An examination of Beaufort Shelf Winter Water in the Canadian Beaufort Sea

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1. Introduction:

- Beaufort Shelf Winter Water (BSWW) is cold (near the freezing temperature), salty (salinity greater than 32) water that is formed on the Canadian Beaufort Shelf in winter (Melling and Lewis, 1982)
- Until recently, it was thought that BSWW was formed about 1-2 times per decade.
- To form BSWW, Melling (1993) suggested that there needed to be both strong westerly winds in summer (to advect Mackenzie River water off the shelf) and strong easterly winds in winter (to cause upwelling)
- BSWW has fewer nutrients than PWW (Melling and Moore, 1995) so an increase in BSWW could influence primary production
- Using year-round CT sensor and ADCP data collected from moorings, we examine the properties of BSWW during the winter of 2009-2010.

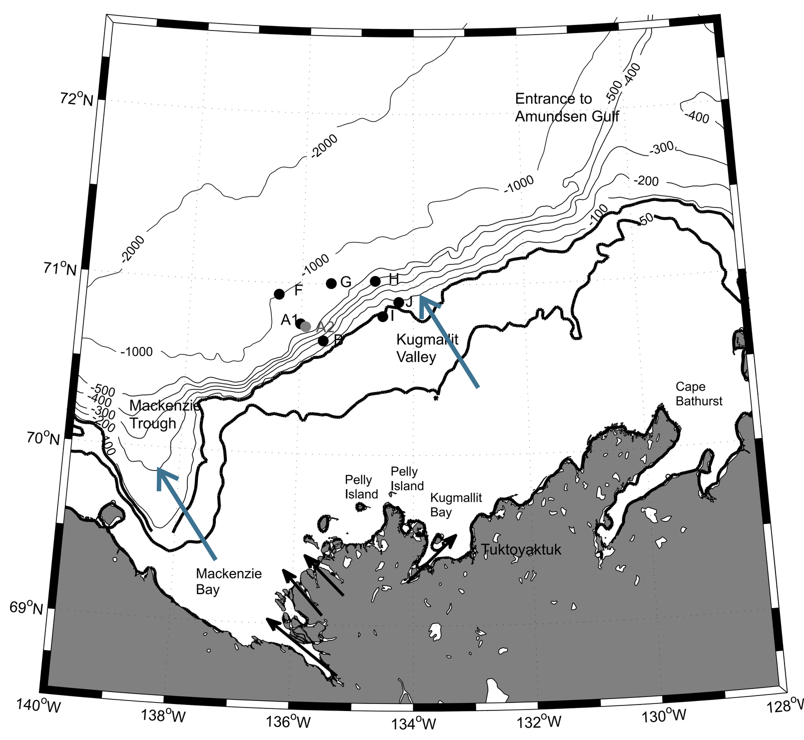

Figure 1: Bathymetric map of the study area. Mooring locations are marked by circles. The thick black lines mark the 50 m and 75 m isobaths. Blue arrows mark known areas of cross-shelf exchange – the Mackenzie Trough (Williams et al., 2006) and the Kugmallit Valley (Williams et al., 2008).

2. Data

- Two moorings (I and J) were on the continental shelf and six moorings (B, H, A2, A1, G, and F) were on the continental slope
- Data were collected from moorings from about 21 July 2009 – 11 September 2010
- Moorings had 1 – 4 RBRduo CT sensors, an ASL Ice Profiling Sonar, 1-2 RBI ADCPs, and some biochemical sensors (oxygen, fluorescence, and transmission on moorings B, I, and J)
- CT data were collected every 10 minutes and ADCP data were collected every 2 minutes in 4 – 16 m bins
- Here data collected from only the near-surface (43 – 73 m) and subsurface (131 – 163 m) CT sensors were examined
- To identify regions where BSWW could be formed, 12.5 km resolution advanced microwave scanning radiometer-EOS (AMSR-E) daily sea ice concentrations (SIC) were examined.

