Marine Chemistry 12.742
Problem Set #3

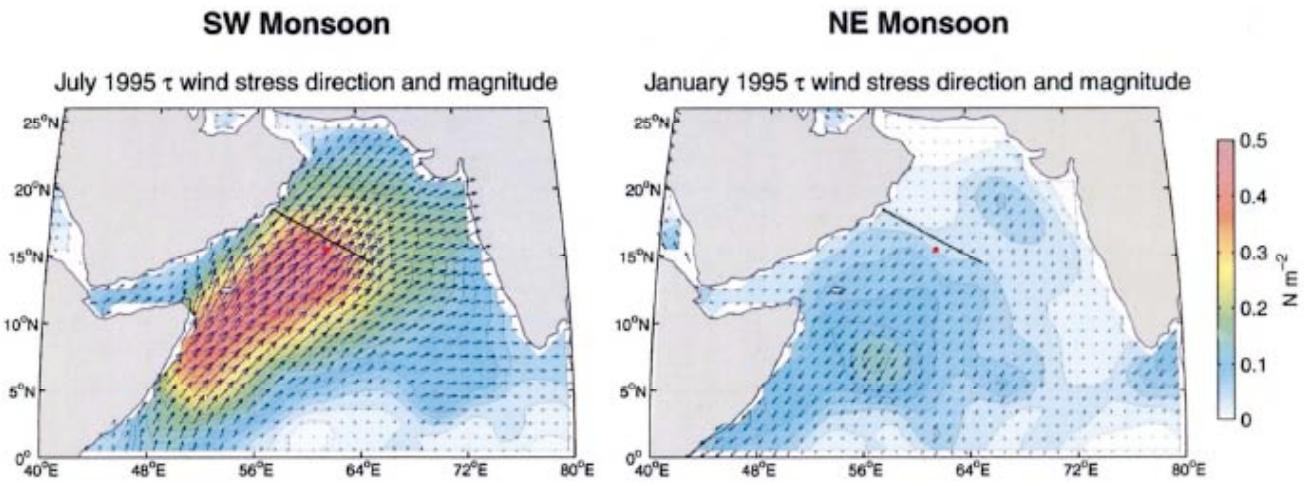
Show calculations for all work

Problem 1:
Your officemate, a geology student, describes to you a recent paper showing evidence from an Ocean Drilling Program (ODP) leg that at several periods in the past the Mediterranean Sea became isolated from the Atlantic, dried up, and leaft behind thick evaporite deposits behind in the sedimentary record. Assume that the Mediterranean Sea has an average depth of ~2500m and a salinity of 36.0 on the PSS.

a) For a single evaporation event, what would be the sequence and approximate thicknesses of the different layers salts deposited?
b) What factors could complicate this estimate?
c) How frequently would the Mediterranean have to evaporate to play a significant role in the ocean Cl^- and Na^+ balance? Hint: How much salt is in the Mediterranean and how does it compare with the annual river inputs assuming a $70x10^6$ y residence time.

Problem 2:
Apply the principle of constant proportions for the major ions in seawater to answer the following questions.
a) What is the $[Mg^{2+}]$ in mmol kg^{-1} at a salinity of 29.356 on the PSS?
b) What is the salinity of a water sample if $[Br^-]$ = 0.913 mmol kg^{-1}
c) Cite **two** examples where one of the major constituents of seawater behaves non-conservatively. Explain and draw hypothetical open ocean vertical profiles for one of these species.

Problem 3:
In 1995, the U.S. Joint Global Ocean Flux Study (JGOFS) conducted an extensive, year-long process study in the Arabian Sea. One of the objective of the campaigns was to identify the biogeochemical responses to the different physical forcing occurring during the summer southwest monsoon and winter northeast monsoon. Based on the windstress maps for the two seasons and what you know about Ekman pumping, describe your best-guess for the patterns of the following for each season:
a) wind-driven upwelling and downwelling
b) coastal upwelling, SSTs and nutrients

