Deep-Sea Research II 108 (2014) 60–68

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

The link between meiofauna and surface productivity in the Southern Ocean

L. Lins[a,b,*], K. Guilini[a], G. Veit-Köhler[c], F. Hauquier[a], R.M.S. Alves[a], A.M. Esteves[b], A Vanreusel[a]

[a] Marine Biology Research Group, Ghent University, Krijgslaan 281 S8, 9000 Ghent, Belgium
[b] Meiofauna Laboratory, Federal University of Pernambuco, Av. Prof Moraes Rego 1235, 50670-901, Cidade Universitária, Brazil
[c] Senckenberg am Meer, DZMB – German Centre for Marine Biodiversity Research, Südstrand 44, D-26382 Wilhelmshaven, Germany

ARTICLE INFO

Available online 20 May 2014

Keywords:
Primary productivity
POC flux
Benthic–pelagic coupling
Deep sea
Meiofauna

ABSTRACT

Particulate organic carbon (POC) export fluxes generally reflect patterns of primary production in the upper ocean, sinking to the seabed and acting as a food source for benthic organisms. Data on meiobenthic communities from two SYSTem COupling cruises (SYSTCO) in the deep Southern Ocean (RV Polarstern ANT-XXIV/2, north–south transect along the prime meridian, and ANT-XXVIII/3, east–west transect along the Polar Front) were combined with surface and benthic environmental parameters, as well as POC flux estimates based on satellite measurements. It was tested to what extent meiofaunal communities were determined by prevailing conditions of an east–west increase in net primary productivity (NPP) and bottom Chlorophyll *a* (Chla) concentration, and a westwards, divergently decreasing estimated POC flux. Nematodes dominated the meiofauna (84.4–92.4%) and occurred with a westward increase in relative abundance and density for the ANT-XXVIII/3 stations, associated with a parallel increase in NPP and Chla. Nematode biomass was negatively correlated to the estimated POC flux. Along the north–south transect no significant correlation was found but higher estimated POC fluxes at stations south of the Polar Front were associated with higher meiofauna diversity and density at higher taxon level, while stations located at the Polar Front, which were associated with lower POC fluxes, contained communities with lower diversity and density.

1. Introduction

Surface-water productivity in the Southern Ocean (SO) is largely determined by the unique environmental features of this region. The SO consists of water masses south of the Polar Front (PF), which marks the northern extent of low salinity and cold water (Knox, 1994). Due to its vastness, the SO plays an important role in the global ocean circulation system and possesses the fastest surface ocean current in the world, the Antarctic Circumpolar Current (Griffiths, 2010). The SO receives low terrestrial input and its prevailing flow of energy is defined by phytoplankton surface productivity, followed by sinking and breakdown in the pelagic and benthic microbial loop (Griffiths, 2010; Rowe et al., 2008 and references therein). Nevertheless, benthic–pelagic coupling is strongly influenced by the high seasonality of primary production resulting in rather low resource availability during most parts of the year (Gooday, 2002; Peck et al., 2006). Surface primary production, together with varying water depth, current regimes and seasonal ice coverage over large parts of the SO, lead to complex interactions with the benthos, the richest element of the food web in terms of number of species (Griffiths, 2010; Gutzmann et al., 2004; Peck et al., 2006).

Export fluxes of particulate organic matter (POM) through the vertical water column frequently reflect general patterns of primary production (Lutz et al., 2002) and are considered an important process for the benthic–pelagic coupling, as most of the POM consists of labile carbon compounds (Sachs et al., 2009). However, the transport of POM to the deep sea is considered relatively inefficient, with only about 1% to 3% of the primary production reaching the deep seabed and the rest being broken down on its way to the bottom (Lutz et al., 2002). Numerous variables determine the intensity of these export fluxes, including photosynthetic production, zooplankton grazing, oxidative depth-dependent remineralization rates and water depth (Lutz et al., 2002). In addition, sea-ice formation and lateral advection linked mainly to the Antarctic Circumpolar Current may regulate primary

* Corresponding author at: Marine Biology Research Group, Ghent University, Krijgslaan 281 S8, 9000 Ghent, Belgium. Tel.: +32 9 264 8531.
E-mail address: lidia.linspereira@ugent.be (L. Lins).

http://dx.doi.org/10.1016/j.dsr2.2014.05.003
0967-0645/

production and shape the fate of surface-produced organic matter in the SO (Griffiths, 2010). Seasonal sea ice has been suggested to be an important environment for sea-ice algal photosynthesis, providing suitable light and nutrient levels, as well as contributing to organic carbon export to the deep sea, favoring benthic organisms' establishment (Brandt and Ebbe, 2009; Brandt et al., 2011; Guilini et al., 2013; Sachs et al., 2009; Vancoppenolle et al., 2013; Veit-Köhler et al., 2013).

