Impact of ice retreat on biological pump and carbon sink in the western Arctic Ocean

Based on Chinese Arctic cruise

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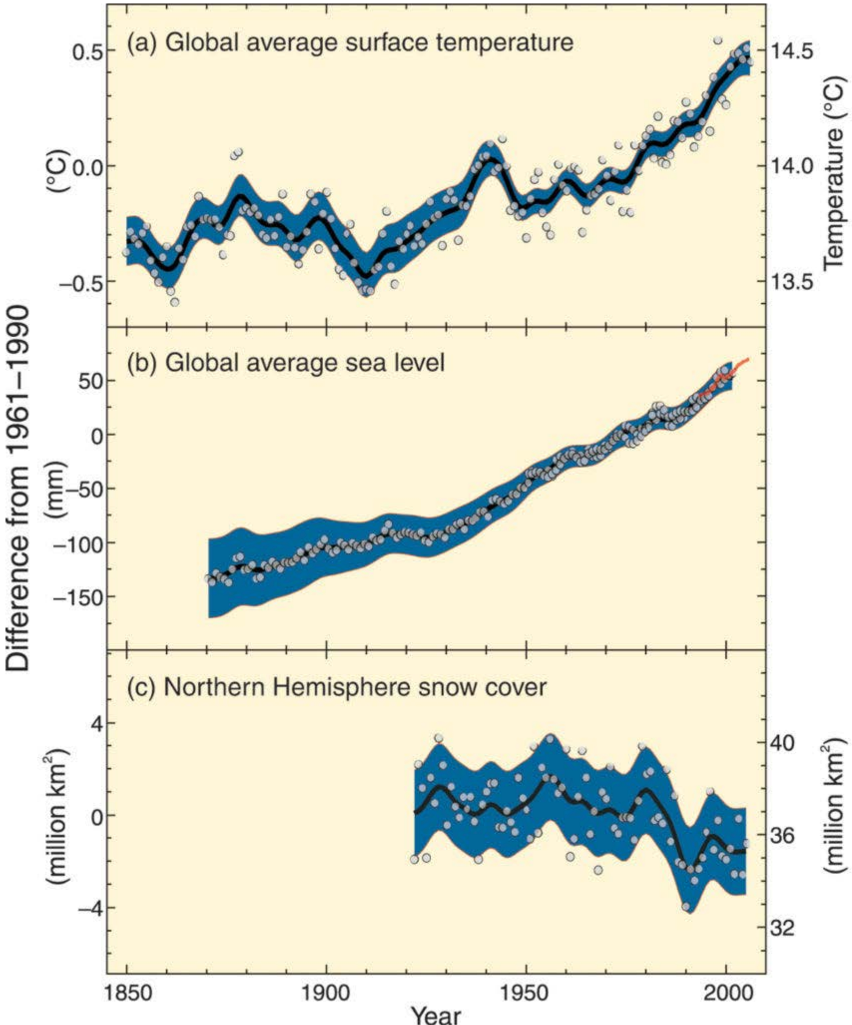
Key Points of Presentation

- **Overview the impact of shrink sea ice on phytoplankton , biological pump and carbon sink**
  - impact of sea ice conditions on phytoplankton
  - Change in nutrient concentrations in recent decades
  - Carbon sink mechanism and processes in the Arctic Ocean
- **future work**
  - **A**rctic **R**apid **C**hange-**L**ong Term ice and **O**cean **O**bservation **P**rogram(ARC-lOOP)
  - Contributions to the MOSAiC

1、Background



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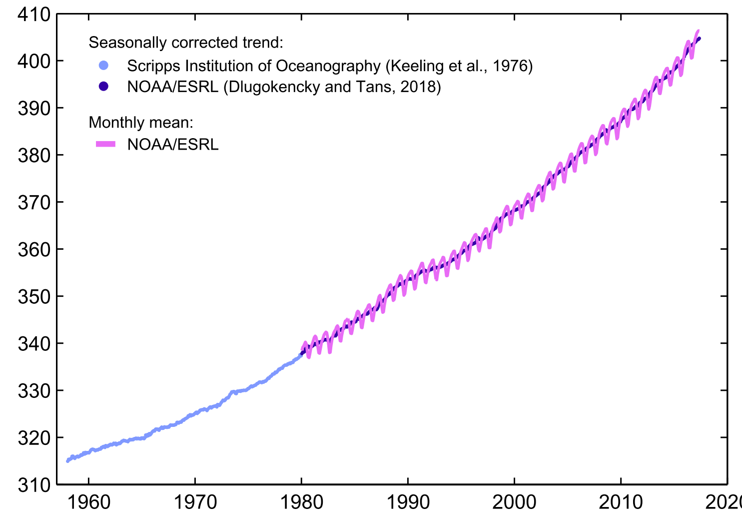
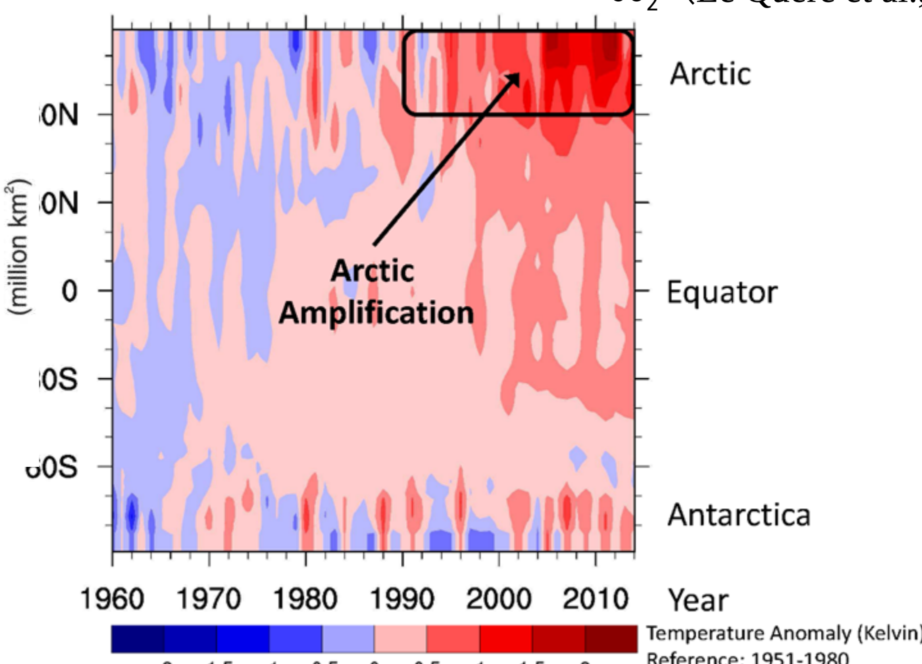
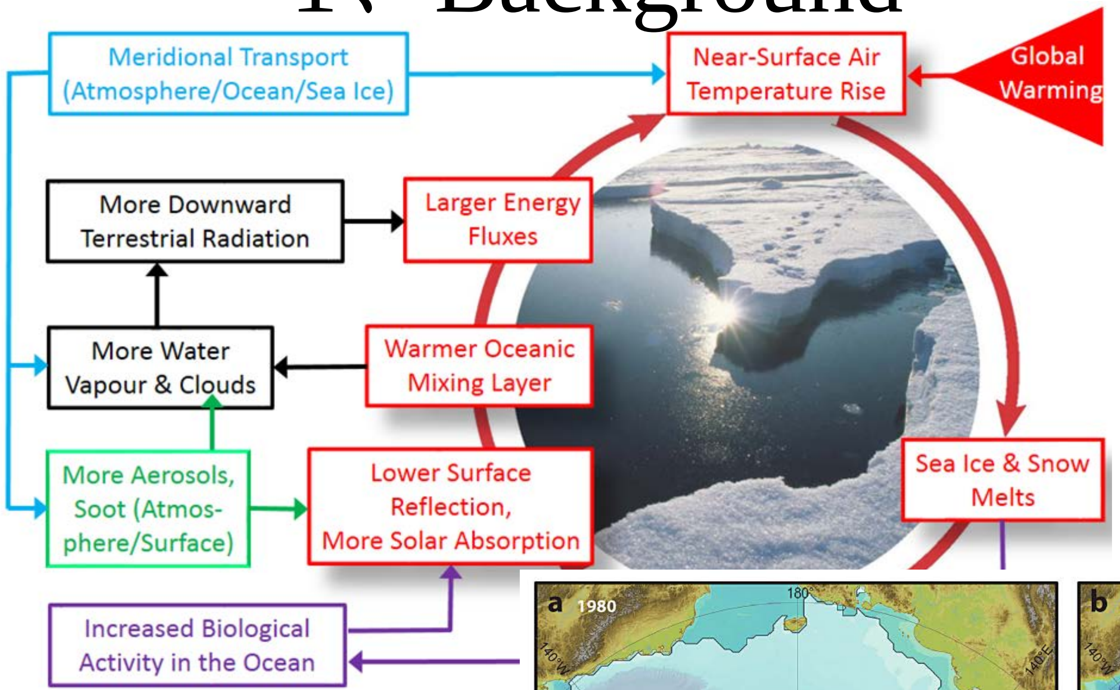


