RECENT CHANGES IN THE UPPER OCEAN OF THE CANADA BASIN AND THEIR POSSIBLE IMPLICATIONS IN THE NORDIC SEAS

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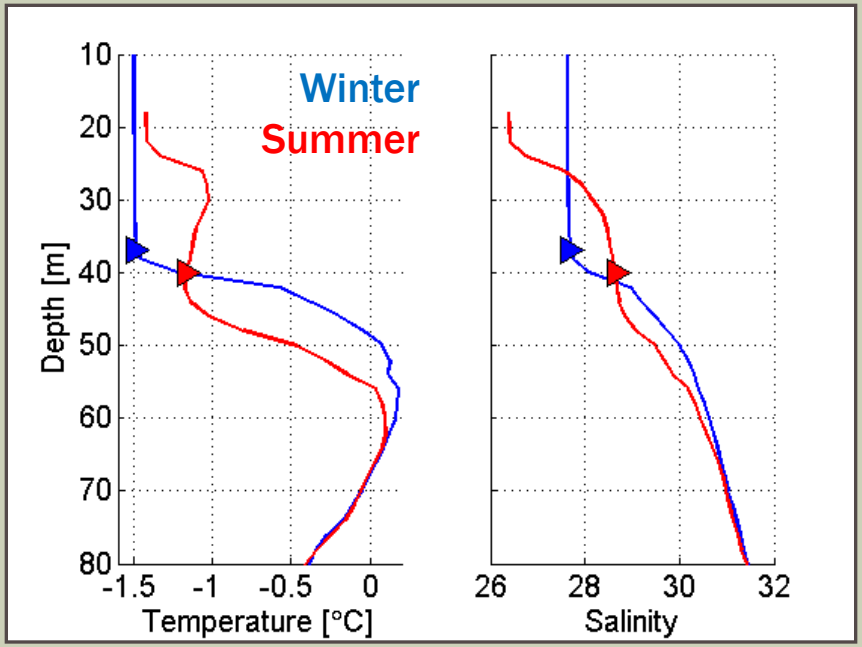
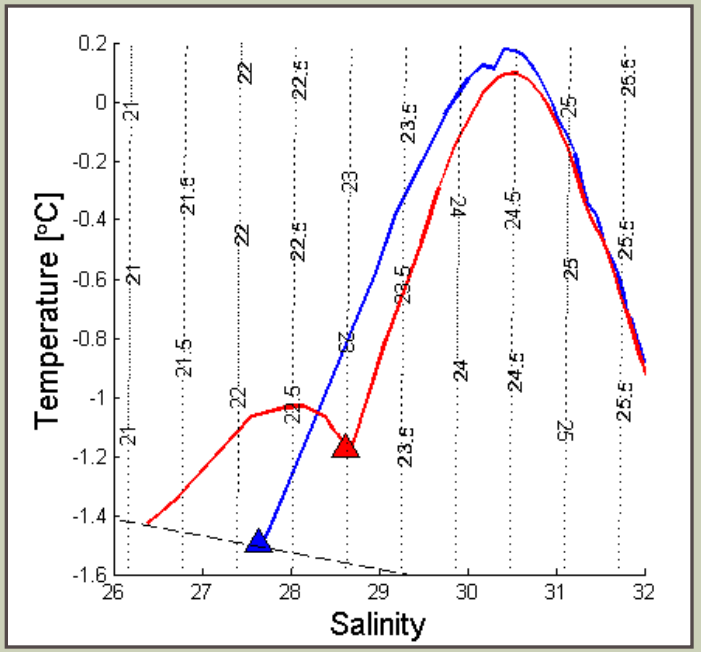
THEORY: PROPERTIES OF WINTER MIXED LAYER ARE MAINTAINED BELOW THE SUMMER HALOCLINE



