

Ocean Acidification Observation Network for the Arctic and sub-Arctic Pacific Oceans

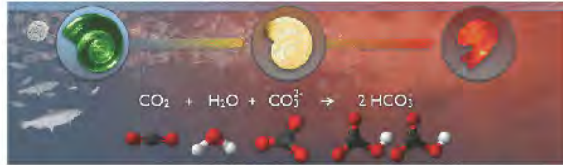
Liqi Chen

Key Lab of Global Change and Marine Atmospheric Chemistry(GCMAC),
Third Institute of Oceanography(TIO), SOA, PR China
E-mail: chenliqi@tio.org.cn

Outline

- Introduction
- Key regions in northern Pacific and Arctic Oceans as a Bellwether in the World Oceans' Acidification
- Chinese National Arctic Research Expedition(CHNARE)
- Initiate the Ocean Acidification Observing Network in the northern Pacific and Arctic Oceans (nPOA-ON)

GOA-ON and AMAP-AOA

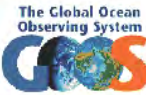
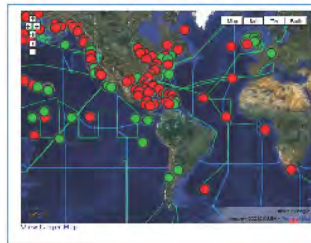


Toward a Global Ocean Acidification and Ecosystem Response Observing Network

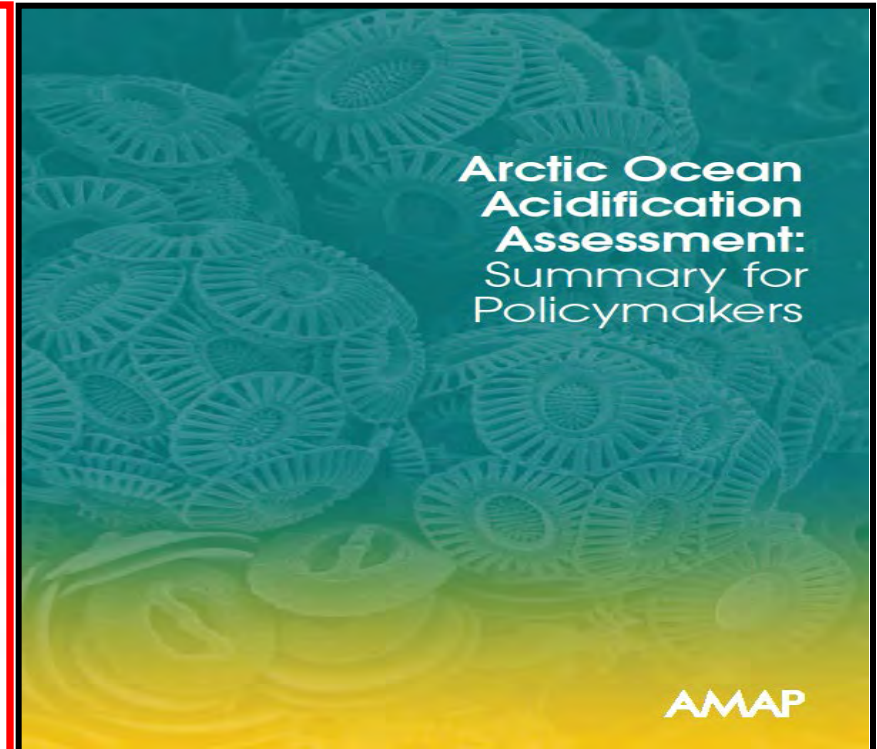
An international workshop held at the University of Washington
Seattle, WA, USA
26-28 June 2012

Sponsored by:

NOAA, IOCCP, GOOS, IOOS, and UW



GOA-ON: **G**lobal **O**cean **A**cidification and Ecosystem Response **O**bserving **N**etwork



AMAP-AOA: **A**rctic **M**onitoring **A**ssessment **P**rogram: **A**rctic **O**cean **A**cidification Assessment

Key region in the western Arctic Ocean

- Rapid sea ice retreating
- Fast expansion of aragonite undersaturation state in the Arctic Ocean

Sea Ice extent in recent years is dropping much more rapidly than previous years

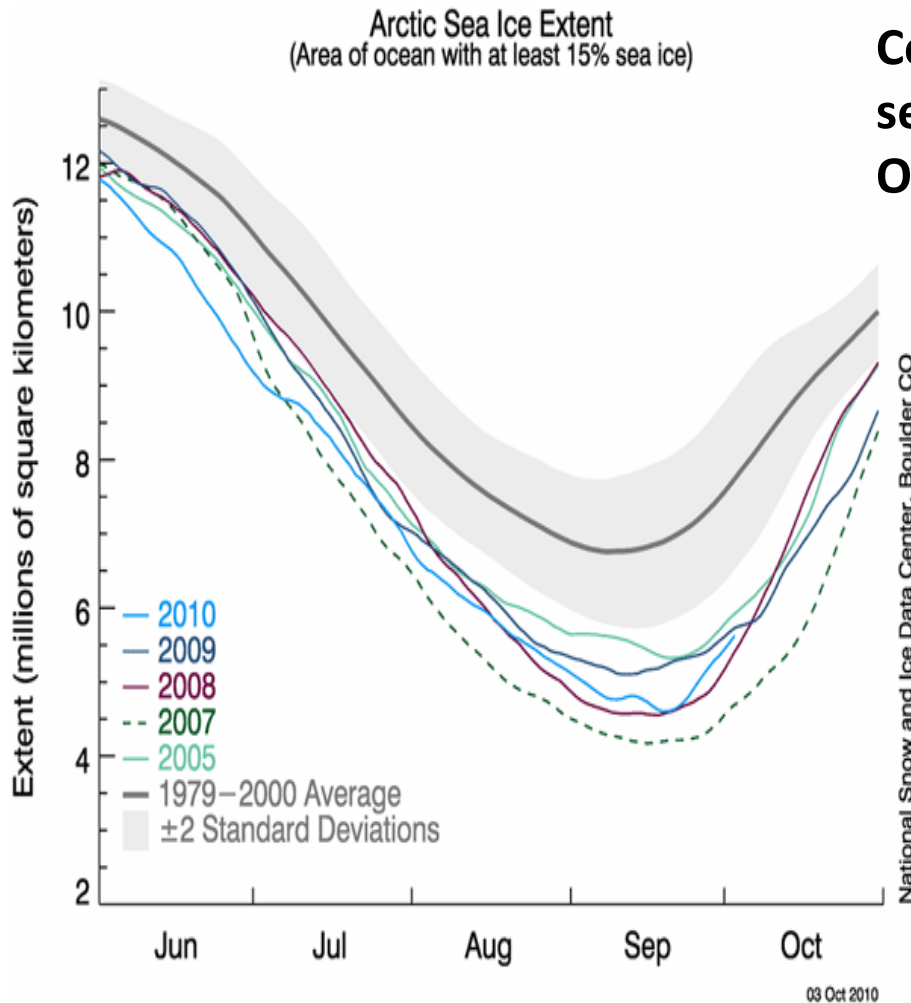
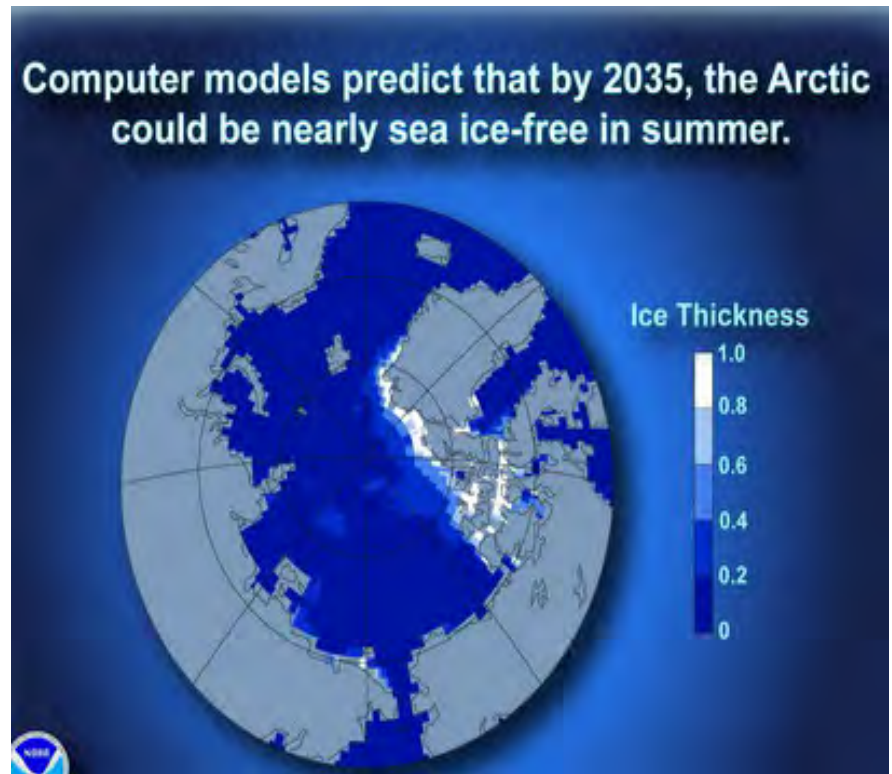


Photo: NSIDC

Computer models predict nearly **2035** sea **ice-free** in summer in the Arctic Ocean