CO_2 （Le Quéré et al., 2018)

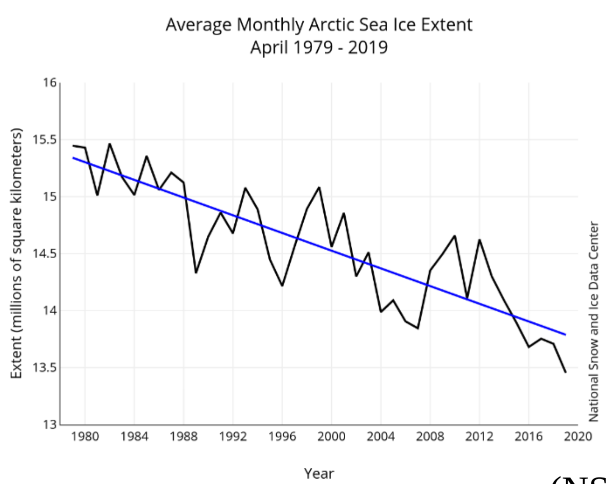


(Wendisch et al., 2017)

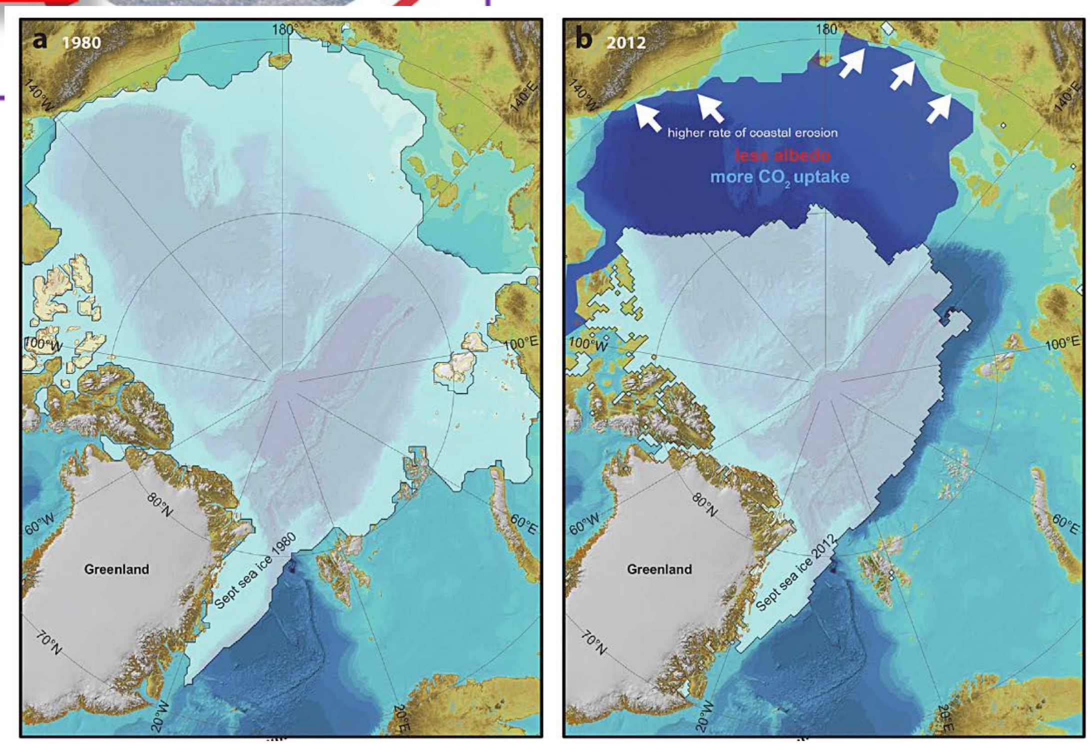
1、Background



(Wendisch et al., 2017)



(NSIDC)



(Jakobsson et al., 2014)

2. Our Researches in the Western Arctic Ocean

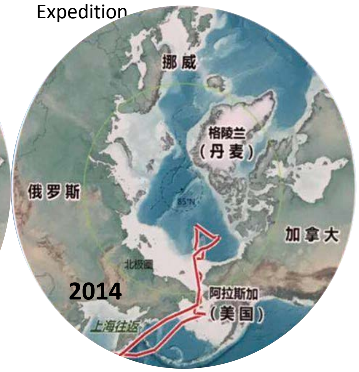
1st Chinese Arctic Research Expedition

2cd Chinese Arctic Research Expedition

3rd Chinese Arctic Research Expedition

4th Chinese Arctic Research Expedition

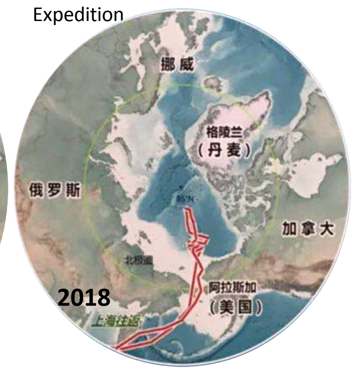
5th Chinese Arctic Research Expedition



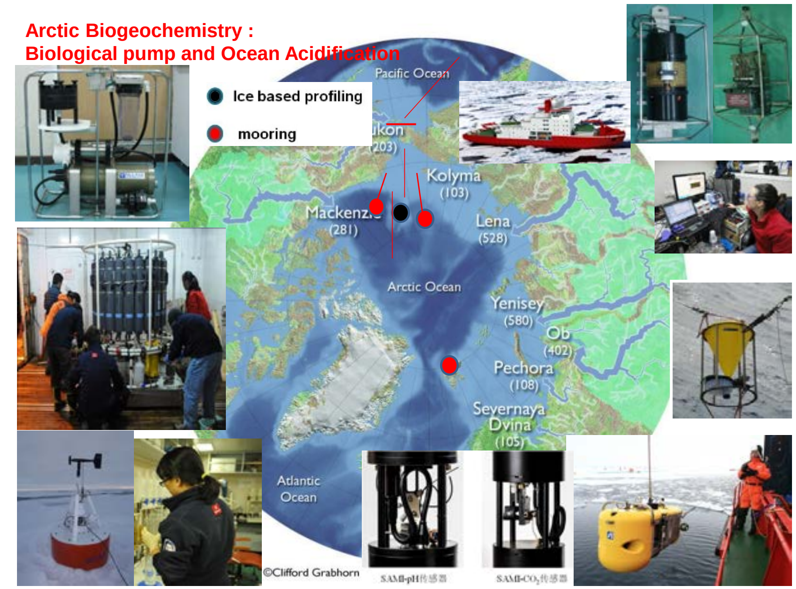
6th Chinese Arctic Research Expedition

7th Chinese Arctic Research Expedition

8th Chinese Arctic Research Expedition



9th Chinese Arctic Research Expedition



[Profiling, ocean/ice sampling]: Oxygen, chl-a, nutrients, POC, PN, $\delta^{13}C$, $\delta^{15}N$, BSi, Chl-a, pigments etc.

