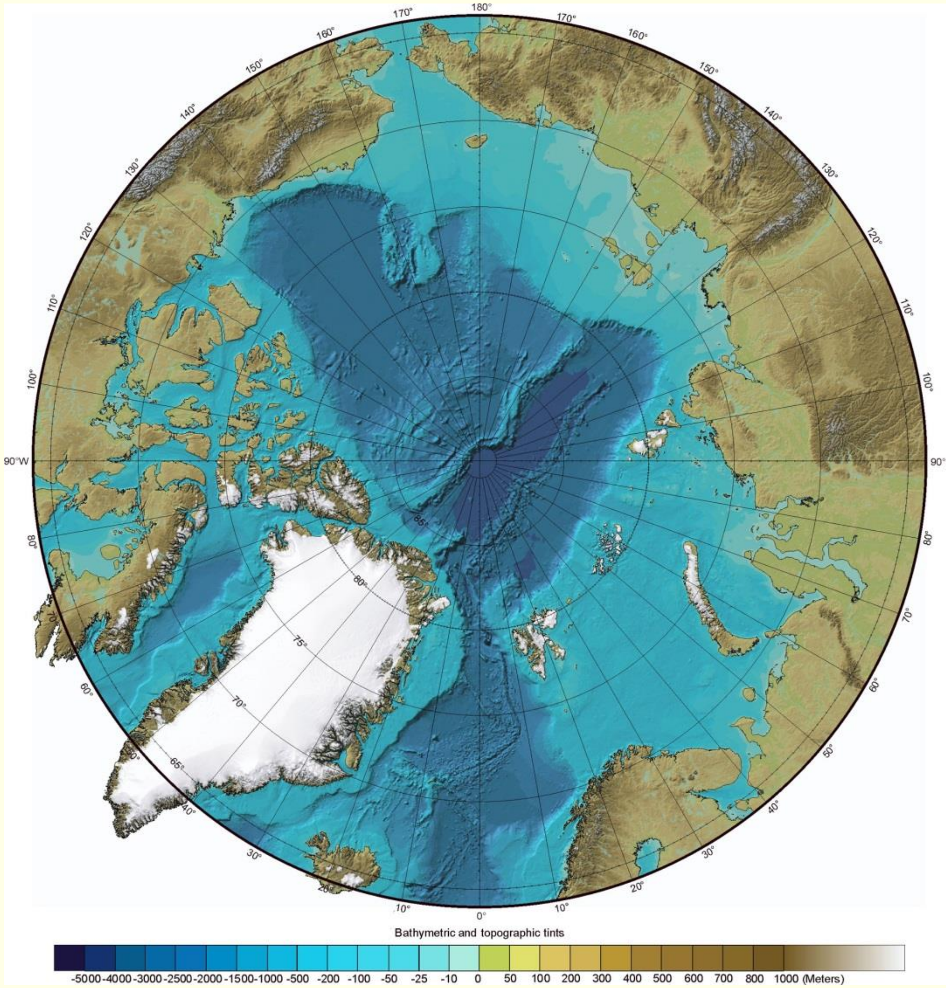

Zooplankton of the Arctic Ocean: patterns of diversity and productivity

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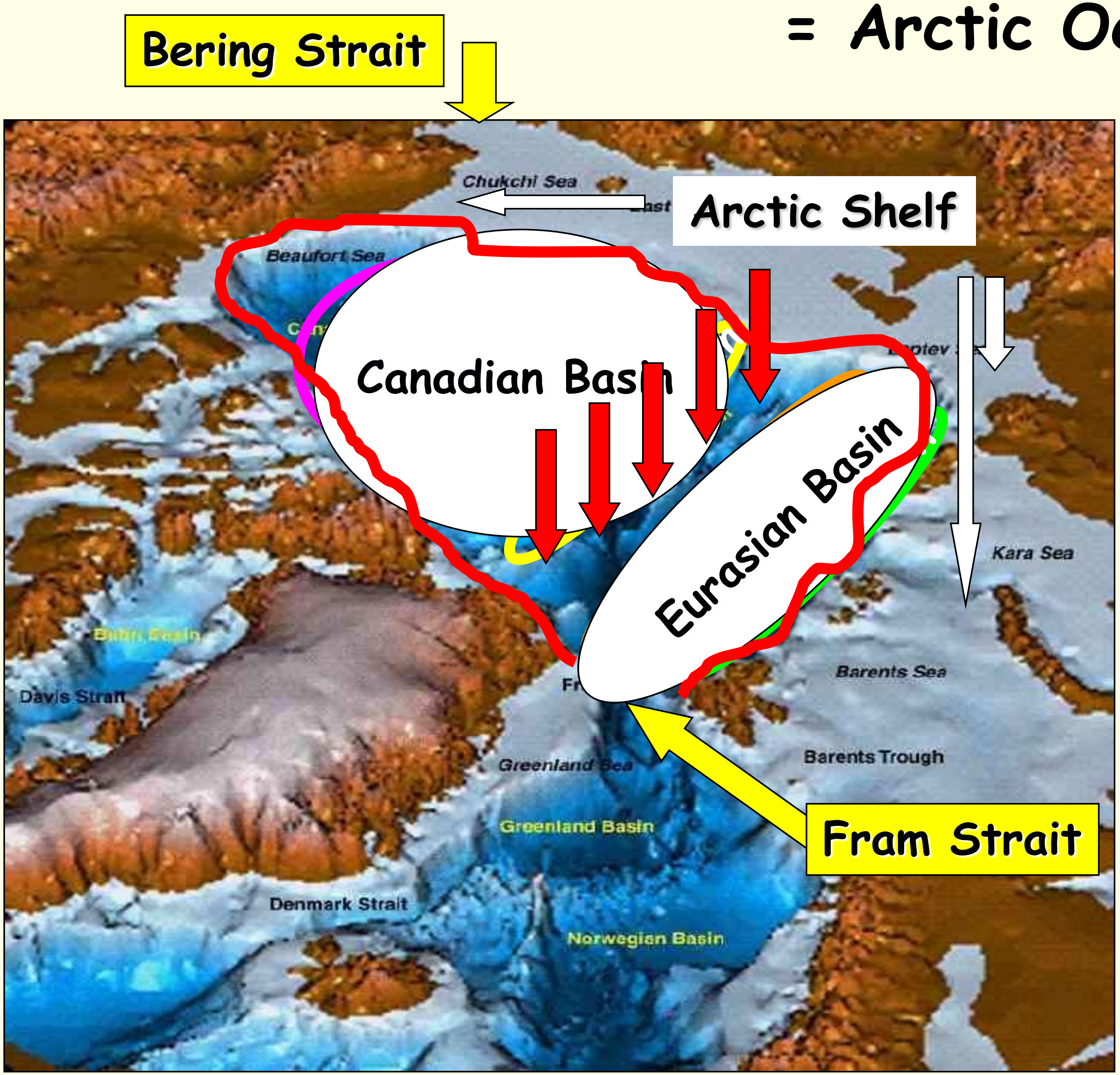
ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

UNIVERSITY OF ALASKA
FAIRBANKS

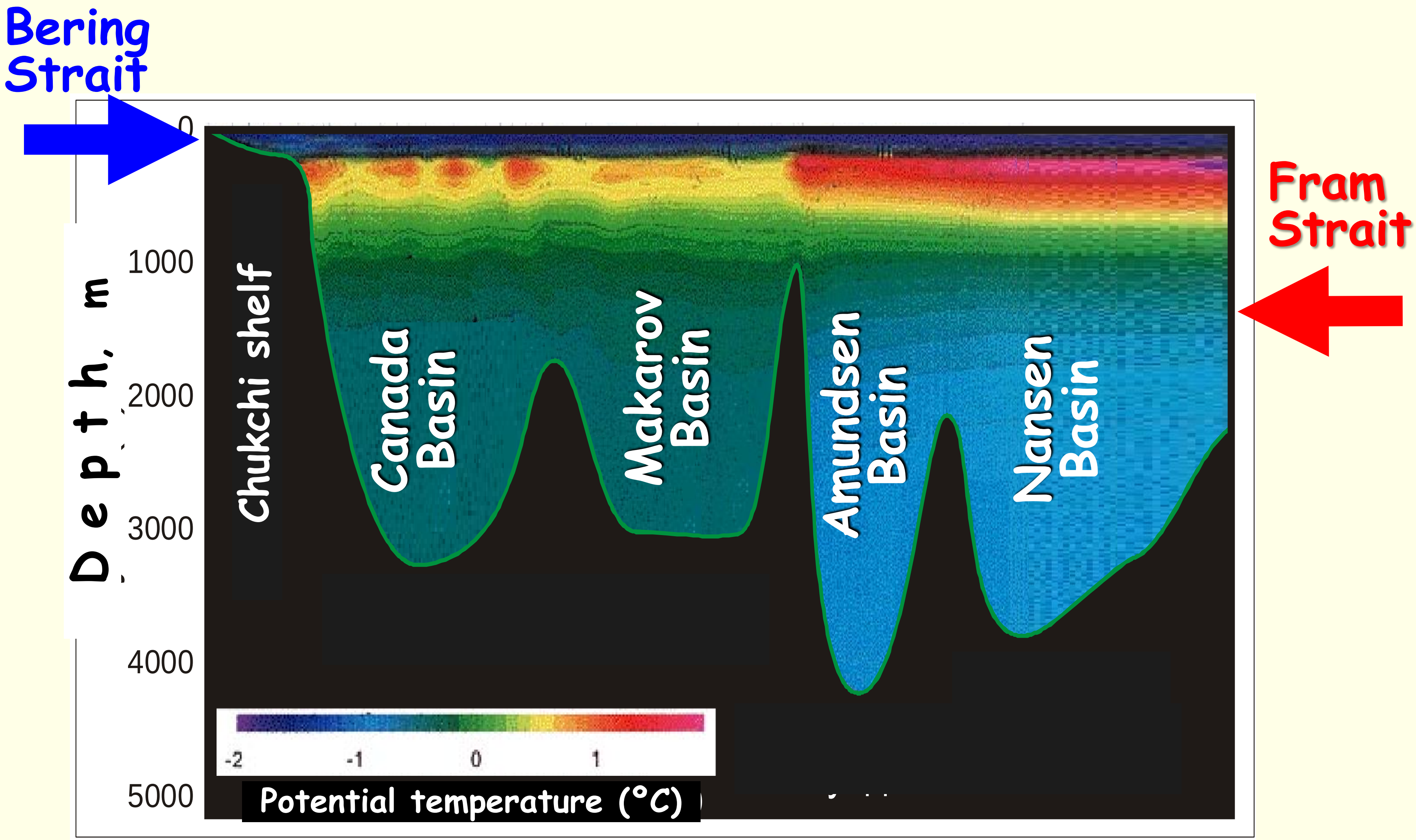
The Arctic Mediterranean Sea = Arctic Ocean



