Thinning of the cold halocline in the Beaufort Gyre

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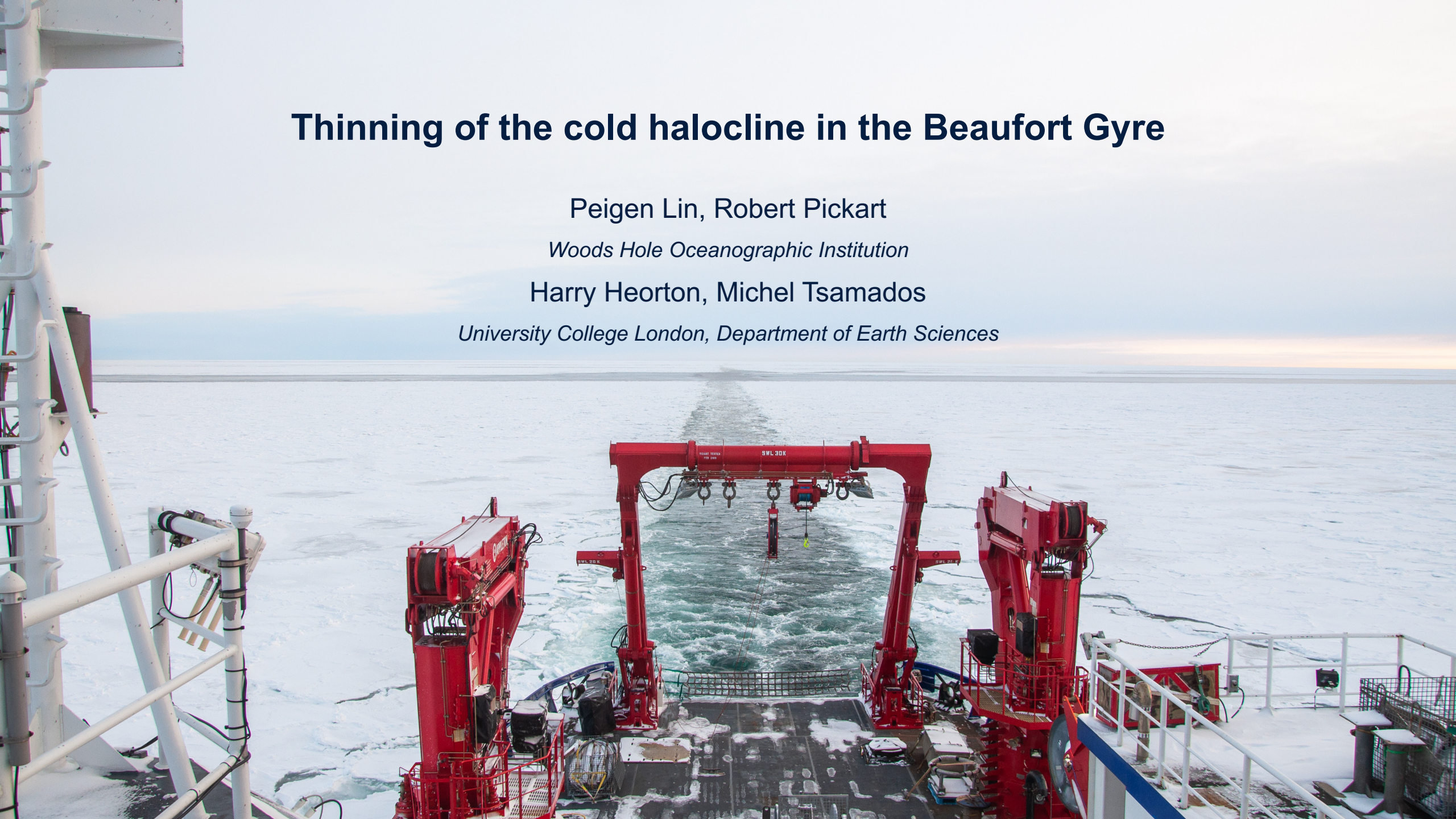
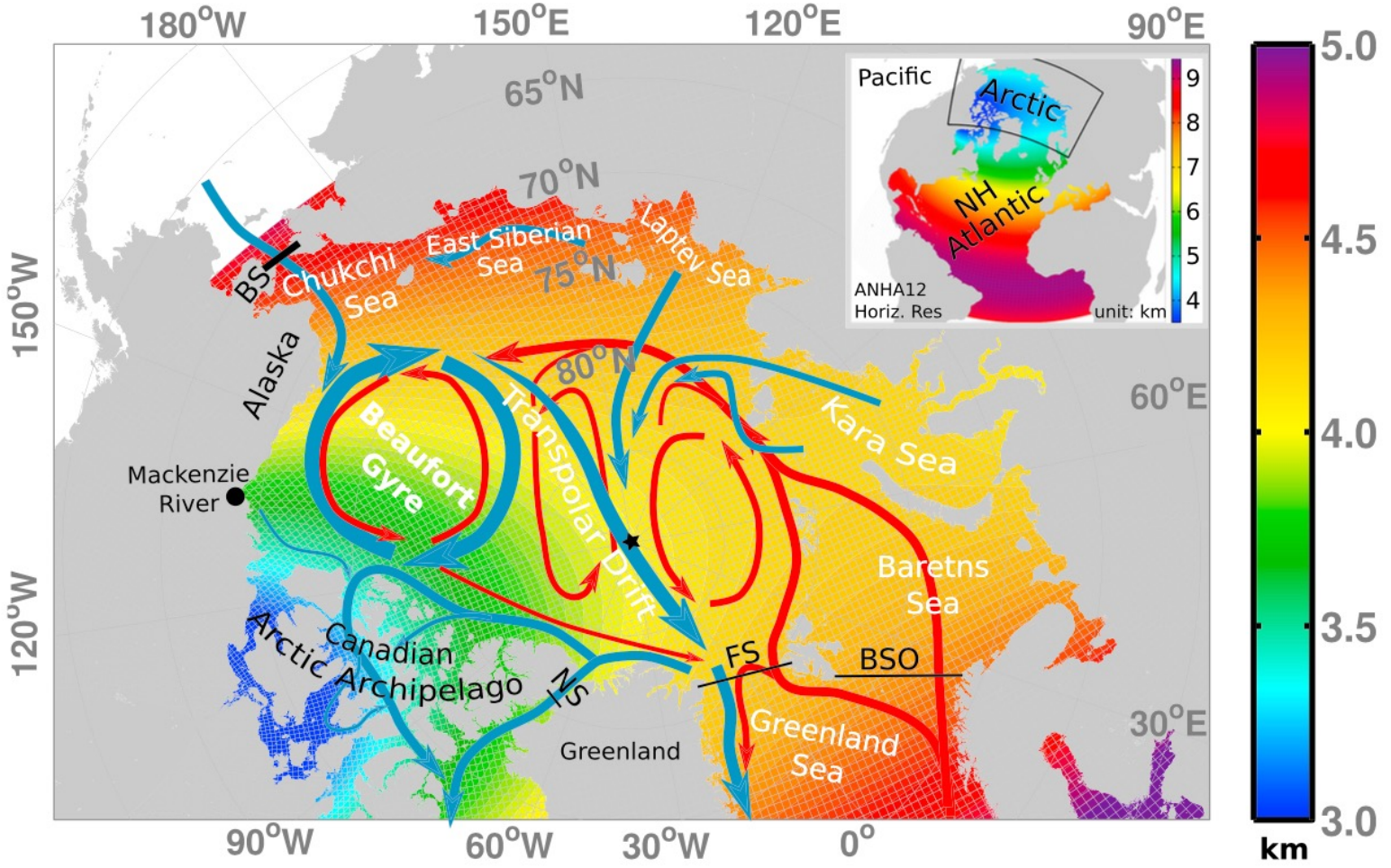


Outline

- 1. Overview of the Beaufort Gyre
- 2. Long-term trend of the Beaufort Gyre
- 3. Causes of the thinning cold halocline layer in the gyre region.