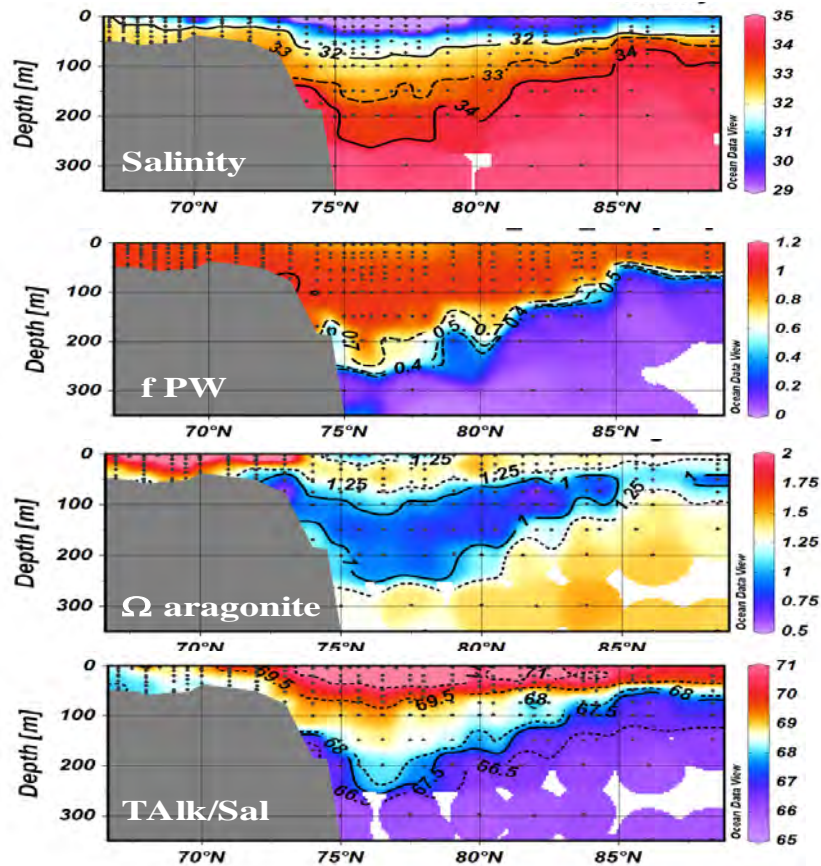
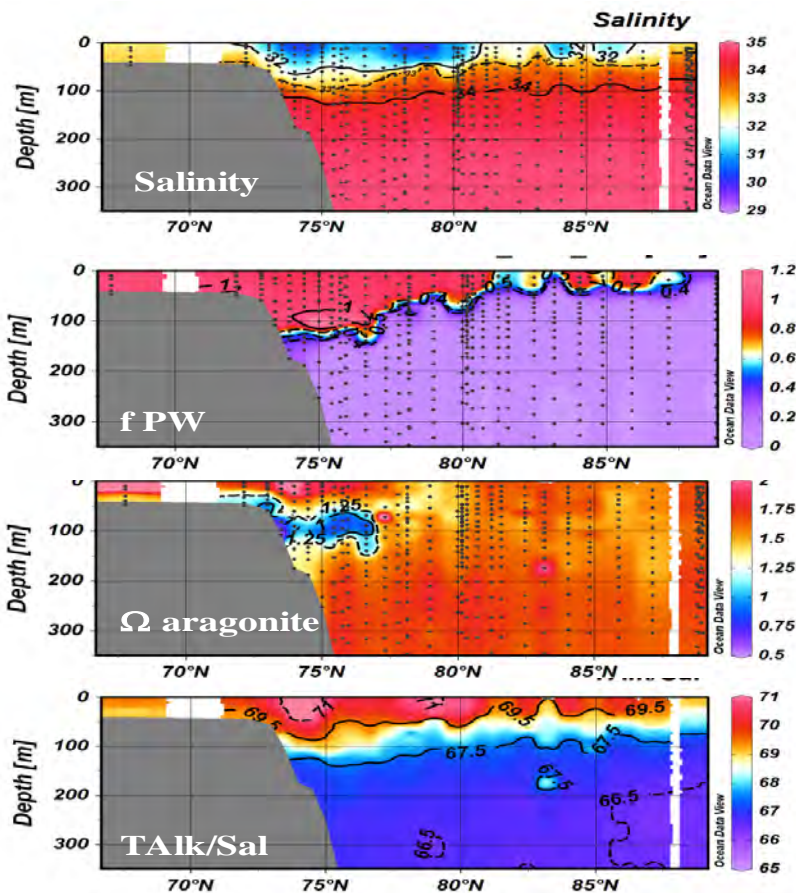


Wang and Overland, 2009

Latitudinal distributions of Ω aragonite, salinity, fraction of Pacific water and TAlk/Sal ratio in the upper 350 m along 170°W

1994

2010

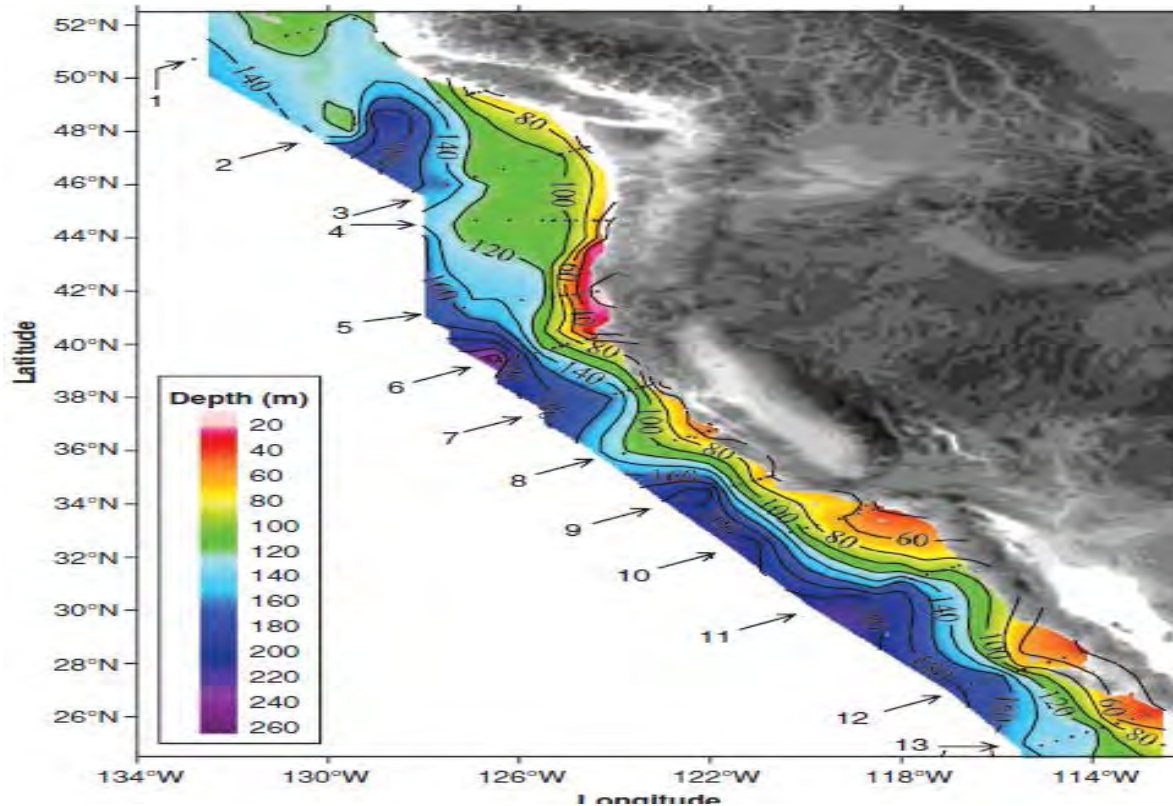


Qi et al., unpublished

Key region in the northern Pacific Ocean

- Corrosive and acidified Pacific water
- Shoaling of the aragonite and calcite saturation horizons from south to north in the Pacific

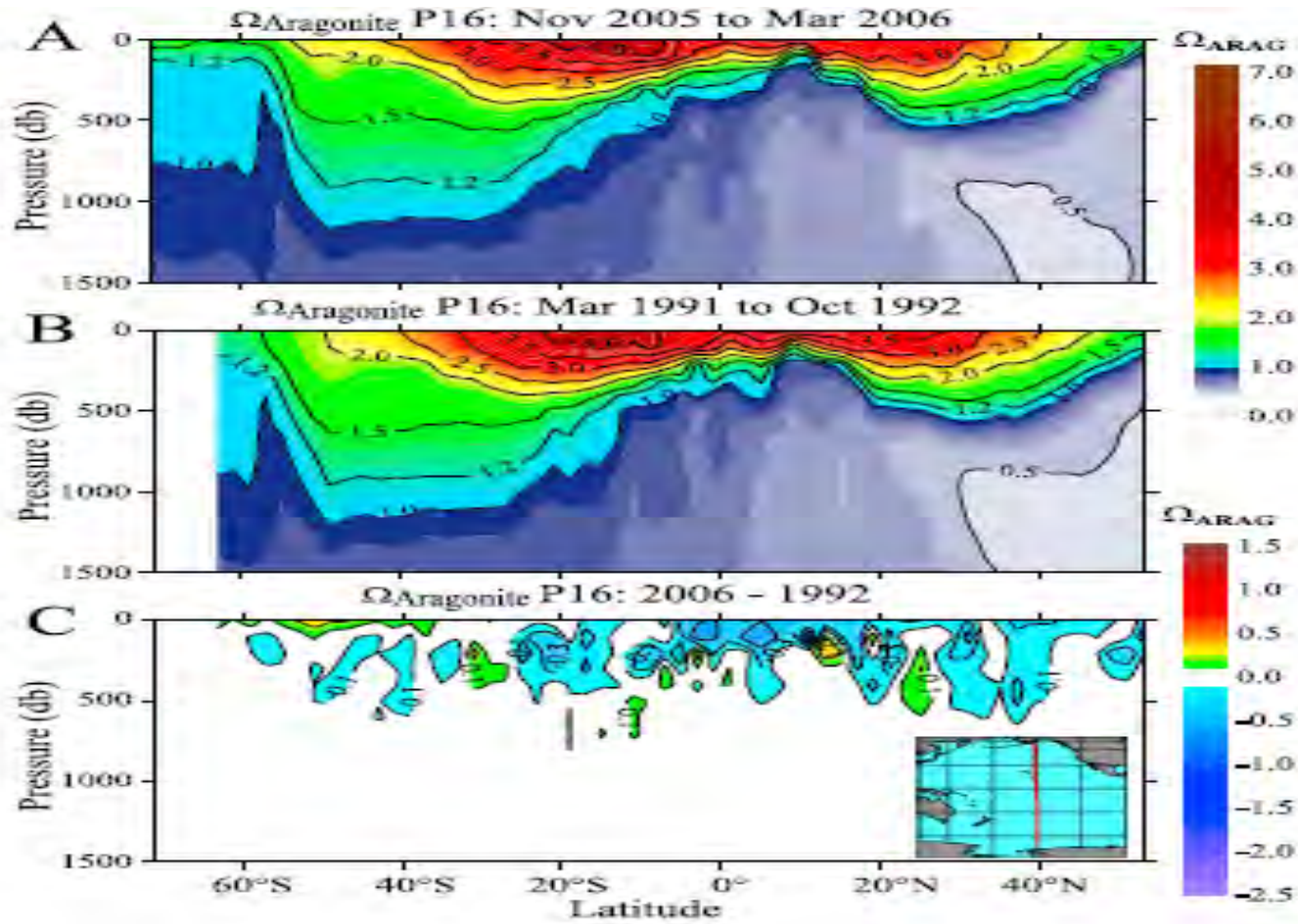
Distribution of the depths of the **undersaturated water** (aragonite saturation < 1.0 ; $\text{pH} < 7.75$) on the continental shelf of western North America from Queen Charlotte Sound, Canada, to San Gregorio Baja California Sur, Mexico



On transect line 5, the **corrosive water** reaches **all the way to the surface** in the inshore waters near the coast. The black dots represent station locations.

