Marine Policy 45 (2014) 333–341

Contents lists available at ScienceDirect

Marine Policy

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

# Assessing the quality of data required to identify effective marine protected areas

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ARTICLE INFO

*Article history:*
Received 12 June 2013
Received in revised form
30 July 2013
Accepted 9 September 2013
Available online 9 October 2013

*Keywords:*
Data quality
Marxan
Marine protected areas
Marine and coastal conservation planning
Marine biodiversity
Decision support tools

ABSTRACT

This study aims to evaluate the effectiveness of currently available substrate data to designate marine reserves to meet conservation objectives. The case study site is Lyme Bay (approx. 2460 $km^2$), in the western English Channel. An area of 240 $km^2$ in Lyme Bay was designated 'closed to bottom dredging' in July 2008 with the aim of protecting reefs which are an important habitat for *Eunicella verrucosa* (pink sea fan). The effects of using different substrate data resolution on the selection of sites to protect a range of biotopes using the Marxan package are determined. The effect of including a closed area on the efficiency of a marine reserve network is also investigated. Findings suggest that substrate data did not capture the biodiversity of the area and that using no data at all was equally effective. If low resolution data are all that are available then other options, such as expert opinion, or other data, such as activity use information could be used instead. Including a predefined closed area into the analysis led to an increase in area required to meet conservation goals using high resolution biotope data. It also increased the area of the reserve using the three substrate layers with no increase in protection for biotopes. This suggests that when designing networks of marine protected area sites, including current protected areas may be inefficient, resulting in larger areas being protected with no increased conservation of marine biodiversity. Policy makers must be prepared to adapt management in light of these findings and be aware of the shortcomings of the data available for use in marine conservation planning.



## 1. Introduction

With the growing human pressures on the marine environment there has been recognition by many governments of the need to protect the marine environment. This is demonstrated by numerous national and international commitments to the conservation of marine biodiversity such as the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) [1], the European Union's (EU) Natura 2000 network under the EU Habitats Directive [2] and UK's Marine and Coastal Access Act 2009 [3]. A common theme in the implementation of such protection is the designation of marine protected areas (MPAs) as a tool for conservation. These may be identified for a number of reasons including protection of one or a number of species, habitats or biotopes.

The UK has created the Marine and Coastal Access Act 2009 [3] to introduce a framework for marine and coastal management in the UK, to balance among other aspects the growing needs of conservation, energy and resource extraction. The Act provides tools to designate a network of marine conservation zones (MCZ), which are marine protected areas with varying levels of protection, for the conservation of rare, threatened or representative habitats and species. The MCZs will, in conjunction with the Natura 2000 sites, fulfil the UK's commitment, agreed under a number of international declarations including the World Summit for Sustainable Development 2002, the OSPAR Convention (1992) and EU directives, to designate an ecologically coherent network of Marine Protected Areas by 2012. The OSPAR Convention requires the UK to protect and conserve the marine environment and to manage human activities that can have an adverse impact on particular declining or threatened marine species [4]. biodiversity actions plans (BAPs) were created by the European Union as a response to its commitments under the 1992 Convention on Biological Diversity and the UK has produced these for the protection of particular (or significant or threatened) species and habitats.

Systematic conservation planning is a structured, quantitative approach to the planning of both single MPAs and networks of reserves; it can be used to identify reserve networks that capture the most biodiversity whilst reducing area or other costs, and it will, in theory, allow for the more effective protection of biodiversity [5,6]. Within a network other MPAs in the surrounding area should be considered in the selection of new sites [7].

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http://dx.doi.org/10.1016/j.marpol.2013.09.013

MPA networks that contain fewer larger areas have lower area to edge ratios than networks with many smaller areas. This makes them easier to comply with or enforce [8] and reduces edge effects [9]. Using the planned marine space effectively by protecting a proportion of biodiversity in the most compact (size and number of areas) way possible will reduce potential conflict with other sea users.

MPAs not designed systematically tend to have higher associated costs and are less effective at protecting the marine environment than MPAs chosen with stated objectives and in a systematic way [10]. Roberts et al. [11] found that many MPAs have been created based on narrow socioeconomic criteria, often linked to fisheries management, rather than sound environmental data. They conclude this has led to many sub-optimal MPAs which give a false sense of the conservation of the marine environment.

An issue facing marine planners in the UK, and globally, is that comprehensive biological data, such as presence/absence data for species or detailed habitat maps, are not available for the majority of the marine and coastal environment. Obtaining such data is very expensive and requires considerable time and expertise and so surrogates, such as substrate or other environmental characteristics, are sometimes used to represent marine biodiversity. However, gathering even surrogate information, such as sidescan data, can be resource intensive and may not represent biotopes very effectively [12]. Rodrigues and Brooks [13] reviewed the effectiveness of surrogates for biodiversity conservation planning and concluded that surrogates derived from abiotic data did not adequately represent marine biological diversity.

