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The Value of Marine Conservation

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The Value of Marine Conservation

by

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Abstract

The marine environment provides essential ecosystem services that are critical to the functioning of the earth's life support system and the maintenance of human well-being. Marine Protected Areas (MPAs) are recognised as being the mechanism though which marine natural capital may be conserved. This thesis focuses on the value associated with marine conservation in a case study area, Lyme Bay, England where a 'closed area' was created in 2008. A review of literature spanning 20 years shows that despite sound ecological knowledge of a marine area, the reliance on traditional neo-classical economic valuations for marine spatial planning can obscure other issues pertinent to the ecosystem approach. A further valuation of the marine leisure and recreation industry shows that the industry is of economic significance and that the MPA enables the protection of the most valuable sites but has limited benefits for protecting the full resource base. In terms of ecological value, a 'service orientated framework' was developed to enable decision makers to understand the links between benthic species, ecological function and indirect ecosystem services. Results spatially identify which ecosystem services occur and demonstrate the value of the MPA in ensuring delivery of these ecosystem services. In relation to the social value of the MPA the research reveals that support for the MPA is strong amongst the majority of stakeholder groups. Values are expressed as the economic, environmental and social benefits of the MPA. However, there have been clear social costs of the MPA policy and these have been borne by mobile and static gear fishermen and charter boat operators. Each valuation methodology can inform decision making. Though, if ecosystem service valuation is to become a deliberative tool for marine conservation and planning, then there is a need for a larger societal discussion on what activities and trade-offs society considers acceptable.

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Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the graduate committee.

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Responses to consultations:

Mee, L., Stevens, T., **Rees, S** and Marshall C. (2008). DEFRA Consultation on measures to protect biodiversity in Lyme Bay; Response from the Marine Institute at the University of Plymouth. 11pp

Marine Institute (2009). DEFRA consultation on delivering Marine Conservation Zones and European Marine Sites (a draft strategy for marine protected areas) and the Draft Guidance Notes 1-4. Response from the Marine Institute at the university of Plymouth. Prepared by Siân Rees and Charlotte Marshall. 18pp

Reports

Attrill MJ, Bayley DTI, Gall SC, Hattam C, Jackson EL, Langmead O, Mangi S, Marshall C, Munro C, **Rees S**, Rodwell L, Sheehan EV, Stevens, TF. Strong S. 2010. Lyme Bay – a case-study: measuring recovery of benthic species; assessing potential “spillover” effects and socio-economic changes, Annual Report, December 2010. Report to the Department of Environment, Food and Rural Affairs from the University of Plymouth-led consortium. Plymouth: University of Plymouth Enterprise Ltd. 53 pages.

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Attrill, M.J., Fowell, S., Hall-Spencer, J., Hattam, C., Jackson, E.L., Langmead, O., Mangi, S., Marshall, C., Munro, C., **Rees, S.,** Rodwell, L., Sheehan, E.V., Stevens, T.F. (2009). Lyme Bay – a case-study: measuring recovery of benthic species; assessing potential “spillover” effects and socio-economic changes, Annual Report, December 2009. Report to the Department of Environment,

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Conference presentations

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2009 Plymouth Marine Science Partnership Conference. Marine Institute, Plymouth UK. The value of marine biodiversity to the recreation industry, Lyme Bay, UK.

2009 International Marine Conservation Congress. George Mason University, Virginia, USA. Incorporating the ecosystem approach and the value of marine biodiversity into marine spatial planning.

2010 CMS Conference. Socio Economics in the Marine Environment. Reconciling Social and Economic Issues with Environment Programmes in Practice. 1st December 2010. London. Lyme Bay and Socio-Economics: Lessons from Practice.

2010. Marine Institute Conference. Plymouth, UK. The Socio-Economic Impacts of the Lyme Bay Closed Area.

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Chapter one: Introduction

1.1 Background

Marine ecosystems provide a number of essential ecosystem services, such as the provision of food and climate regulation, which underpin life on earth. These ecosystem services form the constituent parts (e.g. food, shelter, clean water) that are essential to maintain human well-being (Millennium Ecosystem Assessment, 2005;Beaumont et al., 2007;Austen et al., 2011). As such, these services are of value to humankind. Ecosystem services have been defined as the conditions and processes through which natural ecosystems and the species that make them up sustain and fulfil human life (Chee, 2004).The marine environment and its stocks of natural capital provide a number of essential ecosystem services that are critical to the functioning of the Earth's life support system and the maintenance of human wellbeing. The Millennium Ecosystem Assessment Report (2005) groups these services into four overarching roles:

- **Supporting roles** include the underpinning of ecosystems through structural, compositional and functional diversity;
- **Regulatory roles** through the influence of biodiversity on the production, stability and resilience of ecosystems;
- **Cultural roles** from the non-material benefits people derive from the aesthetic, spiritual and recreational elements of biodiversity; and
- **Provisioning roles** from the direct and indirect supply of food, fresh water and fibre, and so on.

It is held that the amount of ecosystem services provided depends on the quality and extent of the ecosystem and its physical and biological characteristics (Vaze et al., 2006). Research is showing that widespread and intensive human activity in the world's oceans and the subsequent loss of marine populations and species are believed to be impairing the ability of marine ecosystems to provide the essential ecosystem services that contribute to human well-being (Chapin III et al., 2000;Hooper et al., 2005;Worm et al., 2006;Halpern et al., 2008;CBD, 2010). Marine Protected Areas (MPAs), designated though a system of marine spatial planning, are recognised as being the mechanism though which marine ecosystem services may be conserved as, 'they are the only approach to marine resource management specifically designed to protect the integrity of marine ecosystems and preserve intact portions and examples of them'(Sobel and Dahlgren, 2004).

In response to international and European drivers for MPAs (European Community Council Directive, 1992;OSPAR Convention, 2002;Secretariat of the Convention on Biological Diversity, 2004) the UK Administrations are tasked to substantially complete an ecologically coherent network of MPAs by 2012 (HM Government, 2011). To support the UK Government in meeting these international and European commitments and to achieve the Government's aim of 'clean, healthy, safe, productive and biologically diverse oceans and seas' (Defra, 2002) the development of the Marine and Coastal Access Act (MCAA) (HM Government, 2009), and the Marine (Scotland) Act (2010), and the forthcoming Northern Ireland Marine Bill (2012) are providing the legal frameworks to develop Marine Plans (guided at a national-level by the Marine Policy Statement (HM Government, 2011)), and enable the designation of a new type of Marine Protected Area (MPA) called a Marine Conservation Zone (MCZ).

Decision making, especially where the natural environment is concerned, is inherently exposed to high conflict potential (McShane et al., 2011;Minteer and Miller, 2011) thereby necessitating a methodology for capturing the complex context of ecosystem function and service provision (Salafski et al., 2001). Building on the foundation of the MEA descriptors of ecosystem services research has further defined ecosystem services to translate the complexity of those marine ecosystem functions that are provided by marine biodiversity into marine ecosystem services (Daily, 1997;De Groot et al., 2002;Beaumont et al., 2007;TEEB, 2010). These descriptors have broadened the inclusion of this range of values into decision making for marine nature conservation. As a result, the consideration of economic, social and ecological values in decision making (the ecosystem approach) through defining ecosystem services has therefore become integral to marine conservation planning and policy in the UK (OSPAR Commission, 2006;European Parliament and Council, 2008;HM Government, 2009;HM Government, 2011). For the purpose of this research a single set of ecosystem service descriptors have been chosen (Table 1.1). These descriptors have been chosen as they are the most relevant to marine policy making as they we as the evidence base to inform the development of the Marine and Coastal Access Act 2009.

Table 1.1 The ecosystem services provided by marine biodiversity

Ecosystem Services	**Millennium Ecosystem Assessment role**	**Definition**
Food provision	Provisioning	Plants and animals taken from the marine environment
Raw materials	Provisioning	The extraction of marine organisms for all purposes, except human consumption
Leisure and Recreation	Cultural/Provisioning	The refreshment and stimulation of the human body and mind through the perusal and engagement with living marine organisms in their natural environment
Resilience and resistance	Regulatory	The extent to which ecosystems can absorb recurrent natural and human perturbations and continue to regenerate without slowly degrading or unexpectedly flipping to alternate states.
Nutrient cycling	Supporting	The storage, cycling and maintenance of availability of nutrients mediated by lining marine organisms
Gas and Climate regulation	Regulatory	The balance and maintenance of the chemical composition of the atmosphere and oceans by living marine organisms
Bioremediation of waste	Supporting	Removal of pollutants through storage, dilution transformation and burial.
Biologically mediated habitat	Supporting	Habitat which is provided by living marine organisms

Disturbance prevention and alleviation	Regulatory	The dampening of environmental disturbances by biogenic structures
Cultural heritage and identity	Cultural	The cultural value associated with the marine environment e.g for religion, folk lore, painting cultural and spiritual traditions.
Cognitive values	Cultural	Cognitive development, including education and research, resulting from marine organisms.
Option use values	Cultural	Currently unknown potential future uses of the marine environment.
Non-use values – bequest and existence	Cultural	Value which we derive for marine organisms without using them

Adapted from (Beaumont, Townsend et al. 2006)

1.2 Valuing Ecosystem Services

Ecosystems services and the reserves of natural capital provide the platform for continuing economic trade, development and the maintenance of human wellbeing. Therefore, we place a ‘value’, albeit a monetary, social, emotional, environmental or cultural value, on these services in recognition of their fundamental role.

It is recognised that the value of ecosystem services is broader than simply providing a monetary valuation and that the development of both environmental and ecological economics can be seen as a ‘commitment among natural and social sciences and practitioners to develop a new, pluralistic understanding of the way in which different living systems interact with one another, and to draw lessons from this for both analysis and policy' (Costanza et al., 1999). The ecosystem approach demands that environmental, economic and social sustainability are balanced in the decision making process (Laffoley et al., 2004). 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 (Constanza et al., 1997). The concept of value is broad. Pearce and Turner (1990) 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.

Decision makers must be aware that if they focus on valuing the types of ecosystem services that are amenable to economic value then it is possible that they may end up only managing those economically valuable services at the expense of the rest (Robinson, 2011). Whilst economic valuations ecosystem services have received much press, other valuation methods that value a resource from an ecological and social perspective are also gathering pace to inform decision making and policy.

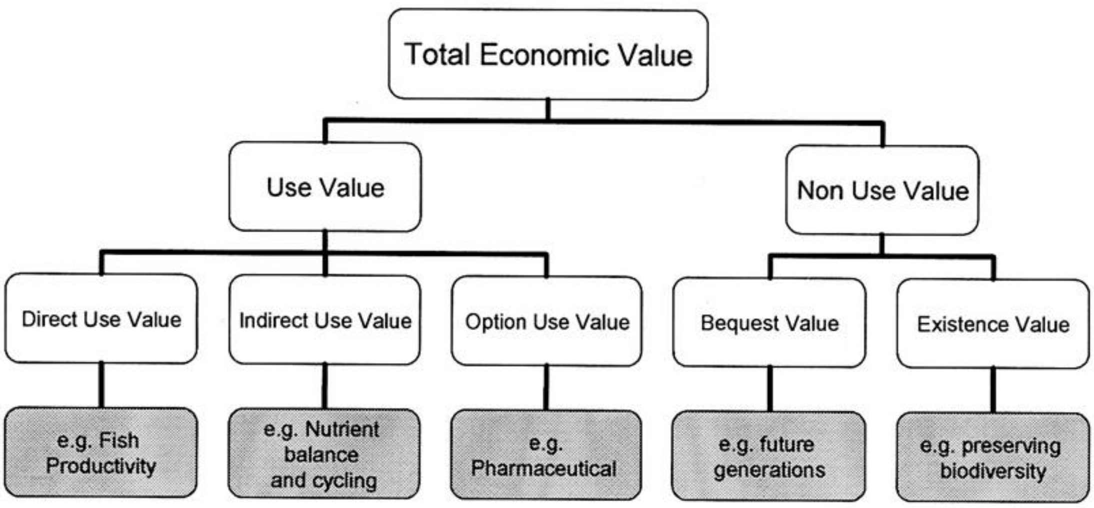
1.2.1 Economic values

The field of economics can provide a framework for quantifying value. Essentially economics is the study of how scarce resources are or should be allocated (Black, 1997). The predominant branch of economics, neoclassical economics, revolves around four types of capital – human, manufactured, financial and natural. The economies of the developed world focus on the first three to transform natural capital (ecosystem services) in to consumable products and services (Chee, 2004). Neo-classical economics focuses on the market as the mechanism for allocation (Daly and Farley, 2004). The world market economy is where buyers and sellers of goods or assets trade. What is bought and sold on the market is driven by what we desire therefore, what we are willing to pay and/or what we are willing to sacrifice to sate those desires. The prices subsequently formed in markets convey information and provide motivation for decision makers (Black, 1997).

The field of economics, in its broadest sense, provides a framework for valuing the environment which equates instrumental value with money. The development and application of the Total Economic Valuation (TEV) framework provides a holistic method for valuing a diverse range of goods and services. This methodology has been described as ‘a watershed in the importance given to the environment within the decision theory (Plottu and Plottu, 2007).

Developed by Pearce and Turner in (1990) (Figure 1.1) the TEV ‘recognises both the marketed and non-marketed values of natural capital and ecosystem services’(Costanza et al., 1999).

Figure 1.2: Total Economic Value (Beaumont, Townsend et al. 2006)



By combining these values into a single approach it enables a comprehensive assessment of ecosystem goods and services by translating ecological complexity (structures and processes) into a more limited number of ecosystem functions (De Groot et al., 2002). The TEV also enables complex information to be distilled into a format which can be more readily understood by environmental managers (Beaumont and Tinch, 2002). Therefore, ‘it theoretically allows the TEV of the environment to be included in a cost benefit analysis, the decision support method advocated by the neo classical economic approach’ (Plottu and Plottu, 2007) which is currently used by policy makers in project appraisals.

The TEV framework combines the economic, deliberative and participatory methodologies to try and ascertain relevant values (Parliamentary Office of Science and Technology, 2007). These methodologies attempt to reveal an individual’s Willingness To Pay (WTP), to have or to maintain a current ecosystem service or, an individuals’ Willingness to Accept (WTA) payment (or compensation) for the loss or degradation of an ecosystem service. The five main approaches used to determine WTP and WTA are encompassed in the following methodologies:

- Market prices can be used to estimate the value of ecosystem goods and services that are traded in formal markets such as timber and fish.
- Cost methods, based on the cost of damage caused by the loss of an ecosystem service, or expenditure to prevent damage, or the cost of replacing the ecosystem service altogether.
- Revealed preference methods, such as the travelling and access costs people are willing to pay to use an ecosystem for recreational purposes;

- Stated preference methods, such as surveys to determine peoples willingness to pay for ecosystem services in hypothetical markets; and,
- Deliberative and participatory valuation methods ranging from group based deliberative monetary valuation to citizens juries.

Based on the TEV framework, on a global scale, Constanza et al (1997) placed a single figure on the value of marine biodiversity and estimated that marine systems provide ecosystem services to the value of $20.9 trillion annually, 63% of the value of global ecosystem services. Whilst these aggregated figures have no doubt raised the profile of the 'value' of ecosystem services, monetizing the environment is not without its critics. It can be argued that the value of ecosystem services is infinite as 'the economies of the Earth would grind to a halt without the services of ecological life support systems' (Constanza et al., 1997). The decline in ecosystem services we are witnessing is a direct result of the fact that many of these values are not quantified. As they have no assigned value, the services they provide are essentially 'free'. In terms of traditional economics the 'elementary theory of supply and demand tells us that if something is provided at zero price [free], more of it will be demanded then if there was a positive price'(Pearce et al., 1991). This can lead in the long-term to a level of demand for a natural resource which outstrips the capacity of the environment.

In addition, monetization of the wide range of goods and services provided by the environment can create a comparison and phenomena which may sometimes be seen as rather meaningless (e.g. recreational use *versus* patrimonial stake of environment) (Plottu and Plottu, 2007). However, difficult as it may be (both practically and theoretically) to place a value on ecosystem goods and services there is a bottom line which justifies the cause for monetization, 'if the environment is not monetized, it is automatically excluded from any kind of economic calculation and can therefore have no impact on the determining of rational choice' (Plottu and Plottu, 2007).

1.2.2 Ecological value

An ecological value is the importance or worth of the ecological feature (a habitat or species) in contributing to ecosystem service delivery. Decision makers need a detailed understanding of how ecological function is linked to ecosystem services and how they can be can be defined and valued at a local to regional scale (Loreau et al., 2001;Chan et al., 2006).

In terms of assessing ecological value previous research shows that the functional characteristics of species strongly influences ecosystem processes (Hooper et al., 2005). Biological Traits Analysis (BTA) is a method which has been proposed to assess ecosystem function in marine benthic environments (Bremner et al., 2003;Bremner et al., 2006a). BTA uses a series of behavioural (e.g. feeding), life history (e.g. age) and morphological characteristics (e.g. body size) of species to define ecological function (Bremner et al., 2006b). The ecological function of a species is then used to infer an aspect of ecosystem function (Lavorel and Garnier, 2002;Bremner, 2008).

In previous research relating to the marine environment BTA has been used to illustrate how ecosystems function in relation to the biological assemblages (Bremner et al., 2006b;Frid et al., 2008). BTA has also proved useful as a tool to show how changes in species composition caused by anthropogenic impacts affect ecosystem functioning (Tillin et al., 2006;Hewitt et al., 2008). These studies have applied BTA to infer that the ecological function of benthic species contributes to the delivery of *all* ecosystem services. However, issues arise with this approach as marine managers, when working with stakeholders, may need to make trade-offs between different ecosystem services when decisions are made on the use of a marine area (Kremen, 2005). Managers will therefore need a more detailed understanding of how ecological function is linked to these services and how they can be can be defined at a local to regional scale (Loreau et al., 2001;Chan et al., 2006).

1.2.3 Social values

Individuals are known to base their decisions within a social context (Videras et al., 2012). The social context of MPAs in relation to stakeholders is however complex and often simplified when management policies are defined (Salas and Gaertner, 2004;Urquhart et al., 2011). It is known that the success or failure of an MPA can be influenced by how the perceptions and behavioural response of stakeholders to the designations are understood and ingrained in the policy approach (Symes and Hoefnagel, 2010;Lédée et al., 2012). Therefore the analysis of the social impacts of MPAs may have significant impacts for policy development (Mascia et al., 2010).

Following the implementation of the UK Marine and Coastal Access Act in 2009, the involvement of stakeholders in the MPA planning process is underwritten in UK law (HM Government, 2009). Social values are therefore assessed in the UK MPA planning process via participatory methods where stakeholders are involved in the spatial decisions over where MPAs may be sited in relation to defined ecological criteria and resource use patterns. However, final decisions, which must be signed off by the UK Secretary of State, are informed by an Impact Assessment. The formal Impact Assessment process assess values via a ‘goods and services’ approach and a range of monetary valuation techniques are provided to assess the costs and benefits of different policy options (Defra, 2008a). Whilst valuing decisions for marine conservation in this manner provides the essential function of translating ecological complexity into a format that can be readily understood and used by mangers and policy makers (De Groot et al., 2002), it is believed that the framework is not meaningful to the general public who connect culturally with the concepts of nature, place and landscape rather than services (Watson and Albon, 2011). Indeed, presenting the monetised costs and benefits can do little to change the behaviour of stakeholder groups regardless of economic benefits if they feel marginalised from the decision making process (Pollnac and Pomeroy, 2005).

It is recognised that socio-economic studies that assume that economic valuation is the primary measure of social impacts will fail to understand the wider cultural aspects of value (Carr, 2000). The means of assessing social values for decision making in the marine environment is currently limited to public participatory methods, economic modelling and attitudinal surveys (Voyer et al., 2012). A measure of attitudes (perceptions) is recognised as being a method whereby social values can be captured (Lédée et al., 2012;Leleu et al., 2012). MPA managers who miss out the social context in management decisions and fail to acknowledge the unique nature of fishing activities and wider stakeholder responses to change are risking the future ability of MPAs to meet all stakeholders needs(Agardy et al., 2011;Voyer et al., 2012).

1.3 Thesis aim

The aim of this thesis is to develop an integrated approach to value marine conservation. The objectives of this work are to:

1. determine the economic, ecological and social values associated with ecosystem services in a decision making context;
2. test methodologies for the practical application of economic, ecological and social valuation; and
3. Make recommendations to include ecosystem services and their value in decision making for marine nature conservation.

This thesis is presented as a compendium of research chapters that each provides aims and objectives for the study, a full literature review, methods, results, discussion and conclusion. All research was undertaken in a case study area.

1.4 Rationale for the case study site

The case study area of Lyme Bay was chosen as a focus for this research for a number of reasons. Firstly, there was already a wealth of data available. Collecting ecological, social and economic data to a level of detail required for a meaningful analysis is expensive and beyond the scope of a three year PhD. By using these valuable secondary data sources I was able to build on knowledge to develop methodologies and make recommendations for the broader Marine Protected Area (MPA) planning processes running concurrently in the UK. Secondly, when I started this PhD in October 2007 it was likely that a Department for Environment, Food and Rural Affairs (Defra) and Natural England funding bid, proposed by a consortium of scientists from the Plymouth Marine Science Partnership, to monitor the biological recovery and socio economic impacts of the closed area, would be funded from 2008 to 2010. I was written into this bid and as a result gained much support in data collection and benefitted from the research expertise of the group. Thirdly, I had worked as a project officer in Lyme Bay on behalf of the Devon Wildlife Trust prior to the closure so I was familiar with the key stakeholders and the politics of the closure.

1.5 Thesis outline

The chapter two is a literature review and scene setting exercise focusing on the designation of a statutory 206 square kilometre ‘closed area’ (an MPA) in Lyme Bay, South West England on the 11 July 2008. The closure was designated to protect the reef substrate and the associated biodiversity from the impacts of trawling and dredging with heavy demersal fishing gear. The chapter examines 34 reports written over a 20 year period in order to understand how the values associated with the ecosystem approach were included in the decision making process. This chapter was written during the development of the UK Marine and Coastal Access Act (2009) and was researched and written to provide recommendations for the Marine and Coastal Access Bill (Defra, 2008d). With the Government seeking win-win scenarios for stakeholders in the designation of Marine Conservation Zones under the Marine and Coastal Access Act (2009) this chapter discusses lessons learnt from this MPA process in Lyme Bay and makes recommendations to guide the development and implementation of marine legislation in the UK and Europe.

Chapter three develops a methodology for economic valuation and explores the value of marine biodiversity to the leisure and recreation industry within the context of Marine Spatial Planning (MSP). The ‘refreshment and stimulation for the human body and mind through the perusal and engagement with living marine organisms in their natural environment’ (Beaumont et al., 2007) is an ecosystem service that can be derived from taking part in marine leisure and recreation activities. Chapter two demonstrated that neo-classical valuations, in particular fisheries economics, have traditionally received much focus in decision making for marine nature conservation. As the economics of the fisheries in Lyme Bay remain a core focus in the Defra and Natural England Lyme Bay project (MB0101), chapter three develops a methodology to examine the economic value (monetary value) and spatial activity (non-monetary value) of the leisure and recreation industry as an indicator of the value of leisure and recreation as an ecosystem service in Lyme Bay. In order to detail the value (turnover and expenditure) and spatial extent (frequency of visits) questionnaire data were gathered from key recreation stakeholders in Lyme Bay: divers; anglers; charter boat operators and dive businesses. This chapter advances a methodology by which marine leisure and recreation activity may be included in marine spatial planning. It also improves our understanding of the extent and the relative economic importance of these activities on a local scale. Recommendations are made in this chapter for including this sector and therefore leisure and recreation as an ecosystem service in broader planning activities.

Chapter four focuses on developing a methodology for spatially valuing benthic ecological function in the case study area. Focusing on the indirect ecosystem services of nutrient cycling, the bioremediation of waste and gas and climate regulation, a ‘service orientated’ framework was developed to define the pathways between the ecosystem service, the ecosystem processes and the ecological function of benthic species. Using existing data sets available to marine planners in the case study area, a Biological Traits Analysis (BTA) of benthic species was undertaken. BTA data were then integrated with substrate data. The development of this methodology has made progress on making information available to decision makers of the links between the benthos and the delivery of these indirect services. However, several limitations of this approach are apparent. Most notable is the missing link of a measure of 'how much' function is required to maintain the delivery of these ecosystem services to ensure human well-being. With no such reliable measure this research recommends a precautionary approach to including percentage targets for broad-scale habitats in MPA planning.

Chapter five develops a thematic framework methodology for a cost-benefit analysis of the case study area. The research is based on the premise that the ecosystem services framework (use and non use values) does not fully capture the full extent of social values experienced by stakeholders and that the perceptions and links between costs and benefits are complex when property rights are affected by an MPA. Qualitative data collected from the Defra Lyme Bay (MB0101) were analysed in order to understand the themes associated with the economic, environmental and social costs and benefits of the MPA in Lyme Bay following its establishment in 2008. 241 individuals were interviewed via questionnaire between 2008 and 2010 to determine perceptions and attitudes towards the MPA. This chapter furthers our understanding of the complexity of social values at play when an MPA is designated and makes recommendations as to how these may be addressed. It also highlights the lack of a coordinated management and monitoring programme for the broader UK MPA network. Drawing from experience in Lyme Bay, recommendations are made for the development of a network of MPAs around the UK coast under the United Kingdom Marine and Coastal Access Act (2009).

Chapter six is a concluding chapter which places the results of this thesis in context with recent research on ecosystem services and policy development.

Chapter two: Is there a win-win scenario for marine nature conservation? A case study of Lyme Bay, England.

