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Variability of water mass distribution on the northern Chukchi regions in the Arctic

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KOPRI
Korea Polar Research Institute, KIOST

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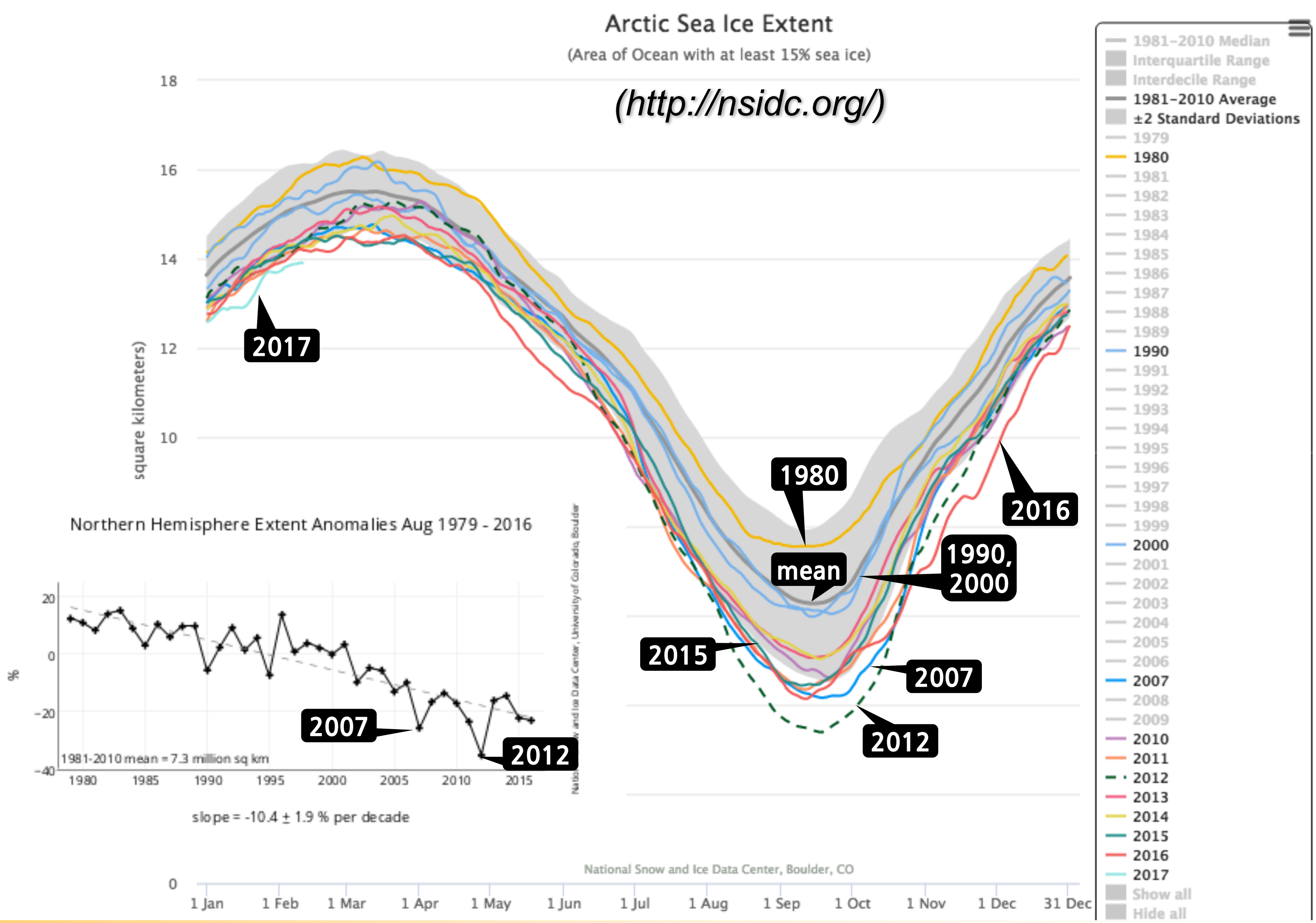
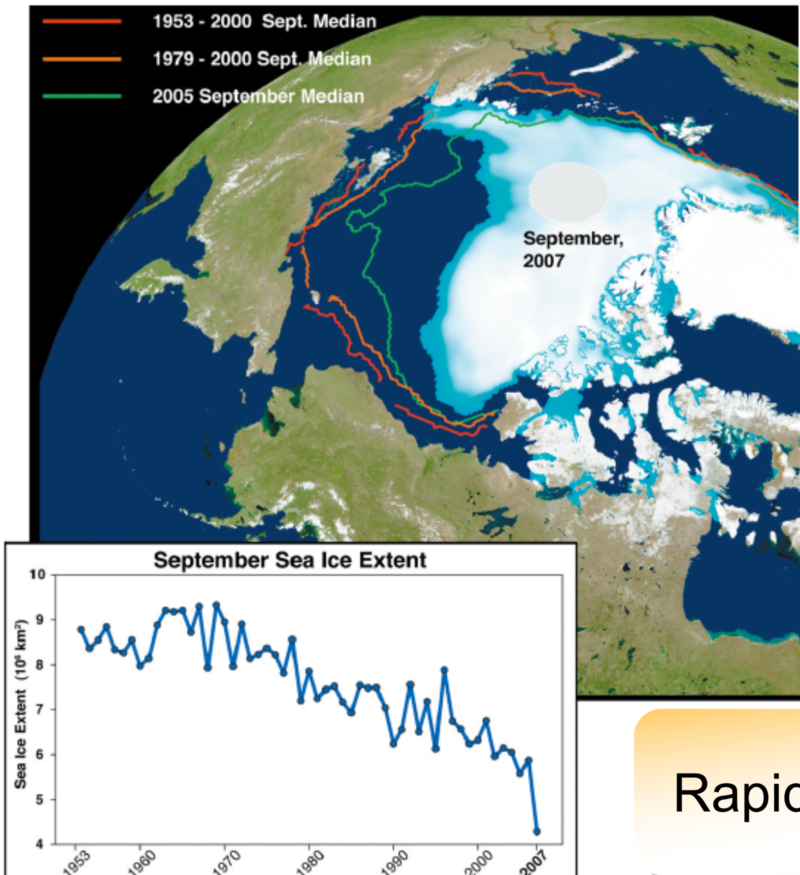
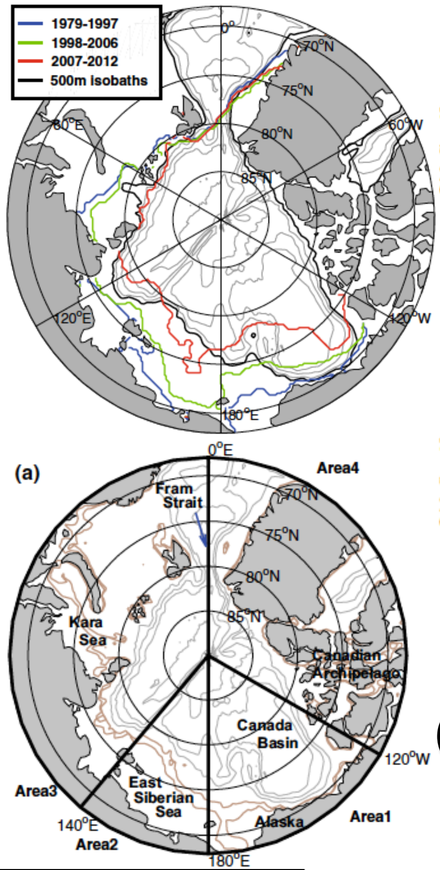
Background: Sea Ice Extent

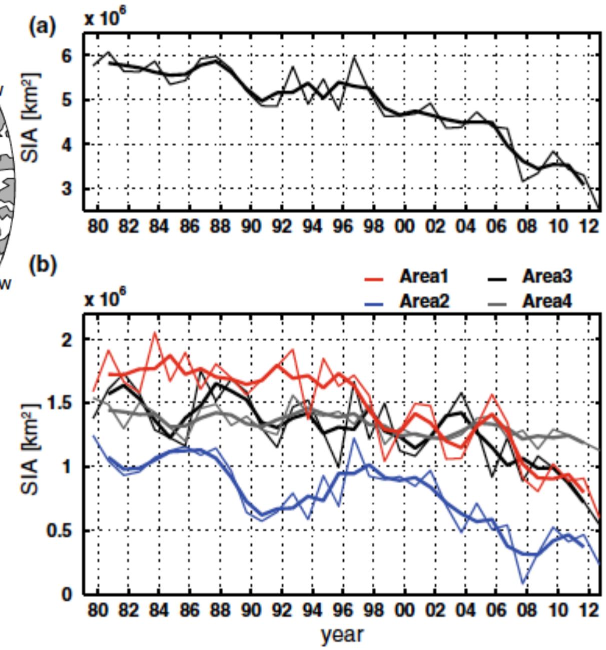


- Annual trend of sea ice extent: 1981-2010 mean vs. recent 7 years
- Sea ice extent anomaly (Aug): -10.4 % for decade

Background: Sea Ice Extent







(Yoshizawa et al., 2015, JO)

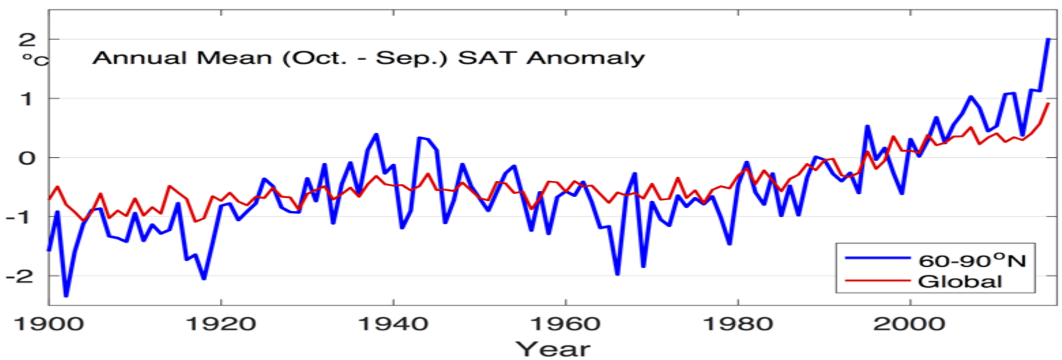
Rapid reduction of sea ice in the Pacific Sector