Information on the scale and resolution of ecological data used to plan MPAs or in marine planning is not widely reported in the literature. For example in the Great Barrier Reef Marine Park it was stated that the ecological data was in the range 10 km to 100 km [14] with no specific resolution given. Table 1 shows the wide range of resolutions of data used in marine planning and different ways of interpreting the base survey data (modelling and interpolating). There is no general consensus of what resolution of ecological data should be used when planning to protect marine biodiversity as this is driven by both the spatial variability of the biodiversity and the scale of the management envisaged [15]. In reality the data used is often simply that which is available as there are seldom funds to gather new data.

In the light of the limited data availability, it is necessary to use what is available as effectively as possible in the creation of spatial plans and decision support tools have been developed to aid in this task. Marxan is a spatial planning decision support tool [16,17], frequently used for the design of marine protected areas [18]. It performs 'n' randomised iterations and selects the outcomes that meet preset criteria to select appropriate sites for marine reserves if relevant habitat and species data are available.

Marxan has been used to produce outputs to support the rezoning of the Great Barrier Reef Marine Park multiple-use plan in Australia [19]. There was comprehensive data in this study for only a few habitats and species and therefore a bioregional approach combined with expert option was used to mitigate against only protecting sites that had been sampled, as species or habitat data would only be available for those sites. Lieberknecht et al. [20] used Marxan to test the draft criteria for the identification of nationally important biological marine areas as part of the Irish Sea Pilot [21]. Marxan has also been used to determine a network of fishing sites needed to sustain the commercial fishing industry off the Pacific coast of British Columbia, selecting areas required for fishing and for marine reserves [22].

This study aimed to evaluate the effectiveness of currently available surrogate data (substrate) to designate marine reserves to meet defined conservation objectives. In the case study area high quality biotope data is available to contrast with the outputs and hence assess the extent of protection afforded. An effective MPA is defined here as one which has the least area and boundary possible to represent all biotopes by a stipulated amount. The objectives of this study were to analyse scenarios in Marxan to investigate the implications of (1) using different resolutions and complexity of substrate data, (2) incorporating a predefined closed area and (3) using no data at all.

## 2. Methods

### 2.1. Study area

Lyme Bay is situated in the western English Channel (Fig. 1) and spans east Devon and west Dorset. The study area is defined by a line between Portland Bill in the east and Start Point in the west with an area of 2460 km$^2$ (Fig. 1). The Bay contains a variety of substrates: reef habitats in the northern section, muddy substrate with isolated seagrass beds in the west, as well as sandy, gravel and cobble substrates. The depth increases gradually offshore with a maximum depth of over 50 m along much of the line between Portland Bill and Start Point.

Lyme Bay was selected because there has been substantial controversy in the Bay, between fishing and conservation interests, and there are high quality biotope and substrate data available (see section 2.2) which have been collected as a result of an ongoing controversy concerning the impact of bottom fishing, using mobile or towed gear, on the high biodiversity reef areas [12,23].

The Devon Wildlife Trust has campaigned since 1992 to protect the reefs in Lyme Bay. In 2002 the Devon Wildlife Trust came to a voluntary agreement with the local fishing community to protect two areas of reefs covering approximately 5 km$^2$. The agreement broke down in 2005 when evidence was found to suggest that dredging had occurred within the agreed 'protected' areas [24]. In July 2008 the UK government designated a closed area to bottom dredging of 240 km$^2$ focused around the most important rocky reef area in the bay (Fig. 1) which has led to further animosity between fishers and conservationists [25].

Lyme Bay is an important area for the pink sea fan, *Eunicella verrucosa*, a species protected, together with its habitat, under the Wildlife and Countryside Act 1981 (Section 9, part 1), listed as nationally scarce by Natural England and a priority UK BAP species. It is also an area of economic and cultural importance in

**Table 1**
Benthic, biological data used in marine planning.

| Marine plan or marine protected area | Resolution |
|---|---|
| Plymouth and Estuaries SAC, UK | Between 100 m and 2 km for benthic biotope data [50] |
| Marine spatial plan, Belgium | $250 \times 250$ m$^2$ modelled benthic data [51] |
| New Zealand | EEZ mapped to 1 km scale [52] |
| England MCZ project | Data ranges from 1–2 to 9 km grid with the data interpolated to a 1.85 km grid, with some finer scale habitat species data used where available [53] |