

# Fish community-based measures of estuarine ecological quality and pressure–impact relationships



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## ABSTRACT

Community-based responses of fish fauna to anthropogenic pressures have been extensively used to assess the ecological quality of estuarine ecosystems. Several methodologies have been developed recently combining metrics reflecting community structure and function. A fish community facing significant environmental disturbances will be characterized by a simplified structure, with lower diversity and complexity. However, estuaries are naturally dynamic ecosystems exposed to numerous human pressures, making it difficult to distinguish between natural and anthropogenic-induced changes to the biological community. In the present work, the variability of several fish metrics was assessed in relation to different pressures in estuarine sites. The response of a multimetric index (Estuarine Fish Assessment Index) was also analysed. Overall, fish metrics and the multimetric index signalled anthropogenic stress, particularly environmental chemical pollution. The fish assemblage associated with this type of pressure was characterized by lower species diversity, lower number of functional guilds, lower abundance of marine migrants and of piscivorous individuals, and higher abundance of estuarine resident species. A decreased ecological quality status, based on the EFAI, was also determined for sites associated with this pressure group. Ultimately, the definition of each pressure groups favoured a stressor-specific analysis, evidencing pressure patterns and accounting for multiple factors in a highly dynamic environment.

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## 1. Introduction

Estuaries are widely regarded as naturally stressed ecosystems, where only fish species that can accommodate or adapt to the inherently dynamic physico-chemical conditions thrive (McLusky and Elliott, 2007). In addition to natural variability, estuaries are exposed to different types and magnitudes of pressures from human activities, making it difficult to disentangle between natural and anthropogenic-induced changes in the biological community (Elliott and Quintino, 2007).

Over the past three decades, increased awareness and legislation worldwide have led to the development of various methods to assess the ecological quality of aquatic ecosystems and the impacts of anthropogenic pressures (see review in Borja et al., 2008). Accordingly, several fish-based assessment methods have been recently proposed to assess the ecological integrity of estuaries, particularly in Europe due to the implementation of the Water Framework Directive (e.g. Borja et al., 2004; Coates et al., 2007;

Breine et al., 2010; Delpech et al., 2010; Birk et al., 2012; Cabral et al., 2012; Pérez-Domínguez et al., 2012).

The purpose of an environmental indicator is to summarize and quantify the fundamental information of a complex ecosystem, in order to facilitate communication and management (Whitfield and Elliott, 2002; Harrison and Whitfield, 2004). Estuaries sustain various ecological functions for fish communities by providing habitats for resident species, refuge from predators, nursery areas for marine migrant species, habitats for reproduction as well as migration routes for diadromous species (Haedrich, 1983; McLusky and Elliott, 2004; Elliott et al., 2007). Therefore, a holistic approach to environmental quality assessment in estuaries based on fish communities should comprise key metrics of community structure, such as species diversity and composition, and function, such as nursery function and trophic integrity (Elliott and Hemingway, 2002; Harrison and Whitfield, 2004). Given the resilience of the estuarine community to environmental variability, the biotic response patterns to natural stress may be similar to responses to anthropogenic stress, hence the inclusion of measures of ecosystem function are of paramount importance for proper ecological assessment (Elliott and Quintino, 2007).

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Most assessment tools, including fish-based indices, are composed by several metrics based on the assumption that a multimetric approach is more robust and sensitive to a broader range of pressures than individual metrics (Karr et al., 1986; Deegan et al., 1997; Hughes et al., 1998). Nevertheless, the number of metrics and their selection criteria has been object of recent studies (Quataert et al., 2011; Drouineau et al., 2012; Pérez-Domínguez et al., 2012). Despite the different approaches of the indices, they all rely on a priori hypotheses regarding pressure–impact responses, which are measurable with the several metrics (Roset et al., 2007). It is generally acknowledged that a community facing increased anthropogenic induced stress shows decreased diversity and decreased abundance of species with high habitat and environmental specificities (e.g. disturbance sensitive species), while generalist species have increased dominance, resulting in a simplified community structure (e.g. Odum, 1983; Karr and Chu, 1999).

Multi-metric indices development for ecological assessment can follow a general (i.e. unspecific) or a stressor-specific approach based on available data sets, knowledge on the autecology of biological groups, and assessment experience (Hering et al., 2006). Recently, several fish-based indices were developed as indicators of human pressure in estuaries, focussing mainly on chemical status and habitat physical changes (e.g. Uriarte and Borja, 2009; Breine et al., 2010; Delpech et al., 2010; Cabral et al., 2012). In general, anthropogenic pressure assessment has relied on pressure indices (conjugation of multiple pressure indicators) (Aubry and Elliott, 2006), or on individual measures that serve as proxy of anthropogenic stress (e.g. Delpech et al., 2010), which does not facilitate the

identification of specific stressor categories or aid in the definition of specific remediation measures for management and improved ecological quality.