This chapter has been published as:

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2.1 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 (De Groot et al., 2002). Several ecosystem functions are thought to be in decline as a direct result of continuing impacts and human demands (Covey and Laffoley, 2002;Laffoley et al., 2004). 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’ (OSPAR Commission, 2003). 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 (Sobel and Dahlgren, 2004). In order to meet International, European and National marine nature conservation objectives, the proposed United Kingdom (UK) Marine and Coastal Access Bill 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 (Defra, 2006). 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' (Hiscock et al., 2006). 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 (Defra, 2001;Jones, 2008). 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 (Defra, 2007b).

The ecosystem approach demands that environmental, economic and social sustainability are balanced in the decision making process (Laffoley et al., 2004). 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 (Constanza et al., 1997). Conflict arises between stakeholders as the concept of value is broad. Pearce and Turner (Pearce and Turner, 1990) 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 206km^2 ‘closed area’, or MPA, was designated by the UK Government on the 11July 2008. This case study provides an opportunity to reflect on the 16 year process which has led to this designation and explore some lessons learnt for the Marine and Coastal Access Bill and the proposals for win-win outcomes for all stakeholders in the designation of Marine Conservation Zones.

2.1.1 The Lyme Bay case study area

The Lyme Bay case study area is approximately 2460 km^2 (Stevens et al., 2007) 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 (Figure 2.1). Lyme Bay includes the fishing ports of West Bay and Brixham and the towns of Lyme Regis, Torquay and Exmouth.

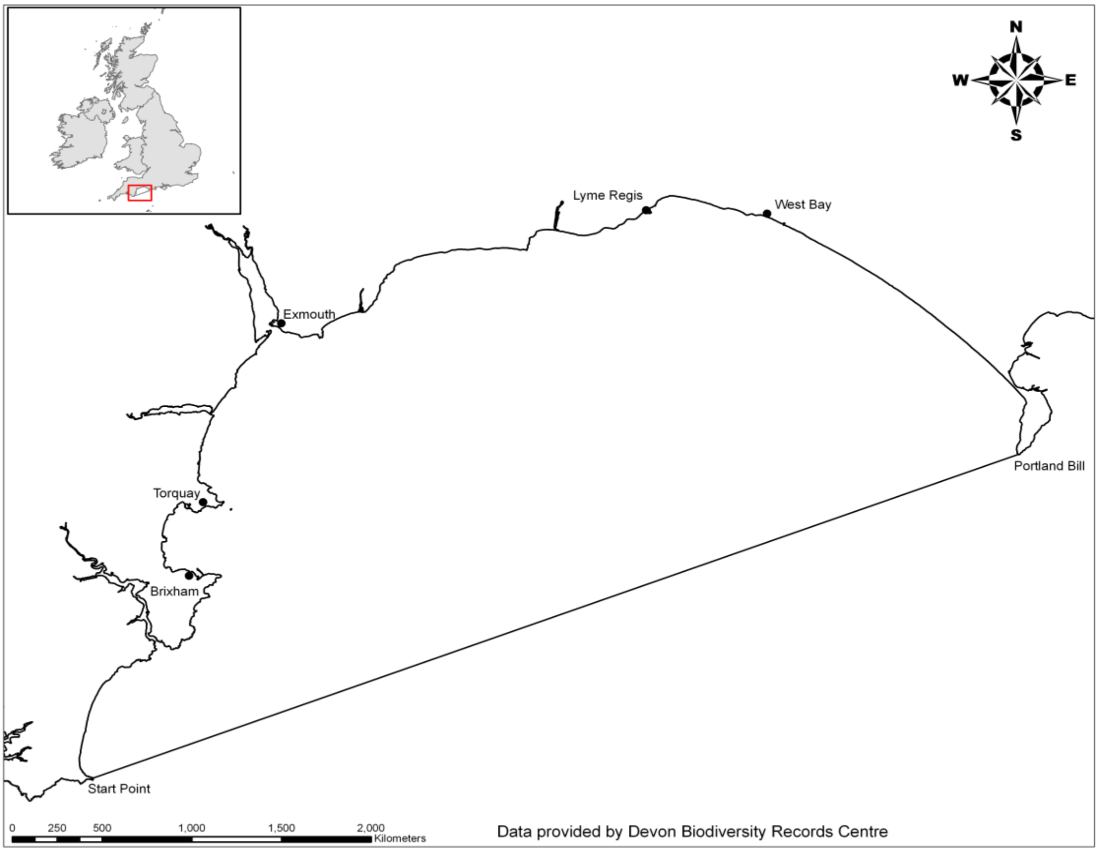

Figure 2.1 The Lyme Bay case study area

2.1.2 An area of nature conservation interest

The marine environment of Lyme Bay is rich and biologically diverse. In the 1960s Holme (Holme, 1961;Holme, 1966) 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 (Eagle and Hardiman, 1977;Eagle et al., 1978).

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 (Black, 2007)) 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 2.1.

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 (Hiscock, 2007; Jackson, 2008).
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 (Hiscock, 2007; Jackson, 2008). Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Jackson, 2008)

Table 2.1 The species within the reef area which are listed for conservation.

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) (Jackson, 2007). Eelgrass (*Zostera marina*) beds in the sandy/muddy sediments adjacent to Torquay (Hirst and Attrill, 2008) are listed for conservation under the Bern Convention on the Conservation of European Wildlife and Natural Habitats 1982 and the IUCN Red List (Tyler-Walters, 2007).

In 2007, Lyme Bay as a whole was identified as a ‘marine biodiversity hotspot’ (Hiscock and Breckels, 2007). These are defined as areas of ‘high species richness that include rare and threatened species’ (Hiscock and Breckels, 2007). 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).

2.1.3 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 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 (Collie et al., 2000;Tillin et al., 2006).

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 (Stevens et al., 2007). Species such as the pink sea fan (*Eunicella verrucosa*) which is nationally uncommon (Hiscock, 2007) and the sunset cup coral (*Leptopsammia pruvoti)* which is nationally rare (Jackson, 2008) attract divers to the area. Charter boat operators run wildlife watching trips throughout the Bay to take people birdwatching or further offshore to see dolphins. Several small fishing boats (6-10 metres long) supplement their income by chartering boats to anglers (Forster and Munro, 1995). 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 206km^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 Statutory Instrument 1584 on the 11 July 2008 (Defra, 2008c).

2.2 Methodology

2.2.1 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 (Gubbay, 1988) 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.

2.3 Results

2.3.1 Themes of reports

The themes of thirty four reports from 1988-2008 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).

2.3.1.1 Environmental data (1988-1998)

The majority of studies from 1988-1999 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 2.2).

		Theme		
Year	Title	Env.	Eco.	Soc.
1988	A Coastal Directory For Marine Nature Conservation (Gubbay 1988).	1		
1991	Benthic marine ecosystems in Great Britain: a review of current knowledge. Western Channel and Bristol Channel and approaches (Davies 1991).	1		
1992	An Investigation into the Effects of Scallop Dredging in Lyme Bay (Munro, 1992).	1		
1993	Benthic and Ecosystem Impacts if Dredging for Pectinids (Lart et al., 1993).	1		
1993	Lyme Bay. A Report on the Nature Conservation Importance of the Inshore Reefs and the Effects of Mobile Fishing Gear (Devon Wildlife Trust, 1993).	1		
1995	Lyme Bay Environmental Study. Subtidal Benthic Ecology: Epibenthos (Cleator, 1995).	1		
	Lyme Bay Environmental Study. The Physical Environment (Nunny, 1995b).	1		
	Lyme Bay Environmental Study. Subtidal Benthic Ecology: Sediment Infauna (Grist & Smith, 1995).	1		
	Lyme Bay Environmental Study. The Physical Environment: Sediments (Nunny, 1995a).	11		
	Lyme Bay Environmental Study. Environmental Quality: Sensitivity Analysis (Smith, 1995).	1		
	Possible Special Areas of Conservation (SACs) in the UK - marine and coastal sites (The Wildlife Trusts, 1995).	1		1
1996	Coasts and seas of the United Kingdom. Region 9, Southern England : Hayling Island to Lyme Regis (Barne, 1996a).	1		1
	Coasts and seas of the United Kingdom / Region 10, South-West England: Seaton to the Roseland peninsula (Barne, 1996b).	1		1
1997	Lyme Bay. A Nature Conservation Profile (Covey, 1997).	1		1
1998	Coasts and Seas of the United Kingdom. Marine Nature Conservation Review: Benthic marine ecosystems of Great Britain and the north east Atlantic (Hiscock, 1998).	1		
2000	Lyme Bay Reefs - A Report on the Area's Fisheries (Devon Wildlife Trust, 2000b).		1	1
	Report on the Areas of Greatest Nature Conservation Importance Within the Reefs Known As Saw Tooth Ledges and Lanes Ground - Lyme Bay (Devon Wildlife Trust, 2000a).	1		
2001	Feasibility Study into the Management of Beer Home Ground (Davis, 2001).		1	1
2002	Effects of scallop dredging on sessile macro fauna in Lyme Bay: Interim results for 2001 and 2002 (Hoskin, 2002).	1		
2003	The Commercial Benefits of Marine Protected Areas (Davis & Stanford, 2003).		1	1
2004	The timing and settlement of scallop spat in Lyme Bay, Devon and its use as a fisheries enhancement tool (Saville, 2004).	1		1
	Initial Results of a Visual Survey on the Impacts of Dredging for Scallops on the Seabed (Devon Wildlife Trust, 2004).	1		
	Sustainability from the Market (Stanford, 2004).		1	1
2006	Independent Scoping Study. Options for Spatial Management of Scallop Dredging Impacts on Hard Substrates in Lyme Bay (Stevens, 2006).			1
2007	Lyme Bay Pink Sea Fan Survey 2006-2007 (Black, 2007).	1		
	Marine Reserves - TLC for our seas and sea life (Browning, 2007).			1
	Surveys for Marine Spatial Planning in Lyme Bay (Stevens et al., 2007).	1	1	1
	Informing Community Stakeholders - The Devon Pilot Project (Rees, 2007).			1
	Estimate of Economic Values of Activities in Proposed Conservation Zone in Lyme Bay (Homarus Ltd, 2007)		1	
	Marine Biodiversity Hotspots in the UK. A report identifying and protecting areas for marine biodiversity (Hiscock & Breckels, 2007).	1		1
	Lyme Bay Reefs. A 16 year search for sustainability (Devon Wildlife Trust, 2007a).	1	1	1
	The Impact of Scallop Dredging in Lyme Bay an Eye-witness Account (Devon Wildlife Trust, 2007b).			1
2008	Quantification of epibenthic fauna in areas subjected to different regimes of scallop dredging activity in Lyme Bay, Devon (Hiddink et al., 2008).	1		
2008	Lyme Bay Proposed MPA. Indications of Social and Economic Impacts (Curtis & Anderson, 2008).		1	

Table 2.2 Themes of reports written between 1988 and 2008.

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 (Gubbay, 1988). 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 (Cleator, 1995), benthic sediment infauna (Grist and Smith, 1995), hydrography (Nunny, 1995b), and sediments (Nunny, 1995a). 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’ (Hiscock, 1998).

Much of the focus during this period was on the inshore reefs of Lyme Bay. Studies showed that the Lyme Bay reefs (Figure 2.2) 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 reef substrate needed to be protected in their entirety (Gubbay, 1988;Devon Wildlife Trust, 1993;Devon Wildlife Trust, 1998). 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 (Munro, 1992). 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 on the sands and gravels (Munro, 1992). 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 (Devon Wildlife Trust, 1993;Lart et al., 1993).

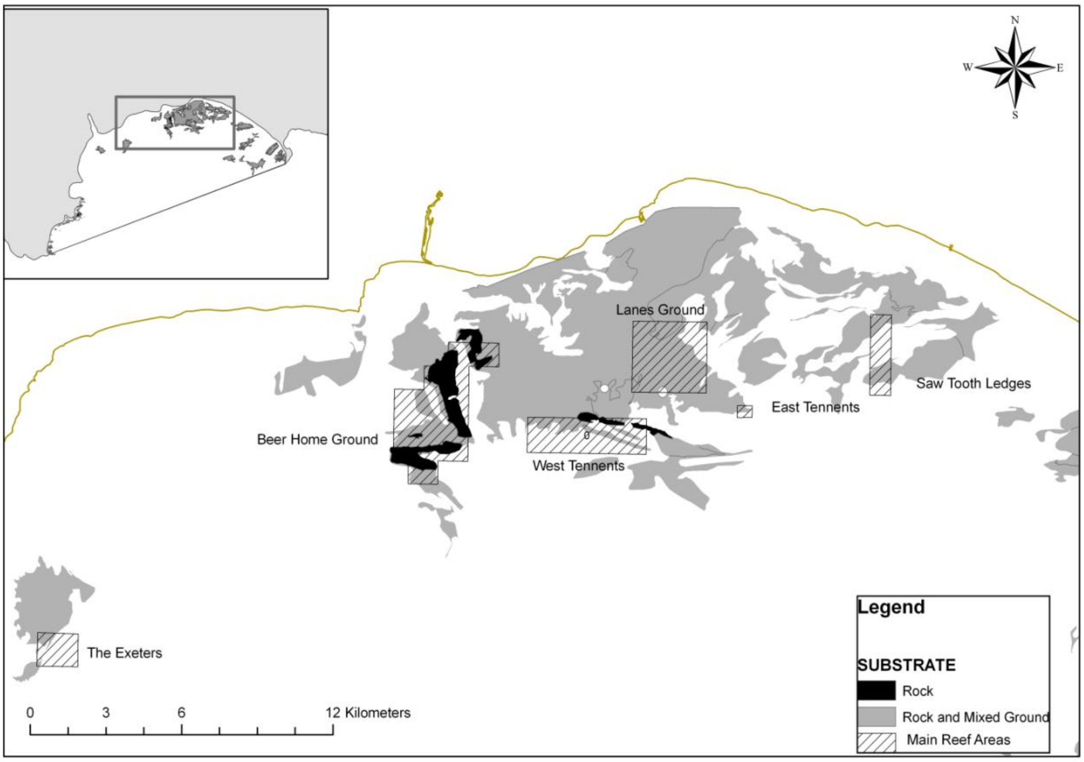

Figure 2.2 The named reefs of Lyme Bay as known in 1995. Overlaid on substrate data. Reef co-ordinates supplied by charter boat skipper John Walker.

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 (Davies, 1991;Barne, 1996b;Barne, 1996a;Hiscock, 1998). 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) (The Wildlife Trusts, 1995). In 1997, the sublittoral bedrock and mixed bedrock areas of Lyme Bay were identified by Natural England as a ‘Prime 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 (Covey, 1997).

2.3.1.2 Incorporating social and economic data (2000-2006)

Reports from 2000-2006 encompass elements of the environmental, economic and social aspects of MSP in Lyme Bay (Table 2.2). From 2000-2004 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 (Devon Wildlife Trust, 2000b). There was also ongoing work to investigate and document the impacts of scallop dredging on the reef habitats (Devon Wildlife Trust, 2004). 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 areas could be sited on the reefs (Devon Wildlife Trust, 2000a). In 2001, two voluntary closed areas for the reef areas of Saw Tooth Ledges and Lanes Ground encompassing 10.3km^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 (Davis, 2001) (Figure 2.3).

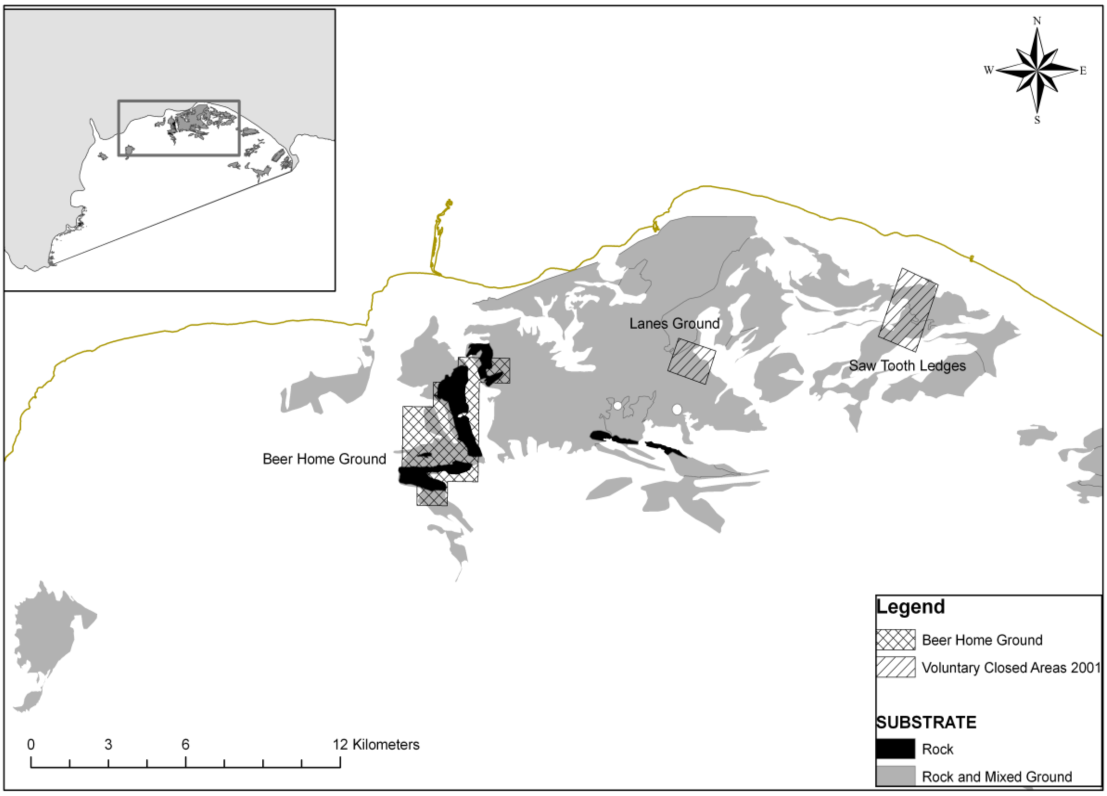

Figure 2.3 The 2001 voluntary closed areas and Beer Home Ground overlaid on the substrate data.

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 (Davis and Stanford, 2003). 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 (Hoskin, 2002). 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 (Hoskin, 2002).

There were very few temperate studies of the value of MPAs to commercial industries relative to Lyme Bay but Davis et al (Davis and Stanford, 2003) 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 (Stanford, 2004), and through the rearing of scallop spat for seeding purposes as a fisheries enhancement tool (Saville, 2004).

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 (Ambios, 2006). 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 (Figure 2.4) 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.

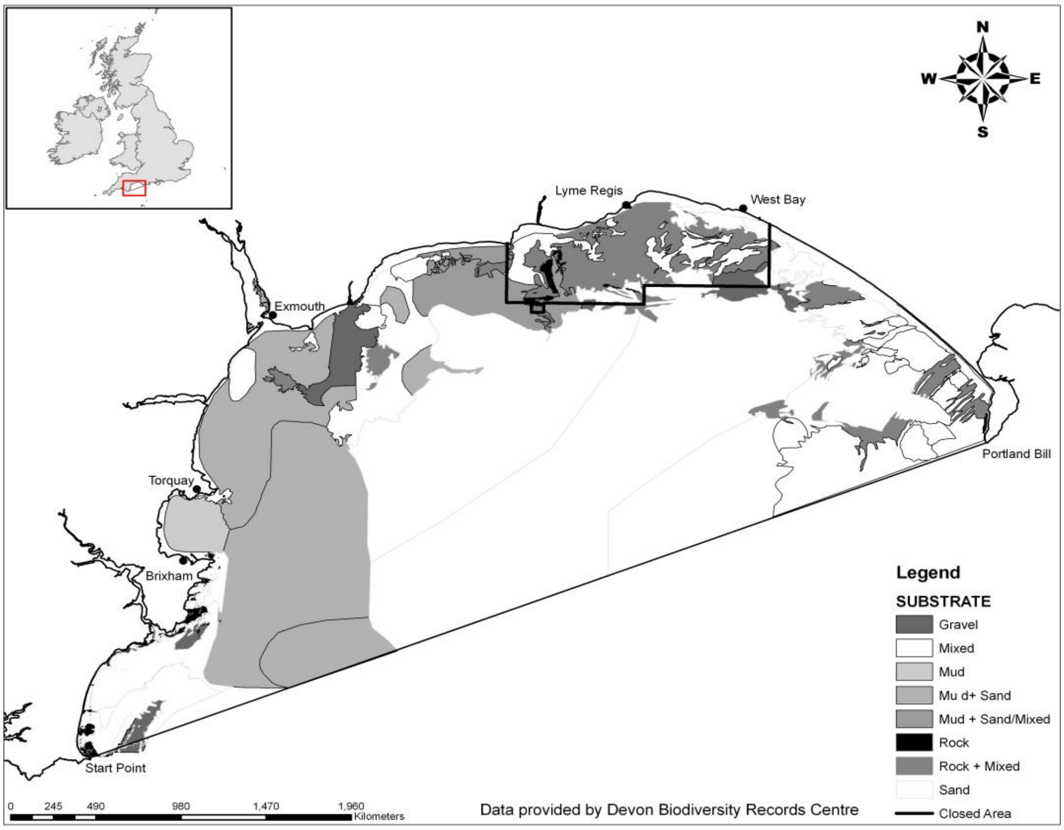

Figure 2.4 Substrate map of Lyme Bay and the statutory closed area. Source: Devon Wildlife Trust.

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 (Devon Wildlife Trust, 2007). This ultimately led to the breakdown of the voluntary local agreements.

In 2006, adopting the precautionary principle (Defra, 2002) 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 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’ (Devon Wildlife Trust, 2007) (Figure 2.5).

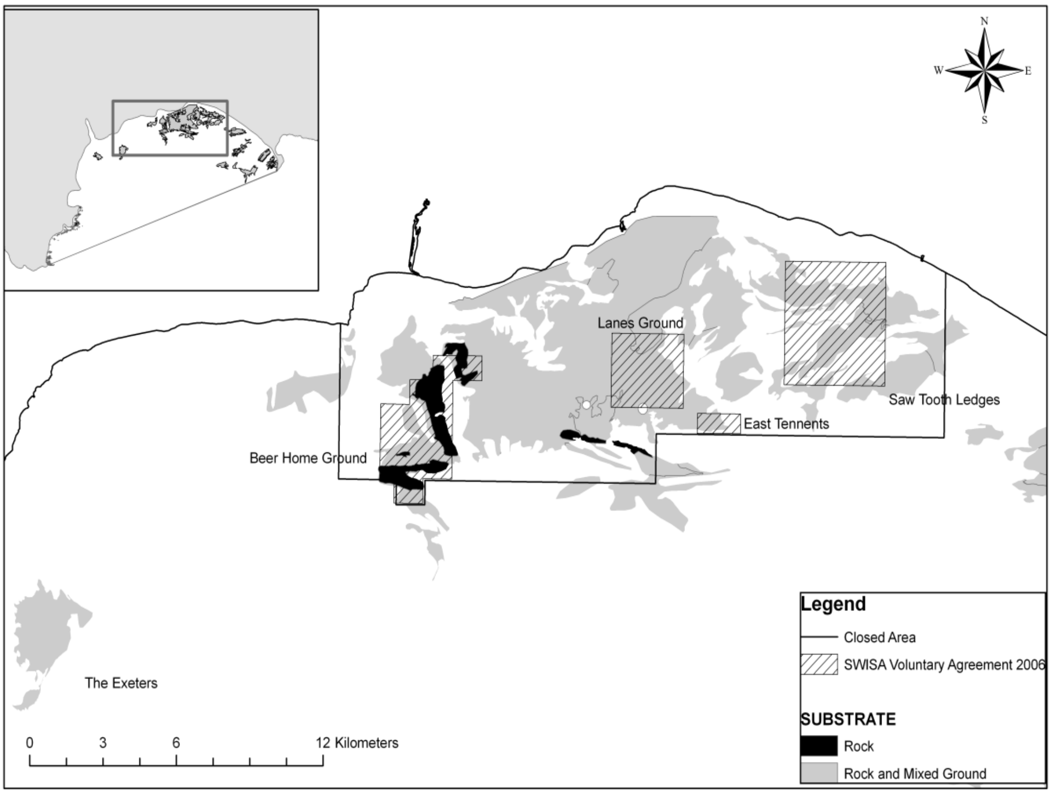

Figure 2.5 The Natural England and Devon Wildlife Trust proposed 206km² closed area and the Defra agreed voluntary closed areas 2006.

During 2006, the consultancy firm, Royal Haskoning, were 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 (Haskoning, 2007). 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’ (Stevens, 2006). 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’ (Stevens, 2006).

2.3.1.3 A focus on economics (2007-2008)

In 2007, Natural England and Devon Wildlife Trust challenged the Government’s decision to close 41.2km^2 rather than the proposed 206km^2 citing that the Government had mis-interpreted the data and had delineated the 41.2km^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 (Devon Wildlife Trust, 2007)). 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 (Black, 2007). 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 (Haskoning, 2007).

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 2.2) (Homarus Ltd, 2007;Stevens et al., 2007;Curtis and Anderson, 2008). 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 (Rees, 2007). An analysis of species' and habitats' sensitivity to physical disturbance was carried out by Stevens et al (2007) 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 (Stevens et al., 2007).

This period is marked by four studies which focus solely on economics to assess the relative economic importance of activities in Lyme Bay. Table 2.3 summarises the results.

	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 (Homarus Ltd, 2007).

[b] Value of activities in Lyme Bay (Stevens et al., 2007).

[c] Value of activities in the closed area (Curtis & Anderson, 2008).

[d] Value of activities in the closed area. Combined scallop and other demersal towed gear landings (Defra, 2008f).

