Arctic Change 2015 – Homework 4   Due 11:30am Monday 4th May 2015 / 44

Goals – to reinforce key points from the lectures, and to encourage quantitative thinking
- Fill in Name (Last, first) and student number at the top of all pages, and staple pages together.
- Space indicates expected length of answer, but if you need more space, add extra pages with name and student number at the top, indicating which question you are doing.
- Questions 1-5 will be graded. Question 6 is optional, for the curiosity of the more mathematical.
- HANDWRITE your answers, show your workings, use metric units, give answers to a reasonable number of significant figures and do your best to make your paper clear and easy to read.
- Although you may discuss the questions with others, complete the homework on your own.

Question 1 - Roles of Pacific and Atlantic Waters in the Arctic.
/1.5pt 1a) Give typical values for temperature, salinity and volume flux (in Sv) for summer Pacific waters entering through the Bering Strait.

/1.5pt 1b) Give typical values for temperature, salinity and volume flux (in Sv) for winter Pacific waters entering through the Bering Strait.

/2pt 1c) Once these waters (Pacific Summer Water, and Pacific Winter Water) reach the Arctic, which one will be lower in the water column, and why? Give typical depth ranges of each of these waters in the Arctic.

/6pt 1d) Give 3 reasons why Pacific Waters are important in the Arctic. For each reason, write a sentence (or more) explaining the impact of Pacific Water on the Arctic ice or on Arctic ecosystems. For each reason, state (with explanation) in which season the impacts are the greatest.
1e) Name the 2 entrances for Atlantic Water into the Arctic Ocean. For each entrance, give an estimate (or range of estimates) of the volume flux (in Sv) of water entering the Arctic.

1f) Name 2 chemical tracers used to track Atlantic Water in the Arctic Ocean. For each, explain the source of the tracer.

1g) Atlantic Waters in the Arctic are often defined as waters warmer than 0ºC at salinities greater than 33 psu. From the Temperature-Salinity (T-S) diagrams given in the lecture notes, what is the salinity range of the Atlantic Waters?

1h) How does this compare to the salinity range of Pacific waters found above?

1i) At each *, circle the word that makes the sentence correct:
The Pacific water layer is much thicker/thinner* than the Atlantic water layer.
In the Arctic Ocean, Pacific Waters are generally found above/below* the Atlantic Waters.
This is because Pacific Waters generally have higher/lower* densities than Atlantic Waters.
The difference in density is mostly due to differences in temperature/salinity*.

**Question 2: How long do things stay in the Arctic?**

2a) Give approximate residence times in the Arctic for each of the following layers:
   Sea-ice ________________________
   Pacific waters __________________
   Atlantic waters __________________
   Deep waters ____________________

2b) Why do you think the residence times differ?

2c) Why might we care that the residence times differ?
Question 3: Effect of the Arctic Oscillation (AO) on the various layers in the Arctic:

3a) On the following maps, draw schematically the circulation requested. (AO=Arctic Oscillation.)

/6pt

3b) Mark if each of the following statements are true or false:

- Sea-ice motion patterns are similar to Pacific water flow patterns  
  True/False
- Sea-ice motion patterns are similar to Atlantic water flow patterns  
  True/False
- Pacific waters move faster than sea-ice  
  True/False
- Atlantic waters move faster than sea-ice  
  True/False
- Atlantic waters move faster than Pacific waters  
  True/False
- Eddies are only found in Pacific waters  
  True/False
Question 4 - Biological processes

4a) If an organism is autotrophic, what does that mean? What is its source of energy? What is its source of carbon? Give an example of an autotrophic organism we have mentioned in lectures.

4b) If an organism is heterotrophic, what does that mean? What is its source of energy? What is its source of carbon? Give an example of a heterotrophic organism we have mentioned in lectures.

4c) What do we mean when we say an organism “fixes carbon”? What sort of organisms most commonly fix carbon – autotrophs or heterotrophs?

Question 5 - Arctic Exploration

5a) Pick an Arctic Expedition that captures your imagination. For that expedition, write a short paragraph describing the expedition to someone not familiar with the Arctic. In your paragraph include the following information:
- (1 pt) dates of the expedition
- (1 pt) main mode of transport (e.g., name of ship(s), method of propulsion if by sledge, etc)
- (1 pt) main goal of the expedition
- (3 pts) short narrative of the expedition and lessons learned from the expedition
Extra assignment for 3 credit option (10 pts)

Choose one following 2 papers:


For the paper of your choice, prepare (in your own words) a ~ half page (~ 500word) summary of the main findings of the paper. This summary may be handwritten or typed.

**Question 6: Quantifying the possible effects of double diffusive intrusions.** (Not for credit, just for interest.)

Measurements imply that Atlantic Water moves around the edges of the basins of the Arctic Ocean (following topography) at a few cm/s (say 1-5 cm/s) in a pan-Arctic boundary current. From a combination of observational results, scalings and theory, it is hypothesized there is a significant transport of waters away from the boundary current driven by double diffusion, and these studies cite a speed of intrusions growing away from the boundary current (perpendicular to the main direction of the boundary current) of ~ 1-2 mm/s.

Consider how these speeds compare with observations of the 1990s warming that entered the Arctic Ocean. In particular, consider how far intrusions would spread into the basin in the time taken for waters to move around the basin perimeter.