PROPERTIES AND PATHWAYS OF THE ARCTIC'S PACIFIC SUMMER WATER: 2003 – 2013

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Abstract

Pacific Water flows northward through Bering Strait and is modified by surface buoyancy fluxes and mixing as it crosses the Chukchi Sea and enters the Canada Basin. The seasonally-warmed **Pacific Summer Water (PSW)** may be subdivided into **Alaskan Coastal Water (ACW)** and saltier **summer Bering Sea Water (sBSW)**; these are commonly traced by temperature peaks in their respective salinity ranges. Measurements from Ice-Tethered Profilers, moorings and hydrographic surveys show significant variability in these water masses between 2003 and 2013. In addition to changes in ACW and sBSW pathways during the past decade, the heat and freshwater content of the PSW have increased by about 40%, with the largest changes in the southern Canada Basin.

Study area and measurements

Pacific Summer Water in the Central Canada Basin (CCB) is analyzed using Ice-Tethered Profiler (ITP) and Beaufort Gyre Observing System (BGOS)/Joint Ocean Ice Studies (JOIS) data.

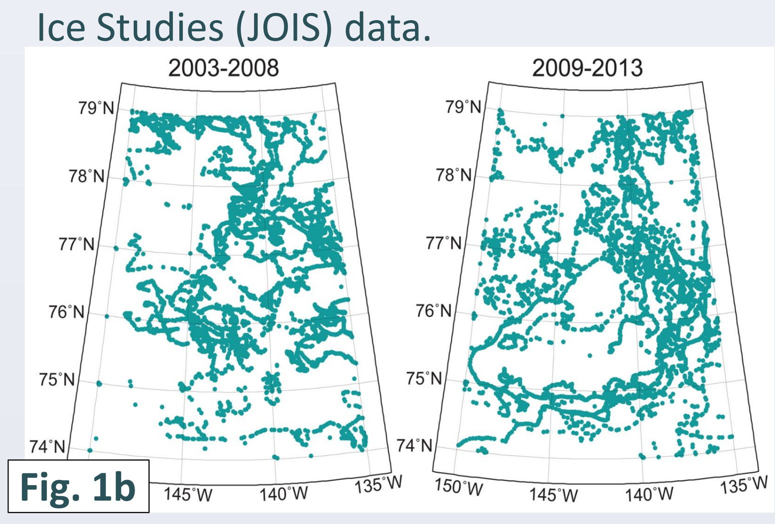


Fig. 1b: Profile locations in the CCB; 9960 CTD and ITP profiles over all seasons:

Sept. 2003 and 2013.

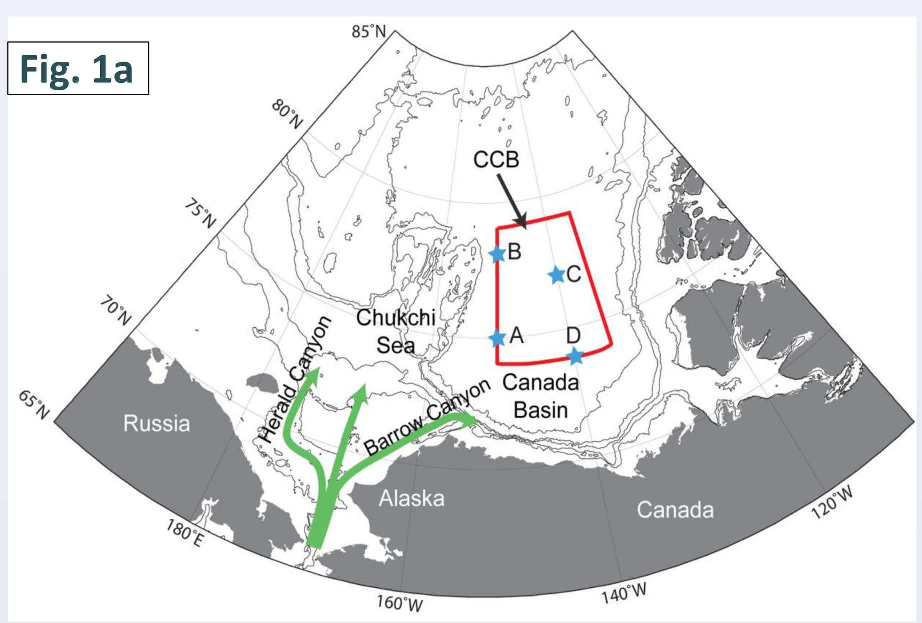


Fig. 1a: Map showing the CCB; Stars show BGOS moorings and green arrows show schematic pathways of PSW inflow.