[e] Revised value of activities in the closed area following interviews with local MFA officers (Defra, 2008f).

Table 2.3 Economic valuations of activities in Lyme Bay.

2.3.2 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 41.2km^2 of the reef habitat with the options to close areas of 41.2km^2, 85.7km^2 and 206km^2 of reef habitat on either a statutory or voluntary basis (Defra, 2007a). Seventy percent of the respondents to the Defra consultation wrote to Government in favour of the full 206km^2 closed area (Defra, 2008f). Mee et al (2008) 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 (Mee et al., 2008).

Ongoing research into the recovery of the 2006 voluntary closed areas by Hiddink et al (2008) showed that the closed areas, which had not been trawled, supported a greater abundance of sessile species (Hiddink et al., 2008). Following a public consultation (September -December 2007), a review of responses and an Impact Assessment, Defra announced their decision to statutorily close 206km^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.

2.4 Discussion

2.4.1 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 206km^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 (Homarus Ltd, 2007) 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 (Defra, 2008b). The Curtis et al (Curtis and Anderson, 2008) 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 25-50% of the landings from the two adjacent ICES rectangles (Defra, 2008b). 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 (Defra, 2008b).

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.

2.4.2 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 41.2km^2 voluntary closed area was considered as a compromise option that did not fulfil conservation objectives (Devon Wildlife Trust, 2007). This stance is not uncommon. Laffoley et al (2004) 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' (Laffoley et al., 2004).

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 of 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 (Beaumont et al., 2008). 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 (Green and Short, 2003).

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 (Kamenos et al., 2004). 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)* (Hall-Spencer et al., 2003). 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 (Jones et al., 2000).

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 (Beaumont et al., 2006). The 2008 Government decision to close 206km^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' (Defra, 2008b).

2.4.3 Lessons for the Marine and Coastal Access Bill

Experience from Lyme Bay should guide the development and implementation of the forthcoming marine legislation in the UK and Europe. A common standard needs to be set for the information decision makers need for MSP. 34 reports have contributed to the decision for a closed area in Lyme Bay as well as 7,900 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 (Stevens et al., 2006).

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’ (Kumar and Kumar, 2008). 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 (Constanza and Herman, 1992).

When balancing environmental, social and economic interest, conflict is an almost inevitable part of the process of protected area management (Nursey-Bray and Rist, 2008), 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 (Defra, 2008f). 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’ (Kumar and Kumar, 2008). It is essential that the objectives of the MPA are clear (Jones, 2008), that stakeholder expectations are managed and that mechanisms for conflict resolution are built into the MSP and adaptive management process (Jones and Burgess, 2005;Nursey-Bray and Rist, 2008).

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 (Defra, 2008e). 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 (Plasman, 2008), particularly the involvement of fishermen in MPA network design (Klein et al., 2008b). However, there is also a pressing need for a network of MPAs (OSPAR Commission, 2003;Secretariat of the Convention on Biological Diversity, 2004) 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 Bill must provide the arena to advance a framework for weighting or even integrating (Gilliland and Laffoley, 2008) the diverse value set held by multi sectoral stakeholders who will naturally conflict in the MCZ designation process.

2.5 Conclusion

2.5.1 Is there a win-win scenario for marine nature conservation?

Constanza et al (1992) 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'(Constanza and Herman, 1992). 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 Marine and Coastal Access Bill 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 (Lockley, 2008). 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 (Ballantine and Langlois, 2008), coupled with the societal benefits derived from the protection of marine biodiversity (Walser and Newmann, 2008), it may be that a collective societal change in values will facilitate future win-win situations.

Recent development of the Marine and Coastal Access Bill recognises 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' (Defra, 2008d). This suggests that an immediate win-win scenario is no longer being sought. This is further emphasised 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 development of the Marine and Coastal Access Bill 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 Bill 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.

Chapter three: The value of marine biodiversity to the leisure and recreation industry and its application to marine spatial planning.

This chapter has been published as:

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(Appendix 3).

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3.1 Introduction

In order to make decisions about how biodiversity is used as a resource there is a need to improve understanding of the value of the resource to humans (Crowder and Norse, 2008). In terrestrial based systems recreation has been valued as an ecosystem service for conservation planning purposes (Chan et al., 2006;Hein et al., 2006;Raymond et al., 2009). On land, the conservation of biodiversity has been linked to ensuring that the flows of benefits received by humans from their interaction with biodiversity via recreation activities are maintained (Chan et al., 2006). Within the marine environment, in terms of research which explores the links between marine biodiversity and the delivery of ecosystem services, conservation planning lags behind its terrestrial counterparts. There is a pressing need to understand these links in response to developing legislation.

The United Kingdom (UK) Government is committed to implementing a network of Marine Protected Areas (MPAs) (United Nations, 2002;OSPAR Commission, 2003;Secretariat of the Convention on Biological Diversity, 2004;European Parliament and Council, 2008) and applying the ecosystem approach to marine management in order to achieve the sustainable use of all marine goods and services (European Parliament and Council, 2008). The UK Marine and Coastal Access Bill will provide the legislative framework to realise this network of MPAs in UK waters. An ecosystem services approach to understanding the values provided by marine biodiversity has been proposed as a framework by which the ecosystem approach can be incorporated into decision making for marine spatial planning (Beaumont et al., 2007).

The marine leisure and recreation industry comprises one of the stakeholder groups who directly use the marine environment. As such, they are one of the beneficiaries of an ecosystem service derived by humans from marine biodiversity. This ecosystem service has been defined as the ‘refreshment and stimulation for the human body and mind through the perusal and engagement with living marine organisms in their natural environment’ (Beaumont et al., 2008). Marine leisure and recreation is considered mainly to be a direct-use (non-consumptive) value where the benefit is received from either a direct or indirect interaction with the resource (Pearce and Turner, 1990;Beaumont et al., 2006). An economic valuation of the use of the ecosystem service can improve the information base available to policy makers when making decisions about the use of marine resources and potentially inform choices on their conservation and sustainable use (King, 1995). For use in long term planning initiatives valuation can provide a baseline against which to measure any changes in the quantity or quality of the ecosystem service and its subsequent impact on human welfare (Constanza et al., 1997).

Lyme Bay has been chosen as a case study because it contains marine habitats that are important for conservation on both a national and international scale. These habitats include an extensive rocky reef which hosts species such as the pink sea fan (*Eunicella verrucosa*) which is nationally uncommon (Hiscock, 2007) and the sunset cup coral (*Leptopsammia pruvoti)* which is nationally rare (Jackson, 2008). High species richness in the Bay which includes the presence of rare and threatened species has resulted in the area being defined as a marine biodiversity hotspot (Hiscock and Breckels, 2007).

There is a 206km^2 'closed area' which was designated by the UK government on the 11 July 2008 to protect a section of the reef habitat from the impacts of using towed demersal fishing gear (Defra, 2008c). Fishermen using static gear and people undertaking recreation activities (e.g. diving and angling) are still permitted in the closed area. Previous valuations of the marine leisure and recreation industry in Lyme Bay contributed to the decision making process for a closed area in Lyme Bay (Homarus Ltd, 2007;Stevens et al., 2007). However, these reports did not provide detailed spatial data for recreation use.

This chapter provides a method to incorporate the value of the marine leisure and recreation industry as an indicator of the value of the ecosystem service into decision making for resource use planning. I achieve this by assigning proportionate values to recreation sites, identifying 'recreation hotspots' and determining the value associated with areas of conservation interest, to inform a long term cost benefit analysis of the closed area policy in Lyme Bay.

3.1.1 The recreation industry in Lyme Bay

Lyme Bay is located in south west England (Figure 3.1). The Bay can be delineated by a straight line drawn between Start Point in South Devon and the tip of Portland Bill in Dorset encompassing a sea area of 2460 km^2. Sub aqua diving, sea angling and wildlife watching trips are key components of the leisure and recreation activities undertaken in Lyme Bay. These activities make use of the natural marine resources that stem from biological diversity. Wrecks have been included as representing areas of rich marine biodiversity as the structure creates a habitat which enables the settlement of reef associated species (Zintzen et al., 2008) and provides shelter for aggregations of fish.

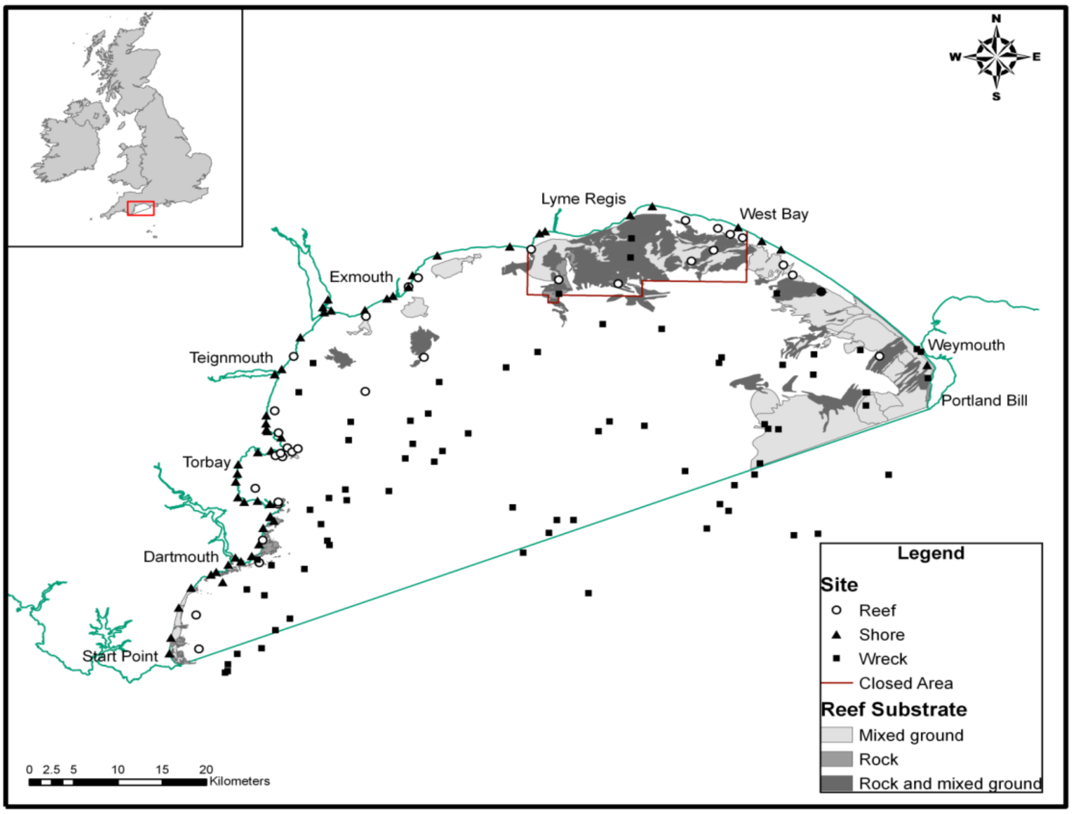


Figure 3.1 Marine leisure and recreation sites in Lyme Bay and the associated reef substrate. Source: Devon Biodiversity Records Centre and Stevens et al (2007).

Diving and angling activities in Lyme Bay are supported by dive businesses, which offer services to divers including gear and training, and the charter boat industry whose skippers take sea anglers and/or divers (who are not using their own boats) to suitable sites to carry out their recreation activity. Charter boat operators also take people out on wildlife watching trips throughout the Bay to observe species such as bottlenose dolphins (*Tursiops truncatus*) and guillemots (*Uria aalge*).

3.2 Methods and materials

3.2.1 Questionnaire design and delivery

Four questionnaires were developed to determine the value of the activity of the different recreation groups (dive businesses, dive clubs, sea anglers and charter boat operators) in both monetary and non monetary terms (Appendix 1). The questionnaires were piloted on sample groups. Three of these questionnaires (dive clubs, sea anglers and charter boat operators) were further developed with an interactive map for use on-line (Plymouth Marine Laboratory, 2008).

The owners of dive businesses were interviewed face to face. Dive club members and sea anglers were contacted and asked to participate in this research through the use of on-line forums and email invitation. Charter boat operators were contacted via telephone because attempts at email contact were unsuccessful.

3.2.2 Data analysis

3.2.2.1 Recreation hotspots (non market value)

Recreation hotspots were determined via the use of a map of Lyme Bay populated with 171 known reef, wreck and shore sites known to be used by these recreation groups. Respondents were asked to identify sites they visited in 2008 and also give an indication of the frequency of visits to each site on a scale of 1-5 where 1= a site rarely visited in 2008 and 5= a site frequently visited in 2008. Respondents were invited to add further sites to the map.

To identify recreation hotspots the results were summed to give a frequency count for each site. To display the data spatially, Lyme Bay was divided into

1km^2 planning units using Geographic Information Systems (GIS). The frequency count was divided into five categories using Jenks optimisation method which classifies natural breaks in the data (frequency counts) to define categories for use in conservation planning (Day et al., 2008). These categories were defined as rarely visited, seldom visited, sometimes visited, often visited, and frequently visited. For the purpose of this research hotspots were defined as the top two natural break class ranges (often visited and frequently visited).

3.2.2.2 Monetary values

Monetary values were elicited by asking questions designed to determine expenditure (anglers and divers), and business turnover (charter boats and dive businesses). This is consistent with previous studies in Lyme Bay (Cappell and Lawrence, 2005;Homarus Ltd, 2007;Stevens et al., 2007). Harbour masters at the Lyme Bay ports of Lyme Regis, West Bay, Dartmouth, Torquay, Brixham, Paignton, Portland and Weymouth were interviewed via telephone to substantiate levels of diving activity. A range in monetary valuation is given for each group to allow the decision maker to take into account the variability in monetary values for each activity. The following methods were used to determine the value of each recreation activity in Lyme Bay.

3.2.2.3 Divers

The total estimated value of dive club expenditure in Lyme Bay was determined by multiplying the mean expenditure per diver per day by the number of diver days leaving from Lyme Bay ports.

3.2.2.4 Sea anglers

40 individual sea anglers were interviewed. These individuals represented 15 out of the 18 clubs within 25 miles of Lyme Bay. Club membership for the 18 clubs was determined from records of membership held by the National Federation of Sea Anglers. Where the club membership was not known (n=6) the mean club membership of 69 members was used (Cappell and Lawrence, 2005). The total estimated value of sea angling club member activity in Lyme Bay in 2008 was determined by:

i) dividing the sample group (n=40) into three categories representing the level angling activity in a year: low (0-20), medium (21-50) and high (50+) number of trips per year. This allowed for the high variability in the number of trips per year by individuals,

ii) for each activity category (shore and boat) the mean number of trips per year (shore and boat) and the expenditure per day was calculated from the sample group. An estimate for the number of club members who participate in sea angling in each category was determined by calculating the proportion of the sample group who were club members in each category,

iii) the total number of trips per year was calculated by multiplying the number of club members by the mean number of trips per year in each activity category (shore or boat). The percentage of these trips which were shore or boat trips was determined by the proportion of trips taken by the sample group in each activity category,

iv) the total expenditure on shore angling and boat angling was then determined by multiplying the number trips by the mean expenditure per day. The results were summed across all activity categories to provide the total estimated value of sea angling club activity in Lyme Bay.

Previous research shows that 10-25% of all anglers belong to a club (Cappell and Lawrence, 2005). To include non club activity this research uses a conservative assumption that 25% of sea anglers in Lyme Bay are club members. Therefore, the total estimated value of angling club activity was multiplied by a factor of 4.

3.2.2.5 Charter boat operators

From an internet search of services offered by charter boats in the Lyme Bay area 51 operators were identified as active in 2008. The total estimated value of charter boat activity in Lyme Bay was determined by calculating (i) the actual turnover of the sample group representing 19 operators and (ii) the turnover of the remaining 32 operators using the mean turnover of the sample group. The results were summed to give a total estimated value.

3.2.2.6 Dive businesses

There were 10 dive businesses operating in Lyme Bay in 2008. The total estimated value of dive business activity in Lyme Bay was determined by calculating (i) the actual turnover of the sample group representing 6 businesses and (ii) the turnover of the remaining 4 businesses using the mean turnover of the sample group. The results were summed to give a total estimated value.

3.2.2.7 A valuation of the Lyme Bay closed area.

To spatially quantify the monetary value of the marine leisure and recreation industry in the closed area a value was derived for each site and each recreation group by (i) dividing the total estimate value of the recreation activity by the total frequency count in Lyme Bay (ii) This was then multiplied by the total frequency count of each individual site. Results were summed across all recreation groups.

3.3 Results

3.3.1 Non monetary valuation

Recreation activity occurs across Lyme Bay (Figure 3.2). 12.3% of the Lyme Bay planning units contain sites which are used by the marine leisure and recreation industry. Sites which can be defined as hotspots have a frequency count >38.1 (Figure 3.2). Less than 3% of all the sites used by sectors of the marine leisure and recreation industry are hotspots. 22% of all the hotspots are in the Lyme Bay closed area. The majority of hotspots are within 6nm of the coast.

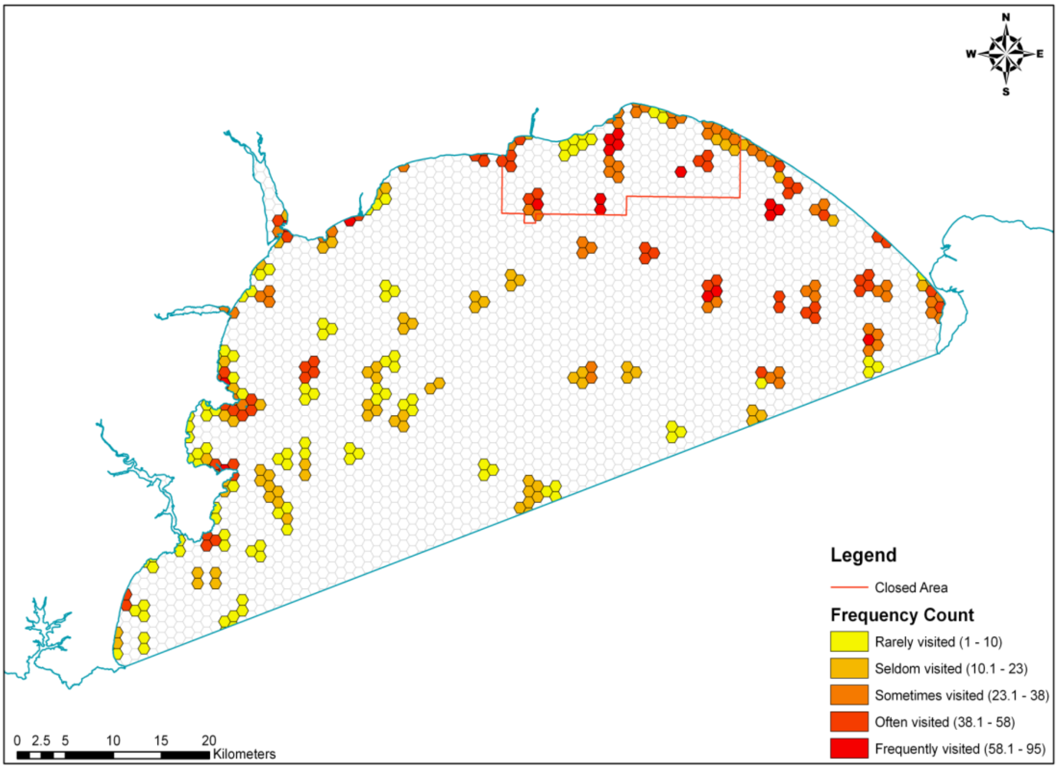


Figure 3.2 Marine leisure and recreation hotspots in Lyme Bay based on 1km^2 planning units. Hotspots are defined in this research as sites which are often visited and frequently visited by recreation groups.

3.3.2 Monetary valuation

Of the sectors studied, sea anglers have the highest total estimated expenditure per year in Lyme Bay of £13 687 992 (Table 2.1). The estimated expenditure by divers through trips they make with dive clubs in Lyme Bay is £1 048 956 per year (Table 3.2). The boat charter and dive businesses in Lyme Bay which rely on marine biodiversity have a combined turnover of £3 542 919 per year (Table 3.3).

	Trips per year	% of sample club members (n=40)	Mean number of trips per year (+/-sd)	% shore	% boat	Mean expenditure per day on angling		Number of club members within 25 miles of Lyme Bay [a]	Total number of trips per year	Number of trips (shore)	Number of trips (boat)	Total expenditure on shore angling (+/-sd)	Total expenditure on boat angling (+/-sd)
						Shore (+/-sd)	Boat (+/-sd)						
Low activity	0-20	37.5%	11 (+/-6)	67	33	£30 (+/-17)	£56 (+/26)	790	8690	5822	2868	£174 660	£160 608
Medium activity	21-50	35%	34 (+/-10)	64	36	£30 (+/-17)	£56 (+/26)	737	25058	16037	9021	£481 110	£505 176
High activity	51+	27.5%	88 (+/-21)	57	43	£30 (+/-17)	£56 (+/26)	579	50952	29043	21909	£871 290	£1 226 904

[a] There are 18 sea angling clubs within 25 miles of Lyme Bay. Membership numbers were available for 15 clubs from the National Federation of Sea Anglers. Where club membership was not available the mean club membership of 69 member was used (Cappell and Lawrence 2005) totaling 2106 sea angling club members registered in 2008.	Total estimated value of angling club activity in Lyme Bay	£3 419 748
[b] 10-25% of sea angers belong to a club (Cappell and Lawrence 2005).This research uses a conservative estimate of 25% of anglers are a member of a national sea angling club.	High estimated value of club activity	£5 163 830
	Low estimated value of club activity	£1 675 666
	Total estimated value of angling activity in Lyme Bay[b]	£13 678 992
	High estimated value of angling activity [b]	£20 655 320
	Low estimated value of angling activity [b]	£6 702 664

Table 3.1 Total estimated monetary value of sea angling activity in Lyme Bay.

	Mean expenditure per diver per day (n=411) (+/-sd)	Number of diver days leaving from Lyme Bay harbours [a]	Total estimated value of dive club expenditure in Lyme Bay (boat dives only)	High estimated value	Low estimated value
Dive Clubs	£61 (+/-£21)	17196	£1 048 956	£1 410 072	£687 840

[a] Diver days estimated via interviews with Lyme Bay harbour masters (not including charter boats)

3.2 Total estimated monetary value of dive club activity in Lyme Bay.

	Actual turnover of sample group (+/-sd)	Number of businesses in Lyme Bay	Mean turnover (+/-sd)	Total estimated value of business activity in Lyme Bay	High estimated value	Low estimated value
Dive Businesses	£905 326 (n=6)	10	£150,888 (+/- £170 876)	£1 508 878	£2 192 382	£825 374
Charter Boat Operators	£757 785 (n=19)	51	£39 883 (+/- £27 196)	£2 034 041	£2 904 313	£1 163 769

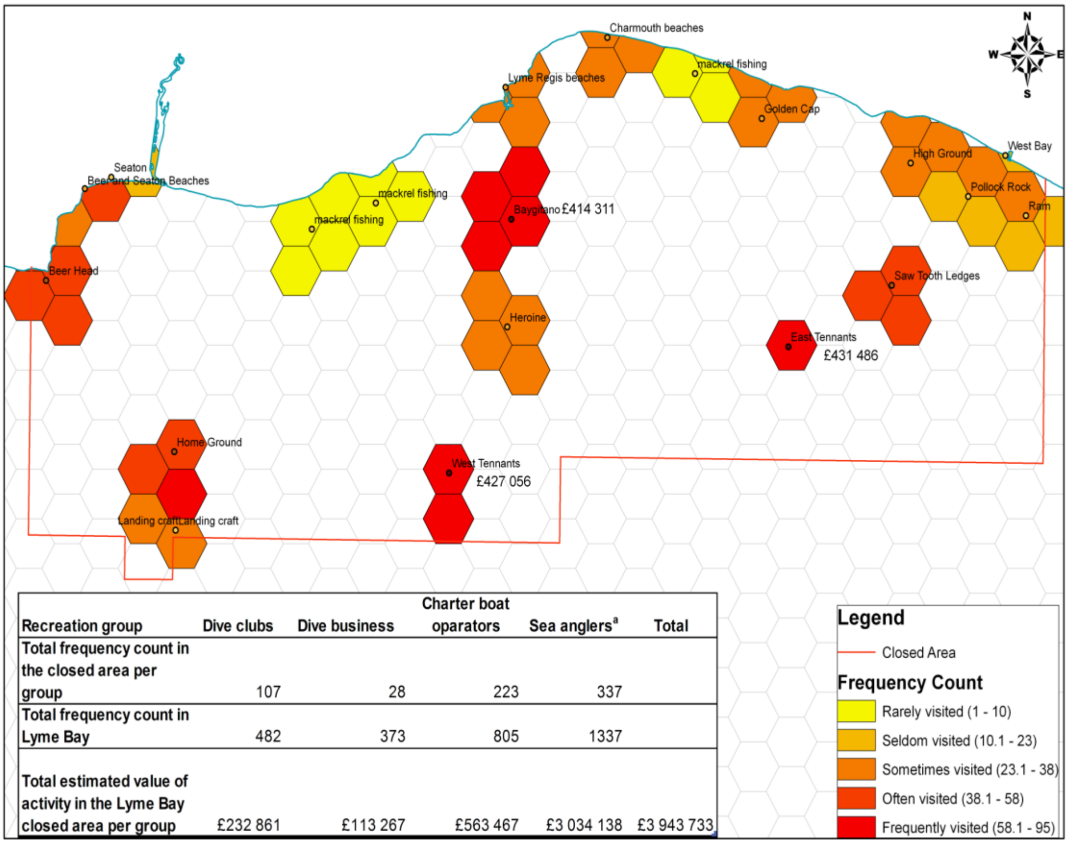
Table 3.3 Total estimated monetary value of business activity (dive businesses and charter boat operators) in Lyme Bay.

