PICES contribution to WGICA: Climate, Physical and Chemical Oceanographic, and Lower Trophic Level Ecosystem Aspects in the Pacific Gateway of the Arctic Ocean

PICES-2018 Annual Meeting
W2: MONITOR/FIS Workshop
PICES contribution to Central Arctic Ocean (CAO) ecosystem assessment Second Workshop
25 October 2018, Yokohama, Japan.

Shigeto Nishino (JAMSTEC)

PICES contribution to WGICA: Climate, Physical and Chemical Oceanographic, and Lower Trophic Level Ecosystem Aspects in the Pacific Gateway of the Arctic Ocean

Updates:

PICES contribution to Central Arctic Ocean (CAO) ecosystem assessment First Workshop (PICES WG39 Workshop in Sapporo) 23–24 March 2018, Sapporo, Japan.

3rd Meeting: ICES/PICES/PAME Working Group on Integrated Ecosystem Assessment for the Central Arctic Ocean (WGICA) 24–26 April 2018, St. John's, Canada

PICES contribution to WGICA: Climate, Physical and Chemical Oceanographic, and Lower Trophic Level Ecosystem Aspects in the Pacific Gateway of the Arctic Ocean

Contents:

1. Arctic warming and sea ice reduction
2. Atmospheric and ocean circulation
3. Water masses
4. Nutrients and primary production
5. Carbon/biogeochemical cycles and ocean acidification

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Contents:

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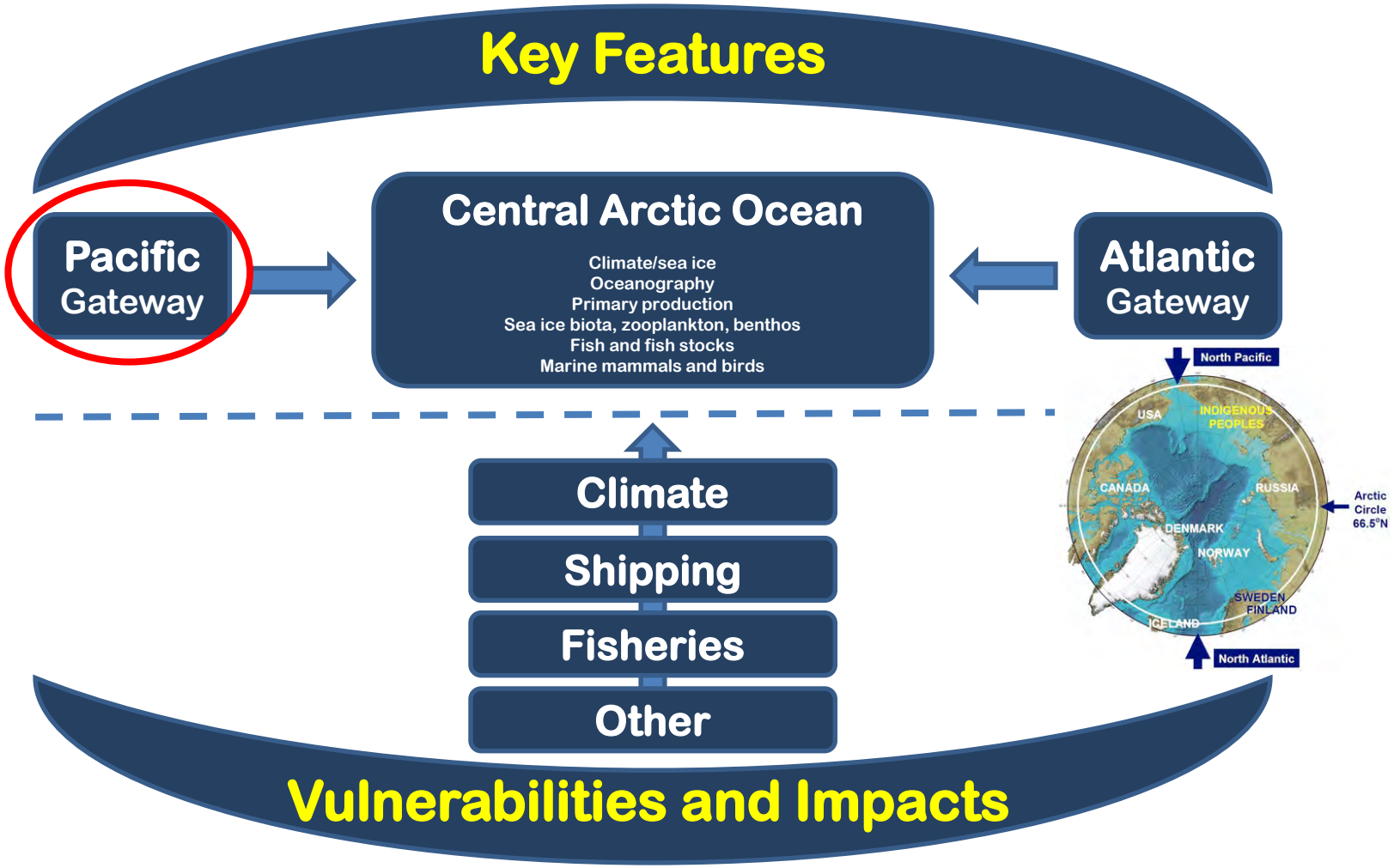
Topics on the Pacific gateway

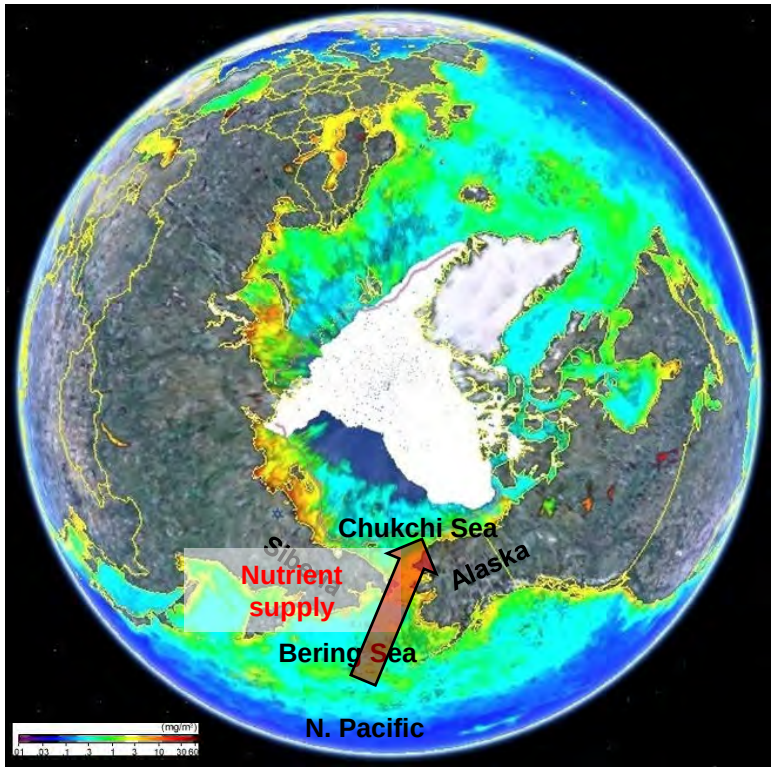
Integrated Ecosystem Assessment



Biological hotspots in the Pacific Arctic Region

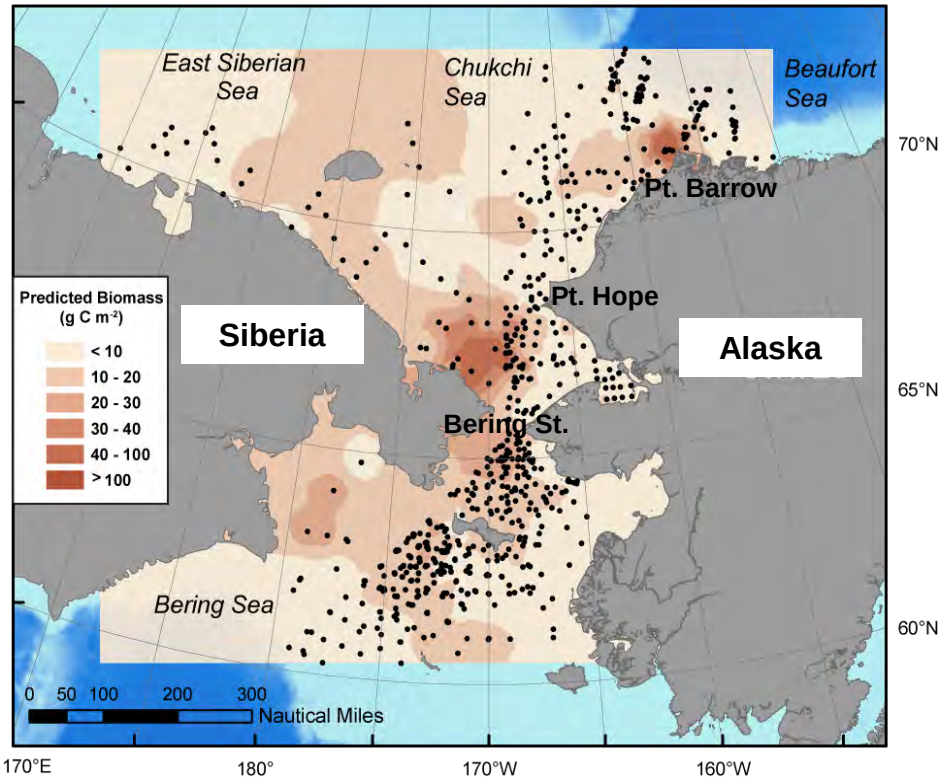
The Bering/Chukchi Seas and Canada Basin are areas in the Pacific Arctic characterized by northward advection and spreading of Pacific-origin water that transports nutrients into the Arctic Ocean, and thus plays an important role in phytoplankton distributions.

Phytoplankton biomass [Chl-*a*; mg/m^3]
(Satellite image in Aug – Sep 2007)



