



## Original Articles

# What can indicators of good environmental status tell us about ecosystem services?: Reducing efforts and increasing cost-effectiveness by reapplying biodiversity indicator data



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## ABSTRACT

The EU Marine Strategy Framework Directive (MSFD) requires member states to manage their marine ecosystems with the goal of achieving Good Environmental Status (GES) of all European Seas by 2020. Member states assess GES according to 11 descriptors set out in the MSFD, and their associated indicators.

An ecosystem service approach is increasingly being advocated to ensure sustainable use of the environment, and sets of indicators have been defined for ecosystem service assessments. We considered whether a selection of GES indicators related to biological descriptors, D1 Biodiversity, D2 Non-indigenous species, D4 Food webs and D6 Seafloor integrity, may provide information relevant to ecosystem services, potentially allowing use of collected environmental data for more than one purpose. Published lists of indicators for seven selected marine ecosystem services were compared to 296 biodiversity-related indicators included within the DEVOTOOL catalogue, established for screening marine biodiversity indicators for the MSFD. We concluded that 64 of these biodiversity indicators are directly comparable to the ecosystem service indicators under consideration. All 296 biodiversity indicators were then reassessed objectively to decide which of them could be useful as ecosystem service indicators. To carry out this step in a consistent and transparent manner, guidelines were developed among the co-authors that helped the decision making process for each individual indicator. 247 biodiversity indicators were identified as potentially useful ecosystem service indicators. By highlighting the comparability between ecosystem service and biodiversity indicators it is hoped that future monitoring effort can be used not only to ensure that GES is attained, but also that ecosystem service provision is maximised. It is recommended that these indicators should be tested across EU regional seas to see if they are useful in practice, and if ecosystem service assessments are comparable across regional seas.

## 1. Introduction

Biodiversity is closely linked to ecosystem functioning, which in turn underpins the provision of ecosystem services on which humanity depends, such as Food provision and Climate regulation (Heiskanen et al., 2016; Lique et al., 2016). According to the Convention on Biological Diversity (CBD, 1992), biodiversity is defined as “the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological

complexes of which they are part; this includes diversity within species, between species and of ecosystems”. Yet, biodiversity is threatened worldwide by pressures such as habitat loss, overexploitation and pollution (Halpern et al., 2008; Knights et al., 2013). International environmental agreements, such as the Aichi Biodiversity Targets for 2020 in the Convention of Biological Diversity (CBD, 1992), the EU Biodiversity Strategy 2020 (BD; COM/2011/0244), and recent European Union legislation (e.g. the EU Marine Strategy Framework Directive (MSFD; 2008/56/EC)) are placing increasing emphasis on

Abbreviations: ES, ecosystem services; MSFD, marine strategy framework directive; GES, good environmental status; EU, European Union; NIS, non-indigenous species

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halting biodiversity loss (Laurila-Pant et al., 2015; Liqueste et al., 2016).

The MSFD “establishes a framework for community action in the field of marine environmental policy”, which promotes the preservation and protection of marine waters in European member states (European Commission, 2008). One aim of the MSFD is for each member state to take measures to achieve and maintain Good Environmental Status (GES) in all four European Seas (i.e. Baltic Sea, Black Sea, Mediterranean and North East Atlantic) by the year 2020, through country-specific programmes of measures (Börger et al., 2016). The MSFD defines GES as: “the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations.” This definition implies that ecosystem services and societal benefits should be taken into consideration when measuring GES but at the same time these aspects are not mentioned in either the descriptors or associated criteria (Borja et al., 2013). Recently, changes were suggested to some elements of the MSFD, including criteria and Annex III, these are now awaiting acceptance. Among these changes is the acknowledgement that member states may also assess ecosystem services under MSFD. These changes demonstrate the importance of comparing ecosystem service indicators and biodiversity-related indicators (from now on biodiversity indicators).