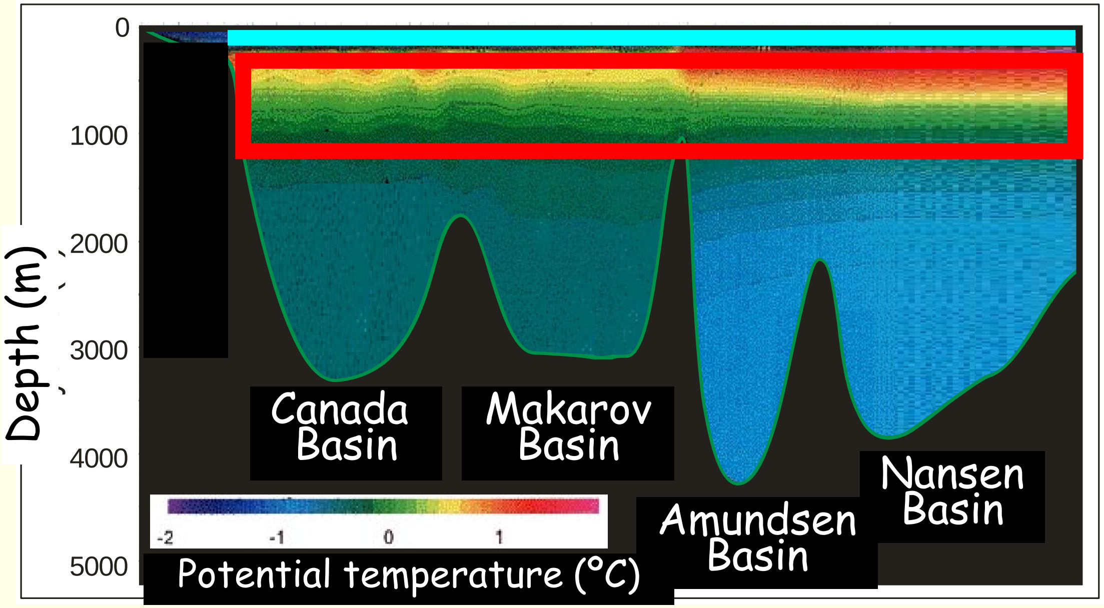
Water exchange with the North Pacific via shallow (70m deep) Bering Strait

Water exchange with the North Atlantic via deep (2000m) Fram Strait

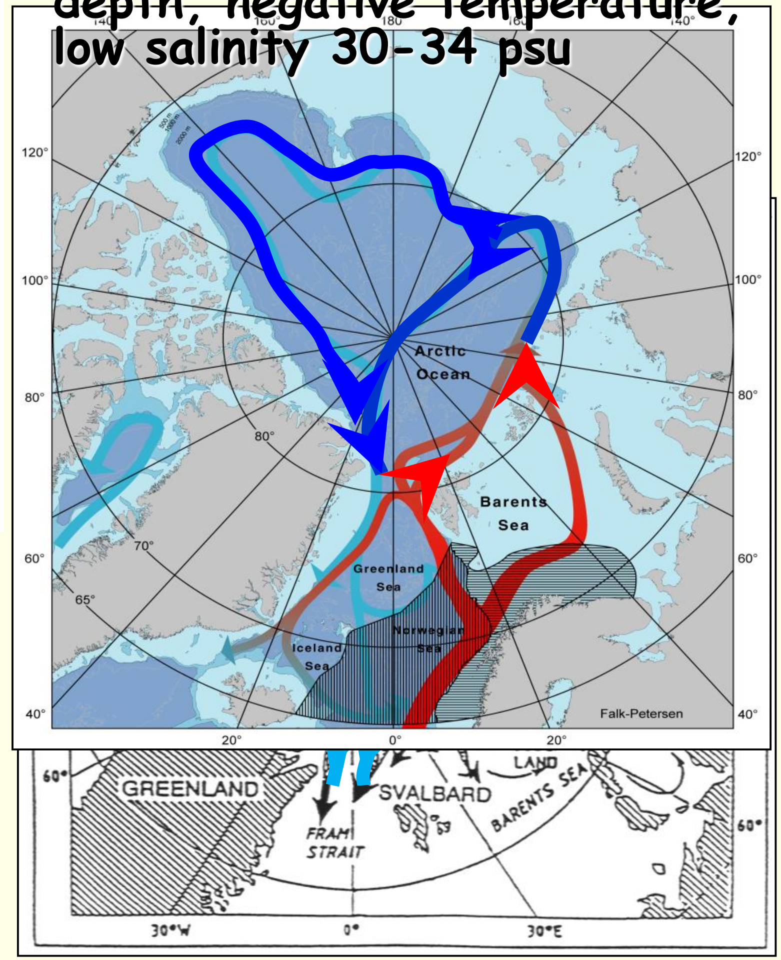
Section through the Arctic Ocean



Water masses and circulation



Polar surface water: 0-200 m depth, negative temperature, low salinity 30-34 psu



Atlantic water:
200-900 m depth, positive temperature, salinity 34-34.9

Arctic Bottom water:
below 1000 m, negative temperature, higher salinity 34.93-34.99

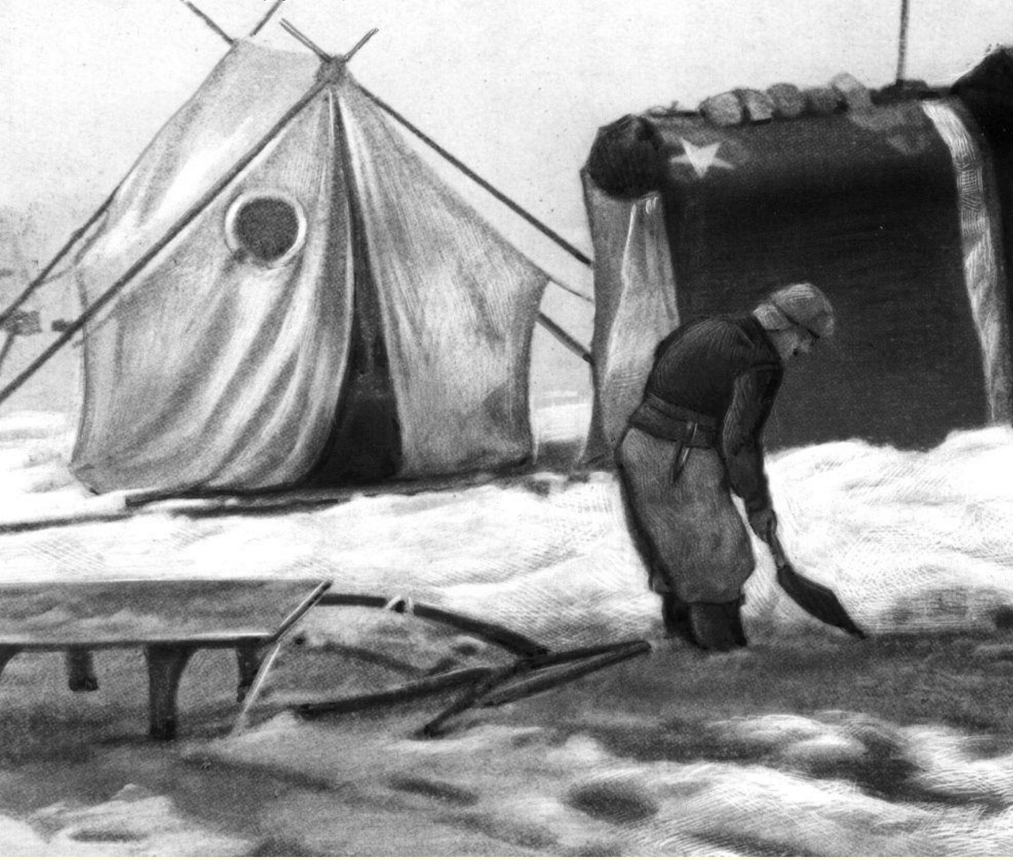
First zooplankton collections were obtained during the “Fram” drift in 1893-1896

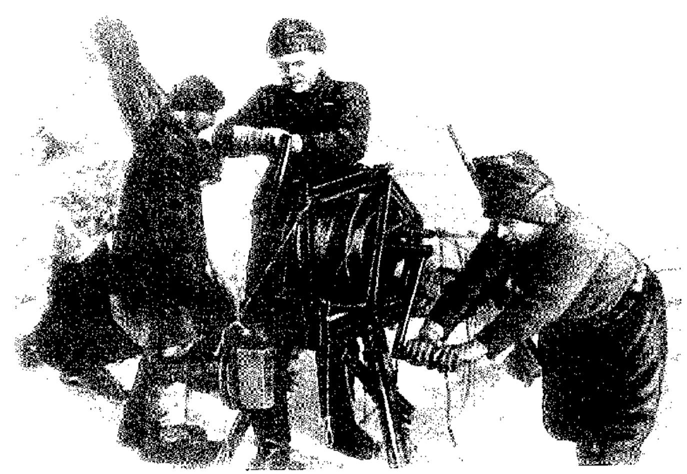
G.O. Sars, 1900. The Norwegian North Pole Expedition 1893-1896. Scientific results. F. Nansen (ed.). V.1, No. 5. 141 pp.

The first list of AO crustacean zooplankton with description of new species

Russian drifting ice station "North Pole" (NP1) 1937-1938

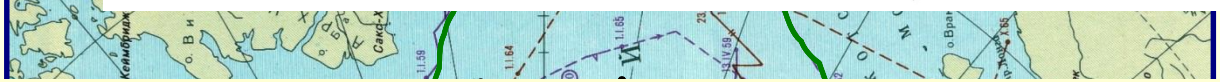
9 months of drift,
zooplankton collected at 14 locations down to 1500m using a hand winch





Vardagens arbete.

