Arctic zooplantkon communities in a changing environment

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(With contributions from colleagues)

UiT The Arctic University of Norway,
Visiting professor at Tokyo University

Tokyo University seminar, 22 September 2023

ECOTIP

This project is funded by the European Union under grant agreement No 869383

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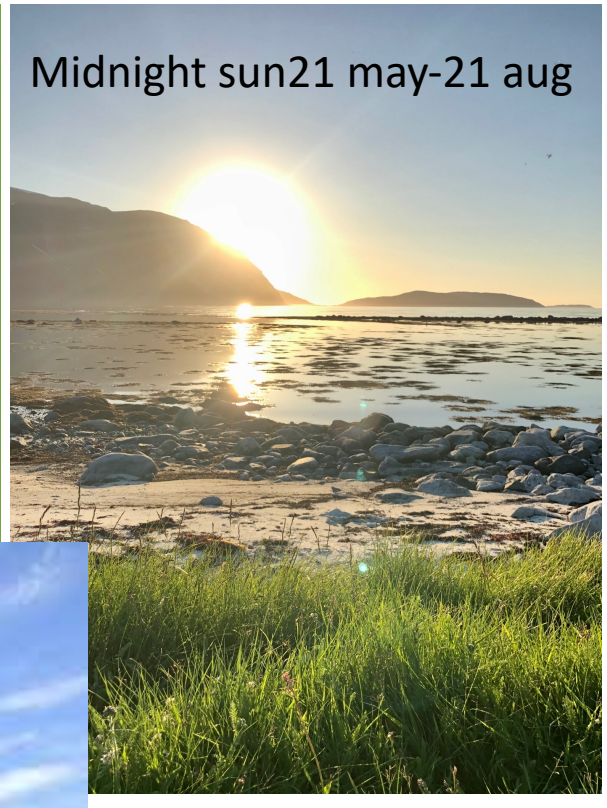
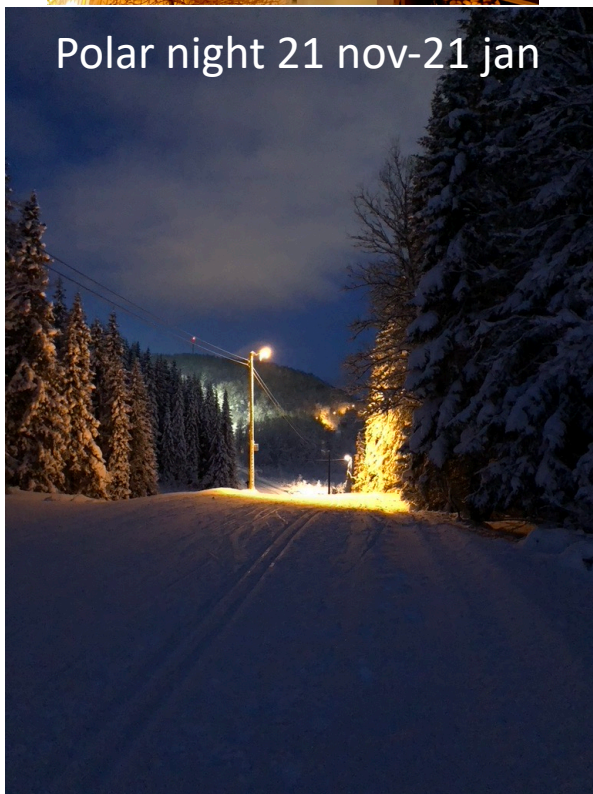
UiT The Arctic University of Norway

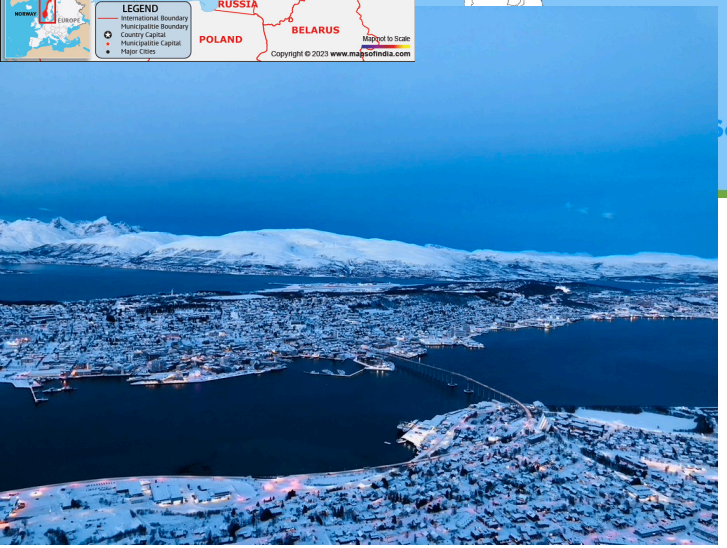
My background

Professor in zooplankton ecology, UiT the Arctic University of Norway

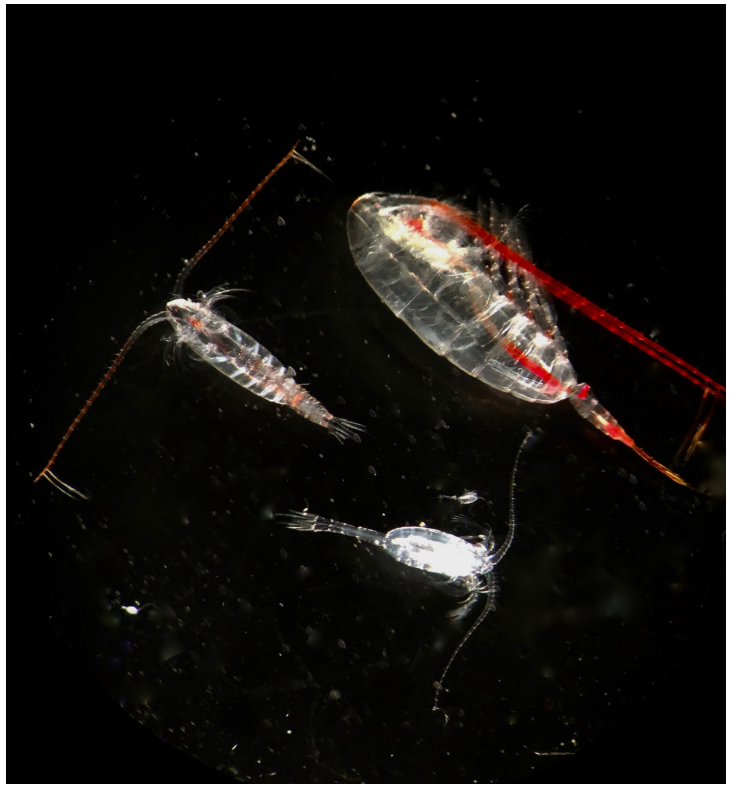
Norwegian, live in Tromsø (69 N)

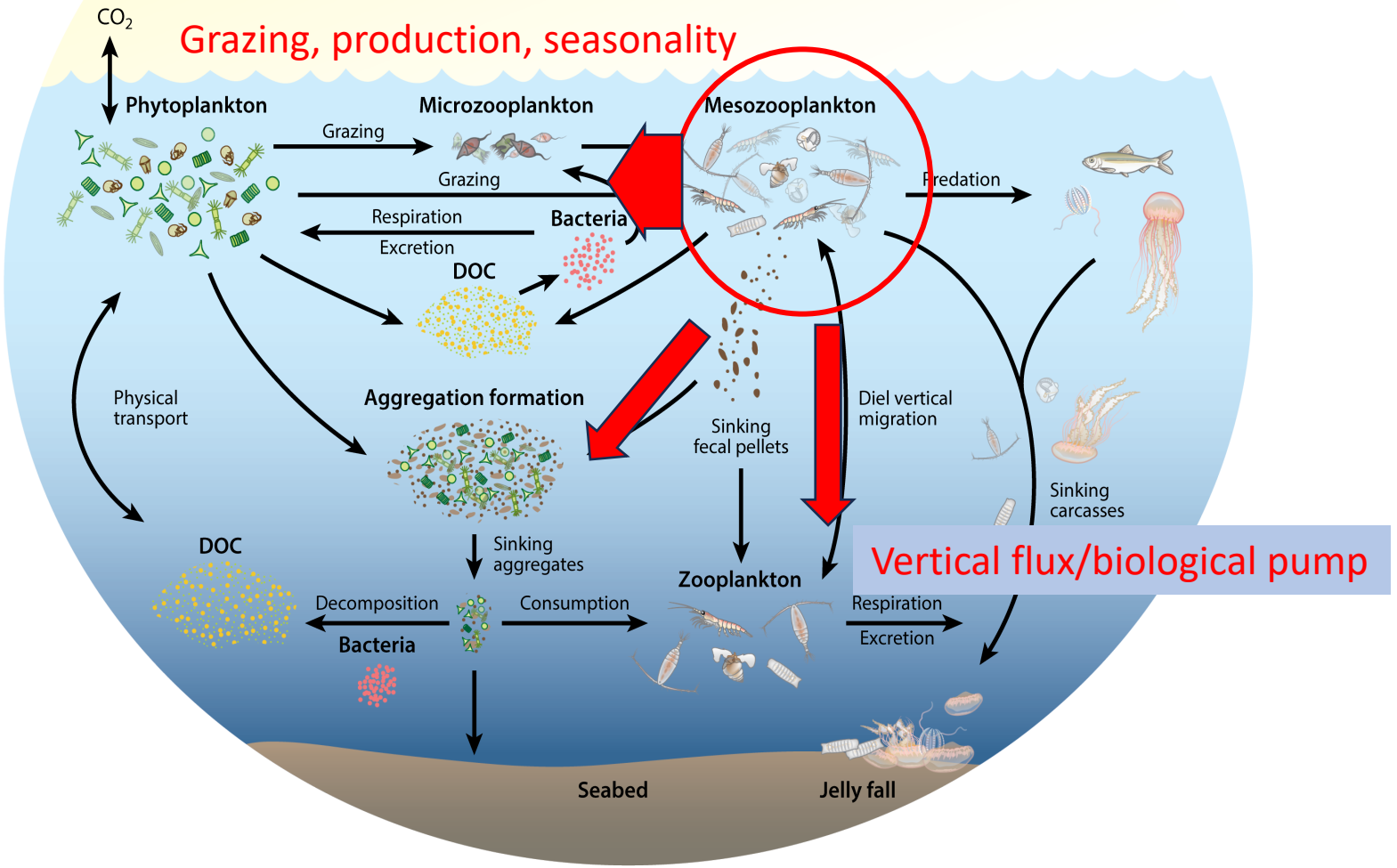






Researach interests – zooplankton in (Arctic) foodwebs





Steinberg DK, Landry MR. 2017.
Annu. Rev. Mar. Sci. 9:413–44

Norwegians and the ocean

Coastline length Noway: **28 953** km (+ islands = 100 953 km)

Japan:**29 751** (+ islands = 34 000 km)

The marine Norway is 5.3 x the size of the terrestrial Norway

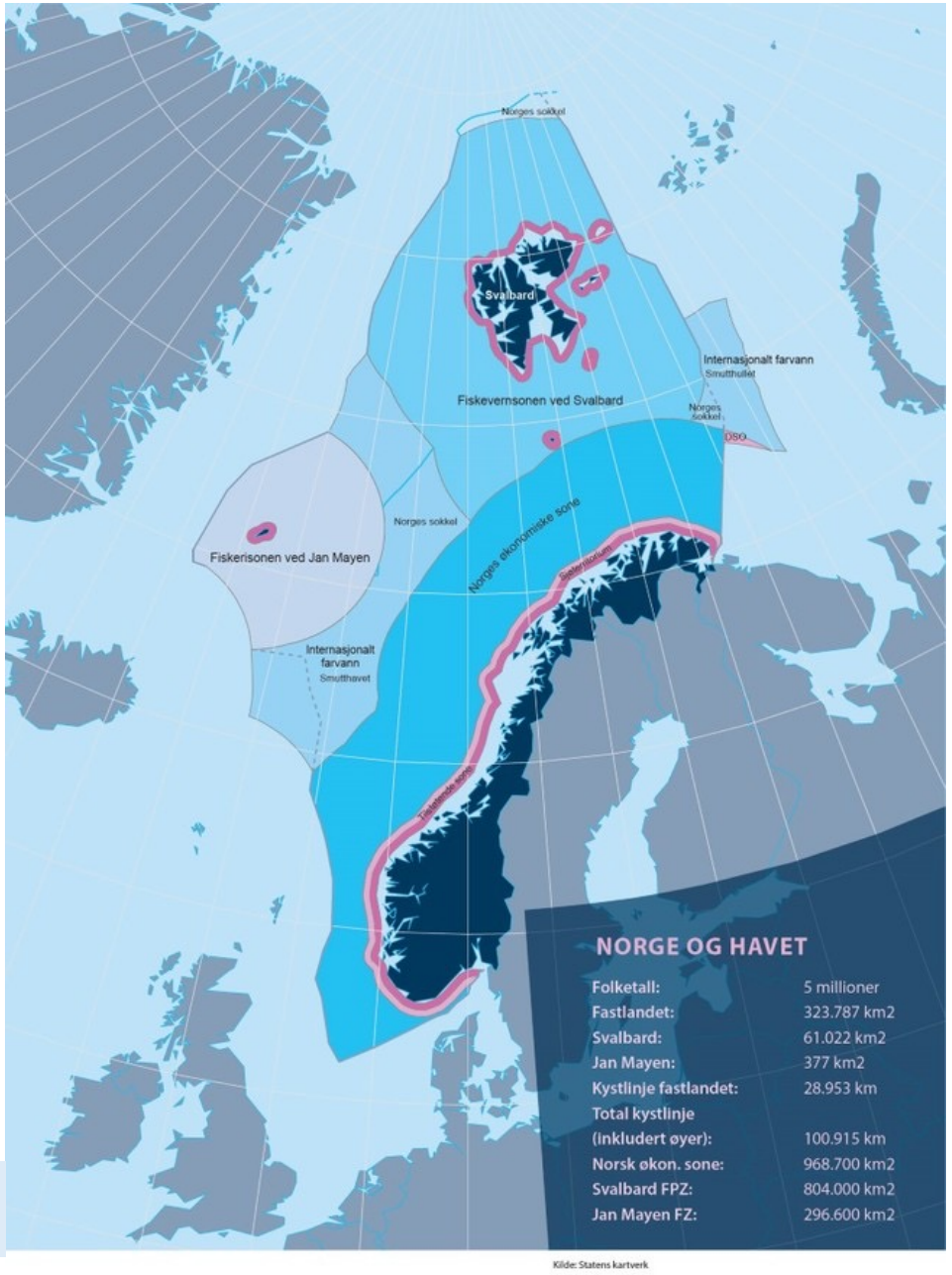
80% of this marine region is north of the Arctic circle

The Norwegian welfare is to a large degree based on resources from the ocean

11% of Norwegian employers in ocean industries

20% of employers in the Norwegian Arctic in ocean industries

Use require regulations and management



From AH Hoel: The Norwegian economical zone includes 200 nautical miles. Illustrasjon: regjeringen.no.

