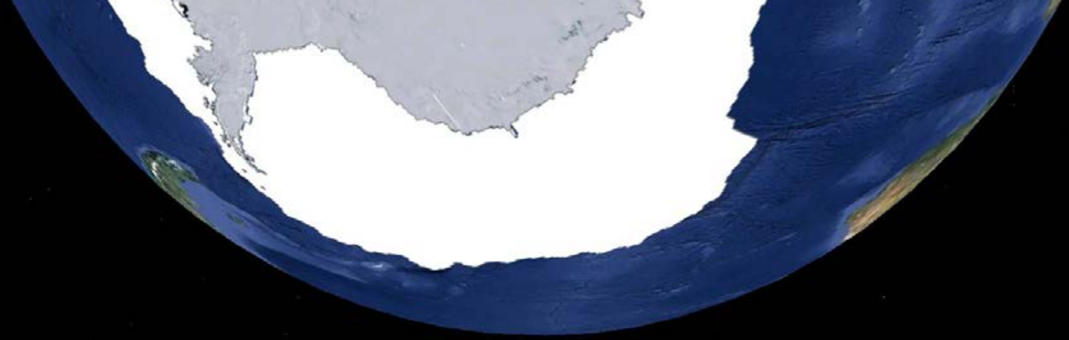


A bi-polar perspective on sea ice

H. Flores, C. David, B. Lange, M. Fernandez-Méndez, M. Bayer, E. Kilias, C. Wolf, C. Lalande, I. Peeken, B. Meyer, G. Dieckmann, a.m.o.

Outline

1. Differences and similarities between the Polar Regions
2. Productivity
3. Biodiversity
4. Climate change
5. Conclusions

PACES II

Topic 1: Changes and regional feedbacks in Arctic and Antarctic

WP 4

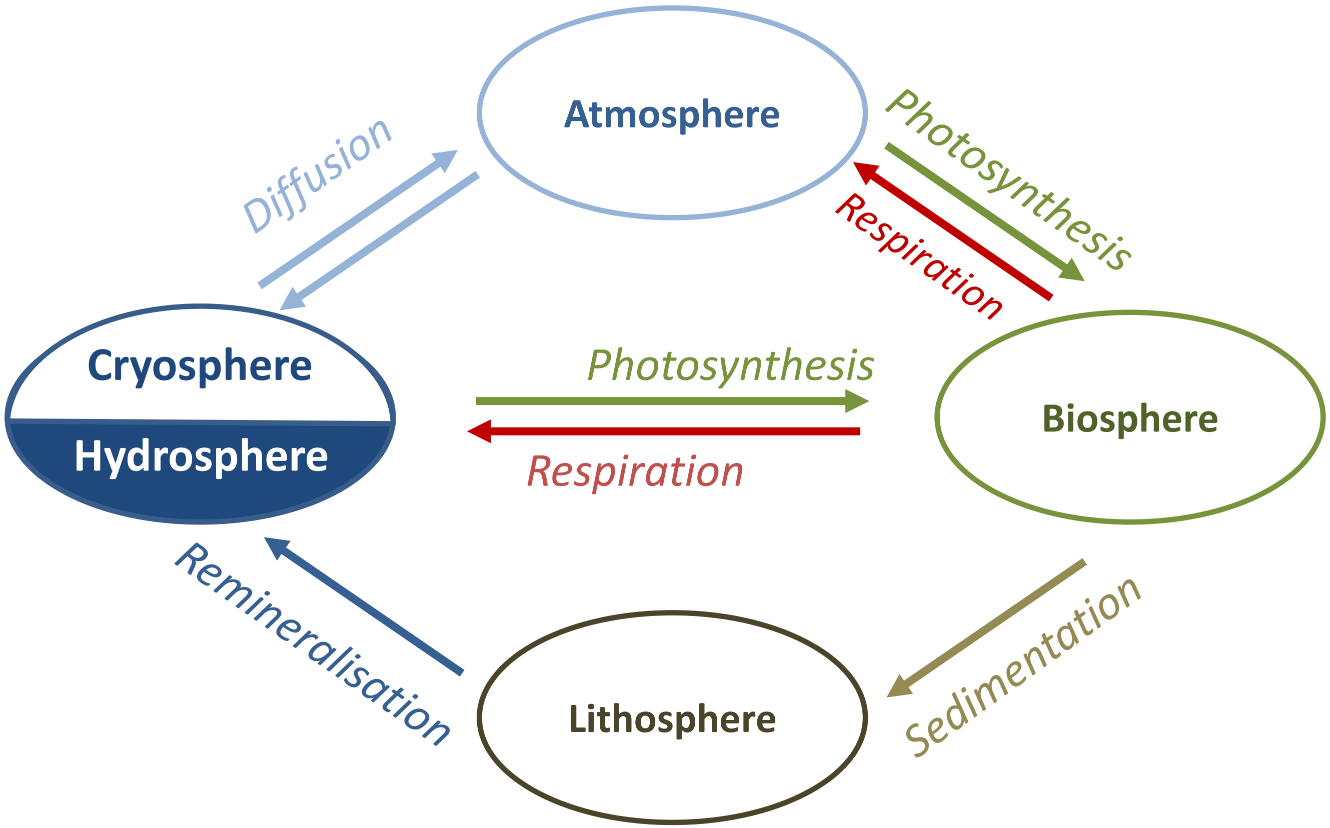
- *To provide evidence and understanding of the **causes and consequences of variation in sea ice cover for the hydro-, bio- and geosphere of the Arctic Ocean** and beyond*

WP 5

- *Assess the changes that occur in the Southern Ocean, **identify the processes that link physics, chemistry and biology**, and determine the feedback mechanisms to the global climate system*

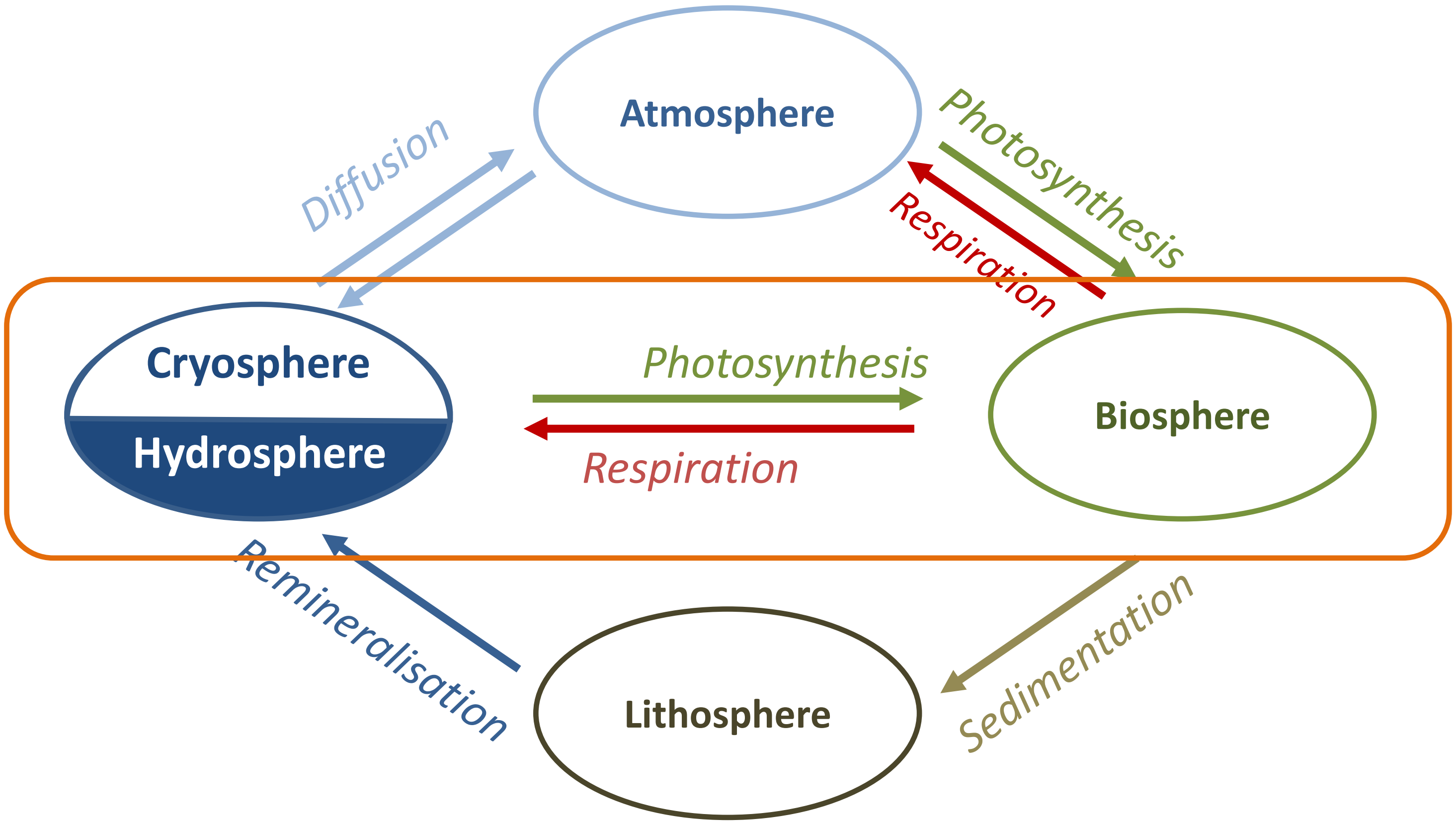
Biogeochemical cycling in Polar ecosystems

