SAMBR: Sea Ice Biota

Sea Ice Biota Expert Network:

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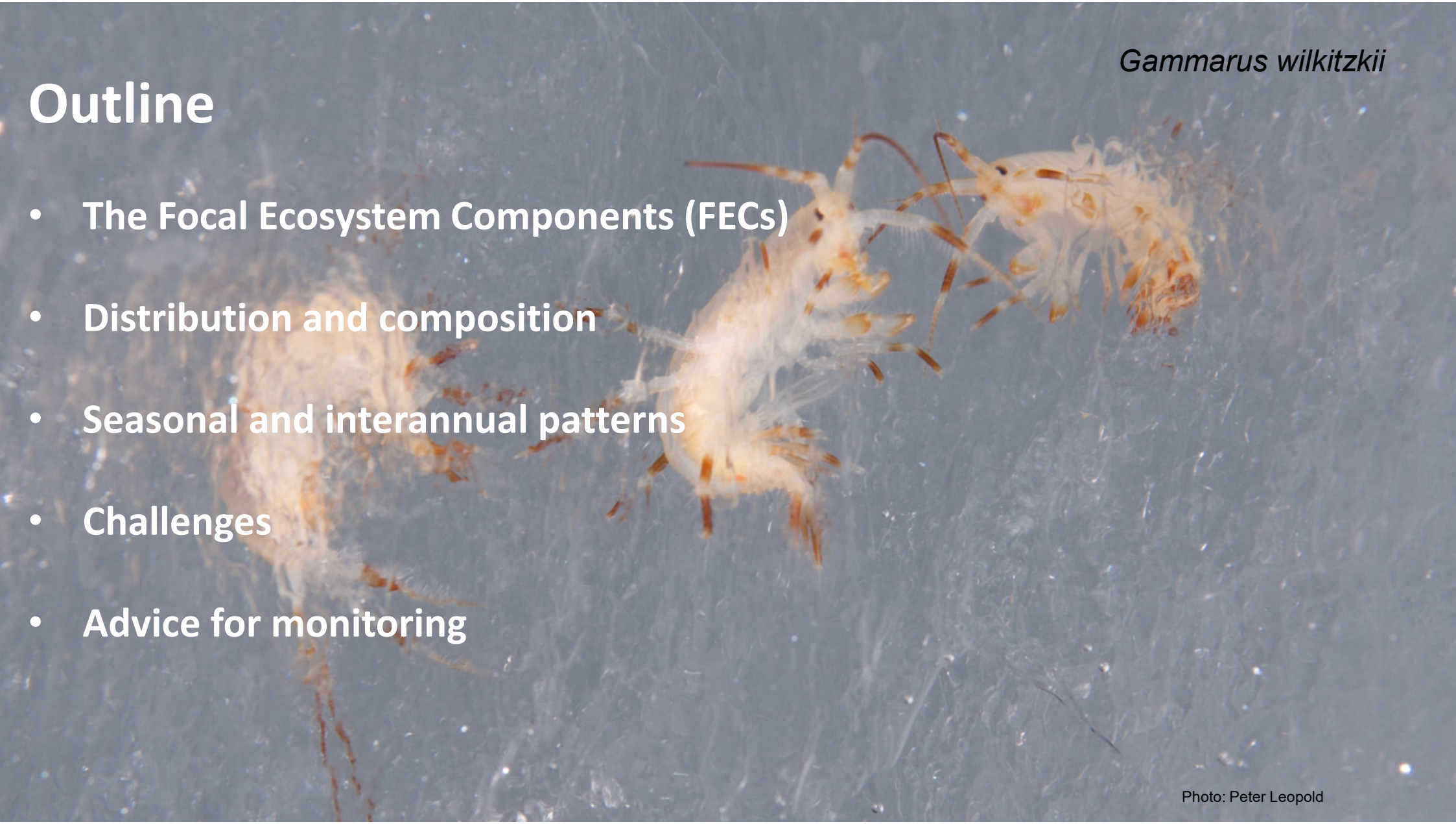
Cecilie von Quillfeldt, Norwegian Polar Institute, Norway (Presenter at the ABC 2018)

Arctic Biodiversity Congress 2018

Picture: P. Leopold



Outline

- The Focal Ecosystem Components (FECs)
- Distribution and composition
- Seasonal and interannual patterns
- Challenges
- Advice for monitoring

The Focal Ecosystem Components (FECs)

Nitzschia frigida

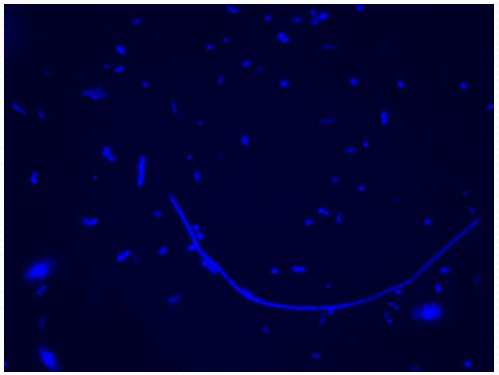
FYI Ridges are hot spots for algal growth since they protect against currents and provide a favourable light environment.

Photo: Peter Leopold

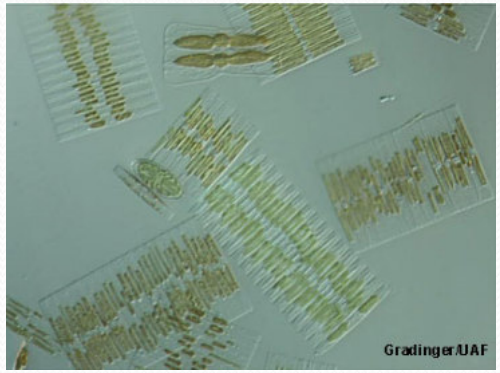
Sea ice biota > 2000 species

Sea ice biota is not monitored regularly at any location and our description was, therefore, based on synthesis of available data from a series of research projects.