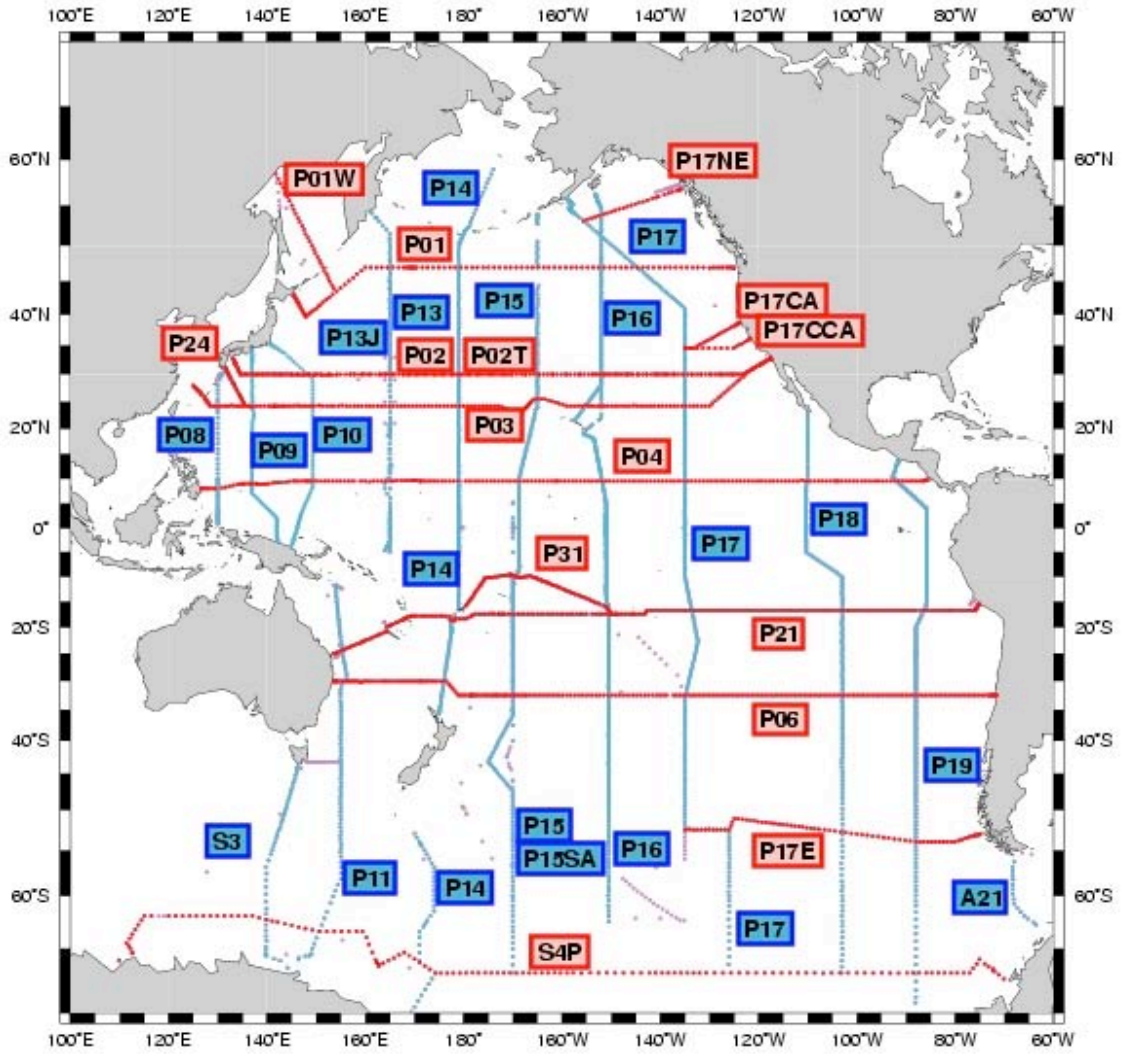


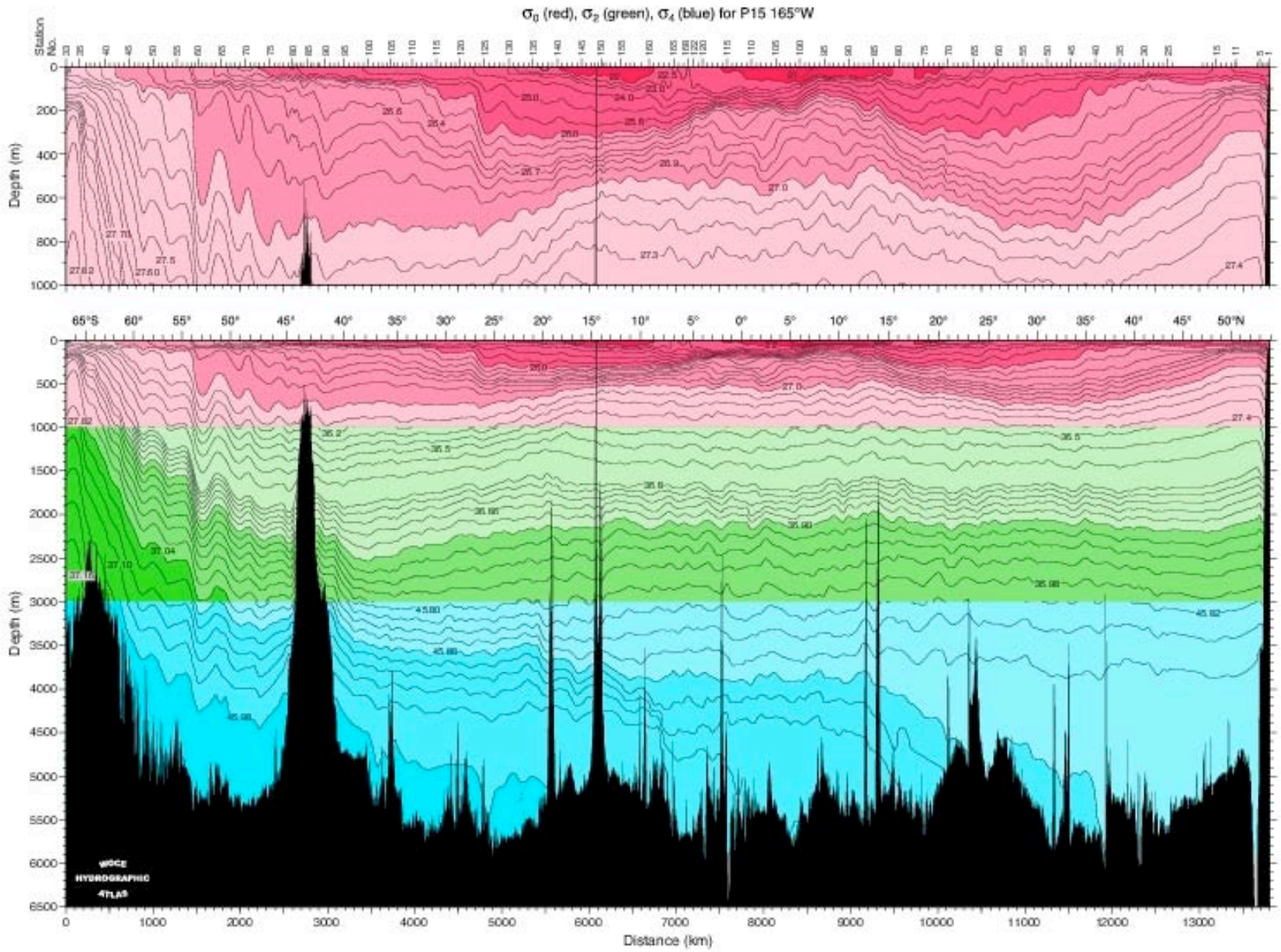
Problem 4:
The World Ocean Circulation Experiment (WOCE) conducted a global survey in the 1990s of ocean hydrographic and carbon system properties. Included below are contoured plots from section P15 in the Pacific Ocean from the WOCE Pacific Atlas, http://www-pord.ucsd.edu/whp_atlas/pacific_index.htm. Based on the plots,

