Towards the dominance of Boreal zooplankton in the European Arctic?

Agata Weydmann (1), Jacob Carstensen (2), Ilona Goszczko (1), Katarzyna Dmoch, Anna Olszewska (1), Slawomir Kwasniewski (1)

(1) Institute of Oceanology, Polish Academy of Sciences, Sopot, POLAND; (2) NERI, Aarhus University, Roskilde, DENMARK; Presenter contact details: agataw@iopan.gda.pl

Summary

We studied summer mesozooplankton composition between 2001 and 2009, in the epipelagic zone of the West Spitsbergen Current (WSC) and adjacent areas, which constitute a transition zone between warmer Atlantic and cold Arctic waters. The novel spatial analysis method of principal coordinates of neighbour matrices (PCNM) and the following variation partitioning, were applied to disentangle the contributions of environmental variables and spatial differences in explaining zooplankton variation. In spite of the large geographical area covered, environmental factors explained 30.6% of zooplankton variability, while the spatial distribution of sampling stations was responsible for 27.2%, whereas 12.5% was a common share of both predictors, coming from their correlations. We observed a gradual transition from dominance of ubiquitous and Boreo-Arctic species towards increasing contribution of Boreal ones such as *Calanus finmarchicus*.

Introduction

The West Spitsbergen Current (WSC) transports Atlantic waters and associated biota through the Norwegian and Greenland Seas, and thus influences both physical and biological properties of the Arctic Ocean (Walczowski et al. 2012). The WSC is a transition zone between the considerably warmer Atlantic and the cold Arctic domains, and as such it is a suitable place to study effects of climate change in Arctic and sub-Arctic marine ecosystems. Knowing that temperature has increased significantly in the Arctic over the last 3-4 decades, it is hypothesized that effects of temperature increases could be assessed from biological long-term monitoring data in the Arctic region (Carstensen et al. 2012). However, most of the existing biological data sets from the Arctic have much shorter time scale of monitoring and are without a consistent spatial factor.

The goal of this study was to describe the inter-annual and spatial variability of the mesozooplankton community in the Atlantic-Arctic transition zone, using an almost decadal long and spatially comprehensive monitoring data set from the West Spitsbergen Current. We also wanted to disentangle the variation of zooplankton taxonomic composition and its demographic structure between two sets of explanatory variables: environmental factors and spatial distribution of sampling stations.

Materials and Methods

Mesozooplankton was sampled annually in the end of June and beginning of July, within a three weeks' time window from 2001 until 2009, usually during or slightly after the spring bloom. The spatial extent of this data set covers multiple sampling stations including the WSC, shelf areas of Spitsbergen and Barents Sea and the Greenland Sea with the Fram Strait, what resulted in 138 samples in total. Species abundance data (ind. m^{-2}) were log transformed [$x'=\log(x+1)$] prior to all following analyses to allow identifying the possible influence of numerically less important taxa. To study the relationships between the mesozooplankton community and both environmental variables and spatial distribution of sampling sites redundancy analysis (RDA) was applied in CANOCO 4.5 and the following novel statistical method for variation partitioning, principal coordinates of neighbour matrices (PCNM) (Legendre et al. 2009).

Results and Discussion

The mesozooplankton community in the study area exhibited large spatial and interannual variations, with a smooth change from the dominance of ubiquitous and Boreo-Arctic taxa such as *Oithona similis* and *Triconia* sp. in the beginning of the study period towards stronger dominance of Boreal taxa, like *Calanus finmarchicus*, which was the most abundant species in 2009. The most abundant species was *Oithona similis* and the most important, in terms of biomass, was *Calanus finmarchicus*; both species found at all stations.

The increasing proportions of Boreal species over the study period and shift to their dominance in 2009 were mainly due to high counts of *Calanus finmarchicus*. The observed trend in the increasing numbers of Boreal copepods at the gateway to the Arctic is consistent with strong biogeographical shifts in all copepod assemblages and the northward extension of warm-water species by more than 10° latitude, associated with a decrease in the number of colder-water species, described in the eastern North Atlantic and European shelf seas (Beaugrand et al. 2002). However, this data set is too short to assess if the observed increasing dominance of Boreal species in the WSC and adjacent areas is just a temporary phenomenon or constitutes a more persistent trend.

Environmental variables explained 30.6% of the variance in species–environment relationships in the RDA model (p=0.001). The most important predictors were station water depth and water temperature, explaining 13% and 9% of species variability, respectively. The gradient between the northern and southern part of the study area is clearly seen along the temperature eigenvector in the ordination plot (Figure 1).

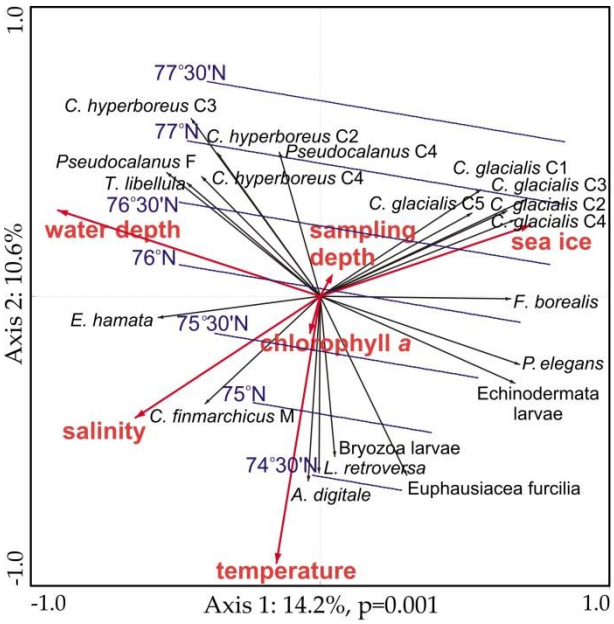

Figure 1. Ordination plot from RDA showing the relationship between abundances of 20 best fitted zooplankton taxa and environmental variables as well as the latitudal range based on Generalised Linear Model.

PCNM allowed for explaining 27.2% of the mesozooplankton community variance. However, after applying variation partitioning for RDA, these proportions changed into: 18.1% of variation being explained by environmental factors alone, 14.7% by the spatial distribution alone, while 12.5% was a common part of both. The results indicate that variation resulting from changes in water and sampling depth, temperature, salinity, chlorophyll *a* and sea ice concentrations was more important for the WSC mesozooplankton community than the one explained by the spatial distribution of sampling stations, in spite of the large geographical extent of the study area.

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