SIO 210 Problem Set 2
October 16, 2018
Due October 25, 2018 (1 week)

1. If the sampling rate for a time series of, say, ocean velocity, is 1 day, and the length of the time series is 2 years, and you wish to do a time series analysis:
(a) What is the Nyquist frequency?_____
(b) What is the fundamental frequency?_____
(c) If the region has semi-diurnal tides, will the tidal frequency be aliased?_____ Explain briefly.
(d) If the phenomenon you are measuring is affected by El Nino, which has a time scale of 3 to 7 years, compare the length of time series you would need to resolve the El Nino cycle with this length of time series. Use the concept of 'degrees of freedom'.

2. Consider heat transport and divergence associated with nearly horizontal gyre circulation. The Pacific Ocean is approximately 10,000 km wide. Its upper layer (wind-driven subtropical gyre – clockwise circulation) is approximately 1,000 m deep. Consider a west-to-east cross-section at about 30°N across the whole width of the Pacific, from Asia to North America, for this layer. Assume that there is a narrow, northward-flowing, western boundary current (Kuroshio) and a very broad, southward-flowing, interior flow across most of the section. For the following questions, assume that velocity does not vary with depth within this layer.

(a) If the water in that cross-section is moving southward at 1 cm/sec, calculate the total southward volume transport, in MKS units. (Ignore the Kuroshio for this calculation.)

(b) If this same amount of water is returning northward in a western boundary current that is 100 km wide (and still 1 km deep), calculate the average northward velocity of the western boundary current.

(c) If the average oxygen content of the northward flow in the western boundary current is 150 μmol/kg, calculate the net northward transport of oxygen in the western boundary current, in units of μmol/sec. Use the information from (b) to calculate.

(d) Suppose this circulation is transporting 1 PW of heat northward. If all of the northward flow is of one temperature and all of the southward flow is of another temperature, what is the temperature difference between the northward and southward flow? Use typical (uniform) values for density and specific heat, as given in class or in a textbook.

(e) Explain why I asked you to calculate a temperature difference in (d), rather than the actual temperature.

(f) Calculate the average air-sea heat flux between this section and the northern edge of the Pacific Ocean (Japan/Russia/U.S./Canada). Use very simplified assumptions about the width and

length of this region (i.e. don't worry about calculating the exact dimensions, just approximate it). Ignore the Bering Strait – assume there is no leakage out of this large "box".

3. Surface gravity waves: refer to upcoming Mackinnon lecture notes for Oct. 23 or material in DPO chapter 8.
(a) Write down the expression for phase speed c for surface gravity waves if their wavelength λ is much shorter than the water depth. _____

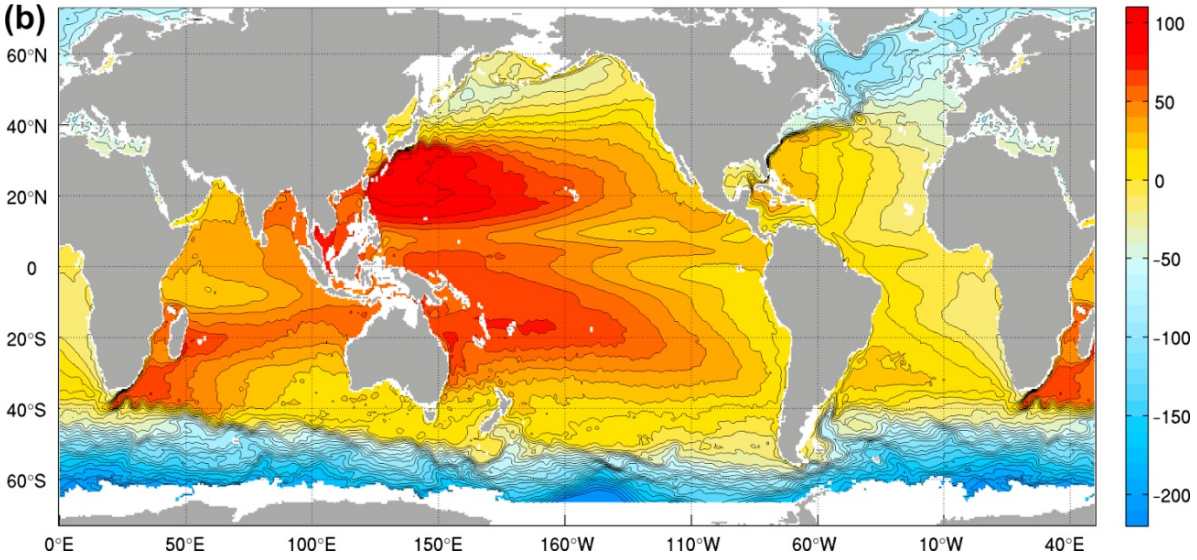
(b) Are these 'deep water' waves or 'shallow water' waves? Explain briefly.

(c) Write the expression for wavenumber k in terms of wavelength λ._____

(d) Evaluate the phase speed for a wavelength of 10 meters._____ and for a wavelength of 500m._____

(e) Using these results, suppose the waves are generated by a a storm 1000 km away.
Which wave from (d) will reach you first? _____
How long will it take for the 500 m wavelength waves to reach you?_____

4. This is a map of sea surface height (not exactly, but close enough for this problem set). (DPO Fig. 14.2b). Contours are in centimeters.



