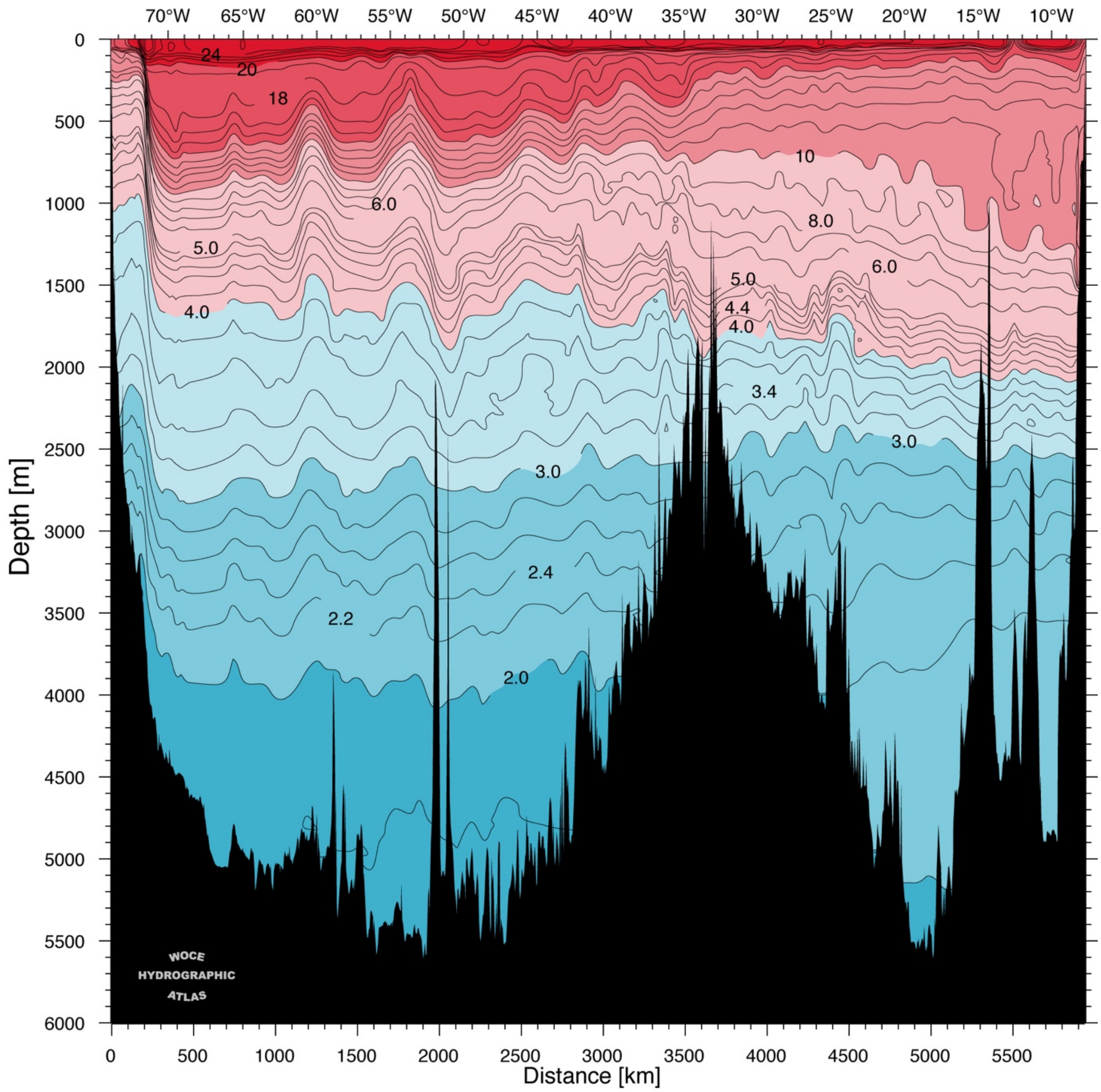
SIOC 210
Problem Set 3
Nov. 14, 2019, due Nov. 21
Problems 1 and 2 are very similar to the questions that were distributed on Oct. 24. Since I provided an answer key for that problem set, I have altered the questions somewhat.

1. (a) On the attached potential temperature section, from the North Atlantic at 36°N, indicate the direction of the near-surface flow (upper 100 m) close to the western end of the section, that is, in the Gulf Stream. First note where the Gulf Stream is in this figure (it is not exactly at the boundary).
Assume it is geostrophic. Explain how you know the direction of the current given the temperature section. Note that this is a VERY narrow feature.