Most drifting ice stations started their drift **in the Canadian Basin**, where the strongest and thickest ice platforms were chosen to build the ice camps, and they drifted mostly **within this basin**



Period of sporadic semi-quantitative sampling,

Different sampling methods and gears,

Different sampling layers (predominantly surface layers 0-100, 0-500 m),

Difficult to draw any inter-regional and quantitative comparison…

New Age since 1980-es:
«Breaking the ice…»

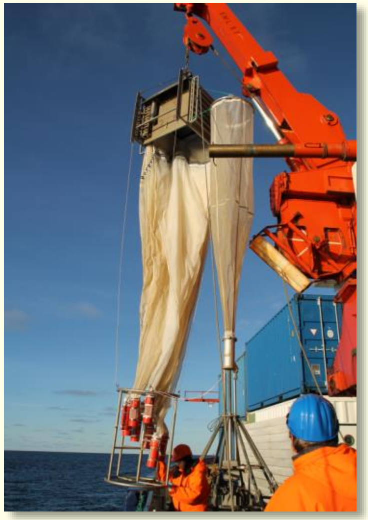
Icebreaker “Polarstern”, Germany

“Academician Fedorov”, Russia

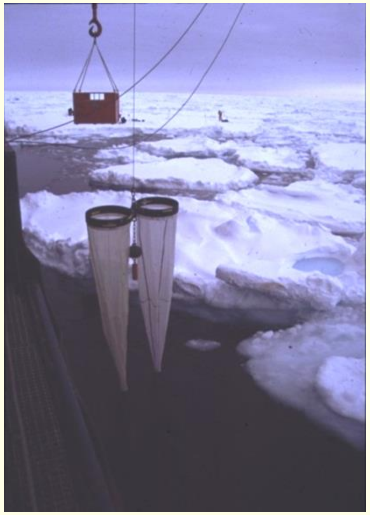
USCGC “Healy”, USA

Modern gears and standard sampling methods

Multinet:
Quantitative vertical sampling (5 to 9 layers)



Bongo net:
Oblique or vertical sampling

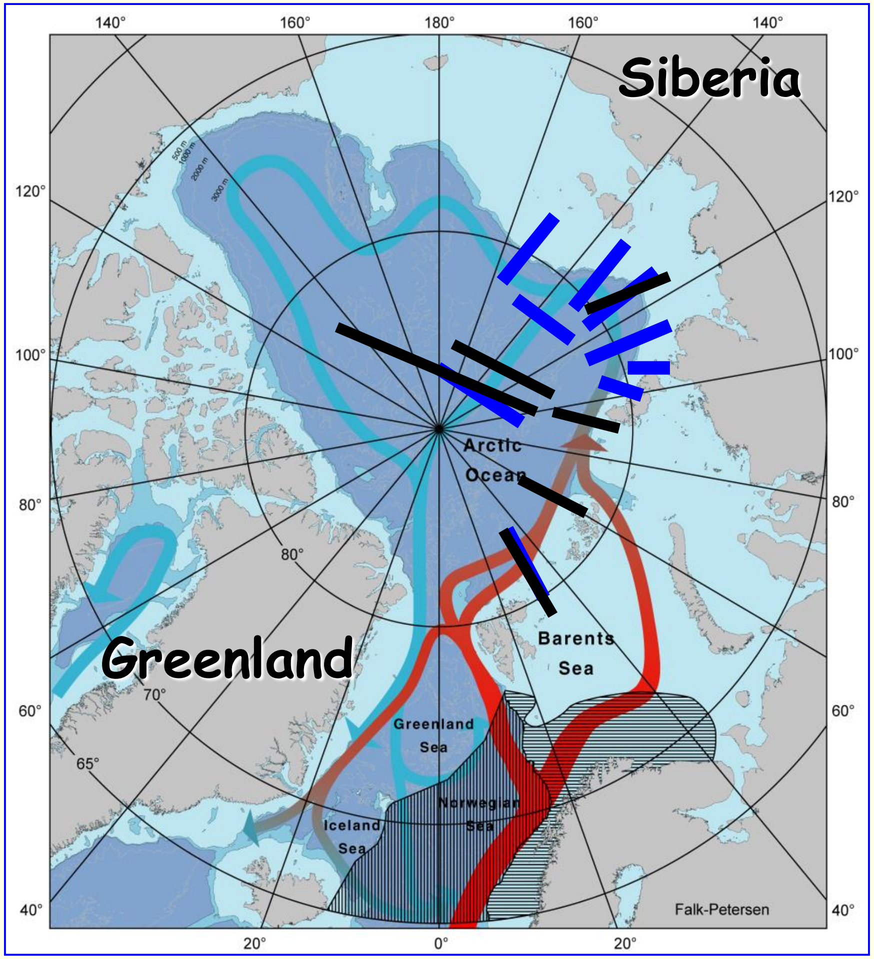


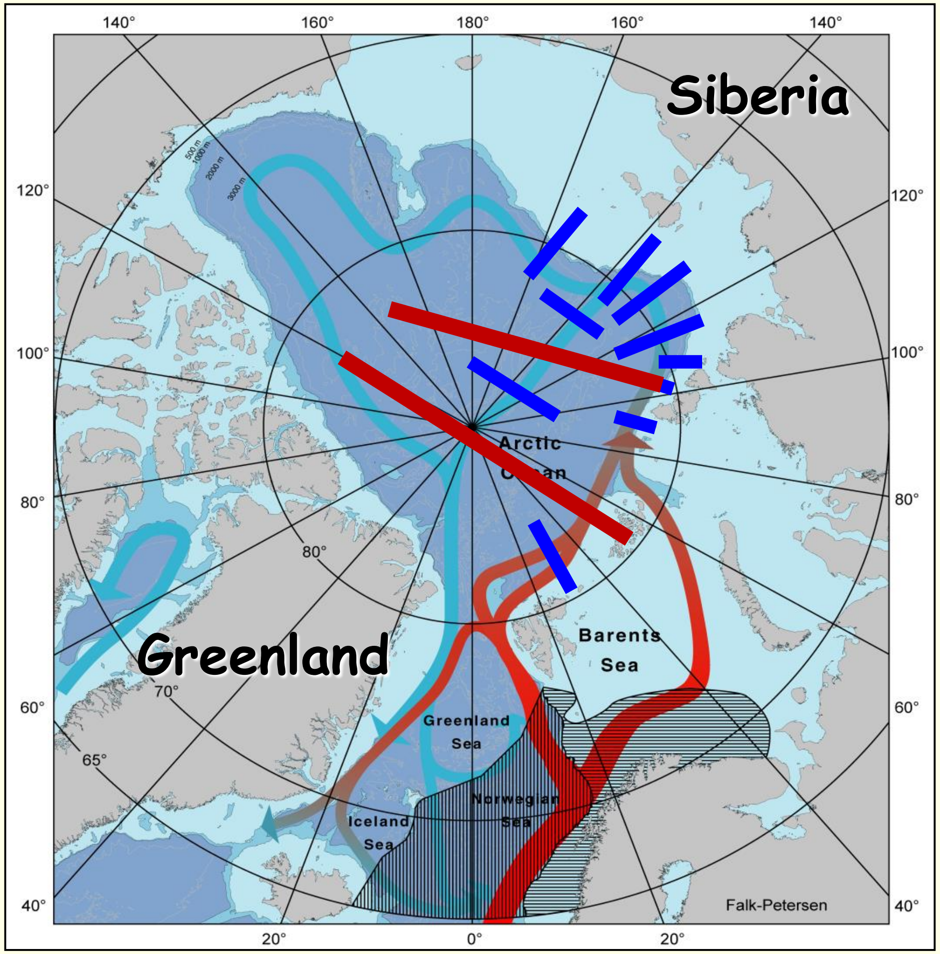
ROV:
In situ observations and collection of fragile organisms

Scuba divers

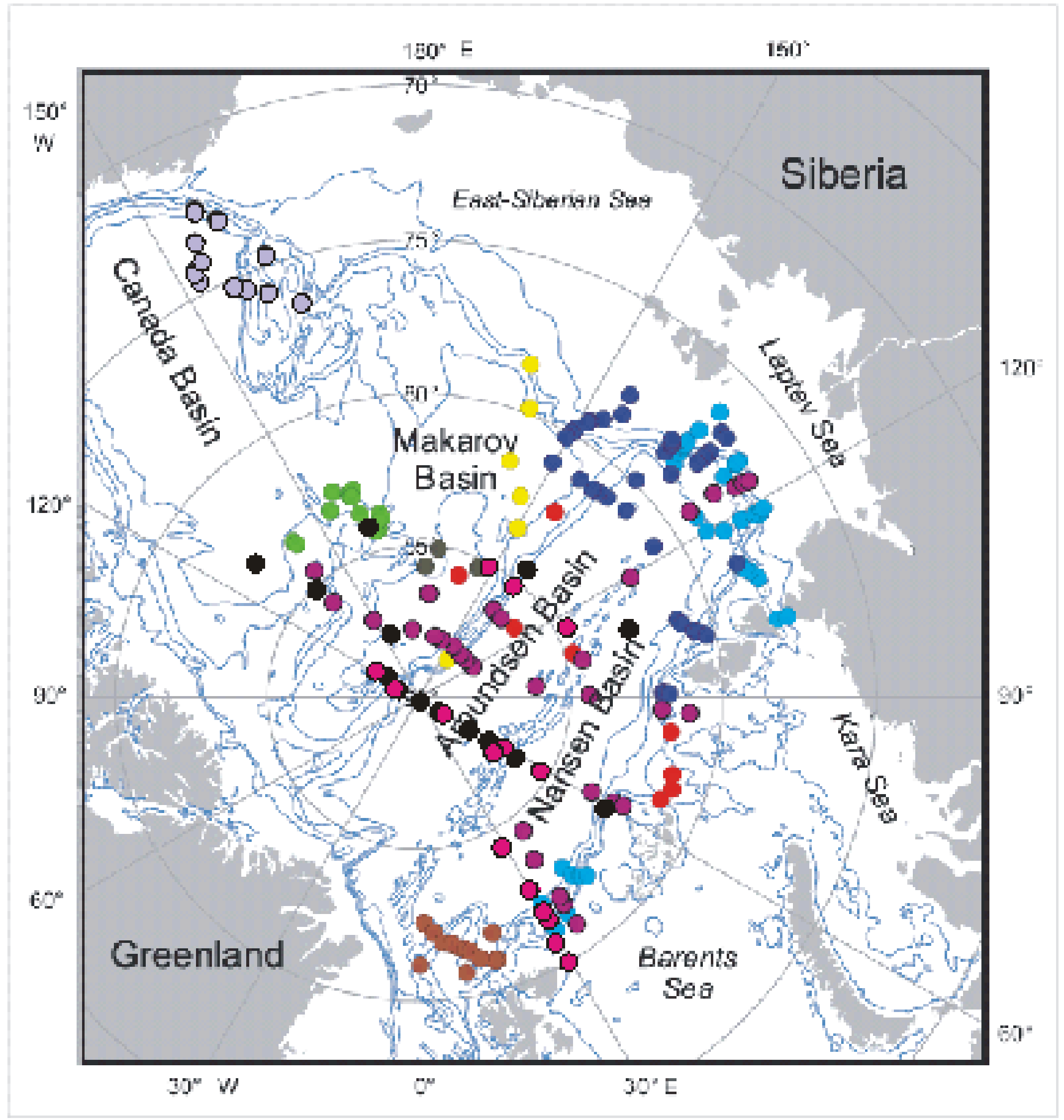
„Polarstern“ zooplankton sampling programs in the central Arctic, 1993-2015

