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Zooplankton distribution and feeding in the Arctic Ocean during a *Phaeocystis pouchetii* bloom

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ABSTRACT

In early summer 2007 we determined the vertical distribution of mesozooplankton (>200 μm) and assessed the copepod feeding rates in 19 stations distributed along the East Greenland Current and the Fram Strait. The study coincided with a bloom of the haptophyte *Phaeocystis pouchetii* in the colonial form. Copepods dominated the zooplankton community numerically, and were mainly distributed within the upper 150 m (except for *Metridia longa* and *Oithona spp.*, that inhabited deeper waters), without showing a clear avoidance of the *P. pouchetii* layer. Copepod diet was diverse, ciliates having a relevant share (40% of the diet). Copepods also displayed active grazing upon the colonies of *P. pouchetii*. In general, feeding rates were low (on average, daily ration was 1.6% of body carbon), likely due to the scarcity of nano and microplankton during the study (<100 μg C L^{-1}). Consequently, the trophic impacts on both the nano- and microplankton standing stocks and on primary production were negligible. These results suggest that during the period of study the transfer of carbon and energy from lower trophic levels towards copepods was low.

1. Introduction

The Arctic Ocean is currently one of the most sensitive marine ecosystems confronted with global change (Wassmann, 2011). Warming and ice loss will affect the radiative balance of polar waters, resulting not only in a presumable disruption of the global conveyor belt (Spielhagen et al., 2011), but also in likely changes in the phenology and species composition of the autotrophic and zooplankton communities. Such changes would result in alterations of the functioning of the planktonic Arctic food webs, affecting as a whole the biological and biogeochemical processes in the water column (Agustí et al., 2011). In spite of this relevance, our knowledge of the structure and, especially, the functioning of Arctic planktonic food webs is still scarce, limiting our ability to detect ecological changes related to climate variability (Daase and Eiane, 2007; Wassmann, 2011). This lack of knowledge extends to the zooplankton level as well, and, in particular, to copepods. Copepods are key organisms responsible for the transfer of primary production to upper trophic levels (either directly or via microzooplankton; Calbet and Saiz, 2005), and they are also involved in the recycling of nutrients in the upper layer and in the downward export of biogenic carbon to the deep ocean.

Here, we present data from a multidisciplinary cruise conducted in the framework of the Spanish Project ATOS (Aportes atmosféricos de carbono orgánico y contaminantes al océano polar: tasas, significación y prospectivas), and the International Polar Year. The survey took place in early summer 2007 on board the Spanish R/V Hespérides and covered waters along the East Greenland Current and the Fram Strait. The Fram Strait is a region of confluence of North-Atlantic waters and the export of Arctic Sea ice through the East Greenland current (Hop et al., 2006); therefore, it is considered particularly important and very sensitive to any effects induced by global change. In this study we determined the vertical distribution of mesozooplankton and experimentally assessed copepod feeding rates on autotrophic and heterotrophic prey, with a two-fold goal: (i) to evaluate the contribution of protozooplankton to the diet of Artic copepods and compare it to those reported at lower latitudes, and (ii) to establish the flux of carbon through the copepod community and evaluate the impact on their prey populations.

Contrarily to the still widely accepted view that polar copepods are mainly herbivorous (e.g., Blachowiak-Samolyk et al., 2007; Saunders et al., 2003; Søreide et al., 2008), the limited

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number of available studies analyzing the diet composition of Arctic copepods suggest that in occasions the contribution of protozooplankton can be high (e.g., Levinsen et al., 2000; Møller et al., 2006), similar to the general pattern found in most of the oceans (Saiz and Calbet, 2011). Generally, with the exception of the extensive data set provided by Campbell et al. (2009) in the Beaufort and Chuckchi Seas, reports on copepod diet composition and daily rations in most areas of the Arctic are either lacking, based only on gut contents fluorescence, or are relying on too few observations to withdraw general conclusions or patterns. In particular for the Fram Strait area, most of the previous copepod feeding studies were based on the gut fluorescence method (e.g., Båmstedt, 1984; Tande and Bamstedt, 1985), which neglects the heterotrophic components of the diet (Saiz and Calbet, 2011). To our knowledge, only the works by Barthel (1988, 1990) or Smith (1988), restricted to few observations, contemplated microscopic counts. As a consequence, there are no thorough studies on the carbon fluxes mediated by zooplankton in the Fram Strait, despite being one of the most studied and sensitive zones in the Arctic. During the study we benefitted from the fact that the cruise was coincident with the late phase of a bloom of the colonial form of the haptophyte *Phaeocystis pouchetii*, a recurrent phenomenon in the area (Schoemann et al., 2004). This phenomenon broadened the range of scenarios to be faced by zooplankton during our study. In addition, instead of focusing on a copepod stage- and species-specific approach (typically limited to a few species and/or stages), to obtain a better picture of the fluxes at the community level we conducted the experiments using the natural copepod assemblages.