(b) Sketch the expected sea surface height above this current. (Ignore the large eddies that are east of about 67°W).

(c) Look at the isotherm slopes beneath this surface flow, down to 2000 m depth. Describe what they look like.

Sketch the change in the geostrophic current (Gulf Stream) with depth (vertical shear in the geostrophic current), on the vertical section, using our conventional icons for arrows either along the page or in and out of the page.
Source of figure: http://whp-atlas.ucsd.edu/atlantic/a03/sections/printatlas/A03_THETA.jpg



2. On the attached Pacific property sections (from DPO 6th chapter 4):

(a) Label the "4 layers" (schematically)

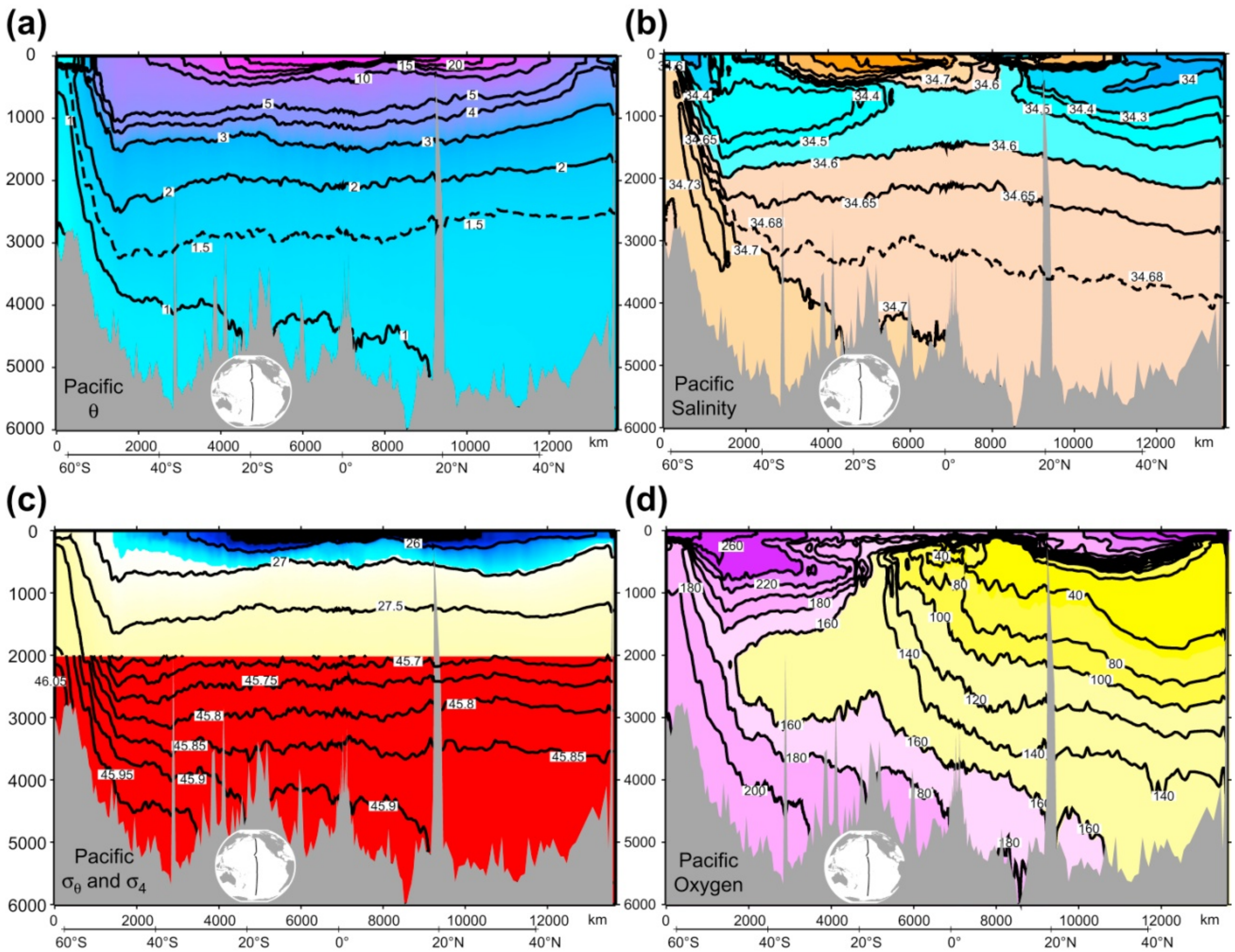
(b) Label the major water masses based on our class examples.