Stations in 1993-1998, 2007, 2011 were located along sections crossing the core of the Atlantic Boundary current





Zooplankton station locations, 1993-2015



Stratified sampling of the water column with MN at 202 locations;

153 sts. at bottom depth >1000 m

Expeditions:

1) RV "Polarstern":
- ARK IX/4, 1993
- ARK XI/1, 1995
- ARK XII, 1996
- ARK XIII, 1997
- ARK XIV, 1998
- ARK XXII/2, 2007
- ARK XXVI/3, 2011
- PS94, 2015

2) USCGC "Healy", 2005

3) "North Pole" stations:
- NP-22: 1975-76
- NP-23: 1976-77

Research objectives:

- **Study of the zooplankton diversity** throughout the **entire depth range** to produce detailed inventory and to document any ongoing changes in the species composition;

- **Biomass and abundance assessment:** how much and where?
- **Study of regional biomass variability:** what factors shape it?
- **Polar zooplankton ecology**:

  - study of life strategies and reproductive biology of epi- and mesopelagic zooplankton to better understand their life traits;

  - study of lipid contebt and starvation potential of lipid accumulating key copepod species;

  - organic carbon content analysis, C/N ratio, stable isotopes ratio, dry mass, and lipid composition in dominant plankton taxa

Species composition and diversity

CENSUS OF MARINE LIFE

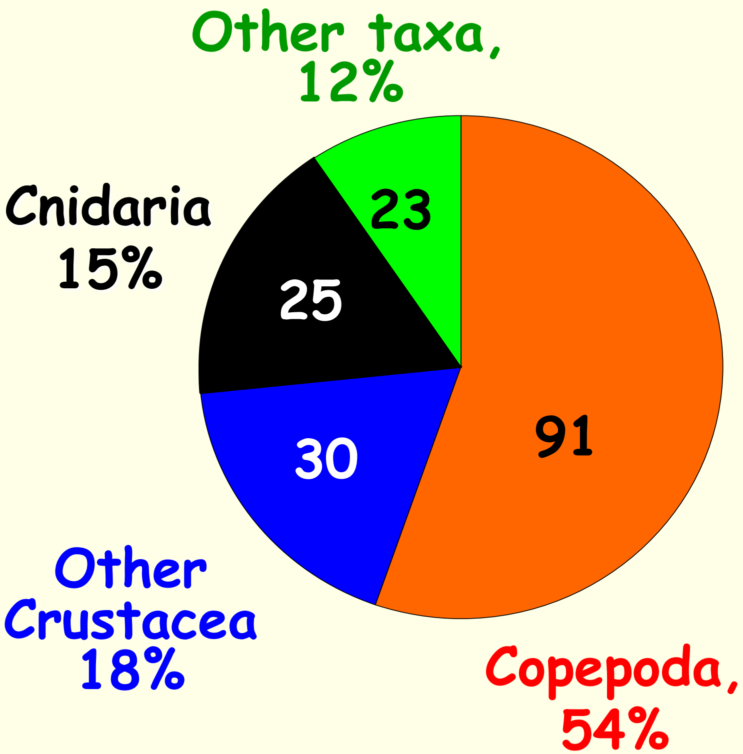
Sub-project of the CoML 'Arctic Ocean Diversity' (ArcOD) program, 2007-2010

- **Detailed inventory of the zooplankton fauna of the deep Arctic Ocean**
- **Comparison of the zooplankton composition in the four major deep basins of the Arctic Ocean separated by underwater ridges (Nansen, Amundsen, Makarov, Canada basins)**
- **Analysis of patterns of zooplankton diversity vs. water depth**

Kosobokova et al., 1998; Kosobokova & Hirche, 2000; Markhaseva & Kosobokova, 1998, 2001; Stepanjants & Kosobokova, 2006; Kosobokova & Hopcroft, 2010, Kosobokova et al., 2011; Andronov & Kosobokova, 2011; Zasko & Kosobokova 2014

Zooplankton diversity and taxonomical composition

A total of 175 metazoan species

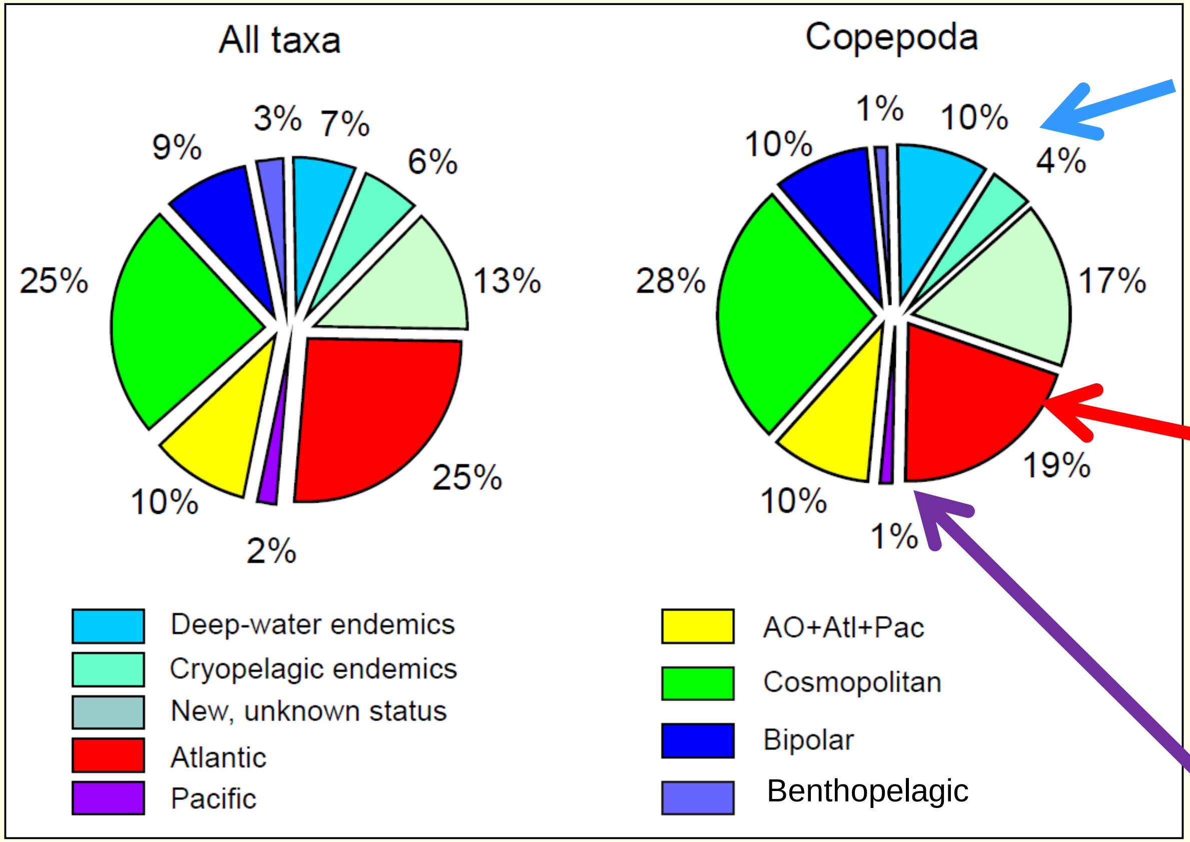


Taxon	No. of species
• Arthropoda (Crustacea):	122
Copepoda	91
Ostracoda	5
Hyperiidea	6
Gammaridea	11
Mysidacea	4
Euphausiacea	4
Decapoda	1
• Cnidaria:	25
Scyphozoa (Scyphomedusae)	3
Hydrozoa (Hydromedusae)	15
Siphonophora	7
• Ctenophora	7
• Gastropoda (Pteropoda)	2
• Annelida (Polychaeta)	5
• Nemertea	1
• Chordata (Larvacea)	4
• Chaetognatha	4

Kosobokova et al. 2011, Kosobokova 2012

Biogeography of AO zooplankton:

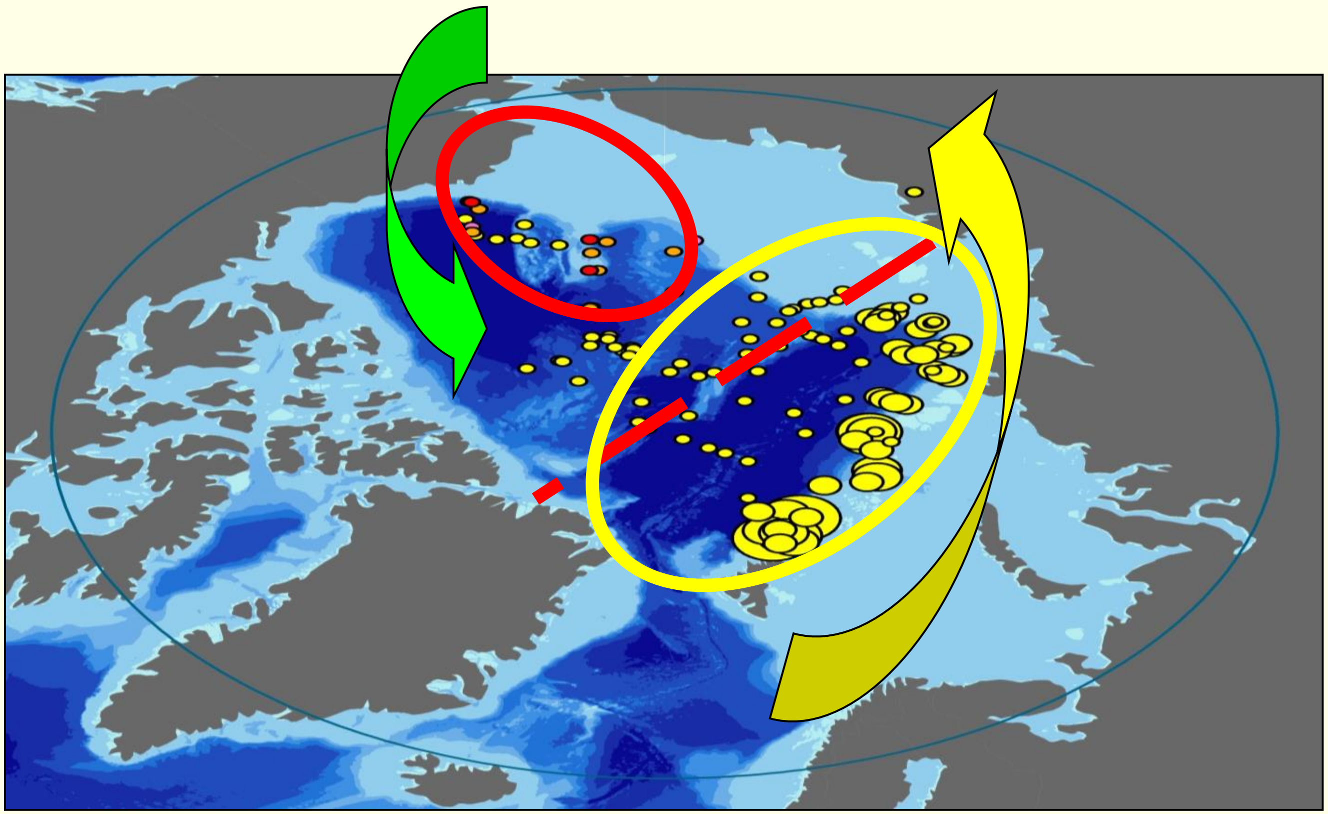
85% resident species (locally reproducing), and 15% expatriates (not reproducing)

