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Inter-annual differences of ichthyofauna structure of the Guadiana estuary and adjacent coastal area (SE Portugal/SW Spain): Before and after Alqueva dam construction

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Abstract

The objective of this study was to evaluate how inter-annual changes in the volume of freshwater input and water parameters (salinity, temperature, major dissolved nutrients, seston and chlorophyll *a*) affect fish assemblages in the Guadiana estuary (South Portugal). During the sampling period (two distinct hydrological years), 56 fish species were identified. Anchovies (*Engraulis encrasicolus*) and barbells (*Barbus* species) dominated the abundances in the high inflow year (2001), but *Pomatoschistus* species were the most important taxa in the low inflow year (2002). Barbells and Portuguese toadfish (*Halobatrachus didactylus*) dominated the biomass in both years under different inflow conditions, but a reduction in barbells' biomass occurred during the low inflow year. Multivariate analysis indicated a persistent spatial structuring of the estuarine community for both years and in different seasonal periods. Changes in salinity and seston, which were mainly due to changes in freshwater input, had an important influence on the structure of the fish assemblages. In 2002, the increased salinity in the upper estuary allowed colonization by marine species of an area that usually contains freshwater, decreasing even more the habitat for indigenous freshwater species in the downstream area of the Guadiana River. There was also a decrease in the abundances of planktivorous and omnivorous fishes and an increase in carnivorous fishes during the low inflow year. As fishes in these systems are important regulators of processes in the trophic web, changes in the dominant feeding groups can have consequences on water quality, particularly in relation to the occurrence of plankton blooms.

Keywords: estuarine fish; community diversity; estuarine environment; ecosystem management; freshwater–seawater interface; Portugal; Guadiana River

1. Introduction

Fish assemblages in estuaries can include larvae, juveniles and adults of species of both marine and freshwater origin, with migratory or sedentary behaviour. Estuaries are widely recognized as nursery areas for young fishes, offering food and shelter for larval and juvenile stages (Blaber and Blaber, 1980; Whitfield, 1999). Worldwide, one of the most influential landscape processes that affects faunal community structure and function in estuaries is the freshwater inflow quantity (Sklar and Browder, 1998), quality and the seasonal pattern of input (Wolanski et al., 2004). In estuarine ecosystems that are under the influence of a Mediterranean climate, such as the Guadiana estuary (SE Portugal/SW Spain), natural river inflows can vary markedly, within and between years, due to differences in annual rainfall, which is linked to Northern Atlantic Oscillation (NAO) (Alveirinho et al., 2004).

Extensive development has occurred in the Guadiana River basin over the past century, and the consequent reduction in river flow might have contributed to decreases in water quality (Rocha et al., 2002) and to fish habitat modifications, which might be more intense during consecutive drought years. Construction of the Alqueva dam was finished in early 2002, creating a water body with a potential area of 250,000 ha, which,

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under specific situations, might cause severe changes in downstream ecosystems, including the estuarine biota. Following construction of the dam, changes in fish community structure, spawning behaviour and larval and juvenile migration patterns were predicted to occur in the Guadiana estuary, along with shifts in fisheries catches in adjacent coastal areas (Chícharo et al., 2003). However, there are few publications describing the effects of dams on fish assemblages, and none describing how freshwater inflows affect fish community structure, both in space and time, in the Guadiana estuary.

The objectives of this study were (1) to characterize the estuarine fish assemblages based either on taxonomic or functional guilds of the assemblages of estuarine fish and to assess whether there were structural differences between and within two distinct hydrological years (2001 (before) and 2002 (after) Alqueva dam construction) and (2) to evaluate the role of environmental variables affecting assemblage structure.

2. Materials and methods

2.1. Study area

The Guadiana River estuary is located in the southern border between Portugal and Spain (Fig. 1). Its catchment basin is the fourth largest in the Iberian Peninsula, approximately 67,500 km^2, and is 5.9 times larger than the area of Portugal. The Guadiana River has an irregular hydrological regime, with severe droughts and floods, and it is under increasing pressure for exploitation of water resources. Mean monthly river flow volumes vary markedly on a seasonal and yearly basis.