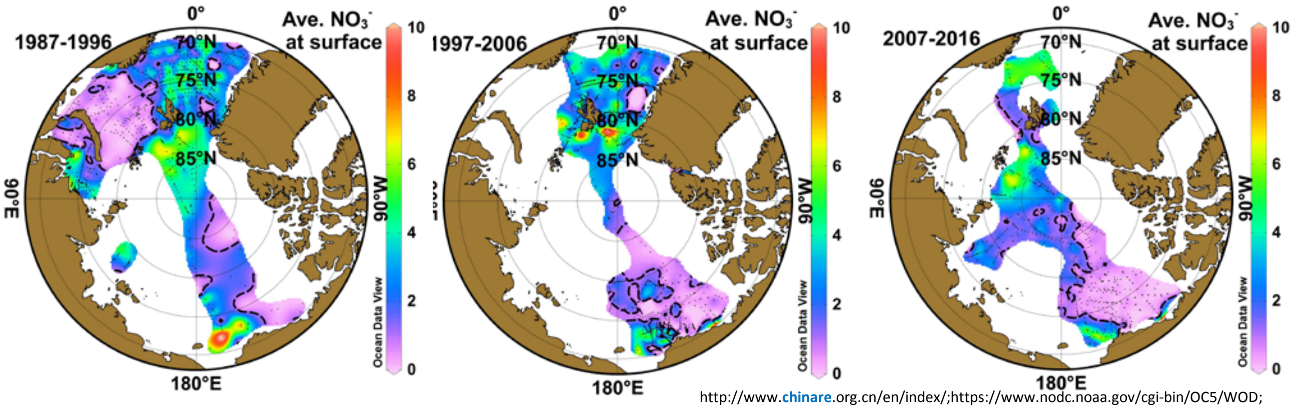
[Primary production]: carbon/nitrogen uptake, oxygen release

[Particle fluxes]: sediment traps,

Chinese Arctic Research Expedition since 1999

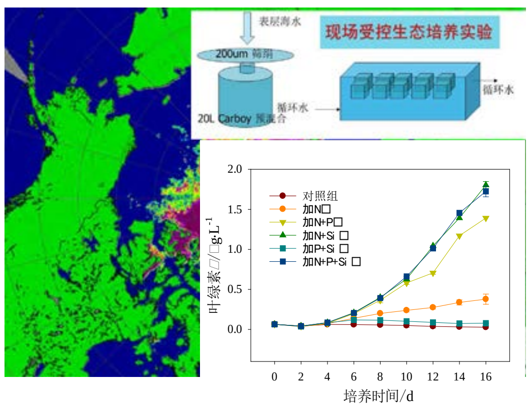
2.1 Enhanced biological pump, Oligotrophic trend in surface water and subsurface ocean acidification

N limitation in the Arctic Ocean

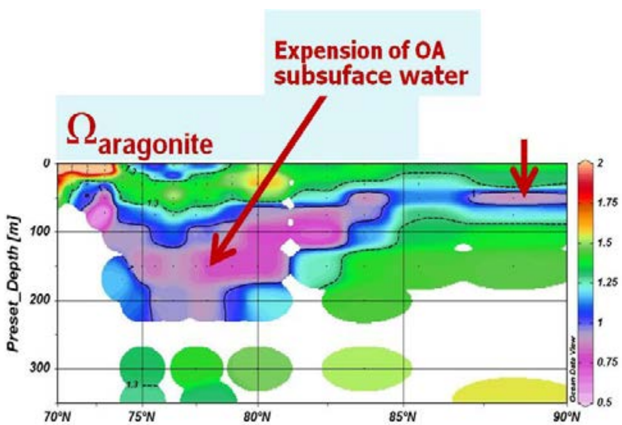


http://www.chinare.org.cn/en/index/;https://www.nodc.noaa.gov/cgi-bin/OC5/WOD; http://cdiac.ornl.gov/oceans/datmet.html ; http://manida.awi.de/

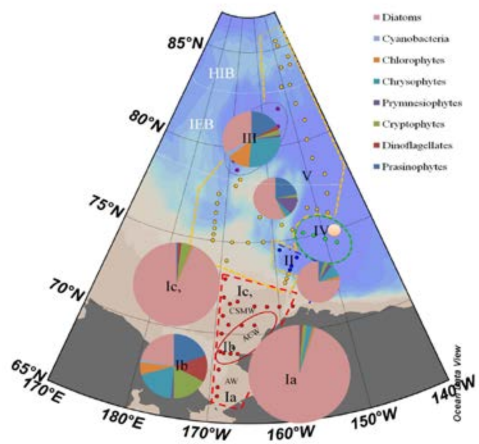
Average nitrate concentration (μM) of top 30 m water column in the Arctic Ocean, Zhuang et al., 2019 submitted



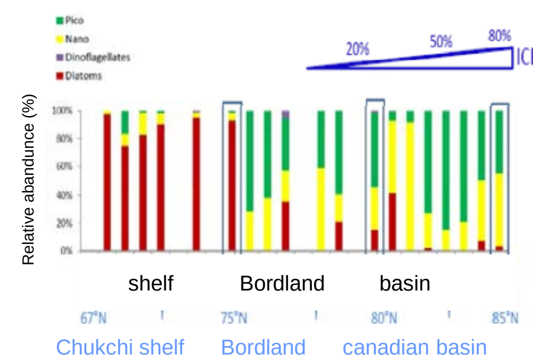
N limitation in the central Arctic, Li et al., AOS, 2014;



Expension of OA in subsurface water Qi et al., NCC2017;



Phytoplankton communities : pigment analysis

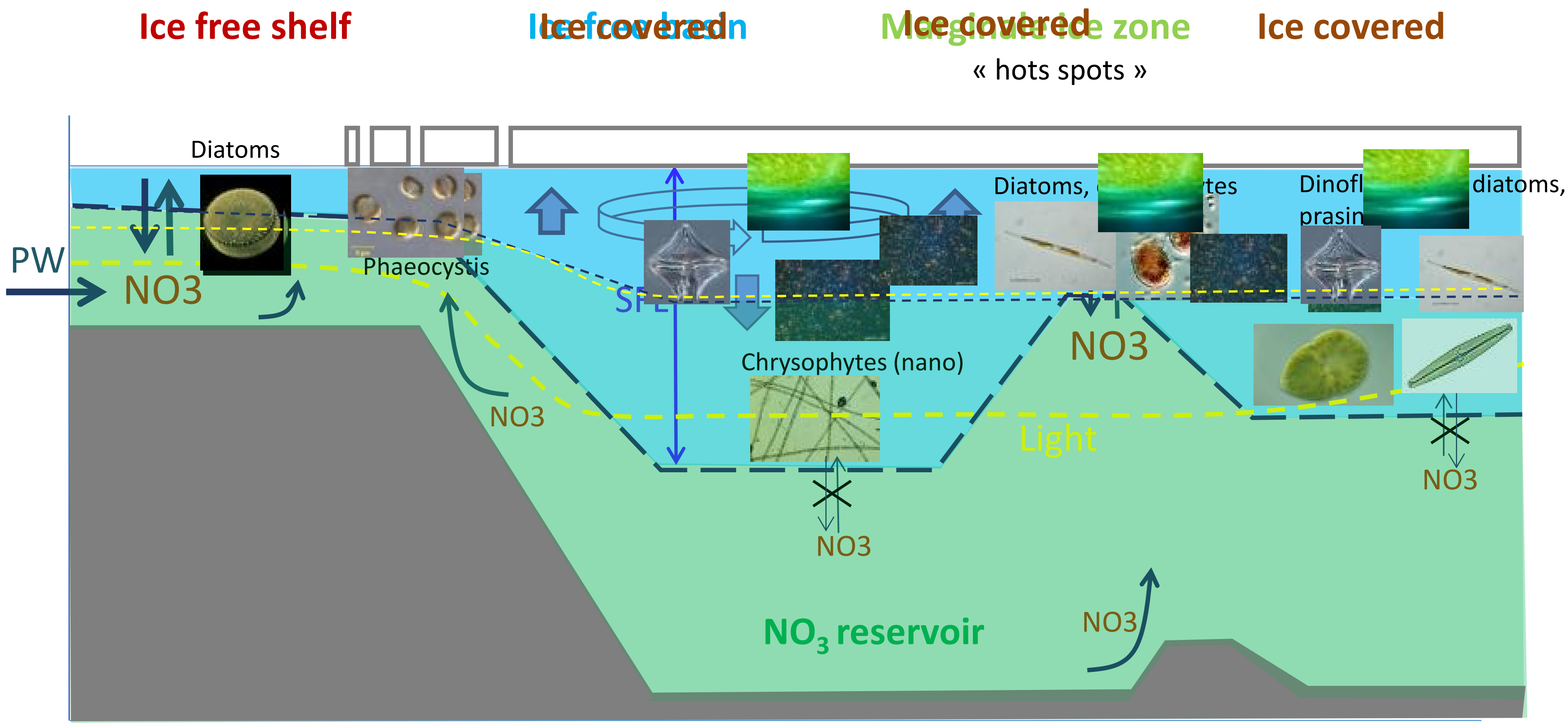


Couple et al., Biogeosciences,2012,2015;
Jin et al., AOS,2017;
Zhuang et al., Continental Shelf Research, 2016;
Zhuang et al., Deep Sea Research, 2018:
Zhuang et al., Polar Science, 2018

2.2 Conceptual view: impact of sea ice conditions on phytoplankton

After the ice retreat over the deep basins (1994)