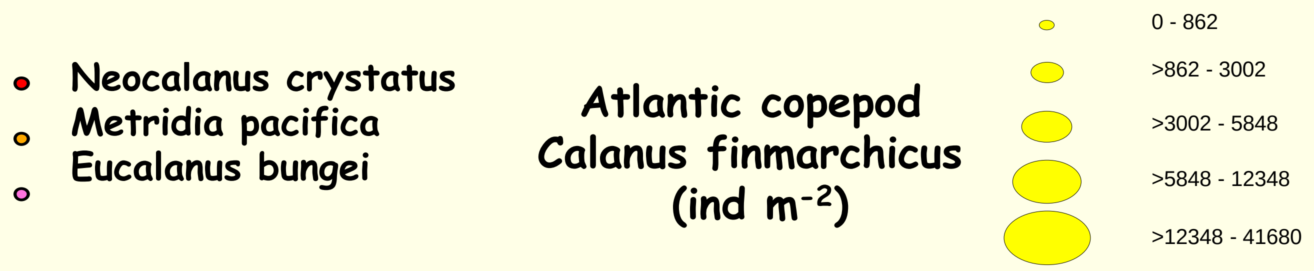


- High rank of endemism due to isolation of the Arctic Ocean deep basin;
- Large portion of species shared with North Atlantic due to permanent advection of fauna with Atlantic water and similar conditions at depths;
- Small portion of species shared with the Pacific due to isolation by the shallow Bering Strait and wide shallow Chukchi Sea shelf

