

Dynamics of Marine Ecosystems

Exam 2 Review. Monday, October 24, 2011

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Note. Inclusion of a topic in this review does not imply inclusion on the test, and exclusion in the review does not imply exclusion of the topic on the test. You should review all materials presented to you in class and in readings as you prepare for the exam.

I. Definitions and Concepts

a. ENSO

Walker circulation

SOI index = $[P_{diff} - P_{avgdiff}] / SD(P_{diff})$. So if SOI is negative, you've got warm event conditions. SOI + is La Nina.

Warm event: weaker equatorial upwelling, weaker Ca current upwelling, warmer Ca current temp, deeper Ca current thermocline, W.Pac warm pool spreads across equator

b. PDO

Not quite sure what drives it. Longer cycle than ENSO.

+ PDO is like negative ENSO – weaker eq upwelling, much weaker Ca current upwelling, warmer Ca current, deeper Ca current thermocline, W. Pac warm pool spreads to east
Is additive w/ ENSO

c. NAO

Not quite sure what drives it. Longer cycle than ENSO but highly variable (on order of weeks)

+NAO = warmer waters off SE USA & N. Europe. +NAO correlates w/ lower phytopl biomass, lower zoopl biomass in central N. Pac, diff in fish populations & copepod pops w/ diff temp preferences

Go over Georges Bank vs Barents Sea for cod stocks

d. Anomaly

Difference from the normal. So you see bigger temp anomaly numbers in E. Eq. Pac than in W. Eq. Pac.

e. CalCOFI

Started in 1950's. Measured everything they could think of. Constant site location. Lots of sites in a small area.

f. CPR

Opportunistic sampling of North Sea & N. Atl since 1931. Just zoopl & now some phytopl. Occasional temp measurements. Big area surveyed. Cheap.

g. Isotopic 'del' notation

$$\text{delE} = \left[\frac{(\text{h/l})_{\text{sample}} - 1}{(\text{h/l})_{\text{std}}} \right] \times 1000$$

More – means has less of the heavy isotope. More + means has more of the heavy isotope.

We care about the 'weird' (heavy) isotope b/c biology is lazy & wants the light isotope.

h. Rayleigh distillation

The heavy isotope wants to stay in the most stable form. Solid > liquid > gas in terms of stability. Go over evap & precip. Heavy oxygen wants to stay in the water – and wants even more to stay in the water when the system is cold - during evap, so ^{18}O is a tracer for temp & salinity. Compounding b/c warmer places also tend to have more evap (so saltier water). That's why ^{18}O is a proxy for salinity in W.Pac & temp in E.Pac.

Draw clouds & snow over ocean.

i. $\delta^{13}\text{C}$ & DIC in depth profile

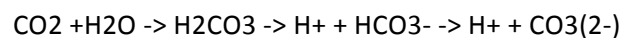
Sikes lecture 10/7/11, page 8, bottom panel

^{13}C is of the DIC.

Less DIC at surface b/c of photosynthesis (organic!!!) ^{13}C at surface is high b/c biology is lazy & photosynthesizers want the $^{12}\text{CO}_2$ instead of the $^{13}\text{CO}_2$, leaving the $^{13}\text{CO}_2$ in the water.

Peaks in both at ~1000m due to remineralization (can see by O_2 profile)

j. CO_2 in seawater



Increase in H^+ concentration means decrease in pH.

The 4 carbonate sps in seawater are: $\text{CO}_2(\text{aq})$, H_2CO_3 , HCO_3^- , and CO_3^{2-} . Bicarb is most abundant b/c ocean pH is buffered by dissolved salts.

More CO_2 can dissolve in water b/c there are multiple steps to the reactions. So if CO_2 dissolves in water, it can dissociate to bicarb or carb which means that now there's not as much CO_2 so more can dissolve in, which dissociates, so more can dissolve, etc.

k. Organic versus inorganic; dissolved versus particulate C in seawater

$\text{CH}_2\text{O}(n)$ is organic.