Observed worldwide declines in standing stocks with depth are generally attributed to a decrease in food availability (e.g. POC flux, Rex et al., 2006), although other factors such as predation, competition and/or life history traits may also play a role (Ramirez-Llodra et al., 2010; Soetaert et al., 2002). A few studies report on the link between surface primary production and benthic communities in the SO. Some of them have highlighted the relationship between surface primary producers and standing stocks (i.e. abundance and biomass) of meiofauna and nematodes, but these studies are mainly restricted to shallow waters (Vanhove et al., 2000). Wei et al. (2010) used models to predict which factor contributed most to benthic–pelagic coupling worldwide. Shallow-water as well as deep-sea communities were found to be positively linked to surface primary productivity and particulate organic carbon (POC) flux. Two recent papers compared the fatty acid composition of deep-sea nematodes to that of the sediment (Guilini et al., 2013) and studied the short-term response of nematode community structure to a natural phytodetritus pulse (Veit-Köhler et al., 2011). Both studies suggested a fresh phytodetritus diet based on (1) the relatively high proportion of fatty acids indicative for plankton detritus in nematodes and (2) a vertical movement in the sediment towards surface layers as a response to food input. No studies in the SO, however, integrated seasonally-based surface primary production or estimated POC flux data with meiofauna standing stocks and seafloor labile organic matter in order to link responses between those variables. Estimated POC fluxes reflect primary productivity processes and might be a better predictor than net primary productivity (NPP). Together with sediment Chlorophyll *a* (Chla), estimated POC fluxes can reflect how much labile organic matter reaches the deep seabed, since the algorithm takes into account both NPP and water depth. Metazoan meiofauna provide a good tool for studying standing stock patterns in the SO deep sea relative to surface productivity mainly due to their omnipresence and low mobility. Among the meiofaunal groups, nematodes usually dominate both in abundance and biomass, occurring frequently in percentages higher than 90% (Giere, 2009).

In order to assess differences in meiofauna standing stocks (i.e. density and biomass) according to different surface-water productivity regimes in the SO, we integrated data from two sampling campaigns along a north–south (N–S) and an east–west (E–W) transect in the Atlantic part of the Southern ocean covering different water depths to test the following hypotheses:

1) Meiofauna standing stocks in the SO are related to surface primary productivity.
2) Estimated POC fluxes and environmental sea-floor labile organic matter (depth-related variables) determine small-scale patterns of meiofauna standing stocks.

2. Material and methods

2.1. Study area and sampling procedure

During the RV Polarstern ANT-XXIV/2 (28.11.2007–04.02.2008) and ANT-XXVIII/3 (07.01.2012–07.03.2012) cruises (Bathmann and Herrmann, 2010; Wolf-Gladrow, 2013) to the SO, samples from deep-sea sediments were collected in the framework of ANDEEP-SYSTCO and SYSTCO II projects, respectively. The study area comprises of nine stations distributed along a N–S (Prime Meridian between 49°S and 70°S) and an E–W (between 10°E and 39°W) transect, covering depths ranging from 1935 m to 5323 m (Fig. 1 and Table 1). Samples for the ANT-XXVIII/3 campaign comprised both spatially different stations as well as one station which was sampled before and after an eddy (Eddy Pump project) event (Table 1). Eddy Pump was a parallel project which intended to identify eddy structures between 50° and 60°S, where the upwelled deep-water masses interact with the atmosphere, in order to study the effect of circulation and carbon pumps. Sampling was conducted using a Multicorer (MUC) equipped with 12 plexiglass cores to retrieve virtually undisturbed sediment cores. During the ANT-XXIV/2 campaign (henceforth referred to as NS-2007/8) the inner core diameter was 9.4 cm (equivalent to 69.4 cm^2 cross-sectional surface area) while for the ANT-XXVIII/3 (EW-2012) campaign it was 6 cm (25.5 cm^2 cross-sectional surface area).

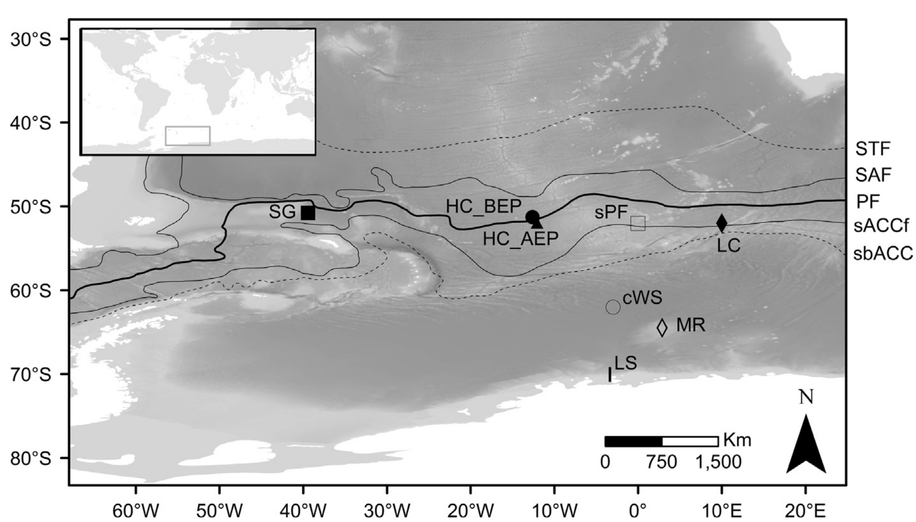

Fig. 1. Location of ANT-XXIV/2 and ANT-XXVIII/3 stations. Exact coordinates are given in Table 1. The map displays features of the Antarctic Circumpolar Current (Orsi and Harris, 2001): Subtropical Front (STF), Subantarctic Front (SAF), Polar Front (PF), southern Antarctic Circumpolar Current Front (sACCf) and southern boundary of the Antarctic Circumpolar Current (sbACC). Bathymetry data provided by ETOPO1 and world boundaries by ESRI (Amante and Eakins, 2009). Sampling stations are represented by symbols: SG (South Georgia), HC_BEP (High Chlorophyll before Eddy Pump), HC_AEP (High Clorophyll after Eddy Pump), sPF (South Polar Front), LC (Low Clorophyll), cWS (central Wedell Sea), MR (Maud Rise) and LS (Lazarev Sea).