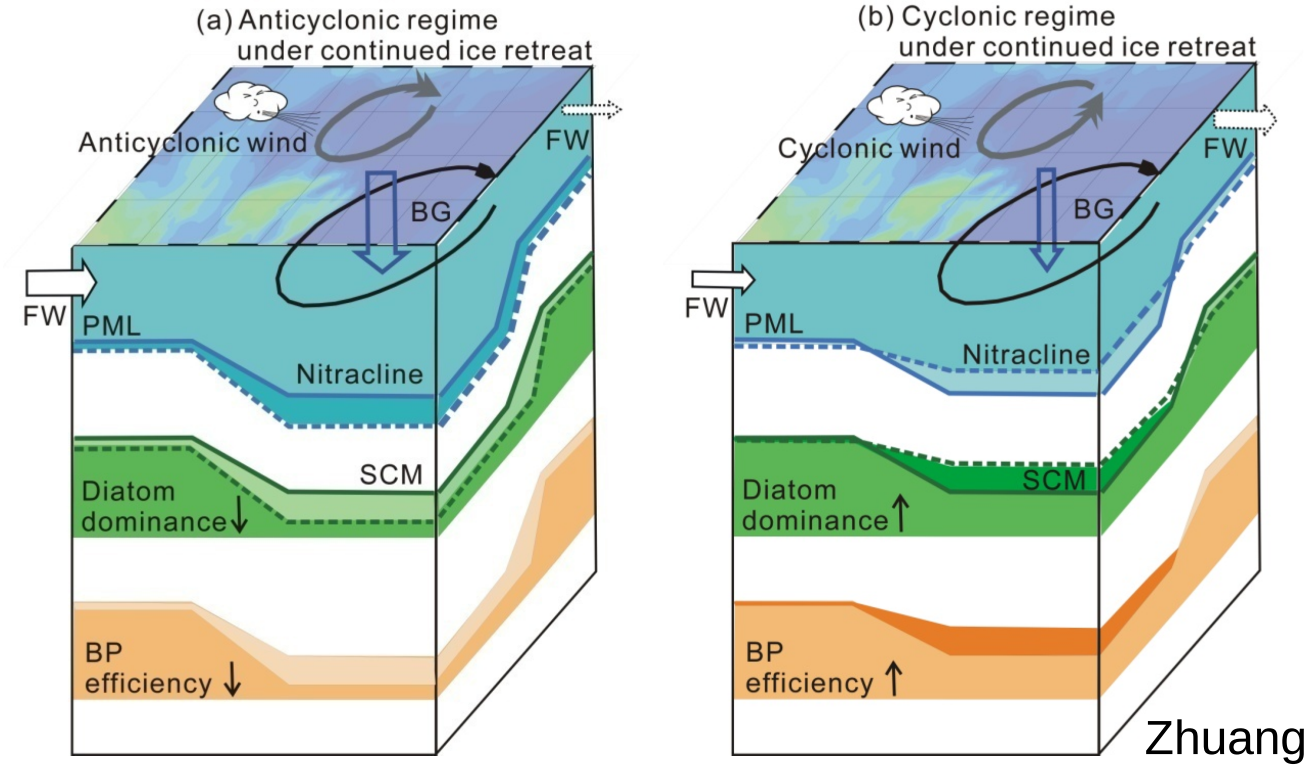
Before the ice retreat over the deep basins (1994)



- **Consequences of ice retreat**
  - **A more complex Ecosystem over the deep basins**
  - **Contrasted phytoplankton communities (species, size, depth)**
  - **Implications on carbon uptake ?**

P Couple et al., 2015

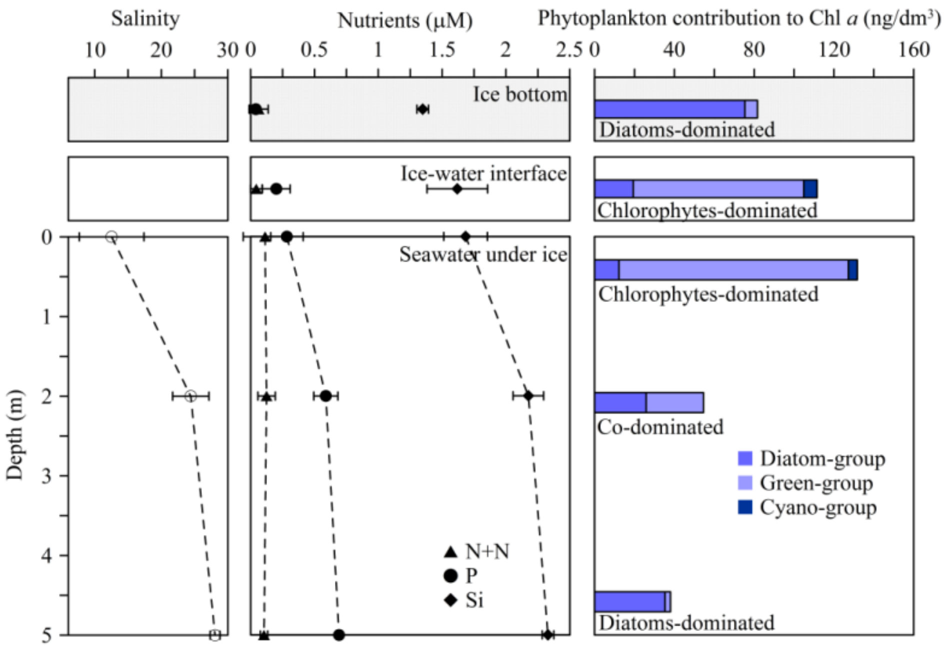
2.3.Biological carbon pump driven by the Beaufort Gyre in the western Arctic Ocean



Zhuang et al., 2018, DSR-1

Possible changes in nutrient concentration and phytoplankton composition under (a) anticyclonic and (b) cyclonic wind regimes. BG: Beaufort Gyre; FW: freshwater; PML: polar mixed layer; SCM: subsurface chlorophyll maximum; BP: biological pump. The solid/dashed lines indicate the present state and the expected change under different wind regimes, respectively. In the case that anticyclonic winds continue to dominate (a), the depths of the nitracline (blue line) and SCM (green line) would increase, and the dominance of diatoms and the efficiency of the BP would both decrease. These changes would be due to the stronger Ekman convergence and the addition of freshwater. In the case that the wind regime changes to cyclonic rotation (b), the depths of the nitracline and SCM would decrease, the diatom biomass would increase, and the efficiency of the BP would be enhanced.