3.3.3. A valuation of the Lyme Bay closed area

The closed area protects a part of the turnover and expenditure generated by the marine leisure and recreation industry in Lyme Bay. Local dive and charter boat businesses generate a turnover of £676 734 per year through their use of this area (Figure 3.3). Sea anglers and divers spend £3 266 999 a year visiting sites in the closed area.

The most valuable site in the closed area (and in Lyme Bay as a whole) is the wreck of the Baygitano with recreation groups generating £414 311 expenditure/turnover per year visiting the site. The most valuable reef site in the closed area (and in Lyme Bay) is the West Tennents reef with recreation groups generating £427 056 of expenditure/turnover per year visiting the site (Figure 3.3).

Proportionally charter boat operators make the most use of the closed area (Figure 3.3). Anglers spend the most money on their activity in the closed area (£3 034 138 per year). In all cases the closed area protects less than 27% of the economic value of these groups. Dive businesses currently derive the least benefit of the closed area policy in Lyme Bay leaving 92% of their resource base (the dive sites) unmanaged.



Recreation group	Dive clubs	Dive business	Charter boat oparators	Sea anglers[a]	Total
Total frequency count in the closed area per group	107	28	223	337	
Total frequency count in Lyme Bay	482	373	805	1337	
Total estimated value of activity in the Lyme Bay closed area per group	£232 861	£113 267	£563 467	£3 034 138	£3 943 733

Figure 3.3 A monetary and non monetary valuation of recreation activity in the Lyme Bay closed area showing (i) the marine leisure and recreation hotspots in the Lyme Bay closed area based on 1km^2 planning units. Hotspots are defined in this research as sites which are often visited and frequently visited by recreation groups. (ii) A monetary valuation of the three most visited sites in Lyme Bay, the wreck of the Baygitano, the East Tennents reef and West Tennents reef. (iii) The total estimated value of recreation activity in the Lyme Bay closed area per group and aggregated. [a] When aggregating values 12% must be removed from the total to take into account sea anglers expenditure on charter boats

3.4 Discussion

3.4.1 Confidence in monetary values

Confidence in the total estimated value of dive businesses is high because 60% of dive businesses took part in face to face interviews. The standard deviation of the mean turnover of a dive business is large as dive businesses vary in size. Attempts were made to determine the size of the businesses in Lyme Bay which were not interviewed for this research via information on their websites. These businesses were judged to be small-medium sized operators therefore confidence in the total estimated value of dive businesses remains high.

Confidence in the total estimated value for the turnover of the charter boat industry in Lyme Bay is high because 37% of charter boat operators were interviewed via telephone. Charter boat turnover has previously been estimated to be £45 000 (Cappell and Lawrence, 2005) and £46 598 (Stevens et al., 2007) per vessel. This is consistent with the mean turnover estimated in this study for charter boats in Lyme Bay of £39 883. This is a proportional value as vessels from Weymouth and Dartmouth do not spend all of their time in Lyme Bay.

Sea angling in the south west region of the United Kingdom as a whole generates expenditure of £165 million each year (Cappell and Lawrence, 2005;Lawrence, 2005). It is therefore plausible that sea angling expenditure in Lyme Bay can be valued as £13 678 992 per year as there are several large ports and access sites in the Lyme Bay area. The range in values for sea angling is the largest of all the recreation groups. This highlights the fact that sea angling is a widespread activity where participants take part on many different levels e.g. boat and/or shore angling and either as a committed hobbyist spending up to £10,000 a year on the sport or simply going angling once or twice a year. This makes the ‘average angler’ difficult to define hence the values in this study are divided into angling activity categories of low, medium and high depending on the number of trips per year. Despite this irregularity the total estimated value may still be considered as an underestimate. Club membership is estimated to represent 10-25% of all anglers. This research has multiplied the total estimated value of club angling in Lyme Bay by a conservative factor of 4 to represent the inclusion of non club affiliated sea anglers. However, Lyme Bay is a popular holiday destination so the number of non club affiliated anglers could potentially be higher than the 75% used in this research.

Confidence in the total estimated value of dive club activity in Lyme Bay is high and may be considered as an underestimate of the potential value of diving activity in Lyme Bay as there are access points within the Bay which are not monitored by a harbour authority. The sample group indicated that 28% of their diving activity was from a shore location. This extra volume of diving as not been accounted for in the total estimated value of diving activity in Lyme Bay.

3.4.2 Double counting

Questionnaires were specifically designed to avoid double counting between groups to indicate a more accurate value when values are aggregated. Therefore sea anglers were asked how many of their trips were from the shore, using their own boat or hiring a charter boat. Sea anglers’ expenditure on charter boats (12%) was removed from the total.

The number of diver days leaving from Lyme Bay ports was not inclusive of charter boat activity, and two dive businesses make use of charter boats. This does not affect the turnover of the dive business only the profit and was not considered to be double counting.

3.4.3 The strengths of valuation studies for use in marine spatial planning

The monetary valuation is largely demonstrative of the relative economic significance of the marine leisure and recreation industry. The marine leisure and recreation industry in Lyme Bay can be valued at least as £17 million of expenditure/turnover per year from the use of the marine resources. This enables the industry to be compared with other direct use values within the context of marine spatial planning. Marine policy has typically favoured the fishing industry in marine planning and conservation conflicts (Laffoley et al., 2004) and the provision of a monetary valuation for an alternative use of marine biodiversity could become a powerful tool for influencing the decision making process.

The non monetary valuation is also an important tool for use in marine spatial planning as the frequency count provides a relative value of sites to the marine leisure and recreation industry which can then be discussed by all stakeholders involved in the marine spatial planning process. The data can be used to create a data surface where relative values (cost) can be assigned, based on the frequency counts (including areas of zero value) and used in conservation planning optimisation software such as MARXAN (Ball and Possingham, 2000). Lessons from both terrestrial and marine conservation planning indicate that projects in which the different stakeholders are involved in mapping areas of value enables more focussed management actions and can empower local involvement in the management process (Raymond et al., 2009).

The information which has been derived from this economic study enables stakeholder groups to be identified and can help define possible management options which may affect the costs and benefits of marine biodiversity to each stakeholder group (Scott, 1996). In addition, monetary valuations from this case study area could be used as a basis for value transfer to other sites in south west, England. Value transfer offers a method of estimating monetary values for the marine leisure and recreation industry for use in marine spatial planning without performing relatively costly and time consuming primary valuation studies (Brander et al., 2007).

Supporting a monetary valuation with spatial data and frequency counts provides a means by which to value individual sites. These data could be used to support compensation claims by members of the recreation and leisure industry if a site they consider valuable has been damaged or destroyed by human actions. The draft UK Marine and Coastal Access Bill proposes compensation for breaches to marine licensing conditions which damage the marine environment (Defra, 2008d). Application of the Precautionary Principle also requires that those who cause damage should be held responsible (Defra, 2006). Fishermen also feel that they should be financially compensated if excluded from fishing grounds under plans for Marine Conservation Zones (MCZs) (Jones, 2009). Although there are no plans for a compensation package for fishermen under the UK Marine and Coastal Access Bill, the rights of other stakeholders to make a living from using the same resource will also need to be considered if the issue of compensation is raised. This demonstrates the difficulty of assuming property rights for an open access resource.

Determining the proportional value of a site can provide a detailed valuation of the current use of a marine area and provide an evidence base for conserving particular marine sites, in this case the Lyme Bay reefs. A strong economic case for protection could also be made for other recreation hotspots in Lyme Bay and this would need to be considered for future marine spatial planning scenarios. This level of detail in the valuation can also enable the monetary value of recreation to be included and compared to sectors of the fishing industry in a long term cost benefit analysis of the Lyme Bay closed area policy.

3.4.4 The weaknesses with valuation studies for use in marine spatial planning

Valuation should be used with caution as the use of a site may be influenced by external factors such as weather and swell. For example, respondents to the questionnaire stated that the poor summers of 2007 and 2008 influenced their choice of recreation activity and location. Monetary valuation can also be influenced by the prevailing economic climate such as an economic recession or changes to regular costs such as fuel. Such external factors must be considered in the valuation process. Non monetary valuation can also be influenced by external factors as values can also change, largely depending on the ideas, attitudes and beliefs of the individual and the collective progress of society over time (Pearce and Turner, 1990).

Monetary valuations of recreation use are also limited by the fact that these activities are unregulated therefore the estimated valuations remain a ‘best guess’ based on all the available evidence available within time and budget. For example, it is impossible to contact all divers and sea anglers using a specific planning area because many recreation users do not belong to a club or organising body. Future marine spatial planning initiatives will, when estimating value, remain limited by an unknown sample size of these two recreation groups.

Monetary valuation studies are often not defined by parameters upon which comparisons can be made with other economic valuations. It is important that all valuations are considered within the context of how the data is collected and analysed and the limitations of valuation are understood (Kumar and Kumar, 2008). It would be inappropriate, for example, to compare the turnover of a dive business with the turnover of a fishing vessel plus the additional revenue generated from fish processing and staff employed. An attempt must be made to compare like with like by being explicit about the multipliers used in the methodology. Marine spatial planners are unlikely to be economists therefore researchers must be transparent as to how figures are collected and calculated so that economic valuations can be understood by non-economists.

Valuation studies on a single ecosystem service can obscure the wider value of marine biodiversity and the goods and services provided. In this instance the valuation of the recreation industry focuses on the direct use direct use of the resource. It must be maintained that marine biodiversity also provides essential supporting and regulatory services which support human well being (Constanza et al., 1997;Millennium Ecosystem Assessment, 2005).

The value of the marine leisure and recreation industry and the links to biodiversity could also include the expenditure of individuals who come on holiday to coastal locations and enjoy activities such as rock pooling and bird watching. There are additional reasons other than the interaction with marine biodiversity as to why people take part in marine leisure and recreation activities. For example, it is believed that that sea angling has direct benefits for health via relaxation and stress relief (Crabtree et al., 2004). These benefits are difficult to quantify but remain part of the matrix of valuation.

A limitation of a direct use valuation of marine biodiversity via the use of the marine resource is that the reasons why people take part in the activity are not considered and the extent to which their participation is linked to marine biodiversity is not explored. For example, diving is an activity which is traditionally associated with diverse marine habitats e.g. reefs. World popular dive sites are areas of rich biodiversity e.g. The Great Barrier Reef. However, the extent to which the individual's enjoyment of diving is linked to the physical act of diving and/or if the enjoyment of diving increases with increasing biodiversity remains unresearched.

3.5 Conclusion

It is the current policy climate that demands that a case is made for conservation that balances environmental with economic and social interests (the ecosystem approach). Valuing the marine leisure and recreation industry can provide an argument for the sustainable use of areas of rich marine biodiversity. However, it is not necessarily a meaningful proxy for the value of marine biodiversity and its ecological functions. 'The refreshment and stimulation for the human body and mind through the perusal and engagement with living marine organisms in their natural environment' (Beaumont et al., 2008) is one of many services provided by marine ecosystems.

A direct use valuation of the marine leisure and recreation industry enables comparison with other sectors (e.g. fishing) that make use of the natural resource. A comparative valuation by no means excludes the importance of fisheries in planning. In this case study the economic value provides evidence that the marine leisure and recreation industry is a key stakeholder in planning for long term regional economic sustainability that is based on managing marine biodiversity as a resource which provides an essential ecosystem service to humans.

Both monetary and non monetary valuations have a role in marine spatial planning. Non monetary values represented spatially provide a baseline by which to plan with multiple stakeholder groups. Proportional monetary values of different sites can provide a baseline against which the costs and benefits of MPAs can be measured to determine future marine spatial planning scenarios.

A valuation of the marine leisure and recreation industry can support conservation objectives as the economics can justify and enable policy makers to designate areas for conservation when it may be to the short term detriment of other economic interests. However, difficulty may well arise in the future if recreation use is deemed to be unsustainable in relation to the conservation objectives of the MPA. Dive tourism can, for example, have adverse effects on benthic features (Hasler and Ott, 2008;Luna et al., 2009). It remains the case that economic and ecological values can conflict (Farber et al., 2002). There is still an issue of how to value the irreplaceable and fundamental supporting and regulatory functions of marine biodiversity when set against competing economic interests in marine spatial planning. This issue will continue to underpin the case that is made for designating marine protected areas on scientific criteria alone regardless of monetary values.

Chapter four: Incorporating indirect ecosystem services into marine protected area planning

4.1 Introduction

The constituents of human well-being (security, health, access to materials for a good life and good social relations) are inextricably linked to the services provided by the functioning of ecosystems (Millennium Ecosystem Assessment, 2005).

The ecosystems of the marine environment have a key functional role in the delivery of a range of services from the ‘direct uses’ such as the provision of food and raw materials to the ‘indirect uses’ such as the regulating and supporting services that contribute to the maintenance of a habitable climate (Covich et al., 2004;Beaumont et al., 2007;Austen et al., 2011). Widespread and intensive human activity in the world’s oceans and the subsequent loss of marine populations and species may be impairing the ability of marine ecosystems to provide the essential ecosystem services that contribute to human well being (Chapin III et al., 2000;Hooper et al., 2005;Worm et al., 2006;Halpern et al., 2008). In order to maintain the flow of ecosystem services to humans, one of the key recommendations from the Millennium Ecosystem Assessment was to focus and increase research into measuring, mapping and modeling ecosystem services to enable an assessment of how a change in the delivery of ecosystem services may impact upon human welfare (Fisher et al., 2009).

The United Kingdom Government is committed under International and European agreements to implementing a network of Marine Protected Areas (MPAs) and to the application of the ecosystem approach to the management of the marine environment to achieve the sustainable use of marine ecosystem services (United Nations, 2002;OSPAR Commission, 2003;Secretariat of the

Convention on Biological Diversity, 2004;OSPAR Commission, 2006;European Parliament and Council, 2008). These commitments are underpinned by a requirement to adopt management measures to enable the functioning of marine ecosystems to be maintained (OSPAR Commission, 2006;European Parliament and Council, 2008;HM Government, 2011).

Previous research shows that the functional characteristics of species strongly influences ecosystem processes (Hooper et al., 2005). Biological Traits Analysis (BTA) is a method which has been proposed to assess ecosystem function in marine benthic environments (Bremner et al., 2003;Bremner et al., 2006a). BTA uses a series of behavioural (e.g. feeding), life history (e.g. age) and morphological characteristics (e.g. body size) of species to define ecological function (Bremner et al., 2006b). The ecological function of a species is then used to infer an aspect of ecosystem function (Lavorel and Garnier, 2002;Bremner, 2008).

In previous research relating to the marine environment BTA has been used to illustrate how ecosystems function in relation to the biological assemblages (Bremner et al., 2006b;Frid et al., 2008). BTA has also proved useful as a tool to show how changes in species composition caused by anthropogenic impacts affect ecosystem functioning (Tillin et al., 2006;Hewitt et al., 2008). These studies have applied BTA to infer that the ecological function of benthic species contributes to the delivery of *all* ecosystem services. However, issues arise with this approach as marine managers, when working with stakeholders, may need to make tradeoffs between different ecosystem services when decisions are made on the use of a marine area (Kremen, 2005). Managers will therefore need a more detailed understanding of how ecological function is linked to these services and how they can be can be defined at a local to regional scale (Loreau et al., 2001;Chan et al., 2006).

Research is gathering pace on projects to spatially map direct uses in the marine environment e.g. recreation and fisheries (Klein et al., 2008a;Rees et al., 2010b). There has been less focus on indirect service provision which is defined as those benefits which are 'derived from the environment without the intervention of man' (Pearce and Turner, 1990;Beaumont et al., 2007). This research focuses on the indirect regulating and supporting services of, gas and climate regulation, bioremediation of waste and nutrient cycling as defined in Beaumont *et al.* (2007).

4.1.1 Gas and climate regulation

The maintenance of a habitable climate and atmosphere is underpinned by a series of biogeochemical processes as well as the regulation and exchange of carbon by biotic and abiotic processes in both marine and terrestrial environments (De Groot et al., 2002). Marine organisms have a significant role in the carbon cycle, particularly via the regulation of carbon fluxes and the capacity of the marine environment to sequester carbon dioxide (Nellemann et al., 2009).

In the benthic system the regulation of carbon takes places in several different ways. Carbon can be fixed via the processes of primary production and secondary production. Organic carbon is sequestered within the sediment and cycled between the sediment and overlying water by the feeding and movement of benthic fauna which facilitates the microbial decomposition process (Snelgrove, 1997;Bremner et al., 2006a).

4.1.2 Bioremediation of waste

The marine environment receives a large amount of waste from anthropogenic sources. Oceans have the capacity to dilute and metabolise some pollutants. Benthic organisms have an impact on this capacity. Marine organisms can reduce the concentrations of some pollutants in the water column and sediments via metabolic processes (Snelgrove, 1997). The movement of the sediment via bioturbation, feeding habit and mobility increases the rate at which pollutants are incorporated into the sediment (Aller, 1983;Snelgrove, 1997).

4.1.3 Nutrient cycling

Nutrients (e.g. nitrogen, phosphorous, sulphur, silicon and metals) are essential for the maintenance of human well-being. The cycling of nutrients is a support service that takes place across the land, sea and air environments and in all marine habitats. It is largely facilitated by microbial and bacterial processes which enable nutrients to be made available to support biological production. Nutrients are essential for growth and primary and secondary producers assimilate carbon and nutrients to create biomass. If nutrients are not available then biological productivity, which underpins most other services including those that provide direct benefits such as food, can be limited in both the terrestrial and marine environment.

Within the shallow coastal marine environment nutrient cycling, in particular nitrogen, is closely linked to benthos and occurs mainly within the sediment (Snelgrove, 1997;Austen et al., 2002). Key processes of the nitrogen cycle which occur in the benthic environment are those which facilitate the decomposition and incorporation of nutrients both into and out of the sediment. These processes and the rates at which these reactions occur, are sensitive to the availability of oxygen in the sediment (Snelgrove, 1997). The availability of oxygen in the sediment is facilitated by the sediment reworking activities of benthic macrofauna (Austen et al., 2002;Widdicombe and Austen, 2005).

In this research a 'service orientated ' approach was developed as this is most likely to translate across the science-policy interface (Kremen, 2005;Raffaelli, 2006). For a given case study area the services of interest are identified, followed by the identification of the processes and functions that affect the delivery of those services linked to the ecology of the case study marine area. Here, the framework was applied to Lyme Bay in SW England. To inform ongoing debate regarding marine planning, conservation, and the long term delivery of ecosystem services the described research aims to:

1) Define the spatial area over which benthic species operate for the delivery of the indirect services of nutrient cycling, gas and climate regulation and the bioremediation of waste in a case study area;

2) Link the provision of services with current conservation policy;

3) Make recommendations for the inclusion of indirect service provision in marine spatial planning policy.

This novel approach provides the link between the current understanding of the ecological function of benthic species and indirect ecosystem service provision. Results can be applied to local marine spatial planning initiatives and to inform wider planning policy.

4.2 Materials and methods

4.2.1 Case study area

Lyme Bay was chosen as it is a data rich case study area. The offshore reef areas have been identified as a draft Special Area of Conservation (dSAC) under the European Union's Habitats Directive (92/43/EEC) for the Annex 1 habitat criteria for reefs. Additionally, there is currently a 206km^2 statutory MPA within the Bay. This closure was designated on the 11th July 2008 by the UK Department for Environment, Food and Rural Affairs (Defra) to protect the marine biodiversity of the reefs from the impact of fishing with dredges and other towed gear.

The Lyme Bay study area is approximately 2460km^2 and is defined as the sea area which is enclosed by a line drawn between Portland Bill in Dorset and Start Point in Devon (Figure. 4.1). This study focused on the benthic habitats which comprise of sublittoral rocky reefs (defined as areas of rock and mixed ground in the northern section (mixed ground is defined as seabed consisting of combinations of sand, gravel, pebbles, cobbles and boulders (Black, 2007), extending to soft sediment areas as the depth increases offshore. Lyme Bay has been identified as a 'marine biodiversity hotspot' (Hiscock and Breckels, 2007). These are identified as areas of high species richness that include rare and threatened species. The benthic habitats of Lyme Bay have been much studied (Rees et al., 2010a). To inform both statutory and non statutory marine spatial planning processes, extensive survey work to produce detailed biotope and substrate maps of Lyme Bay was commissioned by the Devon Wildlife Trust in 2005 (Ambios, 2006). These maps were further refined by Stevens *et al*. (Stevens et al., 2007).There is a large amount of available data relating to benthic assemblages. Any conclusions that can be drawn from these data sets can be used to inform ongoing conservation planning activity both locally and regionally.

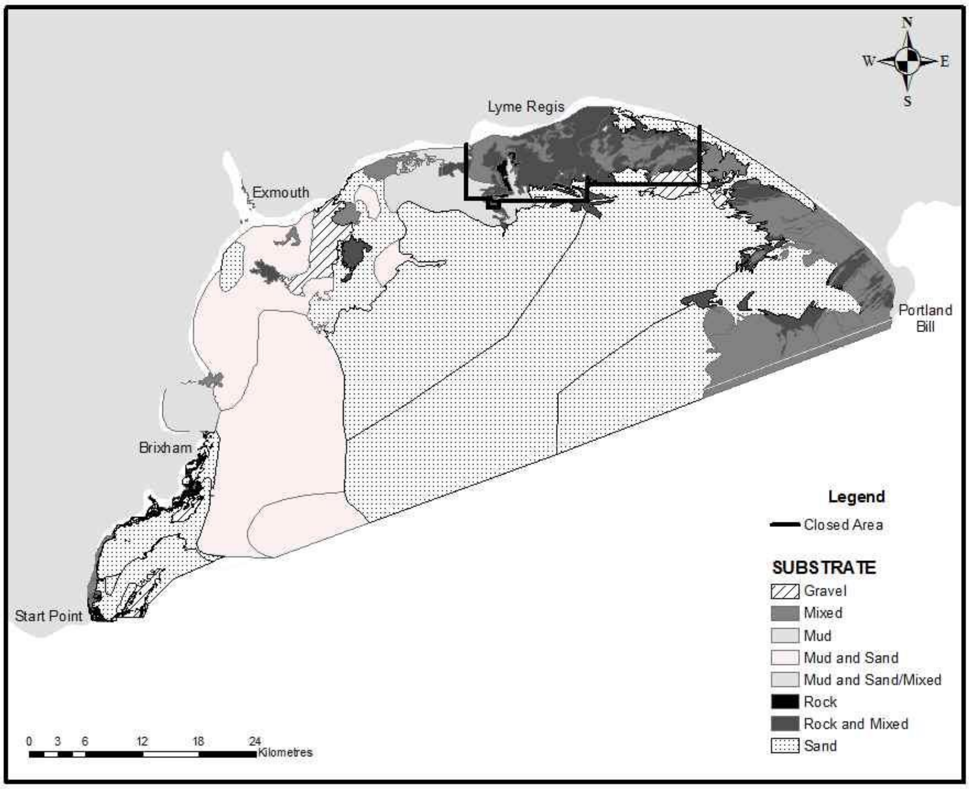


Figure 4.1: The Lyme Bay case study area showing the 2008 closed area and substrate. (Source of substrate data: Devon Biodiversity Records Centre).

4.2.2 Data selection

Species distribution data (presence only) across 464 survey sites (Figure. 4.2) were extracted from three data sets, made available by Devon Biodiversity Records Centre, Data Archive for Seabed Species and Habitats (www.dassh.ac.uk) and the University of Plymouth:

- Sea Search dive surveys (Wood, 2007)
- Grab sample and drop video surveys undertaken by Ambios Ltd on behalf of the Devon Wildlife Trust (Ambios, 2006)
- University of Plymouth drop video surveys (Stevens et al., 2007)

These surveys were undertaken to quantify patterns of marine biodiversity at a scale relevant to marine spatial planning within the case study area of Lyme Bay (Stevens et al., 2007).

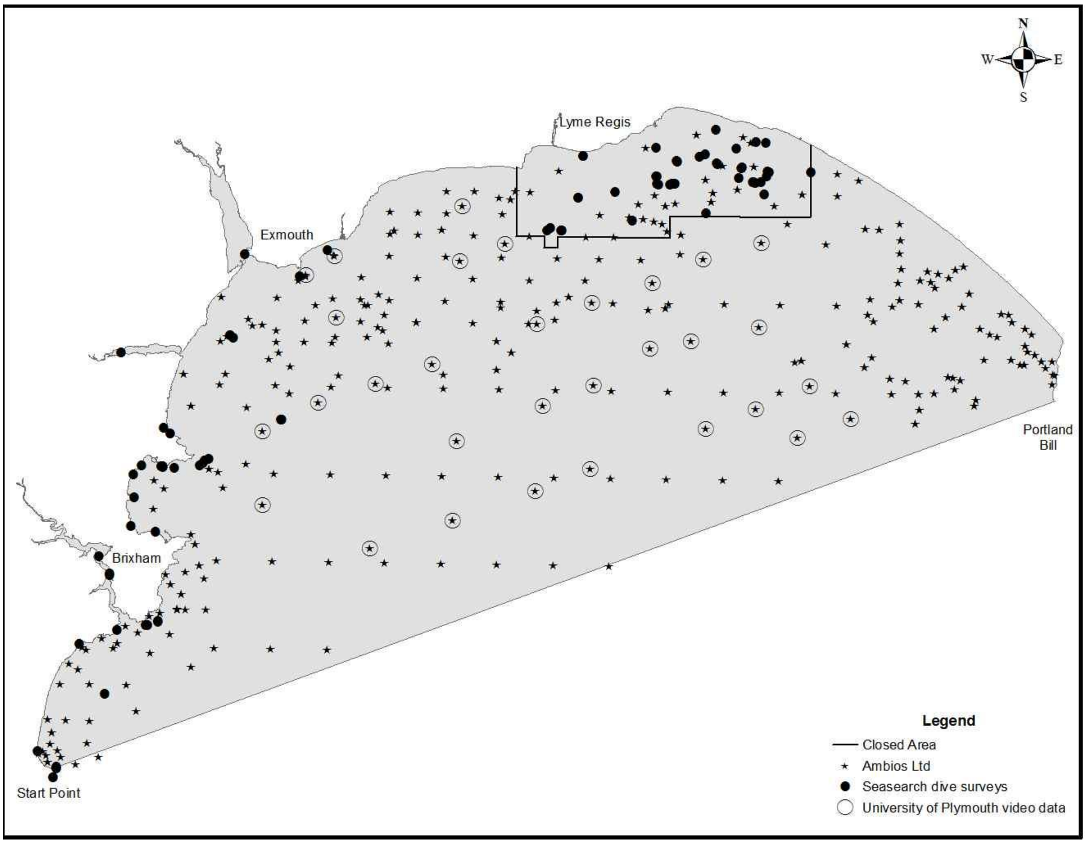


Figure 4.2: Survey sites in Lyme Bay

4.2.3 A service orientated framework and Biological Traits Analysis (BTA)

The services of interest were identified, followed by the identification of the processes and functions that affect the delivery of those services linked to the ecology of Lyme Bay.

