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Carbon fluxes within the epipelagic zone of the Humboldt Current System off Chile: The significance of euphausiids and diatoms as key functional groups for the biological pump

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ABSTRACT

The information from 54 drifting sediment traps deployed between 1997 and 2006 along the Humboldt Current System off Chile (from 19.9°S to 42.2°S) was analyzed to contribute to unveiling the recurrent global-ocean issue of the lack of relationship between gross primary production (GPP) and particulate organic carbon (POC) export below 50 m depth.

When the proportion of carbon that effectively sinks is relatively low compared to the carbon being fixed through GPP, a significant amount (average of 32%) of the sinking organic matter is composed of diatoms, regardless of GPP rates. Such a fraction seems to be affected by the physiological state of phytoplankton. In contrast, when the fraction of carbon sinking is high relative to GPP, most of sinking organic matter is composed of euphausid faecal strings. Such a situation occurs at relatively low values of GPP and chlorophyll-a. Most of these high sinking rates of pellets and low phytoplankton biomass occur during summer, when physical conditions favour the presence of phytoplankton blooms, and when the GPP/Biomass ratio indicates healthy phytoplankton physiological conditions. All this evidence supports the assessment of the relevance of euphausiids as key species in the Humboldt Current System pointing to (i) the top–down control that euphausiids are capable of exerting over primary producer biomass, and (ii) euphausiids' paramount role on total organic carbon flux over the Concepción continental shelf, regarding both POC export to the sediments and possibly the channelling of GPP directly to higher trophic levels.

1. Introduction

The Humboldt Current System (HCS) off Chile is one of the most productive areas ever recorded (Daneri et al., 2000). The underlying factors encompassing such high primary production (PP) are diverse, but the continuous (northern area: 20–30°S) and seasonal (central-southern area: 30–40°S) fertilization of surface waters due to upwelling events seems to be partially the cause. The importance of the continental margins in the carbon export (*sensu* biological pump concept) is widely recognized (Walsh, 1991; Liu et al., 2000). However, in the vast area covered by the HCS, little information on the functioning of the biological pump is available and it is restricted to specific upwelling centers in the central (Grünewald et al., 2002; González et al., 2007) and northern (González et al., 2004; Pantoja et al., 2004) HCS.

Traditionally, a positive relationship between primary production (PP) and particulate organic carbon (POC) flux has been assumed in both biogeochemical cycling and global climate change models (Berelson, 2001). However, the usefulness of such models is strongly limited by the varying natural complexity of the processes involved (reviewed by Boyd and Trull, 2007; Buesseler et al., 2007; De La Rocha and Passow, 2007). High PP in the upper productive layer would enhance the carbon export due to diatom aggregation and sinking after the bloom and/or faecal pellet production and export due to zooplankton grazing. The organic carbon export mediated by these processes might be enhanced when refractory and dense mineral ballast provided by mineral skeletons

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