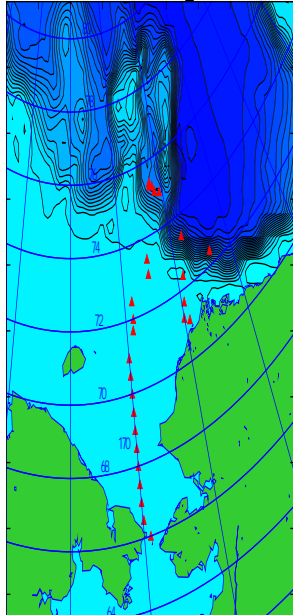
Feely et al., Science, 2009

Aragonite saturation state for (a) (Ω_{arag}) for 2005/06, (b) 1991/02, and (c) Ω_{arag} difference (2005/06–1991/02) along the P16 section from Antarctica to Alaska

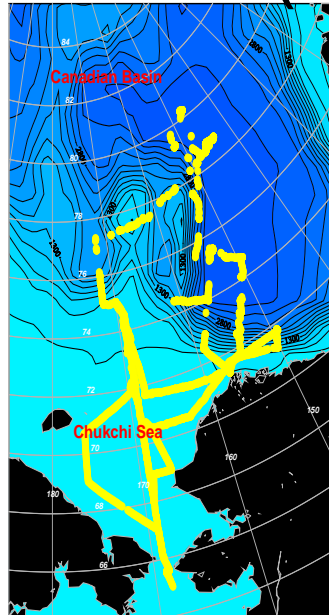


Chinese National Arctic Research Expeditions (CHINARE-Arctic)

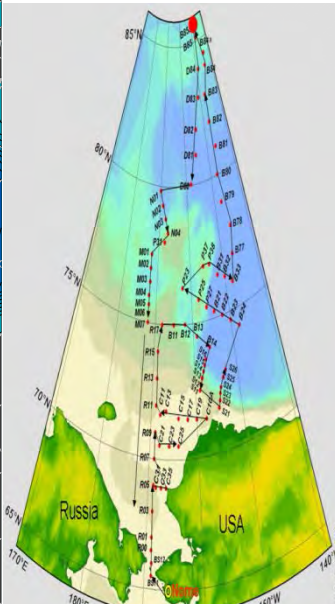
Chinese National Arctic Research Expedition (CHINARE-Arctic)-First to Sixth



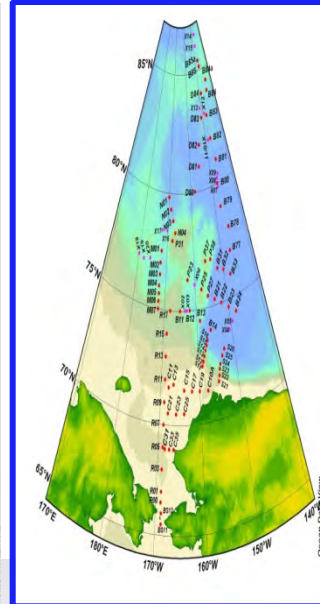
1999



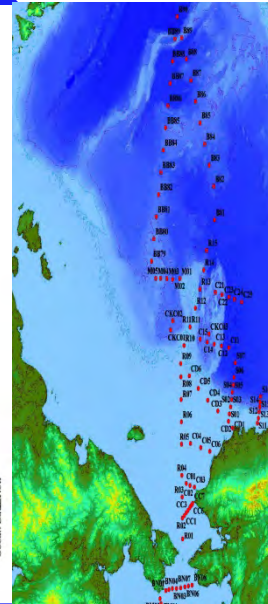
2003



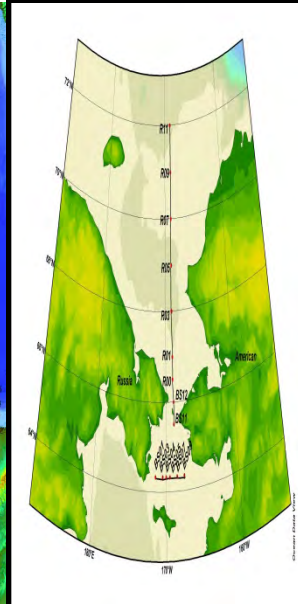
2008



2010



2012



2014

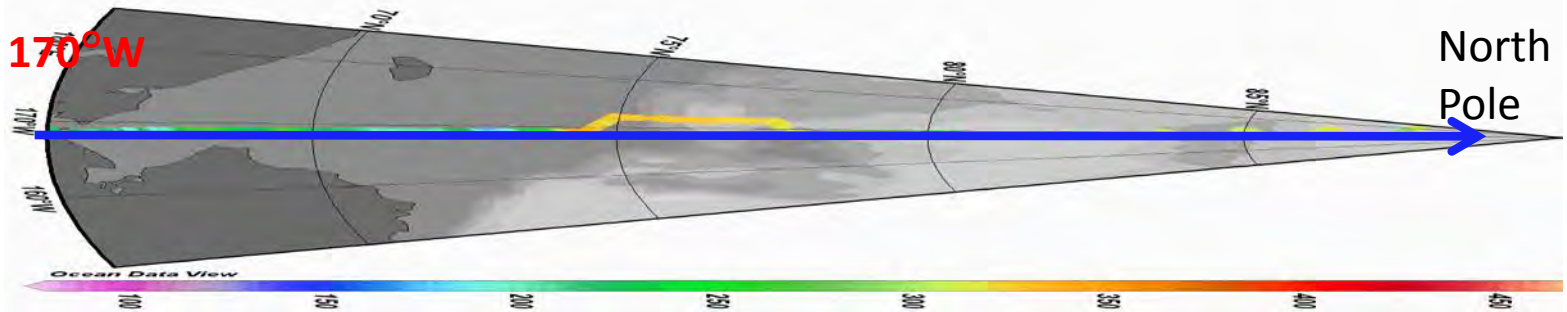


$p\text{CO}_2$ Latitudinal Distribution in the west Arctic Ocean along section 170° W