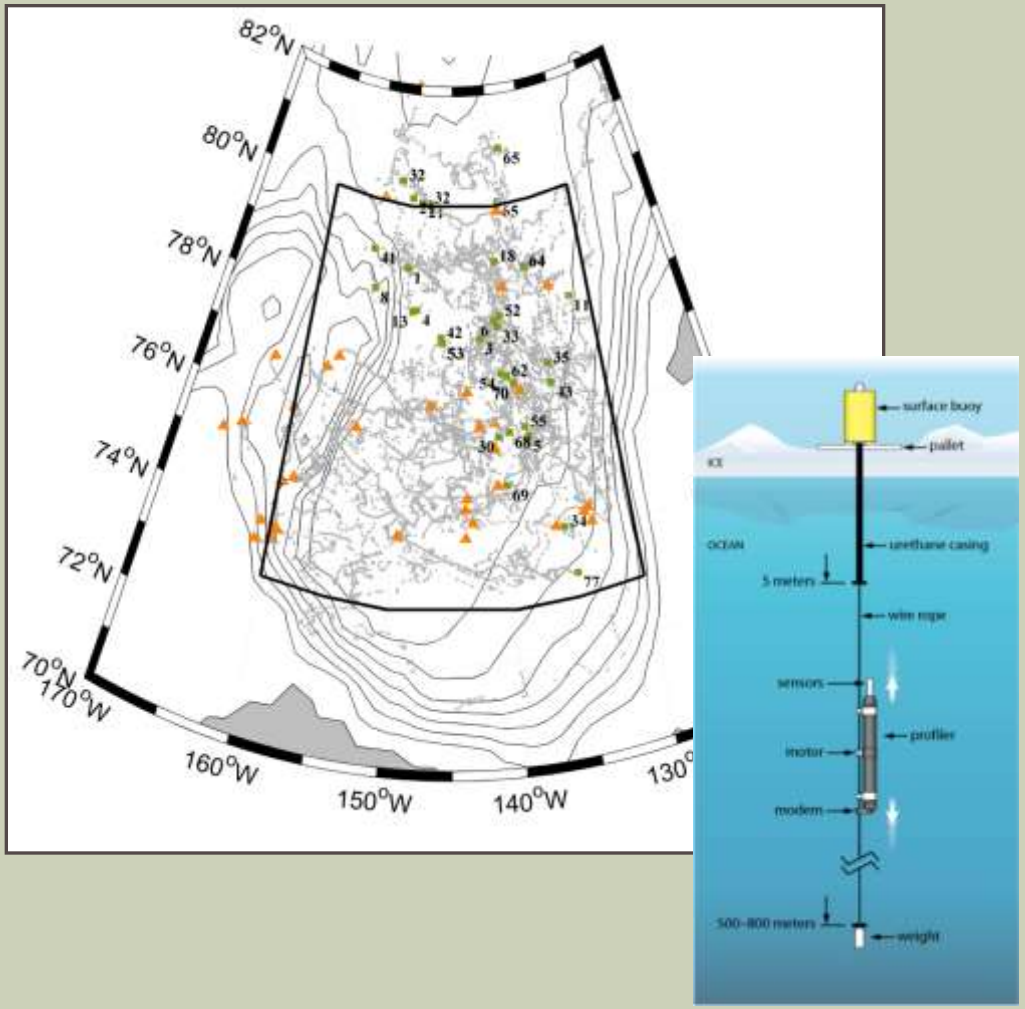
- Winter Mixed Layer is generally both isopycnal and isothermal in the Arctic Ocean
- Remnant Winter Water is recognized from the temperature minimum



- Increase in temperature and salinity due to diffusion
- Downwelling due to Ekman pumping

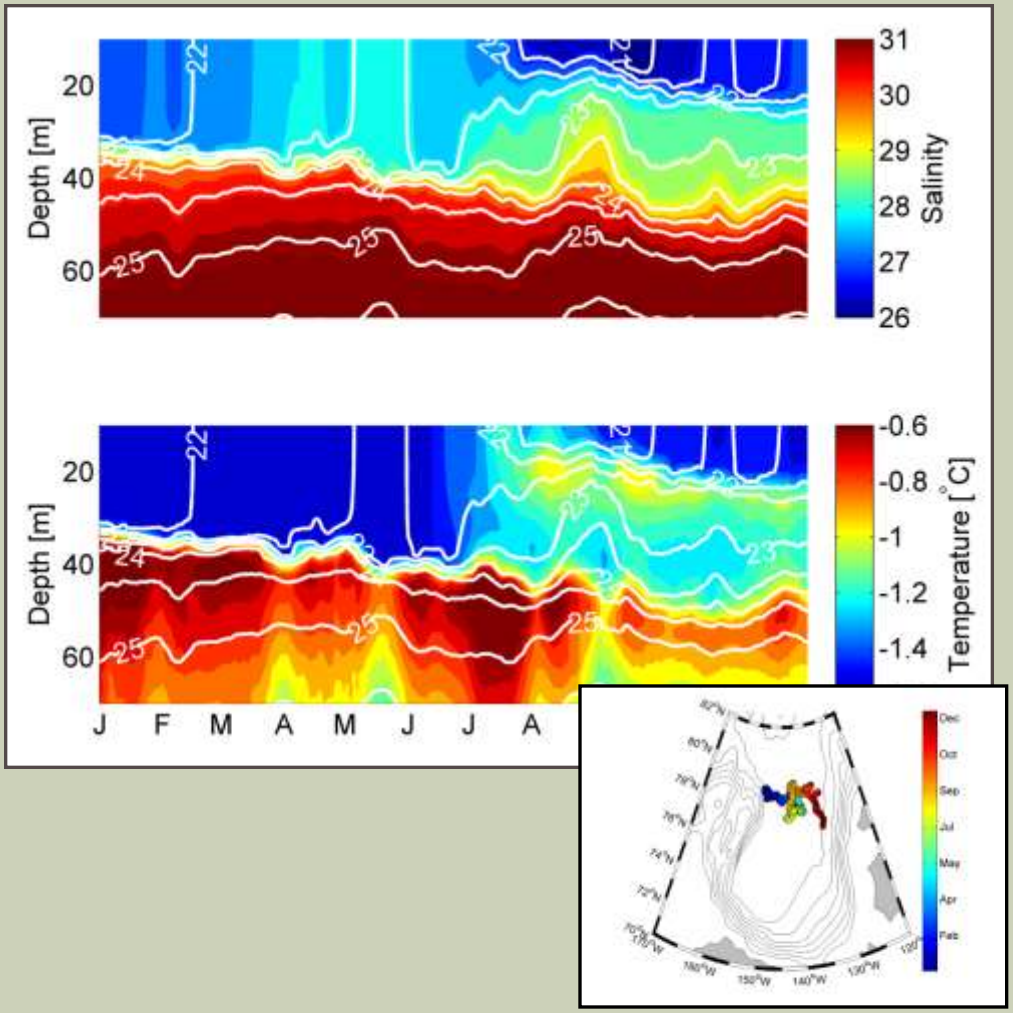
MATERIAL:
YEAR-ROUND ITP OBSERVATIONS 2006-2013