Bacteria



Diatoms



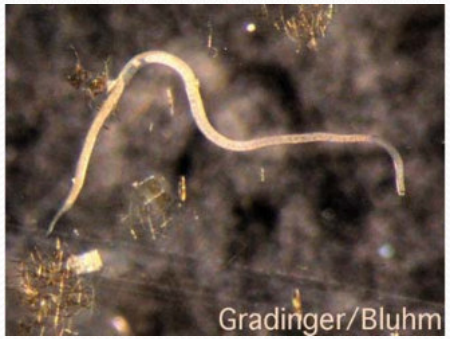
Copepods

Benthic larvae

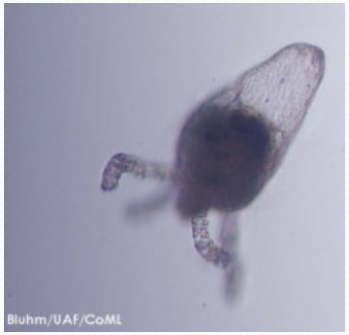
Acoela

Ampipods

Nematods

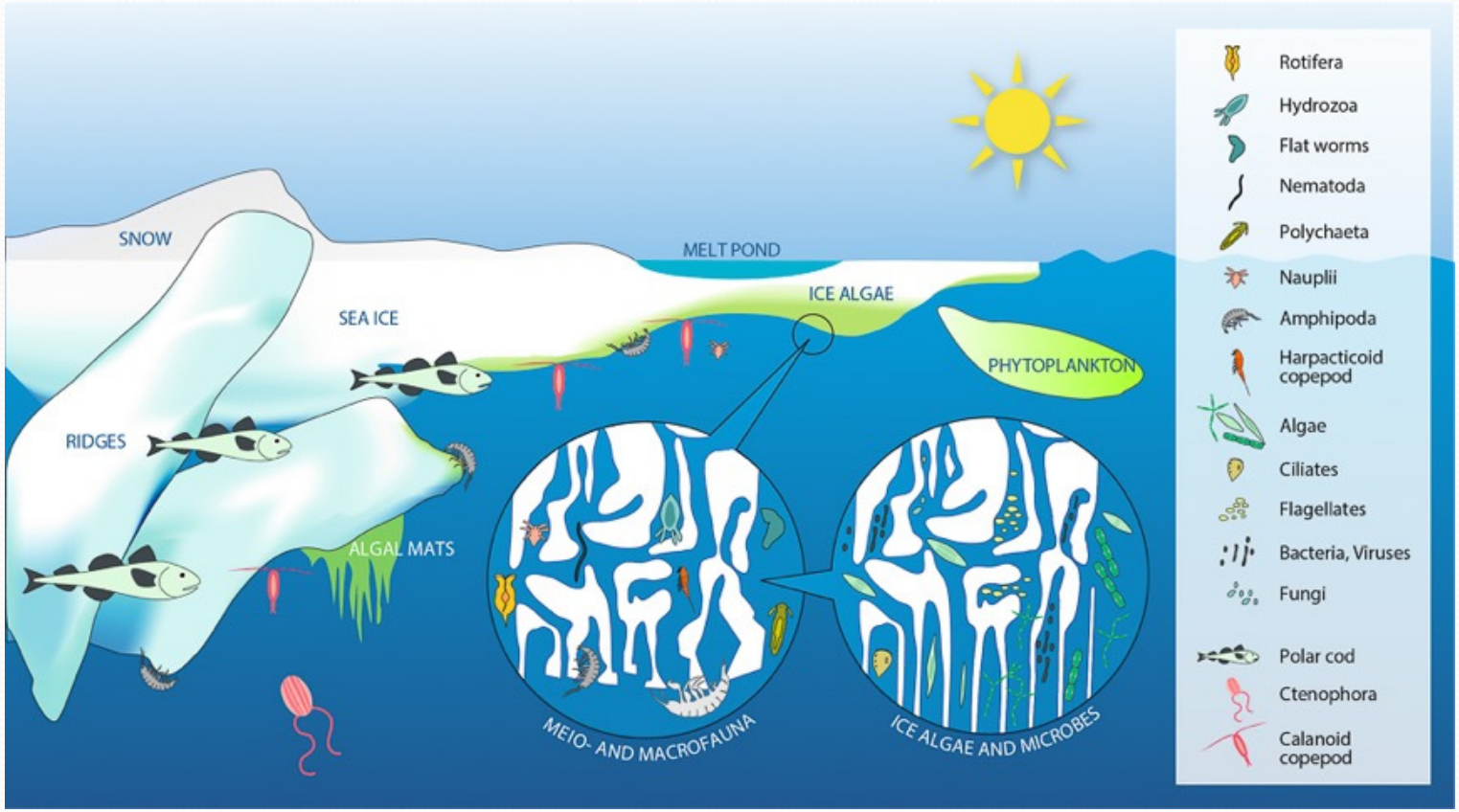


Hydroids



Polar cod

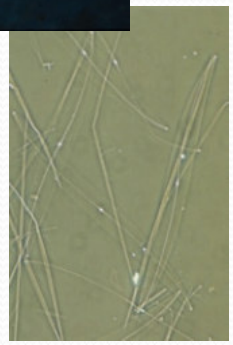
The Focal Ecosystem Components (FECs) (circles) in sea ice



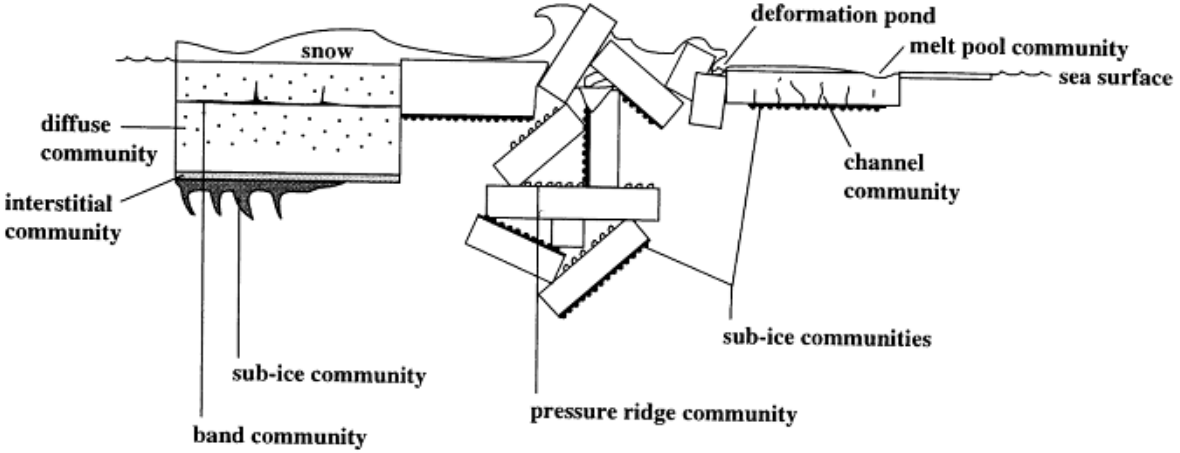
Sea ice provides a wide range of microhabitats for diverse biota including microbes, single-celled eukaryotes (labelled algae), multicellular meiofauna, larger under-ice fauna (represented by amphipods), as well as polar cod (*Boreogadus saida*). Modified from Bluhm et al. (2017).

Source: SAMBR (2017)

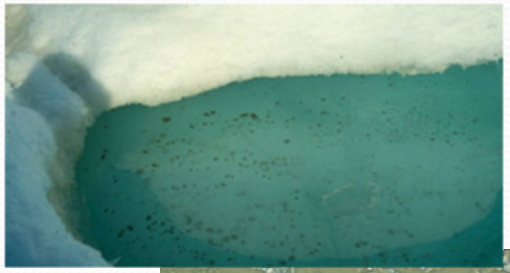
Different types of ice algal communities

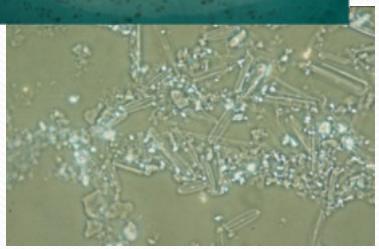


Band community

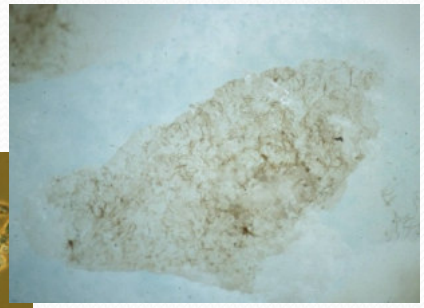


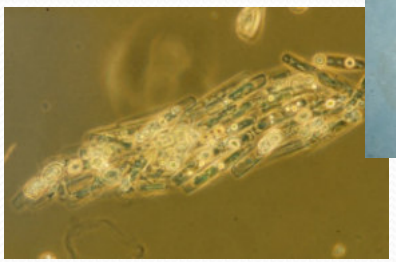
Modified from Syvertsen (1991)

