

Variations of the Pacific-origin Waters in the Chukchi Borderland, Arctic Ocean



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Background

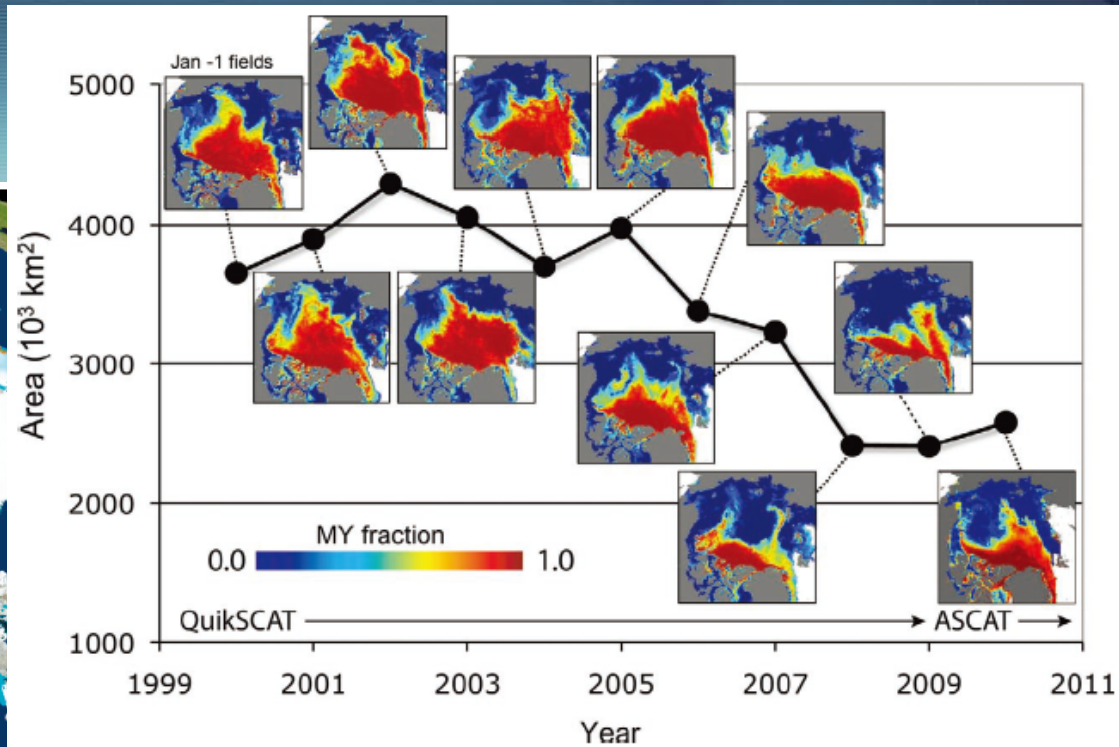
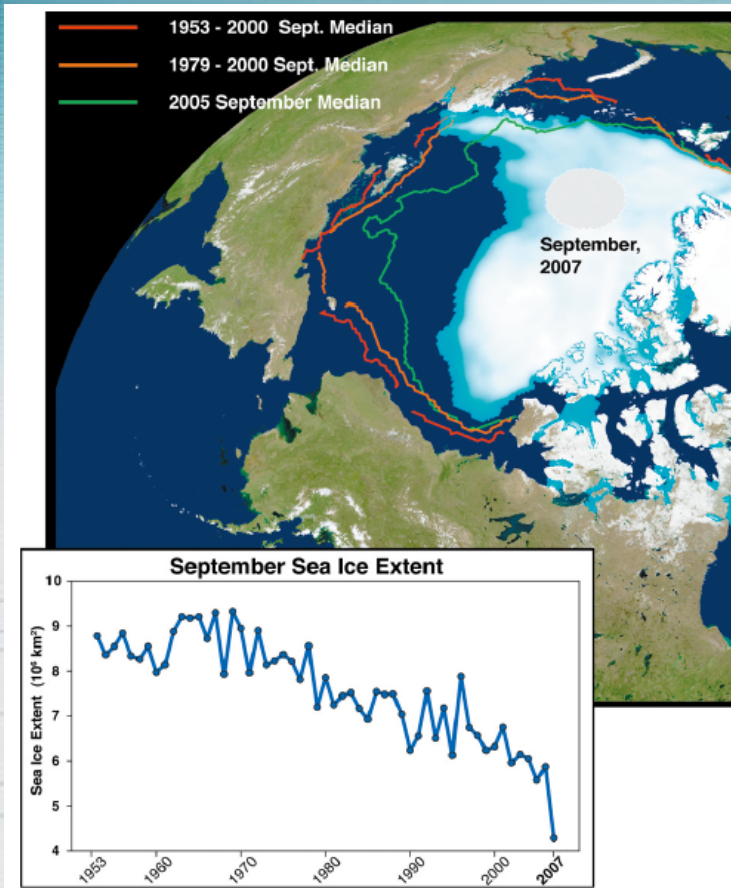


FIG. 1. Satellite-based Arctic Ocean multiyear ice (MYI) coverage. Composite time series shows MYI area on 1 Jan each year. Maps show fraction (part of a unit) of MYI. [Adapted from Kwok and Untersteiner (2011).]

(Polyakov et al., 2012, BAMS)

Rapid reduction of sea ice on
Pacific Arctic Region

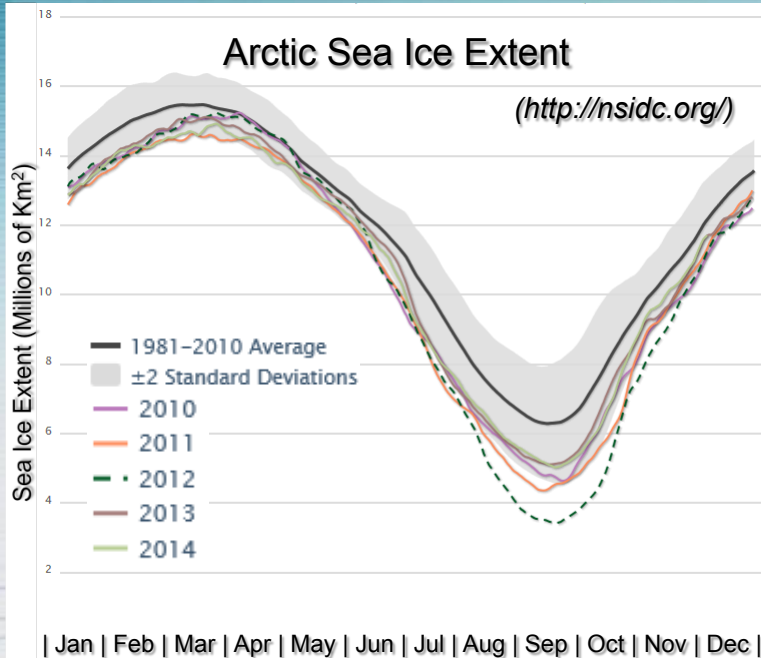
Fig. 1. Sea ice concentration for September 2007, along with Arctic Ocean median extent from 1953 to 2000 (red curve), from 1979 to 2000 (orange curve), and for September 2005 (green curve). September ice extent time series from 1953 to 2007 is shown at the bottom.

(Stroeve et al., 2008, EOS)

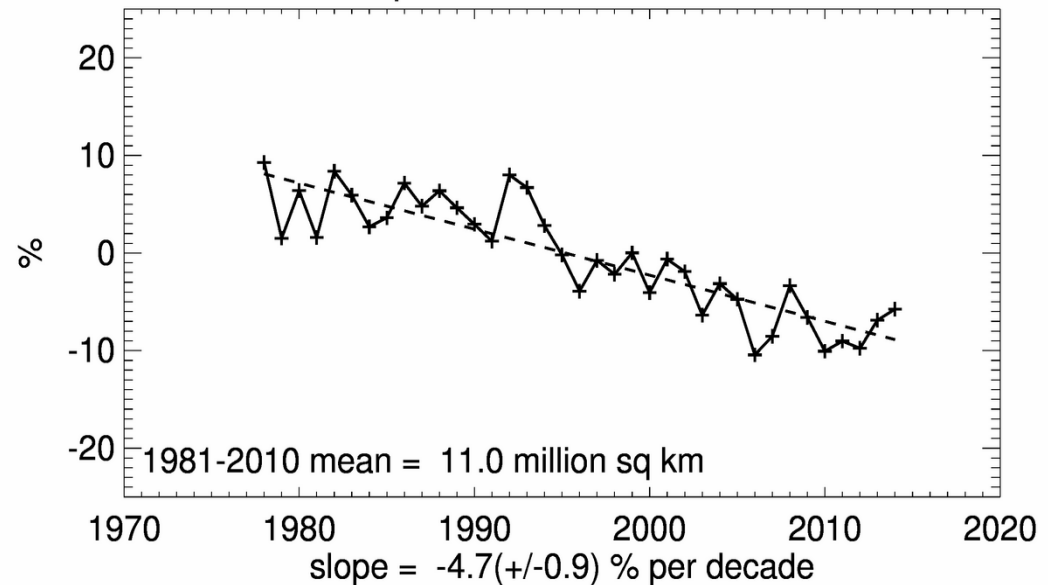
Background

Arctic Sea Ice Extent

(<http://nsidc.org/>)



