INTRODUCTION

I. INTRODUCTION TO CLASS

A. SYLLABUS
B. READING TABLES AND GRAPHS
C. METRIC SYSTEM

I. WHY STUDY OCEANOGRAPHY?

1.

2.

3.

4.

5.

6.

7.

8.

"OCEANOGRAPHY" = The study of
water, life, atmosphere (weather), earth (crust under ocean), coasts, etc.

A. SCIENTIFIC METHOD: Basis of all scientific reasoning including social sciences

1. Observe…….

2. Hypothesis: ideas (many)

3. Test/ Experiment…….

4. Accept/ Change or reject ideas…….

"Theory" – Accepted set of facts & reasons

III. Introduction to Ocean(s)

Ocean(s) cover 71% of E's surface = over 2/3 of world

-Interconnected = all one big ocean

P. -97% of all water

-divided into oceans, seas, bays etc.

A. **PLACE NAMES** = oceans, seas, bays, channels, straights, etc

B. OCEANS

OCEAN	**AVERAGE DEPTH**	**DEEPEST POINT**	**AREA**
PACIFIC	3 miles	Mariana Trench 7 mls.	1/3 of E 1/2 of OC.
ATLANTIC	3 miles	P. Rico Trench 6 mls.	1/6 of E
INDIAN	3 miles	Java Trench 5 mls.	1/6 of E
Vs. ALL CONTINENTS	**Aver. Height** ½ Mile	**Highest point** Mt Everest 6 mls.	1/3 of E

* Deepest point is TRENCH Same depth in all Oceans

IV. HISTORY OF OCEANOGRAPHY

A. **EXPLORERS** – Navigation knowledge – travel to know where you are ……going

1. **ANCIENT**

A. **Mediterranean** - Egyptians, Greeks, Romans, Etc.

P. Used sun & stars to go straight

B. **Vikings & Arabs** - could cross oceans 1000 AD
Explored & mapped the Indian Ocean

C. **Chinese** - Invented magnetic compass , invented paper (maps)

D. **Polynesians** – colonized Pacific islands
Used stars, sun clouds, birds, waves (P.), floating plant matter

2. **EUROPEANS:** Mapped……

P. A. **Portugeuse** – sexton (measure star angles….latitude)

B. Spanish - didn't have a scientific way of thinking

C. **British** –

P. 1. James Cook – mapped Pacific in 1770's (Alaska, Hawaii, etc.)

2. Charles Darwin – figured out atolls,
discovered Evolution 1830's

3. HMS Challenger – 1870's,

P. 1st true oceanographic cruise
examined water, organisms (4000 new animals),
discovered trenches

P. 4. Longitude – Still used to locate, accurate clock…..

3. **UNITED STATES RESEARCH** – Inherited British scientific values

1. **Scientific Institutions** -
   A. Universities = Scripps (UCSD), Woods Hole (MIT)
   B. Non-Profit = Greenpeace, Cousteau Soc,
      Sea World, Monterey Aquarium
   C. **Glomar Challenger** (1968-83) –drilled holes …….
P. Resolution (1985 - ?)

2. **Military**
   A. Navy – research $
   B. Coast Guard

3. **Government Agenicies**
   A. **NOAA** – National Oceanographic Atmospheric Administration

   B. Coast & Geodetic Survey = create maps
   (Bureau of Commercial Fisheries)

4. **PRIVATE COMPANIES**
   A. Oil Exploration - spends billions of dollars
   B. Sea farming = future possibilities

5. **MODERN TECHNOLOGY**
P. A. Mini subs (submersibles)
      1. Alvin =1st submersible, most famous
      2. Japanese - best deep sea mini- subs
   B Satellites = (US)
P. 1. **Sea Sat** – 1978 - Temperature
      2. **TOPAX** – 1990's – Tells waves (+wind) size & direction

V. **ORIGIN OF EARTH**

A. **FORMATION OF PLANETS**

1. Gas & dust cloud ….formed solar system

P.

2. Eddies = formed planets (earth)

3. Sun ignited =

4. Heat melted earth = * 4.6 Billion years ago
   =age of earth. Then earth cooled…oceans & life formed

B. **LAYERS OF EARTH**

1. **Gravitational Separation** – 3 layers

P.

a. Core – made up of iron and nickel = heavy (uranium= heat)
b. Mantle – 5/6 of earth's volume (84%) – solid, but moves slowly
c. Crust – Very thin……., brittle

C. **EARTH'S CRUST**

1. **Continental Crust** – makes 1/3 of surface, …..continents
   a. Thicker (~40 miles)
   b. older (billions of years)
   c. Lighter rock; lighter color (granite)

2. **Oceanic Crust** – 2/3 of surface……under deep ocean
   a. Thinner ~4 miles thick (1/10 of co. crust)
   b. younger (millions of years)
   c. Heavier, black rock (basalt)

3. **Cross sections** – all have vertical exaggeration (10 times)

4. **Isostacy** – crust floats on mantle…equilibrium,

   a. when **weight added** = sags down
      when wt. Removed = goes up
      example: Volcano's, mountains, ice caps

P.

   b. Thicker it is = the higher it floats on the mantle
      Ex: cont. crust (= dry land)
      Thinner it is = lower elevation
      Ex: oceanic crust – ….always covered by ocean

VI ORIGIN OF WATER – origin from molten rocks……steam!

a. **OUTGASSING**

P. Volcano releases gasses
H2O (steam) ……condenses into rain, which flows into ocean
4.5 billion years

b. **CHANGES IN ATMOSPHERE**

CH4 -----→ CO2 (Carbon Dioxide) * Important
Figure 1 NH3 -----→ N2 (Nitrogen gas)
early atmosphere was CO2 + N2 (no oxygen)= billions of years ago

c. **UNIQUE EARTH** – only planet with ocean, life, water and oxygen

1. **Four Inner planets**
   Mostly rock (Mercury, Venus, Earth, Mars)
   Moon, Mercury, Mars = no atmosphere
   =no volcanoes (no water = no life)

2. **Four Outer Planets** =huge planets
   mostly made up of H + He = no water…..
   Jupiter moons = frozen oceans….life?….exploration

3. **Venus vs. Earth**
same size = "right size"

a. both: have an atmosphere (gas) = volcanoes

b. **Venus**: atmosphere mostly steam (CO2)
CO2 = greenhouse gas, which is **HOT!**
600 F = no ocean's (just vapor) = no life

c. **Earth** = used to be the same as Venus 3-4 B.Y. ago
now changed. Why?

1. far enough from sun –
it's cool enough for water to be liquid = ocean
2. life evolved in ocean (4 B.Y. ago)
3. algae converts CO2 to oxygen
4. removes CO2 from atmosphere (by 2 B.Y. ago)
5. cooler = more water = more ocean =more life

P.

(algae)

d. **Ocean Water** – slowly filled up
a. depth increased

b. always been salty! Why?
salt is from **chlorine** (volc. gas…..)
and **sodium** (2% of volcano rocks)

Figure 1

PLATE TECTONICS "Theory"

I. CONTINENTAL DRIFT – now called pl.tect.

A. WEGNERS HYPOTHESIS – (1912……)

1. **PANGEA SPLIT APART** – (pan = all, gea = world)

P. =all cont.s together

2. **EVIDENCE**:

A. **Continents All Fit Together**

P. Closer fit if you match the edge of "shelf"

B. **Geology matched =** Mountain ranges + rocks

P. match between cont.s that used to touch (ages, too)

C. **Fossils Matched**

P. Types and ages match up across cont.s
ex: dinosaurs, coral, etc

d. **Paleo-Climates Matched**

P. ex; desert, tropics, ice

* no way to explain continental drift because technology didn't exist yet

II. PLATE TECTONICS

A. PLATES – 12 "crust" pieces continually moving

P.

1. Seven major plates

P. N. Am. S. Am. Africa, Eurasia, Antarctic, India-Australia
= half co.cr. and half oc.cr

Pacific plate= 99.9% of oceanic crust, biggest pl.
(Coastal Calif. = about only co.cr.on Pacific plate)

B. PANGEA

P. * Began break-up 200 million years (m.y.) ago

C. MANTLE Convection - * How it occurs!

Mantle is solid…..

P. Heat from core (Uranium)
Hottest mantle rises, coolest sinks…..
Moves 1 inch per year (1"/yr)

* cause of plate tectonics (disc. in 1960s)
= mantle convection drags plates horizontally !!

D. Lithosphere & Atmosphere

P. "Asthenosphere" – weak, partly melted
over 60 miles (100 km) deep
"Lithosphere" – rigid outer layer

P. = both crust and upper-most mantle
-Slides over asthenosphere
So, 12 plates are lithosphere plates
(Like eggshell on cracked egg)

E. SEISMIC BELTS – quake zones

P. - 90% of earthquakes occur near lithos. Plate boundaries
=where plates are moving …….each other

P.

- same as volcano belts (90%….)

III DIVERGENT PLATE BOUNDARIES

= Pulling apart = spreading = rifting, due to mantle convection

A. Sea Floor Spreading =rifting

P. - Plates pull apart at 1" per year
- Basalt "magma" (…..) oozes out as lava (…..)
= creates oceanic crust when cooled
ex: Iceland

B. Oceanic Ridge and Rift Valley (discovered in 1950's)

Ridge= huge mountain range that goes

P. 1 1/2 times around the world = 40,000 mls long
(just like a seam on baseball).

Rift Valley goes right down the middle of the ridge
Very long & straight, with steep sides

Oc.cr. younger = closer to R.V.
Oc. cr. higher = " " "

C. Paleo-magnetism – Proved plate tect. in 1960s
= " ancient"+ " rock magnetism"

1. Magnetic orientation

- in magma, magnetite crystals point to mag. pole (north)

P. - when magma solidifies, crystals freeze
= can tell where magnetic pole was when cooled
- invisible

2. Magnetic pole reversal

P. - about every 1 mill.years, mag. poles (N & S) switch!
* basalt rock from different periods have "opposite" magnetic orientation
= "Normal" (to N.) & "Reversed" (to S.) polarity

3. **<u>Magnetic stripes</u>** - on seafloor, invisible!
   - In 1960's, ships towed magnetometers…..
P. - stripes of normal & reverse magnetism in rock
   = symmetric (mirror image) on both sides of RiftValley
   - due to magnetic crystals lining up with different poles when basalt formed,
   - oc. cr. separates at the same rate on both sides of R. V.