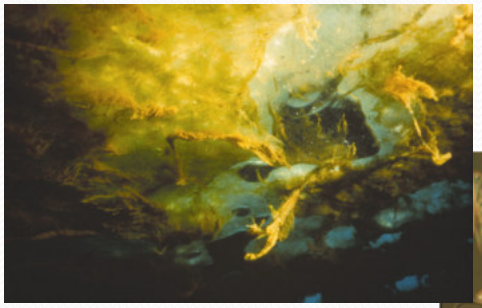


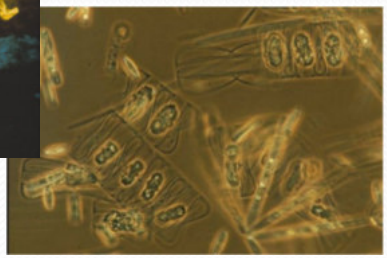


Melt pool community









Sub-ice communities

Photos: C. von Quillfeldt, B. Gulliksen

Typical interstitial community

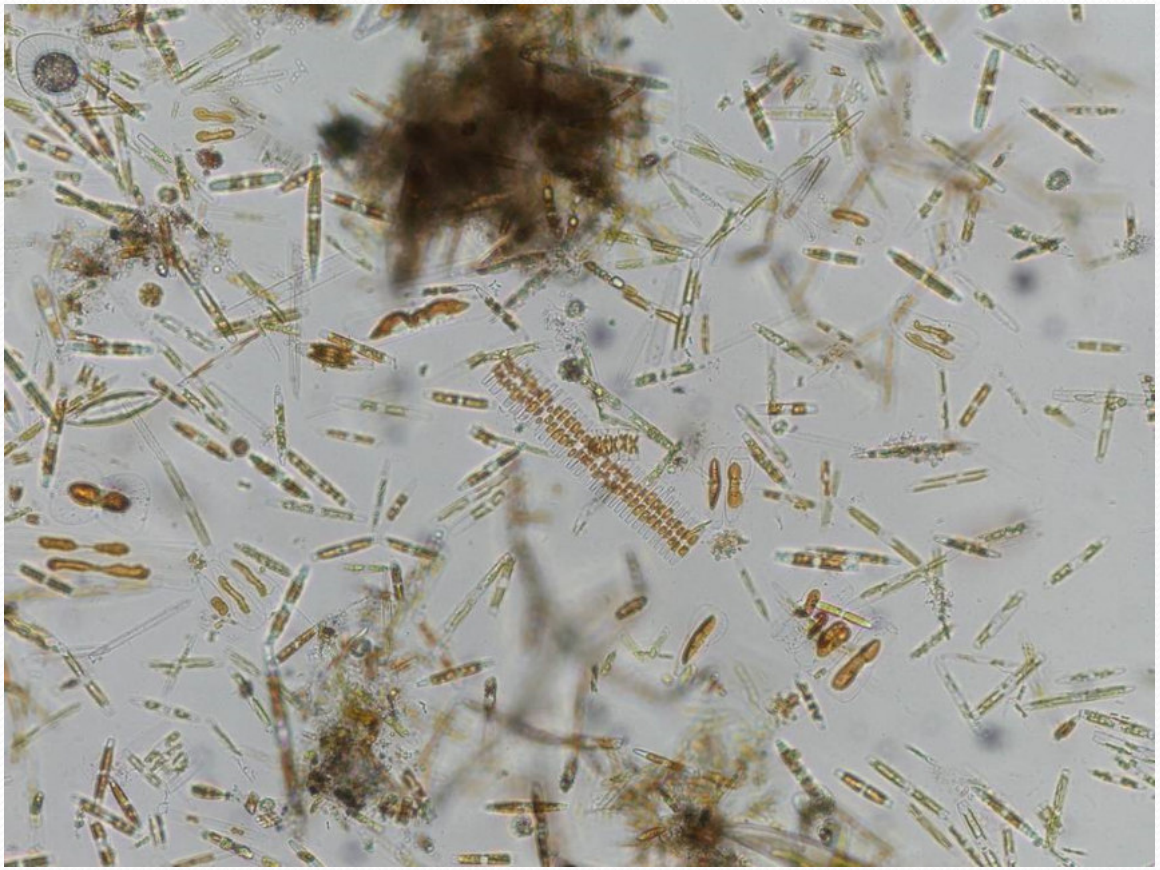


Photo:J. Wictor

Photo:J. Wictor

Distribution and composition

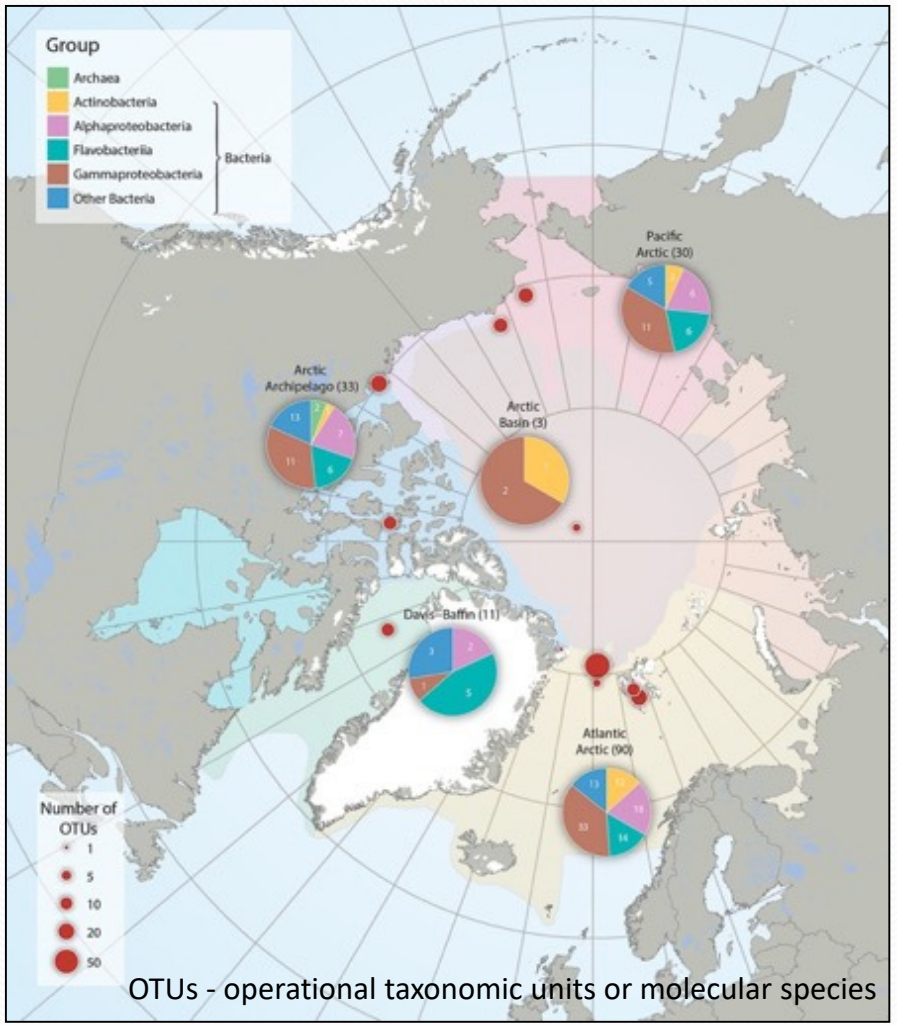
Eursirus holmi

Photo: Peter Leopold

Bacteria and Archaea –

single-celled microbes lacking a nucleus

- Principal actors in carbon and nitrogen cycling.
- The total diversity of Bacteria and Archaea found in sea ice spans the phylogenetic tree, but the dominant taxa are concentrated within Gram-negative bacterial groups.
- The five most common taxa represented 50% of all sequences in the dataset.
- No known bacterial or archaeal genera unique to sea ice.

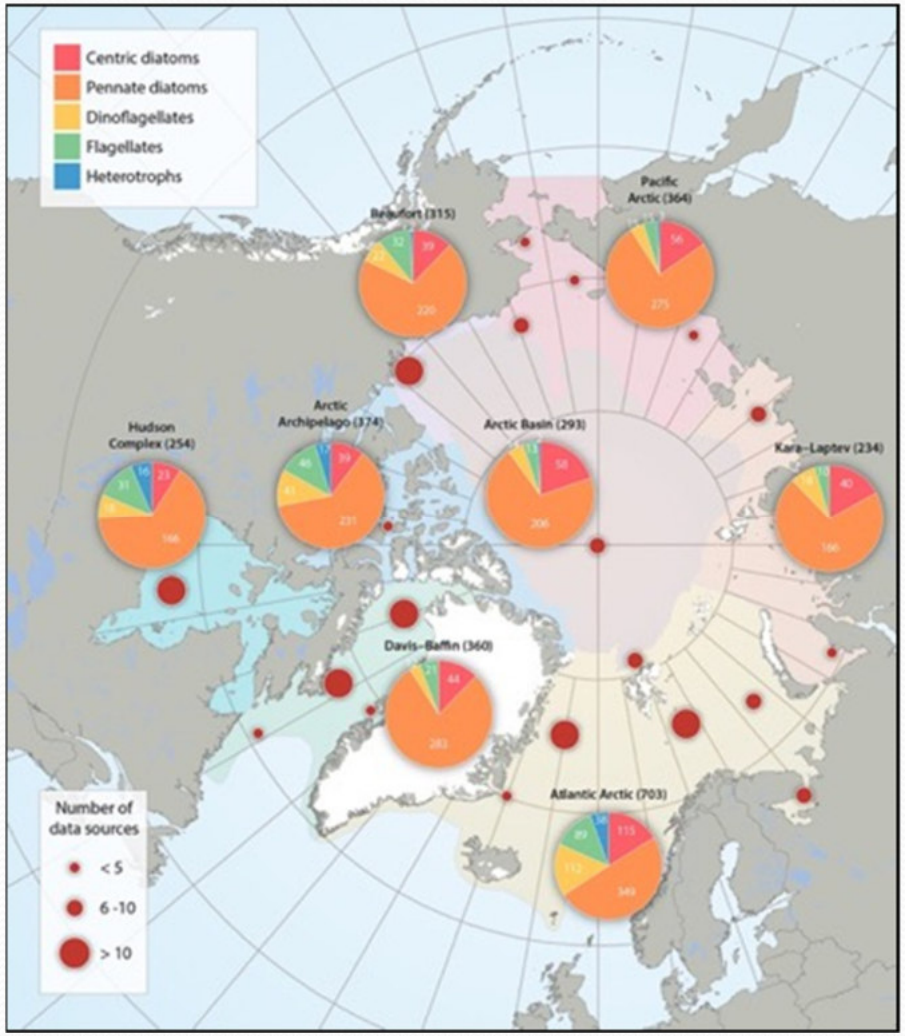


OTUs - operational taxonomic units or molecular species

Source: SAMBR (2017)

Ice algae and other single-celled eukaryote groups

- High diversity across regions, but variation between regions.
- Most groups of eukaryote are represented.
- More species in 2016 (1276) than in 2011 (1027).
- Species > 20 µm 82 % of all species recorded.
- Greatest proportion of species < 20 µm in the Atlantic region (most samples).
- Pennate diatoms most common circumpolar.