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)

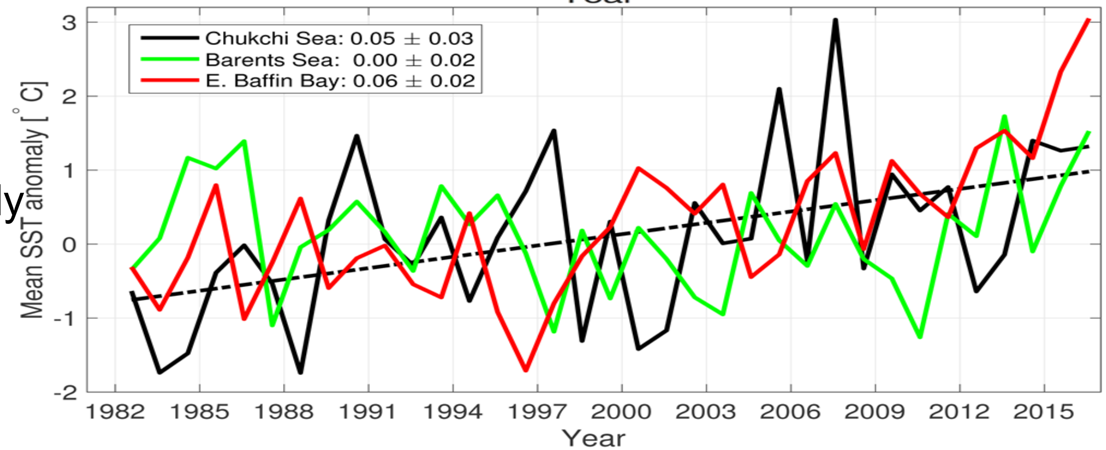
Background: Surface Temperature

Land Surface Air Temperature



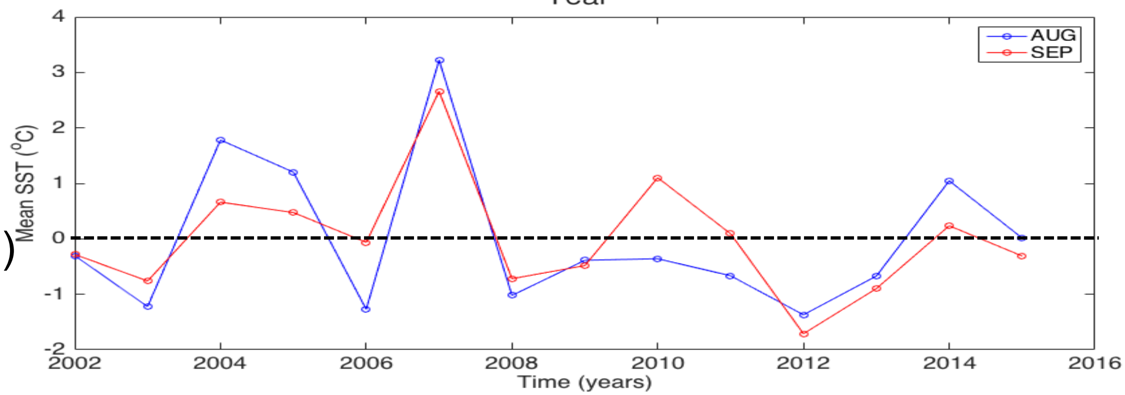
(Overland et al., 2016, ARC)

Mean SST anomaly (NOAA OI)



(Timmermans, 2016, ARC)

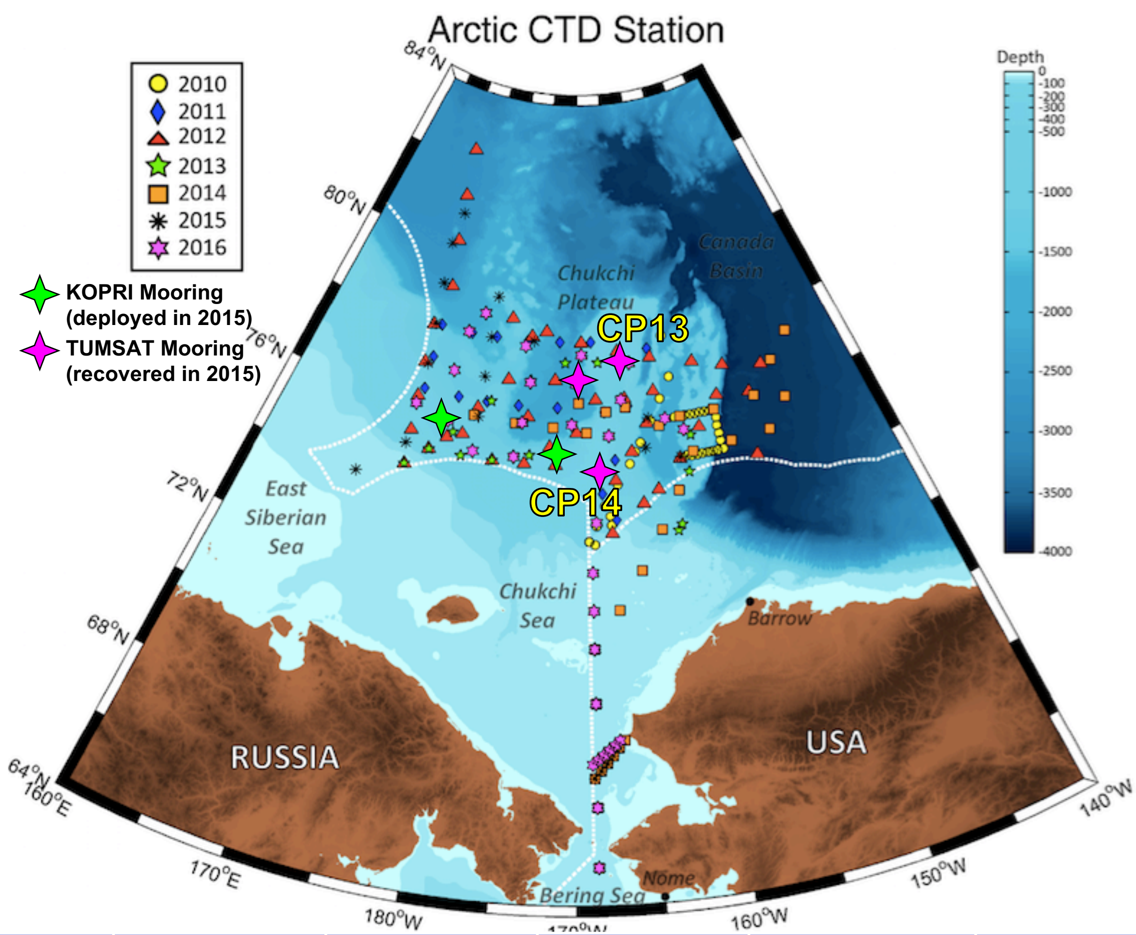
Chukchi Sea SST (MODIS-Aqua: 4km)



Objective

Under such an environmental change in western Arctic Ocean, we would like to understand water mass distribution and its variability in northern Chukchi regions (i.e., Chukchi Borderland, etc.)

Data: KOPRI Arctic Cruises (2010~2016)