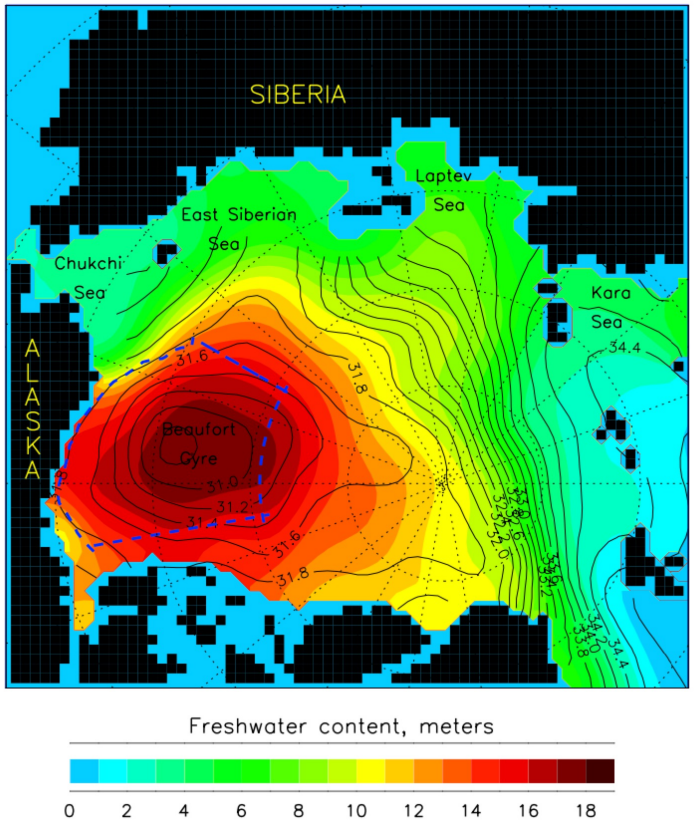
1. Beaufort Gyre



Hu et al., 2019

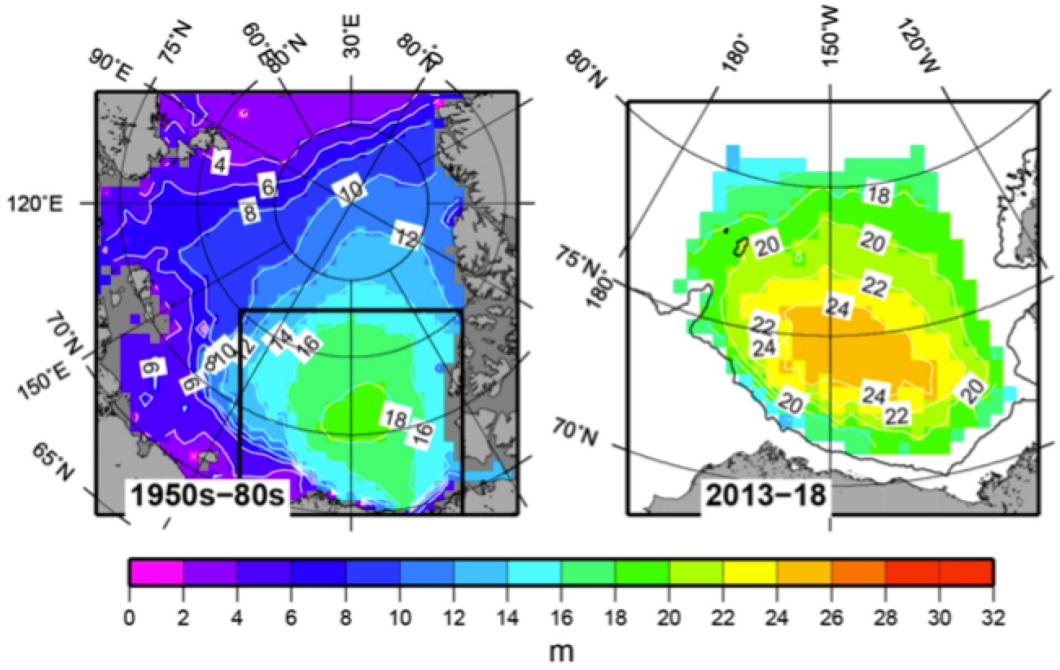
1. Beaufort Gyre

Largest freshwater reservoir in the Arctic



Proshutinsky et al., 2009

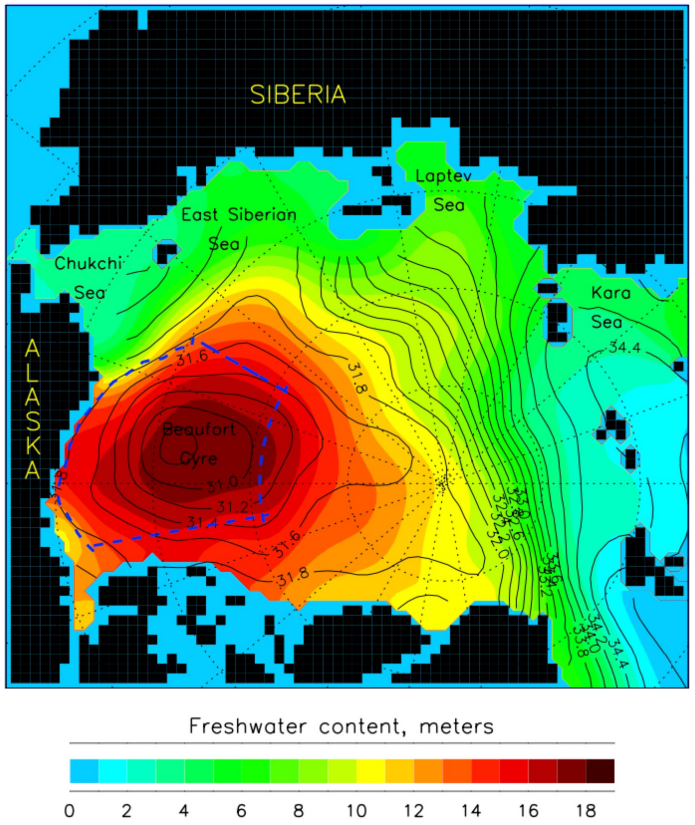
Freshwater content



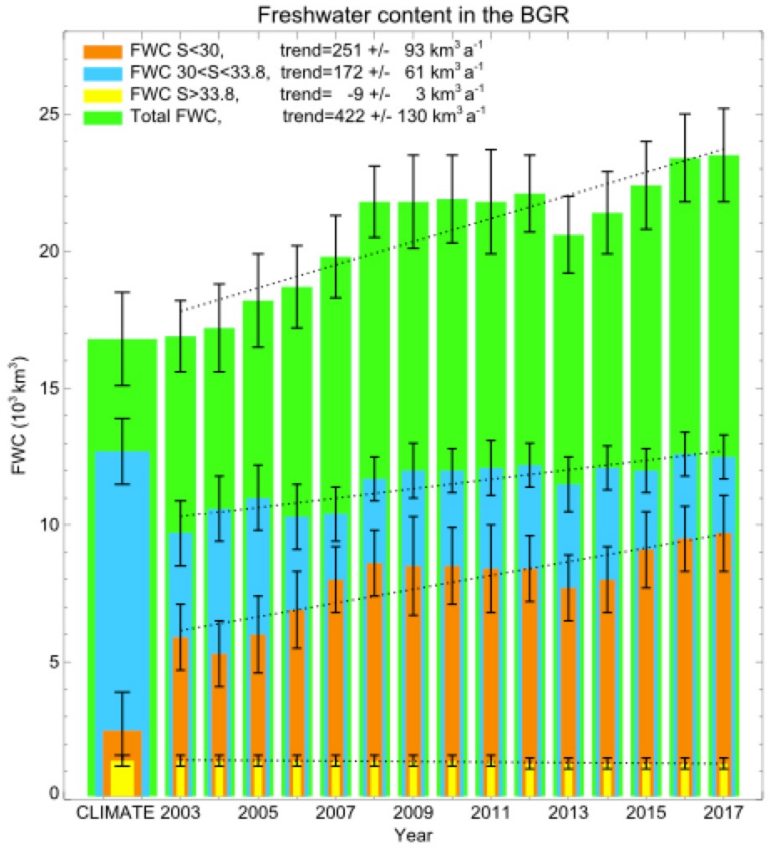
Proshutinsky et al., 2019a

1. Beaufort Gyre

Largest freshwater reservoir in the Arctic



Proshutinsky et al., 2009

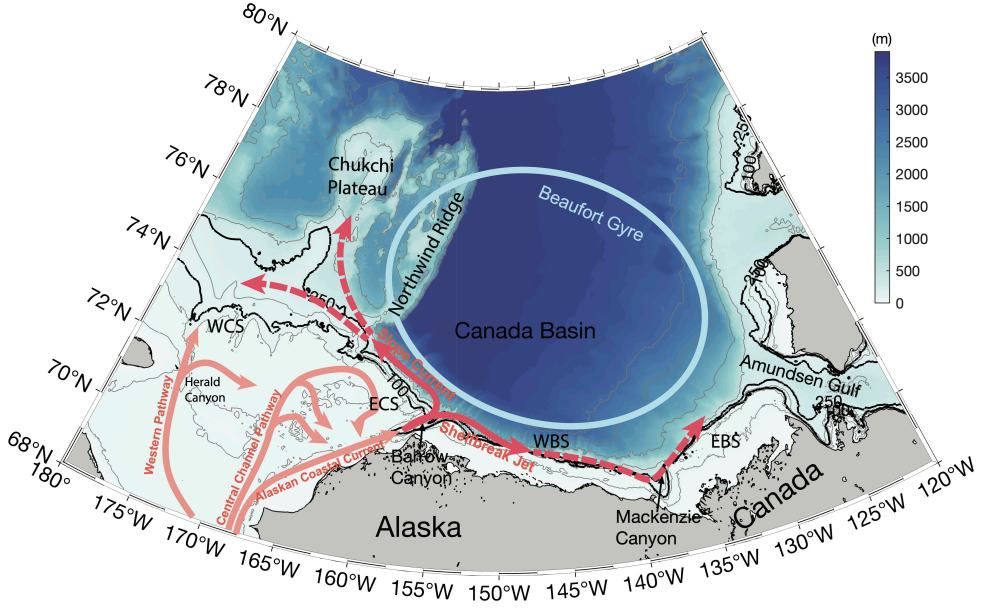


Proshutinsky et al., 2019a

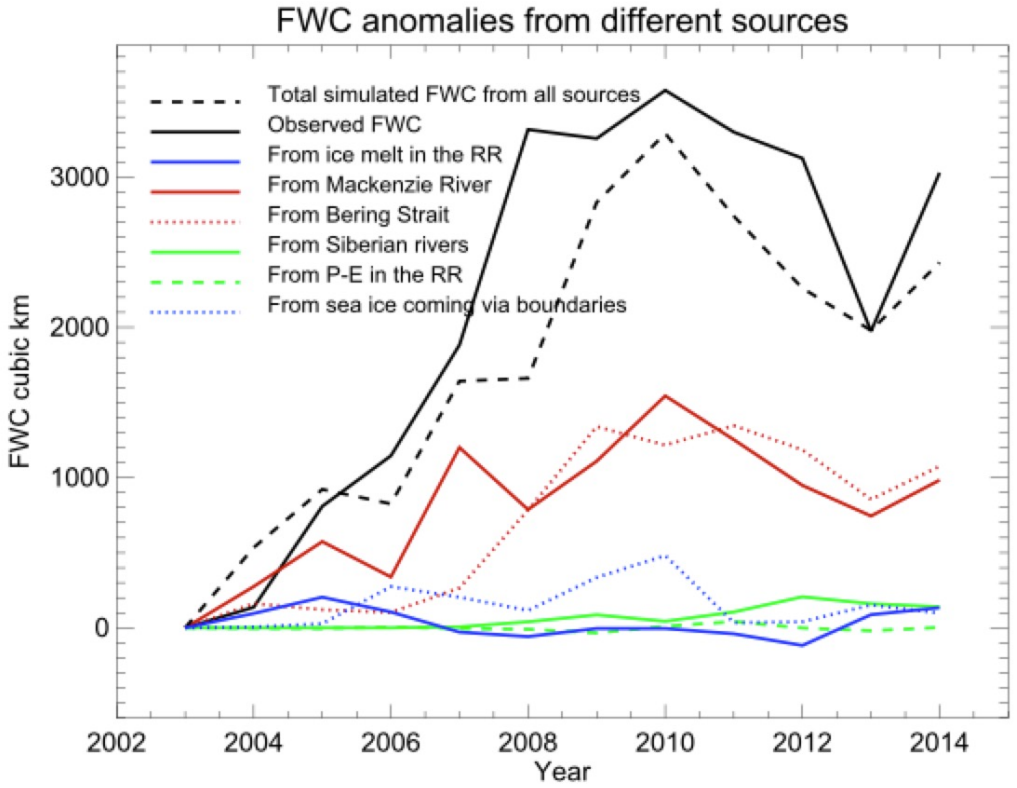
1. Beaufort Gyre

Freshwater sources:

1. Pacific-origin Water



Lin et al. 2021

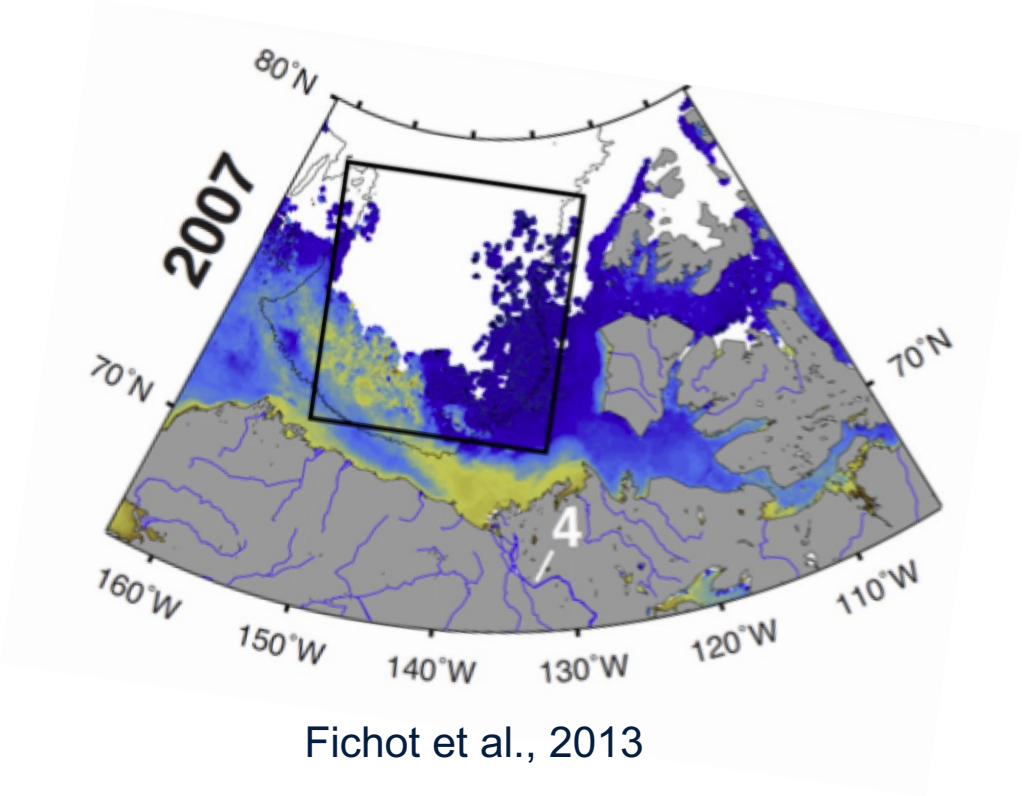


Proshutinsky et al., 2019b

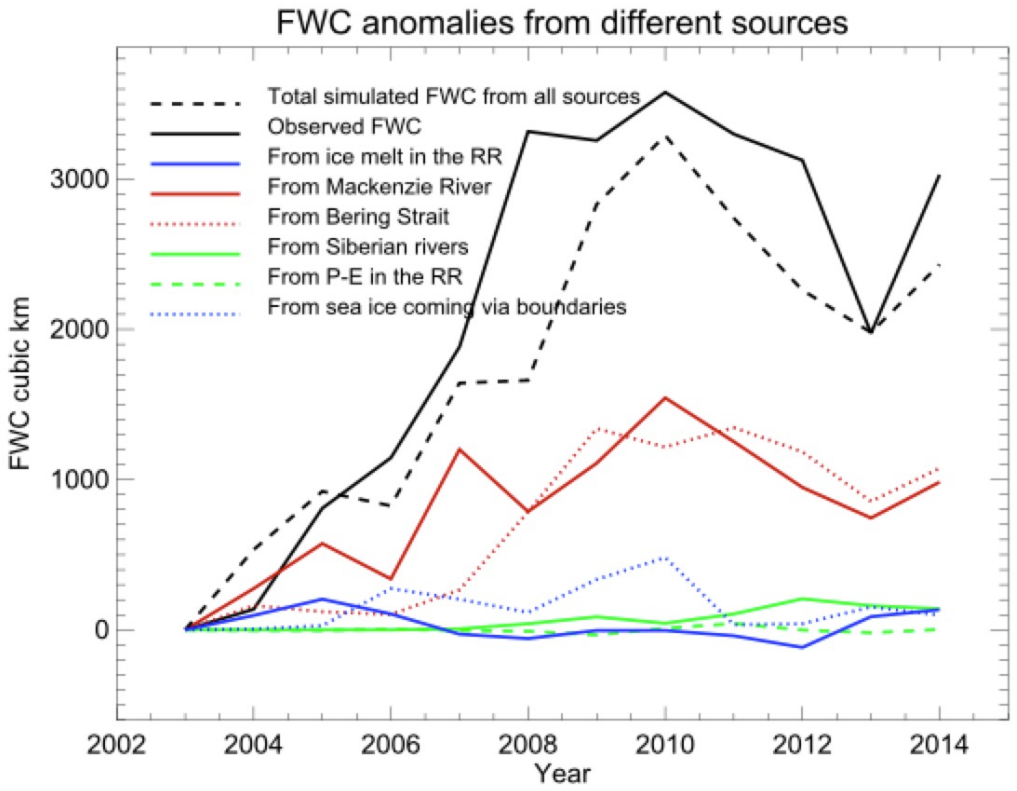
1. Beaufort Gyre

Freshwater sources:

1. Pacific-origin Water
2. Mackenzie River runoff



Fichot et al., 2013

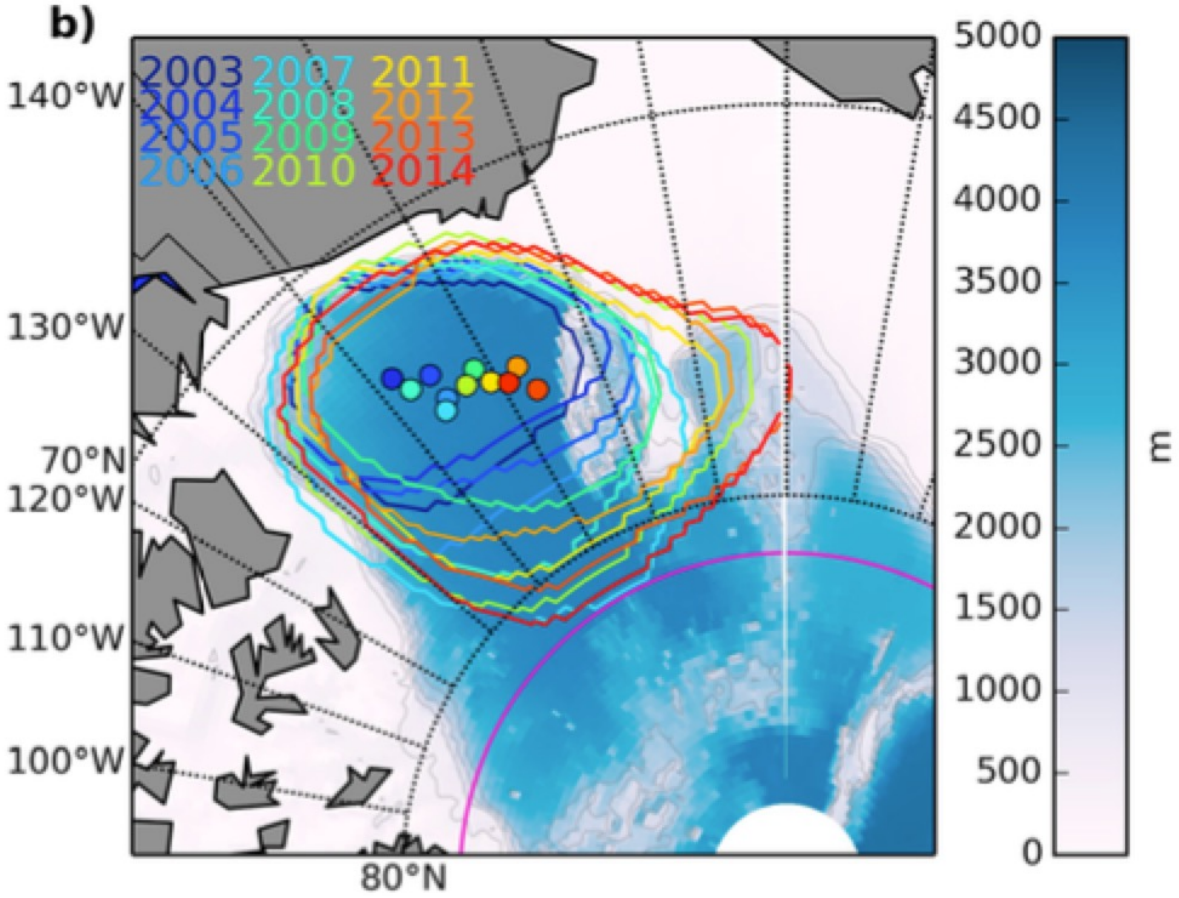


Proshutinsky et al., 2019b

1. Beaufort Gyre

Northwestward shifting of the Beaufort Gyre.

The strength and location of the gyre are associated with intensity of the surface forcing and location of the Beaufort High, respectively (e.g., Proshutinsky et al., 2009; Zhang et al., 2016; Regan et al., 2019).



Regan et al., 2019

1. Beaufort Gyre

Beaufort Gyre is potentially stabilizing in recent years.

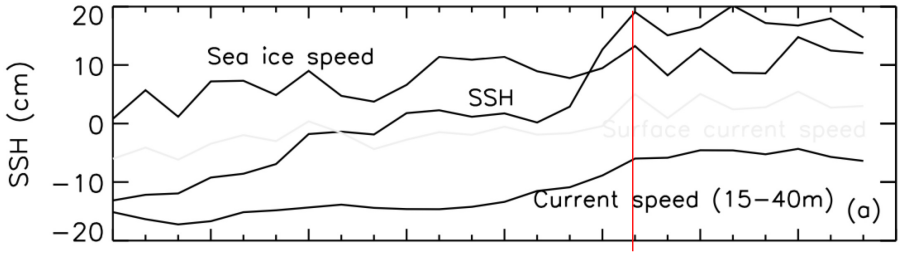
1. Change of the surface forcing

(Meneghello et al., 2017, 2018; Zhong et al., 2018)

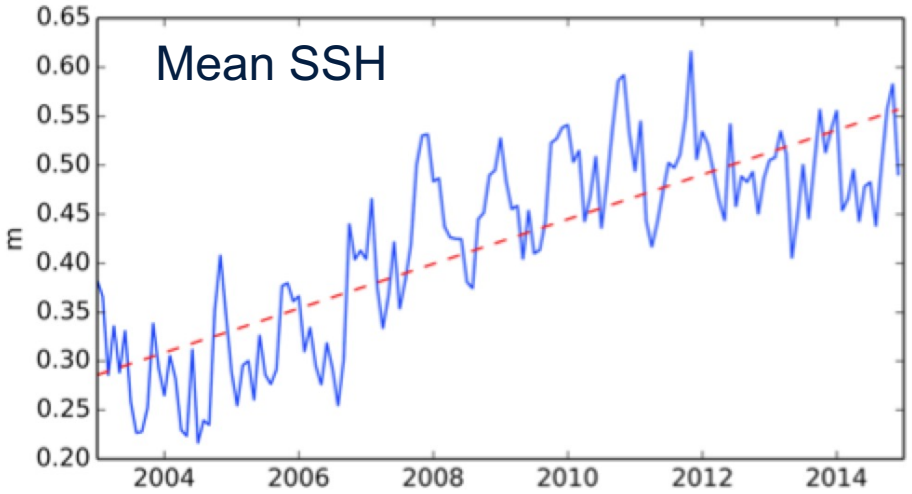
2. Eddy dissipation

(Manucharyan and Spall, 2016; Armitage et al., 2021)

Zhang et al., 2016



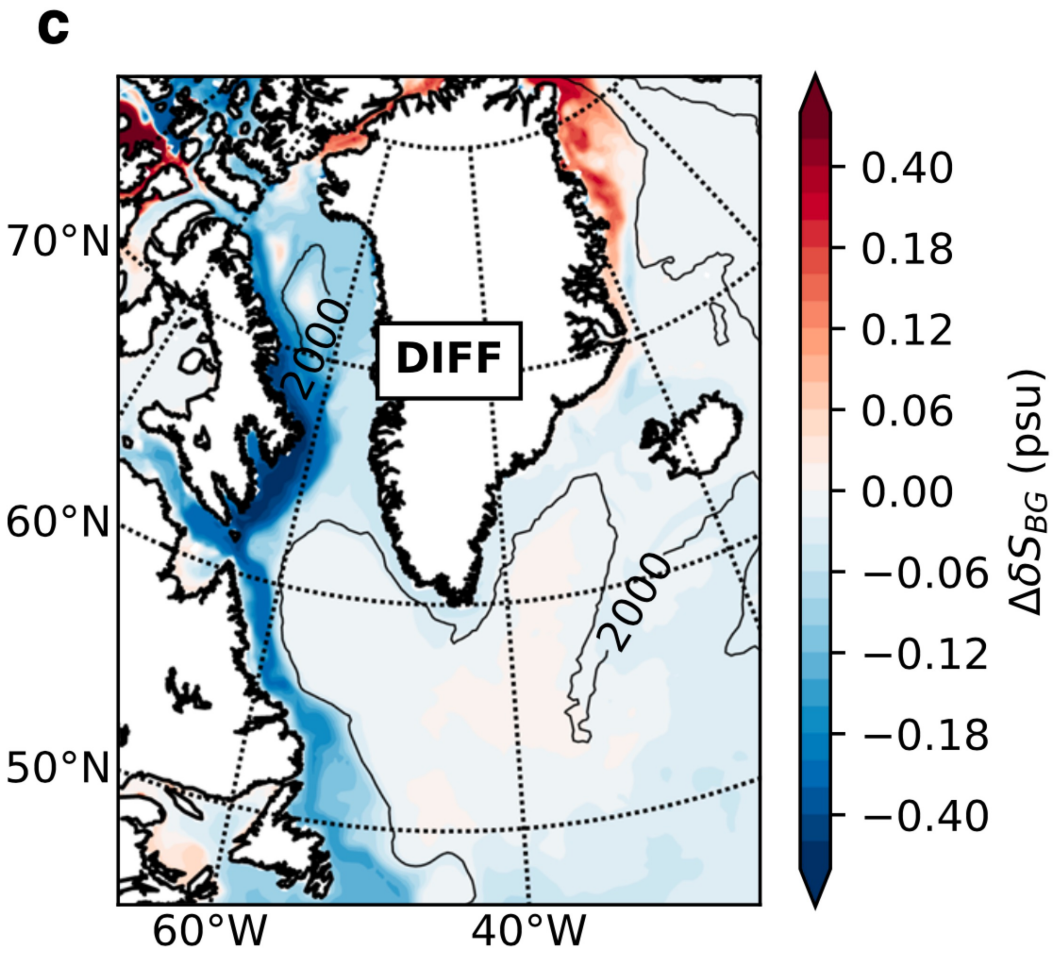
2008



Regan et al., 2019

1. Beaufort Gyre

If released within a short period, the excess freshwater could potentially impact the large-scale ocean circulation by freshening the upper subpolar North Atlantic.