Identify the processes that link physics, chemistry and biology

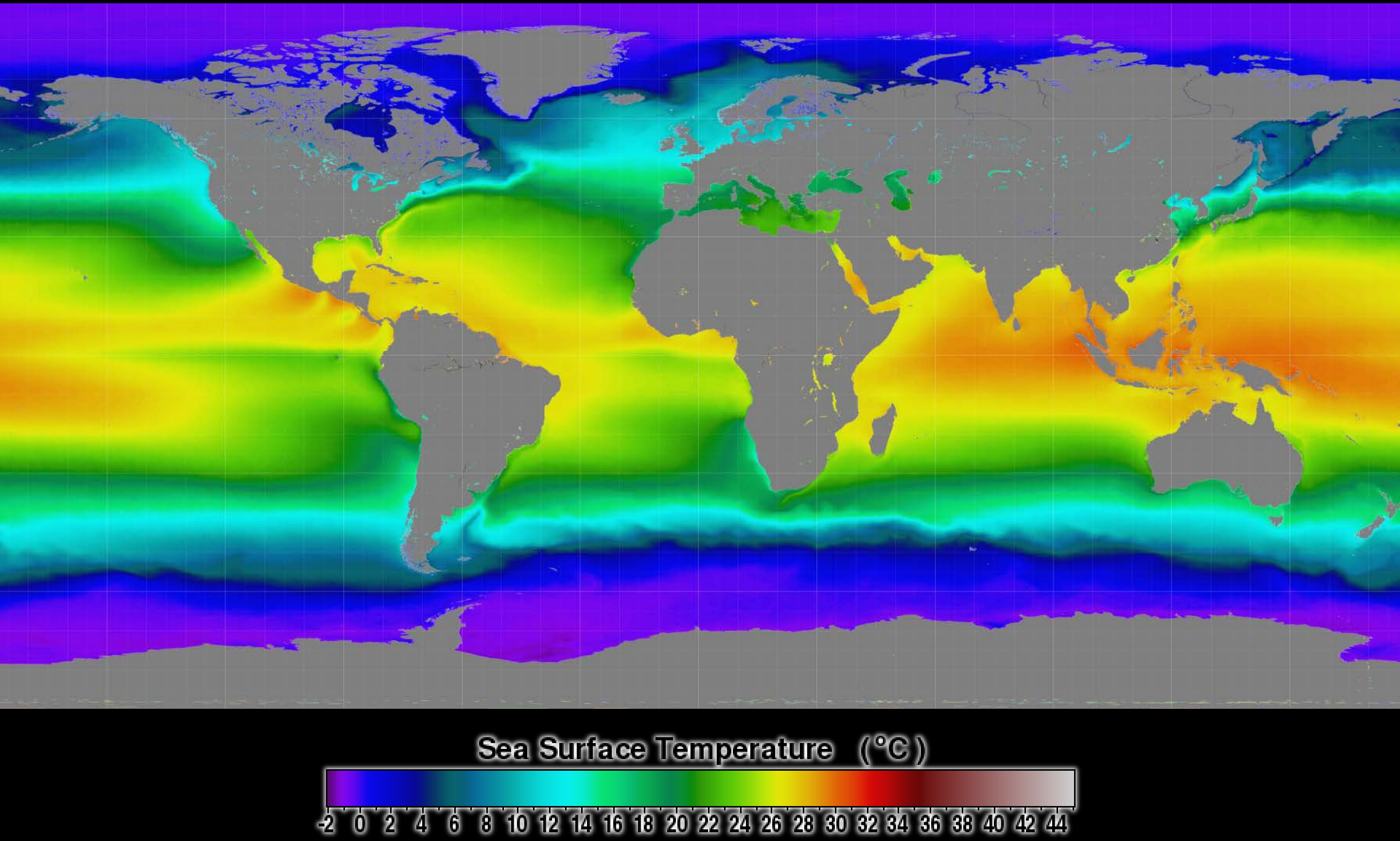


Biogeochemical cycling in Polar ecosystems

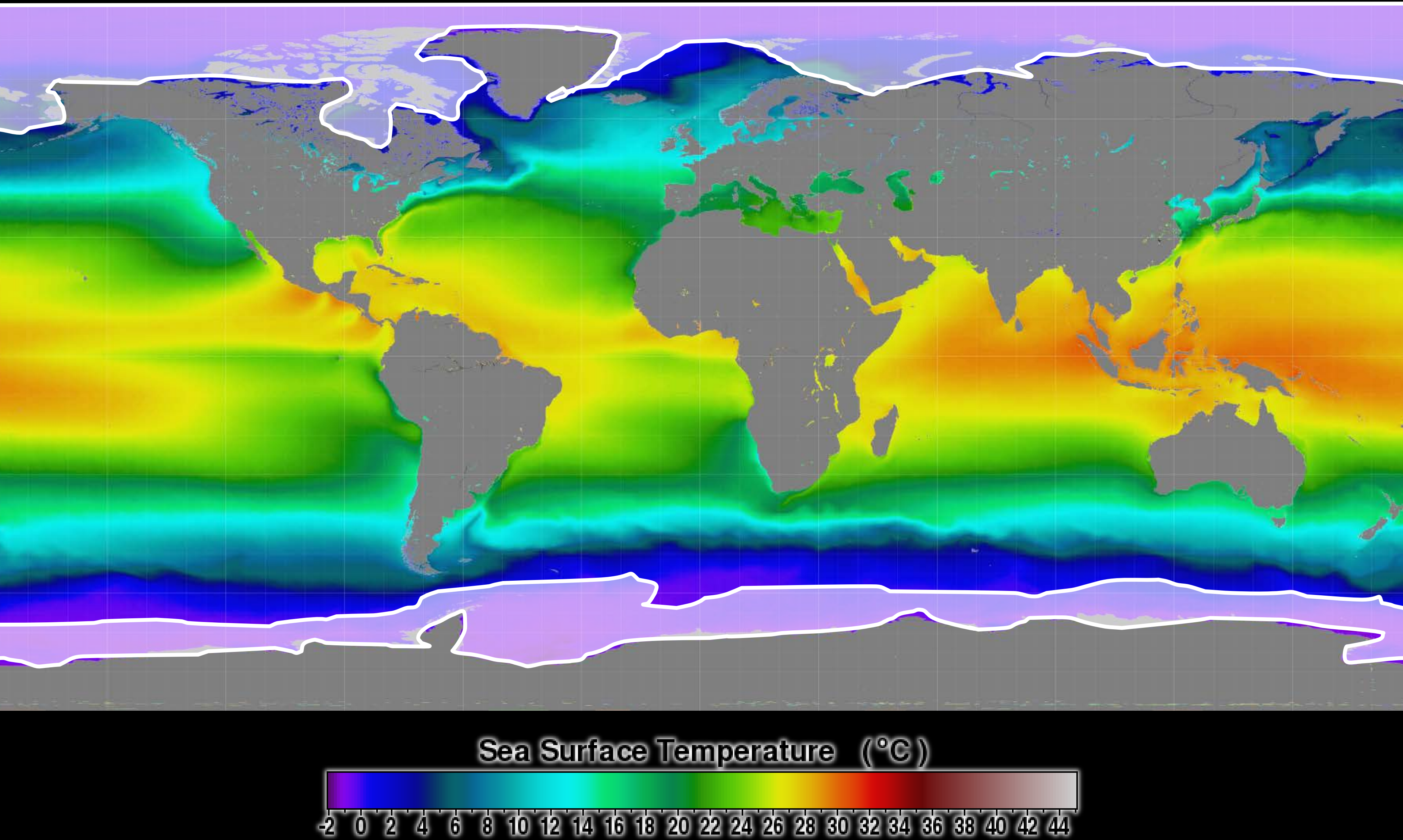
Identify the processes that link physics, chemistry and biology



Global sea surface temperature



Global sea SST and sea ice zones



Differences in hydrography

Arctic Ocean

- Mediterrenean ocean
- 16 mio skm SIZ
- Broad, shallow shelves
- Trans-polar currents
- Low nutrient concentrations

Antarctic Ocean

- Open ring ocean
- 20 mio skm SIZ
- Narrow, deep shelves
- Circum-Polar currents
- High nutrient concentrations
- Iron-limited

Differences in sea ice

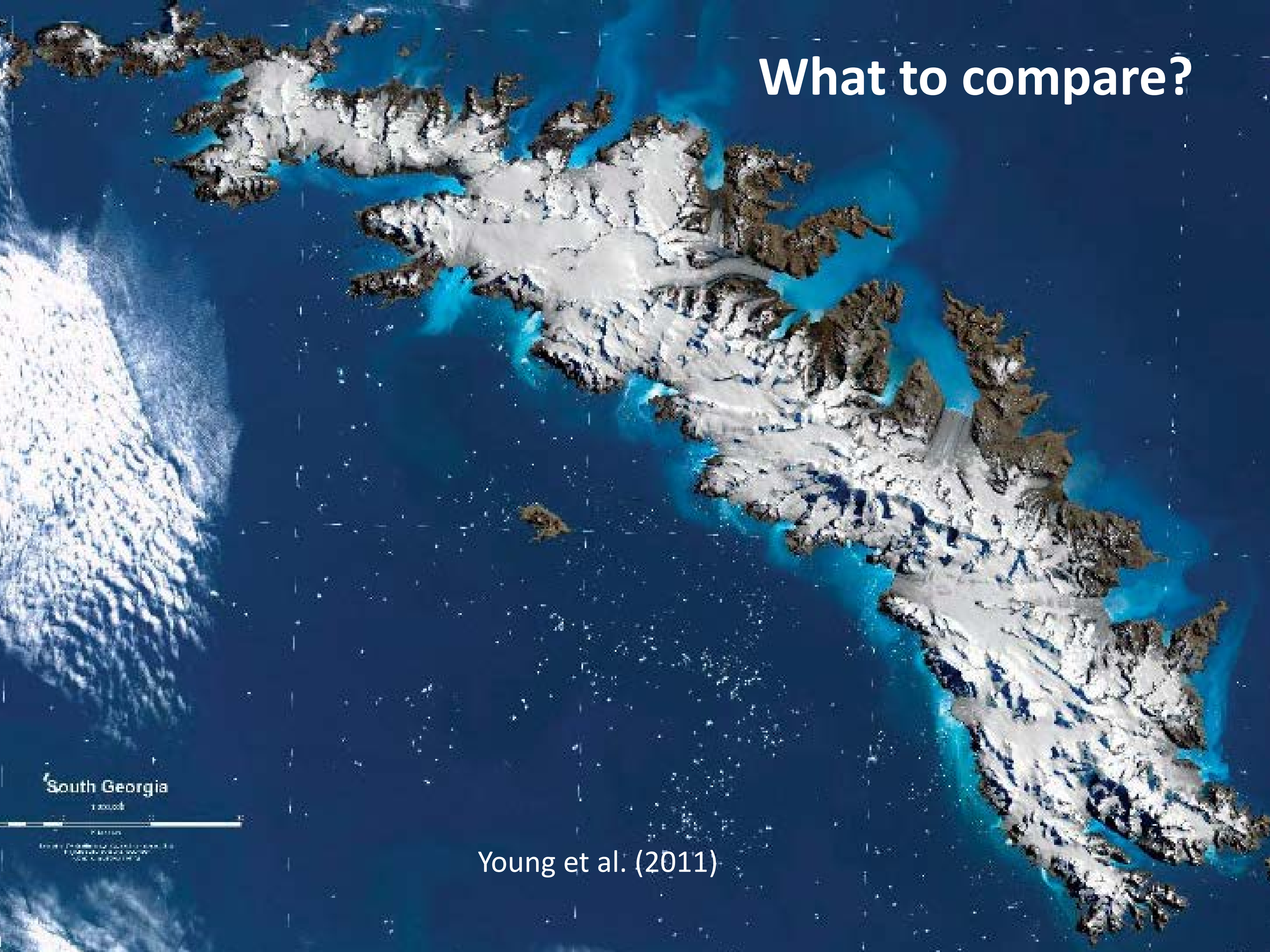
Arctic Ocean

- MYI dominant (?)
- Little snow
- Melt ponds
- Aggregates / *Melosira*

Antarctic Ocean

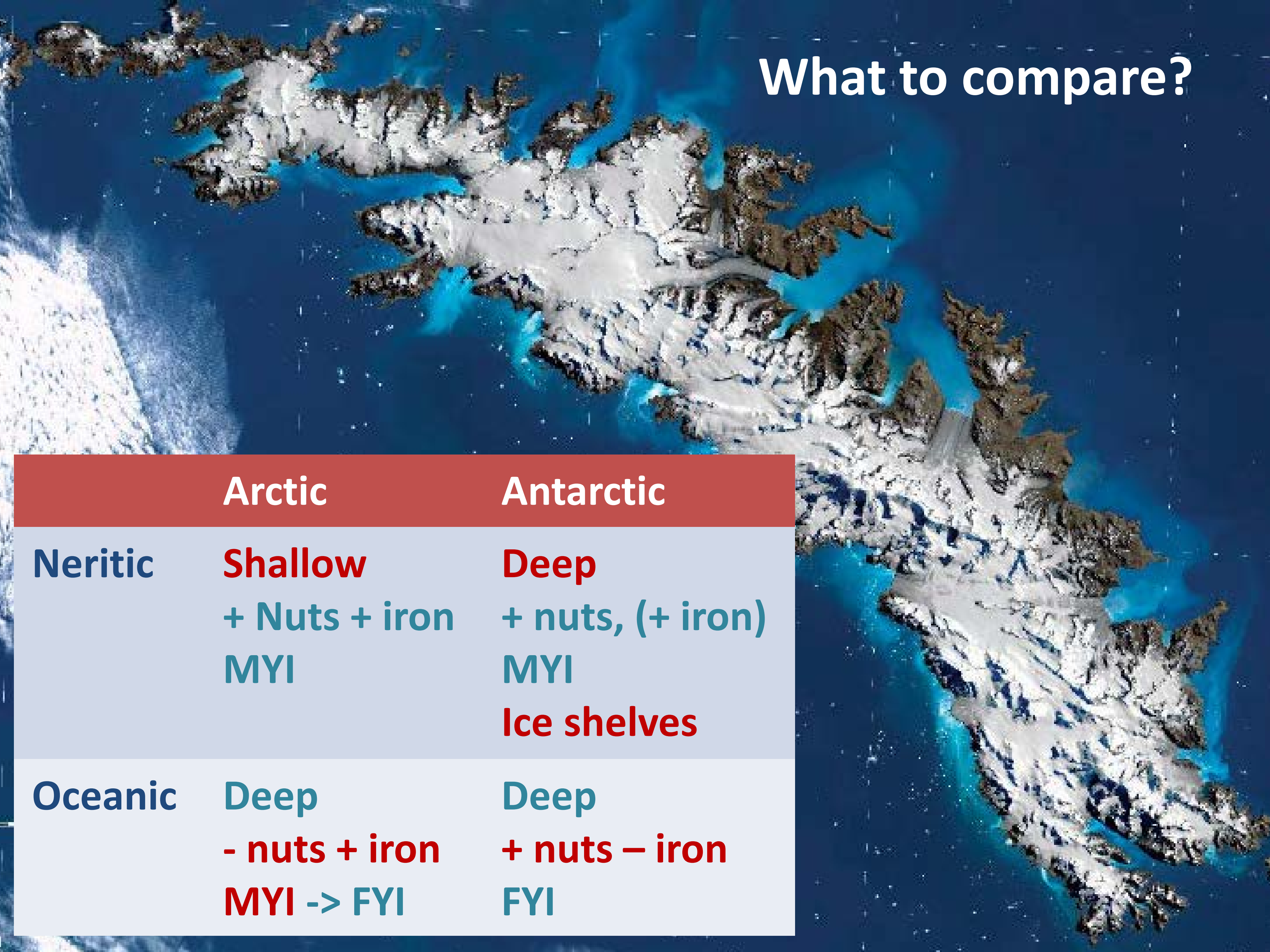
- FYI dominant
- Snow cover
- Ice shelves
- Platelet ice habitats

What to compare?