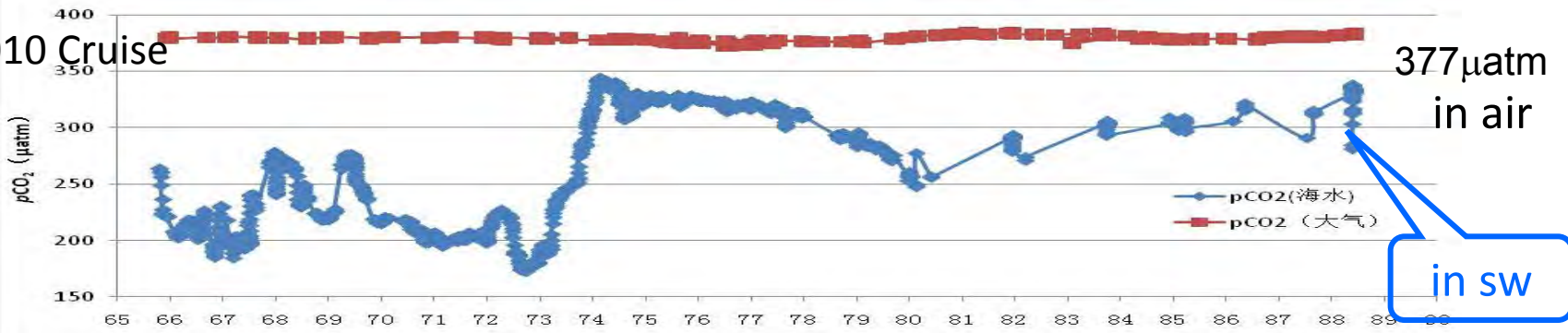
Section 170° W

Bering Strait

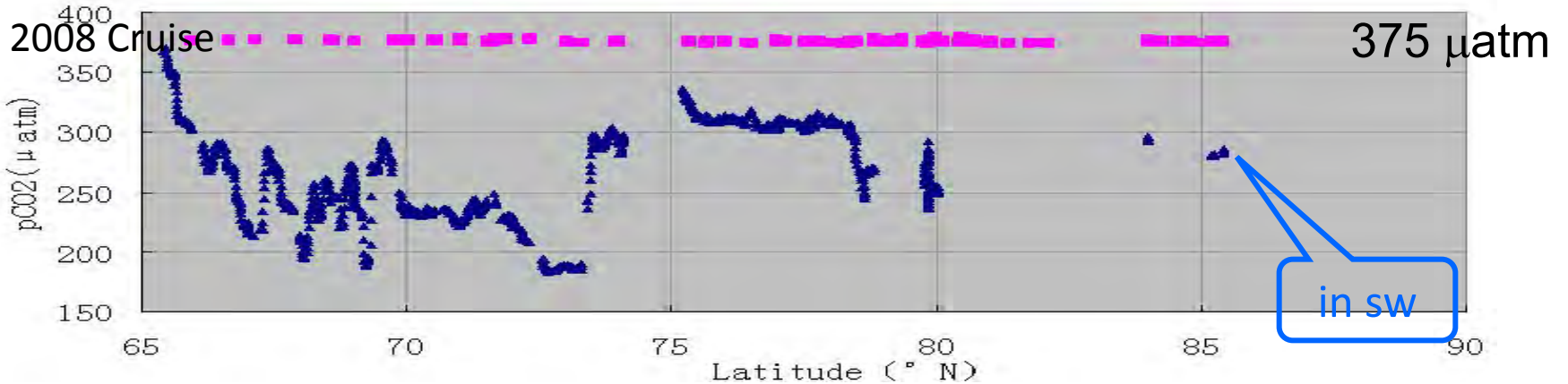
North Pole



2010 Cruise

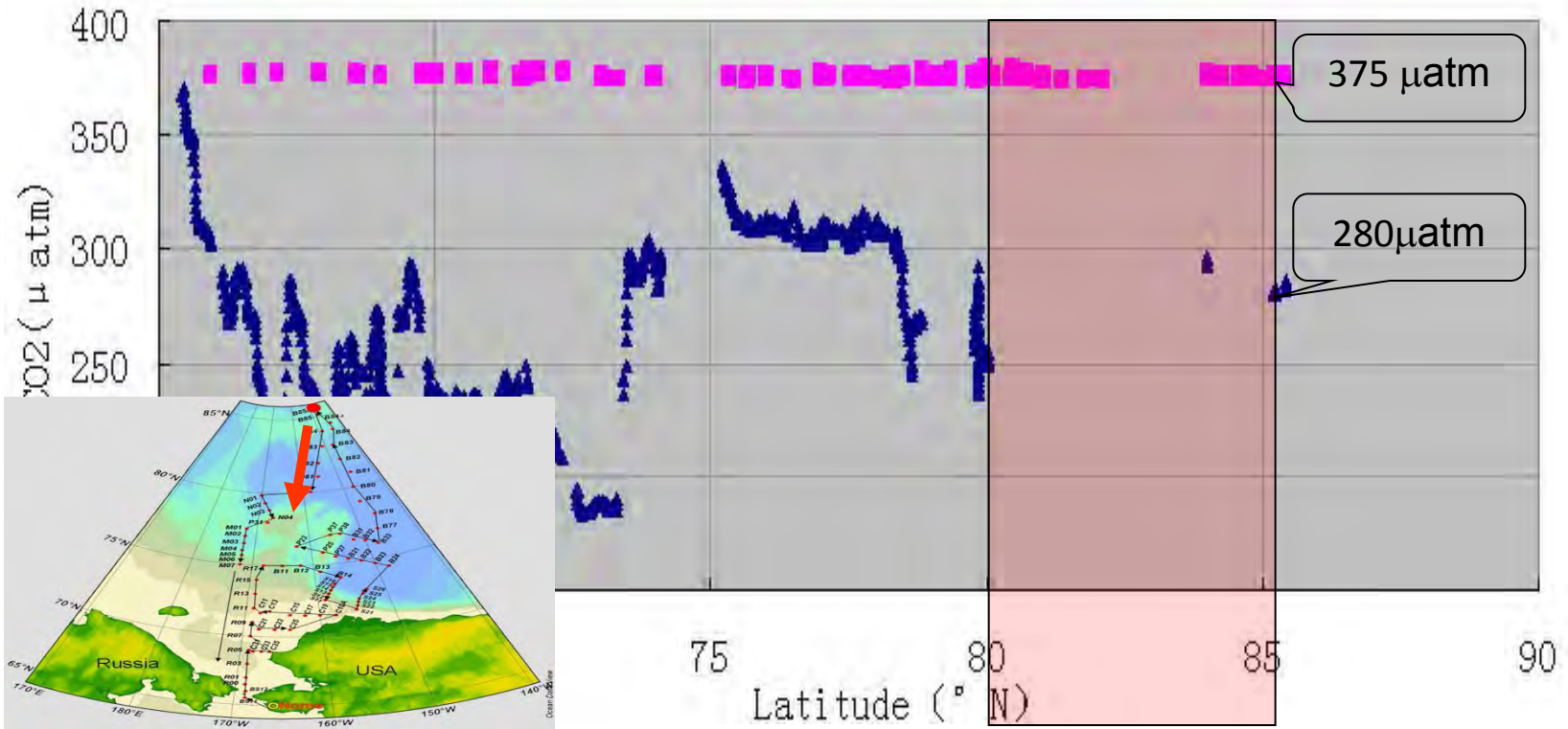


2008 Cruise



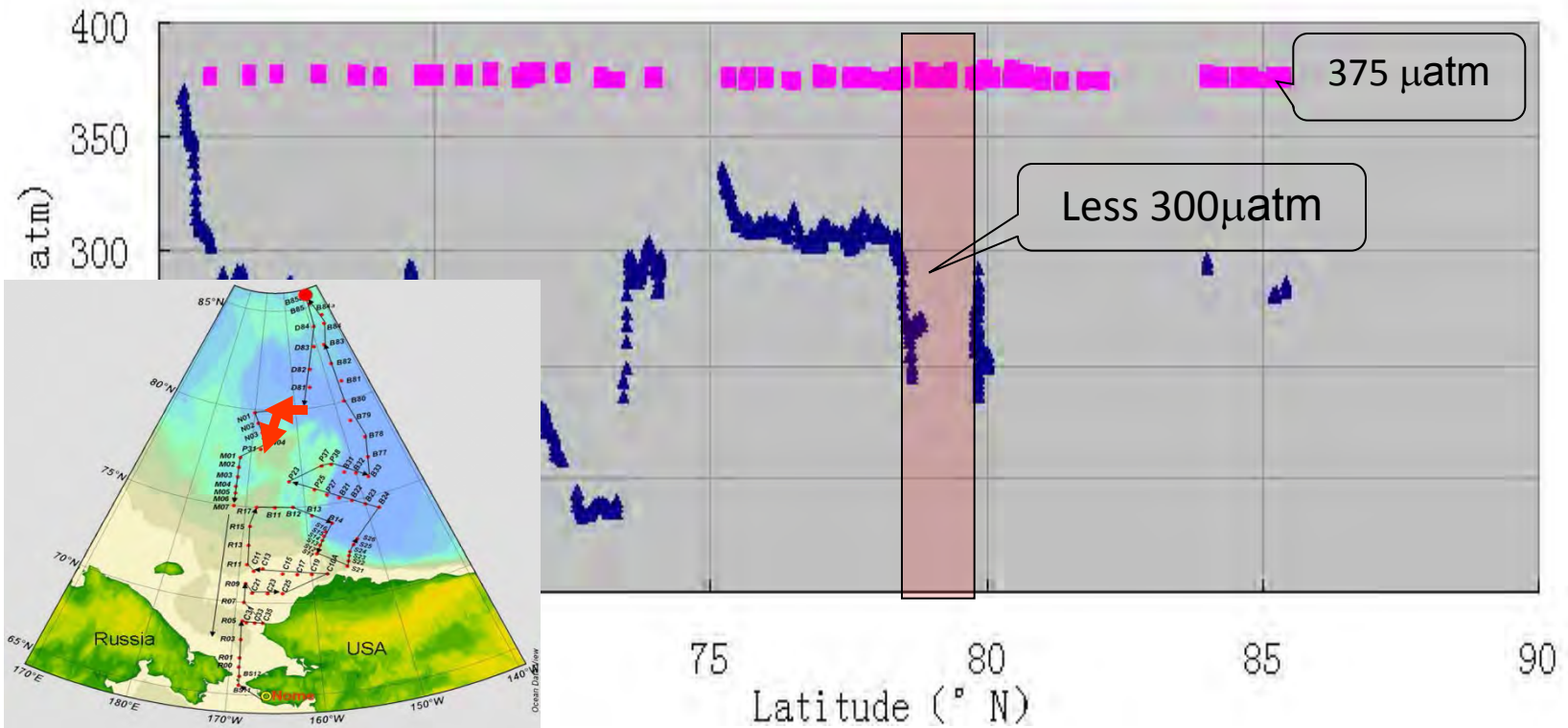
pCO₂ in Canada Basin under ice cover

Variations of surface pCO₂ between 29 Aug to 9 Sep, 2008 in western Arctic Ocean



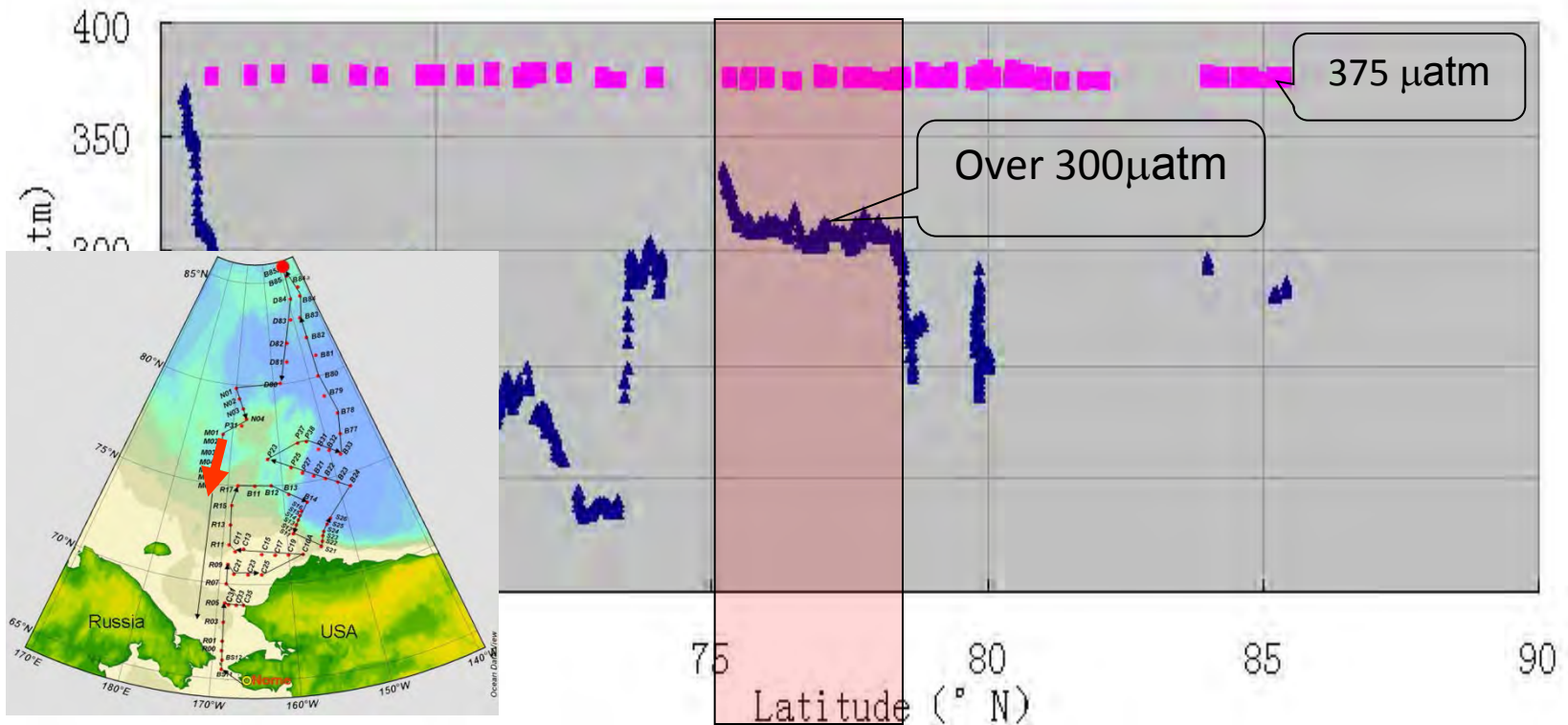
pCO₂ in Canada Basin with pack ice

Variations of surface pCO₂ between 29 Aug to 9 Sep, 2008 in western Arctic Ocean



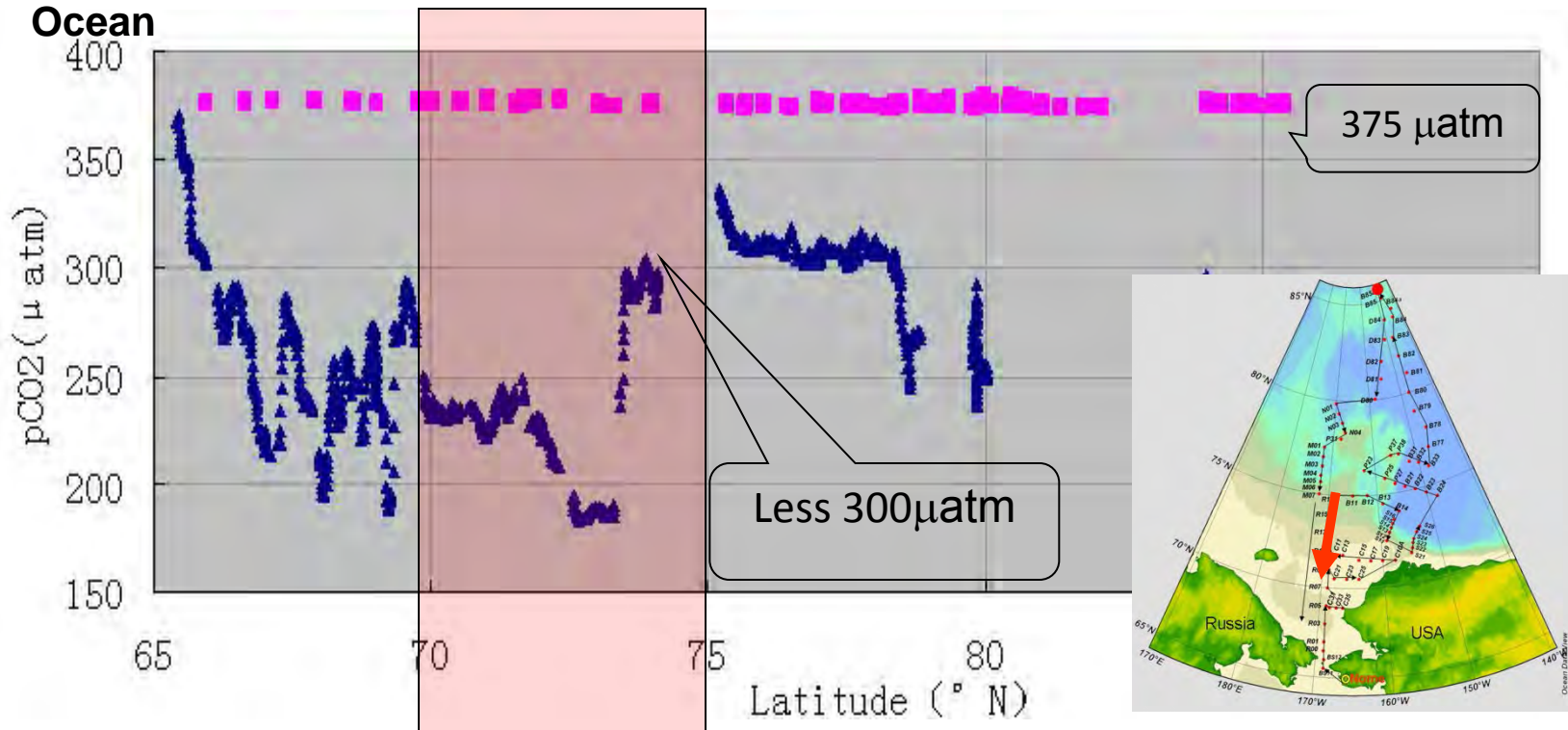
pCO₂ in Canada Basin with a prolong open water