The three ecosystem services selected for study were nutrient cycling, gas and climate regulation and the bioremediation of waste. Nutrient cycling supports the other two regulatory services but, in addition, these three services are highly interlinked in the marine environment through the functional roles performed by benthic species (Snelgrove, 1998). Three ecosystem processes were selected which collectively and in combination largely enable delivery of the three services, namely energy fixation, energy transfer, and the burial and enhancement of microbial decomposition. Each of these processes maps partially onto the delivery of the three services (Table 4.1).

Ecosystem Service	Process	Description	Function	References	Trait Category	Trait
Nutrient Cycling Gas and Climate Regulation Bioremediation of Waste	Energy Fixation	The respiration of gases and the assimilation of carbon and nutrients by primary producers to create biomass.	-carbon fixation -nutrient cycling -respiration of gases	(Hiscock et al. 2006; Bremner 2008)	Environmental Position	Epifloral
					Feeding Method	Photoautotroph
	Energy Transfer	The respiration of gases, The excretion of organic matter, the assimilation of carbon and nutrients and the metabolising of pollutants by secondary producers operating at the water column/surface interface.	-carbon assimilation - trophic support and maintenance of marine biomass -consumption of pollutants -nutrient cycling -respiration of gases -resuspension of organic matter	(Snelgrove 1997; Snelgrove 1998; Bremner, Rogers & Frid 2006a; Bremner, Rogers & Frid 2006b)	Environmental position	Epifaunal /Epibenthic
					Feeding Method	Active suspension feeder Passive suspension feeder Surface deposit feeder Interface feeder
	Enhancement of microbial decomposition	The role of secondary producers in the burial of organic matter and supply of nutrients and oxygen via bioturbation activities which enhance the microbial decomposition process at the surface/subsurface interface.	-decomposition of organic matter -movement - consumption -burial (sequestration) - detoxification - cycling of organic materials and nutrients into and out of the sediment	(Snelgrove 1997; Petersen, Kristensen & Bjerregaard; Snelgrove 1998; Pearson 2001; Austen et al. 2002; Bremner, Rogers & Frid 2006b; Bremner, Rogers & Frid 2006a)	Environmental position	Epifaunal /Epibenthic Infaunal
					Movement	Burrower Crawler
					Habit	Tubicolous Burrow dweller
					Bioturbation	Bioturbator

Table 4.1: A service orientated framework linking the provision of the ecosystem services of nutrient cycling, gas and climate regulation and the bioremediation of waste to functions that are influenced by the biological traits of benthic marine organisms. A definition of the traits can be accessed from BIOTIC (The Marine Life Information Network for Britain and Ireland (MarLIN) 2006)

A multi-trait approach was adopted that included as many traits as possible that are closely linked to these ecosystem processes with the aim of providing the most complete description of how the ecology functions in the case study marine area (Bremner et al., 2006b;Bremner, 2008). Species can be sorted into groups of effect traits that represent a functional role or that contribute to a process (Lavorel and Garnier, 2002;Giller et al., 2004;Bremner et al., 2006a) (Table 4.1).

Fourteen biological traits that relate directly to the ecosystem processes (Table 4.1) were chosen from a list of 248 traits listed in the Biological Traits Information Catalogue (BIOTIC) (The Marine Life Information Network for Britain and Ireland (MarLIN), 2006).

In order to comprehensively capture the function of species in the case study area, multiple traits were selected and therefore several traits overlap within the same process (this is because not all records within BIOTIC are complete). For example, a species may be referenced in BIOTIC as being a 'crawler' under 'movement type' (therefore exhibiting some bioturbator potential) but not referenced as a 'bioturbator' under the category of 'bioturbation'. The inclusion of multiple traits ensured that the role of each species would be included in the data analysis. If the species is recorded in BIOTIC as both a crawler and a bioturbator then it was only scored once within the process. Epifaunal and epibenthic species were only counted in the burial and enhancement of microbial decomposition if they also expressed relevant traits under the movement, habit and bioturbation category.

The Biological Traits Information Catalogue (BIOTIC, The Marine Life Information Network for Britain and Ireland (MarLIN) 2006, www.marlin.ac.uk/biotic) was used to determine the attribution of relevant biological traits for species found in the study area. Of the total of 452 species identified from the survey data 383 species were successfully matched via the BIOTIC database.

4.2.4 Data analysis

Each survey site was scored for the number of species which demonstrate traits defined within the ecosystem processes of energy fixation, energy transfer and the burial and enhancement of microbial decomposition. Where a species demonstrated traits in more than one process (for example a species may be both a suspension feeder (energy transfer) and a burrower (enhancement of microbial decomposition) a score was given under each process. Where a species demonstrated two or more traits within the same process (for example a species recorded within the BIOTIC database as both a burrower and a burrow dweller) the species would only be scored once. The scores were summed over each survey site providing a ‘process by site’ matrix. To display the data spatially the ‘process by site’ matrix was imported into GIS (ArcMap version 9.3.1). Data were displayed using ‘graduated symbols’ where the size of the symbol indicated the relative score for each key process at each site. The relative score (excluding sites where 0 was recorded) was divided into five categories using Jenks optimisation method which classifies natural breaks in the data by reducing variance within groups but maximising variance between groups.

To enable an analysis of the three processes and the relationship with substrate, the ‘process by site’ matrix data were joined spatially using the ESRI Arc GIS tool ‘Spatial Join’. The spatially joined data were re-exported to

Microsoft Excel to enable analysis of the data. To remove sampling bias in the data (e.g. there are more species which display biological traits in the rock substrate as there has been more sampling effort in this substrate type) the total for each key process within each substrate type was divided by the number of surveys undertaken, providing an average relative value for each key process within each substrate type.

4.3 Results

The Biological Traits Analysis of species in Lyme Bay show that the species which have traits that facilitate the key process of energy fixation are distinct from species which facilitate the key processes of energy transfer and the burial and enhancement of microbial decomposition within Lyme Bay. Many species possess traits which facilitate both energy transfer and the burial and enhancement of microbial decomposition.

The spatial results show (Figure. 4.3) that the key process of energy fixation occurs in the inshore waters of Lyme Bay. This analysis represents the epiflora and photoautotrophs within Lyme Bay. Species which demonstrate traits that contribute towards the transfer of energy process can be seen within the protected (closed) area of Lyme Bay (Figure 4.4) and on the rock and mixed substrates along the coast from Brixham to Start Point. They include species such as *Alcyonium digitatum (Linnaeus)* and *Eunicella verrucosa* (Pallas). Benthic species which demonstrate the traits that contribute towards the process of enhancement of microbial decomposition were also found across all sites in Lyme Bay (Figure. 4.5). Relevant activities include the burrowing of the bivalve mollusc *Abra alba* (Wood) and *Ariencola marin* (Linnaeus).

The substrates of mud, gravel and rock are the most favourable for the energy fixation process as the substrate hosts species such as *Zostera marina* (Linnaeus), *Laminaria hyperborea* (Gunnerus), *Lithothamnion corallioides* (P & H Crouan). The mud and sand substrates are the least favourable for the presence of species which demonstrate traits that facilitate energy transfer processes in Lyme Bay (Figure. 4.6). The soft substrates of mud and sand and mixed are more favourable for the enhancement of microbial decomposition than the harder substrates (Figure. 4.6).

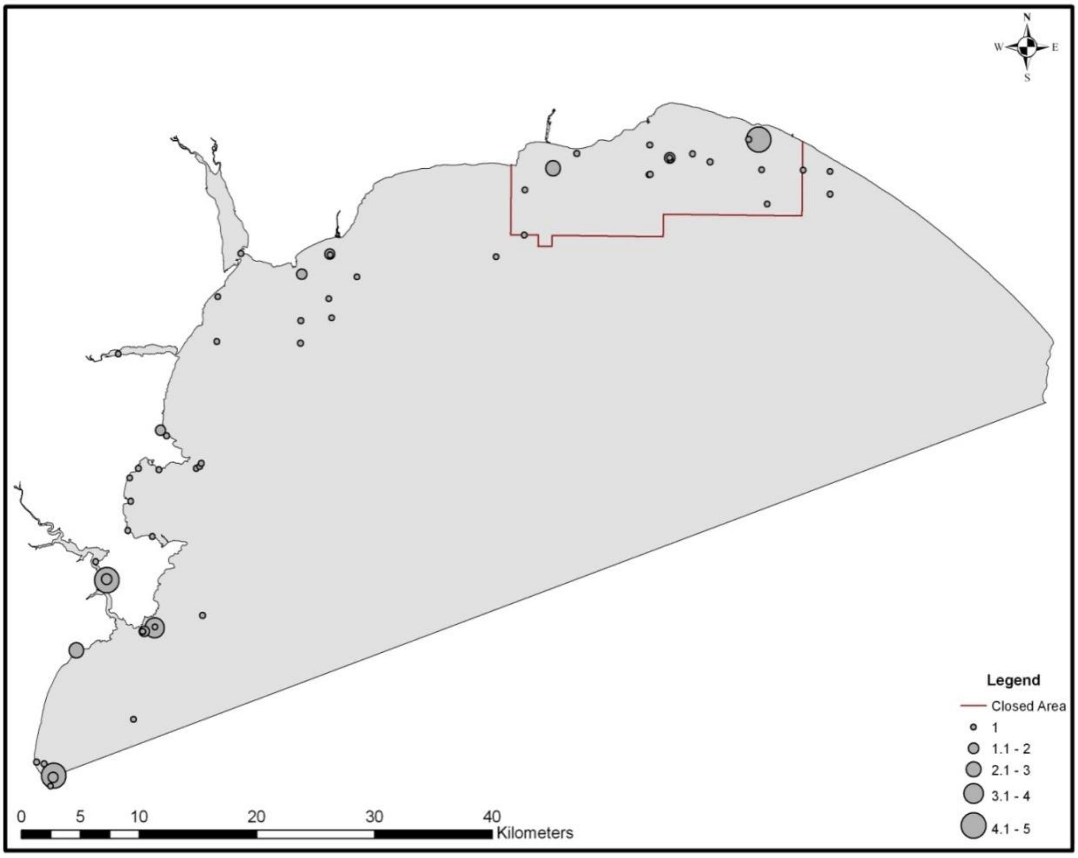


Figure 4.3: The delivery of the process of energy fixation facilitated by benthic species in the Lyme Bay case study area. Data are displayed as graduated symbols (Jenks optimisation) where the size of the symbol indicates the count for the process at a survey site.

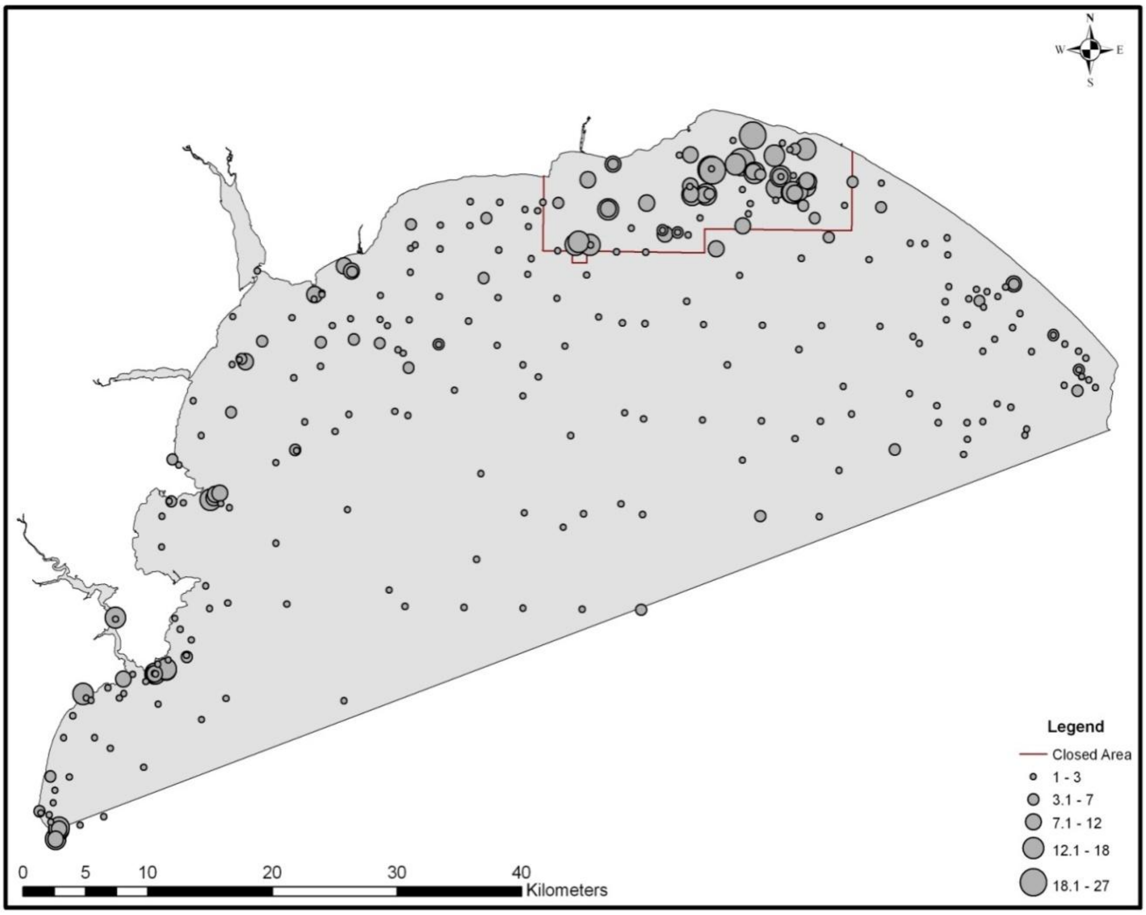


Figure 4.4: The delivery of the process of energy transfer facilitated by benthic species in the Lyme Bay case study area. Data are displayed as graduated symbols (Jenks optimisation) where the size of the symbol indicates the count for the process at a survey site.

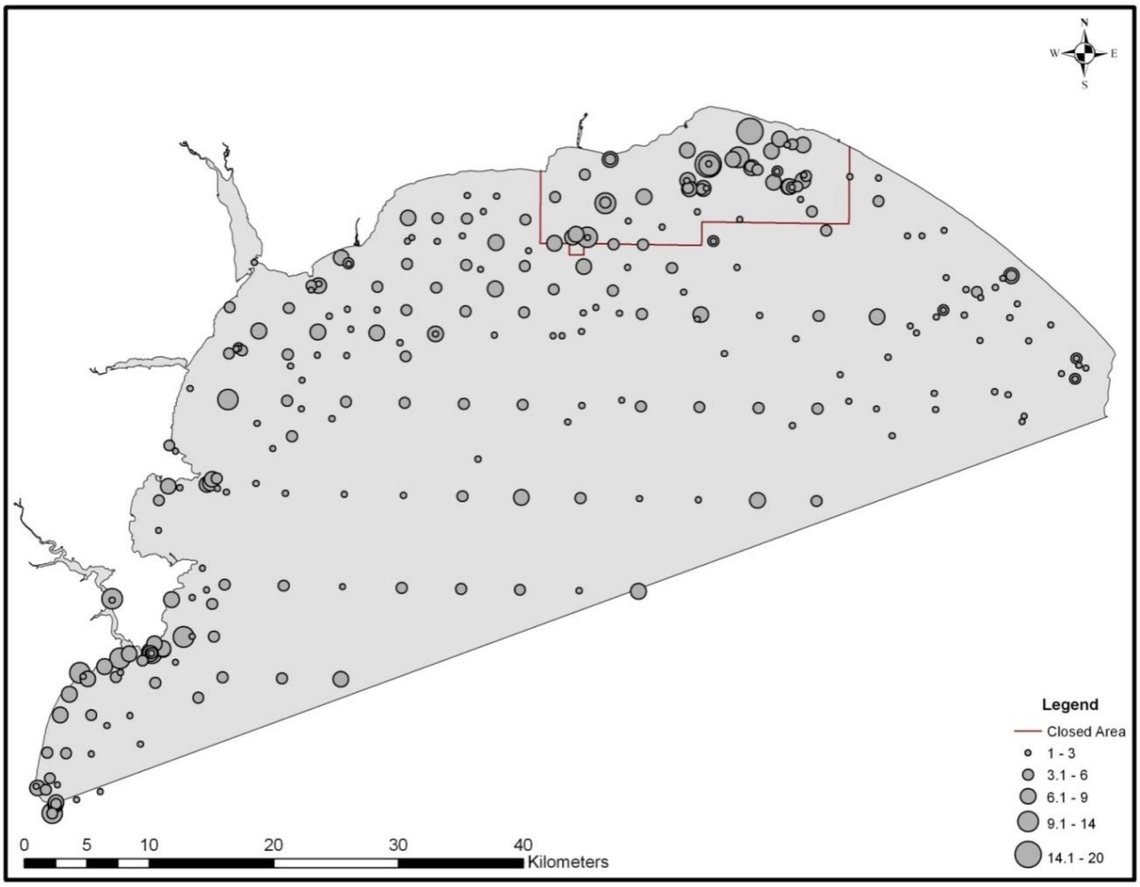


Figure 4.5: The delivery of the process of burial and enhancement of microbial decomposition facilitated by benthic species in the Lyme Bay case study area. Data are displayed as graduated symbols (Jenks optimisation) where the size of the symbol indicates the count for the process at a survey site.

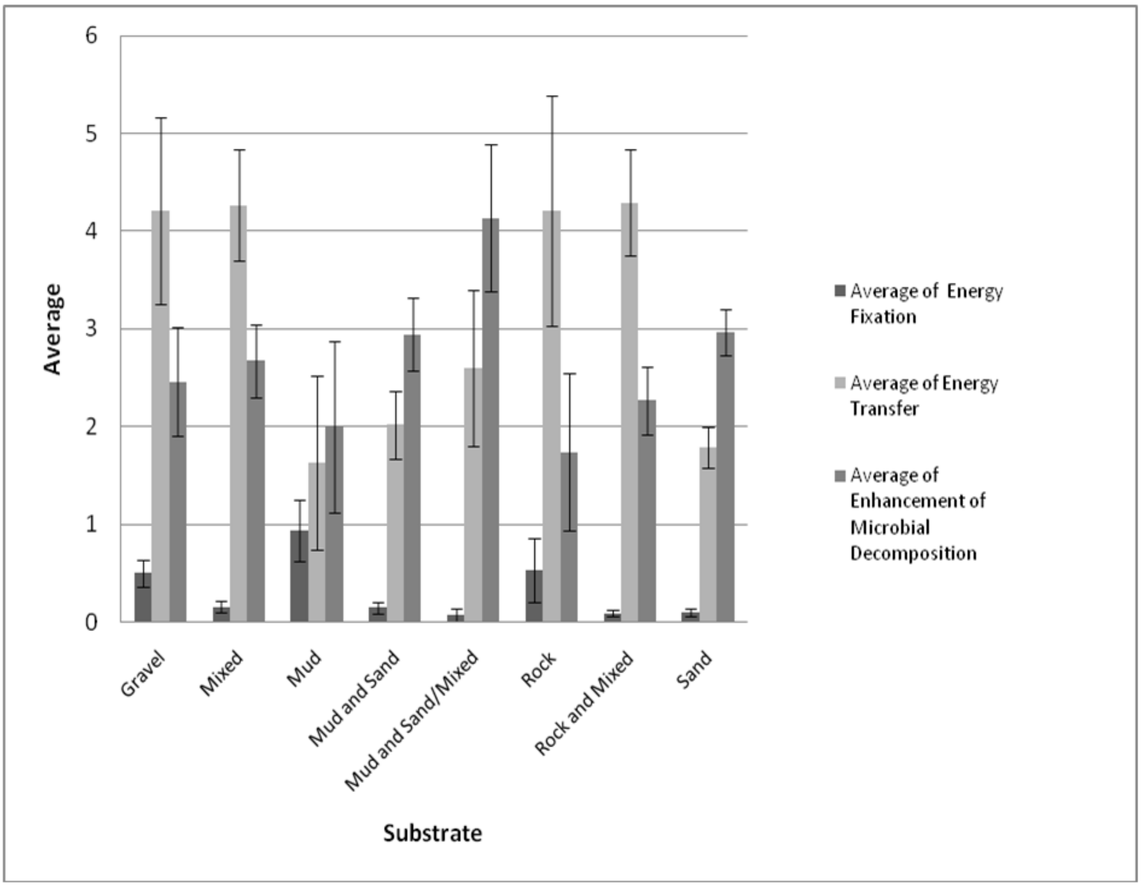


Figure 4.6: The relationship between substrate type and the delivery of the processes of energy fixation, energy transfer and the enhancement of microbial decomposition in the Lyme Bay case study area. The standard error of the mean is shown for each process within each substrate type.

4.4 Discussion

The ecosystem processes which can contribute to the delivery of the indirect ecosystem services of nutrient cycling, gas and climate regulation and the bioremediation of waste are facilitated by the benthic flora and fauna across Lyme Bay. The main spatial differences are that the energy fixation process is inevitably limited to the shallow waters where light penetrates the water column enabling primary production in the benthos. Energy transfer and the enhancement of microbial action are distributed broadly across Lyme Bay with the former favouring the harder substrates and the latter favouring the soft substrates.

4.4.1 Implications for conservation and management

The results show that the protected (closed) area within Lyme Bay contains benthos which could potentially contribute to the delivery of the ecosystem services of gas and climate regulation, the bioremediation of waste and nutrient cycling. However, the processes of energy fixation, energy transfer and the burial and enhancement of microbial decomposition are also delivered by benthic species across the substrate types throughout Lyme Bay.

4.4.2 How much function is there?

The use of BTA in this context enabled exploration of how the indirect services are delivered and spatial visualization of the potential for the benthic species to deliver these services. This approach, however, does not enable the amount of functioning to be quantified.

Previous research has focused on species richness (species biodiversity) or the range of traits within biological assemblages (functional diversity) to indicate an amount of functioning and therefore the delivery of all ecosystem services. However, no clearly defined relationship between species diversity and ecosystem functioning has been demonstrated (Chapin III et al., 2000;Ieno et al., 2006;Somerfield et al., 2008). Although functional diversity is considered to be the most relevant indicator of the link between function and ecosystem services there is no standardised metric (Petchey and Gaston, 2006;Somerfield et al., 2008). For example, a species may provide an ecological function that contributes to the delivery of all services or just one service (Petchey and Gaston, 2006). There is also considered to be significant functional redundancy within the marine environment (Snelgrove, 1997). In other words, areas that are functionally diverse may not provide more ecosystem function. Furthermore, different scenarios of biodiversity loss will affect the ecological function of benthos in different ways. This uncertainty makes it difficult to truly establish how subtle changes in biodiversity will affect ecosystem services (Snelgrove, 1998;Raffaelli, 2006).

Therefore a measure of ‘how much function’ there is or whether one marine habitat is more functionally important or valuable than another is not possible to quantify. This poses difficulties for conservation planning.

4.4.3 How much function do we need?

At present, on a local level in Lyme Bay or regionally, there is no perception or evidence that maintenance of the global climate, or the capacity of Lyme Bay to bioremediate waste, or the underpinning nutrient cycling is affected by human uses of the benthic environment. Unless an entire trophic type was removed from the system it is unlikely that any local effects would be noticed. For example, local extinction of filter feeders might cause increased turbidity. Unlike some direct use ecosystem services such as food provision and recreation, which are experienced and managed across local or regional scales, indirect services are broad, large spatial-scale ecosystem services.

In the near future, as marine spatial planning is implemented, marine managers will be required to make decisions and tradeoffs between spatially different ecosystem services (Kremen, 2005). In determining '*how much function do we need?*' managers will require an understanding of the potential contribution of all substrate types (and broad habitat types) to indirect service provision. They will also need to consider the impacts of human activities on the benthic environment and the sensitivity of some species to disturbance and how these in turn will affect service provision.

4.4.5 Other influences

The delivery of indirect ecosystem services is not solely linked to the ecological functions of benthic assemblages. Functioning is also affected by the physical and chemical properties of the system, e.g. tidal currents and pH (Hiscock et al., 2006;Bremner, 2008), as well as interactions between the pelagic and terrestrial systems. Analysis of the whole system remains impossible because of a lack of information on how these systems interact to provide these broad ecosystem services (Petchey and Gaston, 2006).

