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Ecological quality assessment of small estuaries from the Portuguese coast based on fish assemblages indices

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ABSTRACT

The importance of establishing the ecological quality of estuarine systems has been widely acknowledged and led to the development of several fish community-based multimetric indices. Nevertheless, a question rose about the accuracy of these tools when natural disturbance is acting upon the organization of the systems' communities. Four multimetric indices were used to examine their ability to differentiate the ecological status of five small estuarine systems (southern Portugal), and also to test if they reflected the level of anthropogenic pressures. Fish assemblages from Mira, Odeceixe and Aljezur (in the Southwest coast), Gilão and Bensafrim (in the South coast) estuaries were sampled seasonally for one year, and anthropogenic sources of pressure were identified and quantified. We found that although the applied indices provided information on ecological condition differentiation among systems, they are unable to explain different classes of ecological status in systems with equivalent pressure levels.

1. Introduction

Estuarine ecosystems are among the most valuable in the World because of their high productivity and their fundamental role concerning ecosystem services (Costanza et al., 1997). Nevertheless, this widely accepted statement is actually coupled with the knowledge that these ecosystems are facing increasing and significant human-induced impacts, which include physical and chemical transformation, habitat destruction and changes in biodiversity (Halpern et al., 2007). The ultimate challenge of scientists and policy makers is to manage estuarine systems in order to improve their ecological quality, prevent further deterioration, and ensure the progressive reduction of pollution. These are the main objectives of the water framework directive, developed for the European context, which has the final goal of achieving a "good ecological quality status" for all water bodies by 2015 (EC, 2000; Borja et al., 2006). This directive urged the development of consistent tools to assess the ecological status of estuarine systems.

The task of evaluating ecosystems health is far from simple mainly because of the complexity of the systems, and the consequent articulation of a number of interacting components. In general, these components vary in type, structure and function within the whole system (Costanza and Mageau, 1999). This complexity lead to a biological criterion of ecosystem integrity, where biological indicators are used to increase the probability that an assessment program will detect degradation due to anthropogenic influences (Karr, 1991; Nip and Udo de Haes, 1995; Whitfield and Elliott, 2002). The general idea is that, when ecosystems are not suffering from unusual external perturbations, we observe certain well-defined developmental trends (Odum, 1985). Thus, ecological integrity indicates the divergence from natural conditions, which is attributable to human activities (Karr, 1991).

Along with other biological components of aquatic systems, fish-based indicators have been considered a good way of evaluating the environmental status of the ecosystem (e.g. Brind'Amour and Lobry, 2010). In this regard, several multimetric indices have been developed (e.g. Karr, 1991; Deegan et al., 1997; Harrison and Whitfied, 2004; Harrison and Whifield, 2006; Breine et al., 2007; Coates et al. 2007; Breine et al., 2010; Delpech et al., 2010), all attempting to meet the assumptions that the ideal index would be sensitive to all human-generated stresses exerted on biological systems, while also having limited sensitivity to natural variation in physical and biological environments.

At this point it is clear that we have to be able to distinguish deviations induced by human activities from the ones resulting on changes of the ecosystems' equilibrium state originated by natural processes. This is especially difficult in the case of estuaries, since they are naturally stressed and highly variable ecosystems that are at the same time, exposed to high degrees of anthropogenic stress, a problem recently termed as "Estuarine Quality Paradox" (Dauvin et al., 2007; Elliott and Quintino, 2007). The

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difficulty level increases exponentially wherever individual disturbances are so large that a single disturbance event can affect a relatively large proportion of the system, making the achievement of an equilibrium state unlikely (Strugel, 1991).

Small estuaries, with low river flow and narrow mouth openings that can periodically be closed to the sea, are, with this regard, examples of estuarine systems where the achievement of an ecological equilibrium is probably driven by distinct processes when compared to larger systems. This sustains that there must be a range of ecosystems that can legitimately be considered "natural" (Strugel, 1991).

The aim of the present work is to provide information on the ecological integrity of five scarcely known small estuarine systems of the Portuguese coast. We used the available data concerning the main driving forces of anthropogenic impacts and also applied a selection of fish-based multimetric indices to fish community data. We attempted to answer two main questions: Are the selected estuarine systems at an equivalent ecological integrity status? And if they differ, are the fish-based multimetric indices reflecting natural or anthropogenic driving forces?

