Introduction to Marine Science

Unit 1
Lectures 1: Introduction to Marine Science
Lecture 2: Scientific Method
Lecture 3: History of Marine Science
Lecture 4: Marine Science Technology

Introduction to Marine Science

Lecture 1

What is Marine Science?

- Define:
  - Branch of Earth science that studies the ocean biome
  - Aka: Oceanography
  - It is an interdisciplinary science.
- Topics covered include:
  - Geological Oceanography-Plate Tectonics and Geology of Sea Floor
  - Chemical Oceanography-Density, Temperature, Pressure, Salinity
  - Physical Oceanography-Currents, waves, and tides
  - Biological Oceanography-Ocean Organisms and Ecosystems
  - Human-Use and Environmental issues that affect the ocean.

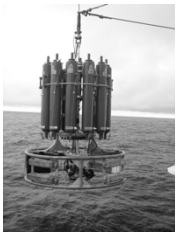
Branches of Marine Science

- Geological Oceanography (Marine Geology)
  - Studies the geology of the ocean floor (Bathymetry) including plate tectonics

Branches of Marine Science

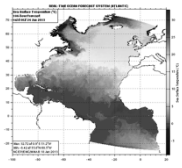
- Chemical Oceanography (Marine Chemistry)
  - Study of the chemistry of the ocean and its chemical interaction with the atmosphere.

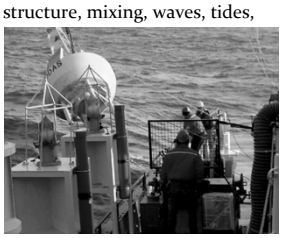
CTD Rosette is an instrument used by chemical oceanographers to measure conductivity, temperature, depth (pressure), fluorescence, dissolved oxygen, and other parameters, and water samples at various depths.



Branches of Marine Science

- Physical Oceanography (Marine Physics)
  - Studies the ocean's physical attributes including temperature-salinity structure, mixing, waves, tides, and currents.





Branches of Marine Science

- Biological Oceanography (Marine Biology)
  - Study of the plants, animals, and microbes of the oceans and their ecological interactions with the ocean.

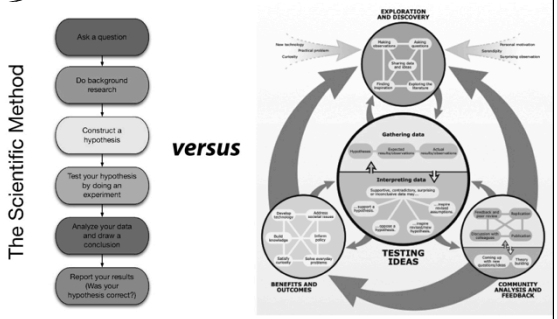
Are you excited to learn more about me and my friends and the environment in which we live?

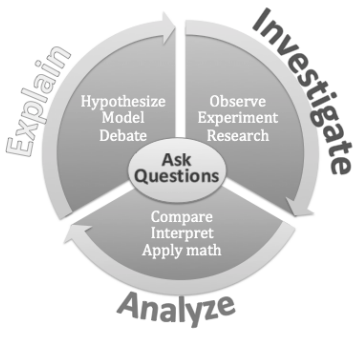
The Scientific Method

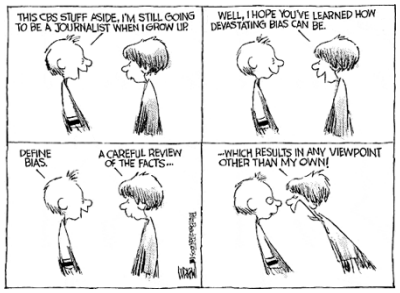
Lecture 2

Scientific Method

- Science-method used to learn about the universe
  - Must be based on observable and/or measurable evidence.
  - Science is NOT truth, but the best explanation available based on existing evidence.
  - Designed to guard against bias (opinions.)

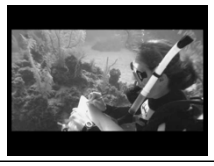






Scientific Method

- Objective-Question your are trying to answer
- Background-research the objective
- Hypothesis-an educated guess about the objective
  - Must be testable
  - "If _(I do this)___, then __(this)__ will happen because_____."



Examples:

- **If skin cancer is related to ultraviolet light , then *people with a high exposure to uv light will have a higher frequency of skin cancer.***
- ***If leaf color change is related to temperature , then exposing plants to low temperatures will result in changes in leaf color.***

Manipulated Variable vs. Responding Variable

Scientific Method

- Experiment-Procedure to test the hypothesis
  - Select the variables:
    - Manipulated Variable-What is being tested or manipulated in the experiment
    - Responding Variable-What is being measured or observed in the experiment.
    - Controlled Variables-things that are kept constant in the experiment

Scientific Method

- (2) Experimental Types:
  - Controlled
    - Experimental Group-treated with independent variable
    - Control Group-identical to the experimental group except for the independent variable.
  - Natural-no control group, based on observations taken from a natural system.

Scientific Method

- Data Analysis-Organizing data to make conclusions
  - Quantitative Data-based on numbers
  - Qualitative Data-based on observations
  - Data is commonly organized using tables and graphs
  - Data is usually interpreted using statistical analysis

Scientific Method

- Conclusion-determining whether the data supports the hypothesis
  - If no, then the hypothesis is rejected.
    - Knowledge is still gained
    - Hypothesis can be refined and tested again.
  - If yes, then experiment is repeated to confirm
    - If confirmed, then hypothesis can become a theory.
    - Theory-analytic structure designed to explain a set of observations.

