G202 Notes - Oceans and Coasts

I. Oceans

A. Introduction

1. Oceans: Pacific, Atlantic, Indian, and Arctic
2. Seas, gulfs, bays- partially landlocked smaller bodies of water that are subdivisions of larger oceans
    a. Pacific Ocean- largest of all oceans, bordered by 5 of 7 major continents, occupies of 0.33% of earth's surface.
        (1) extends from Arctic to Antartic circles, but is largely in tropical latitudes.
    b. Atlantic Ocean- 0.5 of Pacific ocean area, shallower than Pacific
    c. Indian Ocean- 90% of which lies south of the equator
    d. Arctic Ocean- much shallower than rest, connected to Pacfic via Bering straights
    e. Antarctic Ocean- more or less contiguous with Atlantic, Arctic and Indian Oceans, not distinguishable.

B. Chemical Composition:

1. H_2O, and 3.5% total salts by weight: salts primarily in form of NaCl, as well as chlorides of Mg, S, Ca, and K.

    a. Salinity decreases in areas of heavy freshwater influx such as high ppt areas and river mouths.
    b. Salinity highest in areas of high evaporation rates, restricted arms of the ocean such as the Red Sea.

C. Temperature: temps decrease with increasing latitude, range from >80° F in equatorial regions to 28° in polar regions (28 degrees is average freezing point of sea water)

D. Density of Ocean Water: (mass/volume):
1. Density of seawater = function of salinity and temperature, in general > salinity, > density; < temperature, >density.
2. Thus deep, cold water has a higher density than light, warm water.

E. Movement of Ocean Waters:
1. ocean water mostly exists in liquid state, liquidity results in ocean water in constant state of motion.
2. Ocean water set in motion by numerous external forces:
    a. wind,
    b. crustal movements/earthquakes,
    c. gravitational influence of moon and sun.
    d. density and temperature contrasts

II. Tides:

A. What are tides?

1. diurnal, vertical fluctuation of sealevel under the influence of planetary gravity. Results in bulging of sealevel sytematically throughout the day, around the world.

2. tides set in motion by gravitational attraction of the moon and sun (heavenly bodies close and large enough respectively to influence force of gravity on earth).
   a. gravitational pull of sun and moon result in pulling at the ocean surface, causing it to bulge.

   b. Moon has most significan daily impact on tidal levels. Gravitational effectiveness of sun relative to the moon in 44%.

3. Normal tidal bulges: influenced by moon primarily, moon in line with equator, pulling bulge equatorially, low tides at top and bottom, hide tides at equator

   a. tidal bulge follows the moon as it orbits around earth
      (1) water facing the moon is drawn/bulged towards the moon,
      (2) side opposite moon is also bulged outward because the solid portion of the earth (facing the moon) is pulled away from the ocean on the side opposite the moon.

   b. at same time as tidal bulge, there are compensating low tides at 90 degrees to the bulge

   c. Entire effect is complicated by the earth's revolution from east to west, also coupled with moons revolution around earth: result in 2 complete tidal cycles every 24 hours and 50 minutes.
      (1) (i.e. 2 high and 2 low tides over each day

B. Spring Tides: sun and moon in alignement equatorially, result in highest tides possible, largest bulge at equator.

C. Neap Tides: sun aligned with equator, moon with poles, perpendicular to one another, results in lowest tides possible at equator.

D. Tidal Cycles: rising tide or flood tide occurs for 6 hr and 13 min, reaches high tide, then falling tide or ebb tide for 6 hr and 13 min, until low tide, happens twice each day about.

1. tidal range: vertical difference between high and low tide. Height of tidal range varies with configuration of coastline, from several feet to perhaps 50 feet, as the highest tidal fluctuation noted.

III. Currents: currents move water both horizontally and vertically.
   A. can be set in motion through temperature/salinity gradients, as well as shear force exerted by wind to produce surface currents.

   B. current paths can be influenced by oceanic configuration, continental shapes, seafloor topography, and the Coriolis effect (centrifugal force exerted by earth's rotation).

IV. Waves:
   A. Wind-driven, intimate link between atmosphere and hydrosphere

   B. wave energy is transmitted through water, in form of crests and troughs, water molecules are for most part not physically moved by waves, but serve to transmit energy, waves break onto continental shores as result of decreasing depth as the wave moves inland.

