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Stakeholder priorities for multi-functional coastal defence developments and steps to effective implementation

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ABSTRACT

To fulfil international conservation commitments, governments have begun to recognise the need for more proactive marine planning policies, advocating sensitive engineering design that can deliver secondary benefits above and beyond the primary purpose of developments. In response, there is growing scientific interest in novel multi-functional coastal defence structures with built-in secondary ecological and/or socio-economic benefits. To ensure research efforts are invested effectively, it is first necessary to determine what secondary benefits can potentially be built-in to engineered coastal defence structures, and further, which of these benefits would be most desirable. It is unlikely that secondary benefits are perceived in the same way across different stakeholder groups. Further, their order of priority when evaluating different options is unlikely to be consistent, since each option will present a suite of compromises and trade-offs. The aim of this study was to investigate stakeholder attitudes towards multi-functional coastal defence developments across different sector groups. A preliminary questionnaire indicated unanimous support for implementing multi-functional structures in place of traditional single-purpose ones. This preliminary survey informed the design of a Delphi-like study, which revealed a more nuanced and caveated level of support from a panel of experts and practitioners. The study also elicited a degree of consensus that the most desirable secondary benefits that could be built-in to developments would be ecological ones – prioritised over social, economic and technical benefits. This paper synthesises these findings, discusses the perceived barriers that remain, and proposes a stepwise approach to effective implementation of multi-functional coastal defence developments.

1. Introduction

Climate change is leading to rising and stormier seas, increasing coastal erosion and flood risks [58]. In response, natural coastlines around the world are being replaced and reinforced by hard engineered structures such as seawalls, breakwaters and groynes (hereafter 'coastal defence structures'; [2,21,26,30,61]). The negative environmental impacts of these structures have been reasonably well-studied. In addition to direct loss and disturbance of species and habitats [32,66], coastal defences can degrade natural landscapes [14], facilitate the spread of non-native species [4,11,53,76,92], and alter coastal processes, often with unintended knock-on effects elsewhere [14,47]. Further, these artificial structures tend to be poor-quality habitats, supporting depauperate [19,40,41,78] and 'non-natural' [21,78] communities. Soft engineering approaches such as beach replenishment, sand dune stabilisation and managed realignment are widely considered to be more sustainable options for flood and erosion risk management [15,47,49,99,100]. These practices do also, however, carry considerable and often-overlooked environmental implications [83,84,88], and may prove to be unsustainable over time [71]. Nevertheless, in scenarios where no alternative options are viable for protecting people, property and infrastructure, shoreline management policies continue to recommend a strategy of 'hold the line' (e.g. in the UK: Environment Agency 2009 [33]). This means that local authorities

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will be required to maintain existing defences and potentially implement additional 'hard' protection measures.

In order to fulfil international marine conservation commitments (laid out in the OSPAR Convention and the Convention on Biological Diversity; also see [80] for an outline of some relevant European and UK legal instruments), governments have begun to recognise the need for more proactive marine planning policies and legislation. This study focuses on UK planning policies and stakeholders, but similar challenges are being faced across Europe and the world [51,54,82]. The UK's Marine Policy Statement [56] advises that in addition to avoiding harm to marine ecology and biodiversity (§2.6.1.3), developments also "*may provide, where appropriate, opportunities for building-in beneficial features*" (§2.6.1.4). Although not prescribing a definitive obligation, this clearly advocates sensitive engineering design that can deliver secondary benefits above and beyond the primary purpose of developments – in the context of this study, coastal protection.

To date, there are few examples of truly and purposefully-designed multi-functional coastal defences around the world (but see [52,59,73,74,87,94,98]). Single-purpose artificial reefs have been implemented to provide habitat for commercial fish species [93,97], to enhance marine biodiversity [5,7], and to provide amenity functions such as surfing [91], diving [103] and sea angling [104]. Their success, however, has been variable [8,28]. There are many similarities between artificial structures designed for habitat and amenity, and those designed for coastal defence, suggesting that multi-functional coastal defence structures should be viable [18]. Indeed several of these habitat and amenity services have been reported to arise incidentally as secondary functions from traditional coastal defence structures (e.g. [24,90]). It has been argued, however, that unless designed with specific objectives in mind (e.g. target species), net ecological benefits are unlikely to be truly realised [18,89,95], and recreational uses are unlikely to be compatible (e.g. [1]). Nevertheless, artificial surfing reefs are increasingly being adopted for coastal protection [64] and there is an expanding body of evidence to support the potential for ecologically-beneficial designs to be incorporated into coastal defence structures [12,20,35,38,39,78,86,87,95].

