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Monitoring benthic biodiversity restoration in Lyme Bay marine protected area: Design, sampling and analysis

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ABSTRACT

Long-standing concerns about the effects of scallop dredging and demersal trawling on high diversity mudstone reef and cobble habitats in Lyme Bay, southwest England, were addressed by the exclusion of bottom towed fishing gear from a 206 km^2 area in July 2008. A consortium led by Plymouth University Marine Institute was funded by the UK Department of Environment, Food and Rural Affairs to design and implement a study (initially funded for 3 years) to examine the effects of the closure on both nekton and epibenthos. This paper provides a detailed account of the methodology employed from survey design to data analysis to provide a protocol for future MPA monitoring programmes. Information on historical fishing effort, substrate distributions and current and previous closure boundaries was overlaid using GIS to locate suitable monitoring sites. Non-destructive and cost-effective techniques, including a towed high-definition video array and static baited video, were used to quantify changes in relative abundances of epibenthos and nekton over three years at sites previously fished but now closed to bottom towed fishing compared to both fished and un-fished reference sites. The monitoring programme as described provides a model for robust, cost-effective evaluation of the efficacy of policy instruments for feedback into the adaptive management cycle.

1. Introduction

Marine conservation concerns have been increasingly addressed over the last two decades by means of area-based methods [1,2], including Marine Protected Areas (MPAs, however defined), rather than fishery-specific management tools [3]. This has been a general trend, but with different rates of uptake internationally according to management culture, history and established pattern of use [4]. In the UK, adoption of this so-called ecosystem approach [5,6] has been relatively recent [7]. Prior to 1981, protection of marine sites in the UK relied on Voluntary Marine Conservation Areas (VMCAs). More than 20 were established, and some are still extant, but they provided limited protection, and were not systematically selected. Legislative changes in the Wildlife and Countryside Act 1981 provided for the designation of statutory Marine Nature Reserves (MNRs); however only three were ever established: at Lundy (1986), Skomer (1990) and Strangford Lough (1995) [8]. More recently, policy shifts at the European and national level have led to the on-going designation of a network of small multiple-use MPAs designed to represent and conserve marine habitats and species. These Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), collectively called European Marine Sites (EMSs) are required under European law [9,10]. However, while welcomed by conservationists, there are concerns that they do not contain no-take areas [11], and that their effectiveness may therefore be limited. Only Lundy, re-designated as the UK's first Marine Conservation Zone (MCZ) in 2010 under the Marine and Coastal Access Act 2009, contains a no-take area.

In contrast, international adoption of MPAs has been widespread and rapid [12–15]. Common (but by no means universal) themes have been the designation of relatively large areas containing a combination of zones with varying levels of protection, clearly articulated goals and objectives for each MPA, and formalised consultative processes with significant stakeholder input [16–18].

This international adoption of MPAs as a management tool has been mirrored by the rapid development and adoption of quantitative methods of planning for such areas [19–22], specifically in evaluating design alternatives to minimise economic, social or ecological cost [23,24], for instance by using optimisation techniques such as the software package 'Marxan' [25].

Implementation of area-based management, however well designed, is not always followed by robust post-implementation assessment (e.g. [26]) of the efficacy of the management measures, from the points of view of stated management aims, unintended consequences, and economic impacts on users [5]. A range of studies has highlighted that this aspect of MPA management [27,28] lags markedly behind advances in planning and design.