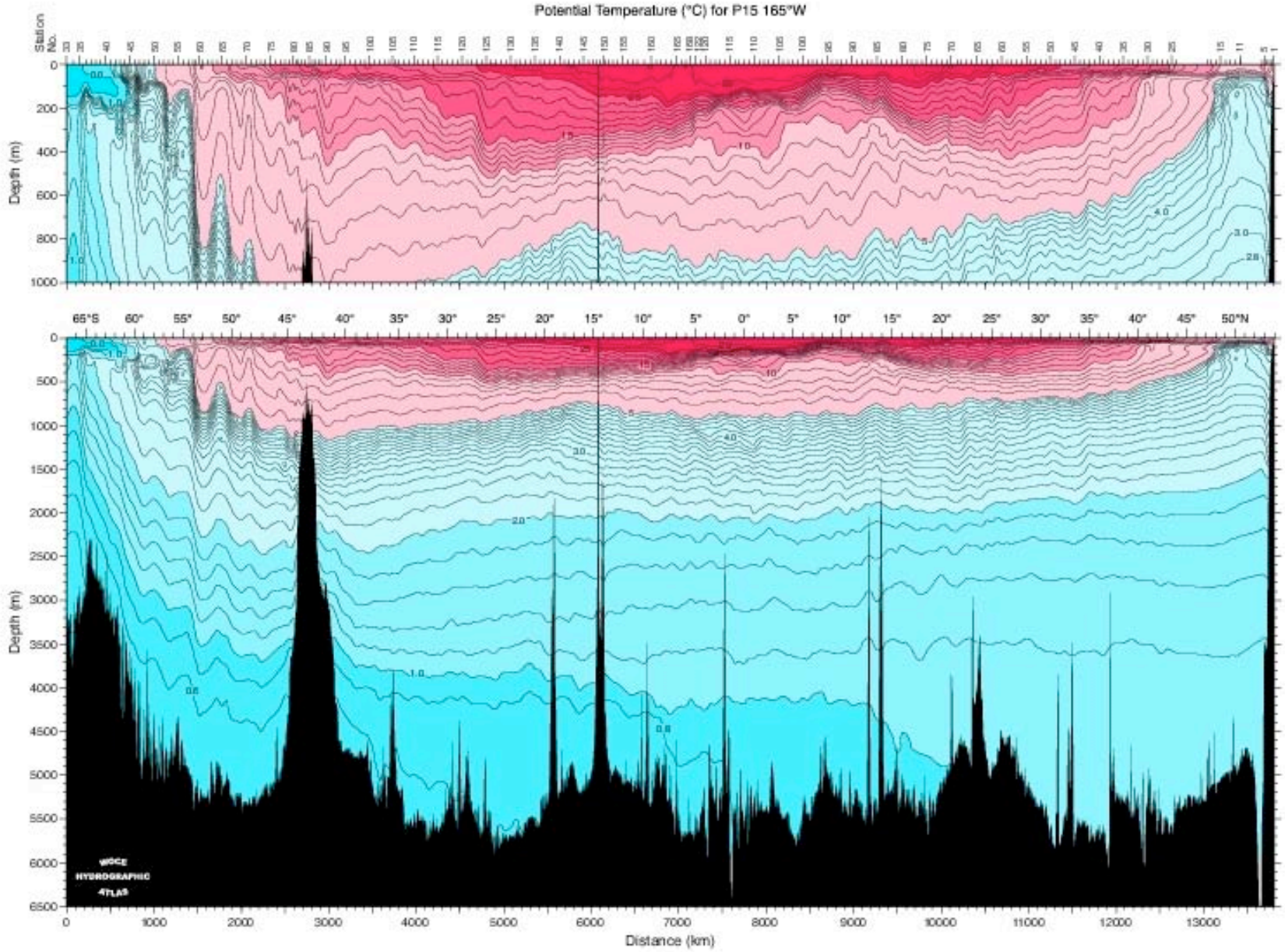
a) Show the location and direction of the major upper ocean geostrophic currents along P15 (Hint, remember that geostrophic flow involves a balance between pressure gradients and rotation; pressure gradients will appear in hydrographic sections as density fronts).