Northern Hemisphere Extent Anomalies Nov 2014



(<http://nsidc.org/>)

Annual trend of sea ice extent
1981-2010 mean vs. recent 5 years

Monthly sea ice extent anomaly
nearly 40 years, 20% reduction

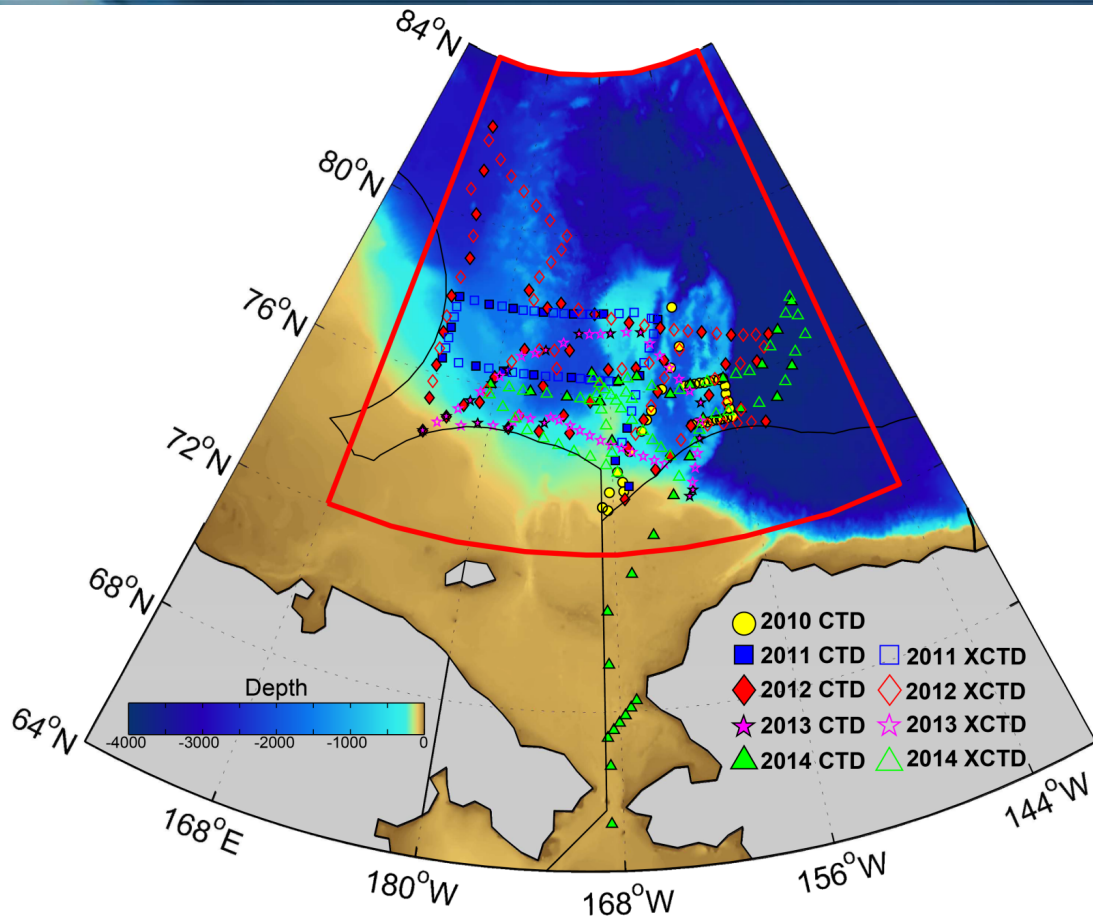
Research Objective

- ✓ **To investigate spatial/temporal variations of Pacific waters and their distributions on the Chukchi Borderland**
- ✓ **To identify the upper ocean's response to the atmospheric forcing or sea ice behavior**

3.

Method & Data

I/B ARAON Arctic Cruises (2010~2014)



	2010	2011	2012	2013	2014
CTD	38	18	44	16	32
XCTD	*	33	48	36	51
Duration	07/20~08/10	08/02~08/16	08/04~09/06	08/24~09/01	08/01~08/23

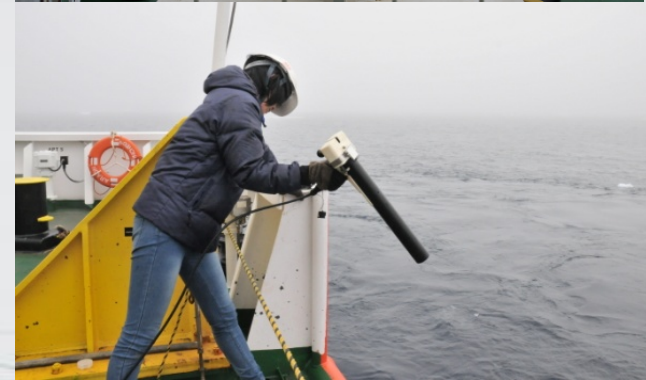
Method & Data

Equipment

- CTD, Lowered ADCP, XCTD
- Ocean Mooring System
- Bio/Geo/Chemical equipment

Observed Items

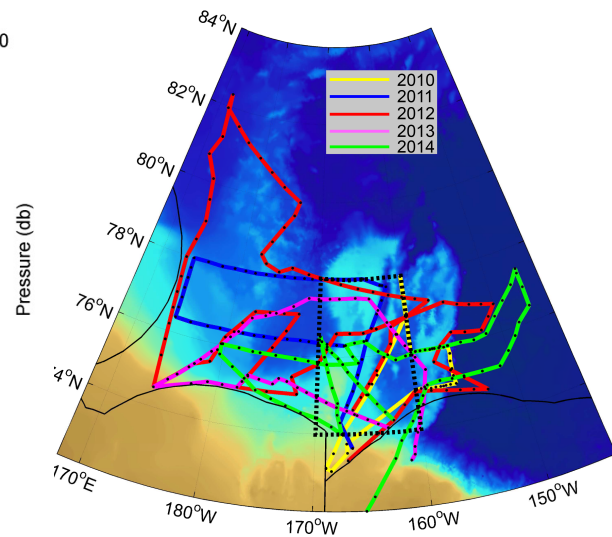
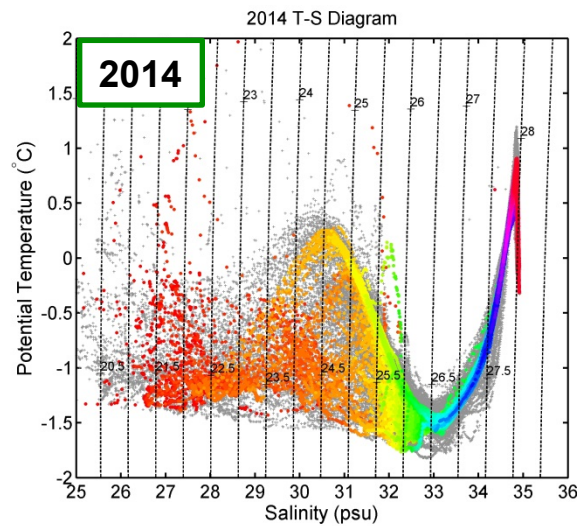
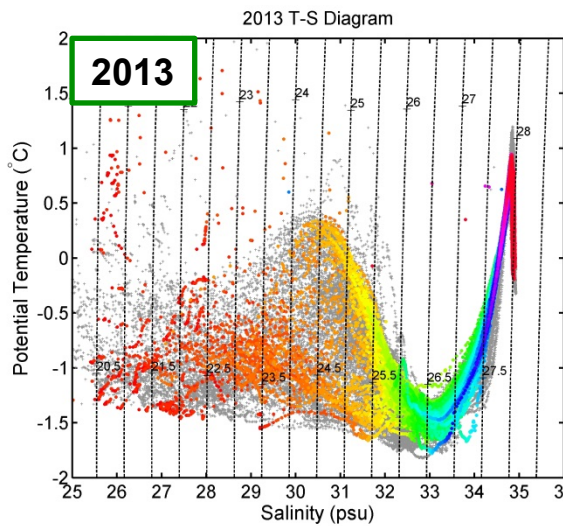
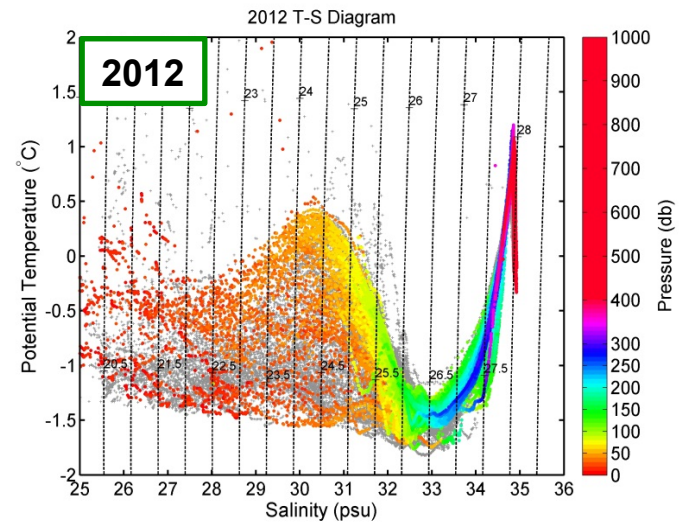
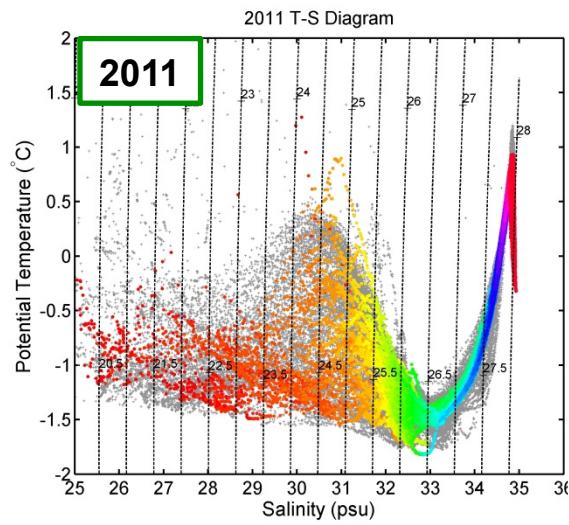
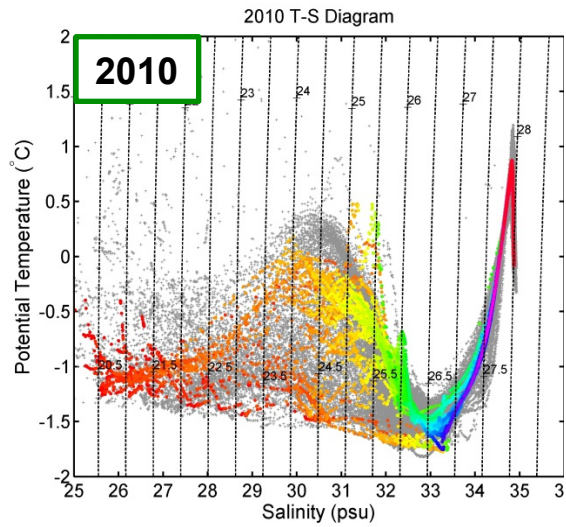
- Temperature, salinity, DO, fluorescence, PAR, transmission, backscatter, water velocity
- Primary production and new production,
- Phytoplankton composition,
- Chlorophyll-a and HPLC,
- Zooplankton composition and abundance
- Bacterial and virus biomass
- Micro-zooplankton biomass, composition, and grazing
- Nutrients, POC, PON, DOC, DON, DOP
- N₂O gas, pCO₂, DIC, pH, SS, TA
- Atmospheric components



