Comparison on vertical distribution of pelagic copepod abundance, biomass and community structure between Atlantic and Pacific sector of the Arctic Ocean

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Objective

Recently, a great reduction of sea ice coverage has been reported for the Arctic Ocean during summer. The reduction has been reported to be greater for regions which connect the Arctic with the Atlantic and the Pacific Ocean, respectively. Since the pelagic fauna differs between the Atlantic and the Pacific Ocean, the effects of sea ice loss on the species and, thus, the Arctic ecosystems are expected to be different. However, little information is available on the differences in pelagic community between the Atlantic and Pacific sectors of the Arctic Ocean. In this study, we investigated planktonic copepod abundance, biomass and community structure in the Atlantic and Pacific sectors of the Arctic Ocean, and address their differences.

Material & Methods

Field sampling

Fram Strait

Zooplankton sampling was conducted at one station (78°50'N, 1°59'W) during 1 July 2011. Samples were collected from five depths (1500–1000–500–200–50–0m) by a vertical Multi Net haul (MN: 150 µm mesh, 0.25 m² mouth opening).

Chukchi Sea

Zooplankton was sampled at one station (73°48'N, 159°58'W) during 27 September 2013. Samples were collected from four depth strata (1000–500–200–100–0 m) by a vertical haul with a Vertical Multiple Plankton Sampler (VMPS: 62 µm mesh size, 0.25 m² mouth opening).

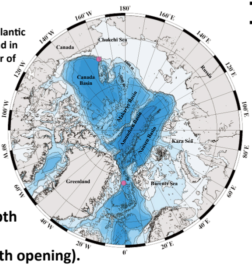
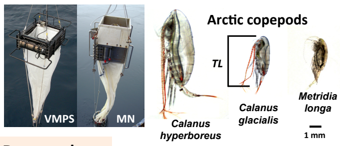


Fig. 1. Location of sampling stations in the Fram Strait (Atlantic sector of the Arctic Ocean) and in the Chukchi Sea (Pacific sector of the Arctic Ocean).

- Zooplankton samples were immediately preserved with 5% buffered formalin.
- At each station, temperature, salinity and dissolved oxygen were measured by CTD casts. Chlorophyll *a* (Chl. *a*) was also measured with fluorescence sensor.



Sample analyses

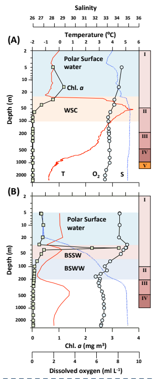
- In the land laboratory, enumeration for taxa and species/stage identification of copepods were made under stereomicroscope.
- Total length (*TL*) was measured for each species and stages. Carbon masses were then calculated from *TL* using length-mass regression (Yamaguchi et al., 2002).

Data analyses

- Based on zooplankton abundance, cluster analyses (Bray-Curtis connected with UPGMA) were made.
- Species diversities (*H'*) were also calculated based on copepod abundance.
- To clarify the depth distribution of each species or taxon, depths where 50% of the population resided (50% distributed layer: $D_{50\%}$, Pennak, 1943) were calculated. Additional calculations of $D_{25\%}$ and $D_{75\%}$ were also made.

Results & Discussion

1. Hydrography



- Temperature in the Fram Strait was higher than in the Chukchi Sea (30-1000 m).
- Salinity in the Chukchi Sea was lower than in the Fram Strait (0–300 m).
- The differences in hydrography between the two sectors were caused by the West Spitsbergen Current (WSC) at the station in the Fram Strait and the Bering Sea Summer and Winter Water (BSSW and BSWW) at the station in the Chukchi Sea.

Fig. 2. Vertical distribution of temperature, salinity, dissolved oxygen and Chl. *a* in the Fram Strait (A) and the Chukchi Sea (B). Depth ranges of sampling layers are shown in the numbers in the right columns. Note that depth scale is in log-scale.

2. Spatial changes in abundance, biomass and copepod diversity

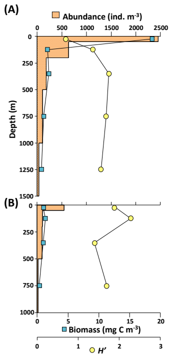


Fig. 3. Vertical distribution of copepod abundance, biomass and species diversity indices (*H'*) based on their abundance data in the Flam strait (A) and in the Chukchi Sea (B).