Variations of surface pCO₂ between 29 Aug to 9 Sep, 2008 in western Arctic Ocean



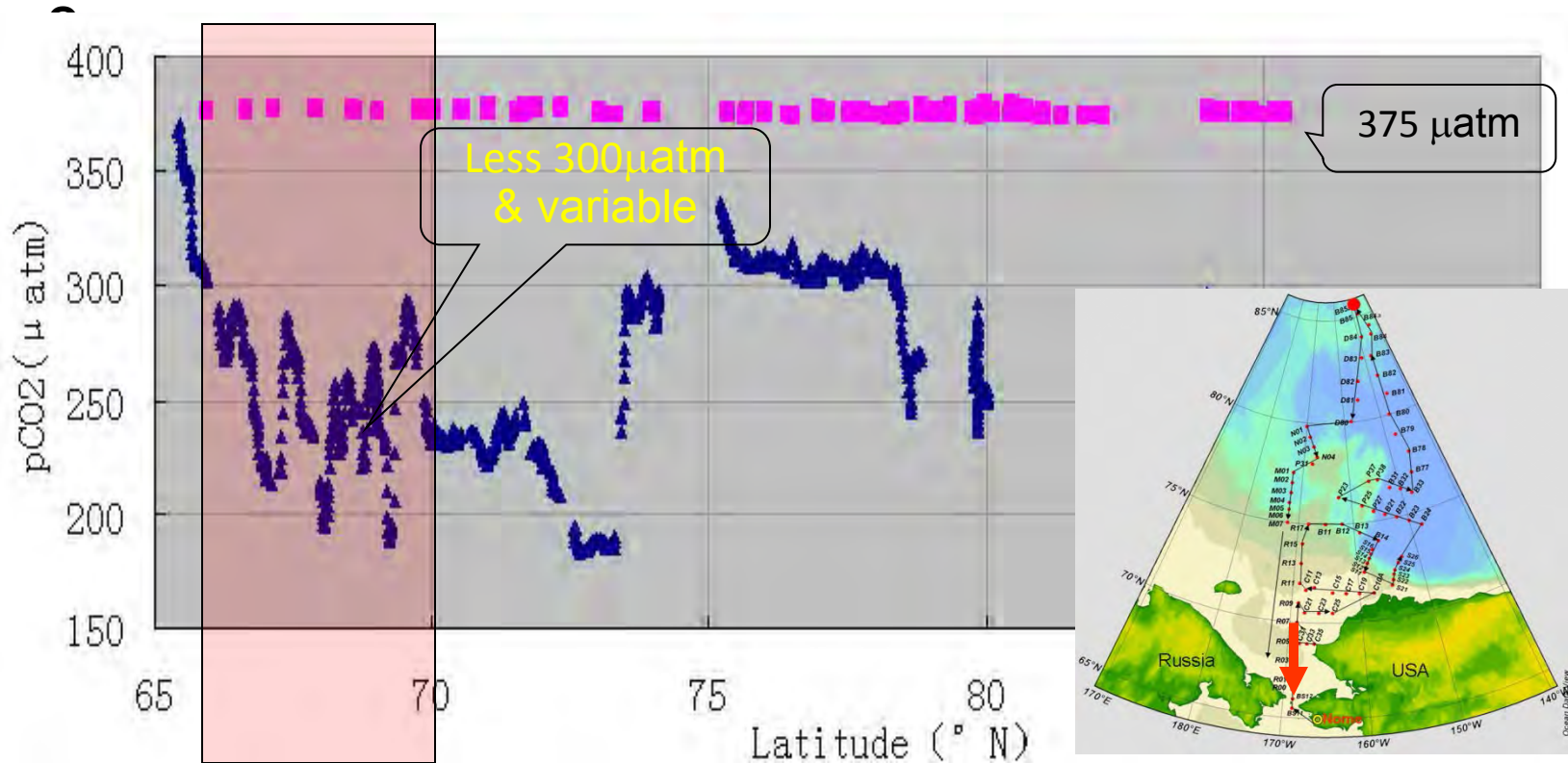
pCO₂ in a marginal water

Variations of surface pCO₂ between 29 Aug to 9 Sep, 2008 in western Arctic Ocean



Bering water influencing area

Variations of surface pCO₂ between 29 Aug to 9 Sep, 2008 in western Arctic

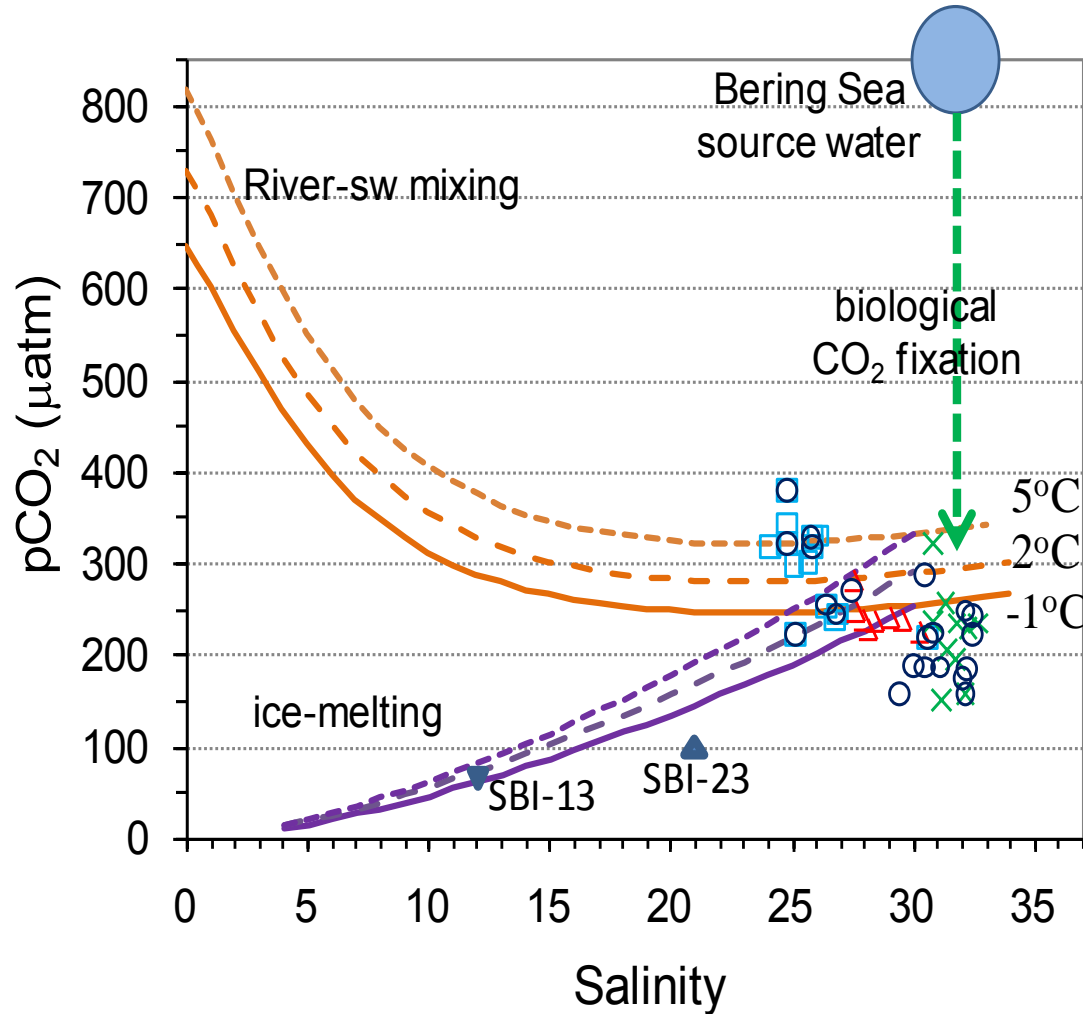


Pink dot line in air

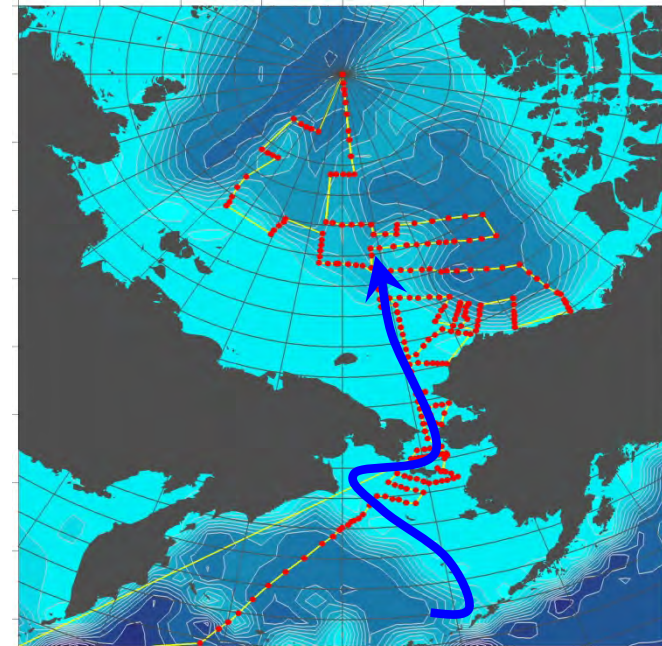
Blue line: in surface water

Major controlling mechanisms
for surface $p\text{CO}_2$ changes in the
western Arctic Ocean