2.4. Freshening impact on the phytoplankton dynamics in the central Arctic

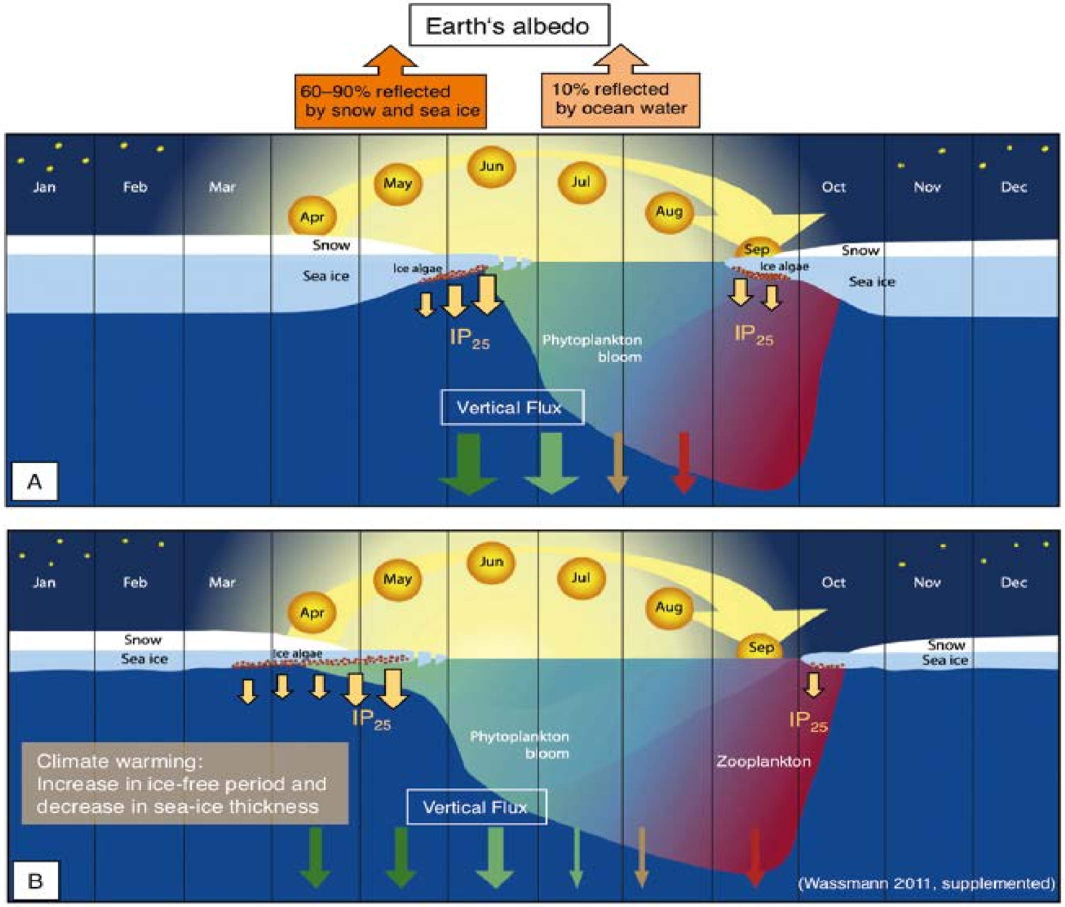


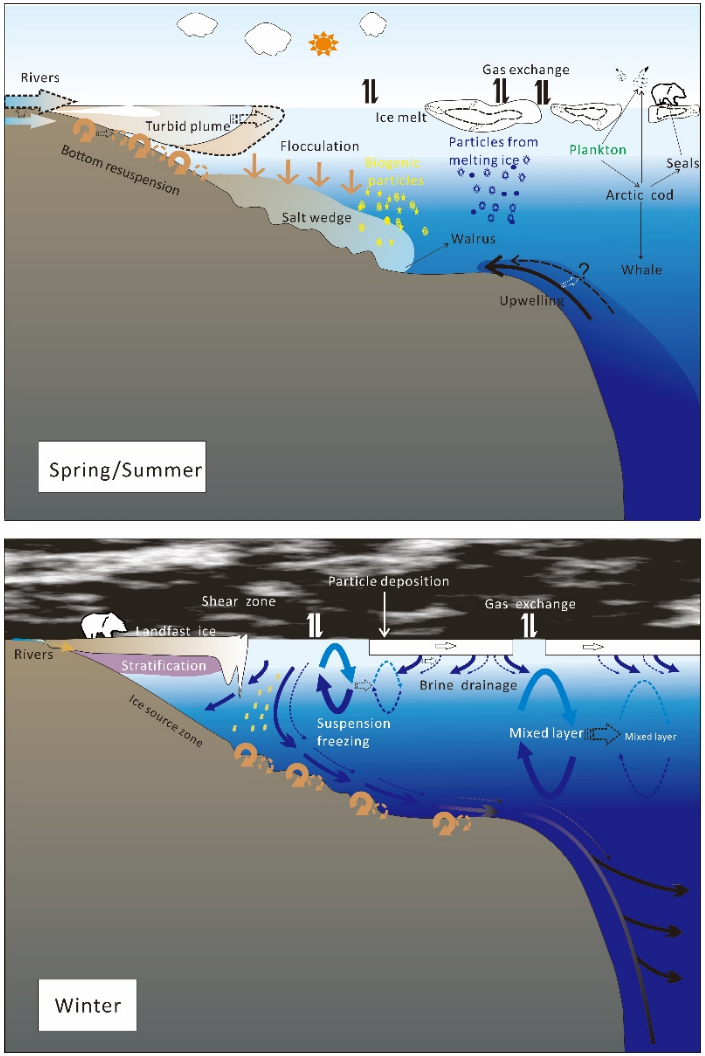
●A dramatic salinity gradient together with an alternation of dominant algae from chlorophytes to diatoms occurred at top 5 m of the seawater under ice in the high Arctic Ocean.

●Phytoplankton community in the surface layer under ice might become more chlorophytes in the future freshening Arctic Ocean.

Zhuang et al., 2017, AOS

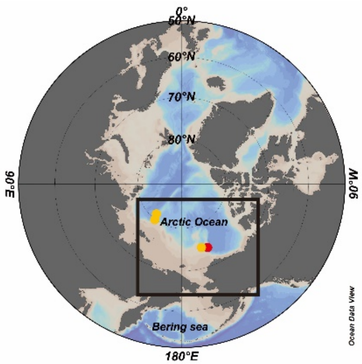
2.5.Carbon sink mechanism and processes in the Arctic Ocean