Fram Strait

Both copepod abundance and biomass were highest at 0–50 m layer (3132 ind. m⁻³ and 18.6 mg C m⁻³) and decreased with increasing depth. Species diversity was low in the surface layer (*H'*=0.70) and had peak at 200–500 m layer (1.74).

Chukchi Sea

Copepod abundance was highest at 0–50 m (518 ind. m⁻³), while high biomass was occurred at 100–250 m (1.3 mg C m⁻³). Species diversity was high even in the surface layer, and the highest value (2.27) was occurred at 100–250 m.

3. Cluster and NMDS analysis

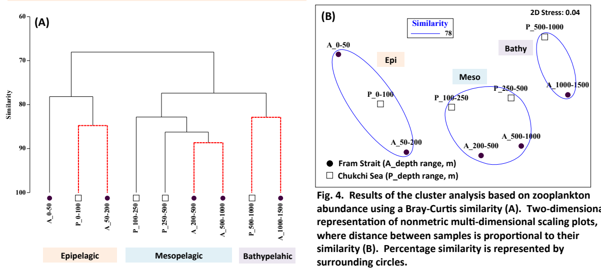
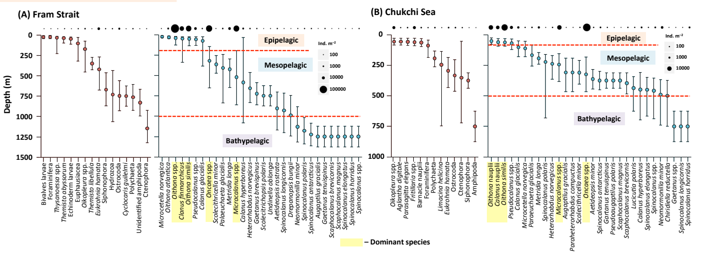


Fig. 4. Results of the cluster analysis based on zooplankton abundance using a Bray-Curtis similarity (A). Two-dimensional representation of nonmetric multi-dimensional scaling plots, where distance between samples is proportional to their similarity (B). Percentage similarity is represented by surrounding circles.

- The zooplankton community clustered into three groups.
- Epipelagic group: 0–200 m
  Mesopelagic group: 100–1000 m
  Bathypelagic group: 500–1500 m

- These results on community classification suggest that there were small geographical differences between the Atlantic and Pacific sector in the Arctic Ocean. Vertically changing patterns were robust.

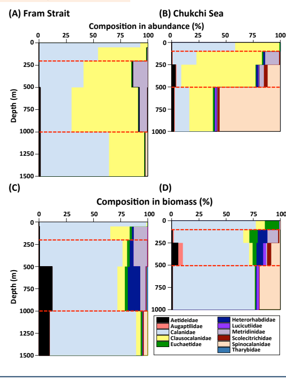
4. Vertical distribution



The distribution depth and dominant species in the two regions corresponded well : *Oithona* spp. ($D_{50\%}$: 32–63 m), *Oncaea* spp. ($D_{50\%}$: 319-324 m), *Microcalanus* spp. ($D_{50\%}$: 245-542 m). *Calanus finmarchicus* distributed in the epipelagic layer ($D_{50\%}$: 49 m) in the Fram Strait, but was not observed in the Chukchi Sea.

Fig. 5. Vertical distribution patterns of zooplankton in the Fram Strait (A) and in the Chukchi Sea (B). For each species or taxon, upper solid circles indicate abundance (ind. m⁻²: water column) and lower open circles indicate 50% distribution depth ($D_{50\%}$). Vertical bars indicate depth ranges where 25% ($D_{25\%}$) and 75% ($D_{75\%}$) of the population was distributed.

5. Composition



- In abundance, Clausocalanidae including *Microcalanus* spp. dominated in the mesopelagic layer of both regions. Spinocalanidae dominated the bathypelagic layer in the Chukchi Sea.
- For biomass, the predominance of Calanidae at 0–50 m in the Fram Strait was caused by *Calanus finmarchicus*.
- The dominance of Calanidae in the other layers was due to *C. hyperboreus* which distributed over wide depth and geographical ranges.

Fig. 6. Vertical changes in the composition of families of calanoid copepods in terms of abundance (A, B) and biomass (C, D) in the Fram Strait (left) and in the Chukchi Sea (right)

References

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Conclusion

Despite large geographical distances, different sampling gear and different seasons, the zooplankton communities of the Atlantic and the Pacific sector of the Arctic Ocean were similar. At both stations, the community composition changed significantly with depth. *C. finmarchicus*, which is advected with the WSC, only occurred in the surface layer of the Atlantic sector.

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