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Influence of oceanographic features on the spatial and seasonal patterns of mesozooplankton in the southern Patagonian shelf (Argentina, SW Atlantic)

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ABSTRACT

Surveys conducted during spring, summer and late winter in 2005–2006 over the southern Patagonian shelf have allowed the seasonal distribution of mesozooplankton communities in relation to water masses and circulation to be investigated. In this system, most of the shelf is dominated by a distinct low salinity plume that is related to the runoff from the Magellan Strait (MSW), while the outer shelf is highly influenced by the cold and salty Subantarctic water (SAW) of the boundary Malvinas Current. Separating these two, the Subantarctic Shelf water mass (SASW) extends over the middle shelf. Correspondingly, the structure of the MSW and SAW mesozooplankton communities was found to be clearly different, while the former and the SASW assemblages were barely separable. This relatively fresh water mass is actually a variant of Subantarctic water that enters into the region from the south and the shelf-break, and hence its mesozooplankton community was not significantly different from that of the SAW water mass. Dissimilar species abundance, in turn associated with different life histories and population development, was more important than species composition in defining the assemblages. Total mesozooplankton abundance increased about 2.5-fold from the beginning of spring to late summer, and then decreased at least two orders of magnitude in winter. Across all seasons copepods represented >70–80% of total mesozooplankton over most of the shelf. Copepod species best represented through all seasons, in terms of both relative abundance and occurrence, were *Drepanopus forcipatus* and *Oithona helgolandica*. Although seasonal differences in abundance were striking, the spatial distribution of mesozooplankton was largely similar across seasons, with relatively higher concentrations occurring mainly in Grande Bay and surroundings. The well defined spatial patterns of mesozooplankton that appear from our results in conjunction with the southward wide extension of the shelf and the predicted current path and speed suggest that plankton production is locally enhanced in the Grande Bay area and has the potential to be exported downstream.

1. Introduction

The recognition of planktonic biogeographic patterns in the ocean and the mechanisms responsible for their establishment and maintenance can provide significant insights about the configuration and variability of communities (e.g., Brinton, 1962; Frost, 1989; Ohman et al., 2012). Ocean water masses represent specific habitats for pelagic organisms, their characteristics mostly defining the niche of plankton communities either directly or indirectly, by conditioning preferred depths, food availability, feeding modes, etc. Boundaries between water masses are characterized by dynamic oceanographic fronts, physical interfaces which play a role in regulating the spatial and temporal variations in the plankton diversity and productivity patterns (Le Fèvre, 1986). Determining where biogeographic boundaries exist is therefore a necessary step to understanding the processes that underlay the patterns. At the same time, large scale studies of changes occurring in the ocean, due to climate change or anthropogenic effects, are mostly performed running biogeochemical models (e.g., Aumont et al., 2015). These models are built based on the, so far, limited knowledge on the ecosystem components and processes. Hence, studies of community structure, trophic relations and niche adaptation to the environment are crucial to develop more realistic biogeochemical models.

Extending from Cape Blanco (~47°S) to Burdwood Bank (~55°S) in the Southwestern Atlantic, the wide southern Patagonian shelf (Fig. 1)

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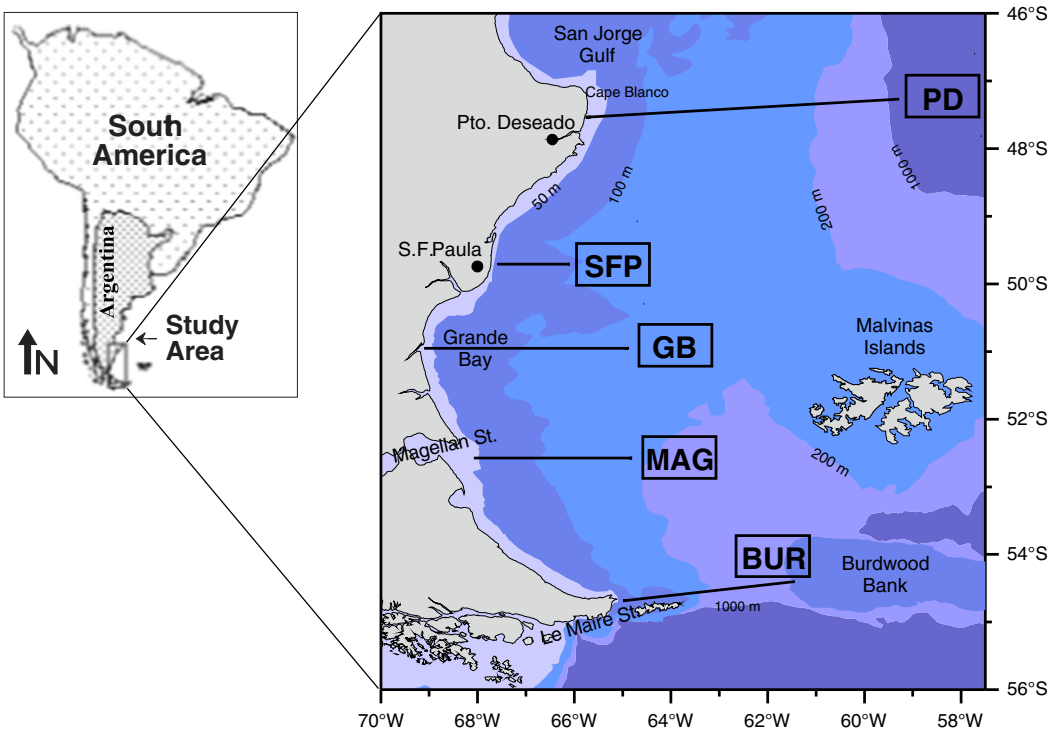

