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Review

Is there a win–win scenario for marine nature conservation? A case study of Lyme Bay, England

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ABSTRACT

A statutory two hundred and six square kilometre 'closed area' in Lyme Bay, South West England entered into force on the 11 July 2008 to protect the reef substrate and the associated biodiversity from the impacts of trawling and dredging with heavy demersal fishing gear. This case study provides an example of how the ecosystem approach has been incorporated into decision making for marine nature conservation and shows that despite sound ecological knowledge of a marine area, the current reliance on traditional neo-classical economic valuations for marine spatial planning can obscure other issues pertinent to the ecosystem approach. With the Government seeking win–win scenarios for stakeholders in the designation of Marine Conservation Zones under the Marine and Coastal Access Act, experience of marine spatial planning in Lyme Bay has revealed that a win–win must be a long-term goal based on a thorough evaluation of the environmental, social and economic values of marine biodiversity.

1. Introduction

Marine biodiversity provides a number of essential ecosystem functions, such as the provision of food and climate regulation, which underpin life on Earth, without which humans would not be able to survive [1]. Several ecosystem functions are thought to be in decline as a direct result of continuing impacts and human demands [2,3]. Policy to manage human impacts on marine ecosystems which enables the long-term functioning of these ecosystems is essential.

Marine Protected Areas (MPAs) are 'areas for which protective, conservation, restorative or precautionary measures have been instituted for the purpose of protecting and conserving species, habitats, ecosystems or ecological processes of the marine environment' [4]. MPAs, designated though a system of Marine Spatial Planning (MSP), are one mechanism by which an area of ocean may be managed specifically to protect the integrity of marine ecosystems [5]. In order to meet International, European and National marine nature conservation objectives, the United Kingdom (UK) Marine and Coastal Access Act will enable the designation of a new type of MPA entitled a Marine Conservation Zone (MCZ).

Through MSP and the application of the 'ecosystem approach' to decision making, the Government is seeking a win–win situation for all stakeholders in the process of designating MCZs [6]. A win–win scenario in this context is the result of a conflict resolution process whereby all stakeholders' views have been considered before a decision is made. To aim for a win–win in the short term sets the bar (and stakeholders' expectations) high. Experience of Marine Spatial Planning (MSP) and the Marine Protected Area (MPA) designation process in the UK context is that discussions with stakeholders are 'complex, uncertain, unstable, unique and laden with value conflicts' [7]. The fact that just three statutory Marine Nature Reserves (as opposed to a planned network) were designated under the Wildlife and Countryside Act 1981 attests to this. This failure for broad scale marine nature conservation has been attributed to weak legal provisions for designation powers in the Wildlife and Countryside Act and a lack of political will to make decisions in favour of marine conservation in the face of stakeholder conflict [8,9]. In addition, Special Areas of Conservation (SAC) and Special Protection Areas (SPA) designated under the European Community (EC) Birds Directive 79/409/EEC and Habitats Directive 92/43/EEC remain multiple use sites and statutory powers to prevent damaging activities are limited, as a result they do not provide the means to protect the range of habitats and species that are important to UK waters [10].

The ecosystem approach demands that environmental, economic and social sustainability are balanced in the decision-

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making process [3]. The process of making choices as an individual or as a society about ecosystems and their use implies a process of valuation (monetary or non monetary) of the respective parts [11]. Conflict arises between stakeholders as the concept of value is broad. Pearce and Turner [12] state that any object can have a number of different values assigned to it because of 'differences in the perception of held values of human valuators'. Furthermore, the concept of "value" is multifaceted; it can be social, monetary, emotional, environmental or cultural. A win–win situation demands that all these aspects of value are understood and stakeholders agree upon an equitable balance of resource use.

Lyme Bay has been chosen as a case study to explore the concept of a win–win scenario because it is an area of nature conservation interest which has a history of conflict between stakeholders. A 206 km^2 'closed area', or MPA, was designated by the UK Government on the 11 July 2008. This case study provides an opportunity to reflect on the sixteen-year process which has led to this designation and explore some lessons learnt for the implementation of the Marine and Coastal Access Act and the proposals for win–win outcomes for all stakeholders in the designation of Marine Conservation Zones.

1.1. The Lyme Bay case study area

The Lyme Bay case study area is approximately 2460 km^2 [13] and is defined here as the sea area which is enclosed by a line drawn between Portland Bill in Dorset and Start Point in Devon (Fig. 1). Lyme Bay includes the fishing ports of West Bay and Brixham and the towns of Lyme Regis, Torquay and Exmouth.

1.2. An area of nature conservation interest

The marine environment of Lyme Bay is rich and biologically diverse. In the 1960s Holme [14,15] identified sediment communities of the otter shell (*Lutraria lutraria*), the auger shell (*Turritella communis*) and the burrowing mud shrimp (*Callianassa subterranea*) in the offshore sand and mud sediments of Lyme Bay. Further environmental studies in 1977 and 1978 identified species such as the sea potato (*Echinocardium cordatum*) and the brittlestar (*Amphiura filiformis*) in the sublittoral sediments [16,17].

The reef areas, comprising of rock and mixed ground (mixed ground is defined as seabed consisting of combinations of sand, gravel, pebbles, cobbles and boulders [18]) extend from Portland Bill to central Lyme Bay and off Start Point. The species within the reef area which are listed for conservation are highlighted in Table 1.

Other habitats of conservation importance outside the reef area are the maerl beds (*Lithothamnion corallioides*) located in the gravel substrate and listed for conservation under the UK BAP, IUCN Red List and the Habitats Directive (92/43/EEC) [19]. Eelgrass (*Zostera marina*) beds in the sandy/muddy sediments adjacent to Torquay [20] are listed for conservation under the Bern Convention on the Conservation of European Wildlife and Natural Habitats 1982 and the IUCN Red List [21].

In 2007, Lyme Bay as a whole was identified as a 'marine biodiversity hotspot' [22]. These are defined as areas of 'high species richness that include rare and threatened species' [22]. The offshore reef areas between Portland Bill and Lyme Bay are under consideration by Natural England as a Special Area of Conservation (SAC) under the Habitats Directive (92/43/EEC).