Source: SAMBR (2017)

Melosira arctica drives sympagic-pelagic-benthic coupling in the central Arctic Ocean

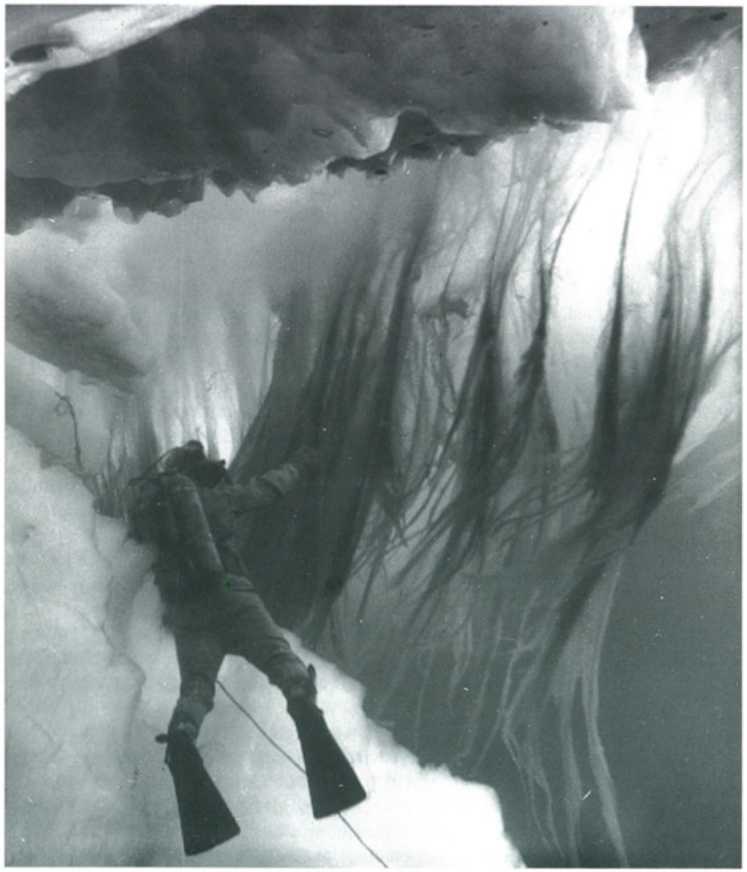
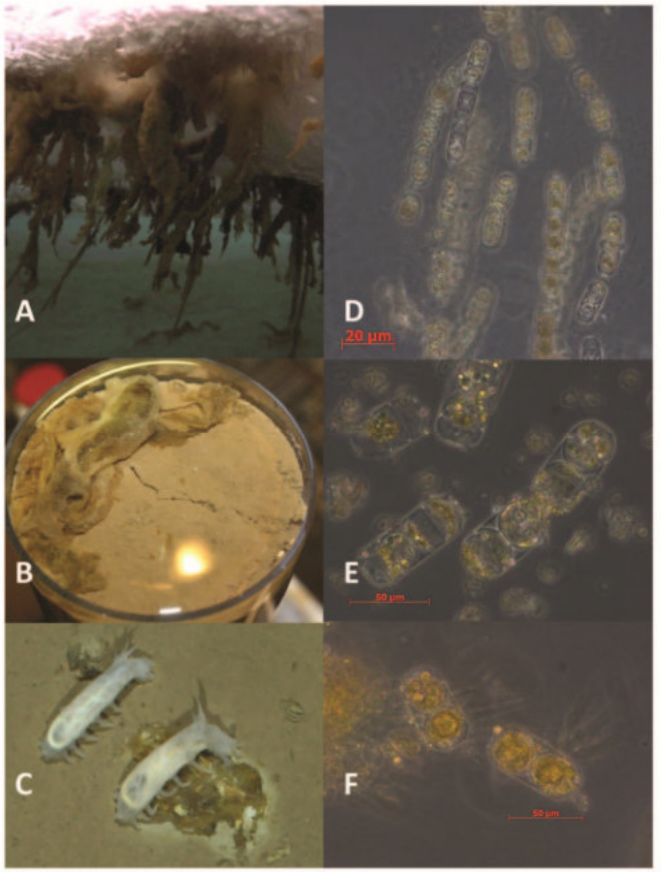
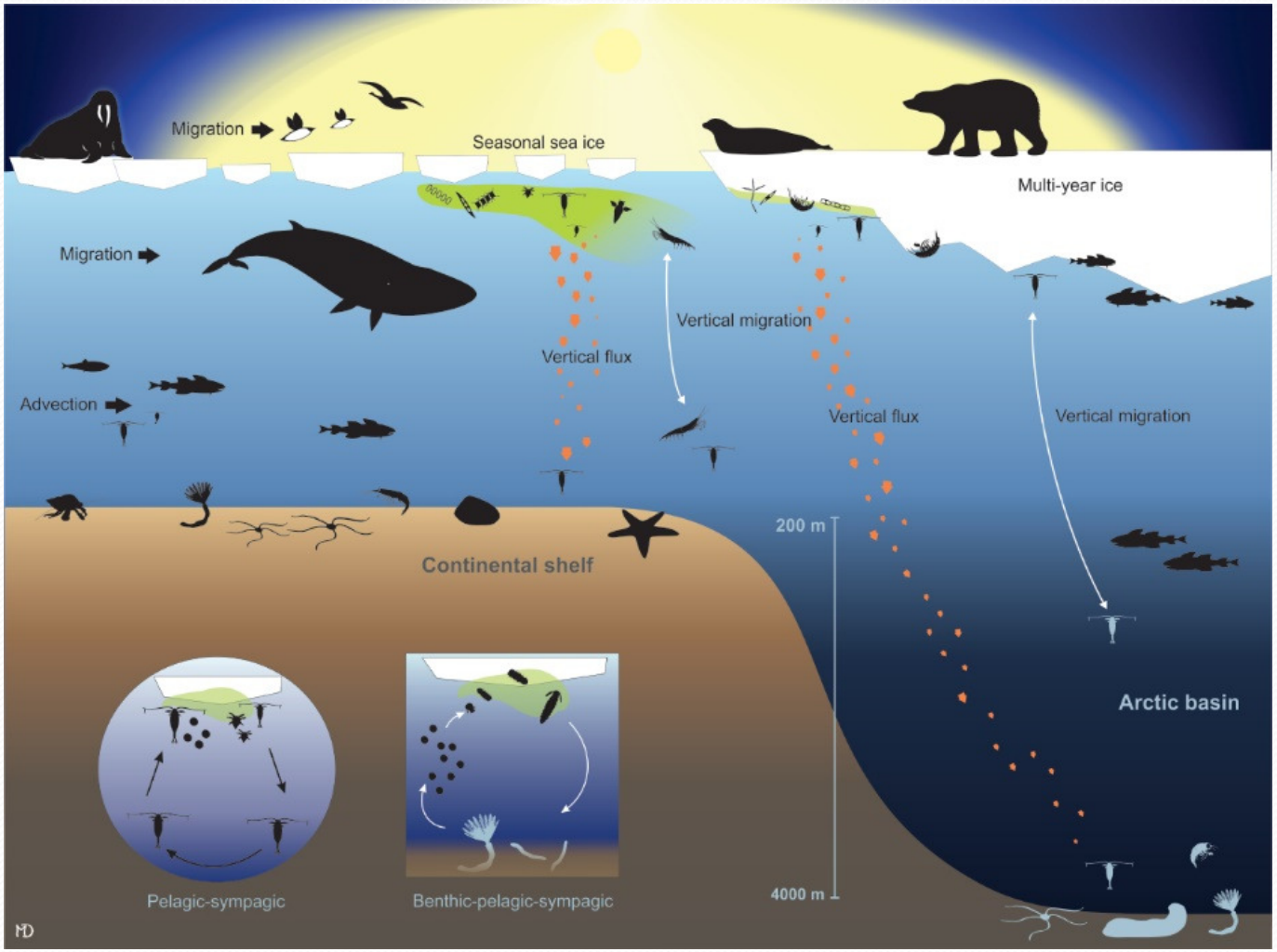


Figure 21 The assemblages of *Melosira arctica* on the lower surface of the Arctic sea ice (NP-22, July, 1980; 81° N, 138° E; photo V. Grichenko).



