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Meso-zooplankton abundance and spatial distribution off Lützow-Holm Bay during austral summer 2007–2008

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A B S T R A C T

To elucidate spatial differences in mesozooplankton community structure in local scale, vertical hauls using a 60-μm mesh closing net were carried out off Lützow-Holm Bay in January 2008. All of the zooplankton samples collected from three layers (0–100, 100–200, and 200–500 m) at seven stations were dominated by *Oithona* spp., *Oncaea* spp., *Ctenocalanus citer*, *Microcalanus pygmaeus*, and copepod nauplii. The cluster analysis of mesozooplankton abundances showed three distinct groups according to sampling depth, which appeared to be due to the preferential vertical distribution of dominant copepods. The other cluster analysis on integrated abundance upper 500 m revealed that mesozooplankton community structures at stations located on the western and eastern edges of the observation area (Cluster A) differed from those at the central stations (Cluster B). Abundance of copepod nauplii, *Oithona* spp., and *C. citer* differed between Clusters A and B, which was likely caused by differences in recruitment and early development in the dominant copepods, being associated with the timing and duration of ice edge blooms. This suggests that such heterogeneity in abundance and recruitment/development of dominant taxa was likely caused by local heterogeneity in sea ice dynamics. This may affect our understanding of zooplankton distribution.

1. Introduction

Copepods are a common key component in various marine ecosystems, as predominant secondary producers and major drivers of the biological carbon pump. Consequently, information on their abundance, biomass, and the spatio-temporal changes at various scales is fundamental to understanding marine ecosystems. In recent decades, significant underestimation of numerical predominance of small copepod abundance, which causes various biases on understanding of ecosystems, have been reported in various regions (Turner, 2004; Riccardi, 2010). This is also true in the Southern Ocean, where zooplankton communities are dominated by smaller copepods, such as the genera *Oithona* and *Oncaea*, two small calanoid copepods *Ctenocalanus citer* and *Microcalanus pygmaeus*, as well as nauplii (Dubischar et al., 2002; Tanimura et al., 2008; Ward et al., 2012; Ojima et al., 2013). Therefore, information on spatial and temporal variation in the composition of small zooplankton taxa is needed for a better understand the Antarctic Ocean ecosystems.

In the Antarctic Ocean ecosystem, information on ice edge phytoplankton blooms in association with sea ice retreat is essential in understanding Seasonal Ice Zone (SIZ) ecosystems, which account for >60% of production in the Southern Ocean (Smith and Nelson, 1986). This production sustains the greater part of the huge biomass of secondary producers, such as krill and copepods, which are important prey for various predators in the SIZ. There are a number of studies on the mechanisms of ice edge blooms and their impact on (or relation to) various ecological components. Notably, most studies have focused on biomass dominant large taxa (krill and large copepods) as key secondary producers (see review of Conover and Huntley, 1991; Atkinson et al., 2012). Therefore, the

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abundance of small-sized copepod taxa and their nauplii have been underestimated by previous studies focusing on larger animals collected with coarser mesh nets, which has led to a biased understanding of zooplankton community structure.

Several epipelagic copepods, including smaller taxa, in the SIZ have a life-cycle strategy more or less related to ice edge blooms. In most cases, e.g., the large copepod *Calanoides acutus* and the smaller copepods *C. citer* and *Oithona similis*, ice edge bloom generally affects their development rather than their food supply for reproduction, which occurs 1–2 months before the bloom (Atkinson et al., 2012). While sea ice retreat usually occurs from north to south, its heterogeneous retreat occurs in relation to ocean current patterns, such as the Antarctic Circumpolar Current (ACC) and the Antarctic Slope Current (ASC), and gyres are also common in the Eastern Antarctic Ocean (Nicol and Raymond, 2012; Massom et al., 2013). Furthermore, strong connectivity between ocean currents and bottom topography has been reported in this area (Bindoff et al., 2000; McCartney and Donohue, 2007; Meijers et al., 2010; Massom et al., 2013). Such heterogeneous ice retreat may cause differences in the timing of ice edge phytoplankton blooms and productivity, depending on the local bottom topography. Hence, we hypothesize that the copepod developmental phase, which depends on ice edge phytoplankton production, differs even in areas at the same latitude because local differences in topography result in heterogeneous ice retreat.