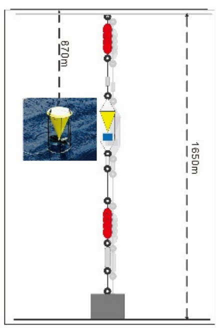


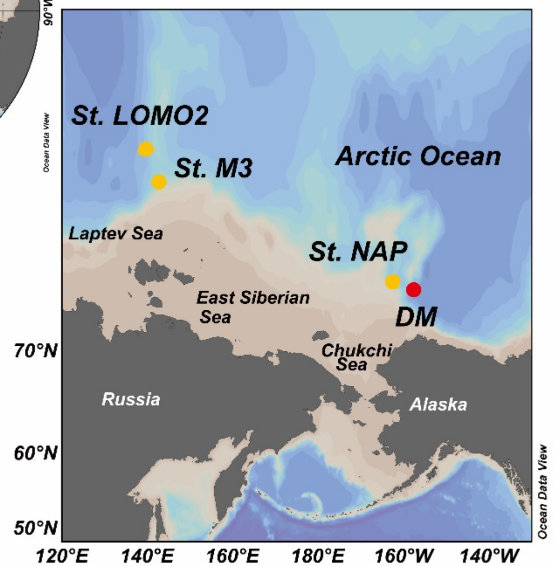


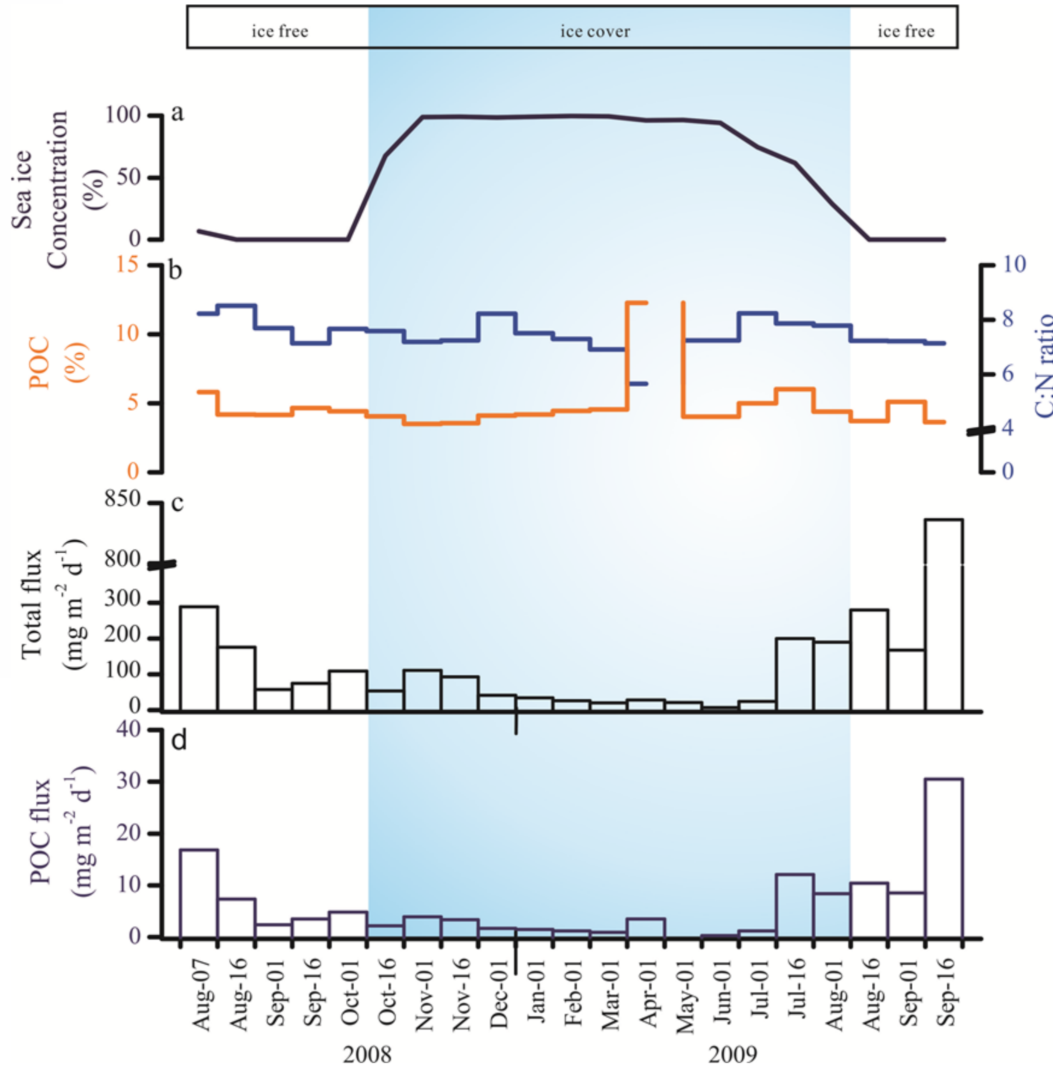
Chen et al., 2015

2.6. Carbon sink mechanism and processes in the Arctic Ocean-Sediment traps deployment



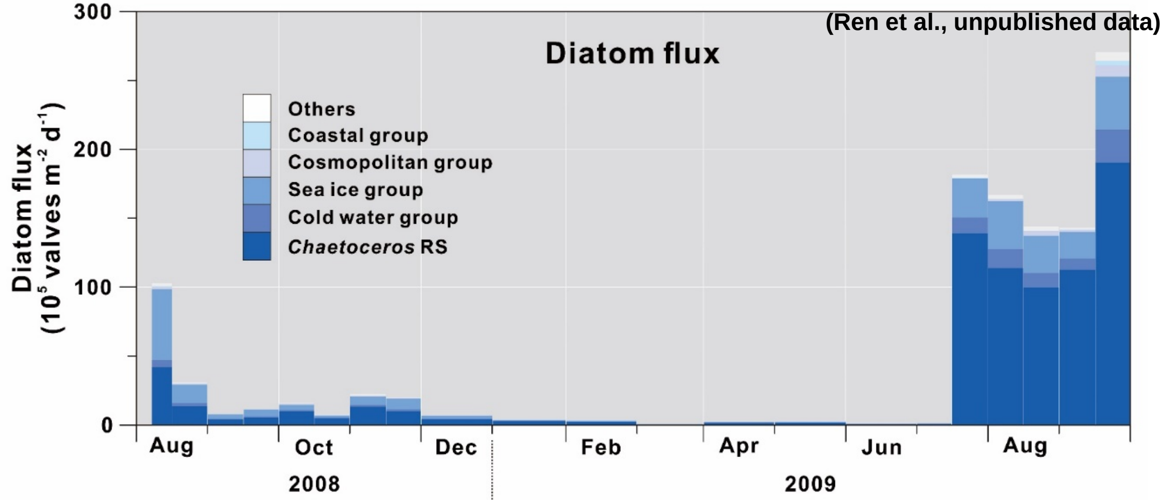


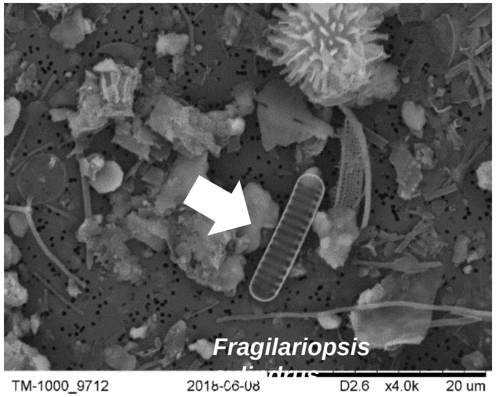


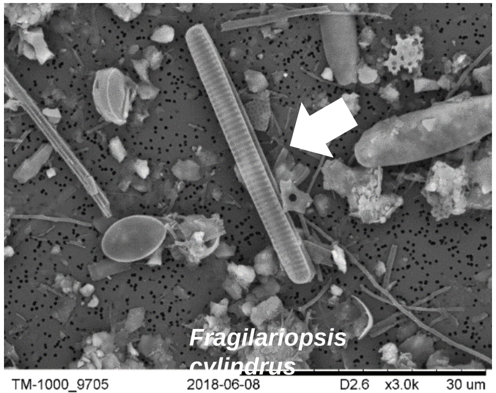


Bai & Chen et al., Progress in Oceanography, 2019

2.7. Diatom flux in western Arctic, 2008-2009

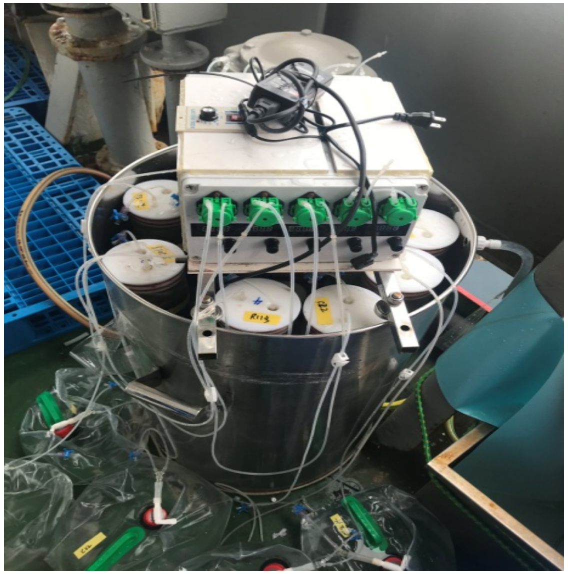






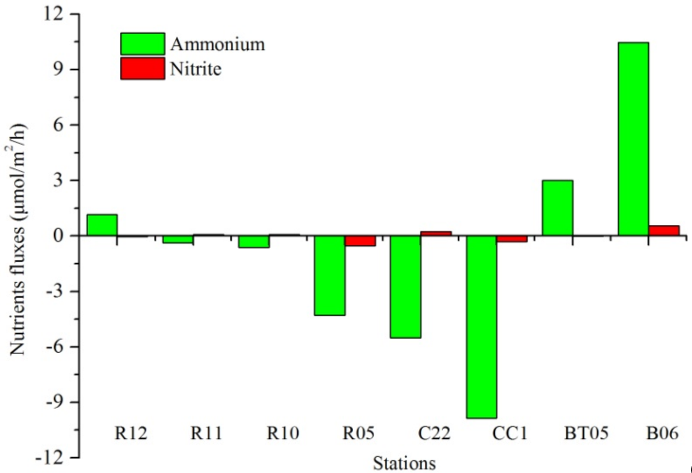
- *Chaetoceros* resting spores were the predominant species, which accounted for >40% of the diatom composition. The sea ice diatom group, including *Fossula arctic*, *Fragilariopsis cylindrus* and *F. oceanica*, dominated the rest diatom assemblage throughout the observing period.
- Higher diatom fluxes in summer 2009 were likely attributed to the interplay between weakened Beaufort Gyre, strengthened Pacific water inflow and distribution of the sea ice pattern.

2.8. Nutrients fluxes and nitrogen biogeochemical processes across the sediment-water interface in the Arctic shelf areas