Guadiana is a mesotidal estuary, with an average amplitude of 2 m. In this study, the Guadiana estuary was divided into three sub-areas: upper, middle and lower estuary (Fig. 1). Additionally, a fourth area, located in the marine boundary of the estuary and named the 'sea area', was sampled. This classification is commonly used to subdivide estuaries (Olausson and Cato, 1980), according to the sedimentology of the area (Gonzalez, 1995) and the ecohydrological characteristics that were described by Chícharo et al. (2001). The upper area is mainly the freshwater section, still with a tidal influence but with a salinity close to zero (tidal freshwater <0.5). The middle section is the salinity-mixing zone (0.5–25), whereas in the lower area, salinity is usually very close to seawater (>25).

2.2. Environmental parameters

Nine sampling stations that were distributed along the study area (Fig. 1) were sampled during intermediate ebb tides every 2 months from January 2001 to September 2002. Freshwater inflow data, obtained from the Instituto Nacional da Água (www.inag.pt), were measured at the Pulo do Lobo hydrometric station (37°48′N, 7°38′W), which is located a few kilometres above the last point of tidal influence (Mértola) and from the uppermost sampling station (Alcoutim).

At each station, vertical water-column temperature and salinity profiles were measured using a YSI 6600 CTD. Water

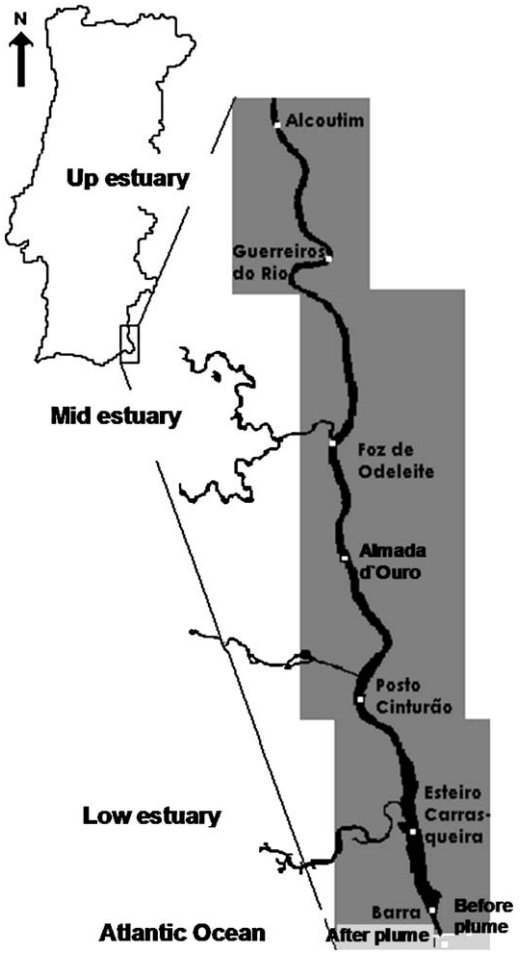

Fig. 1. Sampling stations, sub-areas (upper, middle and lower) in the Guadiana estuary (Alcoutim, AL; Guerreiros do Rio, GR; Foz de Odeleite, FO; Almada de Ouro, AO; Posto Cinturão, PC; Esteiro da carrasqueira, EC; Barra, B; Before plume, AP; After plume, DP).

samples for the analysis of the amount of seston and for chlorophyll *a* concentrations were collected at the surface and near the bottom with a van dorn bottle, and kept in the dark and then cooled until sample processing.

Seston and organic matter were determined by filtering water samples through pre-ignited and pre-weighed 0.7-μm pore filters (Whatman GF/F). After sample filtration, filters were washed with distilled water, dried at 60 °C and re-weighed after cooling for seston determination. To determine organic matter, dried filters were placed in an oven for 4 h at 450 °C to burn all the organic matter retained in them, and the filters were re-weighed after cooling.

Chlorophyll *a* concentration was determined by filtering water samples through 0.7-μm pore filters (Whatman GF/F). The filtration pressure did not exceed 100 mm Hg, and the filters were kept frozen (−20 °C) until spectrofluorimetric analysis was carried out using acetone as the extraction solvent (Welschemeyer, 1994).

Sediment samples were collected during preliminary sampling in June 2000 at stations B, EC, PC and AO. Sediment organic matter was determined by the difference between the dry weight (60 °C/24 h) and the ash-free dry weight (450 °C/4 h).