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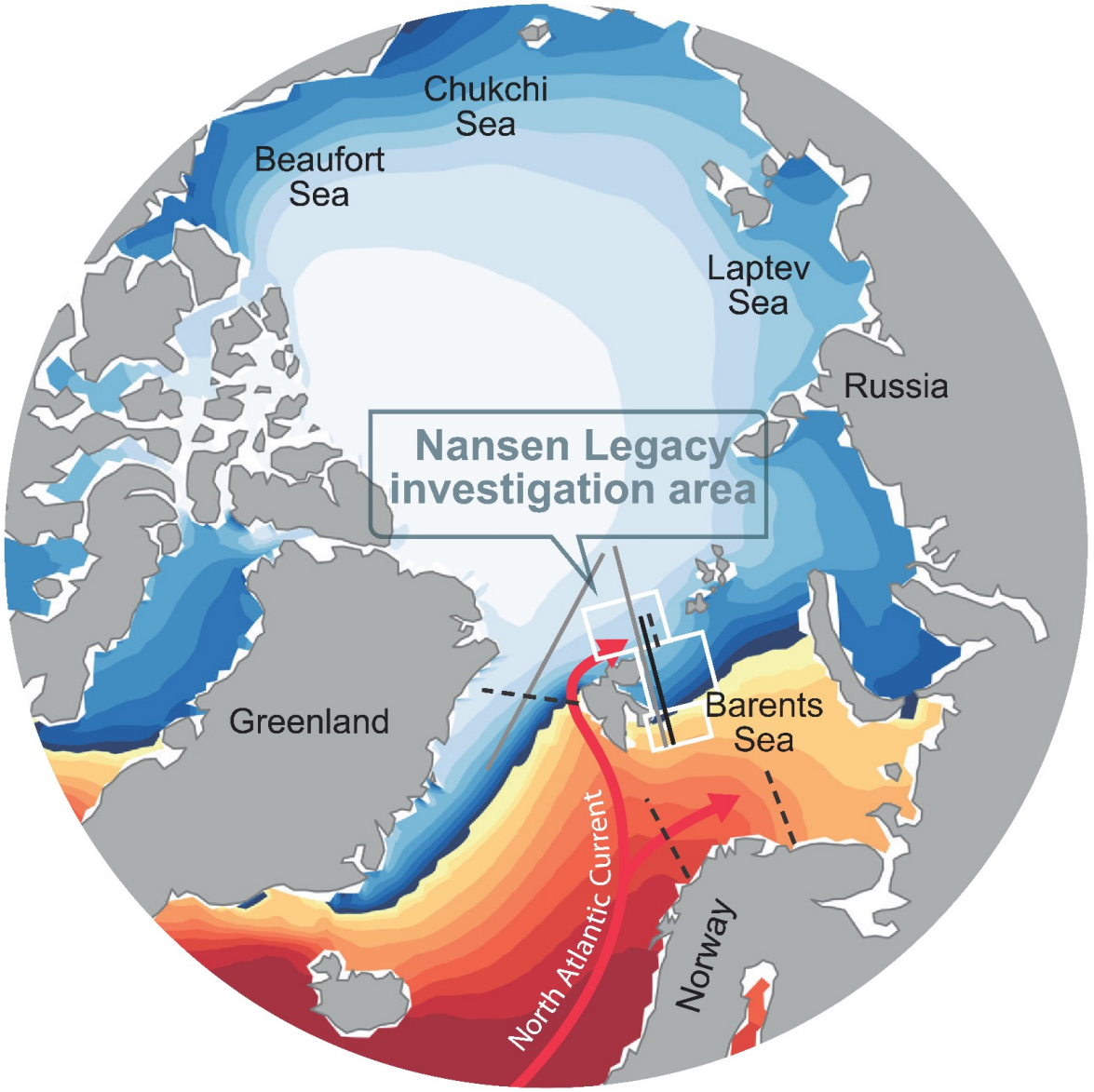
Funded by

Kunnskapsdepartementet | The Research Council of Norway

UNIS | Norwegian Meteorological Institute | NTNU | Akvaplan niva | NERSC



Project period: 2018-2024

PI, Marit Reigstad (UiT)

Co-PI: Tor Eldevik, Sebastian Gerland

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21
research expeditions to the
northern Barents Sea and
adjacent Arctic Ocean
Kronprins Haakon
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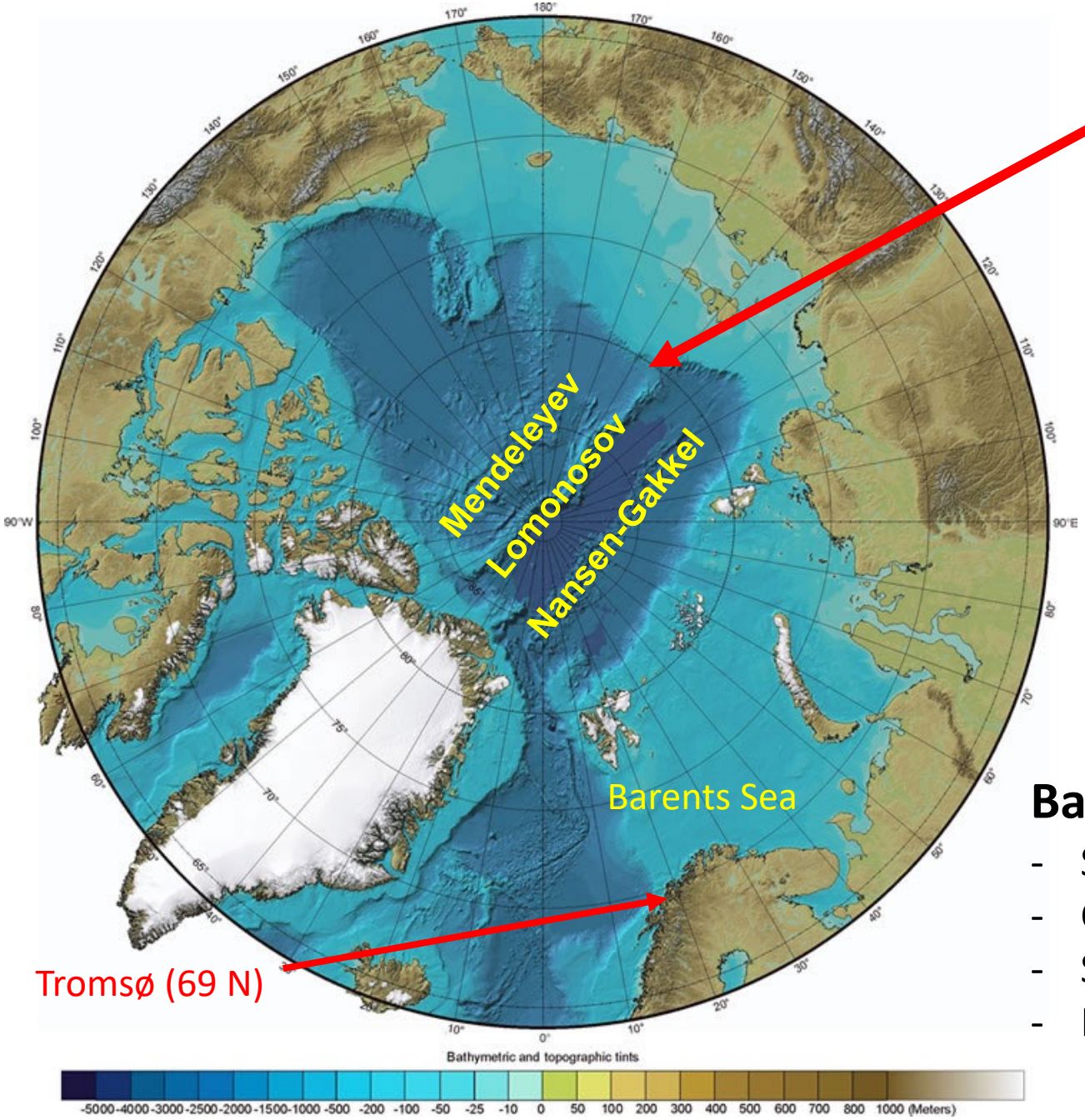

Arctic Ocean:

- Mediterranean ocean
- High degree of connectivity (Framstait and Beringstrait)
- 50 % is shelf sea (50-200 m deep)
- Central basin
- 3 deep ocean ridges
- 2 deep basins

Barents Sea (71-82 N, 15-60 E)

- Shallow shelf-sea
- Compex hydrography: warm in south, cold in north
- South: Home to to Arctic cod, largest fishery in Norway
- North: seasonally ice covered and less known

The Arctic Ocean: Connected by a complex “roadmap” of warm and cold ocean currents from the Pacific and Atlantic

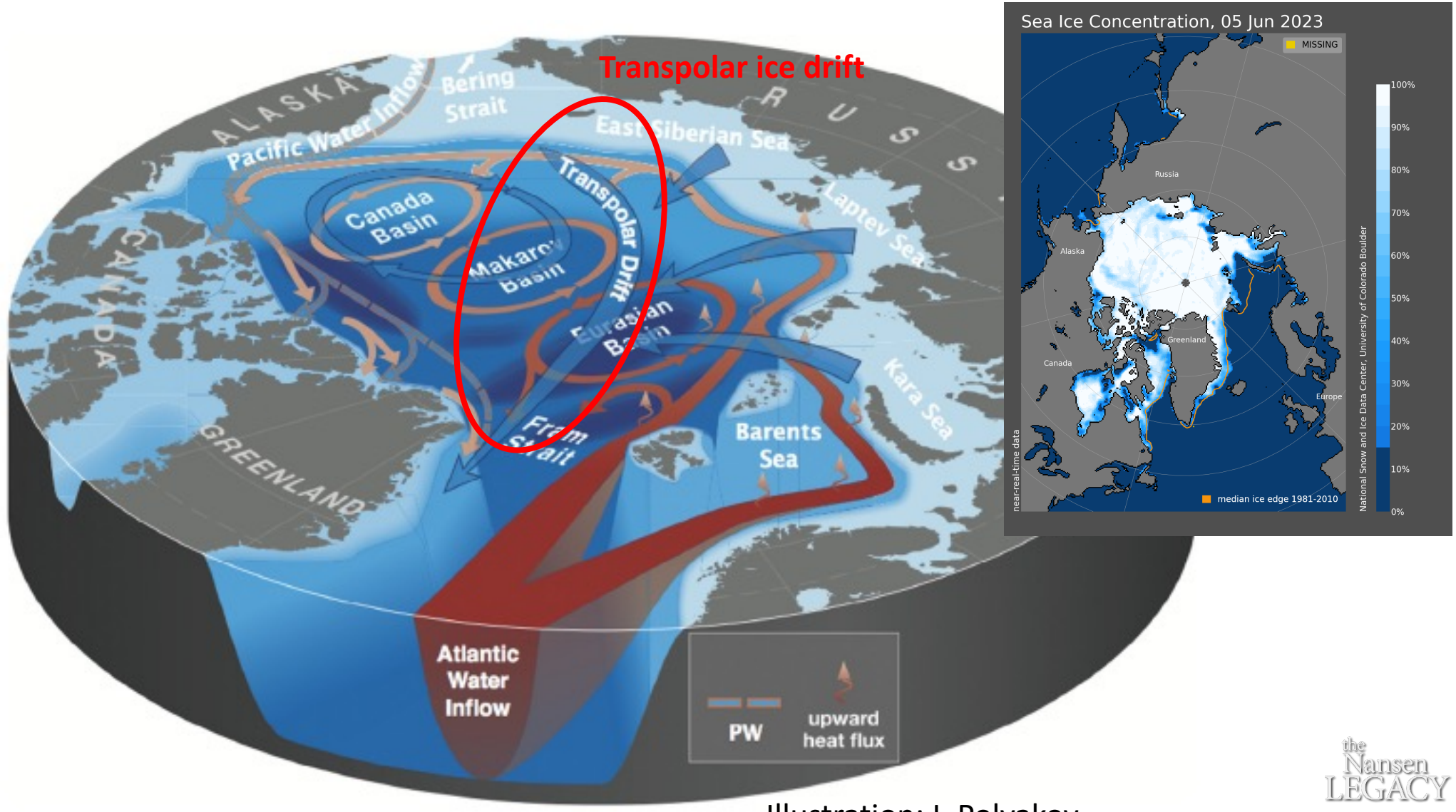

Illustration: I. Polyakov

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The seasonal ice zone has extended from shelf to basin