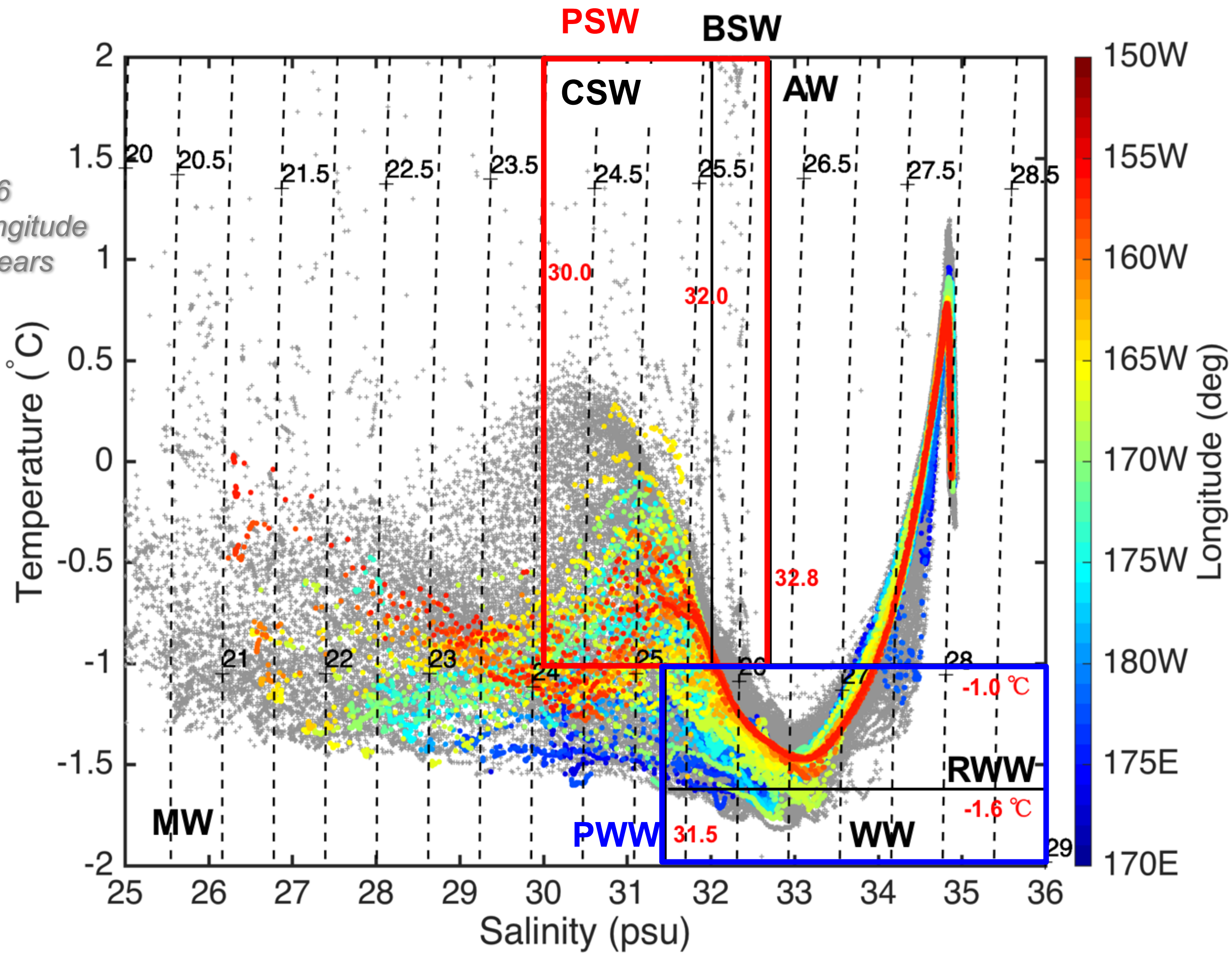


	2010	2011	2012	2013	2014	2015	2016
CTD	38	18	44	16	32	42	34
XCTD	*	33	48	36	51	61	38
Period	07/20~08/10	08/02~08/16	08/04~09/06	08/24~09/01	08/01~08/23	08/01-08/21	08/05-08/20

Results: T-S Diagram

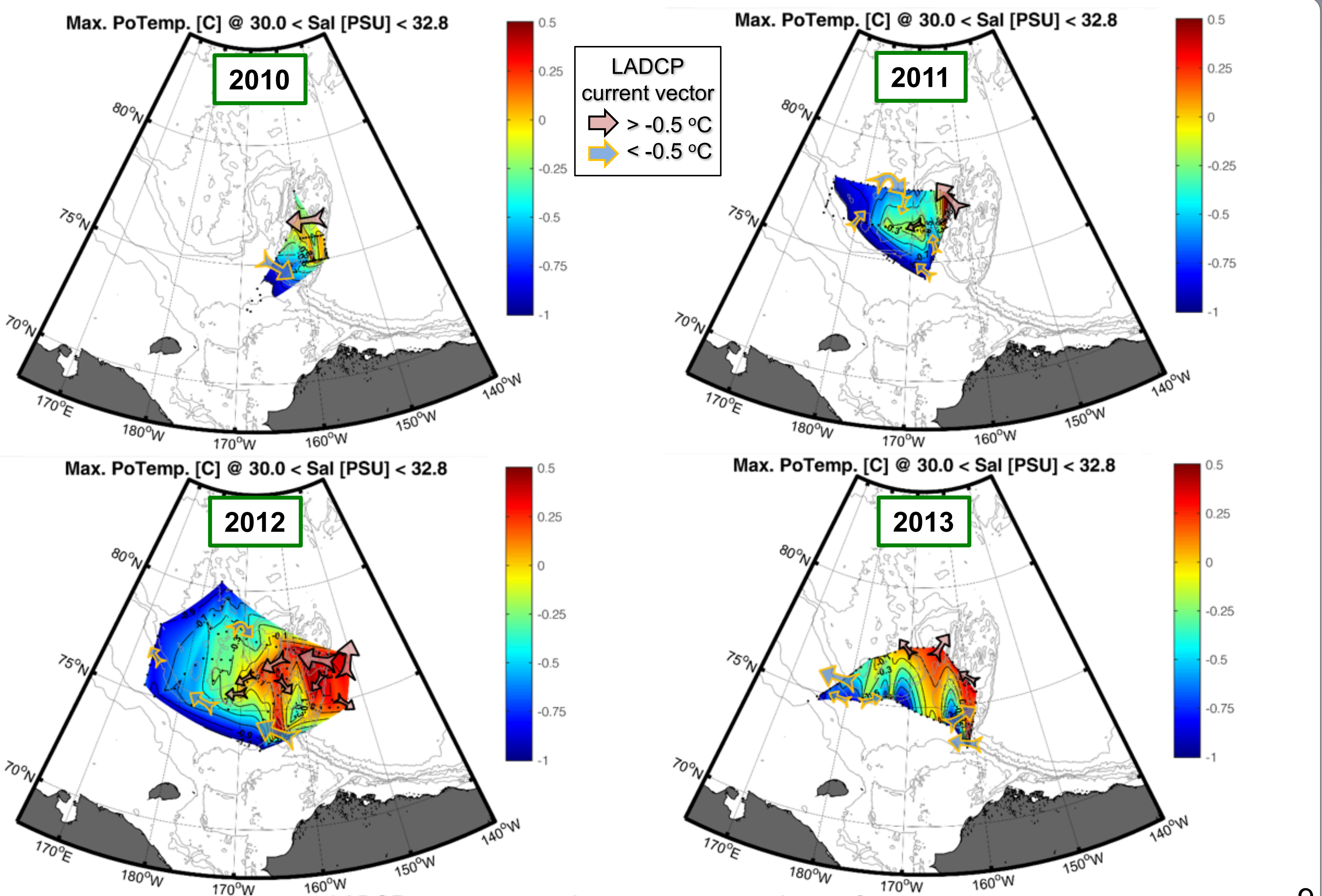
(Water mass criteria based on Itoh et al., 2015; Gong & Pickart, 2015)

Colored dots: 2016 mapped by longitude
Gray dots: other years



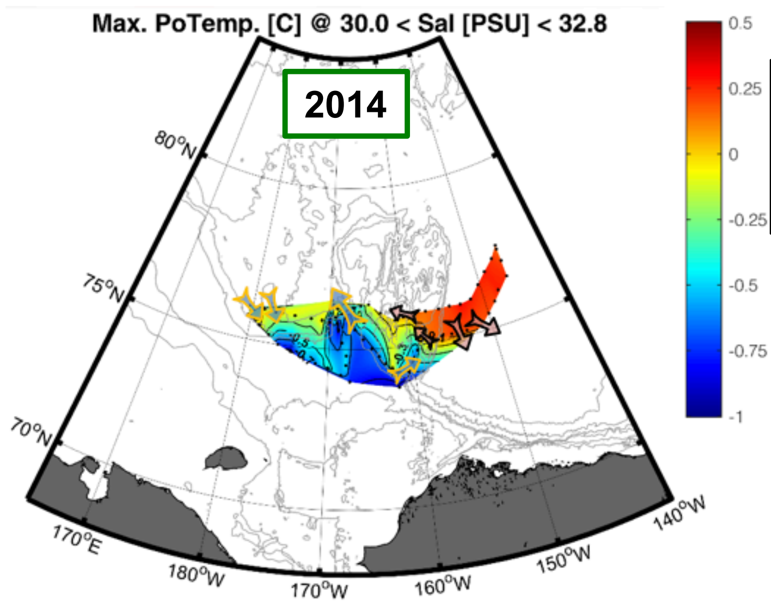
MW: Melt Water; CSW: Chukchi Summer Water; BSW: summer Bering Sea Water; RWW: remnant Winter Water; WW: newly ventilated Winter Water; AW: Atlantic Water

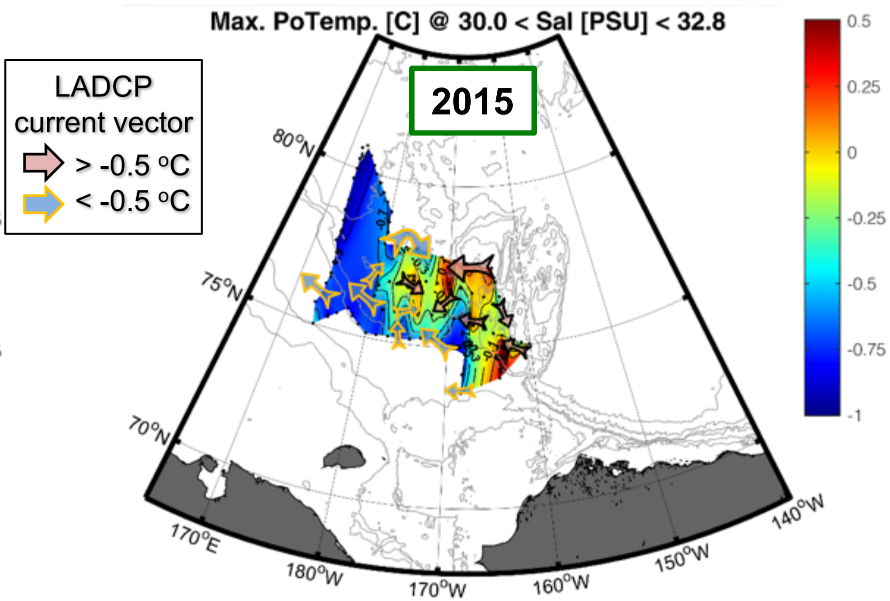
Distribution of Summer Water (θ_{max})

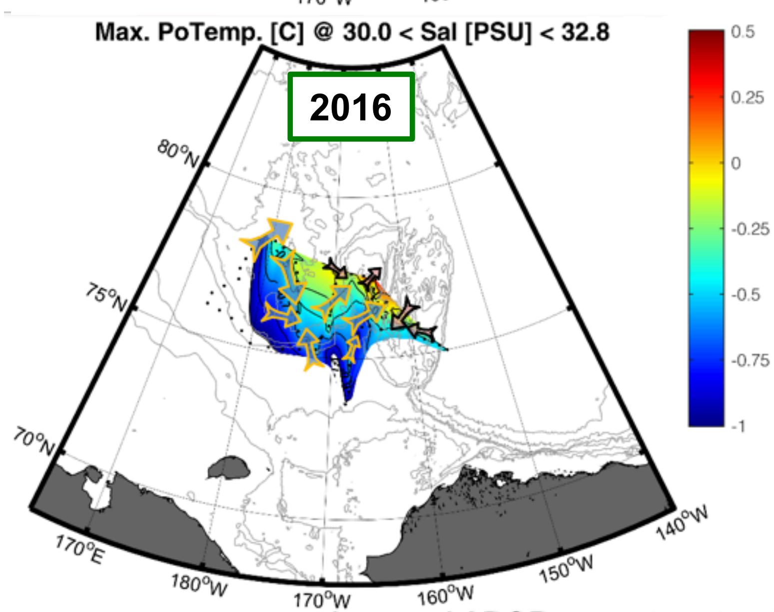


Lowered ADCP current vector does not mean a pathway of water mass.