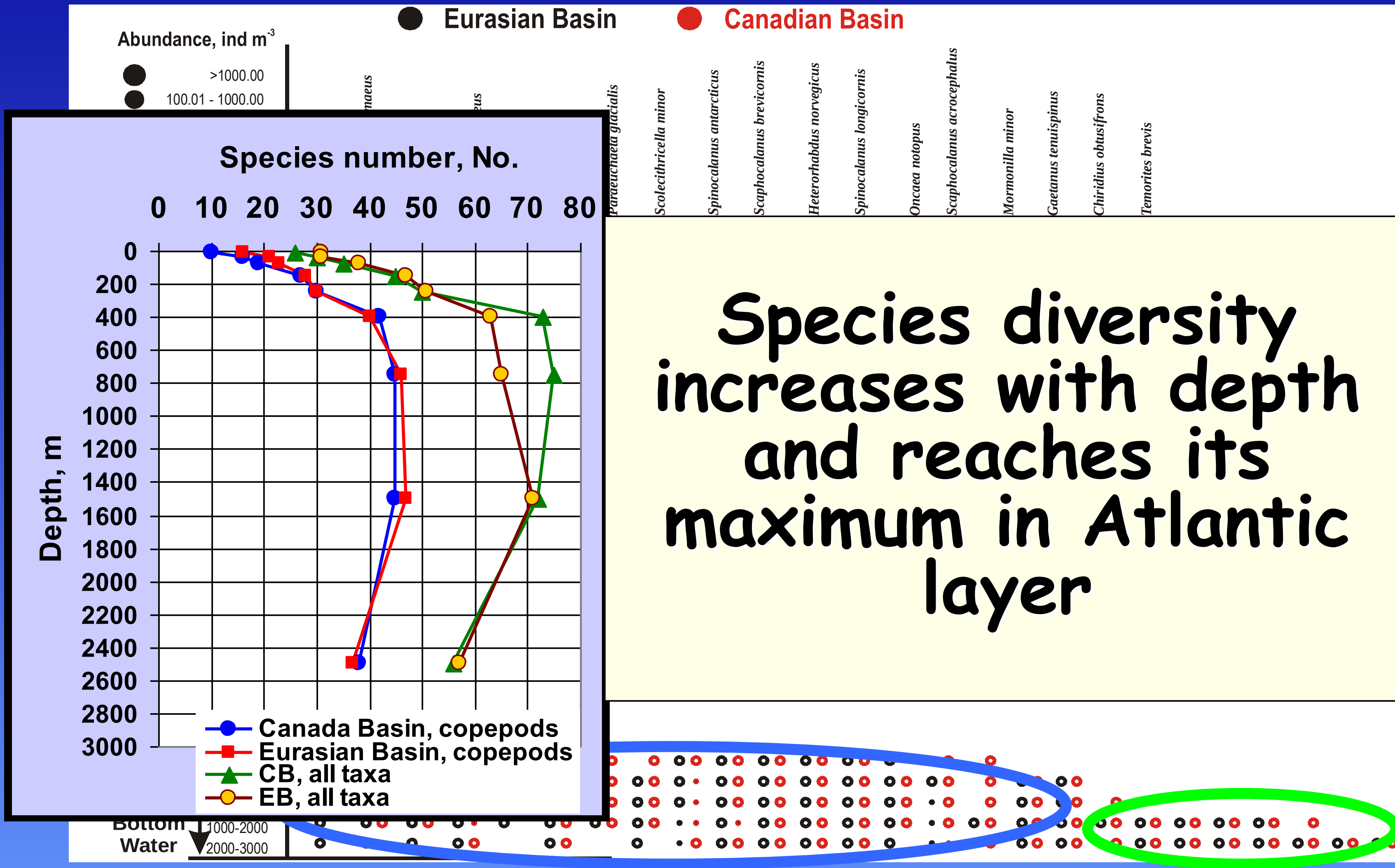
Kosobokova 2012

Oceanic expatriates: Advection and distribution of Atlantic vs. Pacific species



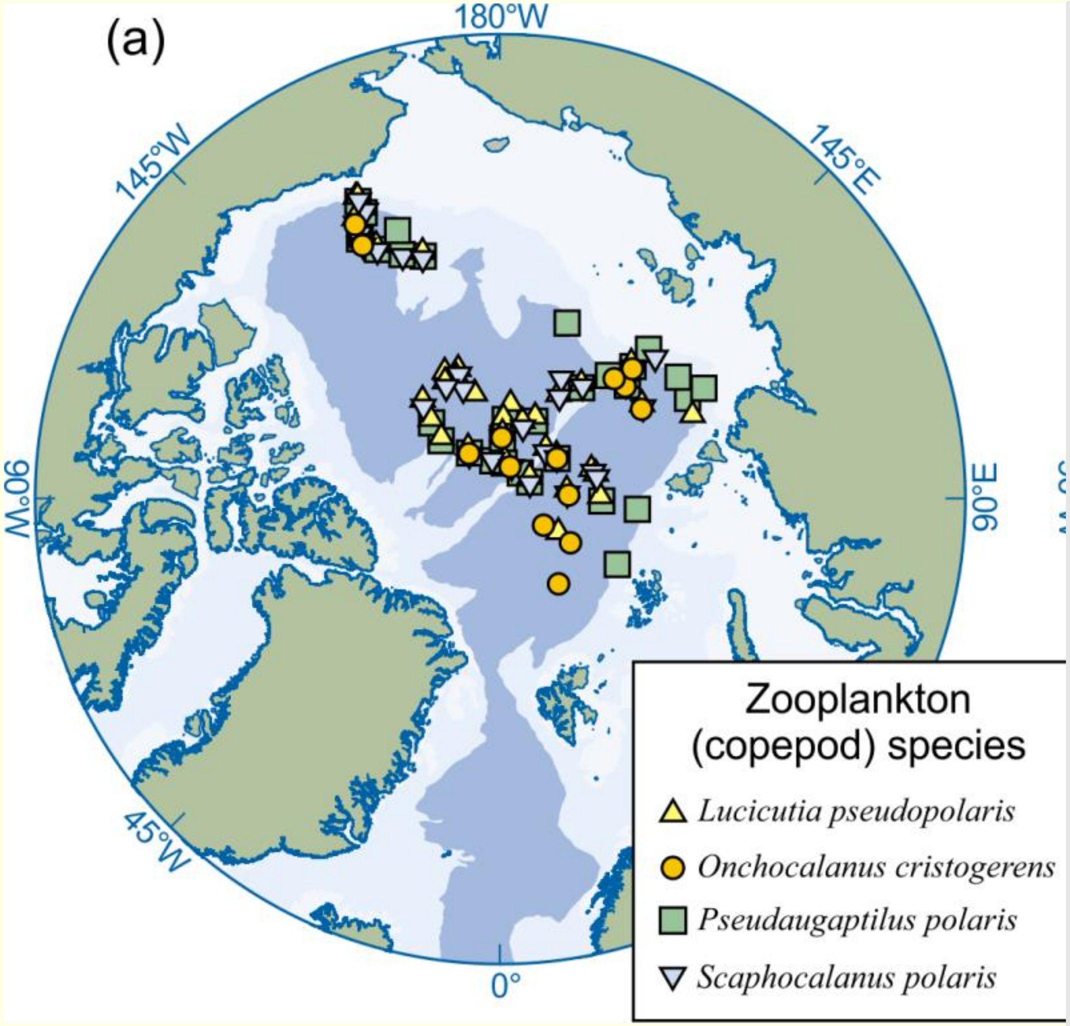


Vertical ranges of species



Species diversity increases with depth and reaches its maximum in Atlantic layer

Deep-water residents: Lomonosov Ridge is not a barrier for the deep-water fauna

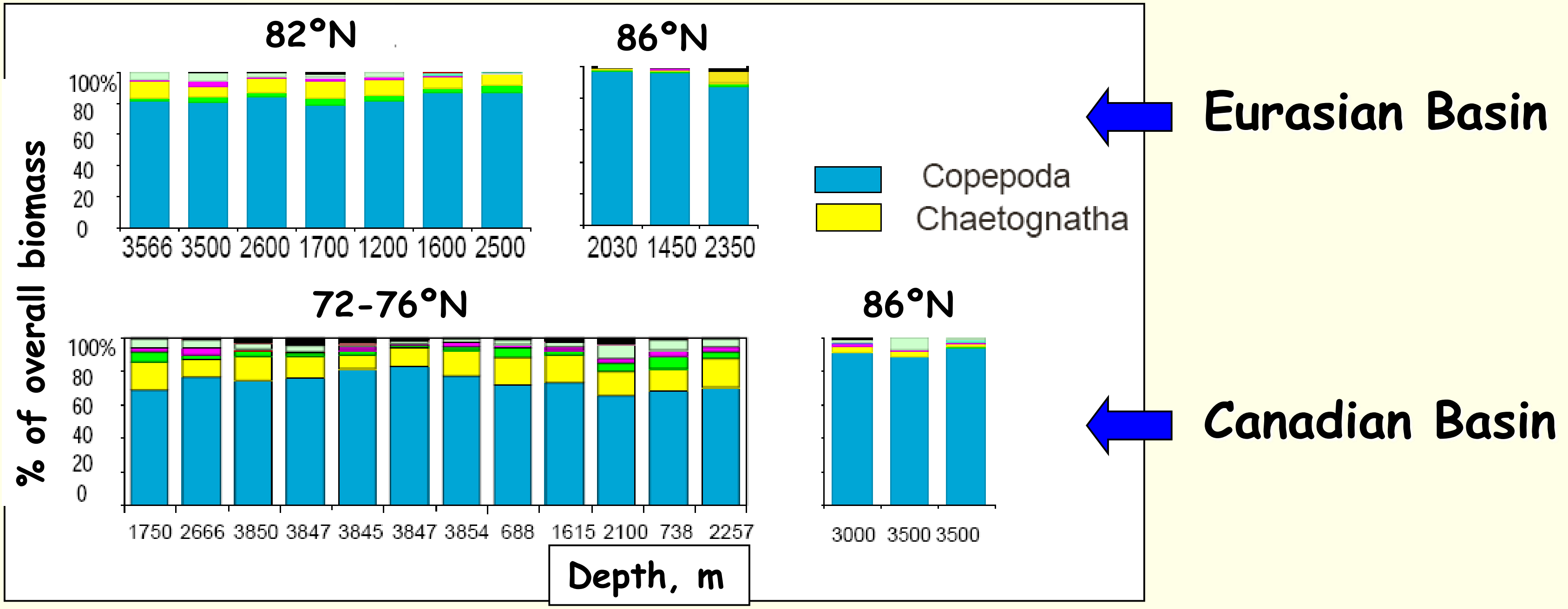


Almost all deep-water species occur on both sides of the Lomonosov Ridge

=

There is an effective exchange of plankton fauna over the underwater ridges

Quantitative composition: copepods dominate biomass



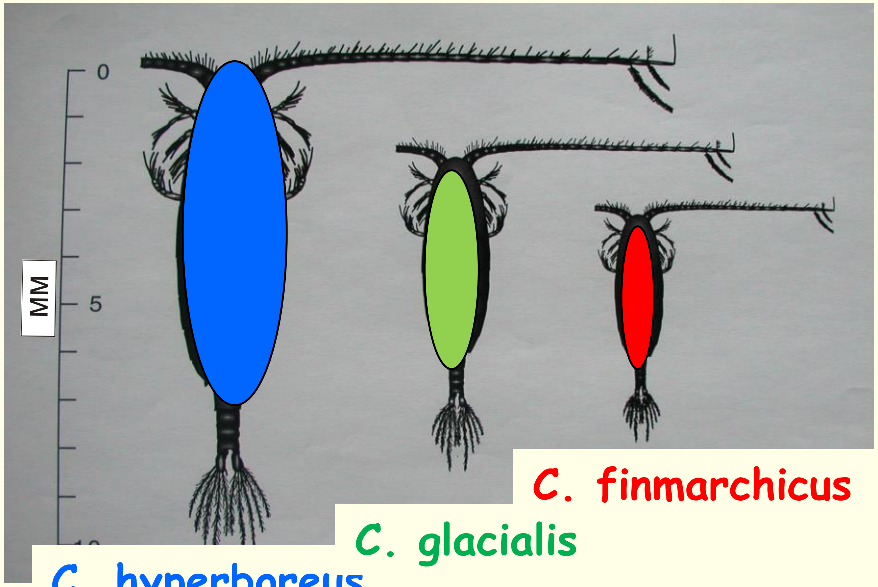
Region	Eurasian Basin	Canadian Basin
	Mean ± SD	Mean ± SD
Continental slope	88.0 ± 11.4	74.4 ± 2.2
Basins south of 82°N	80.9 ± 5.0	75.1 ± 4.6
Basins north of 85°N	91.4 ± 2.8	93.4 ± 5.4

Share of copepods

Key copepod species

Biomass (%)

Species	Body length, mm	Eurasian Basin <82°N	Eurasian Basin >85°N	Canadian Basin
Calanus glacialis	5.0	19.6	14.8	9.9
C. hyperboreus	8.0	21.5	46.5	29.2
C. finmarchicus	3.2	11.2	0.5	0
Metridia longa	4.5	12.1	4.4	7.4
Total		64.4	66.2	46.5