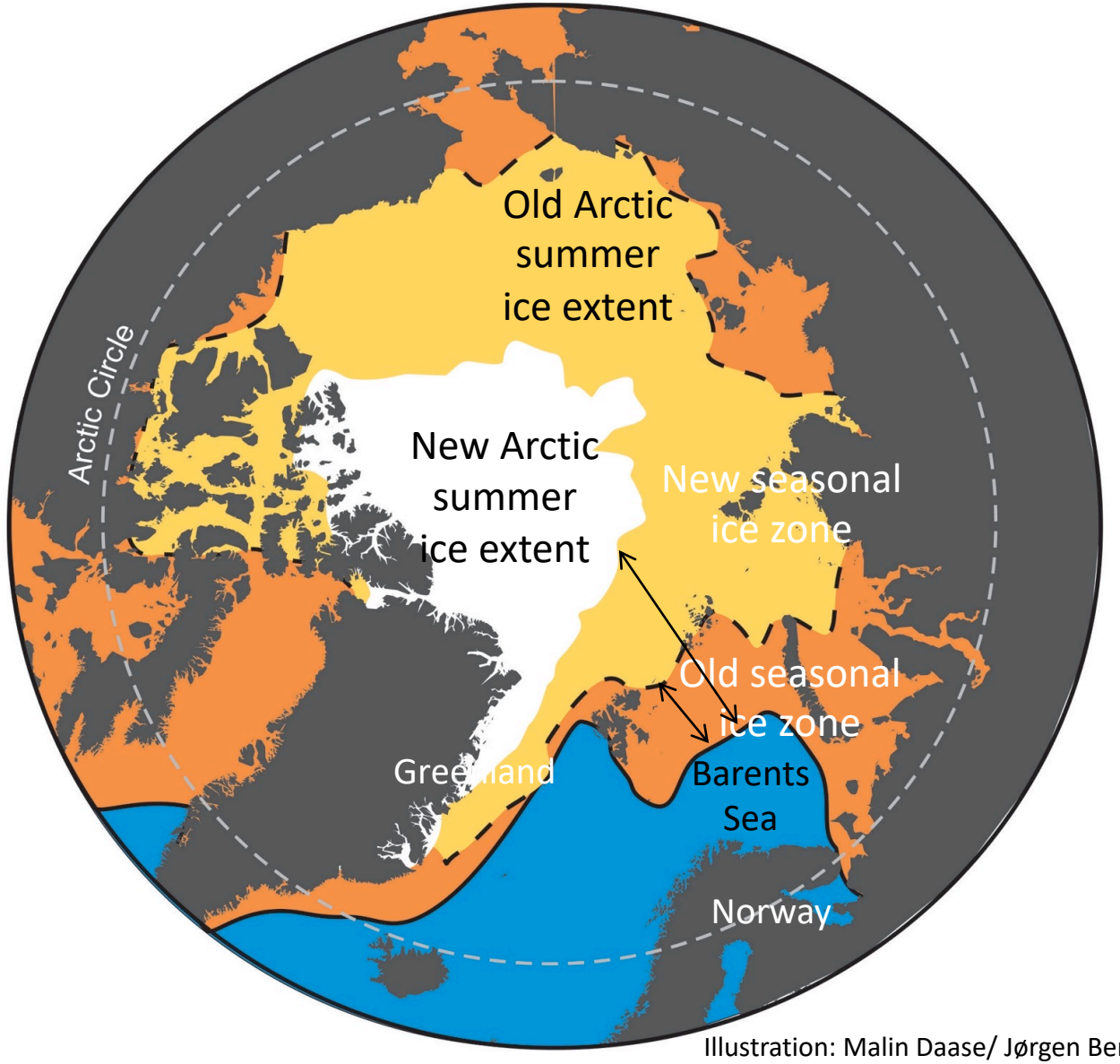

Illustration: Malin Daase/ Jørgen Berge

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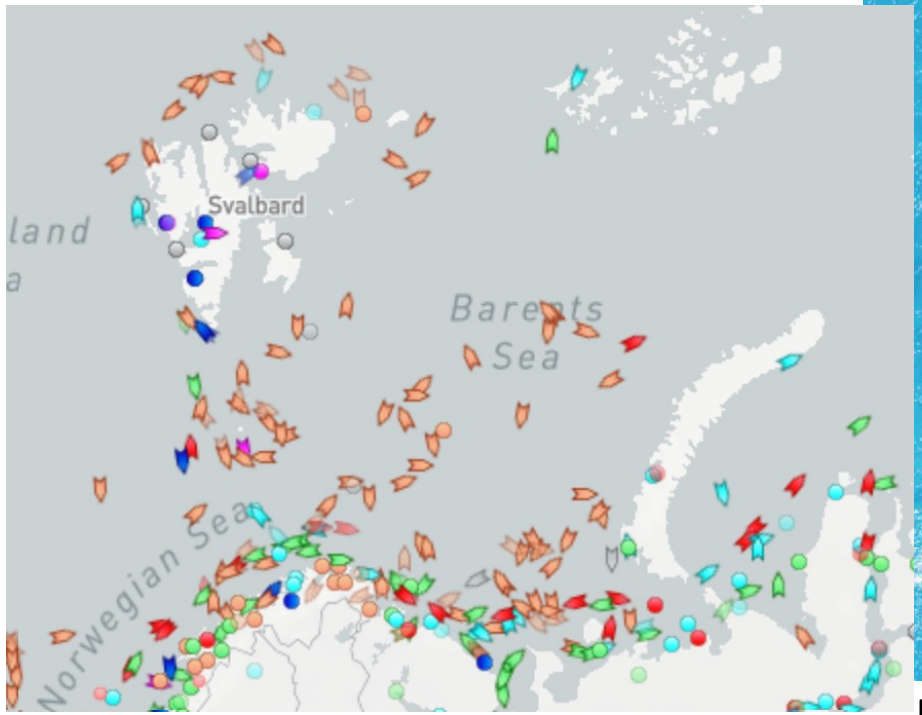
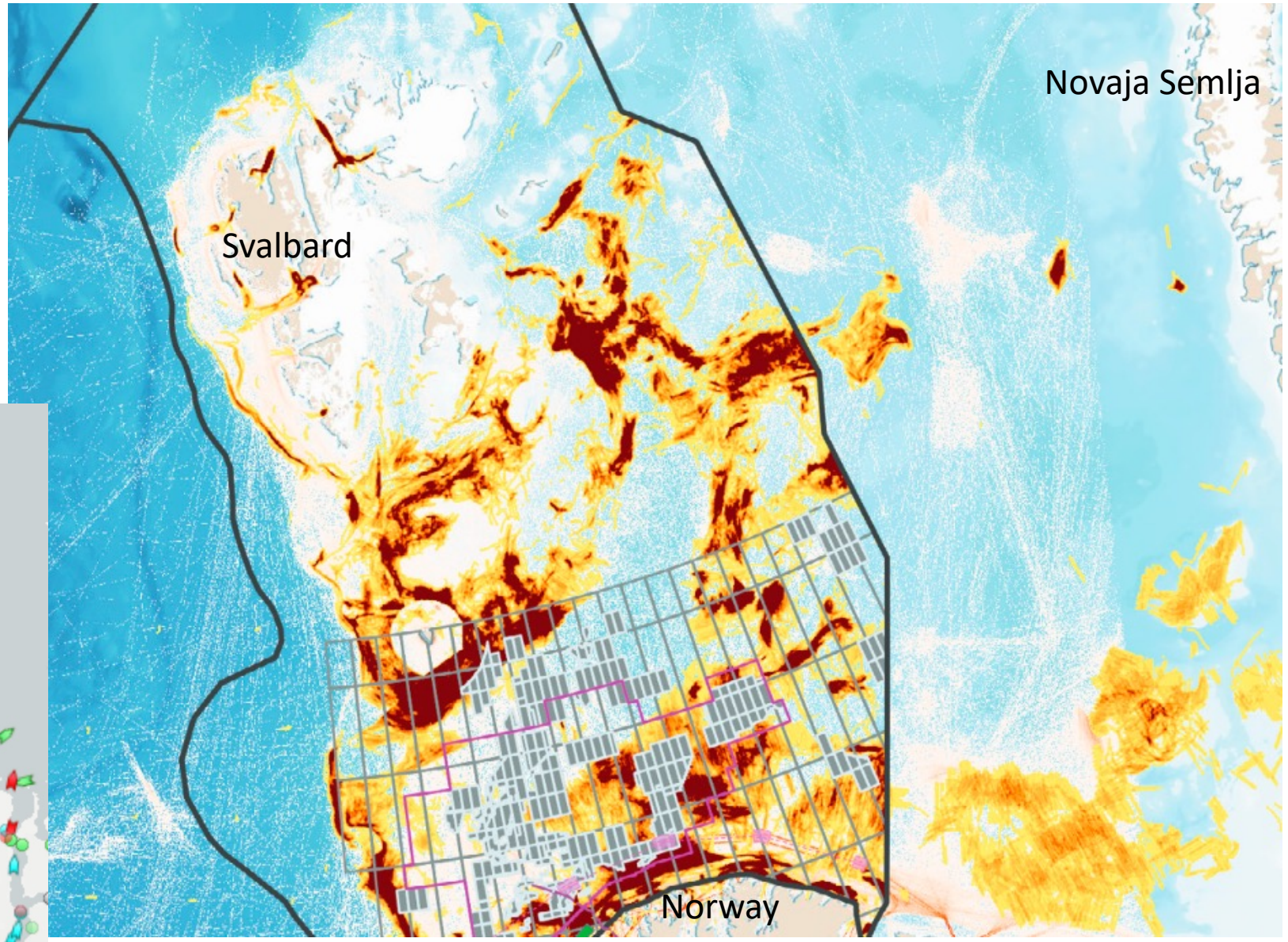
Activities in the Barents Sea

- Fisheries
- Active permission to search for petroleum resources



The Barents Sea, 13 Sept-22. www.marinetraffic.com



From Figure 7.1 Management plan for Norwegian marine region. Meld. St. 20 (2019-2020)

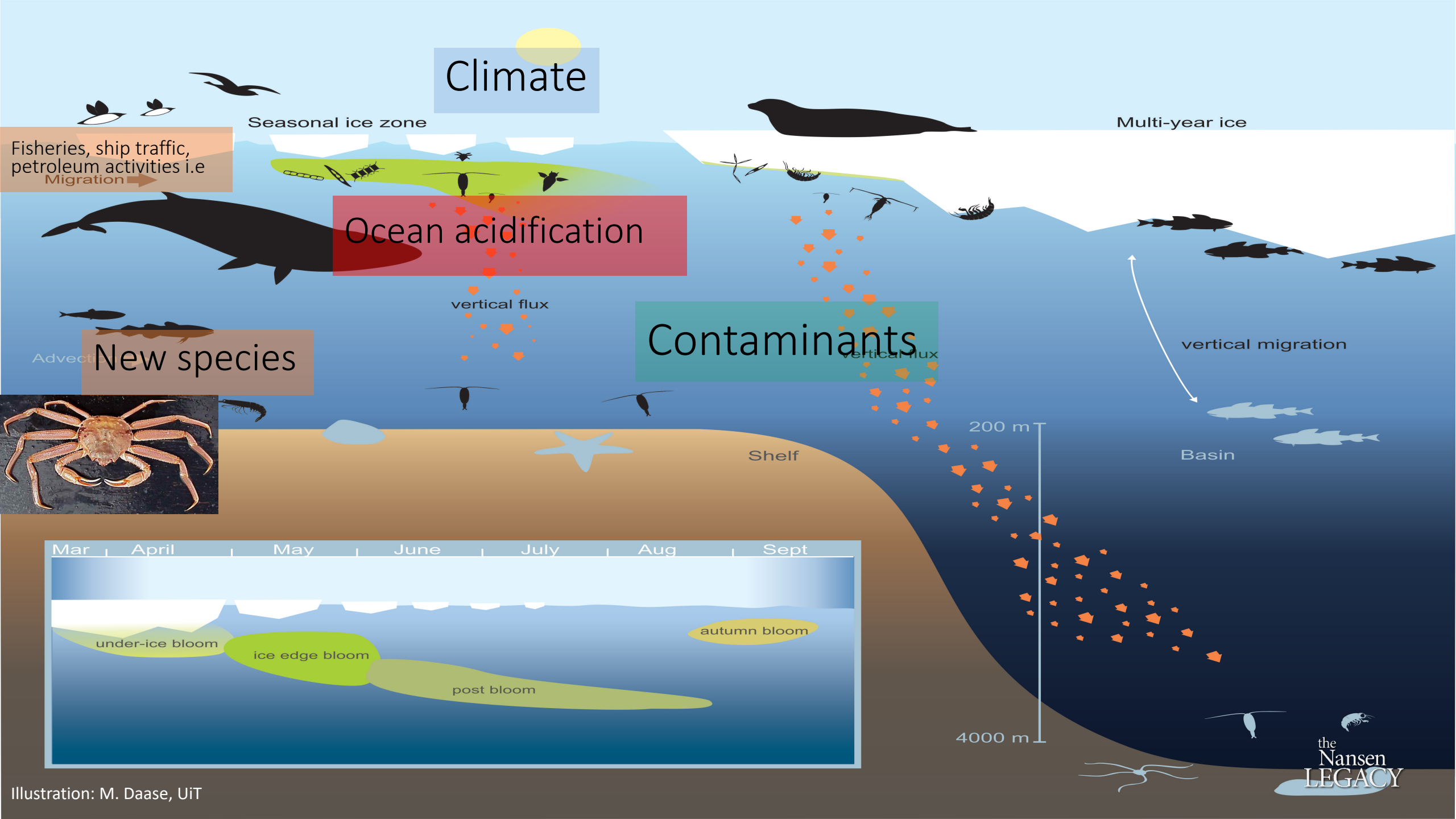
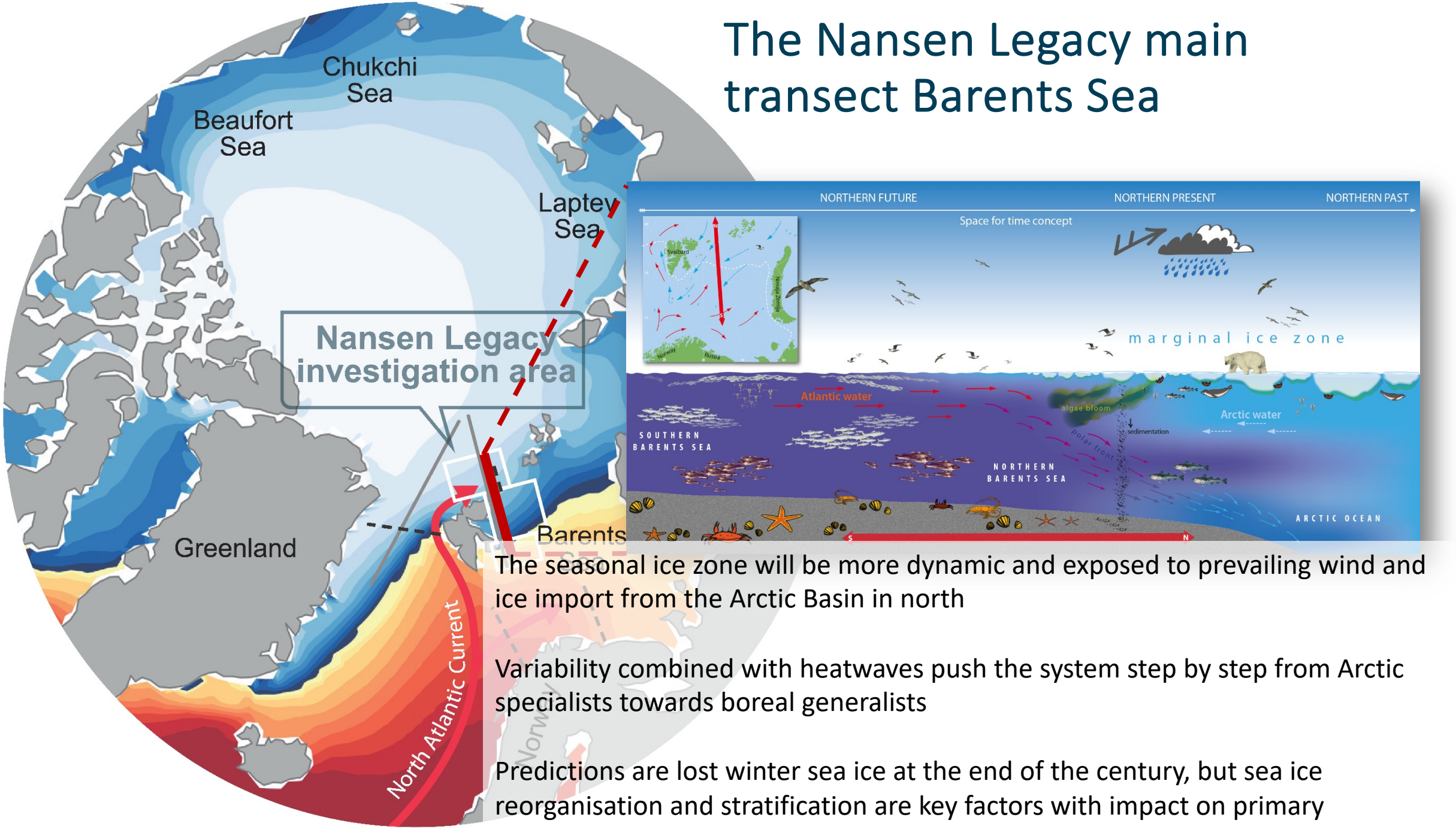


Illustration: M. Daase, UiT

The Nansen Legacy main transect Barents Sea

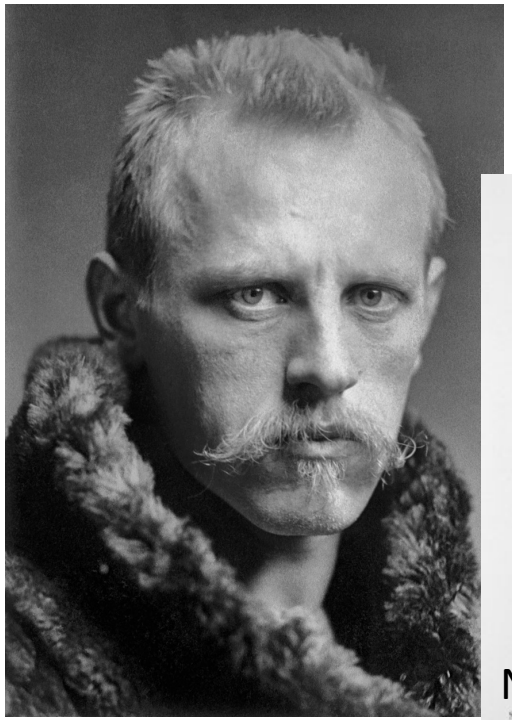


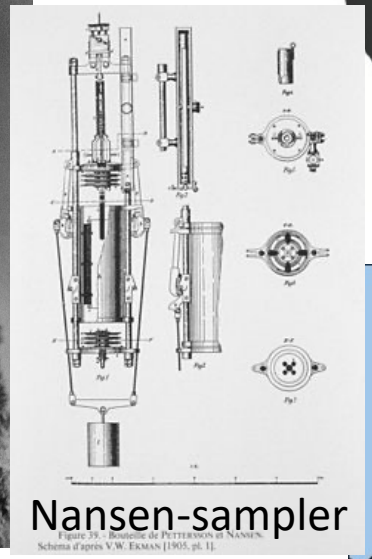
The seasonal ice zone will be more dynamic and exposed to prevailing wind and ice import from the Arctic Basin in north

Variability combined with heatwaves push the system step by step from Arctic specialists towards boreal generalists

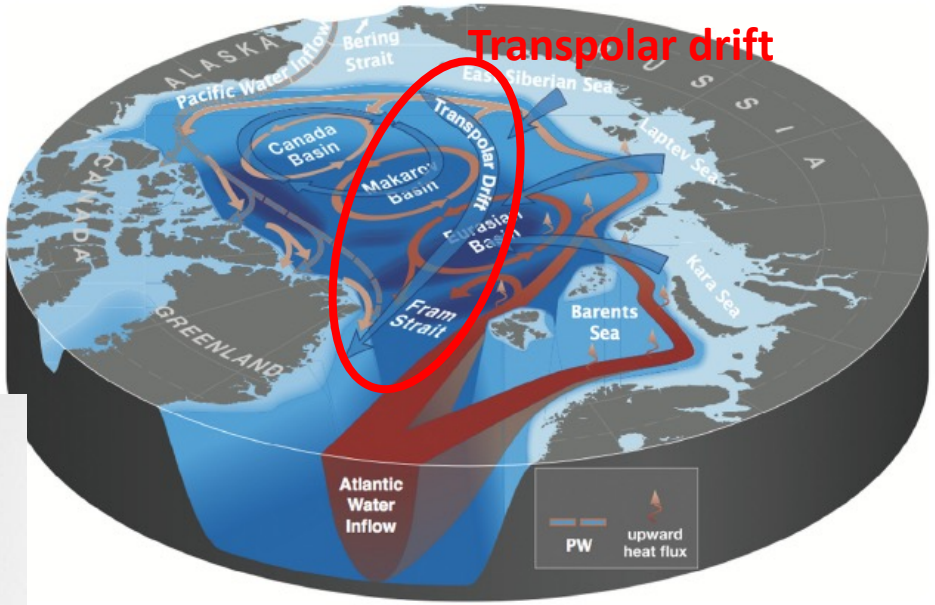
Predictions are lost winter sea ice at the end of the century, but sea ice reorganisation and stratification are key factors with impact on primary production

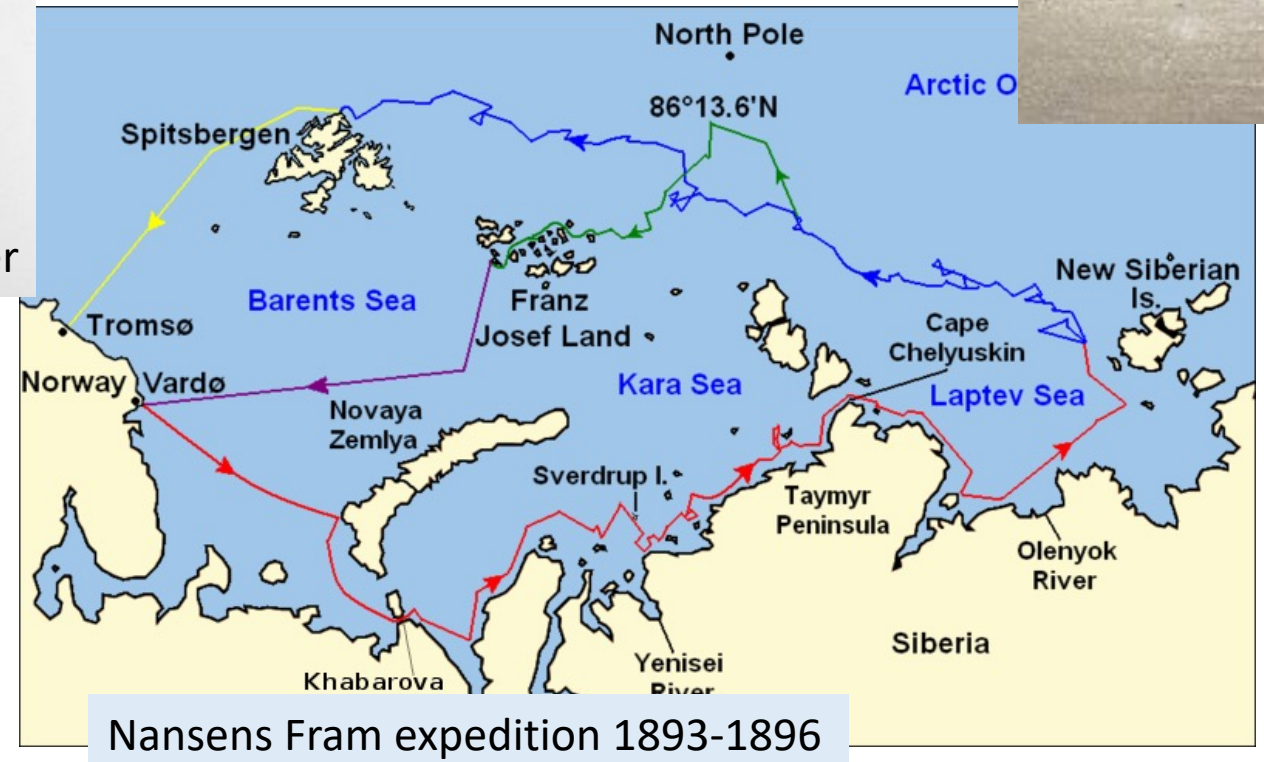
Fridjof Nansen (1861-1896)