Boetius *et al. Science* (2013)

Ocean depth matters

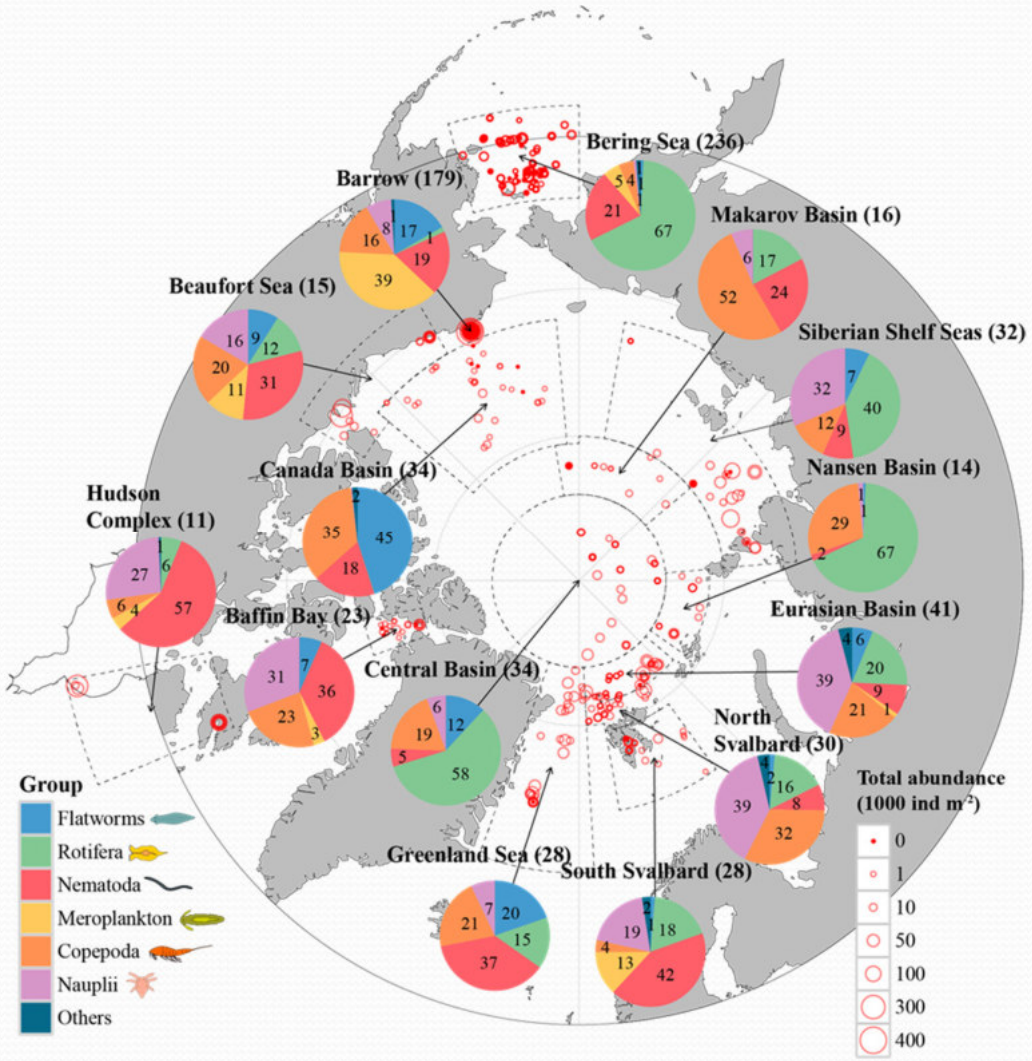


Source: von Quillfeldt et al. 2018

Sea ice meiofauna –

multicellular organism in the ice

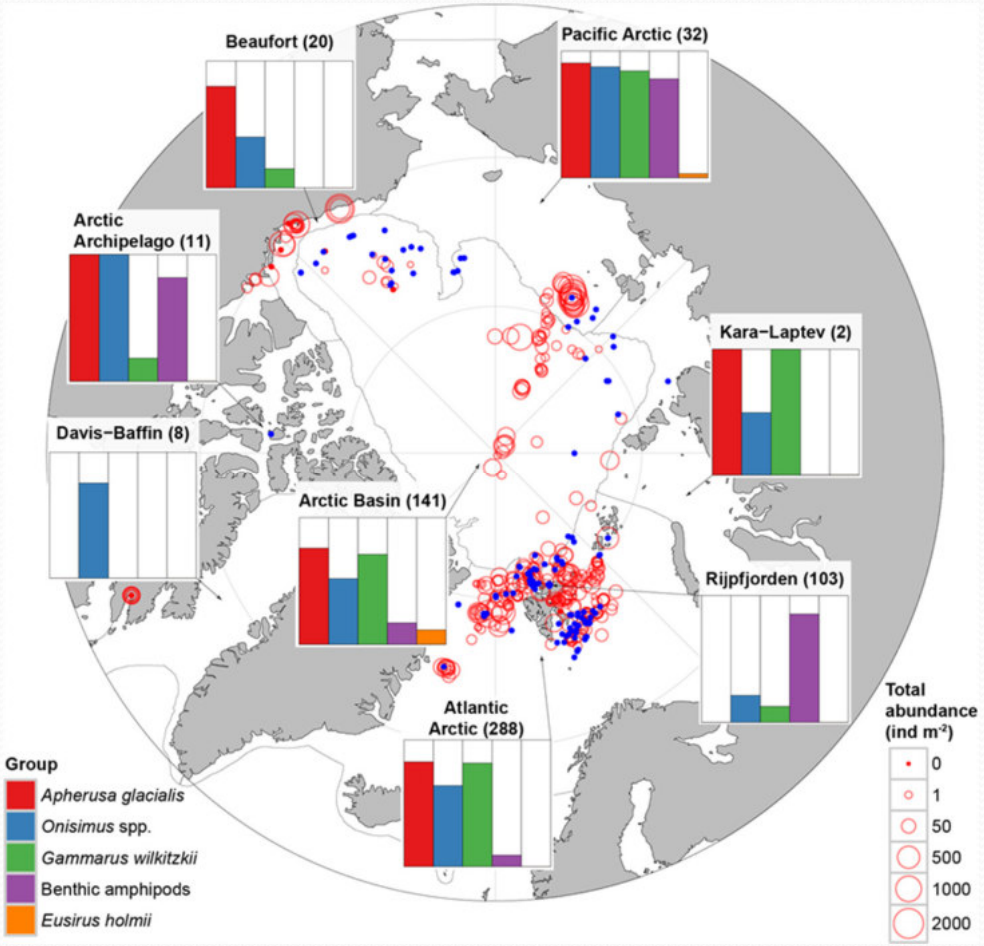
- Many of the same species circumpolar, but variable relative dominance.
- Higher diversity near land than further offshore.
- The relationship pelagic/benthic species increases with distance from land.
- Difficult to distinguish between geographically differences and seasonal variations.
- Few studies/usually in spring.
- A few species may be endemic to sea ice.



Source: SAMBR (2017)

Macrofauna, e.g. ice associated amphipodes

- *Apherusa glacialis* (small), the most common species circumpolar, but contributes little to total biomass.
- *Gammarus wilkitzkii* (large) dominates the biomass.
- *G. wilkitzkii* is typical for multi-year ice with complex structure, but may be common in landfast ice and annual ice.
- Benthic amphipods dominate in shallow areas, but may be transported to deeper areas.