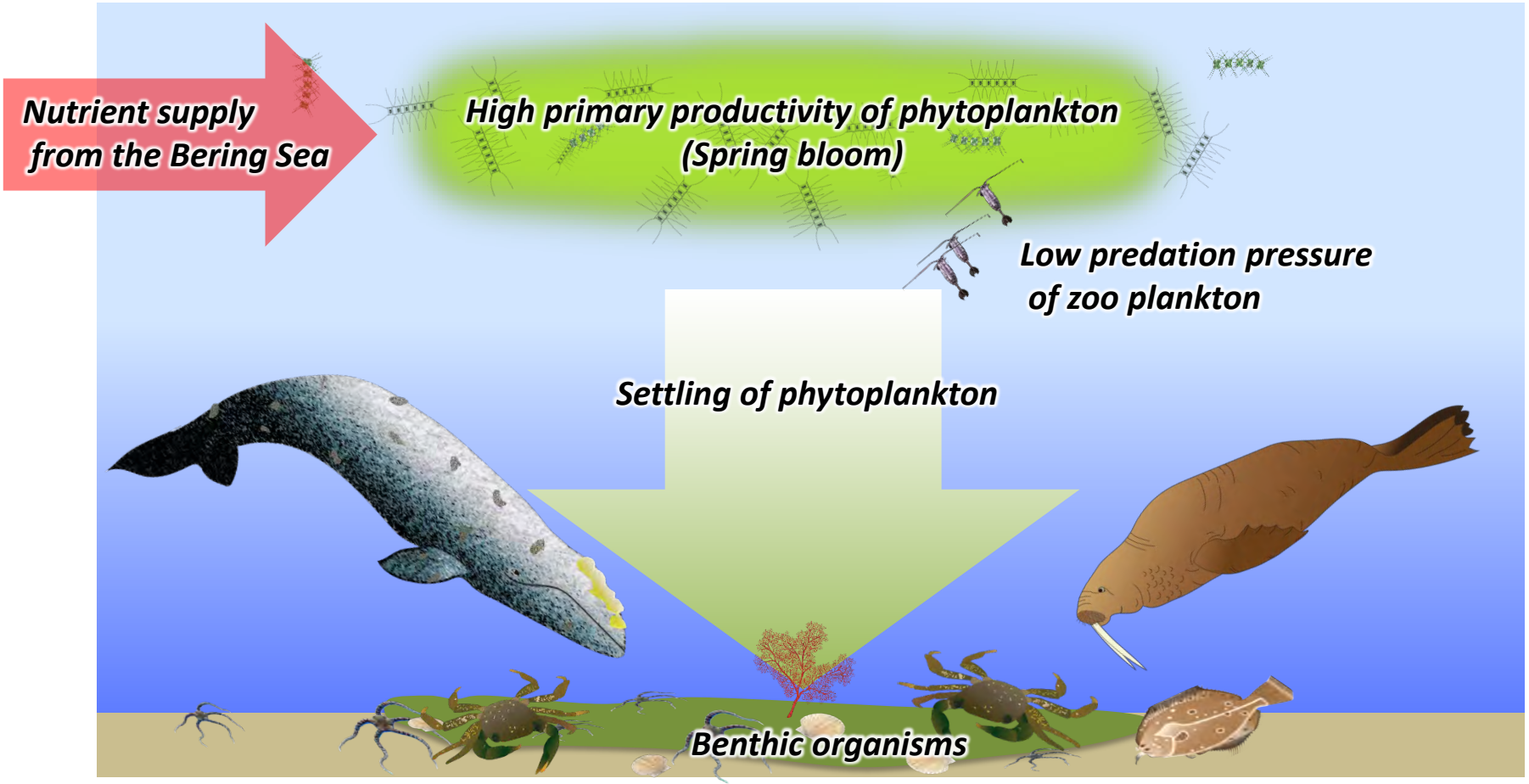
[NASA Earth Observations]

Benthic infaunal biomass [g C/m^2]
(In-situ data from 1973 to 2004)



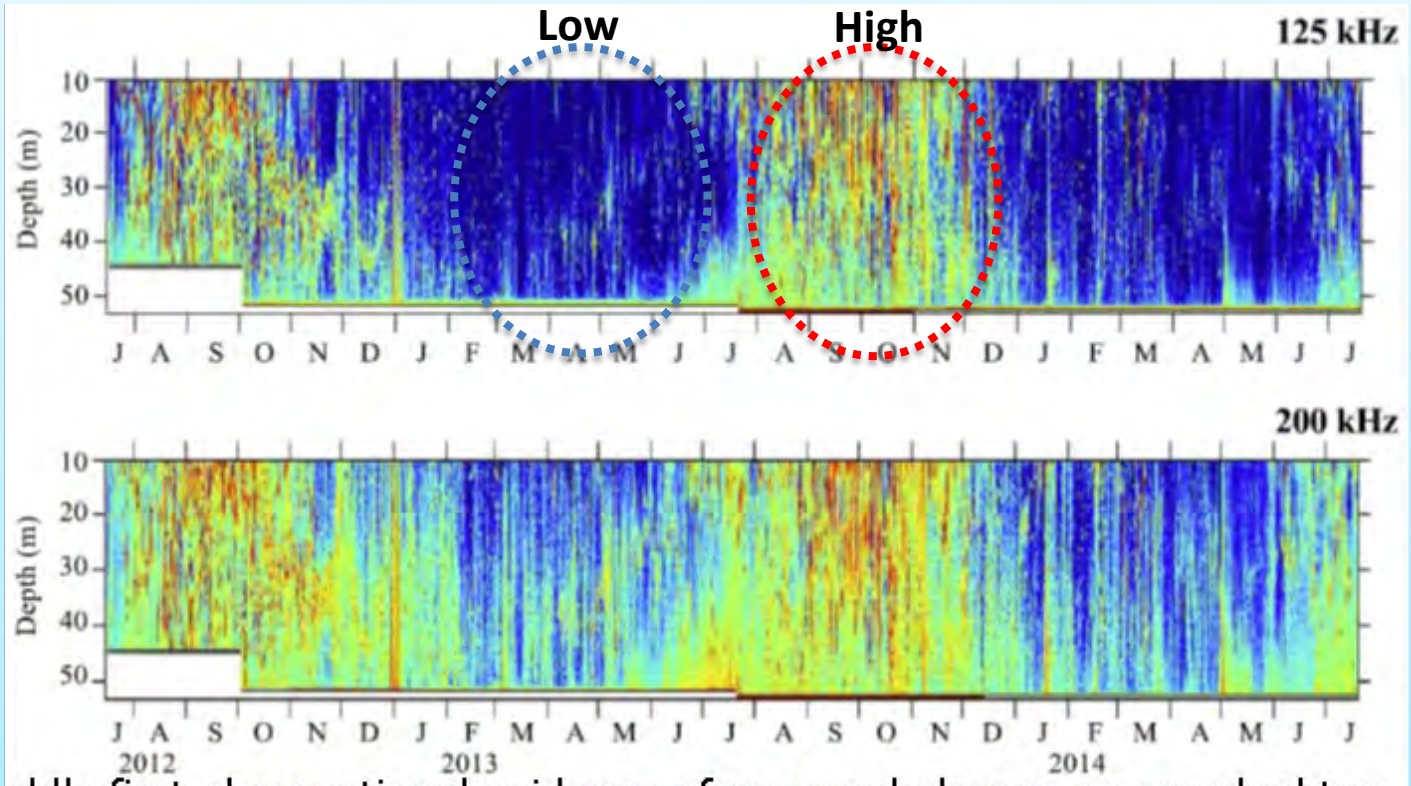
[Grebmeier *et al*., 2006]

Biological hotspots in the Pacific Arctic Region



DBO-3 mooting results on fall bloom, ocean acidification and zooplankton dynamics

1. Nishino et al., *Biogeosciences,* 2016 (Press released)
2. Yamamoto-Kawai et al., *Biogeosciences,* 2016 (Press released)
3. Kitamura et al., *Cont. Shelf Res.*, 2017



World's first observational evidence of seasonal change on zooplankton dynamics in the Hope Valley of the southern Chukchi Sea revealed by Acoustic Zooplankton Fish Profiler [Kitamura et al., 2016]

Seasonal
southern Chukchi Sea between Jul. 2012 and Aug. 2013 [Yamamoto-Kawai et al., 2016]

zooplankton
hi Sea
et al., 2016]

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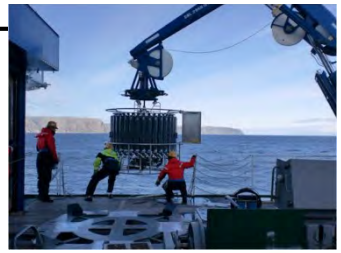
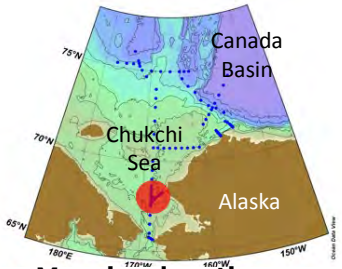
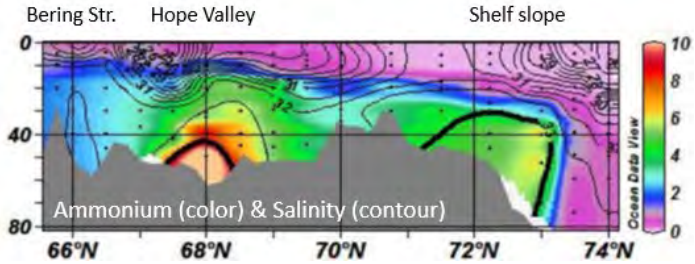


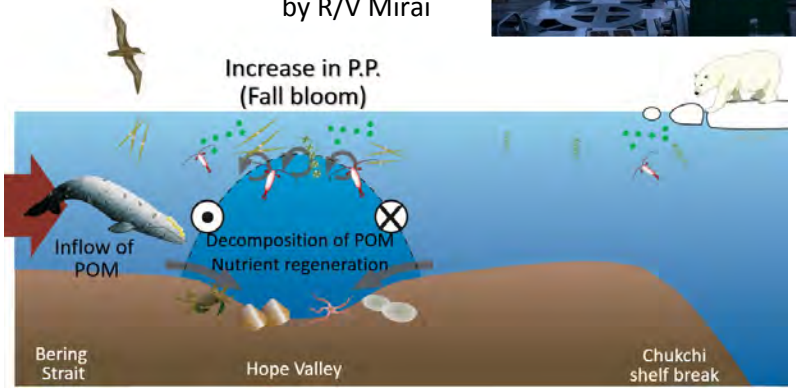
Hydrographic survey by R/V Mirai



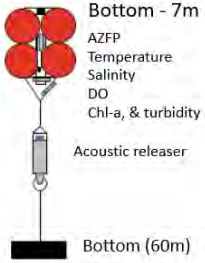
Mooring location



Vertical distribution of Ammonium (color) and salinity (contour) along 168.8W line in September 2012 in the Chukchi Sea of the Arctic Ocean. [Nishino et al., 2016]

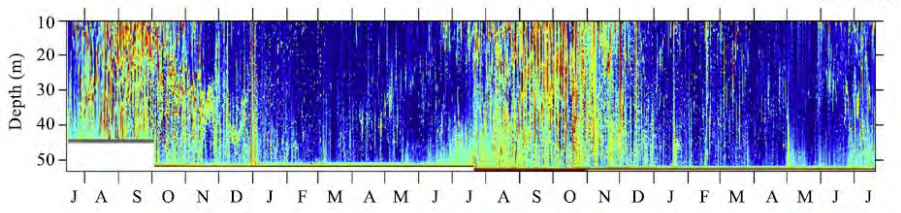


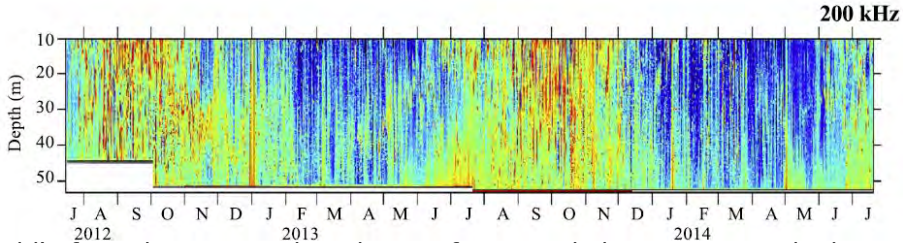
Schematic of fall bloom in the Hope Valley in the southern Chukchi Sea [Nishino et al., 2016]