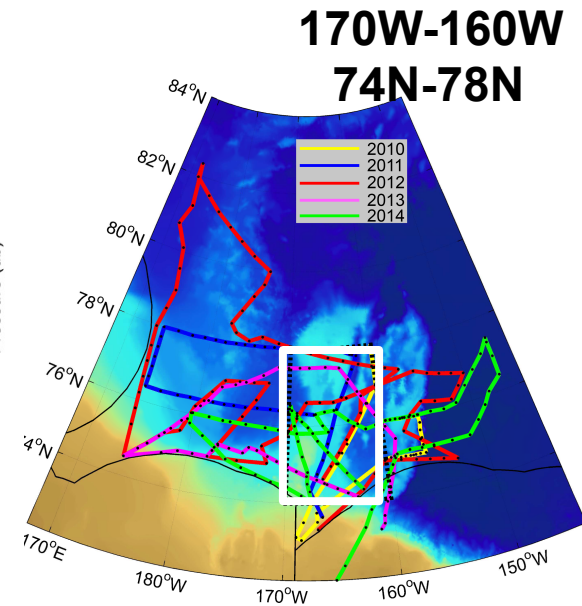
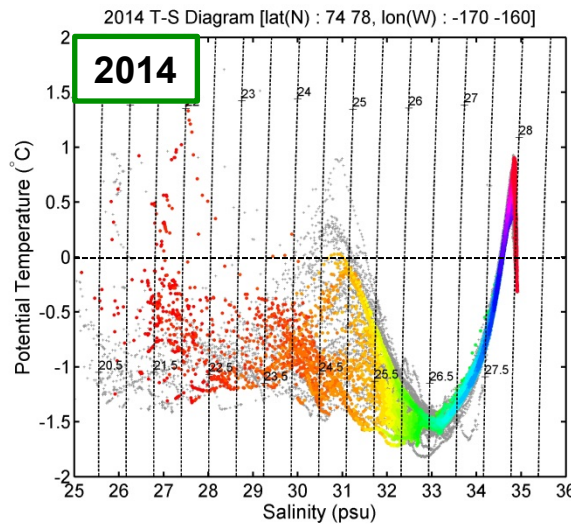
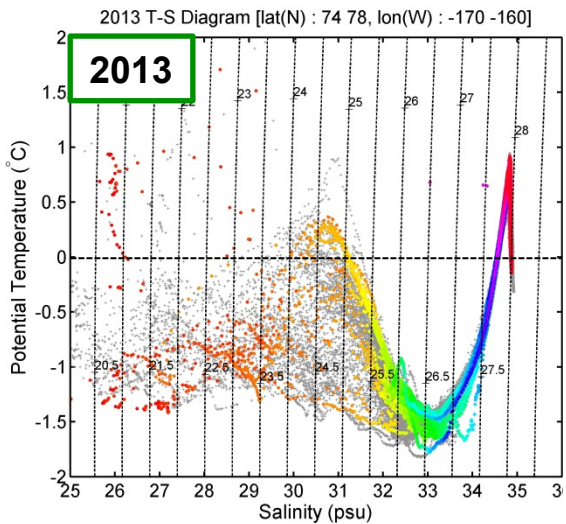
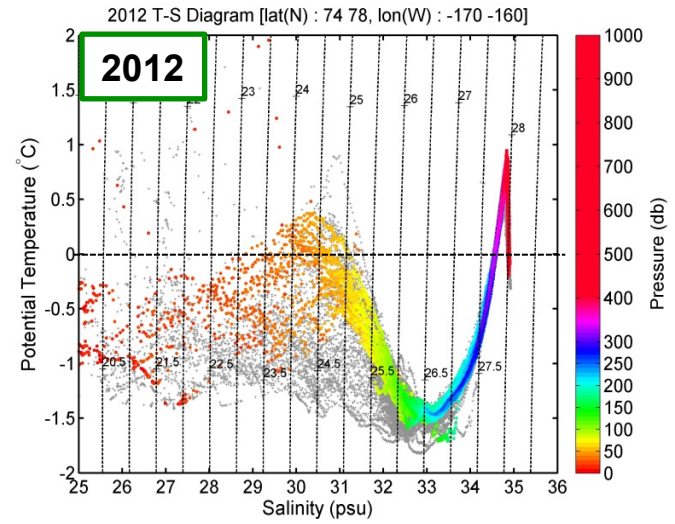
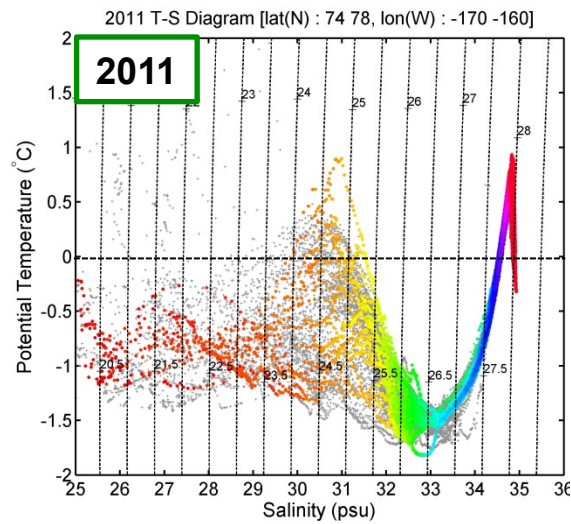
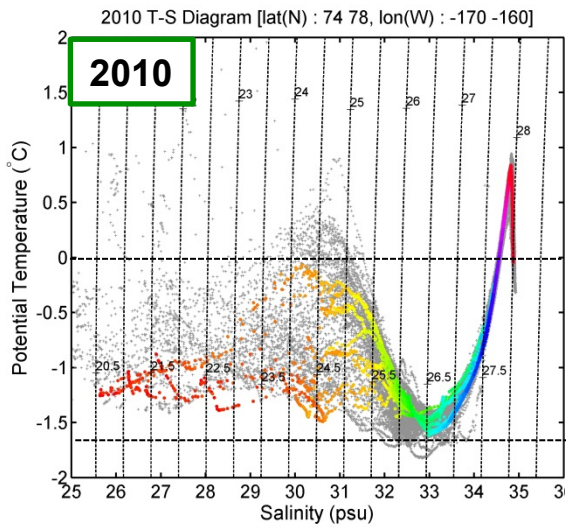
4.

