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Zonation of macrobenthos across a mesotidal sandy beach: Variability based on physical factors

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ABSTRACT

The dynamic and unstable nature of sandy beaches results in a highly variable distribution of macroinfauna inhabiting the intertidal fringe. Storm-induced sediment movement on the beaches could alter the distribution of organisms, leading to an indistinct zonation scheme. In this context, the zonation pattern of macroinfauna was studied monthly during 2010 in an exposed mesotidal sandy beach on the SW Atlantic coast of Argentina (39°S). Faunal samples were collected with a plastic core (0.02 m^2) at 10 to 12 levels along five replicated transects extending from above the drift line to the low tide swash zone. Sand samples were also taken at each level. Wave height and period were measured *in situ* and data of wind speed and direction were provided by the National Weather Service (SMN). The relationship between the formation of zonation schemes, meteorological data and the physical features of the beach were explored. The results show some significant trends: the supralittoral zone was characterized by the absence of organisms on all sampling occasions. During most of the year the zonation scheme comprised two zones, both within the littoral zone; during winter months, no zonation schemes were found. This contrasting pattern could have been determined by the harsh wind-driven waves, leading to sand movements and thus promoting variations in faunal distribution. Sedimentological changes driven by storms could therefore be the cause of a hidden zonation scheme occurring during winter months, highlighting the importance of a climatic variable in the detection of macrofaunal zonation patterns.

1. Introduction

Sandy beaches are dynamic and unstable habitats and therefore the distribution of macrobenthic fauna across the intertidal zone has a highly variable spatial structure (McLachlan and Jaramillo, 1995; Brown, 1996; Schlacher et al., 2008; Schlacher and Thompson, 2013). Most of the studies evaluating zonation patterns on sandy beaches were conducted on microtidal beaches (tidal range < 2 m) (e.g. Defeo et al., 1992; Brazeiro and Defeo, 1996; Schlacher and Thompson, 2013; Santos et al., 2014) and report mostly the formation of zonation schemes in the intertidal zone. Dean's dimensionless parameter (Wright and Short, 1984) allow the classification of beaches into beach types, ranging from dissipative beaches, with wide surf zone, fine sand and flat beach profile, to reflective beaches, with short surf zone, coarse sand and steep slope. A series of intermediate states are recognized between the above extremes (Short, 1996). Dean's parameter is a good predictor of biological descriptors of benthic communities across different geographic regions and is also relevant in establishing the zonation patterns of macrofauna; the number of biological zones depends on the beach type and so, reflective beaches present fewer zones than those dissipative (Defeo and McLachlan, 2005; Jaramillo et al., 1993) and on very harsh reflective beaches, only the supralittoral zone may be found. However, the model of Wright and Short (1984) was developed for microtidal environments (Masselink and Short, 1993). Tidal effects must be taken into account when the zonation patterns of a beach are studied, since elevated tidal energy (i.e. tidal range > 2–3 m) increase the degree of dissipativeness of a beach (McLachlan et al., 1996).

Tidal range also determines the vertical dimension of the intertidal habitat and therefore has an impact on the distribution of organisms. Far less is known about the zonation patterns on macro-to-mesotidal beaches than on microtidal beaches (Degraer et al., 2003; Veiga et al., 2014). Working on intermediate mesotidal exposed sandy beaches of Spain, Rodil et al. (2006) and De la Huz and Lastra (2008) found no distinct intertidal zonation for macrofauna. The same occurs on sandy beaches of the Gulf of Gabès (Pérez-Domingo et al., 2008) and along the coast of Scotland (Raffaelli et al., 1991). In a study comparing zonation patterns over a wide range of conditions including contrasting tidal ranges, McLachlan et al. (1996) found an indistinct zonation in most cases and no more than three zones on any of the beaches.

Sandy beaches with higher tidal ranges are usually more heterogeneous compared with microtidal beaches, displaying intertidal sandbars intercalated with runnels (Masselink and Short, 1993; Gingold et al.,

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2010). Wave action during storm events has different effects on beach profiles of different areas of a coastline (Lee et al., 1998). Several authors emphasize the damage caused on the Argentinian coast (39°S, Atlantic Ocean) by strong winds from the SE and SW quadrants (Marcomini and López, 1997; Caló et al., 2000; Fiore et al., 2009), which cause a significant rise in mean sea level (Marcomini and López, 1997), with the consequent change in sedimentary balance (loss-gain of sediments in the beach) (Bustos et al., 2011; Semeoshenkova et al., 2016). These events increase the erosive action of waves, changing the position of typical landforms, generating what is known as storm profiles or winter profiles, since these events occur mainly during winter. Beach profiles therefore show a significant seasonality: during summer they are characterized by a uniform profile of concave shape, almost no bars are distinguished and the prominent landform is the berm. During winter, the profiles are characterized by a convex shape associated with the accumulation of sediment in the area of the bar, a not very marked berm and in some cases the formation of bars and channels (Perillo, 2003). This natural variability can induce changes in the distribution of intertidal macroinvertebrates across the intertidal zone. Hence, temporal studies are needed for a full picture of zonation patterns, requiring intensive sampling to provide unbiased estimates (Defeo and McLachlan, 2005) and to accurately describe the spatial structure on many ocean-exposed sandy beaches (Schlacher and Thompson, 2013).