Distribution of Summer Water (θ_{max})







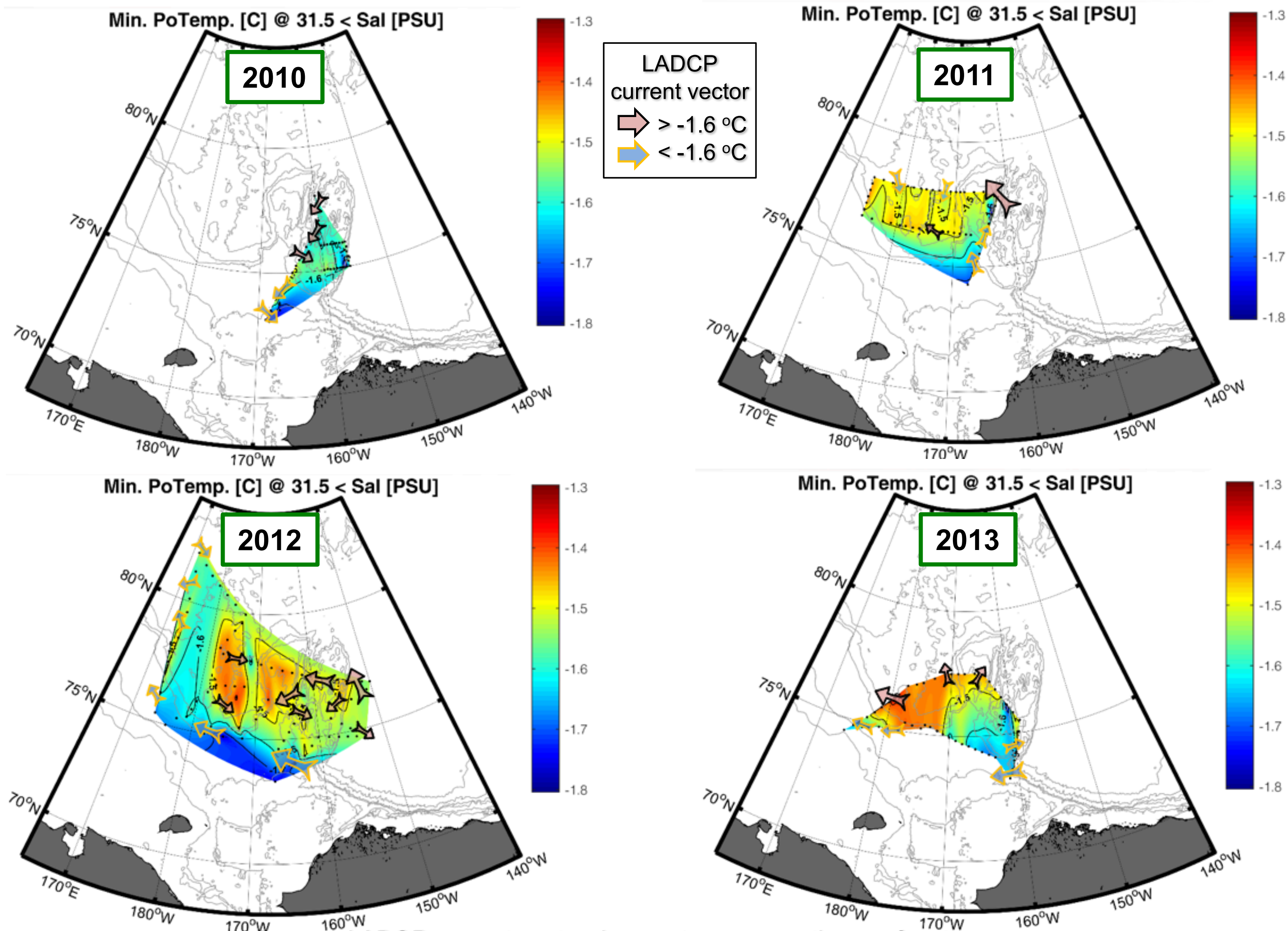
Findings

1. *Warm summer water tends to extend westward from Beaufort Sea*
2. *Cold summer water tends to extend northward from the shelf (toward MR, CP and NWR)*
3. *Eastward cold summer water tends to depress warm summer water showing temporal variation*

Warm summer water from Beaufort Sea is distinguished from cold water (< ~ -0.5 ℃) flowing from the shelf

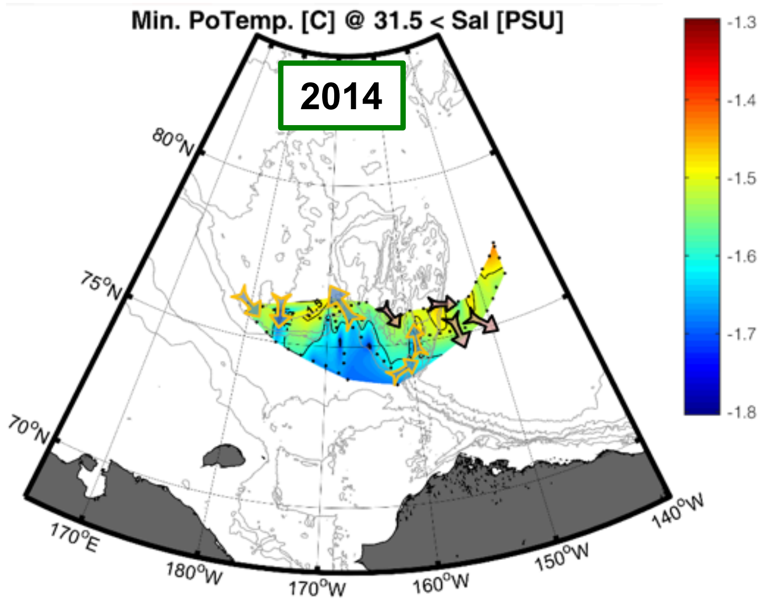
Lowered ADCP current vector does not mean a pathway of water mass.

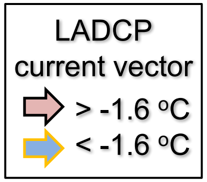
Distribution of Winter Water (θ_{min})

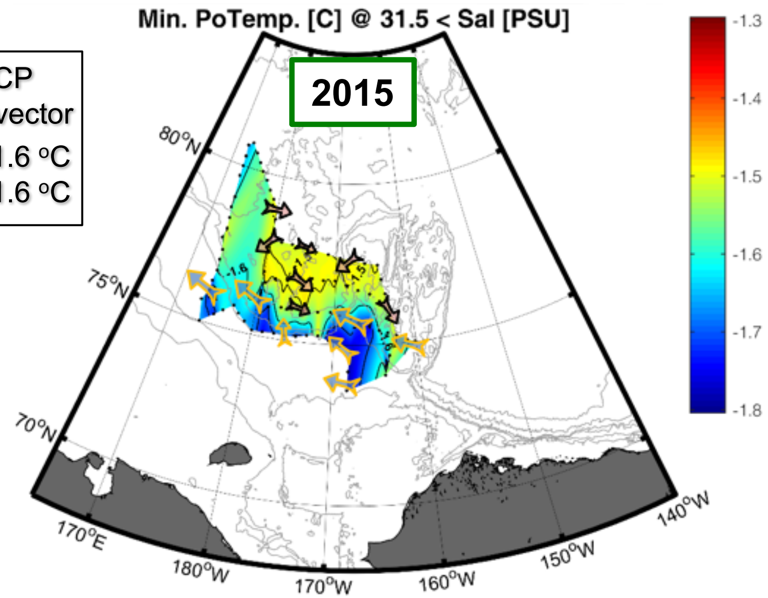


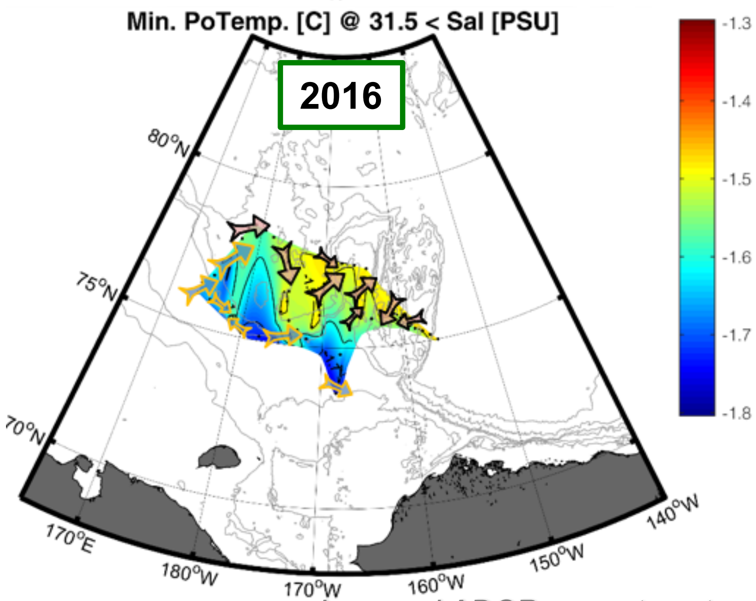
Lowered ADCP current vector does not mean a pathway of water mass.