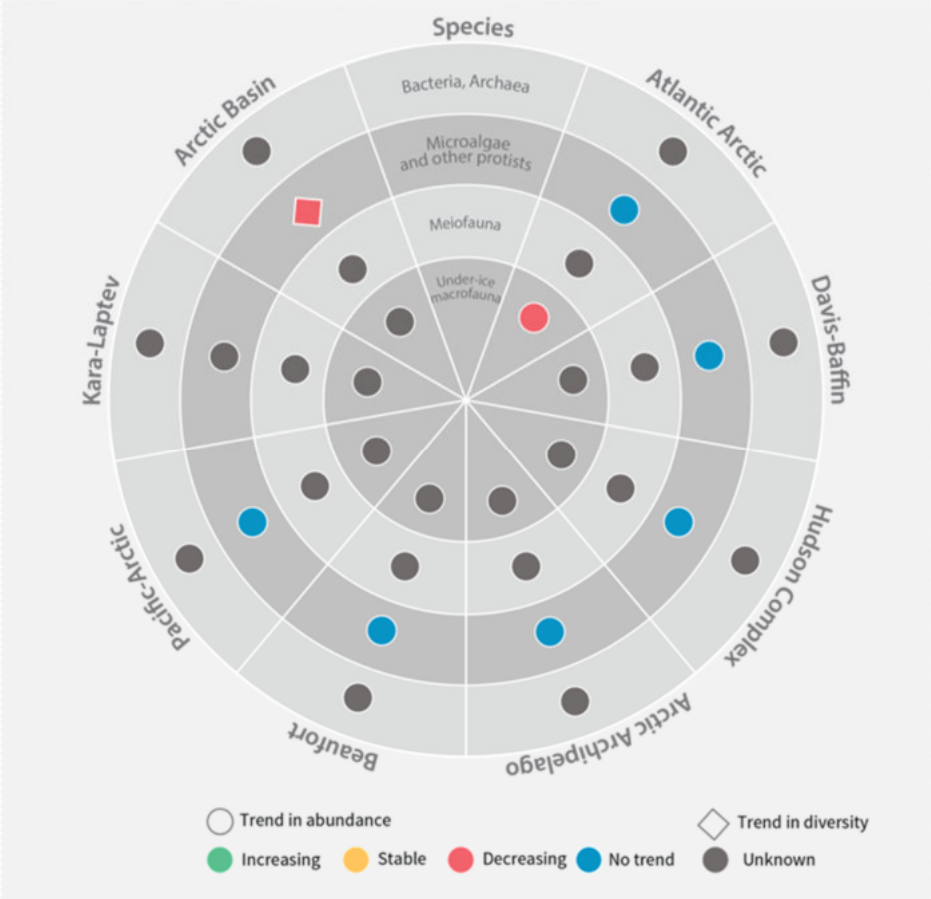
Source: SAMBR (2017)

A future of algal lumps?

Seasonal and interannual patterns

Assmy *et al.* (2013)

Trends in sea ice biota across Arctic marine areas



Baseline data are generally **lacking**, and it is challenging to **distinguish** between natural variations and changes in assemblages due to anthropogenic modification.

The high variability in for example the number of single-celled algae across the Arctic can be related to **sampling effort** in time and space, rather than actual differences.

Source: SAMBR (2017)

Important drivers

- ***Light*** conditions under the ice are modulated by day length (i.e., seasonally) as well as by snow depth, ice thickness and particle content in the ice.
- ***Ice properties, such as thickness, structure, drift, age and stage of freezing/melting,*** largely influence the seasonal occurrence of sea ice biota.
- ***Temperature, salinity and inhabitable space within sea ice*** are closely related.
- ***Water depth and distance from land*** affect the community types recorded in sea ice.
- ***Nutrient concentrations*** available to sea ice biota are also an important factor, primarily a function of: (1) nutrient concentrations in the ice and underlying water masses after the winter; (2) nutrients supplied by advection; and (3) biological uptake and remineralization processes.

Several of the above environmental variables are currently changing in the Arctic.

Direct or indirect impact on diversity, biomass and processes.

Climate change: different types of communities

Infiltration community

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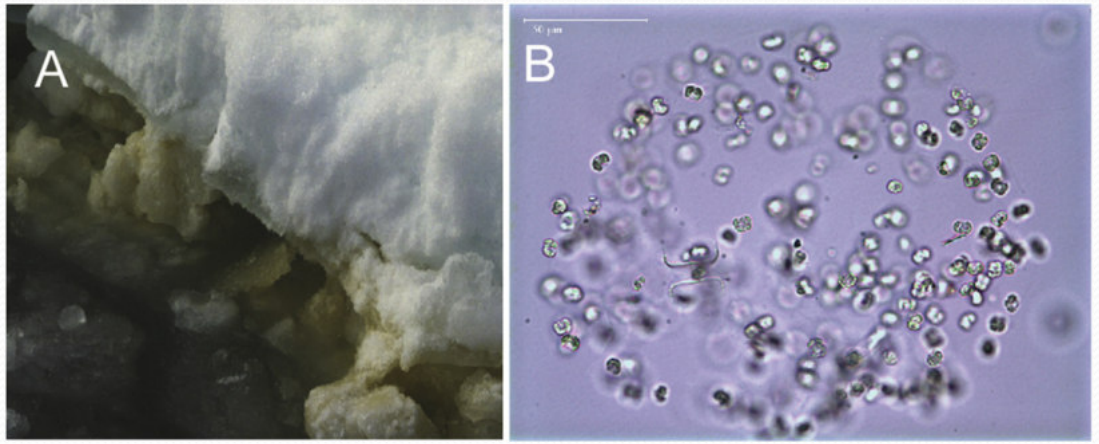

Sub-ice community

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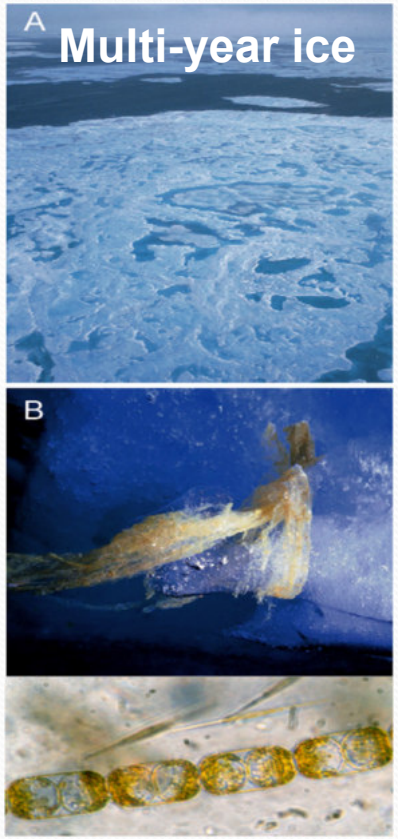
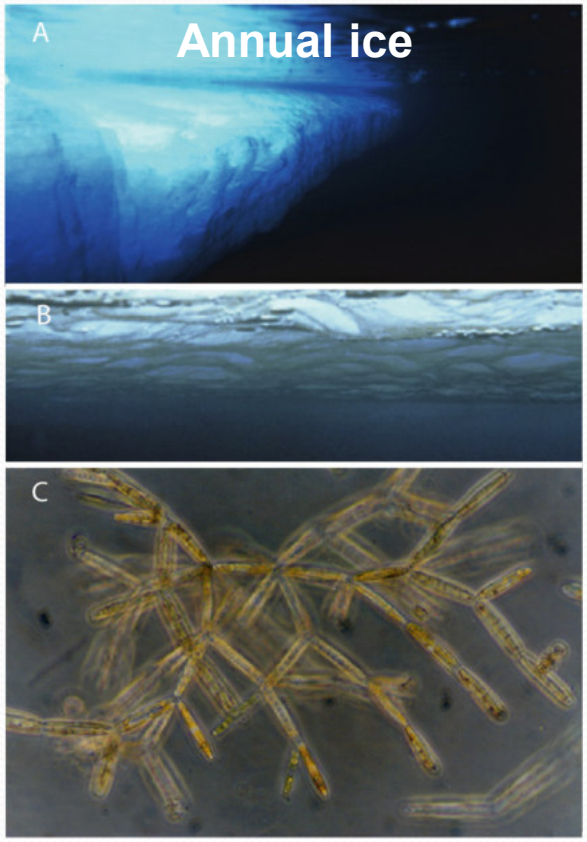
Photo: E.N. Hegseth, E. Leu, B. Gulliksen, C.H. von Quillfeldt