   C. Storm Surge - pile up of ocean water / wall of water generated by intense winds and ocean storms

V. Coastal Dynamics

   A. Beach and coastal areas represent sites of dynamic sedimentation, erosion and re-working of river-born sediments as they reach coastal regions

      1. Dynamic interaction between wind, waves, sedimentation and erosion
      2. Coastal areas noted for extremely variable meteorologic conditions
      3. Hurricanes and storms profoundly influence coastal morphology

         a. Wave energy and wind energy during coastal storms exhibit great capability to do work in the form of erosion and transportation of sediment

            (1) Eg. storm wash-over processes
            (2) storm surges
            (3) changes in coastal morphology via erosion and sedimentation

   B. The Ocean and Wave Activity

      1. Beach/coastal sand/sediment profoundly influenced by wave action
         a. waves provide motion/energy for transportation and erosion of sediment

      2. Waves generated by wind shear blowing across ocean surface for long distances
         a. shear creates orbital rotation of water to form water waves
            (1) orbital motion = circular to and fro motion, diminishing in intensity at depth from surface

            (2) Although the wave is passed through the water as a medium; actual water molecules are NOT displaced as the wave is propagated

      3. Wave Morphology

a. Wave crest: high upper peak of wave train
b. Wave trough: low separating two crests
c. Wave Height: vertical distance between crest and trough

(1) Avg. Wave Ht = 1 to 15 Feet
(2) Storm Waves up to 50 Ft wave height
(3) "Tsunami" = seismically induced water wave

(a) highest "tidal wave" recorded = 278 Ft off coast of Japan.

d. Wave Length: horizontal straight line distance between two crests or two troughs

(1) Avg. wave length = 130-1300 Ft

e. Wave Velocity: average 15-55 mi/hr

f. Wave base: depth at which the energy of the wave is totally dissipated in water
(1) Wave Base = 0.5 (Wavelength)

4. "Surf" Zone: zone along coastal area where waves overturn and "break" upon themselves

a. High energy water environment

b. Wave breaking occurs in response to shallowing of water depth as wave approaches beach
(1) As depth < wave base, wave "feels" bottom and wedges water upward

(a) "Breaker" a wave that is oversteepened to the point of the crest toppling forward (moving faster than main body of wave)

(b) "Surf Zone": coastal zone characterized by numerous breakers

C. Nearshore Circulation Processes

1. Wave Refraction: Tendancy of wave to become refracted as it reaches shore

a. net result is wave train becoming more parallel to shore
b. Wave Crests usually approach shore at some angle other than parallel.
(1) Results in sweeping of wave along coastal interface

2. Longshore Currents:

a. Current established as wave crest approaches beach at some angle to shore

b. Longshore Current: current forms parallel to shore as more and more waves refract in that direction

(1) Longshore currents can effectively transport large volumes of sediment along a shoreline (parallel to shore)

3. Rip-Currents

a. Narrow Currents that flow perpendicular to shoreline in a seaward direction (seaward return flow of water)_
b. Highest velocity at surface, dying out at depth
c. Effective seaward sediment transportation mechanism, moving sediment beyong beach zone onto shelf

D. Beach Morphology

1. Beach: strip of sediment (sand or gravel) that extends from low tide line to a zone of permanent vegetation inland (or rock cliff as applicable).

a. Beaches subject to breaking waves
b. Subject to tidal influences

2. Beach Subdivision

a. Foreshore: zone between mean high and low tide
(1) Beach Face: steepest inclination of beach exposed to wave action at high tide level

b. Marine Terrace: gently sloping platform seaward of the foreshore/beachface.
(1) Wave Built Terraces: constructed of wave sorted sediment

(2) Wave-Cut Terraces: rock benches erosionally cut by wave action

c. Backshore: upper portion of beach landward of high-tide water line

(1) Beach Berm: wave deposited platforms sloping gently landward

3. Beach Composition

a. Commonly sand

(1) Quartz sand beaches: quartz resistant to weatherin
(2) Black sand beaches:
(a) volcanic lithic fragments
(b) Heavy mineral "lags"

(3) Carbonate sand beaches in tropical areas

b. Gravel beaches
(1) imbricate "shingle" fabric to gravel orientations

4. Beach Climatic Cycles
a. Seasonal summer-winter cycles

(1) Winter: waves higher and of shorter wavelength

(a) storm waves common
(b) beach erosion high

(2) Summer: low height, longer wavelength waves

E. Longshore Drift and Coastal Morphology

1. "Longshore Drift": Longshore currents move sediment parallel to shore as waves strike shore at angle

2. Surf zone transport of sand and sediment
a. sand transported parallel to shoreline

3. Depositional Features

a. Spit: a "tail" or fingerlike ridge of sediment built by longshore drift off of a point of land, extending out into open water

b. Baymouth bar: ridge of sediment deposited so as to cut a bay off from the open ocean

(1) result of sediment migrating across the mouth of an open bay
(2) storm processes may be effective mechanisms for "closing" off bay inlets.

c. Tombolo: a bar of sediment connecting a former island to the mainland

(1) result of wave refraction around the island, converging on the landward side of the island forming a depositional bar built outward from the mainland.

d. Tied Island - island tied to mainland by tombolo

4. Beach Erosion Control

a. Jetties: rock walls built along each side of a bay or harbor mouth

b. Groins: rock walls (perpendicular to shore) used to form barriers to longshore drift and sediment erosion

c. Breakwater: energy dissipator built parallel to shore to lessen wave energy

(1) may create "slack water" areas behind breakwater and result in sediment infilling of the area.