- Drift of ITPs: sea ice drift speed is one magnitude larger than the surface currents in the Canada Basin
- Interannual variability in the location of the ITPs and in the location of the Beaufort Gyre



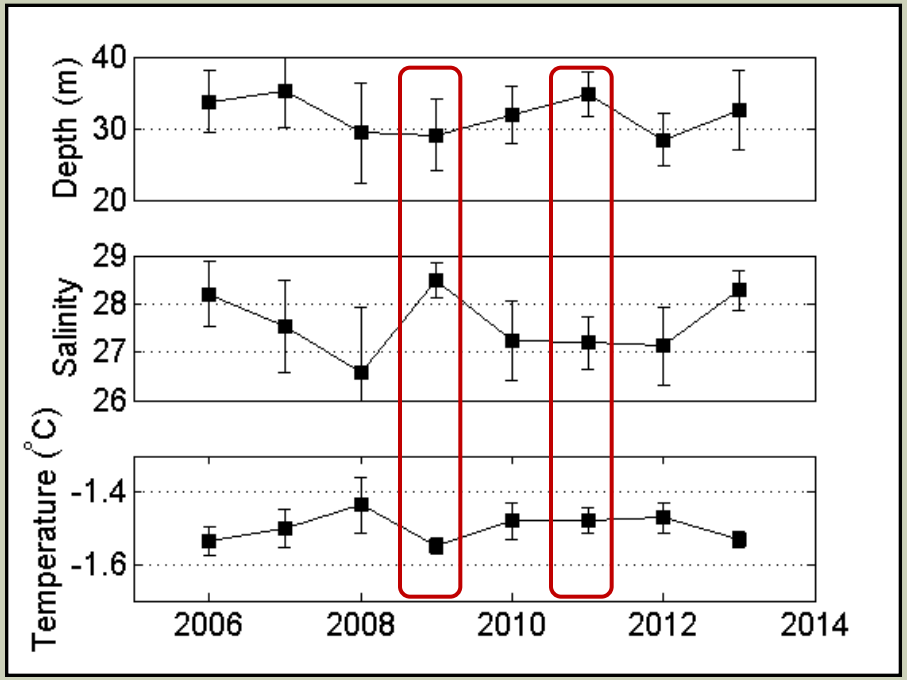
INTRODUCTION:
SEASONAL EVOLUTION OF THE UPPER OCEAN

- The Winter Mixed Layer maintains depth of ~30 m until June
- The Summer Mixed Layer ~16 m (Toole et al., 2010)
- The Near-Surface Temperature Maximum around depths 15-25 m (Jackson et al., 2010)
- The Remnant Winter Water below the NSTM (or the seasonal halocline if the NSTM is not present)