Scientific Method

- Report Results, Procedures, and Conclusions
  - Important because allows other scientist to verify your work and to build on what you have learned.
  - These reports typically appear in scientific journals.

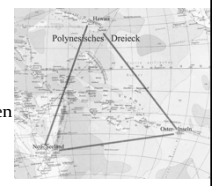
History of Marine Science

Lecture 3

Historical Marine Science

1. Ancient Explorations (5000BC-800AD)
   1. Egypt-first recorded sea voyage (3200 BC)
   2. Phoenicians
      1. Established first trade routes through Mediterranean Sea
      2. Use stars for navigation
   3. Polynesians-navigated through open ocean
   4. Greeks-developed complex maps including latitude and longitude system.

      *Viewed Earth and Round not Flat!



- Middle Ages (the "Dark Ages"; 800-1400AD)
  - Scientific discovery suppressed throughout Europe due to political views.
  - Vikings (790-1100AD)
    - Global Warming allowed for exploration and trade routes
    - Complex vessel design
  - Chinese
    - Invented the magnetic compass (1,000)
    - Vessels designed with central rudders and water tight compartments

- European Voyages of Discovery (1400-1700)
  - Vasco da Gama (1496-1424)-1st expedition around Cape of Good Hope to India~allowed for faster trade route.
  - Columbus (1469-1524)-discovered "new world"
  - Vespucci (1454-1512) 1st person to recognize South America as a continent unlike Columbus
    - "America" comes from his name.
  - Balboa (1500's)-1st person European to sail in the Pacific by crossing over the Panama
  - Magellan (1519)-1st to sail around the world.
  - Sir Francis Drake-2nd circumnavigation of the world

- Birth of Marine Science (1700-1900)
  - James Cook
    - 1st Scientific ocean expedition
    - Invented chronometer in 1735 (clock that works accurately on the ocean)
  - United States Exploring Expeditions (Wilkes Expedition)
    - Proved the existence of Antarctica
    - Gathered specimens of flora and fauna from Antarctica and throughout the Pacific
  - Matthew Maury
    - Published "Physical Geography of Sea"
    - Described global win and current patters, making sailing more efficient.

- Charles Darwin (1831)
  - Studied coral reef growth-coral grow upward
  - Proposed seafloor sinks
  - Proposed Theory of Natural Selection
- Challenger Expedition (1872)
  - Mapped the seafloor (discovered the Mid-Atlantic Ridge and the Marianas Trench)
  - Discovered organisms in deepest parts of the ocean
  - Cataloged 715 new genera and 4,717 new species

- 20th century Marine Science
  - German Meteor Expedition (1925)
    - Established pattern of ocean water circulation
    - Mapped the Atlantic seafloor
- Atlantis (1931)
  - 1st shipped designed exclusively for marine science
  - Confirmed the existence of the Mid-Atlantic Ridge
- Challenger II (1951)
  - Measured depths of Atlantic, Pacific, and Indian Oceans
  - Found the deepest known part of ocean (10,838 m) named the "Challenger Deep"

Marine Science Technology

Lecture 4

Marine Science Technology

- Submersibles and Self-Contained Diving
  - Advantage-handled delicate samples, direct observation
  - Submersibles:

1. Bathysphere:
   - Steel sphere
   - Oxygen circulated via umbilical to surface.
   - Movement restricted to up and down motion

Marine Science Technology

- Bathyscaphe:
  - Sphere attached to a large float almost like a blimp
  - No umbilical to surface; allowed for horizontal movement.
  - Deepest diving of all submersible

Bathysphere Trieste: Made it all the way down to the Challenger Deep at 10,900 m.

Marine Science Technology

- Deep-Diving Submersible (Modern Day)
  - Less fragile than others.
  - More maneuverable
  - Equipped with robotic arms
  - Cannot go as deep due to its acrylic sphere.

Marine Science Technology

- Self-Contained Diving
  - Hard-Hat Diving:
    - Air Supplied from surface through hose
    - Heavy and tied to surface

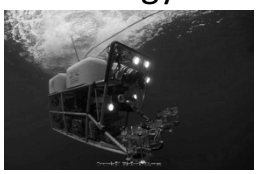
  - Fluess's Scuba
    - Recirculated pure oxygen in a tank
    - Can't be used deeper than 10 m due to pressure

Marine Science Technology

- Cousteau's Scuba:
  - Used compressed air
  - Allowed for deeper and longer dives; used by divers today
  - Light weight and easily used

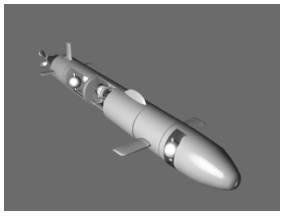
Marine Science Technology

- ROVs, AUVs, Electronic Navigation, and Satellites
  - ROV (Remote Operated Vehicle)
    - Small, unmanned sub
    - Video Camera
    - Umbilical Surface
    - Used to help find the Titanic wreckage in Atlantic



Marine Science Technology

- Autonomous Underwater Vehicle
  - Untethered robotic device
  - Can follow a pre-programmed path, no manpower is needed.
  - Used to collect data



Marine Science Technology

- Electronic Navigation
  - Sailors use to use stars for navigation
  - Long Range Navigation (LORAN)
    - Based on radio signal transmitters
    - Can determine your position with two signals
    - Accuracy to within a few meters
    - Not accurate when far from shore.
    - Method is being phased out due to advances in technology

