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Recent benthic foraminiferal assemblages and their relationship to environmental variables on the shoreface and inner shelf off Valencia (Western Mediterranean)

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ABSTRACT

The environmental variables that determine the distributions of benthic foraminiferal assemblages on the shoreface and inner shelf of the north of Valencia province (Western Mediterranean) are identified. The possible influence of variables such as water depth, distance from shore, hydrodynamics, substrate type, carbonate content, organic matter content and human activity is evaluated. Multivariate cluster-Q-type analysis and redundancy analysis (RDA) are used to identify the environmental variables that have the greatest influence on the assemblage distribution.

The spatial distribution of the assemblages is closely associated with water depth and substrate. The diversity and abundance of foraminifera shells increase with depth and their conservation improves. The most common species in the study area are *Ammonia beccarii*, *Rosalina globularis*, *Buccella granulata*, *Planorbulina mediterranensis*, and *Lobatula lobatula*. The presence of wastewater in the study area has not polluted the foraminiferal assemblages (absence of anomalous shells). The direction of the discharge plume is a potential source of nutrients for deep water.

1. Introduction

Benthic foraminifera are unicellular protoctists with calcareous tests that live in all deep oceans. These organisms play a major ecological role in the ecosystem; their wide range and calcareous tests make them suitable for providing interpretation and extrapolation tools for palaeoecological and palaeoenvironmental reconstructions (Usera et al., 2002; Leorri and Cearreta, 2009; Milker et al., 2009; Blázquez and Usera, 2010; Blázquez and Ferrer, 2012). Recently, benthic foraminifera have been used as bioindicators for environmental studies. In shallow inner shelf environments, attempts to identify the environmental variables that could control the distribution of benthic foraminifera are difficult due to the high variability of the system. The distribution may be controlled by abiotic factors such as grain size, organic matter, salinity, dissolved oxygen, and by biotic factors such as predation, competition and reproduction (Colom, 1974; Murray, 1991, 2006; Jorissen, 1999). Therefore the analysis of benthic foraminifera has provided a proxy for evaluating the quality of the ecosystem. The increase in human activity on inner shelf areas has promoted a great deal of research into the effects of pollution (Martin, 2000; Sen Gupta, 2002; Bergin et al., 2006; Ferraro et al., 2006; Irabien et al., 2008).

In the western Mediterranean, several studies of recent benthic foraminifera have been carried out, in Italy (Donnici and Serandrei-Barbero, 2002; Frontalini and Coccioni, 2011; Magno et al., 2012), on the French Mediterranean coast (Mojtahid et al., 2008; Goineau et al., 2011; Fontanier et al., 2012; Barras et al., 2014) and off the Spanish coast (deep-sea) (Mateu, 1970; Milker et al., 2009; Mateu-Vicens et al., 2010; Contreras-Rosales et al., 2012). At present there are few studies of the superficial distribution of benthic foraminifera on the inner shelf of the eastern seaboard of Spain (Blázquez, 1996; Usera and Blázquez, 1997) and hardly any of the inner shelf or shoreface off the coast of Castellón province and the north of Valencia (Blázquez and Alcántara-Carrió, 2009). The few studies performed to date indicate the presence of two ubiquitous species in the inner shelf of the southern part of the study area: *Ammonia beccarii* (Linné) and *Elphidium crispum* (Linné), and a sharp increase in the diversity and abundance of foraminifera in substrates colonised by seagrass.

