ESCI 101 ~ Principles of Earth Science I

Syllabus
The Earth
Plate Tectonics
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The Rock Cycle
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Sediments
Sedimentary Rocks
Metamorphic Rocks
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Oceans & Coasts

Overview | Notes | Laboratory | Extras

Notes

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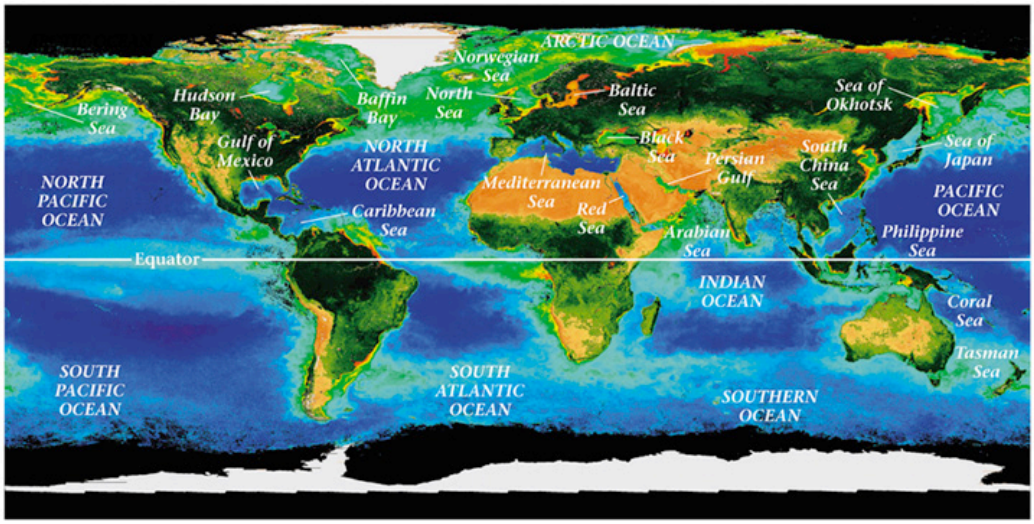
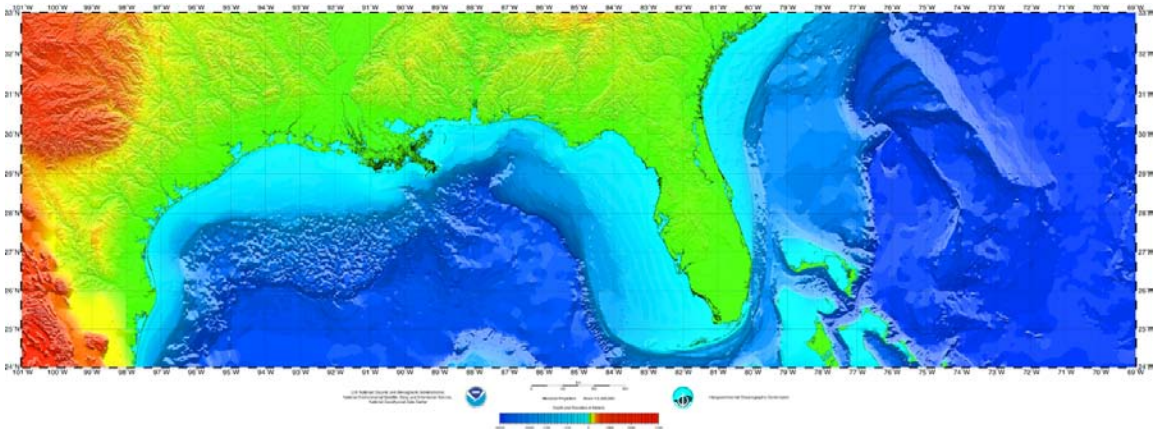
Landscapes Beneath the Sea - Ocean Water - Ocean Currents - Tides - Waves - Coastal Landforms

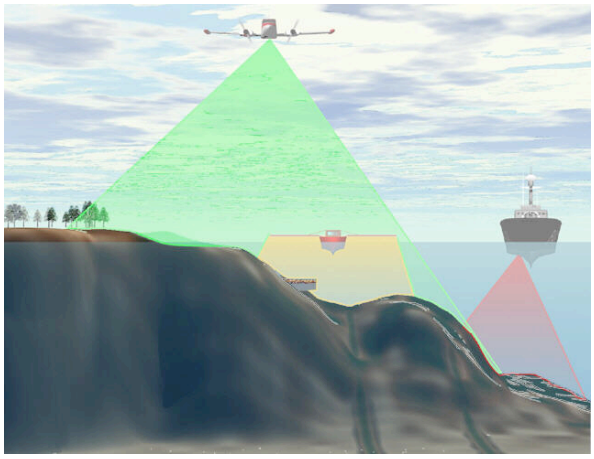


Oceans of the World

- **Landscapes Beneath the Sea**
  - **Bathymetry** - variation in depth of the ocean floor

