

## Spatial and temporal changes of coastal demersal assemblages in the Gulf of Cadiz (SW Spain) in relation to environmental conditions

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### Abstract

Changes in space and time in “global values” (numerical abundance, biomass, diversity ( $H'$ , Shannon–Wiener), number of species ( $S$ )) and in the structure of demersal assemblages were studied in a coastal fringe of the Gulf of Cadiz between the Guadiana and the Guadalquivir rivers. Further, the seasonal patterns in length–frequency histograms and the percentage of juveniles of 10 selected species were calculated based on literature data on length at first maturity ( $L_m$ ). Twenty-four successive monthly demersal fishery surveys were conducted between March 2002 and February 2004 at eight fixed stations between 5 and 30 m depth, from which 175 hauls were analysed. Fifty-seven taxa belonging to four orders of fish, cephalopods and crustaceans were selected for analysis. Environmental characterisation included the variables depth, sediment type, bottom temperature (BT), total bottom chlorophyll (BChl), and bottom suspended solids (BSS). Relationships among environmental variables as well as their spatial and temporal changes were explored through Spearman rank correlation ( $R_s$ ) and Kruskal–Wallis tests. Their relation to global values was assessed through  $R_s$ . Differences in global values with respect to space (station) and time (year and season) was assessed through ANOVA techniques via GLM. Spatial and temporal differences in demersal structure were analysed through different multivariate routines from PRIMER including between-matrix correlation analysis (RELATE), analysis of similarities (ANOSIM), species contributions to similarity/dissimilarity (SIMPER), non-metric multidimensional scaling (MDS) and group-average cluster analysis. The degree of match between species-similarity matrices (Bray–Curtis, root–root transformed) and environmental similarity matrices (Euclidean distance) was assessed through the BIO-ENV approach also from PRIMER. Individual  $R_s$  correlations between selected species and environmental variables also were performed at each station. A strong spatial gradient related to depth, sediment type, and BT (all related to the distance from the Guadalquivir River mouth) was responsible for most of the explained variability in global values and demersal species structure. The shallowest stations, also close to the Guadalquivir River mouth, showed higher numerical abundance and biomass values, and lower  $H'$  and  $S$  values. Typical or abundant species from those stations included fishes from the families Sparidae (particularly *Diplodus bellottii*), Haemulidae, Soleidae or the stomatopod *Squilla mantis*. Some small pelagics like *Engraulis encrasicolus* were also important at those stations, although were excluded from the analyses to reduce bias. Northwestern deeper stations were defined by higher relative densities of cephalopods and several pleuronectiform fish. Significant seasonal differences in the abundance of several species also were observed at most stations, mainly between summer and

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winter. Species like *Merluccius merluccius* were particularly abundant in winter, whereas *Arnoglossus laterna* was more abundant in summer. Length–frequency analyses showed that changes in abundance were, in many cases, related to the massive appearance of small individuals in the area. Juvenile stages were observed either exclusively or temporally for many of the analysed taxa, revealing the high importance of this zone as a nursery.

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## 1. Introduction

The fisheries at the Gulf of Cadiz (included in ICES region IXa) have traditionally represented an important socio-economic activity for the coastal population of SW Spain. An important multi-species–multigear artisanal fishery exploits the coastal fringe of the Gulf (Sobrino et al., 1994; Silva et al., 2002). Bottom trawling is forbidden at the first 10 km offshore, which embraces a shallow area of a maximum depth of ca. 30 m. Species catches vary greatly in space and time in association with the highly diverse environmental traits encountered in the shelf and the species life cycles (Sobrino et al., 1994; Ramos et al., 1996). Some commercially important species in the area include hake (*Merluccius merluccius*), several Sparidae, wedge sole (*Dicologoglossa cuneata*) cephalopods like octopus (*Octopus vulgaris*) or cuttlefish (*Sepia officinalis*), and crustaceans like *Squilla mantis* or *Melicertus kerathurus*.

The Gulf of Cadiz is a highly suitable habitat for the reproduction of many commercially important marine species (e.g., Jiménez et al., 1998; Millán, 1999). Several authors have repeatedly shown the important role of the Guadalquivir River estuary, or close by areas, in attracting spawning or juvenile development of several marine taxa (Baldó and Drake, 2002; Drake et al., 2002; García-Isarch et al., 2003; Ruiz et al., 2006). Recently, Baldó et al. (2006) showed how ichthyoplankton assemblages make different spatial use of the prevailing oceanographic–biological conditions in the Gulf, which have lately been studied in detail (García-Lafuente et al., 2006; Navarro and Ruiz, 2006). The key role of the Guadalquivir River for the fisheries of this area motivated the declaration of a portion of the Guadalquivir estuary and adjacent coastal zone as fishing reserve (BOJA 123, 2004).

Despite the latter facts, there is a paucity of studies addressing the multispecific associations of demersal species in the area, and the few existing do not consider most of the shallowest fringe of the

Gulf (e.g., Baró and Serna-Quintero, 2000). More often, studies on coastal demersal species have been restricted to the estuary or have focused on one or few species (e.g., Drake et al., 2002; Sobrino et al., 2005). The need to study coastal assemblages at locations close to river mouths has been repeatedly pointed out, as these areas are postulated to be used both by estuarine and purely marine species and by species that appear exclusively in this interphase habitat (Blaber et al., 1995).

Existing works on demersal assemblages usually identify depth or substrate type as the main environmental variables forcing biological structure, followed secondarily by various hydrographic parameters (Fariña et al., 1997; Moranta et al., 1998; Demestre et al., 2000; Baró and Serna-Quintero, 2000; Labropoulou and Papaconstantinou, 2004). Temporal variation has received less attention, although clear seasonal patterns have been identified in shallow–environmentally dynamic areas (e.g., Prista et al., 2003). The importance of identifying changes in demersal assemblage structure with respect to space and time, as well as to find correlates with oceanographic variation, is regarded as a key issue in order to understand and manage coastal areas of high fishery importance. Within this frame work the present work aimed to analyse the spatial and temporal variation of some ecological parameters as well as the structure of coastal demersal assemblages in relation to various environmental parameters in the coastal fringe of the Gulf of Cadiz.

## 2. Material and methods

### 2.1. Study area

The study area was comprised of eight fixed stations (A1–A8) between 5 and 30 m depth in a coastal area of the Gulf of Cadiz between the Guadalquivir and Guadiana river mouths (Fig. 1). This area is characterised by shallow waters and large environmental oscillations partly derived from

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