Nansen-sampler

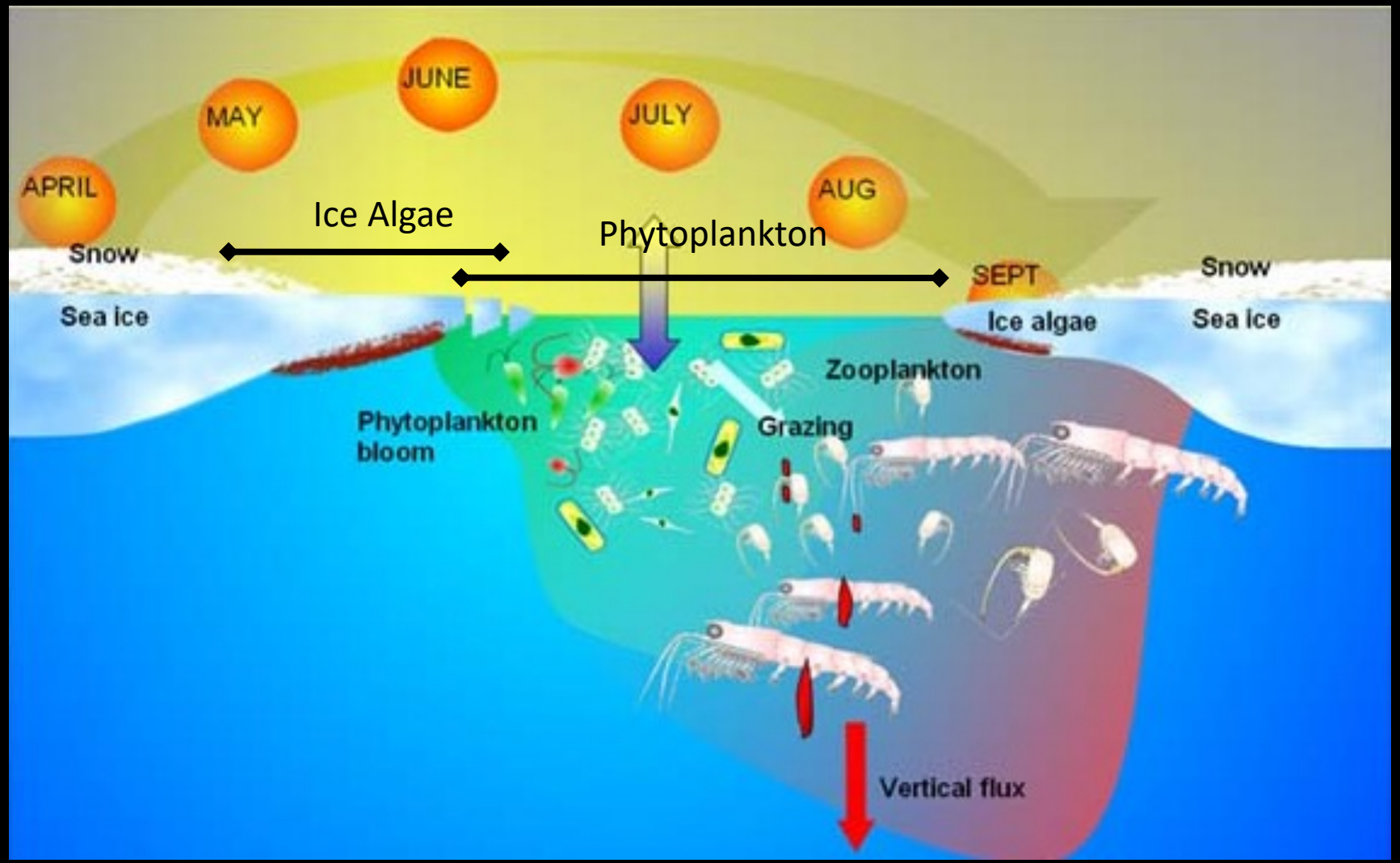




Nansens Fram expedition 1893-1896

A Polymath:
Physical oceanographer
Neurobiologist
Nobel Peace price (1922)
Polar explorer

Arctic foodwebs, zooplankton and seasonality



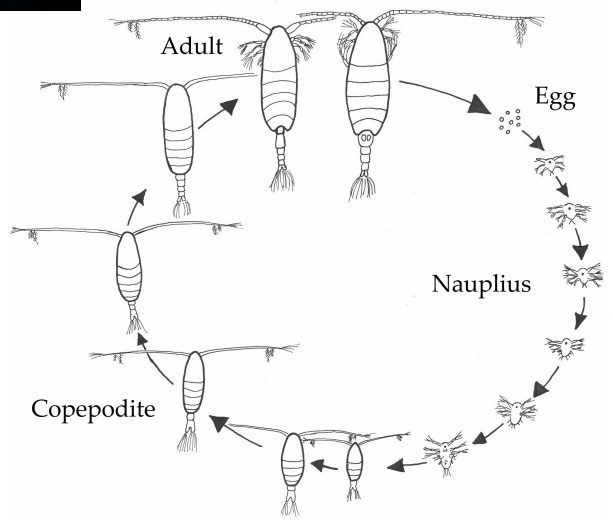
Adaptation to seasonality: Lipid reserves

Calanus hyperboreus
4-7 mm, 60% dw is lipids

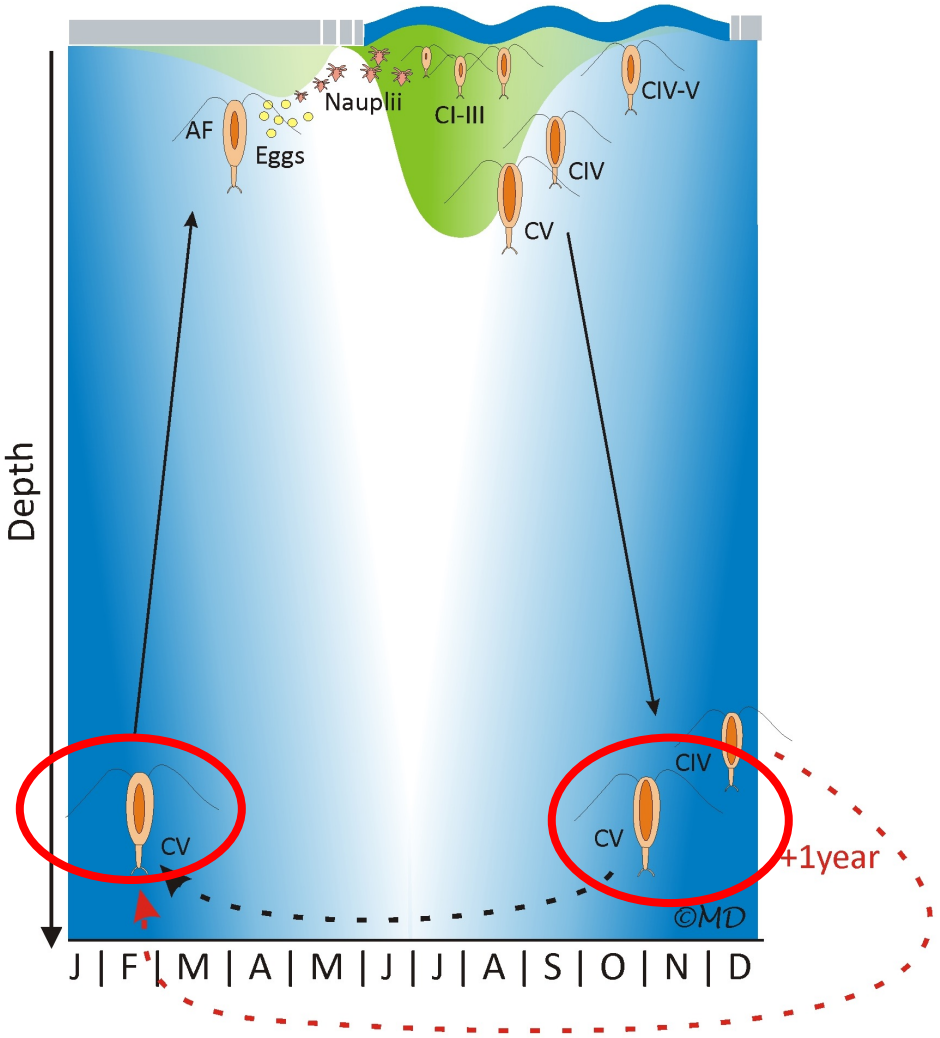
Calanus glacialis
3-5 mm, 60% dw is lipids

Calanus finmarchicus
2-3 mm; 40% dw is lipids

Diapause: Aadaptation to Arctic seasonality e.g. *Calanus glacialis*



Diapause October-March!
"Seasonal vertical migration"



Are Arctic ecosystems “sleeping” during winter?

The Polar night is high season for egg production and larval life in the northern Barents Sea. This *Calanus hyperboreus* female carries > 300 eggs ready for spawning in December. It is not hibernating.

Janne Søreide, UNIS

Foto: Christine Gawinski, UiT

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Polar night food web: Some copepod species we assumed were hibernating in winter are active feeding on small unicellular animals during winter. In spring they feed on microplants.

Kohlbach et al. 2021

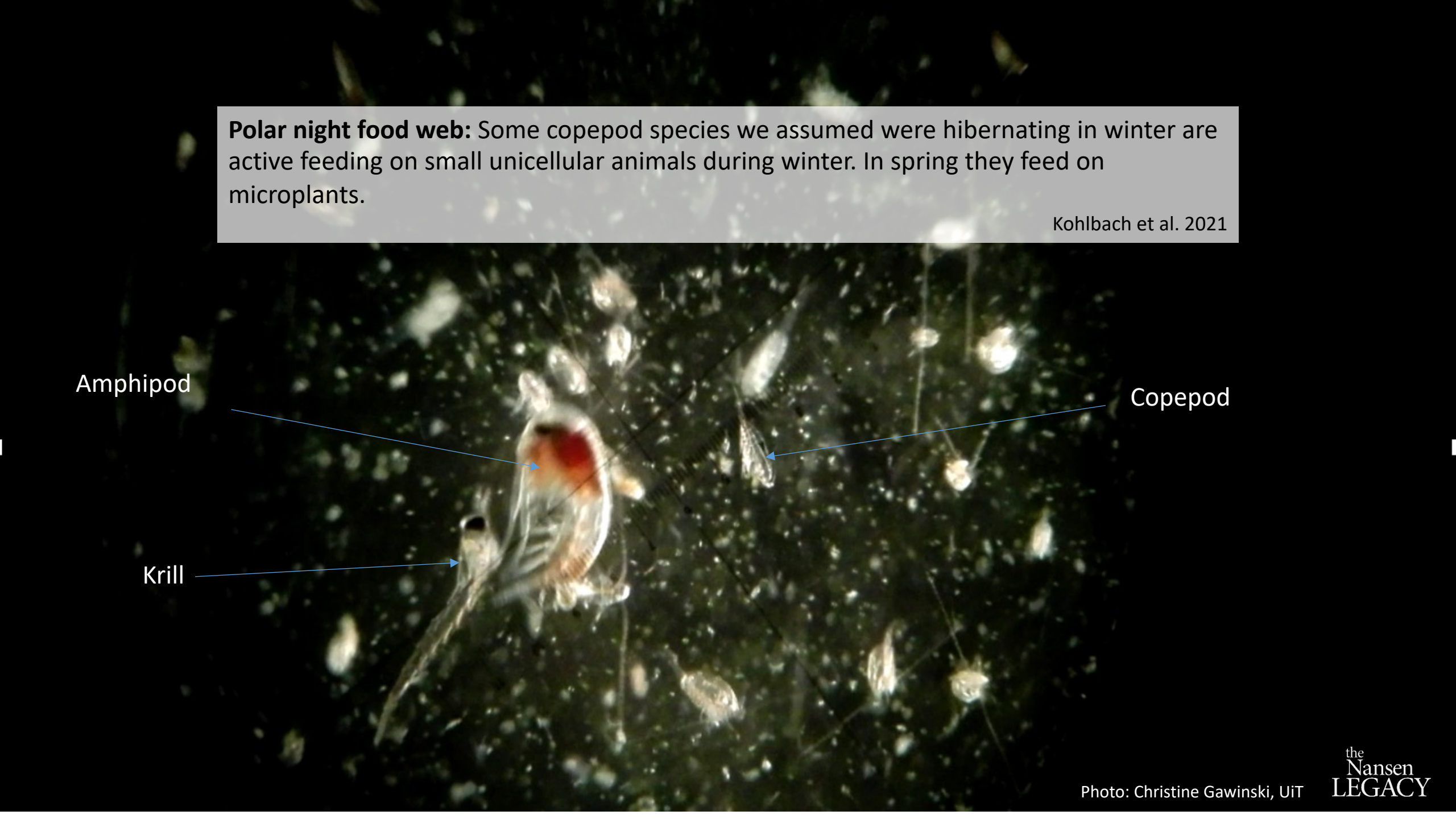

Photo: Christine Gawinski, UiT

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Marine heatwaves

in the Barents Sea and their ecological implications

Photo: Frank Nilsen, UNIS

- Increased frequency and duration on marine heatwaves in the Barents Sea since 2000
- The Barents Sea increase correspond to 2 x global average

Mohamed et al. 2022, Frontiers Mar Sci

- Species and ecosystems respond different to each heat wave – species or communities, - local or regional
- Step-wise changes
- Predictions more challenging

Eriksen et al. 2020, Frontiers Mar Sci
Husson et al. 2022, Global Change Bio.

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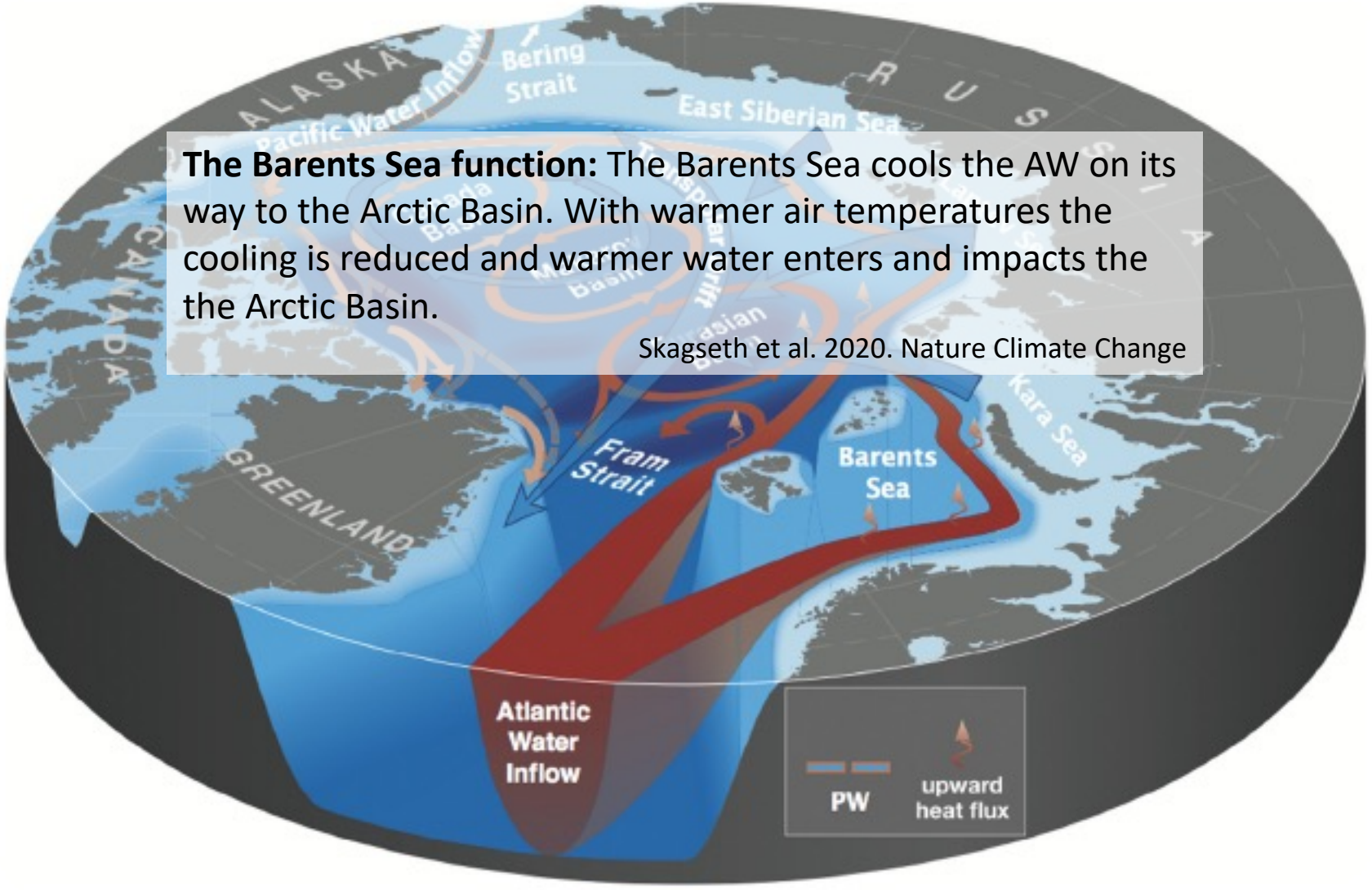
16 global climatic tipping points: the Barents Sea ice loss is one of six with <2°C threshold

Armstrong McKay et al. 2022, Science

Stronger heat transport with the AW current impacts both the Barents Sea and the Arctic Basin



The Barents Sea function: The Barents Sea cools the AW on its way to the Arctic Basin. With warmer air temperatures the cooling is reduced and warmer water enters and impacts the the Arctic Basin.