2. Material and methods

2.1. Study areas

Five small estuarine systems located in the Portuguese coast were sampled: Mira, Odeceixe and Aljezur (in the Southwest coast), Gilão and Bensafrim (in the South coast) (Fig. 1).

The Mira estuary is located in the protected area of Parque Natural do Sudoeste Alentejano e Costa Vicentina (PNSACV), this system was already considered the least impacted estuary of the Portuguese coast, when compared to larger ones (Vasconcelos et al., 2007) and, being 30 km long with a 100 m wide mouth opening, it is the largest system in the present work. Odeceixe and Aljezur estuaries, also included in PNSACV, are 6 km and 7 km long, respectively, and both have 50 m wide mouth openings. These two systems are located in areas with small villages with a low number of inhabitants. Bensafrim and Gilão estuaries are 4 km and 6 km long and have 65 m and 150 m wide mouth openings, respectively. The two latter estuaries are located near cities, in areas where tourism is the main economical activity, with high seasonal population fluctuations and unknown sewage loadings. The terminal part of Gilão is included in a natural park (Parque Natural da Ria Formosa – PNRF).

River flow is mainly torrential in all estuaries, directly dependent on rainfall, and influences spatial and temporal variations in salinity.

2.2. Fish community sampling

In each system, three equivalent sectors were defined in order to cover the entire potential tide and salinity range of each system: sector A, near the estuary mouth; sector B, intermediate; and sector C, in the upper part of the estuary with a lower marine influence. With the exception of the Mira estuary, the upstream limit of sector C was mainly defined by navigability range. Sampling

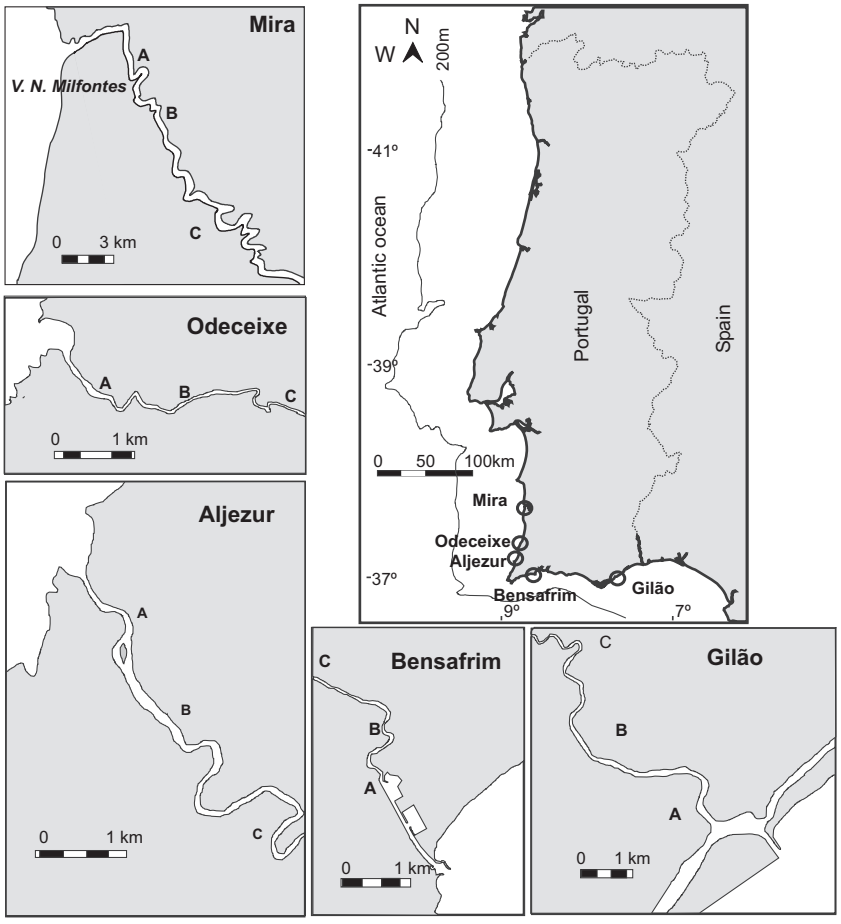

Fig. 1. Map of Portugal showing the location of the five estuarine systems studied: Mira, Odeceixe, Aljezur, Bensafrim and Gilão. Sectors in which sampling took place (A, B and C) are shown for each estuary.