1.3. A history of conflict

For the last sixteen years there has been conflict concerning how the resources provided by the marine biodiversity in Lyme Bay are used by different stakeholders. The main point of contention has been the use of heavy fishing gear on the reef area, i.e. trawls and dredges. The use of heavy gear on the seabed directly affects the

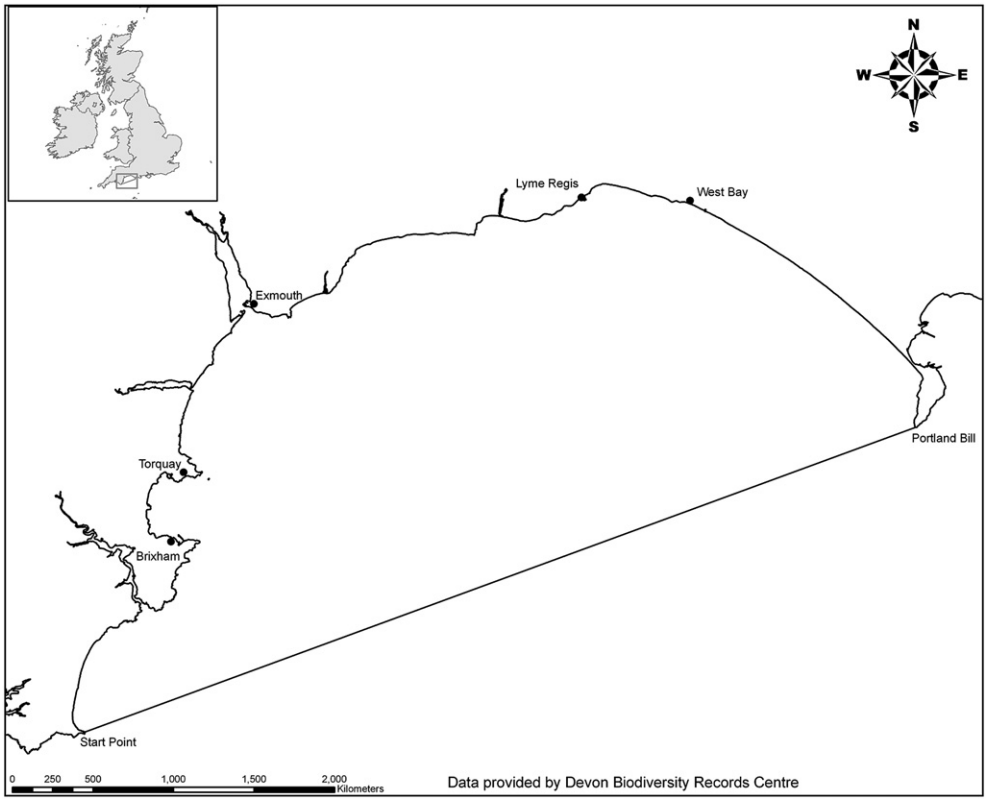

Fig. 1. The Lyme Bay case study area.

Table 1
The species within the reef area which are listed for conservation.

Latin name	Common name	Listed for conservation
Axinella dissimilis	Erect, branching sponge	Nationally important marine features
Pentapora fascialis	ross coral	Nationally important marine features
Alcyonium digitatum	Dead man's fingers	Nationally Important Marine Features
Eunicella verrucosa	Pink sea fan	Wildlife and Countryside Act 1981, the UK Biodiversity Action Plan 1995 (UK BAP). The International Union for Conservation of Nature (IUCN) Red Data List [19,20].
Leptopsammia pruvoti	Sunset cup coral	Wildlife and Countryside Act 1981, the UK Biodiversity Action Plan 1995 (UK BAP),the International Union for Conservation of Nature (IUCN) Red Data List [19,20]. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) [20]

benthos by the removal of both target and non target species as well as disruption to the physical surface and sub-surface features and biota [23,24].

Traditionally within Lyme Bay, fishermen towing demersal fishing gear (otter trawls, beam trawls, scallop dredging) avoid the rocky areas and fish on the mixed sediment areas (sands, gravels, cobbles). Static gear fishermen place pots in the rocky areas to catch crabs and lobster. Diving, angling and charter boats operate around the reefs and wrecks of Lyme Bay [13]. Species such as the pink sea fan (*Eunicella verrucosa*) which is nationally uncommon [25] and the sunset cup coral (*Leptopsammia pruvoti*) which is nationally rare [26] attract divers to the area. Charter boat operators run wildlife watching trips throughout the Bay to take people bird-watching or further offshore to see dolphins. Several small fishing boats (6–10 m long) supplement their income by chartering boats to anglers [27]. Recreational mackerel (*Scomber scombrus*) fishing trips are increasingly popular.

The conflict in Lyme Bay has largely focused on the reef area. In 1992, local divers and static gear fishermen reported to Non Governmental Organisations (NGOs) and Natural England (then English Nature) that the use of heavy fishing gear on the reef areas was resulting in physical damage to the seabed and, in some cases, loss of static gear. A campaign for an MPA was then initiated by the local NGO, the Devon Wildlife Trust.

Through this conflict between different groups, a process for protection of the reefs has gradually evolved. On the 19 June 2008, a 206 km^2 statutory closed area (MPA) was designated by the Department for Environment, Food and Rural Affairs (Defra) to protect marine biodiversity from the impact of fishing with dredges and other towed gear. The designation entered into force through the Statutory Instrument 1584 on the 11 July 2008 [28].

2. A thematic search of the literature

A search of the literature, of predominantly NGO, independent (academic institutions and or consultancy's) and government agency reports, which have contributed to the decision-making process for the MPA designation in Lyme Bay was conducted to assess the theme of each report. These themes were:

- *Environment*. Includes reports which classify and describe the species and habitats of Lyme Bay and their interaction with the environment. This theme also includes studies which assess impacts to biodiversity;
- *Economic*. Reports which define the distribution and consumption of marine resources in monetary terms, and
- *Social*. Reports which study resource use interactions between stakeholders and provide recommendations for the sustainable management of the marine environment.

Thirty-four reports were reviewed as to which theme(s) they addressed. Responses to Defra consultations on Lyme Bay have not been considered even though they have influenced the process because respondents were required to comment on specific themes.

The year 1988 was chosen as the starting point for this thematic study as the Coastal Directory for Marine Nature Conservation [29] represents the first attempt in the UK to collate information on the marine environment to inform decision making for designating Marine Nature Reserves under the provisions of the Wildlife and Countryside Act 1981.

3. Themes of reports

The themes of thirty-four reports from 1988 to 2008 were reviewed. The process of reports can be divided into three distinct chronological phases. 1) Environmental Data (1988–1999), 2) Incorporating Social and Economic Data (2000–2006) and 3) A Focus on Economics (2007–2008).

3.1. Environmental data (1988–1998)

The majority of studies from 1988 to 1999 were focussed on the environment theme to further understanding of the species and habitats of Lyme Bay and identify areas of marine nature conservation interest in UK waters. Reports were undertaken by staff from NGOs, Government advisory organisations and consultants (Table 2).