P. - G. Challenger drilled holes in seafloor
   - calculated rate ex: $\frac{\text{1 mill. inches}}{\text{1 mill. years}}$ = 1 inch/yr.
P. -map of the seafloor created

*1968 = first proof of plate tectonics!

IV. <u>CONVERGENT BOUNDARIES</u>

= plates coming together due to mantle convection (going down)

A. <u>"Subduction" zone</u> – "going under"
- Thinner, heavier oc. crust subducted into the mantle
P. (Cont. crust can **NOT** subduct because it is too light)
- Subducting oc. crust melts (~100 ml.s deep)
- Magma rises to form volcano chain (~100 mls from trench)
P. - magma is granite (new cont. cr.!)

- Earthquakes – when plates jerk past each other
- Most tsunamis formed
* dangerous !

B. <u>Island Arc Volcanism</u>

-Oc. crust collides with another oc. crust
P. = Volcano **island** chain parallel to trench (edge of oc.)
-"arc" ……..
ex: Japan, Philippines, Aleutians = west Pacific Oc.
also Puerto Rico (Atl. Oc.) and Java (Ind. Oc)

C. Oceanic Cr.– Continental Cr. Collision

P. - Chain of volcanoes (mtn. range) on continental edge
- Trench close to cont.

P. *ex: Cascades, Alaska, Mexico, Andes = Eastern Pacific!*
= world's largest quakes (~9.0…. every ~500 years)

D. Continental – Continental Collision

-(Co. Cr. can't subduct = too light)

P. - Creates thickest crust = highest mountain ranges
Now: Himalayas = (India – Eurasia…….. 40 m.y.)

P. Ancient = formed most mtn. ranges (Alps, Appalachian)
? ?
-Quakes (India, 2003), but no volcanoes……..

V TRANSFORM PLATE BOUNDARIES

= Plates go past each other

A. Transform faults

P. - Faults cut & shift Rift Valleys and oc. ridge
= Zigzag pattern of R.V. and Oc. ridge

P. - Most on oc. crust
??

P. - Quakes = plates jerk past each other
- No volcanoes (……..)

B. San Andreas Fault

P. - Large transform fault that slices cont. cr. (Calif.)
- S. Cal on Pacific plate= going N.W.
- Gulf of Calif. getting larger …..Calif. will become island

VI OPENING OF OCEAN BASINS

=Divergent , creates oc. cr. from continent

A. Continental Rifting

P. 1. M.C. makes cont. crust bulge
ex: Nevada area
2. Stretching causes Rift Valley = long deep lakes
P. ex: east Africa rift zone
3. gap is filled by basalt = new oc. cr.
- Long, narrow, straight sea formed
P. ex: Red Sea, Gulf of Calif. (newest)
4. widens to "ocean"
ex: Atl. & Ind. Oceans

B. Continental Shelf

- Stretched edges of cont. cr. = thin = low = flooded by ocean
P. - Pangea fits well if you use the outer edge of shelf (Co.Cr.)
Lab

Ocean Size

- Atl. & Ind. Oceans getting larger
- Pacific Ocean getting smaller (less oc. cr.)
P. How?
- Subduction ="Ring of fire" = most volc. and quakes

E. Oceanic Crust "Recycled"

P. - Oc. crust formed at rift valley
- Oc. cr. destroyed at subduction zone
* oldest oc. cr. = 190 m.y. (average only 60 m.y.)
P. = Oldest oc. cr. only 1-4% of earth's age
(ex: like finger nails……..)

D. **Historic Global Sea Level**

- More water from out-gassing of volcanoes
= too much water for just oceanic cr.
= flooded on to cont. cr.
= cont. shelf = 1/5 of all cont. cr.

E. Hot Spot Volcano Chains

= straight line of volcanoes (not "arc" = not subd. zones!)
- often in middle of plates (no trenches = " " ")

1. **Hot Spots** = stationary "fountain" (lava lamp) in mantle

P.
- plate moves over stationary hot spot
(ex: sewing or welding machine)
- young (new) volcano on hot spot end of chain
- islands older farther from " " " " "
- more eroded " " " " " " "
- can tell plate motion direction

P. *ex: Hawaii*
-Kilauea most active volc……
- Loihi next volc……
- plate going to NW

MAJOR FEATURES OF OCEAN FLOOR

I. CONTINENTAL MARGIN

A. Continental Shelf = important (fishing, oil…….)

P.
- Shallow = less than 600 ft (aver. 200')
- Flat = "sediment" (mud & sediment) covers….
- Shelves big = 1/16 (6%) of E's surface

1st page in text

1. Narrow Shelf – less than 50 mls.(…km) wide
- "leading edge" on cont.
- "active margin" = "Subduction zone"
  ex. Pacific (west coast U.S.)

P.

2. Wide Shelf - more than 50 mls. wide
- "trailing edge" of Co. = middle plate!

P.
- "passive" (text) = no quake or volc.
- Wide = caused by stretching co. cr. (rifting=thin)
  ex: Atlantic Oc. (east coast)

in notes p. 20
- Covered by sediment (100's m.y.s) = thick

B. Continental Slope
- Outer edge of cont. shelf

P.
- " " " cont. crust
- from 600 ft. to 3 mls. deep
- Not steep cliff = looks it due to vertical exaggeration (only 4 degree slope)

1. Submarine Canyons -

P.
- cut into cont. slope and shelf
- huge (Grand Cyn size)
  ex: Monterey Canyon
- eroded by sed. "mudflows"

C. Continental Rise

P. - Long wedge (pile) of sed. along base of slope
= many "fans"

1. **Submarine Fans** = "deep sea fan" in text

P. - pile of sed. at base of a canyon
- huge = 100's mls. long

P. *ex. Bengal fan……..*

D. California Borderland

P. - So. Calif. shelf = 150 mls. wide
- not flat ……..

Fig. 3 - Cont. cr. broken by "faults"……S.A.F…..15 m.y.s

1. **Banks** – submarine mntn. "range" (long….)
   - going up between 2 faults (……quakes)
   - forms islands (if above sea level)
   - *ex. Catalina Island*

2. **Basins** = submarine valleys
   - dropped down between 2 faults
   - ex. San Pedro Basin – offshore now
   - L.A. Basin filled with sediment (….1 m.y…rivers)

3. **Escarpments** – cliffs formed by faults

II DEEP SEA FLOOR

P. 16 in notes **A. Ocean ridge system**

1. Pattern

P. - 1000 miles wide & 1 ½ mi high
- huge = ¼ of all oceanic crust
- along center of Atl. & Ind. Oc.

P. - young = no sed. yet = bare basalt

2. Rift Valleys

P. - huge valleys in mid. of ridges
- ½ mi deep, steep sides, long & straight

P. - lava……..
- formed by rifting …..quakes

A. Hydrothermal Vents

- Submarine "hot springs"…on R.V. floor

P. - Discovered ~ 1980
- HOT (600 degrees F.) water flows out
- full of metal sulfides = "murky or cloudy"
- "Black Smokers" = towers of minerals that grow rapidly (~30 ft. high), temporary

3. Transform Faults

P. = rips in oc. cr. …..shift R.V.s
- Fracture zone = 1000's miles long

P. = cracks in oc. floor…..extension of Trans.Flt.s

B. Abyssal Plains – between ridge and slope

P. (Very deep) (flats)
- 3 miles deep = ½ of all oc. cr.
- smooth, flat= mud (depos. …..100+ m.y.s)
- farther from R.V. = older crust = thicker sed.

1. Seamounts = submarine mtns.

P. - volcanoes w/ ***rounded*** tops
- 20,000 in Pacific!

= old volcanoes always under sea = never erode

2. Tablemount (= Guyot)

P. = old subm. volcano mtn. with ***flat*** top

a.) Once was an ISLAND= "eroded" to flat

b.) Sank below sea level

P. 1. submerged as moving off ridge (on Oc. Cr.)
2. sink (o.c. sags) due to isostacy (heavy volc.)

ex. Hawaii

C. Trench

- Long trough above Subd. Zn.

P. - "Arc" shape on map = concave to continent

1. Near Island Arcs = deepest trenches

- chain of volcano islands

deepest trenches = less sed. from islands

ex: Mariana, Puerto Rico, Java trenches

see p.18 in notes

-On map = Cont., sea, island, trench, ocean (ab.pln.)

2. Trenches near Continents

P. - not deep = trench fill…..with sed. from cont.(rivers)
- *Ex: Cascade trench…… Columbia River*

P. **D. <u>Volcano Chains</u>**

-Straight line of volcanos (not Arc)

-Often in the middle of plates (NO Subduction zone!!!)

P. **1. <u>Hot Spots</u>**

-stationary plume (like lava lamp) in mantle

a. plate moves over stationary hot spot
(ex: sewing machine)

b. young (modern volcano) at hotspot

c. islands older (eroded) farther from hot spot

d. Kilauea – biggest volc…..

e. Loihi seamount - newest

-can tell plate motion = to N.W.
ex: Pac. Pl. goes NW

SEDIMENTS

I. SEDIMENT MATERIALS = 1 km (1/2 ml.) thick

A. Minerals = makes up sand
= solid w/ definite chemical composition

P. 1. **Quartz** = most famous - common in sediment
hard, resistant, sand

2. **Feldspar** = most common (1/2 of all rocks)
– slowly decomposes = turns into mud/ clay

P. 3. **magnetite** = black, magnetic

They make up our beach sand

B. Rocks - made out of minerals

1. **Sandstone** – rock made out of sand on bottom of sea
2. **Shale** – rock made of mud (soft = clams dig holes)
3. **Limestone** – only rock made out of shells or coral

="Sedimentary" rocks:
These are created under the sea floor,
and then got buried and compacted into rock

4. **Basalt** – volcano, from lava (Oc. cr. + Hawaii)
5. **Granite** – volcano – (Cont. Cr.) – light in color

= "igneous" rocks

II <u>CLASSIFICATION OF SEDIMENTS</u> – by where particle is from

A. <u>Lithogeneous = "</u>Rock originated"
= most sediment (all mud and sand)

P. **1. <u>Erosion</u>** – mountain erode rivers take to ocean
= particles broken up in streams in mountains (not on beaches)

P. **2. <u>Deposition</u>** – sediment settle out (deposit)
- when water slows down

A. <u>SIZE</u>

BOULDER	**COBBLE** (Size of baseball)	**PEBBLE** (gravel)	**SAND** (grains)	**SILT** mud (gritty)	**CLAY** Mud (slippery)

COARSE **FINE**
(bigger) Most ocean sediment (small)

(speed)