In this context, the aim of this work is to assess the variability of fish community-based metrics in response to different categories of anthropogenic pressure in estuaries. Specifically, to distinguish impact levels of different pressures based on responses of fish metrics, either individually or combined in a multi-metric index.

## 2. Material and methods

### 2.1. Study area and anthropogenic pressure assessment

Eight estuarine sites, from five estuaries along the Portuguese coast were considered in the present study (Fig. 1). Environmental characterization per site was based on: dissolved oxygen, temperature, salinity, mean depth – determined during fish sampling surveys using a multi-parameter probe, and intertidal area – determined with aerial photographs, nautical charts and GIS software by França et al. (2009). Each site included a mosaic of the three main habitat types present in these estuaries (subtidal, soft-bottom intertidal, saltmarsh) (França et al., 2012). The anthropogenic pressure assessment was based on 14 indicators (Table 1), after the work by Aubry and Elliott (2006), selected based on the quality and accuracy of available data. Data was acquired mainly from governmental and public sources and merged to obtain a database for the studied estuarine sites referring to the period considered. Government agency and public institution records provided coherent and comparable data required for the present

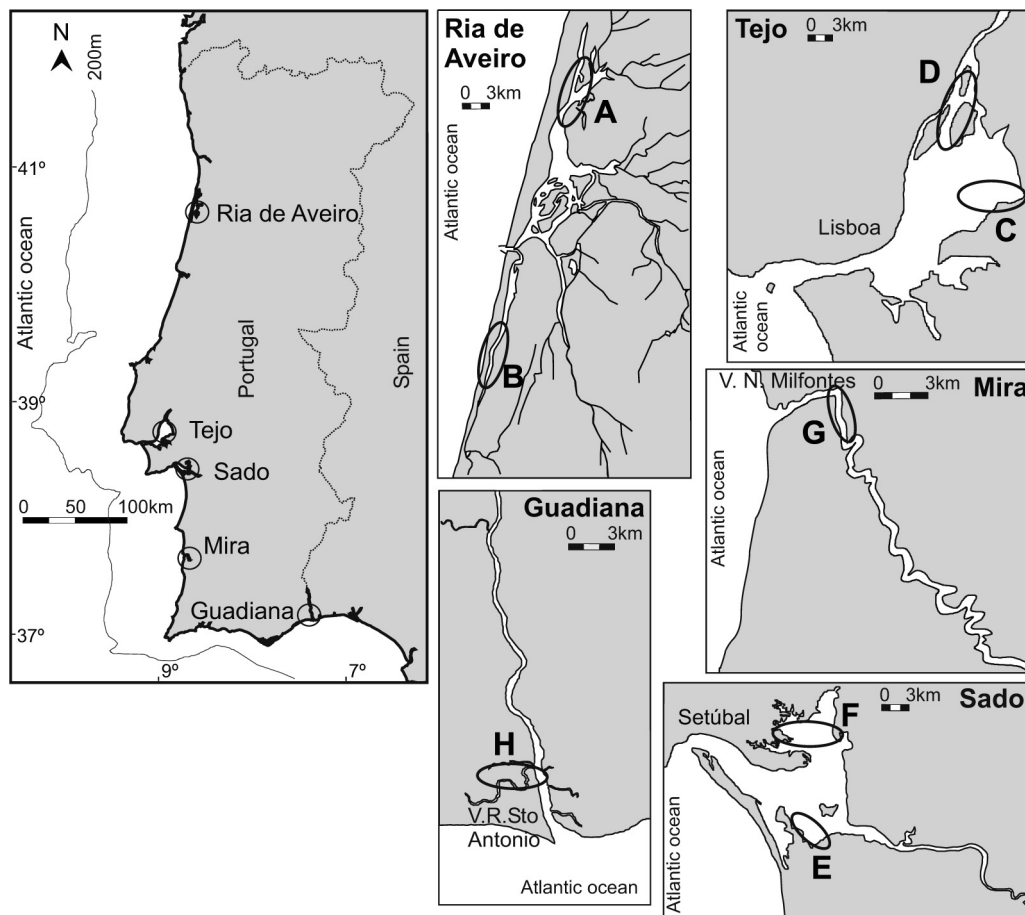


Fig. 1. Location of sampling sites (A to H) in the Ria de Aveiro, Tejo, Sado, Mira and Guadiana estuaries, along the Portuguese coast.

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