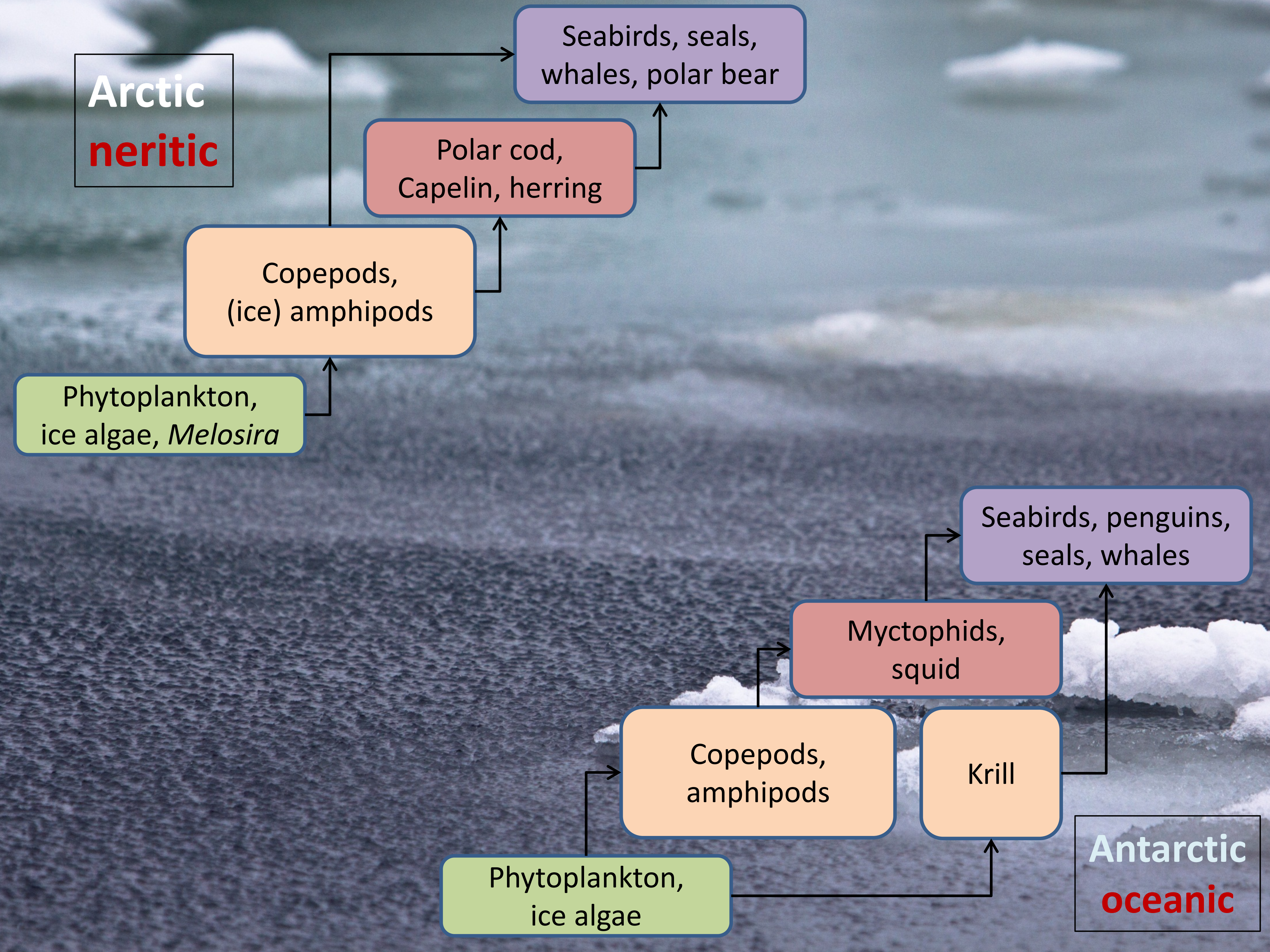


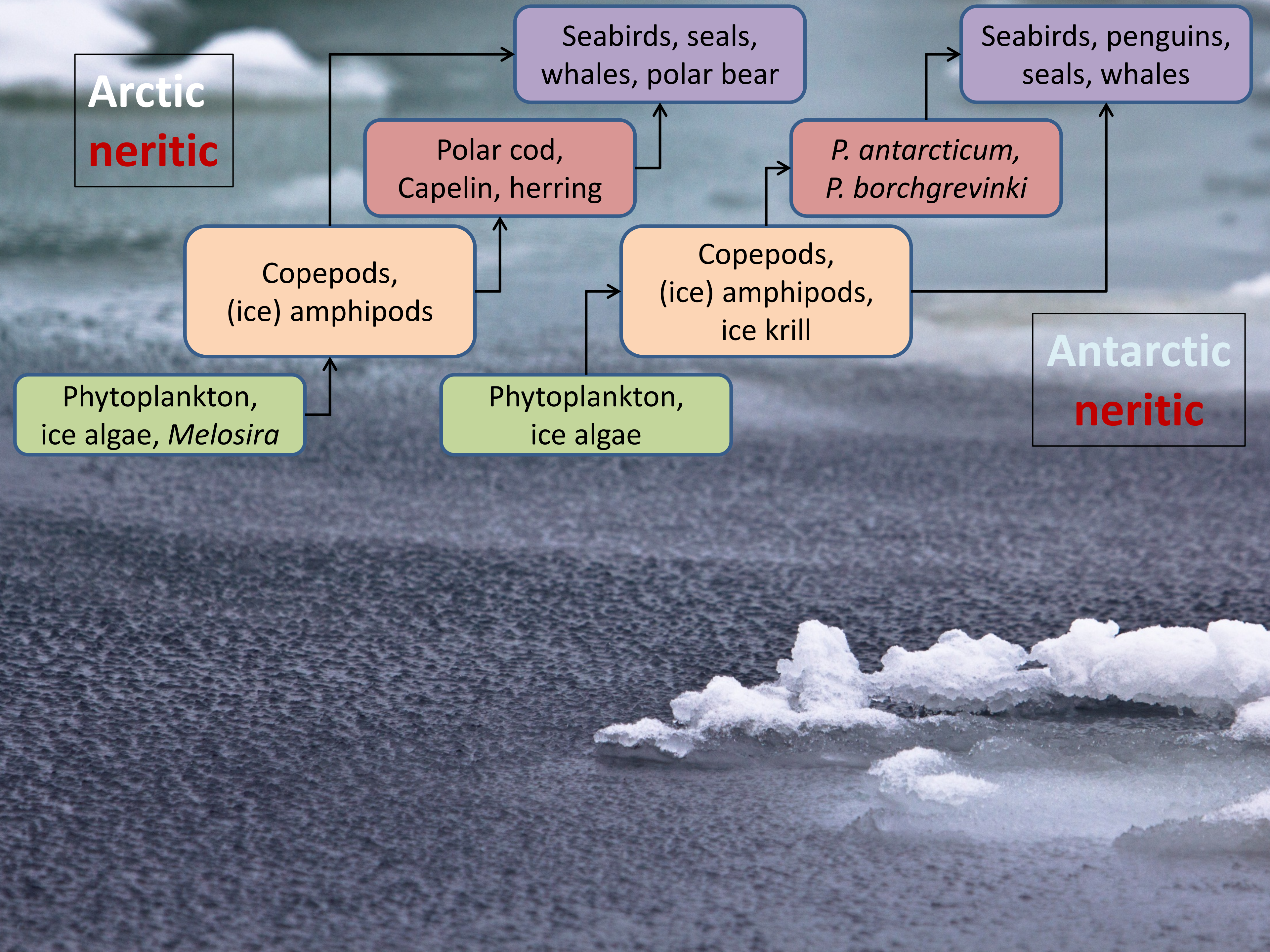
Young et al. (2011)

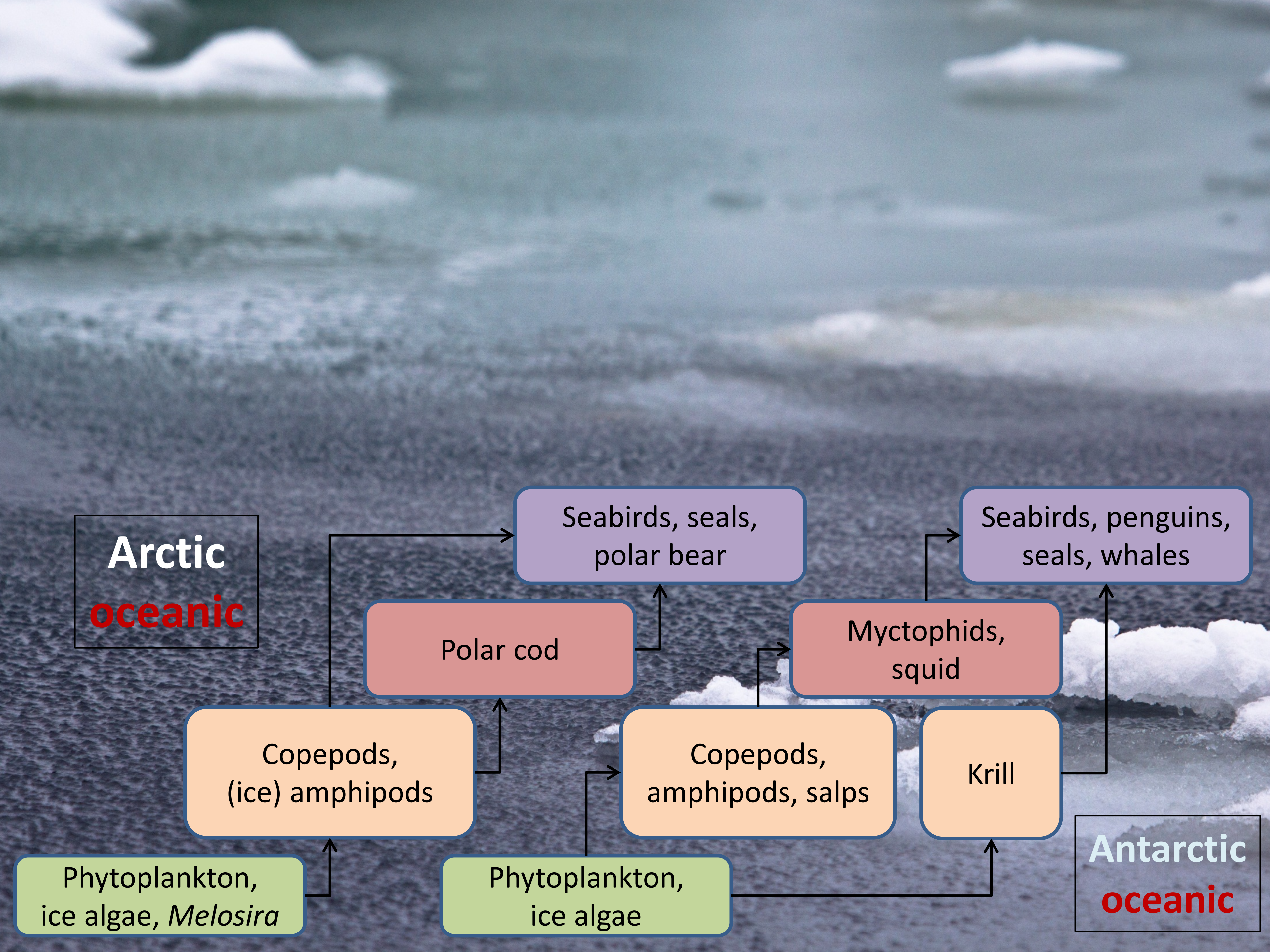
What to compare?



	Arctic	Antarctic
Neritic	Shallow + Nuts + iron MYI	Deep + nuts, (+ iron) MYI Ice shelves
Oceanic	Deep - nuts + iron MYI -> FYI	Deep + nuts – iron FYI

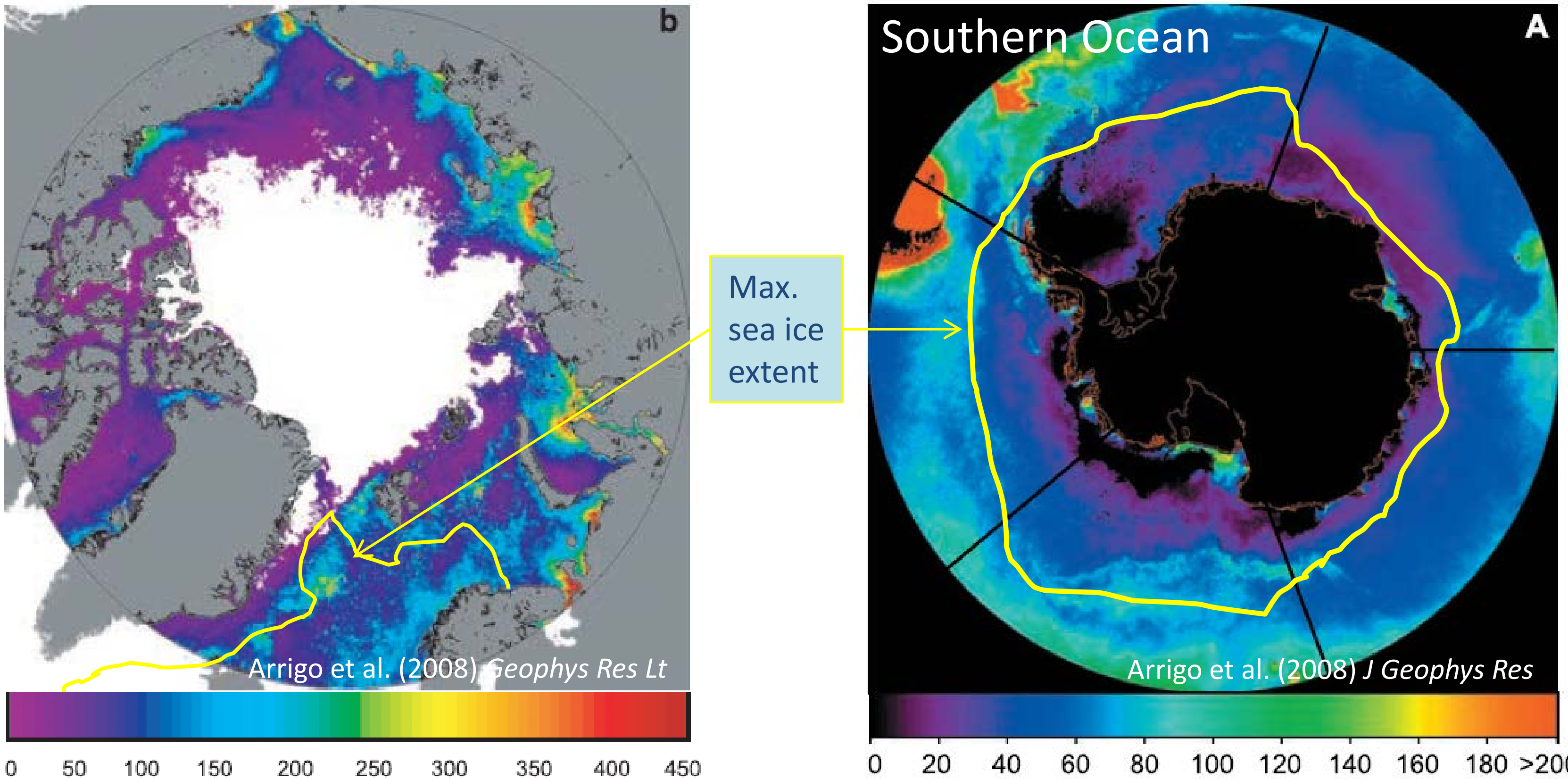

Arctic
neritic
Seabirds, seals, whales, polar bear
Polar cod, Capelin, herring
Copepods, (ice) amphipods
Phytoplankton, ice algae, *Melosira*
Seabirds, penguins, seals, whales
Myctophids, squid
Copepods, amphipods
Krill
Phytoplankton, ice algae
Antarctic
oceanic


Arctic
neritic
Seabirds, seals, whales, polar bear
Polar cod, Capelin, herring
Copepods, (ice) amphipods
Phytoplankton, ice algae, *Melosira*
Seabirds, penguins, seals, whales
P. antarcticum, P. borchgrevinki
Copepods, (ice) amphipods, ice krill
Phytoplankton, ice algae
Antarctic
neritic