In 1988, the inshore reefs of Lyme Bay were identified as an area of 'Marine Nature Conservation Interest' as part of the Marine Conservation Society's Coastal Directory [29]. In 1995, research undertaken for Kerr McGee, an oil exploitation company, led to a wide body of research on the marine benthic environment in Lyme Bay to document the epibenthos [30], benthic sediment infauna [31], hydrography [32], and sediments [33]. The reports concluded that there were areas of Lyme Bay which were 'notable for dense populations of several south western species near to or at the eastern limits of their distribution along the English channel and the circalittoral limestone and shale ridges of the West Tennents Reef and Saw Tooth Ledges were considered to support particularly rich communities' [34].

Much of the focus during this period was on the inshore reefs of Lyme Bay. Studies showed that the Lyme Bay reefs (Fig. 2) supported nationally important biological communities, that damage to the seabed had significant implications for the biological communities that could be supported and that the areas of reefs substrate needed to be protected in their entirety [29,35,36]. A 1992 survey of a mudstone reef site known locally as the Exeters and reported by divers to support colonies of ross coral (*Pentapora fascialis*) and pink sea fan (*Eunicella verrucosa*) found the site to be flat and muddy with occasional patches of low flat rock rather then the ledges previously reported by divers [37]. Lacking definitive evidence of fishing activity on the site, the degradation of the Exeters was thought to be attributable to the use of 'rock hopper' trawls which enabled boats to access rocky sites rather than remain

Table 2
Themes of reports written between 1988 and 2008.

		Theme		
Year	Title	Env.	Eco.	Soc.
1988	A Coastal Directory For Marine Nature Conservation [29].			
1991	Benthic marine ecosystems in Great Britain: a review of current knowledge. Western Channel and Bristol Channel and approaches [30].			
1992	An Investigation into the Effects of Scallop Dredging in Lyme Bay [31].			
1993	Benthic and Ecosystem Impacts if Dredging for Pectinids [32].			
1993	Lyme Bay. A Report on the Nature Conservation Importance of the Inshore Reefs and the Effects of Mobile Fishing Gear [33].			
1995	Lyme Bay Environmental Study. Subtidal Benthic Ecology: Epibenthos [34].			
	Lyme Bay Environmental Study. The Physical Environment [35].			
	Lyme Bay Environmental Study. Subtidal Benthic Ecology: Sediment Infauna [36].			
	Lyme Bay Environmental Study. The Physical Environment: Sediments [37].			
	Lyme Bay Environmental Study. Environmental Quality: Sensitivity Analysis [38].			
	Possible Special Areas of Conservation (SACs) in the UK - marine and coastal sites [39].			
1996	Coasts and seas of the United Kingdom. Region 9, Southern England : Hayling Island to Lyme Regis [40].			
	Coasts and seas of the United Kingdom / Region 10, South-West England: Seaton to the Roseland peninsula [41].			
1997	Lyme Bay. A Nature Conservation Profile [42].			
1998	Coasts and Seas of the United Kingdom. Marine Nature Conservation Review: Benthic marine ecosystems of Great Britain and the north east Atlantic [43].			
2000	Lyme Bay Reefs - A Report on the Area's Fisheries [44].			
	Report on the Areas of Greatest Nature Conservation Importance Within the Reefs Known As Saw Tooth Ledges and Lanes Ground - Lyme Bay [45].			
2001	Feasibility Study into the Management of Beer Home Ground [46].			
2002	Effects of scallop dredging on sessile macro fauna in Lyme Bay: Interim results for 2001 and 2002 [47].			
2003	The Commercial Benefits of Marine Protected Areas [48].			
2004	The timing and settlement of scallop spat in Lyme Bay, Devon and its use as a fisheries enhancement tool [49].			
	Initial Results of a Visual Survey on the Impacts of Dredging for Scallops on the Seabed [50].			
	Sustainability from the Market [51].			
2006	Independent Scoping Study. Options for Spatial Management of Scallop Dredging Impacts on Hard Substrates in Lyme Bay [52].			
2007	Lyme Bay Pink Sea Fan Survey 2006-2007 [18].			
	Marine Reserves - TLC for our seas and sea life [53].			
	Surveys for Marine Spatial Planning in Lyme Bay [13].			
	Informing Community Stakeholders - The Devon Pilot Project [54].			
	Estimate of Economic Values of Activities in Proposed Conservation Zone in Lyme Bay [55]			
	Marine Biodiversity Hotspots in the UK. A report identifying and protecting areas for marine biodiversity [24].			
	Lyme Bay Reefs. A 16 year search for sustainability [56].			
	The Impact of Scallop Dredging in Lyme Bay an Eye-witness Account [57].			
2008	Quantification of epibenthic fauna in areas subjected to different regimes of scallop dredging activity in Lyme Bay, Devon [58].			
2008	Lyme Bay Proposed MPA. Indications of Social and Economic Impacts [59].			

on the sands and gravels [37]. It was concluded through further investigation in two separate reports, one conducted by Devon Wildlife Trust and one by the Seafish Industry Authority, that the use of mobile fishing gear on the reefs caused damage to the structure of the reef and its biological communities [35,38].

The data on marine biodiversity in Lyme Bay were included in the Joint Nature Conservation Committee's (JNCC) Marine Nature Conservation Review which collated all known records of marine biodiversity between 1987 and 1998 with the view to inform government decision making regarding areas of marine nature conservation interest [34,39–41]. During this period Lyme Bay was identified by English Nature (now Natural England) as a 'Sensitive Marine Area' and the reefs were proposed as a possible Special Area of Conservation (SAC) under the Habitats Directive (92/43/EEC) [42]. In 1997, the sublittoral bedrock and mixed bedrock areas of Lyme Bay were identified by Natural England as a 'Prime