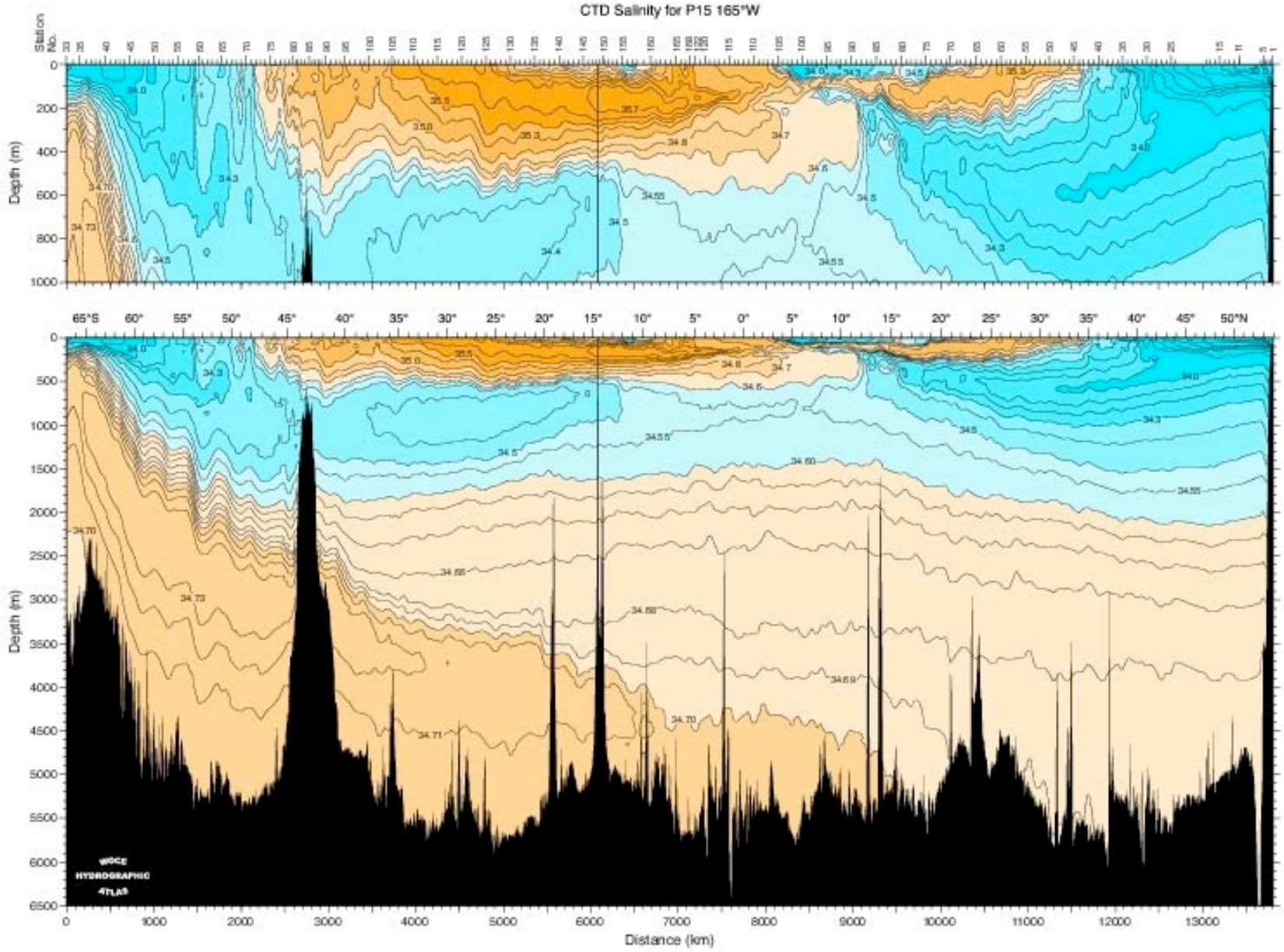
b) Based on the density, temperature and salinity plots identify the major water masses along the section.