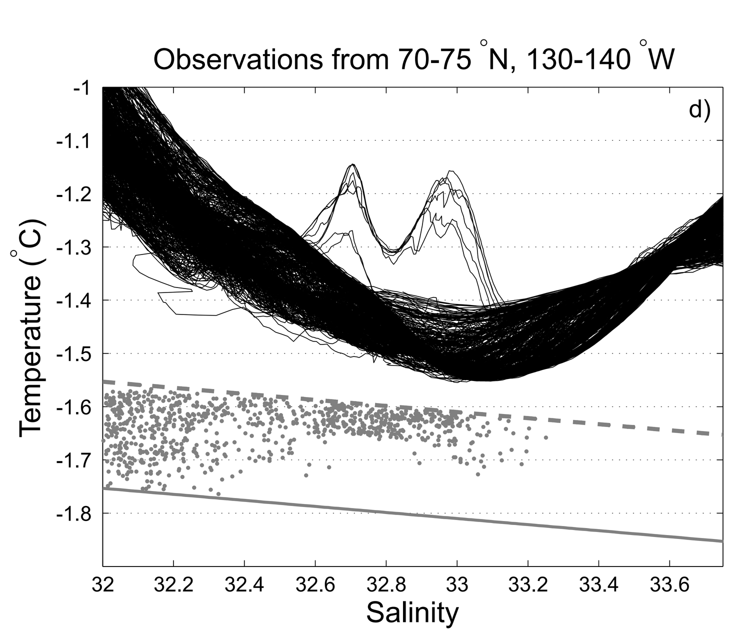

Figure 2: The black lines show CTD temperature-salinity diagram from 2009 – 2012 collected by ITPs and icebreakers. The grey dots are CT sensor data of BSWW collected by the Beaufort Shelf moorings. The solid grey line is the freezing temperature and the dashed grey time is 0.2°C warmer than the freezing temperature.

3. Definition of BSWW

- To ensure that BSWW differed from Pacific Winter Water (PWW; a temperature minimum at the salinity 33.1), year-round CTD data collected with ice-tethered profilers (ITP) in the southeastern Canada Basin from 2009 – 2012 were examined (Figure 2)
- The coldest PWW was -1.55°C, or 0.27°C warmer than the freezing temperature
- We defined BSWW as water that was colder than 0.2°C above the freezing temperature and saltier than 32.

4. Results

- Observations of BSWW were most frequent from mid-November to December and April to July at the near-surface (53-74 m) CT sensor and most frequent from January to mid-February at the sub-surface (131 – 163m) CT sensor
- At the near-surface CT sensor, BSWW was most common at moorings I and A2 and least common at moorings G and F
- At the subsurface CT sensor, BSWW was most common at moorings B and F and least common at moorings A2 and H
- At the near-surface CT sensor, the coldest and saltiest BSWW was observed at mooring J in November
- At the sub-surface CT sensor, the coldest BSWW was observed at moorings B and F in January
- These results suggest that:

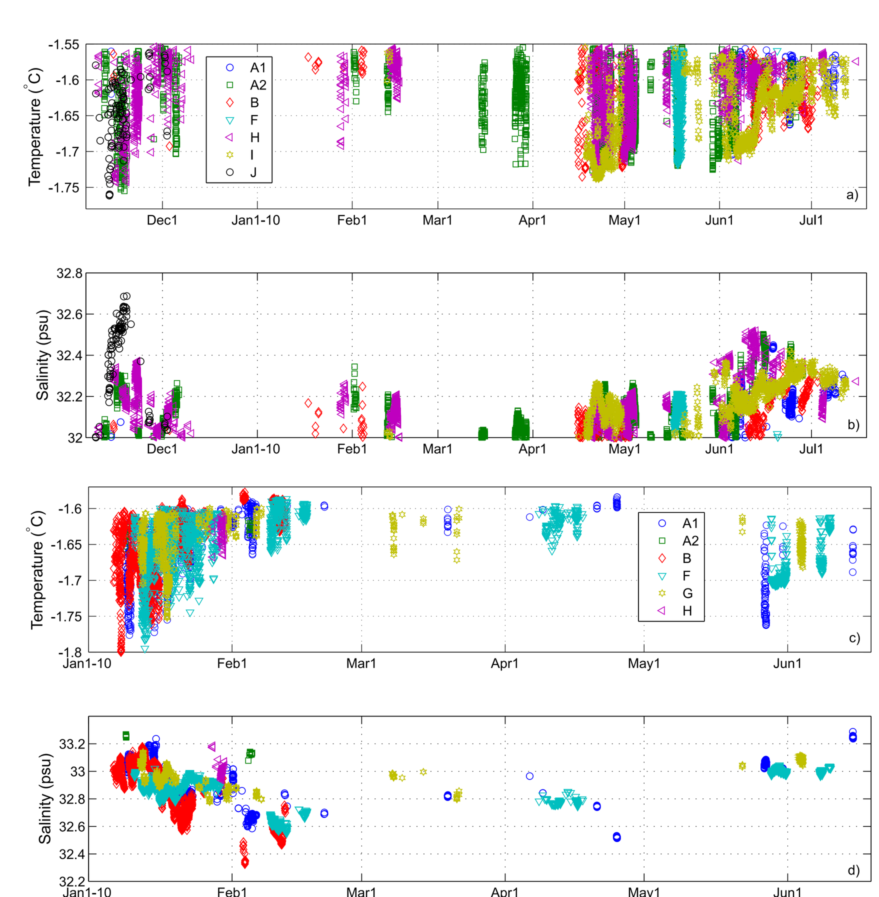

Figure 3: The observed a) temperature and b) salinity of BSWW observed from November 2009 – July 2010 at depths 53 – 74 m (no BSWW was observed at 43m at mooring G). The c) temperature and d) salinity of BSWW observed from January – June 2010 are shown for depths 131 – 163m. Moorings I and J are on the continental shelf so have no instruments at these depths.

1) BSWW observed at the near-surface CT sensor has different properties and is observed at different times than BSWW observed at the sub-surface CT sensor
2) Depending on advection time, BSWW observed at the near-surface CT sensor was likely formed in October to December 2009 and April to June 2010
3) BSWW observed at the sub-surface CT sensor was likely formed in the fall of 2009.

5. Currents Associated with BSWW

- To understand how BSWW is transported to the moorings, the current speed and direction were examined when BSWW was observed
- Results from the near-surface (53 – 74m) CT sensor show that BSWW could have been primarily advected from the east to moorings along the continental slope, from the south at mooring I, and from the northwest at mooring J
- Results from the sub-surface (131 – 163m) CT sensor show that BSWW could have come from a number of directions except at moorings A2 and B where most BSWW came from the southwest.

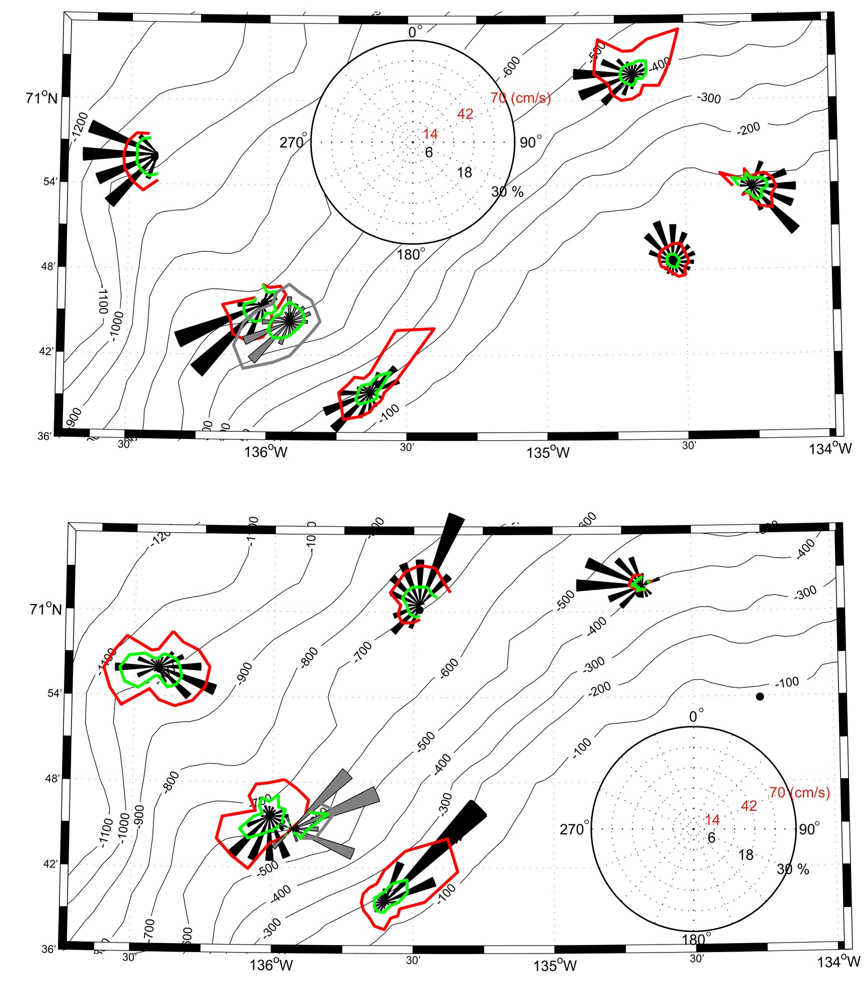

Figure 4: An examination of the average current speed and direction when BSWW was observed at (top) the near-surface CT sensor and (bottom) the sub-surface CT sensor. The black (and grey at mooring A2) bars represent the percentage of time that the current was in each direction. The red line is the maximum current speed in each direction and the green line is the average speed in each direction.