Ecosystem functioning is also strongly linked to microbial groups present in the marine environment. For example, in coral reef systems it has been found that the bioremediation of waste requires a diverse microbial community (Nystrom and Folke, 2001). Exactly how the larger macrobenthic organisms of this study impact upon microbial communities and hence impact upon microbially mediated ecosystem functions remains a research challenge (Petchey and Gaston, 2006).

4.4.6 Can we plan for the long term delivery of indirect services?

Integrating ecosystem services into conservation planning and management remains a key challenge (de Groot et al., 2010). Conservation planning in the marine environment focuses on marine habitats and species. The UK Joint Nature Conservation Council and Natural England (Ashworth and Stoker, 2010) propose that a network of marine conservation zones should include percentage targets for broad scale habitats classified at the European Nature Information System (EUNIS) level 3 and percentage targets for the inclusion of a select few species and habitats identified for protection in existing conservation legislation under the EU Habitats Directive, the UK Wildlife and Countryside Act (Biodiversity Action Plan (BAP) species) and the Oslo Paris Convention (OSPAR). Yet, there is no clear link between biodiversity and functional diversity.

Conservation policy that focuses on biodiversity alone may result in areas which are functionally important but not biodiverse being left out of the planning process (Frid et al., 2008). The inclusion of percentage targets for broad scale habitats in conservation is an essential precautionary approach to maintaining the long term delivery of indirect services.

4.4.7 Incorporating what we know into management.

The use of Biological Traits Analysis (BTA) is a practical application for planning for the long term delivery of indirect services. In this study the use of BTA increased spatial awareness of where the links are between the ecological functions of benthic species and their potential to contribute towards the delivery of the ecosystem services of gas and climate regulation, bioremediation of waste and nutrient cycling. This study develops only a partial assessment of ecosystem functioning in relation to indirect service provision. Yet incorporating what is currently known about the basic roles that marine species have in the delivery of ecosystem services can inform the progress of management and policy relating to the use and protection of the benthic natural resource.

In this instance, the presence of species across Lyme Bay which contribute to the processes of energy transfer and the enhancement of microbial decomposition provides a strong argument for the incorporation of the OSPAR recommendations to include percentage targets for broad scale habitats and to manage human activities within them. In response to the lack of information on ecosystem function, which species or habitats are critical for maintaining function and the delivery ecosystem services, there is a need to include 'uncertainty' into the planning process (Foley et al., 2010). A 'protect a bit of everything' approach is largely precautionary and should remain open to the principles of adaptive management (Salafski et al., 2001) as our understanding of the links between ecology, function and services improves.

Chapter five: A thematic cost-benefit analysis of a Marine Protected Area.

5.1 Introduction

Attesting to the fact that humans are components of ecosystems, the authors of the Millennium Ecosystem assessment refocused the international conservation debate by explicitly linking the constituents of human well-being (security, health, access to materials for a good life and social relations) to the services provided by functioning ecosystems (Millennium Ecosystem Assessment, 2005). By providing this anthropogenic link as a focus of policy development, this approach provided a firm footing for the concept of ecosystem based management (considering the social, ecological and economic aspects) in the development of conservation planning and policy.

In the marine environment, it is recognised that management measures to enable ecosystem functioning must be maintained if the flow of ecosystem services to humans is to continue (OSPAR Commission, 2006;European Parliament and Council, 2008). Marine Protected Areas (MPAs) are the main tool in the conservation planning toolbox for protecting elements of ecosystem functioning. As such, the MPA literature largely has an ecological focus (Thorpe et al., 2011). It is increasingly becoming recognised within this planning and designation process that humans are integral to ecosystem processes, often referred to as the social-ecological system (Armsworth et al., 2007;Curtin and Prellezo;Pollnac et al., 2010). The establishment of an MPA can potentially impact numerous socially charged issues (Mascia et al., 2010) which, if ignored or compartmentalised, can result in the failure of the MPA to meet the ecological objectives for which it was primarily designed (Christie, 2004). Indeed research shows that because marine reserves are at the interface between social and ecological systems, short term biological gains associated with MPA designation may be compromised unless social issues are addressed in the planning and management process (Christie et al., 2003;Christie, 2004;Klein et al., 2008a;Pollnac et al., 2010;Rosendo et al., 2011).

In the UK, recognising that social and ecological systems are intrinsically linked has shaped the development of marine conservation planning policy so that social, economic and ecological factors are considered together in the planning process (Defra, 2008d;European Parliament and Council, 2008;HM Government, 2011). The UK administration is committed to substantially completing an ecologically coherent network of MPAs by 2012 as part of a broad-based approach to nature conservation (HM Government, 2011). Even though it is well established in the scientific literature that social complexities need to be included in the MPA planning process (Mascia, 2003;Fabinyi et al., 2010;Pollnac et al., 2010), planning in the UK, prior to the Marine and Coastal Access Act 2009, focused on ecological systems and/or fisheries economics and largely left out the broader social context (Rees et al., 2010a).

Following the implementation of the UK Marine and Coastal Access Act in 2009, the involvement of stakeholders in the MPA planning process is underwritten in UK law (HM Government, 2009). In the MPA network planning process stakeholders are involved in the spatial decisions over where MPAs may be sited in relation to defined ecological criteria and resource use patterns. However, final decisions, which must be signed off by the UK Secretary of State, are informed by an Impact Assessment. The formal Impact Assessment process advocates a ‘goods and services’ approach and a range of monetary valuation techniques are provided to assess the costs and benefits of different policy options (Defra, 2008a). Whilst valuing decisions for marine conservation in this manner provides the essential function of translating ecological complexity into a format that can be readily understood and used by mangers and policy makers (De Groot et al., 2002), this framework is not meaningful to the general public who connect culturally with the concepts of nature, place and landscape rather than services (Watson and Albon, 2011). Indeed, presenting the monetised costs and benefits can do little to change the behaviour of stakeholder groups regardless of economic benefits if they feel marginalised from the decision making process (Pollnac and Pomeroy, 2005). It is therefore the equitable sharing of the perceived costs (which result from an MPA policy) and perceived benefits (which are the result of protecting ecosystem services) amongst local stakeholders, and a participative decision making forum, which can have an impact on the success of a protected area policy (Adams et al., 2004;Christie et al., 2009;Mascia et al., 2010;Jones et al., 2011).

The policy goals (benefits) of an MPA can mean different things to different stakeholders (Jentoft et al.) and all perspectives must be considered in decision making. To provide insight into social issues in decision making and management this research focuses on a case study area where a 206 km^2 MPA was designated in 2008. The aim of the study is to:

1) Assess the extent of support for the MPA policy;

2) Document the costs and benefits of the MPA designation from the stakeholders' perspective;

3) Make recommendations as to how results can inform adaptive management in the case study area; and

4) Make recommendations for the wider MPA network due to be instated in UK waters in 2012.

5.1.1 Study area

Lyme Bay is located in south-west England, UK, encompassing a sea area of 2460 km^2 (Figure. 5.1) and contains marine habitats that are important for conservation on both a national and international scale. The offshore reef areas have been identified as a potential Special Area of Conservation (pSAC) under the European Union's Habitats Directive (92/43/EEC) for the Annex 1 habitat criteria for reefs. The reef substratum hosts species such as the pink sea fan (*Eunicella verrucosa*), which is nationally uncommon (Hiscock, 2007), and the sunset cup coral (*Leptopsammia pruvoti*), which is nationally rare (Jackson, 2008). The Bay supports both a fishing and leisure and recreation industry (Stevens et al., 2007;Rees et al., 2010b). Following a government consultation exercise, a 206 km^2 MPA was designated by the UK government in July 2008 to protect a section of the reef substrate from the impact of trawl and dredge fishing gear (Defra, 2008c).

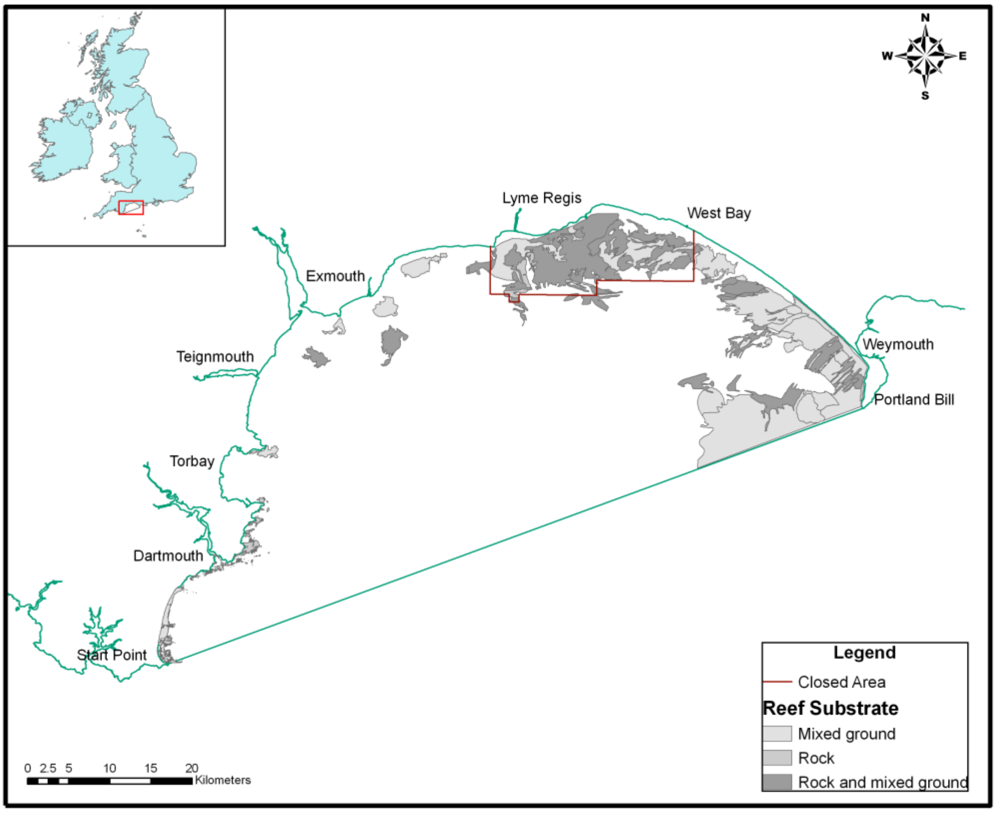


Figure 5.1: Map of Lyme Bay showing local towns, the Lyme Bay MPA and the areas of reef substrate.

5.2 Methods

5.2.1 Primary data

Five questionnaires were developed to collect data on the perceptions and attitudes of the main Lyme Bay stakeholder groups towards the closure (Appendix 1). These stakeholder groups comprise of commercial fishermen, sea anglers, dive businesses, divers and charter boat operators. The questionnaires were repeated each year for the three year duration of this project 2008 - 2010. A combination of methods (e-mail, postal surveys, web forums, face to face interviews, telephone interviews) were used to gather the data, with every effort made to contact stakeholders in the Lyme Bay area. An approximate number of stakeholders that are known to undertake the activity in the vicinity of the MPA are provided along with the number of stakeholders who took part in the research and the sample size (Table 5.1).

	Fisherman (mobile gear)	Fisherman (static gear)	Fisherman (scallop diver)	Diver	Charter boat operator	Dive business owner	Angler
Approximate number of stakeholders in Lyme Bay [a]	50 [a1]	90 [a2]	1 [a3]	724 [a4]	51 [a5]	10 [a6]	2106 [a7]
Number of stakeholders involved in this research between 2008 and 2010	19	34	1	78	27	9	73
% of stakeholder group	38.0	37.8	100.0	10.8	52.9	90.0	3.5
Number of questionnaires completed by this group between 2008 and 2010 [b]	22	49	3	93	35	14	93
Number of questionnaires with qualitative data 2008 and 2010 [c]	22	49	1	51	29	14	68

[a] The approximate number of stakeholders undertaking their activity in the vicinity of the Lyme Bay MPA. Source: a1, a2, a3 (Defra 2008), a4, a5, a6 and a7 (Rees et al 2010)

[b] Questionnaire were made available to all stakeholder groups each year. Some respondents repeated the questionnaire each year (e.g. the dive business owners) other stakeholders only participated once or twice between 2008 and 2010.

[c] Qualitative data was extracted from all questionnaires between 2008 and 2010. Some stakeholders did not provide answers to the qualitative questions each year. To create the thematic framework each opinion from each stakeholder was only coded once during the 3 year period. So if a stakeholder repeated a theme each year it was only recorded once.

Table 5.1: Table showing the approximate number of stakeholders operating in the vicinity of the Lyme Bay MPA and the number of stakeholders involved in this research between 2008 and 2010.

In order to elicit stakeholders attitudes towards the MPA, respondents were asked the question ‘to what extent do you support the MPA policy in Lyme Bay’. Responses were given on a Likert scale where 1= no support and 5 = fully support. Qualitative data were also gathered from a series of open ended questions relating to the respondents’ views on the MPA policy and the advantages and disadvantages of the MPA policy.

5.2.2 Data analysis

The mean and standard deviation were calculated for each stakeholder category for each year (2008, 2009 and 2010). Using the Likert data provided by respondents, data were tested for normality using the Shapiro-Wilks test. None of the data fitted normal distribution and therefore the degree to which opinions vary within stakeholder groups by year was analysed using a non-parametric independent samples Kruskal-Wallis test.

The qualitative responses gathered in the surveys were extracted and analysed using the text analysis software NVivo8 (QSR International, 2010), which enables analysis of open ended responses and allows coding of themes. The analysis involved coding responses into a thematic framework of environmental statements (reflecting the respondents' perception of the species and habitats in Lyme Bay); economic statements (reflecting the respondents' perception of changes in income, turnover or expenditure relating to the MPA policy) and social statements (reflecting the respondents' perception of the social impacts of the closure). These statements were further evaluated and coded into themes which were either positive (benefits) or negative (costs).

Relationships between statements in the thematic framework were analysed using NVivo 8 (QSR International, 2010) by setting a relationship link between statements when a stakeholder provided a statement which could be coded under two separate themes. A count of each relationship link was determined by the number of times the relationship link between themes was made by the stakeholders.

5.3 Results

5.3.1 Measure of support for the Lyme Bay MPA policy

The results show that the majority of stakeholders support the MPA policy in Lyme Bay (Figure. 5.2). All stakeholders from the leisure and recreation sector show support for the MPA with consistent responses on the Likert scale between 2008 and 2010 of 4 or higher. Findings show that mobile gear fishermen have the lowest support for the MPA policy followed by static gear fishermen, while sea anglers show the highest support (Figure 5.2). The level of support for the closed area policy by mobile gear fishermen decreased significantly between 2008 and 2009 ($p < 0.05$), while support from static gear fishermen increased significantly between 2008 and 2009 ($p < 0.001$) over the three years.

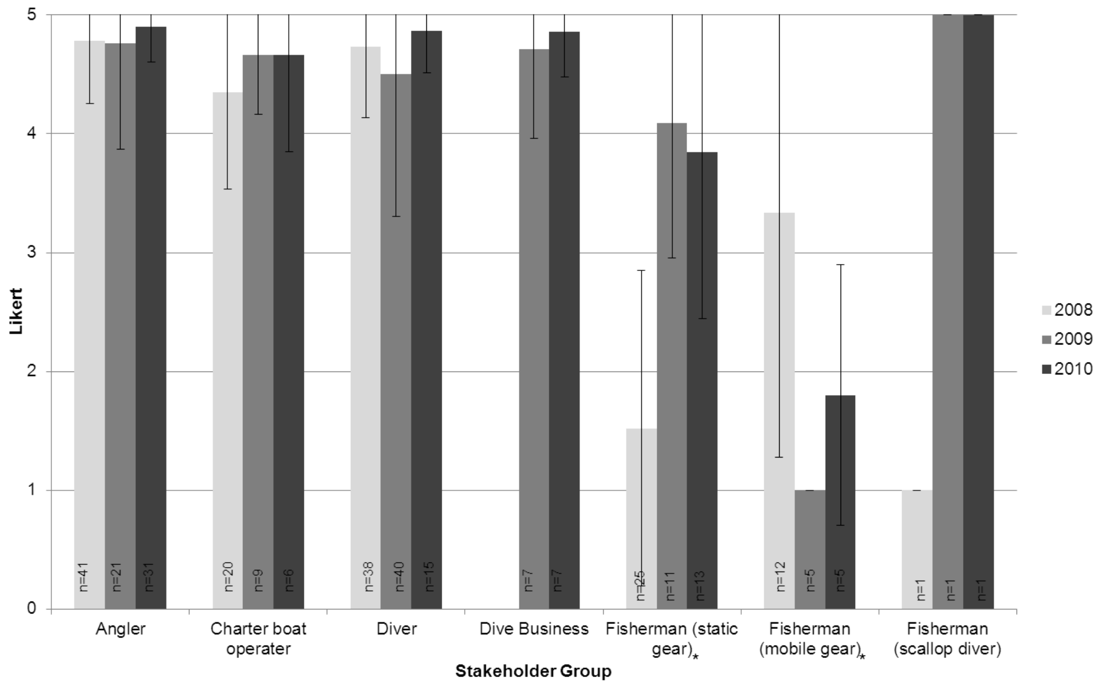


*Figure 5.2 On a scale of 1-5 where 1= no support and 5 = fully support to what extent do you support the closed area policy (MPA) in Lyme Bay? Bar chart showing the mean and standard deviation of Likert scale responses for each stakeholder group who took part in the survey between 2008 and 2010. Variance in the range of means across years within each stakeholder group was analysed using Kruskal-Wallis test. * = significant differences at $p < 0.05$; n = sample size.*

5.3.2 Thematic framework

The thematic framework (Table 4.2) demonstrates that there are numerous economic, social and environmental costs and benefits of the MPA policy in Lyme Bay as perceived by different stakeholder groups. Each stakeholder group can be identified in the following results section by initials e.g. CB= Charter boat operator, D= Diver, DB = Dive Business, A= Angler and F = Fisherman.

	Total sources	Charter boat operator n=29	Diver n=51	Dive business owner n=24	Angler n=68	Fisherman (static gear) n=44	Fisherman (mobile gear) n=22	Fisherman (scallop diver) n=1	Percentage of total sources n=357
Economic benefits									
More fish	22	2	8	4	3	4	0	1	6.2
Increased tourism	16	4	6	2	3	0	0	1	4.5
Gear safety	14	0	0	0	0	12	1	1	3.9
Increased spending in local businesses	11	5	1	2	3	0	0	0	3.1
Increased catches or improved catch quality	7	1	0	0	0	6		0	2.0
Increased fishing effort in the closed area	8	0	0	0	0	7	1	0	2.2
Less gear conflict	8	0	0	1	0	5	1	1	2.2
Future business security	1	0	0	0	0	0	0	1	0.3
Economic costs									
Displacement affecting traditional property rights	17	1	0	2	0	8	6	0	4.8
Increased costs	13	0	0	0	0	4	9	0	3.6
Gear conflict (loss and damage outside MPA)	6	0	0	0	0	6	0	0	1.7
Loss of profit	6	0	0	0	0	3	3	0	1.7
Poor catch quality (outside MPA)	2	0	0	0	0	0	2	0	0.6
Job losses	1	0	0	0	0	0	1	0	0.3
Environmental benefits									
Potential to protect biodiversity and allow habitat recovery	51	6	19	5	17	3	0	1	14.3
More fish and shellfish	30	4	3	0	16	7	0	0	8.4
More biodiversity and habitat recovery	13	1	7	1	0	2	0	2	3.6
Less suspended sediment	3	0	1	0	2	0	0	0	0.8
Environmental costs									
Displacement of trawling activity affecting biodiversity and habitats (outside MPA)	10	0	0	3	4	2	1	0	2.8
Increase in effort within the closed area affecting biodiversity and habitats	7	2	1	1	1	0	2	0	2.0
Decline in fishing quality	1	0	0	0	1	0	0	0	0.3
Social benefits									
Improved recreation experience	21	2	7	0	12	0	0	0	5.9
Decreased social tensions	6	0	1	1	0	4	0	0	1.7
Increase in environmental awareness	5	1	2	1	1	0	0	0	1.4
Benefits to the wider public	4	0	2	1	0	1	0	0	1.1
Job and enterprise opportunities	3	1	0	0	0	1	1	0	0.8
Opportunity for sustainable fishing industry	3	0	1	0	1	0	0	1	0.8
Less travelling time to fishing grounds	1	0	0	0	0	1	0	0	0.3
Social costs									
Increased social tensions (ouside MPA)	21	5	0	0	6	9	1	0	5.9
Unfairness and discrimination	17	2	1	1	0	3	10	0	4.8
Increased time and effort fishing	9	0	0	0	0	3	6	0	2.5
Negative effect on recreation experience (outside MPA)	6	3	0	0	3	0	0	0	1.7
Increased dangers for fishermen	4	0	0	0	0	1	3	0	1.1
Loss of employment	4	0	0	0	0	1	3	0	1.1
Loss of traditional property rights	4	0	0	0	0	0	4	0	1.1
Financial hardship	1	0	0	0	0	0	1	0	0.3
TOTAL number of statements		40	60	25	73	93	56	9	

Table 5.2 The economic, environmental and social costs and benefits of the Lyme Bay MPA as perceived by stakeholder groups between 2008 and 2010. Results are presented as a count of coded statements for each stakeholder group. The shading of cells from light to dark indicates coding density under each theme by each stakeholder group. The darker the shading the more

statements coded under that theme. Unless otherwise stated, costs and benefits relate to inside the MPA.

5.3.3 Economic costs and benefits

The most common statement under economic costs and benefits theme is the potential of the MPA to provide more fish (22 sources, 6.2% of total statements; Table 4.2) e.g. '*Fishermen will benefit in the future from the overspill'* (CB9). This sentiment of future economic benefits is supported by seven of the eight stakeholder groups with the most statements provided by divers and dive business owners.

The second most common economic theme is linked to an economic cost of the MPA whereby displacement has affected traditional property rights (17 sources, 4.8% of total statements; Table 4.2). Statements coded under this theme relate to the economic disadvantages resulting from boats displaced from the MPA including increased competition for resources e.g. '*By closing the area it has affected other areas. Small boats such as ours have been pushed into an ever small area. We are not large enough to fish elsewhere'* (F12). Statements relating to displacement effects were most commonly mentioned by the static and mobile gear fishermen (Table 4.2). Also mentioned under this theme was the impact of the MPA on a business resource resulting from displacement of fishing vessels e.g. '*Swyre Ledges have been ruined in the last two seasons. I have a group* [of divers] *from Yorkshire who used to come every year but now they say the ledges are like a ploughed field'* (CB11).

Other economic benefits of the MPA policy perceived by stakeholders in Lyme Bay are the potential for increased tourism (16 sources, 4.5% of total statements; Table 4.2) e.g. '*More people will come to the area because of the*

MPA' (CB1) and fishing gear safety inside the MPA '*I am working more pots due to no risk of gear being towed away by scallopers' (*F45).

5.3.4 Environmental costs and benefits

The environmental benefit of the Lyme Bay MPA policy to potentially protect biodiversity and allow habitat recovery is the theme with the most recorded sources (51 sources, 14.3% of total statements; Table 4.2). All stakeholder groups apart from the mobile gear fishermen have had statements coded under this theme. Included in this theme are stakeholders perceptions of what the MPA policy will provide in the future. This theme contains different statements to the 'more biodiversity and habitat recovery' theme (13 sources, 3.6% of total statements; Table 4.2) as these statements are realised advantages e.g. 'The *number of scallops was amazing; the reef is starting to recover well'* (D60), rather than perceptions of the future potential of the MPA.

Perceptions coded under the potential of the MPA to protect biodiversity and allow habitat recovery are based on future unrealised advantages e.g. *'The fishing and marine life will now flourish'* (A28) and *'I can't wait for it to return to the stunning area it used to be in the 90s'* (D48). In addition statements under this theme include the potential of the area to provide a refugium and nursery ground for fish stocks e.g. '*Fish will have more chance to spawn in peace'* (F40) and, '*as fish move around others areas will benefit from a safe breeding area'* (A38). Also mentioned under environmental benefits are statements relating specifically to the MPA and the presence of more fish and shellfish (30 sources, 8.4% of total statements; Table 4.2) e.g. '*we see more flatfish caught since the closure, especially dabs'* (A18). These statements are most commonly mentioned by the angling community.

The most statements of the perceived environmental costs of the MPA relate to comments from dive business owners (5 statements; Table 4.2) and anglers (6 statements; Table 4.2) who have stated that the displacement of trawling activity is affecting biodiversity and habitats outside of the MPA e.g. '*The area that was closed was already trashed and now the bigger boats have moved onto new areas'* (DB4).

5.3.5 Social costs and benefits

The most common social benefit of the MPA policy mentioned by stakeholders, most notably the angling and diving community, is the improvement in recreation experience (21 sources, 5.9% of statements; Table 4.2) e.g. '*The diving is of better quality due to the undisturbed sea bed'* (D43).

The most common social costs are most strongly felt by the mobile gear fishermen who feel a sense of unfairness and discrimination (17 sources, 4.8% of total statements; Table 4.2) resulting from a policy that has affected their traditional user rights, e.g. '*This area has been fished for generations. What happened to the gentlemen agreement* [the voluntary closures] *why bother?'* (F21) and '*whilst a lot of good will come in time from this policy, it was wrong to deny families who had fished for generations in this area the right to do so'* (F39). Other members of stakeholder groups have provided statements concerning the fairness of the MPA indicating a local sense of empathy with the mobile gear fishermen who have been affected.