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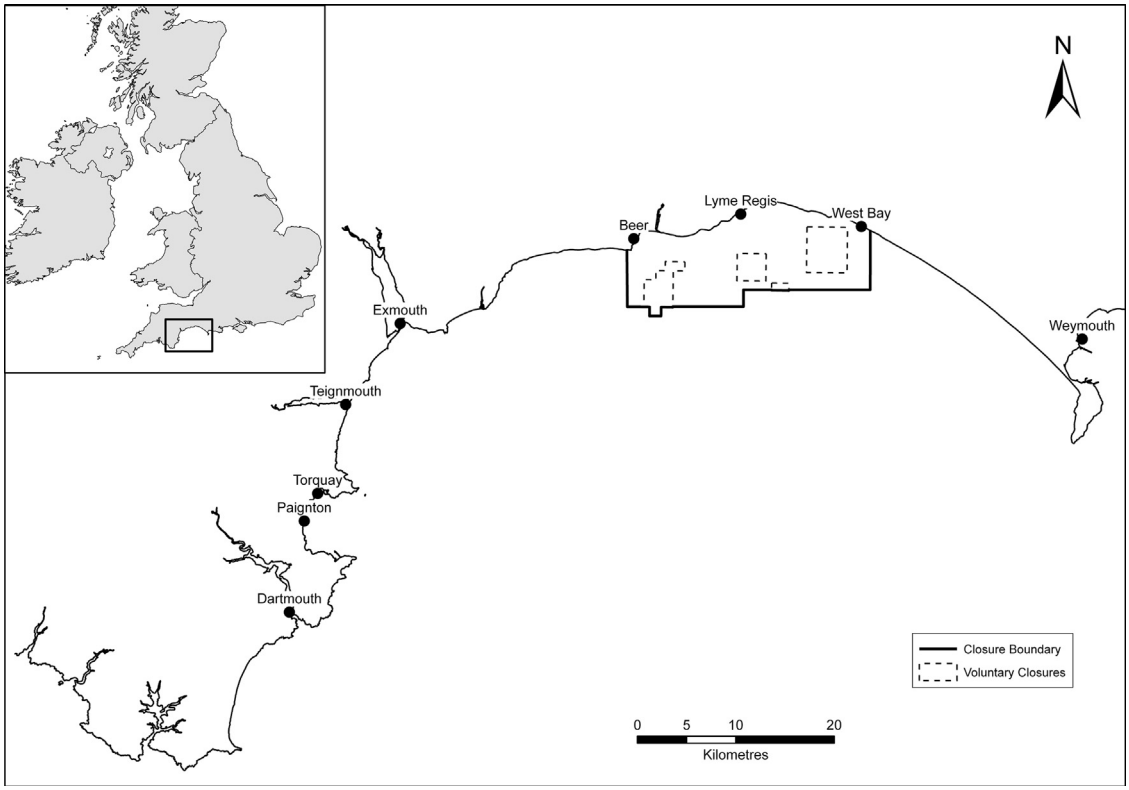

Fig. 1. Location map showing closure boundary and ports.

This is at odds with contemporary adaptive management approaches [5,29] which, in essence, seek to treat management as a series of experiments, so that the consequences can be quantified and fed back into the next design phase.

Lyme Bay, on the southwest coast of the UK (Fig. 1), was the setting for an ongoing resource use conflict [30] between the conservation values of high biodiversity mudstone reefs [31,32] and the social and economic importance of scallop dredging to the local and regional economy [33]. Concerns about the effects of scalloping, specifically the negative impacts of dredging on iconic species such as the Pink Sea Fan *Eunicella verrucosa* (listed since 1992 under Schedule 5 of the UK Wildlife and Countryside Act 1981), and erosion of the soft mudstone substratum itself, had been raised for many years [34,35]. Small voluntary closures were implemented initially in 2001, and again in 2006 [36], but for a variety of reasons were regarded as either not successful, or of insufficient size to be effective [36]. Legislative and policy changes in Europe and the UK, in particular the European Commission Marine Strategy Framework Directive [37], laid the foundation for the Statutory Instrument (SI) [38] excluding bottom towed fishing gear from a 206 km^2 (60 nm^2) area in the northern portion of the bay. This took effect in July 2008 [38]. At the time of its designation, Lyme Bay was the largest UK MPA. It was the first declared under the regime adopting the ecosystem approach to marine nature conservation in the UK [39], and although not a no-take zone, is an important test case for the emerging UK marine spatial planning landscape [7,31], particularly as the UK moves to designation of a network of MCZs within its waters.

Concurrent with the closure, and in keeping with the contemporary adaptive management ethos [5,40,41], the UK Department of Environment, Food, and Rural Affairs (DEFRA) funded initially a three-year study to evaluate the effectiveness of the closure and its socio-economic consequences.

The DEFRA brief identified eight explicit aims [42], encompassing sampling design, selection of indicator species [43], quantification of "recovery" (our quotes) [42] and socio-economic impacts [44]. Throughout this paper the use of the term "recovery" is avoided, because it implies a shift towards a pristine or at least un-impacted state, which does not exist in Lyme Bay (or indeed, virtually anywhere [45]), because a range of extractive and potentially disturbing activities continue within the areas closed to bottom towed fishing gear (potting, netting, angling, diving and hand collection of scallops). The term "restoration" is used instead, to suggest improved status over time, in comparison to less impacted reference areas.

This paper reports on the development and implementation of a robust monitoring programme to quantify restoration of epibenthos subsequent to the imposition of the SI, including the appropriate methods, design, and analyses, plus example data from the first two years of this important trial of marine conservation policy in the UK. Detailed analyses of the effects of the closure, including consideration of a range of ecological drivers for small-scale variation, have been reported to the funding agency [42] and are in preparation for publication (Sheehan et al. in prep). The aim of this paper is to:

- outline the background information used and approach taken in designing a broadly-based and low-impact monitoring programme to quantify changes in benthic biodiversity after the implementation of the SI, and
- report on the practical and logistical aspects of implementation of such a programme for a large MPA.

2. Survey and analytical design

2.1. Study rationale and spatial design

Tests of the effectiveness of management interventions seldom take place on a blank canvas. In the case of the Lyme Bay closure,