VI. COASTAL GEOMORPHOLOGY

A. Coast Defined: marginal land area near sea

1. includes beach and strip of land inland from it

2. Coastal Character

a. Rocky to mountainous

(1) e.g. New England, Northern California

b. Broad, gently sloping sediment plains

(1) southeastern U.S.

B. Erosional Coasts

1. Wave erosion dominant process

a. wave action against rock, associated with both mechanical and chemical weathering and erosion

2. Headlands: protrusions of land/rock separated by irregular coastal bays

a. Tendancy for coastal straightening with time via the coastal/wave erosion process

3. Sea Cliffs: wave-cut erosion of headland areas

(1) Process: undercutting, stoping and slope retreat

(a) Sea Caves: stoped-out undercuts at the base of a cliff face via wave erosion

(2) Up to several feet of erosional retreat per year

4. Wave-cut Platform or Terrace: horizontal bench of rock formed beneath the surf zone as a coasts retreats by wave erosion

5. Sea Stacks: resistant erosional remnants left seaward as the coast retreats landward via erosion

6. Sea Arches: bridges of rock left above sea stacks, forming a arch via differential erosion

C. Depositional Coasts

1. Gently sloping coastal plains forming primarily as a result of sediment deposition

   a. much lower land gradients compared to erosional coasts
   b. sites of low-lying coastal wetlands, swamps and marshes

2. Barrier Islands: emergent ridges of sand formed parallel to the shoreline, forming off shore island "barriers" for wave activity relative to the shore proper

   a. Back Barrier Lagoons: slack or quiet water areas that lay between the seaward island and the land.
   b. Lee side barriers: high energy wave activity

   c. Tidal Inlets
      (1) Tidal currents erode channels through barrier island deposits

3. Deltas: accumulations of sediment formed by sediment-laden rivers emptying into standing bodies of water

   a. Influenced by
      (1) sediment supply
      (2) wave energy
      (3) tidal energy

D. Drowned Coastal Areas (i.e. "Submergent" coast lines)

1. Common presently as result of current interglacial period
   a. sea level has been rising over the past 10,000 years as glacial ice from the last ice age (Wisconsin) has melted

      (1) During glacial advance: much ocean water is locked up in ice via evaporation

         (a) net result: worldwide lowering of sea level
         (b) evidence that sea level may have been 300-600 Ft below its present level at various stages during the Pleistocene

      (2) During interglacial periods: ice melts and sea level rises

2. Estuaries: "drowned" river valleys
   a. lower reaches of river valleys inundated as sea level rises

3. Fjords: drowned or submerged glacial valleys

E. Tectonically Uplifted Coasts (Emergent Coasts)
1. Coastal areas elevated by tectonic forces
a. e.g. coast of central and southern California
b. Land areas uplifted relative to sea level
2. Principal Feature: Uplifted marine terraces

F. Organically Influenced Coasts
1. Marine Organisms can drastically influence coastal areas
2. Coral Reef Build-up
a. Carbonate sedimentation
b. Barrier Reef Complexes
(1) e.g. Great Barrier Reef of Eastern Australia

VII. Coastal Hazards

A. Global Warming / Melting of Ice Caps / Sea Level Rise
1. Coastal flooding / inundation of cities
a. majority of world's population lives in coastal areas

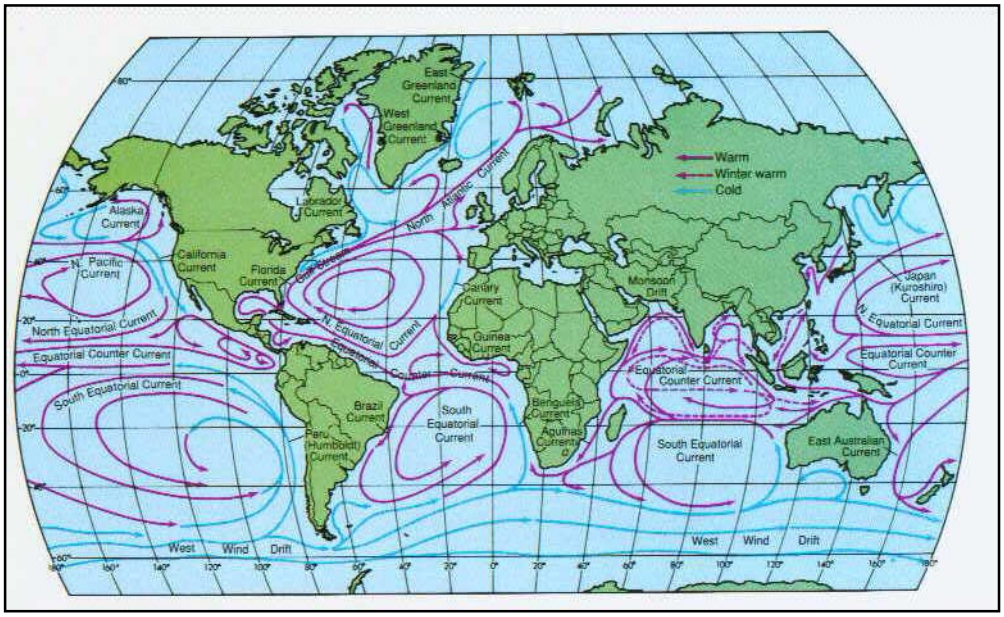
B. Coastal Erosion / Landsliding
1. wave erosion / undercutting
2. landsliding