Climate change: different species composition



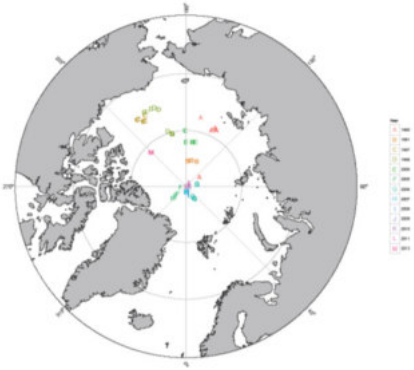
Melosira arctica



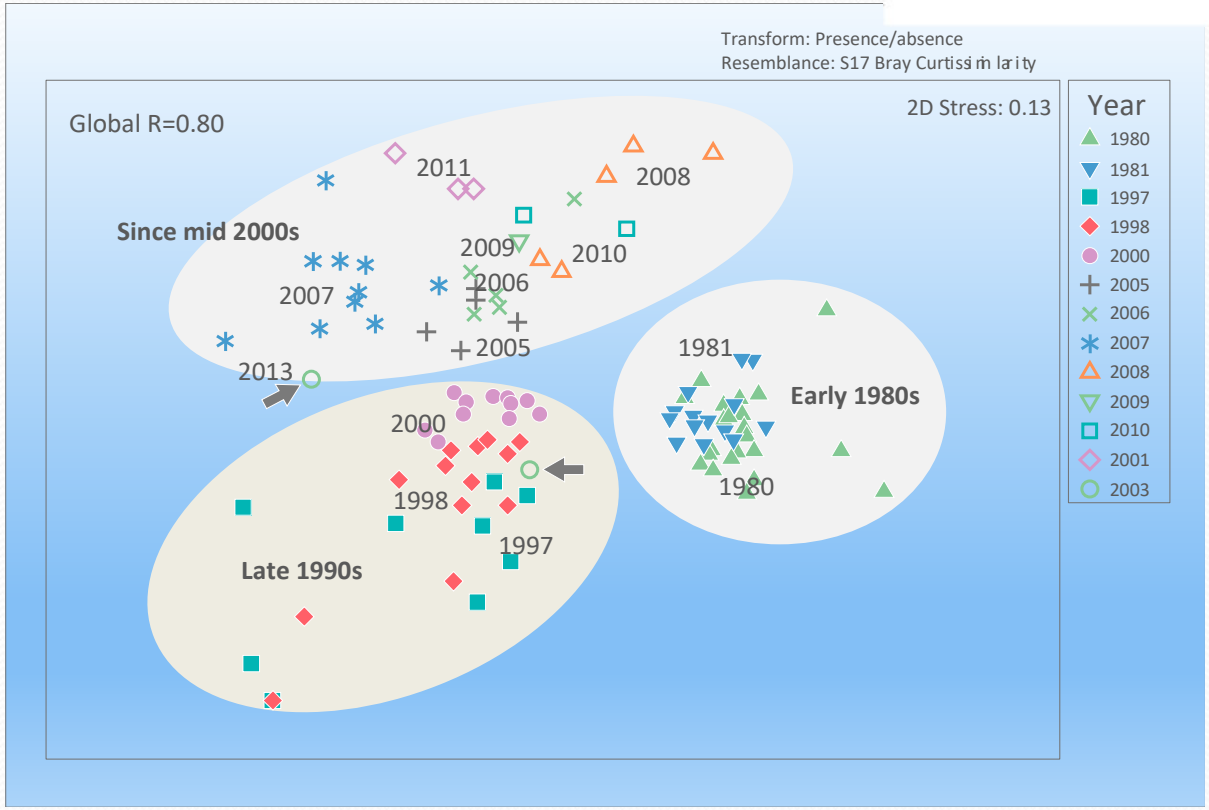
Nitzschia frigida

Photos: G. Johnsen, E.N. Hegseth, B. Gulliksen

Ice algal community changes in the central Arctic Basin?



- A major **decrease** from 50-70 species in 1980-2006 to <30 in recent years.
- Community structure seems to have **shifted**
  - From dominance of pennate diatoms to increased occurrence of dinoflagellates
- For decades, the dominant multi-year ice in the central Arctic Ocean was a relatively stable ecological system with a rather consistent species composition of flora and fauna.
- **Possible introduced biases** due to variations in ice types, ice thickness, sampling date, region and number of ice cores collected.



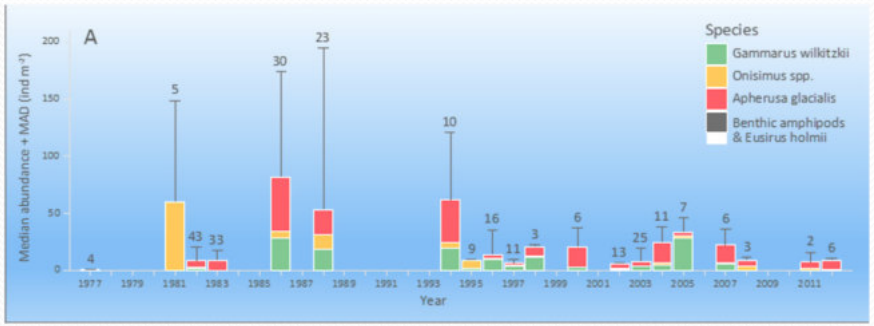
Source: SAMBR (2017)

Multi-decadal time series of ice amphipods from 1977-2012 in the Svalbard area

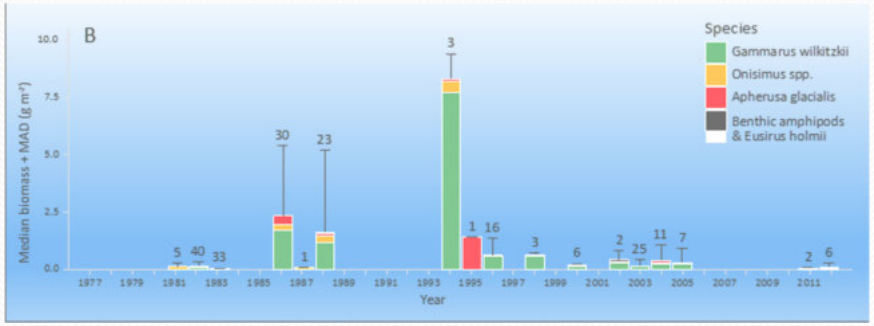
- With decreasing extent of multi-year sea ice, abundance and biomass of ice amphipods have **declined** in the Eurasian Arctic.
- Some species may survive on the sea floor or in the water column.
- Annual ice has to be colonized every year.
- A gradual change of the sea ice ecosystems is expected.

Courtesy; H. Hop, NPI

Abundance (individuals m^{-2})



Biomass (g wet mass m^{-2})

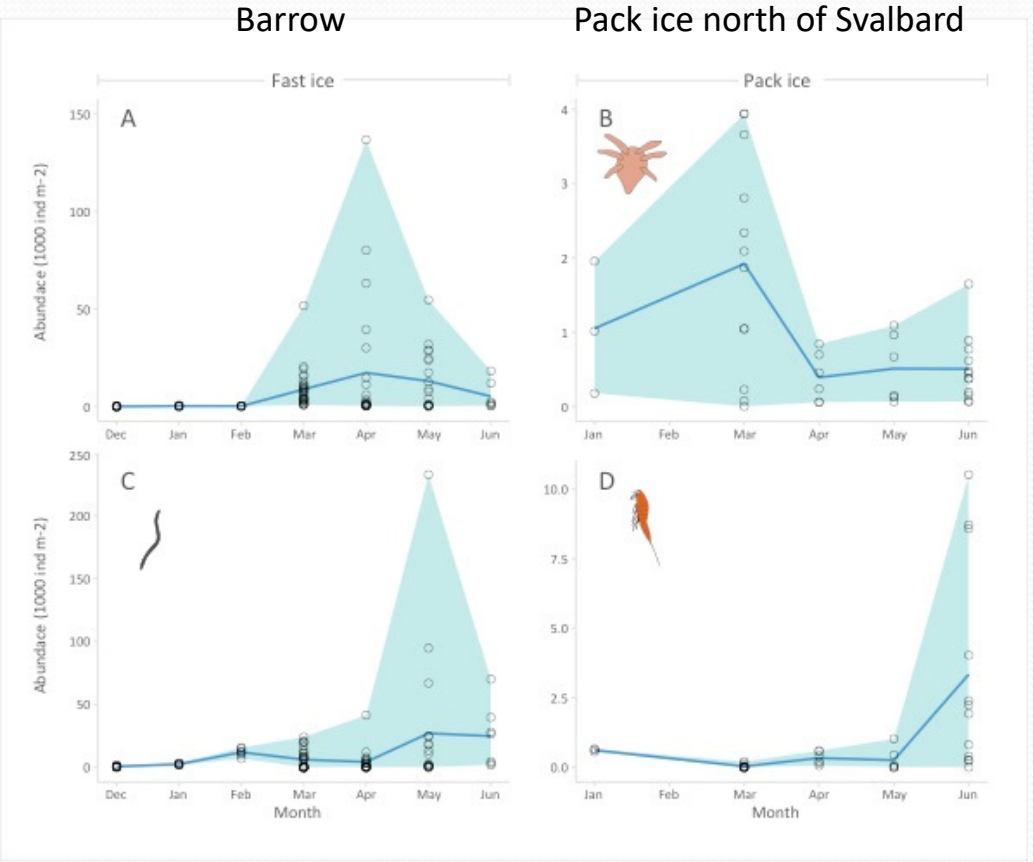


Modified from Hop *et al.* (2013)