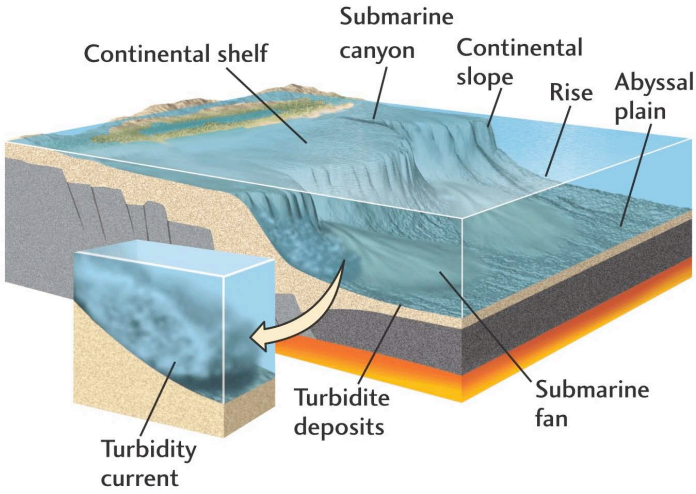


Bathymetry map of the SE U.S., colors represent different elevations.



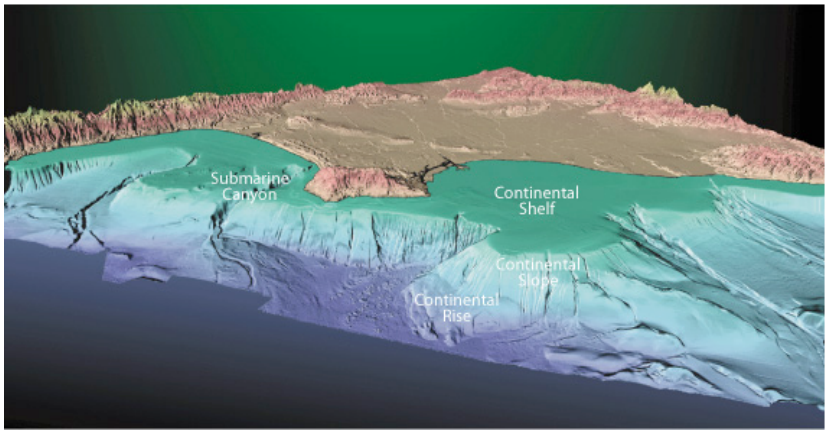
How bathymetric maps are made.

- **Continental Shelves** - a gently sloping submerged edge of the continent
  - Sand- and mud-covered platform
  - Water depth does not exceed 500 m
  - Fringes the continent



Parts of the ocean floor

- **Continental Slopes** - region of steep slopes between the continental shelf and the continental rise
  - Covered in mud
  - Cut by deep submarine canyons
- **Continental Rise** - a broad and gently sloping ramp that rises from an abyssal plain to the continental slope
  - Muddy and sandy sediment
  - 100's of kilometers wide

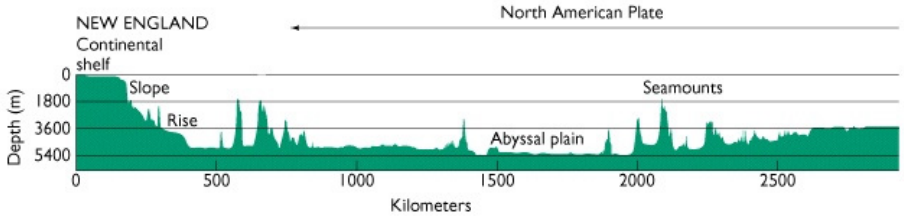


Depiction of the coast off of Los Angeles

- **Abyssal Plain** - a flat, sediment-covered province of the sea floor
  - Covered in microscopic plankton shells (which eventually could be transformed into oil) and mud, both of which settle out of suspension

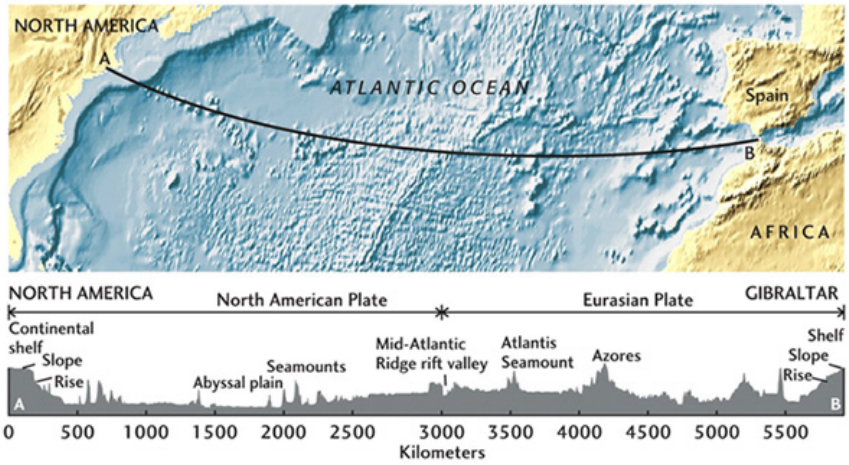
Nannoplankton found on the abyssal plain

