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Seasonal, tidal and diurnal changes in fish assemblages in the Ria Formosa lagoon (Portugal)

Joaquim Ribeiro*, Luis Bentes, Rui Coelho, Jorge M.S. Gonçalves, Pedro G. Lino, Pedro Monteiro, Karim Erzini

Centro de Ciências do Mar, Faculdade de Ciências do Mar e do Ambiente, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal

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Abstract

Fish fauna were collected in two different subtidal shallow sites, seagrass and sand, using a small beam trawl in the Ria Formosa lagoon (South Portugal). Samples were taken at low and high tides, during day and night, and in each season. Fish assemblages associated with each site were significantly different, with seagrass site supporting greater fish abundance and higher number of species than sand. These site-related differences in fish assemblages were stronger than any other factor studied. Both sites showed seasonal variations in their fish assemblages, mainly because of recruitment of marine juvenile migrants during spring and summer. No significant tidal or diel changes were observed in the fish assemblages of either site, but there was a significant site–tide interaction, with higher fish abundance in seagrass at low tide. In sand, tide effect was evident only for certain species, with resident species more abundant at high tide and marine species more abundant at low tide. Within the Ria Formosa coastal lagoon, ichthyofaunal composition and structure is mainly influenced by site followed by season.

Keywords: fish fauna; coastal lagoon; seagrass; sand; temporal variations; Ria Formosa; South Portugal

1. Introduction

Shallow areas of estuaries and coastal lagoons contain some of the most productive coastal habitats, such as tidal flats, seagrass beds, subtidal channels and salt marshes (Pihl and Rosenberg, 1982; Weinstein, 1982; Kneib, 1997). Many of these shallow habitats support diverse and abundant fish assemblages, and sustain significant populations of juveniles of many commercially important fish species (Bell and Pollard, 1989; Potter et al., 1990; Edgar and Shaw, 1995a; Lazzari and Tupper, 2002). However, the ichthyofauna is heterogeneously distributed among the different types of habitats, according to sediment type, vegetation preference and temporal scale (tidal, diel, lunar, seasonal). Several studies have compared seagrass beds with non-vegetated substrates, in particular sand, and have generally reported that the seagrass supports different and more abundant and diverse fish assemblages than non-vegetated habitats (e.g. Heck et al., 1989; Sogard and Able, 1991; Connolly, 1994a; Gray et al., 1996; Jenkins et al., 1997; Guidetti, 2000; Travers and Potter, 2002). Besides the differences in fish assemblages associated with the various habitat types, ichthyofaunal compositions and structure can also undergo consistent cyclical and temporal changes within habitats. Seasonal shifts in fish communities are common, as a result of sequential immigration and emigration of certain fish species (Hyndes et al., 1999; Thiel and Potter, 2001). Tidal and diel shifts in fish assemblages have also been reported by several authors (e.g. Sogard et al., 1989; Rountree and Able, 1993; Gray et al., 1998; Griffiths, 2001; Methven et al., 2001; Morrison et al., 2002; Guest et al., 2003). The aim of this study was to examine

* Corresponding author.
E-mail address: jribeiro@ualg.pt (J. Ribeiro).

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the effect of season, tide and diel variations in fish assemblages associated with two subtidal sites, seagrass and sand, present in the Ria Formosa coastal lagoon (Algarve, South Portugal).

2. Materials and methods

2.1. Study area

This study was carried out in the western part of the Ria Formosa (Ria Faro-Olhão). The Ria Formosa is a large tidal lagoon extending for about 55 km along the south coast of Portugal, with a maximal width of 6 km (Fig. 1). A seaward belt of dunes protects a system of salt marshes, subtidal channels and tidal flats, with a total surface area of approximately 170 km^2. The tidal elevations are 1.30 and 2.80 m at mean neap tide and spring tide, respectively, and the minimum and maximum areas covered by water during spring tides are 14.1 and 63.1 km^2 (Águas, 1986). A strongly branched system of creeks and channels is connected with the ocean by six outlets. The average depth is less than 3 m, with 14% of the lagoon surface permanently submersed (subtidal channels) and the intertidal area covers approximately 1/3 of the total area of the lagoon. The system has semi-diurnal tides, with 50–75% of the water volume exchanged during each tide (Águas, 1986). The lagoon does not receive any permanent freshwater input: salinity is 35.5–36.9 all year, except for surface waters for brief periods after winter heavy rainfalls (Falcão et al., 1992). Water temperature varies from 12 to 28 °C (Sprung, 1994).