C. Tsunami
1. seismic sea waves
2. tidal wave front / inundation

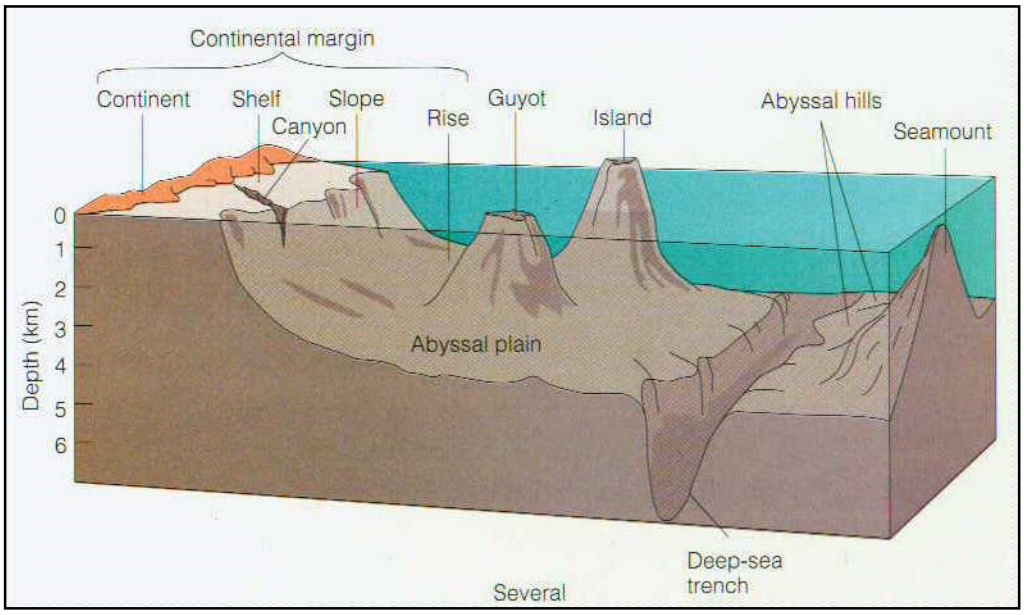
D. Hurricanes / storms
1. high winds / property damage
2. storm surge / beach erosion
3. high volume rains / coastal flooding

E. Land Development
1. ecosystem destruction
2. dune destabilization / erosion

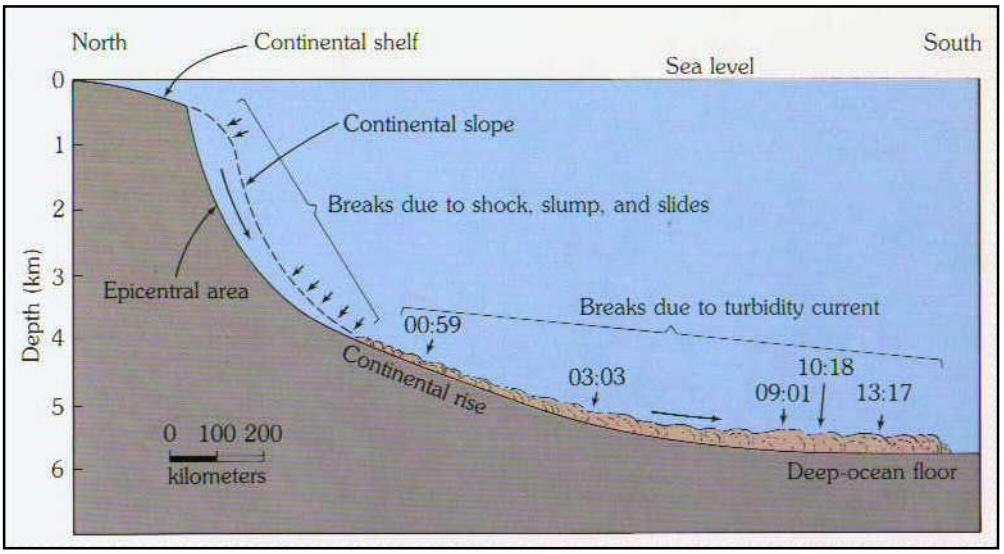
F. Water Resource Issues
1. Poor water quality associated with saline (salty) water
2. Salt water intrusion of fresh groundwater system
3. Wetland destruction / ecosystem decay
4. Overdevelopment