To assess the status of the seas and to be able to monitor changes in environmental status, each member state has to carry out regular assessments addressing 11 descriptors that describe a state, or a pressure, or both. These are: Descriptor (D) D1–Biological diversity, D2–Non-indigenous species (NIS), D3–Commercial fish and shellfish, D4–Food webs, D5–Eutrophication, D6–Sea floor integrity, D7–Hydrological conditions, D8–Concentration of contaminants, D9–Contaminants in fish and other seafood, D10–Litter, D11–Energy and noise. These 11 descriptors are further defined by a set of 29 criteria and 56 indicators. Indicators are variables that provide information on complex phenomena and if properly selected can show changes of such phenomena (Kandziora et al., 2013; Hattam et al., 2015). A requirement of the MSFD is that indicators focus on essential biological components of the ecosystem, from taxonomic groups through habitats to ecosystems (Borja et al., 2014; Berg et al., 2015). Member states considered the different criteria and indicators, and for those of relevance to their seas they defined a series of indicators to be used to describe a baseline, and then in regular monitoring programmes to assess the success of their programmes of measures.

The biological components relevant for biodiversity assessments are described by Cochrane et al. (2010), and specifically listed in Table 1 of the Annex III of the MSFD. The biodiversity components include predominant seabed and water column habitat types, as well as specific habitats that have biodiversity conservation importance. Biological

communities associated with those seabed and water column habitats, such as phytoplankton and zooplankton communities, angiosperms, macro-algae and invertebrate bottom fauna, or species belonging to groups such as fish, marine mammals and reptiles, and seabirds are also included in the biodiversity components. Currently there are a number of operational indicators available for the assessment of GES (Teixeira et al., 2016), and more are being developed to be used in robust and cost-efficient monitoring and assessments (Heiskanen et al., 2016).

Besides monitoring the status of marine waters, the MSFD dictates that member states shall adopt an ecosystem-based management approach in their programmes of measures to “enable the sustainable use of marine goods and services” (Paragraph 8 of the MSFD preamble). Ecosystem-based management is focused on ecosystems and human interactions within these systems, and thus necessitates an understanding of the linkages within and between the biological components of the ecosystems as well as with social and economic systems (McLeod et al., 2005; Atkins et al., 2011). Furthermore, it is stated in the MSFD Article 1, Paragraph 3.: “Marine strategies shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generation”. This anticipates that there is a link between GES and the sustainable use of ecosystem goods and services. Although many of the GES indicators are well described and used by EU member states, there is no operational example describing how these could also be used in the assessment of ecosystem services, although some regional (Hasler et al., 2016) and EU-level (Maes et al., 2016) suggestions have been made. Here we conceptualise ‘sustainable use’ in the sense of ‘weakly sustainable use’ (sensu Rossberg et al., 2017) i.e. usage that can be continued indefinitely in its current form. The key concept to assess status and trends of potential uses of an ecosystem, particularly relevant in local and regional settings, is that of ecosystem services (Maes et al., 2012; O’Higgins and Gilbert, 2014). Ecosystem services are the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010) and are increasingly being considered in marine policy and planning (Fisher et al., 2009; Börger et al., 2014; Pendleton et al., 2016).

In the Millennium Ecosystem Assessment (MEA, 2005) ecosystem services were split into four groups: i. provisioning, such as food and timber; ii. regulating, for example regulating climate or water flows; iii. cultural, such as aesthetic experience derived from being in nature; and iv. supporting, for example supply of larval fish (in this example supporting the service of Food provision). This approach was criticised as it did not differentiate between processes and services or services and benefits, potentially leading to double counting (Fisher et al., 2008). Since then several alternative classifications have been proposed

**Table 1**

Descriptions of the seven ecosystem services addressed in this study, adapted from: Böhnke-Henrichs et al. (2013, European Commission (2014), Atkins et al. (2015) and Hattam et al. (2015).

Ecosystem service	Description
Food provision	The availability of marine flora and fauna for human consumption that can be caught from the wild
Climate regulation	The contribution of the marine environment to the maintenance of a favourable climate
Disturbance prevention or moderation	The dampening of the intensity of environmental disturbances such as storm floods, tsunamis and hurricanes and including the prevention of coastal erosion
Bioremediation of waste	The removal of waste input from humans into the marine environment, e.g. excess nutrients, and chemicals, as well as hazardous substances
Biological control	Control of pest species such as sea lice, invasive species, harmful algal blooms, blooming macro-algae, disease bearers such as <i>Escherichia coli</i>
Leisure, recreation	The provision of opportunities for tourism, recreation and leisure that depend on a particular state of marine ecosystems, in particular abundance of charismatic species, species targeted by anglers, species and habitats visited by snorkelers and divers, also water is of sufficient quality to serve as bathing water
Aesthetic experience	The contribution of the marine environment to the existence of a seascape that generates a noticeable emotional response within an individual observer

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