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ScienceDirect
Deep-Sea Research I 54 (2007) 1025–1041
DEEP-SEA RESEARCH PART I
www.elsevier.com/locate/dsri

Microzooplankton composition, biomass and grazing rates along the WOCE SR3 line between Tasmania and Antarctica

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Received 4 July 2006; received in revised form 30 April 2007; accepted 2 May 2007
Available online 17 May 2007

Abstract

Microzooplankton species composition and grazing rates on phytoplankton were investigated along a transect between ~46 and 67°S, and between 140 and 145°E. Experiments were conducted in summer between November 2nd and December 14th in 2001. The structure of the microbial food web changed considerably along the transect and was associated with marked differences in the physical and chemical environment encountered in the different water masses and frontal regions. On average microzooplankton grazing experiments indicated that 91%, 102%, and 157%, (see results) of the phytoplankton production would be grazed in the <200, <20 and <2 μm size fractions, respectively, indicating microzooplankton grazing was potentially constraining phytoplankton populations (<200 μm) along most of the transect. Small ciliates in general and especially oligotrich species declined in importance from the relatively warm, Southern Subtropical Front waters (6.8 μg C/L) to the colder waters of the southern branch of the Polar Front (S-PF), (~0.5 μg C/L) before increasing again near the Antarctic landmass. Large changes in microzooplankton dominance were observed, with heterotrophic nanoflagellates (HNF), ciliates and larger dinoflagellates having significant biomass in different water masses. HNF were the dominant grazers when chlorophyll *a* was low in areas such as the Inter-Polar Frontal Zone (IPFZ), while in areas of elevated biomass such as the S-PF and Southern Antarctic Circumpolar Current (SACC), a mix of copepod nauplii and large heterotrophic and mixotrophic dinoflagellates tended to dominate the grazing community. In the S-PF and SACC water masses the tight coupling observed between the microzooplankton grazers and phytoplankton populations over most of the rest of the transect was relaxed. In these regions grazing was low on the >20 μm size fraction of chlorophyll *a,* which dominated the biomass, while smaller diatoms and nanoplankton in the <20 μm size fraction were still heavily grazed. The lack of grazing pressure on large phytoplankton contributes to this region's potential to export carbon with larger cells known to have higher sinking rates.

Keywords: Microzooplankton; Grazing; Dilution experiments; Biomass; Phytoplankton; Southern Ocean

1. Introduction

The Southern Ocean, because of a combination of physical (seasonal cooling and ventilation) and biological (primary production) factors, is one of

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doi:10.1016/j.dsr.2007.05.003

the largest oceanic sinks for carbon and consequently has a major influence on global climate. An important factor in determining how much carbon is removed from the upper ocean is the structure of the food web (Eppley and Peterson, 1979; Michaels and Silver, 1988; Legendre and Le Fevre, 1995).

The microbial components of the food web often dominate in Southern Ocean waters, with pico- and nano-phytoplankton frequently dominating phytoplankton biomass (Detmer and Bathmann, 1977; Laubscher et al., 1993). Although krill, copepods and salps are clearly important phytoplankton grazers in some Southern Ocean regions (Dubischar and Bathhmann, 1997), the smaller microzooplankton (protistan) grazers often emerge as the most significant (Hewes et al., 1987; Burkill et al., 1995; Becquevort, 1997; Klaas, 1997). Microzooplankton grazers are generally classified as zooplankton in the $<200\,\mu m$ size range. While there is some disagreement about this classification, it has remained a convenient way to separate smaller zooplankton such as ciliated protozoa, heterotrophic dinoflagellates, nanoflagellates, and copepod nauplii from larger grazers. It has been hypothesized that in some Antarctic waters microzooplankton grazing is a major cause of phytoplankton bloom suppression (Lancelot et al., 1993; Burkill et al., 1995; Timmermans et al., 1998). In contrast, others have reported low or unmeasurable grazing by microzooplankton at times in parts of the Southern Ocean (Caron et al., 2000). Overall, previous studies indicate that a knowledge of the structure and function of the marine microbial community especially the impact of microzooplankton grazing, is central to developing an understanding of the fixation and flux of carbon and nutrients in the Southern Ocean.

The size distribution of phytoplankton in the Southern Ocean indicates that microzooplankton grazing often maintains phytoplankton populations $<10\,\mu m$ in size at relatively low levels (Hall and Safi, 2001; Landry et al., 2001). Microzooplankton have also been reported to dominant grazing even in the presence of large diatoms. For example, the size of microzooplankton grazers during peak biomass periods is skewed toward larger forms such as *Protoperidinium* and large ciliates, which are capable of grazing large prey (Rivkin et al., 1999). With substantial potential for carbon consumption, growth and turnover, microzooplankton are also likely to play an important role in nutrient cycling (Brzezinski et al., 2001; Fennel and Neumann, 2003). Hall and Safi (2001) and Landry et al. (2002) suggest that grazer suppression of the smaller, stronger phytoplankton competitors for iron is key to the emergence of larger phytoplankton, as reported in some iron-limited Southern Ocean waters. By affecting phytoplankton size structure in this way microzooplankton grazing may have a direct effect on carbon export from surface waters.

This study, through the measurement of microzooplankton grazing and phytoplankton growth rates, aims to contrast and compare the structure of the microbial food web over a large range of oceanic zones with contrasting physical and chemical constraints. By measuring these rates along the World Ocean Circulation Experiment (WOCE) SR3 transect from ~46°S (south of Tasmania) to near the Antarctic coastal waters at ~67°S during the early summer, we wanted to characterise changes in the microbial food web in a number of different water masses, when phytoplankton growth should be near its maximum. We also aim to compare the impact of different microzooplankton grazers along this transect and to gain an insight into how effectively microzooplankton may constrain phytoplankton populations and affect phytoplankton population structure and, in turn, carbon export.

2. Methods

2.1. Field sampling

Sampling for dilution experiments was carried out at 14 stations along the SR3 transect from ~46°S, south of Tasmania, to ~67°S, off the Antarctic coast, on a voyage by the R.V. *Aurora Australis* between November 2nd and December 14th 2001 (Fig. 1). At these stations water was collected either using a 100-L snatcher bottle deployed on a Kevlar line to a depth of 15 m or using a Seabird (SBE-9 plus) CTD and rosette fitted with 24 10-L Niskin bottles. The CTD was also used to assess a variety of physical and biological variables during this voyage at a total of 135 stations along the SR3 transect. Water masses were categorised following Trull et al. (2001a), Sokolov and Rintoul (2002) and Aoki et al. (2006) based on their physical and chemical properties (Fig. 1). The water column at each station was characterised with profiles of temperature and salinity obtained from the CTD. Discrete water samples were also collected from at least 7 depths at each station using