1. **<u>Size vs. Energy of Water</u>**
   -smaller sediment is moved easier
   -smaller sed. deposit in slower water
   (larger " " " faster ")

WATER ENERGY	SEDIMENT REMOVED	SEDIMENT DEPOSITED	EXAMPLE
FAST	Sand, Silt, Clay	Cobbles, Pebbles	River
MEDIUM (Waves)	Silt, Clay	Sand	Beach
SLOW (Small Waves)	Clay	Silt	Bay Harbor Shelf
CALM	None	Clay	Deep Sea Floor

At each speed (energy)
1. One size deposited = sand~beach
2. Smaller Sediment removed to calm areas = silt, clay
3. Larger sediment left behind uphill = cobble, pebble

B. <u>Sorting</u> – how many different grain sizes

SORTING	GRAIN SIZE	WATER ENERGY	EXAMPLES
"Good"	One size	One consistent speed	Beach, bays
"Poor"	Many sizes	Many water speeds	Rivers, submarine fans turbidity currents

C. <u>Maturity</u> – roundness of grain
-angular (new) → rounded (old)
- due to no. of times rolled around

P. **3. <u>Distribution on shelf</u>**
- lithog. = 99% of the shelf
- sand near shore, mud is farther from shore
- so much lithog. sed., it overwhelms other types of sed. (except rare coral reefs)

4. <u>Distribution in deep oceans</u>

A. <u>Turbidites</u> – found on cont. rise =100% lithog.
- Turbidity currents = submarine mudflows

P. - Go down + erode submar. canyon
- Spread out = submar. fans

P. - Alternating layers of sand & mud
- after sand & mud buried = compressed into sandstone, shale

Lab *ex: Palos Verdes rocks*

B. <u>Abyssal Clays</u> – on abyssal palins

P. ~ 1/2 of deep sea floor
- only clay settles = very calm water
- only 1" of clay per 25,000 years
- most clay from land…..carried by currents 1000s ml.s

P. (~10% from dust in wind)
- red color = rust……

P. *ex. Pacific Ocean*

C. <u>Oceanic Ridges</u> – no lithogenous sediment
= ocean crust too young (new)

B. Biogenous Sediments – "life originated"
=Deposits of shells

1. Shelf Biogenous Sediment - rare

A. Shells and Oyster Beds - rare
ex. shell beaches in Florida
*Calcium carbonate ($CaCO_3$) = limestone

P. **B. Algae Mats** (stromatolites)
- Mounds of algae = $CaCO_3$ layers
- Very rare now, but was common B.Y.s ago
- Removed CO_2 from oc…….

P. **C. Coral Reefs** – $CaCO_3$
- Made by animal w/ algae growing in it
- Coral needs 5 things:
Warm, salty water, hard sea floor,
Wavey (oxygenated), and shallow (light)
- *ex: Great Barrier Reef in Australia*

P. **1. Fringing Reef** ~ grows on fringe of island
ex: Hawaii (you can walk out to it)

P. **2. Barrier Reef**
- when island sinks due to isostacy,
coral grows up on top of old fringing reef
(can take boat across lagoon = calm water)
ex: Puerto Rico or Florida

P. **3. Atoll**
- Coral grows on original reef as island totally sinks…
- No volcano island AT ALL
- Calm lagoon can have sand islands with people + plants.
- Atolls in warm water (tablemounts in colder water)

PG 28
in notes

2. <u>Deep Ocean Oozes</u> covers 1/2 of deep sea floor

"Ooze" = mud w/ over 1/3 microscopic shells

P. - from <u>plankton</u> = microsc. animals & algae living at surface

- When dead = sink to seafloor (slow deposit)

~ half clay & half shells

* the major sediment in deep ocean

A. <u>Siliceous Ooze</u> – Mud with ~1/2 "silica" (SiO_2) shells

P. **1. <u>Diatoms</u>** - algae

2. <u>Radiolarians</u> - animal

P. - silica dissolves (slowly) in sea

P. = silic. ooze only found where there is lots of plankton

= piles up so fast, it gets buried and won't dissolve

3. <u>Distribution on Sea Floor</u>

-1/7 of deep sea

- under areas w/ lots of plankton (= lots of nutrients)

A. <u>Equatorial</u> = many radiolarians

P. B. <u>Semi-polar</u> (N.& S.) = diatoms

green & other cold areas (Ex: California)

4. <u>Siliceous Rocks</u> – made of silica ooze

P. A. <u>Diatomite</u> – lightest wt. rock

mined in California, crushed up to make:

pool fliters, added to "flat" paint

P. B. <u>Diatomaceous shale</u> = mixed with mud

= kitty litter

C. <u>Flint</u> – buried =compressed

used in arrowheads (humans ….~ 1 m.y.s)

B. <u>Calcareous Ooze</u> – mud with 1/3 microscopic shells of calcium carconate ($CaCO_3$)

P.

1. **<u>Coccolithophores</u>** – algae (plant)
2. **<u>Foraminifera</u>** – animals
3. **<u>$CaCO_3$ disolves</u>** in cold H_2O
   =has more CO_2 (Ex: soda) = more acid = more dissolving

A. <u>semi-polar areas</u> = no calcium plankton (oozes)
- dissolved even at the surface

B. <u>deepest ocean floor</u> =no calcium ooze
- Cold & high pressure = most CO_2 = most acid
= All $CaCO_3$ dissolved

4. **<u>Calcium Compensation Depth = CCD</u>**

P. = depth below which $CaCO_3$ dissolves = no calcium ooze
= CCD ~ 2 1/2 ml.s deep

P. abyssal plain = no calcar. ooze (only clay)
* cal ooze only on oc. ridges (except in polar)
~ 1/2 of sea floor (esp Atl. Oc.)

5. **<u>Chalk</u>**

P. - rock from calc. ooze *(ex: Eng. Channel)*

C. Hydrogenous Sediment

From dissolved minerals (in sea)
-"precipitation" = solid from liquid
-very important economic use
-mine ancient sediments (now on land)
-creates jobs & products

1. Evaporites = minerals from evaporation

P. -formed when sea dries up and becomes hot & dry
(ex: Mediter. Sea 5 m.y. ago, or dry lakes today)

A. Limestone = $CaCO_3$
= first precipitation = on rim

* used in cement (=cooked limestone)

B. Gypsum = 2nd mineral to precipite
- used in plaster and "drywall" for walls

P. **C. Salt** = NaCl
- Last to precipitate
- Most of the evap. sediment
- Thicker layer = up to 500 ft deep in Med.Sea

Mined for 3 uses: food, melt road ice,
and used to make chlorine

NOTE: THERE ARE NO EVAPORITES ON THIS PAGE

2. <u>"Shelf" Hydrogenous Sediments</u>

A. <u>Carbonate platform</u> = flat limestone layers
ex: Florida, Bahamas, Yucatan (Mex.)
- Deep water (cold =dissolves CaCO3) flows as current over a shallow bank (warms up) =CO2 low= CaCo3 precipitates as flat layers

B. <u>Oolites</u> = round white sand – same process
-Except they are large concentric (onion-like)layers of CaCO3 depos. on rolling sand (shallow = wavey)

3. <u>Manganese Nodules</u> – 1" – 3", potato like

P. - tiny concentric layers = grow very slowly by precip.
- grow 1" thick per million years

P. ~1/4 manganese …..on abyssal plane (clay)
- *ex: Pacific Oc*.

P. - mined in the future? No…… due to cost

4. <u>Phosphates</u> – nodules on the shelf
- 10% phosphate, mined in Florida for fertilizer

5. <u>Metal Sulfide Deposits</u> = black smokers (RiftV.)

P. - ("iron") sulfide precipitates …inches / day
- when hot water hits cold water = chimneys grow

6. <u>Iron Deposits</u> – 80% or world's iron (used in steel)
- 2 b.y.old sed. = no O2……

D. <u>Collecting Samples</u> – devices dropped……

P. 1. <u>dredge</u> = cage, collects rocks and drags

Cruise in lab 2. <u>mud grab</u> = clam shell sampler

3. <u>drilling</u> = "drill bit"

a. for basalt (Ex: Glomar challenger)

P. b. for Oil = most of drilling, shelf, go down 1–2 miles

P. 4. <u>analysis of cores</u> (in storage):

a. plankton shells = show "paleo-climates"

P. b. age of basalt = how old

c. find oil

MARINE CHEMISTRY

I. WATER MOLECULES – atoms bonded (glue)

P. Nucleus …….protons + neutrons, electrons…….
molecules (more than 1 atom)

P. **A. H_2O molecule** - one oxygen and two hydrogen atoms
Negative(-) Positive(+)

Covalent bond (very strong)
=Holds together no matter ….
liquid, ice, or vapor
(like super glue)

B. Polarity (~~Di~~ – polar molecule)
+H and –O at opposite end of "molecule"

* Hydrogen bonds = H2O molecules
-Attract to each other like magnets = easily broken
-(opposites attract) + and --

- stronger in water than any other liquid, water is unique

II PROPERTIES of WATER

A. Surface Tension

-Surface of H2O clings together
-Due to hydrogen bonds (magnetic balls)

B. Solvent Properties of Water

-Water is best dissolver of all natural liquids
- Crucial to all life (vitamins, sugar, sodium, CO2, etc.)

P.