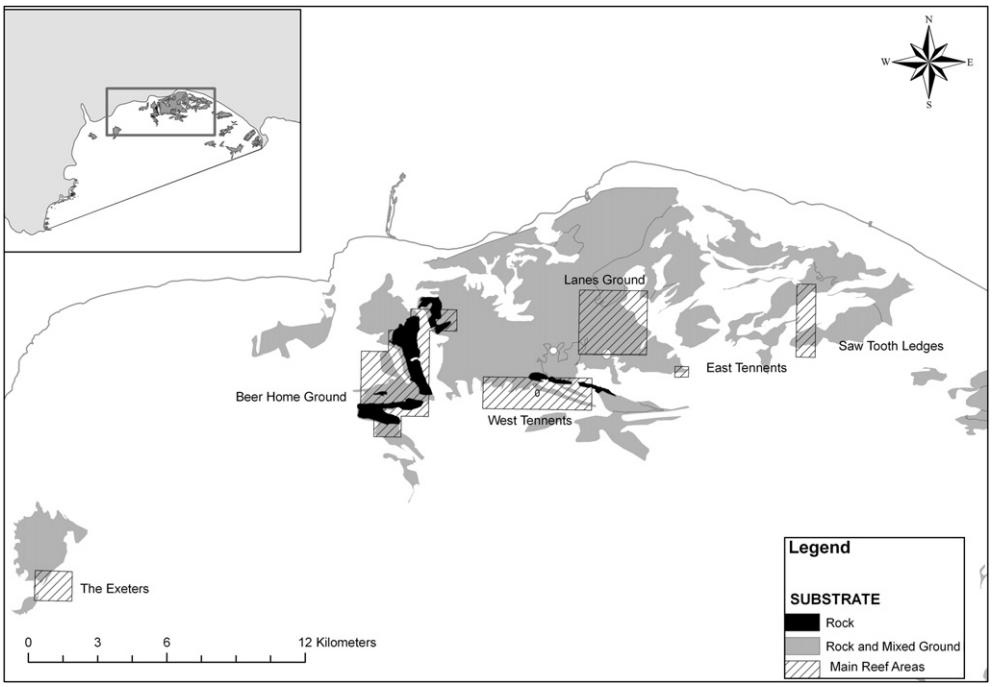

Fig. 2. The named reefs of Lyme Bay as known in 1995. Overlaid on substrate data. Reef co-ordinates supplied by charter boat skipper John Walker.

Biodiversity Area'. These areas were identified within the wider study of the Lyme Bay Marine Natural Area as areas of maximum opportunity where resources could be targeted to effectively achieve wildlife conservation [43].

3.2. Incorporating social and economic data (2000–2006)

Reports from 2000 to 2006 encompass elements of the environmental, economic and social aspects of MSP in Lyme Bay (Table 2). From 2000 to 2004 research involved further investigations into the conservation importance of the reefs, with a particular focus on the sites of Saw Tooth Ledges and Lanes Ground [44]. There was also ongoing work to investigate and document the impacts of scallop dredging on the reef habitats [45]. This period was marked by the involvement of fishermen as key stakeholders in the design and implementation of 'closed areas' to secure the long-term sustainability and viability of the local fishing industry.

The NGO reports written during this period attempted to understand the distribution and nature of the local fishing fleet in order to inform the decision-making process as to where closed

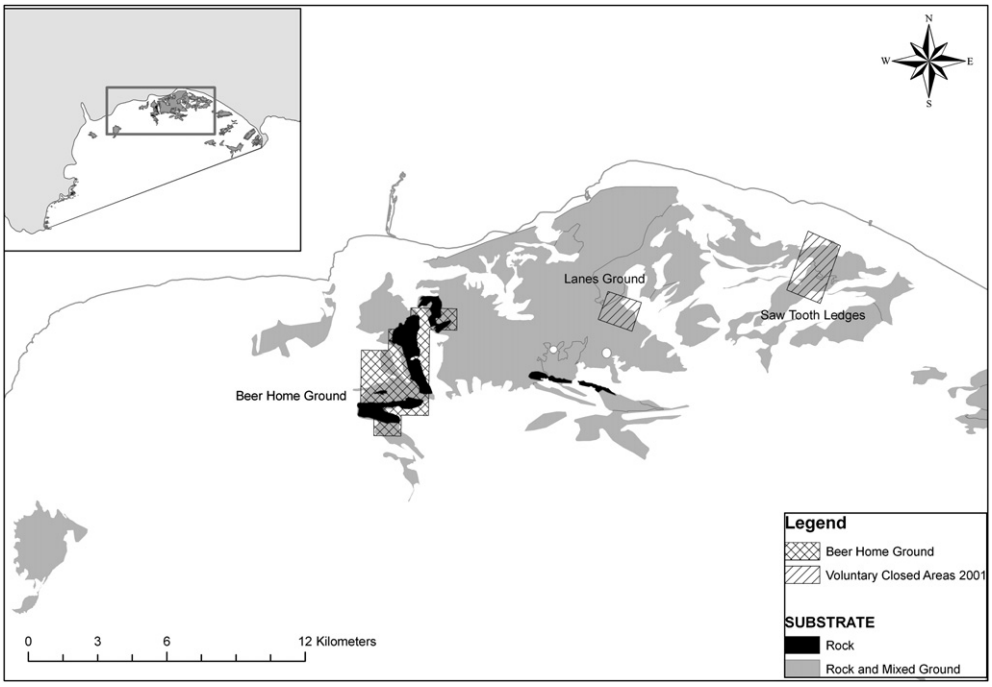

Fig. 3. The 2001 voluntary closed areas and Beer Home Ground overlaid on the substrate data.

areas could be sited on the reefs [46]. In 2001, two voluntary closed areas for the reef areas of Saw Tooth Ledges and Lanes Ground encompassing 10.3 km^2 were agreed by Devon Wildlife Trust, local mobile gear fishermen and the South West Fish Producers Organisation. A feasibility study on a third closed area, Beer Home Ground, was initiated by the Beer Home Ground Management Group (Devon Sea Fisheries Committee, East Devon District Council, Devon Wildlife Trust and local fishermen) and carried out by Devon Wildlife Trust's Lyme Bay Project Officer. This third voluntary closure could not be agreed due to the economic importance of the site to local mobile gear fishermen [47] (Fig. 3).

With the successful negotiation of two voluntary closed areas, Project Officers at Devon Wildlife Trust and the Beer Home Ground Management Group sought to build an evidence base for an MPA by further investigating the commercial benefits of MPAs [48]. Yearly monitoring from 2002 was established to assess the abundance of five indicator species: branching sponge (*Axinella dissimilis*), ross coral (*Pentapora fascialis*), dead man's fingers (*Alcyonium digitatum*), pink sea fan (*Eunicella verrucosa*) and king scallops (*Pecten maximus*), in the dredged and undredged areas [49]. The results of the surveys showed that there were signs of recovery of benthic species within the closed areas, though longer term studies were needed to assess change [49].

There were very few temperate studies of the value of MPAs to commercial industries relative to Lyme Bay but Davis and Stanford [48] were able to draw on world examples that demonstrated that MPAs could have benefits for fisheries including an increase in the mean size, age and biomass of stocks and an increased abundance or density of stocks. Project work was also initiated by Devon Wildlife Trust to look at sustainable fishing options for scallopers through food accreditation schemes such as the Marine Stewardship Council certification programme [50], and through the rearing of scallop spat for seeding purposes as a fisheries enhancement tool [51].

