

The addition of large quantities of sand to the beach system.
very expensive.

e.g. 24 kms of Miami Beach-\$64 million dollars.

Does not last very long (Miami one of few exceptions).

Other alternative - let nature take its course!