1. Ionic Bond = pos.& neg. ions charged atoms
-dissolved = solid breaks into pos.
and neg. "ions" surrounded by H2O molecules

See notes PG 42

2. Dissolving Rate = how much it dissolves
- highly polarized dissolves fastest

A. Highly Polarized "substance" – (solid liquid or gas)
-Dissolves 1. Easily; 2. fast, and 3. A lot
-Salt hard to precipitate (last)
-Highly polarized substances hate to precipitate

B. Non- Polar Substances – no ions
-Doesn't dissolve (H2O can't surround molecules)
ex: oil, (oil from plants, animals & plankton)
(petroleum= plankton ….sed……buried…MYs)
-store food so it won't dissolve. ….prevent dissolve

Pg 40 - 41 In notes

C. Moderate – CaCO3 & silica – dissolve slowly,
- Come out first = during evap…..

3. **<u>Effects of Dissolving Solids</u>** – on water
   -They create ions = interfere with the hydrogen bonds
   = lessens H2O properties

   A. <u>Freezing Point Lower</u>
   – than in fresh H2O (0 C = 32 degrees F)
P. = 29 degrees F (-4 C) sea water freezes
   because it's 3.5% salt

III <u>DISSOLVED MATERIAL</u> = salinity, measured by:

% = percent (ex. 3.5%)
o/oo = Parts per thousand (ex. 35%o) used in Oceanography
PPM = parts per million (ex. 35,000ppm)
PPB = parts per billion

Oc.
Cruise <u>Niskin bottle</u> = used to collect water at specific depths
In lab

A. Types of Dissolved Substances

1. Major Constituents = 6 ions

99% of dissolved solids = white stuff

CL	Chlorine	55% of all dissolved solid, major part of salt 87%
Na	Sodium	31% , part of salt = 7/8
SO4	Sulfate	8%
Mg	Magnesium	4%
Ca	Calcium	1% + sulfate = gypsum + CO2 = CaCO2 (Lst)
K	Potassium	1%

2. Dissolved Gases

GAS	**IN ATMOSPHERE**	**IN OCEAN**
N2= Nitrogen	78%	15 ppm
O2 = Oxygen	21%	10 ppm
Co2 – Carbon dioxide	.035% 350 PPM	100 ppm

Depends on pressure, temp & organisms

A. <u>Photic Layer</u> – sunlit layer
- Algae uses up Co2, creates O2
= CO2 low, oxygen high (*opposite)

B. <u>Aphotic Layer</u> - dark
- Animals (hide) = uses O2 & creates CO2
= O2 low and CO2 high

C. <u>"pH"=</u>Measures acidity
CO2 in H2O = carbonic acid

1. **<u>More CO2</u>** – more acid
- lower pH
ex: aphotic layer
(below CCD = most acidic)

2. **<u>Less CO2</u>** – less acid
-higher pH
ex: Photic layer

Acidic neutral Alkaline (base)

(Natural liquids) (water) (8=seawater)

3. **<u>"Buffer"</u>** = pH neutralizer
Sea is natural buffer
CO2 –> carbonic acid (H2CO3) –> bicarbonate (HCO3)
(Alkali ocean = 8)

P. Seawater neutralizes any acid (Ex: volcano gases)
Good for life, most animals can't handle pH changes
Needs to be steady pH (for B.Y.'s)

B. Salinity

1, Mixing – keeps sea (esp. deep) same
-due to currents

2. "Constancy" – (six major constituents) exist as constant percentage (of white stuff) everywhere

P. -Always 55% Cl and 31% Na ….
= 86% salt everywhere

Measure salinity by measuring "chlorinity"
(chlor. X 1.8 = sal.)

true in all seawater even if surface salinity changes

3. <u>Variations in Surface Salinity</u> – average 3.5%

P. * caused by "climate" processes at surface

A. <u>Decrease Salinity</u> = dilute = less than 3.5%
Ex: rain, rivers, Ice melt (summer in polar)

B. <u>Increase Salinity</u> = remove H_2O and concentrates salt

1. Evaporation – (dry, hot) = more than 3.5%
2. Freezing sea ice (Ex: Arctic Sea in winter)

P. 46
In notes

C. <u>Latitude</u>= effects climate, which changes sal.

P.

1. **<u>Polar</u>** - average 3.4% (sea freezes and melts)
   Ex. Arctic
2. **<u>Semi-Polar</u>** – lowest salinity (3.2%)
   rain, cool = low evap.
   Ex. Alaska
3. **<u>Temperate</u>** – low winter, high summer = seasonal
   Ex. US, Japan, Europe
4. **<u>Semi-Tropics</u>** – highest salinity = hot, dry
   Ex: Medit. Sea
5. **<u>Equatorial</u>** – medium sal. = raining & high evap
   Ex. SE Asia

P. distinct pattern on map or chart

IV <u>CONSTANT COMPOSITION</u> = cycled in sea

Amount of dissolved substances stay the same

A. <u>Sources of Dissolved Substances</u>

P. Fig 5

1. rivers = Ca, Si, Na …….. from mtns.
2. Volcano gas – <u>H2O, CO2, Cl</u>, nitrogen, sulfur
   the three most important things….
3. Atmosphere – adds CO2
4. Animals – adds CO2
5. Algae – adds O2
6. Hydrothermal vents (R.V.) – Ca, manganese

Simultaneously for BYs

B. <u>Removal of Dissolved Substances</u>

1. hydrogenous sediment – Ca, CO2, manganese nodules
2. biogenous sediment – silicaooze, diatom

permanently removed CO2 locked up in limestone (CaCO3)

3. Algae – removes CO2
4. animals – remove O2
5. Atmosphere – removes O2

*Balances between sources of removal over B.Y.'s

PHYSICS OF OCEAN AND CLIMATE

I. Physical Properties of Ocean

A. Density = Temperature Layers

2 layers in ocean = can't mix!

1. **Thermocline**
   - sudden change in **temperature** between warm surface layer and cold deep layer
   - up to ½ mls (1 km) deep (note: not photic zone)

2. **Pycnocline**
   = sudden change in **density** (weight or heaviness)
   - due to thermocl. (temp.change)
   * two layers = cannot mix

-not in semi-polar: no thermocl. = water can mix
= nutrients can rise = lots of plankton = lots of fish

B. Sound ~ speed = (1 mile per sec. in ocean)
= 4 X faster than air = goes farther in sea

1. **"Sonar"** = echo sounding = send sound down, bounces back, measures time difference

2. **"Sofar" layer** = sound travels very far
   - experiment: sound from Calif. detected in Hawaii,
   = evidence of global warming
   (atmos. warms --> ocean warms = sound slows down)

C. <u>Light Transmission</u>

-Visible light from sun = white (all colors mixed)

1. <u>Clear Water</u>

- blue light goes farthest thru H2O
- red light goes shortest thru H2O before absorbed

= reflected light is only blue (R,Y, G absorbed)

* clear deep water looks blue
because all other colors are absorbed

2. <u>"Murky" Water or Shallow Water</u>

Cruise lab

- blue, green, & yellow light reflected.
- due to plankton = no red can go thru water

= water looks aqua/turquoise
and submarines look blue

D. <u>Density of Water</u> = denser = heavier

1. **<u>Temperature</u>**- colder
2. **<u>Ice</u>** – floats due to crystal shape – 1/10 lighter than water
3. **<u>Salty</u>** – salt is dissolved rock (3 x heavier)
   ex: river water floats

E. **<u>Desalinization</u>**

- get fresh water from sea….
- expensive….. *ex. Persian Gulf*

V SEA ICE

A. Polar Ice – permanent sea ice, no land, Arctic ocean

P. - (150') thick in winter, thinner in summer (6')
- ice caps rotate clockwise every 3 years

B. Pack Ice – winter only sea ice (freezing sea ice)
- Both Arctic and Antarctic
~ 2 m. (6 ft) thick (ice breakers…..ships…)
- In summer = breaks up into packs & melts

C. Shelf Ice – very thick ice = 1000 ft thick
-Permanent = over 3 Antarctic seas
-Ice from land ice cap

D. Icebergs – "ice mtn"s. , 1/10 above sea level

P. **1. Pinnacled** – from glaciers (ice river)
-mostly in Greenland + Alaska
-"calving" a piece of ice breaking off……
-they float south in currents
-Titanic……. 1912

2. Tabular – huge, flat ~ 1000' thick
-from Antarctic shelf ice
-huge = largest moving objects on E. (size of L.A. County)

Begin Test 3 Notes:

I. CLIMATE

Climate+ aver. Weather……

A. Heat "Capacity" = liquid water stores (holds) heat
more than any other substance on E.
(water takes in more heat = takes longer than any other substance)
-water gives off more heat (cooling)
= heat battery of E.

B. **"Latent"** (potential, hidden) **Heat** -
water vapor stores heat =takes a lot of energy to vaporize water

A. Evaporation – evap….. molecules
Takes heat from others = cools remaining H2O
(ex: sweat keeps humans cool)

hotter= more evap…. (up to 1 inch/day in tropics)
* no hot oceans (max…90 F)

B. Condensation – when water vapor turns back into liquid
(rain clouds) = gives off heat!
(ex: wet & cold soda can)

* vapor stores heat in atmosphere = latent heat

C. "<u>Moderating" Effect of Water</u> – on climate

Nearness to ocean = 2nd most important factor on climate

P. 60 (1st = latitude)

In notes

1. <u>"Humidity"</u> (= vapor)

All is from oc. (our rain …from oc.)

P. a. humid climates = wind ward side of land

-If mtn range blocks moisture = rain shadow

(ex: N. Cal redwoods vs. Nevada desert)

b. more humid = "moderate" temp (latent heat = vapor)

(ex. S.Fran, PV, Hawaii)

2. <u>Moderate Temperatures of Climate</u>

due to H. cap …oc. is "heat sponge"

-Closer to ocean = more moderate temperature

nearby oceans absorb heat (day, summer)

** and release heat when cold (nights, winter)

ex: South Bay (ECC)	vs.	Las Vegas
45 – 85 degrees		30 – 120 degrees
40 degree annual "range"		90 degree annual "range"

("range" = difference between high and low)

II HEAT BALANCE OF ATMOSPHERE

A <u>Solar Energy</u>. Electromagnetic spectrum

Gamma Rays	**Xrays**	**U V rays**	BGYOR (visable)	**Infra Red (heat)**	**Micro Waves**	**Radio Waves**

OZONE V R

1. <u>Energy in Atmos</u>:

P. -UV absorbed by "ozone layer"

ozone layer destroyed by "freon"…….

-Infrared – absorbed by clouds (50% of E…)
-Visible light goes thru atmos. and
Re-radiated heat goes atmosphere

2. **<u>Greenhouse Effect</u>** = heat trapped by atmosphere
"greenhouse gases" = H_2O + CO_2
* heat kept in atmosphere (good for moderate life)

3. **<u>Global Warming</u>** = CO_2 increase (ex: cars & power plants)

P.
A. Climate changes (ex. Russia)
B. Sea Level Rises – ice melts, sea expands
C. More hurricanes and stronger El Ninos

III Atmosphere Heat Balance

A. **Heat Surplus**

P. More heat at tropics
Rays at poles spread out….. = colder

1. **Tropics** – Ocean & atmos. warm = excess of heat

2. **"Poleward" Flow of Excess Heat**
toward pole, most by wind

C. **Atmosphere Circulation**

P. 1. **Convection** – due to sun
- heat rises at equator & sinks at pole
P. on non-spinning E. = wind toward equator

2. **Belts of Airflow** – real earth = more complex
P. 3 belts (cells) in each hemisphere = 6

IV. CORIOLIS EFFECT (C.E.)= apparent "turning" of wind (& other….) due to E's rotations

A. Deflection = turning

P. turns to right in N. hemisphere
" " left " S. "
(ex: merry-go-round)

B. Effects on Storm

= low air pressure = wind blows in storm

P. + turns to right (N. Hem)
= spiral in counter-clockwise

1. Hurricanes or typhoons = largest storm
- winds spiral into "eye" (speed = 75 MPH)

P. A. created over tropical ocean
-lots of evaporation & latent heat

P. B. move to west
C. turn toward poles (Cor. Ef.)
Damage due to:

P. 1. heavy winds (roofs….)
2. much rain (1 ft…day)
3. waves……
4. storm surge….

P. *Most destructive force on earth
ex: east coast U.S: Hurricane Andrew= $40 billion
Galveston= 6000 killed (1900)
= "heat frisbees"

IV. <u>ATMOSPHERE CIRCULATION</u> = winds

* caused by convection & Cor. Ef.