Preliminary Results

CTD/XCTD: θ -S Diagram



CTD/XCTD: θ -S Diagram (local area)



CTD/XCTD: Anomaly of θ , S (local area)

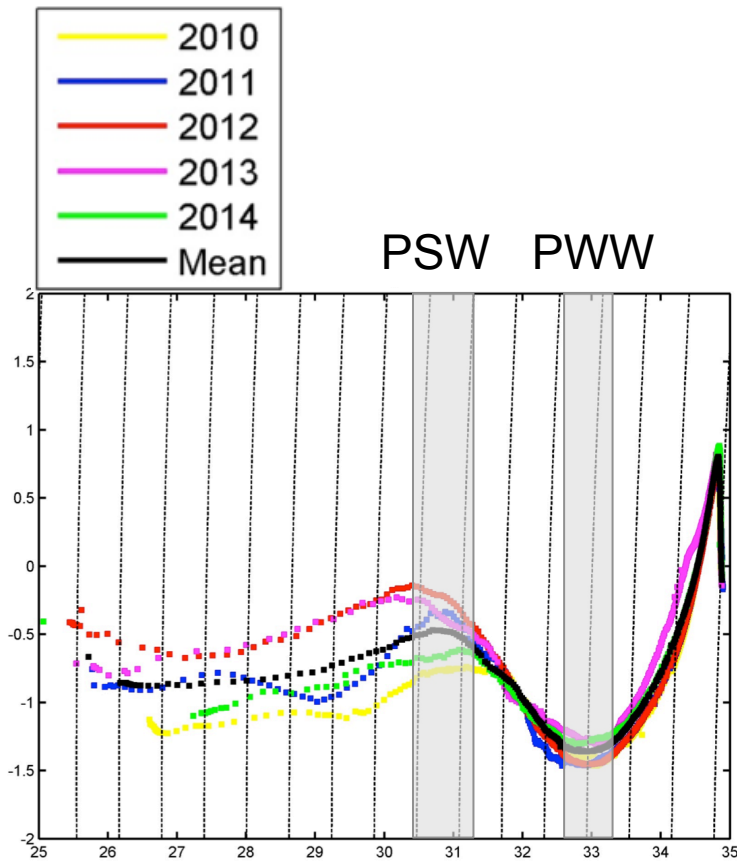
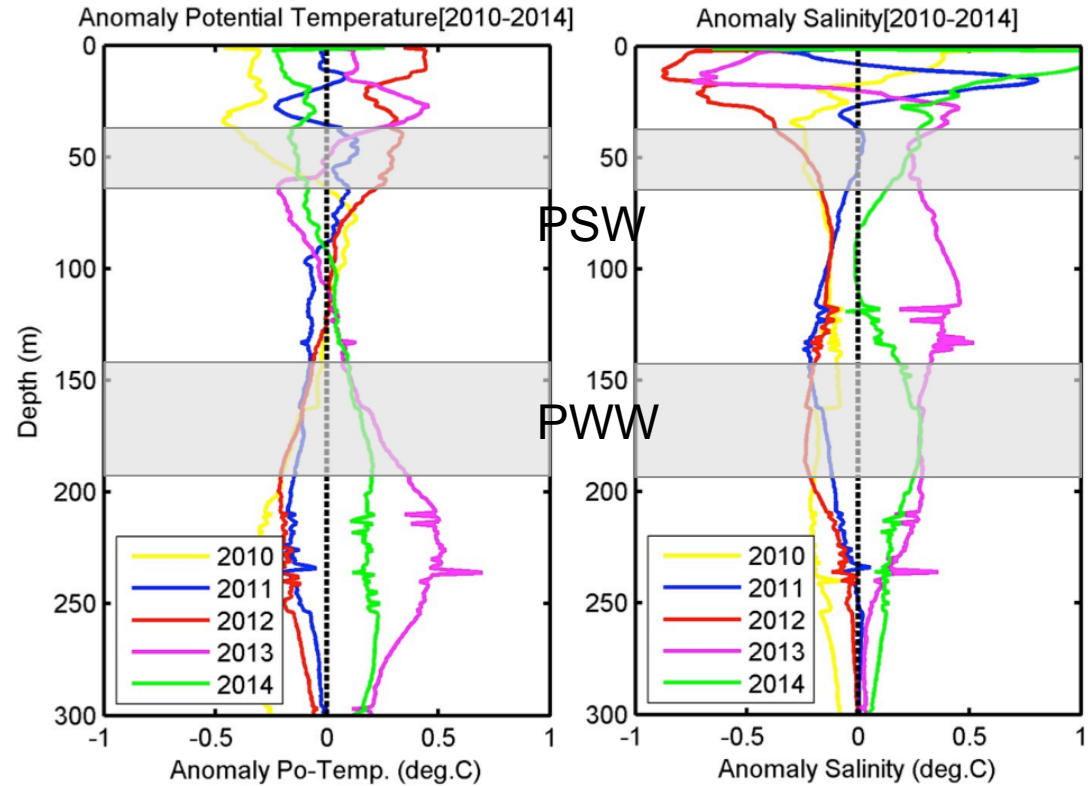


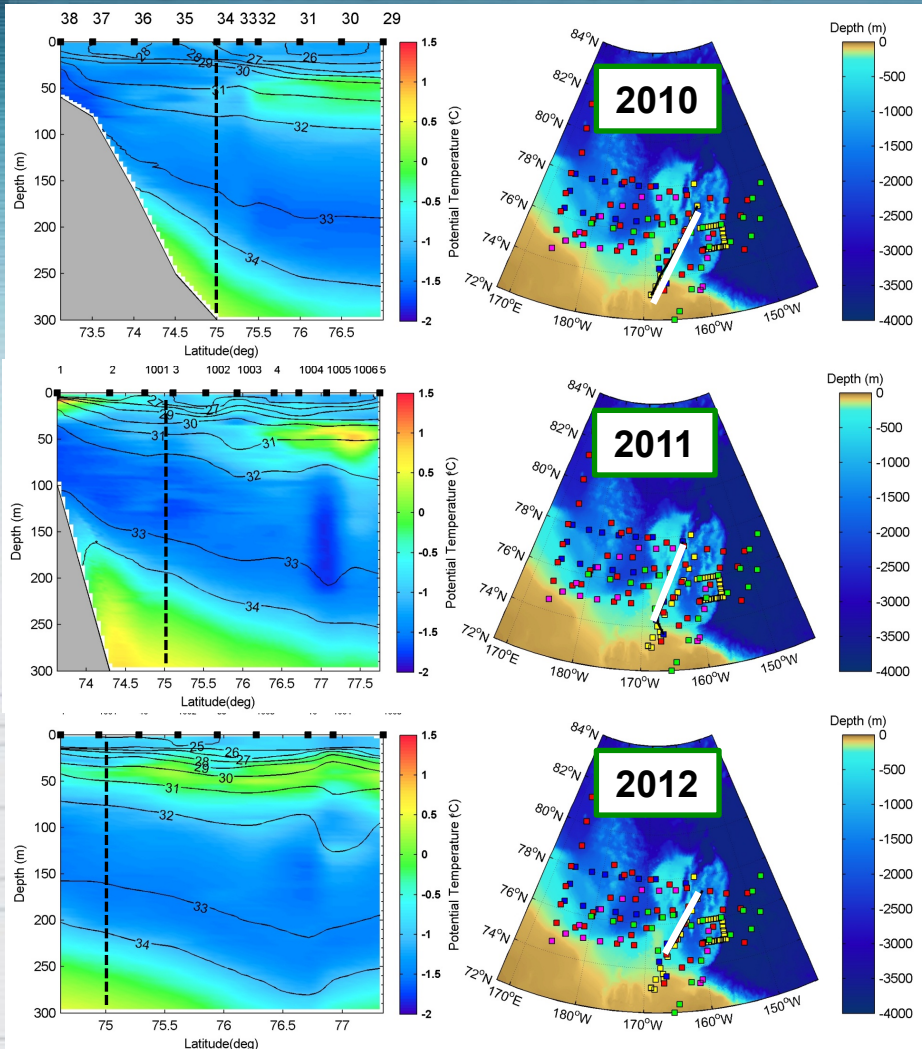
Diagram of θ -S averaged on the area ($170^{\circ}\text{W}\sim 160^{\circ}\text{W}$, $74^{\circ}\text{N}\sim 78^{\circ}\text{N}$) each year