  - 4,000 - 6,000 m below sea level
  - Broken by occasional submerged volcanoes (**seamounts**)



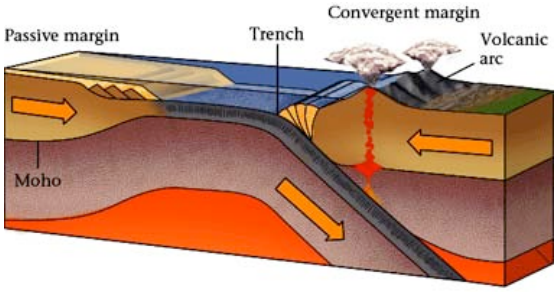
Seamounts

- **Mid-Ocean Ridge** - a series of mountains formed by volcanism at a plate rift
  - 2-km high submarine mountain belt



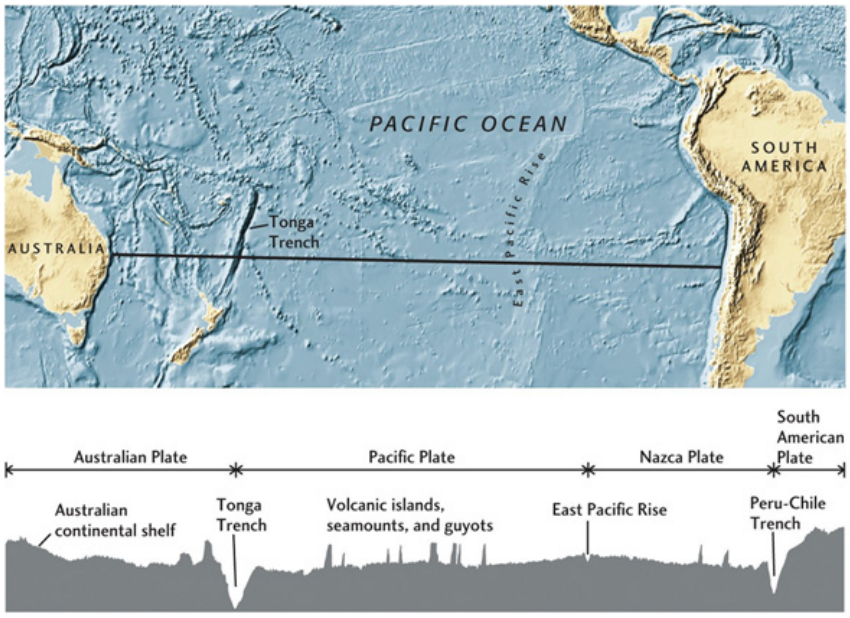
Atlantic Ocean - cut by the Mid-Atlantic Ridge, also depicts 2 passive margins - the East Coast of North America and the West Coast of Africa and Spain

- Plate Margin Types:
  - **Passive Continental Margin** - margins that are not plate boundaries and host few earthquakes
    - Broad continental shelves
    - Shelf formed from stretched continental crust that cools and sinks
    - Covered with sediment washed off the continent



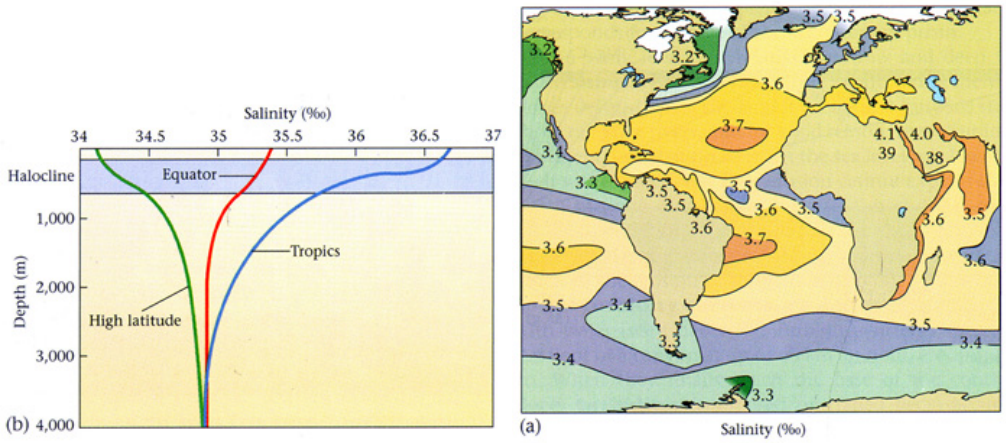
Passive and Active margin (convergent margin)