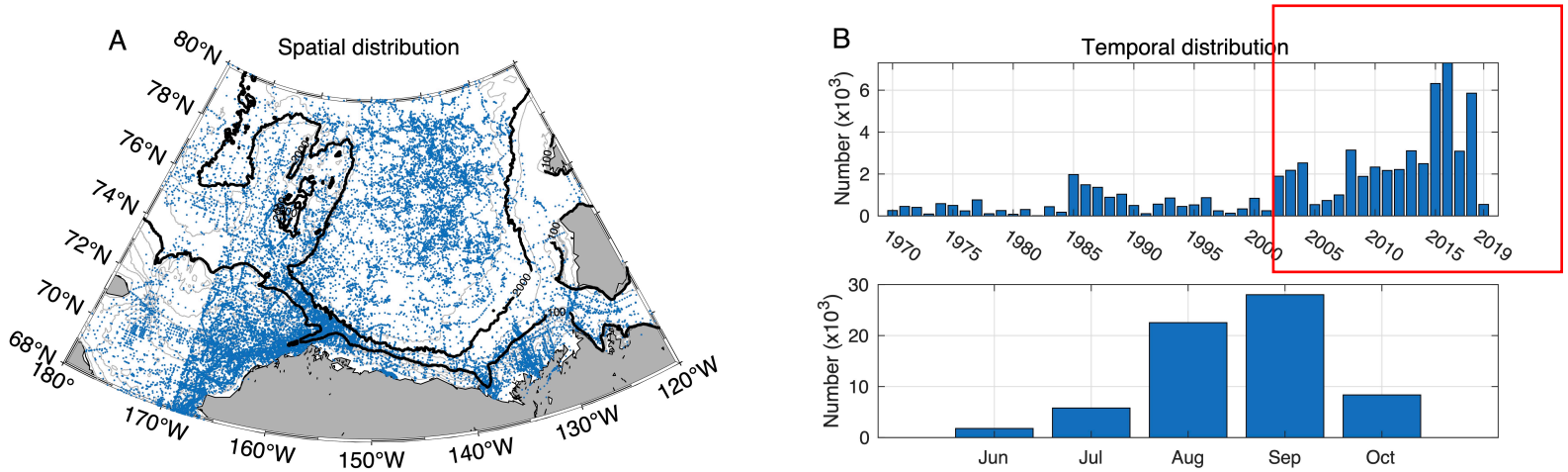
Zhang et al., 2021

Questions

- Whether the Beaufort Gyre is continuously stabilizing in the recent decade?
- How does the water column respond to the changes?

Data and Methods

Hydrographic profiles

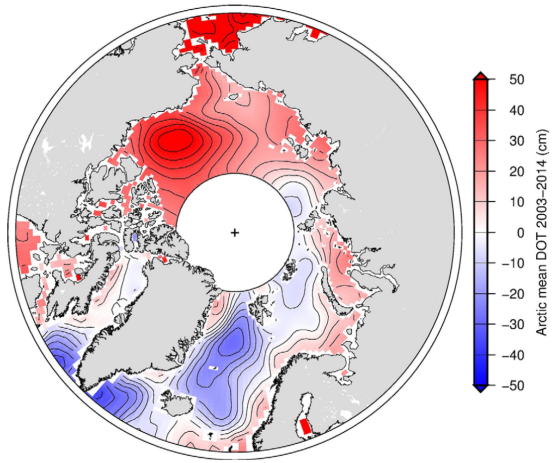


2003-2019

Lin et al., 2021

DOT data

1. 2003-2014 (Armitage et al., 2016)
2. 2011-2019 (Heorton & Tsamados)



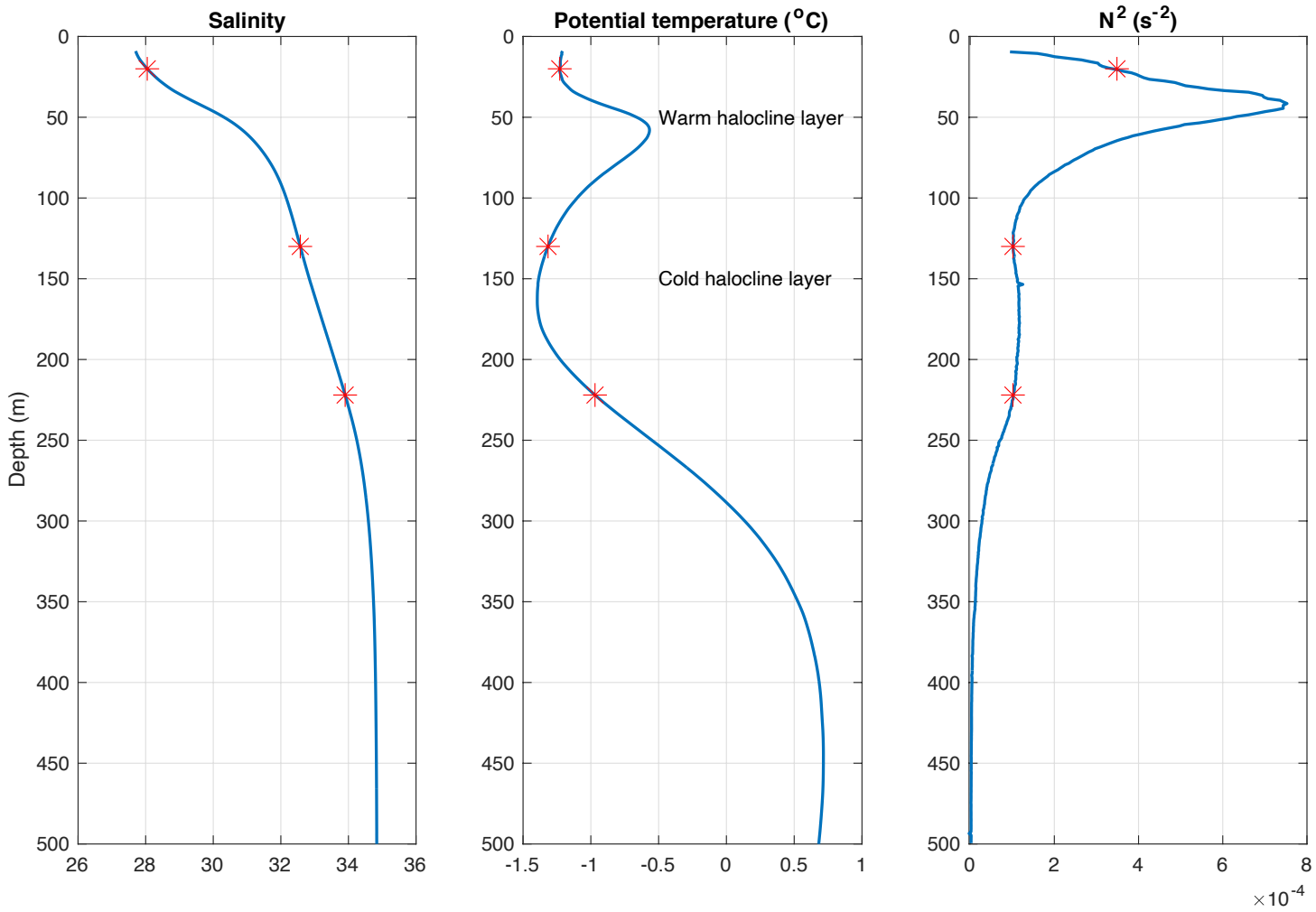
Barrow Canyon moorings
GLORYS12 reanalysis
ERA5

Data and Methods

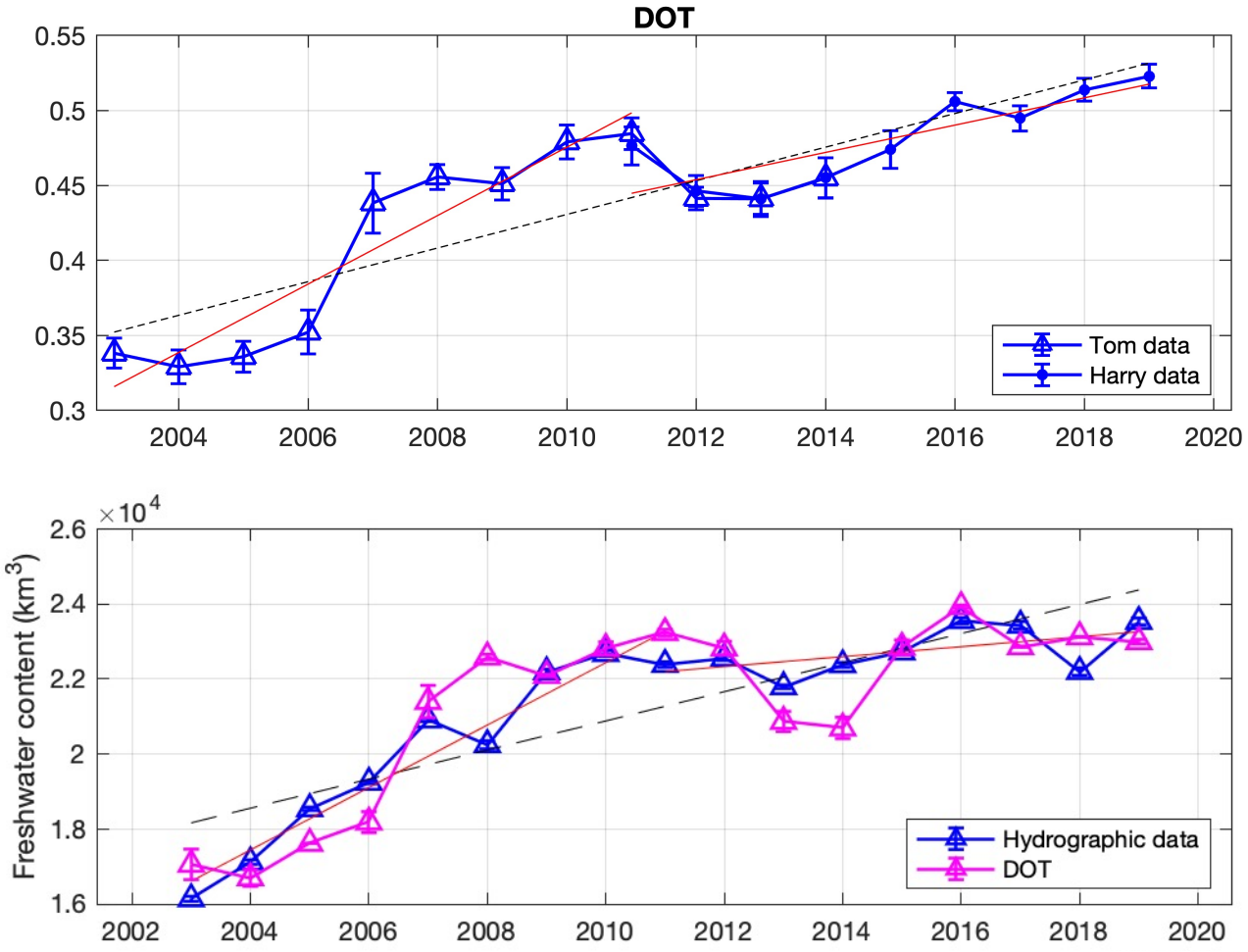
Base of cold halocline layer (CHL)
A ratio of density gradient due to temperature versus the density gradient due to salinity. (Bourgain and Gascard, 2011)

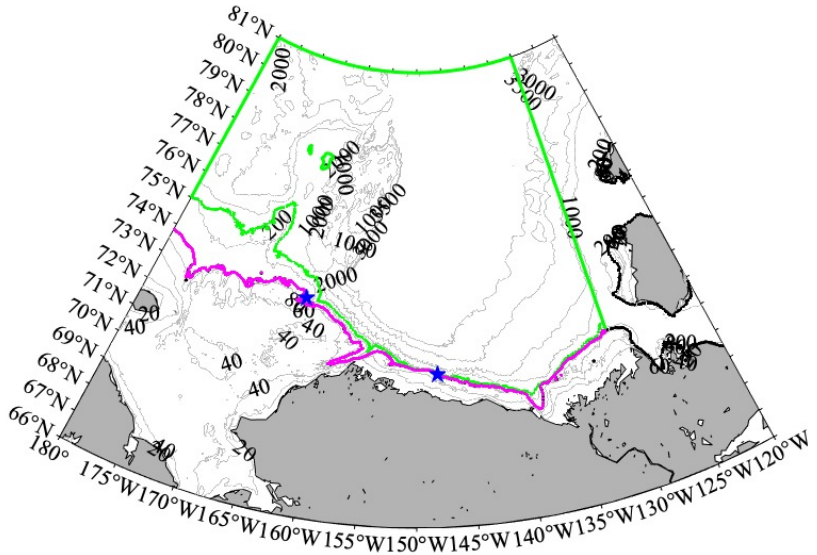
$$R = \alpha \Delta T / \beta \Delta S, \text{ =0.05}$$

Salinity of CHL is 32.6 to 34.