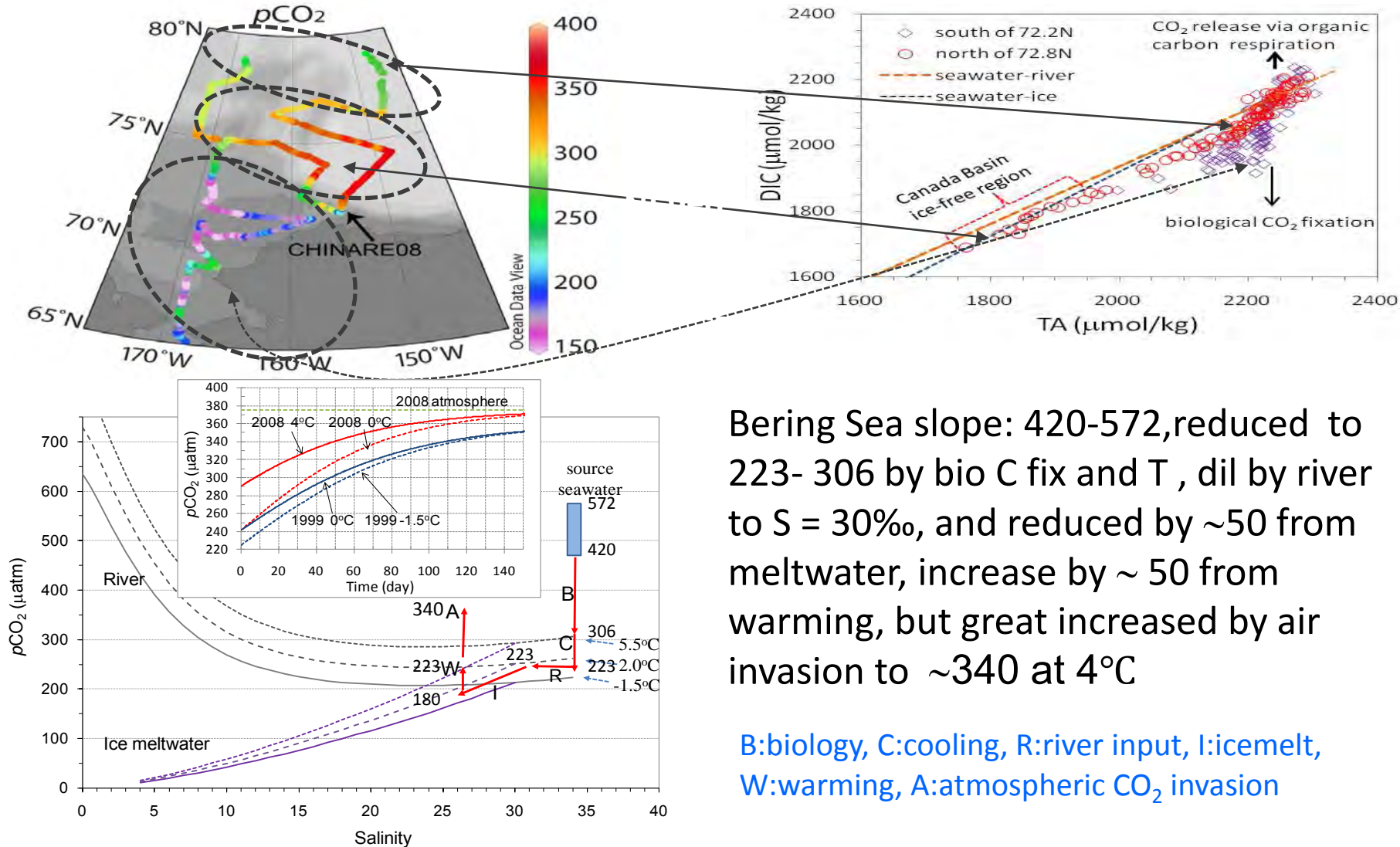
A mixing Model for controlling pCO₂ in the western Arctic Ocean



Variations of surface pCO₂ during Bering Sea waters inflow to and over in the western Arctic Ocean surface



Major control surface $p\text{CO}_2$ by Air-Sea CO_2 gas exchange



Bering Sea slope: 420-572, reduced to 223- 306 by bio C fix and T , dil by river to $S = 30\text{‰}$, and reduced by ~ 50 from meltwater, increase by ~ 50 from warming, but great increased by air invasion to ~ 340 at 4°C

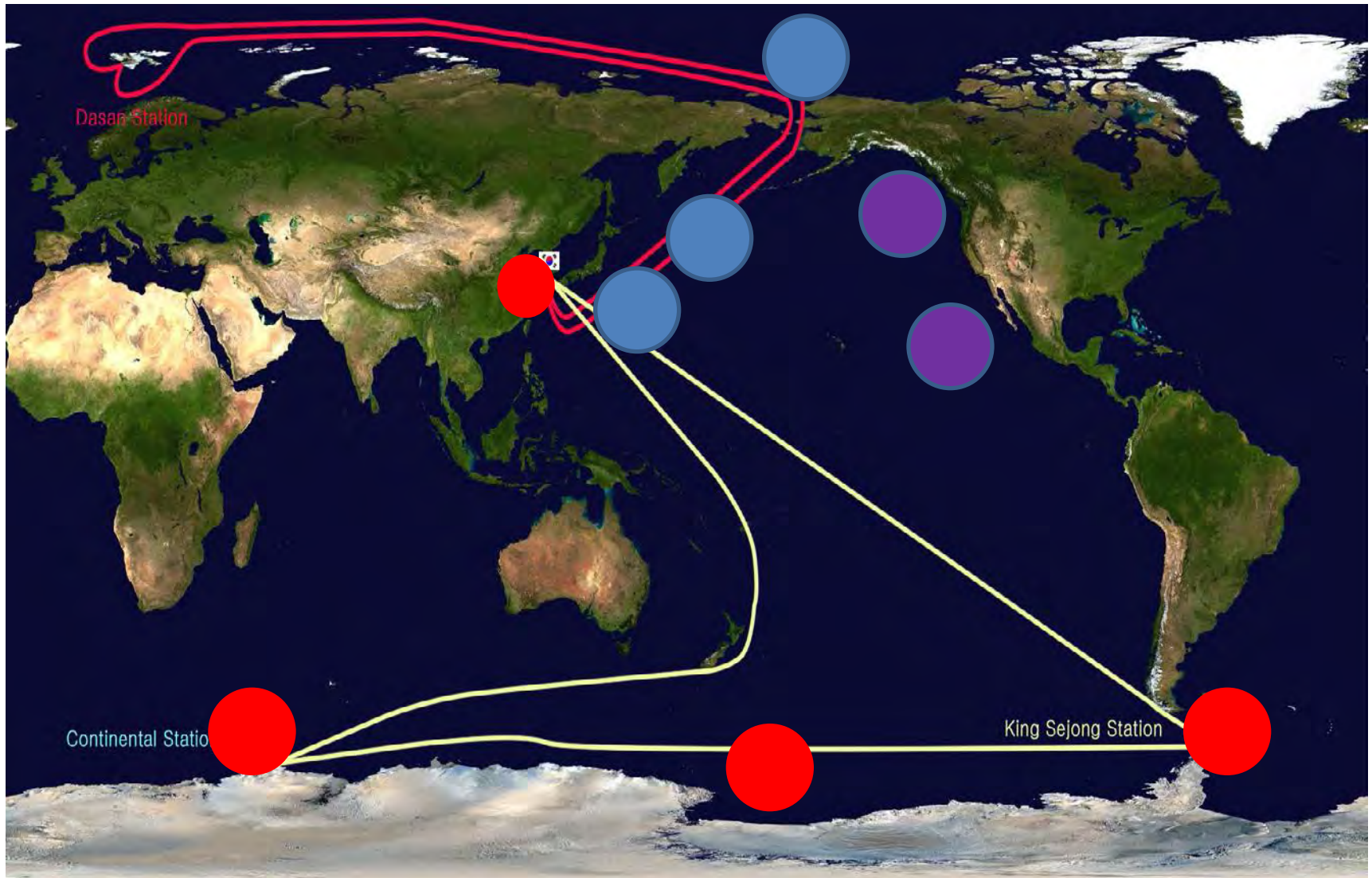
B:biology, C:cooling, R:river input, I:icemelt, W:warming, A:atmospheric CO_2 invasion

Changes of CO₂ fluxes in ten years in regions of the western Arctic Ocean

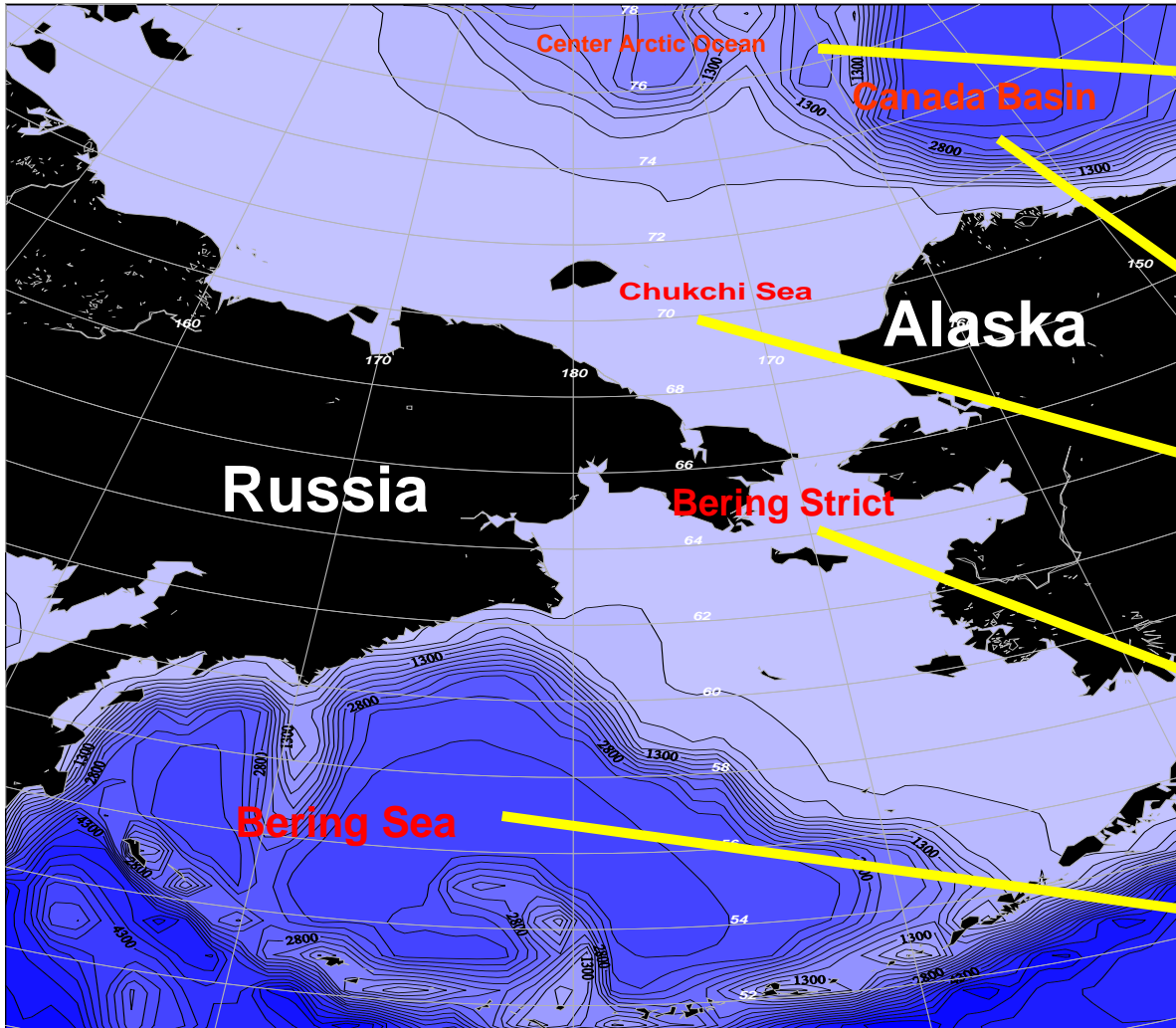
Year	Chukchi Seas (<i>mmol C/ m²d¹</i>)	Canada Basin (<i>mmol C/ m²d¹</i>)
1999	-18.9 ± 6.8	Covered Ice
2003	-18.2 ± 7.0	-14.0 ± 2.7
2008	-16.5 ± 4.4	-10.4 ± 1.6
2010	-26.8 ± 9.2	-7.15 ± 2.8

