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Polychaete response to fresh food supply at organically enriched coastal sites: Repercussion on bioturbation potential and trophic structure

N. Venturini [a,b,*], A.M.S. Pires-Vanin [a], M. Salhi [b], M. Bessonart [b], P. Muniz [b]

[a] Instituto Oceanográfico da Universidade de São Paulo (IOUSP), Praça do Oceanográfico 191, Cidade Universitária, 05508900, São Paulo, SP, Brazil
[b] Facultad de Ciencias, Universidad de la República, Iguá 4225, 11400, Montevideo, Uruguay

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ABSTRACT

We investigated the vertical distribution, abundance, specific and functional structure of polychaete assemblages at four organically enriched sites. The effects of fresh organic matter input from the water column driving by upwelling were evaluated. Temperature and salinity values indicate the intrusion of South Atlantic Central Water (SACW) in spring, a nutrient-rich water mass. The dominance of the conveyor belt transport (CONV) in the station influenced by SACW, in the spring survey, is associated with fresh organic matter input as indicated by higher amounts of polyunsaturated fatty acids. Conversely, the predominance of the diffusive mixing (DIFF) bioturbation category, in the sites without SACW influence is related to the preferential accumulation of more refractive food resources as indicated by higher concentrations of short chain saturated fatty acids. At the site influenced by SACW, the changes in polychaete assemblages were not all evident during proceeding upwelling conditions, but may persist at the end of the upwelling. Polychaetes in the study area seemed to be limited by the quality but not the quantity of food. The delay in polychaete response to fresh food supply may be related to the organic enrichment and the prevalence of refractory material in the sediments.

1. Introduction

The functioning of the benthic compartment is essential for the whole ecosystem. Organic substances present in bottom sediments represent the main energy source for benthic organisms. Temporal and spatial variations in the quantity and quality of organic detritus that attain sediment surface can have strong influence on the distribution and metabolism of benthic organisms and on the dynamic of benthic processes (Pearson, 2001). Benthic organisms receive detritus of continental and planktonic origin, as food items they transmit energy to high levels of the trophic web, and also, by their activity they contribute to the recycling of nutrients taking part in biogeochemical cycles (Duineveld et al., 1997).

Mean size of sediment particles, silt and clay contents, sediment stability, dissolved oxygen concentration and organic content are conventionally known as structuring factors of benthic communities in subtidal unconsolidated substrates (Snelgrove and Butman, 1994). Besides, food availability and biological interactions such as predation and competition influence their specific composition and functional structure (Roth and Wilson, 1998). Nevertheless, once established a benthic community is able to change local geochemical conditions through the reworking of sediment particles during feeding, excretion and locomotion of organisms within and through different sediment layers (Flach and Heip, 1996). Particularly, in coastal marine environments where the overlying water is oxygenated, the activity of benthic fauna capable of bioturbation is recognized to influence the composition of organic matter (Aller, 1982; Kristensen and Holmer, 2001).

Benthic responses to variable organic loads are well established (Diaz and Rosenberg, 1995; Gray et al., 2002; Hyland et al., 2005; Pearson and Rosenberg, 1978, among others). In contrast, the impact of the quality of the organic material on the composition and functional structure of benthic communities is not fully understood (Wieking and Kröncke, 2005). One reason for this is that the effects of sinking detritus on macrobenthic communities differ widely among habitats, depth and locations. Also, they would vary depending on concentration, timing of release and background organic content of sediments before the input (Quijón et al., 2008). Another reason is the intrinsic relativity in defining organic matter quality due to its heterogeneous composition (Hedges et al., 1988). A universal definition of the quality of organic matter does not exist, and several compounds or compound classes have been used as indicators of its sources and maturity degree in suspended material, as well as, in the sediments (Cowie et al., 1992). In particular, fatty acids (FA) have been regularly used in geochemical studies for determining the source, transformations and the fate of organic material in marine sediments because of their good potential of preservation and great structural diversity, coupled with a high biological specificity (Budge

* Corresponding author at: Oceanología, IECA, Facultad de Ciencias, Iguá 4225, 11400, Montevideo, Uruguay. Tel.: +598 2525 8618; fax: +598 2525 8617.
E-mail address: rulo@fcien.edu.uy (N. Venturini).

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and Parrish, 1998; Carrie et al., 1998; Dunn et al., 2008; Zimmerman and Canuel, 2001).

In highly dynamic coastal environments, effects of food pulses on macrobenthic populations are difficult to demonstrate due to the great spatial variability of the sedimentological environment, sources, quality and concentration of organic matter, and also, in macrofaunal abundance and community complexity (Kelaher and Levinton, 2003; Wieking and Kröncke, 2005). To date few studies have focused on the response of macrofauna to the input of fresh food in shallow-water environments (Quijón et al., 2008 and references therein). Less effort has been done to relate the vertical distribution, bioturbation potential and the trophic structure of macrofauna to in situ organic matter profiles both in coastal (Dauwe et al., 1998), shelf (Weissberger et al., 2008) and deep-sea sediments (Witte, 2000). Most studies have been developed under controlled laboratory conditions mimicking the pulse of fresh food to sediments and considering single species of macrofauna (Bianchi, 1988; Ingalls et al., 2000), multispecies assemblages (Waldbusser et al., 2004) or the whole community (Grossi et al., 2003; Josefson et al., 2002). These types of works are useful for the understanding of biological influence on early diagenetic process, however, they represent a simplification of the reality so they should be complemented with in situ experiments and field studies. Polychaetes frequently constitute the dominant group of soft-bottom benthic macrofauna. Due to their wide range of feeding forms and life styles polychaetes promote intense effects on the biogeochemistry of sediments being some of them considered as keystone species for the functioning of coastal marine environments (Waldbusser et al., 2004). For these reasons, they represent an appropriate proxy for macrobenthic distributional and functional studies, at least when they constitute the dominant component of macrofauna.