Distribution of Winter Water (θ_{min})







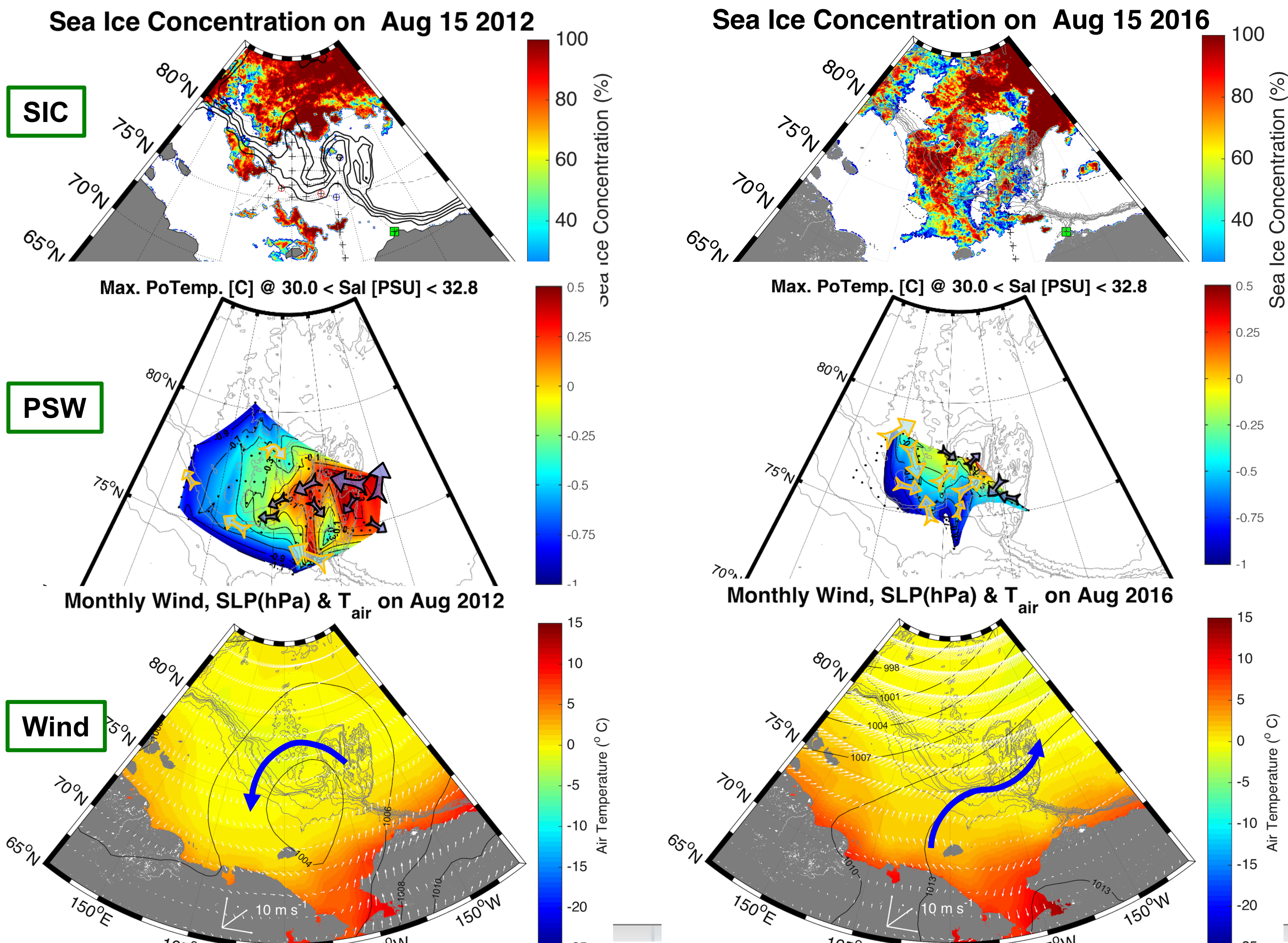


Findings:

1. *WW tends to extend to the MR, CP, and NWR similar to cold summer water*
2. *RWW exists in the Chukchi Borderland and seems to be depressed by WW in recent years*

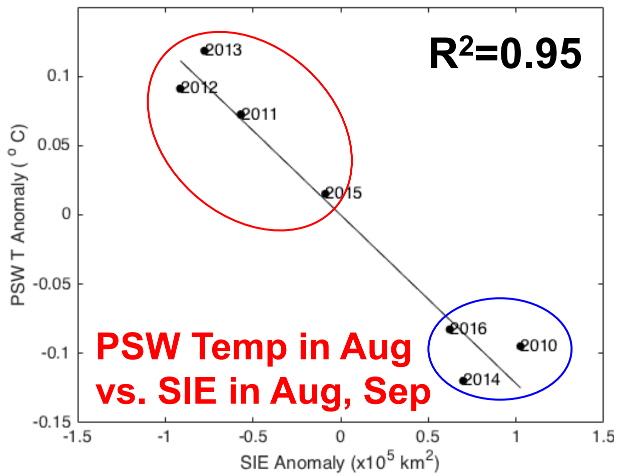
Lowered ADCP current vector does not mean a pathway of water mass.

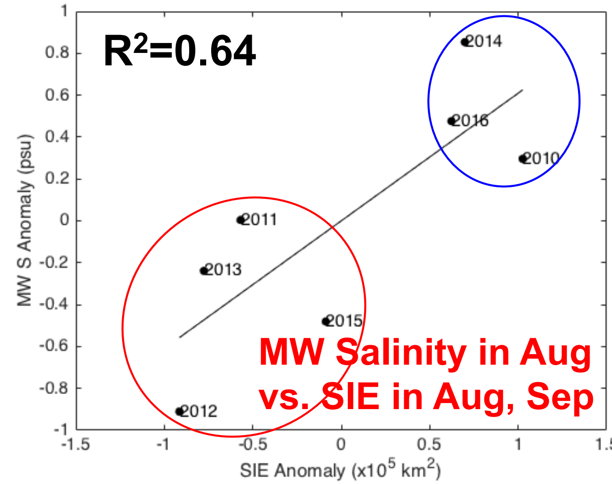
Comparison (2012 vs. 2016)



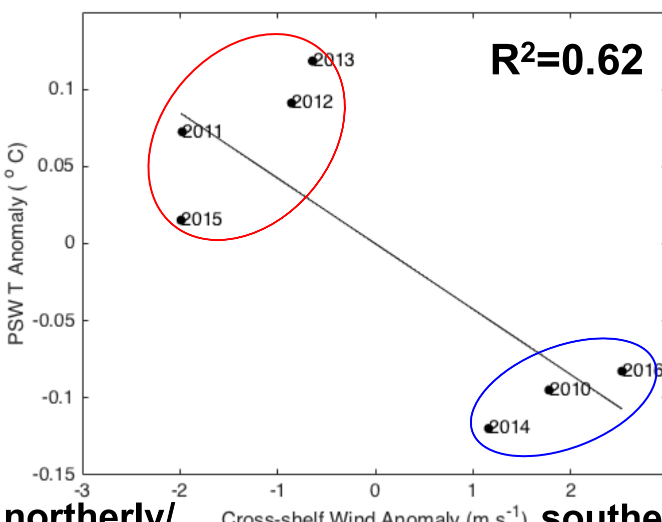
Anomaly correlation

2011, 2012, 2013, 2015 ⟷ **2010, 2014, 2016**





Southerly/southwesterly winds intensify eastward along-shelf current
→ Eastward cold CSW tends to depress warm summer water flowing from the Beaufort Sea