Fig. 1. Location of sampling transects across the southern Patagonian shelf during early spring (October 2005, GEF 01), late summer (March 2006, GEF 02) and late winter (September 2006, GEF 03). PD, Puerto Deseado; SFP, San Francisco de Paula; GB, Grande Bay; MAG, Magellan Strait; and BUR, Burdwood Bank.

sustains a highly productive ecosystem (Lutz et al., 2010; Segura et al., 2013; Dogliotti et al., 2014). Zooplanktivorous taxa are dominant at intermediate levels of the food web (Ciancio et al., 2008; Padovani et al., 2012) and mesozooplankton, in turn preying on smaller plankton, is therefore a key trophic component (Sabatini and Álvarez Colombo, 2001; Sabatini et al., 2004, 2012; Antacli et al., 2014a,b).

The hydrographic structure of this region has been described extensively from historical observations (Guerrero and Piola, 1997; Bianchi et al., 1982, 2005) and numerical simulations indicate a strong influence of circulation on the spatial distribution of water properties (Palma et al., 2008). Three water masses primarily defined by salinity reflect the dominant circulation patterns, i.e., Magellan Strait water (MSW), Subantarctic shelf water (SASW) and Subantarctic water (SAW). Local circulation is driven by large freshwater inflows, high tidal amplitudes, westerly winds and the strong influence of the Malvinas Current flowing northwards along the shelf-break (Palma et al., 2008; Matano et al., 2010; Palma and Matano, 2012). The contrast between the MSW with the SASW generates the Magellan salinity front, a middle shelf front that extends parallel to shore along most of the study area. The sharpest horizontal gradient of salinity occurs offshore and corresponds to the shelf-break front, which forms from the contrast of SASW with cold and dense SAW. Small tidal, estuarine-plume fronts related to freshwater discharges onto the shelf are also present at short distance from shore (Sabatini et al., 2004). Frontal dynamical interaction generates a cross-shelf circulation that is probably related to the inflow of nutrient-rich waters from offshore. This enrichment mechanism may be essential for the productivity of the inner and middle shelf system (Matano et al., 2010).

Given the importance of salinity in determining the structure and distribution of water masses in the region, it is worth considering that the effects of global warming on Patagonia temperature are predicted to be larger than the global mean (IPCC, 2014) and glaciers, which are a major source of freshwater into the ocean, are melting fast (Rignot et al., 2003; Schneider et al., 2007). Projections suggest also a rise in annual rainfall (IPCC, 2014), and surface runoff is anticipated to intensify as consequence of increasing drainage of continental rivers along the coast of southern Patagonian (Pasquini and Depetris, 2007). These circumstances emphasize the significance of studies focused on plankton-hydrographic linkages in the region, which is besides geographically and oceanographically connected with the southeastern Pacific and Southern Ocean (Lara et al., 2010; Matano et al., 2010).

Previous work in the study area has been mostly restricted to summer/fall and thus little is known about the seasonality of zooplankton communities. After the pioneering surveys conducted in the late 70s over the entire Argentine Sea which covered roughly an annual cycle (e.g., Carreto et al., 1981; Ramírez, 1981) and the overall patterns of zooplankton biomass described earlier by Sabatini and Álvarez Colombo (2001), this is actually the first time that seasonal data on the southern Patagonian shelf are reported from cruises carried out during spring, summer and late winter in 2005–2006.

Results from the first of these cruises showed that the spatial patterns of mesozooplankton in early spring were distinctly defined across-shelf, with typical communities that mirrored the distribution of water masses and fronts to a significant degree (Sabatini et al., 2012). After these findings, it was suggested that the distribution of mesozooplankton assemblages in waters off southern Patagonia was likely determined by niche adaptation. To investigate this hypothesis, here we used multivariate analysis to determine the distribution patterns of mesozooplankton during the three sampling periods, and examined on the seasonal scale whether the community structure is related to the typical water masses of the southern Patagonian shelf. Present results will further contribute with baseline information regarding the seasonality of zooplankton dynamics in relation to hydrography before major environmental changes may take place in the region.

2. Material and methods

2.1. Sampling

Mesozooplankton communities were investigated during three surveys conducted to the southern Patagonian shelf (47°–55°S) in early spring (GEF 01, October 2005), late summer (GEF 02, March