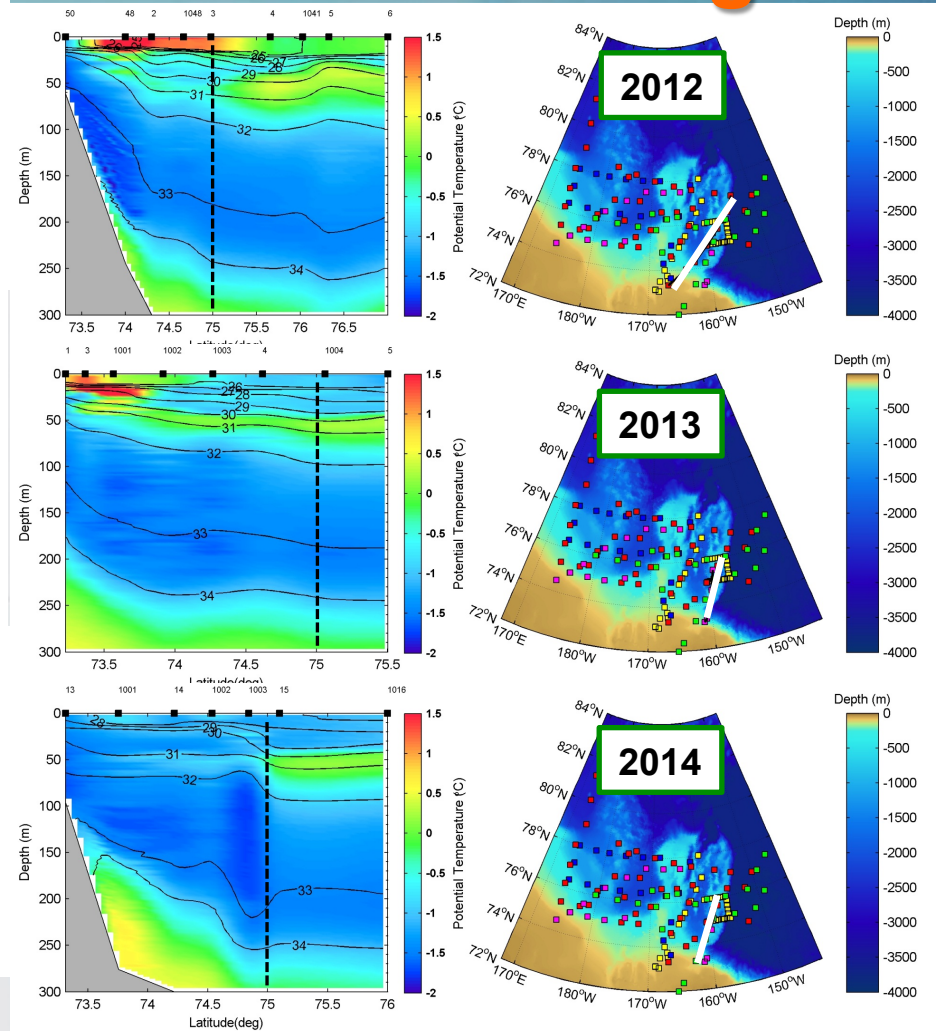
Potential temperature anomaly
 PSW: negative in 2010, 2014
 PWW: positive in 2013, 2014

CTD/XCTD: N-S transect

Chukchi Plateau

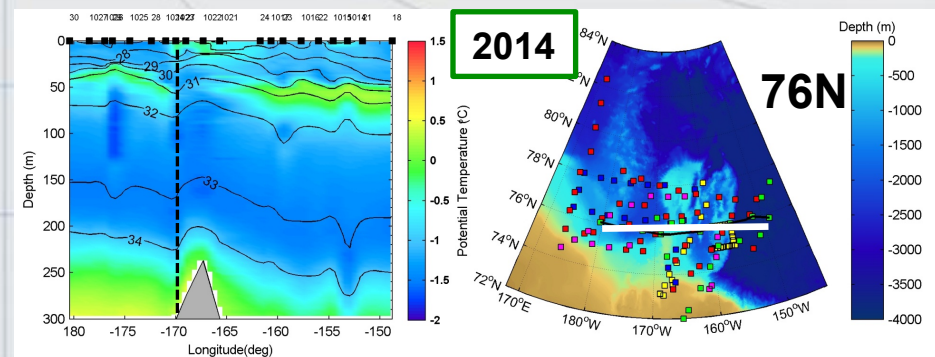
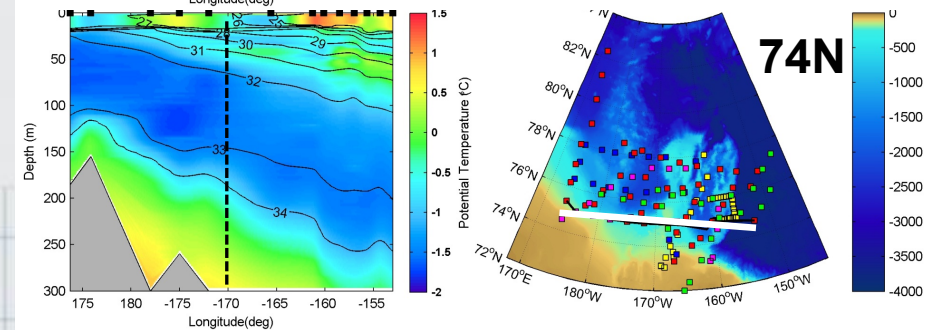
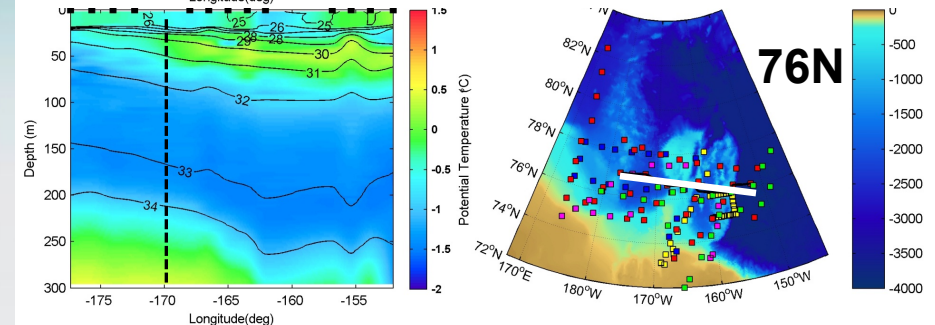
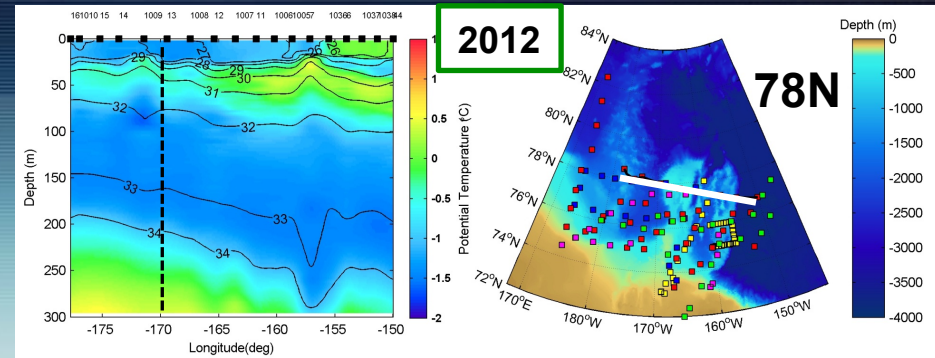
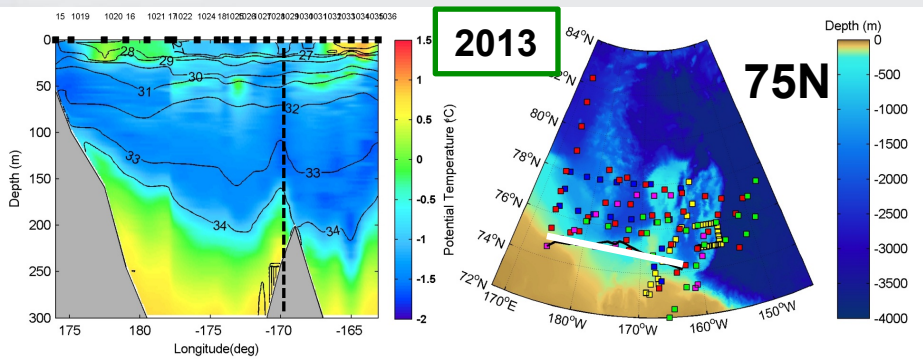
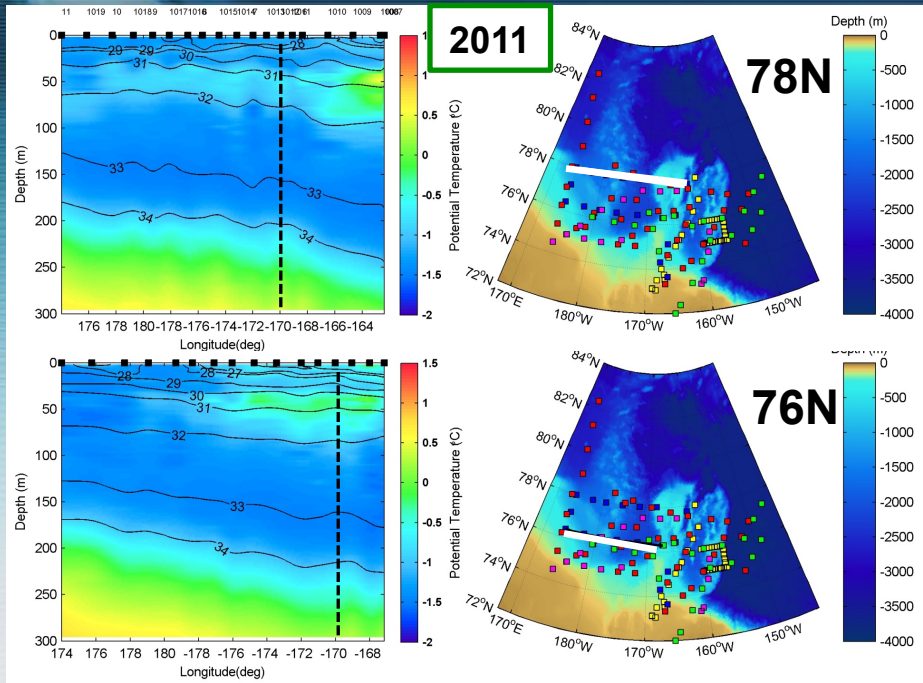