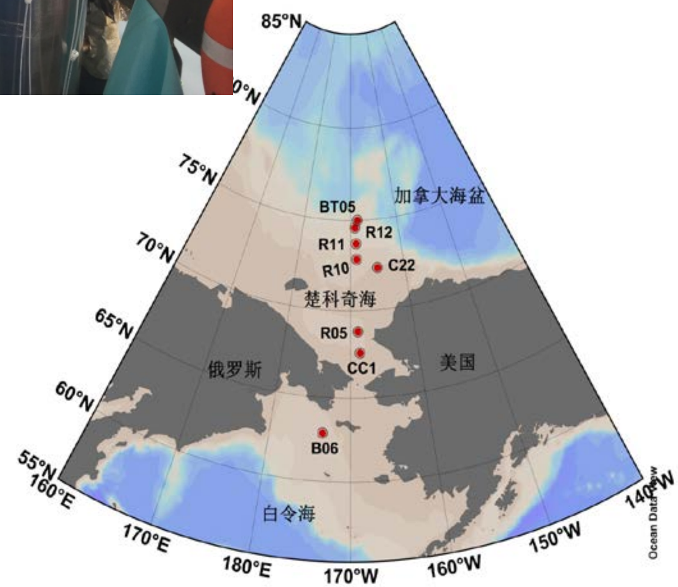


The sediment incubation equipment

Field sampling on “Xuelong” during the 9th Chinese Arctic Research Expedition

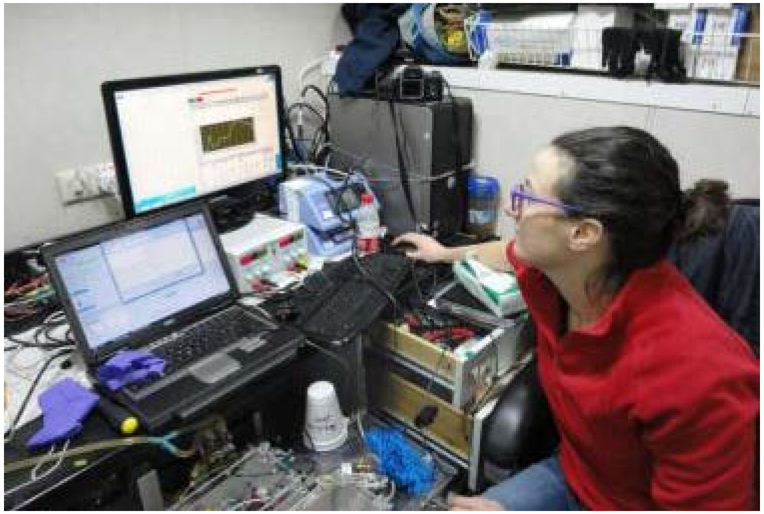


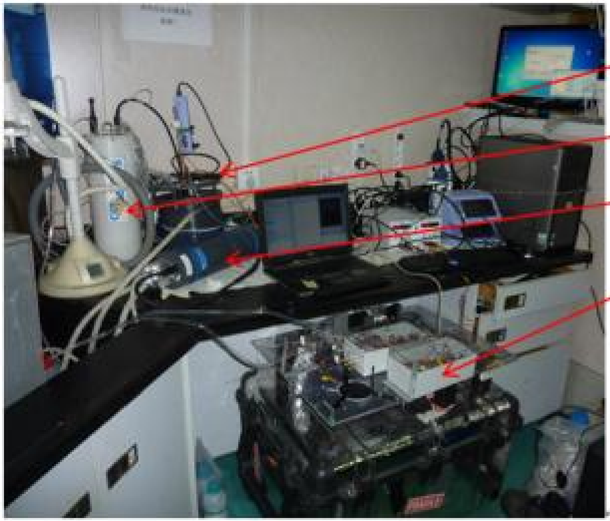
Inorganic nitrogen fluxes



Study area and sediment sampling locations

International cooperation



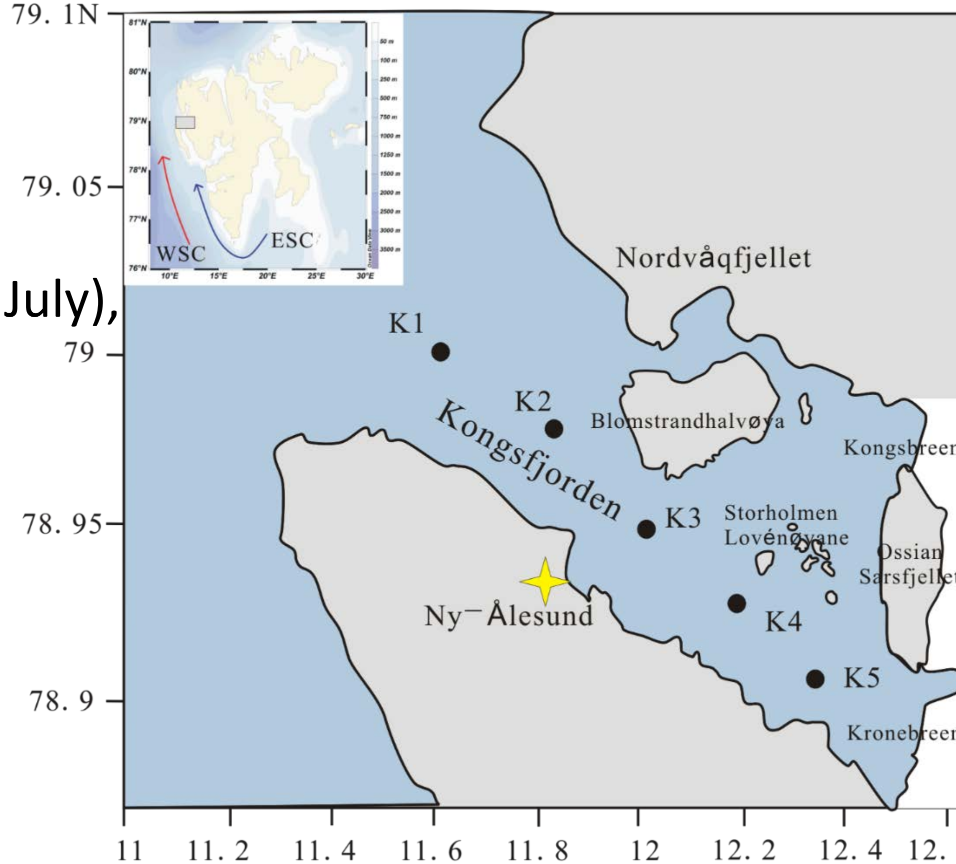


1) Bench top analyser from NOCS (Southampton, UK)
2) SP200-SM *In situ* sensor from SensorLabs® (Gran Canaria)
3) SeaFET® *In situ* sensor from Satlantic® (USA)
4) APASCHsw Bench top analyser (LOCEAN/IPGP, Paris)

3. Our Researches in the Svalbard

- 1.Regular expedition
- Data: Since 2006, summer cruise (every July), and spring cruise (May,2018-)

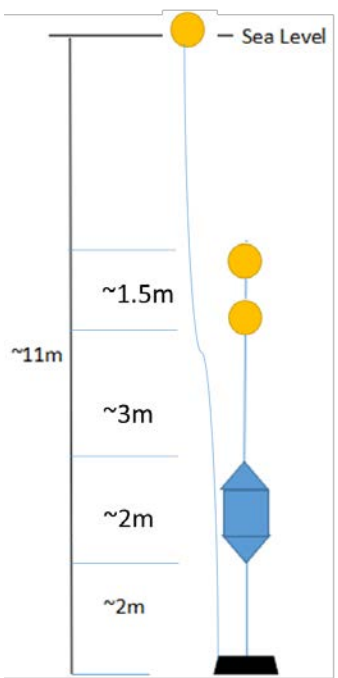
  (Nutriens, Chl a, Pigments etc.)
- Aim: Ecosystem of the Kongsfjord

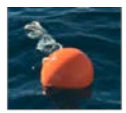


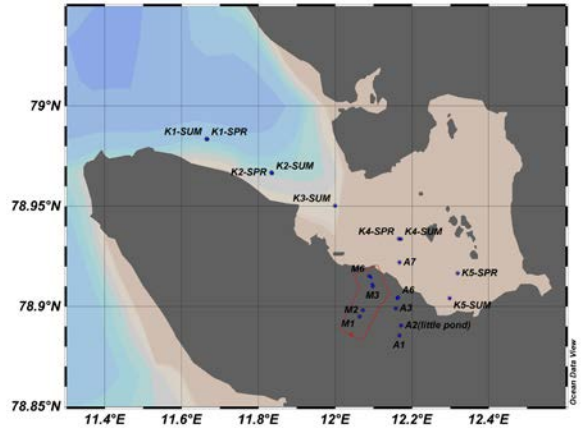
Ji & Jin et al., data not published

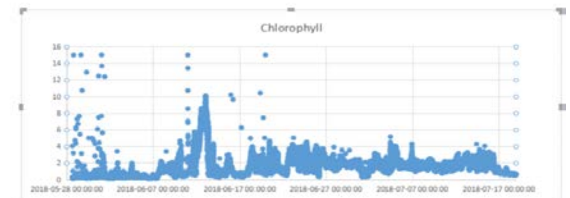
3. Our Researches in the Svalbard

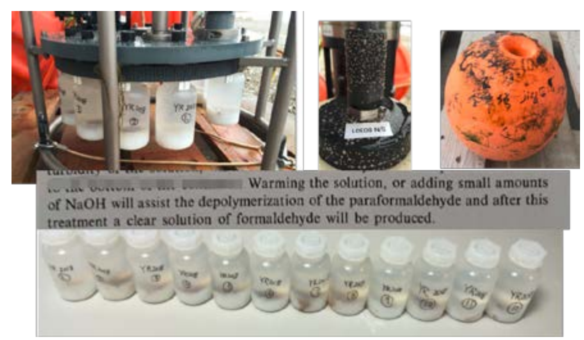
- 2. Time series Mooring
- Data: Since 2018, from May to July
  (CTD and a sediment trap)
- Aim: Effects of the riverine influx