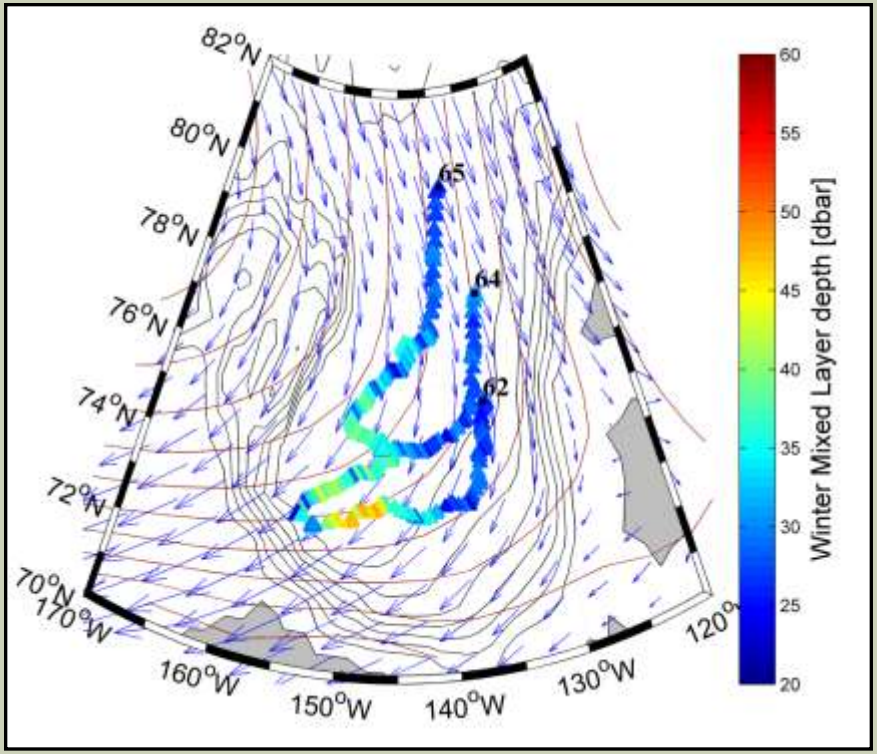
CHANGES IN THE WINTER MIXED LAYER

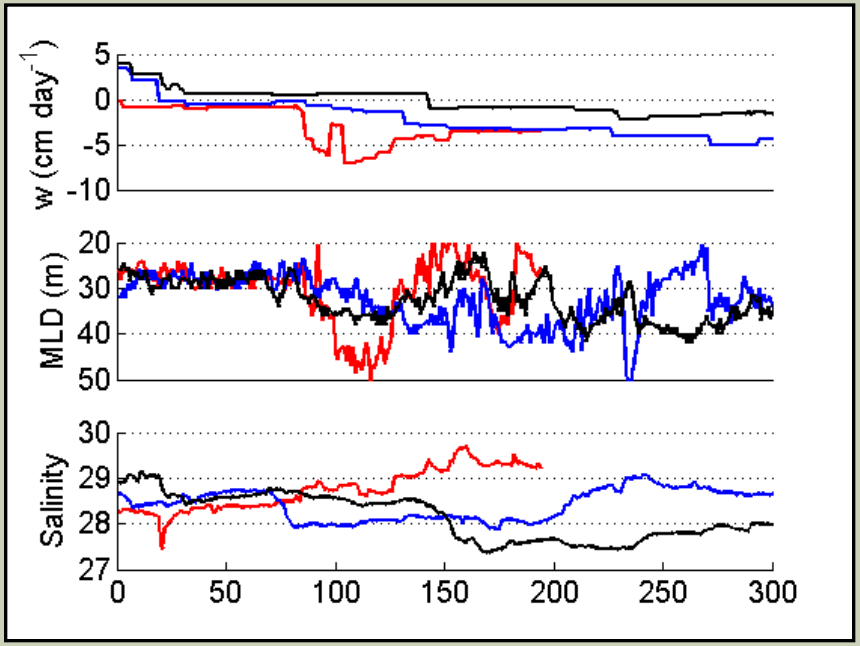
- Average depth ~35 m, salinity ~27.5, temperature ~ -1.5°C
- Large interannual variability but no trend for the period 2006-2013
- WML depth does not depend only on surface salinity:
  - 2009 shallow WML (~30 m) with high salinity (~28.5)
  - 2011 deep WML (~35 m) with low salinity (~27)



CASE STUDY: WINTER CONVECTION ENHANCED BY EKMAN PUMPING IN 2013

- Deepening in time or space?

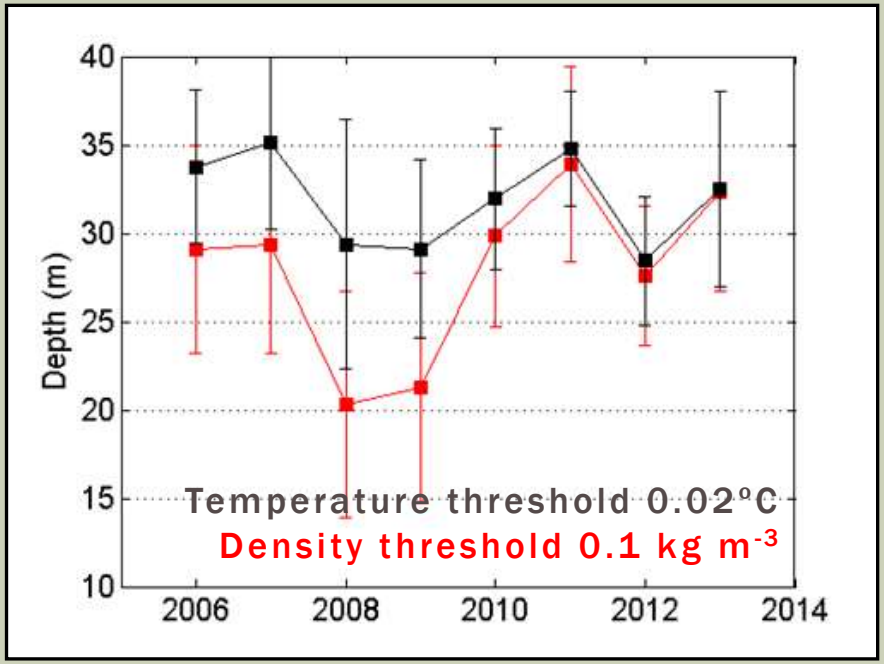




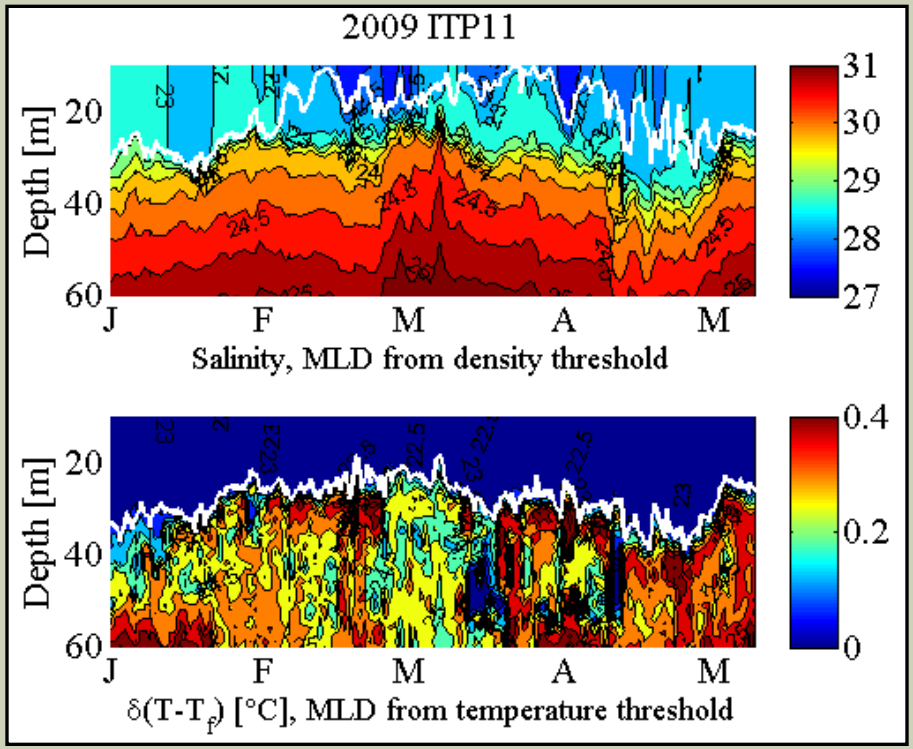
ITP62 – red, ITP64 – blue, ITP65 - black