In this context, we hypothesize that storms-induced sediment movement could alter the distribution of the macrofauna. The biological zonation schemes along these intertidal coasts will therefore vary strongly throughout the year, showing a subdivision in zones only during months not preceded by storms. To test this hypothesis, we examined the zonation structure of the intertidal macrobenthic community of an exposed mesotidal sandy beach during one year and explored the relationship between zonation schemes, meteorological data and the physical features of the beach.

2. Materials and methods

2.1. Study area

This study was conducted on an exposed dissipative sandy beach located along a continuous coastal fringe within the Provincial Nature Reserve Pehuen Có-Monte Hermoso (39°S; 61°W) (Fig. 1). The area has a mesotidal regime with semidiurnal tides, low slope, and is backed by extensive sand dunes. The intertidal zone spans a mean length of 120 to 170 m from the base of the dunes to the swash (Bustos, 2012; Huamantinco, 2012). The mean amplitude ranges between 2.32 and 3.35 m for neap and spring conditions respectively, with a mean value of 3.10 m (Servicio de Hidrografía Naval, 2009). A description of the physical features and the macrobenthic community of this area can be found in Carcedo (2014), Carcedo et al. (2015a) and Carcedo et al. (2015b). The area has a temperate climate; the average temperatures oscillate between 14 and 20 °C and the mean annual precipitation is 650 mm (Carbone, 2003; Campo de Ferreras et al., 2004). The storms characterized by winds from the sea (S, SW and SE quadrants) with

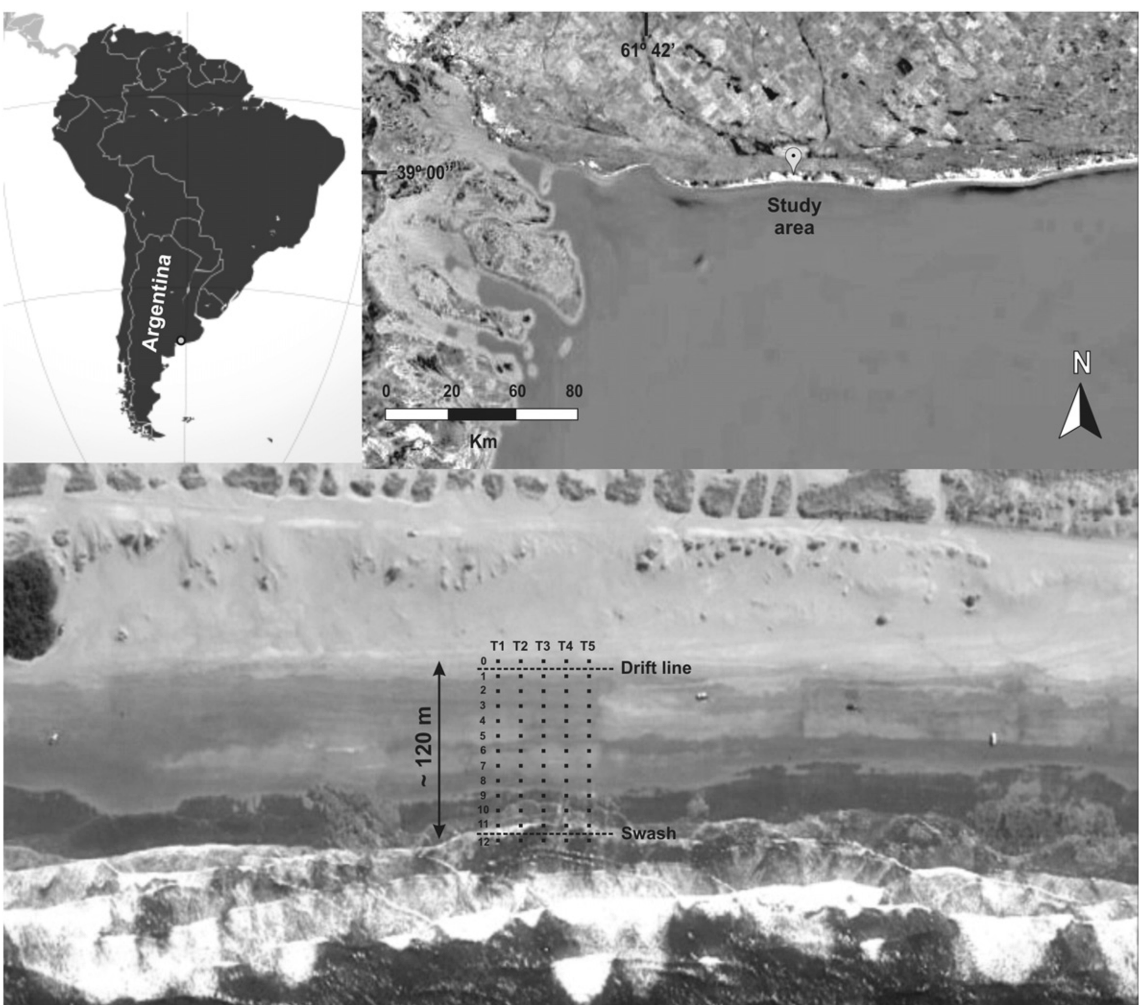

Fig. 1. Study area showing the location of the beach sampled and the spatial layout of the fauna collections.