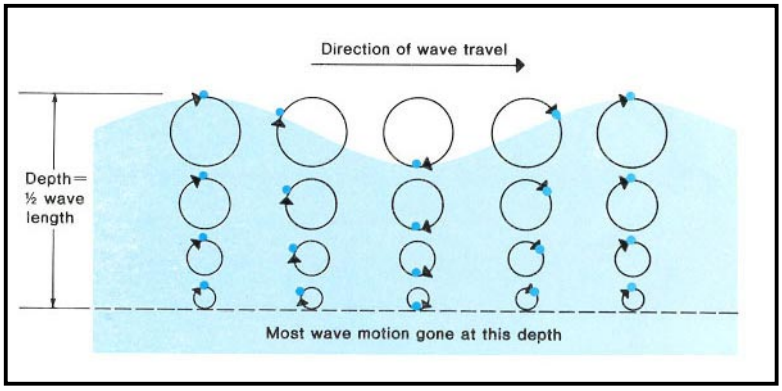
Global Ocean Circulation



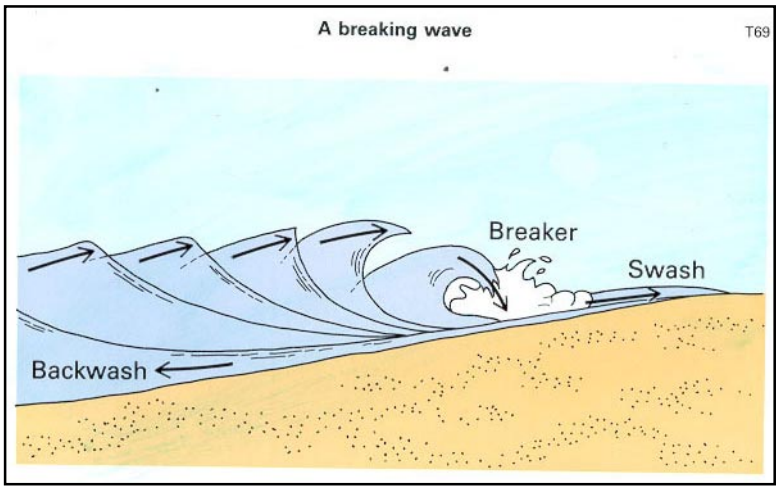
Marginal Marine Features



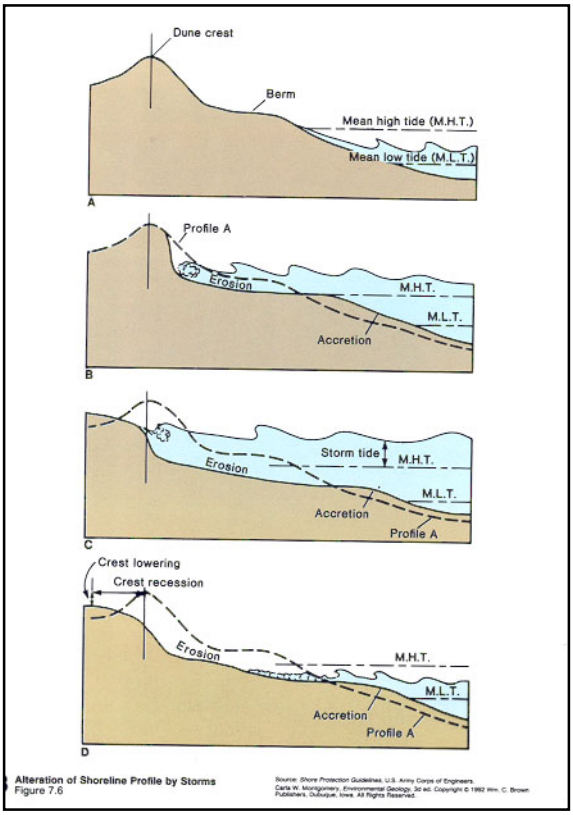
Offshore Profile