- **Active Continental Margin** - a margin that coincides with a plate boundary and hosts many earthquakes
  - Narrow continental shelves
  - Sediment from the continent spreads out over the accretionary prism (material scraped off the downgoing plate)
  - Steep descent to the sea floor - trench
  - > 8 km deep



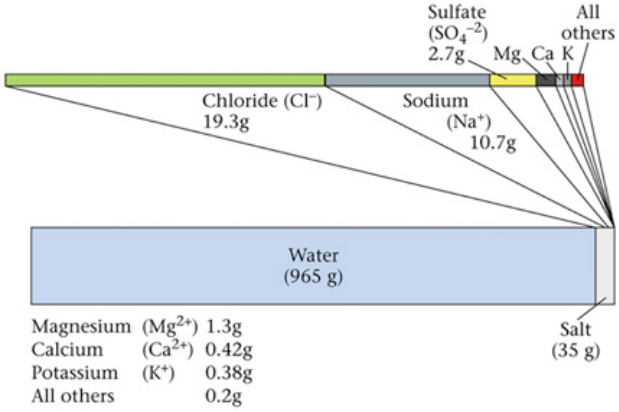
Map and cross depicts an active margin off the western coast of South America

- **Ocean Water**
  - Composition
    - **Salinity** - concentration of salt (Sodium (Na^+)) in water
      - 3.5 % dissolved salt ions (freshwater - 0.02%)
      - Increases water's density
        - Reason why you float higher in salt water than in freshwater
      - Not constant
        - Can be diluted by the input of freshwater from streams or melting glaciers
        - Can be concentrated by evaporation of water which leaves behind salt
      - Changes with depth



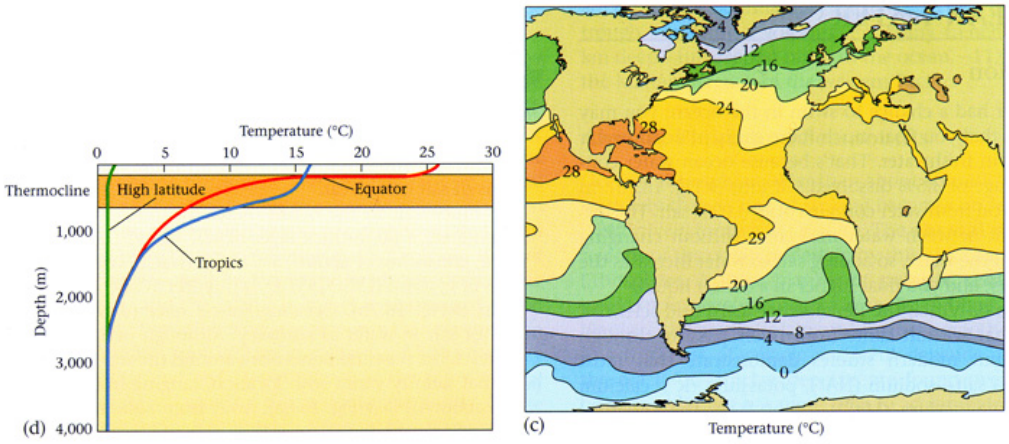
Salinity distribution graph (vertical salinity changes) and map (horizontal changes) of the oceanic water

- Other components
  - Potassium (K+), Calcium (Ca2+), and Magnesium (Mg2+) - from chemical weathering of rocks
  - Chloride (Cl-) and Sulfate (SO4-2) - from volcanic gases



Ocean Components

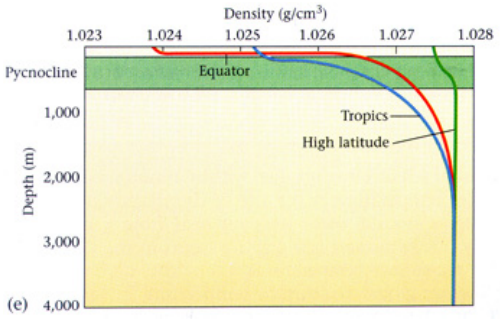
- Temperature
  - Average temperature 17 °C (62.6 °F)
  - Ranges from freezing to 35 °C (95 °F)
  - Varies with depth
  - Warm, less dense water floats on top of cold water
  - Water temperature decreases abruptly



Temperature distribution graph (vertical temperature changes) and map (horizontal changes) of the oceanic water