Ji & Jin et al., data not published

4. Future Work

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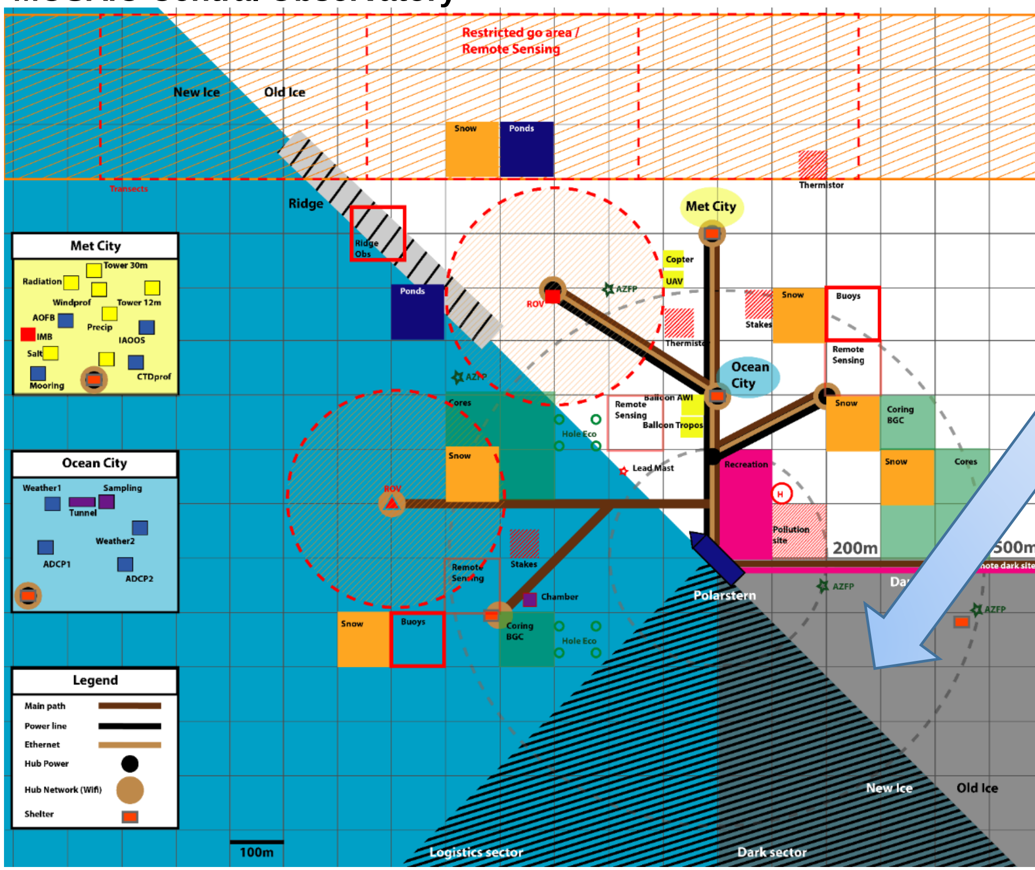
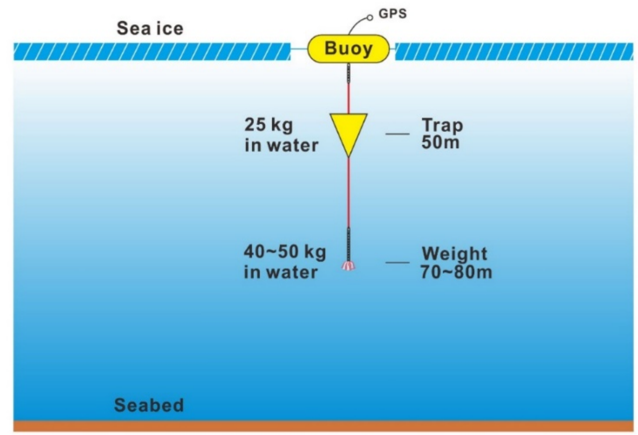
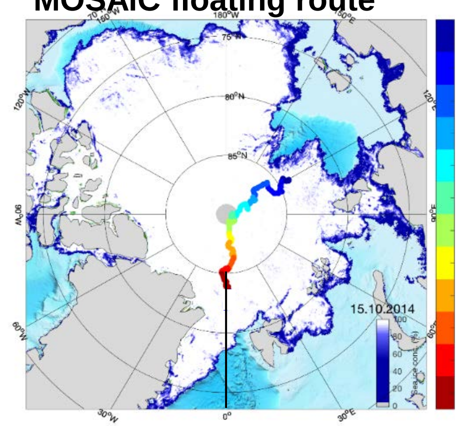
Sediment trap in MOSAiC, 2019-2020

MOSAiC Central Observatory





MOSAiC floating route



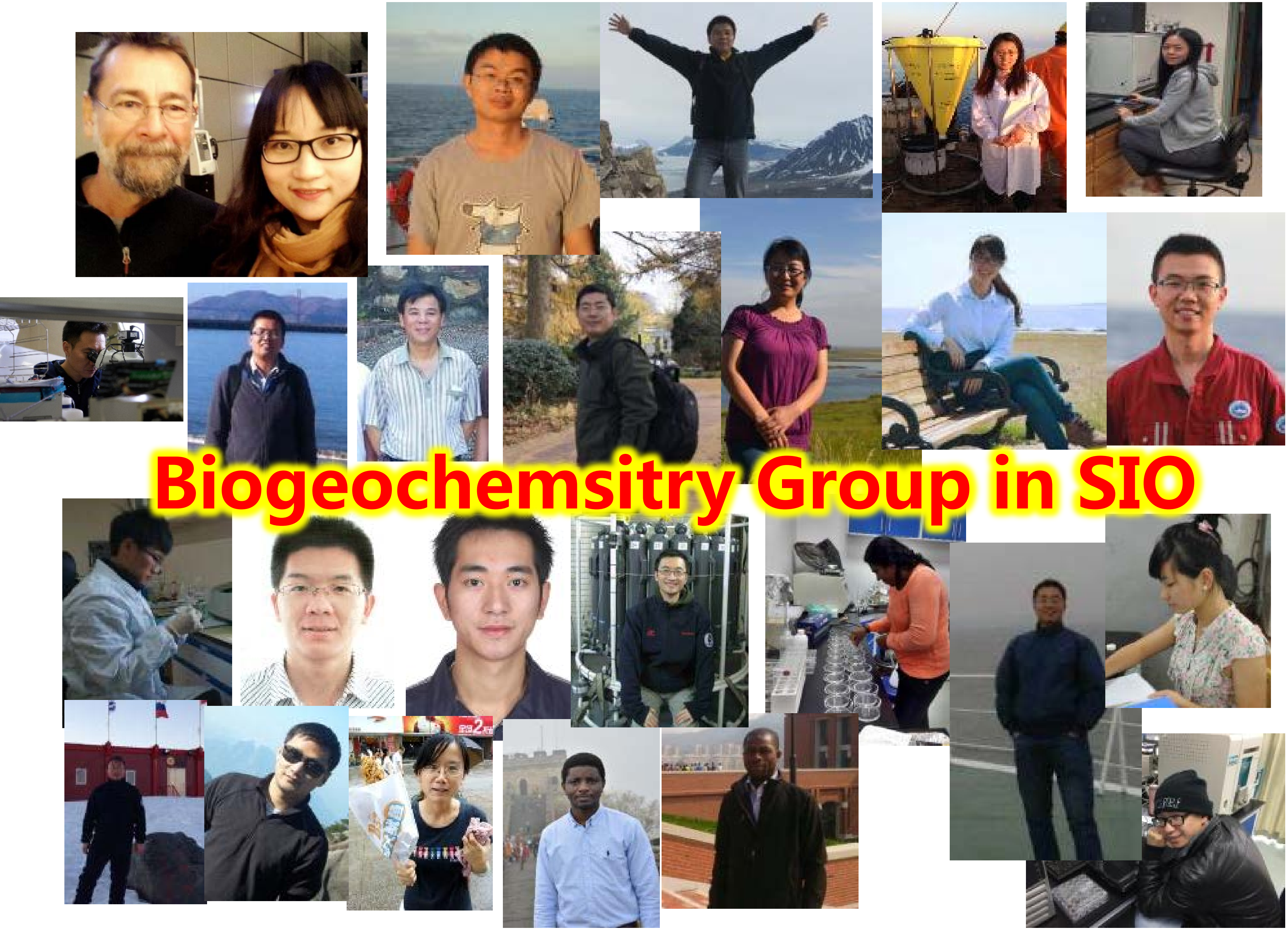
- Ice tethered sediment trap deployment during MOSAiC 2019-2020, floating from the central Arctic to the Atlantic.

MOSAiC International Arctic Drift Expedition

Summary

- Sea ice retreat leads to a more complex Ecosystem over the deep basins , Contrasted phytoplankton communities (species, size, depth) and a three-decade trend of declining nutrients in the Arctic Ocean.
- Higher total and diatom fluxes in summer 2009 were likely attributed to the interplay between weakened Beaufort Gyre, strengthened Pacific water inflow and distribution of the sea ice pattern


Thank you for your attention!
XUE LONG


Biogeochemsitry Group in SIO