



Temporal variation of polychaete assemblages and their bioturbation potential in subtidal sedimentary bottoms

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ABSTRACT

Temporal variation patterns and bioturbatory activity of polychaete assemblages have been insufficiently studied. Two subtidal fine-sediment sites have been sampled in order to describe and compare polychaete temporal variation patterns. In order to estimate bioturbation potential (BP), a new approach is proposed that aims maximum versatility for comparative studies. Both assemblages differed significantly in terms of temporal variation of sedimentary and faunal attributes. The most exposed site was dominated by species characteristic of muddy-fine sand and presented a seasonal pattern with higher densities and BP values from mid-summer to early winter. The most sheltered and muddy site was dominated by *Paradoneis lyra* and presented an irregular temporal variation. Signs of moderate organic enrichment were found, particularly in the less exposed site. Spatial and temporal variations appear to be related to sediment features and hydrodynamic stress, which also affect BP of each assemblage. Our results suggest that the bioturbatory activity of polychaetes is more extensive and relevant in finer sediments.

1. Introduction

Polychaete annelids are among the most important taxa in marine soft-bottom benthic communities (Fauchald and Jumars, 1979). For instance, they are commonly the dominant taxonomic group, in terms of both density and species richness, in muddy bottoms of the NE Atlantic (e.g. Bachelet et al., 1996; Barrio Froján et al., 2012; Buchanan et al., 1978; López-Jamar, 1978; Martins et al., 2013). Spatial distribution of polychaete assemblages in shallow soft bottoms is mainly controlled by the hydrodynamism and the type of substratum (Simboura et al., 2000). The temporal variation patterns of such assemblages are less thoroughly studied but, in general, temporal variation is known to be significant at different scales (Morrisey et al., 1992); this is closely related to the species life cycles (Boero, 1994; Constable, 1999; López-Jamar and Parra, 1997) and their biotic interactions (Buchanan et al., 1986; Posey, 1990; Rhoads and Young, 1970), but also to changes in environmental factors, particularly sediment features (Buchanan and Moore, 1986; Dauvin and Ibanez, 1986). On the other hand, high dominances of some polychaetes have been frequently associated to anthropogenic organic enrichment (e.g. Pearson, 1975; Pearson and Rosenberg, 1978; Grall and Chauvaud, 2002), though it has been observed that such dominances may also respond to natural

supply of organic matter (Rodríguez-Villanueva et al., 2003).

Polychaetes play important roles in the functioning of soft-bottom benthic ecosystems (van der Linden et al., 2017), acting as ecosystem engineers that may influence the hydrodynamic conditions in the bottom-water interface (Alves et al., 2017), the composition of the benthic community (Zühlke, 2001) and even the distribution of juvenile fishes (Ryer et al., 2013). Polychaete bioturbatory activities are particularly relevant because they have significant effects on the structure of associated fauna (Braeckman et al., 2014b; Eklöf et al., 2015), the survival of juveniles of other species (Whitton et al., 2016) and biogeochemical processes such as nutrient cycling (Maximov et al., 2015), having the ability to act as drivers of meaningful processes such as hypoxia mitigation (Norkko et al., 2012).

The term bioturbation has been inconsistently used along scientific literature, but some consensus has been recently achieved around the definition by Kristensen et al. (2012), which states that bioturbation in aquatic environments includes all transport processes carried out by animals that directly or indirectly affect sediment matrices, including both particle reworking and burrow ventilation. Bioturbation is a key component of benthic-pelagic coupling (Queirós et al., 2015) that may influence the composition and structure of benthic infaunal communities (Kanaya, 2014; Widdicombe and Austen, 1999), sediment

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granulometry (Montserrat et al., 2009), patterns of sediment suspension and transport (Nasermoaddeli et al., in press), chemical gradients within the sediment (e.g. Pischedda et al., 2008; Stahl et al., 2006) or biogeochemical cycles (e.g. Braeckman et al., 2014a; Douglas et al., 2017; Mermillod-Blondin et al., 2005); some of these influences are partly mediated by its effect on the composition and structure of bacterial and archaeal communities (Foshtomi et al., 2015).

Considering its ecological relevance, measuring or estimating bioturbation is of great interest for the study of benthic ecosystems functioning. On one hand, bioturbation metrics focus on the direct measure of the extent of bioturbation within the sediment matrix, bioturbation depth and the biodiffusion coefficient (D_b) being the most widely used examples, usually under experimental conditions (Queirós et al., 2015). On the other hand, bioturbation potential (BP) indexes are based on the composition and structure of benthic communities, considering particular biological traits of the fauna, to estimate their level of bioturbatory impact on the ecosystem. One approach to bioturbation potential was proposed by Swift (1993), but this ignored the size of the organisms, which is a relevant issue regarding their bioturbation potential (Sanders et al., 2007; Sandnes et al., 2000). A latter approach by Solan et al. (2004), which is now widely used in the literature, implemented size into the calculation of BP by considering the square root transformed average biomass of each species. Bioturbation potential indexes present some limitations in their ability to predict certain attributes of bioturbation, such as bioturbation activity (Queirós et al., 2015), an ability that may vary depending on particular environmental features (e.g. Braeckman et al., 2014a). However, some authors regard them as potential indicators of benthic ecosystem functioning (Van Hoey et al., 2013) and they are widely used because of their ability to predict levels of bioturbation without the need of specific measures, by just using ecological data and biological traits knowledge. Thanks to this feature, BP indexes can be applied to the wide range of benthic community structure data available in the literature, thus providing a chance for expanding our knowledge about bioturbation and studying larger scale patterns (Queirós et al., 2015). While the approach to bioturbation potential by Solan et al. (2004) is thoroughly designed and has been proved to correlate with different sedimentary processes (Braeckman et al., 2014a; Queirós et al., 2011; Van Colen et al., 2012), it presents an important shortcoming when it comes to fully exploit the possibilities of BP indexes: biomass data are frequently not available in published time series, preventing the application of BP sensu Solan et al. (2004). Additionally, Solan et al. (2004) removed the explicit consideration of feeding guild from their calculation of BP, while the influence of such trait in the bioturbatory effect of benthic species is well documented (e.g. Kanaya, 2014; Sandnes et al., 2000).

