Ecological Indicators 19 (2012) 98–105

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Testing MEDOCC and BOPA indices in shallow soft-bottom communities in the Spanish Mediterranean coastal waters

S. Pinedo[a,*], E. Jordana[a], F. Salas[b,c], M.D. Subida[d], E. García Adiego[e], J. Torres[f]

[a] Centre d'Estudis Avançats de Blanes, Accés Cala Sant Francesc, 14, 17300 Blanes, Girona, Spain
[b] TRAGSA, Camino del Nelva, s/n, 30007 Murcia, Spain
[c] IMAR-Institute for Marine Research, Department of Life Sciences, University of Coimbra, Largo Marques de Pombal, 3004-517 Coimbra, Portugal
[d] Instituto de Ciencias Marinas de Andalucía (CSIC), Av. Republica Saharauí s/n, 11510 Puerto Real, Cádiz, Spain
[e] Laboratorio de Vigilancia y Control de la Contaminación de Palmones (EGMASA), C/Trasmallo s/n, 11379-Palmones, Los Barrios, Cádiz, Spain
[f] Departamento de CC. Aplicadas y Tecnológicas, Facultad de CC. Experimentales Universidad, Católica de Valencia, C/Guillem de Castro, 94, 46003 Valencia, Spain

ARTICLE INFO

Keywords:
WFD
Marine biotic indices
Macroinvertebrates
BOPA
MEDOCC
Western Mediterranean

ABSTRACT

The implementation of the European Water Framework Directive has enhanced the development of several indices based on benthic invertebrate communities. Some of them, such as BOPA, simplify the calculation employing the taxonomic sufficiency principle to assess the ecological status of ecosystems since they only consider opportunistic polychaetes and amphipods; others, such as MEDOCC, include all the species found in the community, and assign them to four ecological groups: sensitive, indifferent, tolerant, and opportunistic. Anyway, there is the need for testing, validating and improving these indices in different regions and communities. In this study we test the application of MEDOCC and BOPA along the Spanish Mediterranean coastal waters (Catalonia, Balearic Islands, Valencia, Murcia, and Andalusia regions) in order to investigate whether benthic indices with different taxonomic resolution provide similar ecological status assessment. Shallow fine soft-bottom communities were sampled from 2002 to 2010 in a total of 241 locations. The comparison between both indices demonstrated that the concordance for the studied communities reached up to 79% in some areas, although it was less than 30% in natural and anthropogenically modified ecosystems dominated by stress-tolerant species. Even though BOPA index provides good results, in general it evaluates in higher ecological status than MEDOCC does and it does not always allow discriminating more disturbed situations. The assignation of a same species to different ecological groups (some opportunistic polychaetes of one method are classified as indifferent by the other) and the fact that all the amphipods (except genus *Jassa*) are considered as sensitive species in BOPA index but not in MEDOCC, could contribute to the observed discrepancies. Some suggestions to improve the agreement between both methods are pointed and discussed.

1. Introduction

The main objective of the European Water Framework Directive 2000/60 (WFD) is the protection and improvement of the aquatic ecosystems. The objective is to achieve at least "good water status" for all water bodies by 2015. The concept of ecological status developed in the WFD is defined in terms of the quality of the biological community, as well as the systems' hydrological and chemical characteristics. Moreover, the concept implies that in the absence of a comprehensive knowledge of all the pressures on a water body and of their combined biological effects, it will always be necessary to get direct measures with regard to the condition of the biological quality elements (Salas et al., 2006a). Therefore, the implementation of the WFD has enhanced the development and the use of benthic bio-indicators and indices based on soft bottom communities to determine the ecological quality of transitional and coastal waters in Europe.

Determining the presence or absence of one species or group of species has been one of the most used approaches in detecting pollution effects (Marques et al., 2009), specially organic pollution. The relationships between macrofaunal assemblages and the effect of organic enrichment have been described extensively in the literature (Pearson and Rosenberg, 1978; Gray and Mirza, 1979; Warwick et al., 1990; Simboura et al., 1995; Dauer et al., 2000; Borja et al., 2000, 2003; Muxika et al., 2005). In fact, Warwick (1993) considers that the use of indicator species is only applicable to organic pollution studies, including in some cases, oil pollution.

Recent and successful indices (i.e. AMBI, M-AMBI, BENTIX, MEDOCC, and BOPA) designed to evaluate the environmental quality of coastal and transitional waters, are based on the response of

* Corresponding author. Tel.: +34 972336101; fax: +34 972337806.
E-mail address: pinedo@ceab.csic.es (S. Pinedo).

1470-160X/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ecolind.2011.07.024

species and/or taxonomic groups to perturbations and also on the ecological strategies followed by different organisms (Salas et al., 2006b,c; Marques et al., 2009). These indices provide a disturbance classification based on a scale, according to WFD requirements, and most of them examine the relative decrease of sensitive species confronted with increasing organic matter. Some of these indices like AMBI, M-AMBI, BENTIX, and MEDOCC require taxonomic identification to species level. However there are others, such as BOPA index, in which taxonomic effort is reduced making easier its application.

Although numerous authors have used indices based on the species response to disturbances as universal keys (Borja et al., 2003; Muniz et al., 2005; Muxika et al., 2005), sometimes their use is restricted because not all organisms are equally sensitive to all types of pressures and could respond differently to different disturbances and habitats (Dauvin et al., 2007; Afli et al., 2008; Borja and Dauer, 2008; Marques et al., 2009; Teixeira et al., 2010). The existence of different types of indices raises the question about the universality of their application and therefore, stresses the need to require a calibration for testing and validating them in different regions and communities aiming to improve their use. The level of agreement of the direct comparison of different indices can provide information about the frequency, magnitude, and nature of the discrepancies and on how distinct premises may influence indices performance (Teixeira, 2010).