Mooring diagram deployed in the southern Chukchi Sea

Mooring recovery by CCGS S. W. Laurier





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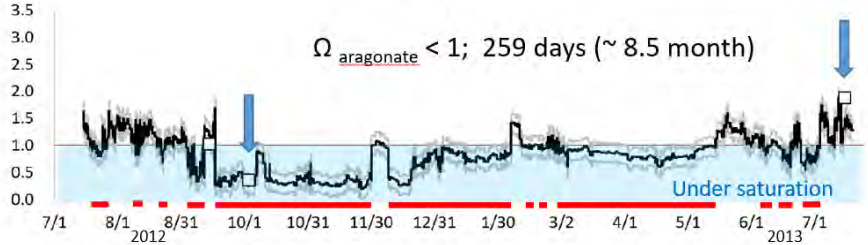
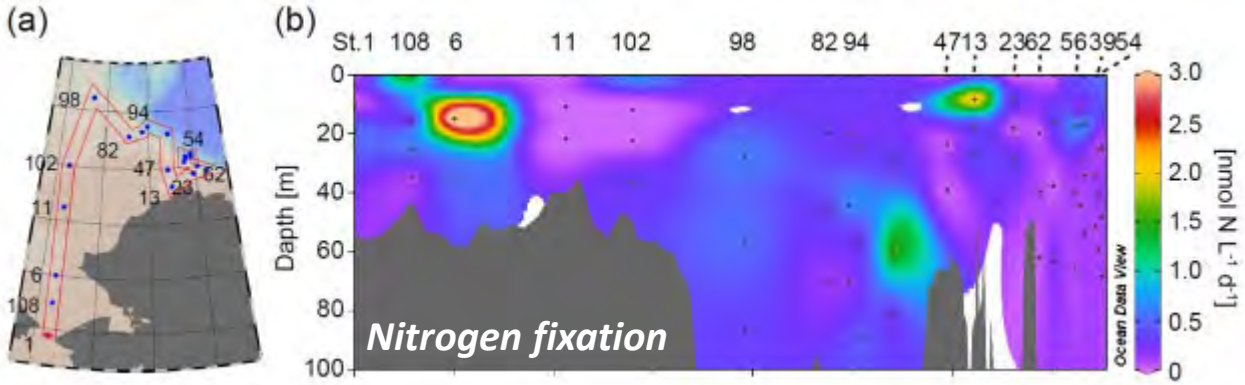
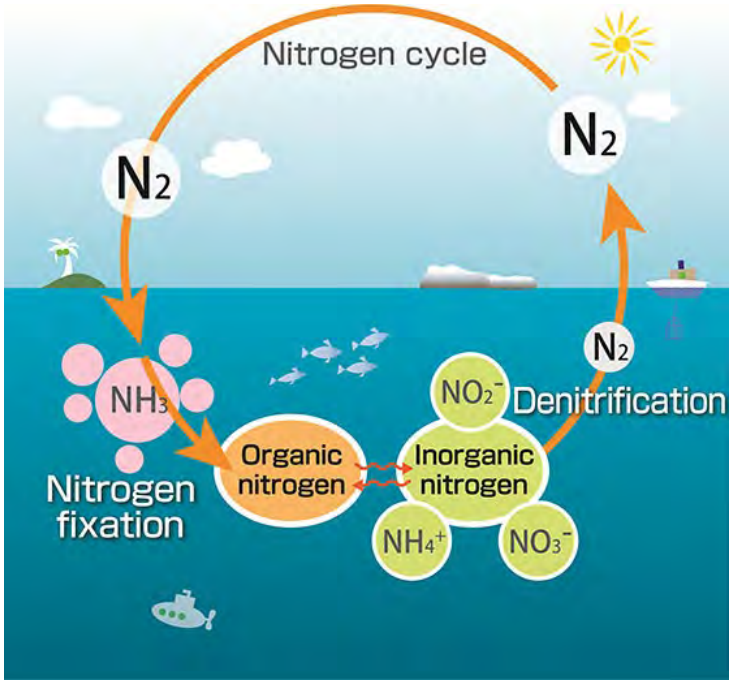


Seasonal variation of CaCO3 saturation state of bottom water in the southern Chukchi Sea between Jul. 2012 and Aug. 2013 [Yamamoto-Kawai et al., 2016]

Extensive nitrogen fixation occurs in the Chukchi Sea without a clear correlation to depth (light intensity) or nitrate concentration

Shiozaki et al., *Limnol. Oceanogr.,* 2018 (Press released)



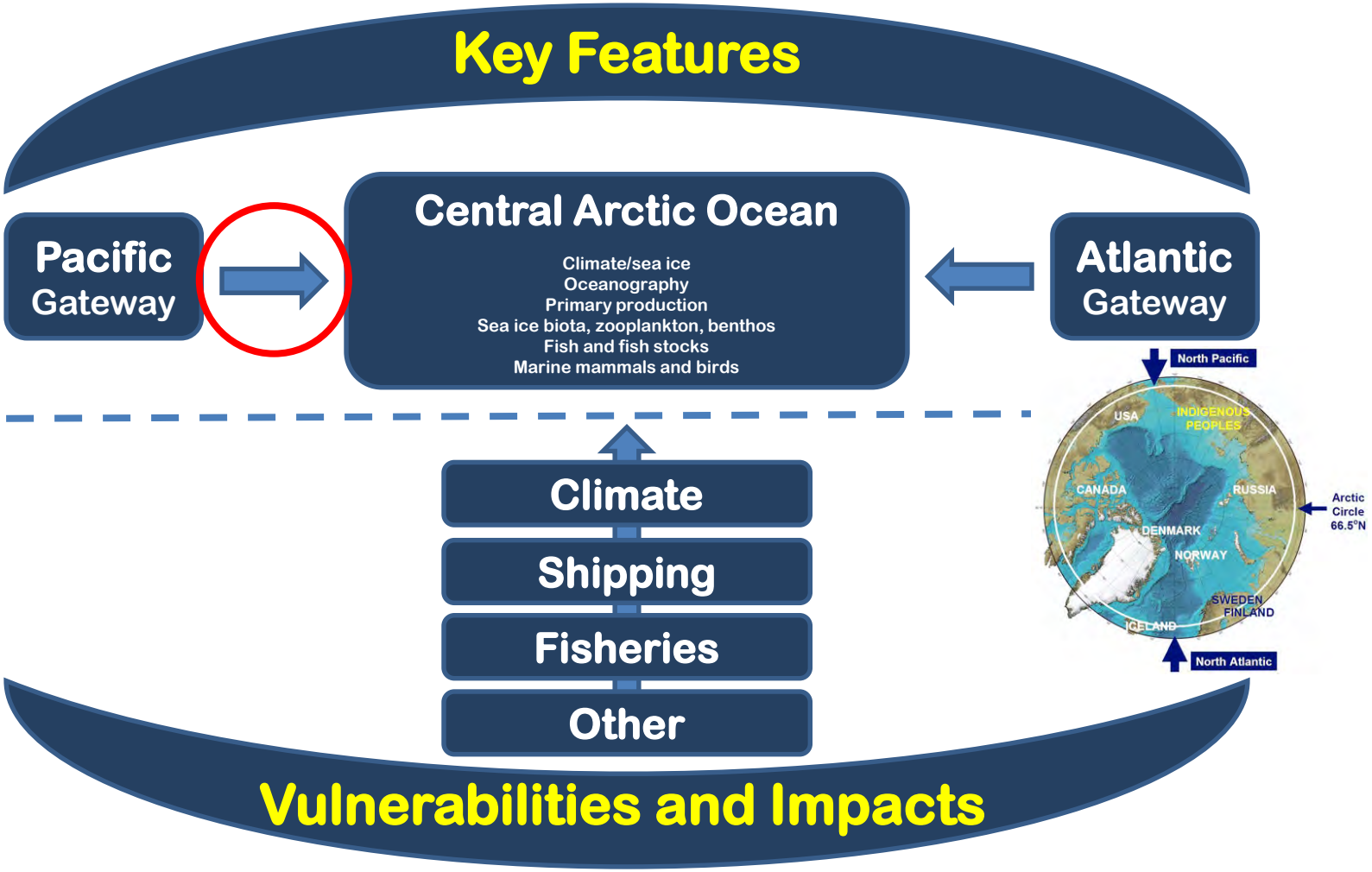


Tropical/subtropical oceans:
- Oligotrophic water
- N fix is high in the surface
- Diazotrophs:
  Photosynthetic cyanobacteria

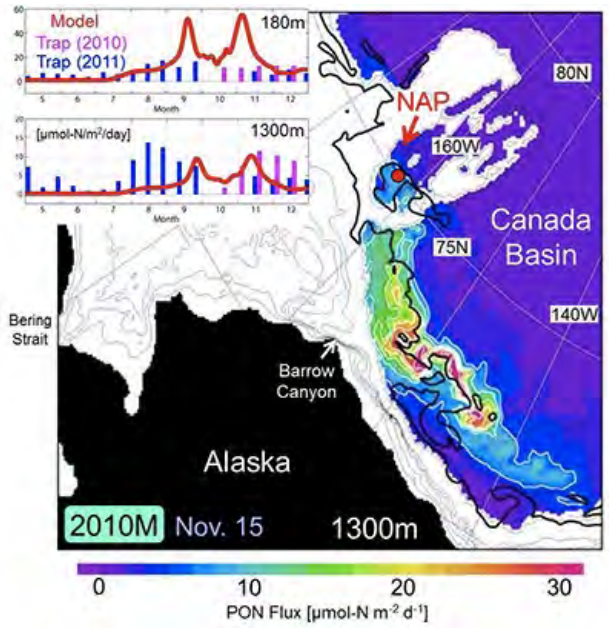
Chukchi Sea:
- Non-oligotrophic water
- N fix is widely detected
- Diazotrophs:
  Non-photosynthetic anaerobic bacteria

Topics on the Pacific-Arctic connecting region

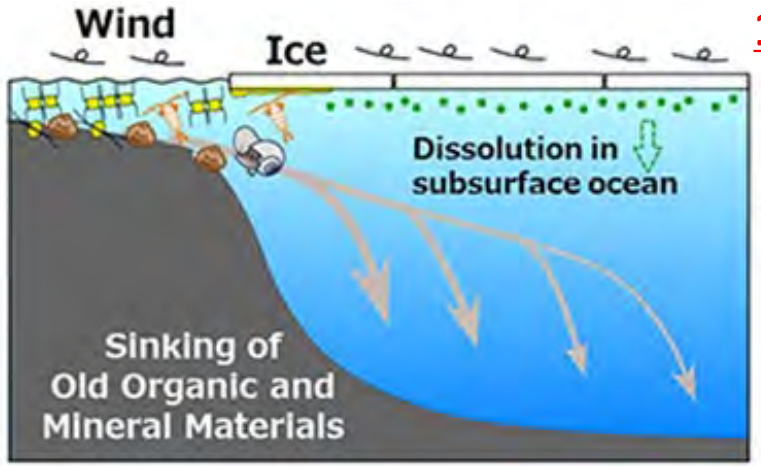
Integrated Ecosystem Assessment



Enhanced role of eddies in the Arctic marine ecosystem

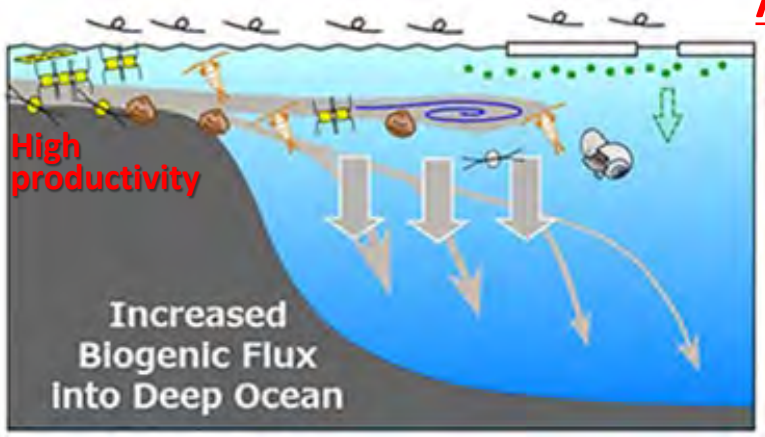


Sea ice retreat causes high biological productivities on the (nutrient-rich) shelves and enhances eddy activity and ocean current in the deep basin area. As a result, plankton habitat is expanding along eddy pathway.