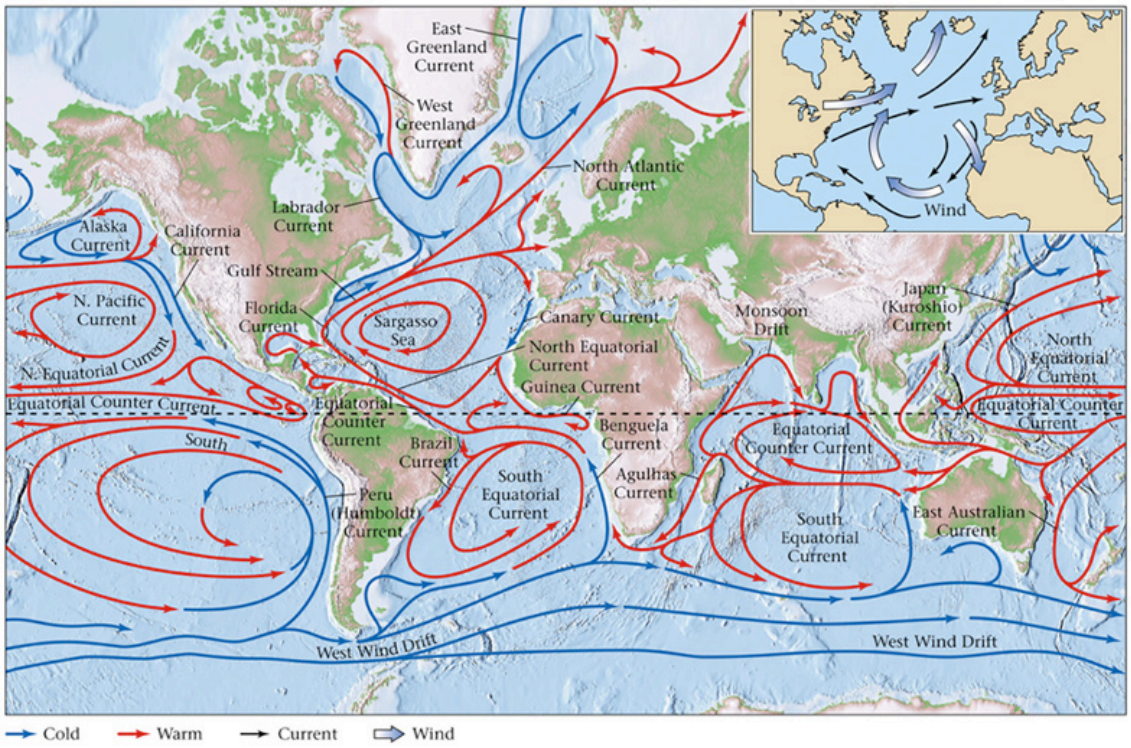
- Density
  - Both salinity and temperature affect density

- Average density 1.025 g/cm3 (freshwater - 1 g/cm3)
- Mostly controlled by salinity
- Density varies with depth



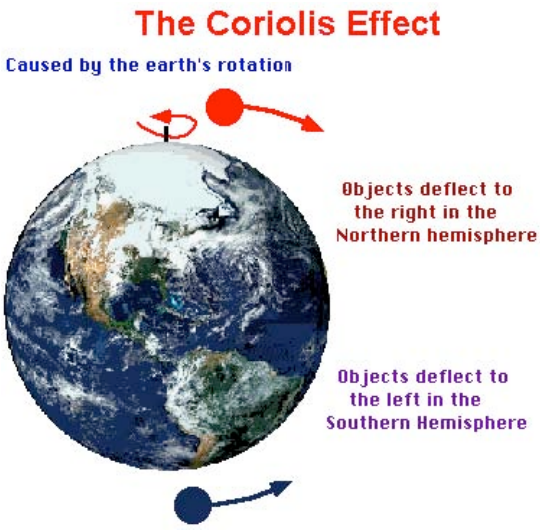
Density distribution graph (vertical density changes)

- **Ocean Currents**
  - 2 levels of currents:
    - **Surface currents** - affects the upper 100 m's
    - **Deep currents** - affects water at the bottom of the sea