P. causes oc. currents….

A. <u>"Tropical Doldrums"</u>

Figure 6 -at heat equator, hottest air rises…… clouds

-rainy (med. salinity) *ex: Indonesia (tropical)*

B. <u>Tradewinds</u> = "easterlies" – from east

-Surface winds to eq. (to replace……..)

- C.E. turns it to west !

ex: Hawaii, Carribean ("semi-tropical")

C. <u>Horse Latitudes</u> ~ 30 N & S

P. 49 - air sinks = dry hot air (no wind)

Notes - highest salinity in ocean

ex: desert belts, Baja, Red Sea

P.

D. <u>Westerlies</u> – winds blow from west

P. - opposite of tropics

- winds blow away from horse lat.
- CE turns it to east !

ex: USA, Japan, Europe (= "temperate")

E. <u>Polar Front</u> ~ 60 N & S

- air rises = clouds ,cool, rainy

ex. Alaska ("semi-polar")

F. <u>Polar</u> = easterlies

- coldest air sinks at poles

ex. Arctic Oc. (polar)

V. SEASONAL CHANGES – due to earths tilt

A. Our Summer – N. hemisphere tilted toward sun
= N. hem. warmer (Jun – Sep)

P.

B. Our Winter – N. H. tilts away from sun
=N. hem. colder (Dec - Mar)

C. Spring and Fall – both hemispheres get equal sun

D. Atmosphere Belts Shift
-In our summer, all atmos. cells shift to N
ex: So. Cal. in Horse Lat (hot, dry)
-In our winter, all atmos. cells shift S
ex: So. Cal. in westerlies (cool, rainy)

E. Seasonal "Lag" – time delay
-Temperature extremes (August & Feb.) lag 6 weeks after "solstices" (June 21& Dec.21)

1. **Near Oceans** – temp lag 8 weeks behind
-due to heat capacity
* takes time to heat up ocean (H. Cap)
(ex: South Bay, S.F.)

F. Sea Breezes

P.

1. Sea Breeze	vs.	2. Land Breeze
-day(noon – 6 pm)		-night (midnight – 6 am)
-land hot= air rises		-land cold=air sinks
- wind from oc.		-wind from land

*Due to heat capacity of oc. wtr.

OCEAN CURRENTS

I. SURFACE CURRENTS ~ 0.1 - 1.0 ml deep; 0-5 knots (mph)

A. 5 major "Gyres" – river like flow of water around ocean
- clockwise in N hemisphere

P.

B. Current Interactions – upwelling & downwelling

1. Upwelling – water rising to surface
- brings nutrients up from sea floor
- lots of algae ….plankton….. fish….fishing
note: no heat source

P. **A. Surface Currents Diverging** -rare
p. 40 in notes At equator…. radiolarians live…ooze

B. Coastal Upwelling -important
Ex: Calif & Peru: east sides of all 5 gyres
p. = cold water…no thermocl…mixing …
- when wind blows parallel to shore,
surface water moves away from shore (Cor. Eff.)
= deep cold water rises
= nutrients from seafloor… = life!

1. Marine Layer – clouds here (spring)
humid sea breeze ….over cold water= …clouds

2. **Downwelling** = sinking water

P. -where currents converge

only cold water sinks = semi polar

p.67 in notes Ex: No. Atl.

C. Causes of Surface Currents + Gyres

1. **Wind** – pushes the surface water due to friction

- westerlies + easterlies are major cause

P. - continents are in the way, causing them to turn

2. **Coriolis Effect**

-surface currents try to turn to the right of the wind direction in no. hem.

P.

A. Eckman Spiral ("Transport" in text)

-Deeper layers move further to the right

P. -Average water direction is 90 degrees right of wind in no. hem (see P.63 in notes)

3. **Geostrophic Flow** ~ each gyre

-Cor. Ef. builds gyre mound

P. 3' – 6' high in middle

(gravity keeps it from getting higher)

- Result: gyre doesn't spin, it flows like a river

D. Tropical Currents

1. Westward Equatorial Currents- WEC
-"pushed" by tradewinds toward west……warm (coral)
P. - builds up warm mound 1' – 3' high
-at the west end (tropics) in all 3 oceans

2. Equatorial Counter Current - ECC
-some water flows back east along equator
= between WEC (no wind) …. pushed by gravity
-very warm (shallow) usually weak

3. El Nino = "ENSO", every 5 years (15 years real big)
P. =warmer than normal oc. water in east Pacific
- changes weather all over the world
P.

Causes: 1. tradewinds weak (ex: 2002)
2. W. Eq. CS. weak
P. 3. warm mound goes down (…gravity)
4. Eq. CC warm surges east (ex: 2003)
5. warm water spreads out on surface (ex: 2004)

Results:
P. 1. More evap… rain (floods) = E. Pacific (ex.Calif. in 04/05)
2. Storm waves =destruction in E. Pac.
P. 3. Warm layer stops Coastal Upwelling = low nutrients
P. = algae + animals die = bad fishing
P. 4. Drought and forest fires in Indonesia (cooler…)

E. <u>GYRES</u> ~ five, each formed by 3 currents

1. <u>WEC</u> – Western Equitorial currents

2. <u>Western Boundary Currents</u> -important

- along the Westside of Gyres, warm

P. - major heat flow (tropics to polar)

- fastest of surface currents (~5 mph or knots)

A. <u>Causes</u>:

1. warm water flows out of warm mound by gravity

P. 2. westerlies "pull" on the water = WBC's to east

ex. Japan Curr. and

B <u>Gulf Stream</u> -in no. Atl.

- 1 ml deep and 50 mls wide (+30 SV)

P. - 1000's mls long

- warm = starts in Gulf of Mex.

P. - "meanders" toward Europe

- warm "eddies" spin off as cold and warm whirlpools (rotate, 1-3 mls deep)

3. <u>Eastern Boundary Currents</u>

P. - east side of Gyre

- cool water flows toward equator

p. 63 in notes - cool= no thermocline=coastal upwelling!= great fishing (ex: Calif Current)

4. <u>Semi-Polar Currents</u>

-no. hem. only ex: Alaska current

5. <u>Antarctic Circulation</u> ~ ("west wind drift" in text)

* greatest of all currents = mixes all 3 oceans

P. - "pushed" by westerlies

cool = reaches to seafloor= nutrients

(algae ….fish….. animals… penguins)

II. DEEP CURRENTS

A. Features ~ (compared to surf currents)
More volume = fill deep ocean
More stable = temp. & salin. constant
Much slower (less than 10 mls per YEAR)

P.

B. Causes

1. **Water Sinking** – in semi-polar

Fig. 7

2. **Water Density** – heavier= sinks
   - **A. Salinity**
     If saltier = denser = able to sink (mix)
     (only if cold)

P. **B. Converging Currents** = able to sink (if cold)

C. Temperature - colder
-if denser (or same) = able to sink
* Thus, it can sink if 2 reasons occur!

3. **High Latitudes** (semi-polar)

P. -cold water will sink if:
A. salty too (under freezing sea ice) =rare
OR
p. 49 in notes B. if cold surf current converges = downwelling = main source *

4. **Flows Away from Poles** = slow, wide current
- horizontal (under tropical thermocline…)

C. Major Deep Currents (water)

1. Antarctic Circulation = AAC

P. - mixes deep water (p.66 in notes)

Figure 7

2. Antarctic Bottom Water = AABW

- densest current
- only in so. Atlantic….. to north under AAC
- cold and salty (formed, frozen sea ice)

3. North Atlantic Deep Water - NADW

* biggest downwelling = source of all deep water
= cause of average properties of deep oc.

P. (sal.3.5%, , temp. 39 , O_2 10ppm)

Cause – surface currents converge (nr. Iceland)

* sinks – flows 8 mls per YEAR

~ 1000 yrs……..…merges with AAC

4. Common Water = CW

AAC flows into and fills Indian and Pacific Oceans

5. Global Oceanic Conveyor Belt ~ 3000 yrs….

P. -returns on surface from W Pac. to Iceland area

6. <u>Intermediate Currents</u>

A. <u>Mediterranean Water</u>

P. -High evap = sal high ~ sinks (cold = in winter)
- 3.5% in and 3.8% out on bottom (Str.of Gibraltar)
(WWII – German Uboats in & out to go past enemy)
- saltier = sinks to ~ 1 ml deep & flows horizontal into Atl.

B. <u>Red Sea</u> = same

III. <u>CURRENT MEASURING DEVICES</u>

A. <u>Equipment</u> – measure speed, direction, & temp.

P. **1. <u>Stationary</u>** – anchored "buoys"
2. <u>Mobile</u> – buoys float w/ current
P. - radio & satellite tracking (90's)
- surface and deep currents
ex. Nikes ……containers off ship….3 yrs around gyre
P. Toys (ducks)…..

WAVES

I INTRODUCTION

A. Gravity Waves = wind "waves" = "chop".....feet high
-raised water = pulled down….. keeps wave going (like domino's)
P. * waves spread out from …… storms

B. Ripples (capillary waves)……inches
- Formed by wind friction = moves water forward

- When wind stops = goes flat!
- Due to surface tension (H. bonds)

C. Formation of Waves- caused by wind
- Windward side= Ripples push water toward crest
- Backside = water toward crest too
* pushes water up wave
- more wind= larger (move "downwind")

D. Size depends on 1. speed of wind
P. 2. duration of time
3. fetch (area of storm= waves stay in it..)
-after wave leaves storm, L doesn't change, H goes down

E. Terminology

Crest, Trough, **waveLength= L** (horiz. dist. between crests),
Wave Height = H…..
Wave steepness = H / L …. ,
Still Water Level = imaginary…..,
Wave speed = measured in knots (or meters per second)
Period = time between waves = 10 sec.

