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Marine habitats ecosystem service potential: A vulnerability approach in the Normand-Breton (Saint Malo) Gulf, France

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ABSTRACT

In this paper is assessed the vulnerability of the benthic habitats potential to deliver ES caused by physical, chemical and biological pressures identified by the Marine Strategy Framework Directive (MSFD) in the Normand-Breton (Saint Malo) Gulf (GNB), in France. The InVEST Habitat Risk Assessment (HRA) model provides useful information for identifying the regions on the seascape where the impacts of human activities are the highest. Additionally, and because the HRA does not address any ES in particular but the whole set of services offered by marine and coastal ecosystems, we analyze the habitats potential to deliver different types of ES (provisioning, regulating and maintenance, and cultural) using habitats vulnerability as a proxy. Concept-driven scenarios are presented to enable the understanding of existing trade-offs as a consequence of different management options. Results provide relevant ES-based information for managers to communicate with stakeholders and prioritize actions for risk mitigation.

1. Introduction

Marine and coastal systems are subject to increasing multiple human uses and pressures including atmospheric and climate change impacts, pollution, resources exploitation or urbanization (Harley et al., 2006; Halpern et al., 2007; Lester et al., 2010; Parravicini et al., 2012). These impacts may compromise the ability of these ecosystems to provide benefits known as ecosystem services (ES) to support mankind (Millennium Ecosystem Assessment, 2005): (i) provisioning (or production) services, such as food and raw materials; (ii) regulating services, such as gas and climate regulation, protection from flood and storms and waste bioremediation; (iii) cultural services such as cultural heritage and identity, cognitive benefits, leisure and recreation and non-use benefits; and (iv) supporting services such as the provision of biologically mediated habitats and nutrient cycling. Regulating and supporting services have also been treated as a single category in marine ES, i.e., regulating and maintenance services (Liquete et al., 2013).

The marine socio-ecosystem delivers multiple ES and is connected with multiple systems of values and with multiple sustainability criteria. This source of complexity explains why governing these socio-ecosystems is a global challenge (European Commission, 2013; UNEP, 2006). One way of dealing with this complexity is by using an ecosystem-based management (EBM) approach. EBM is about maintaining the long-term ability of ecosystems for providing multiple ES (McLeod and Leslie, 2009). It includes local political aspects and considers different management actions at diverse spatial scales of application (Lester et al., 2010). In this context, a core challenge is to be able to consider simultaneously variables and values characterized by limited comparability. The only way to do it is by adopting an approach that considers a multi-criteria analysis (Martinez-Alier et al., 1998). However, knowledge gaps regarding the availability of data and indicators that measure the capacity, flow or

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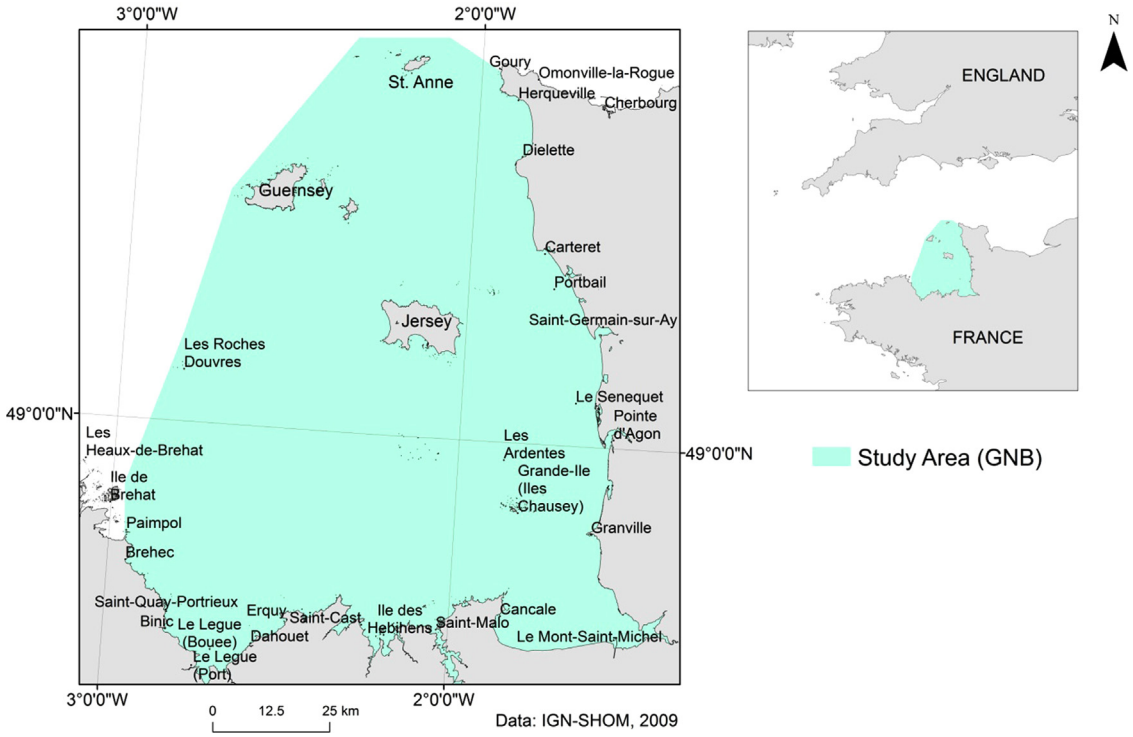

Fig. 1. The Normand-Breton (Saint Malo) Gulf.