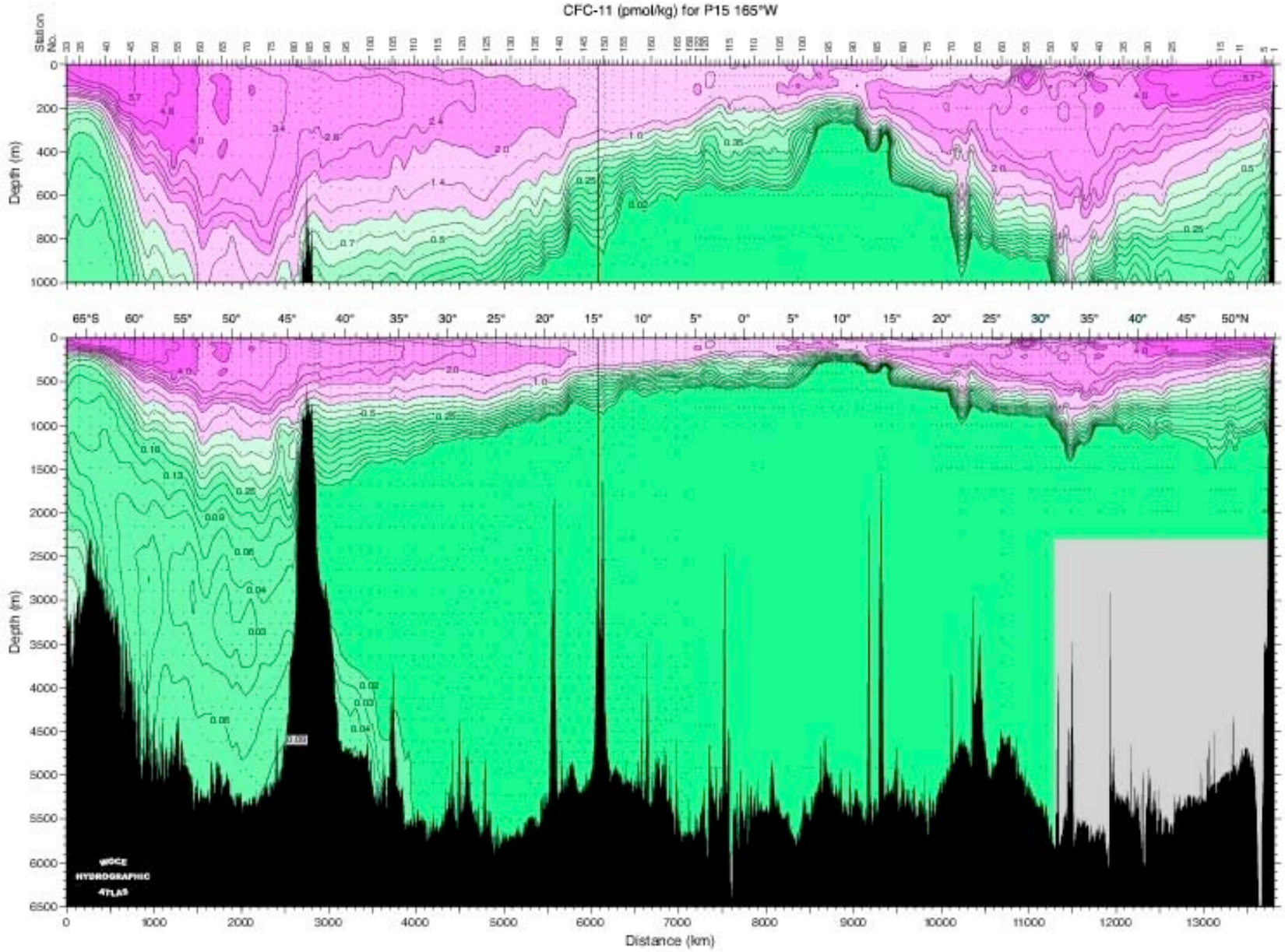
c) Use the transient tracer data (^{14}C and CFCs) to describe the ventilation time-scales along the section. How does this match with your interpretation of the water masses from part b? For 14C, estimate the penetration depth for bomb-radiocarbon.