Skagseth et al. 2020. Nature Climate Change

Illustration: Igor Polyakov

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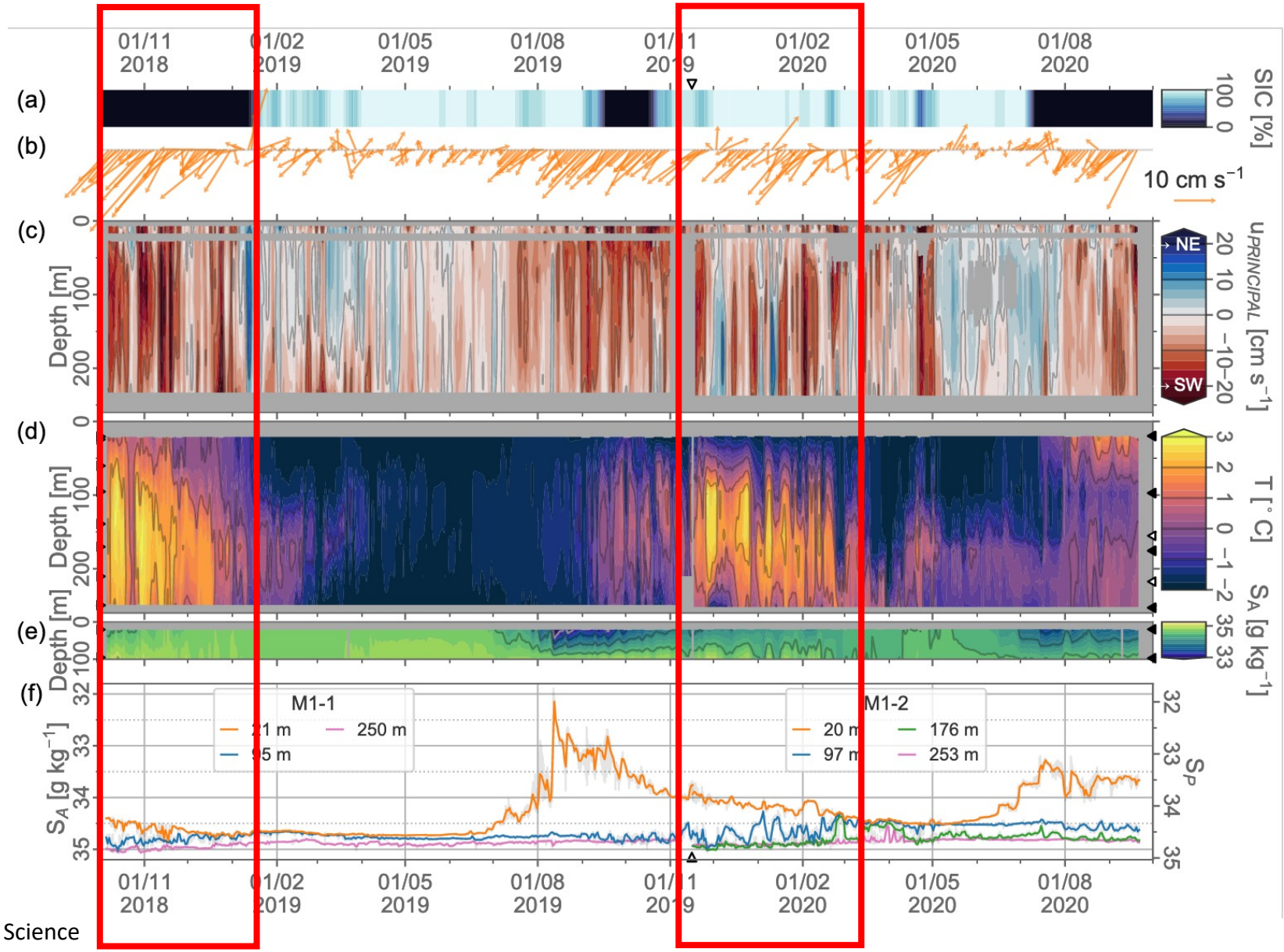
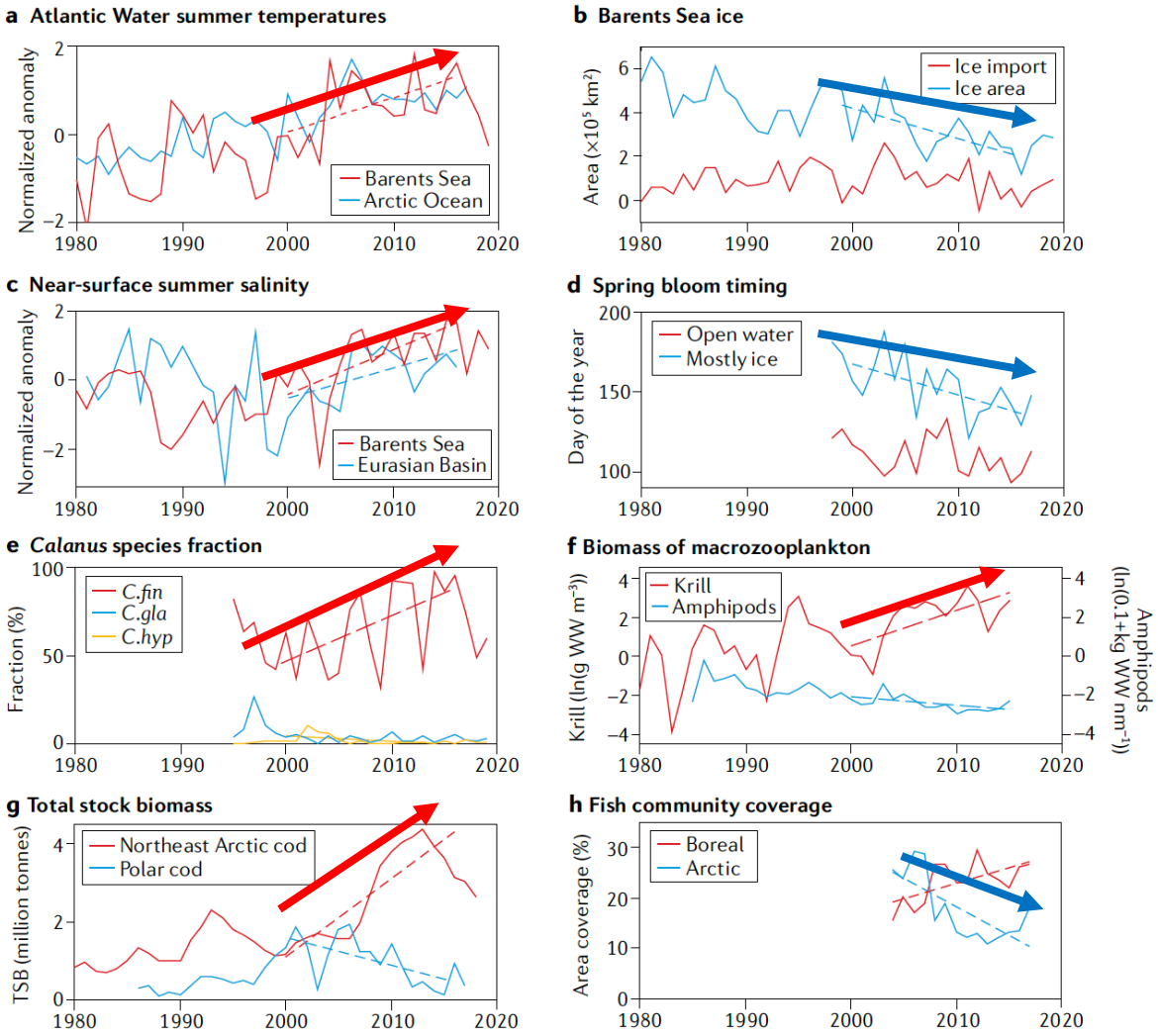
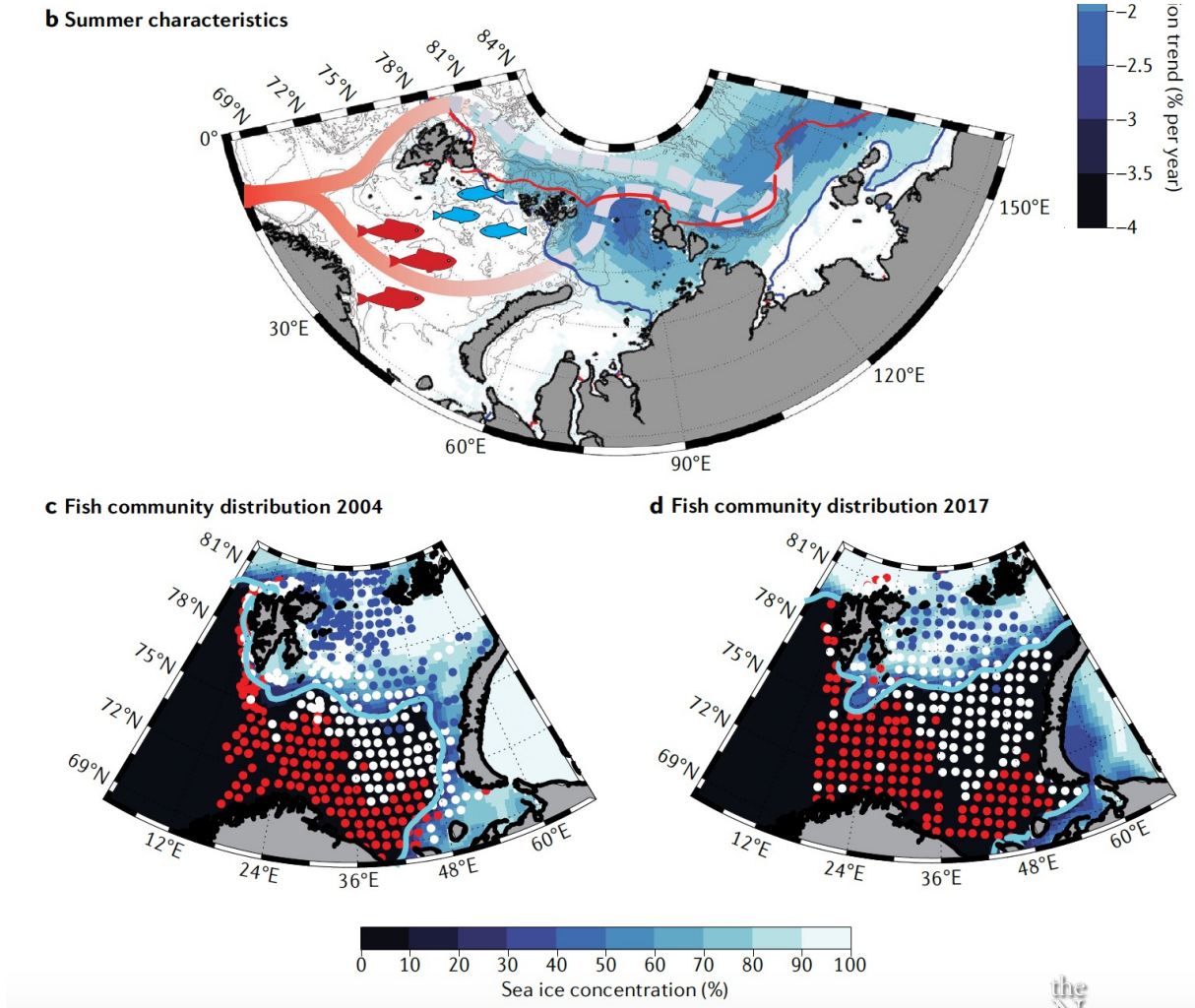
Strongest inflow of warm water during winter



Lundesgaard et al. 2022, Ocean Science

Northern Barents Sea ecosystem is changing - «Atlantification»





Ingvaldsen et al. 2021, Nature reviews Earth and Env.

Based on IMR ecosystem survey data

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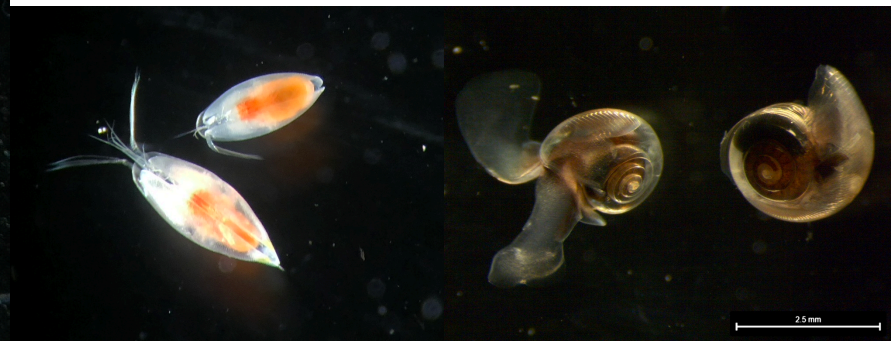
Is the seasonality of Arctic zooplankton influenced by advection?