Characterizing the Pacific Summer Water

Salinities of the Pacific water masses are used to distinguish them from one another and from the near-surface temperature maximum (NSTM).

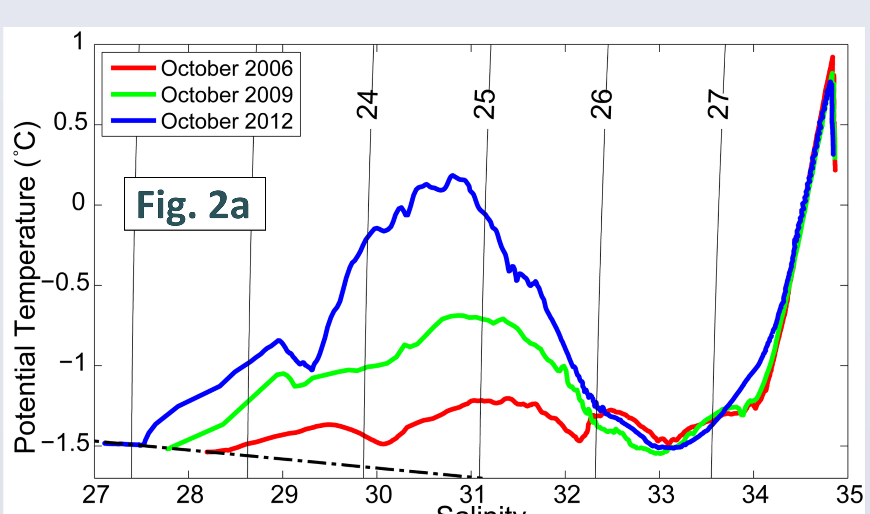


Fig. 2a: Potential temperature vs. salinity profiles from the CCB. Contours indicate potential density anomaly (kg/m3); the dashed line is the freezing line.