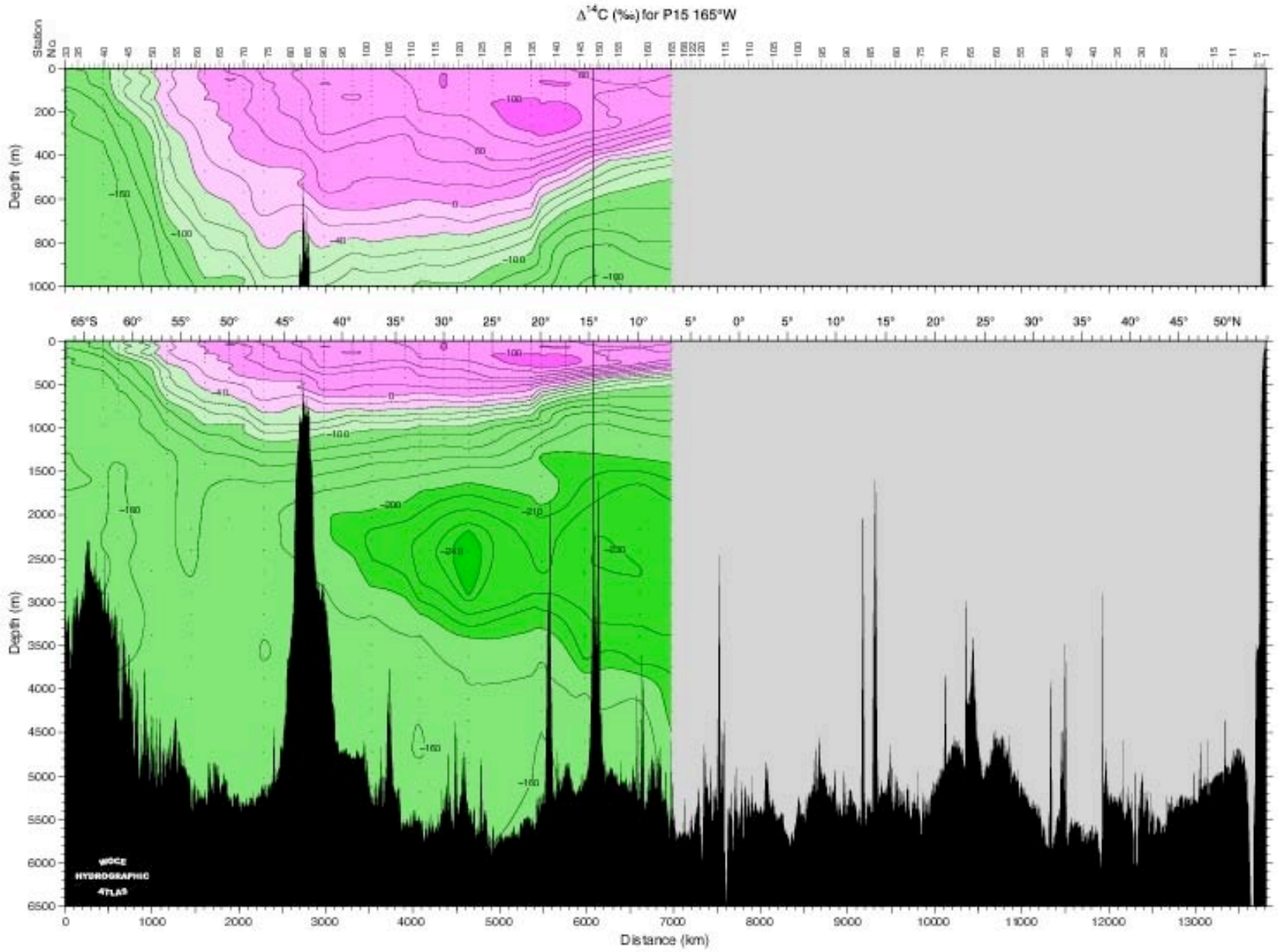



σ0 (red), σ2 (green), σ4 (blue) for P15 165°W
Station No.
Depth (m)
65°S 60° 55° 50° 45° 40° 35° 30° 25° 20° 15° 10° 5° 0° 5° 10° 15° 20° 25° 30° 35° 40° 45° 50°N
Distance (km)
WOCE HYDROGRAPHIC ATLAS


Potential Temperature (°C) for P15 165°W
Station No.
Depth (m)
65°S
60°
55°
50°
45°
40°
35°
30°
25°
20°
15°
10°
5°
0°
5°
10°
15°
20°
25°
30°
35°
40°
45°
50°N
Distance (km)
WOCE
HYDROGRAPHIC
ATLAS


CTD Salinity for P15 165°W
Station No.
Depth (m)
65°S 60° 55° 50° 45° 40° 35° 30° 25° 20° 15° 10° 5° 0° 5° 10° 15° 20° 25° 30° 35° 40° 45° 50°N
Distance (km)
WOCE HYDROGRAPHIC ATLAS


CFC-11 (pmol/kg) for P15 165°W
Station No.
Depth (m)
65°S 60° 55° 50° 45° 40° 35° 30° 25° 20° 15° 10° 5° 0° 5° 10° 15° 20° 25° 30° 35° 40° 45° 50°N
Depth (m)
Distance (km)
WOCE HYDROGRAPHIC ATLAS


Δ14C (‰) for P15 165°W
Station No
Depth (m)
65°S 60° 55° 50° 45° 40° 35° 30° 25° 20° 15° 10° 5° 0° 5° 10° 15° 20° 25° 30° 35° 40° 45° 50°N
Distance (km)
0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000
WOCE
HYDROGRAPHIC
ATLAS