Marine Science Technology

- Global Positioning System
  - Replacing LORAN
  - Based on system of orbiting satellites
  - Works Everywhere in ocean
  - Accuracy within 1-2 m

Unit 2: Geological Oceanograhy

Lectures 5-11

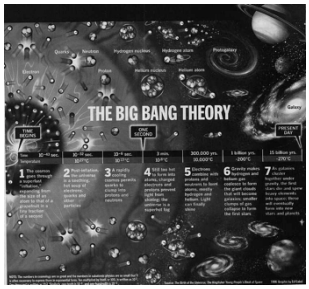
Formation of Earth

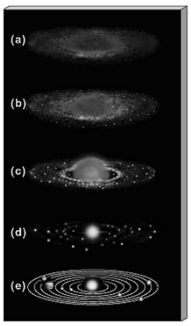
Lecture 5

Formation of Earth

- Big Bang Theory
  - 13.7 billion years ago all the matter in the universe began to expand from a single point
  - Expansion continues today and the universe is speeding up.
- Nebular Theory
  - The solar system formed from a nebula that started to spin because of a nearby supernova.
  - The sun formed from condensing gases at the center of this spinning nebula
  - Masses of gas orbiting the sun condensed and became planets.

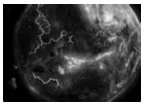
Formation of Earth



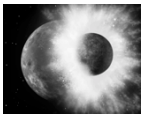


Formation of the Earth

- Formation of Earth
  - Accretion-process by which particles clump together because of gravity



- Orpheus Theory (Giant Impact Theory) -planet sized body struck the Earth during its development, sending some material into orbit, forming the moon.



Formation of Earth

- Density Stratification-heavy dense matter sank to center of Earth, lighter toward surface
  - Densest = Core
- Formation of atmosphere-Earth's crust formed when it cooled significantly
  - Led to formation of atmosphere
  - Formed from gases released by volcanic activity:
    - Water Vapor
    - Nitrogen
    - Carbon Dioxide

Formation of the Earth

- Oceans formed when the Earth cooled for rain to accumulate in the ocean basins.
- Oxygen formed in the atmosphere about 1.5 billion years ago (bya), when photosynthesizing organisms appeared.

Formation of the Earth

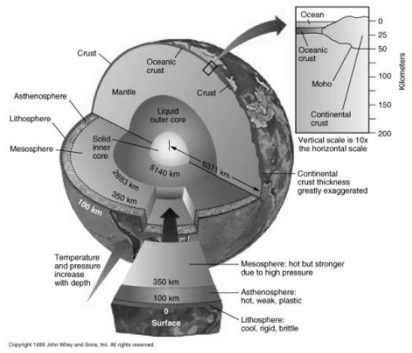
- Anatomy of Planet Earth
  - Inner Core-inner most layer
    - Densest
    - Composition-mostly iron and nickel
    - Temperature: 4,000-5,000 C
    - Remains solid because of high pressure
  - Outer Core-surrounds inner core.
    - Composition: mostly iron and nickel
    - Temperature: 3,200 C
    - Outer core is more fluid and rotates faster than the mantle.

Formation of the Earth

- Mantle-less dense, cooler layer outside the core; 70% of the Earth's volume.
  - Composition: Mg-Fe silicates (rocky)
  - Temperature: 1,100-3,200 C
  - The mantle is a solid, but ductile (it can move)
    - *Think of hot asphault!

Formation of the Earth

- Crust-outer-most layer
  - Asthenosphere-mechanically weak forming region of upper mantle
  - Lithosphere-includes crust and uppermost mantle, hard and rigid outer layer of the planet
  - Moho-boundary between the crust and the mantle
  - Continental crust: low density; averages 40 km thick; primarily granite-type rock (Na, K, Al, Si)
  - Oceanic crust: more dense, averages 7 km thick; primarily basalt-type rock (Fe, Mg, Ca)

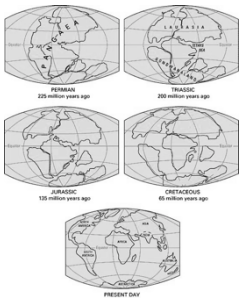


Continental Drift

- Theory of Continental Drift
  - Continental drift-movement of Earth's continents relative to each other.
  - Alfred Wegener proposed that continents were joined
    - Pangaea-original super-continent (250 mya)
    - Panthalassa-ocean that surrounded Pangaea
    - Pangaea eventually broke up into today's continents.

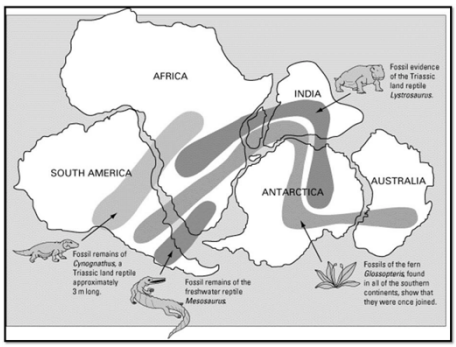
Continental Drift

- Wegener's Theory not accepted at first.
  - Wegener was a meteorologist, not a geologist. Not taken serious on ideas.
  - He also could not explain how continents move.



