Marine Environmental Research 103 (2015) 27–35

Contents lists available at ScienceDirect

Marine Environmental Research

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

Application of "taxocene surrogation" and "taxonomic sufficiency" concepts to fish farming environmental monitoring. Comparison of BOPA index versus polychaete assemblage structure

F. Aguado-Giménez [a,*], J.I. Gairín [b], E. Martinez-Garcia [c], V. Fernandez-Gonzalez [c], M. Ballester Moltó [a], J. Cerezo-Valverde [a], P. Sanchez-Jerez [c]

[a] Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario (IMIDA), Estación de Acuicultura Marina, Puerto de San Pedro del Pinatar, 30740, Murcia, Spain
[b] IRTA Investigación y Tecnología Agroalimentaria, Ctra, De Poblenou Km 5.5, 43450, Sant Carlos de la Rápita, Tarragona, Spain
[c] Departamento de Ciencias del Mar y Biología Aplicada, Universidad de Alicante, Ap. 99, 03080, Alicante, Spain

A R T I C L E I N F O

Article history:
Received 3 July 2014
Received in revised form
27 October 2014
Accepted 31 October 2014
Available online 1 November 2014

Keywords:
Benthic index
Fish farming
Monitoring
Polychaete assemblage
Taxocene surrogation
Taxonomic sufficiency

A B S T R A C T

"Taxocene surrogation" and "taxonomic sufficiency" concepts were applied to the monitoring of soft bottoms macrobenthic assemblages influenced by fish farming following two approaches. Polychaete assemblage evaluation through multivariate analysis and the benthic index BOPA were compared. Six fish farms along the Spanish Mediterranean coast were monitored. Polychaete assemblage provided a suitable picture of the impact gradient, being correlated with total free sulphides. BOPA did not support the impact gradient described by the polychaete assemblage, providing erroneous categorizations. The inclusion of several polychaete families, which were locally identified as indicative of affection to recalculate BOPA, resulted in an improved diagnosis and correlation with the impact gradient. Nevertheless, frequent misclassifications occurred. These results suggest that the structure of polychaete families, sulphides and granulometry conform an appropriate strategy for fish farming monitoring. Biotic indices need to be specifically designed for concrete activities, and regionally validated, because of the environmental plasticity of benthic invertebrates.

© 2014 Elsevier Ltd. All rights reserved.

1. Introduction

Marine soft-bottom macrozoobenthic communities have the inherent ability of integrating the environmental quality status reflecting the system condition adequately. They are relatively immobile residents and exhibit a wide range of tolerance or sensitivity to different stressors (Tataranni and Lardicci, 2010). Also, soft-bottom macrobenthic communities play a key role in the provision of ecosystem services, mainly the cycling of nutrients and material in the sediments, and the maintenance of the benthic food web (Gray and Elliott, 2009). Owing to both prerogatives, macrobenthic invertebrate communities have been widely used as an indicator for environmental assessments, particularly for fish farming monitoring (Karakassis et al., 2000; Carroll et al., 2003; Lee et al., 2006; Aguado-Giménez et al., 2007).

Information from scientific studies on the marine benthic communities applicable to the management of coastal resources is not always easily understandable for a non specialist audience. To facilitate the management and decision-making processes, marine benthic scientists have developed ecological indicators as benthic biotic indices (BBIs hereafter), which supply synoptic information of the ecosystems (Salas et al., 2006). BBIs attempt to simplify the complex multivariate structure extracted from benthic assemblages up to a single (univariate) value that summarizes the ecological status as a function of some ecological characteristic (e.g. sensitivity or tolerance to pollution, trophic strategy, combined with species' richness, abundance, presence – absence, diversity, etc.) (Pinto et al., 2009; Dauvin et al., 2010).