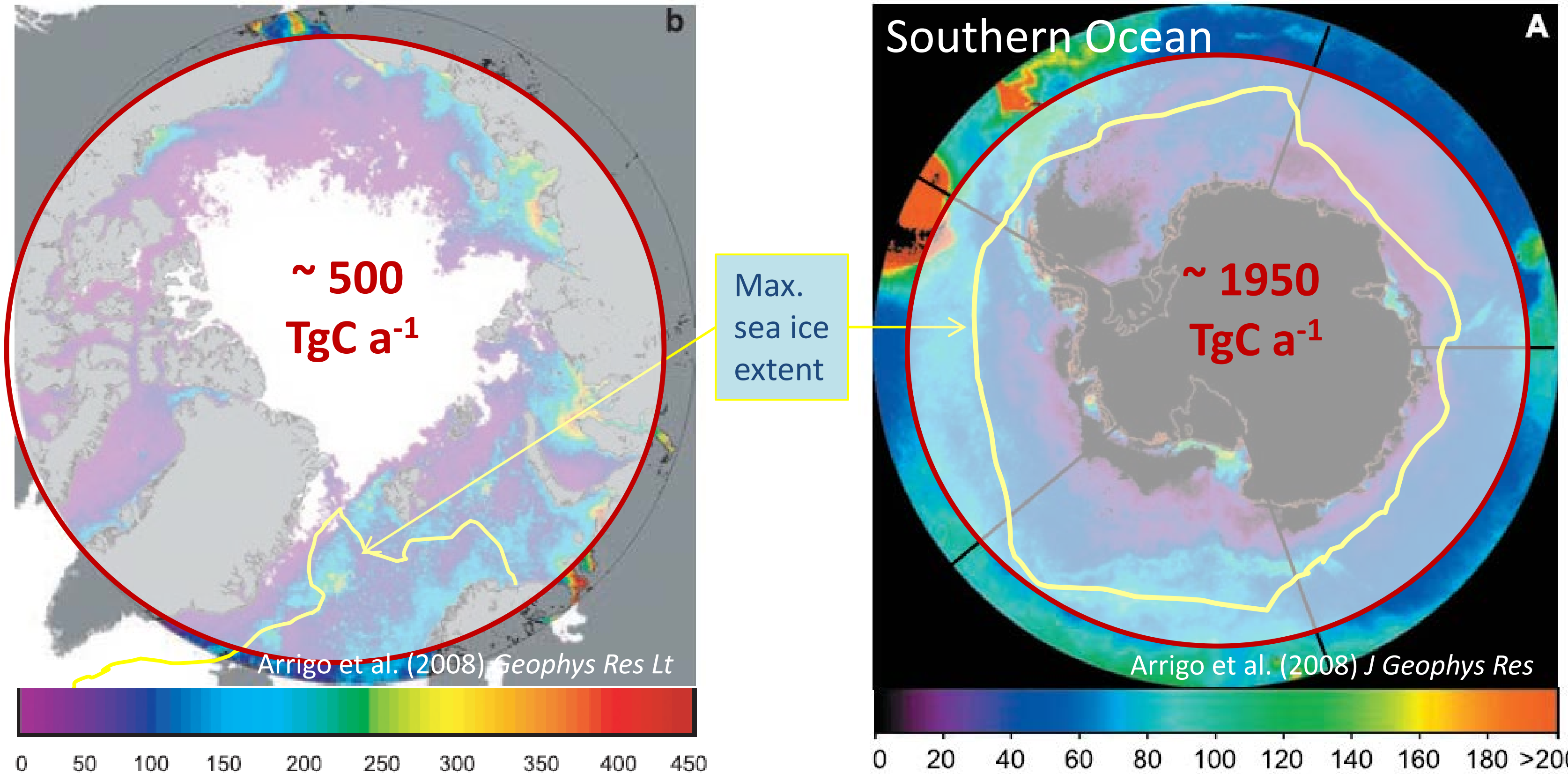
Arctic
oceanic
Seabirds, seals, polar bear
Polar cod
Copepods, (ice) amphipods
Phytoplankton, ice algae, *Melosira*
Seabirds, penguins, seals, whales
Myctophids, squid
Copepods, amphipods, salps
Krill
Phytoplankton, ice algae
Antarctic
oceanic

Productivity



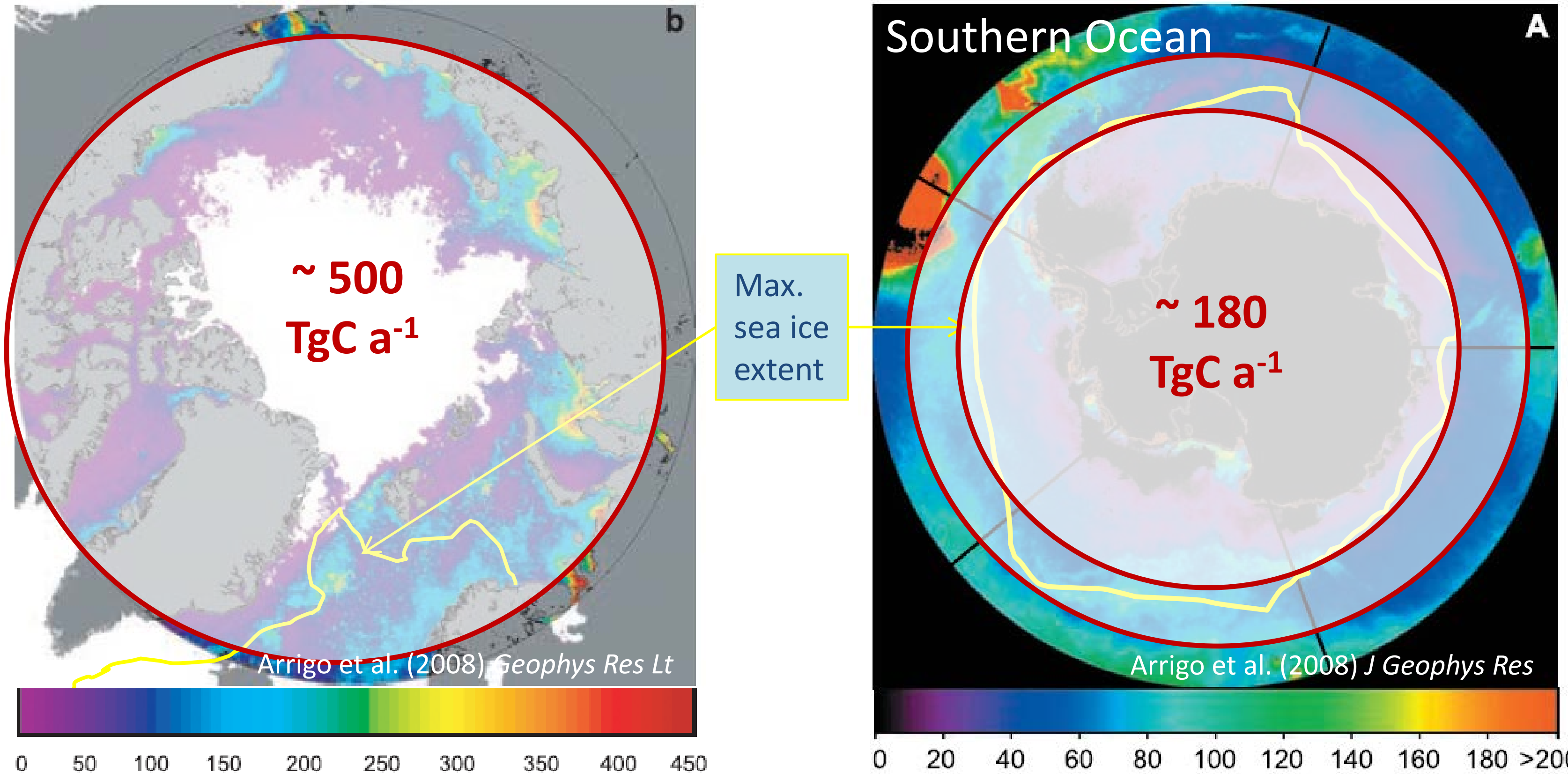
Annual water column primary production (g C m^{-2} y^{-1})

Productivity



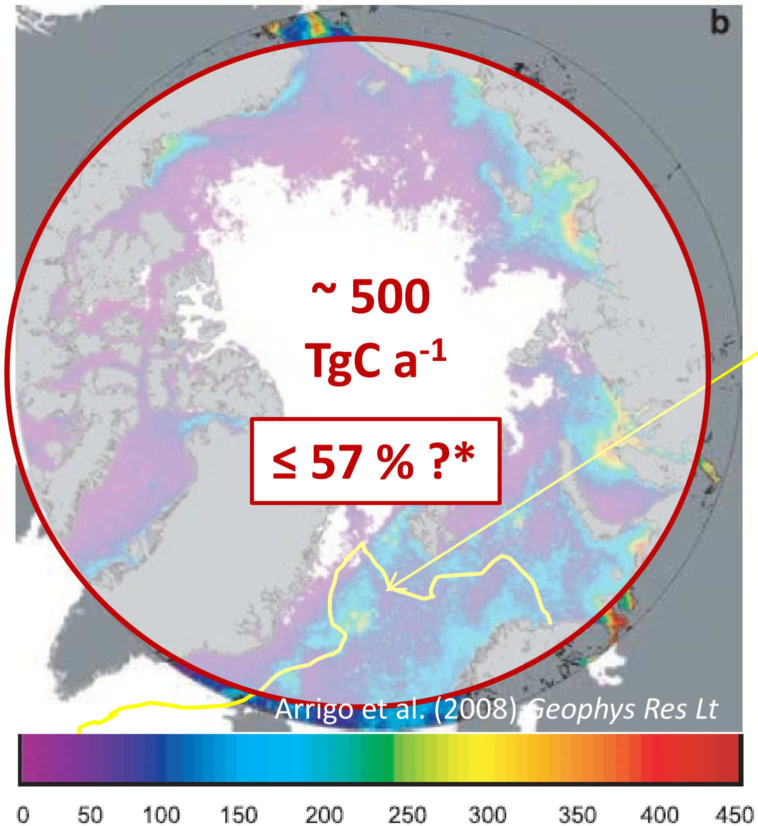
Annual water column primary production (g C m^{-2} y^{-1})

Productivity

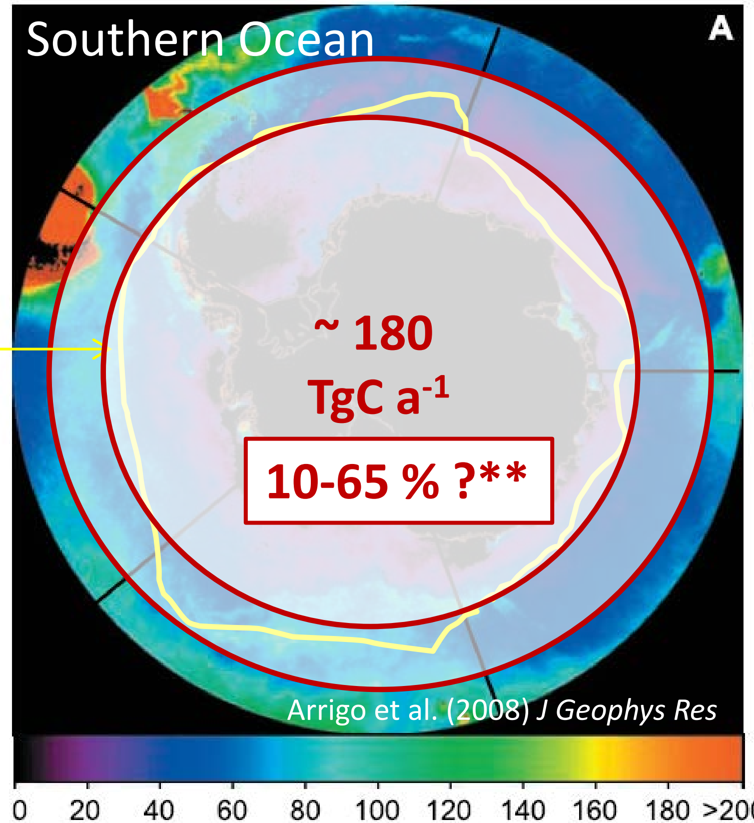


Annual water column primary production (g C m^{-2} y^{-1})

Proportional contribution of ice algal primary production



Max. sea ice extent



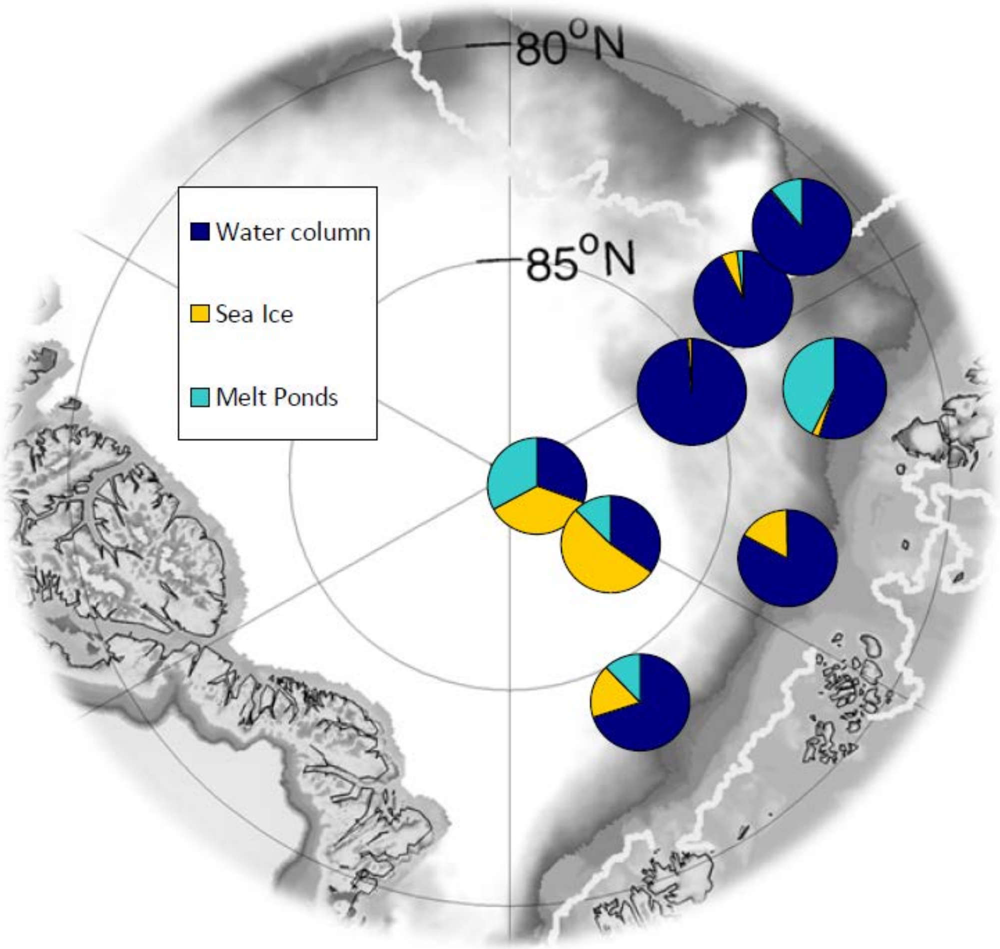
*Gosselin (1997) *Deep-Sea Res II*

** Arrigo & Thomas (2004) *Ant Sci*
McMinn et al. (2010) *Mar Biol*

Annual water column primary production (g C m^{-2} y^{-1})