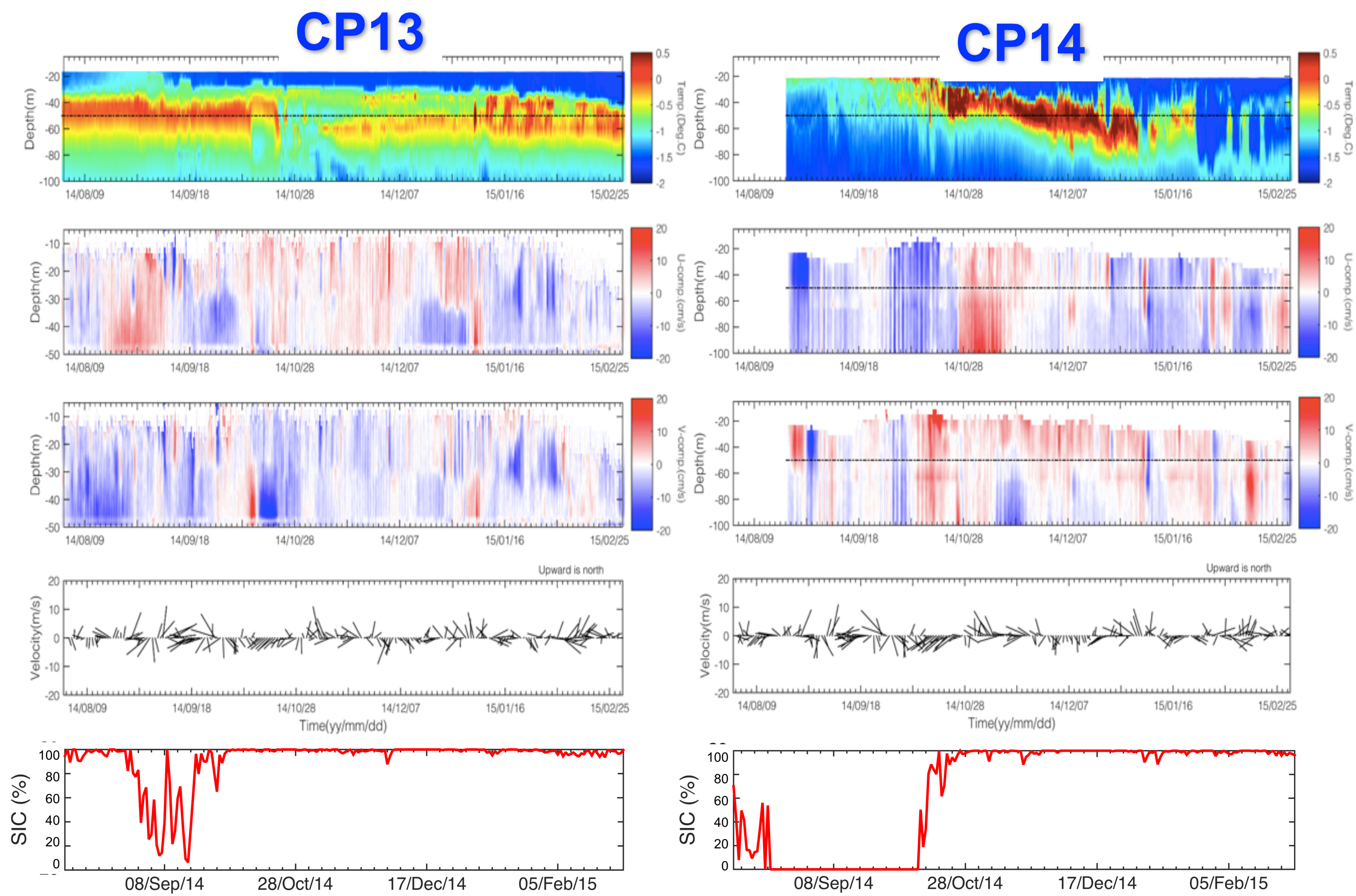


northerly/ northeasterly ⟷ **southerly/ southwesterly**

PSW Temp in Aug vs. cross-shelf Wind in Aug

- PSW & MW selected from the area of [170°W~160°W, 74°N~78°N]
- SIE calculated from the areas of central Arctic and Chukchi Sea
- ECMWF wind (monthly) selected from the shelf areas of [150°E~160°W]

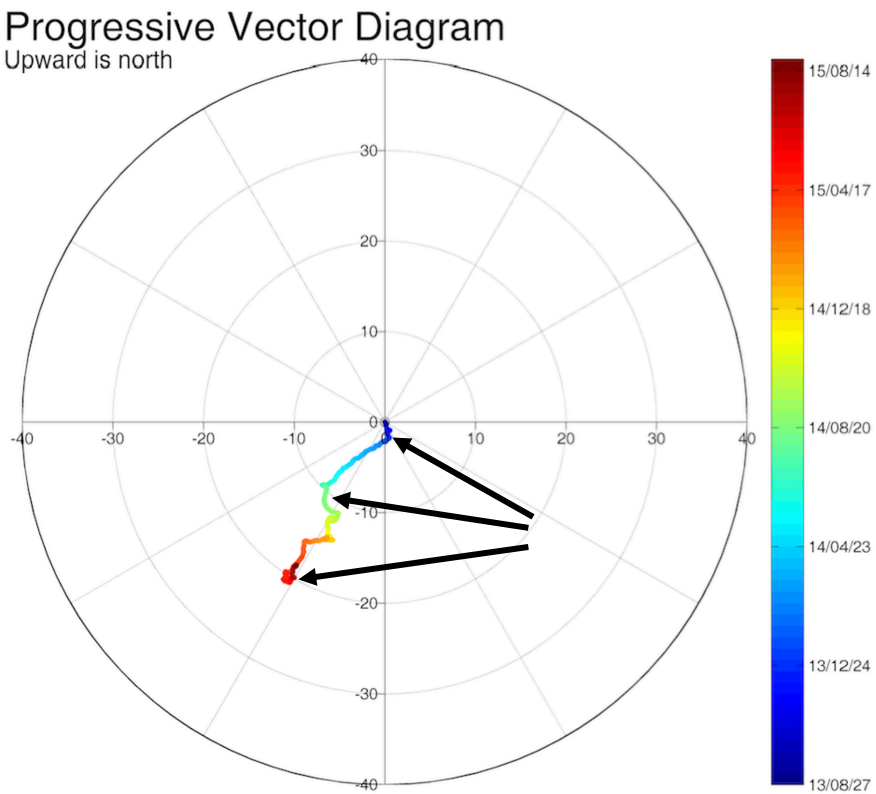
Temporal variation (mooring data)



Data from the ocean mooring systems deployed at two stations:
CP13 (northern Chukchi Plateau), CP14 (southern Chukchi Plateau)

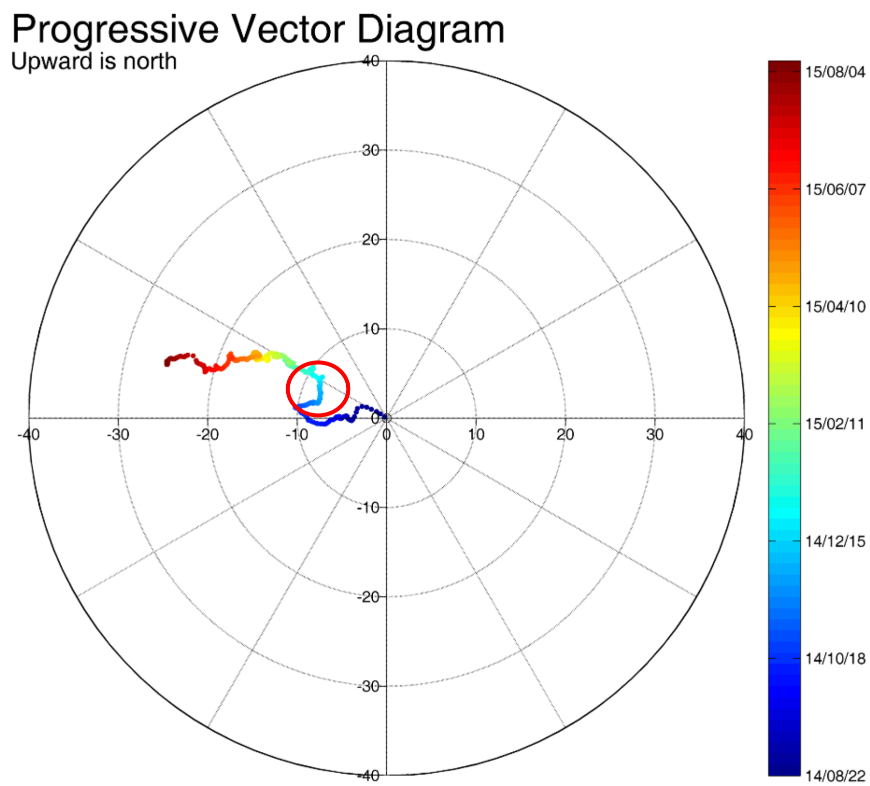
Progressive vector (ADCP)

CP13



Current at 49.5 m (2-year long)
-> Southwestward flow is dominant
-> Southward flow in summer (arrow)

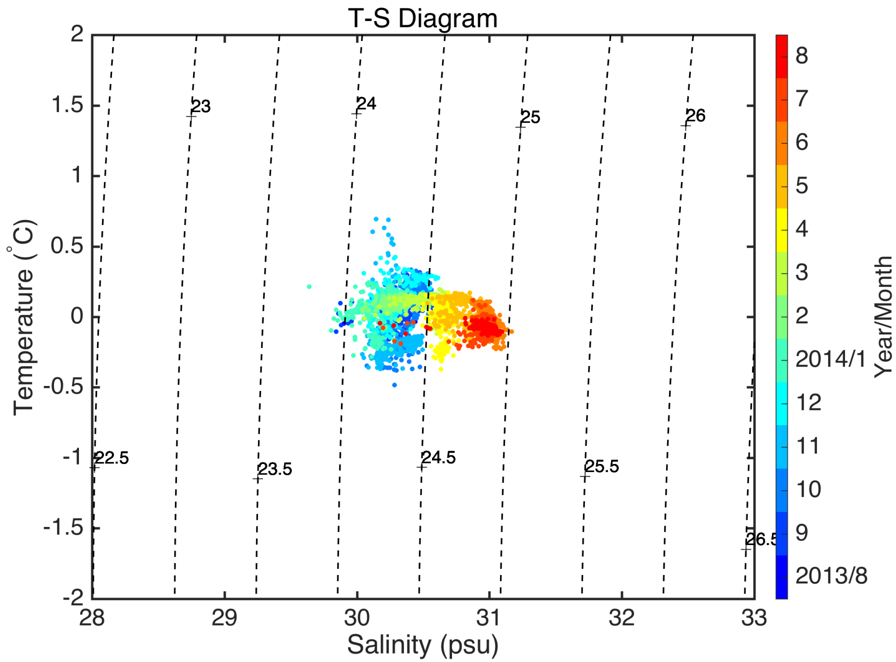
CP14



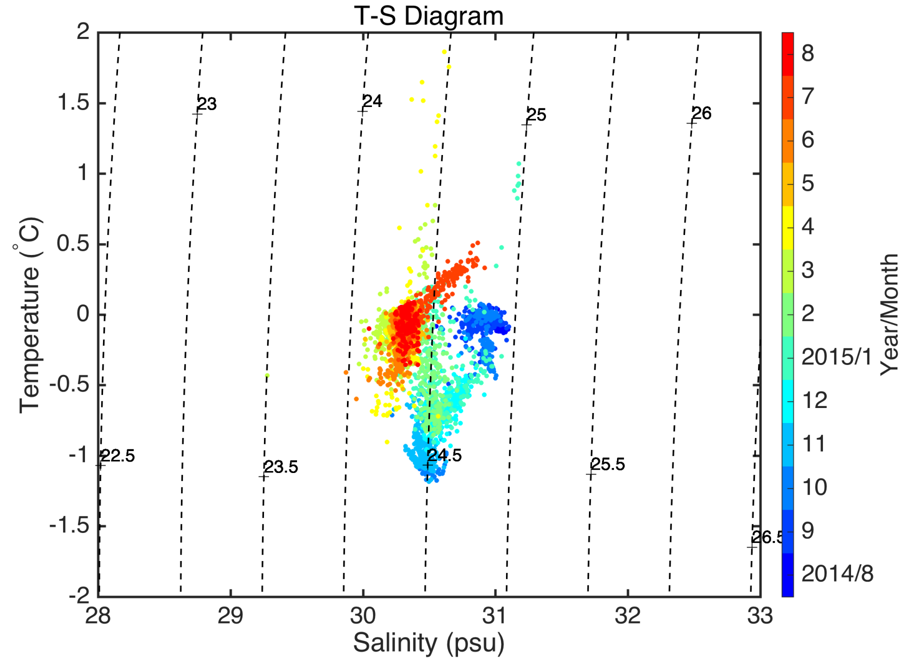
Current at 43.9 m (1-year long)
-> Westward flow is dominant
-> SW exists during eastward/north ward flow (circle)