Other stakeholder sectors have stated that the MPA has resulted in increased social tensions (21sources, 5.9% of total statements; Table 4.2). This perception is most commonly mentioned by the static gear fishermen who mainly operate outside of the MPA e.g. '*I know of one 10m crabber was told by* *a scalloper to move it* [crab pots] *or lose it'* (F12) and *it* [a fishing boat] *missed me by about 20 yards only. I shouted and got a mouthful of abuse back'* (A56).

5.3.6 Overall perceived costs and benefits

In terms of the most common theme for each stakeholder group, charter boat operators, divers, dive business owners, the scallop diver and anglers all provided the most statements coded under the environmental benefits of the potential of the MPA to protect biodiversity and allow habitat recovery (Table 5.2). Static gear fishermen have stated that the economic benefit of the closed area is to provide safety for their gear as the main advantage of the MPA from their perspective (Table 5.2). Themes that are most common to the mobile gear fishermen are the social and economic costs resulting from having to fish outside of the MPA and a strong feeling of unfairness and discrimination of the MPA policy (Table 5.2). Static gear fishermen provided the most statements out of all the stakeholder groups (Table 5.2).

With all stakeholders considered together, the perceived benefits of the MPA represent over 63% of the statements coded and the perceived costs represent 37% of the coded statements (Figure. 5.3). The perceived economic and environmental benefits of the MPA are greater than the perceived economic and environmental costs; however, stakeholders are registering more perceived social costs than benefits from the MPA. The balance of perceived costs and benefits varies across stakeholder groups (Figure.5.3).

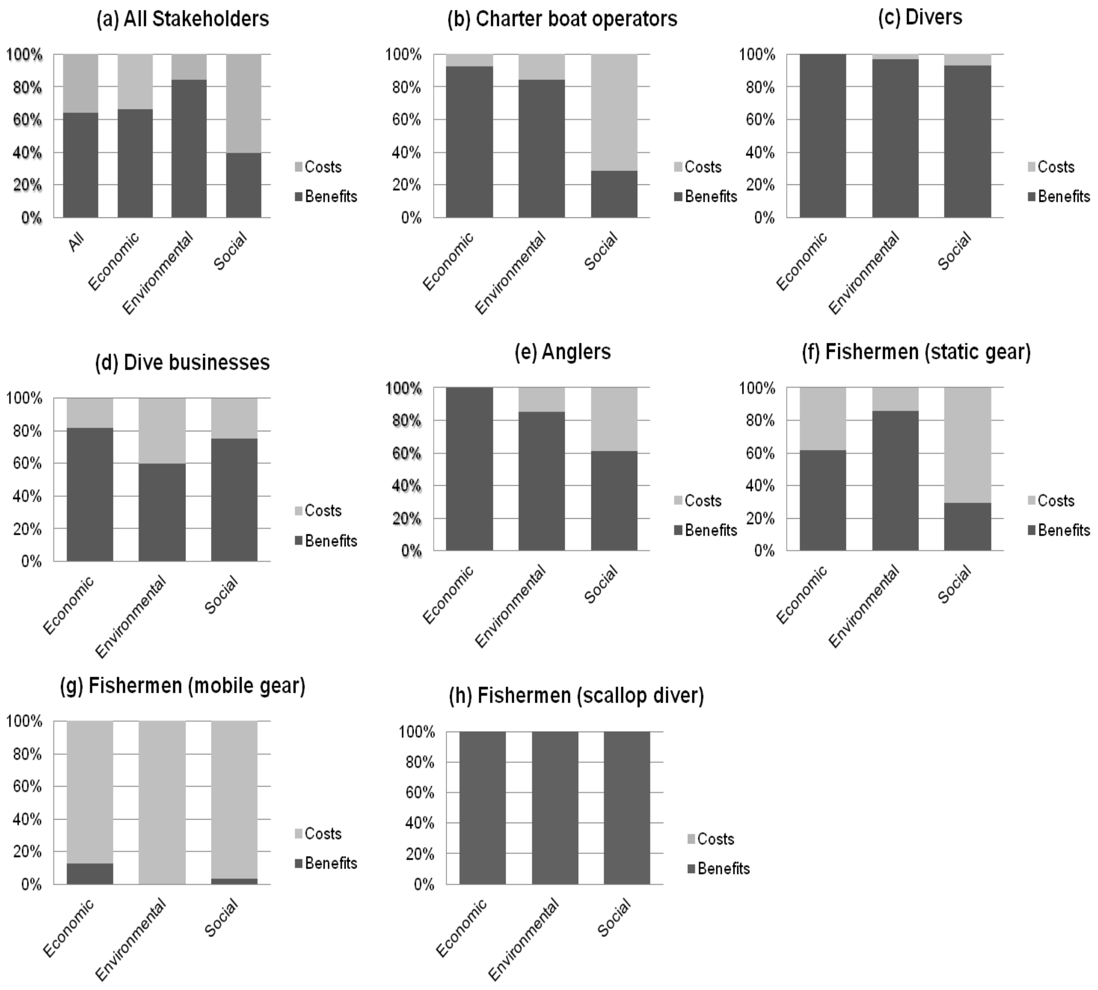


Figure 5.3 the perceived costs and benefits of the Lyme Bay MPA for a) all stakeholder groups and b) to h) individual stakeholder groups. Results presented as percentage of coded statements in each theme.

5.3.7 Relationships between themes

The relationship between themes is demonstrated in Figure.5. 4. Stakeholders do not view any of the themes in isolation, all are connected. The most common link is between the environmental benefit of the MPA to protect biodiversity and allow habitat recovery and the economic benefit of there being more fish to catch. Other relationship links captured include the environmental benefit of there being more fish in the MPA and the economic benefit of being able to catch more fish and shellfish. Increased economic cost is linked to the social cost of increased time and effort fishing (Figure. 5.4). The loss and damage of gear as an economic cost of the MPA is also linked to the social cost of increased social tensions (Figure. 5.4).

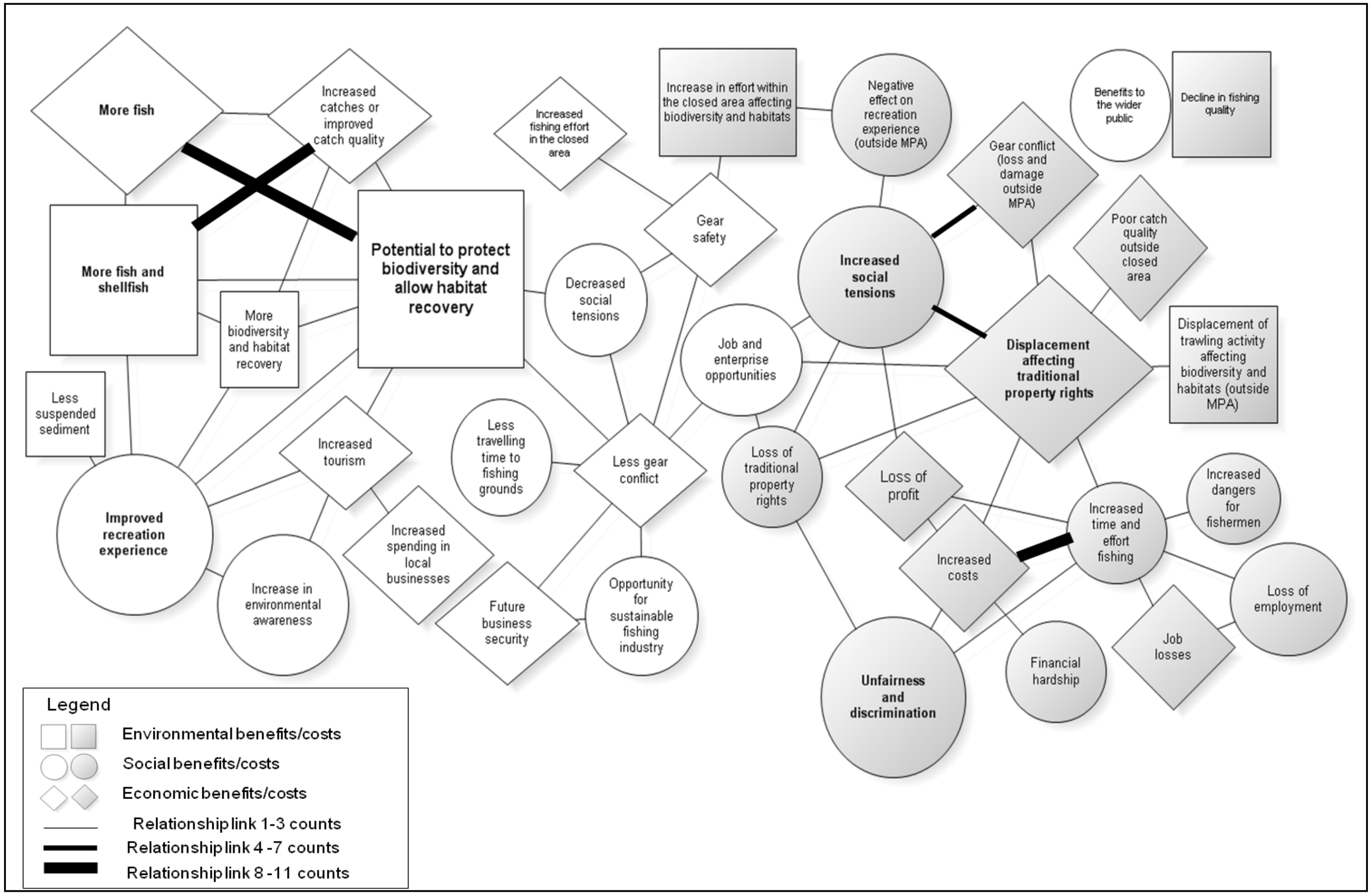


Figure 5.4 the economic, environmental and social costs and benefits and the relationship between themes of the Lyme Bay MPA as perceived by all the stakeholder groups. The size of the shape is in proportion to the number of coded statements in each theme

5.4 Discussion

The results show that the majority of stakeholder groups interviewed for this research support the MPA policy in Lyme Bay; however, the level of support and the motivation for support (or lack of support) for the MPA differs between stakeholder groups. To ensure ongoing support for the MPA, and to achieve the conservation policy objectives intended during its establishment, the following should be considered.

5.4.1 Providing for different stakeholder opinions in management

The management of MPAs has long discussed ‘balancing’ the needs of different stakeholder groups when in reality win-win situations are difficult to realise (Rees et al., 2010a;McShane et al., 2011). Part of the difficulty in providing for all opinions in management is the issue of fair representation of stakeholder groups. Decision making at a local level (namely at workshops and forums) can be influenced by powerful or vocal groups, those with covert agendas and elite individuals (Lane and Corbett, 2005;Jentoft et al., 2011). In addition, their relative importance (if measured democratically as numbers of stakeholders) may be disproportionate to the economic importance of an activity. Economics has traditionally been an emotive subject in conservation planning. As such, economic valuations (in particular fisheries economics) have typically dominated the decision making process when, as in Lyme Bay, they do not necessarily represent the largest economic input to the local area (Rees et al., 2010a). Standardising the results across the stakeholder groups also raises issues of representation and fairness as, for example, the diving and angling community are largely unregulated and with numerous access points. Their true numbers remain an unknown quantity.

Rather than a focus on monetary values, the framework provides stakeholders and decision makers with the necessary information on the intricacies of social issues in order to openly reveal, and honestly discuss, the tradeoffs and 'hard choices' which are a real impact of the realignment of property rights following an MPA designation (McShane et al., 2011); therefore, a balance is not sought. Overall the strength of this thematic framework of perceived costs and benefits brings issues to the forefront that, if left unresolved, may delay or impede the conservation objective (Agardy et al., 2003).

5.4.2 How to manage expectation

Support for the MPA is based on the perception of the potential for the MPA to protect biodiversity and allow habitat recovery. In some cases this future benefit is linked to an economic benefit resulting from the presence of more fish. There is clearly an expectation which is currently unsupported by scientific evidence from the biological monitoring of the MPA (Attrill et al., 2011). Such support is not surprising and inflated expectations have been recorded in MPAs elsewhere (Yasué et al., 2010). MPAs are considered to be the flagship of conservation policy for protecting marine biodiversity: the concept of 'protection equals benefits' has been disseminated to stakeholders via national media campaigns instigated by NGOs and statutory conservation agencies in order to raise them in the political agenda. So, whilst 'protection equals benefits' may be true in some instances (Russ et al., 2008;Pollnac et al., 2010), the linked social-ecological system is proving to be complex (Levin, 2005).

It has been 3 years since the Lyme Bay MPA was designated and biological surveys of the MPA have shown indicators of 'recovery' of the rocky reef habitat (Attrill et al., 2011). It is also recognized within this biological study that any wider benefits from the MPA policy resulting from recovery of the rocky reef habitat will be long term. In order to manage expectation and maintain support it is necessary to work with stakeholders to define ‘what success will look like’ and set goals and objectives to monitor progress. This thematic framework has demonstrated these areas of expectation. If MPAs are to be the front line in marine conservation efforts, to halt the loss of biodiversity by 2020 and maintain ecosystem function, and therefore ecosystem services, then the development of such goals and objectives must be grounded in the ‘real interests’ people have in the benefits of conservation (Perrings et al.). The definition of goals and objectives for an MPA within an adaptive management process can improve communication and standardise stakeholder expectations of the benefits of an MPA policy (Lundquist and Granek, 2005).

5.4.3 Managing marginalized groups

The reordering of property rights in this case study area has meant that the mobile gear fishermen and the mixed gear fishermen have borne the brunt of this policy instrument as they are no longer free to make a living from a section of their traditional fishing grounds. Ongoing resource depletion arising from noncompliance with MPA regulations, and failure to meet conservation objectives in protected areas, can be traced to the actions of marginalized groups (Mak and Moncur, 1998;Adams et al., 2004;Kritzer, 2004;Jones et al., 2011). Mobile gear fishermen perceive the MPA to have a social cost, namely that it is unfair and discriminatory. They are also the stakeholder group which provided the most comments on the economic costs of the MPA. As this group of stakeholders has the potential to impede the biological recovery of the MPA, it is imperative that they are not marginalized from the MPA management process.

In recognition of the plurality of economic, social and environmental factors at play in an MPA, and the different aspects of the costs and benefits of the MPA policy in decision making to different stakeholder groups, future governance must take its lead from an adaptive management process that is constantly informed by rigorous monitoring of the defined goals and objectives (Salafsky, 2011). Governance partnerships can contribute to balanced decision making and engender a perception of 'fairness' amongst stakeholders regarding policy changes (Bavinck and Vivekanandan, 2011). Creating a forum for ongoing dialogue in Lyme Bay, e.g. a management group, would enable stakeholders to remain involved in the management of their resource base.

It is equally important to manage marginalized groups outside the MPA. In this case study, displaced vessels have been identified as causing economic, social and environmental costs outside of the Lyme Bay MPA. Management actions that fail to address the 'outside' MPA as well as 'inside' MPA costs and benefits will hinder the success of the MPA policy (Cicin-Sain and Belfiore, 2005;Bavinck and Vivekanandan, 2011).

5.4.4 Scaling up to a network of MPAs

Local level support for an MPA can provide the necessary foundation for scaling up to a network (Ban et al., 2009). Defining the perceived costs and benefits of this MPA may provide managers with pre-emptive information on challenges they may face, but the prospect of scaling up to a network also brings new challenges.

International experience of networks of marine protected areas has demonstrated that unresolved social issues have prolonged progress towards conservation objectives, e.g. the Great Barrier Reef Marine Park and the MPAs created under the Californian Marine Life Protection Act (Klein et al., 2008b;Russ et al., 2008). In addition, international examples of MPA network success and failure have shown that if institutional capacity to deal with local issues is exceeded, then the network is likely to fail (Christie et al., 2009).This is particularly true in reference to the capacity to monitor and enforce an MPA (Lundquist and Granek, 2005). An institutional capacity assessment of the UK authorities to manage and monitor the UK network is therefore essential.

Values associated with the social, environmental and economic costs and benefits of an MPA will differ depending on scale and different tradeoffs will become apparent (Levin, 2005;Giller et al., 2008). Therefore an additional commitment must be made to deliver a comprehensive social science research agenda that monitors the distribution of costs and benefits alongside the biological research agenda (Christie, 2004).

Chapter six: Conclusion

6.1 Introduction

It is well documented that marine ecosystems provide a number of essential ecosystem services, such as climate regulation and nutrient cycling, which underpin life on earth and are essential to maintain human well-being (Millennium Ecosystem Assessment, 2005;Beaumont et al., 2007;Austen et al., 2011). The development of descriptors (Beaumont et al., 2007) to translate the complexity of marine ecosystem functions into marine ecosystem services has resulted in a broader range of values included in policy. As such, the consideration of economic, social and ecological values in decision making (the ecosystem approach) via defining and valuing ecosystem services has become integral to marine conservation planning and policy in the UK (OSPAR Commission, 2006;European Parliament and Council, 2008;HM Government, 2009;HM Government, 2011). At the inception in of this PhD project in 2007, case studies that focussed on the practical application of this concept in marine conservation planning and management had been recommended in order to integrate ecosystem services and valuation into decision making (Beaumont et al., 2006).

In 2008, the statutory closure of reef habitat in Lyme Bay, UK to fishermen using dredges and demersal trawls (Defra, 2008c) provided an opportunity to undertake research that would further understanding of the economic, social and ecological values associated with ecosystem goods and services in a conservation context. Between 2007 – 2011, four studies were undertaken that demonstrate the practical application of valuation techniques. These valuations of the case study area are exploratory in nature. Therefore each valuation technique could be expanded in scope e.g. to a wider set of stakeholder groups.

The key points from each study are discussed below and considered in relation to the overall aim of the thesis and recent developments in this field of valuation.

The aim of this thesis was to develop an integrated approach to value marine conservation. The objectives of this work are to:

1. determine the economic, ecological and social values associated with ecosystem services in a decision making context;
2. test methodologies for the practical application of economic, ecological and social valuation; and
3. Make recommendations to include ecosystem services and their value in decision making for marine nature conservation.

6.2 Value and decision making

This research has demonstrated (chapter two) that decision making for UK marine nature conservation, in the absence of a statutory framework, was typically an unstructured process where the values of different stakeholder groups were pitted against each other, with each group vying to make their case with policy makers. It also demonstrated that despite an extensive body of research into the vulnerability of the reef habitat to physical disturbance, the UK government were unable or unwilling to make a decision in favour of nature conservation. Ultimately the state of play was altered when a public consultation was instigated and stakeholders responded to support the closure of the reefs on a statutory basis. Evidence that demonstrated the economic importance of the reef habitat to a broader range of stakeholders other than the scallop fleet was influential in the decision making process.

This chapter was written in 2008 and so enabled a forward look towards the development of the UK Marine and Coastal Access Act (H.M. Government, 2009) in relation to the designation of a network of MCZs. The conclusion from this research recommended that, in the decision making process for nature conservation, the value associated with marine ecosystems must be considered in its broadest sense (ecological, economic and social values). Focussing on economics alone can obscure wider values associated with ecosystems. In addition, the government must work to develop a framework by which these values can be assessed.

The Marine and Coastal Access Act (2009) has since entered into force and rapid progress has been made in developing a network of MPAs and MCZs. In September 2011, recommendations for MCZs in English and offshore Welsh waters were published (Balanced Seas, 2011;Irish Sea Conservation Zones, 2011;Leiberknecht et al., 2011;Net Gain, 2011). These recommendations are to be reviewed by an independent scientific advisory panel and the statutory nature conservation agencies. Final recommendations will be put forward to Government in 2012. Each report is supported by an impact assessment that has a predominant economic focus. The recommendations from this chapter therefore still stand and the results demonstrate that methodologies to assess the broader values associated with marine conservation need to be included in decision making.

6.3 Economic valuation

This research (chapter three) developed a methodology for valuing the leisure and recreation industry in Lyme Bay. The monetary turnover of dive businesses and charter boat operators when combined with the expenditure of divers and sea anglers totalled approximately £17 million per year. When compared with landing values of the scallop fleet of £1.8 million a year, the use of economics provides a mechanism through which to compare the economic importance of two respective stakeholder groups. The research also shows that when economic valuations are applied spatially, individual sites may be assigned a relative economic importance or value (hotspots). The conservation of the reefs in Lyme Bay protects some of Lyme Bay's most valuable recreation sites but the recreation industry relies on a diversity of sites, many of which are outside the MPA and remain unmanaged.

In terms of the application of economic valuations to decision making, this research reveals that economic valuation can be influenced by external factors such as a wider UK recession or a run of poor weather that prevents people taking part in recreation activities. It also reveals that valuing the activities of groups that have no formal regulatory body, e.g. sea anglers and divers, remains a 'best guess' based on available evidence. Valuations must be used with caution by decision makers. They need to be sure that the context within which the valuation exercise was undertaken is understood, along with how far comparisons of that valuation can be made to other stakeholder groups. When using economic valuations care must also be taken that the value of other ecosystem services that are less readily valued (e.g. cultural values) are not left out of the mix. In addition, when forwarding the interests of a stakeholder group through a valuation process, then a criteria for the sustainability of that activity and/or the definition of the thresholds of that particular activity to continue in an MPA when set against the conservation objectives must be considered within the decision making process.

Economic valuations of ecosystems services remain central to the development of policy. The UK National Ecosystem Assessment, marine chapter includes an economic analysis of the UK coastal margin and marine habitats (Beaumont et al., 2010). Economic valuations have also been provided for the required impact assessment to support the recommendations for a UK network of MCZs (Balanced Seas, 2011;Irish Sea Conservation Zones, 2011;Leiberknecht et al., 2011;Net Gain, 2011). The results of this study show that monetary valuations are important to maintain the importance of ecosystem services and human well-being in policy. Indeed, when applied spatially in a planning context they can show the relative economic importance of an activity. However, it is in its practical application for planning and management that caution must be exercised. Decision makers must be aware that if they focus on valuing the types of ecosystem services that are amenable to economic value then it is possible that they may end up only managing those economically valuable services at the expense of the rest (Robinson, 2011).

6.4 Ecological valuation

The ecological valuation of indirect ecosystem service provision in the case study area demonstrates that the conservation of the reef habitat secures a level of ecological function (and therefore value) to ensure the delivery of indirect ecosystem services of gas and climate regulation, the bioremediation of waste and nutrient cycling. The provision of those services is not however exclusive to the MPA, they are provided by species and habitats across the Bay.

This research (chapter four) demonstrates that the use of an ecological valuation methodology as a decision making tool is hampered by a lack of supporting science that can neither qualify ‘how much’ function a habitat provides compared to another, nor can it address the fundamental question of ‘how much function we need’ to maintain human well-being. Without such supporting evidence to underpin an ecological valuation, the inclusion of percentage targets for broad scale habitats in conservation is an essential precautionary approach to maintaining the delivery of indirect services.

The scientific foundations for ecological valuations based on ecological function remains limited by a lack of a measure for how much function a habitat provides. Recent calls from scientists in relation to the Convention on Biological Diversity 2020 targets, state that, although individual species have the capacity to provide a disproportionate amount of service within a habitat area, there is growing body of evidence that suggests that a measure of functional diversity would provide the best insurance for securing the delivery of ecosystem goods and services (Perrings et al., 2010). Future developments in this field of valuation may focus on making a case for functionally diverse habitats in conservation planning and policy.

It is recognised that this study develops only a partial assessment of ecosystem functioning in relation to indirect service provision. Yet incorporating what is currently known about the basic roles that marine species have in the delivery of ecosystem services, using available data, can inform the progress of management and policy relating to the use and protection of the benthic natural resource. In this instance, the presence of species across Lyme Bay which contribute to the processes of energy transfer and the enhancement of microbial decomposition provides a strong argument for the incorporation of the OSPAR recommendations to include percentage targets for broad scale habitats and to manage human activities within them. In response to the lack of information on ecosystem function, which species or habitats are critical for maintaining function and the delivery ecosystem services in the marine environment, there is a need to include ‘precaution’ and ‘uncertainty’ into the planning process (Balvanera et al., 2006;Bulling et al., 2010;Foley et al., 2010). A ‘protect a bit of everything’ approach is largely precautionary and should remain open to the principles of adaptive management (Salafski et al., 2001) as our understanding of the links between ecology, divers for change, ecosystem function and the delivery of ecosystem services improves.

In terms of the development of research from the ‘ecosystem services community’ to support marine conservation planning and policy this research has shown that there is a need to further refine the BTA methodology so that ecological function can be quantified at a local to regional scale. In lieu of perfect ecosystem function models for the marine environment, research could support the development of a ‘shortlist’ of biological indicator traits that can provide a measure of the negative effect of environmental stressors. These indicators would be useful for managers to monitor the impact of activities in a marine area.

6.5 Social valuation

The research on social valuation (chapter five) demonstrated a valuation of the Lyme Bay MPA using a thematic framework of the perceived costs and benefits of the MPA on local stakeholders. The results show that stakeholders do not perceive human well-being in the context of ecosystem services but make reference to the social, economic and ecological benefits (values) and costs of the MPA policy in Lyme Bay. These costs and benefits are perceived differently by different stakeholder groups. How these values increase or decrease will largely depend on how the MPA is managed and what trade-offs stakeholders are willing to make. This provides several points for discussion. The MPA in Lyme Bay does indeed have a value but this value is gained at the expense of other stakeholder groups. In the current planning framework in the UK there remains no mechanism to manage marginalised groups. There is also no forum for the voicing of differing opinions on how the MPA can be managed, so unless provisions are made for the onward management of the MPA following its designation then its future success in terms of securing the conservation objectives for which it was designed (its value) will be at risk.

