ARTICLE IN PRESS

Ecological Engineering xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Ecological Engineering

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

Marine ecosystem restoration and biodiversity offset

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ARTICLE INFO

Keywords:
Restoration
Marine ecosystems
Mitigation hierarchy
Offsetting
Environmental impact assessments

ABSTRACT

The mitigation hierarchy is increasingly used in environmental policy as a way of reconciling economic development and biodiversity conservation. The principle of the mitigation hierarchy is to avoid, reduce and offset the environmental impacts arising from development projects by providing ecological gains through conservation or restoration measures. Most of the research on its implementation to date has focused on terrestrial ecosystems. In this study, we investigated the relevance of marine ecosystem restoration in meeting offset requirements. Stemming from a brief literature review on existing restoration techniques for marine ecosystems (e.g. coral reefs, seagrass meadows, macroalgae beds, 'green' marine construction, and marine sediment remediation) and our experience on Environmental Impact Assessments undertaken in mainland France and in its oversea territories, we discuss the main criteria ensuring a suitable use of 'restoration' practice regarding offset requirements. We then clarify the different levels of equivalence that should be met when designing offsets relying on 'restoration' techniques. This study aims to clarify to what extent the environmental impacts of economic activity on marine biodiversity can be offset through marine ecosystem restoration.

1. Introduction

Currently, more than half of the world's population lives within 60 km of the coast (United Nations Environment Programme). This has led to an increase in marine environmental damage due to a number of causes: exploitation of renewable resources (fisheries), non-renewable resources (mineral and energy extraction), coastal artificialization, and the discharge of pollutants and marine debris. According to Halpern et al. (2015), 66% of the ocean show increased human impact over 5 years (2008–2013). As stated by Dulvy et al. (2003), the second leading cause of marine extinction is habitat loss at 37% (the leading cause is exploitation at 55%).

In light of these important environmental stakes, numerous policies could be regarded as tools aiming at halting marine biodiversity loss. One of these, based on the No Net Loss principle, that emerged at the end of the 1980s in the United States,[1] consists of ensuring that the biodiversity impacts caused by a project are balanced or outweighed by measures taken firstly to avoid or minimize these impacts, secondly to undertake on-site restoration, and lastly to offset residual impacts so that no loss results (BBOP, 2012).

As very few studies have examined the implementation of offsets in the marine realm, in this paper, we rely on the observation made by Jacob et al. (2016a) within the framework of French marine Environmental Impact Assessments (EIAs). Indeed, they showed that offset measures proposed in the studied EIAs fell into the following categories, in line with "Offset activities" as defined by the BBOP[2]:

1. Undertaking positive management interventions such as restoration of degraded habitat (referred to as "active restoration" thereafter) (e.g. restoration of coral reefs using larvae collected from colonies after spawning and grown in nurseries before transplantation, creating artificial habitats with the same ecological function as the one lost, planting seagrass from nurseries) or reducing/removing current threats or pressures (referred to as "passive restoration" thereafter)
2. Averting risk (e.g. the creation of marine protected areas – MPAs)

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[1] Recommended at the National Wetland Policy Forum in 1987 and adopted by George H. W. Bush's administration in 1989.

[2] An international collaboration between companies, institutions and organizations, both private and public, that develops best practice in biodiversity offset.

http://dx.doi.org/10.1016/j.ecoleng.2017.09.007
Received 7 July 2016; Received in revised form 22 August 2017; Accepted 9 September 2017

3. Knowledge acquisition measures (e.g. monitoring programs) or awareness-raising measures (e.g. exhibition on the ecological role of Posidonia oceanica)
4. Compensation packages[3] for local stakeholders affected by the development project (e.g. post-larvae capture and culture; the creation of artificial reefs; beach reprofiling and nourishment for tourism; supporting a development program, communication initiatives or product valorization for aquaculture; the eradication of invasive species)

Moreover, alternative measures, not encountered in these EIAs and still subject to debate and discussion, may prove effective in terms of biodiversity offset. These deal with the enhancement of coastal infrastructures aiming at improving "conditions for species through the modification of development activities undertaken primarily for non-ecological reasons" to increase the ecological value of structures (Naylor et al., 2012). This could be undertaken through ecological engineering of coastal structure such as breakwaters, seawalls, jetties, pilings (Dafforn et al., 2015) or eco-design or 'green' marine construction (Pioch et al., 2011). Other types of enhancements can be found in the marine coastal realm such as "removing structures and impediments to natural ecosystem processes that are most likely to promote successful and sustainable ecology" (Elliott et al., 2016), not addressed in this paper and pollution removal via discharge controls, treatment and bioremediation.

Thus offset measures proved to rely heavily on solutions based on marine ecosystem restoration.