1990s (sea ice covered)

- Small Phytoplankton
- Diatom
- Pteropoda
- Bivalvia
- Copepoda



After sea ice retreat

High Eddy Activity
Strong Ocean Current

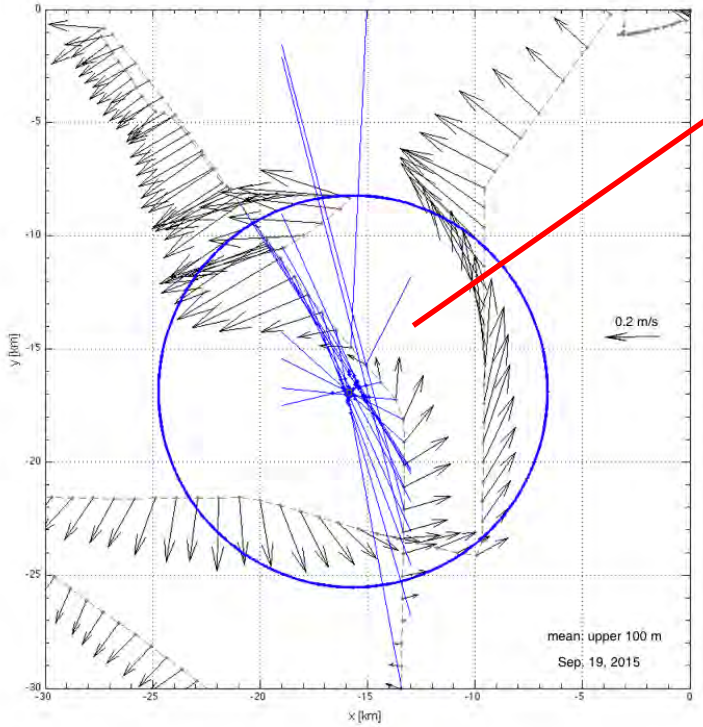
Plankton Habitat is expanding along Eddy Pathway

[Watanabe *et al*. , 2014]

Eddy survey in 2015 using CTD/XCTD/UCTD and ADCP

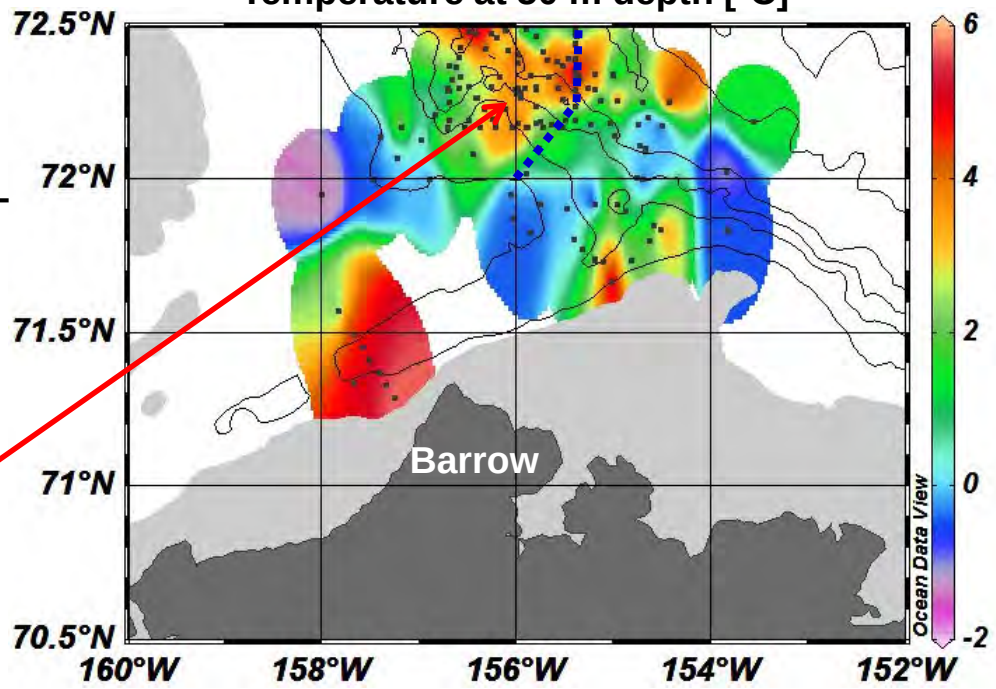
Nishino et al., *Geophs. Res. Lett.,* 2018

Velocities of upper 100 m layer

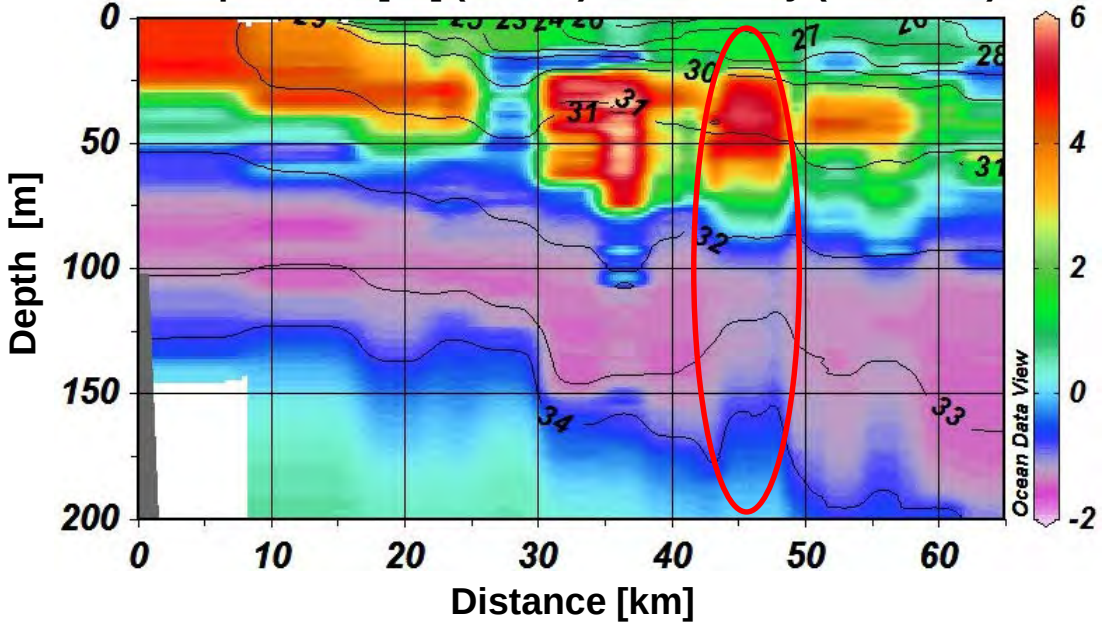


Cyclonic warm-core eddy
D ~ 20 km

Temperature at 50 m depth [ºC]



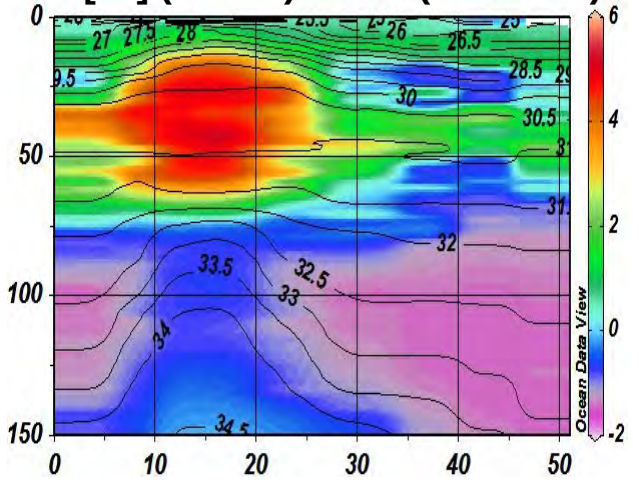
Temperature [ºC] (colors) and salinity (contours)



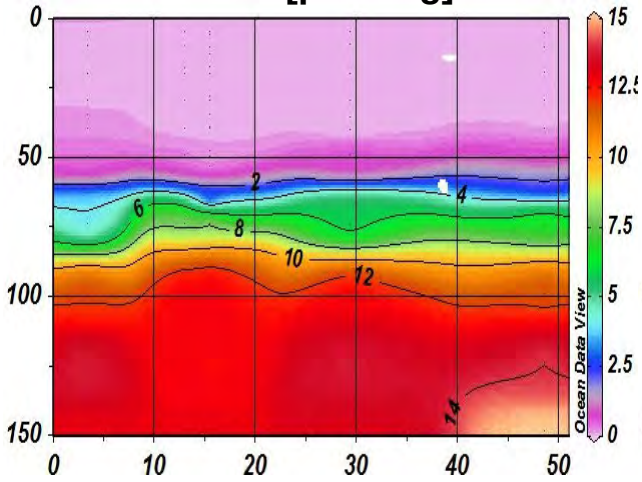
Vertical sections of cyclonic warm-core eddy (CTD/water samplings)

Nishino et al., *Geophs. Res. Lett.,* 2018

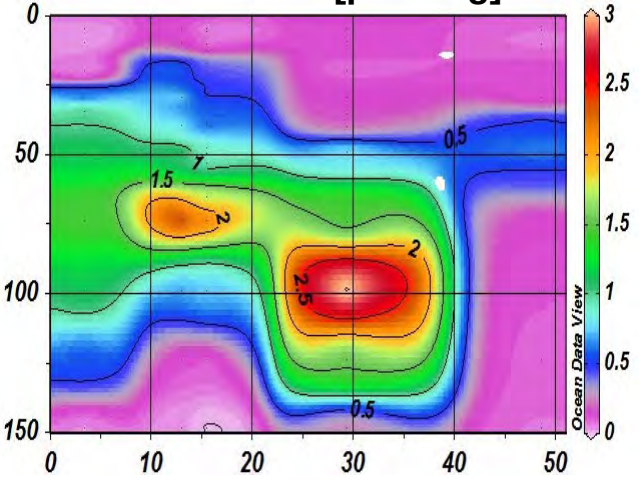
T [ºC] (colors) and S (contours)



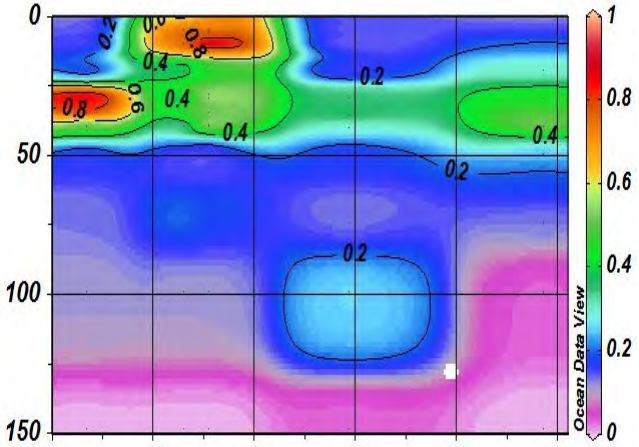
Nitrate [µmol/kg]



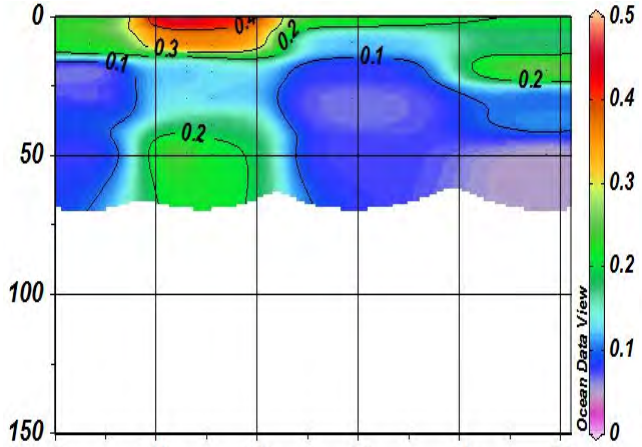
Ammonium [µmol/kg]