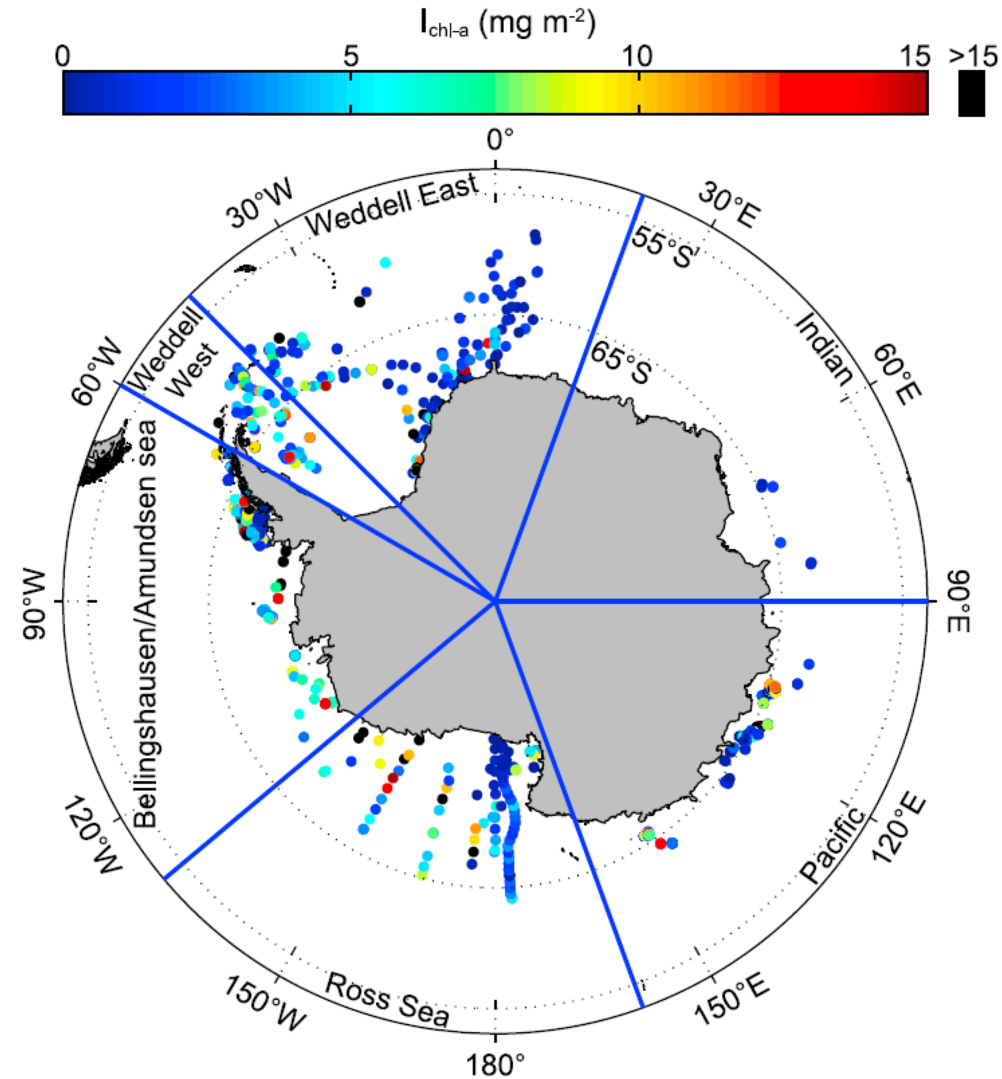
Primary production in the Arctic SIZ

Percentage contribution to PP August-September 2012

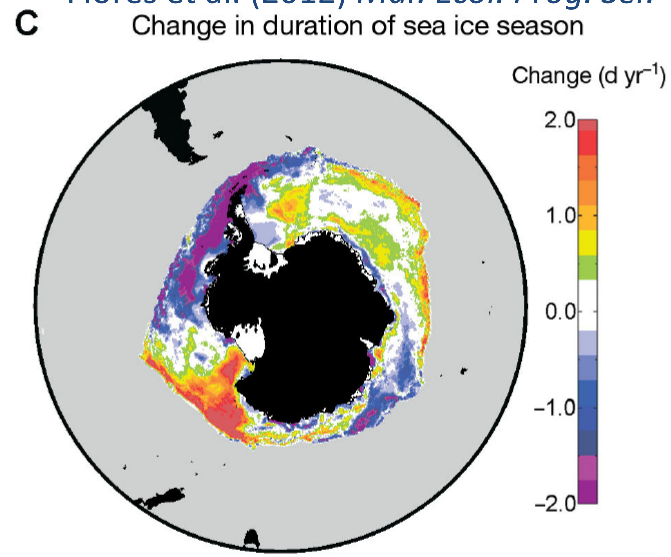


Mar Fernandez-Méndez

Antarctic sea ice algal biomass



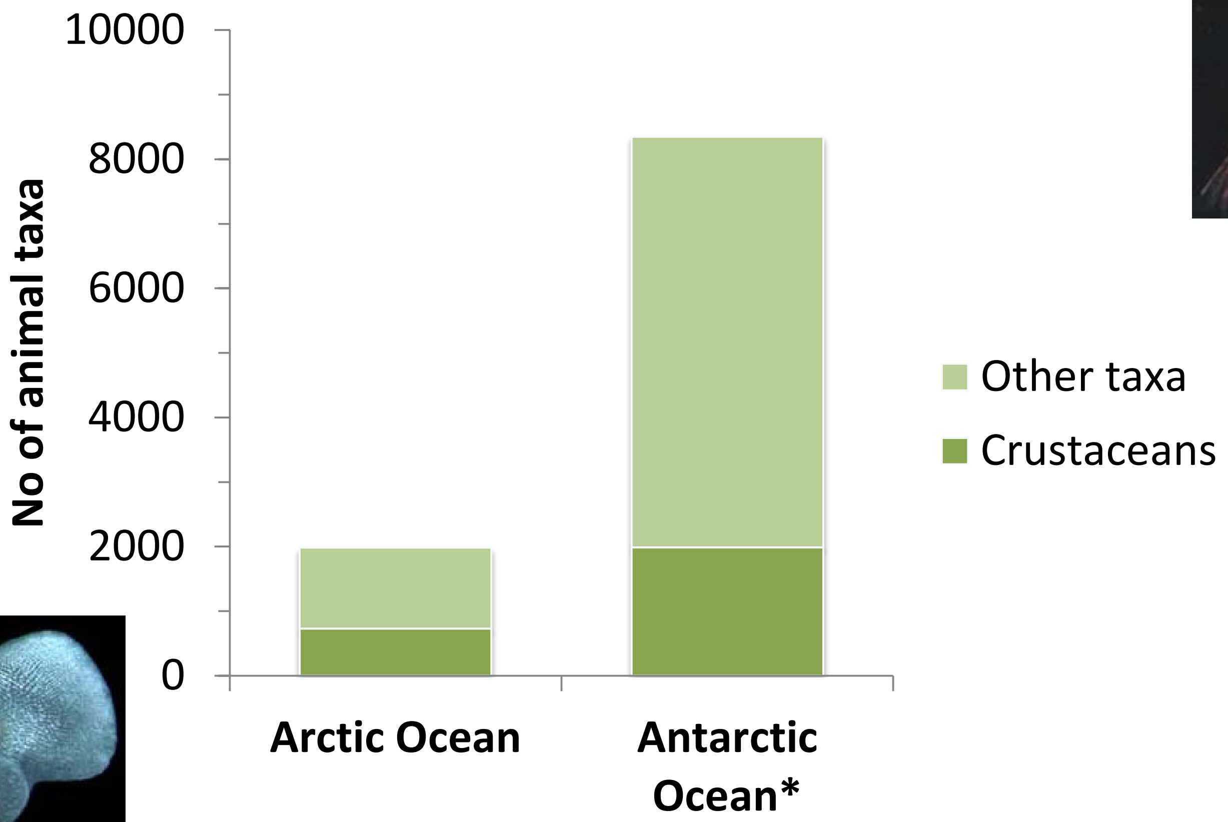
Flores et al. (2012) *Mar. Ecol. Prog. Ser.*



Klaus Meiners
Gerhard Dieckmann

Meiners et al. (2012) *Geoph. Res. Let.*

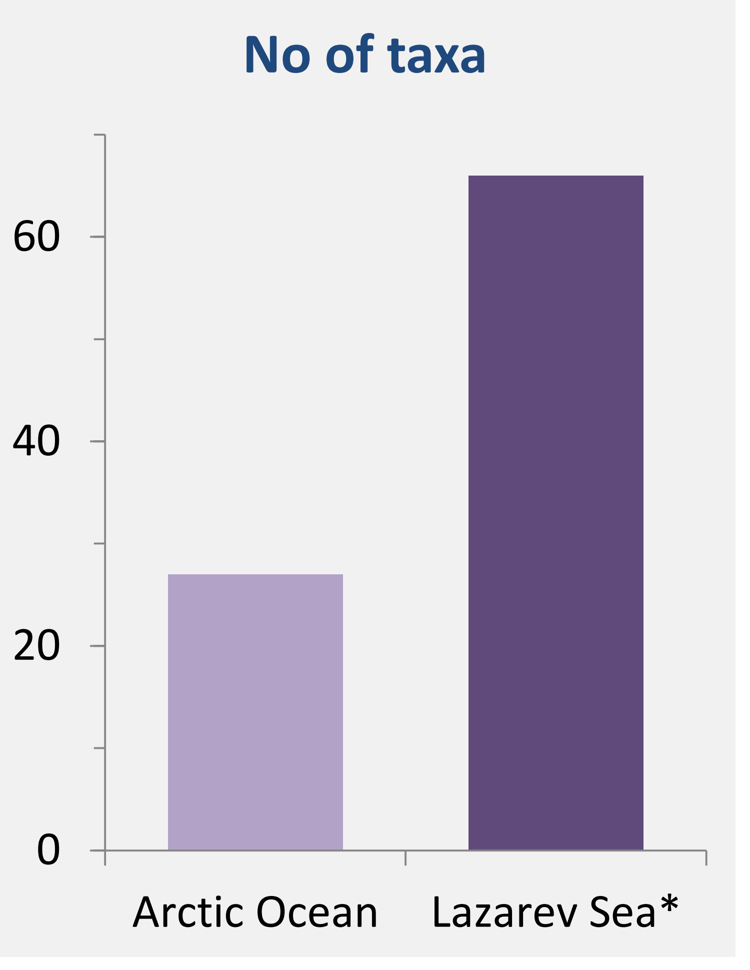
Diversity



* South of 60°S

Census of Marine Life database (2013)