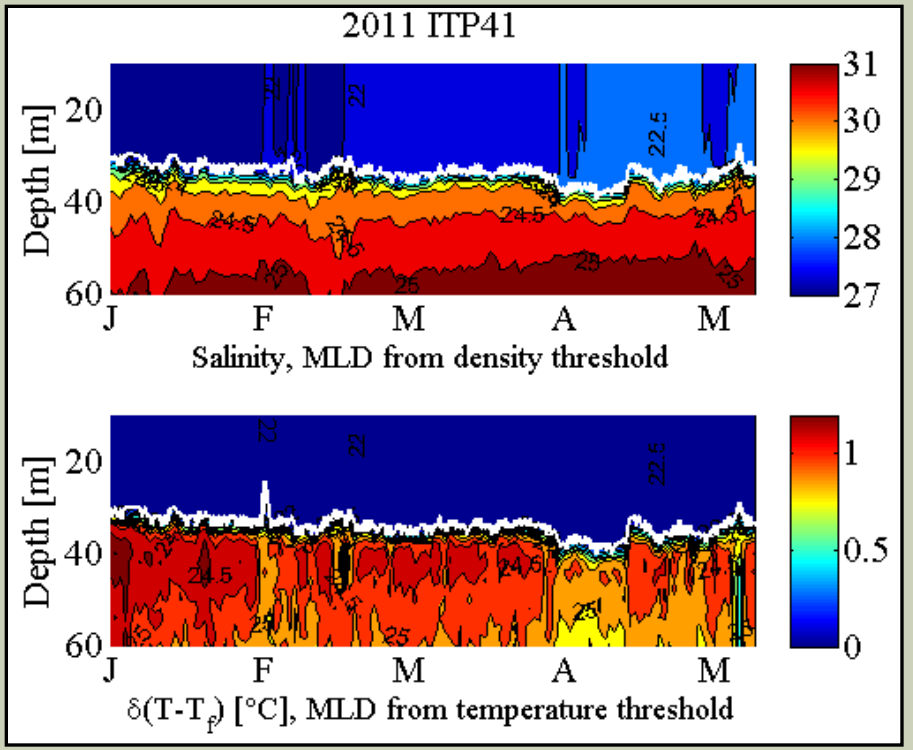
NO SHOALING OF THE WINTER MIXED LAYER?

- Toole et al. (2010): average WML depth in the Canada Basin only 24 m (ITP data 2006-2009)
- The isopycnal layer is ~10 m shallower than the isothermal layer in 2008 and 2009
- Shallow water eddies heave the isopycnals (and isotherms)
- The barrier layer is no longer present after 2009