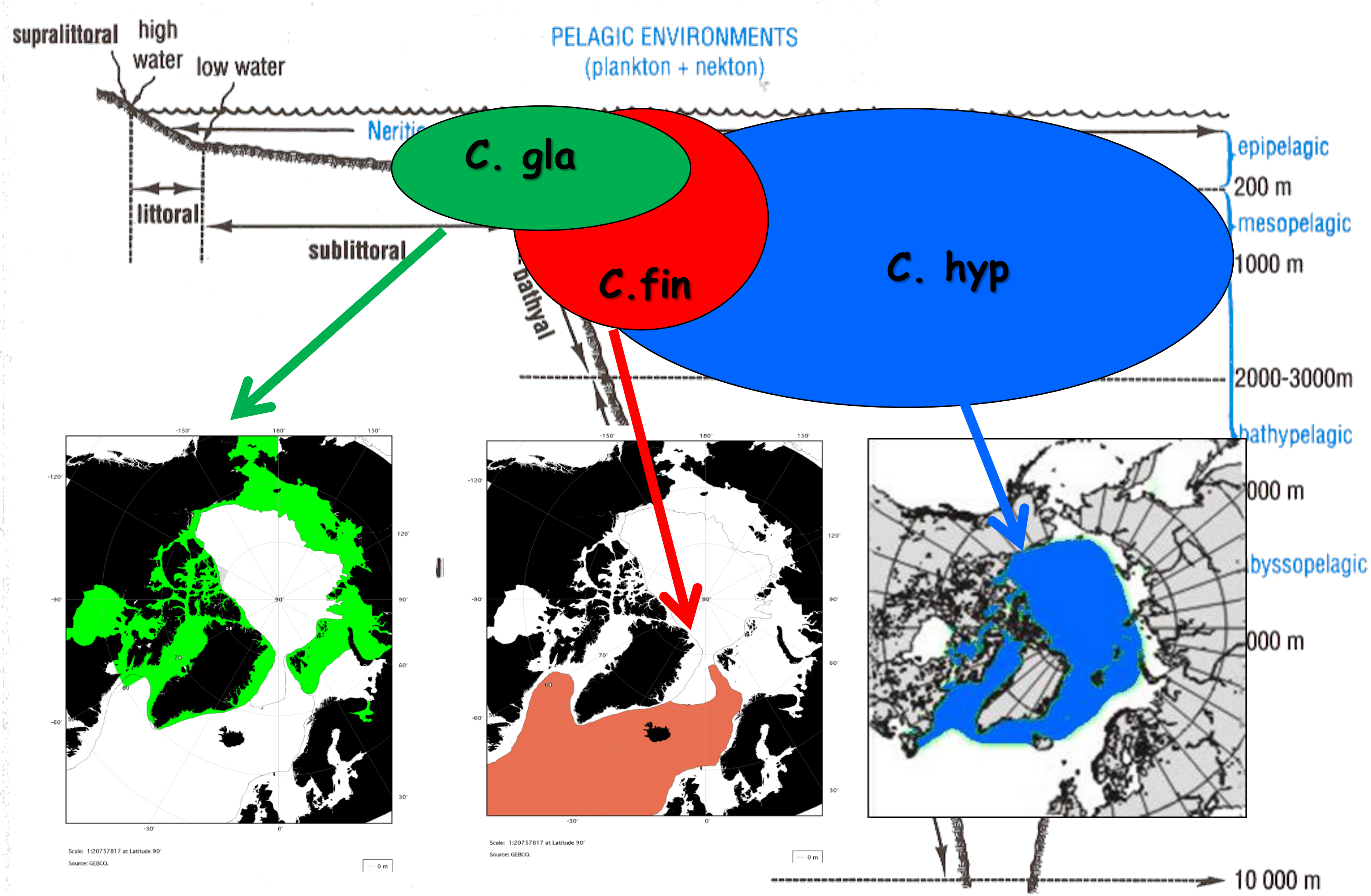
C. finmarchicus

C. glacialis

C. hyperboreus

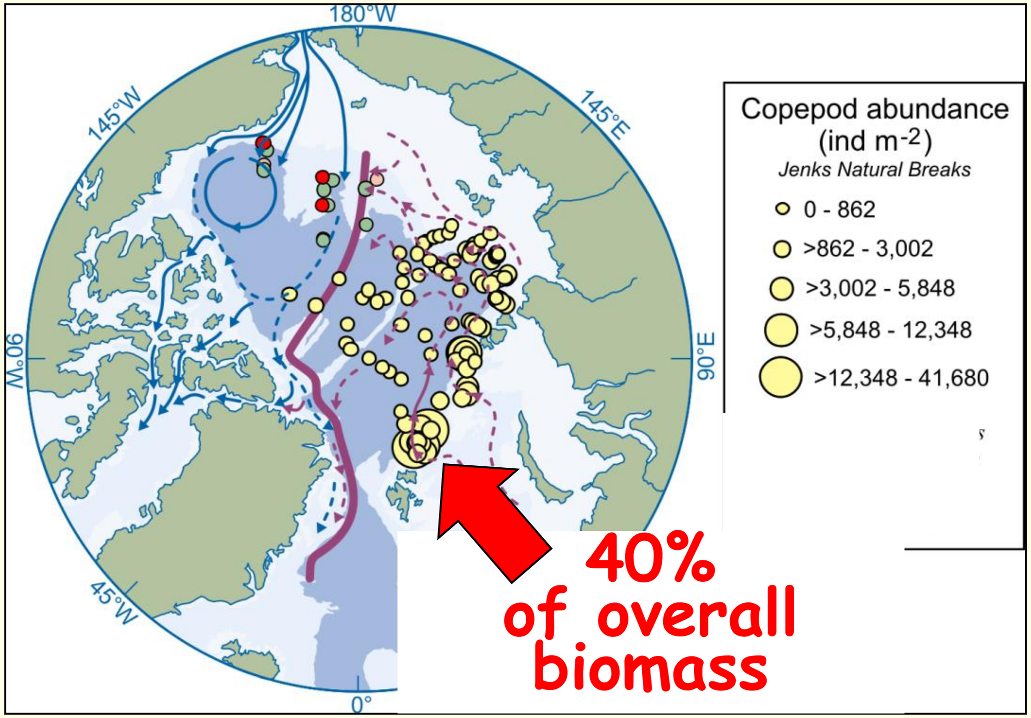
Metridia longa

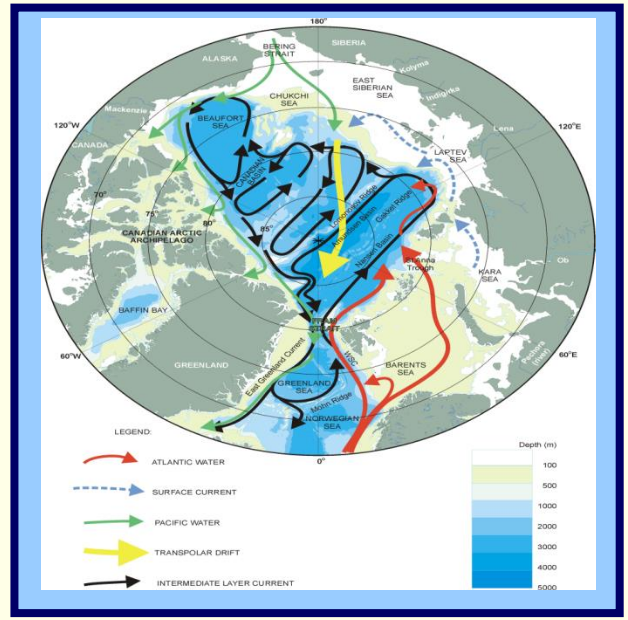
Distribution patterns of the three Calanus species in AO



Calanus finmarchicus

Spatial distribution of CF is closely related to circulation of Atlantic water in Eurasian Basin

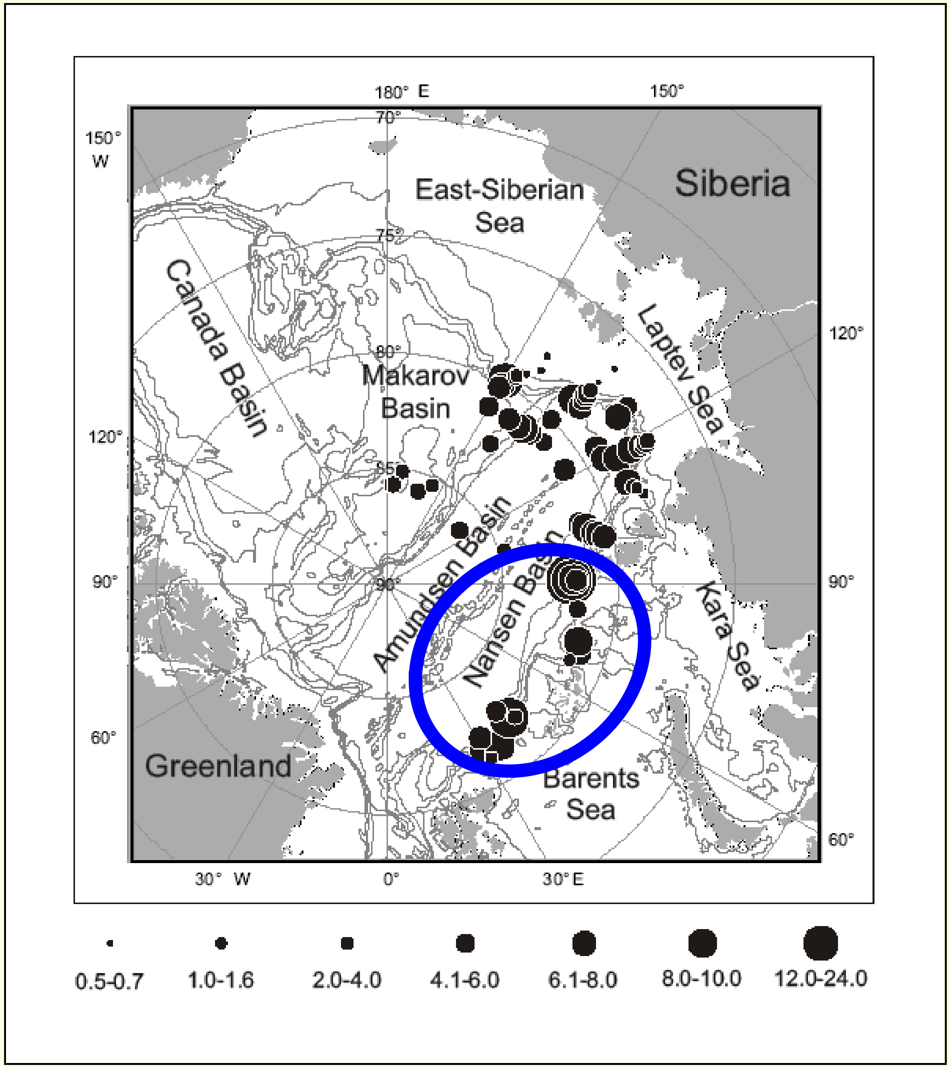




S. Østerhus and B. Rudels

Species	Eurasian Basin <82°N	Eurasian Basin >85°N	Canadian Basin
C. finmarchicus	11.2	0.5	0

Overall zooplankton biomass, g DW m^{-2}, entire water column (0m – bottom)



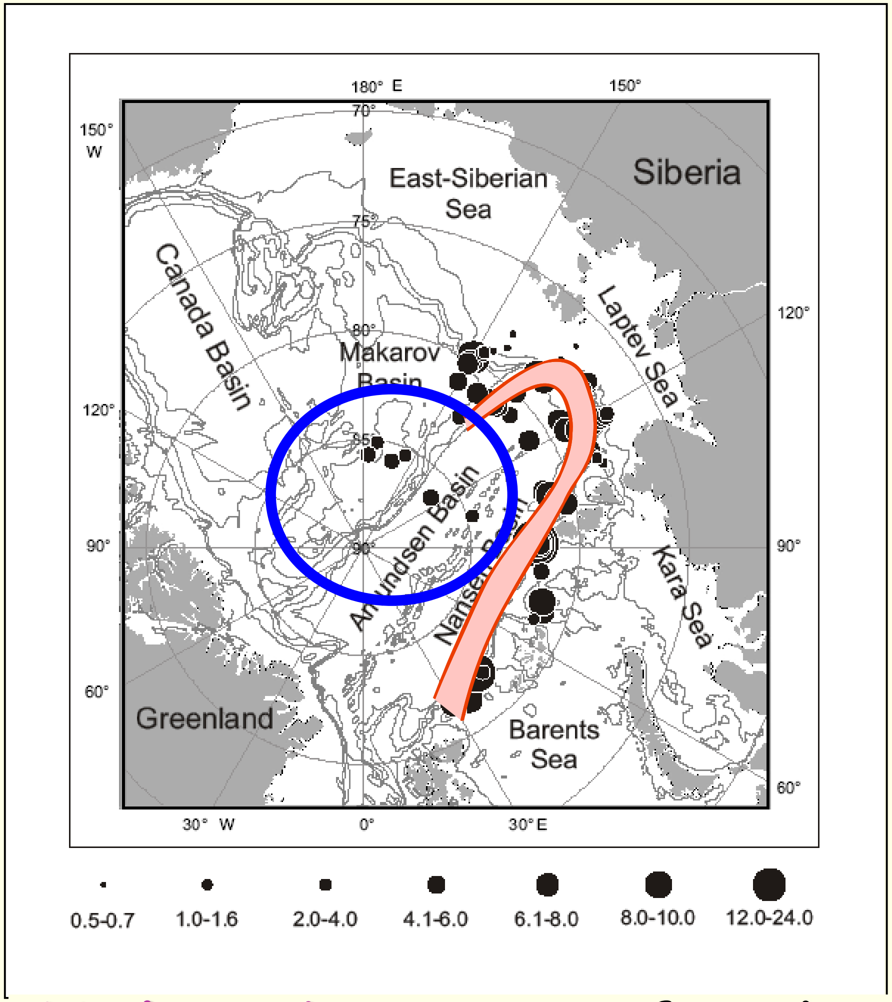
Kosobokova & Hirche, 2009

Typical biomass values within the range:
from 2 to 6 g DW m^{-2},
with maximum
up to **12-24** g DW m^{-2}
(maximum biomass ever found in the Arctic Ocean)

Historical values:

	g DW m-2
Hopkins, 1969a, b	
AMUNDSEN BASIN	0.2-0.4
CANADA BASIN	0.2-0.4
Kosobokova, 1982	
MAKAROV BASIN	1.0-3.0

Major features/gradients



Region	No. of stations	Biomass, g DW m^{-2} mean ± SD
EB, all stations	44	6.2 ± 4.1
EB, south of 81°N	38	6.9 ± 4.1
Basins north of 82°N	8	2.7 ± 0.6