In this work, we compare the use of two indices: the MEDOCC (MEDiterranean OCCidental) index as an example of a more time-consuming index (species level classification), and the BOPA (Benthic Opportunistic Polychaetes Amphipods) index, as an example of simplicity (taxonomic sufficiency). The index MEDOCC was developed and applied to the soft-bottom communities in the Catalan Coast and Balearic Islands in the Northwestern Mediterranean (Pinedo and Jordana, 2007). It classifies the species found in the community in four ecological groups: sensible, indifferent, tolerant, and opportunistic. The calculation of the index is based on the proportion of these four groups. BOPA index (Dauvin and Ruellet, 2007) was created after the study carried out by Gómez-Gesteira and Dauvin (2000) about the effectiveness of the opportunistic polychaete/amphipod ratio for identifying oil spill events. Dauvin and Ruellet (2007) modified the ratio in the BOPA index to allow soft-bottom communities to be divided into the five classes demanded by the WFD. This index considers that opportunistic polychaetes are tolerant, indifferent or favoured by organic enrichment, and amphipods (except the genus *Jassa*) as a particular faunal group sensitive to significant increases in organic matter.

The aim of this study is to test the effectiveness of these two alternative approaches to assess the ecological status of different Mediterranean coastal soft-bottom communities in 241 locations along the Spanish Mediterranean coastal waters (Catalonia, Balearic Islands, Valencia, Murcia, and Andalusia regions). Moreover, some suggestions to improve the applicability of both indices are included.

2. Material and methods

2.1. Study area

The study area is located along 1200 km of the Spanish Mediterranean coast, including five regions: Catalonia, Balearic Islands, Valencia, Murcia, and Andalusia (Fig. 1). One of the major sources of pollution is that derived from the increasing of the population density of urban settlements, especially in the last decades (Eriksson and Zehaie, 2005; Blasco et al., 2009). A direct effect of the increase of the population is the rising of wastewater effluents. The main substances that these coastal waters receive from the wastewater effluents are suspended and dissolved matter, organic matter and nutrients, detergents and other contaminants (Soltan et al., 2001; Blasco et al., 2009). Other sources of eutrophication in this coastal area are originated from the discharges of nutrients and organic matter from agriculture and aquaculture activity (Agència Catalana de L'Aigua, 2005, 2010).

2.2. Data series

A total of 241 locations along the Spanish Mediterranean coasts were sampled. Depending on the region, two to three replicate samples or averaged samples from different surveys, were used: Catalonia (122 replicates, two replicates per sample, collected in 2002 and 2003); Balearic Islands (85 replicates, two replicates per sample, collected in 2005); Valencia (51 averaged samples, collected in 2005); Murcia (71 averaged samples, collected from 2002 to 2010), and Andalusia (45 replicates, three replicates per sample, collected in 2007). The geographical limits of the sampling were 42° 23.6′N-3° 09.7′E near France and 36° 05.70′N-5° 25.45′W near the Strait of Gibraltar. That means from the Northwestern Mediterranean to the south where Atlantic surface cold waters cross the strait with lower salinity and gradually mix with Mediterranean waters.

All samples were collected in shallow fine soft-bottom communities (between 3 and 20 m depth) from June to July. The macrofauna was collected with a van Veen grab (600 cm^2 in Catalonia, Balearic Islands, Valencia, and Murcia; 500 cm^2 in Andalusia) and sieved through a 0.5 mm sized mesh (except in Valencia where 0.63 mm was used) and preserved in a 4% buffered formalin solution. The fauna were sorted and identified at species level whenever possible.

2.3. Computation of indices

BOPA and MEDOCC indices were calculated in each sample. Only samples compliant with the requirements of both methods were considered: for BOPA, samples with more than 20 individuals in the sample and for MEDOCC, fine to very fine sand communities. The values of the BOPA and MEDOCC were calculated from the benthic data series, using the following algorithms:

$$\mathrm{BOPA} = \log\left(\frac{fp}{fa} + 1\right) + 1 \quad (1)$$

where *fp* is opportunistic polychaete frequency, and *fa* is amphipod (excluding G. *Jassa*) frequency. BOPA index varies between 0 (when *fp* = 0) and 0.30103 (when *fa* = 0).

$$\mathrm{MEDOCC} = \frac{(0)(\%EGI) + (2)(\%EGII) + (4)(\%EGIII) + (6)(\%EGIV)}{100} \quad (2)$$

where *EGI*, *EGII*, *EGIII*, and *EGIV* are sensible, indifferent, tolerant, and opportunistic species, respectively. MEDOCC values can vary between 0 (only sensible species are present) and 6 (opportunistic species are the 100% of the total abundance).

BOPA and MEDOCC values were used to assign samples to the five ecological quality status (EQS) defined in the WFD: "high", "good", "moderate", "poor", and "bad". Indices values were transformed from 0 ("high") to 6 ("bad") in MEDOCC and from 0 ("high") to 0.30103 ("bad") in BOPA to an EQS scale from 0 ("bad") to 1 ("high") with a simple values conversion. Since the aim of this study is to compare the ecological status obtained using both indices and to analyse these comparisons in order to improve both methodologies, the use of reference conditions was not considered necessary. Moreover, both indices follow the WFD's normative definitions of "good ecological status". The calibration of BOPA limits was done following the procedure described by Dauvin and Ruellet (2007) taking the MEDOCC limits as the basis. The MEDOCC boundaries