Here we propose a new approach to the calculation of BP, implementing a qualitative measure of individual size into the approach by Swift (1993), and we apply it to the study of the temporal variation of two subtidal polychaete assemblages in fine-sediment bottoms. The main objectives of this study were: 1) to compare the assemblages in terms of composition, structure, richness and bioturbation potential, 2) to determine which species were responsible for the differences between the two assemblages, 3) to analyse the temporal variation patterns of the assemblages and their bioturbation potentials, and 4) to compare the temporal changes in polychaete assemblages to those in sediment features.

2. Materials and methods

2.1. Sample collection and processing

The two study sites were located in the inner half of the Ría de Aldán (Fig. 1), a small estuarine-like embayment in the Galician Rías (NW Iberian Peninsula). The maximum depth of the bay is 45 m in the outer part, and salinity values are fully marine as a consequence of its exposure to oceanic swell and currents. Aquaculture and fishing

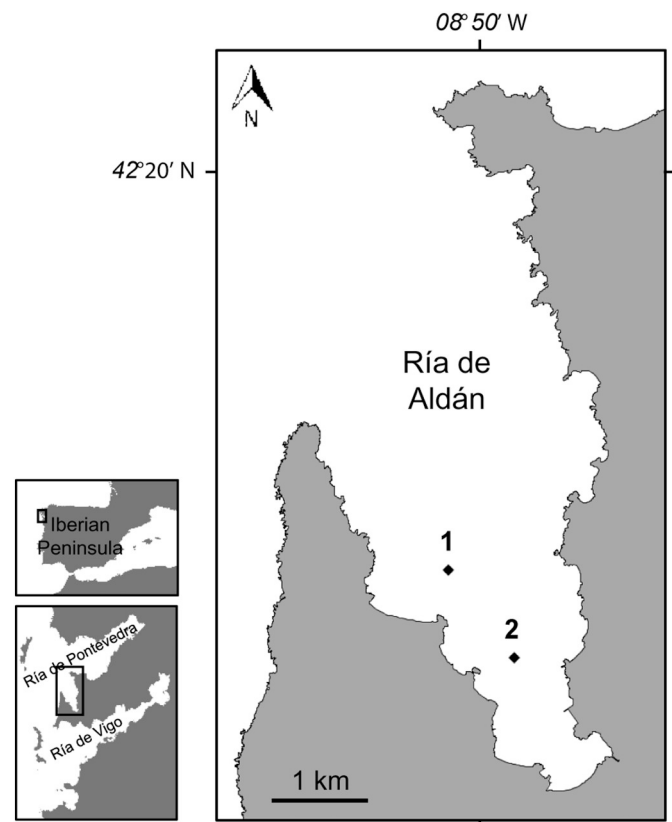


Fig. 1. Location of the Ría de Aldán and the study sites.

activities, especially the mussel culture on rafts, are extensive and socio-economically relevant in the area.

Both sites have similar depths and are close to the raft polygons for mussel culture located in the western half of the bay. They were selected as representative of different kinds of fine sediments (Table 1); the innermost site (Site 2) presents, in general terms, a muddy sediment with high organic matter content, while the outermost one (Site 1) is a muddy sand bottom with moderate organic matter content.

Macrofauna was quantitatively sampled on a monthly basis from May 1998 to May 1999. Five replicate samples were taken at each site and date by means of a Van Veen grab with a sampling area of 0.056 m², thus covering a total area of 0.28 m². Samples were sieved

Table 1

Location of the sampling sites and summary of the characteristics of the sediment and the biotic parameters (mean ± standard deviation).

	Site 1	Site 2
Geographical	42°17'45"N	42°17'15"N
Coordinates	8°50'15"W	8°49'45"W
Depth (m)	18	17
Q ₅₀	0.34 ± 0.48	0.01 ± 0.01
S ₀	1.41 ± 0.18	4.53 ± 1.68
Gravel (%)	5.31 ± 12.71	6.58 ± 4.19
Sand (%)	88.36 ± 12.17	12.55 ± 6.32
Silt + Clay (%)	6.34 ± 3.49	80.86 ± 9.39
TOM (%)	3.19 ± 0.86	12.72 ± 1.66
Carbonates (%)	58.29 ± 7.35	28.93 ± 5.32
N (indiv./m ²)	5685 ± 2692	5784 ± 2712
S (taxa/sample)	26 ± 3	31 ± 8
H'	3.41 ± 0.26	3.08 ± 0.53
J	0.74 ± 0.06	0.63 ± 0.10

Q₅₀: Median grain size, S₀: Sorting coefficient.

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