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Changes of macrobenthos composition under different ENSO cycle conditions on the continental shelf off central Chile

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Abstract

The course of environmental conditions and shelf macrobenthic communities off Central Chile (~36°S) during the strong 1997–98 El Niño (EN) event is compared with a subsequent and basically "normal" period (2002–2003). Changes in macrofaunal community, feeding mode structure, and biomass size spectra are contrasted over time with changes in oceanographic and sediment settings, in order to assess intra- and inter-annual changes in faunal composition during both ENSO periods.

During EN, there was a decrease in biomass and abundance of species known to be well adapted to organic-rich, oxygen-deficient environments, such as the interface-feeding polychaete *Paraprionospio pinnata*. On the other hand the abundance of highly mobile, burrowing polychaetes remained unaffected, or even increased in biomass. The decline of *P. pinnata* lasted several years after the demise of warm conditions, possibly due to negative interactions with those more mobile burrowing polychaetes. The percent contribution of subsurface-deposit feeders to total biomass increased during EN (49.3 ± 12.4% during summer) and declined only in the summer-fall period of 2002–03 (11.1 ± 4.1%). An opposite trend was observed for interface and surface-deposit feeders. From EN to summer-fall 2002–03 (i.e., normal to low oxygen conditions) the size-structure of the macrobenthos switched from a larger to a smaller-sized assemblage. However, biomass was maintained due to successful recruitment and high abundance of both *P. pinnata* and the squat lobster, *Pleuroncodes monodon*.

Our results suggest that the shelf macrofaunal community structure exhibit fluctuations at various time scales, and that these changes are more pronounced during and after a strong EN event. In such cases, the effects of such an event may be recorded at latitudes as far south as 36°S, with consequences in the biota lasting for many years after the demise of warm conditions.

Keywords: Macrobenthos; Feeding modes; Deposit-feeders; Biomass size spectra; ENSO; Central Chile

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1. Introduction

The coastal zone off central Chile (~36°S), strongly influenced by seasonal wind-driven upwelling, is one of the areas with the highest known primary production rates worldwide (Fossing et al., 1995; Daneri et al., 2000). Furthermore, a pronounced oxygen minimum zone (OMZ), located at depths between 50 and 250 m and associated with the Equatorial Subsurface Water (ESSW), partially covers the continental shelf. When upwelling prevails during summer, the OMZ can be found only a few meters from the surface within Concepción Bay (Ahumada et al., 1983). As a result, high accumulation rates of undegraded organic carbon occur (Muñoz et al., 2004a).

A peculiarity of the biota thriving in these organic-rich sediments is indicated by the presence of an important prokariotic community, mostly composed of the filamentous, gliding bacteria *Thioploca* spp., which sometimes has greater biomass than the eukaryotic fauna (Gallardo, 1977; Schulz et al., 2000). The metazoan fauna is small (body sizes < 1.0 mm); dominated both in biomass and abundance by polychaetes, while other groups like mollusks, crustaceans and cnidarians are unusual (Gallardo, 1985; Gallardo et al., 1995). Meiofauna is abundant and dominated by nematodes (Sellanes et al., 2003). It has been also reported that during non-El Niño years, the benthic fauna attains their maximum abundance and biomass during fall and winter, probably due to favorable environmental conditions (i.e., absence of hypoxic bottom waters, less reduced sediments) (Carrasco and Arcos, 1984).

Studies indicate that most of the more abundant polychaete species are well adapted to cope with oxygen-deficient conditions, by having enzymatic mechanisms related with anaerobic pathways (González and Quiñones, 2000); among them, *Paraprionospio pinnata* and *Nephtys ferruginea* are the best adapted. These two species displayed high activities of four pyruvate oxidoreductases, suggesting a high metabolic plasticity to thrive even in anoxic conditions. Consistently, *P. pinnata* is the dominant species among the eukaryotic benthos in the study area (Gallardo et al., 1972, 1995; Carrasco and Carbajal, 1998; Gutiérrez et al., 2000).

Continental shelf benthic communities are often strongly influenced by El Niño (EN), the warm phase of the ENSO cycle, in the Eastern Pacific (Tomicic, 1985; Arntz and Fahrbach, 1996). Off central Chile, seasonal and inter-annual changes in upwelling intensity can lead to changes in bottom-water dissolved oxygen (DO) concentration, in the amount of organic matter reaching the bottom (Gutiérrez et al., 2000), in the quality and lability of deposited organic matter (Neira et al., 2001a; Sellanes and Neira, 2006), and in the sediment nitrogen fluxes (Muñoz et al., 2004b). It is known that the impacts of EN on environmental conditions may last from a few months to several years (Gallardo, 1985; Tarazona et al., 1996). However, very little is known about its effects on benthic communities beyond 23°S (i.e., Antofagasta, Chile), which usually has been considered the southern limit of the most impacted area by strong EN events (Arntz et al., 1991).

During the last strong EN event (1997–98), we learned that at the shelf the most noticeable effects of EN on the macroinfauna were a switch in their composition, the deepening of its distribution within the sediment and an increase in their bioturbation potential, associated with a decrease of the sediment organic matter reactivity (Gutiérrez, 2000; Gutiérrez et al., 2000). However, these studies were carried out during the event, and no comparison was made with non-EN conditions. In the present paper, we fill this gap by comparing macrofaunal community response to changing environmental conditions during two key phases of the ENSO cycle: a warm (EN) phase and a subsequent non-EN phase. The EN phase is the period May 1997–March 1998, one of the strongest warm events of the last decades (Mc Phaden, 1999), and the non-EN phase was the period April 2002–June 2003. In both phases, we examine the structure of the benthic macrofauna, in terms of composition, density, biomass size-spectra, and feeding modes, with the aim to link it with seasonal- and ENSO-related variability of the water column and sediment habitat conditions. Sampling was carried out at a site representing typical shelf conditions for central Chile (i.e., a site where under "normal" conditions, higher fluxes of phytodetritus from the water column to the seafloor occur during summer, and hypoxic bottom water occurs year round). We also identified key species structuring the macrobenthic community, which in turn, may serve as indicators of the prevalent ENSO cycle phase.

We test the hypotheses that (i) EN conditions trigger community changes due to disturbances in the annual oxygen and organic matter flux regime, favoring the dominance of larger-bodied, burrowing organisms instead of smaller-bodied, tube-dwelling