We hypothesise that the diversity, abundance and biomass of zooplankton

1) Changes with seasonality

2) Is higher in areas impacted by Atlantic Water than in areas dominated by local Arctic water masses (Atlantification)

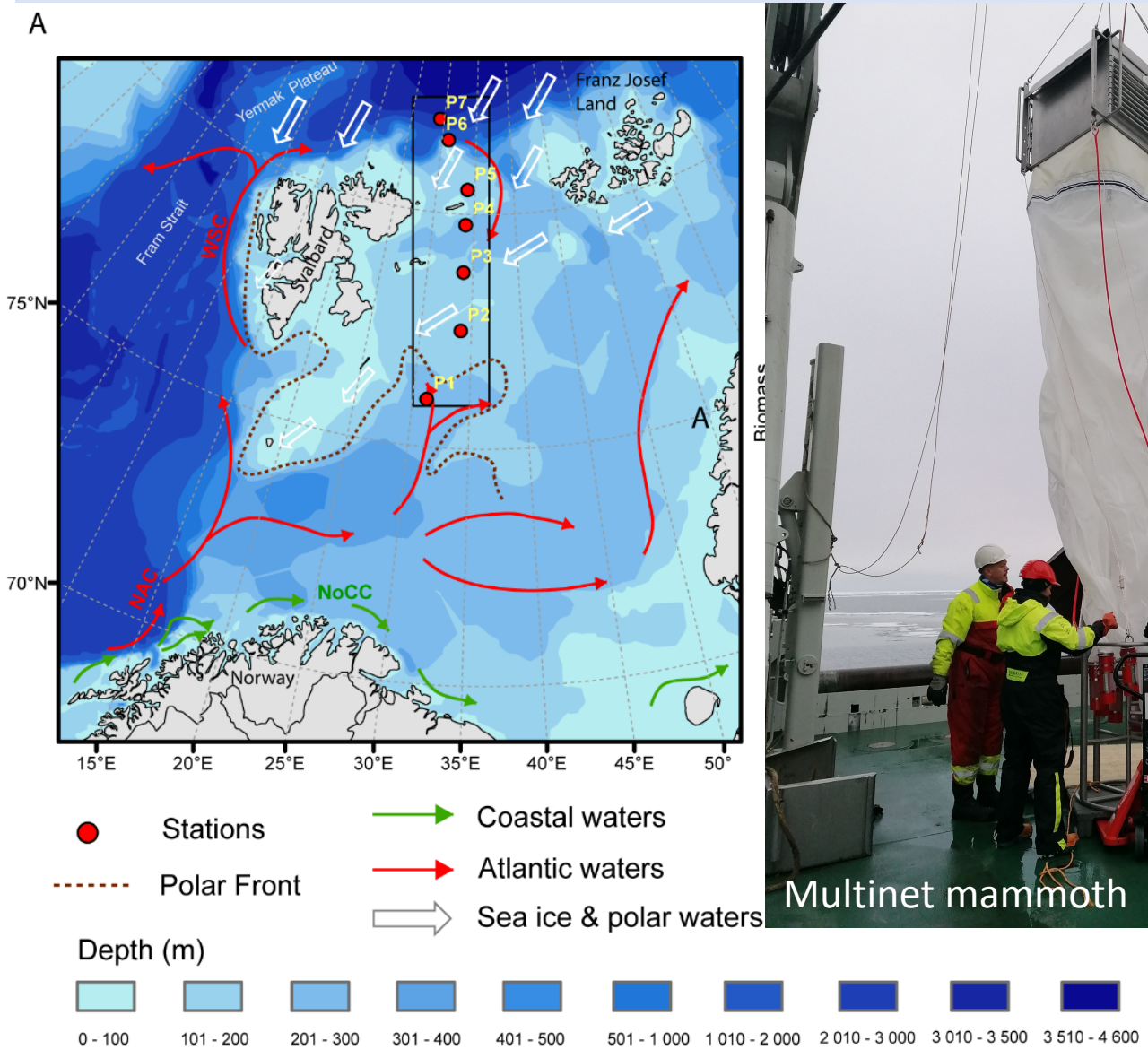


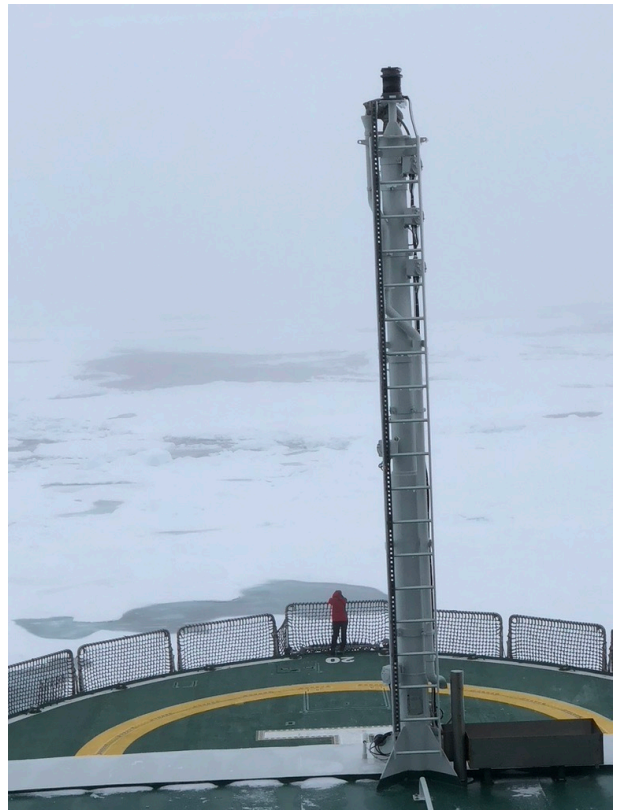
Wold et al. (In revision), Progress in Oceanography

7 stations in the northern Barents Sea
Transect from south of the Polar Front to Polar Basin

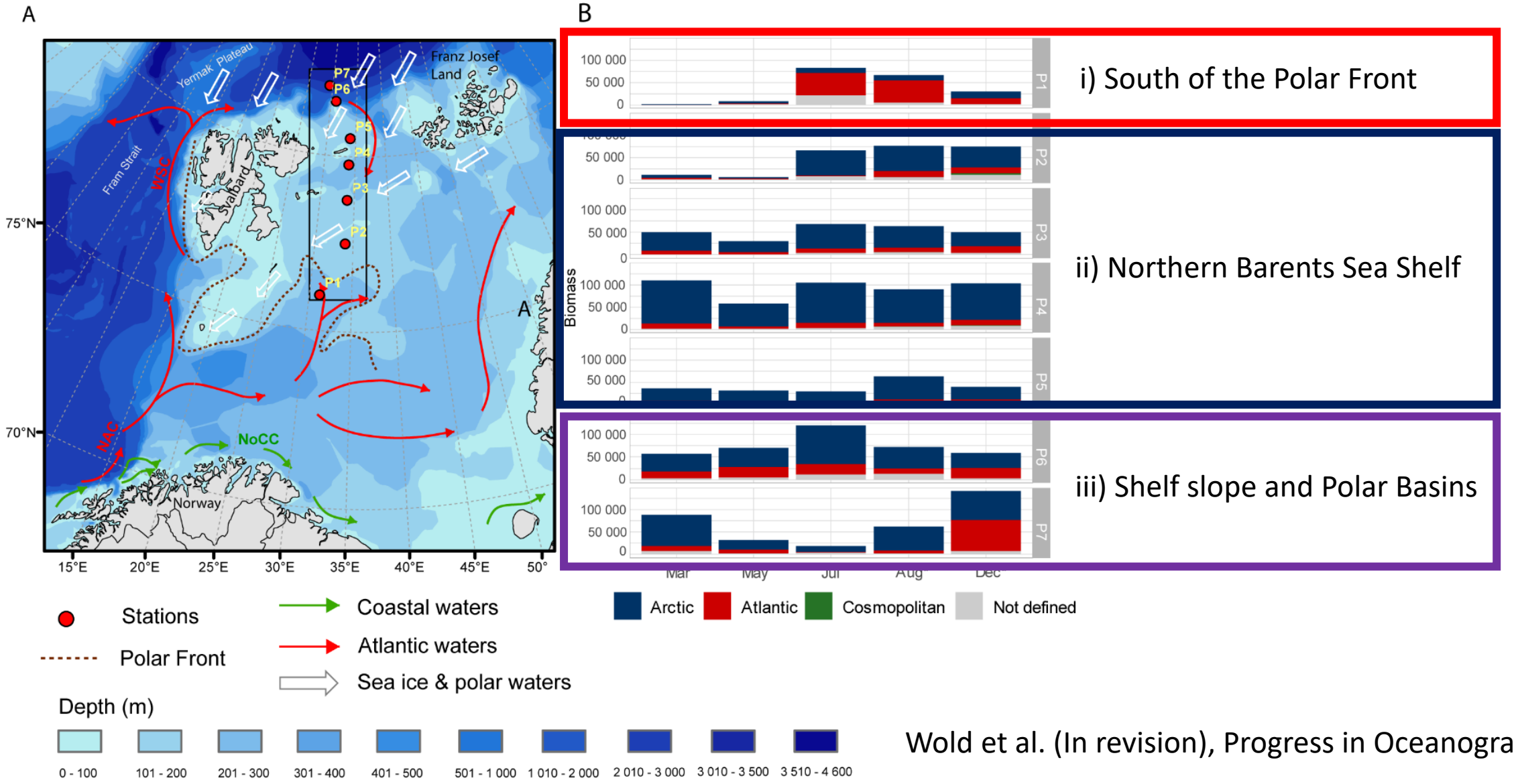
Winter: December, March
Spring/summer: May, July
Autumn: August

Duplicate sampling:
180 µm mesh: large copepods
64 µm mesh: Small copepods



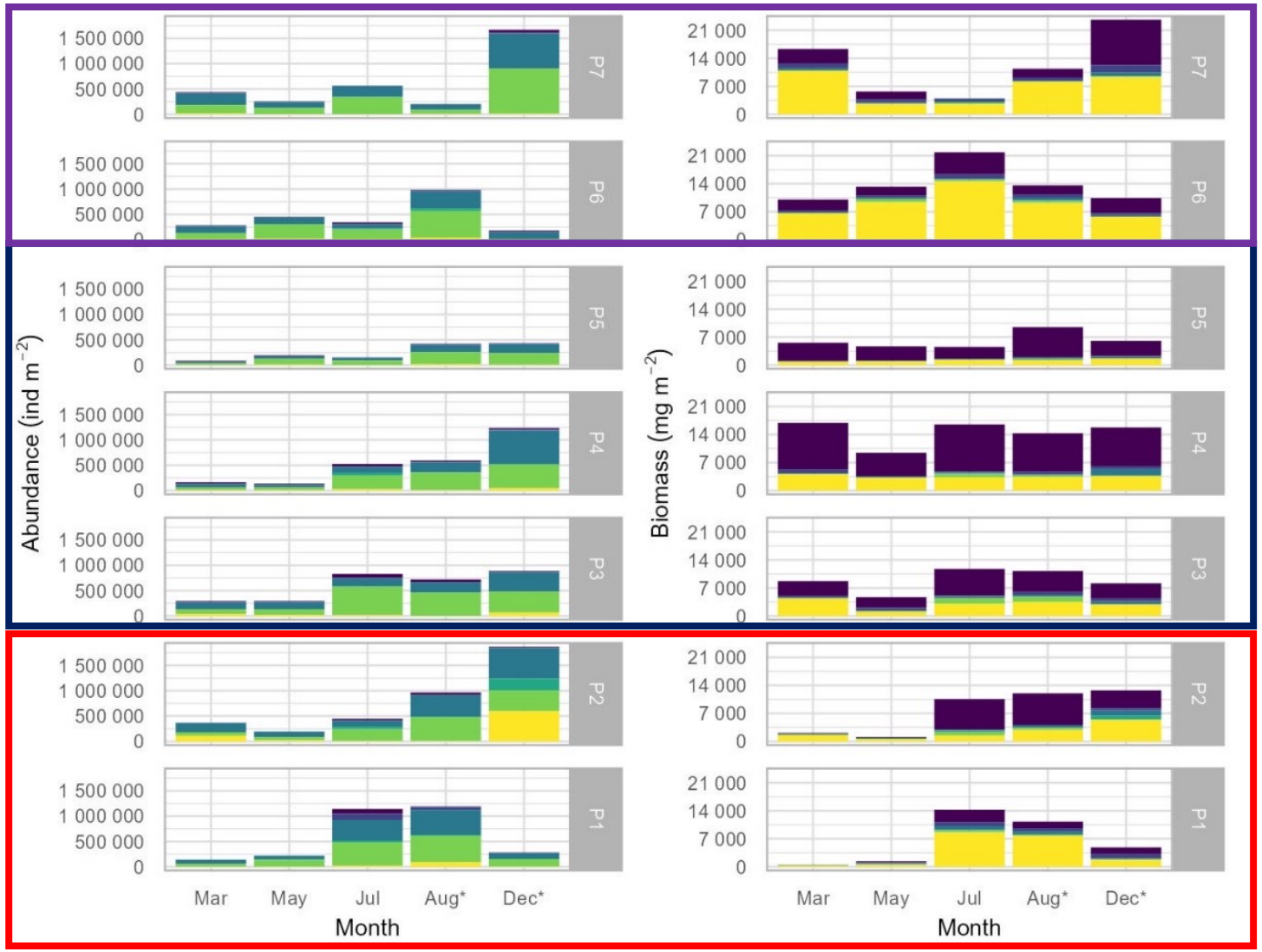


Three distinct biogeographical regions were identified:



Wold et al. (In revision), Progress in Oceanography

Barents Sea copepod distribution



North: Atlantic + deep water carnivores

C. finmarchicus, *Triconia borealis*, *Oncaea* sp., *Paraeuchaeta* spp., *Scaphocalanus brevicornis*, *Spinocalanus* spp., *Gaetanus brevispinus* and *Heterorhabdus norvegicus*

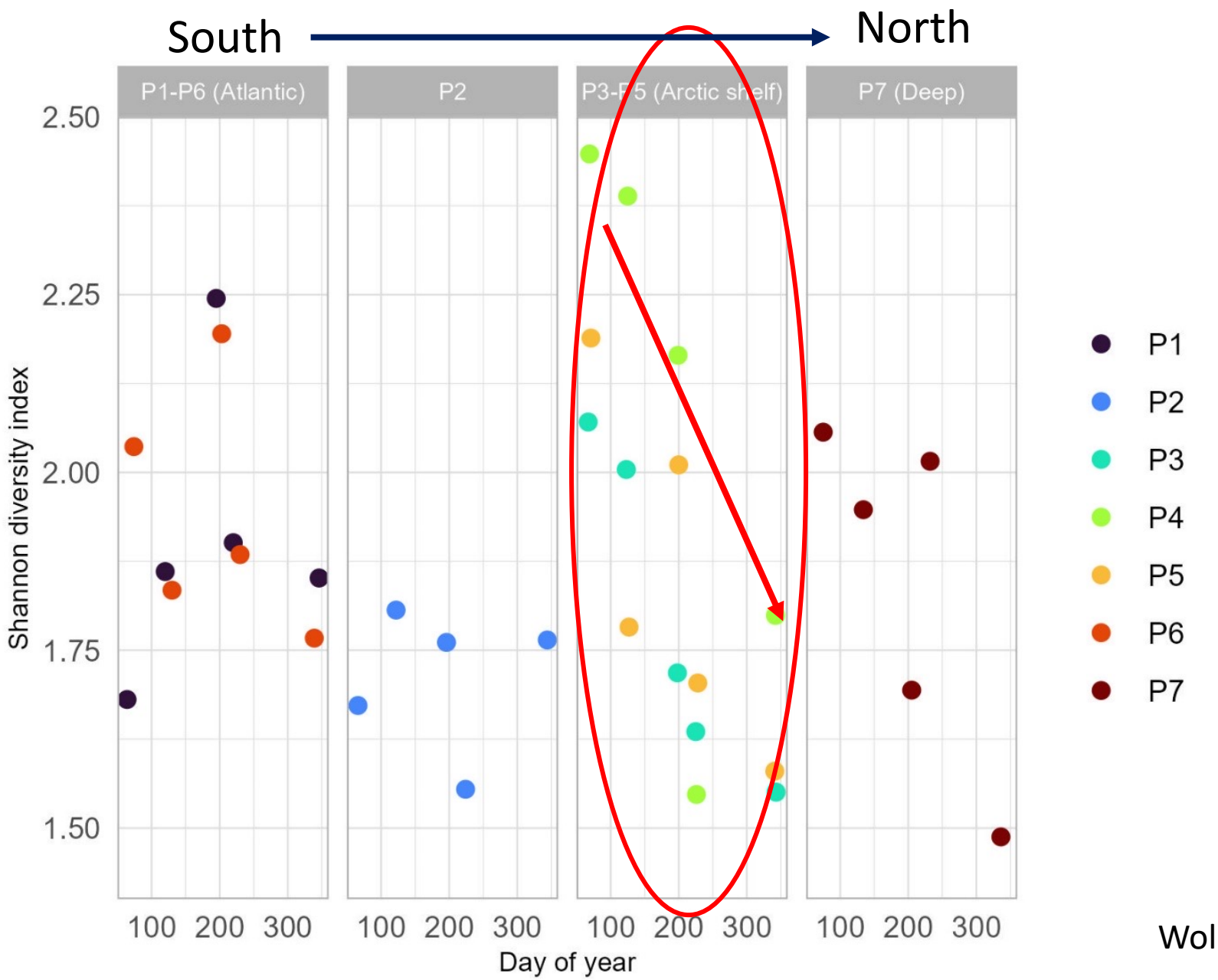
Shelf: Arctic species

Calanus glacialis, *Pseudocalanus* spp., and *Limacina helicina*

South: Atlantic species

Calanus finmarchicus, *Metridia longa*, *Oithona similis*, *Microsetella norvegica*