2. Long-term trend of the BG

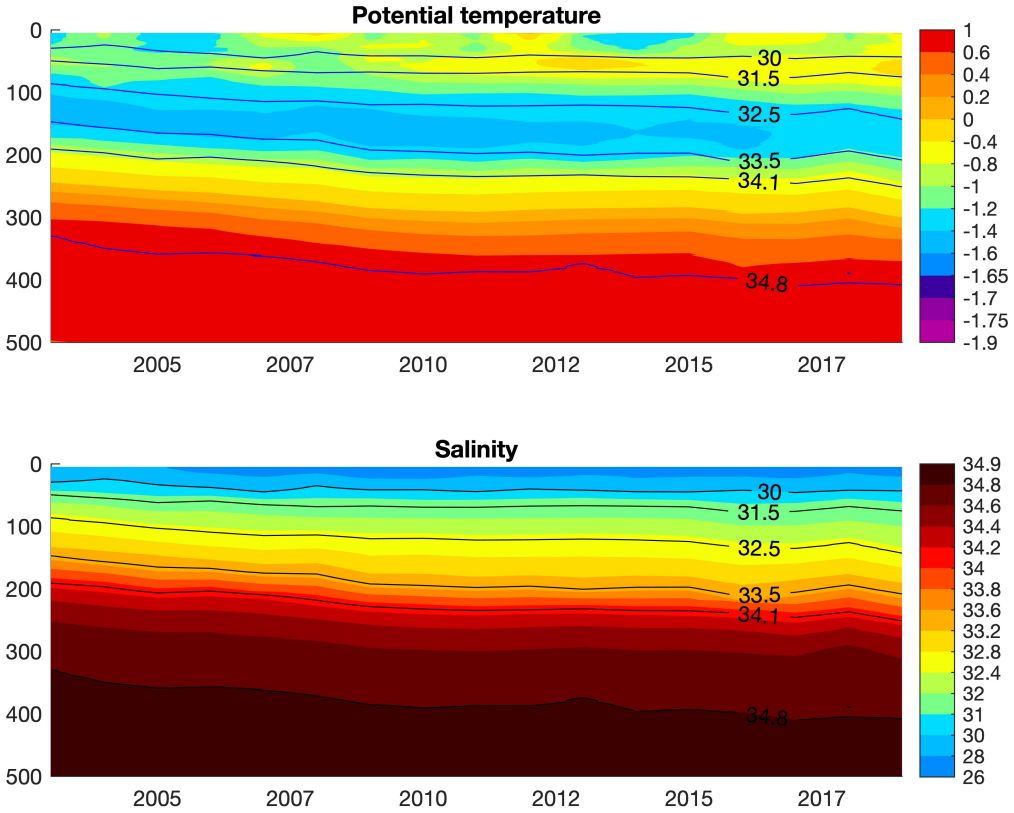


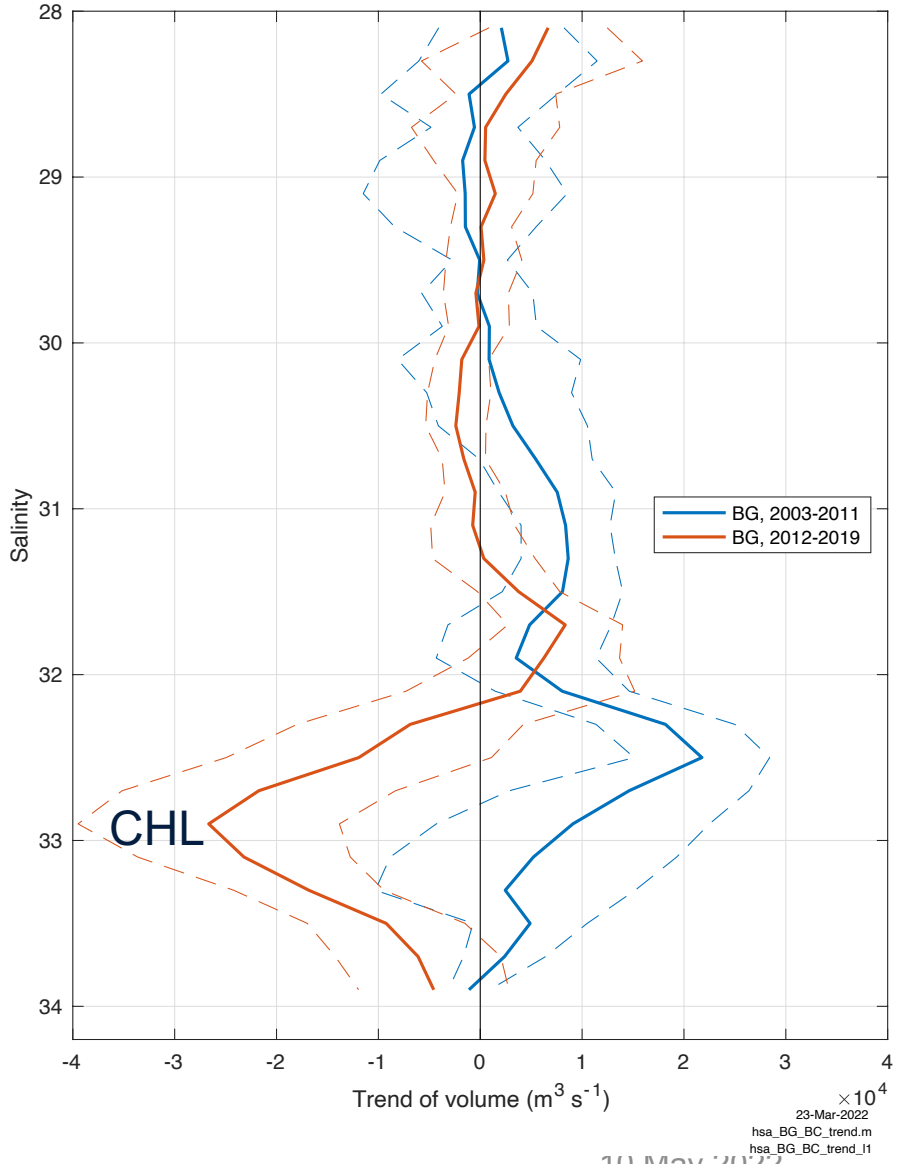


1. The DOT of the BG continuously increases with a smaller rate.
2. Freshwater content has a similar trend.

2. Long-term trend of the BG

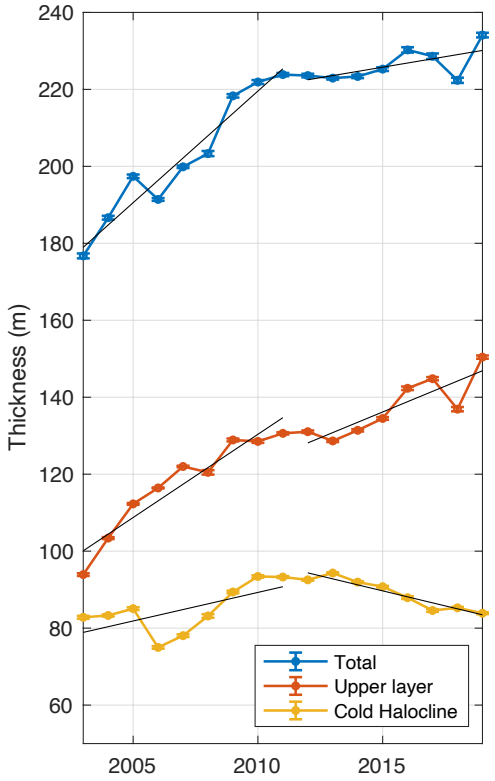
Changes in different layers

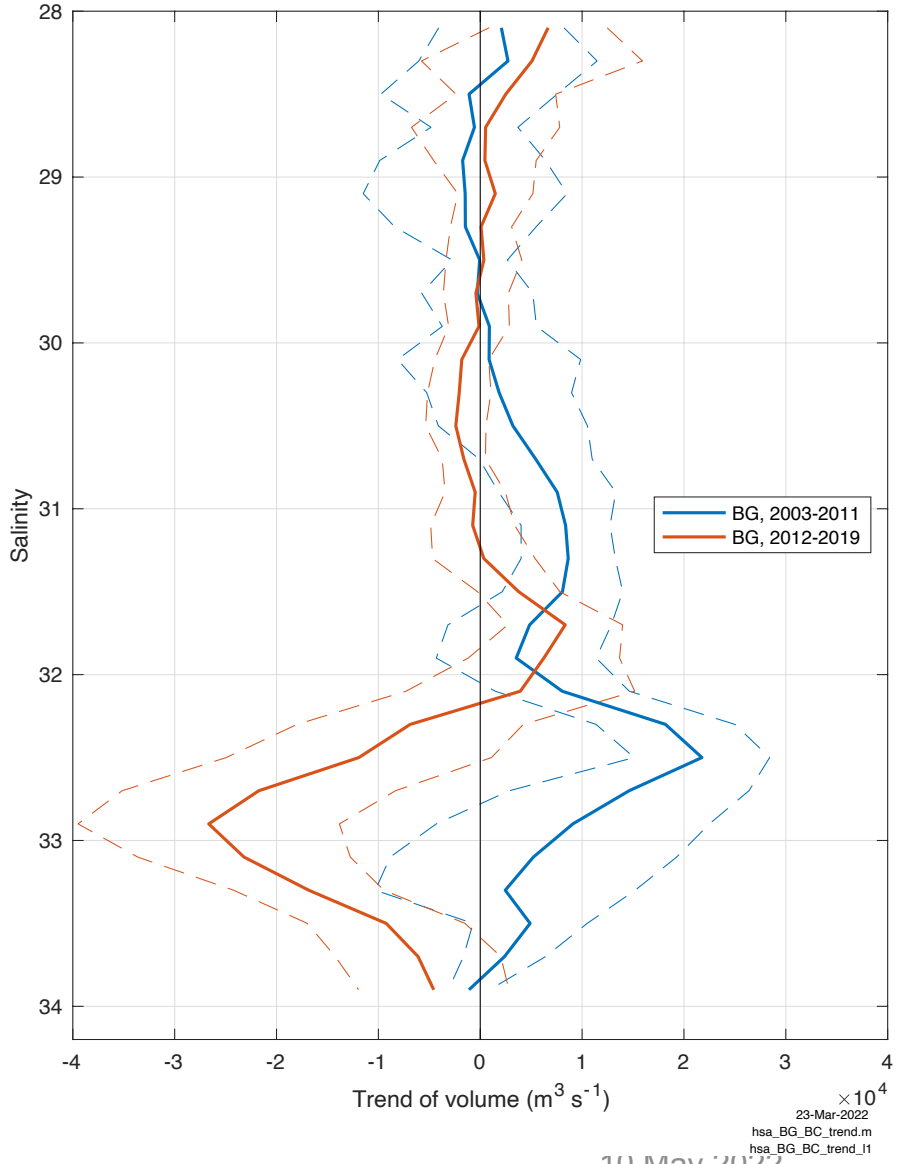




2. Long-term trend of the BG

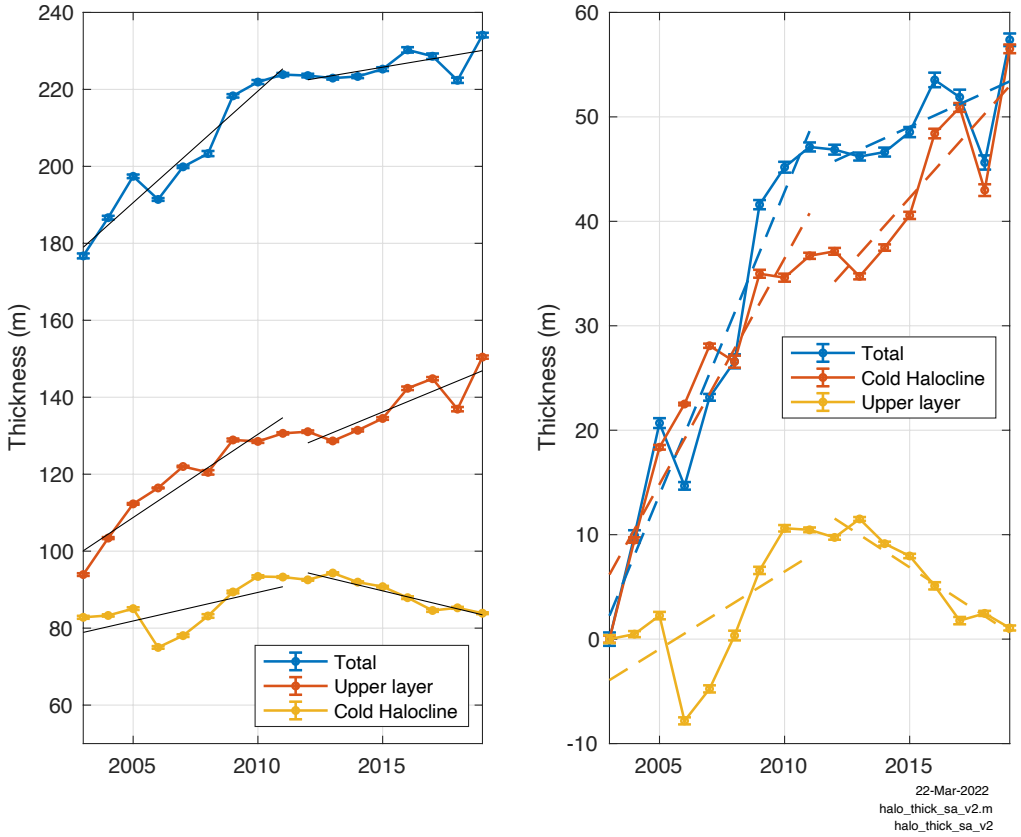