6. Regions of ice formation

- Monthly maps of AMSR-ESIC data were examined to understand where BSWW could be formed (Figure 5)
- Four regions where SIC was less than 100% in winter were identified. These areas are (Figure 6):

1) Mackenzie Bay (MB)
2) The continental shelf from Kugmallit Bay to Cape Bathurst (KB)
3) Southern Banks Island (CBI)
4) Western Banks Island (CBII)

- Daily open water areas were calculated for each region

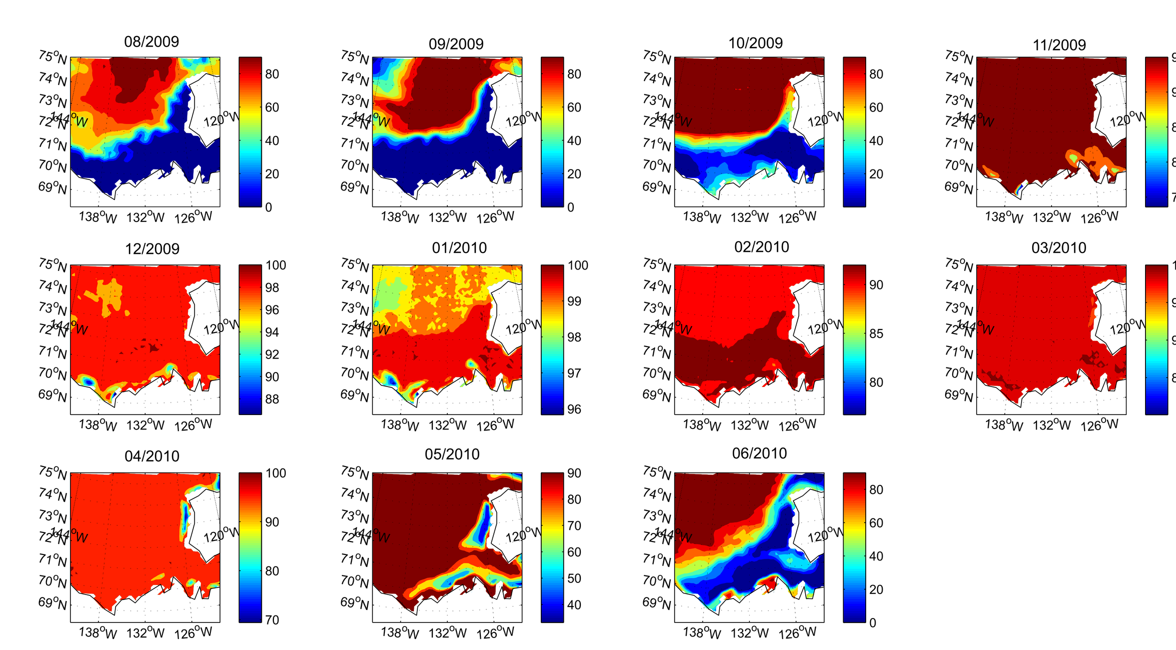

Figure 5: AMSR-E monthly sea ice concentration from August 2009 to June 2010. Contour scales differ between panels to illustrate lower ice concentration regimes.