II. MOTION OF WAVES

A. Orbital Motion

P. -Water doesn't move forward
- Water (+objects…) move in circle orbit

P. -"orbital" motion is less = deeper ….
- until depth = "wave base" = 1/2 wave length (L/2)…

1. Deep Water Waves =any wave ….oc….depth over L/2
- Orbital motion above L/2 (calm under L/2)
a. Sed. not moved = clay dep….
b. Nutrients stay at the bottom …blue…
ex: boat ride

2. Shallow Water Waves =any W….oc… shallower… L/2
- Elliptical motion (oval)
a. Moves sediment (sand, silt)
b. nutrients stirred…..algae…green
c. Friction drag = slows W. down
ex: end of pier

B. <u>Wave Speed</u>

1. **<u>Deep Water Waves</u>** – don't slow down
   - larger L = waves are faster (period is bigger)

2. **<u>Shallow Water Waves</u>** (totally different)
   - shallow depth = slower waves
   - speed 3.1 / D

3. Both= not affected by currents

C. <u>Refraction</u> = bending of waves (on map) …Shallow W.W. only)

1. **<u>Beach</u>** – W.s "turn" almost parallel to shore
2. **<u>Irregular Coast</u>** – W.s "wrap" around point
   =concentrates W. power on headland = larger W.s …. cobbles
   (bays = smaller waves…….mud)

D. <u>Reflections</u>

- Waves bounce off steep wall …..same speed…
- Make very dangerous W.s when coming together
- Breakwater = holey ….rocks =absorbs energy (less W. reflection)

E. Wave Interference

- oc. has many different size waves
- " " " " speeds (+ diff. directions)

1. Constructive Interference

- when different W.s line up crest to cr. (or trough to tr.)
= creates higher crest (+ deeper trough)
*danger = greater height and steeper W.s

a. **Rogue Wave** = huge W.s that damage (sink) ships

2. Destructive Interference

- when diff. W.s line up crest with trough
= cancel out each other = smaller H

* real combinations =change constantly

3. Surf Beat = repeat pattern of W.s coming in
-due to interference
= several large W.s followed by small W.s
"**Wave Set**" =pattern ~ 10 minutes apart

F. Dispersion

As W.s scatter from storm= sorted out
= larger are faster = 1st to shore
…"Surf's Up!"
* danger……
Ultimate Surf Contest……

1. **Swell** = group of large W.s from one storm
South swell…… " " southern "
Normal swell (from west)

G. <u>Diffraction</u> =W.s bend around obstacle
- straight W.s create curved smaller W.s
  ex: harbors, islands
- can occur with deep water W.

III <u>BREAKING WAVES</u> - Results in forward motion

A. <u>Deep Water Waves</u> ~ called "white caps"….windy
- W.s break when wave steepness (H/L) = 1/7
- More wind = H bigger = H/L up = breaks
- break forward (down wind)…… push currents

B. <u>Approaching Shore</u> – shallow water waves
- Shallower = slower Ws.
- following W.s push….closer together
= L gets smaller + H greater = H/L up
- Breaks when H/L = 1/7
* Happens to every W. when depth = 1.3 x H (1.3H)
(measured from still water level)

-Storm W.s = larger height = deeper 1.3H
=break farther out= wider surf zone

C. <u>Surf Zone</u> ~ breaking waves near shore
* water moves back & forth in surf zone (no ellipt. motion)
ex. Swimming

3 Types:

1. <u>Spilling Breakers</u> =foamy white surf zone
-breaking water spills down face of W.
- where seafloor flatter (……1.3H)
ex: storm waves ex. Alaska

2. **Plunging Breakers** (best surf waves)
   - crest curls over….top faster
   - moderate seafloor slope
   - common ex. Calif.

3. **Surging Breakers** = "shore pound"
   - no curl , small waves (sea or bay)
   - steep seafloor , W. surges up beach

Non-wind waves:

IV. TSUNAMI (seismic sea waves)

A. Causes - quakes (subd. zones…….Pac)
-Seafloor up = water up = spreads out as several waves

B. Movement ~ over 400 mph
L= 100 miles
Always shallow water waves
Oc. less than L/2 (100/2 miles = 50 miles)
Shallower sea = slower and **higher!** (up to 100ft.)

C. Destruction ~ due to huge rise in sea level every 20 min
-No curl, danger to low areas = goes inland
ex: Hilo (2 x)
ex. Indian Oc. (2004) = biggest killer…… 300,000 dead

D. Warning Systems – Pacific……

V. STORM SURGES – large sea level rise during storms

- very common!
- low air pressure = mound in oc. = moves with storm
= sea floods land, espec. low coasts
* most destructive natural disaster during most years
-worst= hurricanes = 12' high
-ex: New Orleans 2005 …1000 dead
-occur when largest waves (20') also occurring!!
- ex: Bangladesh: 300,000 dead (1970)

TIDES

I Gravity Causes Tides -oceans attracted to moon, etc

A. Law of Gravitation

-Any 2 bodies will attract each other

Factors:

1. **Mass** – of objects (weight and size)
   - bigger object = more grav. pull

2. **Distance** – closer object = more pull
   *- distance is much more important

G = = mass / dist. x distance

B Earth's Gravity

-E. is very close to ocean = keeps it "flat"

C. Moon's Effect on oceans = main cause of tides

1. **Formation of Tidal "Bulge"**

- one bulge toward and one away from the moon
- ocean closest (A) to moon pulled (to moon)
  more than solid earth (B) = one bulge
- ocean farthest (C) from moon pulled (toward moon)
  less than earth (B) = other bulge

= 2 bulges that cause "lunar tides"

2. **Earth's Effects**

- flattens bulges = only 3' high (if no continents….)

D. <u>Suns Effect</u>

- Also bulges toward + away from sun
- Sun huge, but very far away
- Its pull is about half of moon's

* solar tides = 1 1/2 feet high (…….)

E. <u>Monthly Tide Cycle</u>

-Sun + Moon bulges add or subtract from each other

* creates cycles = twice a month

1. **<u>Spring Tide</u>** ~ during full & "new moon"
   - the sun, moon and earth line up 2x / month
   - constructive interference = 4 1/2 feet
   - highest high & lowest low tides of the month
     = largest tidal range

   ex: Low = tide pools……., ships……
   ex: high = flooding ……., grunion…...

2. **<u>Neap Tide</u>** ~ during "half moons"
   - sun's bulge subtracts from lunar bulge
   - destructive interference = small tidal range
   - when moon, sun, and earth are at 90 degree angle

II TIDE VARIATIONS

A. Earth's Rotation ~ once / day (24 hr)
-We rotate through 2 bulges a day
* we have 2 high and 2 low tides per day

B. Moon's Revolution = orbit around earth
- Every 30 days (actually 29 ½) = "lunar month"
- every day, moon (& tide bulge) go 1/30 farther
- So, we have to go 1/30 of a day to catch up to bulge
** tides are 50 min later everyday
(tide cycle = 24 hrs & 50 min)

C. Tide Chart
- 2 tides per "24 hour, 50 min." period
- tidal range greatest at spring tides ~ 8 ft
- tidal range least at neap tides ~ 4 ft

D. Elliptical Orbit

1. **Moon** ~ distance to earth changes over month
   -So, the 2 spring tides have different ranges

2. **Earth's Orbit** ~ (elliptical) around sun+ effect solar bulge
   - E. closest to sun in January (greatest spring tides)
   - results in greatest tidal range of the year
   - ex: Seal Beach flooded in Jan. = highest spring tide
   - ex: tidepools best

III EFFECTS OF LAND AND SEAFLOOR

A. Oceanic Tide Movements

-Tide bulges trying to go around earth E -> W (following moon)

1. Continents Blocking Bulges

bulges can't go around earth….. 3 oceans

2. Antarctic Tide Effect

= only place where tidal bulges can go around E
following moon = 2 times per day
* send tide N. into all 3 oceans
= source of all tides
- tides act as waves !
- can be opposite direction of current (ex. USA coasts)

B. Ocean's tidal movements

A. Atlantic – tide enters from Antarctic 2x/day

- goes N. up Atlantic as a wave
- "sloshes" around N Atl.…then southward off US
- absorbed by Car. sea & islands

1. Cotidal Lines – lines that show the same high tides

B. Pacific& Indian

- Complicated because wide
- tsunami speed
- Calif = goes N (2 hr to Seattle)

IV **ACTUAL OCEAN TIDES** – observed by us

A. **Effects of Shoreline** - reality

1. **Rivers** – tide currents go in & out up
   -to 100 mls inland
   ex: Amazon R…., Hudson R….NYC)

   A. Tidal Bore – wave sent up river during rising tide
   -Rare = only w/ greatest tide ranges

2. **Bays**
   A. tidal currents – in & out…."tidal inlets"
   ex: Golden Gate…. Alcatraz

   B. funnel shaped – greatest tidal ranges
   ex: Bay of Fundy (E. Canada) = 50 ft
   ex: Cook Inlet, Alaska

   - in and out coincides with hi + low tides = sloshes..

B. **Types**

1. **Semi-Diurnal** = 2 equal tides/ day
   ex. East coast (most common….)
2. **Diurnal** (daily) = only one tide per day
   ex. Gulf coast (rarest)
3. **Mixed** = 2 unequal tides/ day
   (ex: west coast)
   -"sea level" is average Lower Low Water (on charts……)

Begin Test 4 notes:

BEACHES & COASTS

I. BEACHES

A. Parts of the Beach

1. Berm (Backshore)
- dry & flat – above normal waves ex. volleyball…

2. Low Tide Terrace (Foreshore)
- smooth wet sand –exposed at low tide ex: run, shells

3. Offshore ~ beyond low tide = always below water
Surf Zone – area of breakers
Longshore Bar – off shore "sand bar" parallel to shore
- invisible = beyond surf zone
- makes big waves break

B. Materials of beach

1. Sizes

B	C	Peb	Sd	Silt	C

Coarser **finer**

-Usually sand, but some pebbles

A. Size Vs Wave Energy
- Bigger wave = coarser (OR calmer = finer)
- Sands or pebbles left on beach….

B. Steepness of Beach
- Coarser pebbles = steeper beach ex:Alaska
- silt = "mudflat" ex: harbor

2. Components
Quartz, feldspar (light wt…dep. in summer)
Magnetite, etc (heavy….left behind in winter)

C. Creation of the Beach

1. **Elliptical Motion** – beyond surf zone
   -Sh.Wtr. waves lift sand forward toward beach
   = reason sand stays on beach

2. **Surf Zone:** a. **Swash** - wave up on beach
   b. **Backwash** - water returns to sea

3. **Low Wave Activity (Summer)** **C**alif. = most yr.
   - Swash water soaks into dry sand
   = sand stranded up on beach
   * builds up berm = "summer berm"

4. **High Wave Activity (Winter/ Storms)**
   - big waves remove the sand (like headlands)
   * sand remove from beach (small berm)
   - pebbles (+ heavy minerals) left on beach

5. **Longshore Bars (Sand Bars)**
   - winter (eroded) sand piles up beyond surf zone
   - sand stops at bar (ellipt…… SWW……..)