Changes in different layers

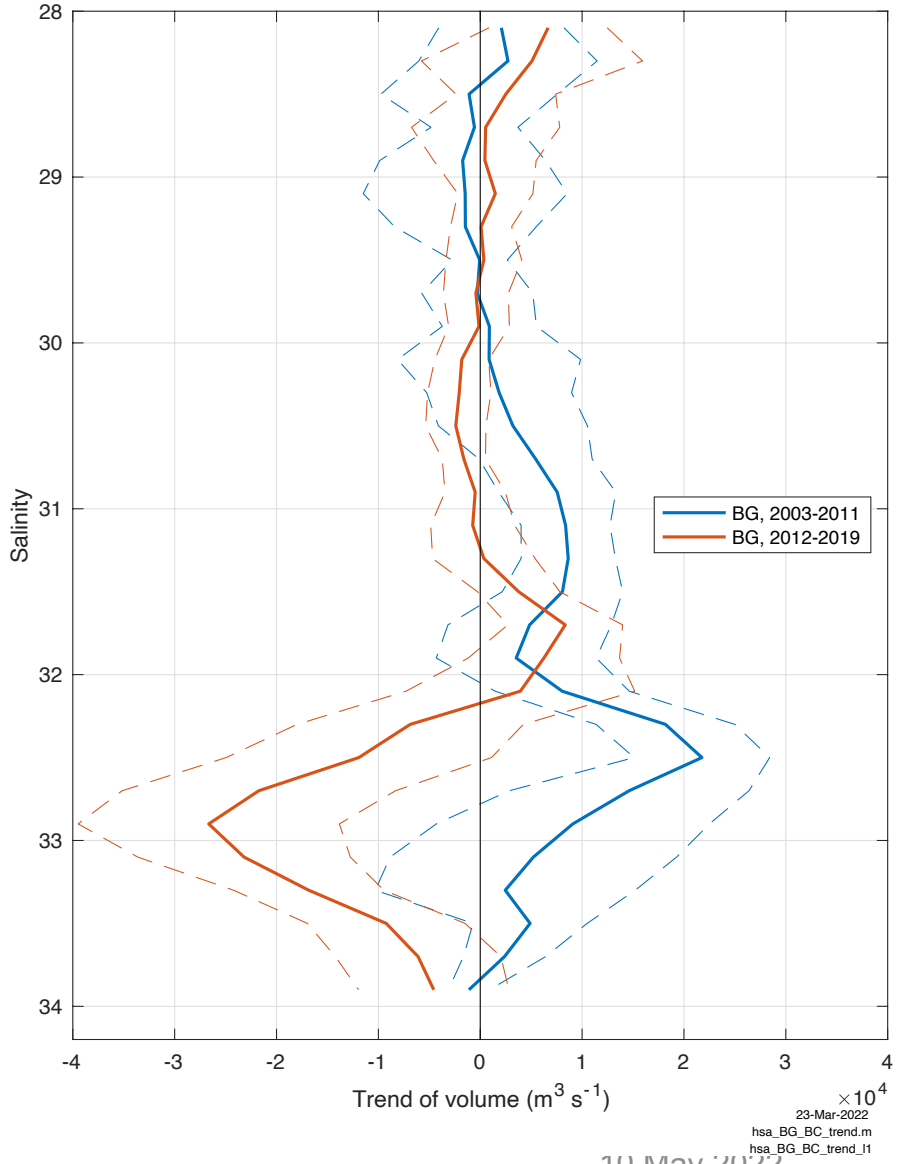




2. Long-term trend of the BG

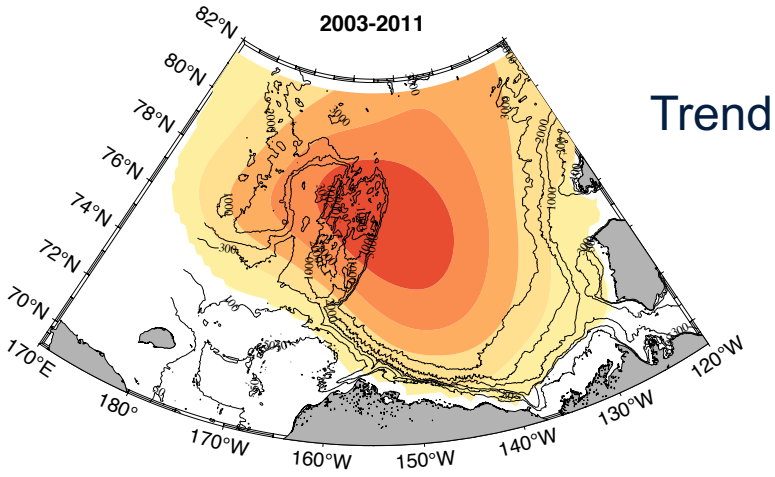
Changes in different layers





2. Long-term trend of the BG

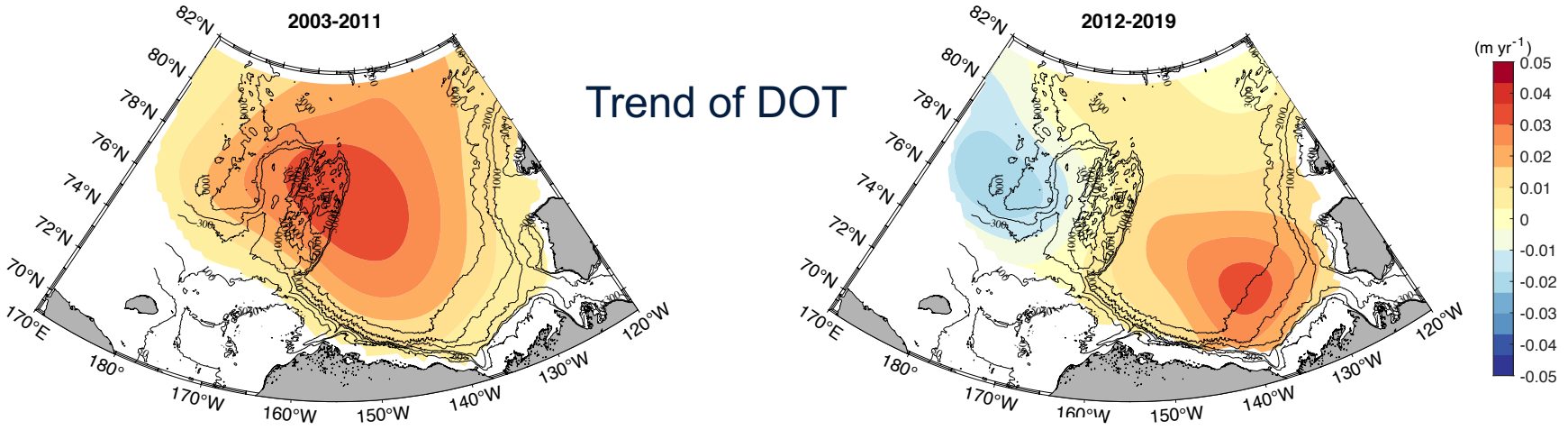
Spatial changes

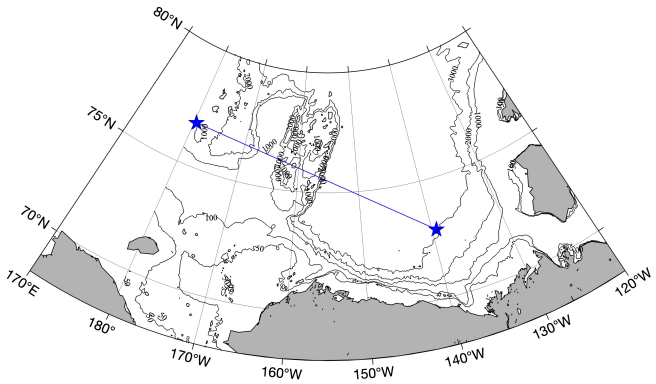


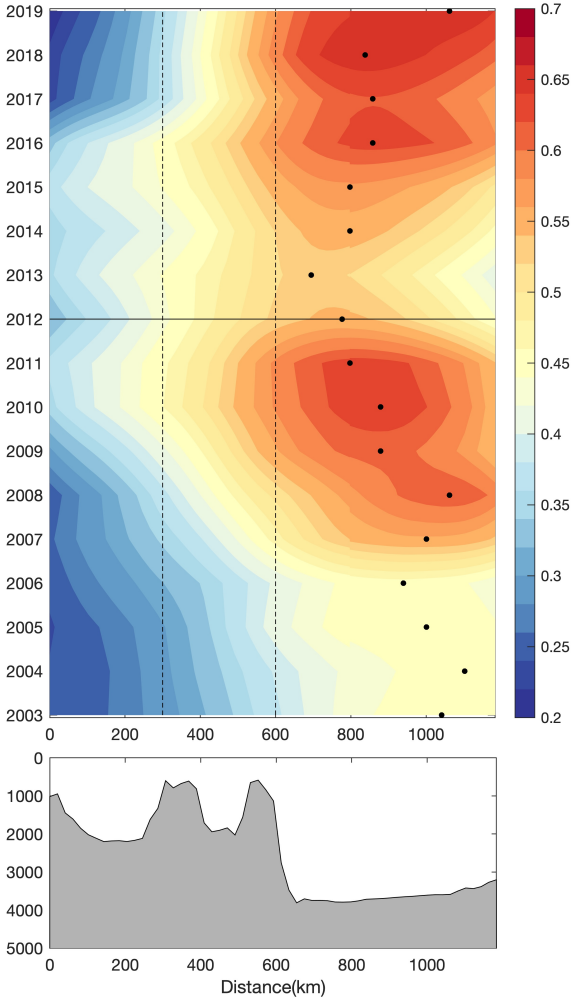
Trend of DOT

2. Long-term trend of the BG

Spatial changes