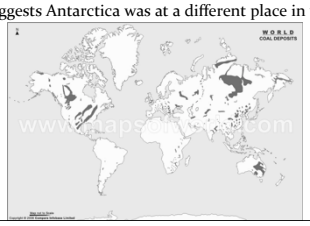
Continental Drift

- Evidence
  - Shapes of the continents fit together like a puzzle
  - Fossils-similar fossils found on adjacent continents
    - Mesosaurus (reptile) found in Brazil and South Africa
    - Lystrosaurus (reptile) found in S. America, Africa, and Antarctica
    - Glossopteris fern fossils found thru s. hemisphere
      - Seeds too heavy to travel by wind and too fragile to cross by sea.
      - Must have been on one continental land mass.



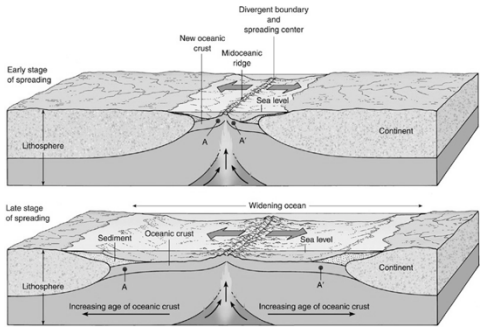
Continental Drift

- Evidence
  - Coal found in Antarctica
    - Coal only forms in tropical regions.
    - Suggests Antarctica was at a different place in the past.



Seafloor spreading

- Theory of Seafloor spreading
  - Seafloor Spreading-crust is created at mid-ocean ridges and is destroyed at trenches
    - Magma pushes up through rift valley of mid-ocean ridges and solidifies into new crust.
    - Seafloor is pushed away on either side of the ridge.
    - Old seafloor is pulled downward at trenches where it melts in asthenosphere.
    - Estimated to take 185-200 million year
    - Demo: http://emvc.geol.ucsb.edu/forteachers/flashmovies/Spreading.swf

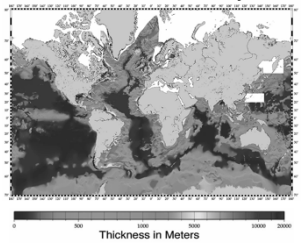


Seafloor Spreading

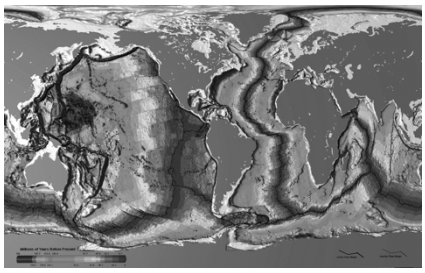
- Evidence
  - Sediment layers become thicker as you move away from ridge

Youngest Seafloor (near ridge) has accumulated less sediment.

Older seafloor (far from ridge) has accumulated thicker sediment layers



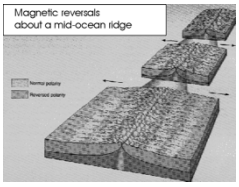
Seafloor Spreading



Age of Seafloor: Mid Atlantic Ridge and East Pacific Rise

Seafloor Spreading

- Evidence
  - Symmetrical pattern in magnetism of minerals on either side of crust
    - When new crust forms it records the polar orientation of the magnetic field at that time. (changes every 1,000 years)
    - Changes in magnetic field are recorded in the seafloor.



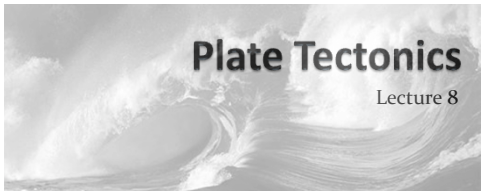


Plate Tectonics

- Theory of Plate Tectonics
  - Earth's lithosphere is divided into plates that move
  - Combines continental drift and seafloor spreading

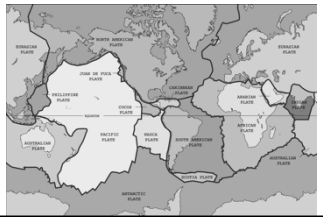
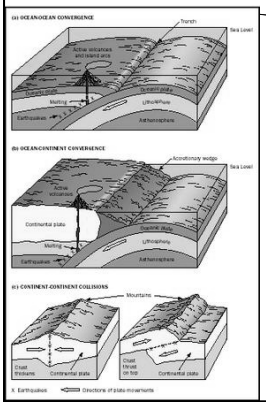


Plate Tectonics

- Plate Boundaries
  - Convergent Boundary-plates come together
    - Subduction-one plate pulled beneath the other
    - Crust is destroyed
    - Types:
      - Two continental plates: produces high mountains
      - Two Oceanic Plates: produces trenches and island arcs
      - Continental + Oceanic: produces trenches and volcanic mountains



Eg: Aleutian Islands and Aleutian Trench in Alaska

Eg: Often produces volcanoes as seen in S. American coast.

Eg: Indian Plate pushed up against Eurasian plate creating Himalaya Mountains.