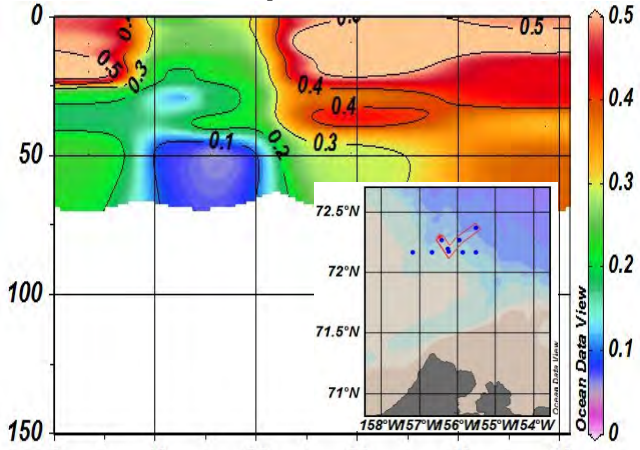
Chl-*a* [mg/m^3]



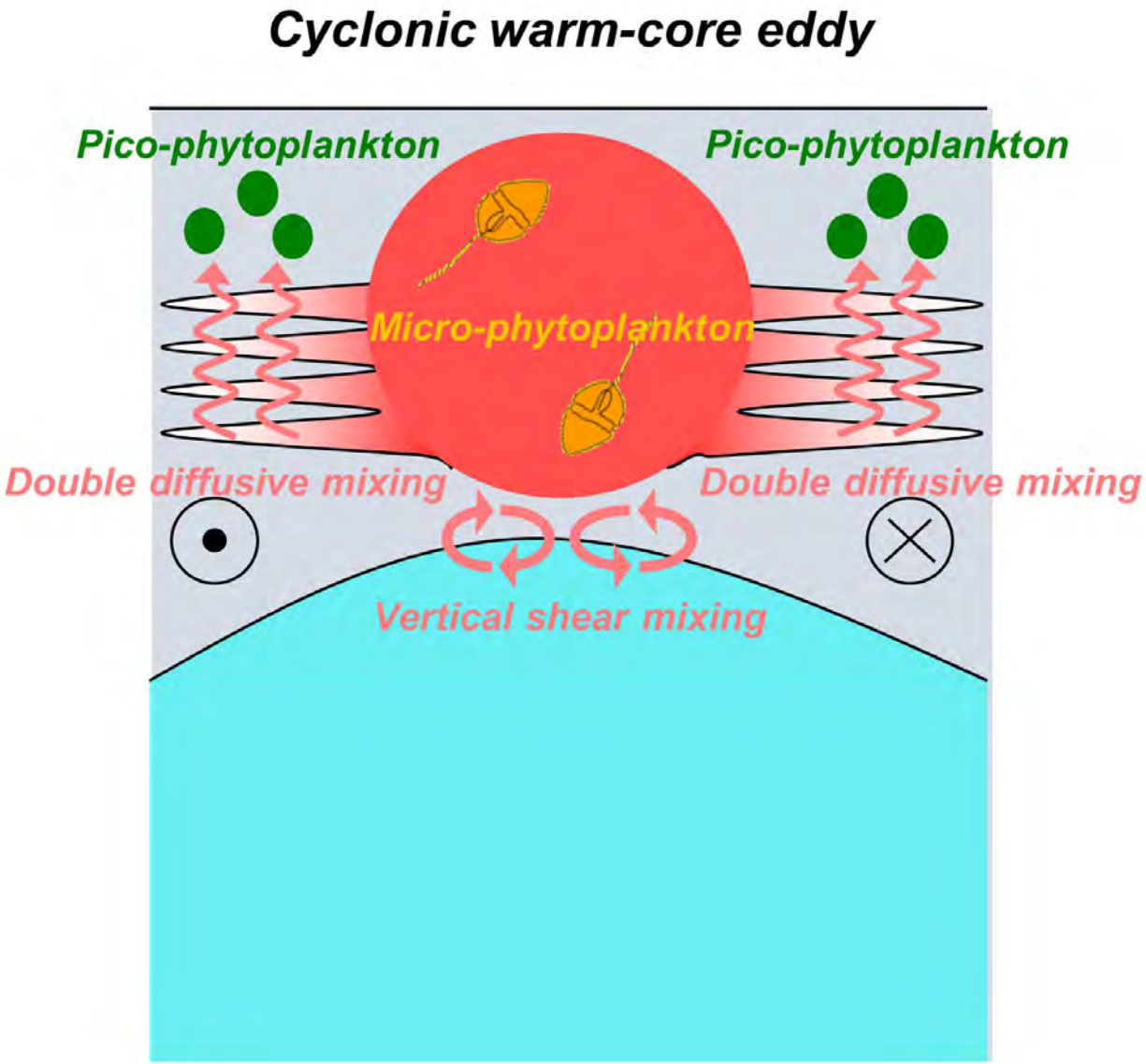
Chl-*a* > 20µm/Total Chl-*a*



Chl-*a* < 2µm/Total Chl-*a*



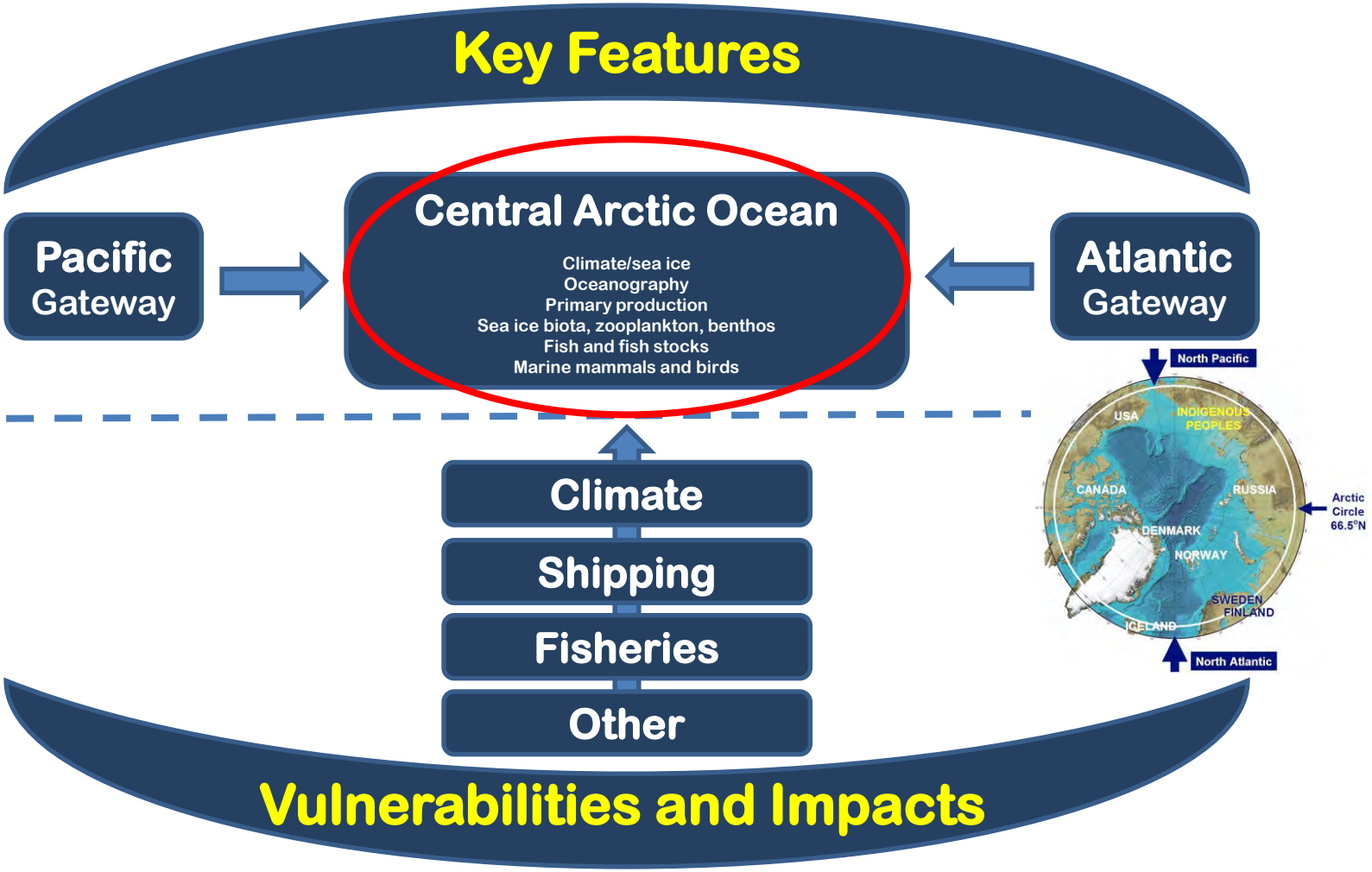
Eddy structure and its impact on the Arctic marine ecosystem



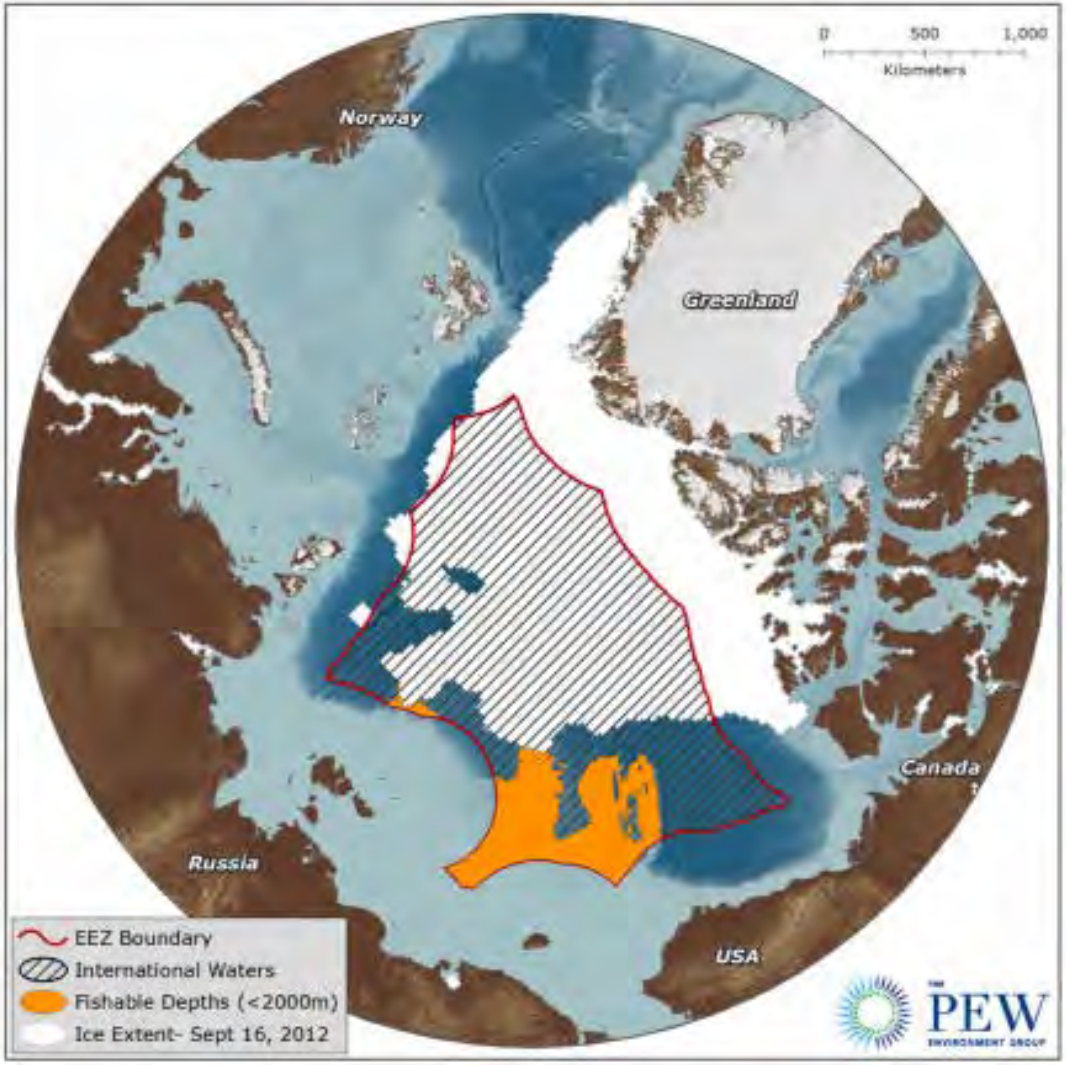
[Nishino *et al*. , 2018]