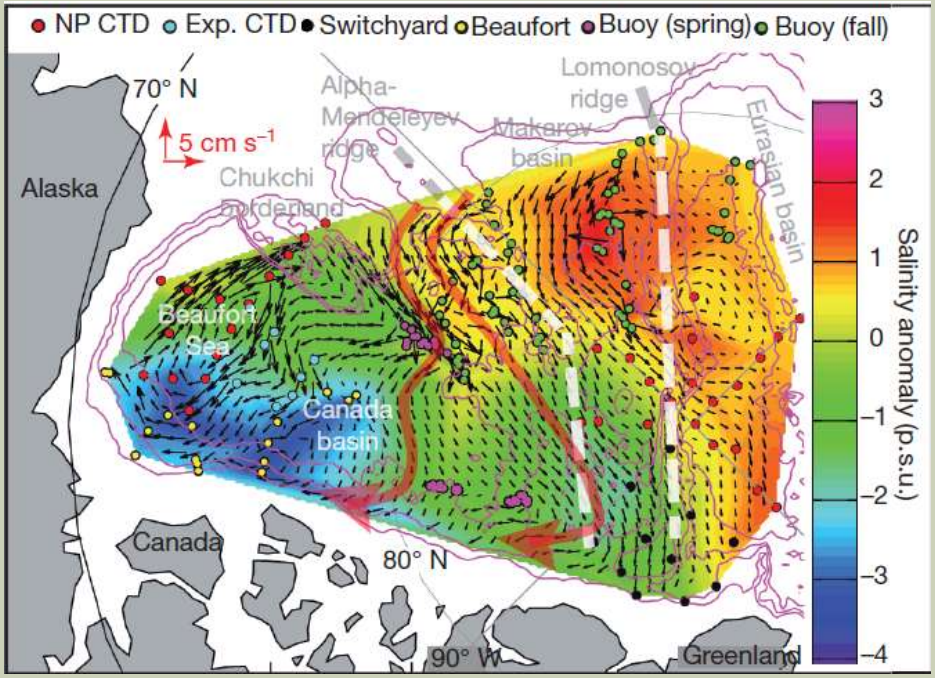
WINTER MIXED LAYER IN 2009 VS. 2011





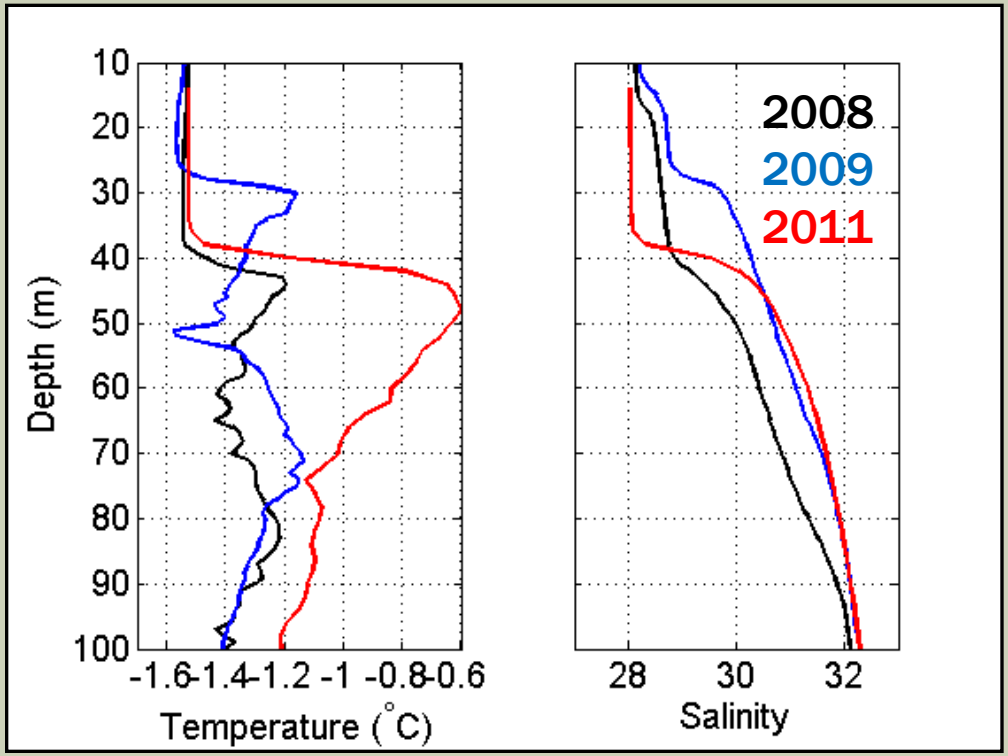
PRECONDITIONS FOR THE PERIOD 2006-2009

- Morison et al. (2012): Eurasian river runoff directed towards the Canada Basin between 2005-2008
- Negative salinity anomaly at depths 50-115 m



WHY IS THE ISOPYCNAL LAYER SHALLOWER THAN THE ISOTHERMAL LAYER?

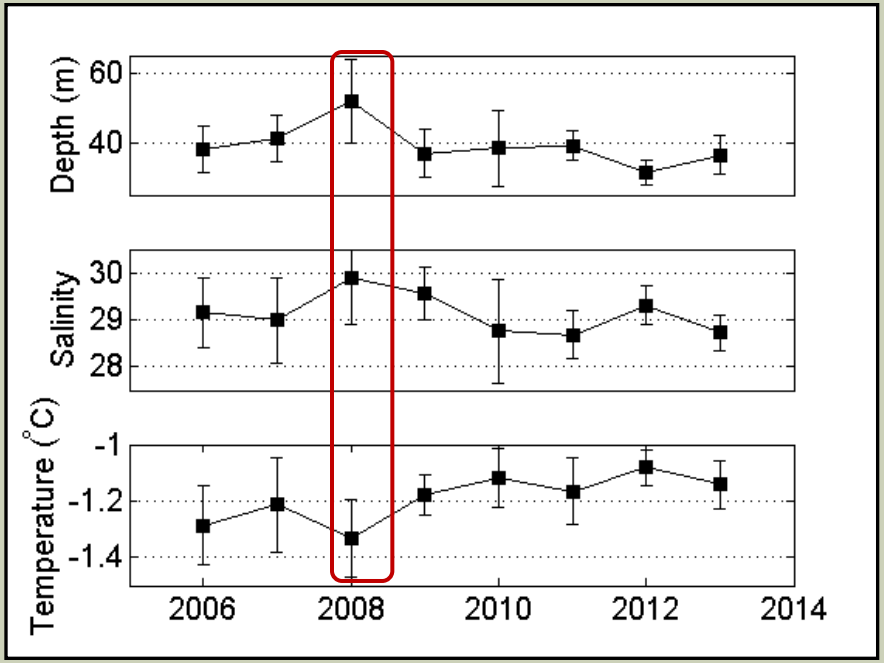
- Barrier layer formation due to upwelling in the edge and convergence within the Beaufort Gyre