Plate Tectonics

- Plate Boundaryies con't
  - Divergent Boundary-plates move away from each other
    - Crust is created
    - Produce mid-ocean ridges
  - Transform Boundary-plates slide past each other
    - Crust is conserved
    - Earthquakes common along these faults.
      - Eg: San Adreas Fault in California

Type of Margin	Divergent	Convergent	Transform
Motion	Spreading	Subduction	Lateral sliding
Effect	Constructive (oceanic lithosphere created)	Destructive (oceanic lithosphere destroyed)	Conservative (lithosphere neither created or destroyed)
Topography	Ridge/Rift	Trench	No major effect
Volcanic activity?	Yes	Yes	No

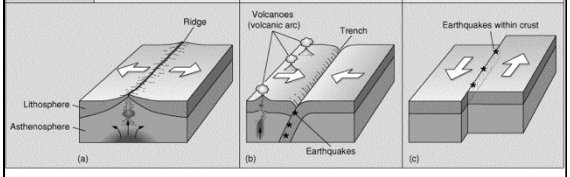


Plate Tectonics

- Plate Movement
  - Mechanism for movement
    - Convection currents within Earth's mantle pulls plates
    - Seafloor spreading pushes plates
  - Hotspot Theory
    - Hot Spot-location on Earth's surface that has experience active volcanism for a long period of time
    - Plates slide over hotspots, producing volcanic island chains
      - Eg: Hawaiian Island Chains

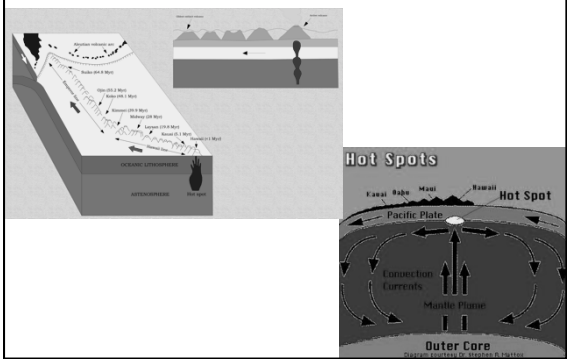
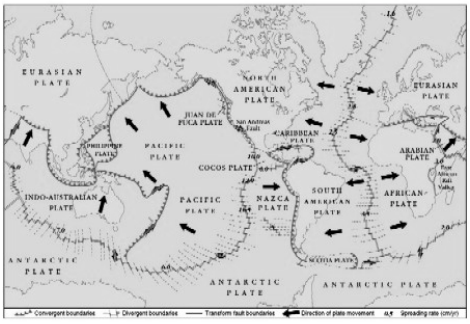


Plate Tectonics

- Plate Movement
  - Predictions over the next several million years
    - Atlantic& Indian oceans will continue to expand
    - Pacific ocean will shrink
    - Australia will move north toward Eurasia
    - S. California will pass San Francisco as it moves N.W.
    - New ocean will form in E. Africa rift valley.
    - Mediterranean sea will close as the Africa moves north.



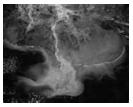
Coastal Formation and Dynamics

Lecture 9

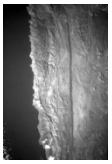
Coasts

- Coastal Classification
  - Based on Tectonic Activity
    - Active Coast-close to tectonic boundary
    - Passive Coast-far from tectonic plate boundary

- Shepard Coastal Classification System
  - Primary Coast-formed by processes not directly related to the ocean
    - River erosion or deposition
    - Erosion from glaciers
    - Tectonic Activity
    - Volcanic Activity



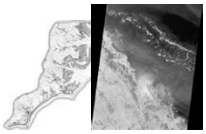
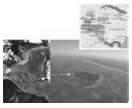
Delta



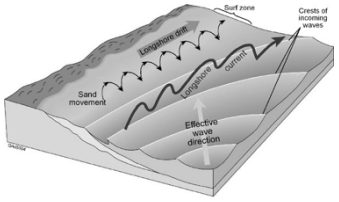
Fault

Volcanic

- Shepard Coastal Classification System con't
  - Secondary Coasts-formed directly by marine action
    - Examples:
      - Wave Erosion
      - Marine Deposition (Barrier Island & Lagoons)
      - Marine Organisms (reefs and mangrove forest)

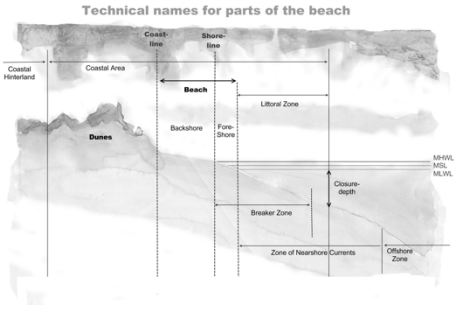




- Shepard Coastal Classification System con't
  - Combination Coasts-both primary and secondary
- Coastal Dynamics
  - Longshore Drift tendency of material to move along the coastline due to longshore current.



Coastal Dynamics

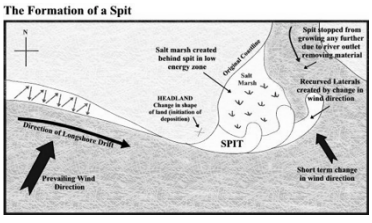
- Sections of a Beach-change due to accretion of sand, erosion and with seasons
  - Dune-hill of sand towards back of beach usually characterized by vegetation
    - Most important part of beach and illegal to walk on because they prevent erosion.
  - Backshore-region rarely touched by seawater
    - Area where you sun tan while at the beach.
  - Foreshore-part that water sometimes covers during high tide
  - Offshore-extends beyond low tide mark



Coastal Dynamics

- Coastal Cell-coastal region that changes in shape but there is no net loss or gain in sand
  - Erosion-loss of sand
  - Accretion-gain in sand

- Coastal Dynmics con't
  - Large-Scale Sand Features
    - Spit-a length of accumulated sand attached to land at one end, pointing in the direction of the longshore drift