Ocean Mooring Data – MicroCAT CTD

CP13 – 47 m
(Aug. 2013 ~ Aug. 2014)



CP13 – 47 m
(Aug. 2014 ~ Aug. 2015)

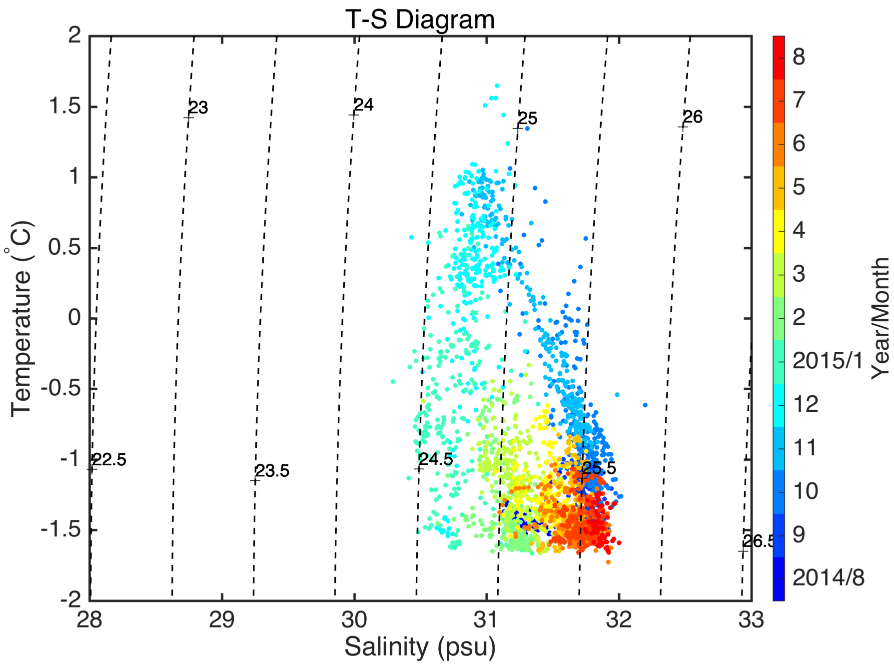


- **Summer water at 47 m was stable**
- **Maintained over winter**
- **Salinity slightly increased (summer 2014)**

- **Summer water at 47 m was disturbed by e vent**
- **Salinity slightly decreased (summer 2015)**

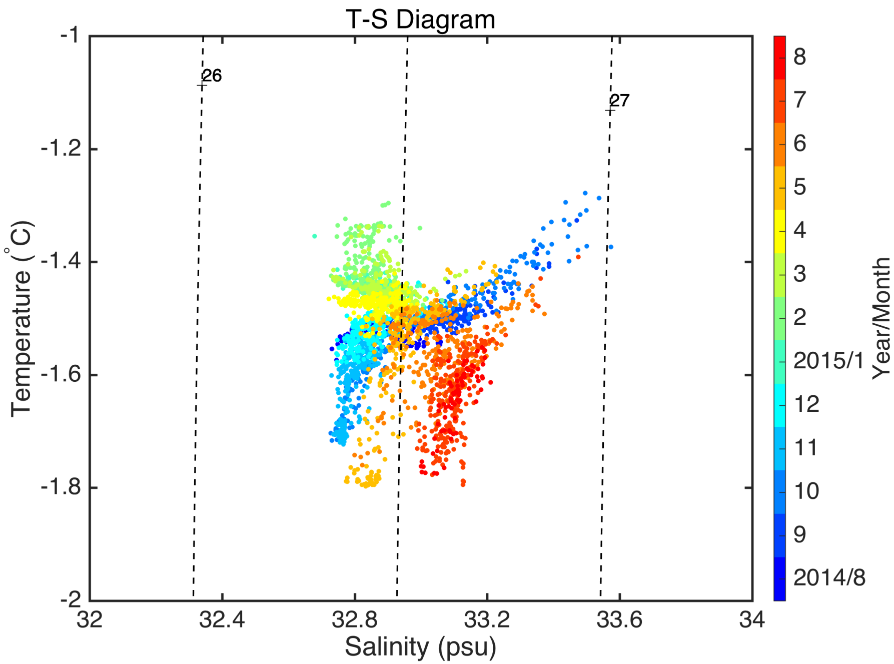
Ocean Mooring Data – MicroCAT CTD

CP14 – 50 m
(Aug. 2014 ~ Aug. 2015)



- **Initially categorized in WW (summer 2014)**
- **Summer water existed until early winter**
- **Back to WW (summer 2015)**

CP14 – 148 m
(Aug. 2014 ~ Aug. 2015)



- **RWW existed in summer 2014**
- **WW (< -1.6 ℃) newly ventilated in spring/ summer 2015**
- **Further analysis needs to be done**

Summary

1) From summertime hydrographic survey data (CTD/XCTD), our findings are:

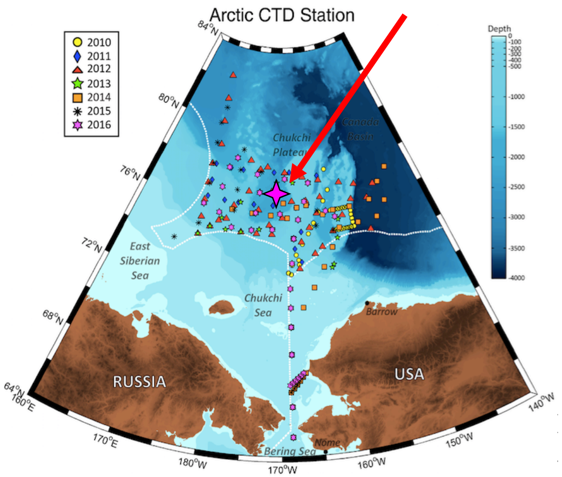
- Two types of PSW: warm SW from Beaufort Sea and cold SW from Chukchi shelf
- Two types of PWW: RWW (warmer, deeper) clearly distinguished from newly ventilated WW (colder, shallower)
- Anomaly of SIE is negatively correlated with PSW temperature anomaly; positively correlated with MW salinity anomaly
- Anomaly of PSW T is correlated with anomaly of cross-shelf wind, that is, southerly/southwesterly winds tend to drive eastward cold water which depresses PSW extending to west.

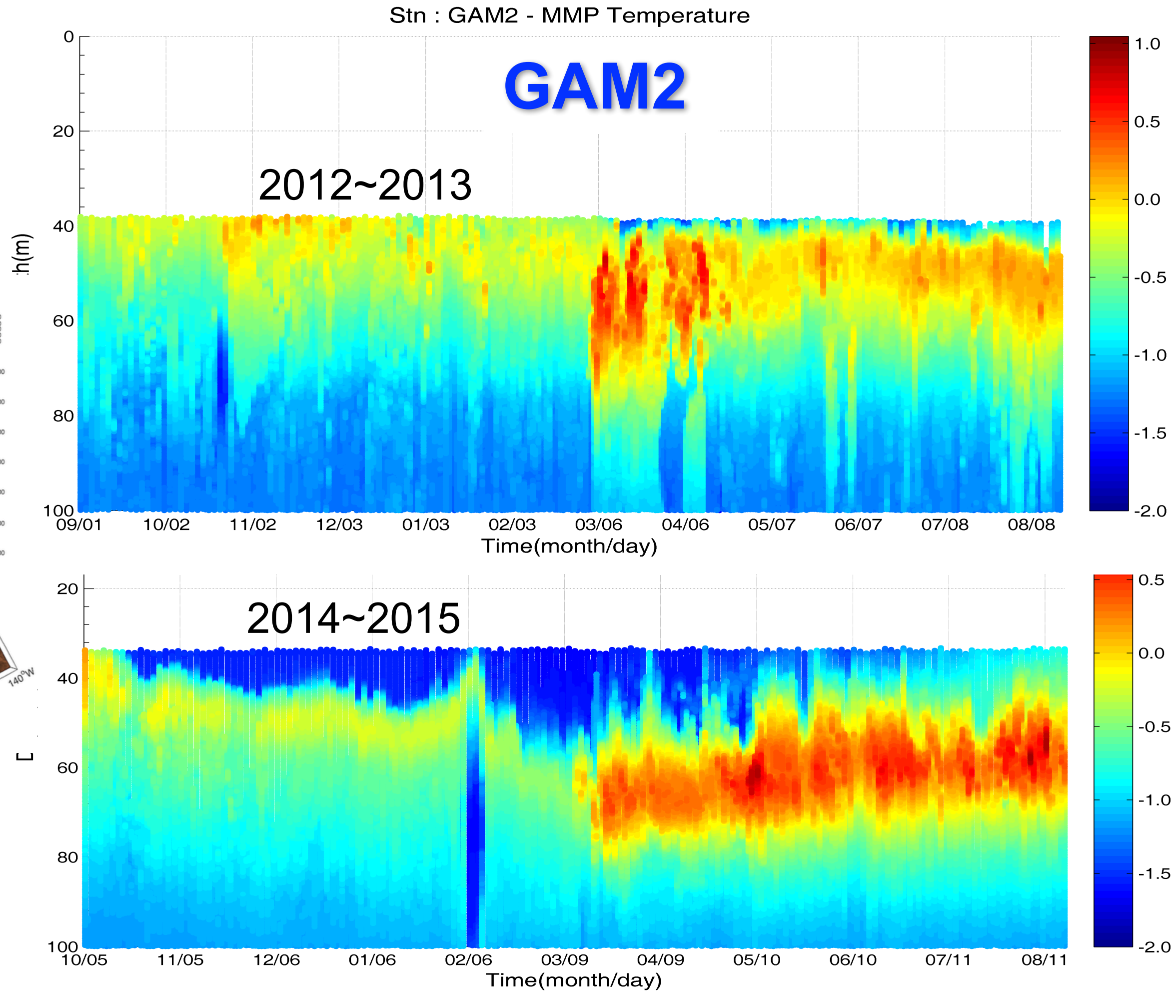
Summary

2) From ocean mooring data, our findings are:

- PSW at CP13 flows southwestward during 2013~2015
- PSW at CP13 flows to south/southeast during summer
- PSW at CP13 distributed stably except for during an event
- Normally 50 m CP14 was occupied by winter water; but SW ventilated by an event during late fall; and then return to normal (winter water)
- In summer 2014 148 m CP14 was occupied by RWW, but by newly ventilated WW during May & Aug 2015

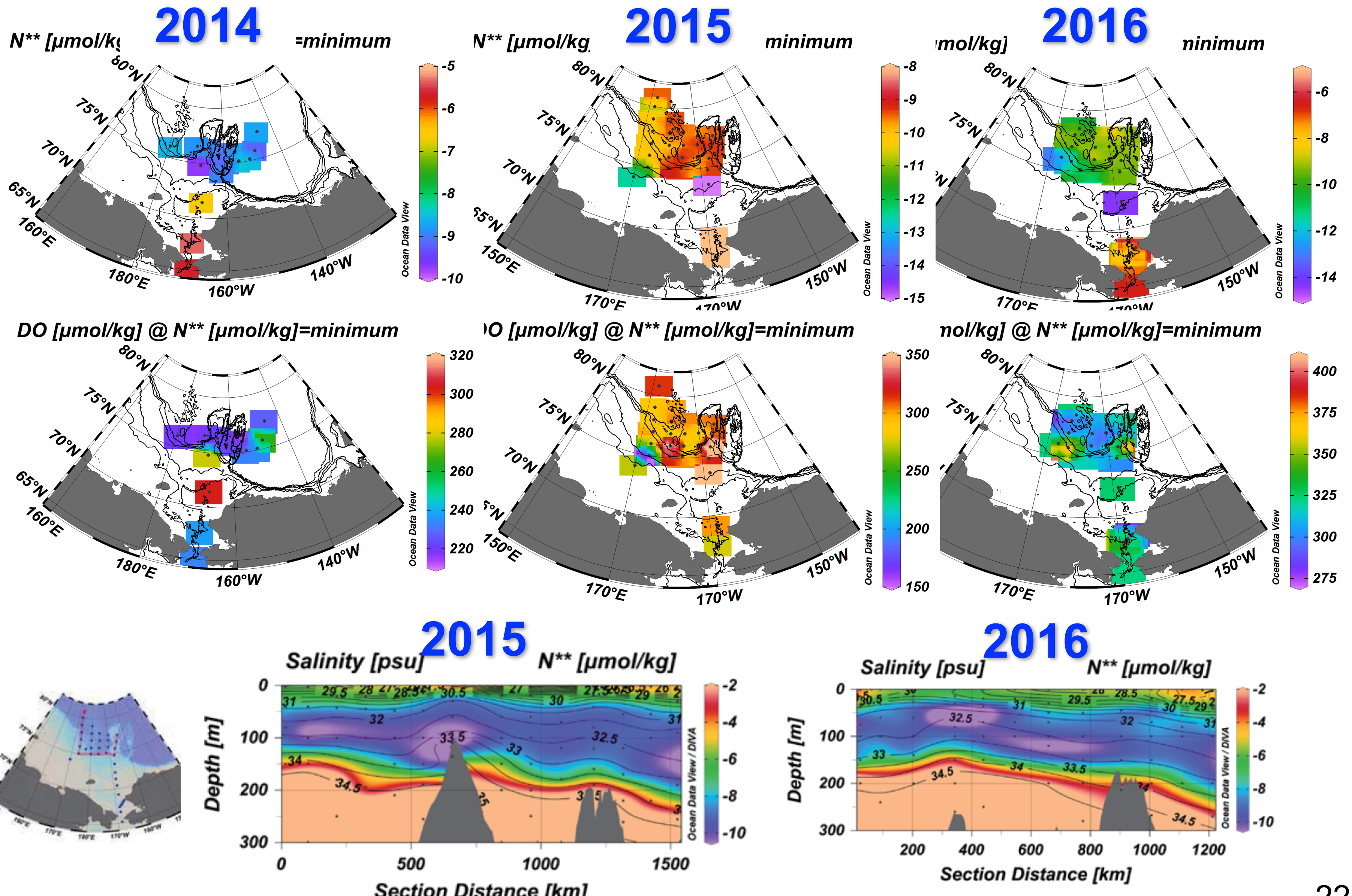
Future Work





*** Q: What processes do govern the variabilities of PSW in the Chukchi Abyssal Plain (CAP)?**

Future Work

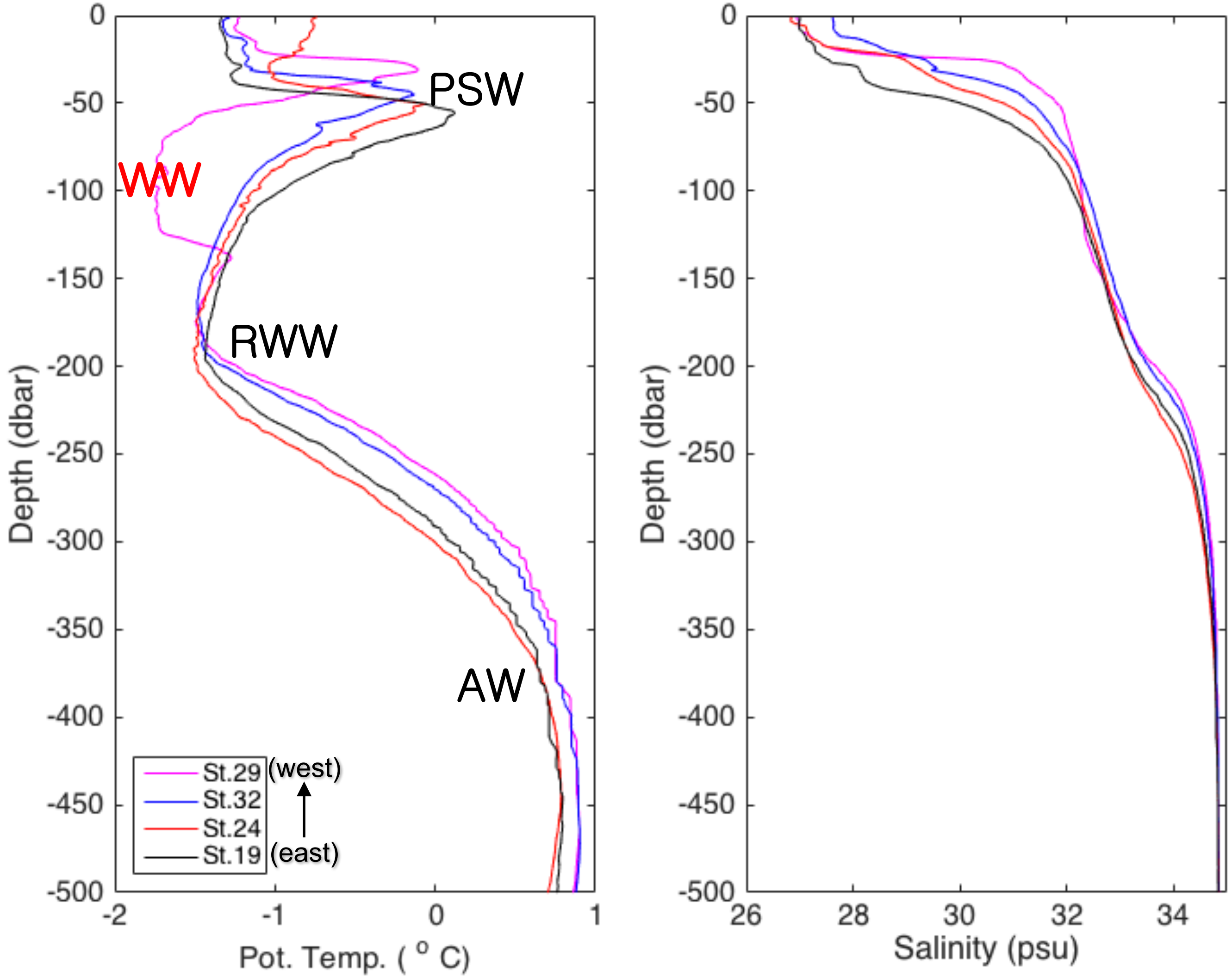

2014
2015
2016
N** [μmol/kg] @ N** [μmol/kg]=minimum
DO [μmol/kg] @ N** [μmol/kg]=minimum
2015
2016
Salinity [psu]
N** [μmol/kg]
Depth [m]
Section Distance [km]
Ocean Data View
Ocean Data View / DIVA

Q & A

Thank you.
Any questions?

Vertical Profiles

Vertical profiles at selected CTD stations in 2014



Q & A

- Denitrification is carried out by heterotrophic bacteria during which NO_3^- (or NO_2^-) serves as the terminal electron acceptor for organic matter oxidation and the nitrogen oxides are reduced mainly to N_2 (Devol, 2008).

- $N^{**} = 0.87([TIN]-16[PO_4]+2.9)$ (µmol/kg) (Codispoti et al., 2005).

- The constant value 2.9 was used to make the global average of N** for the ocean zero, and the value of 0.87 was used to account for phosphate released by the regeneration of organic matter during denitrification.

- Under a process of denitrification, NO_3^- is used for organic matter oxidation instead of oxygen, resulting in a decrease in N** (Nishino et al., 2013).