Parallel studies conducted during the ATOS-Arctic cruise have focused on the metabolic activity of mesozooplankton (Alcaraz et al., 2010) and the grazing of microzooplankton (Calbet et al., 2011), and will be considered in the Discussion section.

2. Material and methods

2.1. Study site, CTD casts and water samples for chlorophyll profiles

The ATOS-Arctic cruise took place in the Greenland Sea, the Fram Strait and an area north of Spitsbergen from the 1st to the 25th of July 2007, onboard the research vessel "Hespérides" (Fig. 1). It included stations located in ice-free open waters, as well as stations close to the sea ice edge (Table 1). The sea ice extent observed that year was a minimum (Zhang et al., 2008) and allowed the ship to sail up to 80°50′N. At each station, profiles of temperature, salinity, and fluorescence were obtained in the morning with a Seabird CTD911, fitted with a Rosette with 12-L Niskin bottles. Water samples for chlorophyll *a* (chl *a*) analysis were taken from 5 depths (including the fluorescence maximum) during the CTD ascent. Aliquots of water were low-pressure (<100 mm Hg) filtered onto both Whatmann GF/F and 5-μm polycarbonate filters, and frozen (-80 °C); filters were later extracted with 90% acetone and analyzed using a Turner Designs fluorometer before and after acidification.

2.2. Composition and standing stocks of zooplankton

At each station (except three cases in which it was not possible), a Longhurst-Hardy Plankton Recorder net (LHPR) fitted with 200 μm gauze was deployed to 350 m depth (or shallower when not possible), and 9 depth intervals (nominally, 0–25, 25–50,

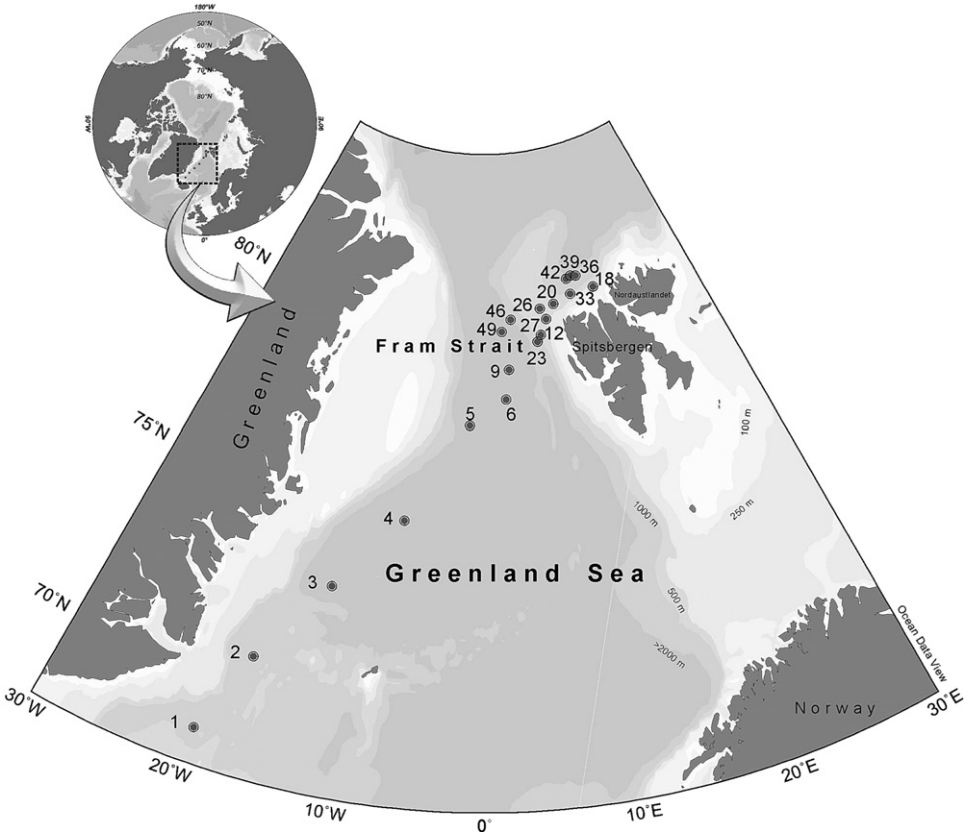

Fig. 1. Sampling grid of the study.