D Minor Beach Features – usually seen at low tide

1. **Swash Marks** -"arcs" at top of swash

2. **Backwash Diamonds** -"V's"downhill of pebbles

3. **Ripples** - little sand ridges (shallow water)

4. **Beach Scarp** -tiny cliff by storm waves (at high tide)

I LONGSHORE TRANSPORT

A. Longshore Current – water moves along shore (parallel)
(different from gyre currents) ex: to south along USA

Cause:
- swash goes up at angle
- backwash straight down due to gravity
= zig zag motion of water
- in surf zone only
- swimmers drift…..

1. Long Shore Drift moving sand along shore
-by LS current (move to south….)

2. Rip Current = rip tide
-dangerous water flows away from shore = fast narrow flow
-big waves trap water…forms mound…. gravity pulls down
~ 4 MPH =can't swim against it
- If caught in it = swim parallel to shore down current

NOT "under tow" (= backwash under swash…trips kids & elderly)

B. Shore Features - large

1. Sand Spit – dry sand bar partly across a bay
-due to longshore drift deposit into bay
-hook …..into bay
ex: Coronado in S. Diego ~ 20 mls long

2. Tombolo – sand bridge out to "island"
-LSD deposits sand in the calm landward side of island
ex: Morro Bay

3. **Bay Mouth Bar** = sand bar across mouth of bay
   -common in dry so. Calif. (lagoon)
   -"Tidal Inlets" form in rainy winter (rivers flow)
   ex: along I-5 to San Diego

4. **Deltas** = sediment deposits at river "mouth"
   - water slows = sed. depos……river splits up
   - flat (at sea level) = flood prone from rivers and storm surges

   A. **Bird Foot Delta** – small waves (bays)
      ex: Mississippi river (N. Orleans) into Gulf

   B. **Wave Dominated Delta**- triangle shape, most common
      -Wavey = L.S.D.moves sand ex: Nile R.
      ex: L.A./Orange County= triple delta and tombolo

   C. **Tide Dominated Delta** – long islands of sediment
      ex: Bangladesh, Holland

C. Coastal Cells = section of the coastline where L.S.D. occurs before being interrupted.
-Sands from rivers……L.S.D to south
=beach wider down current (south) ex: Redondo Beach

1. **Submarine Canyons** - ex: Redondo Canyon
   sand flows down canyon goes down and fills basins
   * removes sand from coastal cell beaches
   = no sand between cells ex: P.V. (near Bluff Cove)
   = good scuba diving = rocks w/ kelp

2. **Dune Fields**
   - wind blows sand (wide beach berm)
   - forms dunes ~ 1 ml. inland
   ex: Manhattan Beach

3. **Man Made Structures** – interferes with L.S.D

   A. **Groin** = stone wall sticking out from beach
      -Sand deposits = "up current" (N) side = wide beach
      -Sand erodes = "down current" (S) side= narrow beach
      ex. Manhattan Bch. (trip), Florida =removed…..

   B. **Breakwaters & Jetties**
      - Walls around harbor & at entrance
      - also traps sand on "up current" side
      - calm = sed. settles ("silting")
      - **Dredging** (barge w/ vacuum pump)…. Expensive…
         - Dump sediment down current (to south)
         - Solution: harbors between coastal cells (ex: Dana Pt.)

   C. **Seawalls** – protects bldgs.
      - Problem: beaches erode in front (leaving no access)
      - Can collapse if built on sediment
      - Calif. Coastal Commission makes decisions……
      - concrete (……....) vs. rock (……) walls

4. **Reduced River Flow** – due to flood control dams
   - captures river sediment ex. L.A /Or. County beaches
   = less sand on beaches (= more erosion)
   ex: Mississippi River delta….15 ft./yr.

5. **Beach Replenishment** – dredge sand from offshore
   - $ 1 million/ mile
   - in most cases, it erodes away (…storms)
   - ex. Miami (and Redondo)

COASTS & ESTUARIES

I TYPES OF COASTLINES

A. Passive Coast = "submergent" (no uplift…)
-"depositional coast"
ex: east coast US…. Atl. Oc.

1. **Coastal Plains** – huge flat areas along coast
(no mtn.s) = sed deposit
ex: E. US., N Europe, E. China…. Most pop.

2. **Barrier Islands** = long, narrow sand parallel to shore
-"tidal inlet"…..in & out of "sound"(bay)
ex: east coast ….. system 2000 mls. long
(cities: Miami Bch, Atl. City, Galveston)
ex. local: Terminal Island
Danger (#1 on east coast) =storm surges flood islands
Solutions: Evacuations over bridges, buildings on pilings

B. Active Coastlines – "erosional coast"
"Emergent"=uplift= mtn.s around Pacific rim

1. **Mountainous Coasts** = rising coasts….rock (ex: P.V.)

A. Sea Cliff Erosions – undermined by waves
1. **Sea stacks** – small bedrock islands
2. **Headland** – Point w/ cliff – hard bedrock
3. **Sea Caves + Arches** - eroded into cliffs
Ex: Abalone Cove park (P.V.)
4. **Blow Hole** – wave → hole in rock= spray into air
ex: La Bufadora (Ensenada)

2. **Tectonic Subsidence** – basins & valleys
   = quakes drop down……..can be filled up by sed
   ex: San Fran. bay ex: LA basin

3. **Marine Terraces** – flat area ……above sea level
   A. wave cut platform = bedrock cut by W.s
   B. uplifted by quakes
   -Multiple = stair-like (wedding cake)
   Common …Pacific
   ex: P.V. = 13 marine terraces (San Pedro)

C. Coast Erosion

1/5 of U.S. coasts critical

1. Calif. = 4" of land per year….sed. rx
2. Miss. R. Delta = 4 meters/yr eroded (plus hurricane erosion!)

II ICE AGES (Pleistocene)

A. Sea Level Lower = 400 ft

-During ice age = ice caps on land= seal level lower

-every 100,000 years…. Over last 2 mill. yrs

B. Rising Sea Level -most ice melted 10,000 yrs ago

- Under sea: cliffs, platforms, beaches ~ 400 ft. below sea level
- 20 miles offshore

1. Marine Archaeology –new field …….
   Study stone age cultures..
   Ex. Native Americans walked..Bering Straight 13,000 yrs ago.

C. **Fjord** = long thin deep bay w/ steep rock walls

1. steep walled valley eroded by glaciers (last ice age)
2. Ice melted ~ 10,000 yrs ago, rising sea flooded valley

ex: Alaska & Norway cruises (1 mill. tourists/year)

III COASTAL OCEAN WATER in bays (vs. open ocean)

-Shallow, less volume, separated from ocean
-like tidepools

A. Temperature range greater = hotter…..smr.; colder…wntr.
easier to change….. due to weather

B Salinity range greater
- Higher (hotter……. summer)
- Lower (rain/ rivers….. winter)

C. Waves - smaller

IV ESTUARIES –"bays"

-Separated from ocean; river at other end
-Where ocean water most affected by humans
ex: biggest cities….

A Definitions

1. **Mouth** – opening to ocean
2. **Head** – river end
3. **Wetlands** – salt water "swamps"
   - **A**. tidal flat = mud flat, no vegetation
   - **B**. salt marsh = grass, temperate (ex. US)
   - **C**. mangroves = trees….. roots, only in tropics
     (holds sediment together – protects from storms)
4. **Inter-Tidal** = exposed at low tide
   - low waves = mud & vegetation
   - richer in life than any other place…..

B. <u>Estuaries of Coastal Plains</u> – flat "topography"
ex. East coast, N. Eur., E. China

1. **<u>Drowned River Valleys</u>**
   - rising sea 10,000 yrs ago flooded…..
   - shore moved ~ 50 mls inland (now = shelf)
   = shallow, long, huge (100 mls) bays
   ex: Chesapeake Bay (D.C., Jamestown, Annapolis, Balt…)

2. **<u>Barrier Island Sounds</u>**

   A. <u>Barrier Islands</u> – bridges to them

   B. <u>Sounds</u> – bays = lagoons (TX)
   - Long and narrow (1ml wide)
   - shallow …..T + Sal. changes
   - calm = mud, wetlands, "shellfish"
   - connected= intercoastal waterway= millions of boats

C. <u>Estuaries of Mountainous Coasts</u> – Ex: west coast

1. **<u>Drowned River Valleys</u>** -
   - deeper & shorter length (flooded mountain canyons)
   - most filled w/ sediment ex: Newport Bay

2. **<u>Tectonic Basins</u>** – PG 92 of notes ex. S. F. Bay

3. **<u>Fjords</u>** – PG 94 of notes ex. Alaska

D. "Circulation" in Estuaries – mixing not due to currents

1. **Estuarine Circulation** – most common
   - **A. Fresh Water Inflow** – river floats as moves out
   - **B. Salt Wedge Concept**
     - salt water from ocean… in at bottom
     - transition mixes "upwards" (due to tides)
     - "brackish" water exits bay at top

2. **Reverse Circulation** – in dry regions (So. Calif.)
   - Reverse of estuarine circulation
   - Evap. = high salin. water sinks & flows out (bottom)
   - ocean water in at surface

   ex. San Diego Bay
   - **A. Mediteranean Circulation** = p. 70 in notes

3. **California** – both (rainy season vs. dry season)

III ESTUARY LIVING CONDITIONS

** estuaries are most "productive" ocean water…..
= nurseries of ocean (1/2 all fish species…….eggs)

A. Good for plants

1. Nutrients – very high
- -Organic matter from rivers = sink (ex: dead stuff)
- * solids trapped by salt water wedge = decay = nutrients high

2. Sunlight – abundant (shallow)

B. Good for Animals

1. **Protection** – hide from predators, fish eggs laid
2. **Plentiful Food** – population high

C. Effects on Nearby Oceans

1. Dissolved nutrients leak out = more algae
2. Small fish leaving = more productivity

IV HUMANS AND ESTUARIES (bays)

A. Metropolitain Areas
= largest cities ……
Why?: harbors, transportation…. rivers & sea meet

1. Wetland Destruction
A. Drain = build wall , pump water out
ex: 1/2 S.F. Bay destroyed = farm, salt production
B. Landfill = artificial land….urban uses
ex: L.A. harbor (largest in….): San pedro to Long Beach
worst quake damage = landfill areas….shake more
worst storm surge damage = land fill and drained areas

B. Flushing Time – time for water in estuaries to flush out to sea
- (tides & rivers)
- Takes from days to years….
ex: London, Portland, SF bay = days
ex. L.A. harbor = years

C. Bottom Sediment
Many pollutants sink = in mud = won't flush!
ex: PCB's in San Diego bay
Dredge? = stir up pollution……..