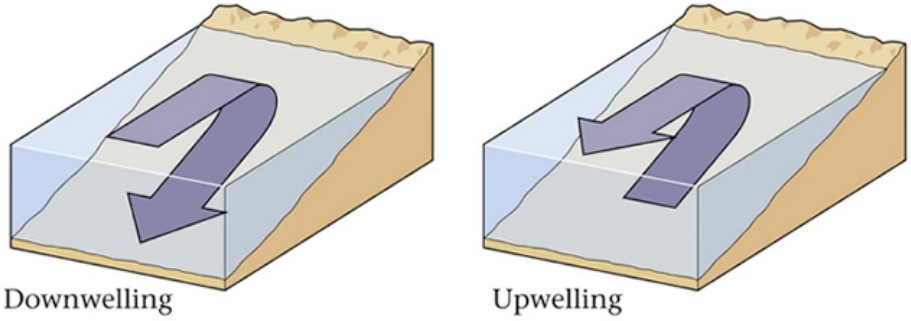
Ocean Currents

  - Surface currents:
    - Major surface currents result from the interaction between the sea surface and the wind
      - Air molecules shear across the surface of the water
      - Friction between air and water drags water along
      - Movement of water due to wind shear does not exactly parallel the movement of the wind
    -  Animation of global surface currents
    - Consequence of the Earth's rotation - creates the **Coriolis effect**
      - Causes surface currents in the Northern Hemisphere to veer toward the right and in the Southern Hemisphere to veer toward the left

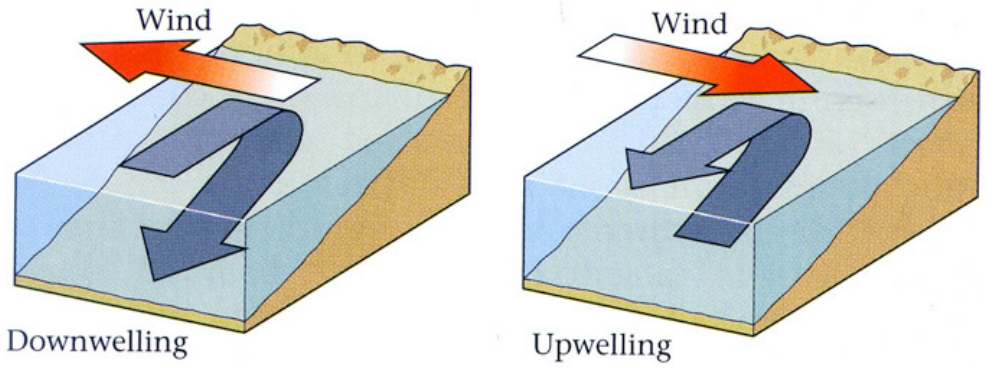


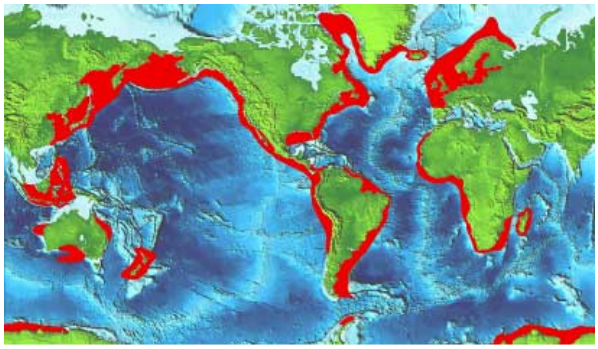
Coriolis Effect

- Deep Currents
  - Water also circulates in the vertical direction
    - **Downwelling zones** - where near-surface water sinks
    - **Upwelling zones** - places where deep water rises



  - Occurs along coastal regions because wind blows parallel to coastlines
    - Wind drags surface water along and the Coriolis effect causes water to deflect at an angle to the wind
      - Water moves towards the coast - too much water --> **downwelling**
      - Water moves away from the coast - too little water --> **upwelling**