In 2005, a large scale survey of the seafloor of Lyme Bay was carried out by Ambios Ltd on behalf of Devon Wildlife Trust who were project partners in the Interreg IIIb Atlantic Area Emergency Response to Oil, Chemical and Inert Pollution from Shipping (EROCIPS) project. The work included side scan SONAR surveys, sediment grab sampling and drop down video surveys [52]. The resulting biotope and sediment map placed the Lyme Bay reefs within the context of the whole bay. This indicated that the reef substrate was confined largely to the north of Lyme Bay extending around to Portland Bill (Fig. 4) The Lyme Bay Reefs were thus defined using JNCC criteria as rocky reef (exposed bedrock and/or mosaic of mixed ground and bedrock) and/or stony reef (areas of pebbles, cobbles and boulders on mud, sand or gravel). Patches of reef were also mapped off Start Point. Other features of conservation importance including maerl (*Lithothamnion corallioides*) and eelgrass beds (*Zostera marina*) were mapped in the Bay.

The closed areas were voluntary rather than statutory. Closure of these areas was agreed by local fishermen and regulated by the local community. However, by the end of 2005 rising fuel costs, higher prices for scallops on the market and the new development of West Bay harbour allowing overnight stays for fishing vessels made scalloping a more lucrative fishing option. The number of scalloping boats in the Bay increased from 9 to 20, with boats travelling from other UK ports to take advantage of the scallop stocks [53]. This ultimately led to the breakdown of the voluntary local agreements.

In 2006, adopting the precautionary principle [54] and to prevent widespread scalloping on the reefs, Natural England applied for a Ministerial Stop Order to close 60 square nautical miles of Lyme Bay to dredging to allow damaged seabed

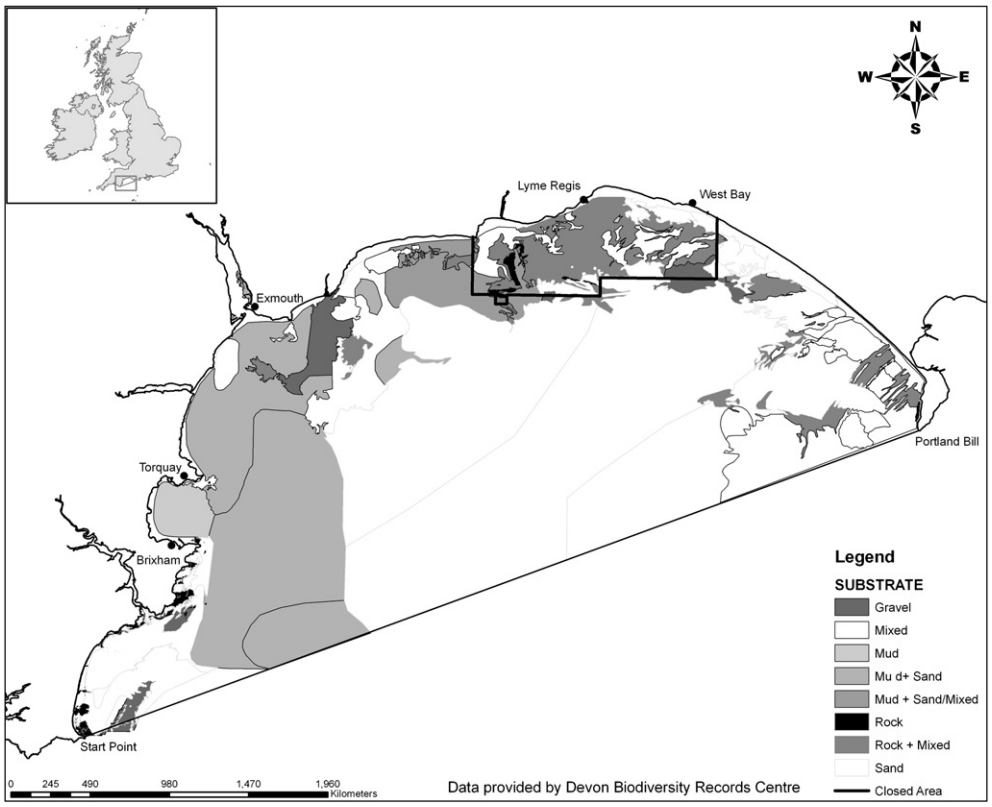

Fig. 4. Substrate map of Lyme Bay and the statutory closed area. Source: Devon Wildlife Trust.

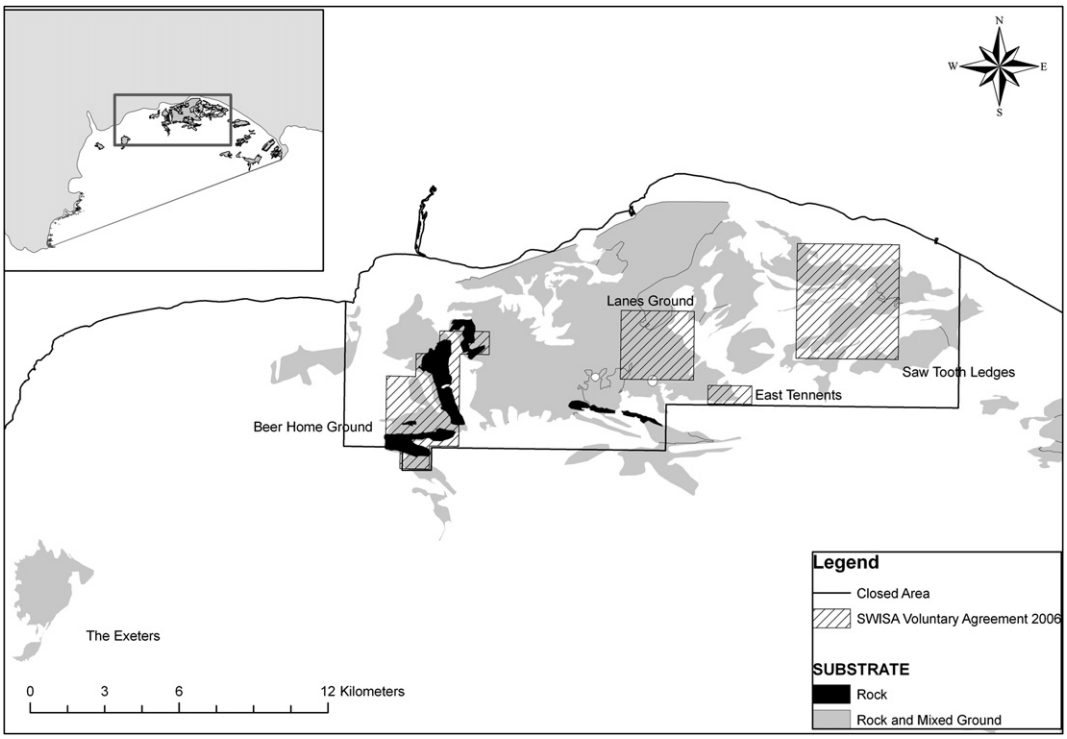

Fig. 5. The Natural England and Devon Wildlife Trust proposed 206 km^2 closed area and the Defra agreed voluntary closed areas 2006.