Northwind Ridge



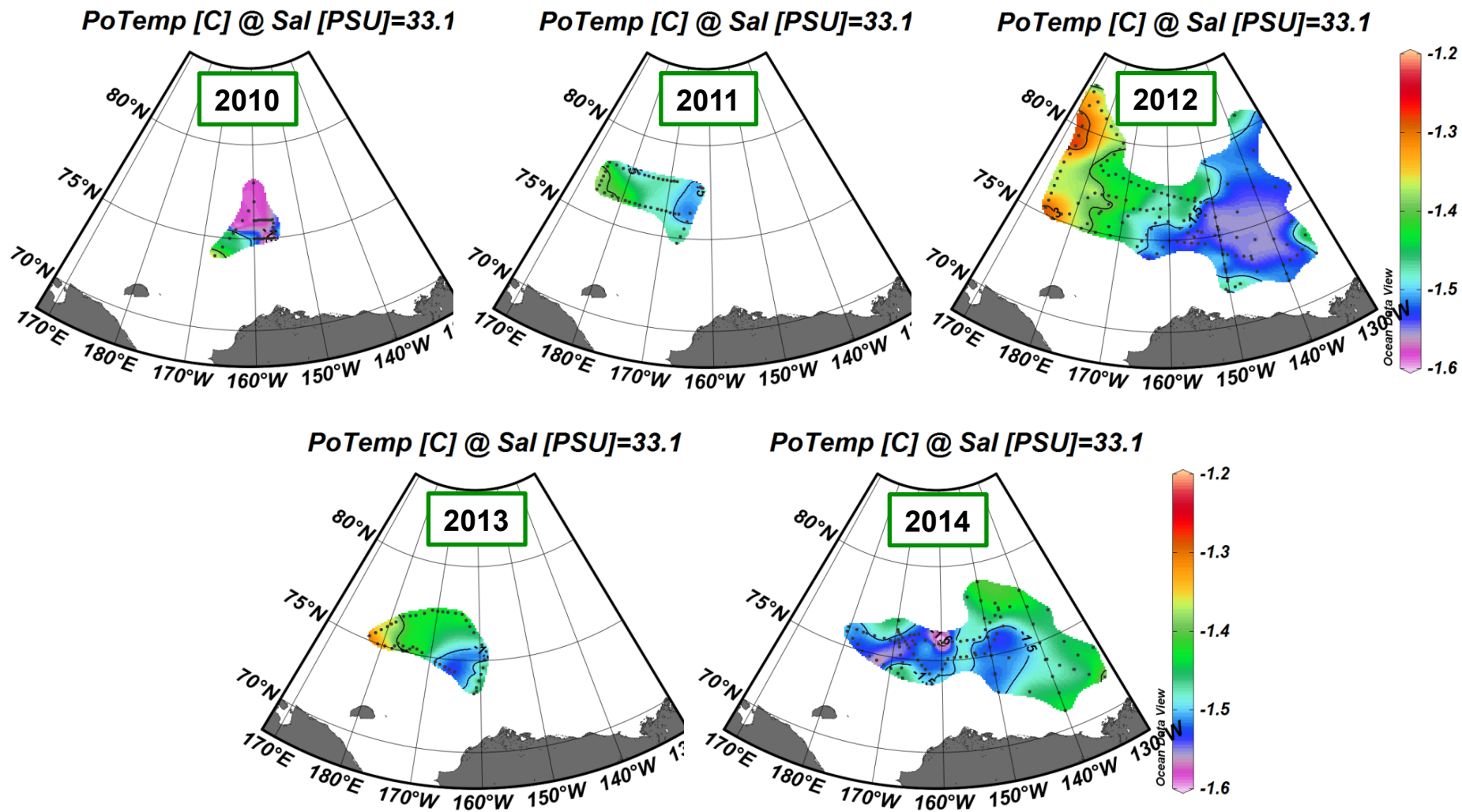
Background color: potential T
Black contours: isohalines

E-W transect



Background color: potential T
Black contours: isohalines

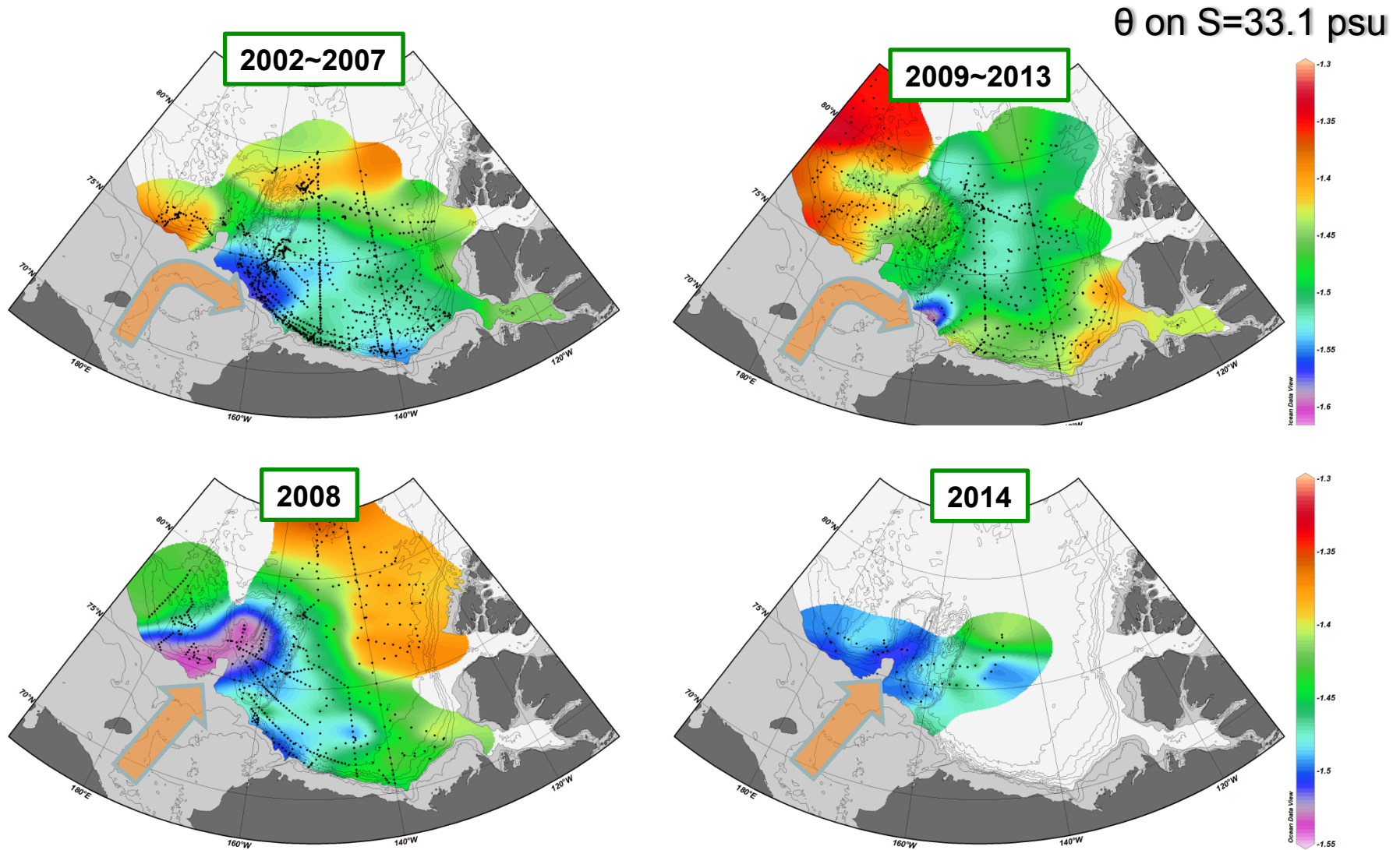
CTD/XCTD: θ on $S=33.1$ psu (PWW)



*CCGS Louis S. St-Laurent (LSSL) data were included in plots of 2012 and 2014.