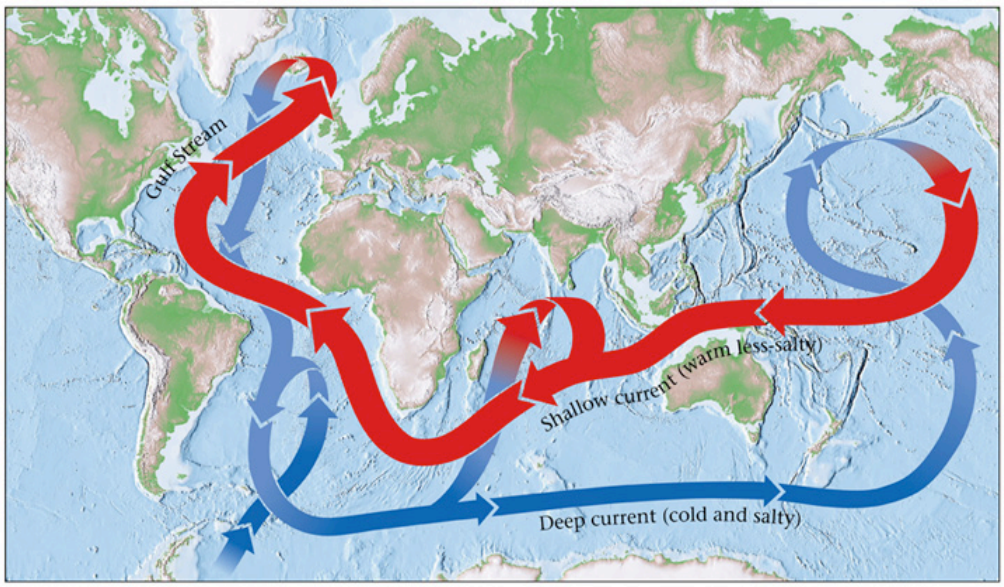


Zones of Upwelling

- Animation of upwellingnimation of upwelling

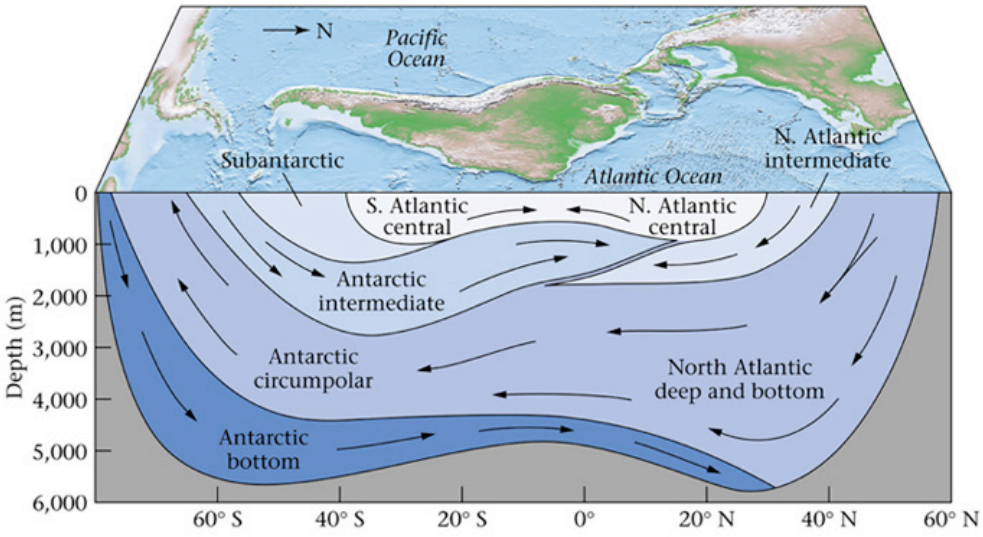
- Can also be driven by contrasts in water density - differences in temperature and salinity – **thermohaline currents**
  - Cold salty water tends to sink
  - Warm, less salty water rises

Thermohaline currents



Thermohaline currents including the warm Gulf Stream

- Variations in density (due to temperature) causes the oceans to be vertically stratified into moving **water masses**
- Water masses mix very slowly



Various water masses including the Antarctic bottom water and Antarctic circumpolar water

- **Tides**
  - **Tides** - cycles of regular rise and fall of the level of water in oceans
    - 2 cycles daily - 2 high tides and 2 low tides
    - **Tidal reach** - the difference in sea level between high and low tides

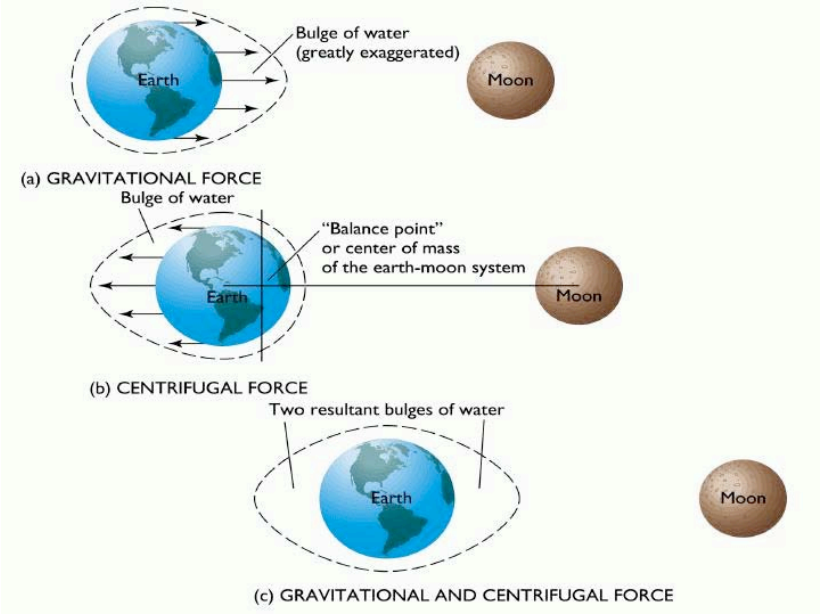
    - **Flood tides** - rising water, nearshore flooded
    - **Ebb tides** - decreasing water, nearshore draining seaward