communities to recover. In August 2006 the Secretary of State reached a decision with the (newly formed) South West Inshore Scallopers Association (SWISA), plus select advisors, to voluntarily close 41.2 km^2 of the reef area, 'protecting 90% of the area where pink sea fans occur' [53] (Fig. 5).

During 2006, the consultancy firm, Royal Haskoning, was contracted by Natural England to assess the offshore reefs from Poole Bay to Lyme Bay for their suitability as a SAC under the Habitats Directive Annex I category for subtidal and offshore reefs [55]. Members of SWISA also engaged with the possibility of wider spatial planning and commissioned a report 'Options for spatial management of scallop dredging impacts on hard substrates in Lyme Bay' [56]. The recommendations of the report were, as a minimum, to 'initiate an interdisciplinary approach to marine spatial planning, combining refined spatial scale mapping and optimisation with economic data' [56].

3.3. A focus on economics (2007–2008)

In 2007, Natural England and Devon Wildlife Trust challenged the Government's decision to close 41.2 km^2 rather than the proposed 206 km^2 citing that the Government had mis-interpreted the data and had delineated the 41.2 km^2 around the 'known' locations of pink sea fans, rather than considering the reef area and its ecological functions as a whole. It was reiterated that pink sea fans are 'signpost species' indicative of a biologically diverse habitat and that diversity of species is an important component for the resistance and resilience of ecosystem functioning (Hiscock quoted in [53]). Further research documented the presence of pink sea fans outside the new closed areas providing evidence that the whole of the reef area could potentially support such biodiversity [18]. The reefs in Lyme Bay were identified by the consultancy, Royal Haskoning, as being an 'excellent' example of reef habitat due to the complex range of substrata, except in recently dredged areas where it was average or partly degraded [55].

During this year there was continuing research into MSP and reports which incorporate the ecosystem approach with a particular focus on the economics of MPA designation (Table 2) [13,57,58]. In January 2007, the beaching of the MSC Napoli within Lyme Bay and the subsequent threat of a large-scale pollution incident reaffirmed with stakeholders the need for wider scale ecosystem management [59]. An analysis of species' and habitats' sensitivity to

Table 3
Economic valuations of activities in Lyme Bay.

	Homarus (2007)[a]	Stevens et al. (2007)[b]	Curtis et al. (2008)[c]	Defra (2008)[d]	Defra (2008)[e]
Scalloping	£162,000–187,000	£1,848,557	£3,000,000	£299,911	£2,680,000
Potting	£177,000	£1,992,916			
Fin fisheries		£7,668,102			
Diving	£85,000	£1,098,411			
Angling	£247,000				
Charter boats		£2,140,000			

[a] Value of activities in the closed area [58].
[b] Value of activities in Lyme Bay [13].
[c] Value of activities in the closed area [57].
[d] Value of activities in the closed area. Combined scallop and other demersal towed gear landings [60].
[e] Revised value of activities in the closed area following interviews with local MFA officers [60].

physical disturbance was carried out by Stevens et al. and proposed, in the absence of a wider marine spatial planning framework to assess their relative importance, the ecological need to protect the reefs in their entirety [13].

This period is marked by four studies which focus solely on economics to assess the relative economic importance of activities in Lyme Bay. Table 3 summarises the results.

3.4. A decision for Lyme Bay

At the end of 2007 Defra released a further consultation, a partial Regulatory Impact Assessment (RIA), to review the original decision to close 41.2 km^2 of the reef habitat with the options to close areas of 41.2 km^2, 85.7 km^2 and 206 km^2 of reef habitat on either a statutory or voluntary basis [60]. Seventy percent of the respondents to the Defra consultation wrote to Government in favour of the full 206 km^2 closed area [61]. Mee et al. responded to the consultation citing that 'sound application of the precautionary principle dictates that the reefs should be closed to mobile bottom fishing by whatever effective means possible to safeguard their long-term future, and to allow proper ecosystem scale planning for the future use of the Bay to occur [62].

Ongoing research into the recovery of the 2006 voluntary closed areas by Hiddink et al. showed that the closed areas, which had not been trawled, supported a greater abundance of sessile species [63]. Following a public consultation (September–December 2007), a review of responses and an Impact Assessment, Defra announced their decision to statutorily close 206 km^2 of Lyme Bay to protect marine biodiversity from the impact of fishing with dredges and other towed gear effective from the 11 July 2008.

4. Discussion

4.1. From environment to economics

Numerous organisations from a range of disciplines have contributed to the research in Lyme Bay over the past twenty years. It has not been a strategic chronological process but rather an ad-hoc reactive, bottom up process led by NGOs with support from nature conservation agencies. All of the reports are considered 'grey literature' as they have not been published in the academic press or been placed under scrutiny through a peer review process. However, these reports document the process by which marine nature conservation has developed. These reports (along with the outcomes of the Defra consultation) have formed the basis for the decision to statutorily designate the 206 km^2 MPA in Lyme Bay.

The succession of reports for Lyme Bay show how the themes have changed during this period from an ecological focus on the reefs and particular species, to consideration of the wider ecosystem functioning though MSP. The move from a focus on the reefs, and in particular the pink sea fan (*Eunicella verrucosa*), as the only species for which there is legal leverage for protection under the Wildlife and Countryside Act 1981, to broader marine spatial planning has served to widen the advocacy for marine environmental protection from species specific protectionism to ecosystem based conservation.

The focus of reports for Lyme Bay follow the evolving understanding of the benefits of MPAs and the policy focus of the UK authorities on the Ecosystem Approach. The adoption and incorporation of the principles of the ecosystem approach enter into the process from the year 2000 with a shift from a pure focus on ecology and conservation objectives to research which considers the economic and social impacts of MPA planning. The reports during the years 2000–2004 show a commitment from NGOs to work with the fishing industry to find coherent solutions to MPA planning. In 2006, the goodwill that had been generated between conservation and fishing interests rapidly broke down, primarily due to a changing economic climate.