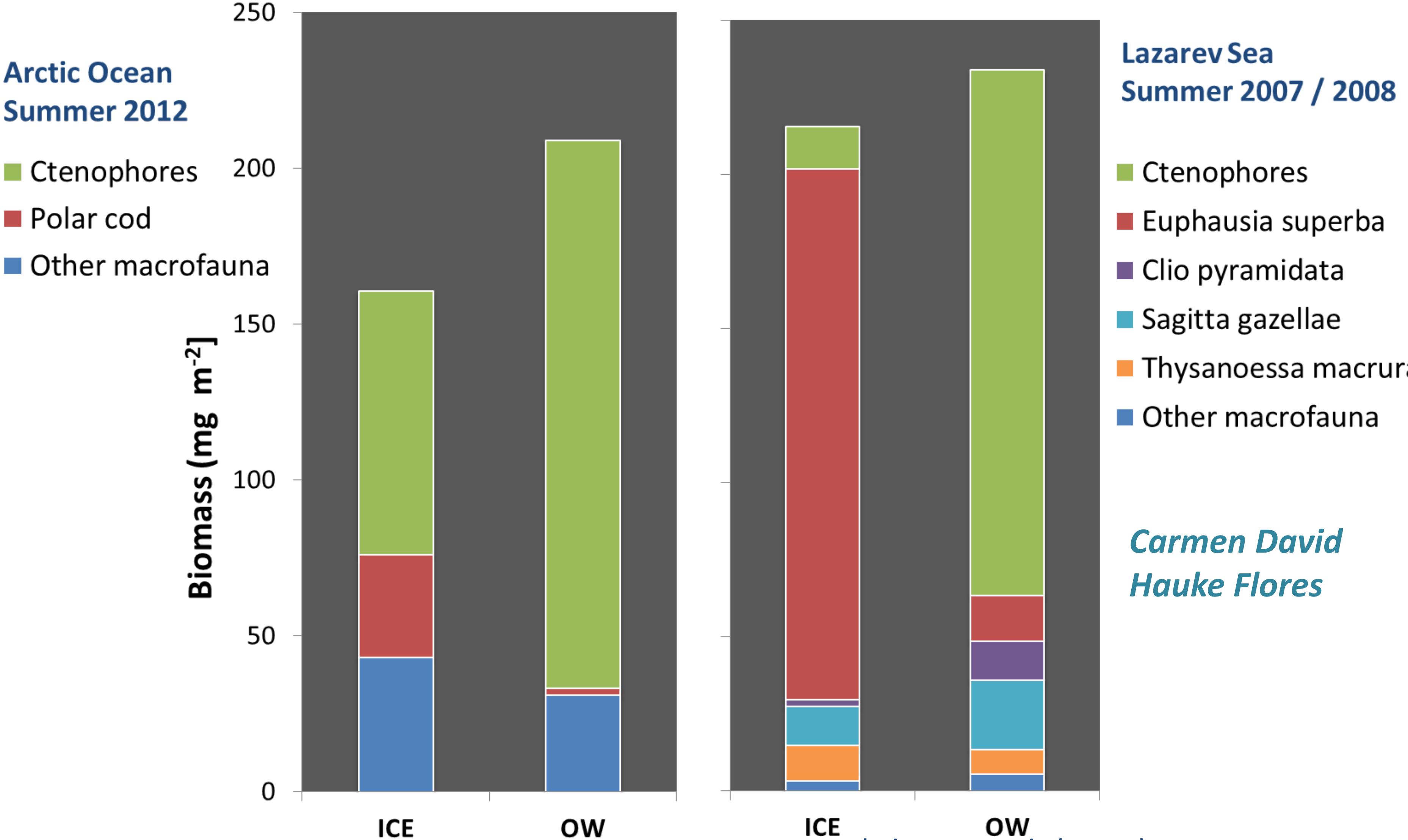
Under-ice fauna



Hauke Flores
Carmen David
Henrieke Tonkes

*Flores et al. (2011) *Deep-Sea Res. II*

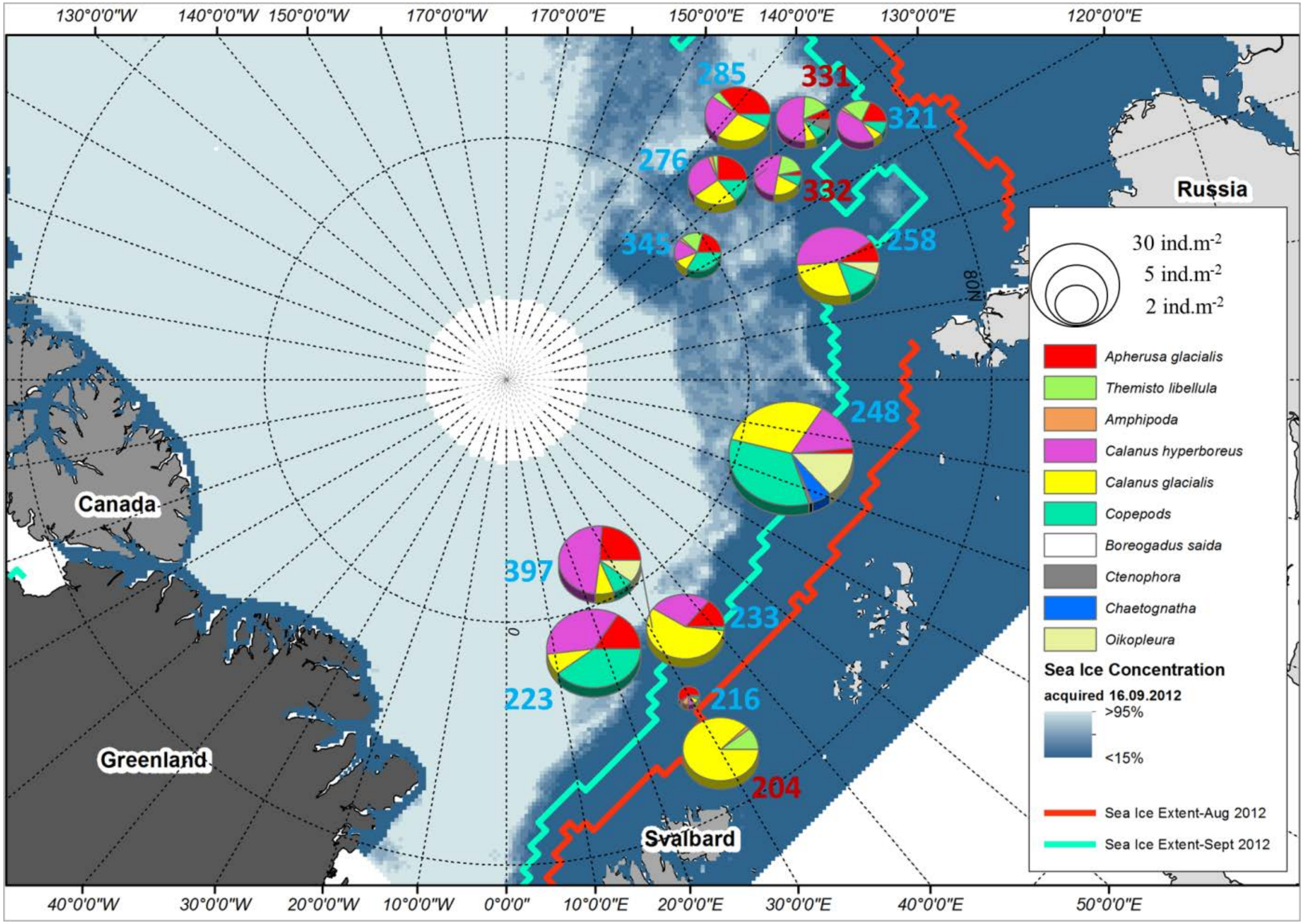
Under-ice fauna



Carmen David
Hauke Flores

*Flores et al. (2011) *Deep-Sea Res. II*

Under-ice fauna

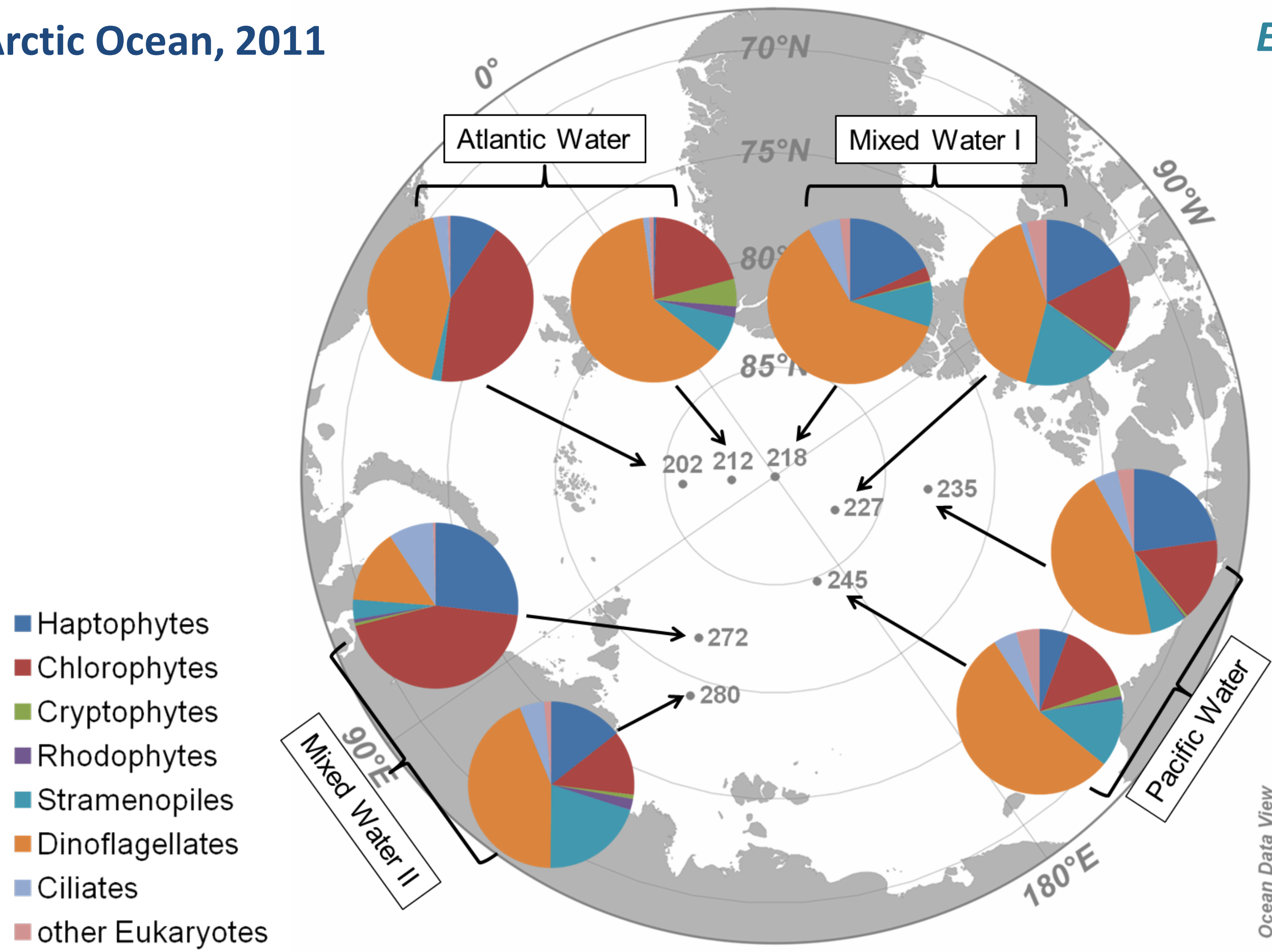


Carmen David, Benjamin Lange

Arctic phytoplankton communities

Arctic Ocean, 2011

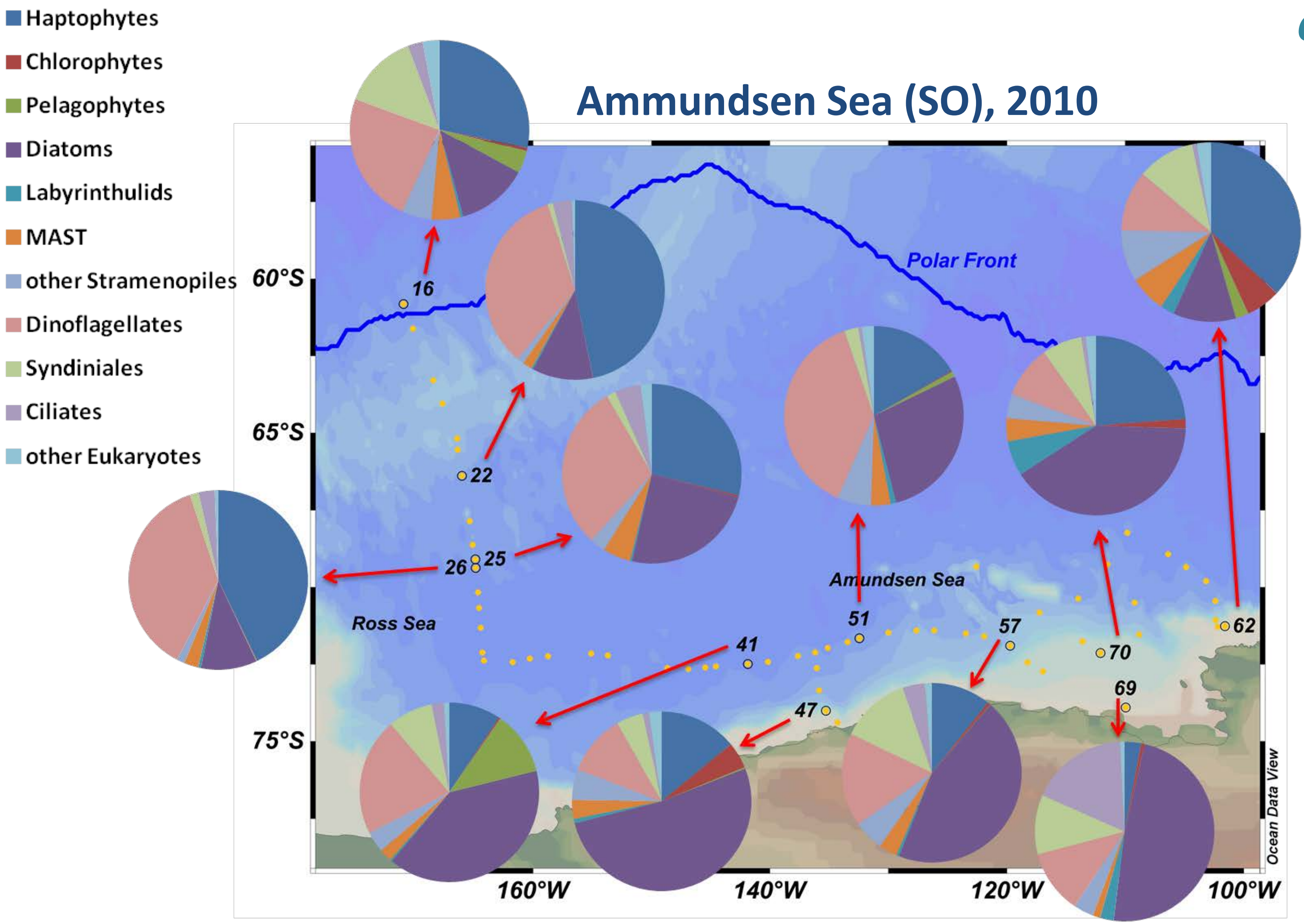
Estelle Kilias



Taxonomical groups identified by 18S rDNA variability(454 pyrosequencing)

Antarctic phytoplankton communities

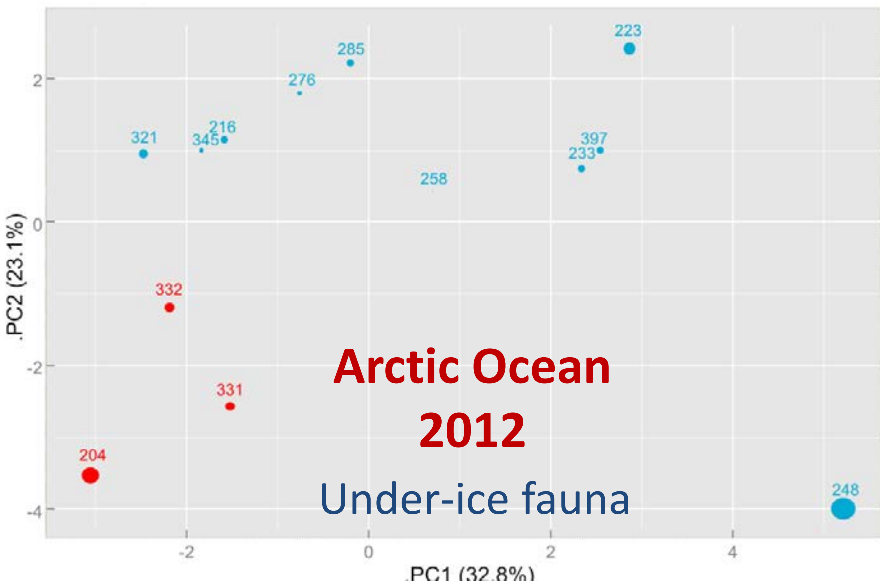
Christian Wolf

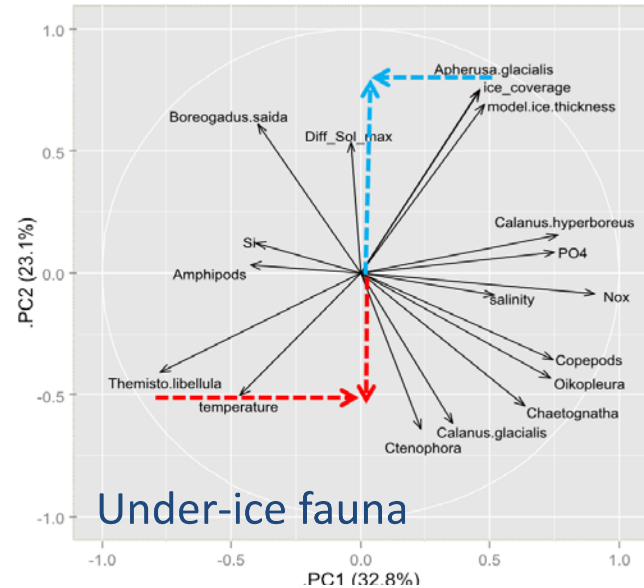


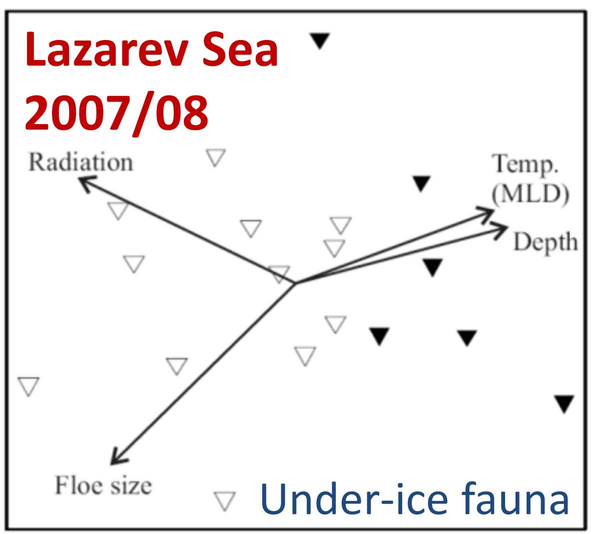
Taxonomical groups identified by 18S rDNA variability(454 pyrosequencing)