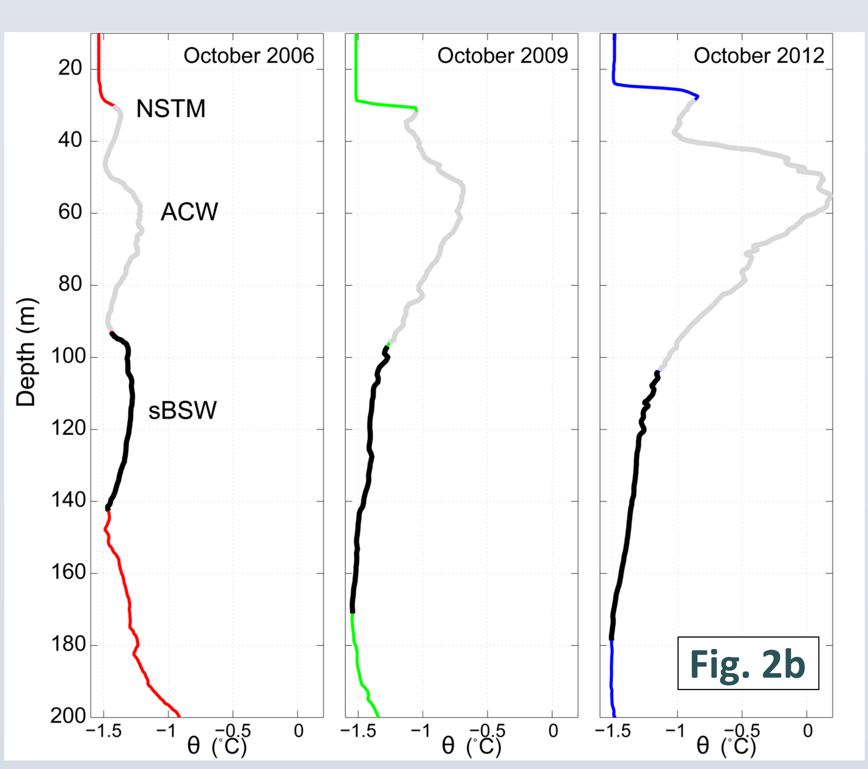


Fig. 2b: Potential temperature profiles corresponding to curves in (a); grey and black portions mark the salinity ranges found in this study to be appropriate for the **ACW (29 < S < 32.2)** and **sBSW (32.2 < S 33)**. A sBSW temperature maximum θ_{max} is absent in the latter two years in the CCB.

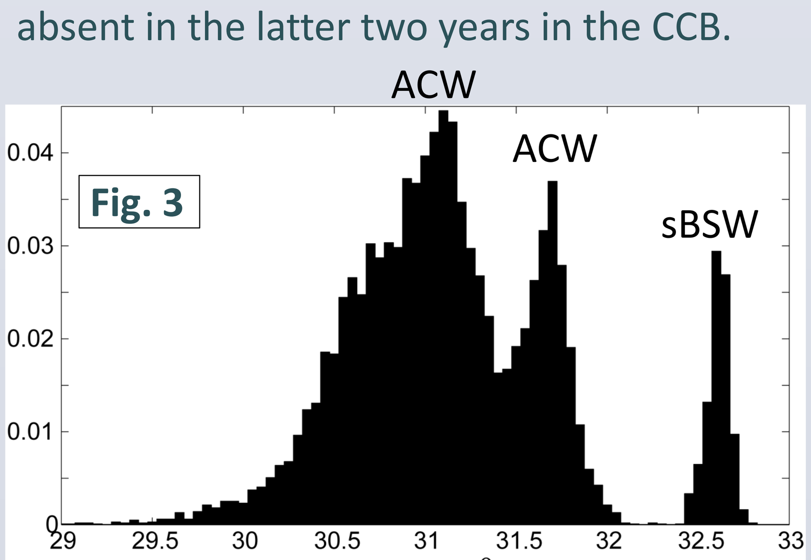


Fig. 3: Salinity of θ_{max} for S < 33 and deeper than 40 m for all CCB profiles.

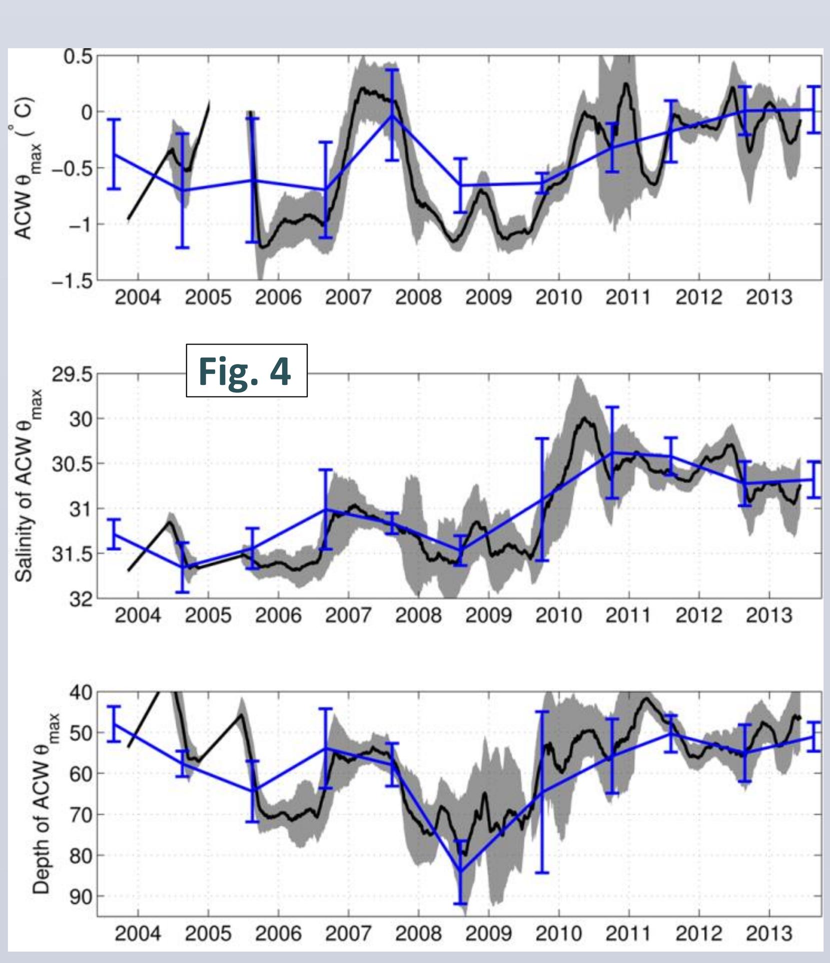


Fig. 4: Properties of ACW θ_{max} in the CCB. ITP data are shown by the black lines: thirty-day means, and the shading represents one standard deviation. BG CTD data are shown in blue, with error bars indicating one standard deviation. Error bars indicate predominantly spatial variability; in most years CTD stations spanning the entire CCB were occupied in the same month.