Source: SAMBR (2017)

Seasonal abundance of meiofauna at landfast sea ice and pack ice

- **Total abundance** of meiofauna can be higher close to land compared to offshore locations.
- In offshore drift ice, the **proportion of species of pelagic origin** within the ice meiofauna is higher than in shallow areas where adults of taxa of benthic origin are also found.
- Different groups reach their **maximum abundance** at different times.
  - Planktonic larvae early in the spring, while nematodes that are living in the sea ice year round later.



Source: SAMBR (2017)

Challenges

Photo: C.H. von Quillfeldt

Challenges

- Patchy distribution
- Sampling
  - When
    - Different times of the year
  - Where
    - Distance from land and depth, landfast ice/drifting ice, annual ice/multi-year ice
  - How
    - Cores, suction pumps, net, preservation
- Analyzing
  - What
    - Whole/parts of the core, all/some organism groups
  - How
    - Molecular techniques, EM, LM, species/genus/family/groups etc.

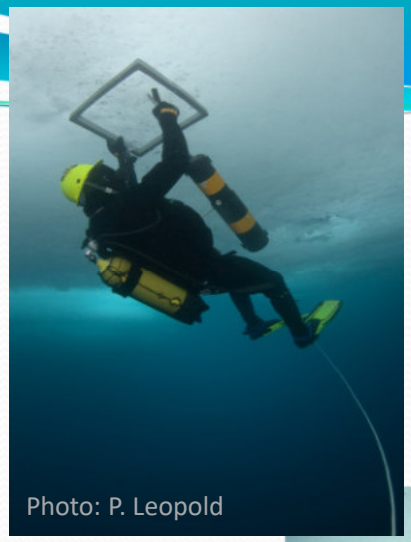


Photo: P. Leopold

Photos: C.H. von Quillfeldt

Conclusions and advice for monitoring

Photo: E.N. Hegseth

Conclusions: sea ice biota

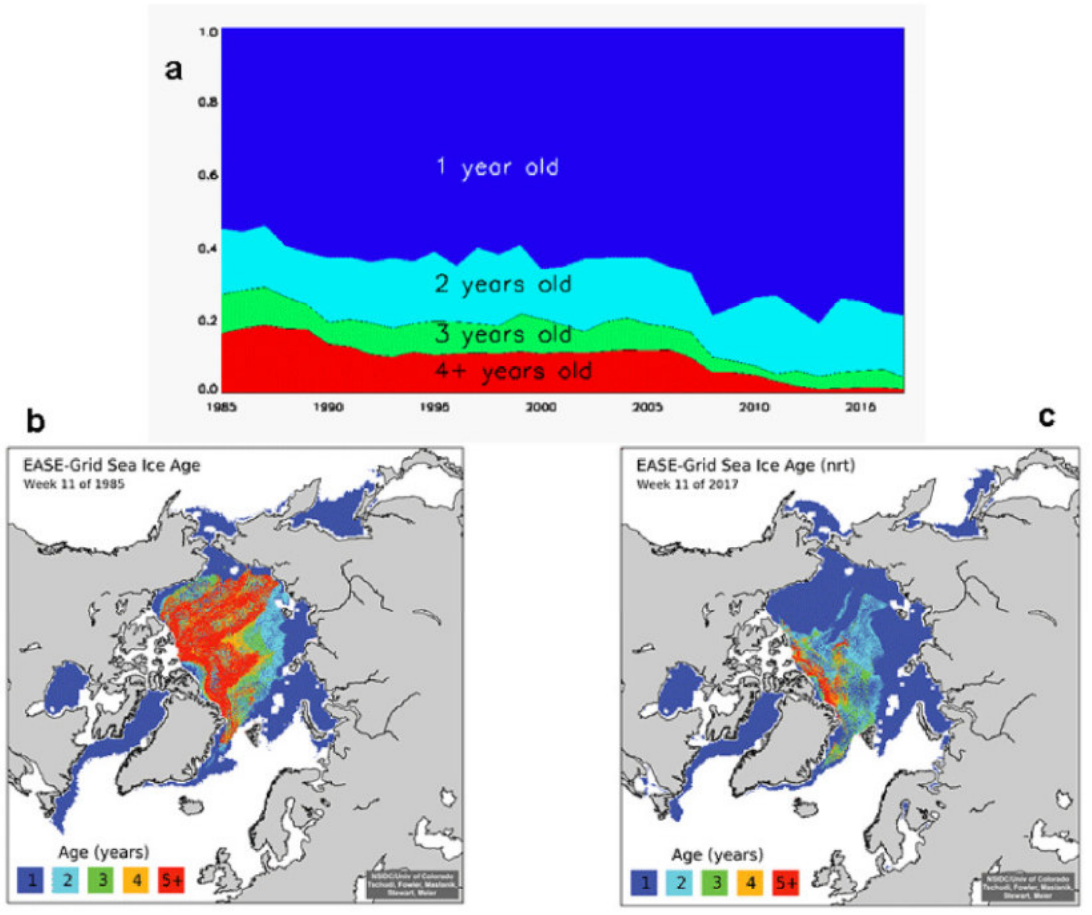
- Sea ice is a species-rich habitat.
- Many sea ice biota taxa are widespread across the Arctic ice cover.
- Sea ice houses some species endemic to the Arctic and species endemic to sea ice. Other taxa occur more widespread.
- Sea ice algal community structure has possibly changed in the central Arctic between the 1980s and 2010s. Simultaneously, this shift occurred when ice conditions changed, i.e. both multi-year sea ice and ice extent declined. Difference in sampling effort is further considered.
- Ice amphipod abundance and biomass have declined in the Svalbard area since the 1980s. Amphipods appear to have been more abundant in the late 1970s to mid-1990s than afterwards.
- The occurrence and distribution of ice biota is highly variable in time and space related to a suite of environmental conditions. Consequently, monitoring the biota in this variable habitat is challenging.

Added snapshots

- **Multiyear sea ice is disappearing and will be replaced by first-year sea ice**, which will cause shifts in ice algal communities with cascading effects on the ice-associated ecosystem.

- **Seasonal duration of first-year sea ice is expected to become shorter, with more snow on the ice**, which may decrease the growth season for ice algae, with unknown consequences for biodiversity.

- Current **declines in sea ice extent** and **thickness** cause reductions in ice-associated flora and fauna in the Arctic.



Source: D. Perovich et al. (2017) Arctic Report Card

Advice for monitoring: sea ice biota

- Establish an **annual monitoring programme from landfast sea ice at selected Arctic field stations** in Canada (Resolute, Cambridge Bay), Greenland (Kobbefjord, Disko Bay, Zackenberg), Norway (Kongsfjorden, Billefjorden, Van Mijenfjorden), and the United States (Barrow).

- Establish a **standardized monitoring protocol**, including sample collection, preservation, microscopic and genetic analyses, taxonomic harmonization, and data sharing.

- Establish **opportunistic monitoring from drifting sea ice during cruises of opportunity**.

- **Collect macrofauna samples in drifting sea ice** via ship-based activities, scuba diving, use of electrical suction pumps, under-ice trawl nets, and remotely operated vehicles.


Thanks for your attention!
Courtesy: P. Assmy, NPI