Topics on the Central Arctic Ocean

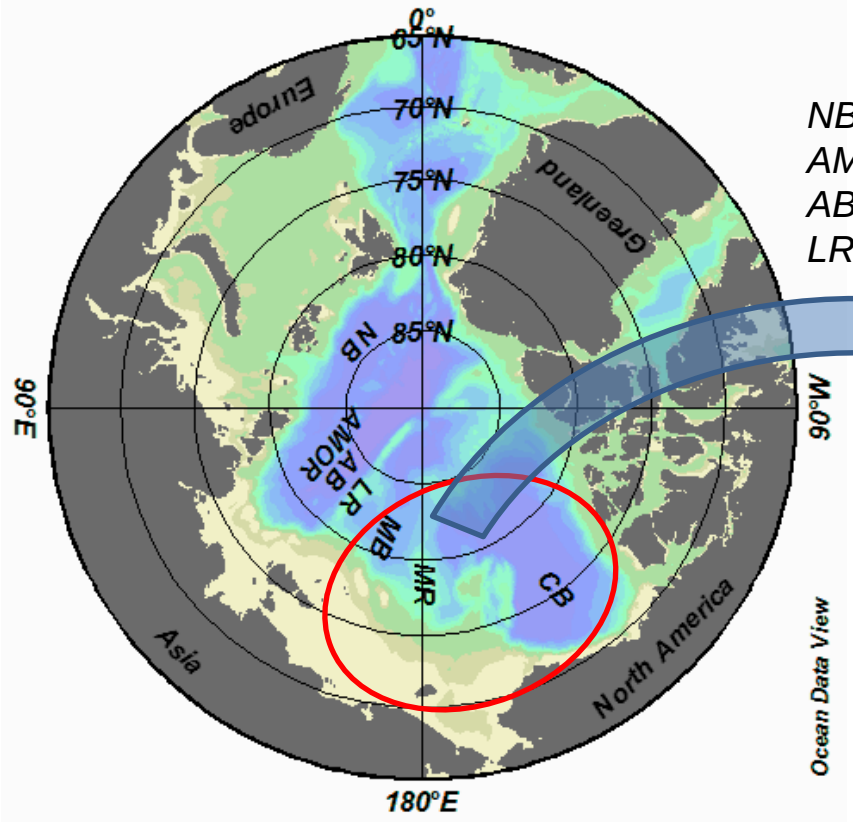
Integrated Ecosystem Assessment



Fishable area in the Arctic international waters

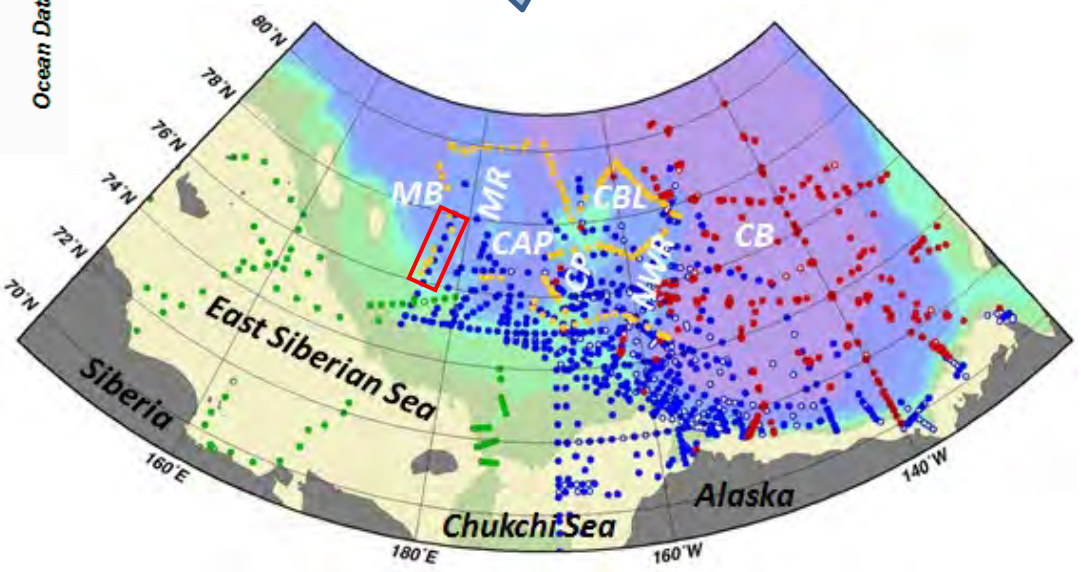


Data were accumulated in the fishable area during 2000s



NB: Nansen Basin
AMOR: Arctic Mid-Ocean Ridge
AB: Amundsen Basin
LR: Lomonosov Ridge

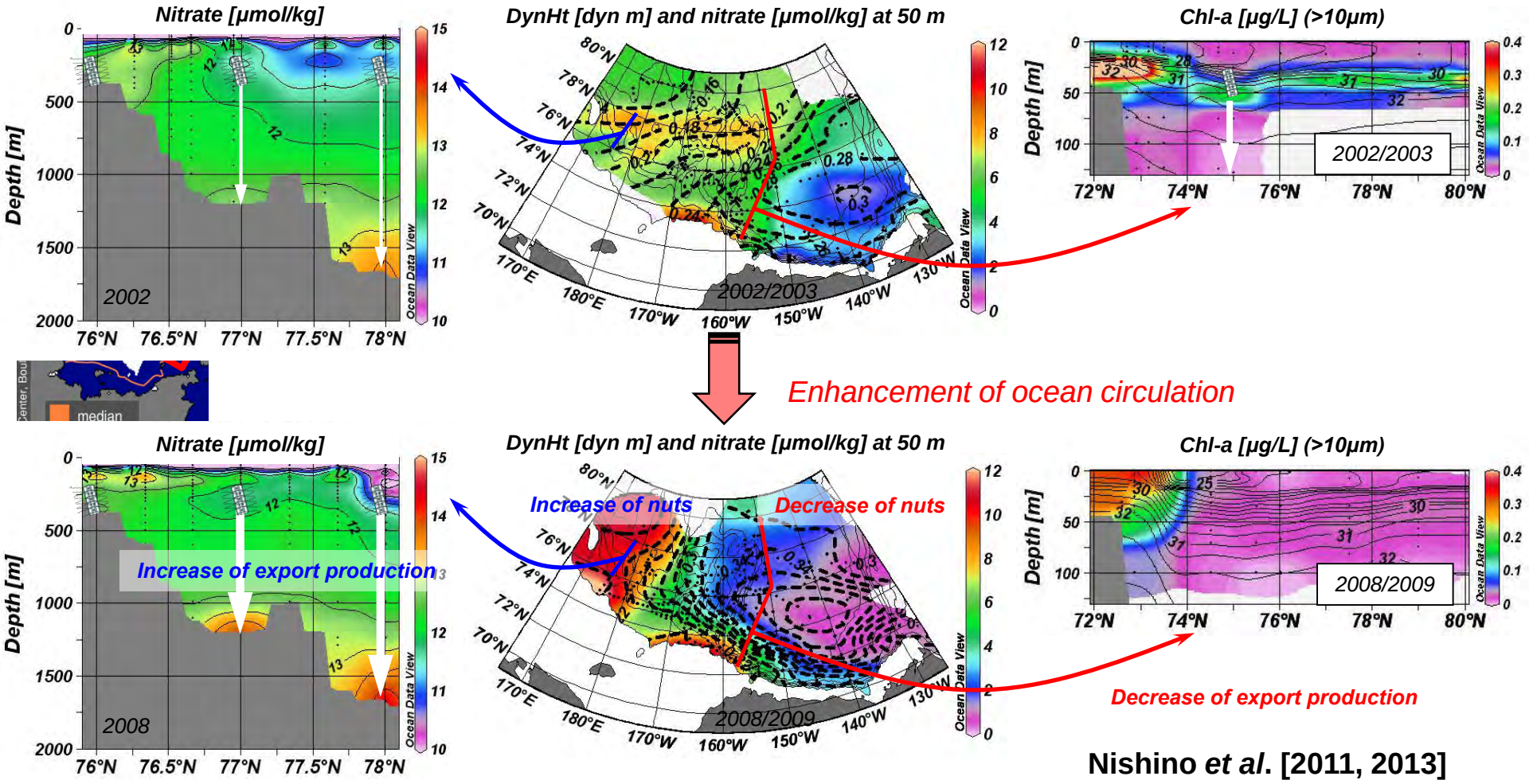
MB: Makarov Basin
MR: Mendeleyev Ridge
CAP: Chukchi Abyssal Plain
CP: Chukchi Plateau
CBL: Chukchi Borderlands
NWR: Northwind Ridge
CB: Canada Basin



- *Russian R/V Yacob Smirniskyi* (2008)
- *Japanese R/V Mirai* (2002-2010)
- *USCGC Polar Star* (2002)
- *CCGS Louis S. St-Laurent* (2003-2010)

Nishino *et al*. [2013]

Changes in biological production caused by the enhancement of ocean circulation

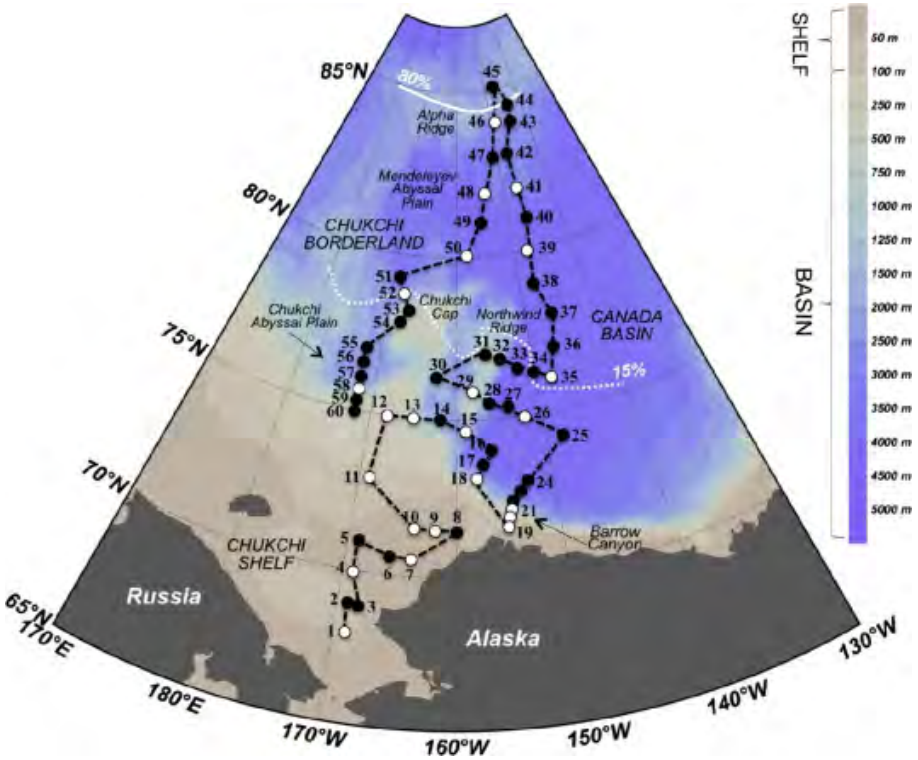


Nishino *et al*. [2011, 2013]

- In the Canada Basin (within the Beaufort Gyre), deepening of nutricline may result in the decrease of export production.
- In the Makarov Basin (outside of the Beaufort Gyre), shoaling of nutricline may result in the increase of export production.