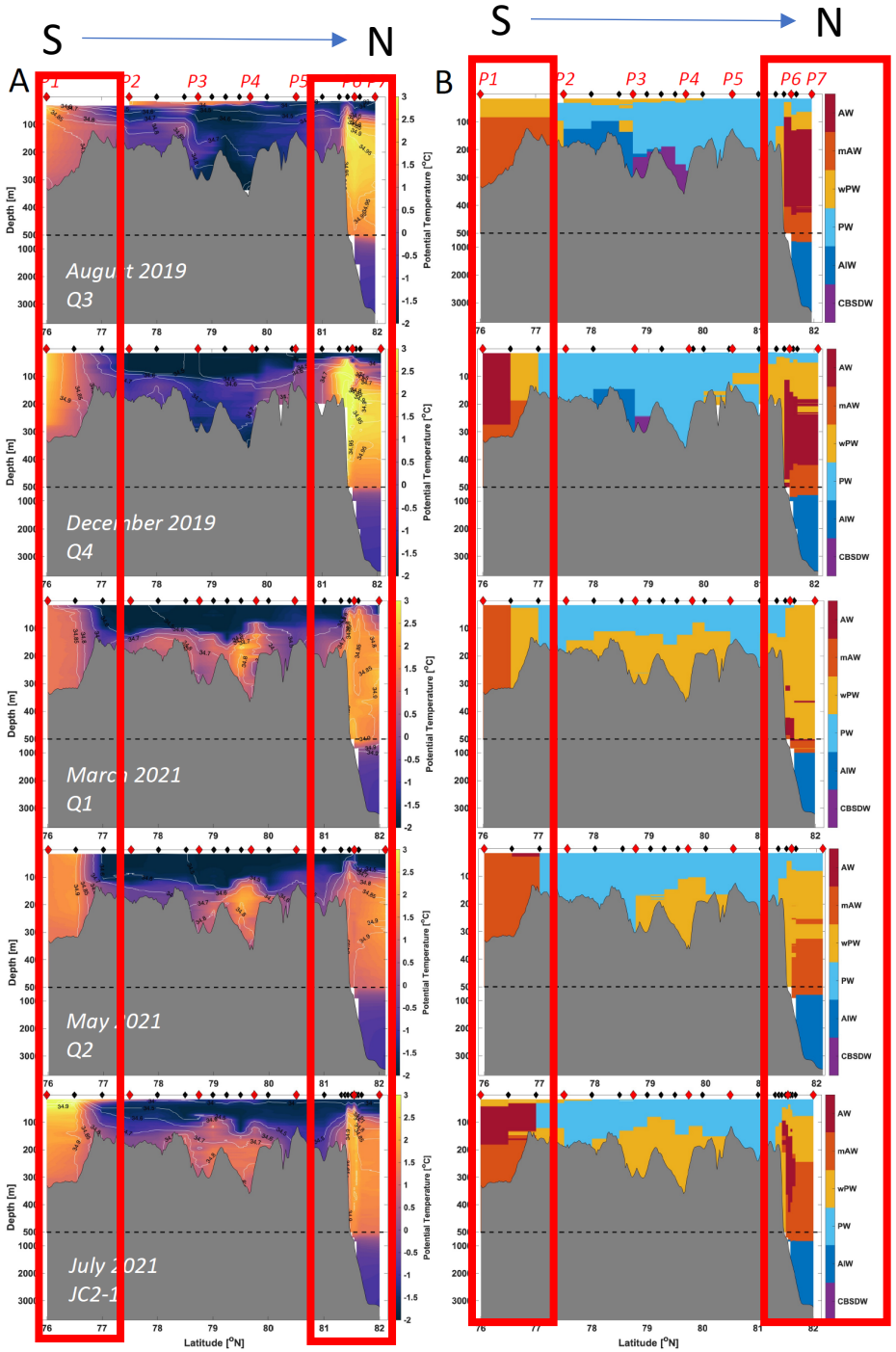
Wold et al. (In revision), Progress in Oceanography



The shelf north of the Polar Front inhabited the highest zooplankton diversity
(Arctic communities)

Diversity decreases towards winter in Arctic communities

Wold et al. (In revision), Progress in Oceanography



Hydrography and watermasses along transect

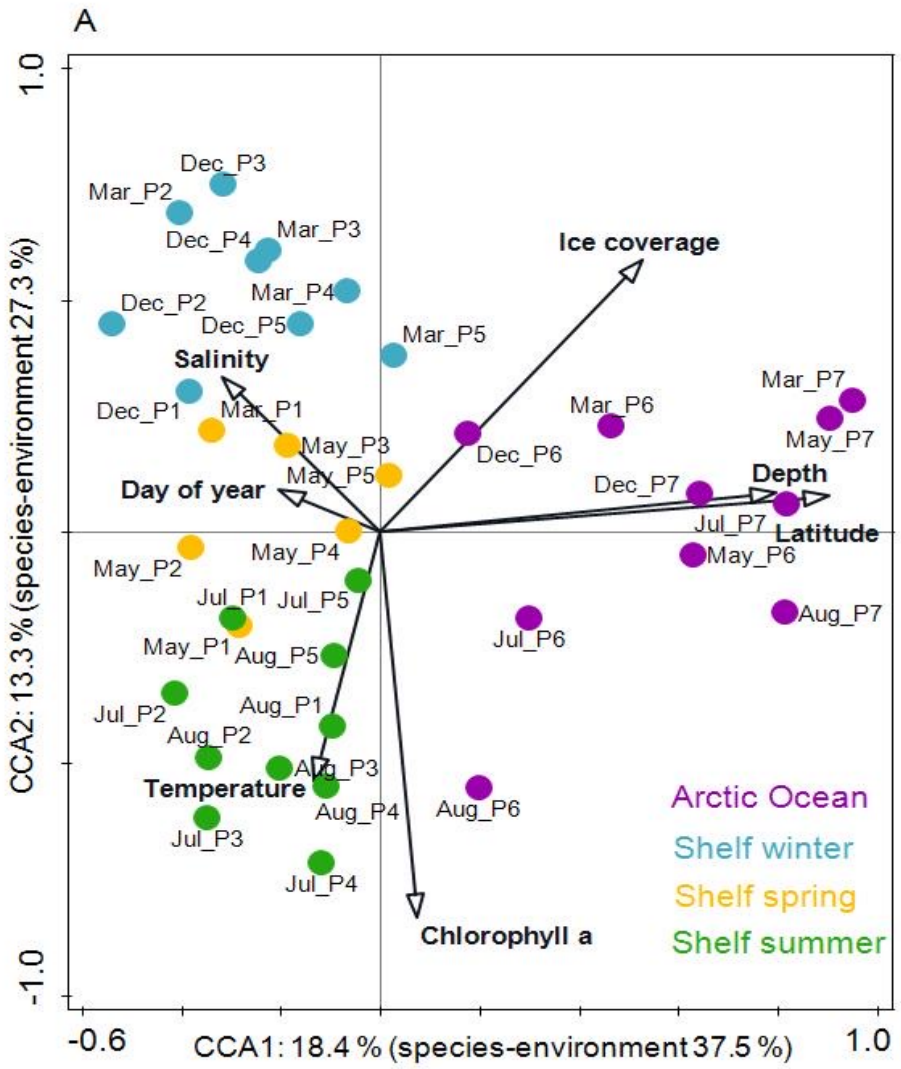
South and north = warm, Atlantic water

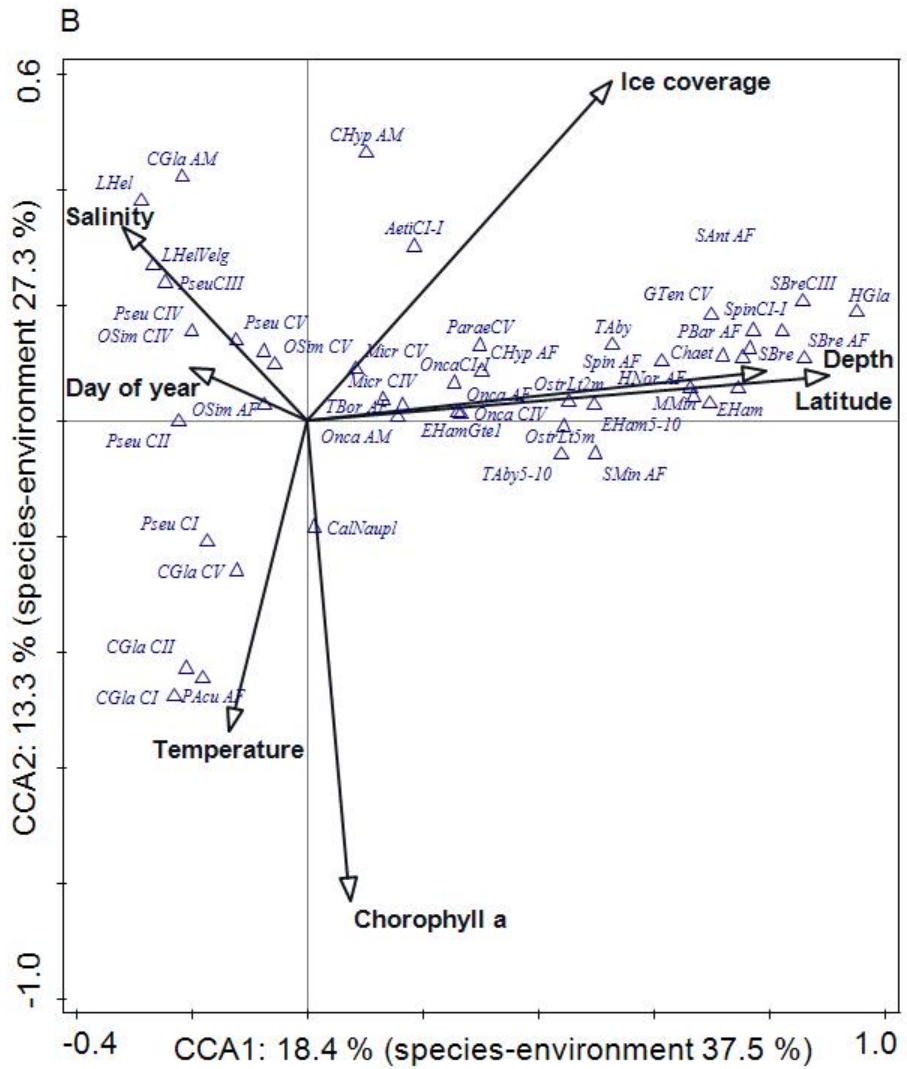
On shelf = cold, Arctic water

Shapes the distribution of zooplankton

Wold et al. (In revision), Progress in Oceanography

Four distinct seasonal zooplankton communities identified



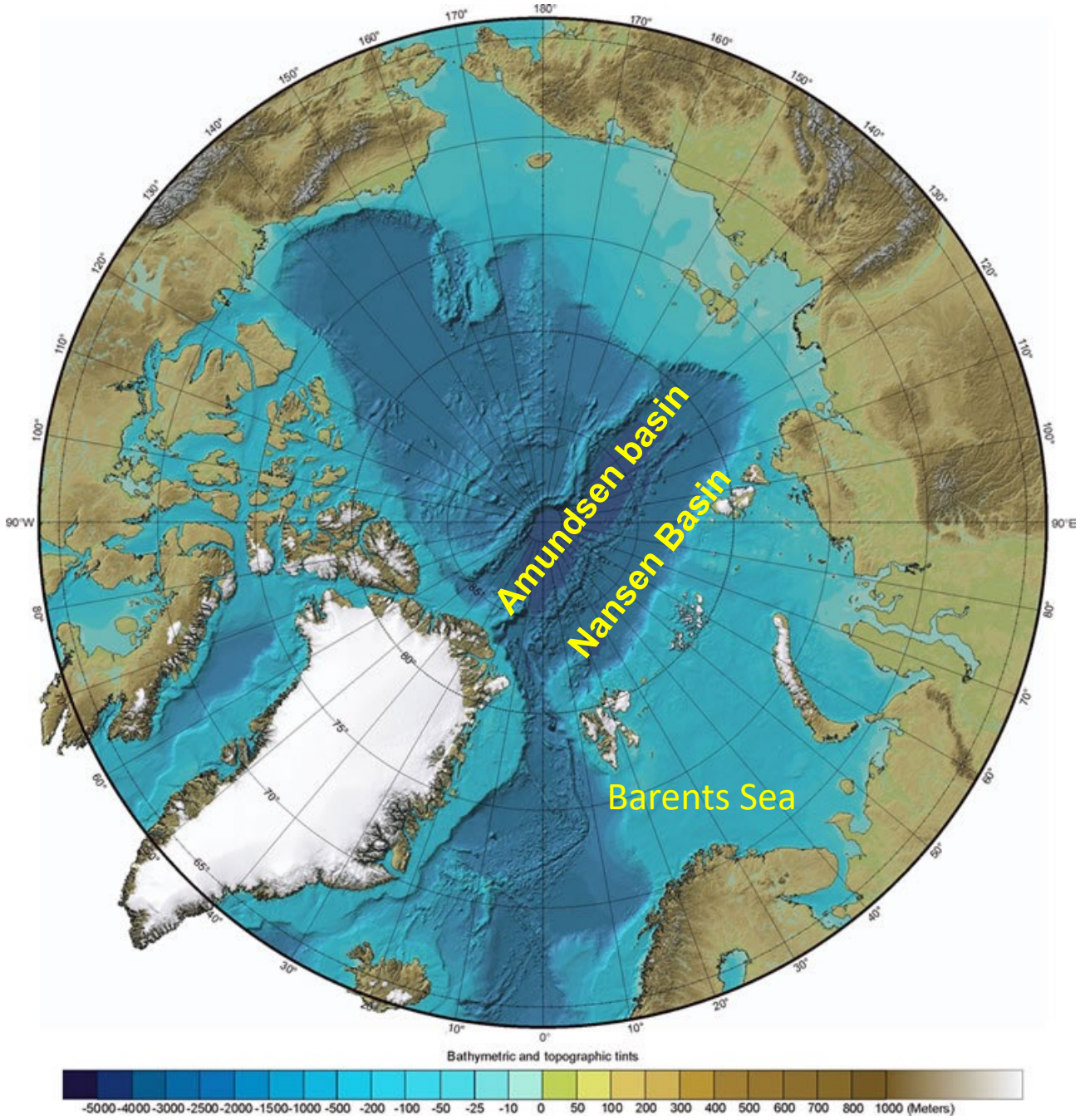


Wold et al. (In revision), Progress in Oceanography

Zooplankton seasonality in the northern barents Sea - Conclusions

- The inflow of Atlantic zooplankton south of Polar Front and north of Spitsbergen was seasonally pulsed
- Atlantification of zooplankton communities was strongest during summer in the southern part and during autumn in the northern part of the investigated area
- Arctic zooplankton communities were restricted to the northern Barents Sea shelf area
- The shelf north of the Polar Front inhabited the highest zooplankton diversity

Wold et al. (In revision), Progress in Oceanography



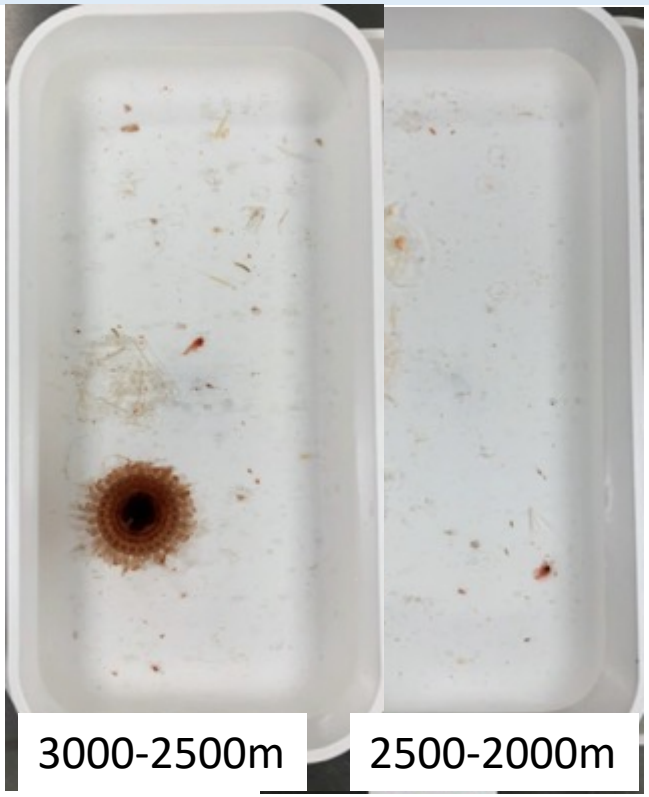
Do we also find zooplankton in the deep, dark, cold and seasonally ice-covered Polar Basins?