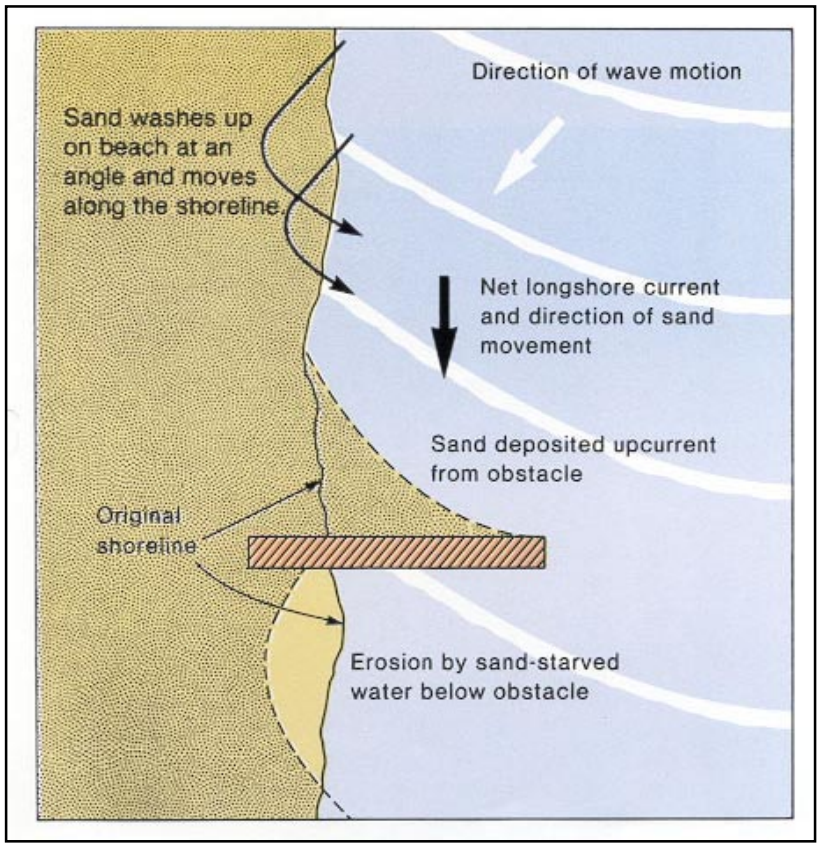
Oscillatory Nature of Waves



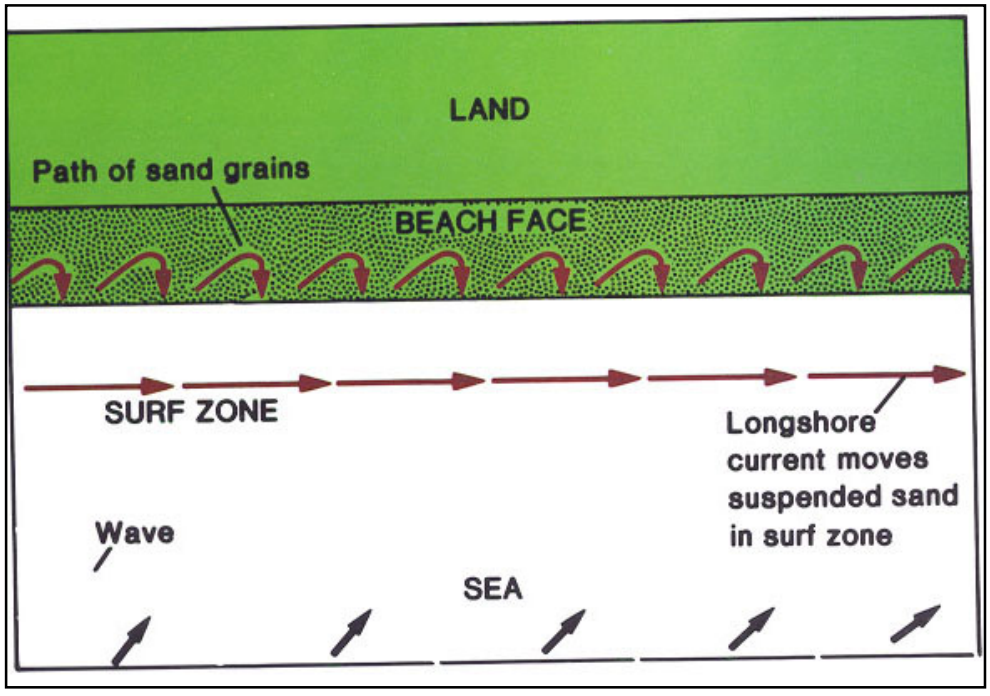
Surf Action of Breaking Waves



Storm Erosion / Wave Modification of Beach