This investigation aimed: 1) to assess the vertical distribution, specific and functional structure, and also the bioturbation potential of polychaete assemblages at four organically enriched sites during upwelling and non-upwelling conditions; 2) to evaluate the effects of fresh food input from the water column on polychaetes' functional structure and bioturbation potential comparing them in upwelling and non-upwelling conditions; 3) to assess based on fatty acid classes, particulate organic matter quality and the relative contribution of different sources of organic matter to the detritus pool. The hypothesis is that polychaete assemblages will differ in the two oceanographic conditions due to changes associated with food quality variation. As the four sites are organically enriched, we expect a major change in the structure of polychaete communities at those sites where the influence of the upwelling is strong.

2. Material and methods

2.1. Study area and description of the sampling stations

The study was conducted in the São Sebastião Channel (23° 30′ to 24° 00′ S; 45° 05′ to 45° 30′ W) located on the northern coast of São Paulo State, which is situated on the SE Brazilian coast (Fig. 1). The 25 km long channel separates the São Sebastião Island from the continent forming a well-sheltered area. The southern and northern entrances to the channel are about 7 and 6 km wide, respectively, being the middle portion the narrowest (~2 km) and the deepest (40 m) one. In the northern region of the São Sebastião Channel the occurrence of a counterclockwise vortex promotes the transport of fine sediments to the south. This fine material is deposited at the continental margin with a lower hydrodynamic energy than the erosive island margin (Furtado et al., 1998).

Wind-driven circulation is intense in the channel having surface currents of a mean speed up to 0.5 m s^{-1}. Prevailing water current direction is to NE, except in summer when there is a two-layer water flow with surface currents directed to the SW, whereas deep currents keep the NE direction. This change in circulation pattern is associated with the intrusion of the South Atlantic Central Water (SACW) during the spring–summer period (Fontes, 1995). Three water masses influenced the SE Brazilian coast: the Tropical water (TW, T>20 °C;

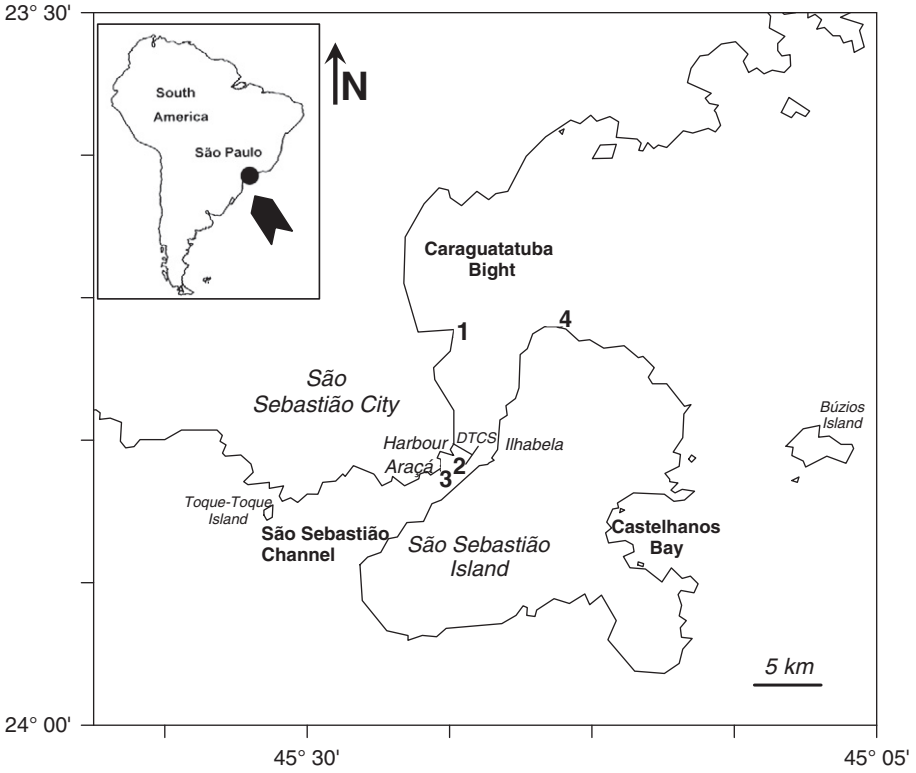

Fig. 1. Map of the São Sebastião area with the location of the four studied sites. DTCS = indicates the oil terminal; Harbour = corresponds to the São Sebastião Harbour and Araçá = indicates the position of the sewage pipe.