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The seagrass *Posidonia oceanica* as indicator of coastal water quality: Experimental intercalibration of classification systems

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ABSTRACT

The pervasive use of ecological indices is increasingly requiring actions of harmonisation. Specifically, within the EU Water Framework Directive, an important effort in methods intercalibration is being done. However, a significant limitation in comparability assessment arises from the datasets used, which have different geographic origins. The purpose of our study was to perform an experimental intercalibration, where data were collected specifically on a set of common sites and following all the requirements of the methods being assessed. Three indices based on the marine angiosperm *Posidonia oceanica*, the POMI, the BiPo and the PoSte, were applied to sites in three different geographical areas of the western Mediterranean: Catalonia, Corsica and Southern Italy (Ischia), distant between hundreds and more than thousands of kilometers. Two indices, POMI and BiPo, showed not only a very good relationship with human pressures (measured on a common scale for all sites) but also a high comparability, in all aspects investigated. The differences found for the third one (PoSte) are hypothesised as being due to a different rationale used to define reference conditions, the different metrics used in the index, and in particular to a different definition of ecological status in relation to the time scale of the response to anthropogenic pressures. Our study demonstrates that indices with very different approaches can provide fully reliable and comparable results.

1. Introduction

The development and application of ecological indicators to assess the status of aquatic environments has been strongly stimulated worldwide by the adoption of large-scale strategies of water management. Specifically, in Europe, the adoption of the EU Water Framework Directive (WFD 2000/60/EC) has led to the development of different classification tools, based on specific organisms or communities, the so-called biological quality elements (BQEs). In coastal waters, these include benthic invertebrates (Borja et al., 2000; Simboura and Zenetos, 2002; Rosenberg et al., 2004), phytoplankton (Devlin et al., 2007; Revilla et al., 2009), macroalgae (Panayotidis et al., 2004; Ballesteros et al., 2007; Wells et al., 2007; Juanes et al., 2008), and angiosperms (Krause-Jensen et al., 2005; Foden and Brazier, 2006; Romero et al., 2007).

To be WFD-compliant, classification tools should met a series of criteria, including: (i) ecological status should be expressed as a numerical value between 1 and 0, the Ecological Quality Ratio (EQR), which represents the ratio between the actual condition and the reference (i.e. pristine or near-pristine) condition; (ii) EQR should show a significant relationship with anthropogenic pressures; and (iii) classification should encompass five status classes (high, good, moderate, poor and bad). Although Member States (MS) are allowed to use their own national classification systems, adequate comparability is searched through the process of intercalibration, undertaken by the different MS within an eco-region (EC, 2000 – Annex V). Intercalibration focuses on validating the class boundaries between high and good status and between good and moderate status. The good/moderate boundary is particularly relevant, due to the legal implications of not obtaining a good status (EC, 2000). Intercalibration ensures the consistency of class boundaries, and provides a common basis for the assessment and interpreta-

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Table 1
Metrics included in each of the three classification systems under study. For a more detailed description of these metrics see the references in the text, Martínez-Crego et al. (2008), Lopez y Royo et al. (2010), and Buia et al. (2004).

Depth	Level	POMI	BiPo	PoSte
Lower limit of the meadow	Population		Depth Type (+ % plagio & leaf cover)	
Intermediate (15 m)	Population	Shoot density Shoot cover Plagiotropic rhizomes	Shoot density	Shoot density
	Individual	Shoot foliar surface Leaf necrosis	Shoot length	Width 2nd intermediate leaf Rhizome elongation Rhizome production Leaf production
	Physiological	N content in rhizomes P content in rhizomes Sucrose in rhizomes δ^{15}N ratio in rhizomes δ^{34}S ratio in rhizomes		
	Community	Epiphyte N content		
	Contaminants	[Cu] in rhizomes [Pb] in rhizomes [Zn] in rhizomes		

