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Research article

Improving marine biodiversity offsetting: A proposed methodology for better assessing losses and gains

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Although the limitations of implementing the mitigation hierarchy have been widely discussed in scientific literature, these studies have drawn mainly on feedback concerning terrestrial ecosystems. In the case of development projects in marine and coastal environments, certain issues must be tackled to improve existing practice. This article focuses on the methodologies used to assess both the ecological losses resulting from a development project and the ecological gains generated by an offset measure. The originality of this article is to propose a standardized, operational approach regardless of the development project and the ecosystem impacted that (i) enhances avoidance and reduction efforts and (ii) assesses biodiversity offset needs based on data available in Environmental Impact Assessments (EIAs). The proposed hybrid method combines a multi-criteria analysis of the state of the environment, inspired by the Unified Mitigation Assessment Method (UMAM), and a more accurate assessment at indicator level inspired by Habitat Equivalency Analysis (HEA). The steps of the method, from the selection of biophysical indicators to offset sizing, are described and are then applied to two EIA case studies: one related to a port extension and the other to an offshore wind farm.

1. Introduction

Applied to development projects, the mitigation hierarchy consisting in the avoidance, reduction and offset[2] of environmental impacts is a practical application of the No Net Loss principle[3] which has received much attention in scientific literature in recent years. In particular, several articles have stressed different limitations that prevent offsetting from achieving its ecological targets – these include lack of data on the state and functioning of the impacted ecosystems, weaknesses regarding assessing ecological equivalence, inadequate planning and monitoring, uncertainty concerning restoration techniques, and inadequate compliance (Levrel et al., 2012; Maron et al., 2012; Bull et al., 2013; Quétier et al., 2013; Bos et al., 2014).

These studies have focused mainly on terrestrial ecosystems (including aquatic environments), where most of the experience in offsetting has been gained. There are fewer offset projects in coastal and marine contexts. Currently, information about marine biodiversity offset practices focuses principally on those related to specific emblematic coastal ecosystems, such as mangrove swamps, coral reefs or seagrass environments. Even in these coastal systems, offset measures are rare, and those proposed may be questionable in terms of ecological equivalence and appropriateness. In open water marine environments, the mitigation hierarchy and

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[2] 'Offsets' are actions permitting the achievement of ecological equivalence. These could be direct actions on an environment (e.g. ecological engineering) or management actions to reduce human pressure on an environment (BBOP, 2012).

[3] The respect of this principle, first introduced in the United States to preserve wetlands, ensures that the impacts on biodiversity caused by a project are balanced or outweighed by measures taken to avoid and minimize the project's impacts, to undertake on-site restoration and finally to offset the residual impacts, so that no loss remains (BBOP, 2012).

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offsetting are poorly implemented, as highlighted by Vaissière et al. (2014) in the context of offshore wind farms in Europe; this review of Environmental Impact Assessments (EIAs) from seven European countries shows an absence of biodiversity offsets linked to offshore wind farm impacts.

The development and application of offsets for coastal and marine projects seems hindered by specific factors such as lack of knowledge concerning marine ecosystem functioning as well as the absence of suitable ecological engineering techniques. A thorough review (Jacob et al.sub.) of about 50 EIAs carried out for coastal and marine projects in France also reveals that an additional pitfall of implementing mitigation measures for coastal and marine contexts lies in the unsuitability of the methodologies used to assess both the ecological losses liable to result from a development project and the ecological gains liable to be generated by an offset measure. These methodologies currently rely mainly on expert judgment.

In this article, we tackle this last issue, proposing a standardized operational approach for assessing biodiversity offset needs that can be used in marine and coastal EIAs regardless of the development project and the ecosystem impacted. Using data from current EIAs, we have combined a macro and a micro view to create a hybrid method. The macro view is based on a multi-criteria analysis of the state of the environment, inspired by the Uniform Mitigation Assessment Method (UMAM), which was developed in Florida to assess offsets in wetlands and shallow coastal areas. The micro view is based on more accurate assessment of indicators, inspired by the Habitat Equivalency Analysis (HEA) developed in the United States and applied to accidental or anticipated impacts on terrestrial and coastal habitats. Though UMAM and HEA are both scaling methods, they have specificities, notably in terms of indicators and time scale, which necessarily lead to different offset assessments. The hybrid approach we propose is designed to benefit from the strengths of each method to better determine the appropriate size of biodiversity offsets, as well as to reinforce avoidance and reduction measures.