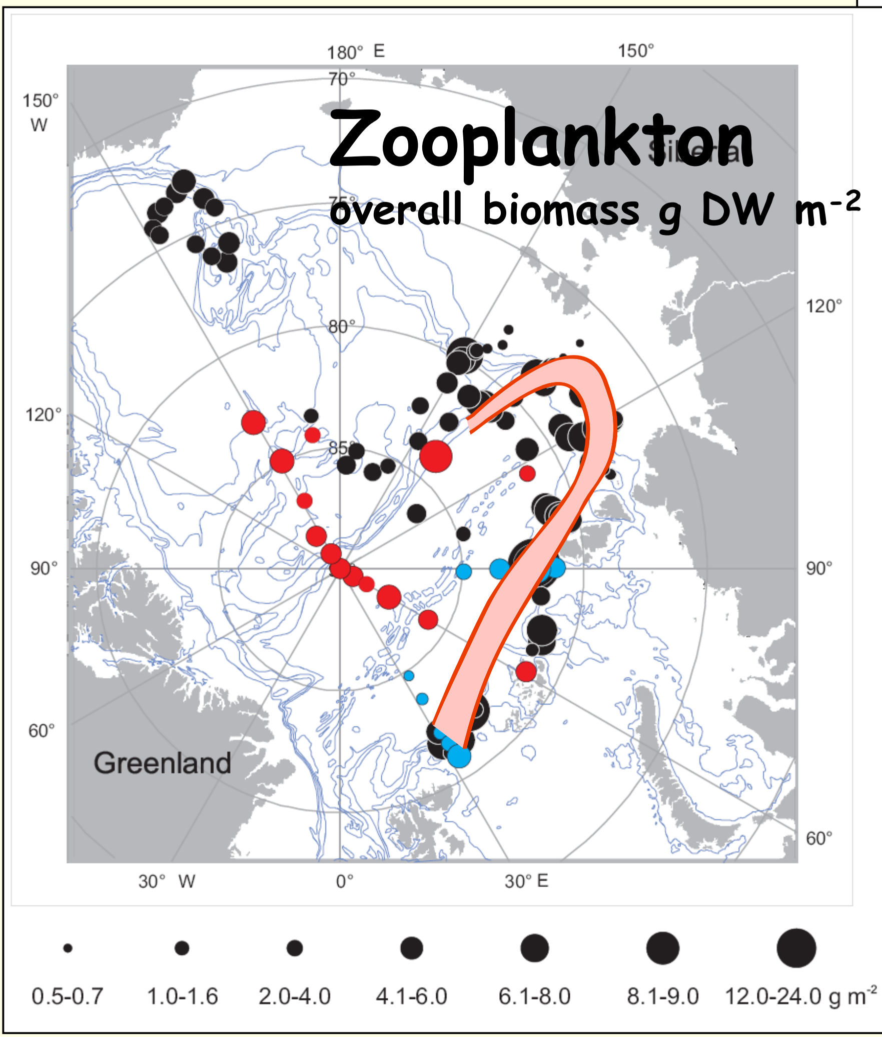
1. A belt of elevated biomass along the Eurasian slope
2. A decrease of biomass within this belt from the West to the East
3. South to north gradient: a decrease of overall biomass from the slope area to the central basins;

Highest biomass is found within or close to the core of the Atlantic Boundary Current

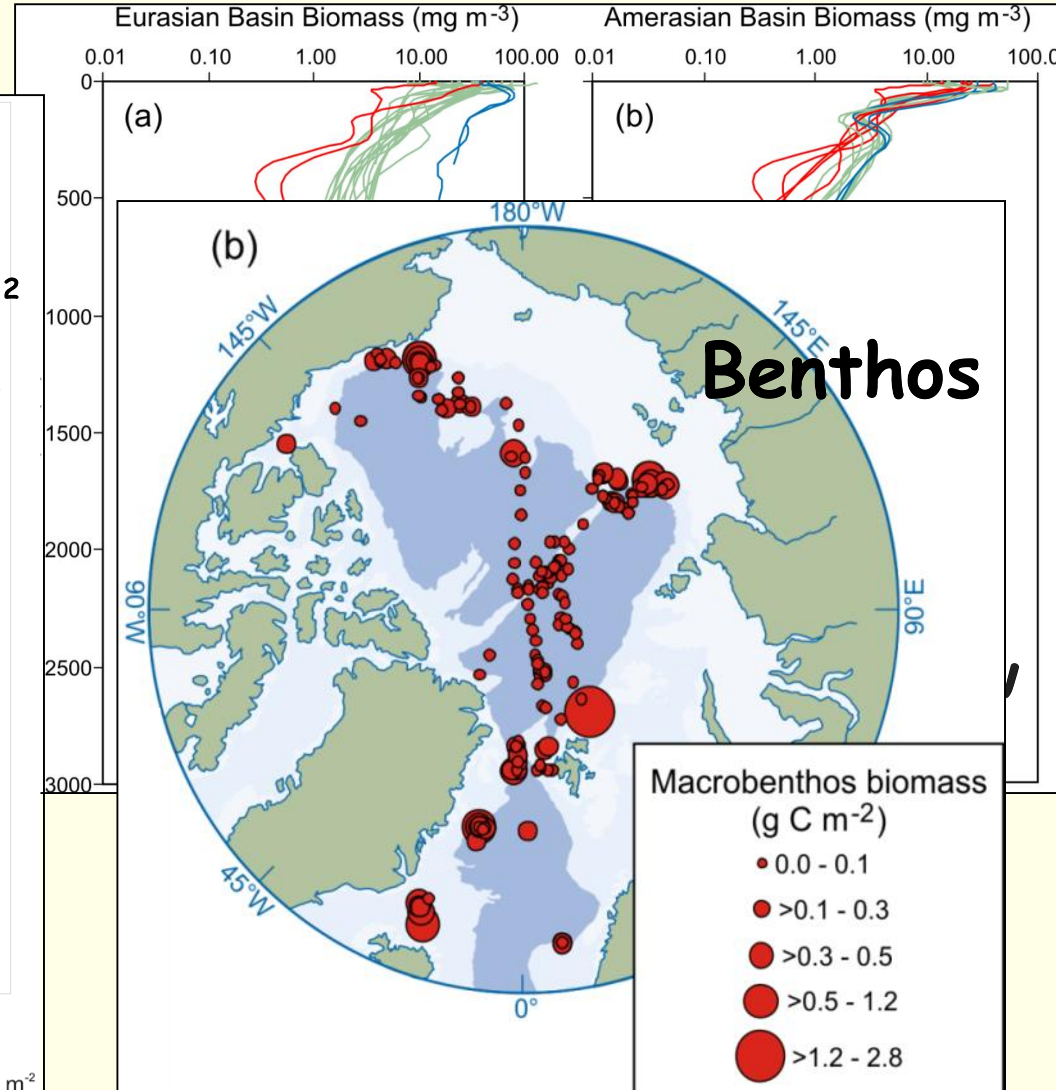
Kosobokova & Hirche, 2009

Local and advected carbon supply

"Carbon Belt" around Eurasian Basin perimeter

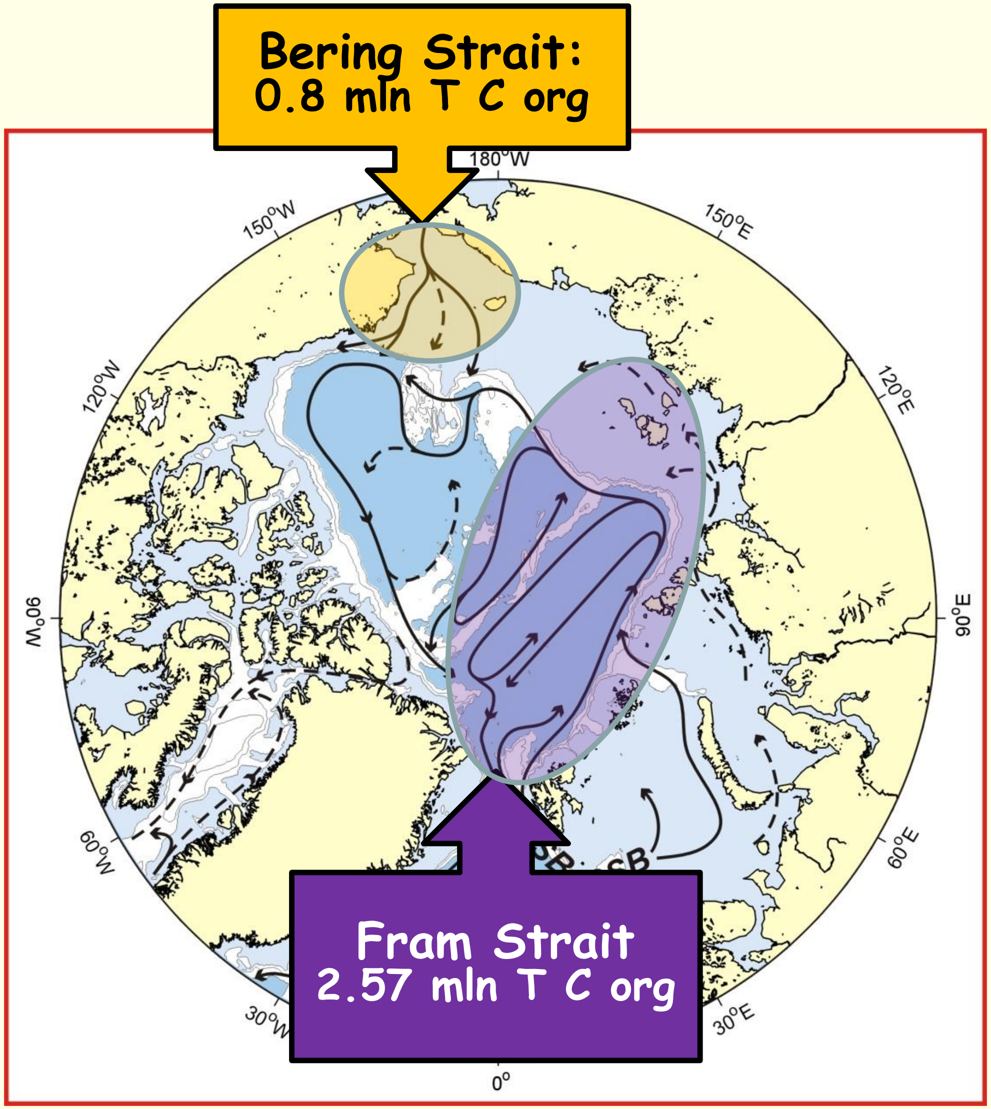


Vertical biomass distribution



Bluhm et al. 2011

Zooplankton advection through the Pacific and Atlantic gateways



Wassmann et al. 2015

Concentration of plankton advected through the Bering Strait is 3 times higher compared to Atlantic gateways;

But

The advective supply of plankton through the Atlantic gateways is 2–3 times higher because of 10 fold difference in amount of advected water;

Allochthonous carbon delivered through the Atl gateways is distributed all along the Eurasian slope E basins southern periphery,

On Pacific side it is restricted to the Chukchi shelf only

Summary:

- Our knowledge on the Arctic Ocean zooplankton diversity seriously improved during two last decades; existing information can be used as a baseline for monitoring the ongoing changes in the AO plankton communities;
- The Arctic Ocean hosts two major zooplankton communities:

  1) An autochthonous low productive community found in the Canada Basin and in its purest form in the inner northern basins;

  2) An allochthonous community consisting of advected species. It has its biomass maximum in the Atlantic boundary current;
- A strong regional variability of biomass distribution in AO is structured by the circulation pattern, and the Atlantic inflow is the most important structuring feature

Thank you for attention

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