Implication for the Ocean
Acidification Observing Network
in the northern Pacific and Arctic
Oceans (nPOA-ON)

Key regions and cruise cover areas



Key survey area in the Arctic and northern Pacific Oceans during CHINARE-Arctic



Center Arctic Ocean

Canada Basin

Chukchi Sea

Bering Strait

North Bering Sea

Improving polar vessel's duration and underway observing capacities



M/V Xuelong 21000 GRT under renovation and able to use for next 20 years

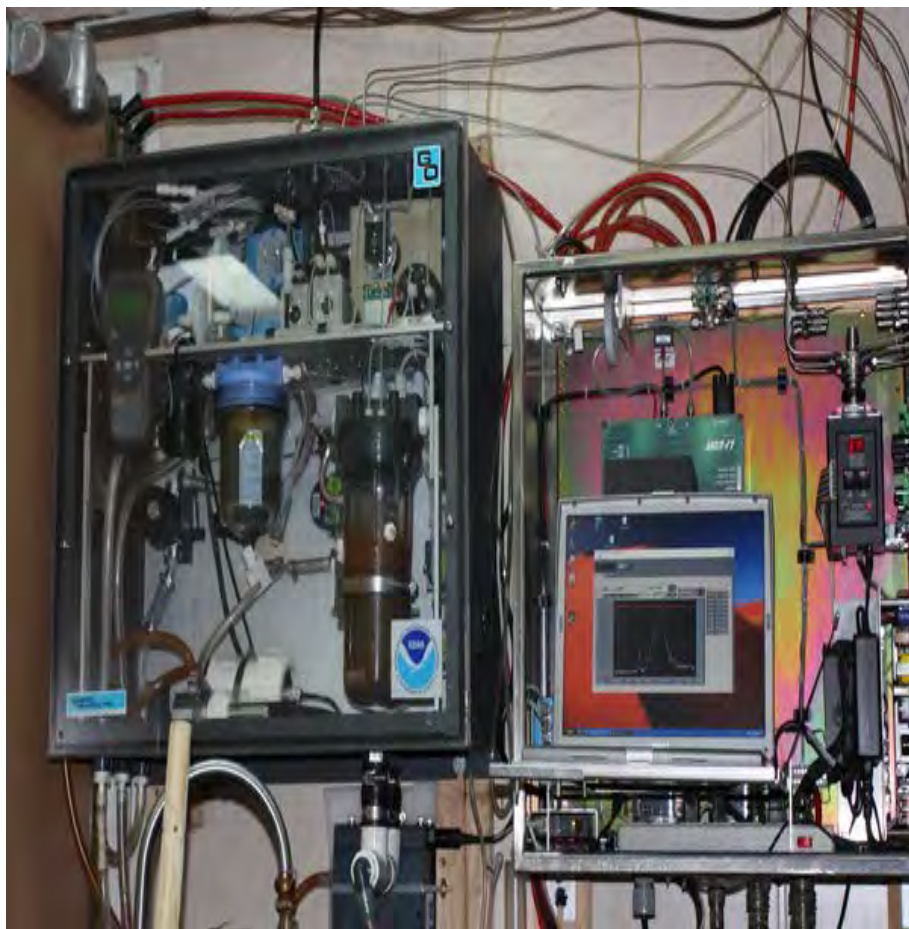


A new Icebreaker 9,950 GRT operated by PRIC, China



M/V XiangYangHong No.3-New Research Vessel 4500 GRT operated by TIO,SOA and be launched in 2016

Underway pCO₂ observation system

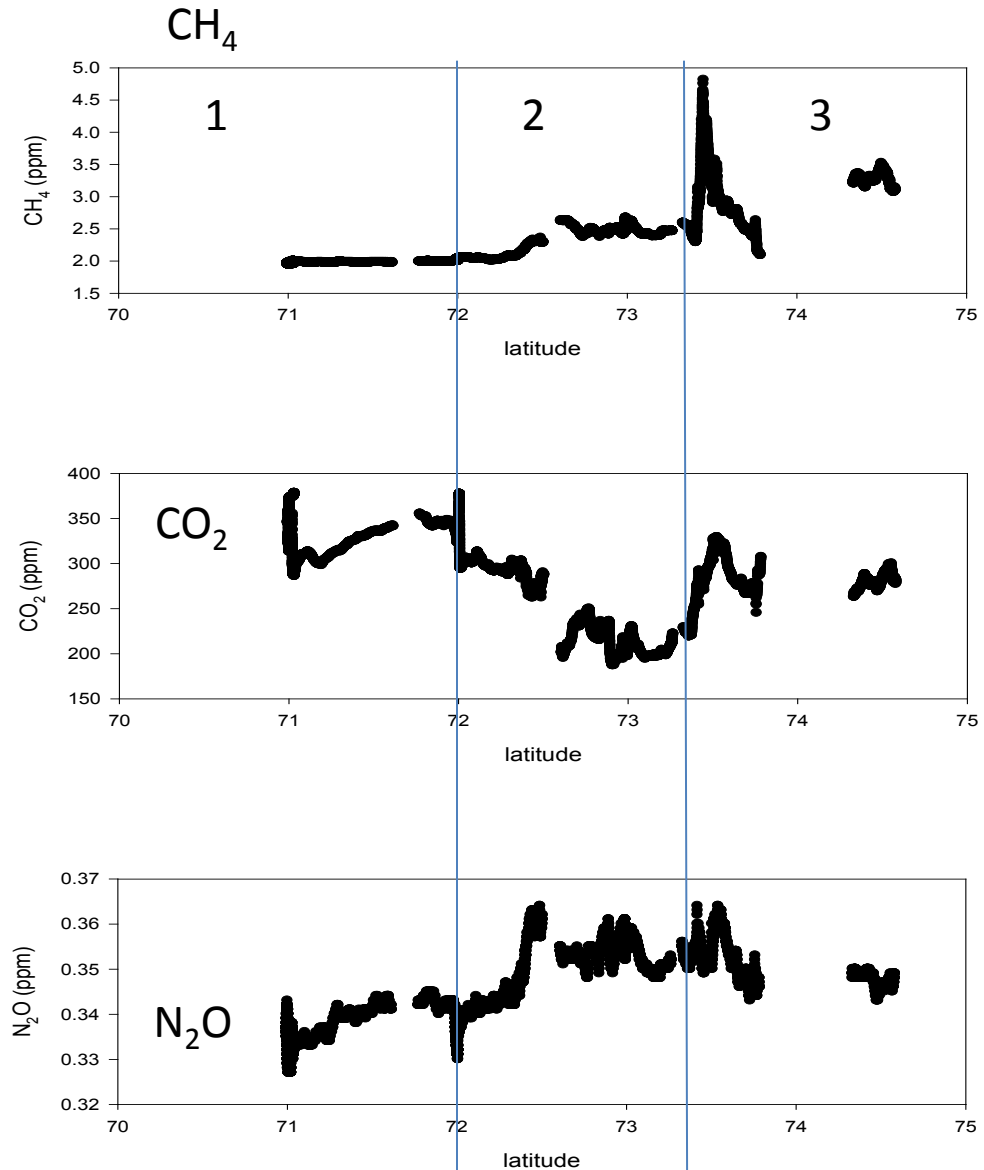
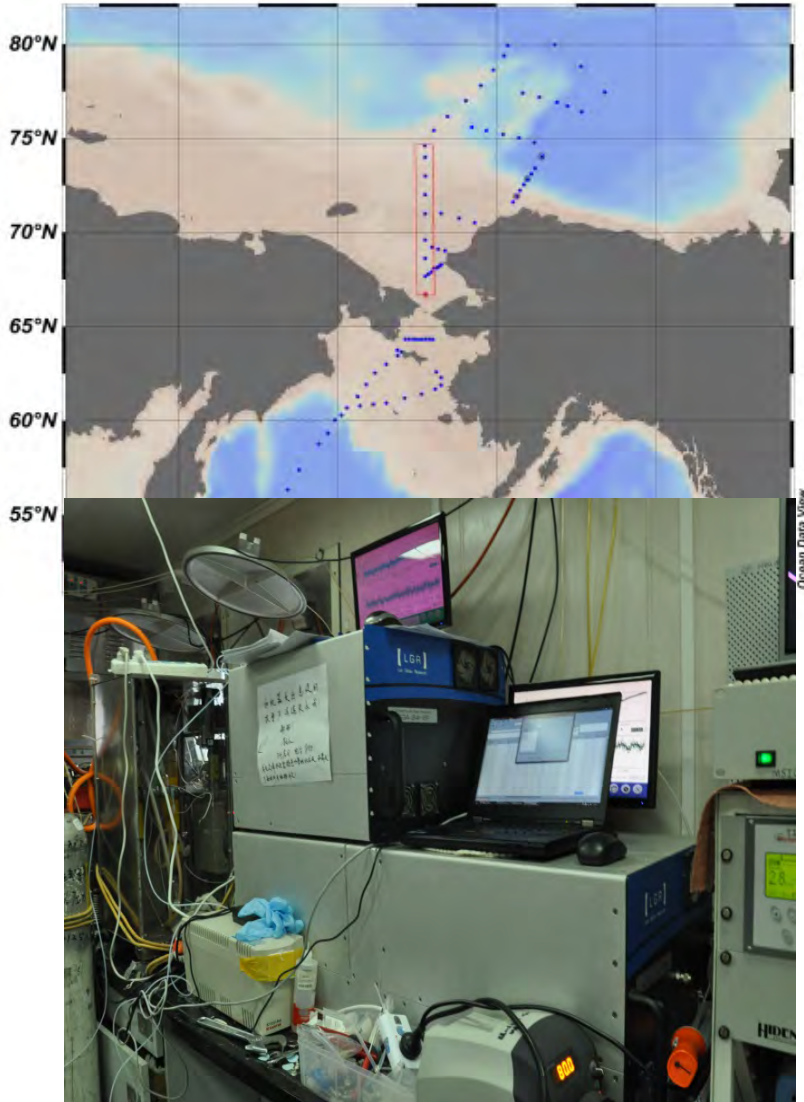