- Costal Dynamics
  - Large-Scale Sand Features
  - Tombolo-spits that extend between two islands

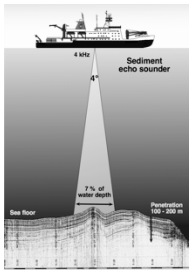
Tombolo at Goat Rock Beach in California

Deep Sea Floor Features

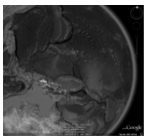
Lecture 10

Mapping the Seafloor Features

- Bathymetry-study and mapping of seafloor elevations
- Techniques:
  - Early explorers measured depth using rope; results often inaccurate
  - Echo Sounder-Determines depth by measuring the time required for sound to leave a ship, reflect off the bottom, and return; a sonar device

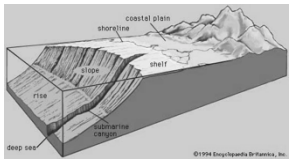


- Techniques con't
  - Multibeam sonar system-takes several soundings at a time; faster method
  - Satellites-measure very large scale sea floor features by determining changes in sea surface elevation

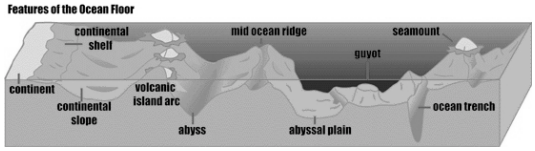


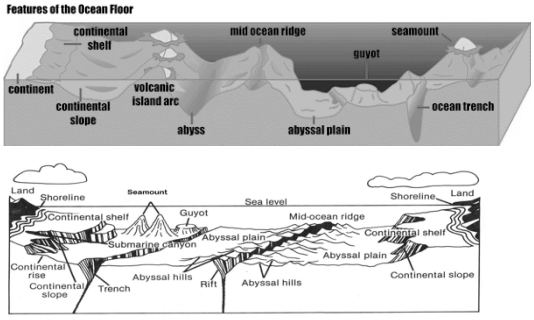
Deep Seafloor Features

- Continental Shelf-closest to coastline; nearly flat borders on the edge of continents that slope toward ocean basins
- Continental Slope-steep slope extending to seafloor
- Continental Rise-gentle slop formed at the base of the slope due to accumulated sediments

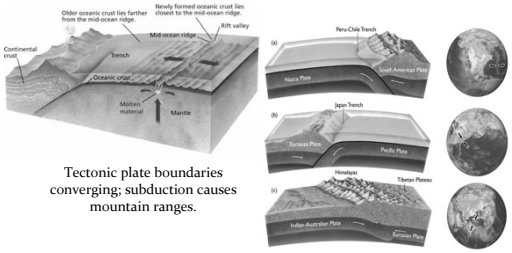


- Abyssal Plain-vast plain extending seaward from the base of the continental slope
- Mid-Ocean Ridge-underwater mountain range, typically having a valley (rift) running along its spine.
- Seamount-steep-sided volcanoes rising abruptly, sometimes piercing the sea surface (island formation)
- Guyot-flat-topped sea mounts





- Trench-long, narrow depressions of the sea floor; deepest parts of the ocean floor.



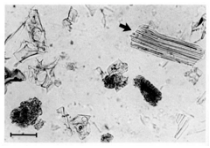
Tectonic plate boundaries converging; subduction causes mountain ranges.

Marine Sediments

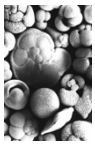
Lecture 11

Sediment Origin

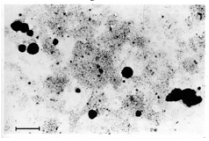
- Lithogenous/Terrigenous-come from land and carriend to ocean via wind or water.
- Biogenous-come from organisms; often composed of calcium carbonate
- Hydrogenous-precipitated directly from seawater; tend to be metal components of Manganese or Ferrous.
- Cosmogenous-come from outer space (meteorites); tend to be metal composites often dark coloration.



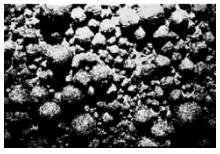
Lithogenous



Biogenous



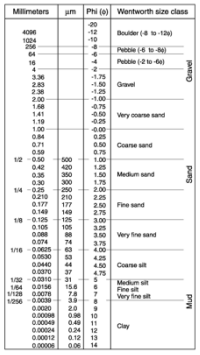
Hydrogenous

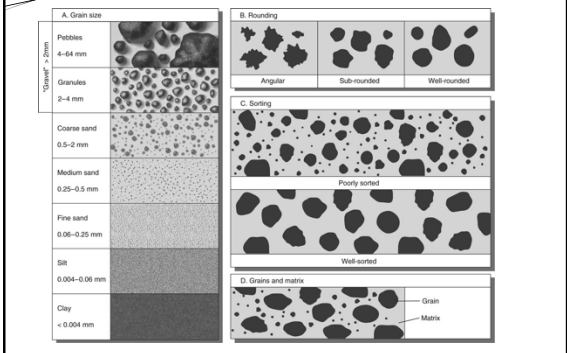


Cosmogenous

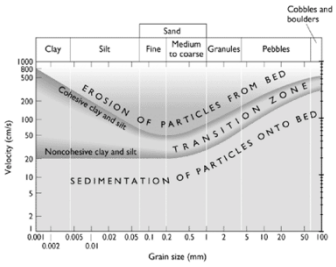
Sediment Size

- Wentworth Scale-classifies sediments based on size
- Sorting-indicates the distribution of grain size of sedmiments
  - Well sorted-all sediment is same size
  - Poorly Sorted-sediment size variable