Despite this known potential and policy recommendation, there remain numerous impediments to implementation of multi-functional coastal defence developments – perhaps as a function of the wider issue of ineffectual science-policy linkages [57,72,101]. Further research is necessary to expand the knowledge base of alternative options, clarify choices and ultimately enable policy-makers to achieve desired outcomes [72]. To ensure research efforts and resources are invested effectively, it is first necessary to determine what secondary benefits can potentially be built-in to engineered coastal developments, and further, which of these benefits would be most desirable. It is unlikely that secondary benefits will be perceived in the same way across different stakeholder groups (e.g. conservation groups, engineers, statutory bodies and researchers; [80]; see also [106]). Further, their order of priority when evaluating different design options is unlikely to be consistent, since each option will probably present a suite of compromises and trade-offs. For example, the addition of pits, crevices and rock pools to intertidal artificial structures may be an effective way of increasing biodiversity [12,20,35,39] and stocks of exploited species [67], but they may not support the same assemblages as found in natural systems [35]. Similarly, pre-cast concrete habitat enhancement units can be cheaply and easily deployed into structures (e.g. see BIOBLOCK demonstration project in [39]), but the net environmental benefits of enhancement using concrete, with its associated large carbon footprint [42], may be reduced [86]. Species of conservation interest can be transplanted onto structures [23,36,81,85], but this may have implications for local authorities tasked with maintaining those structures [3]. And reefs that aggregate commercial fish species may economically benefit professional and/or recreational fisheries [24], but they may lead to over-exploitation of populations if structures attract individuals from surrounding natural habitats rather than produce additional biomass [89]. Habitat interventions may be designed with specific ecological and socio-economic responses in mind, but planners are required to judge the relative merits of each response in order to select the optimal design.

The aim of this study was to investigate stakeholder attitudes towards multi-functional coastal defence developments across different sector groups. A perception study was carried out in England and Wales using a traditional quantitative questionnaire and a semi-quantitative modified Delphi survey [29,79]. Stakeholders in England and Wales were targeted, specifically, because of the scale of the challenges regarding coastal flooding and erosion (i.e. almost 40% of the coastline of England and Wales is already under some form of coastal protection: [68]). The questionnaire was designed to gather preliminary information about perceptions of coastal defences and the potential to incorporate secondary benefits into developments [34]. A modified Delphi technique was then employed to elicit detailed information and professional judgements from a panel of experts and practitioners from seven different sectors. The objectives were to: (i) determine the most important considerations for planning coastal defence developments and their perceived order of priority; (ii) determine the potential secondary benefits that can be built-in to coastal defence developments and their perceived order of priority; (iii) determine the level of support for implementing multi-functional coastal defences; and (iv) identify differences and consensus in perceptions across different sector groups. In light of comments received in the early stages of the Delphi study, a fifth objective was added, to: (v) identify the current barriers to effective implementation and steps for moving forward. This paper synthesises the findings of this study and proposes a four-step process to implementation of multi-functional coastal defence developments that can deliver secondary ecological and/or socio-economic benefits, as recommended by environmental legislation. Although here the focus is on coastal defence structures, the philosophy and findings of this research may be equally relevant for the planning and design of any other developments in the marine environment (e.g. for oil and gas exploration, renewable energy generation, navigation, mariculture, recreation) with the potential to support biodiversity and natural capital.

2. Materials and methods

2.1. Survey instruments

A preliminary questionnaire survey was undertaken between March 2013 and September 2014 to gather scoping information about stakeholder perceptions of coastal defences and their potential to deliver secondary benefits. Questionnaires were distributed to stakeholders (SOM Table 1) and members of the public in England and Wales, and feedback was received from 118 respondents. Only one key finding from the questionnaire is presented in this paper but full details can be found in Evans [34]. Respondents were asked to indicate their level of support for traditional and then multi-functional coastal defence structures on a ten-point forced-choice (i.e. no neutral option) visual Likert scale [6], between 'Not supportive at all' and 'Very supportive'. Responses were anonymised and coded to appropriate sector groups for analysis.

Based on insight gained from questionnaire responses [34], a Delphi survey was devised to elicit detailed information and expert judgements regarding the desirability of secondary benefits that can be built-in to multi-functional coastal defence developments. The method is an effective yet underused and undervalued technique [79] that provides an interactive communication structure between the researchers and a panel of experts with a vested interest in the problem at hand. Questions are asked over a number of rounds, and between each round, responses are analysed and fed back to the panel in an iterative process. This approach allows respondents to carefully consider and develop their answers over an extended period, in the context of rationale