Tides - ebb tide (upper picture) and flood tide (lower picture)

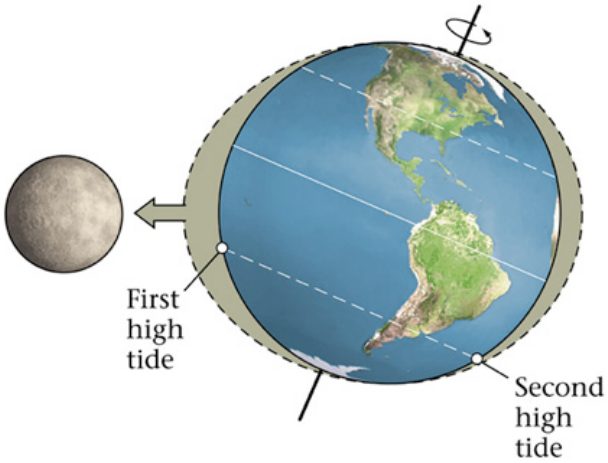
  - **Tidal Flat** - a broad, nearly horizontal surface covered and uncovered by the tides


Tidal Flat

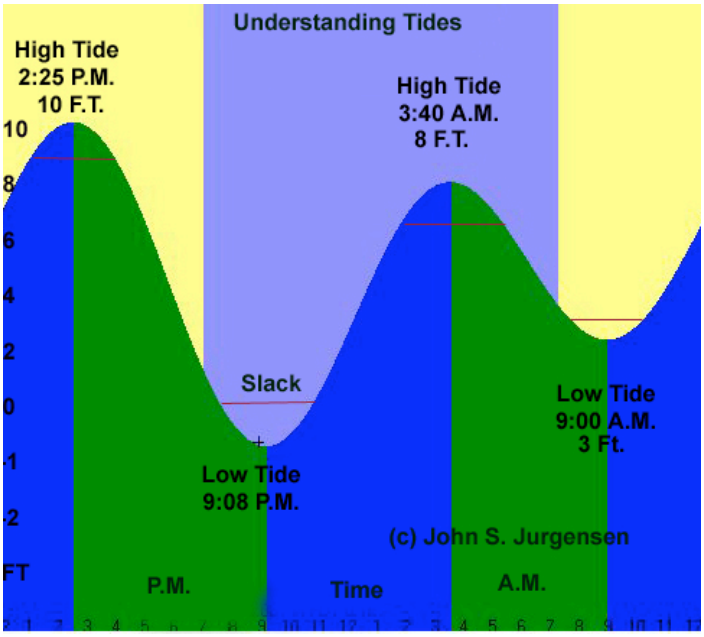
- Tide-generating force -
  - Gravitational attraction of the Moon (and Sun) causes water to bulge outward on the side nearest the moon
  - On the opposite side, inertia created by Earth's rotation causes ocean water to bulge outward in the opposite direction



  - 2 oceanic bulges
    - When a location lies under a bulge, it experiences a high tide - when it passes under a depression, it feels a low tide
    - Earth rotates, bulge remains stationary
    - Any given coastline will move westward through both bulges each day
    - Animation of gravitational attraction of the moon and how it produces tides

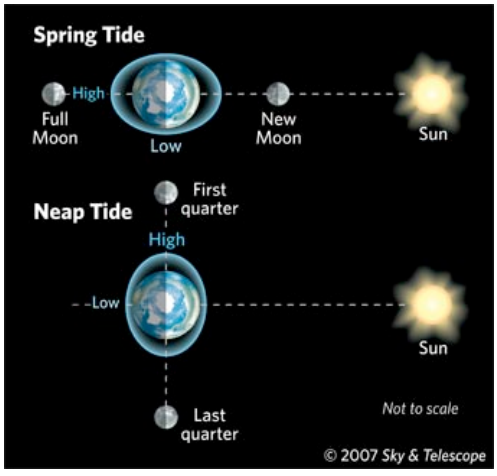


Tidal bulge



Reading tidal graphs - curve shows sea level height for one day and depicts the timing of high and low tides.

- Number of factors influence the timing and reach of tides:
  - Earth's tilt - 2 tides do not reach the same level (one is larger)
  - Moon's orbit - gravitational attraction between the Earth and Moon changes seasonally
  - Sun's gravity -
    - Sun and Moon are at right angles (quarter moon) - extra low tides (**Neap Tide**) -
      - Sun's attraction counteracts the Moon's
    - Sun is on the same side as the Moon (new moon or full moon) - extra high tides (**Spring Tide**) -
      - Sun's attraction adds to the Moon's



Special tides

- Basin shape - controls the tidal range:
  - Open ocean - 0.5 m tidal reach
  - Restricted basins (narrow inlets) - can be greater than 20 m (Bay of Fundy)

Go on to more notes on Oceans