tion of ecological status in European waters. Apart from being a legal requirement, intercalibration addresses a problem which is of wide interest for the environmental science, i.e. the comparability of the different indices across large geographical areas. Intercalibration within the WFD is based on the exchange of data from existing and independently collected datasets, which are used to calculate the different indices (Borja et al., 2007; Foden and De Jonge, 2007). Except in cases in which the metrics are identical, intercalibration is thus generally achieved through indirect approaches (e.g. the definition of common or "similar" metrics, reflecting only partially the respective original methods; Foden and De Jonge, 2007), which do not guarantee a full and complete comparison and harmonisation. Up to now, and as far as we are aware, none of the comparisons among classification systems have been performed experimentally (i.e. joint sampling using different methods for the data acquisition in common sites).

In this paper, we attempt a direct and experimental intercalibration based on the independent work of different teams using different classification systems on common sites. We focus on one biological quality element, angiosperms, and, more precisely, on the seagrass *Posidonia oceanica*, which was selected as the only representative of this BQE in the Mediterranean eco-region (Med-GIG, 2007), due to its recognised ecological indicator possibilities (Pergent et al., 1995; Pergent-Martini et al., 2005; Martínez-Crego et al., 2008) and the monospecific characteristics of most Mediterranean seagrass meadows (Procaccini et al., 2003). A number of WFD-compliant classification systems based on *P. oceanica* have been developed (Buia et al., 2005; Romero et al., 2007; Lopez y Royo et al., 2010; Gobert et al., 2009) or are under development (Casazza et al., 2006). We chose three of them: the POMI (Romero et al., 2007), the BiPo (Lopez y Royo et al., 2010), and the PoSte (Buia et al., 2005). The objectives of this experimental intercalibration are three fold: (i) to determine ecological status, using *P. oceanica*, according to three different indices in three different geographical areas of the Mediterranean, (ii) to evaluate the comparability of the results obtained by the three indices, (iii) to identify the issues responsible for not reaching comparability.

2. Material and methods

2.1. P. oceanica classification systems under study

The three indices or classification systems (POMI, BiPo, PoSte) are each based on a different set of metrics (Table 1), requiring a specific dataset for their application. Each index also relies on a different strategy for metrics aggregation (classification method): the POMI relies on a multivariate analysis, the BiPo on the integration of individual evaluation scales and the PoSte on a data warehousing assessment programme. In contrast, all three indices have set boundaries between status classes, according to the same numerical values on the EQR scale (Fig. 1). Additional details can be found in Buia et al. (2005), Romero et al. (2007) and Lopez y Royo et al. (2010).

2.2. P. oceanica sampling and analyses

Seven sites have been selected for this study, and all are located in the north-western Mediterranean (Fig. 2): Mataró and Montroig in Catalonia (Spain); Punta Bianca, Stareso and Cages in Corsica (France); Lacco Ameno and Scarrupata in Ischia (Italy).

Sites have been selected in each region, according to an *a priori* estimation of a pressure gradient by local experts, in which one site is more subject to anthropogenic pressures than the other. Expert judgement was used to select, at least one site estimated *a priori* as being within the high/good classes, i.e. no identified source of disturbance in the water body (Mataró, Punta Bianca, Stareso, Scarrupata); and at least one site estimated *a priori* as being within the

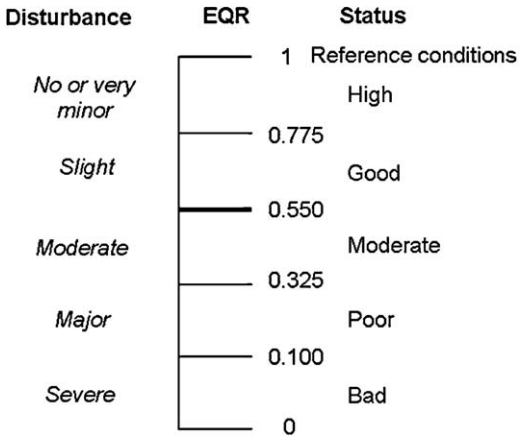

Fig. 1. EQR scale for classification of ecological status of the POMI, BiPo and PoSte indices.