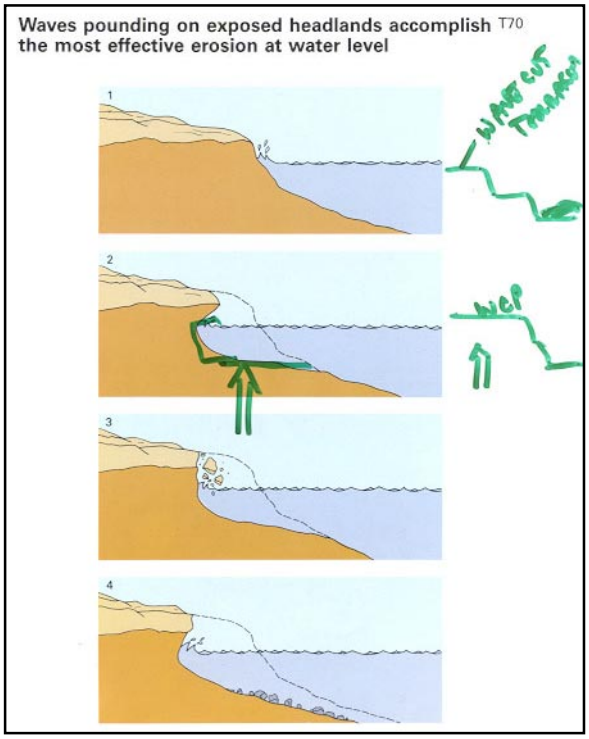


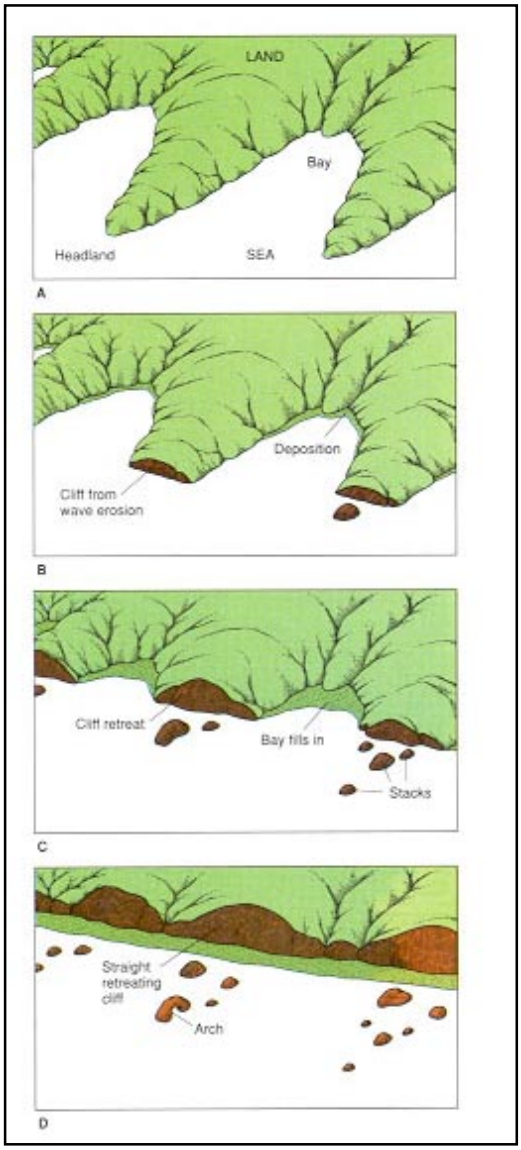
Erosion Control Methods

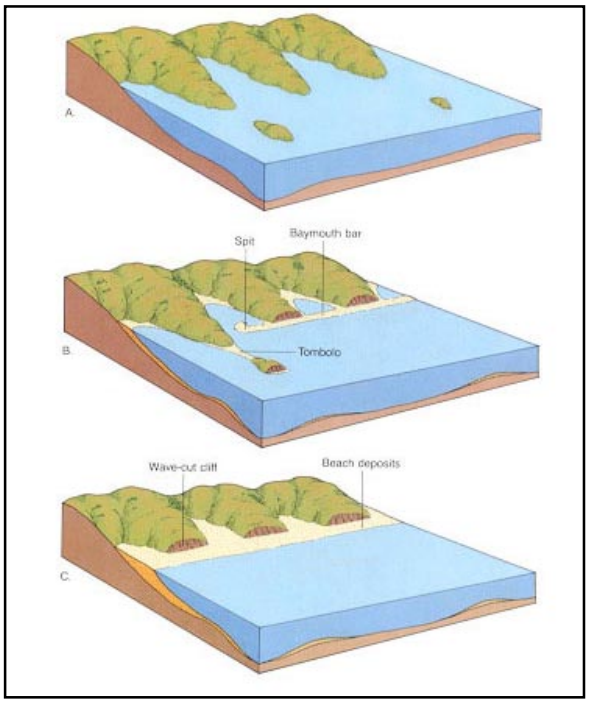


Longshore Currents / Sediment Transport