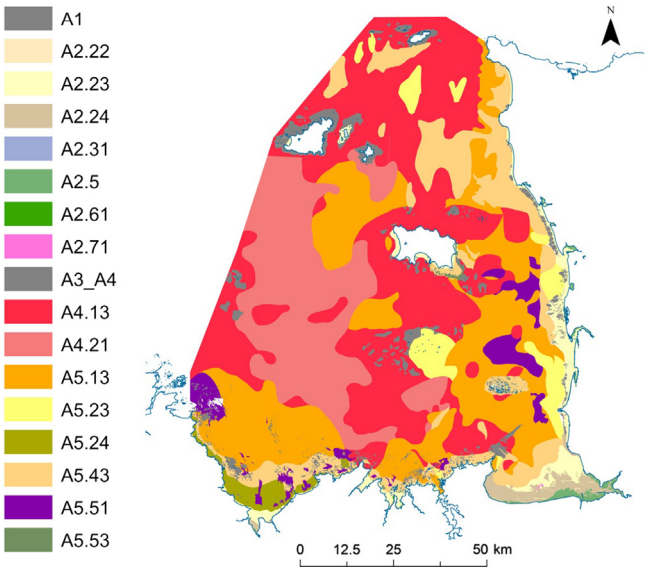

Fig. 2. Benthic habitat compilation using EUNIS 2004 classification in the GNB.

benefit derived from each ES have been highlighted in previous research (Liquete et al., 2013; Townsend et al., 2014).

EBM can be combined with marine spatial planning (MSP) and an ES framework (Lester et al., 2010) to support multi-criteria analysis using a geographical information systems (GIS) (Malczewski, 1999). MSP represents decision-making approaches that use geospatial information to mitigate human uses in the ocean while maintaining or improving ES. The ES framework enables an explicit assessment of the trade-offs in services providing a quantitative approach for assessing the value of MSP versus random planning (Guerry et al., 2012). An ES framework approach requires the knowledge of the status and the changes of the ES in response to different management options (Leh et al., 2013). A reasonable number of studies have mapped and quantified multiple ES for terrestrial (Bai et al., 2012; Bhagabati et al., 2012; Chan et al., 2006; Egoh et al., 2008; Gulickx et al., 2013; Maes et al., 2012; Nelson et al., 2009; Swetnam et al., 2011) and more seldom in marine environments due to difficulties in obtaining data (Guerry et al., 2012; Townsend et al., 2014). Furthermore, for marine ecosystems, ES valuation is generally performed for large habitats (e.g. coral reefs, coastal wetlands, estuaries) while there is a need for a spatially explicit ecosystem service analysis that includes the local scale (Hutchison et al., 2013).

The MSFD (Directive 2008/56/EC) is the pillar of Europe's maritime policy which aims to protect the European marine environment. It was adopted in 2008 and it was due to be transposed into national legislation by 2010. This Directive outlines a legislative frame work at the EU level, at all scales, to reach a "Good Environmental Status (GEnS)" by 2020 and to ensure the sustainable use of marine resources (EC, 2008). This approach clearly promotes an EBM approach for managing the human activities in marine environments.

The supply of multiple ES needs to be traded off because it is impossible to simultaneously maximize its delivery (Barbier et al., 2008; Halpern et al., 2007; Tallis and Kareiva, 2006). The ability of the habitats to deliver ES may be approached using the vulnerability concept which is a function of exposure (i.e., the nature and degree to which ecosystems are exposed to environmental change), sensitivity (i.e., the degree to which a human-environment system is affected by environmental change) and adaptive capacity (i.e.; adjustment in natural or human systems to a new or changing environment (Metzger et al., 2006). An increase in the habitats vulnerability is likely to decrease the supply of ecosystems (Schroter, 2005).

The ES trade-offs that arise from different management options provide relevant information for decision-making by revealing the benefits of an EBM approach (Lester et al., 2010). One alternative way to the use of monetary or biophysical valuation as indicators of marine ES where data scarcity is very present, is to estimate the changes in the vulnerability of marine habitat's as a proxy of the habitat's ability, or potential, to deliver ES. Mapping these changes in the study area will enable a good understanding of the components that can be managed using an EBM approach.

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