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Recolonization of macrofauna in unpolluted sands placed in a polluted yachting harbour: A field approach using experimental trays

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ABSTRACT

A field experiment using trays was conducted at Ceuta's yachting harbour, North Africa, to study the effect in recolonization of placing trays with unpolluted defaunate sediments (fine and gross sands with low contents of organic matter) inside an enclosed yachting harbour characterized by high percentages of silt and clay and high concentrations of organic matter. Sediment recolonization in the trays was mainly undertaken by the species living naturally at the yachting harbour, which recolonized both uncontaminated gross and fine sand trays (such as the crustaceans *Corophium runcicorne*, *Corophium sextonae* and *Nebalia bipes*, the mollusc *Parvicardium exiguum* and the polychaete *Pseudomalacoceros tridentata*). However, other species like the polychaetes *Cirriformia tentaculata* and *Platynereis dumerilii*, although also abundant in the yachting harbour, were unable to colonize the trays through transport of larvae and/or adults in the water column. The recolonization was very quick, and after the first month, the values of abundance, species richness, diversity and evenness were similar in the experimental trays and in the reference area (yachting harbour). Although the multivariate analysis showed that the species composition differed between the trays and the reference area, there were no significant differences in recolonization of gross and fine sands, indicating that other factors different from the granulometry are modulating the recolonization patterns.

1. Introduction

Harbours are generally polluted areas with high concentrations of pollutants in sediment and low hydrodynamism (Estacio et al., 1997; Guerra-García and García-Gómez, 2004a). Natural and artificial perturbations in harbours, such as physical disturbances, oxygen depletion, and toxic chemicals, may cause partial or total defaunation of sediments (Savidge and Taghon, 1988; Lu and Wu, 2000; Guerra-García and García-Gómez, 2005). After these disturbances, processes of recolonization followed by successional dynamic can re-establish the structure of the macrofaunal community. For example, dredging operations in harbours are common human-induced disturbances, and usually reduce the benthic population and defaunate some areas periodically. In this sense, the use of experimental trays has been also very useful to elucidate factors that may affect settlement and colonization of soft bottom benthic species and to determine the patterns of recolonization after defaunation (Wu and Shin, 1997; Lu and Wu, 2000; Guerra-García and García-Gómez, 2006).

Recolonization dynamics depends on both abiotic parameters such as sediment characteristics, and biotic factors such as availability of larvae, juveniles and adults and their substrate preferences (Gray, 1974). The type of in situ experiments is considered to be useful tools for the solution of ecological questions (Arntz and Rumohr, 1982) Although the approach using experimental trays has been used to test different hypothesis related to sediment characteristics and sediment pollution, the effect of placing unpolluted sediment in polluted enclosed areas has not been tested yet. Consequently, the main objective of the present work is to study the effect in recolonization of placing trays with unpolluted defaunated sediments (fine and gross sands with low contents of organic matter) inside a polluted enclosed yachting harbour characterized by high percentages of silt and clay. Taking into account that larvae of most species from the adjacent areas (gross and fine sand used in the experiment) can reach the harbour due to the local currents through a channel (see Guerra-García and García-Gómez, 2004a,b,c) our hypothesis focused on which species will recolonize the trays filled with gross and fine sands located inside the harbour, those of the surrounding community established inside the harbour, or species coming from adjacent areas living naturally in the gross and fine sands and absent in the harbour. This would have implications (1) concerned with understanding if organisms respond to grain-size of the surrounding sediment, and (2) dealing with the use of clean sands, provided to be colonized, to restoration or management strategy in polluted