In the east Antarctic Ocean, particularly off the Syowa Station, there have been several reports on zooplankton abundance and taxonomic composition as determined by fine mesh net sampling (Tanimura et al., 2008; Ojima et al., 2013; Takahashi et al., 2016), although copepod developmental stage composition has, to date, never been evaluated. In this area, there is a basin located between the Gunnerus Ridge and the continental slope off Cape Ann. Such complex bottom topography causes heterogeneous ice retreat (Massom et al., 2013) and strong upwelling of the Circumpolar Deep Water (CDW) in the basin area (Williams et al., 2010). We observed the zooplankton community and the developmental stage of the dominant copepods using a fine mesh net in this area. The aims of this study were (1) to accumulate data on zooplankton abundance and taxonomic composition using fine mesh net, and (2) to elucidate horizontal differences in zooplankton community structure in relation to environmental conditions, in particular on the occurrence of heterogeneous ice retreat in this region.

2. Materials and methods

Observations were conducted at seven stations north of Lützow-Holm Bay during the *Umitaka Maru* cruise (UM0708), from December 2007 to January 2008, as part of the 49th Japanese Antarctic Research Expedition (JARE 49). The vertical temperature and salinity profiles were determined by a CTD (SBE 911 plus, Sea-Bird Electronics). Water samples were collected for chemical and biological analysis at each depth using Niskin bottles attached to CTD rosette system. The surface mixed layer was determined according to Aoki et al. (2007). Chlorophyll *a* (Chl. *a*) concentrations in the >10, 2–10 and <2 μm fractions were determined with a fluorometer (AU-10, Turner designed Ltd.) following the methods of

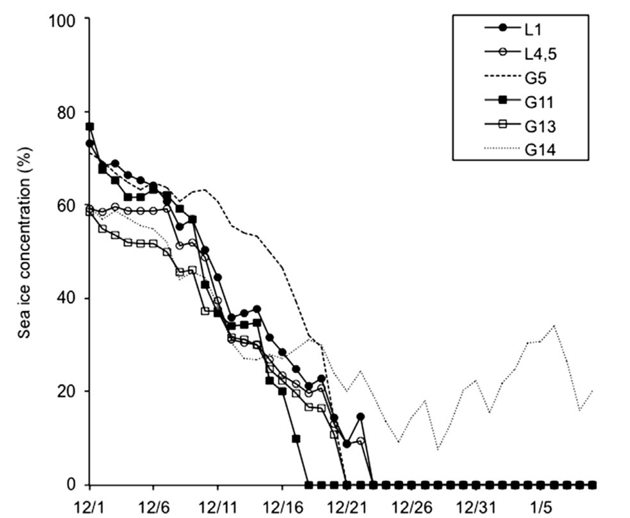

Fig. 2. Time series of daily sea ice concentration at the stations used in this study.

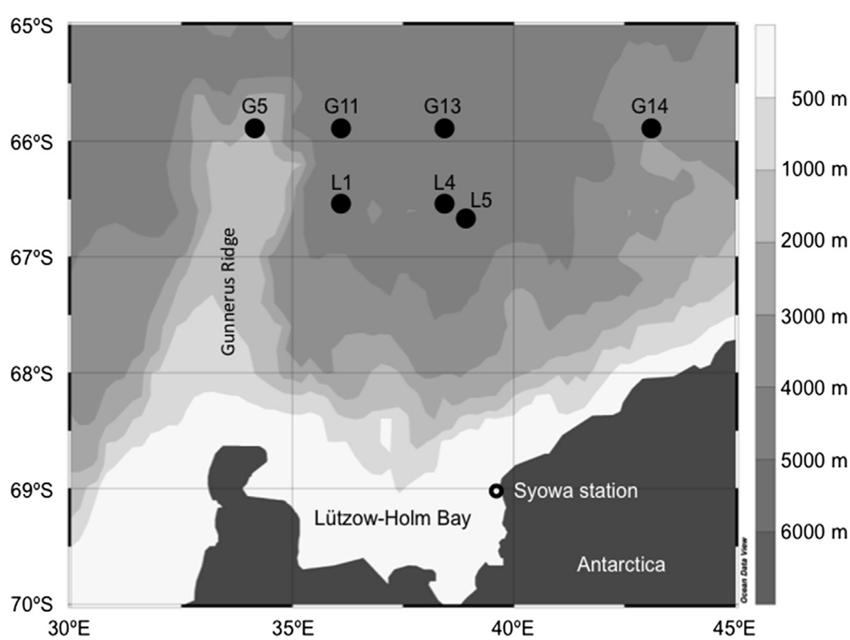

Fig. 1. Location of sampling stations off Lützow-Holm Bay.

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