The ACW θ_{max} shows a general warming and freshening, with considerable interannual variability and warmest temperatures in 2007 and 2010-11.

Pacific Summer Water freshwater and heat content in the CCB

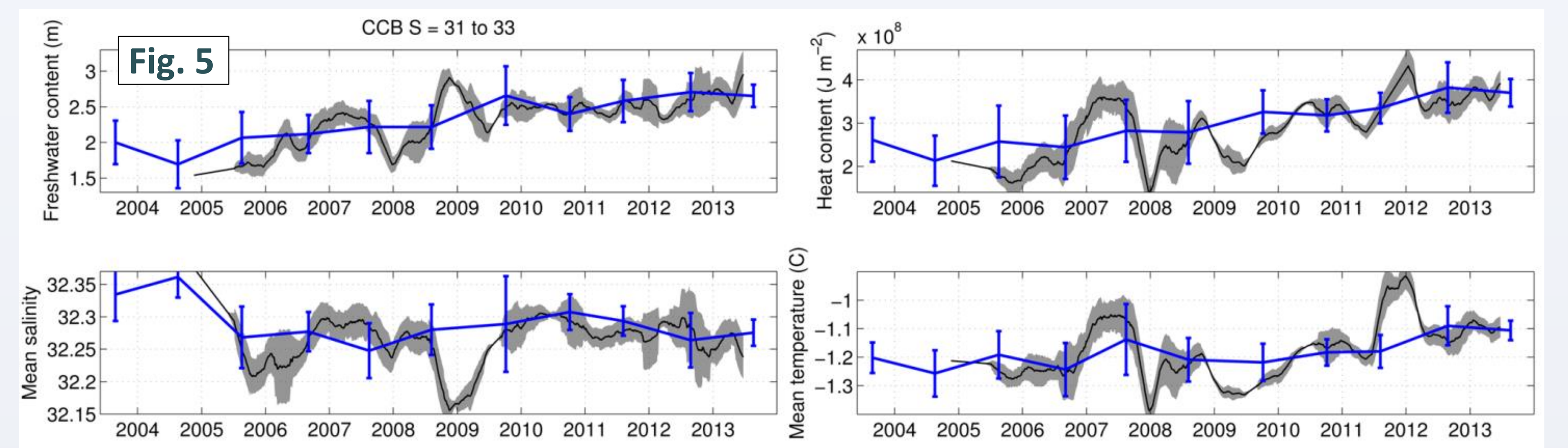
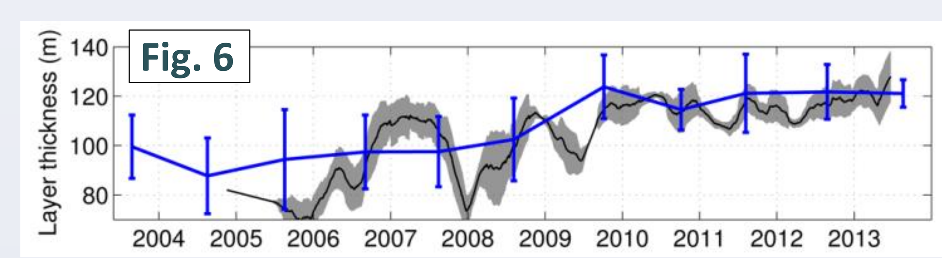
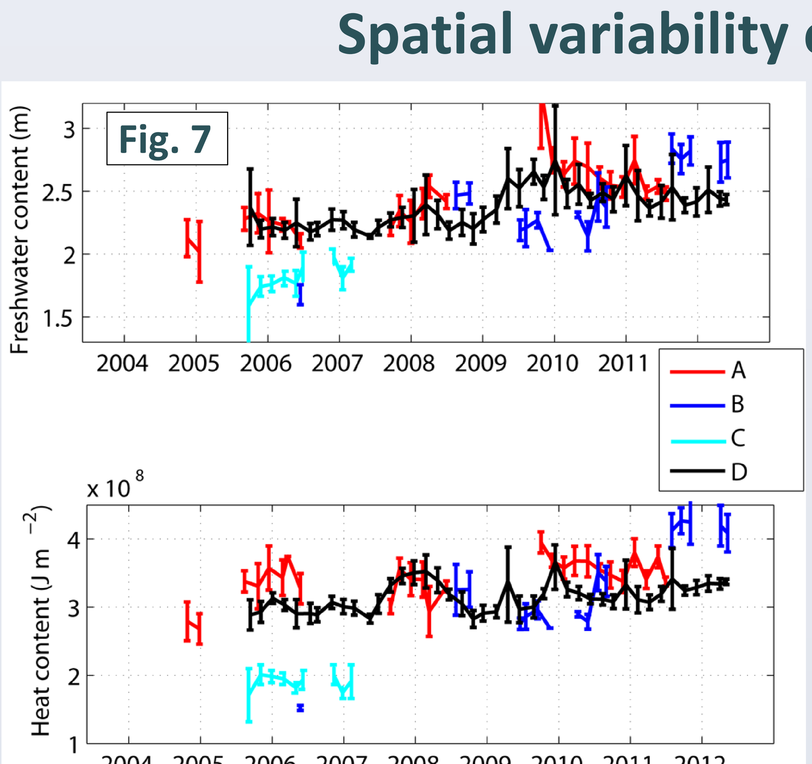