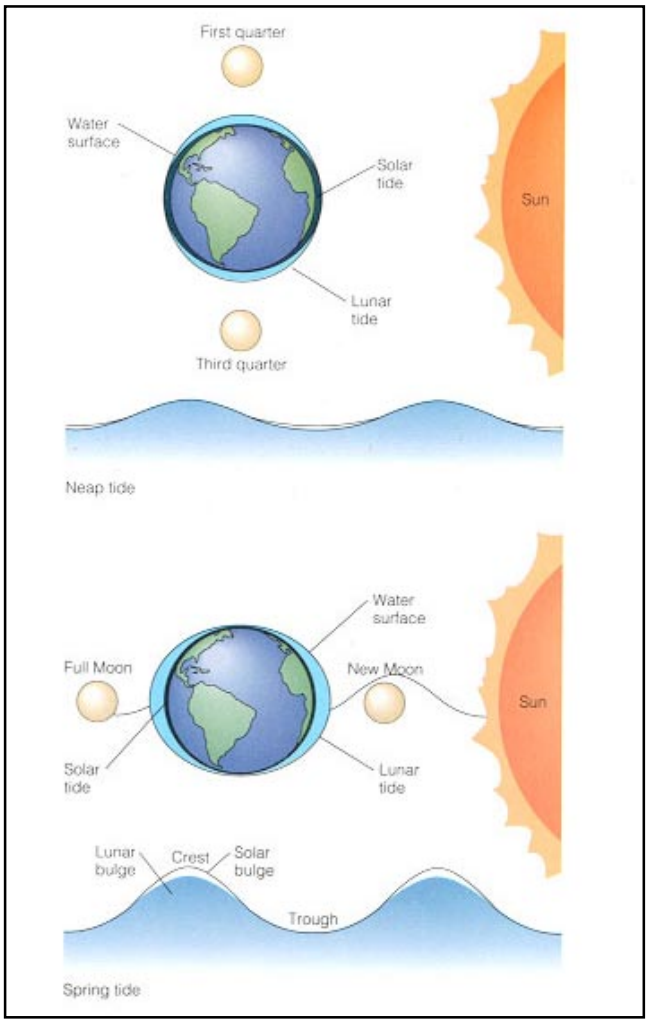
Coastal Erosion Processes in Rocky Headland Areas

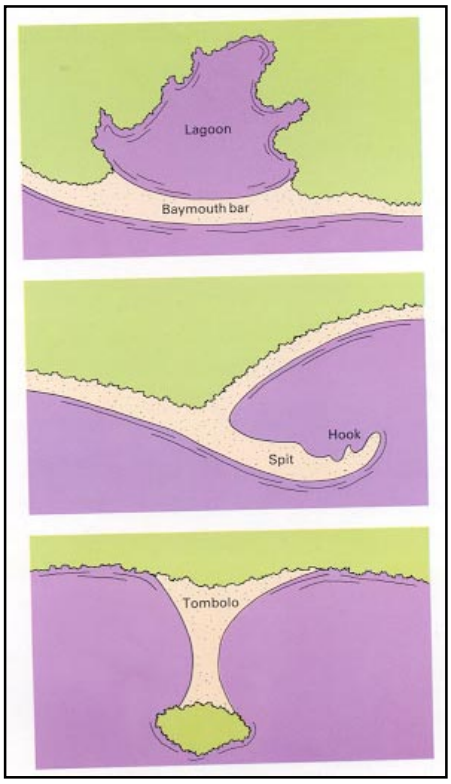


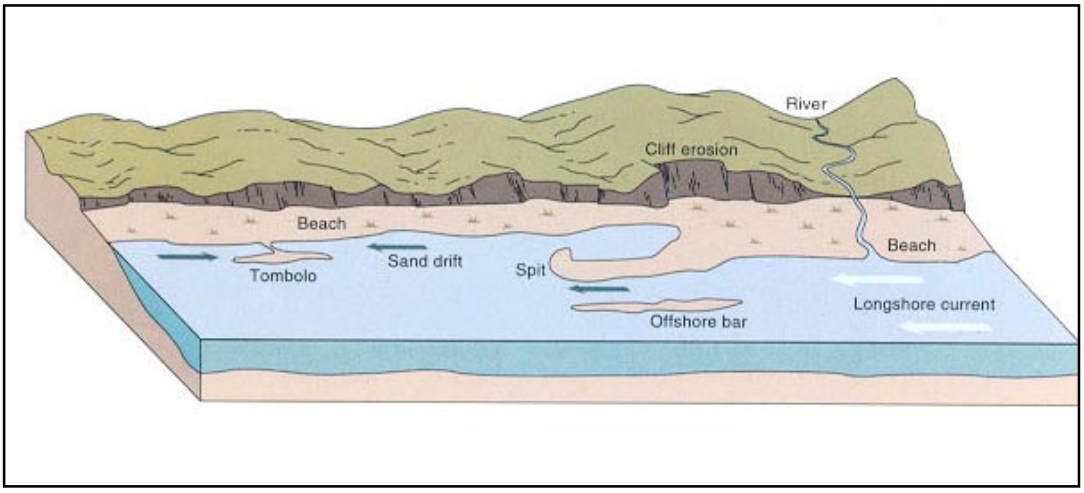




Tide Process







Sand Beach Landforms