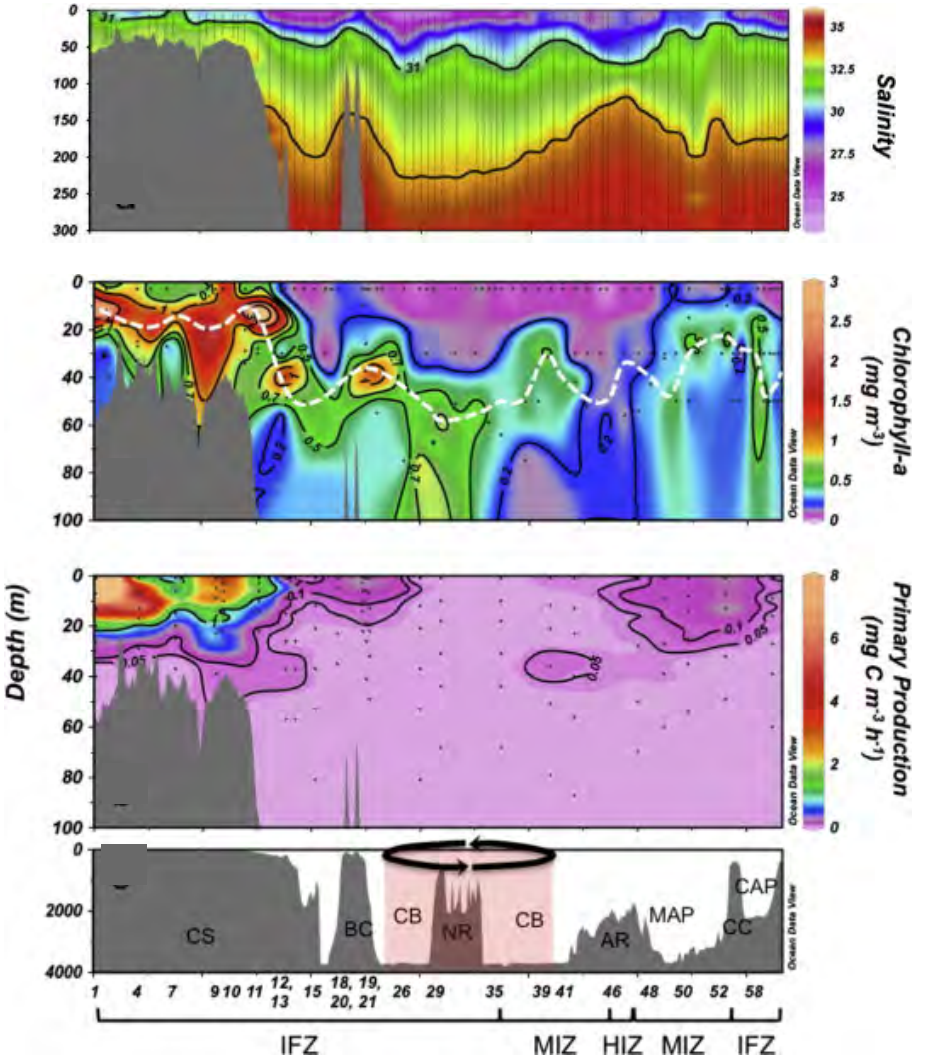
The impact of freshening on phytoplankton production in the Pacific Arctic Ocean

CHINARE 2008



Freshening in future years will likely cause the Arctic deep basin to become more **oligotrophic**, resulting in the **reduction of PP**.

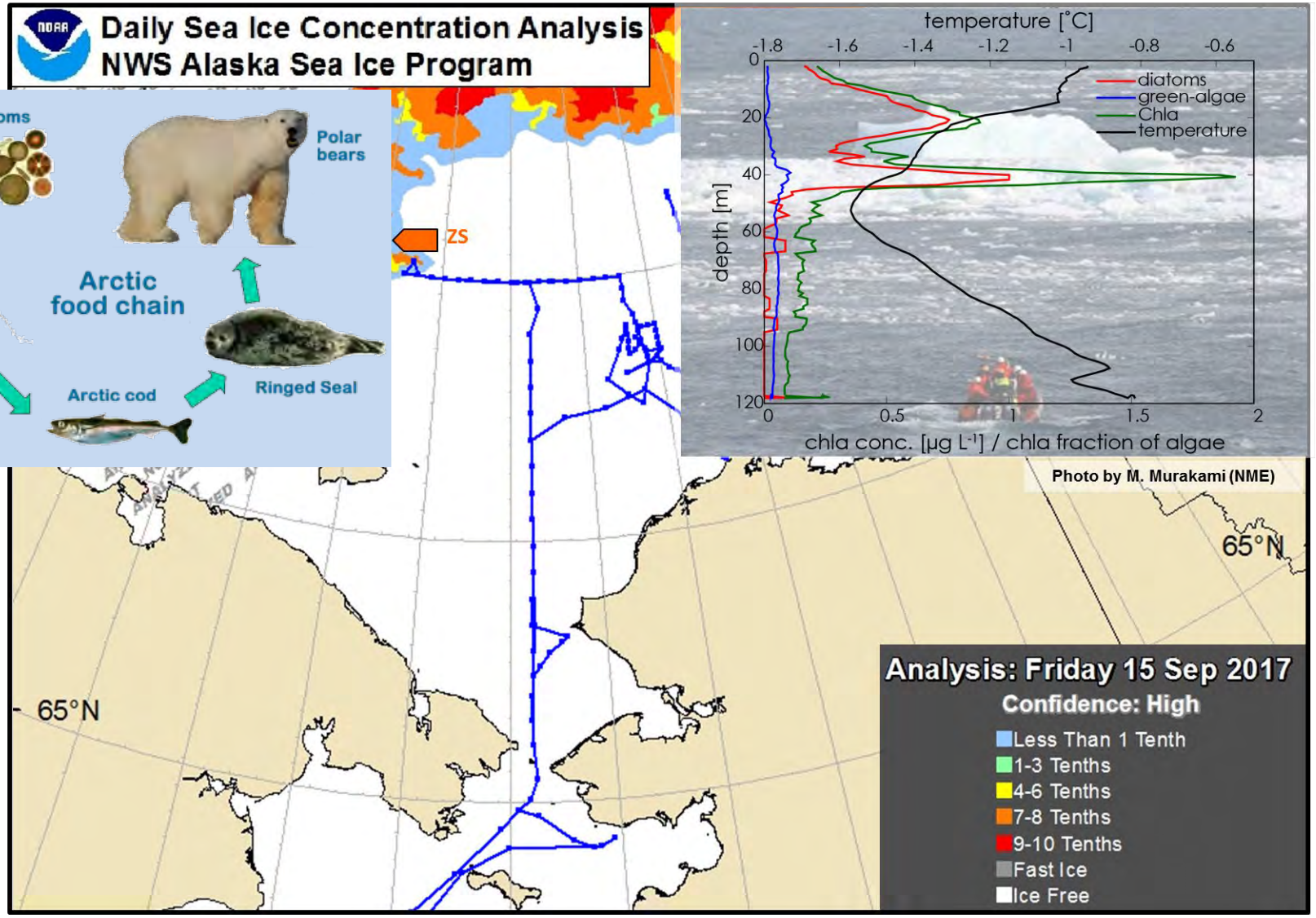
Freshening -> negative impact on PP



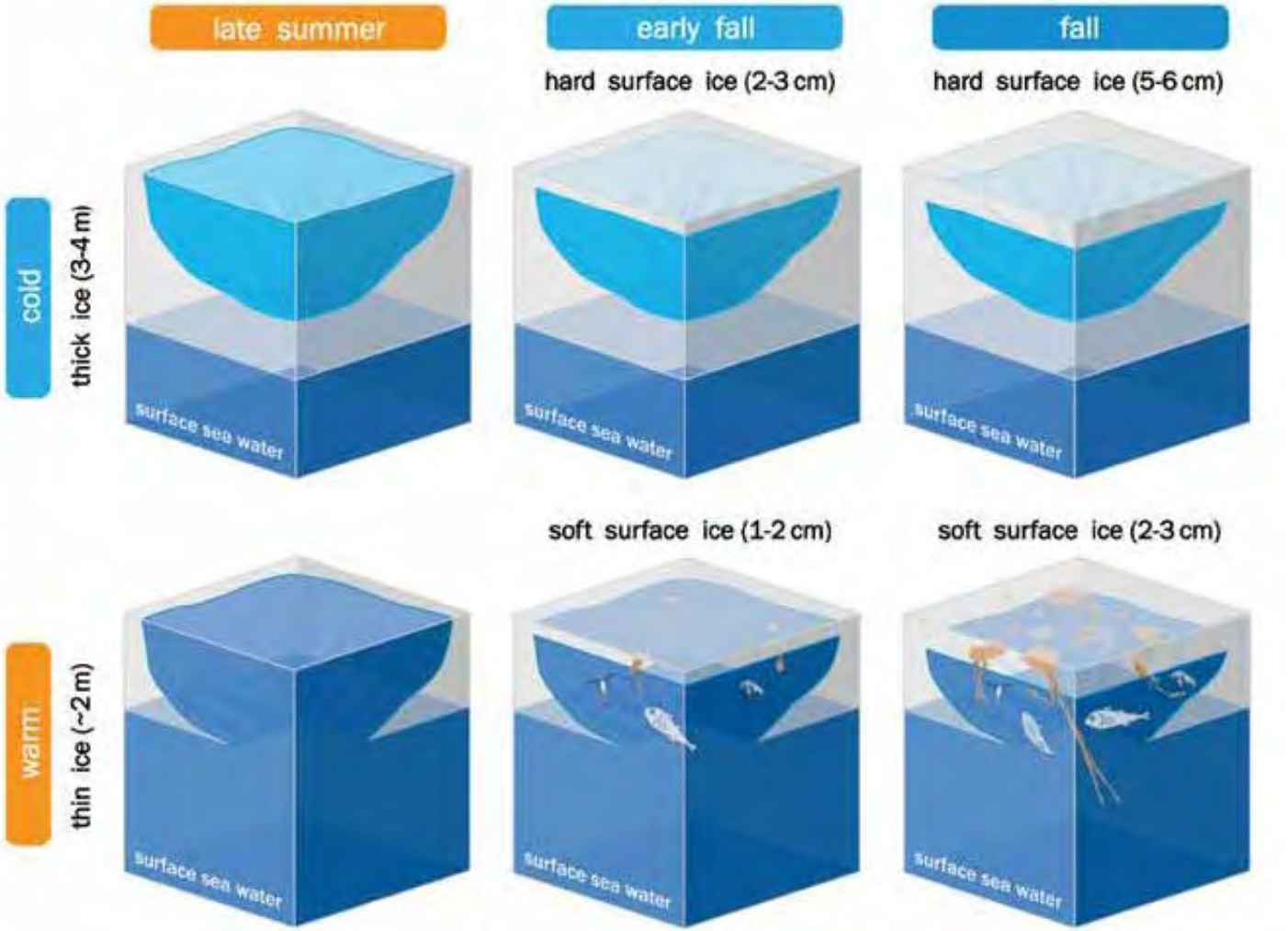
Coupel *et al*. [2015]