Choose 2 of the water masses from (b).

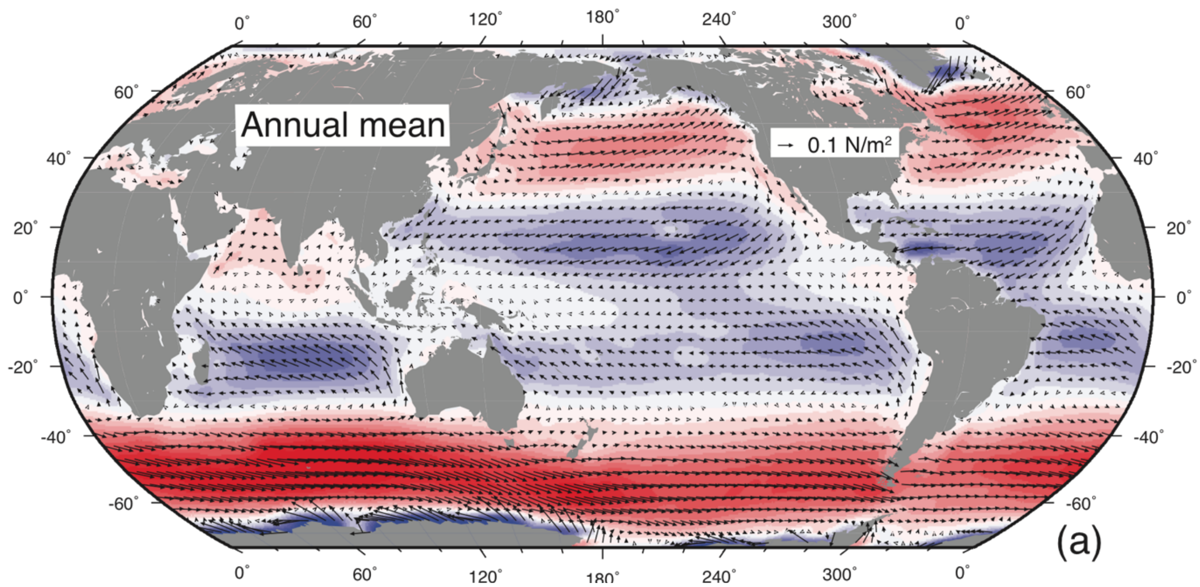
(c) How do you identify each of the two water masses you've chosen?

(d) What is the formation history of the two water masses you've chosen?

(e) Look up the chlorofluorocarbon section that corresponds to this section. The Pacific hydrographic atlas is located at http://whp-atlas.ucsd.edu/pacific_index.html. (There are two CFCs: CFC-11 and CFC-12; just use one of them. CFCs in the large area of uniform cyan are below detection limit.) Describe its main features in terms of these water masses and what you know about their age and ventilation history.
The section in this problem is “P16”.



3. Dynamics: Ekman layers
The attached figure is wind stress at the sea surface (from Chapter 5).



(a) In the North Pacific, label the Trade Winds and the Westerlies.

(b) In the N. Pacific, sketch the direction of Ekman transport in the Trade Winds and Westerlies.

