Supplemental Material for "Freshwater input and vertical mixing in the Canada Basin's seasonal halocline: 1975 versus 2006-2012"

1. Isolating $\delta\Phi$ and δD

Here we provide the algabraic derivation of the equations 20-21, using the definitions provided in Section 3a. First, the mixed-layer freshening ($\mathbb{S}$):

$$
\begin{aligned}
\mathbb{S}_{ITP} &= \frac{\Phi_{ITP}}{D_{ITP}} \\
&= \frac{\Phi_{AJX}+\delta\Phi}{D_{AJX}+\delta D} \\
&= \mathbb{S}_{AJX}\left(\frac{1+\delta\Phi/\Phi_{AJX}}{1+\delta D/D_{AJX}}\right) \\
&= \mathbb{S}_{AJX}(1+\delta\Phi/\Phi_{AJX})(1-\delta D/D_{ITP}) \\
&= \mathbb{S}_{AJX}+\frac{\Phi_{AJX}}{D_{AJX}}\left(\frac{\delta\Phi}{\Phi_{AJX}}-\frac{\delta D}{D_{ITP}}-\frac{\delta\Phi\delta D}{\Phi_{AJX}D_{ITP}}\right) \\
\delta\mathbb{S} &= \frac{\delta\Phi}{D_{AJX}}-\frac{\Phi_{AJX}\delta D}{D_{AJX}(D_{AJX}+\delta D)}-\frac{\delta\Phi\delta D}{D_{AJX}(D_{AJX}+\delta D)}.
\end{aligned}
$$

Second, the potential energy anomaly ($\mathbb{W}$):

$$
\begin{aligned}
\mathbb{W}_{ITP} &= C\Phi_{ITP}(H-D_{ITP}-Z_{ice}) \\
&= C(\Phi_{AJX}+\delta\Phi)\cdot(H-D_{AJX}-\delta D-Z_{ice}) \\
&= C\Phi_{AJX}(1+\delta\Phi/\Phi_{AJX})\cdot((H-D_{AJX}-Z_{ice})-\delta D) \\
&= (1+\delta\Phi/\Phi_{AJX})\cdot(\mathbb{W}_{AJX}-C\Phi_{AJX}\delta D) \\
\delta\mathbb{W} &= C((H-D_{AJX}-Z_{ice})\delta\Phi-\Phi_{AJX}\delta D-\delta\Phi\delta D)
\end{aligned}
$$

where we have defined $C\equiv\rho_0\beta g/2$.

2. Uncertainties in Φ and sFWC

Here we roughly estimate uncertainties in Φ and $sFWC$ due to a lack of near-surface measurements. First, we consider the thin, fresh surface layer that can emerge in during the summer months. Proshutinsky et al. (2009) estimated that this bias causes the freshwater content (referenced to 34.8 psu) to be underestimated by 0.15-0.20m in the top 8m of the ITPs during June-August. If we consider the ITP-average $S_0 = 27.78$ g/kg, this bias would correspond to an underestimate of 5.22-6.96 m·g/kg in Φ (multiply 0.15-0.20 m by 34.8) and 0.19-0.25 m in $sFWC$ (as defined in Section 3; divide 5.22-6.96 m·g/kg by 27.78 g/kg).

References

Proshutinsky, A., and Coauthors, 2009: Beaufort Gyre freshwater reservoir: State and variability from observations. *Journal of Geophysical Research*, **114**, C00A10, doi:10.1029/2008JC005104, URL http://doi.wiley.com/10.1029/2008JC005104.