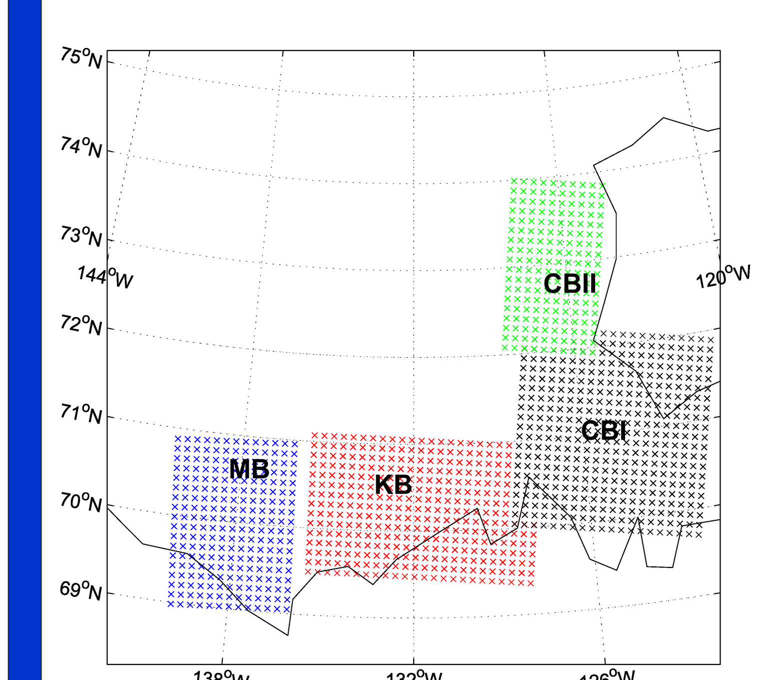

Figure 6: Regions of interest in the southern Beaufort Sea for polynya evolution analysis (including Mackenzie Bay (MB), Kugmallit Bay (KB), southern Banks Island (CBI) and western Banks Island (CBII)) .

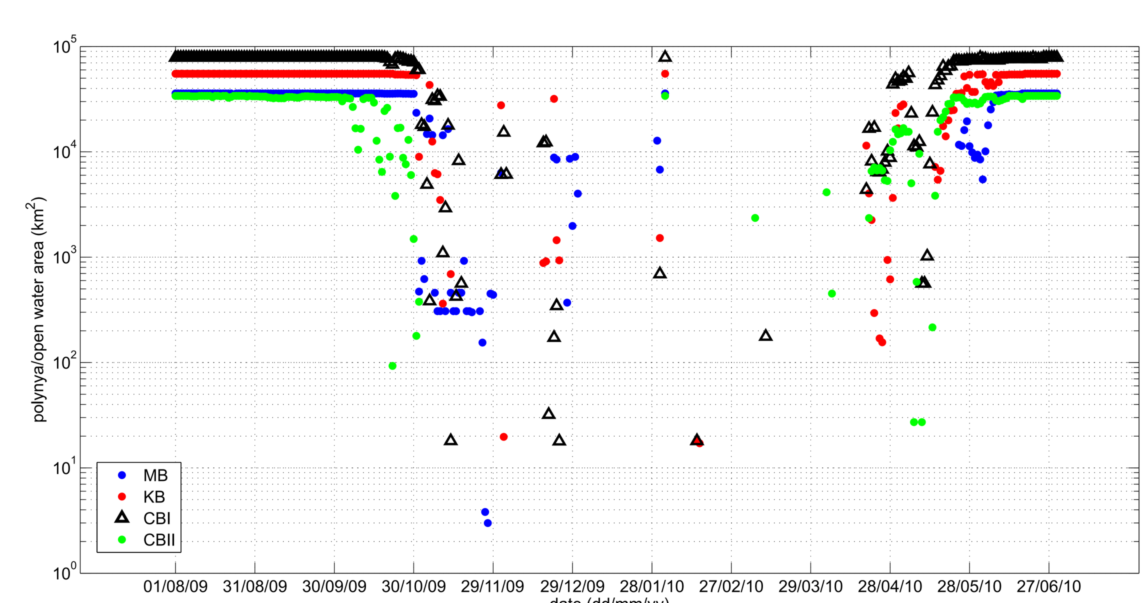

Figure 7: Log-linear plot of daily evolution of polynya/ open water area derived from AMSR-E sea ice concentration data within four regions from August 2009 to July 2010. Open water areas were computed only when the SIC was less than 80%.

- SIC data show that open water regions (where ice could be formed) were present frequently until the end of December at MB, KB, and CBI, at all regions in late January/ early February, and at all regions from the end of April until June
- It is most likely that BSWW was formed at MB, KB, or CBI.

7. Summary and future work

- BSWW was observed in the Canadian Beaufort Sea during the winters of 2009-2010 and it is likely that BSWW was formed at polynyas that were observed throughout the winter
- We will extend our analysis of BSWW to include the winter of 2010-2011 at the same mooring locations
- We will include 3-4 different moorings on the continental shelf (likely within the open water regions) to examine water and in-situ sea-ice properties where BSWW is formed
- Using CT, ADCP, and surface heat flux data we will calculate the amount of ice produced and resulting salt flux to estimate the volume of BSWW formed at each polynya
- Using the 3-D coupled sea-ice ocean DRAKKAR ORCA 025 model we will examine potential pathways from the BSWW formation site to the moorings (to estimate speed of BSWW transport) and pathways from the moorings to estimate the fate of BSWW.

Acknowledgements

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