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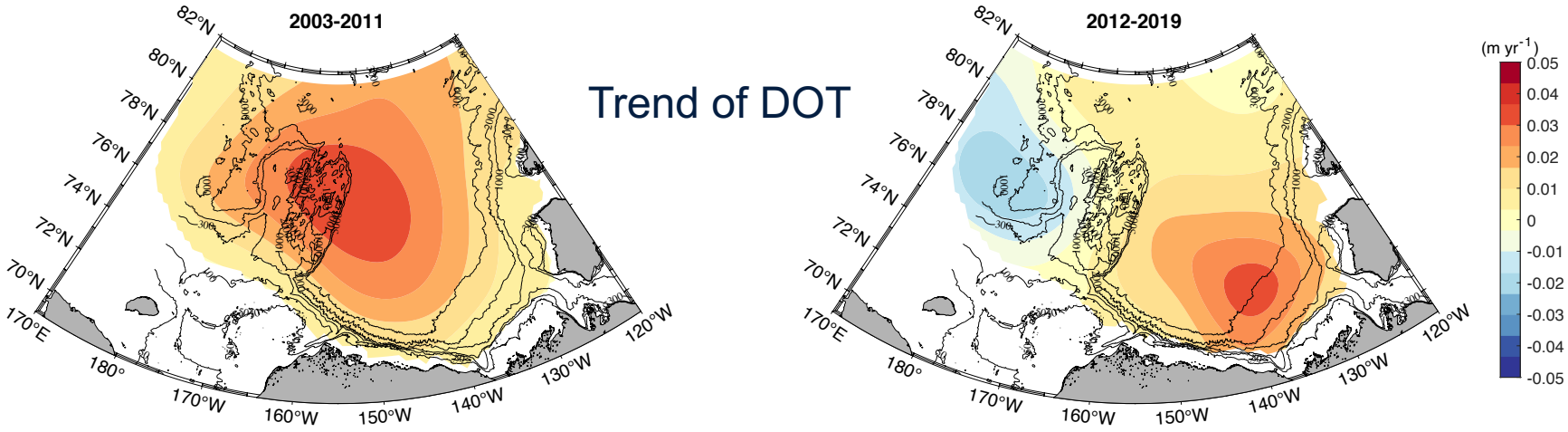
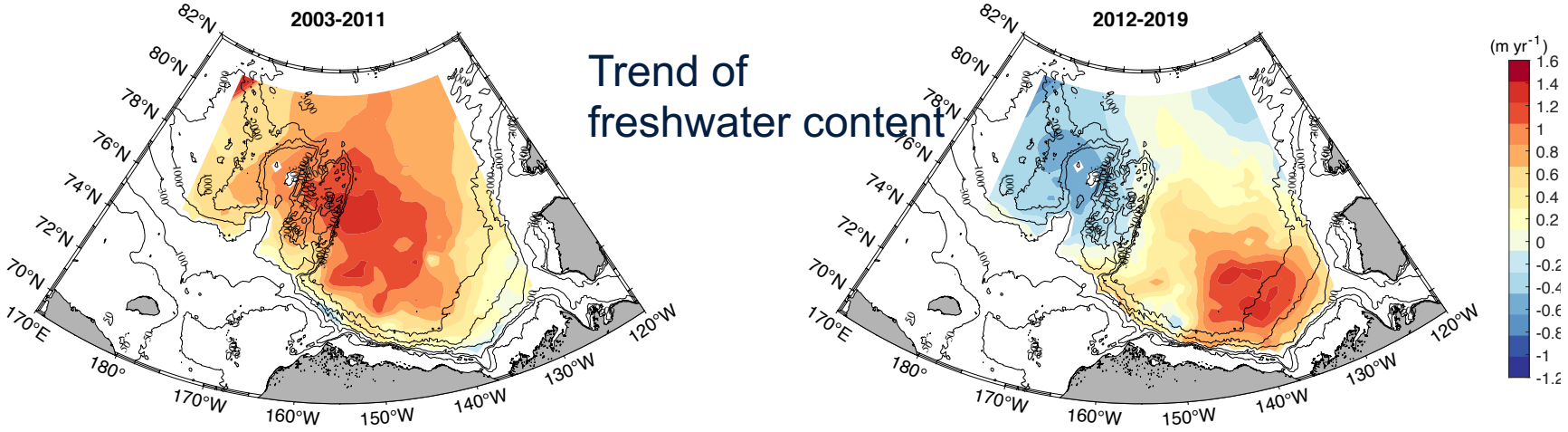
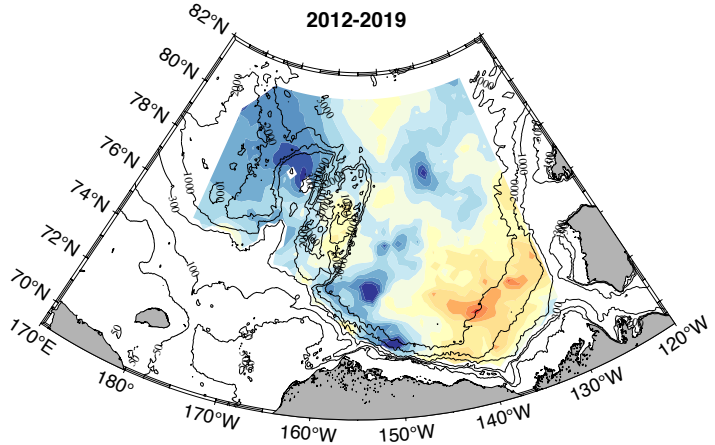


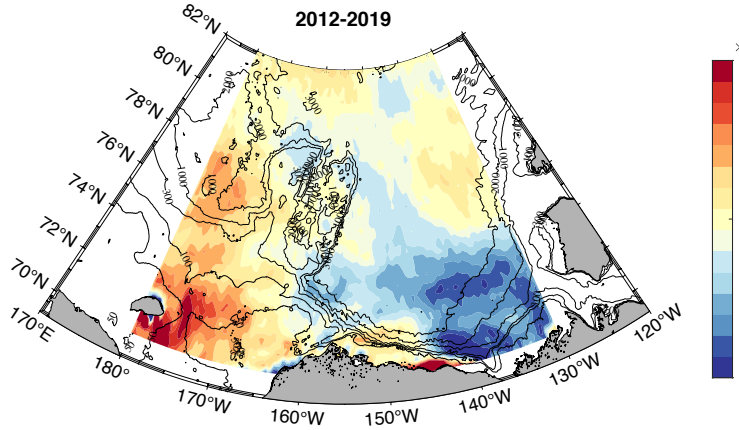
Trend of DOT



Trend of freshwater content

Trend of CHL thickness





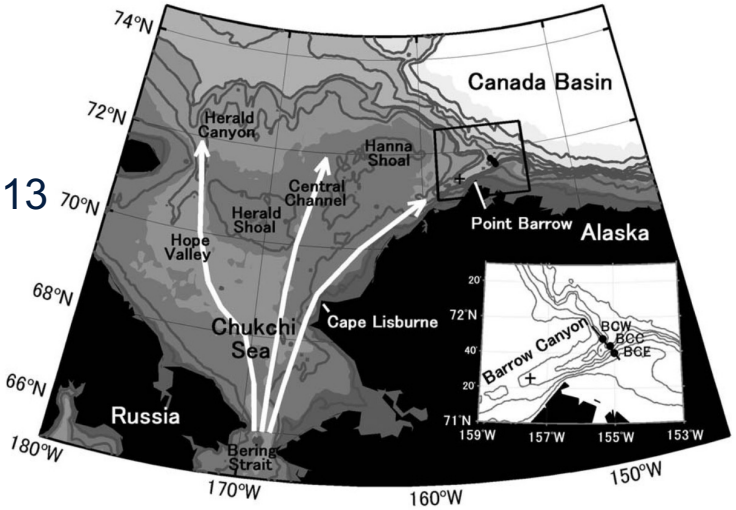
Trend of wind stress curl

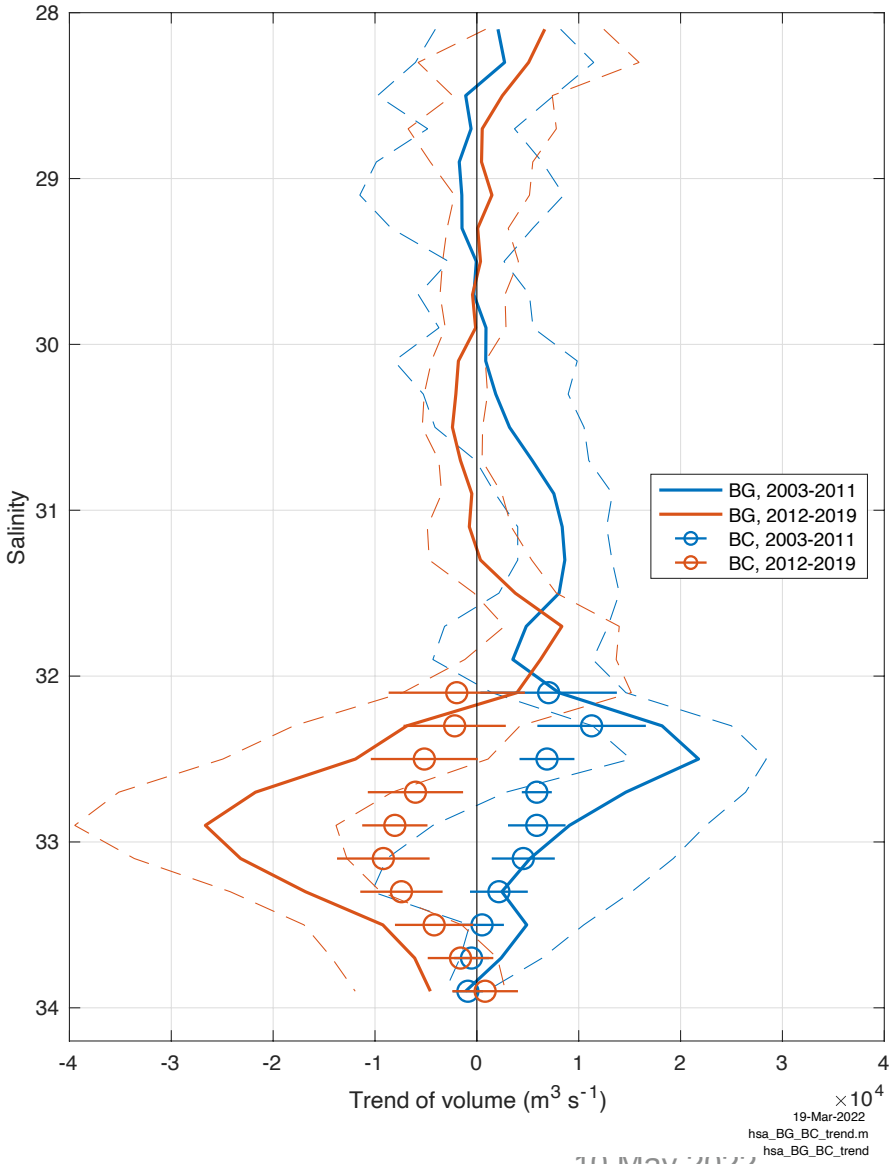
What are the main drivers of the thinning CHL?