(a) Look at the equator in the Pacific Ocean. Estimate the difference in sea surface height (SSH) from the western side to the eastern side of the Pacific, along the equator. _____

(b) What is the pressure gradient force (pgf) associated with this SSH difference? Assume water density of 1025 kg/m^3, and gravity of 9.8 m/sec^2.

(c) If this pgf is associated only with acceleration, calculate the (eastward) acceleration._____ Calculate the (eastward) velocity along the equator after 1 month._____

5. Water masses.
Look at the zonal (east-west) section from the N. Atlantic at 24°N (DPO Fig. 9.22, included here). For each of the following: circle and identify on the sections, and explain what property(ies) you used to identify the water masses.

(a) Identify the mixed layer. What are its salinities, temperatures, oxygen relative to the rest of the water column?

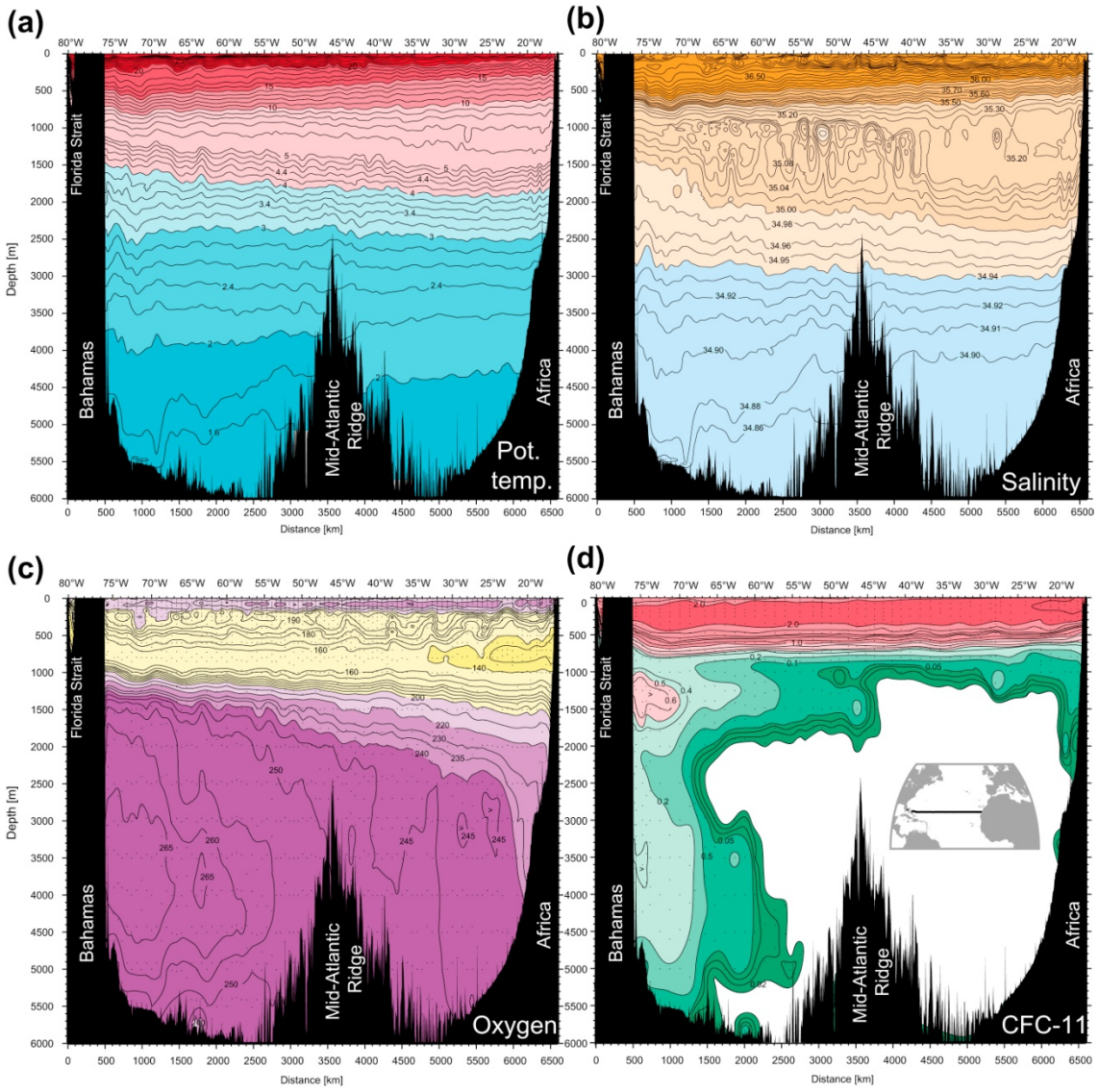
(b) Identify the Mediterranean Water

(c) Identify the main thermocline

(d) Identify the Mediterranean Water

(e) Identify the North Atlantic Deep Water

(f) Identify the Antarctic Bottom Water


(a)
(b)
(c)
(d)
Florida Strait
Bahamas
Mid-Atlantic Ridge
Africa
Pot. temp.
Salinity
Oxygen
CFC-11
Depth [m]
Distance [km]