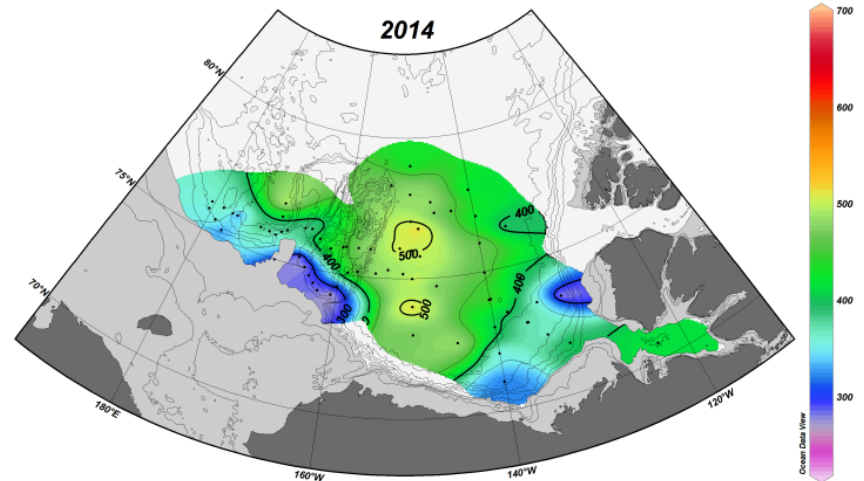
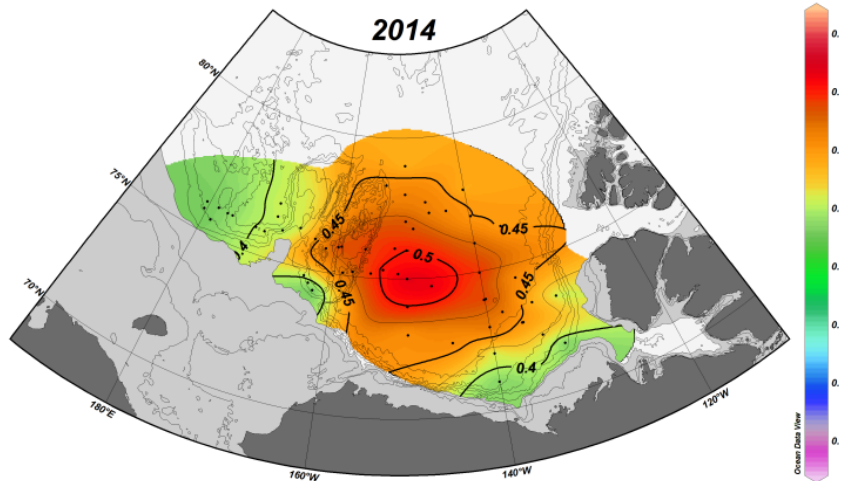
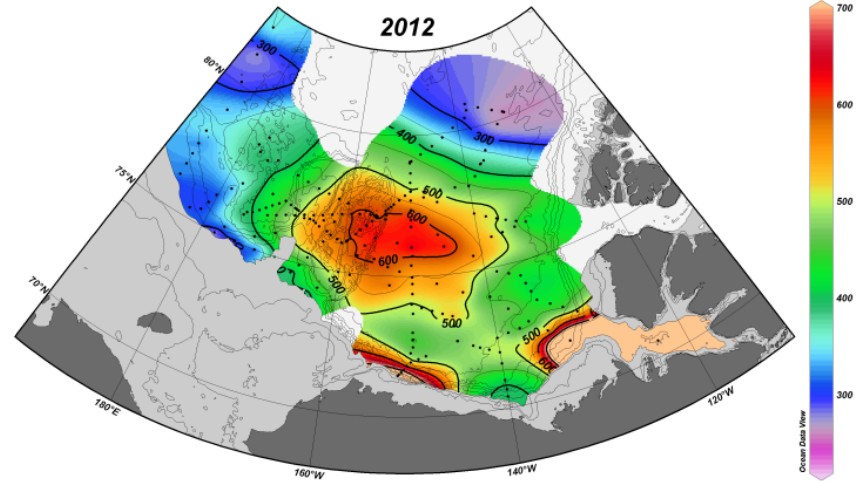
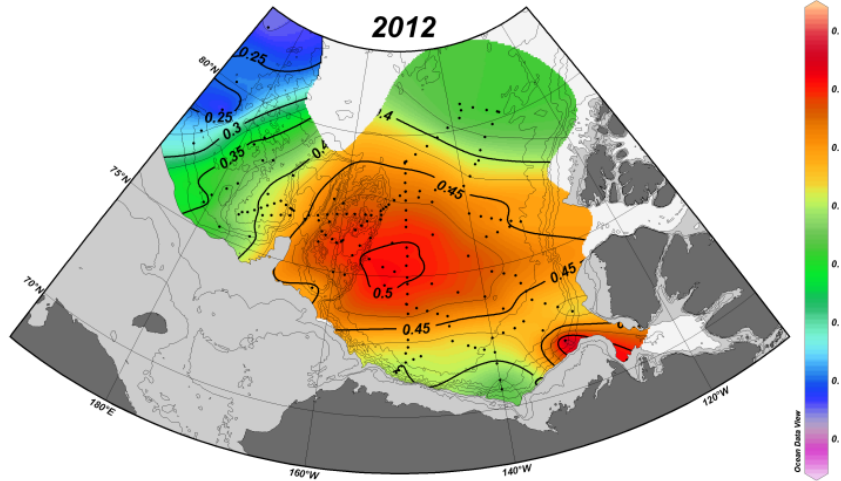
Two spreading pathways of Pacific Winter Water into the Basin