3. Causes of the thinning CHL

1. Pacific-origin Water

Itoh et al., 2013

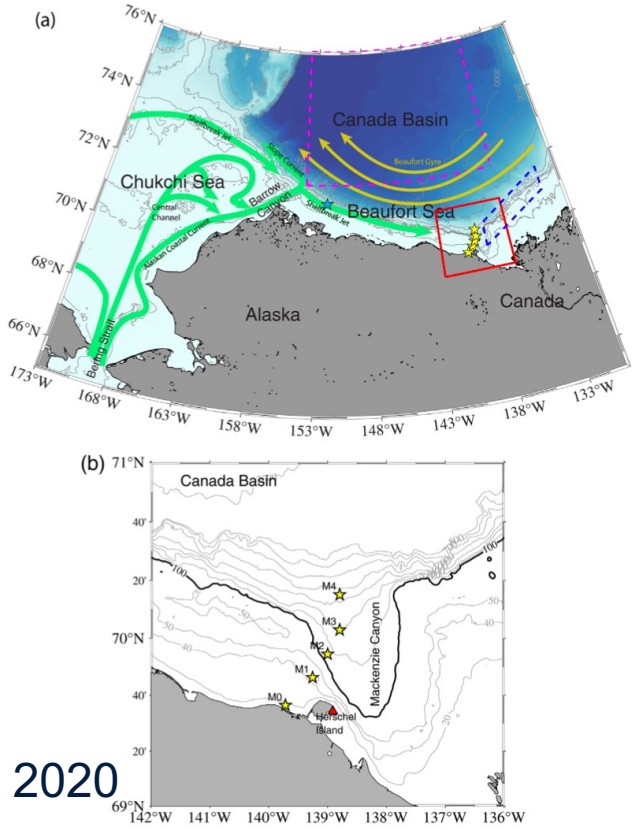




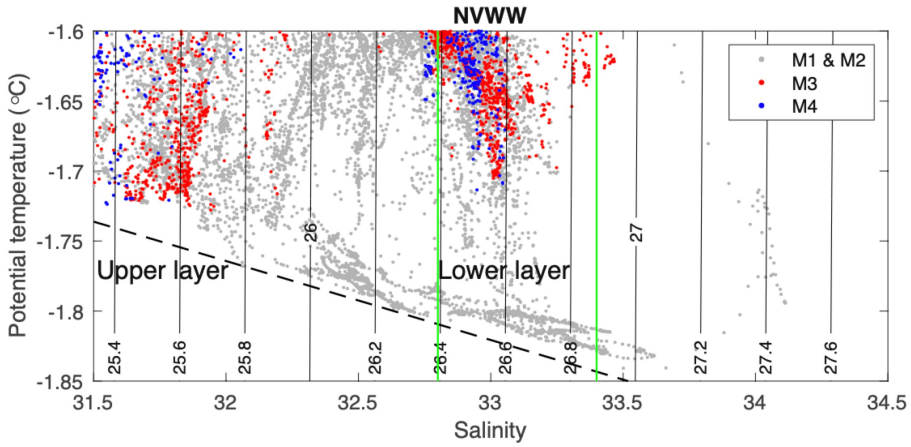
1. The PW has a similar trend shape.
2. The trend of PW is less in the magnitude, particularly in the recent years.

3. Causes of the thinning CHL

1. Pacific-origin Water
2. **Local-formed water in Eastern Beaufort Sea**



Lin et al. 2020

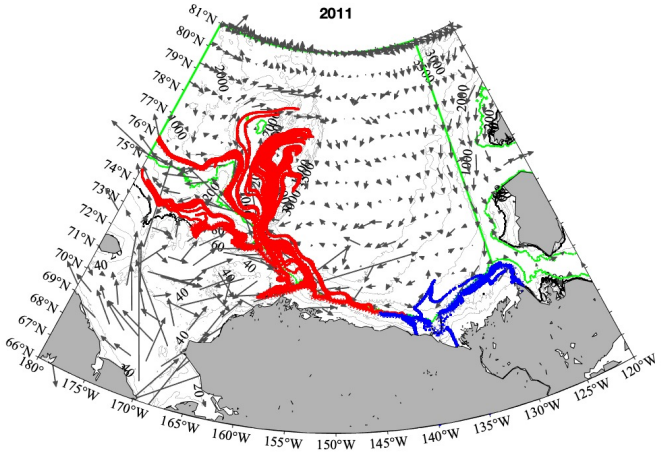


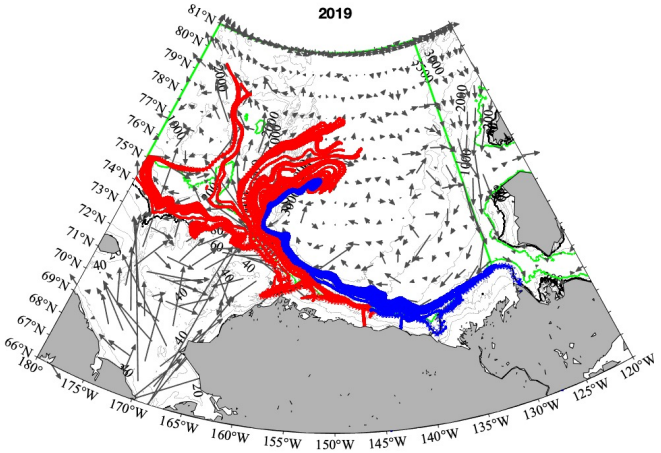
Lin et al., 2021

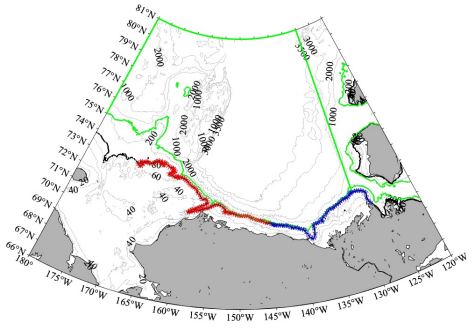
How does this contribute to the thinning of CHL?

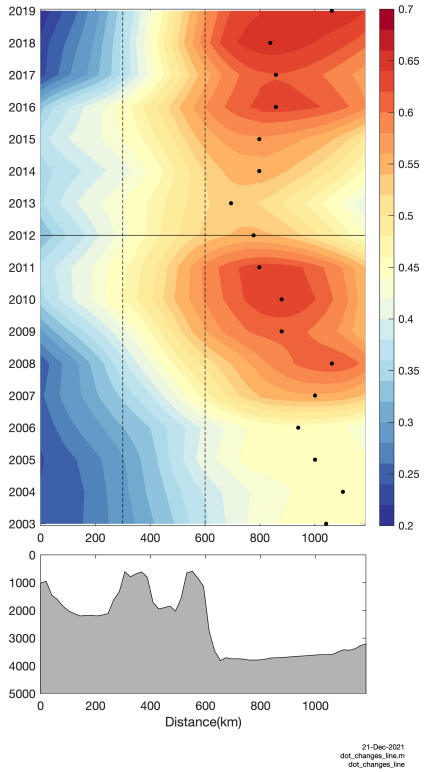
3. Causes of the thinning CHL

1. Pacific-origin Water
2. **Local-formed water in Eastern Beaufort Sea**







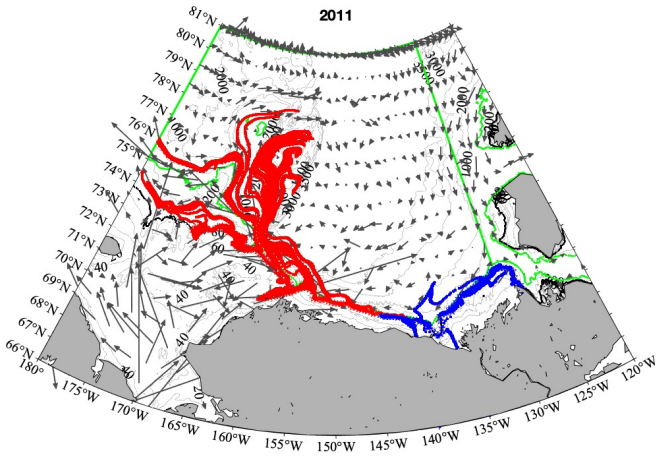


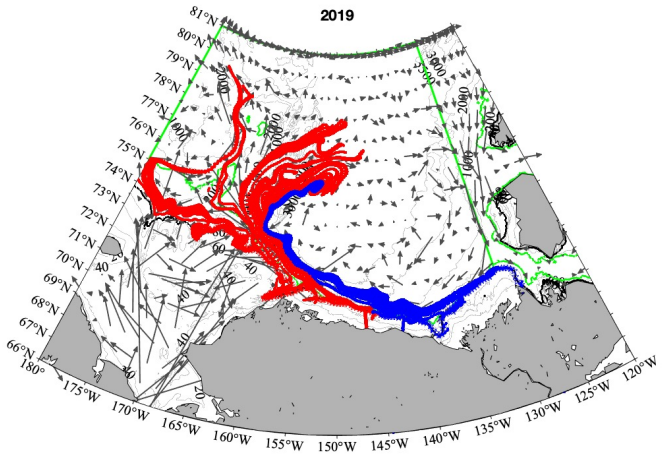
Percentage of tracers into the BG

	BC
2011	90%
2019	84%

3. Causes of the thinning CHL

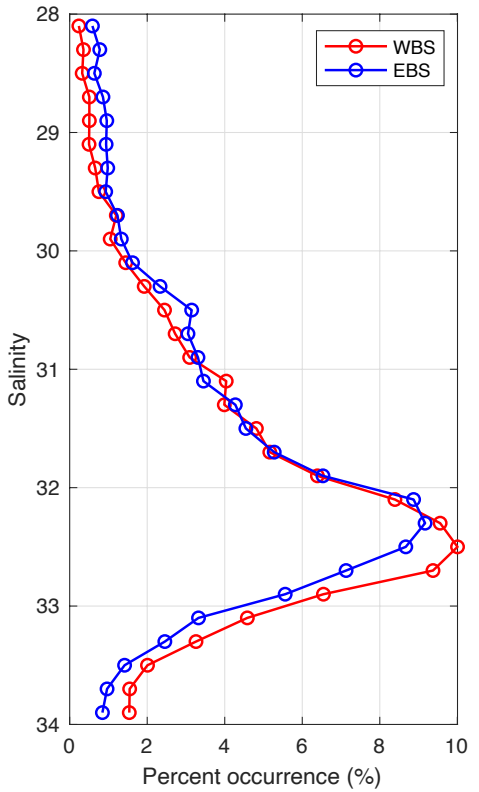
1. Pacific-origin Water
2. **Local-formed water in Eastern Beaufort Sea**

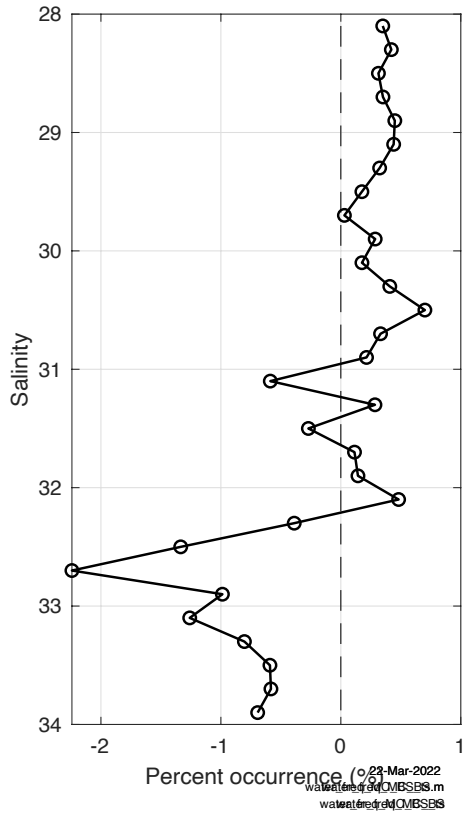




Percentage of tracers into the BG

	BC	EBS
2011	90%	15%
2019	84%	73%
2018	89%	54%





More fresher water from EBS can be trapped into the Beaufort Gyre when the gyre shifts to the southeast.

3. Conclusions

- In the recent decade, the DOT and freshwater content of the BG continuously increase with a smaller rate. Spatially, the BG is shifting to the southeast of the basin, controlled by the change of the basin-scale atmospheric forcing.
- These long-term trends are mainly due to the thinning cold halocline layer (S=32.6-34).
- There are two main drivers of the thinning cold halocline: 1) the less input of the cold halocline water from Pacific and Chukchi Sea; 2) More fresher water from Eastern Beaufort Sea contributes to the basin due to the southeastward-shift BG.

Thank you!