In Section 2, HEA and UMAM methods are briefly described. Section 3 details our proposed hybrid approach with a description of the biophysical indicators we selected, and our two-step approach (prioritization of impacts followed by offset sizing). Section 4 outlines the method's application in two case studies: one related to a port extension and the other to an offshore wind farm. Section 5 discusses possible improvements of the approach for optimized implementation.

2. HEA and UMAM methods

The No Net Loss principle, which emerged at the end of the 1980s in the United States (recommended at the National Wetland Policy Forum in 1987 and adopted by George H. W. Bush's administration in 1989), has led scientists and governments to explore the issue of designing biophysical measures to compensate for specific impacts on the environment. Such measures, called offset projects, usually focus on habitats and traditionally fall under four categories (all situated near the impacted site): creation of new habitat, restoration of damaged habitat, ecosystem enhancement (improvement of environmental conditions in order to enhance ecological function), and ecosystem preservation (Levrel et al., 2012).

Within this institutional context, various scaling methodologies that rely on biophysical[4] assessment have been developed to enable offset sizing. Two kinds of scaling methods can be differentiated, depending on whether they use multi-criteria or single-metric analysis in assessing ecological losses and gains.

HEA and UMAM are two such methods, the first using a single-metric and the second using multiple criteria. Both have the same objective: scaling offset projects to ensure ecological equivalence[5] between losses that result from a development project and gains that come from an offset project. Like other existing scaling methods, they follow the same pattern. Based on a list of ecological indicators, both HEA and UMAM (Dunford et al., 2004; Pioch et al., 2015):

(i) assess the level of ecological functionality losses, derived from the difference between the functionality level before and after the implementation of a development project
(ii) assess the level of ecological functionality gains, derived from the difference between the functionality level before and after the realization of the offset project
(iii) adapt the size or dimension of the offset project (typically, the offset surface area) in order to achieve equivalence between losses and gains in terms of ecological functionality.

However, each of these methods has specific features, which are described in the following subsections. We outline their strengths and weaknesses and discuss how a combined approach could improve marine offsetting projects.

2.1. Habitat Equivalency Analysis (HEA)

Habitat Equivalency Analysis (HEA) was created by the US National Oceanic and Atmospheric Administration (NOAA) in 1995 and incorporated into the Natural Resource Damage Assessment (NRDA) process. This assessment process was then included in the *The Oil Pollution Act* (OPA, 1990) and *The Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA or Superfund, 1980), whose objectives are to offset environmental damage caused by an oil spill or chemical pollution on land and/or in a coastal zone. HEA is also used to offset environmental damage caused by development projects under the National Environmental Policy Act (NEPA, 1969) and the Clean Water Act (CWA, 1972).

HEA is the most common ecological equivalence scaling method used in the United States. It is a generic method applicable to all types of habitats: terrestrial, aquatic or marine habitats (for instance, coral reefs or salmon habitats) (Chapman and Lejeune, 2007).

HEA uses a single indicator in order to assess ecological losses and gains. This indicator can be one species or a group of species (plants or animals) that is representative of the state of both the impacted and offset habitats.

In addition, HEA uses a specific unit to express losses and gains: the Discounted Service Acre Year unit (DSAYs). This generic unit expresses the level of ecological function (S) lost or gained per acre (A) of an impacted ecosystem within a time period of a year (Y).

Another key feature of HEA is temporal dimension analysis. This enables the dynamic of ecological impacts and restoration measures (delay necessary for effective restoration, speed of recovery, etc.) to be taken into account. In addition, the amount of loss or gain per acre for a specific year is discounted (D), i.e. corrected by a ratio

[4] Biophysical indicators are related to both biotic and abiotic components of an ecosystem as well as to the functioning of the ecosystem.

[5] According to the Business and Biodiversity Offsets Programme (BBOP), ecological equivalence can be assessed in terms of “species diversity, functional diversity and composition, ecological integrity or condition, landscape context, and ecosystem services”. In this paper, ecological equivalence is considered in a narrower scope; ecosystem services and some features related to landscape context are not taken into account.