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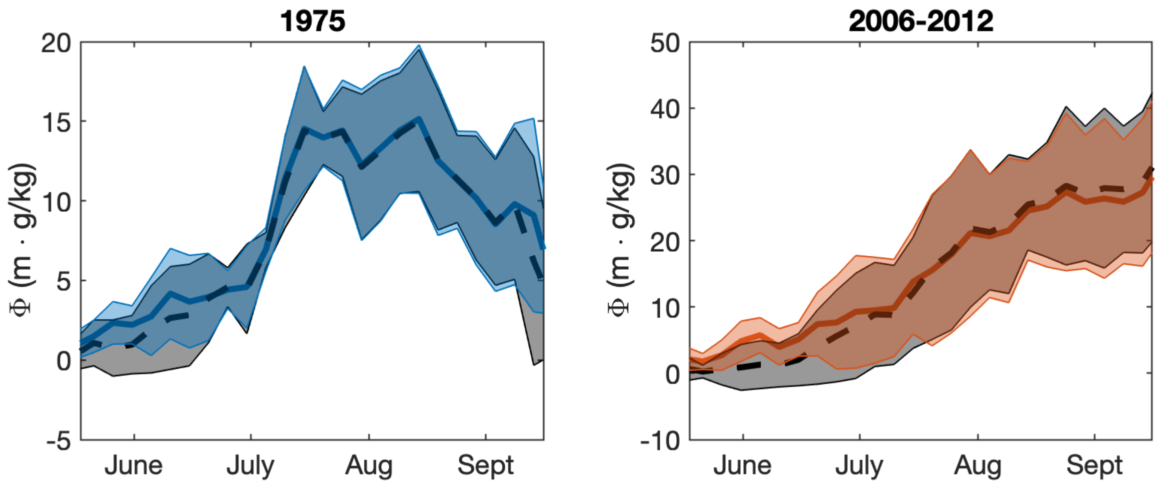

Fig. S1. Salt deficit (Φ) using two different methods for computing S_0 with (left) AIDJEX and (right) ITP data. Blue and red lines indicate results setting S_0 to the average-May surface salinity for the same ITP or AIDJEX ice camp during the same year (as in the main text). Black dashed lines indicate results from setting S_0 to the average surface salinity during May 16-22 (the earliest 7-day period with all AIDJEX ice camps collecting data). Solid lines indicate 5-day averages and shading indicates one standard deviation.

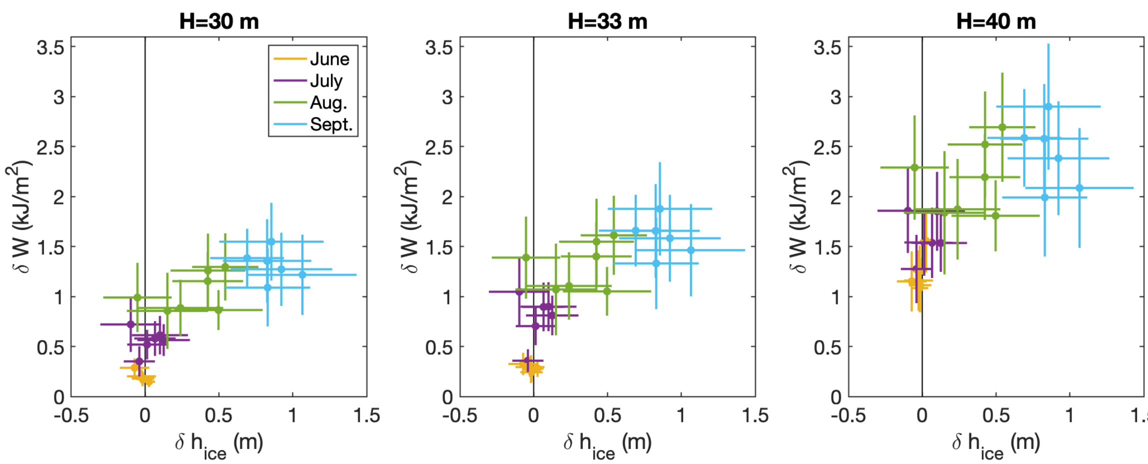

Fig. S2. As in Figure 10 in the main text but using H =20 m, 33 m, and 40 m, respectively. Larger values of H yield larger differences between the ITP and AIDJEX data because differences in the winter halocline are incorporated.