Over the last decades, coinciding with the publication of the European Water Framework Directive (WFD, 2000/60/EC) and the Marine Strategy Framework Directive (MSFD, 2008/56/EC), there was an intensive work for the development of monitoring tools (Dauvin, 2007). In the case of the marine benthic environment, it has led to a revival and emergence of old and new BBIs (Díaz et al., 2004; Devlin et al., 2007; Pinto et al., 2009), with the aim of

* Corresponding author.
E-mail address: felipe.aguado@carm.es (F. Aguado-Giménez).

http://dx.doi.org/10.1016/j.marenvres.2014.10.006
0141-1136/© 2014 Elsevier Ltd. All rights reserved.

standardising methodologies for typifying and monitoring the environment quality of European water bodies. Many of the recently emerged or created BBIs (e.g. AZTI's Marine Biotic Index, AMBI: Borja et al., 2000; BENTIX: Simboura and Zenetos, 2002; Benthic Quality Index, BQI: Rosenberg et al., 2004; Benthic Opportunistic Polychaetes Amphipods Index, BOPA: Dauvin and Ruellet, 2007; MEDiterranean OCCidental Index, MEDOCC: Pinedo and Jordana, 2007; and others) have already been applied to assess the ecological quality status of water bodies at different locations worldwide (e.g. Pranovi et al., 2007: lagoon of Venice, Italy; Afli et al., 2008: Tunisian coasts and lagoons; Labrune et al., 2012: Rhône river, France; Pinedo et al., 2012: Spanish Mediterranean coast; Quiroga et al., 2013: Patagonian fjords, Chile). Most of these indices are based on the concept of macrobenthic sensitivity or tolerance *sensu*, the Pearson and Rosenberg (1978) organic enrichment paradigm. As there are different sources of organic enrichment and, furthermore, this is not the only source of pollution affecting benthic communities, most of BBIs have also been tested under particular sources of stress, such as domestic sewage (de-la-Ossa-Carretero et al., 2009; Sampaio et al., 2011), mining (Marín-Guirao et al., 2005; Gray and Delaney, 2008), dredging, industrial and agricultural wastes (Borja et al., 2003), metalliferous wastes (Simboura et al., 2007), and aquaculture (Aguado-Giménez et al., 2007; Bouchet and Sauriau, 2008; Borja et al., 2009; Nickell et al., 2009; Forchino et al., 2011; Keeley et al., 2012; Karakassis et al., 2013).

However, after several decades of widespread use of these BBIs, their application is still questioned, mainly as regards the sources of stress and geographical plasticity (Green and Chapman, 2011; Keeley et al., 2012). Beside these overall discrepancies, there are many other controversial aspects, such as the assignation of taxa to sensitivity/tolerance levels (Carvalho et al., 2006; Labrune et al., 2012), misclassification of the ecological quality status (Quintino et al., 2006; Bouchet and Sauriau, 2008; Callier et al., 2008), differences in discriminating power among indices (Pranovi et al., 2007), loss of essential information causing loss of diagnostic capability (Sampaio et al., 2011), difficulty in distinguishing natural from human-induced stress in transitional waters (Dauvin, 2007; Elliott and Quintino, 2007), the need of assessing the spatial and temporal variability of the BBI performance (Kröncke and Reiss, 2010; Tataranni and Lardicci, 2010; Quintino et al., 2012), the availability of taxonomic expertise (the so-called “taxonomic impediment; ”Wheeler, 2004; Bevilacqua et al., 2013), and several more as Dauvin et al. (2012) summarized. Finally, the main criticisms of the indices are the huge loss of information by reducing the complexity of a community to a single value, and the misleading biological interpretation of the data they are intending to summarize (Green and Chapman, 2011). Despite this, some of the above-mentioned or other BBIs have been postulated as reliable tools not only in the context of the WFD, but also for the mandatory monitoring of specific operational aquaculture activities like mussel and fish farming as well (Borja et al., 2009; Forchino et al., 2011; Keeley et al., 2012; Karakassis et al., 2013).

Nevertheless, all of the very few comparative studies contrasting the univariate information provided by some BBIs *versus* the multivariate information from the whole assemblage data set, in the context of aquaculture, agree that the multivariate approach is more appropriate to detect the influence of aquaculture on the benthic environment (Aguado-Giménez et al., 2007; Callier et al., 2008; Quintino et al., 2012). Considering that mandatory survey is an additional economic charge for fish farmers, it would be desirable that these studies were very well balanced from a cost/benefit point of view, without forgetting representativeness and robustness. Therefore, a selection of informative but cheap impact indicators (Riera et al., 2012) and the establishment of an adequate sampling design (Fernandes et al., 2001; Aguado-Giménez et al., 2012a; Fernandez-Gonzalez et al., 2013) are needed. The application of some BBIs such as AMBI, BENTIX, BQI, MEDOCC or others, is an expensive and very time-consuming task requiring practised taxonomists for identifying all the fauna to species level (Dauvin et al., 2003; De Biasi et al., 2003; Riera et al., 2012). Nevertheless, others BBIs such as BOPA only works with two faunal groups (polychaetes and amphipods), so its taxonomic effort is much lower. On the other hand, some authors have even proposed that surrogating the whole benthic assemblage to a particular taxonomic group which was able to reflect the natural or human-induced development of the entire assemblage, would represent a significant cost reduction with a minimal loss of relevant information (Olsgard and Sommerfield, 2000; Bertasi et al., 2009; Soares-Gomes et al., 2012). This is the case of polychaetes, whose frequency and abundance in soft bottom and its proven sensitivity to environmental changes makes them an appropriate surrogate taxocene for monitoring programmes (Olsgard et al., 2003; Giangrande et al., 2005; Del-Pilar-Ruso et al., 2009; Musco et al., 2009; Soares-Gomes et al., 2012). Likewise, following the concept of taxonomic sufficiency (Ellis, 1985), it has been evidenced that identifying polychaetes to family level - as unique biological indicator - provides sufficiently accurate assessments in monitoring surveys of aquaculture activities (Tomassetti and Porrello, 2005; Lee et al., 2006; Aguado-Giménez et al., 2012b; Martinez-Garcia et al., 2013).

The aim of this work is to evaluate some indicators that meet some criteria of simplicity (as indicated by the concepts of “taxonomic sufficiency” and “taxocene surrogation” proposed by Ellis (1985) and *sensu* Olsgard and Sommerfield (2000), respectively) as potential tools for the monitoring of fish farming effects on soft bottoms. For that, we assess two alternative approaches under an *a priori* well-defined impact gradient: univariate BOPA index, which uses only polychaetes and amphipods identified to family level, and the multivariate structure of polychaete assemblage also identified to family level, both together with a good sediment descriptor (granulometry) and a very sensitive chemical variable (total free sulphides), as Aguado-Giménez et al. (2012a) suggested. We considered that both approaches provide a good balance between simplicity and robustness. Both methods were compared in terms of discriminating capacity and susceptibility of application in compulsory surveys. In order to ascertain whether specific polychaete families which act as indicator of the impact derived from fish farming would improve BBI results, we also recalculate BOPA using those tolerant polychaete families derived from the results of this study and the definitions from Martinez-Garcia et al. (2013).

2. Materials and methods

2.1. Study area and proceedings for sampling and analyses

The study was carried out at six gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) cage fish farms randomly chosen along the Spanish Mediterranean coast (Fig. 1). At each farm, three zones at increasing distances from the farm were established following a theoretical enrichment gradient downstream: beneath the cages, just outside the farm lease boundaries (60–100 m away from the cages), and a reference zone (0.5 – 1 km away from the lease boundary). This zoning was set in agreement with the proposal of “allowable zone of effects” suggested by Aguado-Giménez et al. (2012a). At each distance, three sites were randomly sampled, where three sediment replicates were collected for polychaete and amphipod assemblage analyses. Three additional samples were also taken for sediment physico-chemical analyses. All sediment samples were collected using a 0.04 m^2

Download English Version:

https://daneshyari.com/en/article/4550722

Download Persian Version:

https://daneshyari.com/article/4550722

Daneshyari.com