2.2. Sampling design

Fish fauna were collected from two different subtidal shallow sites, separated by 1.5 km (Fig. 1). One site represented the seagrass habitat and was located in a medium size subtidal channel (37°00′N, 07°57′W), with around 50 m width and an average depth of 1.5 m at low tide. The tidal current velocity is relatively low compared to that observed in the vicinity of the inlets (Lima and Vale, 1977), and the bottom consists of muddy sandy sediments (sand − 35.7%; silt − 31.7%; clay − 32.6%), covered with several extensive patches of seagrass, *Cymodocea nodosa*. The second site represented the sand habitat and was located in a subtidal channel that gives access to an inlet, artificially opened in 1997 (36°59′N, 07°57′W). The tidal current velocity is much stronger than in the seagrass site, and the sediments were dominated by well calibrated medium-coarse sand (sand − 99.4%; silt − 0.3%; clay − 0.3%). This channel was 30 m wide with an average depth of 1.9 m at low tide and no vegetation was present during the sampling period.

Both sites were sampled on a seasonal basis over a one-year period, with samples taken in May 2001 (spring), August 2001 (summer), November 2001 (autumn) and February 2002 (winter). In each season the sampling took place in one single day, and the two sites were visited at the beginning of the ebb tide (high tide sampling) and at the beginning of the flood tide (low tide sampling), both during the day and night. At each visit, three replicate tows of 200 m each were made, using a beam trawl (2.6 m wide and 0.45 m high at the mouth) with a stretched mesh size of 9 mm in the cod end. Since this sampling gear is not effective for catching pelagic species (e.g. *Atherina* spp., *Liza* spp. and *Sardina pilchardus*), this study focuses on benthic and epibenthic fish communities, present in each sampled site. All samples were taken during neap tide, near the last quarter moon. In the laboratory, all fish were identified to species and counted.

2.3. Data analysis

The independent variables were site (seagrass and sand), season (spring, summer, autumn and winter), tide stage (high/ebb tide and low/flood tide) and diel period (day and night). A four-way factorial analysis of variance (ANOVA) was used to test for differences in the number of species and individuals, with all factors considered fixed (SAS Institute, 1988). Number of species was square-root transformed and number of individuals was ln transformed. When significant main effects were detected in the multifactor ANOVAs,

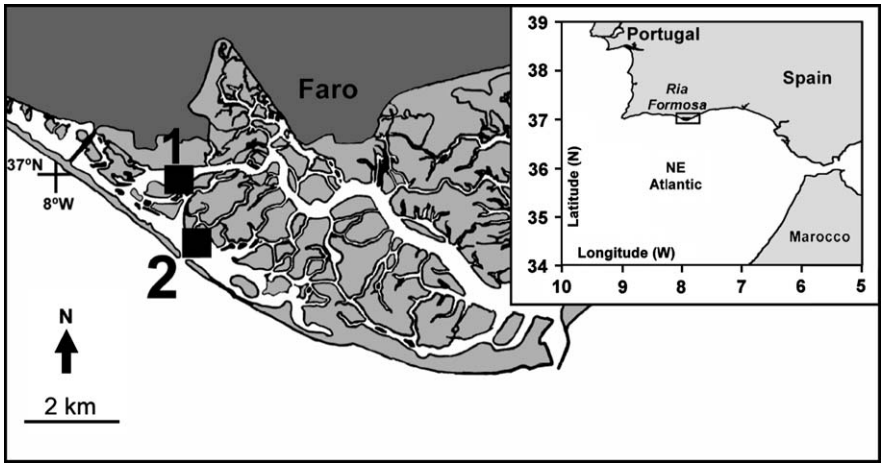

Fig. 1. Western part of the Ria Formosa lagoon (Ria Faro-Olhão) showing the location of the two sampling sites: (1) seagrass and (2) sand.