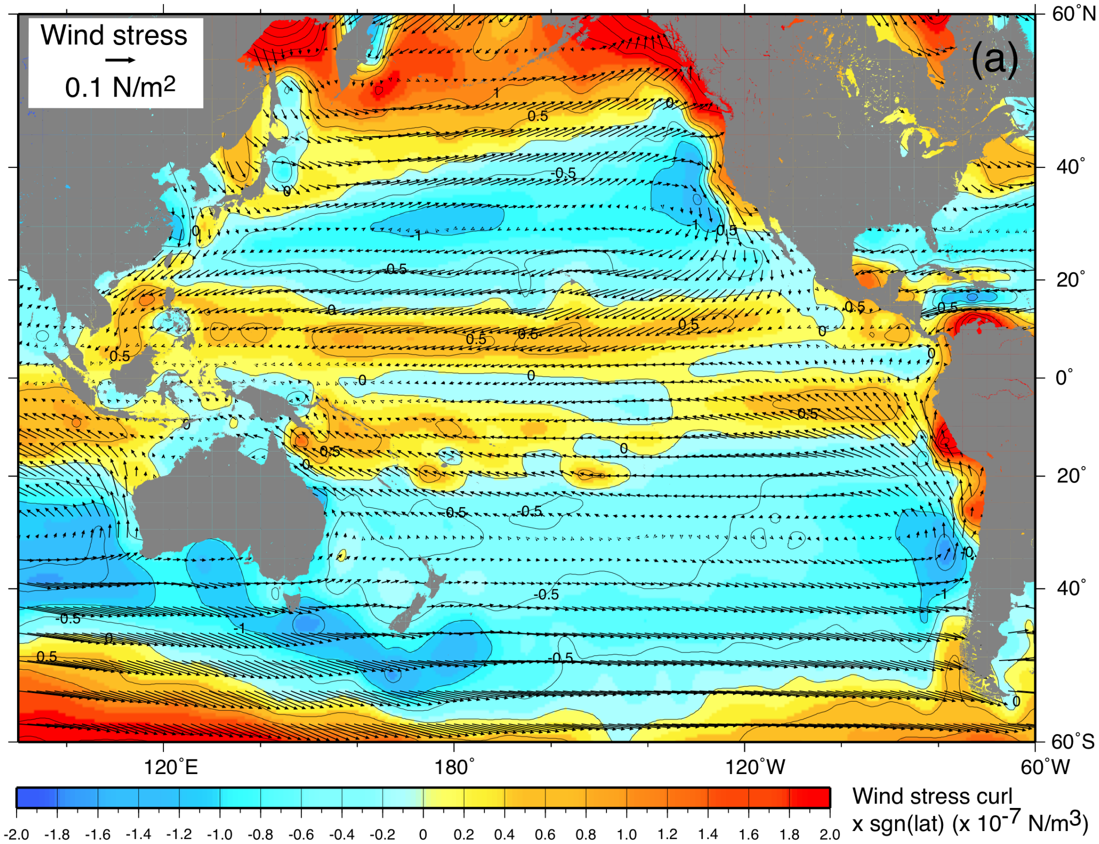
(c) Also in the N. Pacific, sketch the direction of Ekman transport along the California coast.

(d) Calculate the meridional Ekman transport at 40°N: use a single estimate of the wind stress from this map to calculate the local Ekman 'transport' in m^2/sec (so it won't be exact, but please use an exact expression relating Ekman transport to wind stress). Integrate this very approximately across the full width of the N. Pacific to obtain the total Ekman transport in m^3/sec.

(e) Calculate Ekman transport also at 15°N, as in (d). Integrate this very approximately across the full width of the N Pacific.

(f) Write down the terms in the x- momentum equation that are applicable for Ekman transport.

4. Use the wind curl map here and Sverdrup balance to estimate the transport of the Kuroshio at 30°N. Assume that the wind curl is uniform and equals the maximum value of curl at 30°N. Look at the map of Sverdrup transport from lecture or the textbook to compare with your answer.



5. Waves and Tides

Very long swells generated by a distant storm are observed in the open ocean, which is assumed to be very deep (about 5000 m). Their period is T seconds.

a. What is the formula for (deep water) surface wave speed c in terms of wavelength L? (This is the phase speed.)

b. Rewrite this: what is the wavelength L in terms of wave period T?

c. Evaluate the wavelength L if the period T = 20 sec and g = 9.8 m/s^2.

d. Calculate the speed of these waves.

As these waves pass by, water parcels at the surface carry out circular orbits (forward at the crest, then downward, backward at the trough, then upward).

e. If the wave height (from crest to trough) of these waves is H, what is the diameter D of the orbit?

6. Short answer questions about tides: circle correct answer and draw a diagram to explain.

a. Spring tides (times of large semidiurnal tidal range) occur twice a month

   A. when the moon is in the earth's equatorial plane,
   B. when the moon is out of the earth's equatorial plane,
   C. at full or new moon,
   D. at the quarter moons,
   E. at lunar perigee.

Draw a diagram to illustrate your answer.

b. The daily inequality (elevation difference between a high tide and its immediate successor) vanishes for lunar tides

   A. when the moon is in the earth's equatorial plane,
   B. when the moon is out of the earth's equatorial plane,
   C. at full or new moon,
   C. at the quarter moons,
   D. at lunar perigee.

Draw a diagram to illustrate your answer.