Wolf et al. (in press) *Ant. Sci.*

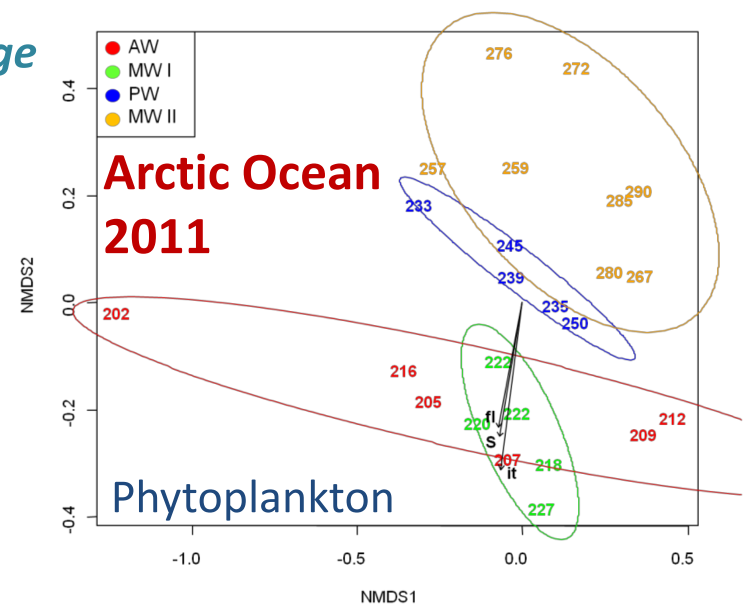
Community analysis





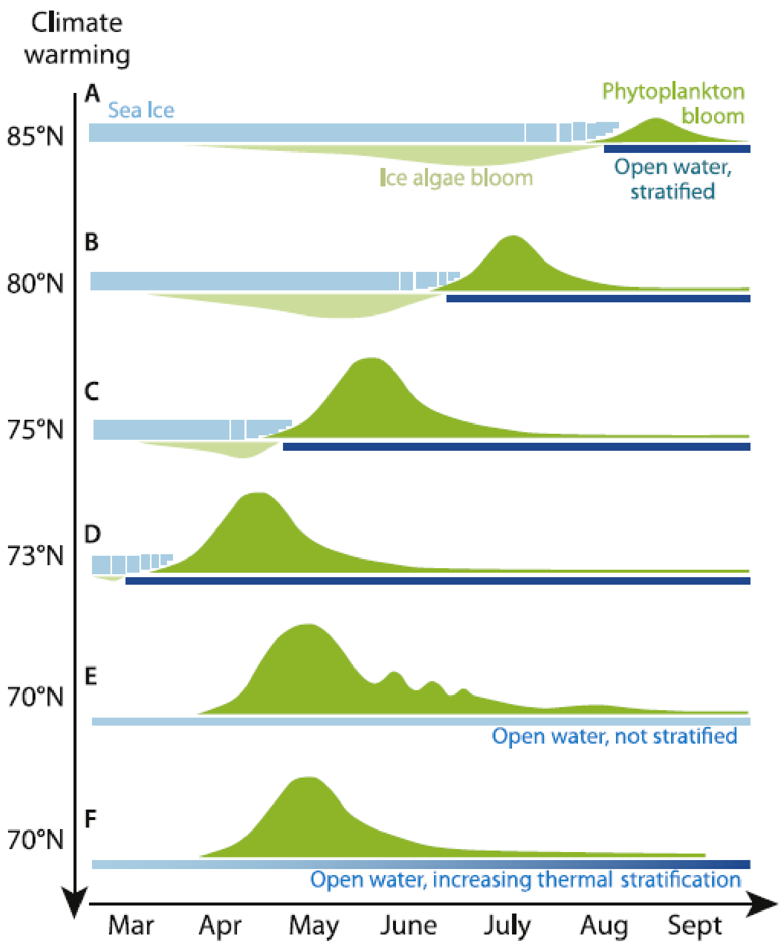


Carmen David
Benjamin Lange
Hauke Flores
Estelle Kilias



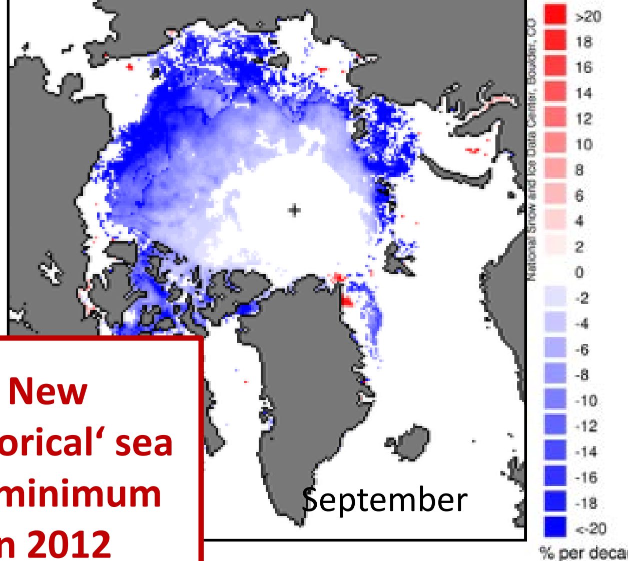
National Snow and Ice data Center (2011) http://nsidc.org

Arctic Ocean climate change



Leu et al. (2011); Wassman et al. (2011)

Sea ice concentration trend 1979-2011



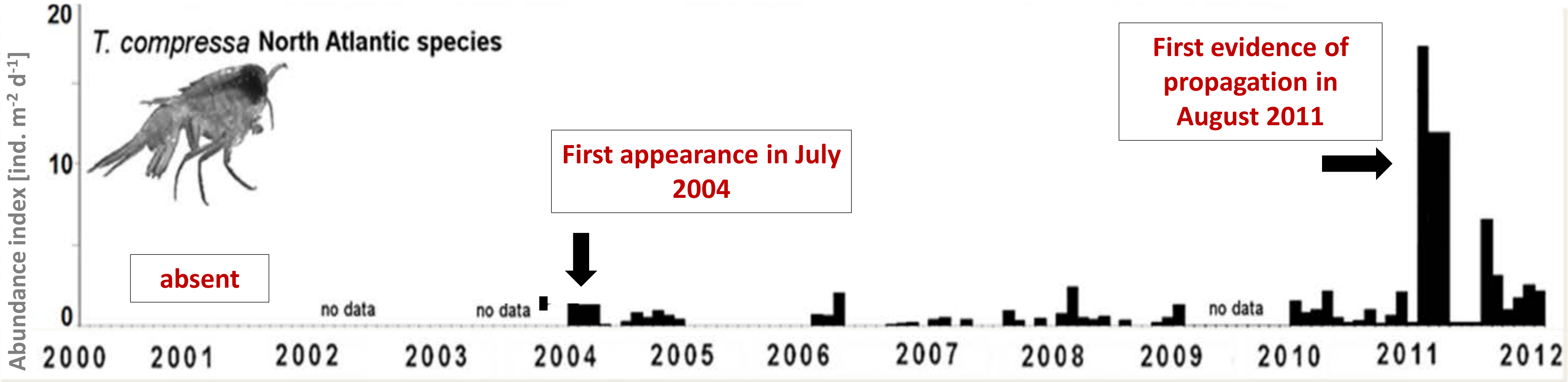
New ‚historical' sea ice minimum in 2012

- Decline of sea ice extent
- Loss of MYI
- Ocean warming
- Acidification
- 'Atlantification'

Themisto compressa

An 'Atlantic' species in the Arctic

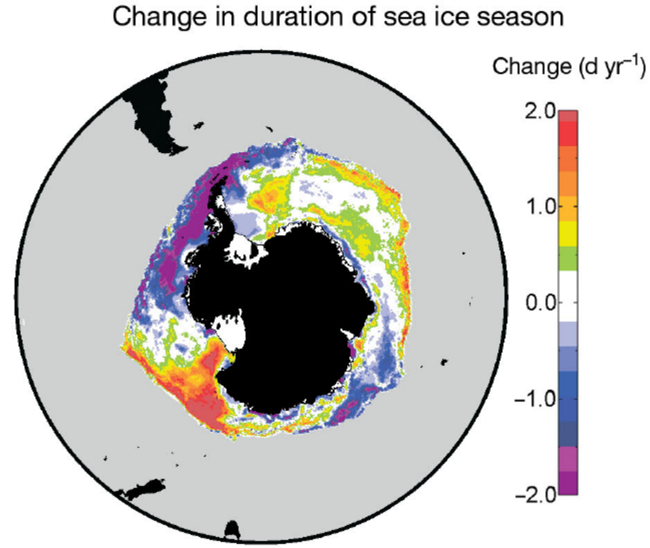
Angelina Kraft

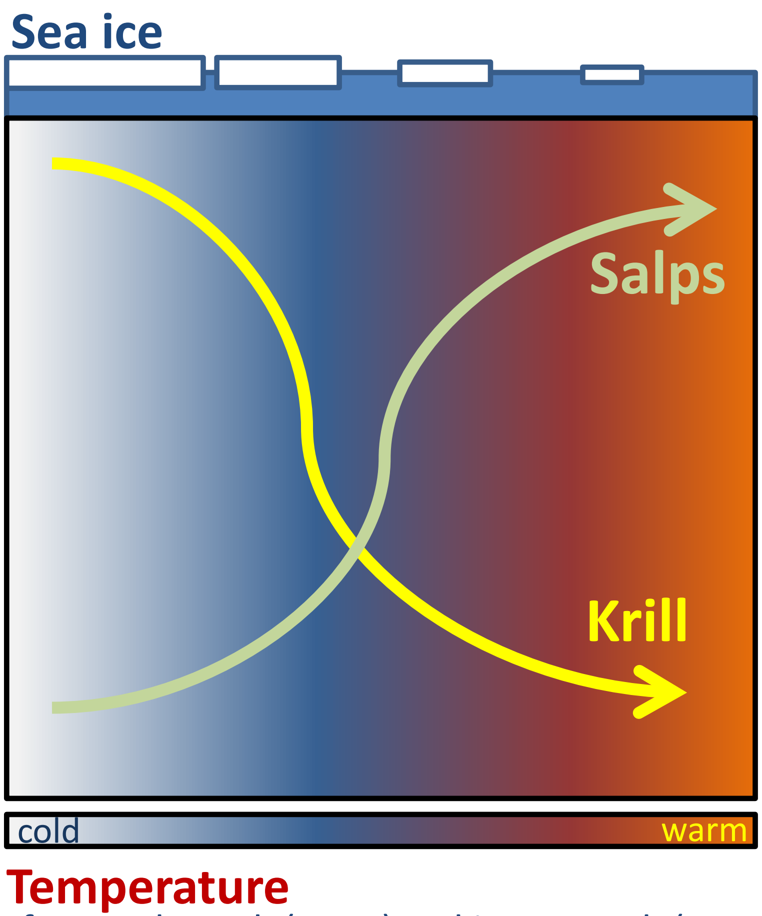


Kraft et al. (in review), *Mar. Ecol. Prog. Ser.*

Flores et al. (2012) *Mar. Ecol. Prog. Ser.*

Antarctic Ocean Climate Change



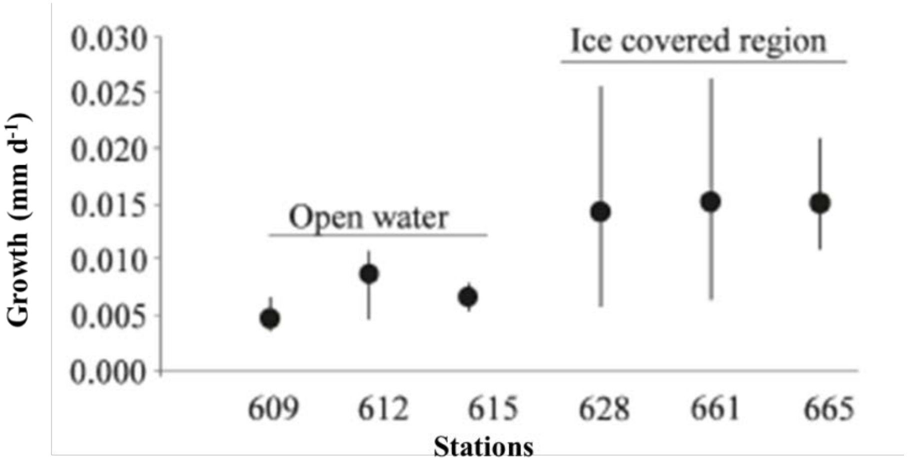


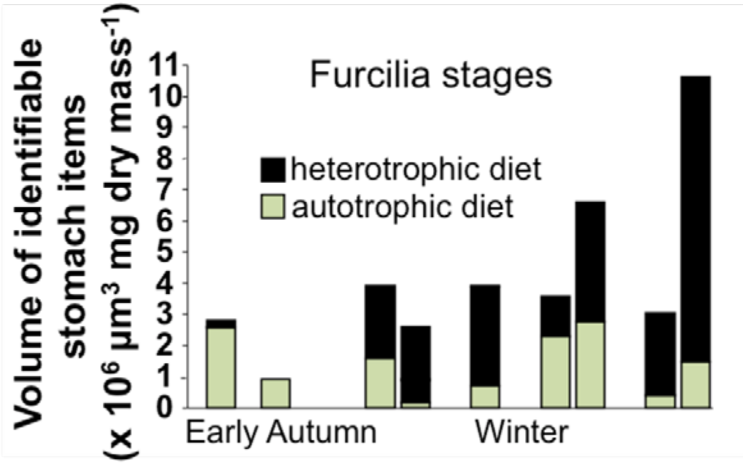
After Loeb et al. (1997), Atkinson et al. (2004)

