

The role of local and regional environmental factors in the interannual variations of *Calanus finmarchicus* and *C. hyperboreus* abundances in the Nordic Seas

Marina Chelak¹, Claudia Halsband², Øystein Varpe^{2,3}, Astthor Gislason⁴, Kristinn Gudmundsson⁴, Stig Falk-Petersen^{2,5}, Ketil Eiane¹



marina.chelak@nord.no

Introduction

Background

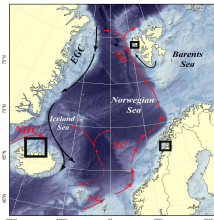
Copepods of the genus *Calanus* are key species in the North Atlantic ecosystem. They are sensitive to climate change and their distribution and abundance is predicted to change because of the warming of North Atlantic^{a,b}. However, the relative role of local and regional drivers and underlying mechanisms of the *Calanus*-environment relationship are not well understood^{c,d}.

This study aims to

- Disentangle the link between local and regional environmental factors and *Calanus* abundance across the Nordic Seas
- Describe the mechanisms underlying the *Calanus*-environment relationship

Material and Methods

1. Collection of data



Northern Norway
1983-2010

Svalbard
1996-2010

Northern Iceland
1990-2011

2. Identification: species and stages



3. Data analysis

- We tested for: **trends** in species abundances, **covariation** between populations, and with local (**T**, **S**, **Chl α** , **bloom timing**) and regional (**NAO**, **AO**) environmental variability (**Kendall's rank correlation test**).
- Stage-specific** responses to environmental variability was established by **Redundancy Analysis** in CANOCO 5.

References

- Chust, G., et al. (2013). "Are *Calanus* spp. shifting poleward in the North Atlantic? A habitat modelling approach." *ICES Journal of Marine Science: Journal du Conseil*.
- Carstensen, J., et al. (2012). "Effects of environmental conditions on the biomass of *Calanus* spp. in the Nordic Seas." *Journal of Plankton Research* 34(11): 951-966.
- Kvile, K. Ø., et al. (2016). "Disentangling the mechanisms behind climate effects on zooplankton." *Proceedings of the National Academy of Sciences* 113(7): 1841-1846.
- Beaugrand, G. (2012). "Unanticipated biological changes and global warming." *Marine Ecology Progress Series* 445: 293-301.

Results

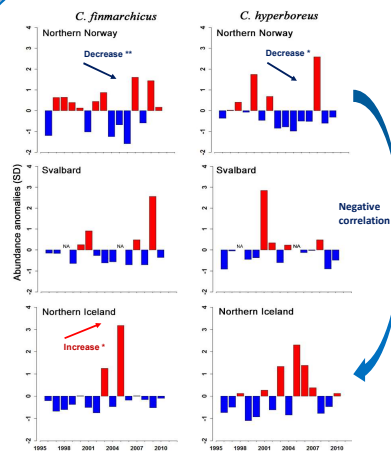


Figure 1. Abundance anomalies (standard deviation units) of *C. finmarchicus* and *C. hyperboreus* in the study locations. Significant trends in *Calanus* populations and correlations between populations are indicated.

Location	Spatial scale of the environmental variable	Effect of the environmental variable	
		<i>C. finmarchicus</i>	<i>C. hyperboreus</i>
Northern Norway	Regional (climate)	High abundance at high NAO: increased fjord production and advective influx of individuals from oceanic population	High abundance at high NAO: increased fjord production
Svalbard	Local (hydrography)	High abundance when high advective input of West Spitsbergen Current (WSC)	High abundance when high advective input of West Spitsbergen Current (WSC)
	Local (phytoplankton)	High abundance when phytoplankton spring bloom is late: improved feeding conditions for early life stages	None
Northern Iceland	Local (hydrography)	High abundance when high advective influx from North Icelandic Irminger Current (NIIC)	None
	Local (phytoplankton)	High abundance at low Chl α concentration: high grazing pressure.	None
	Regional (climate)	None	High abundance at low NAO: increased deep-water transport of individuals from the Greenland Sea.

Figure 2. Hypothesized mechanisms accounting for the observed relationship between *C. finmarchicus* and *C. hyperboreus* populations in the study locations, and important environmental variability acting on local and regional spatial scales.

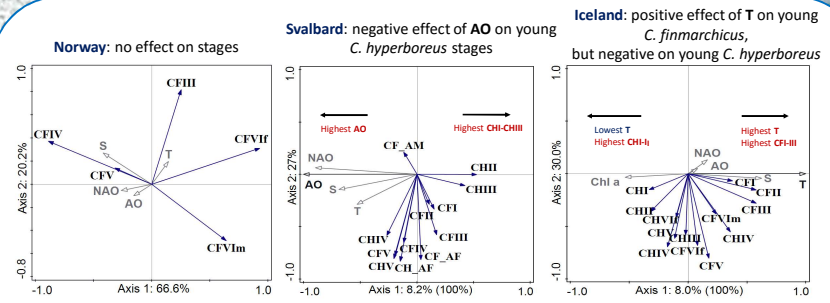


Figure 3. PCA ordination plot of environmental data and *C. finmarchicus* data from northern Norway, and RDA plots of *C. hyperboreus* and *C. finmarchicus* data from Svalbard and northern Iceland. Developmental stages (CI - adults) and environmental variables are represented by arrows, and the angle between the arrows reflects the correlations between the variables. The percentage is the total species variation and species-environment relationships (in parentheses) explained by axes.

Conclusions

- The responses of *Calanus* to environmental factors were both **species- and location-specific**.
- Climate effects on *Calanus* appeared to be mediated mainly through **advection** of water masses, and local effects were mediated through **bottom-up** processes related to food availability, or **advection**.
- The abundance of young developmental stages of *Calanus* may respond differently to environmental forcing than the older copepodite stages and total population abundance. This was particularly clear in the long-lived *C. hyperboreus*.

Correspondence

- Nord University, P.O. Box 1490, N-8049 Bodø, Norway
- Akvaplan-niva AS, Fram Centre, P.O. Box 6606, Langnes, N-9296 Tromsø, Norway
- Norwegian Centre in Svalbard, P.O. Box 156 N-9171 Longyearbyen, Norway
- Marine Research Institute, P.O. Box 1390, Skulagata 4, 121 Reykjavik Iceland, 5 University of Tromsø
- Norwegian Polar Institute Fram Centre, P.O. Box 6606, Langnes, N-9296 Tromsø, Norway

Thanks to:

