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Marine biological value along the Portuguese continental shelf; insights into current conservation and management tools

Inês Gomes[a,b,*], Sergi Pérez-Jorge[c], Laura Peteiro[d], Joana Andrade[e], Juan Bueno-Pardo[a], Victor Quintino[a], Ana Maria Rodrigues[a], Manuela Azevedo[f], Ann Vanreusel[b], Henrique Queiroga[a], Klaas Deneudt[g]

[a] Departmento de Biologia & CESAM, Universidade de Aveiro, Campus Universitario de Santiago, 3810-193 Aveiro, Portugal
[b] Marine Biology Research Group, Ghent University, 9000 Ghent, Belgium
[c] MARE – Marine and Environmental Sciences Centre and Institute of Marine Research (IMAR) – University of Azores, 9901-862 Horta, Portugal
[d] Departamento de Ecoloxía e Bioloxía Animal, Facultade de Ciencias do Mar, Universidade de Vigo, 36310 Vigo, Spain
[e] Sociedade Portuguesa para o Estudo das Aves (SPEA), 1070-062 Lisboa, Portugal
[f] Instituto Português do Mar e da Atmosfera (IPMA), 1495-006 Lisboa, Portugal
[g] Flanders Marine Institute (VLIZ), InnovOcean Site, 8400 Ostend, Belgium

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ABSTRACT

The valuation of nature is an inbuilt component of validating environmental management decisions and an important research field for different disciplines related to conservation, economy and ethics. Here, biodiversity was valued using an ecological approach based on the intrinsic value incorporated in biodiversity *per se,* regardless of any human association. The Marine Biological Valuation protocol was drawn upon the methodology of terrestrial valuation maps, to support the European MSFD environmental status assessment (descriptor 1 – biodiversity) and national marine spatial planning approaches. To apply the protocol on the Portuguese continental shelf we compiled and analyzed national biological databases for a wide taxonomic range of ecosystem components (seabirds, demersal fish, macrobenthos, marine mammals and sea turtles) and assessed the spatial overlap with existing and proposed conservation areas (Natura 2000 network). The resultant maps described patterns of biological value consistent with the physical and biological oceanographic conditions as well as local hydrodynamics of the Portuguese continental shelf. The results of our approach confirm previously identified valuable areas for protection (particularly in the northern and central regions), but also highlights the value of currently unprotected sites, mainly in the southern region. Biological valuation maps showed to be comprehensive tool to compile and spatially analyze biological datasets. By drawing attention to subzones of biological importance, it constitutes a valuable instrument in making appropriate-scale decisions on the spatial allocation of human activities in the context of the Portuguese marine spatial planning, currently facing the pressure and impacts of increased maritime exploitation.

1. Introduction

Biological diversity is recognised as the foundation of healthy ecosystems (Hector and Bagchi, 2007; Worm et al., 2006) and its conservation an important aim of environmental management (Brooks et al., 2006). The valuation (or "attributing importance/weight") of nature is an inbuilt component of validating environmental management decisions. Although the quantification of the wide-ranging value of biodiversity is currently a significant subject of investigation for conservation, economy and ethics disciplines, the methodologies have yet to reach a consensus amongst researchers. In fact, much debate still surrounds the concepts of biological diversity and biodiversity itself. The key challenge is to find ways to evaluate the multidimensional diversity concepts (including all biotic variation from genes to ecosystems level) in useful and operational ways (Purvis and Hector, 2000).

In its broad sense, biodiversity is valued regarding the views of anthropocentrism, as having a transaction and/or utility value (a socio-economic relation to humans) or holding an intrinsic biological value. Valuing nature requires therefore a complex combination of economic, socio-cultural and ecological perspectives (Laurila-Pant et al., 2015; Scholte et al., 2015). An ongoing debate exists around the methods valuing nature to reflect a realistic and integrative contribution of

* Corresponding author at: Departmento de Biologia & CESAM, Universidade de Aveiro, Campus Universitario de Santiago, 3810-193 Aveiro, Portugal.
E-mail address: istgomes@gmail.com (I. Gomes).

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biodiversity in decision making (Chan et al., 2016).

Valuing biodiversity and ecosystem services in monetary terms (assigning a metric value to ecosystem components benefiting humankind) (Costanza et al., 1997) is a contemporary trend (Kubiszewski et al., 2017) enshrined into a number of international frameworks, such as the European Union 2020 Biodiversity Strategy, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), the Millennium Ecosystem Assessment (MA) and in marine policies like the European Marine Strategy Framework Directive (MSFD). Even though there are several classification systems to economically value biodiversity (see de Groot et al., 2002), a unified framework to measure marine monetary metrics in environmental management is still missing (Nahlik et al., 2012). Monetary evidences are believed to be easily conveyed to a broad audience and assimilated into conservation policy-making (Bräuer, 2003). Also, economic valuation can be a pragmatic way forward to add to scientific and ethic approaches to reach conservation goals; a strategy used in other domains like public health and education (Scharks and Masuda, 2016). Several studies have already calculated coastal and marine ecosystem services in different settings: estuarine waters (Barbier et al., 2011), coral reefs (Pendleton, 1995), artificial reefs (Polak and Shashar, 2013), mangrove forests (Huxham et al., 2015), sea grass meadows (Tuya et al., 2014), open sea (Ressurreição et al., 2011) and the deep sea (Jobstvogt et al., 2014). However, most critics to environmental economic valuation point out the fact that many financial proxies cannot reflect the highly complex and dynamic role of biodiversity to human wellbeing (Bartkowski et al., 2015). This is especially true in the marine setting, with fundamental physical and biological differences when compared to the terrestrial environment (Carr et al., 2003). For instance, the relative "openness" of marine populations (i.e., higher rates of import and export than their terrestrial counterparts) along with the way anthropogenic pressures are more diffuse in the marine environment, require broader spatial and temporal scale approaches to value biodiversity in ecologically meaningful ways. Also, several arguments have emerged among conservationists that conventional economic approaches are inadequate for conservation issues since they quantify ecosystem services as marketable, and consequently, replaceable commodities (Gómez-Baggethun et al., 2010; Peterson et al., 2010) contradicting conservation targets (Callicott, 2006; Fanny et al., 2015). Spash (2015) argued that this economic logic of natural systems and its offset principle, does not seek to prevent or reduce biodiversity devastation, but to legitimize it.

A complementary approach values biodiversity through its socio-cultural value; investigating non-monetary human perceptions regarding ecosystem services (Daniel et al., 2012; Kenter et al., 2015). These valuation techniques are however constrained to landscapes greatly shaped by human direct influence (Martin-López et al., 2012) and less competent in offshore marine areas (but see Christie et al., 2017). In the marine environment, the quantification of this socio-cultural component has been mainly treated within the context of marine protected areas (Angulo-Valdés and Hatcher, 2010; Petrosillo et al., 2007).

Finally, the ecological approach to value of biodiversity is based on the intrinsic value of biodiversity *per se,* regardless of any human association. This notion has been the basis not only for environmental ethics but also for biological conservation disciplines. Whether it is based on a philosophical view, or supported by available scientific methods, intrinsic values in nature are now widely accepted by conservationists (Cafaro and Primack, 2014; Doak et al., 2014; Vucetich et al., 2015). In order to reduce the subjectivity of "inherent values", various systematic decision supporting tools have been developed, using biodiversity metrics and spatial analysis to meet conservation targets (e.g. Airamé et al., 2003; Villa et al., 2002). Some studies identify areas of ecological importance, focusing on individual taxa (Fishpool et al., 1998), groups of species (Eken et al., 2004), habitats (Ward et al., 1999), using multiple ecological criteria (Roberts et al., 2003) or highlighting hotspots of rare/endemic species or high species richness (Myers et al., 2000). At a global scale, the Convention on Biological Diversity (CBD) has adopted a scheme to recognize 'Ecologically or Biologically Significant Marine Areas' (EBSAs) in need of protection. Seven scientific criteria are used to define EBSAs (Dunn et al., 2014): uniqueness or rarity; special importance for life-history stages; importance for threatened, endangered or declining species and/or habitats; vulnerability, fragility, sensitivity, or slow recovery; biological productivity; biological diversity; and naturalness.

The Marine Biological Valuation protocol presented here (Derous et al., 2007a, Derous et al., 2007b) was drawn upon the methodology of the terrestrial valuation maps, to fulfill the emergent need on solid spatial information to support marine spatial planning approaches. The protocol developed by Derous et al. (2007c) uses valuation criteria based on a thorough review of academic literature and international legislative documents on marine biological assessment by a panel of experts from Project BWZee – A Biological Valuation Map for the Belgian Continental Shelf. Unlike the EBSA protocol, aiming at identifying areas in need of protection, including criteria related to human impacts, the method reflects on "the inherent value of marine biodiversity, without reference to anthropogenic use". Initially developed for the Belgian part of the North Sea, it has also been applied to the shallow Belgian coastal zone (Vanden Eede et al., 2014) , Azores (Rego, 2007), Denmark (Forero, 2007) and Spain (Pascual et al., 2011). Also, Weslawsli et al. (2009) used a modified version to assess the biological value of the benthic communities in the southern Baltic Sea.

Here, we applied the protocol in the continental Portuguese shelf, using available biological datasets for the distribution and abundance of marine organisms. These maps can serve as integrative baseline information within the European MSFD environmental status assessment (descriptor 1 – biodiversity) and to define priority conservation areas in marine spatial planning (MSP).

Given the contemporary pressure and competitiveness on marine resource exploitation in the maritime setting, meaningful initiatives integrating full spatial coverage biological datasets are crucial for the monitoring of biodiversity (Golden et al., 2017). This is particularly true in the Portuguese case, with one of the largest continental shelf areas in the European Union and where the National Ocean Strategy 2013–2020 is set on the "blue growth" development model. The Portuguese MSP plan establishes the legal basis for the national policy on marine spatial planning and management, using the "Plano de Ordenamento do Espaço Maritimo POEM 2008–2012" (INAG, 2012) as the national reference situation for coastal and ocean planning. However, concerns have arisen that the framework is mainly driven by economical concerns, with environmental conservation coming second to economic goals (Frazão Santos et al., 2015, 2014). Calado et al. (2010) stated that the major operational challenge encountered in developing the Portuguese MSP was the access to suitable quality data and the lack of implementation tools to facilitate an effective public discussion. In this sense, the specific objectives of this work are: (i) to explore, compile and summarize national marine biological databases; (ii) to apply the marine biological valuation approach on the Portuguese continental shelf waters (iii) to assess the spatial overlap of the valuation scores with marine conservation areas (Natura 2000 network) and (iv) to examine the significance of our results in the context of the Portuguese marine spatial planning. To our knowledge this is the first published attempt to combine and spatially evaluate data for a wide taxonomic range of ecosystem components (seabirds, demersal fish, macrobenthos, marine mammals and sea turtles) at the scale of tens of kilometers along the continental Portuguese shelf.

2. Material and methods

2.1. Study area

The Portuguese continental shelf extends from the Galicia Bank to the Gulf of Cadiz for approximately 900 km in length, averaging a width