The most recent years have seen a pronounced shift towards the field of economics in order to influence the agreement for and against nature conservation objectives. Valuations of the impacts of the closed area vary as separate methodologies and assumptions have been applied to the data available. In Defra's Impact Assessment for Lyme Bay it was concluded that the Homarus report [58] was useful report as it improved the understanding of the relative importance of all activities in the closed area but it underestimated the value of the MPA to the scallop fleet as it assumed that the MPA proportionally represented 11.3% of catches in the two adjacent ICES rectangles [64]. Curtis and Anderson [57] report went beyond a study of the direct costs to the fishing sector and applied methodologies to assess the wider social and economic impact of the MPA on the fishing industry. The analysis was considered useful to assess the commercial value of fishing under different MSP scenarios but Defra advised that the results should only be considered as illustrative. The valuation was considered an overestimate as the MPA was assumed to represent between 25 and 50% of the landings from the two adjacent ICES rectangles [64]. Defra note that there are 'limitations and caveats' around all these figures but they give an indication of the scale of the costs to be weighed against the wider economic, environmental and social benefits [64].

The economic reports are marked by their different outcomes, the range of values which have been applied to the same area and the different assumptions applied to the data available. Though the Defra Impact Assessment shows transparency as to how these figures were attained, the discussions are largely based around impacts on fisheries of an MPA. The Lyme Bay case study illustrates that reliance on market valuations and resource use decisions based on traditional neo-classical economics can obscure other issues pertinent to the ecosystem approach concerning whether ecological features should be protected.

4.2. Decision making and balancing the components of the ecosystem approach

Between 1988 and 2008, although there were International, European and National nature conservation obligations, government decision makers were unable or unwilling to respond to a direct need for nature conservation. In 2006 the Government balanced the advice of their own nature conservation advisors, Natural England with that of the fishing industry as the direct beneficiaries of the resource. The 41.2 km^2 voluntary closed area was considered as a compromise option that did not fulfil conservation objectives [53]. This stance is not uncommon. Laffoley et al. [3] have noted from other policy decisions relating to the marine environment that fisheries issues typically drive the decision-making process and that they have a disproportionately negative impact on the health of marine ecosystems compared to the benefits they provide. In addition, the burden of proof is in favour of fishing as 'typically actions are only taken to restrict human activities when the future viability of species or biological communities is in doubt, or where proof of damage to the environment and its features is produced' [3].

Although marine biodiversity is no doubt valuable to the fishing and recreation industries, the benefits of marine biodiversity extend much further than the direct use of the resource. Marine biodiversity in Lyme Bay is linked to large scale processes of direct or indirect benefit (and therefore value) to humans such as nutrient

cycling, gas and climate regulation and the bioremediation of waste. For example, the river catchments of the Exe, Axe, Otter and the Fleet, which empty into Lyme Bay, are all designated as Nitrate Vulnerable Zones (NVZ) due to high nutrient loading in the rivers originating from farmland. The capacity of marine biodiversity to cycle nutrients is an essential function and can alleviate anthropogenic effects, such as excessive nutrient loading, which can result in Harmful Algal Blooms (HABs), eutrophication and other detrimental effects [65]. Bioturbators facilitate nutrient cycling via their physical activity (feeding, moving, burrowing). Bioturbators in Lyme Bay include the burrowing mud shrimp (*Callianassa subterranea*) which are found in abundance on the circalittoral sandy muds in Lyme Bay. Habitat areas such as eelgrass beds (*Zostera marina*) also provide an important ecosystem for the uptake of nutrients from the water column [66].

Marine biodiversity also provides a structural habitat which has a fundamental role in the ecosystem functions of Lyme Bay. The rocky reef, maerl (*Lithothamnion corallioides*), kelp (*Laminaria hyperborea*) and eelgrass (*Zostera marina*) beds provide refugia and nursery areas for juvenile species. For example, maerl provides a refuge for species such as queen scallop (*Aequipecten opercularis*), the green sea urchin (*Psammechinus miliaris*) and other juvenile invertebrates [67]. It is a feeding ground for juvenile Atlantic cod (*Gadus morhua*) and also provides grounds for reserves of brood stock of king scallops (*Pecten maximus*) [68]. Rocky reef areas and the associated biodiversity also provide food and/or shelter to mobile species particularly juvenile fish. Large mobile crustaceans are attracted to rocky areas for the rich supply of food which is attached to the surface of circalittoral rock [69].

The marine biodiversity in Lyme Bay also has a social value as it is part of the cultural heritage of the region. There are several local events associated with marine life and livelihoods incorporating arts, crafts and music. The Marine Week celebrations in Charmouth in 2007 included activities such as plankton trawling and rockpool rambles. Visitor centres with a marine focus at Chesil Beach, Beer, Slapton Sands and Goodrington are all part of this cultural fabric.

It has been cited that a continued decline in UK marine biodiversity will impact upon these wider benefits [70]. The 2008 Government decision to close 206 km^2 of Lyme Bay to protect marine biodiversity represents a shift towards policy decisions which take into account the wider value sets attached to the marine environment and its ecological functions. The rationale behind the decision was stated as being necessary to 'ensure an improved outcome for society and the environment. Without intervention commercial pressures would lead some fishers to continue to pursue activities without adequate regard for the wider costs (on the environment and other users of the marine environment) of their actions' [64].

4.3. Lessons for the Marine and Coastal Access Act

Experience from Lyme Bay should guide the development and implementation of marine legislation in the UK and Europe. A common standard needs to be set for the information decision makers need for MSP. Thirty-four reports have contributed to the decision for a closed area in Lyme Bay as well as 7900 responses to the Lyme Bay consultation (108 unique responses and 7792 NGO campaign based responses) and an Impact Assessment. If this level of information is required before any decision for marine nature conservation is to be made, then the designation of MCZs will be a costly and time consuming process. Planning on this timescale is unlikely to enable the UK government to meet International, European and National policy objectives designed to halt the decline in biodiversity. By requiring stakeholders to prove or disprove environmental damage only serves to polarise the discussion and removes the moderate or 'middle ground' suitable for negotiation. The burden of proof will need to shift to an equal emphasis on the 'value' derived from ecological systems and their sustainable use rather than the current disproportional emphasis on fishing and recreation and their associated market or commodity value. The decision for an MPA in Lyme Bay has recognised this wider social and ecological value of marine biodiversity. To move forward, the burden of proof must be shared amongst stakeholders so that all can work together to reduce ambiguity in the decision-making process [71].