Results from the R/V Mirai Arctic Ocean cruise in 2017

Zodiac boat survey in an ice-edge area



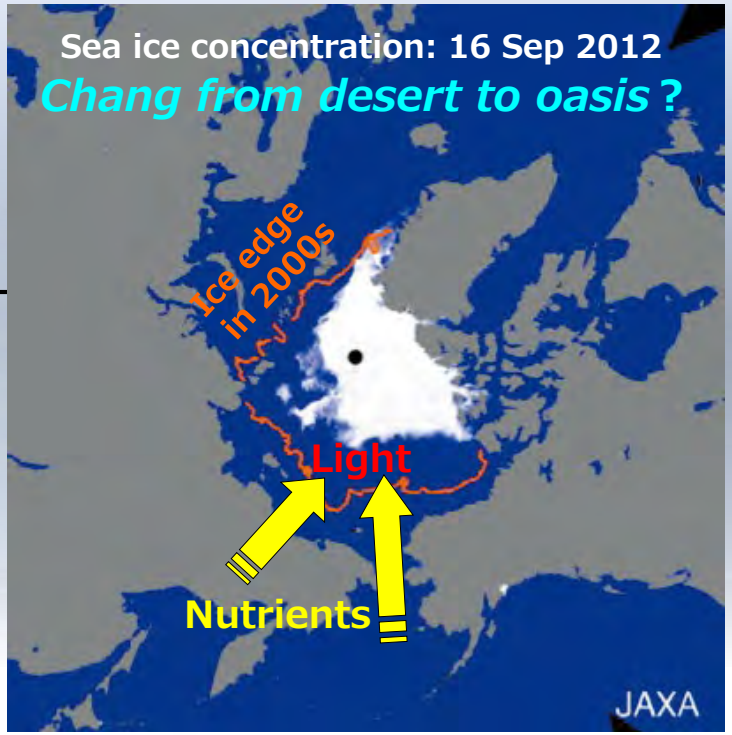
Melt ponds: important sites for ice algal production and marine ecosystems in the central Arctic Ocean



Alternative scenarios for response of pond algae to climate changes in the Arctic

Lee *et al*. [2011]

<Future perspectives>
Changes in marine environments and ecosystem due to the Arctic sea ice loss



Northward shift

$CO_2 \cdot CH_4$

Coastal erosion
Permafrost thawing

Oligotrophication
Change in phytoplankton

Sea ice reduction

Warming and invasion of southern species

Freshening and ocean acidification

Risk to plankton
Impact on ecosystem?

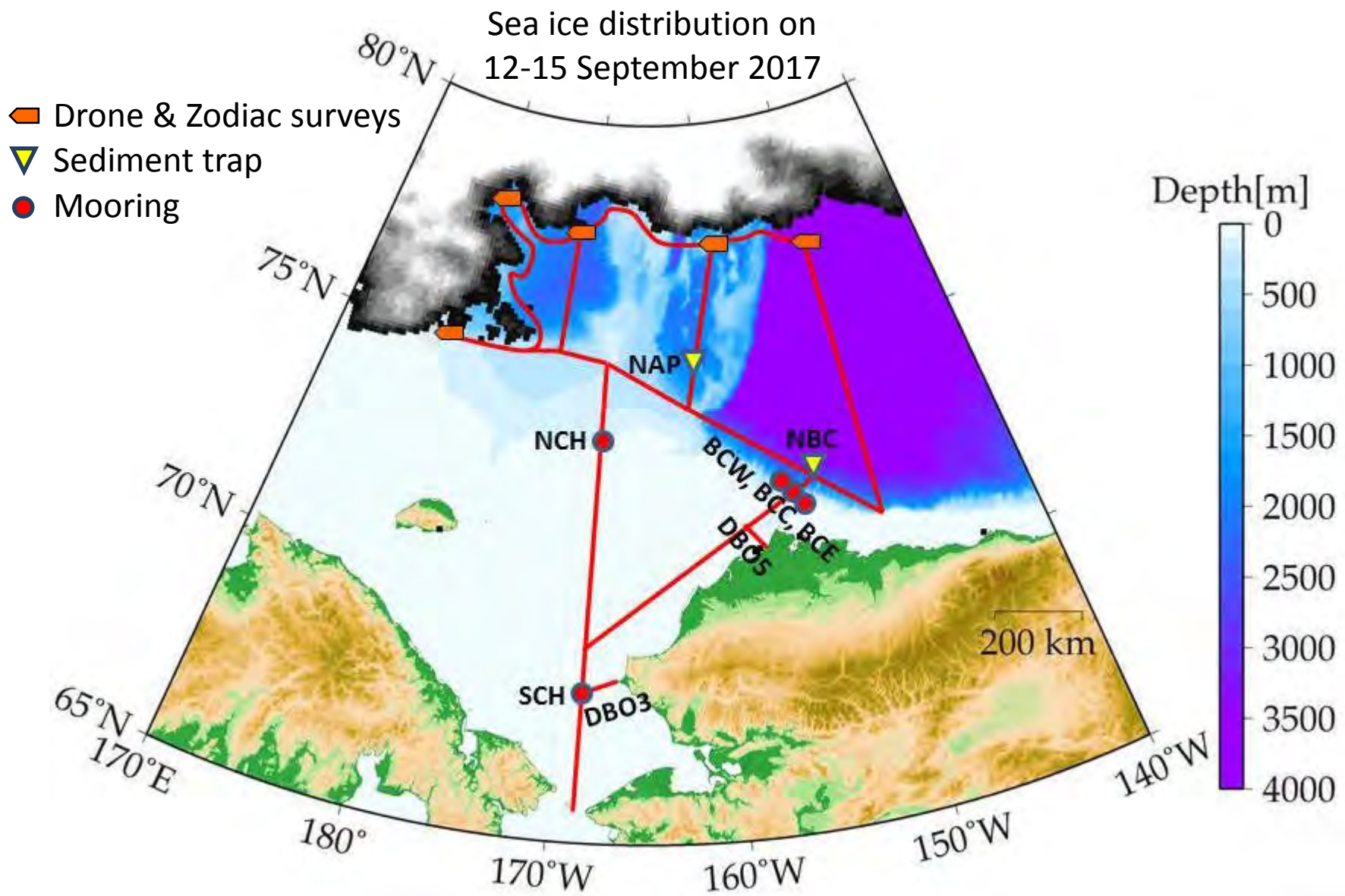
Decrease in prey sedimentation?

Decrease in biological pump

Damage to whaling?

Risk to benthic organisms?

2020 or 2021 R/V Mirai Arctic Ocean cruise plan

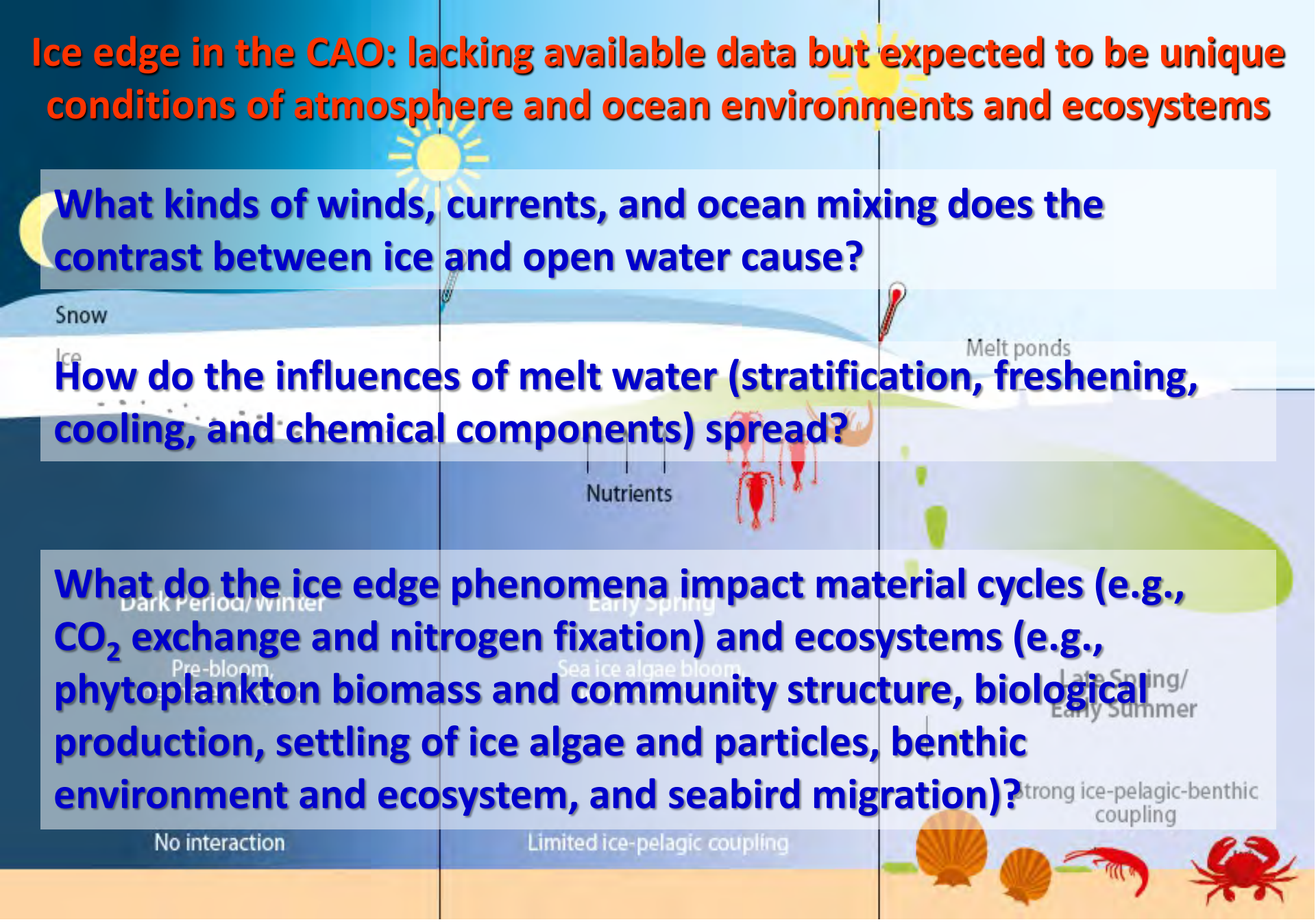


Ice edge in the CAO: lacking available data but expected to be unique conditions of atmosphere and ocean environments and ecosystems

What kinds of winds, currents, and ocean mixing does the contrast between ice and open water cause?

How do the influences of melt water (stratification, freshening, cooling, and chemical components) spread?

What do the ice edge phenomena impact material cycles (e.g., CO_2 exchange and nitrogen fixation) and ecosystems (e.g., phytoplankton biomass and community structure, biological production, settling of ice algae and particles, benthic environment and ecosystem, and seabird migration)?



[SWIPA, 2017]


Snow
Ice
Nutrients
Dark
Pre-bloom,
net heterotrophic
No interaction
Limited ice
Late Spring/
Early Summer
Strong ice-pelagic-benthic
coupling

[SWIPA, 2017]