- Hjulstrom Diagram-shows how sediments move in water based on size
  - Erosion-sediment is removed
  - Transport-sediment is moving along substrate
  - Deposition-sediment is not moving



Unit 3: Chemical Oceanography

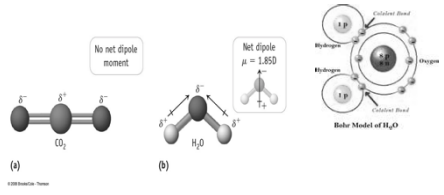
Lectures 12-16

Water Molecule

Lecture 12

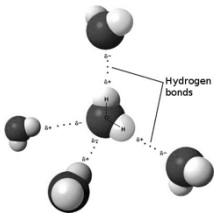
Water's Molecular Structure

- 2 hydrogen atoms polar covalently bonded to one oxygen atom\



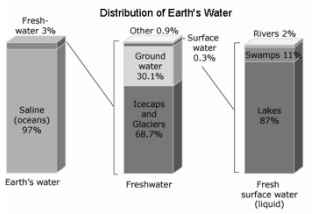
- Hydrogen Bonding-bond between water molecules that forms between their positive and negative ends.

•Water's polarity gives it unique properties:
- •Universal Solvent
- •Cohesion (water-to-water)
- •Adhesion (water-to-different)
- •Liquid @ Room Temperature due to H-bonds unlike alcohol
- •High Specific Heat



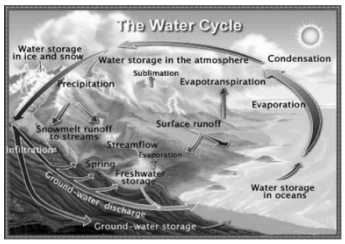
Water Budget

- 71% Earth's surface = water
  - Volume of ocean water = 1.35 billion cubic kilometers (99% of biosphere)



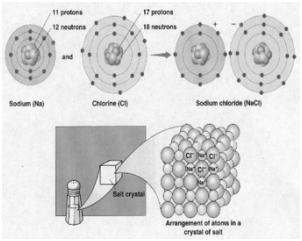
Hydrologic Cycle

- Movement of water thru hydrosphere
  - Evaporation
  - Transpiration
  - Condensation
  - Precipitation
  - Runoff



Salinity

- Salt-ionic compound composed of a cation and an anion
  - Eg: Table Table Salt
- Ionic Bond-atoms transfer electrons to form electrostatic attraction.



- Solution-molecules of one substance homogeneously dispersed among molecules of another substance
  - Solvent-more abundant substance in solution
  - Solute-substance being dissolved in solvent
- Dissociation-when salt dissolves its ions are pulled apart by water molecules
  - Video: http://www.wou.edu/las/physci/ch412/dis_nacl.mov
    - What part of the water molecule interacts with chloride?
    - What part of the water molecule interacts with sodium?

Salinity

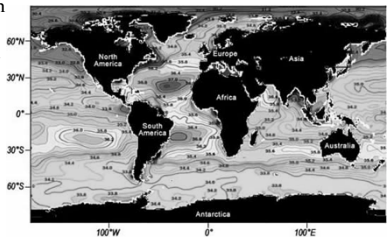
- Salinity-total concentration of dissolved salts (expressed in parts per thousand (ppt, $^{o}/_{oo}$)
- Salt Cycle-how salt is added or removed from ocean
  - Added by runoff, erosion of coastal rock, and hydrothermal vents
  - Removed by certain biological and chemical factors
  - The ocean is in a chemical equilibrium because these processes balance out so the average salinity does not change.

- Ocean's salinity varies very little from 35ppt
  - Brackish-FW mixes with SW (0.6ppt-30ppt)
  - Brine-water saturated with salt, areas of high evaporation

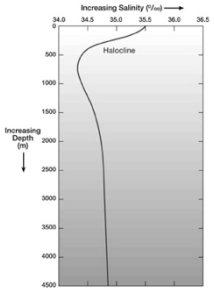
Sea Surface Salinity (SSS)

RED High SSS (≥37)
Blue Low SSS (≤33)

Why is salinity lower at the poles of Earth?

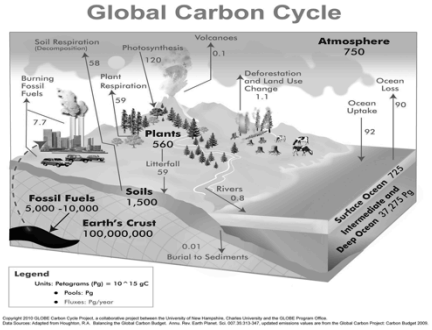


- Halocline=strong, vertical salinity gradient
  - Change in Salinity w/depth



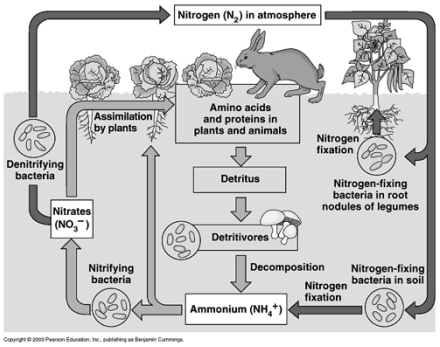
Common Biogeochemical Cycles

- **Hydrologic Cycle**-movement of water
- **Carbon Cycle**
  - Biosphere: carbohydrates and other macromolecules including calcium carbonate
  - Hydrosphere: carbon dioxide, carbonates
  - Lithosphere: carbonates
  - Atmosphere: carbon dioxide