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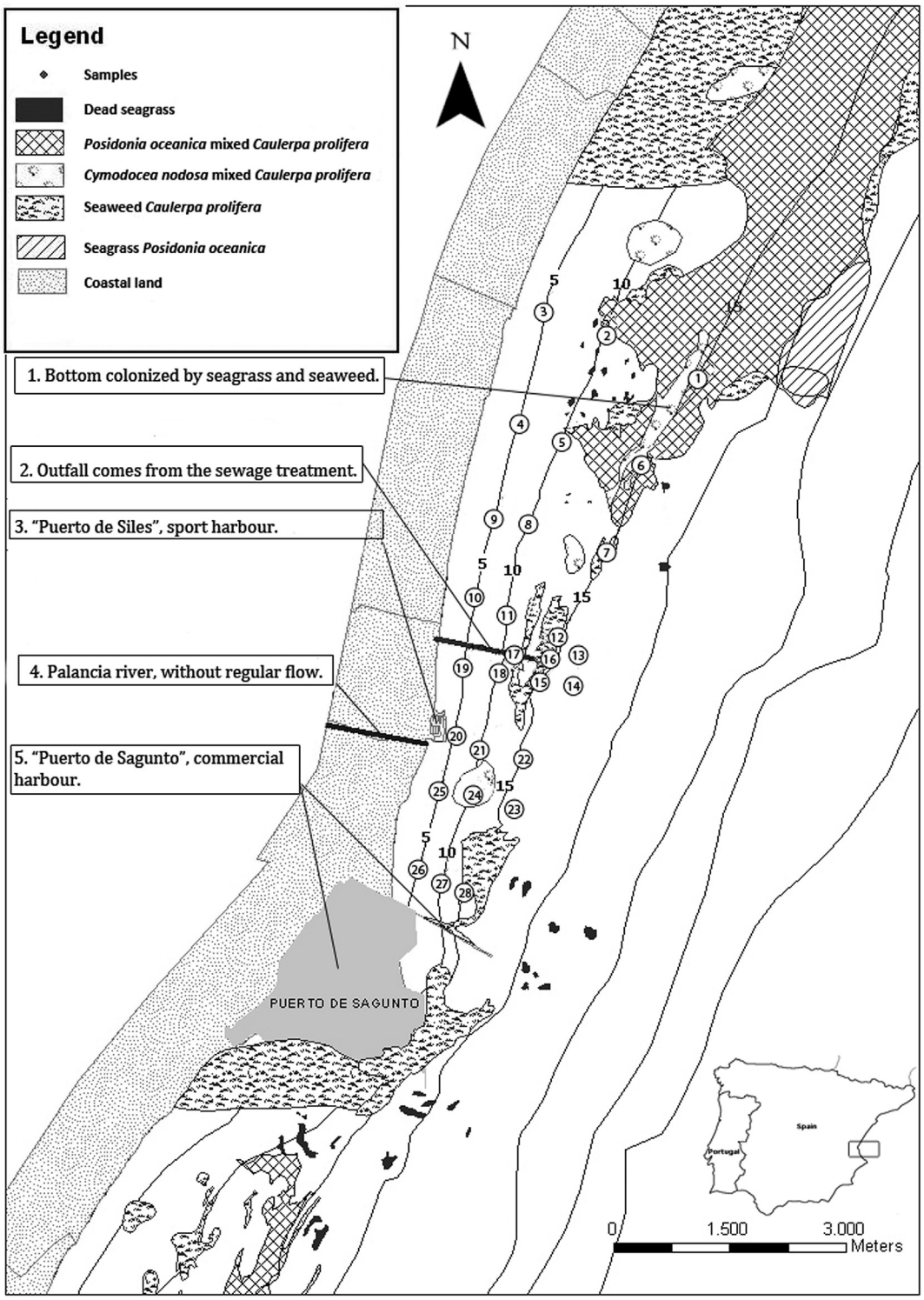

Fig. 1. Location map of the study area with samples' location. North Valencia (Spain).

The aims of this study are to characterise the main benthic foraminiferal assemblages and their spatial distribution on the inner shelf zone between the provinces of Valencia and Castellón, including both live and dead assemblages. We assess the possible influence of variables such as depth, distance from shore, hydrodynamics, substrate type, carbonate content, organic matter content and human activity (e.g., port activity, discharges). To determine the importance of the latter factor, we evaluate the impact of the discharge from an outfall on the distribution of these organisms. This study identifies the dominant assemblages of the different sub-environments and assesses the richness and diversity of these benthic communities by using a series of multivariate statistical analyses.

The study area is located on the coast of Valencia, Spain (Fig. 1). Siliciclastic sediments come predominantly from rivers and their presence on the shelf is controlled by the balance between