Carb, bicarb, carbonic acid, $\text{CO}_2(\text{aq})$ are both inorganic & dissolved. They are converted to organic by photosynthesis.

$\text{CH}_2\text{O}(n)$ can be particulate. Body parts are particulate. CaCO_3 is particulate.

I. Lysocline & CCD

L is the start of significant CaCO_3 dissolution

CCD is depth to which CaCO_3 can be sold b/c of temp & pressure. So, CCD is deeper than lysocline.

Shallower CCD in Pac b/c of deep circulation & accumulation of respired C \rightarrow carbonate system so gives off H^+

II. Practice Problems

- a. ENSO is chicken-and-egg-ish, but you've got to start somewhere. First, tell/draw me how trade winds are set up over the equatorial Pacific. Then tell/draw me how Walker circulation 'piles' up water in the western Pacific.

Dr. Wilkin's lecture from 10/3/11 page3 bottom panel. Be able to explain it.

- b. As your job, you fish some stinky cold water-loving fish off the coast of California. How's business in a +PDO period? In a -PDO period?

+PDO has weaker Ca current upwelling. So less food for fish.

Warmer Ca current = fish move north

Deeper Ca current thermocline = fish go deeper.

If its also a -ENSO year, things are really bad

-PDO has stronger Ca current upwelling. More food for fish.

Cooler Ca current = fish move south.

Shallower Ca current thermocline = fish closer to surface.

c. As your job, you use really fast boats with great gas mileage to catch fish in the North Atlantic between NC (USA) and somewhere close to Iceland. Where would you go during a +NAO period and why? A -NAO period? Would you use your fast boat to zip back & forth between Iceland and NC (b/c NAO variability is on the order of months)?

+ NAO – go to Barents Sea (up near Iceland). B/c +NAO means warmer water in N. Atl, so get better stratification near Iceland (+warmer temps make things grow faster) so you get bigger phytopl bloom. More food for cod to eat. Catch more cod.

-NAO – go to NC/Georges Bank. B/c -NAO means cooler water in N. Atl so NC not as strongly stratified for as long and can get decent-sized phytopl blooms. Up by Iceland, there'd be a really short bloom so little for cod to eat. Near NC, there'd be lots of food.

Wouldn't zip back and forth b/c the generation time of cod is much longer than the time scales of NAO variability. Think about the Linear Tracking Window hypothesis.

d. What is a good tracer for temperature? What are some caveats? How would you deal with these issues? What two things are $\delta^{13}\text{C}$ a good tracer for? Draw a picture of why. $\text{De}18\text{O}$ is a good tracer for temp. Its also a tracer for salinity. On long timescales it tells you how much ice volume.

Alkenones are also a good tracer for temp. Has confounding vital effects.

You can use multiple proxies to deal with the issues of each.

^{13}C is a good tracer for circulation and productivity.

- e. What are the best parts of the CalCOFI dataset? Of the CPR dataset? Why can't we have all of those things?

CalCOFI – longterm. Set points that are gone back to each year. Lots of things measured. Many points over a small area.

CPR – also longterm. Opportunistic = cheap. Sampled over large area.

Gets expensive to have all the best things.

- f. Why is the ocean such a good reservoir for CO₂? How does dissolving CO₂ in seawater lead to ocean acidification? Is the surface ocean acidic? If the surface ocean is not acidic, why does dissolving CO₂ in seawater make it hard for calcifying organisms to make CaCO₃?

B/c CO₂ is a di-protic acid when dissolved in water so its hard to become saturated. Thermocline acts as a cap to keep CO₂ in deep ocean, except at upwelling areas.

When CO₂ dissolves in water, it first combines w/ water and then gives off the H⁺s from water. Increase in H⁺ is the definition of decreasing pH which is the definition of acidification.

The surface ocean is not acidic. Its pH is ~8. But each pH unit change is a 10-fold change in H⁺ concentration. That's why, even though the ocean is not acidic, we worry about the pH decreasing by even 0.1 pH unit.

Bjerrum plot (log scale).