Strictly speaking, ecological restoration refers to the process of assisting the recovery of a damaged ecosystem so that the latter can be self-supporting, resilient to perturbation without further assistance and displays a historical continuity in terms of its structure, functioning and biological composition (Clewell et al., 2010; SER Primer, 2004). This is thus an intentional activity that initiates or accelerates an ecological pathway—or trajectory through time—towards a reference state. In the case of ecological engineering, particular attention is paid to the effectiveness of a solution in economic terms through "manipulation of natural materials, living organisms and the physico-chemical environment to achieve specific human goals and solve technical problems" (SER Primer, 2004). This discipline is related to ecological restoration, but differs in that it can also involve the creation of surrogate ecosystems, services supplied by an ecosystem take priority over biodiversity and historical continuity. Other terms are often found in the literature (Abelson et al., 2016; Elliott et al., 2007) such as enhancement for "a management approach which directly or indirectly increases the ecological value, goods and services of the habitat" or rehabilitation for "practices which lead to partial recovery" and reclamation for "practices that improve either or both the ecosystem structure or function but not toward the original state". Enhancement and reclamation are usually related to ecological engineering. Here, we will use the term 'restoration' in a broad meaning.

Adopting an environmental management perspective, we investigate to what extent 'restoration' can provide relevant offset solutions, that is to say meeting offset requirements. To that end, we compare the results of existing 'restoration' techniques with offset principles. We base our analysis on a brief literature review of available 'restoration' techniques to get a representative (but not exhaustive) overview of current techniques and their relative degree of implementation and on the experience developed mainly in mainland France and in its oversea territories but also in California. This review enables us to assess the effectiveness of such techniques in meeting offset requirements (the definitions and standards used are widely admitted, mostly arising from the BBOP) and to present the main criteria that should be informed in order to ensure a suitable utilization of 'restoration'. In this review, compliance with the equivalence criterion appears to be a crucial element for using 'restoration' solutions as offsets. Thus we clarify the different levels of equivalence that should be met when designing offsets relying on 'restoration' techniques. This approach tend to better inform the numerous trade-offs practitioners and policy-makers face when suggesting or monitoring current offset practice.

2. The relevance of 'restoration' techniques for offsetting

We performed a brief literature review on existing 'restoration' techniques (defined in broad terms) available in the marine realm (including marine coastal ecosystems) using the Web of Science (WoS) (the search criteria is listed in Appendix 1 and topics addressed in articles are in Appendix 2). In this study, we decided to analyze techniques strictly related to marine systems. The following systems were not included: mangroves (since these are interface ecosystems between fresh and salt water), estuaries and coastal wetlands (since these are transitional water ecosystems and have been already widely discussed). Among techniques used for pollution removal, only marine sediment remediation was analyzed (eutrophication was out of the scope since mainly related to controlling telluric inputs: e.g. wastewater treatment plants and wetlands). As very few publications were available on deep-sea ecosystems, they were not covered. As regards artificial reefs, we examined these in the related category when they were used as a substrate for restoring specific ecosystems or to replace the ecosystem function of providing a habitat for particular species; otherwise, they have not been addressed.

Only 155 articles were found to be relevant to the subject of our study, representing 23% of the total results. These were then classified according to a typology based on the environmental issue targeted by the solution: coral reefs, seagrass meadows, invertebrates, artificial habitats, 'green' marine construction, eutrophication, marine sediment remediation, mangroves, macroalgae beds, deep-sea ecosystems, or ichthyofaunal Fig. 1.

The results of the literature review (monitoring parameters, duration of monitoring and the effectiveness of the technique) are displayed in Appendix 3 but Table 1 presents the principle of the technique and the references. The objective was to get a representative (but not exhaustive) overview of current available techniques applicable to marine ecosystems and their relative degree of implementation.

Although extensive literature on mitigation requirements is available for wetlands (Ambrose, 2010; Ambrose et al., 2007; Gardiner, 2002), marine mitigation suffers from a lack of guidelines. Here we propose to assess the relevance of these 'restoration' techniques as offset solutions, comparing socio-economic, ecological, and technological parameters related to restoration decision (Van Dover et al., 2014) to the issues commonly discussed in scientific literature on designing offset measures (Bull et al., 2013; Maron et al., 2012; Quétier and Lavorel, 2011) as well as to the recommendations of the BBOP.[4] Of the criteria used to define the feasibility of an offsetting technique, we analyzed the following four, which we considered the most important:

- the standards used to define the ecological effectiveness of a 'restoration' technique, which enable offset gains to be assessed
- the cause(s) of the failure of a technique, which leads to uncertain outcomes

[3] Compensation is a recompense for some loss or service, and is something which constitutes an equivalent to make good the lack or variation of something else. It can involve something (such as money) given or received as payment or reparation (as for a service or loss or injury) (BBOP, 2012). BBOP defines compensation as reparation of biodiversity offset that falls short of achieving a No Net Loss conservation outcome (that is No Net Loss of biodiversity).

[4] In the framework of biodiversity No Net Loss as defined by the BBOP (2012), ecological equivalence can be assessed in terms of species diversity, functional diversity and composition, ecological integrity or condition, landscape context, and ecosystem services.