D. Pollution - types
1. Oil – on beach natural
A. Platforms – not a major problem in US
ex: Santa Barbara -1969 = worst spill….
B. Tankers = ships
-Almost all spills caused by moving ships
- ex: Exxon Valdez -1989
***Prevention**: double hulls, pipelines,
oil spill prevent equip.,GPS & computer maps

2. **Sewage** – concentrated (cities…..estuaries)
   -diseases sterilized by sea wtr. = 2 days in open ocean

   * **Anoxia** problem: too high nutrients = high algae
   = high bacteria decompose = no O2 = dead animals
   ex: "red tide" in poll. estuaries ~ fish killed

3. **Chemical** – worst pollutant = forever, invisible, toxic
   ex: DDT off PV ~ largest spill in world, destroys birds' shells
   Solution: dredge OR cover w/ mud
   ex: Minamata disease (mercury …..Japan)

4. **Agricultural Run-Off** – from farms
   a. pesticides = poison animals
   b. fertilizers = excess nutrients = anoxia
   ex: Chesapeake Bay & SF Bay

5. **Nuclear Waste** – not common (except Russia)
   -maybe in future?

6. **Thermal Pollution** – power plants = heated water returned
   = 15 degrees F warmer
   = kills organisms, espec. in estuaries

7. **Garbage** – plastics last for 400 yrs,
   - fishing line strangles,
   - plastic bags starve

* most pollution is preventable; just costs money, need to educate
   (US vs. Russia)
* pollution is worst in estuaries……

MARINE CONDITIONS & PRODUCTIVITY

I. MARINE CONDITIONS – of "open ocean" (out at sea)
Compared to "coastal ocean"

A. Temperature – nearly constant = great volume

1. **Sub-Tropical** – always warm (surface) ex. Hawaii

2. **Semi-Polar** – always cold ex: Alaska

3. **Temperate Region**
blue = 30 – 60 degrees latitude – seasons! Ex: USA

B. Best Areas for Nutrients = high product = best fishing
- Nutrients on sea floor (decomposition.)
- Where mixed to photo zone = more algae

1. **Continental Shelfs** – all coasts…. most common
   - waves can mix ….shallow water (<L/2)
   - also rivers and estuaries bring nutr.

2. **Upwelling** – brings nutr. up
   A. coastal – off west coasts (ex. Calif.)
   B. equatorial – along equator

3. **Semi-Polar**
   - no thermocline, mixes water from bottom to top
   - ex: Antarctic …..

C. <u>Sun light</u>

- Oc. life depends on algae (phytoplankton)

1. **<u>Photosynthesis</u>** = creates organic matter

   $H_2O + CO_2$ ----------→ $C_6H_{12}O_6$ + O_2

   sunlight Carbohydrates, waste

   -happening for 4 billion years

2. **<u>Photic Zone</u>**

   - over 130 ft thick (uppermost 1% of ocean)

D. <u>Oxygen</u> – needed by animals ("zooplankton", etc)

1. **<u>Oxygen Minimum Layer</u>** – in aphotic zone

   - dark = animals hide = use up O_2
   - if O_2 < 2ppm = anoxia = zone of death
   - irony = beneath coastal upwelling areas!!!!

   ex: Gulf of Calif.

   = "deadest" ocean is under the "richest" oc. surface

II – PRIMARY PRODUCTIVITY

Algae Created

- Average in ocean = 1/3 aver. productiv. of land
- Due to nutrients on seafloor = far from photic zone
- except well mixed = high productivity = same as land

A. Nutrients = fertilizer
- needed by algae – if one missing = "limiting factor" (die)

1. **Common** – in sea, not limiting = no productivity
   calcium, potassium, sodium

2. **Limiting** – often missing = controls algae population
   - measured in **ppm**
     - **A. Nitrogen** – only usable as nitrate, etc.
     - **B. Phosphorus** – only usable as phosphate, etc.
     - **C. Silica** – used in shells (diatoms)
     - **D. Iron** – So. hemisphere oceans = limiting factor
       -1 solution to Global Warming = ships fertilize oc. w/ iron

3. **Trace Elements** - minerals
   -measured in PP billion
   ex. iodine (edible salt = from sea salt)

B. **Seasons of Productivity** = when !!!

-**sunlight** and **nutrients** can vary by season

- need both for high productivity.

1. **Latitude**

A. S Tropics – 0-30 degrees N+S

Always thermocline = no mix = low prod.

= "deserts of the sea" ex: Hawaii

B. Semipolar = 60 – 80 degrees N+S

- No thermocline = always mixed= hi nutrients
- **Sunlight** in spring & summer only

* algae "blooms" (diatoms) → zoo plankton → whales

C. Temperate – 30 – 60 degrees N + S

- Seasonal change (ex: US, Japan, Europe)
- seasons affect mixing **and** sunlight

SEASON	**Sunlight**	**Temper. → Thermo → Nutrients**			**PRODUCTIVTY**
Winter	Low	Cold	No	High	Low
Spring	High	Cold	No	High	Very High "algae bloom"
Summer	High	Warm	Thermocline	Low	Low – algae die
Early Autumn	Medium	Cold	No	High	Medium high "second bloom"
Late Autumn	Low	Cold	No	High	Low

* Algae blooms = when both sun + nutrients are high

V. TIME SCALE OF LIFE

- universe 13.7 B.Y. old
- earth 4.5 B.Y. old and oceans 4 B.Y. old)
- Life evolved easily (quickly)= most in sea
- Evidence = fossils (seafloor sed.= now rocks)

A. First Occurrence of:

Bacteria & BlueGreen Algae ~ 4000 MY ago = 4 BY
Algae & Zoo Plankton. ~ 1 – 2,000 MY = 1-2 BY
Animals ……~ 550 MY
True fish ……..~ 450 MY
Reptiles …… ~ 300 MY
Birds & mammals ~ 200 MY, but rapidly evolved since 65 MY
(when meteor hit Earth → dust…→ cold → killed dinosaurs)
Whales ~ 50 MY
Humans ~ 1-3 MY

B. Unusual Marine Environments

– vent communities =1980's discovery

A. Black Smokers – hydroth. vents (Rift Valley- 2 mls…..)
- Unique ecosystem (no photosynthesis)
- Bacteria "eat" metal sulfides
- Giant tube worms & clams "eat" bacteria

?? moons of Jupiter= under frozen oceans

B. Cold water (hypersaline) seeps ex: Florida
C. Hydrocarbon seeps = oil & gas seeps ex: Texas
-bacteria "eat"…..

VII **FISHERIES** = fishing, industry & resources

Best fishing= coast upwell., Semi polar, shelf areas

A. Over Fishing = too many fish hunted

-Fish can't reproduce = die off

ex: Cod in N Atl. 1990's

Sardines in Calif.–1940's – "Cannery Row".. Monterey Aqaurium

Salmon in NW – now

Oysters in Chesapeake

1. **Technology** = "better" fishing…..

   -**Factory Ships**: process & freeze, fill to brim, stay out 2 months

   -**Sonar**: locate schools of fish

   -**Drift Nets**: miles long, catch everything…….

   -**Airplanes**: tuna & dolphins (E. Pac)……

   - Satellites: temp (cold = nutrients mix = fish)**

B. Exclusive Economic Zones - EEZ

- 200 mile limit offshore - 1967
- nation controls: 1. fishing (…….quotas)
  2. Oil…….
  3. Pollution

C. **Mariculture = "Marine Agriculture**" – future farming

1. **Kelp** – harvested to make "algin" (commercial gel)
   ex: shampoo, toothpaste, jello, pudding

2. **Fish**
   -salmon hatcheries in US …. release
   - Tuna & salmon in ponds - Japan
   - White sea bass in tanks– (San Diego)
   - Problems: High cost (labor , food) = not in US,
   pollution from fish cages in estuaries = "farm-raised"

3. **Shellfish** – even in US
   - oysters – over 50% from estuaries
   - cultured pearls – Japan (1870's) = ……. pools
   - abalone – in "factories" in Cal.
   - Shrimp – in ponds = mangroves removed
   Ex: Thailand tsunami damage, Honduras hurricane destruction

VIII SCUBA DIVING – certification due to dangers

A. **The Bends** – pain & possible death
   - Due to pressurized air (in tanks) forcing nitro. gas into blood….
   - If rise too fast bubbles of nitrogen in blood….

B. **Nitrogen Narcosis** – drunk feeling
   - Limits how deep divers can go (120 ft limit)

C. **New Technology** – (Nitrox)
   - Oil platforms, navy rescues, marine archaeology (400 ft. deep)

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I. **Nutrient Cycles**

1. **Recycling** – fig 12
   - product. great where nutr. continually mixed up to photic zone

   a. **Slow** = org. matter sinks below photic zone
      before decomp. by bacteria into nutrients
      ex: nitrates…….. on sea floor
      *Can't be used (unless mixed up…..)

II FOOD WEB– network not a chain (cycle)

A. Primary Producers = Algae ex: diatoms

B. Herbivores ="algae eaters"
ex: zooplankton, snails, attached animals

C. Carnivores = "meat eaters"
most fish, mammals, birds in ocean = "big animals"

D. Organic Debris
Dead material

E. Bacterial Decomposers
Rot dead bodies into nutrients = * most important in oc.

III CYCLING OF GASES – fig 12

A. Oxygen – rapid recycling of gases – involves CO2 & O2 gases

B. Carbon Dioxide – in CO2 = slows cycling of carbon
Food has to be eaten (process takes months)

C. Photic Zone = sun lit (algae)
Aphotic Zone = dark = animals hide
Bioluminescence = dinoflagellates glow…….