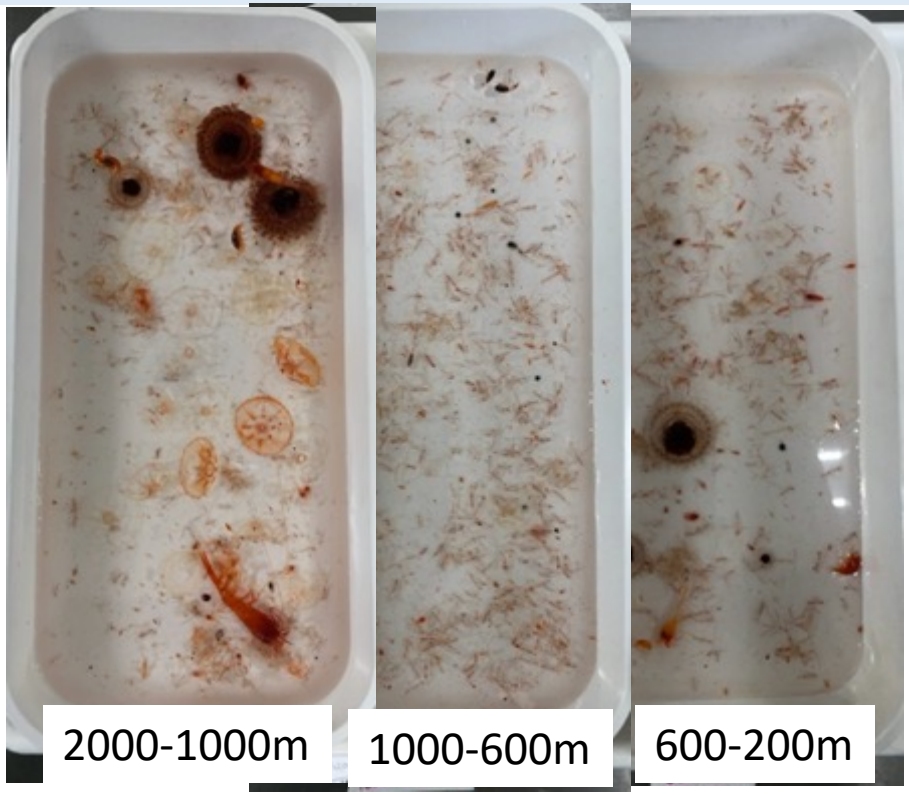
Nansen Basin and Amundsen Basin August/Sept 2021

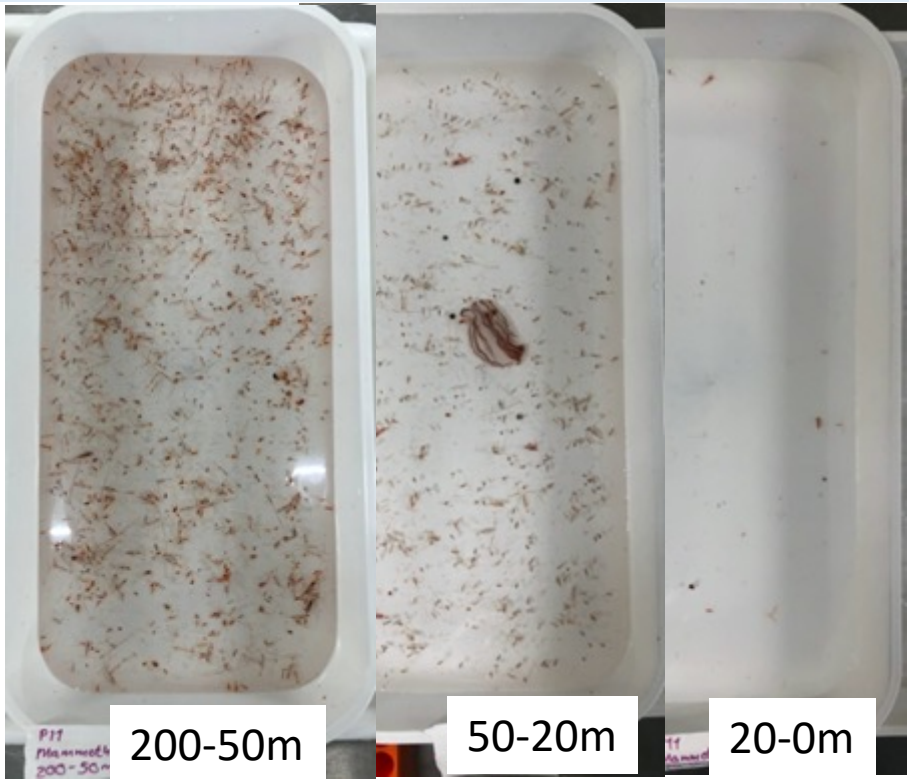
Zooplankton in the Polar Ocean – First impressions

Camilla Svensen (UiT) & Anette Wold (NPI) – Cruise in September 2021

1. **Vertically structured** zooplankton biomass and compostion (87.5 N)





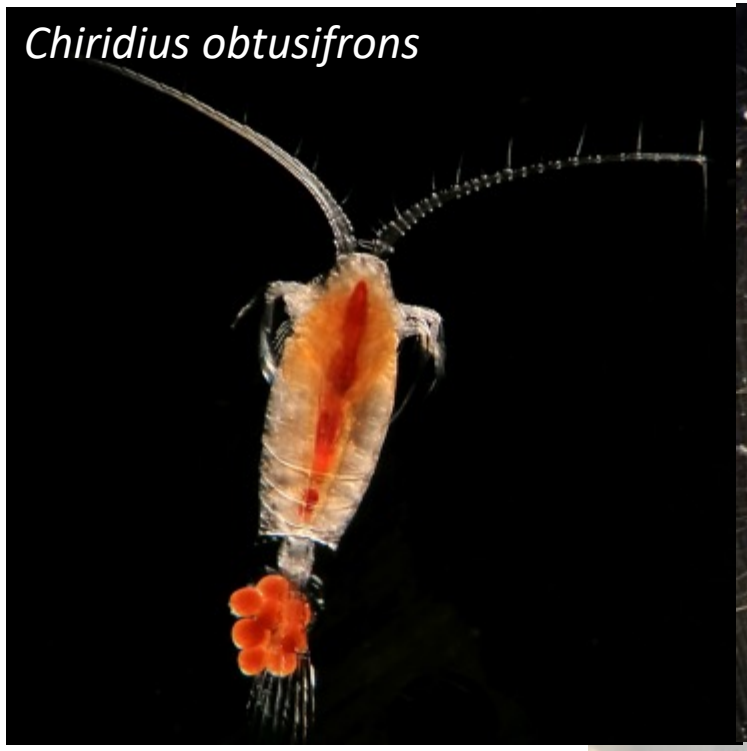


DEEP: Low biomass:
Appendicularians, jellies,
small & big copepods

Middle: High biomass:
High diversity, jellies,
Decapods, Amphipods, copepods

Surface: High biomass:
lower diversity, copepods,
ctenophores

2. High diversity of carnivores and other zooplankton


Chiridius obtusifrons


Paraeuchaeta sp.


Gaetanus sp.

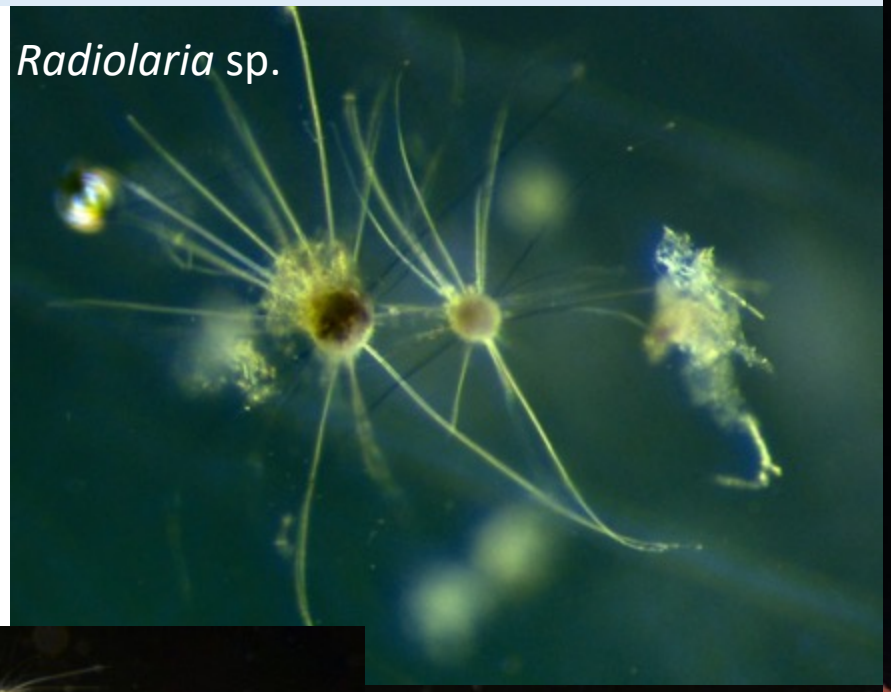

Boroecia sp.


Atolla sp.


Cyclocaris guilelmi


Eusirus holmii

3. Deep basins are full of life



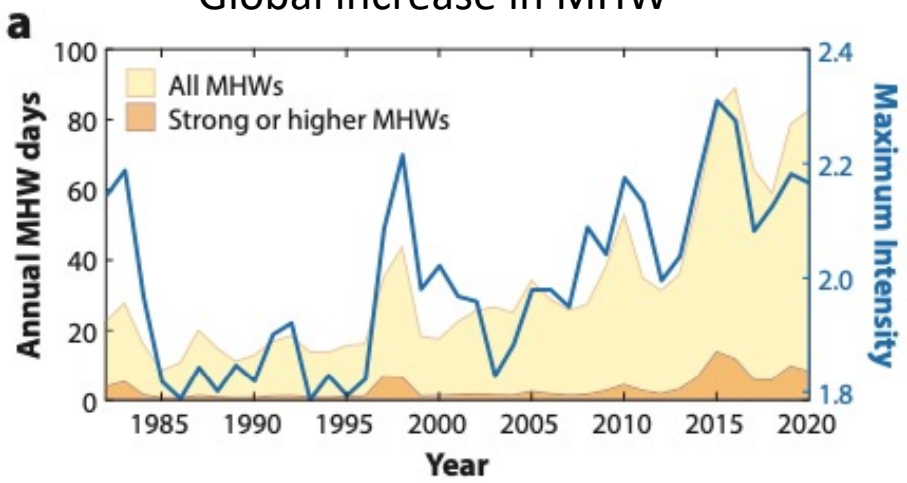
Response of copepods to heatwaves

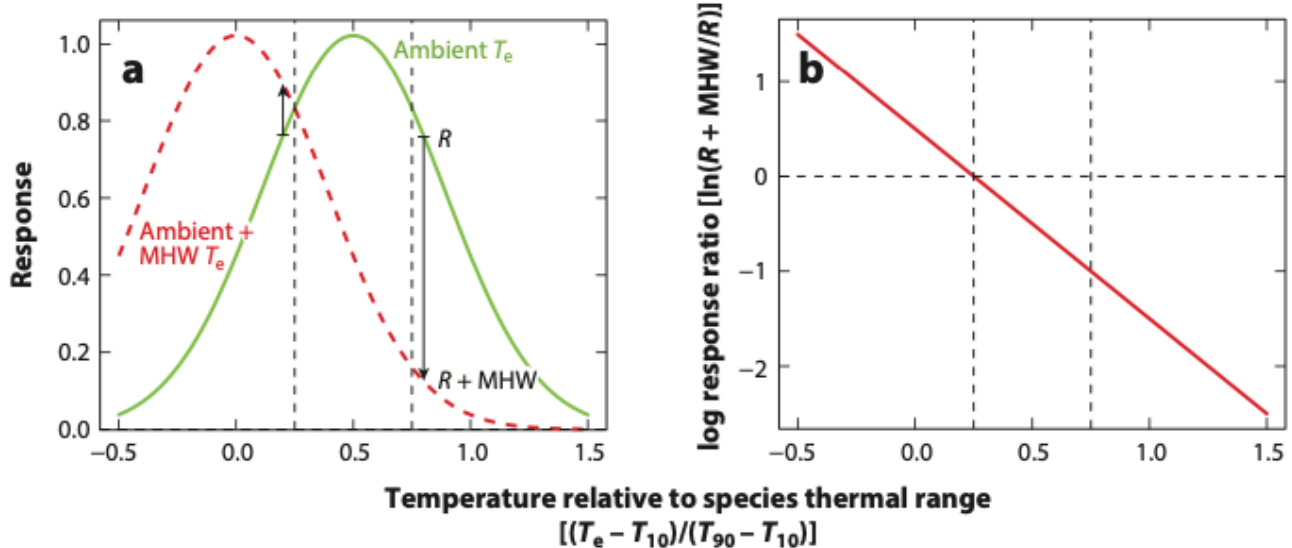
Kazutaka Takahasi, Yuichiro Nishibe, Marja Koski, Camilla Svensen + assistant Yuino

Marine heatwave (MHW): a discrete, prolonged (five days or more) period of anomalously high sea temperature (e.g., >90th percentile relative to local climatology) for any given location and season

(Smith et al. 2023, Annu. Rev. Mar. Sci.)

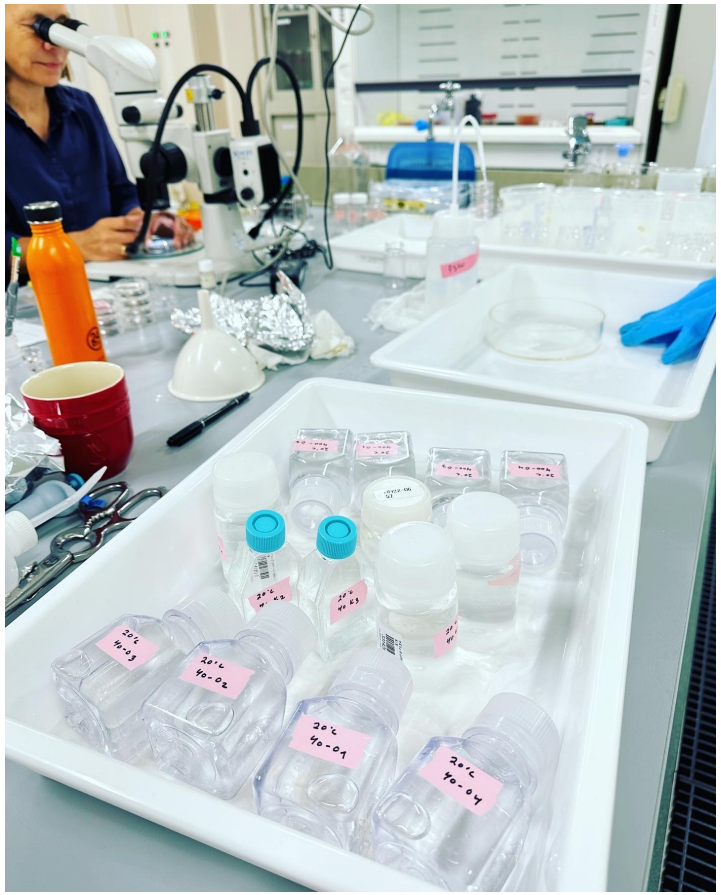
Global increase in MHW





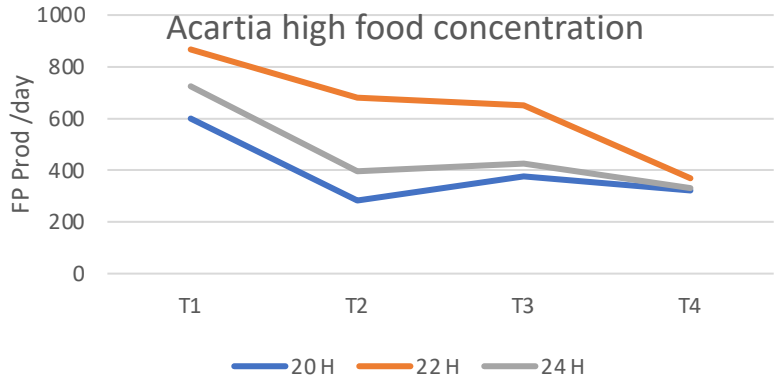
Treatment (4 days duration)

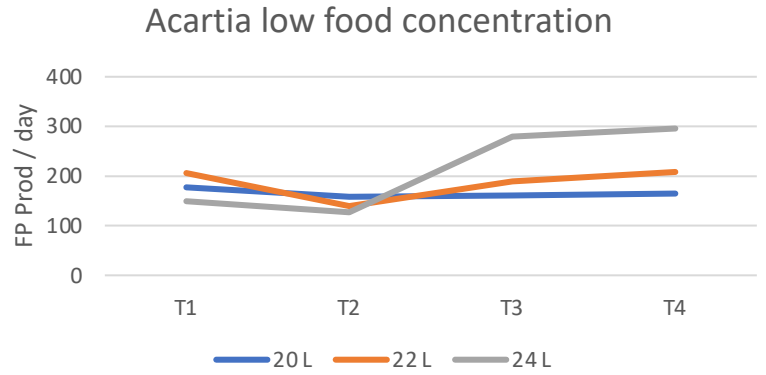
20 C - 22 C - 24 C



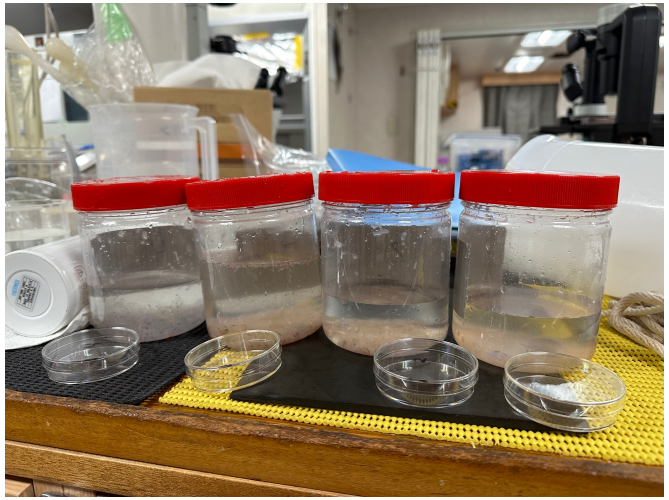
Response variable/daily

Mortality
Grazing rate
Faecal pellet production
Egg production
Egg hatching rate





Response of copepods to heatwaves



Investigate copepod vertical distribution in relation to temperature – link this to experiments from Otsuchi Bay

Thank you for your attention!