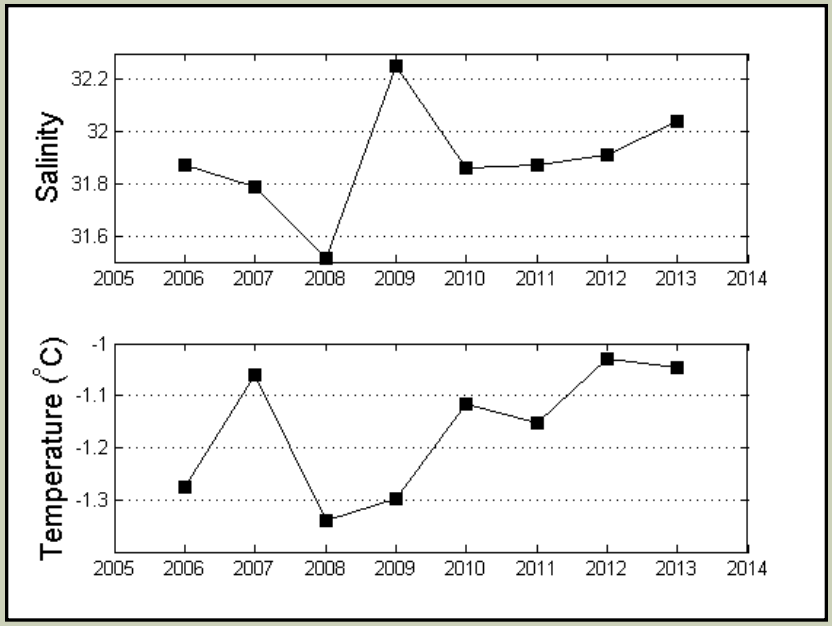
- The absence of the barrier layer may increase heat flux to the base of the WML and sea ice
- Strengthening of the density gradient between WML and BSSW

CHANGES IN THE REMNANT WINTER WATER

- Average depth ~40 m, salinity ~29 and temperature ~ -1.2°C
- Slight decrease in depth and salinity
- Shallow water eddies (Timmermans et al., 2008) with cold and saline core in 2008
- Strong Ekman pumping in 2008 (several stacked NSTM, Jackson et al., 2010)
- Increase in temperature due to increased diffusion from NSTM above and/or BSSW beneath



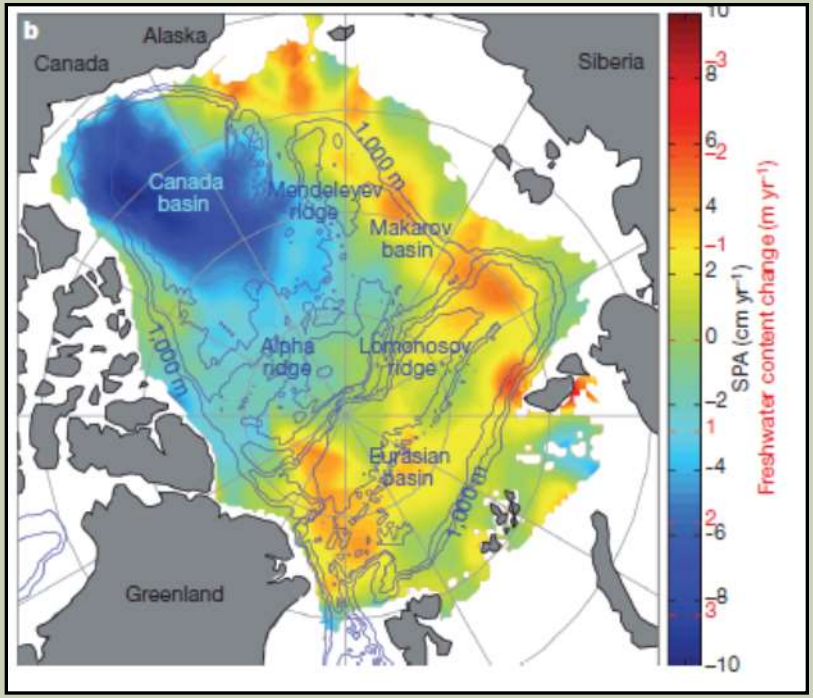
CHANGES IN BERING SEA SUMMER WATER



- Possible increase in BSSW salinity and temperature after the extreme years 2008 and 2009 when BSSW was practically absent