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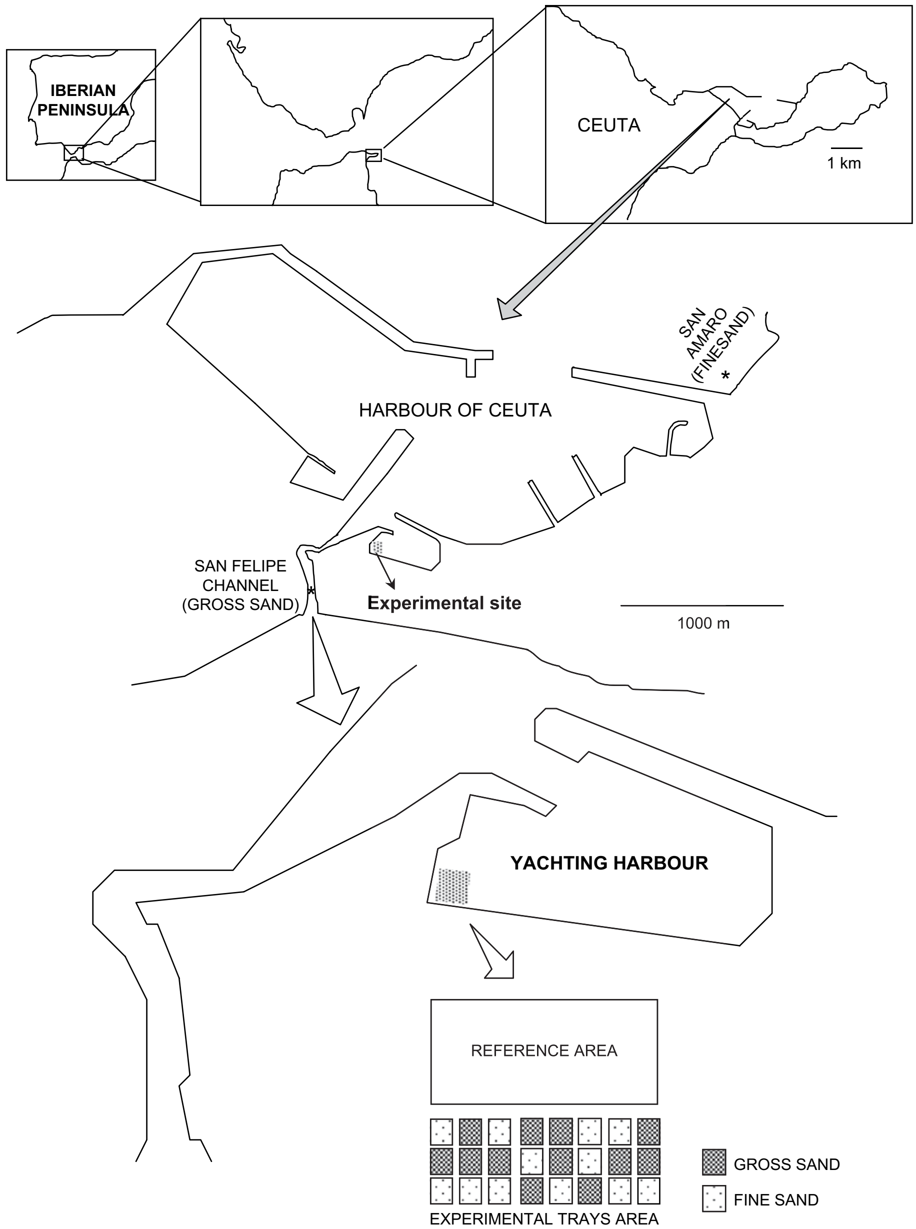

Fig. 1. Study area showing the location of the experimental site at the yachting harbour of Ceuta. Location of San Felipe channel and San Amaro beach is also indicated. Rectangles of gross and fine sand represent the trays with surface of 20×25 cm^2.

areas. In recent years, dredged material has become regarded as a potential resource and used to create and/or improve habitats (Bolam et al. 2006).

2. Material and methods

2.1. Study area

Field experiments were carried out from June to September 1999 at the yachting harbour of Ceuta (Fig. 1). The yachting harbour is an enclosed area located in the harbour of Ceuta, Strait of Gibraltar (35°53′ N; 5°18′ W). The harbour of Ceuta is one of the most important harbours in the Strait of Gibraltar, being the entrance from Europe to Africa. It is characterized by intense shipping traffic, and frequent loading and dumping is involved in shipping operations. Besides the experimental area (yachting harbour), two other adjacent areas were selected for the study, San Felipe Channel and San Amaro. San Felipe channel is located between North and South Bay of Ceuta and it is characterized by a moderate hydrodynamism, and the soft bottom is composed mainly of gross sand. San Amaro is a beach adjacent to the harbour of Ceuta and is composed of fine sands. Water depth is about 3 m in the yachting harbour and San Felipe Channel, and about 4.5 m in San Amaro. The local currents make possible the renovation of water inside the harbour so larvae and adults of macrofauna can potentially reach the different areas of the harbour, including the yachting harbour (Fig. 2). The water equivalents (V) as a measure of hydrodynamics according to the formula suggested by Bailey-Brock (1979) based on the plaster dissolution method described by Muus (1968) and modified by Gambi et al. (1989) ranged from 1.04 to 1.70 in the yachting harbour while it was 9.92–15.81 in the San Felipe Channel during the experiments. Consequently, the hydrodynamic is stronger in the channel. Granulometric composition of sediments from the three studied areas are shown in Fig. 3; while San Felipe channel is mainly