Fig. 5: Freshwater (FW) and heat content in the range **31 < S < 33** in the CCB. FW content is calculated relative to a reference salinity of 33, and heat content relative to freezing temperature. A trend of increased FW and heat content is apparent, with the largest changes before 2010. The FW trend can be largely attributed to changes in PSW layer thickness rather than increases in layer mean salinity (**Fig. 6**). Heat content increases since 2010 are predominantly a result of increased layer mean temperatures.



Spatial variability of Pacific Summer Water



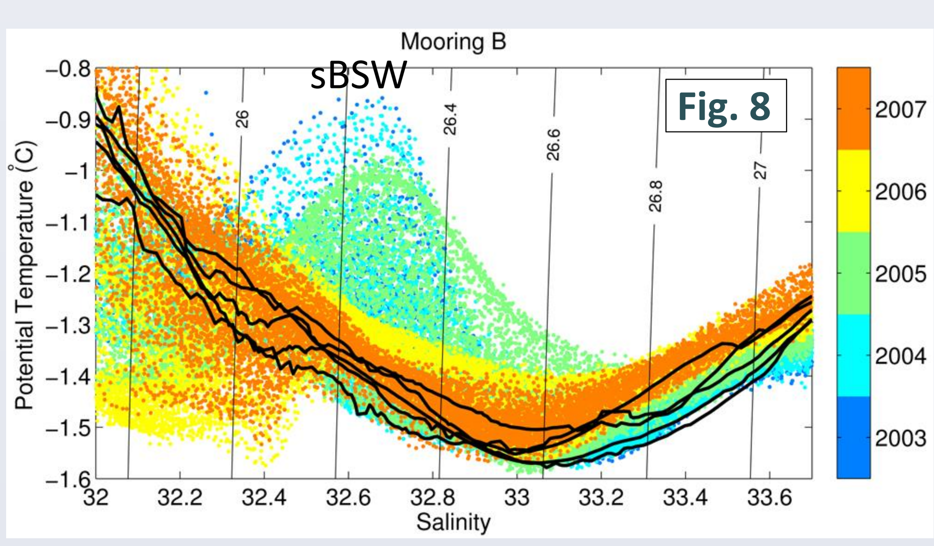


Fig. 7: FW and heat content at the BGOS moorings. **Fig. 8:** Potential temperature vs. salinity at BGOS mooring B. Black lines are CTD profiles in 2008-12.

Southern moorings show higher freshwater and heat content through 2006 than northern moorings. A sBSW θ_{max} is only present at the northern moorings. The water mass structure that now occupies the full CCB can be distinguished by the absence of a sBSW θ_{max}.

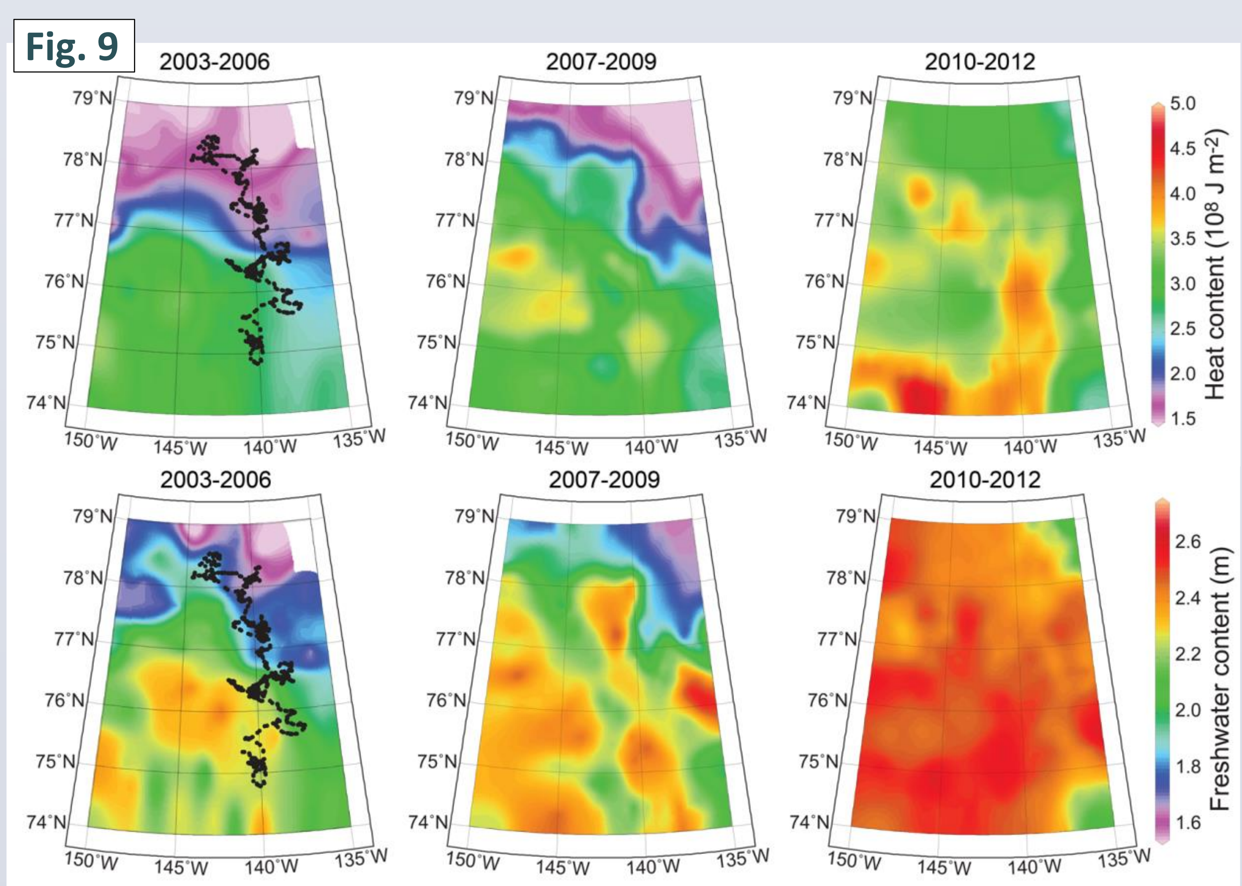
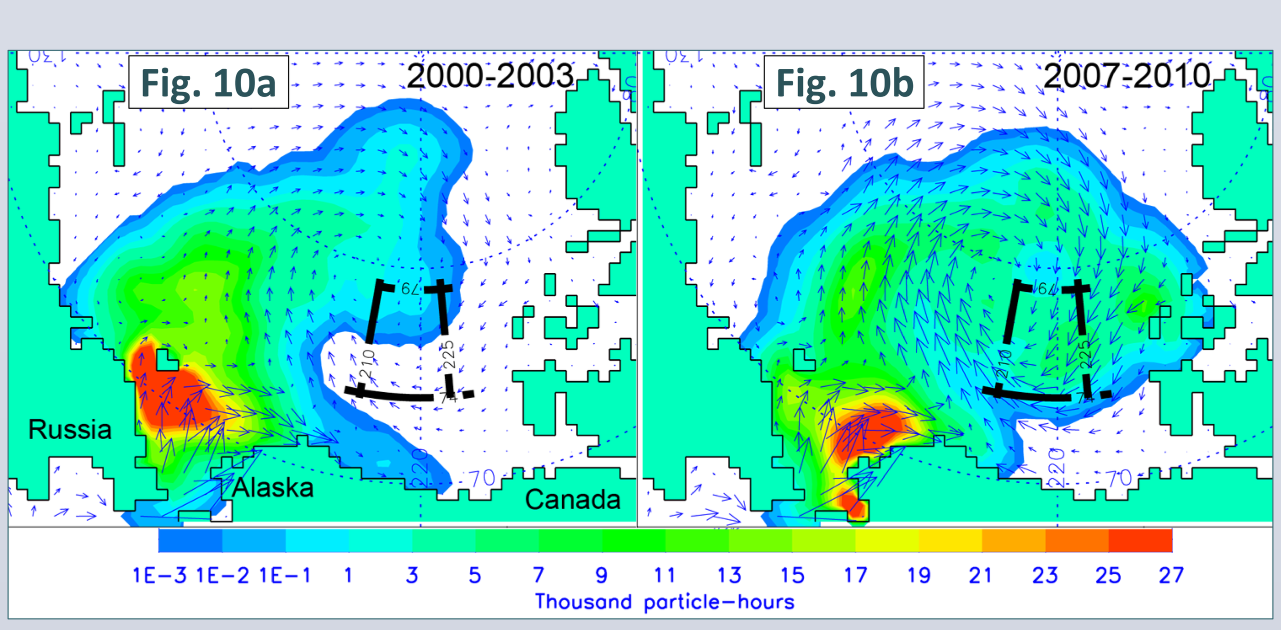


Fig. 9: FW and heat content in PSW in the CCB. A lateral transition is observed between relatively warm ACW and no sBSW θ_{max} to the south, and relatively cooler ACW and warmer sBSW to the north. A shift to the northeast of this transition is observed, while the heat and FW content of the PSW have increased by about 40%.

Fig. 10: Map showing colored contours of PSW tracer particle hours; each map includes particles released in the Chukchi Sea in the 3 years labeled in the top corner. Arrows show average ice circulation.



Model results suggest increased freshwater and heat content in the PSW in the CCB can be attributed in part to stronger anticyclonic wind forcing (Fig. 10b). In recent years, relatively more PSW is transported offshore and into the Beaufort Gyre, instead of in the PSW boundary current along the southern boundary of the Canada Basin (cf. Fig. 10a).

Summary

The PSW in the CCB warmed and freshened between 2003 – 2013; heat and freshwater content increased by about 40%. Model results corroborate the observations and suggest wind-driven shifts in the spreading pathways of the PSW masses.