When designating MCZs, valuations of resource use must be considered within the context of how the data are collected and analysed. Valuation should inform the decision-making process and decision makers need to be 'aware of the overall objectives and limitations of valuation' [72]. In the case of market valuations, numbers are powerful tools and can strongly influence policy makers. Therefore, the methodology used to determine such valuations and the assumptions applied must be clear and transparent. Some of the benefits realised by humans from ecosystem functions cannot be traded to achieve a win–win situation. For example, marine recreation activities generally benefit the local communities whereas the nitrogen cycling capacity of marine biodiversity is a fundamental human life support service but it is not exclusive to the marine biodiversity in Lyme Bay; it is a global trans-boundary process and would need to be considered relative to its operational scale. Valuations are simply tools which can provide the benchmark against which to assess change or weigh the options in a decision-making process. The biggest number does not 'win' and the implementation of policy should not 'hinge upon a precise measurement' of values [73].

When balancing environmental, social and economic interest, conflict is an almost inevitable part of the process of protected area management [74], but not reason to abandon policy commitments for nature conservation. Value, as discussed here, is an inherently broad concept. One respondent to the Lyme Bay consultation explicitly stated that livelihoods were more important than protecting marine areas for biodiversity. Another respondent cited the biodiversity value of the reefs as being the most important factor for decision making [61]. This demonstrates that despite a process of stakeholder involvement win–win situations will remain unlikely as values (and perceptions) held by different groups are so diverse as to be irreconcilable in the short term. In reality, through initiating a process of valuation, it is already implied that gains and losses are part of the picture. Kumar et al (2008) summarise that 'each choice or option – to leave a resource in its natural state, to allow it to degrade or convert into another use – has implications in terms of values gained and lost'. From an environmental psychology perspective, 'environmentally destructive behaviour may be a short term rational choice for an individual, even when in the long-term and for the larger collective it might entail counterproductive outcomes' [72]. It is essential that the objectives of the MPA are clear [9], that stakeholder expectations are managed and that mechanisms for conflict resolution are built into the MSP and adaptive management process [74,75].

The Lyme Bay case study suggests that an immediate commitment will be needed from Government to make decisions for marine conservation in order to secure the long-term benefits enjoyed by humans from ecosystem functions provided by marine biodiversity and to work towards the High Level Marine Objective goal of delivering sustainable marine development [76]. Nature conservation interests in Lyme Bay have only been furthered by a top down intervention from Government when a lengthy bottom up process had largely failed to provide the necessary protection for marine biodiversity in line with the precautionary principle and International, European and National marine conservation

objectives. There remains a strong case for a bottom up approach to MSP and MPA designation [77], particularly the involvement of fishermen in MPA network design [78]. However, there is also a pressing need for a network of MPAs [4,79] and the Lyme Bay case study shows that balancing the demands of the ecosystem approach in a decision-making framework can be a protracted process of data collection and analysis. The Marine and Coastal Access Act must provide the arena to advance a framework for weighting or even integrating [80] the diverse value set held by multi sectoral stakeholders who will naturally conflict in the MCZ designation process.

5. Conclusion – is there a win–win scenario for marine nature conservation?

Constanza et al. [73] noted that whilst win–win opportunities for human activities within the environment may exist they also appear to be increasingly scarce in a 'full' global ecological-economic system'[73]. The form of conflict which arose in Lyme Bay is simplistic, but also typical of other current inshore marine resource use conflicts in UK waters (e.g. The Fal and Helford SAC, Cornwall, UK). It is a scenario which has the potential to be repeated as the UK moves towards the implementation of the Marine and Coastal Access Act and the proposed network of Marine Conservation Zones (MCZs).

The goal of an outright win–win scenario is short sighted, especially if the precautionary principle is evoked for marine nature conservation purposes. To use the example of Lyme Bay and the recent statutory closure there is no absolute 'winner' and no win–win situation for all stakeholders. The scallop and demersal trawl fishermen have lost valuable fishing grounds and will have to fish elsewhere, possibly incurring larger fuel costs. Fishermen using pots and divers have 'won' a sanctuary to continue their activities without conflict with the scallop dredgers and fishermen using demersal trawling gear. Conservationists have 'won' a drawn out and costly argument for a closed area in Lyme Bay to protect the reef habitat yet have perhaps delayed or lost the opportunity for broader scale adaptive management of Lyme Bay in the future as members of fishing groups have threatened to withdraw from engaging with further MSP projects in the south west, UK [81]. The reefs are an important component of ecosystem functioning in Lyme Bay but are by no means the only part. It remains to be seen whether the long-term conflict in Lyme Bay will result in an even longer stalemate between user groups in the process of wider MSP.

Lyme Bay's history of conservation is a modern day 'clash of values' centred around the use of a particular resource and shows how disparate groups have attempted to get their idea of what is valuable prioritised in policy. As all policy decisions are underpinned by the ecosystem approach stakeholders and decision makers should not hope to enter negotiations to achieve an outright win–win. A win–win is likely to be a long-term outcome. At this stage, with few MPAs in UK waters, it cannot be expected that all stakeholders will be influenced of the longer term societal benefits of MPAs and therefore conflict will inherently be part of the process. Human preferences constantly evolve and are influenced by social and cultural practices. As the body of evidence for the success of MPAs continues to grow [82], coupled with the societal benefits derived from the protection of marine biodiversity [83], it may be that a collective societal change in values will facilitate future win–win situations.

The final stages of the development of the Marine and Coastal Access Bill recognized this long-term aim and though the supporting policy documents for the Bill clearly state the involvement of stakeholders as being key to designating a MCZ the 2008 Marine and Coastal Access Bill itself states ' in considering whether it is desirable to designate an area as an MCZ the appropriate authority *may* have regard to any economic or social consequences of doing so' [84]. This suggests that an immediate win–win scenario is no longer being sought. This is further emphasises by giving the Secretary of State the final sign off on the designation process thus adding a further political dimension to the decision-making process.

The implementation of the Marine and Coastal Access Act and plans for Marine Conservation Zones has the capacity to deliver future win–win scenarios for marine nature conservation. By examining the process of how a decision was made regarding nature conservation in Lyme Bay it has made evident that the Marine and Coastal Access Act must provide statutory powers to designate MCZs, demonstrate the Government's commitment to wider marine nature conservation objectives, provide stakeholders with clear objectives as to the purpose of the MCZ network and enable the development of a transparent decision-making framework for delivering the ecosystem approach in the marine environment.

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