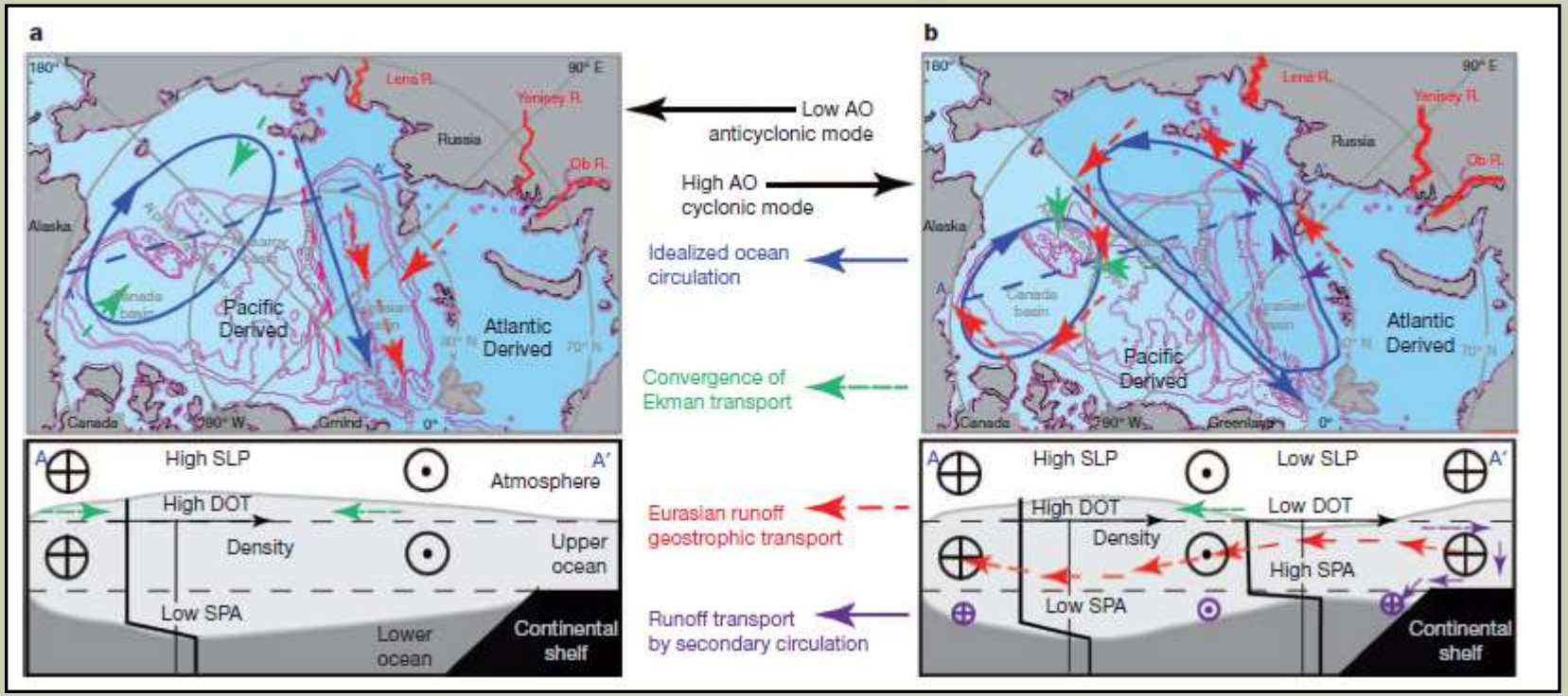
REDISTRIBUTION OF FRESHWATER BETWEEN THE TWO MAIN BASINS

- The change in the Canada Basin does not show the total change in the Arctic freshwater content



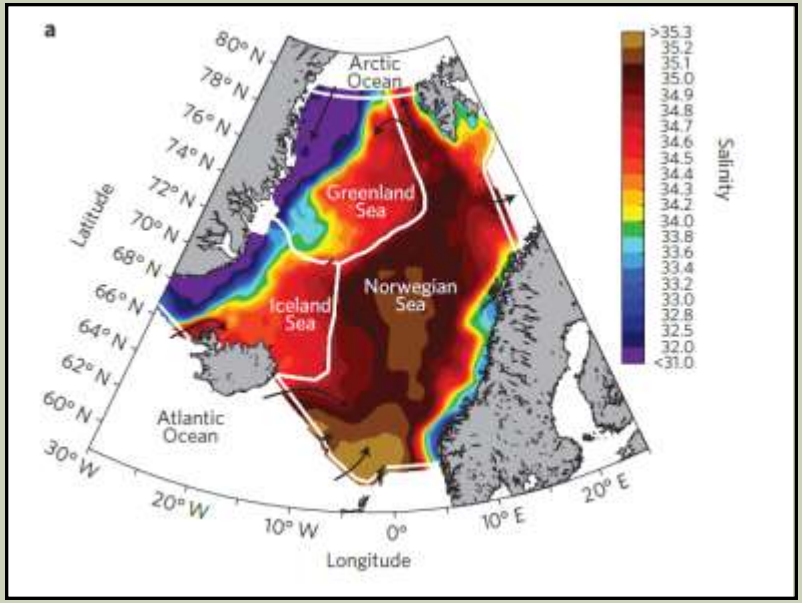
Change in freshwater content 2005-2008 (Morison et al., 2012)

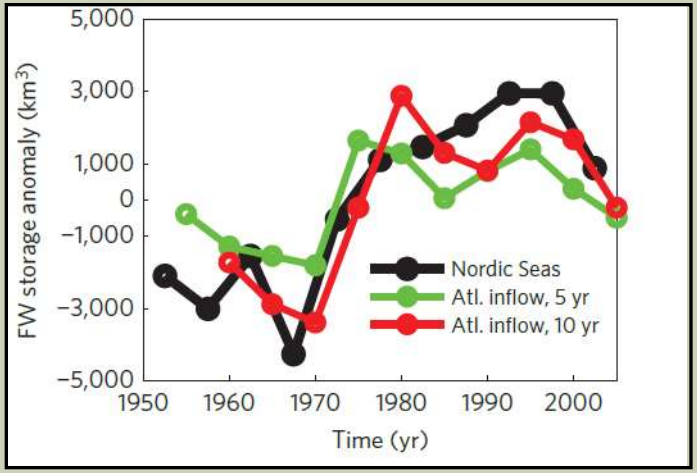
TWO DIFFERENT CIRCULATION PATTERNS



Morison et al. 2012

FW ANOMALIES IN THE NORDIC SEAS DRIVEN MAINLY BY THE ANOMALIES IN THE ATLANTIC INFLOW





Glessmer et al., 2014

CONCLUSIONS

- Freshening of the Canada Basin since the 1990s has stopped after 2008
- Warming of the Bering Sea Summer Water