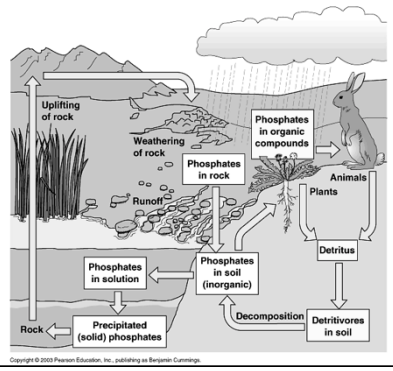


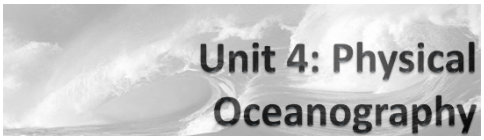
Http://wps.prenhall.com/wps/media/objects/489/501403/CDA51_1/CDA51_1a/CDA51_1a.htm

- Nitrogen Cycle
  - Biosphere: amino acids (proteins), nucleic acids (DNA & RNA), chlorophyll
  - Hydrosphere: ammonia, nitrite, nitrate
  - Lithosphere: NA
  - Atmosphere: nitrogen gas



- Phosphorus Cycle
  - Biosphere: Nucleotides (ATP, DNA, RNA) & in phospholipids
  - Hydrosphere: phosphates
  - Lithosphere: phosphates
  - Atmosphere: NA

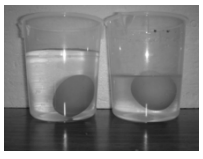




Lectures 17-23

Density

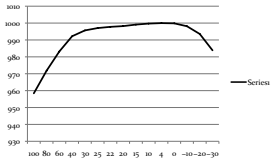
- **Density**-mass per unit volume
  - Density = Mass/Volume (D=m/v)
    - Grams/ milliliter or grams/cubic centimeter (cc)
    - 1 mL=1 cc
  - **Specific gravity**-refers to the density of a dimensionless substance
    - Eg: Fluids like water

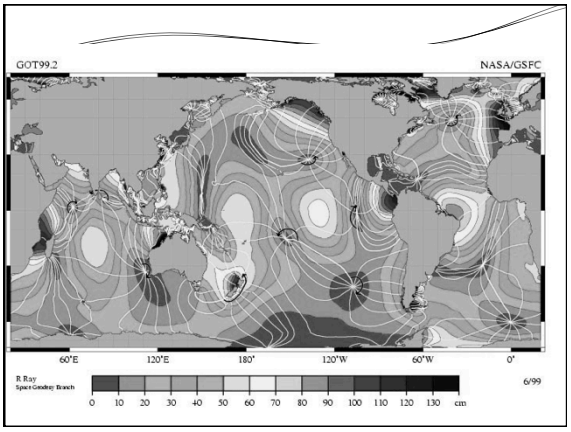


Egg sinks in FW
Egg floats in SW due to its higher specific gravity.

Water Density and Temperature

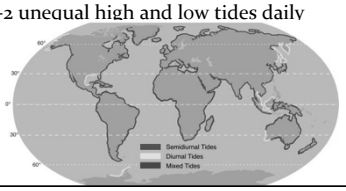
- Maximum density of pure water =1.00 g/mL
  - Water becomes denser as it cools, but only to a point
  - Water's maximum density =3.98°C

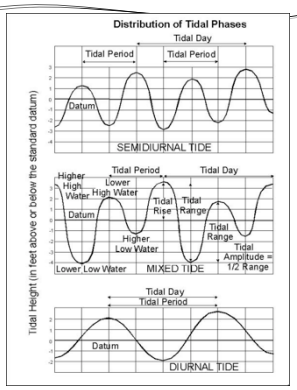




Tidal Patterns

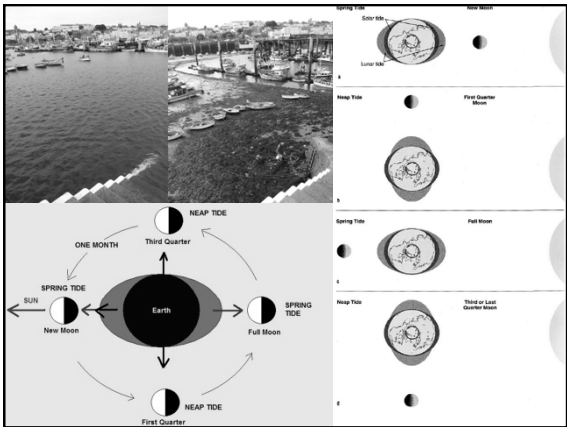
- Semidiurnal-2 equal high and low tides daily
  - Eg: E. coast United States
- Diurnal Tide-1 high and low tide daily
  - Eg. Gulf of Mexico
- Mixed-2 unequal high and low tides daily





Types of Tides

- Spring Tide-extreme tides during each month
  - Caused by the Earth, sun and moon being aligned
  - Occur during the full or new moon
- Neap Tide-weak tides during the month
  - Caused by sun, Earth and moon forming a right angle
  - Occurs during the 1st and 3rd quarter moon phase



Sea-ing the Facts!!!!

Where in the world is the largest tidal ranges recorded?
What is the average high tide and low tide in meters?