- **Regionally different sea ice change**
- **Ocean warming**
- **Acidification**
- **Species range shift**

Overwintering of krill larvae

Bettina Meyer



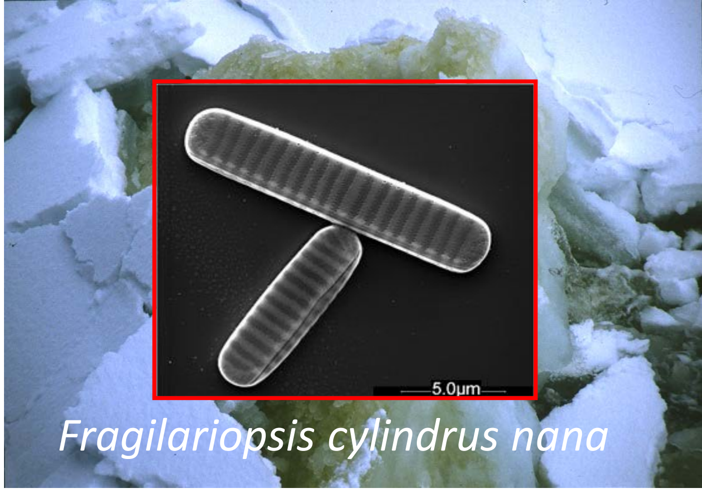


Better growth in sea ice

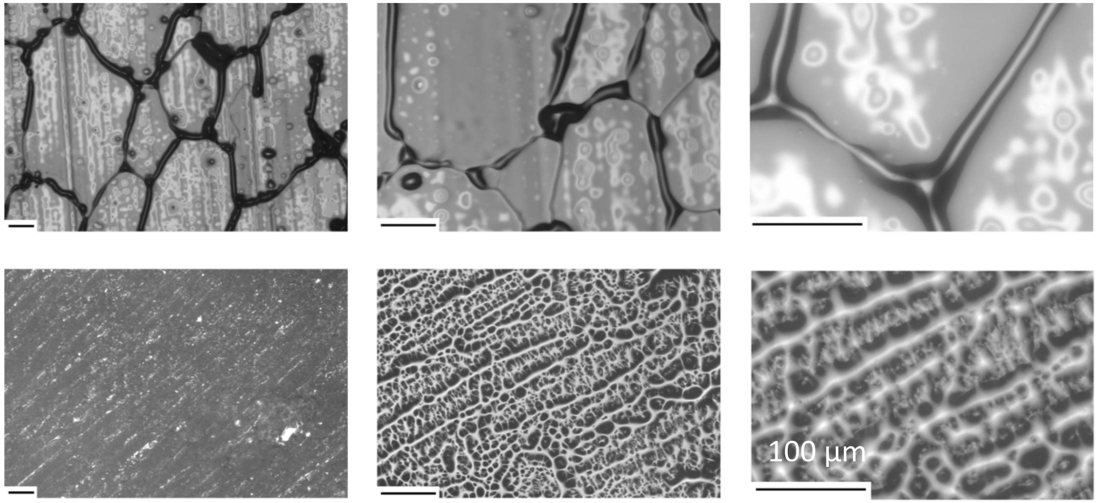
Winter diet: heterotrophic sea ice biota

Meyer et al. (2009), *L&O*

Molecular research on sea ice algae



Bayer-Giraldi et al., 2011



Neg. control

Maddalena Bayer-Giraldi

AFPs

Function of anti-freeze proteins (AFP)

Transcriptome analysis

Anique Stecher

Differences

- Bathymetry
- Topographic isolation
- Stratification & currents
- Nutrient regime
- Sea ice properties
- Diversity

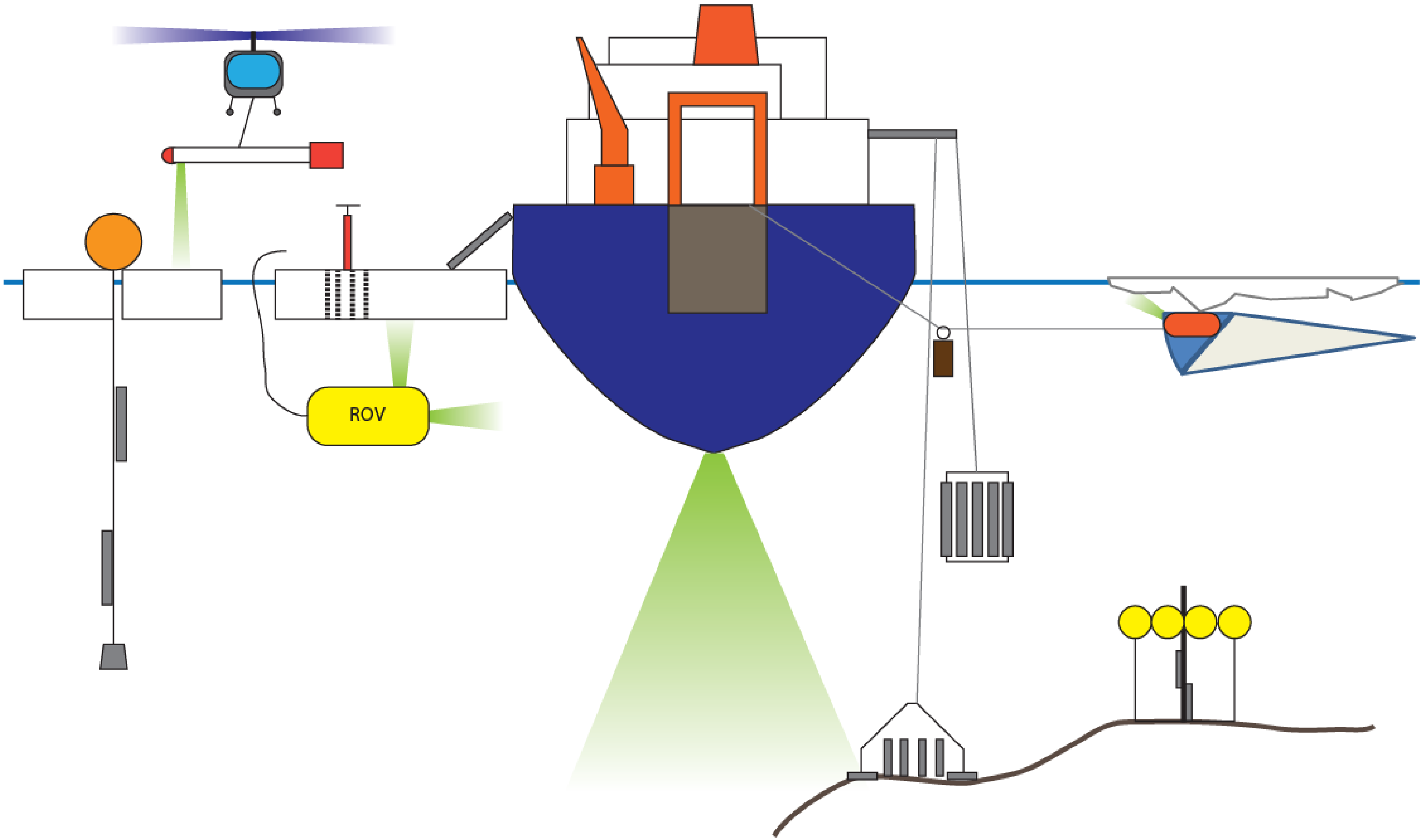
Similarities

- Presence of sea ice
- Cold temperatures
- Pronounced seasonality
- Chemically limited PP
- Organism adaptations
- Rapid environmental change

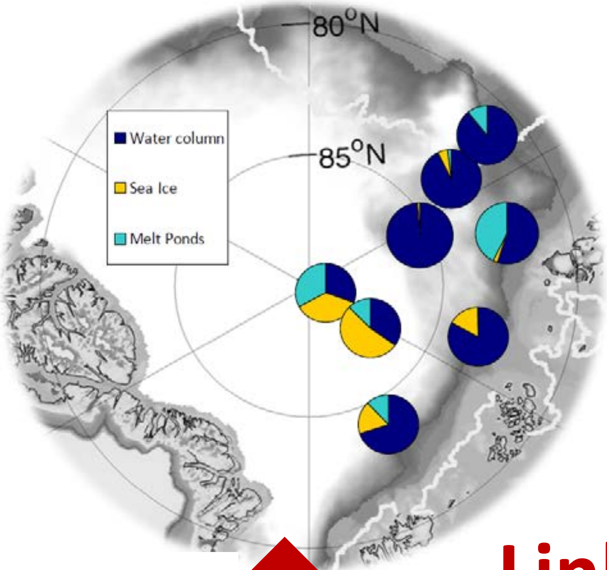
Conclusions

- Sea ice system still **poorly understood**
- **Complementary** approaches allow to identify and compare **drivers of change and ecosystem response** in both Polar Oceans
- Both **empirical and mechanistic studies** are needed to understand the processes of change in Polar systems

Multi-disciplinary surveys

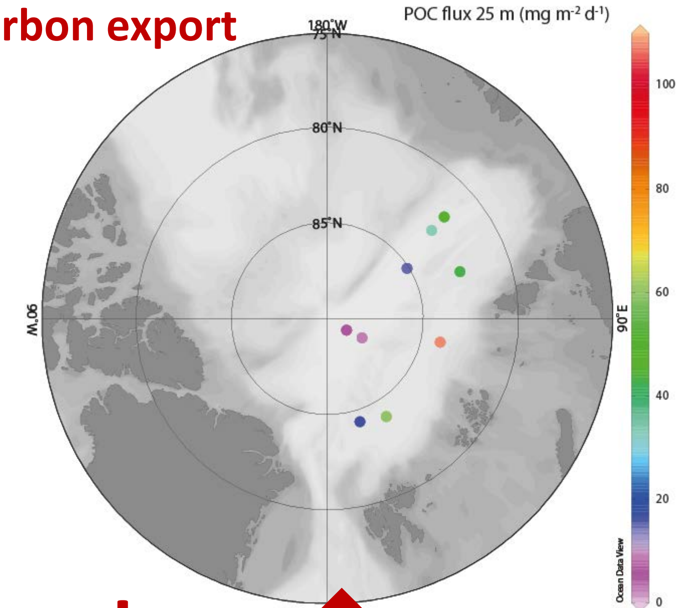


Primary production



Mar Fernandez-Méndez

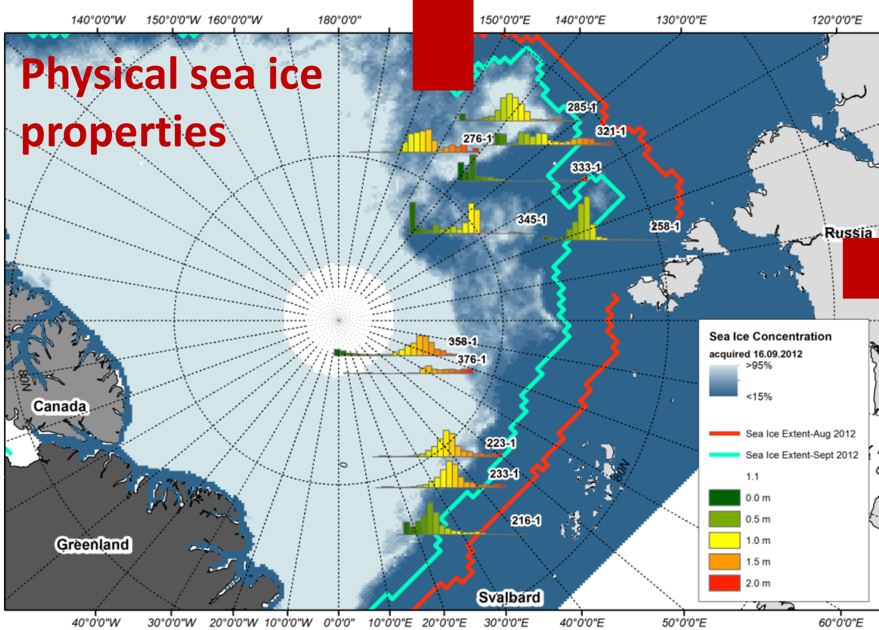
Carbon export



Catherine Lalande

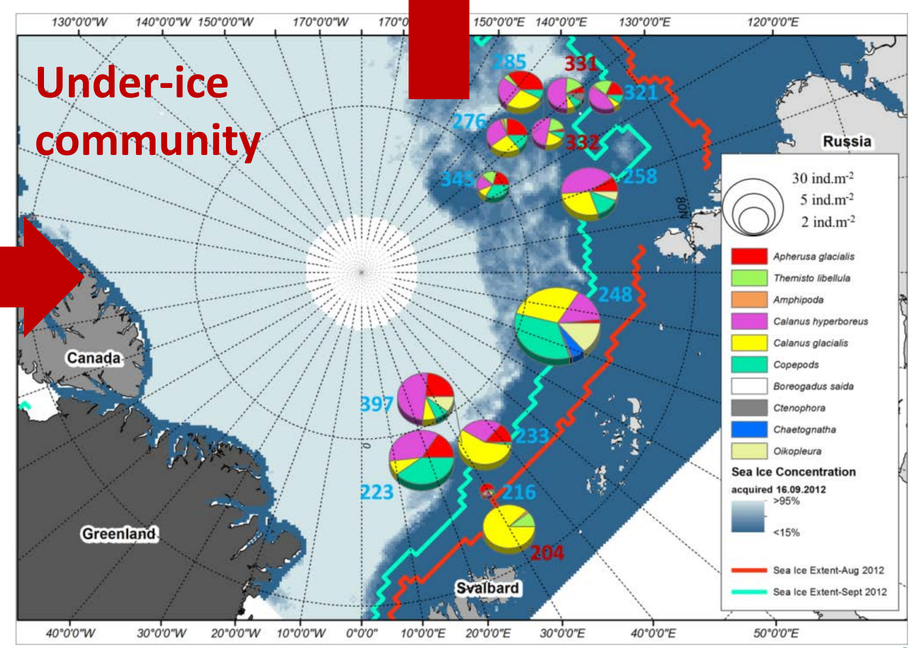
Linking datasets

Physical sea ice properties



Benjamin Lange

Under-ice community



Carmen David

Conclusions

AWI‘s biological sea ice research combines **long-term experience, scientific skills and modern approaches** to address the complexity of future change at both Poles

Internal and external **collaboration and inter-disciplinarity** are key to enhance scientific impact


Thank you