Underway pCO₂ system from NOAA



Underway pCO₂ system from China

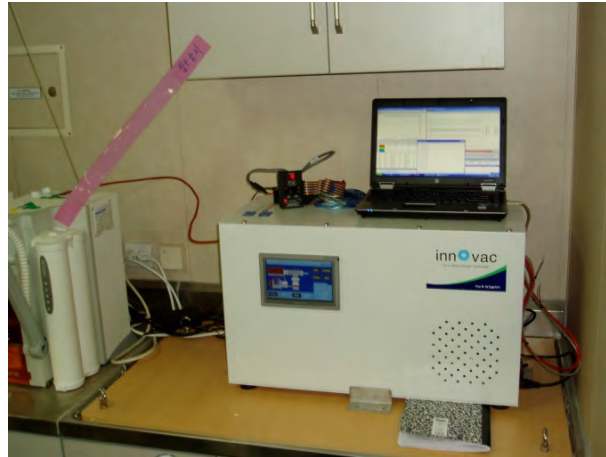
CO₂, CH₄, N₂O underway observation using LGR



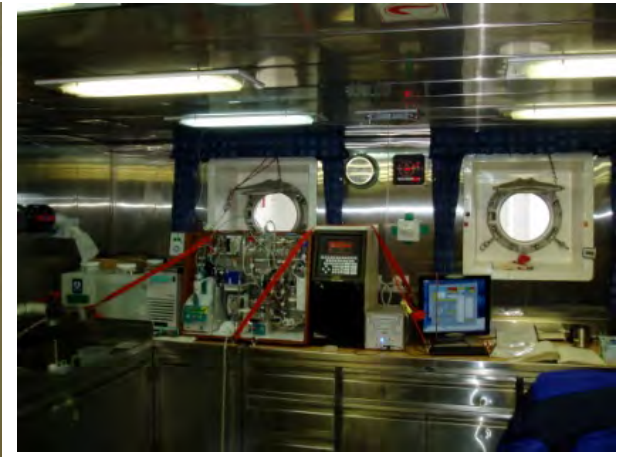
New in-situ probes technology



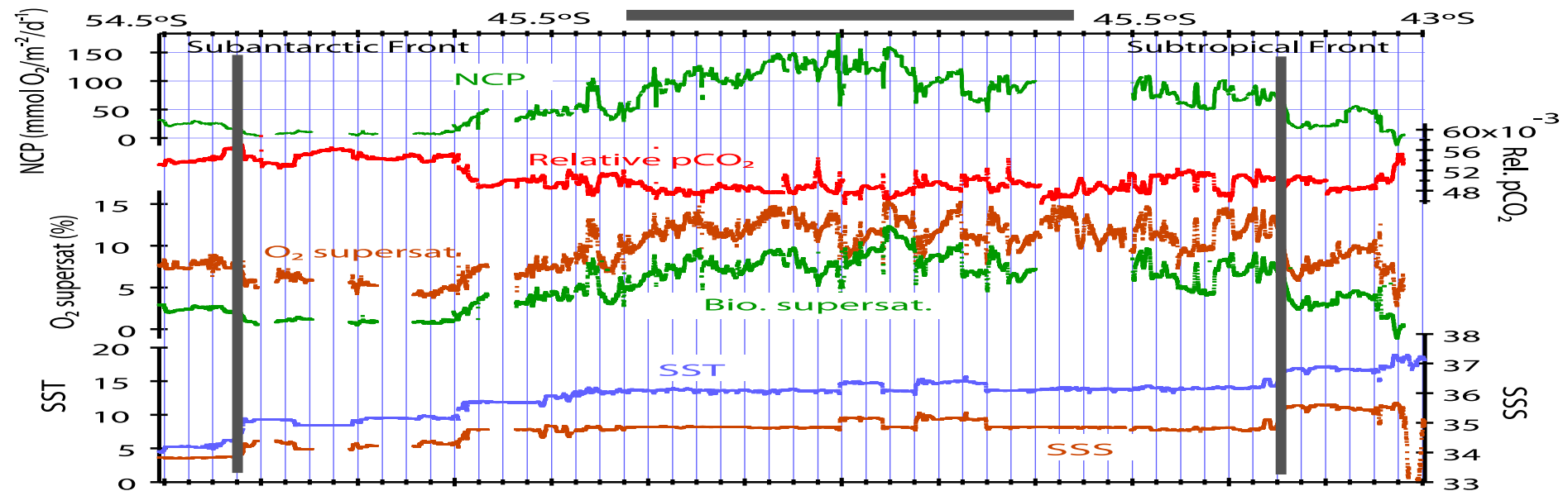
pCO₂ analyzer



O₂/Ar analyzer



DIC & TA Analyzer

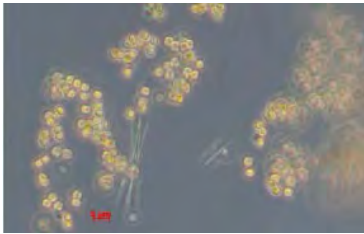


Diatoms in the West Arctic

SHELF

Ice Free

Phaeocystis sp.



Cryptonomas sp.

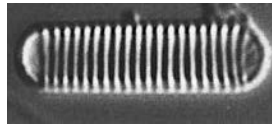


Chaetoceros socialis

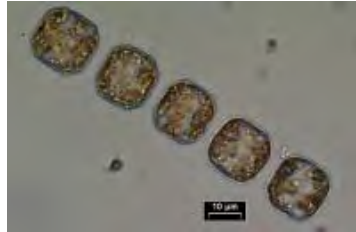


Ice Cover

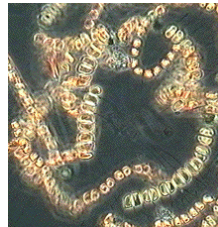
Fragilaripsis cylindrus



Thalassiosira nordenskiöldii



Chaetoceros socialis



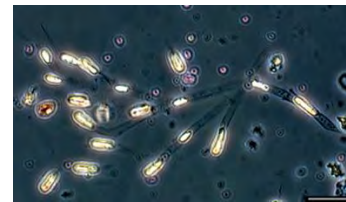
BASIN

Ice Free

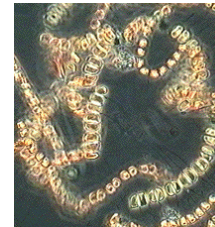
Pyramimonas sp.



Dinobryon belgica



Chaetoceros socialis



Ice Cover

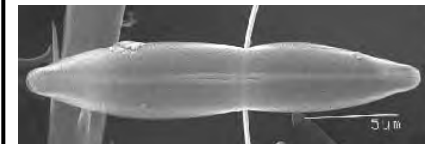
Pyramimonas sp.



Nitzschia frigida

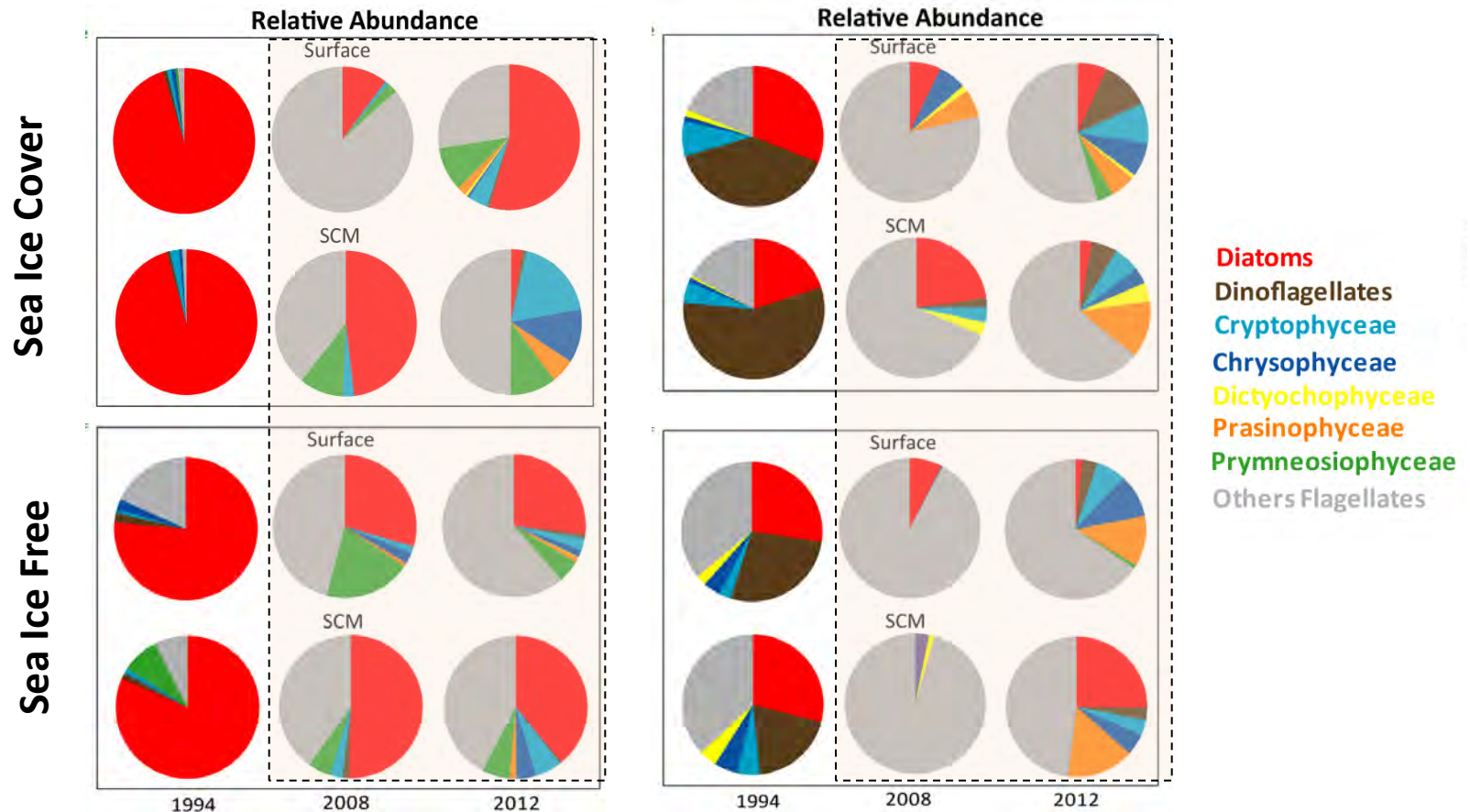


Navicula vanhoeffni



Diatoms dominated in Ice covered area

Abundances of Diatoms and Dinoflagellates in the West Arctic



During the 2 years of intense ice melting

- **Diatoms** and **Dinoflagellates** : relative abundance is decreasing
- Increase of **small flagellates**



Thank You!