Circulation in the basin control the shelf water spreading

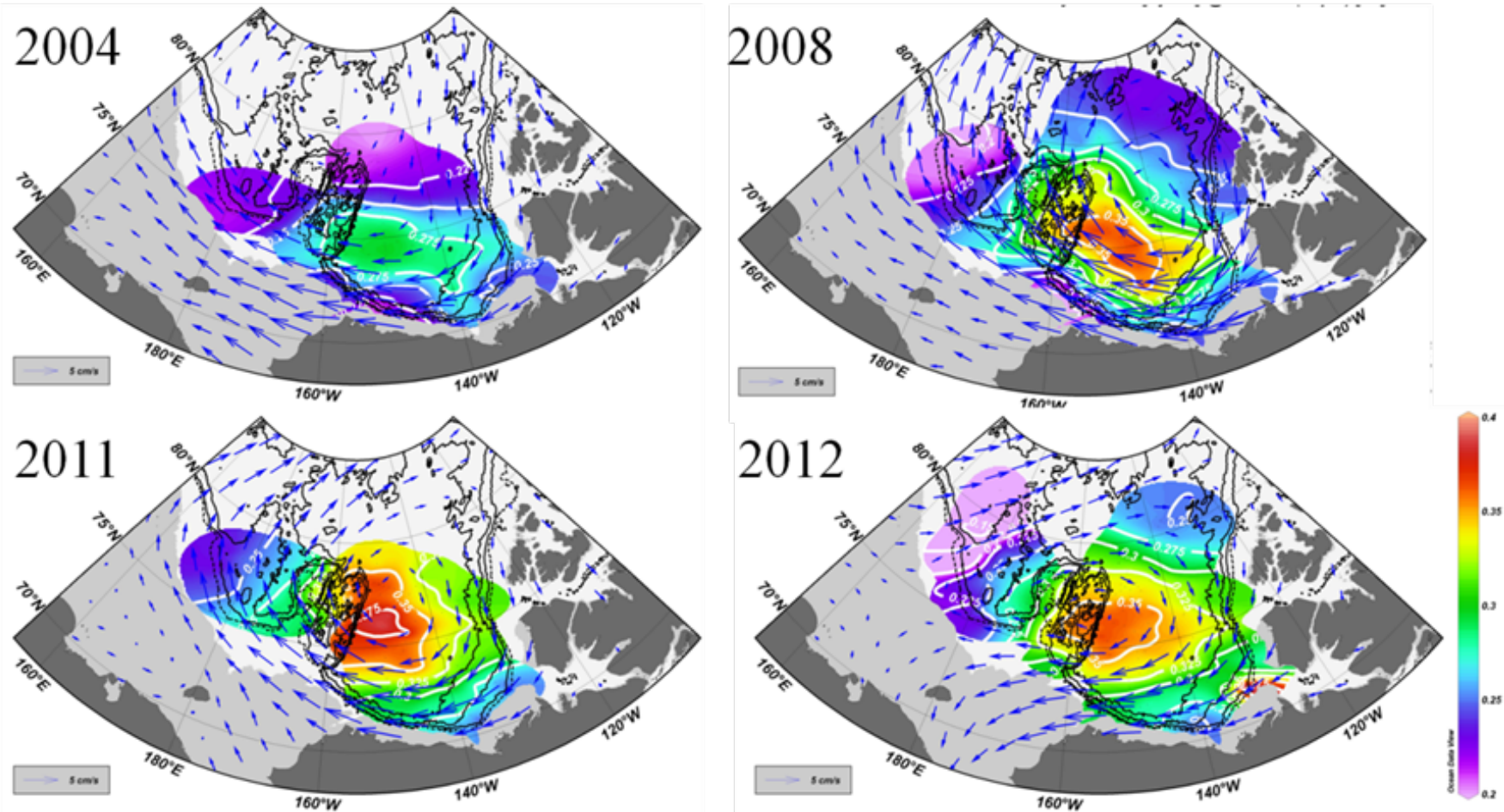


Ocean dynamic Height at 50 dbar Reference 800 dbar

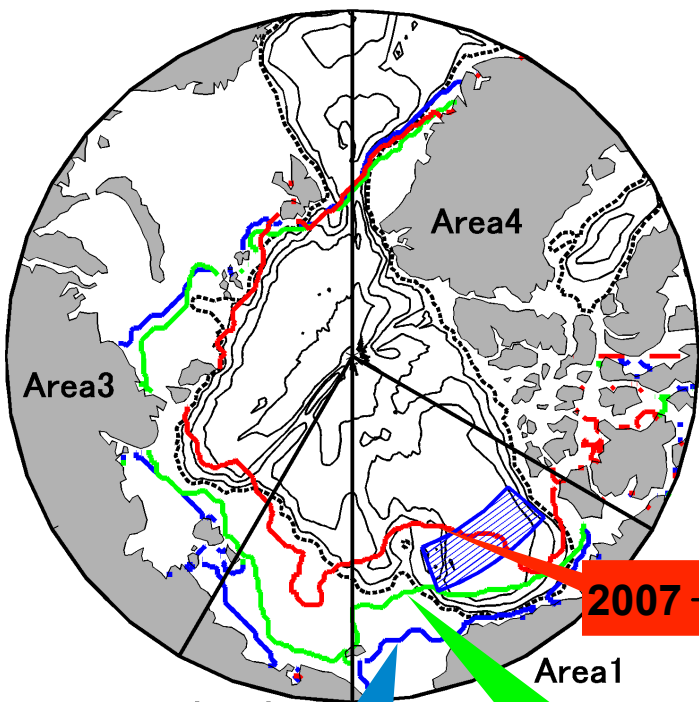
Ocean heat content within Pacific Water layer (20-150m)



Sea Ice Motion vs. DH of Pacific Water Layer



Background color: DH at 100 dbar relative to 800 dbar (oceanic Beaufort Gyre)
Black vectors: average sea ice motion vectors for November – April.

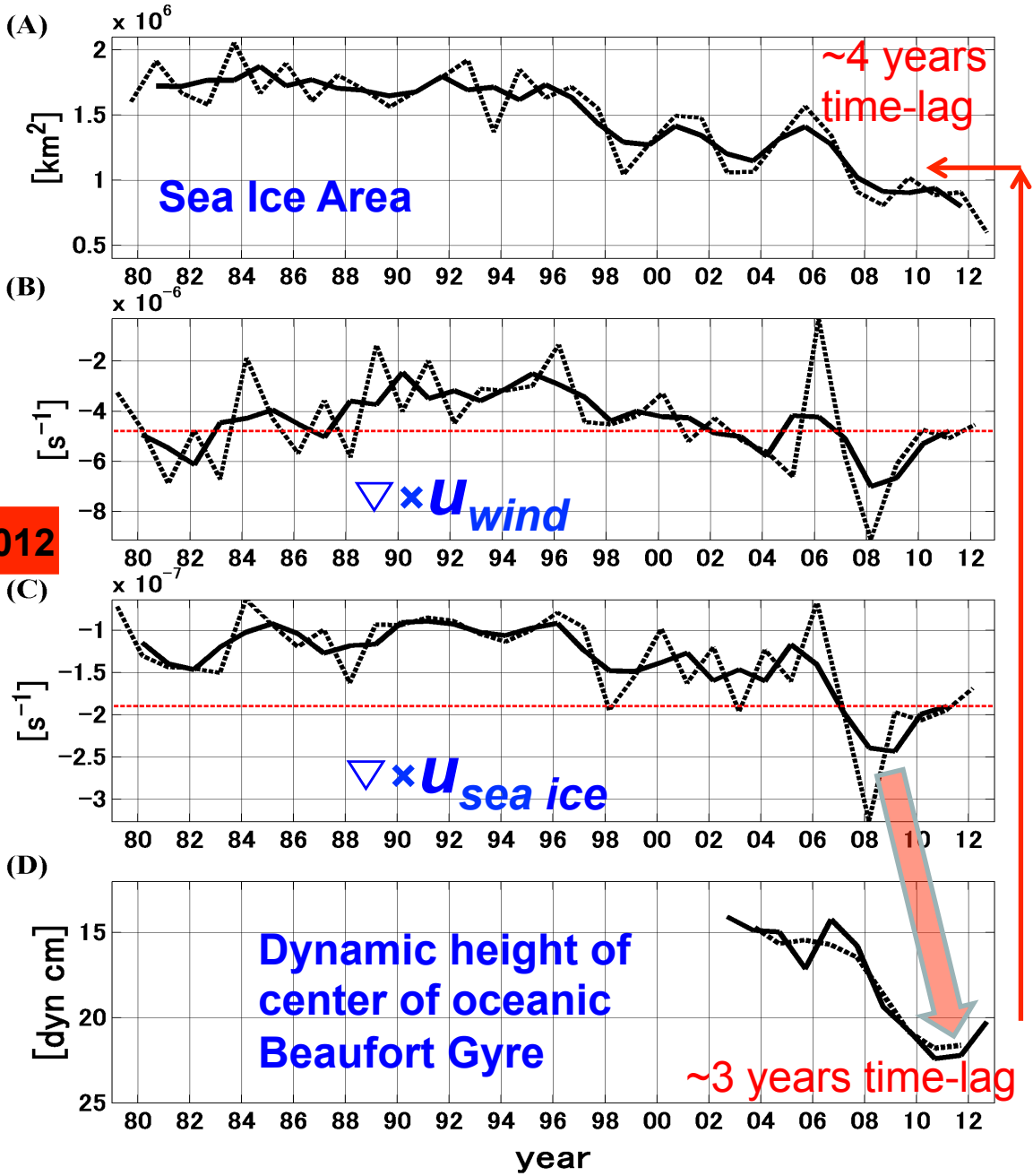


Area2
1979 - 1997

Area1
1998 - 2006

2007 - 2012

Upper ocean response
delayed about 3 years
relative to the surface forcing
(wind or sea ice motion)



(Yoshizawa et al., in revision)

Summary

1) From 2010 to 2014, Pacific-origin waters around the Chukchi Borderland has two different anomaly patterns:

- PSW: Negative θ anomaly in 2010 changes to positive in 2012 and tends to return in 2014**
- PWW: Clearly distinct before and after 2012 event, that is, negative from 2010 to 2012 but positive in 2013 and 2014**

2) PWW spreading pathway is estimated by different two types:

- Turning east to the Canada Basin**
- Going north to the Chukchi Plateau (2008, 2014)**

3) Upper ocean near the Beaufort Gyre appears to respond to the atmospheric forcing delayed by nearly 3 years.

Future Work

- 1) Analyses of observation data are ongoing: Lowered ADCP, long-term mooring data, and so on.**
- 2) Relationships among atmospheric forcing, sea ice motion, and upper ocean circulation will be identified more precisely.**
- 3) Arctic surveys will be conducted continuously in order to monitor the variations of Pacific-origin waters around the Chukchi Borderland and even East Siberian Sea.**

Questions or Comments?