The application of social valuation methodologies is gathering the most pace as a practical tool for valuing ecosystem services in applied conservation management and monitoring. Decisions for nature conservation are essentially a social endeavour to improve human well-being and it is increasingly becoming recognised that, within the planning and management process, ecological gains from conservation measures are subject to social influences (Curtin and Prellezo, 2010;Pollnac et al., 2010;Rosendo et al., 2011). Wider research demonstrates that a thorough understanding of social values in relation to conservation and mechanisms for management and mitigation provides the best chance of securing the long term delivery of ecosystem services as if unaddressed in the onward management process of the MPA, can have detrimental effects on both the ecological gains associated with MPAs and the lives and livelihoods of those that depend on the resource (Christie et al., 2003;Christie, 2004;Klein et al., 2008a;Mascia et al., 2010;Pollnac et al., 2010;Agardy et al., 2011;Rosendo et al., 2011;Leleu et al., 2012). This research demonstrates that, along with a structure for the governance of an MPA, the framing of ecosystem services into those benefits that ‘really matter’ to people may provide the tool for setting and managing stakeholder expectation. The research is topical as the UK is embarking on the implementation of a network of Marine Protected Areas. The development of a thematic cost-benefit analysis in order to understand the issues and trade-offs that have become apparent in the Lyme Bay MPA process demonstrate that social valuation can indeed be expressed outside the domain of economics (Abson and Termansen, 2011) . The outcomes of this work will also have broad international appeal as the development of a thematic cost-benefit analysis for an MPA provides a rigorous grounding for including social issues in MPA planning and management.

6.6 Integrating ecological, social and economic values

This thesis has demonstrated that marine conservation provides value by protecting the delivery of ecosystem services. It also shows that values associated with ecosystem services can be defined in an economic, ecological and social context. When this research began it was considered that it may be possible to neatly tie in the ecological, social and economic values into a framework that would aid decision-making for marine nature conservation. The subsequent development of methodologies in each of these areas proves otherwise. Any attempt to join or aggregate the economic, social and ecological value of the MPA in Lyme Bay, in terms of ecosystem services, would run the risk of a comparison of ‘apples and oranges’ that would serve no purpose. These valuations, in turn, provide methodologies that can inform ecosystem based decision making in an economic, social and ecological context. Each type of valuation has a place at the decision making table.

When considered together, each valuation methodology represents part of the jigsaw needed to inform decision making. Each valuation type can be used for different applications, whether to inform and influence policy, to develop a greater understanding of ecosystems and their role in providing the ecosystem services needed for human well-being, or to support actual decision making and management on the ground.

There is no doubt that ecosystem valuation has changed the discourse of marine nature conservation (de Groot et al., 2010). However, the concept of ecosystem services is an example of where a framework developed by scientists has translated well into policy, but the development of methodologies to define and to value these ecosystem services has raised numerous issues in its practical application. One answer would be to require ‘better data’ and ‘more modelling’. This will no doubt improve information available to decision makers. However, understanding the value of marine conservation in its completeness is a jigsaw that will always have missing parts. As this is the case, it must be remembered that ‘science is not the bottleneck’(Lester et al., 2010) for moving forward. Processes for structured decision-making and decision focussed research can ease the need for completeness in science (Gregr and Chan, 2011).

It is how these values are used together that defines ideologies (Robinson, 2011), so the last point regarding the use of ecosystem services in structured decision making therefore requires us to take a step back and to ask the bigger question of ‘What do we want from conservation?’ All of the valuations in this thesis, ecological, economic and social, have revealed the potential for trade-offs between different uses of the marine resource. The win-wins so eagerly sought by politicians and policy makers in marine management are in reality difficult to achieve (Rees et al., 2010a;McShane et al., 2011). There is an urgent need for a larger societal discussion on what activities society considers acceptable and what level of risk to the future delivery of ecosystem services we are willing to take. The ‘new conservation debate’ is advocating explicitness about these choices and being upfront about the options (McShane et al., 2011;Miller et al., 2011;Minteer and Miller, 2011). It is only then that a valuation of ecosystem services can be placed into context and become a truly deliberative tool for marine conservation and planning.

6.7 Opportunities for further research

Future application of ecosystem services in marine conservation policy, planning and management would benefit from advances in research in the following areas:

1. The development of a set of guiding principles that can serve to orientate strategic analysis and communication regarding trade-offs in decision making;
2. Testing mechanisms to better engage relevant stakeholders and the public in debates about the societal costs and benefits of marine conservation;
3. The development of a safe minimum standard for ecosystem service provision.
4. Further mapping of ecosystem services in case study areas;
5. Modelling ecosystem services in relation to management scenarios; and
6. Linking ecosystem service provision with ‘benefits’ to assess the effectiveness of marine conservation initiatives.

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Appendix 1: Questionnaires

Angling Survey

Date: ………………

Your name:…………………………

Do you belong to a fishing association / club? Yes / No

Name of association / club:………………

Your postcode: ……………………

Costs

1. Approximately, how many days did you spend angling this year ?…….. days

2. How many days have you spent angling days in Lyme Bay this year?.................................(days)

3. Is this more or less than last year? ………………more / less / same *(please circle one)*

If it is either **more** or **less**, can you please briefly explain what has influenced this change?

………………………………………………

……………………………………………………………

4. What % of your angling trips were to the Lyme Bay closed area (see map)………………..

5. Is this more or less than last year?   more / less / same *(please circle one)*

If it is either **more** or **less**, can you please briefly explain what has influenced this change …………

6. Please indicate the percentage of your angling trips to Lyme Bay this year which were:

Shore based……………%   Boat based …………….%

7. Of your boat based angling trips, did you:

Hire a boat? ………….%   Use your own? ………………….%

8. Approximately, what has been the average **cost per day** of your angling trips to Lyme Bay this year (including fuel, accommodation, transport, parking, tackle and bait, and any other cost you may have incurred)?

Shore based angling …………   Boat based angling …………………………………

9. Do you buy bait and tackle locally? Yes / No

If **yes**, please give the name of shop and average spend per visit

Shop name:……………………… Average spend: £…………………

10. Do you collect bait yourself? Yes / No

If **yes**, please can you give details ………………………………………………………………

……

……

Catch

11. What are your main target species? Please give names: ………………………………

……

……

…………………………

Fishing sites

12. Using the enclosed map of Lyme Bay, could you identify the sites where you fished this year? Please could you give an indication of the frequency of visits to each site using a scale of 1-5 where **1 = a site you rarely visit and 5 = a site you visit frequently**.

Your views

13. How many years have you been fishing in Lyme Bay?.....................................years

14. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision to fish in Lyme Bay? *(Please circle one)*

1 2 3 4 5

15. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision as to **where** you fish in Lyme Bay? *(Please circle one)*

1 2 3 4 5

16. On a scale of 1-5, where **1 = strongly against and 5 = strongly support**, to what extent do you support or not support the closed area policy in Lyme Bay? *(Please circle one)*

1 2 3 4 5

Please feel free to comment on any of the statements above
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17. Are there any other advantages of the closed area that have not been asked about elsewhere on this questionnaire?

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18. Are there any other disadvantages of the closed area that have not been asked about elsewhere on this questionnaire?

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Socio-demographic questions (there is no need to complete this section of you took part in the 2009 survey)

The following questions are required to validate the study. Your cooperation in answering these questions is greatly appreciated. Please remember that the answers are anonymous and confidential, and only aggregated data will be used for the project.

19. Gender a) Male b) Female *(circle as applicable)*

20. Age a) 18-24 d) 45-54

b) 25-34 e) 55-64

c) 35-44 f) Over 65 *(circle as applicable)*

21. Your nationality ……………………………………………

22. What is the highest form of education that you have completed? *(circle as applicable)*

a) Primary d) Higher education (university)

b) Secondary e) Postgraduate

c) Further education (Vocational, Technical training, A level)

f) Other (specify) ……….

Thank you for taking part in this survey. We will be following up this survey in 2010 in an attempt to find out how the 60 square mile closure in Lyme Bay is affecting the recreation industry and to make recommendations for future marine protected area planning in the UK.

If you would be happy to participate in the next round of surveys, please could you supply a telephone number and e-mail address for future correspondence. Please be assured that your details will remain completely confidential.

Name:

E-mail:

Telephone:

Please could you recommend another angler to contact?

………………………………………………………………………………………………………
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Do you have any comments on the survey?

………………………………………………………………………………………………………

………………………………………………………………………………………………………

Thank you for your cooperation

Charter Boat Operator Survey

(Please return completed questionnaire to Dr Stephen Mangi, Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH)

Date:…………..…

Your details

1. Interviewee name:…………………………… Post code ……………………………….

2. Boat name and length:…………………………..

3. Home port:……………………………………

Description of your business

4. How many years have you been running your business in Lyme Bay? ....years (only ask if business not interviewed last year)

5. How many people are employed in your business………………….. …… staff

6. On average, how many trips do you do in one year? ………………….trips

7. How many of the following trips did you do this year?

Activity	Total number of trips	Number in Lyme Bay	% in closed area	Is this more or less than last year?	Average charter price	Average number of people per trip
Angling						
Diving						
Other						

8. Please indicate your annual turnover in £.

- ☐ Less than 15,000
- ☐ 16,000 – 20,000
- ☐ 21,000 – 25,000
- ☐ 26,000 – 30,000
- ☐ 31,000 – 35,000
- ☐ 36,000 – 40,000
- ☐ 41,000 – 50,000
- ☐ 51,000 – 60,000
- ☐ 61,000 – 70,000
- ☐ 71,000 – 80,000
- ☐ 81,000 – 90,000
- ☐ Over 90,000

9. What percentage of turnover is from business related to:

Angling ……………….%

Diving ………………   %

Other …………………%

10. Please could you indicate your operating costs as a percentage of your turnover? …..............%

11. Do you publicise the closed area in Lyme Bay for marketing purposes? (Please circle one)   Yes / No

12. How have the following changed for your business since 2008? *(Please circle one and provide an estimate of the percentage change)*

a. Turnover?	increased / decreased / stayed the same	%
b. The number of divers	increased / decreased / stayed the same	%
c. The number of anglers	increased / decreased / stayed the same	%

13. What are the reasons for the changes?

………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

………………………..

Location of dive / fishing sites

14. Using the enclosed map of Lyme Bay, could you identify the sites where your clients visited this year? Please could you give an indication of the frequency of visits to each site using a scale of 1-5 where **1 = a site you rarely visit and 5 = a site you visit frequently**.

Your views

15. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your business this year? *(Please circle one)*

1 2 3 4 5

16. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision as to **where** you take customers in Lyme Bay? *(Please circle one)*

1 2 3 4 5

17. On a scale of 1-5, where **1 = strongly against and 5 = strongly support**, to what extent do you support or not support the closed area policy in Lyme Bay? *(Please circle one)*

1 2 3 4 5

Please feel free to comment on any of the statements above

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18. Are there any other advantages of the closed area that have not been asked about elsewhere on this questionnaire?

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19. Are there any other disadvantages of the closed area that have not been asked about elsewhere on this questionnaire?

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Socio-demographic questions (there is no need to complete this section of you took part in the 2009 survey)

The following questions are required to validate the study. Your cooperation in answering these questions is greatly appreciated. Please remember that the answers are anonymous and confidential, and only aggregated data will be used for the project.

20) Gender a) Male b) Female *(circle as applicable)*

21) Age a) 18-24 d) 45-54

b) 25-34 e) 55-64

c) 35-44 f) Over 65 *(circle as applicable)*

22) Your nationality …………………………………………

23) What is the highest form of education that you have completed? *(circle as applicable)*

a) Primary d) Higher education (university)

b) Secondary e) Postgraduate

c) Further education (Vocational, Technical training, A level)

f) Other (specify) ……….

Thank you for taking part in this survey. We will be following up this survey in 2010 in an attempt to find out how the 60 square mile closure in Lyme Bay is

affecting the recreation industry and to make recommendations for future marine protected area planning in the UK.

If you would be happy to participate in the next round of surveys, please could you supply a telephone number and e-mail address for future correspondence. Please be assured that your details will remain completely confidential.

Name:

E-mail:

Telephone:

Please could you recommend another charter boat operator to contact?

……………………………………………………………………………………………………

Do you have any comments on the survey?

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……………………………………

Thank you for your cooperation

Dive Business Survey

Date…………

Business name: …………………….

Interviewee name: ………………….

Post code ……………………………

Description of your business

1. How many years have you been running your business in Lyme Bay? ....years (Only ask if business not interviewed last year).

2. What services does your business provide? (check with last years answers)

Equipment sales (in store) …………….. Equipment sales (online)………. Equipment hire …………. Training courses ………………… Dive trips ……………………. Boat charter ……………………… Other (specify) ……………………

3. Could you please provide the following details for your business in 2009?

Number of staff employed by your business (full time)……………… (part time)….. ……..

Average price per dive (all inclusive e.g. boat, kit etc) ………………………..

Average price of a dive course ………………………

Average number of divers per trip (shore) …………… (boat)……… ………..

Number of divers qualified in the last year…………………....

Number of divers taken on dive trips each year………………………

4. Please indicate your annual turnover in £.

< 50,000	☐	51,000 - 100,000	☐
101,000 -150,000	☐	151-000 – 200-000	☐

201,000-250,000 ☐ 251,000 – 300,000 ☐

over 300, 000 ☐

5. Approximately, what is your percentage turnover from:

Equipment sales (in store)…………….. Equipment sales (online)…….. Dive trips ………………. Equipment hire ………………… Boat charter …………………… School/training…………………. Servicing ………………………. Other (specify) …………………………

6. Please could you indicate your operating costs as a percentage of your turnover?.................

7. How have the following changed for your business since 2008?:

a) Turnover?	Increased / Decreased?	%
b) The number of students learning to dive?	Increased / Decreased?	%
c) The number of divers on dive trips	Increased / Decreased?	%
d) Total staff number?	Increased / Decreased?	%

What are the reasons for the changes?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………..

8. Do you publicise the closed area in Lyme Bay for marketing purposes? *(Please circle one)*

Yes / No

Location of dive sites

9. Using the enclosed map of Lyme Bay, could you identify the sites where your clients dived this year? Please could you give an indication of the frequency of visits to each site using a scale of 1-5 where **1 = a site you rarely visit and 5 = a site you visit frequently**.

Your views

10. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your business this year? *(Please circle one)*

1 2 3 4 5

11. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision as to **where** you take divers in Lyme Bay? *(Please circle one)*

1 2 3 4 5

12. On a scale of 1-5, where **1 = strongly against and 5 = strongly support**, to what extent do you support or not support the closed area policy in Lyme Bay? *(Please circle one)*

1 2 3 4 5

Please feel free to comment on any of the statements above

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13. Are there any other advantages of the closed area that have not been asked about elsewhere on this questionnaire?

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14. Are there any other disadvantages of the closed area that have not been asked about elsewhere on this questionnaire?

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Socio-demographic questions (there is no need to complete this section of you took part in the 2009 survey)

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15) Gender a) Male b) Female *(circle as applicable)*

16) Age a) 18-24 d) 45-54

b) 25-34 e) 55-64

c) 35-44 f) Over 65 *(circle as applicable)*

17) Your nationality …………………………………………

18) What is the highest form of education that you have completed? *(circle as applicable)*

a) Primary d) Higher education (university)

b) Secondary e) Postgraduate

c) Further education (Vocational, Technical training, A level)

f) Other (specify) ……….

Thank you for taking part in this survey. We will be following up this survey in 2010 in an attempt to find out how the 60 square mile closure in Lyme Bay is affecting the recreation industry and to make recommendations for future marine protected area planning in the UK.

If you would be happy to participate in the next round of surveys, please could you supply a telephone number and e-mail address for future correspondence. Please be assured that your details will remain completely confidential.

Name:

E-mail:

Telephone:

Do you have any comments on this survey?

……………………………………………………………………………………………………

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……………………………………………………

Thank you for your cooperation

Divers Survey

Date: ……………

Your name:…………………………

Post code ………………………..

Name of your club:……………………………..

Diving in Lyme Bay

1. Approximately, how many days have you spent diving this year? ……….. . days

2. How many days have you spent diving in Lyme Bay this year?............days.

3. Is this more or less than last year?   more / less / same *(please circle one)*

If it is either **more** or **less**, can you please briefly explain what has influenced this change ………………………

4. What % of your diving trips were to the Lyme Bay closed area (see map)………………..

5. Is this more or less than last year?   more / less / same *(please circle one)*

If it is either **more** or **less**, can you please briefly explain what has influenced this change …………

6. On average how many other divers have been with you on your diving trip(s) to Lyme Bay this year?.............

7. What, approximately, has been your average **cost per dive** in Lyme Bay this year (including boat fuel, equipment hire, air etc)?.............................

8. What, approximately, has been the **additional average cost per day** of your diving trips to Lyme Bay this year (e.g. transport to and from Lyme Bay, car parking, accommodation, food and drink)? £…………………………

9. During the visits you have made to Lyme Bay this year, how often have you / your club hired a boat through:

a) A private charter …………………… *(please record the number of times)*

b) A dive club boat …………………… *(please record the number of times)*

c) Use your own club's boat …………… *(please record the number of times)*

d) Others (e.g. shore dives only) …… *(please record the number of times)*

Location of dive sites

10. Using the enclosed map of Lyme Bay, could you identify the sites where you / your club dived **this year**? Please could you give an indication of the frequency of visits to each site using a scale of 1-5 where **1 = a site you rarely visit and 5 = a site you visit frequently**.

Your views

11. How many years have you been diving in Lyme Bay?.....................................years

12. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision to dive in Lyme Bay? *(Please circle one)*

1 2 3 4 5

13. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision as to **where** you dive in Lyme Bay? *(Please circle one)*

1 2 3 4 5

14. On a scale of 1-5, where **1 = strongly against and 5 = strongly support**, to what extent do you support or not support the closed area policy in Lyme Bay? *(Please circle one)*

1 2 3 4 5

Please feel free to comment on any of the statements above

…………………………………………………………………………………………………

…………………………………………………………………………………………………

15. Are there any other advantages of the closed area that have not been asked about elsewhere on this questionnaire?

…………………………………………………………………………………………………

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16. Are there any other disadvantages of the closed area that have not been asked about elsewhere on this questionnaire?

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Socio-demographic questions (there is no need to complete this section of you took part in the 2009 survey)

The following questions are required to validate the study. Your cooperation in answering these questions is greatly appreciated. Please remember that the answers are anonymous and confidential, and only aggregated data will be used for the project.

17. Gender a) Male b) Female *(circle as applicable)*

18. Age a) 18-24 d) 45-54

b) 25-34 e) 55-64

c) 35-44 f) Over 65 *(circle as applicable)*

19. Your nationality ……………………………………………

20. What is the highest form of education that you have completed? *(circle as applicable)*

a) Basic Education d) University/College Graduate

b) Secondary Education / High School e) Postgraduate

c) Diploma, Vocational or Technical training f) Other (specify) ……….

Thank you for taking part in this survey. We will be following up this survey in 2010 in an attempt to find out how the 60 square mile closure in Lyme Bay is affecting the recreation industry and to make recommendations for future marine protected area planning in the UK.

If you would be happy to participate in the next round of surveys, please could you supply a telephone number and e-mail address for future correspondence. Please be assured that your details will remain completely confidential.

Name:

E-mail:

Telephone:

Please could you recommend another diver to contact?

……
……

Do you have any comments on the survey?

……

……

……

……

…………………………………………………

Thank you for your cooperation

Fishermen survey

Date………………

Your details

1. Name………………………….. Post code …………………….

2. How would you describe your usual fishing gear?……………………………….

Is this the same gear you were using before the closed area was established? Yes / No

How long have you been using this particular type of gear? ………………..years

Is this your preferred gear type? Yes / No

3. Size of your household: …………………. people

Description of your fishing activity

4. Do you own the vessel you use? Yes / No

How long is your vessel, under 10m or over 10m? …………………..

5. Are there any other boats you own?.......................................

What are the lengths of these boats (under 10m or over 10m)? ………………………..

6. How long have you been a fisher?…………………… years

7. On average how many fishing trips did you make in one month before the closed area was established? ………………………trips

8. On average, how many fishing trips do you make in one month now (after the closure)?..…trips

Income

9. What are your main target species? Please give names ……………….. ………
…………………..

10. Approximately, what is your average catch in tonnes per fishing trip? ………………tonnes

11. Is this more or less what you used to catch before the closed area was established?

More / less / same *(please circle one)*

12. If it is either **more** or **less**, can you please briefly explain what has influenced this change? ……………………………………………
……………………………………………………………….
……………………………………………………………………………………………………
………..

13. Approximately, what is the average daily value of your catch? £/tonne............................

14. How many crew do you have in your boat? …………………………

What % of the year do you employ your crew?……………………..

Do you share your earnings with your crew? Yes / No

If **yes,** what % does each one get……………………

If **no**, how do you pay your crew?...................

15. In your view, has your income from fishing increased, remained stable or decreased in the last year? ………………………………….

What are the reasons behind this change?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………….

16. Do you have any other additional income? Yes / No

17. On average, what is your total monthly income from fishing? £ ………..

18. Based on the total monthly income you have made from fishing, approximately what percentage has been due to you fishing in Lyme Bay?...

Costs

19. Approximately, what has been the average cost per day of your fishing trips to Lyme Bay this year (including fuel, labour, licences, and any other cost you may have incurred)? £ …………

How have the following changed for your fishing activity since 2007:

20. Total costs? increased / decreased / same *(Please circle one)*

Is the change due to the establishment of the closed area or the result of other factors?….

21. Travel time to fishing site? increased / decreased / same *(Please circle one)*

Is the change due to the establishment of the closed area or the result of other factors?….

…………………………………………………………………………………………………

22. Average fishing duration? increased / decreased / same *(Please circle one)*

Is the change due to the establishment of the closed area or the result of other factors?….

……………………………………………………………………………………………………

23. The fishing sites you use? changed / same *(Please circle one)*

Is the change due to the establishment of the closed area or the result of other factors?….

……………………………………………………………………………………………………

24. The gear you use? changed / same *(Please circle one)*

Is the change due to the establishment of the closed area or the result of other factors?…

……………………………………………………………………………………

25. Other changes (specify)…………………………..

Are these changes due to the establishment of the closed area or the result of other factors?

Fishing sites

26. Using the map of Lyme Bay. Please could you indicate:

	% of time spent in each area
Areas visited before July 2008?	

Areas visited after July 2008?	

Your views

27. How many years have you been fishing in the Lyme Bay area?..................years

28. On a scale from 1-5, where **1 is strongly disagree and 5 is strongly agree**, indicate whether you agree or disagree with the following statements: *(Please circle one)*

a) The closed area protects marine biodiversity within the 60 square miles	1	2	3	4	5
b) The closed area benefits wider marine biodiversity in Lyme Bay	1	2	3	4	5
c) The closed area should only exclude scallop dredgers and heavy seabed trawling gear	1	2	3	4	5
d) The closed area should exclude all extractive activities (including scallop diving, angling, pots)	1	2	3	4	5

Please feel free to comment on any of the statements above:

………………………………………………………………………………………………………

………………………………………………………………………………………………………

29. On a scale of 1-5 where **1 = little or no benefit and 5 = a large benefit** please indicate your opinion on how much each of these stakeholder groups currently benefit (financially and non-financially) from the 60 square mile closed area. *(Please circle one)*

a) Fishermen (mid-water (pelagic) trawling)	1	2	3	4	5
b) Fishermen (potting)	1	2	3	4	5
c) Fishermen (scalloping and seabed trawling)	1	2	3	4	5
d) Divers (clubs and businesses)	1	2	3	4	5
e) Sea anglers	1	2	3	4	5
f) Charter boat operators	1	2	3	4	5
g) The general public	1	2	3	4	5
h) Local service providers (hotels, shops etc)	1	2	3	4	5

Please feel free to comment on any of the statements above:

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30. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision to fish in Lyme Bay? *(Please circle one)*

1 2 3 4 5

31. On a scale of 1-5, where **1 = no effect and 5 = a large effect**, how much has the closure affected your decision as to **where** you fish? *(Please circle one)*

1 2 3 4 5

32. On a scale of 1-5, where **1 = strongly against and 5 = strongly support**, to what extent do you support or not support the closed area policy in Lyme Bay? *(Please circle one)*

1 2 3 4 5

Please feel free to comment on any of the statements above

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33. Have you noticed any changes in the number of: *(please circle one)*

Divers operating in the closed area in the last year?	Increased / decreased / stayed the same
Anglers operating in the closed area in the last year?	Increased / decreased / stayed the same
Fishermen using pots in the closed area?	Increased / decreased / stayed the same
Fishermen using mid water (pelagic) trawls in the closed area?	Increased / decreased / stayed the same

Please feel free to comment on the statements above:

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34. Have any other circumstances influenced the way in which you have fished in the last year? Yes / No

If **yes**, please indicate these circumstances

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35. Are there any other advantages of the closed area that have not been asked about elsewhere on this questionnaire?

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36. Are there any other disadvantages of the closed area that have not been asked about elsewhere on this questionnaire?

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Socio-demographic questions

The following questions are required to validate the study. Your cooperation in answering these questions is greatly appreciated. Please remember that the answers are anonymous and confidential, and only aggregated data will be used for the project.

37) Age a) 18-24 d) 45-54

b) 25-34 e) 55-64

c) 35-44 f) Over 65 *(circle as applicable)*

38) Your nationality ………………………………………

39) What is the highest form of education that you have completed? *(circle as applicable)*

a) Basic Education d) University/College Graduate

b) Secondary Education / High School e) Postgraduate

c) Diploma, Vocational or Technical training f) Other (specify) ……….

Thank you for taking part in this survey. We will be following up this survey in 2009 and 2010 in an attempt to find out how the 60 square mile closure in Lyme Bay is affecting the fishing industry and to make recommendations for future marine protected area planning in the UK.

If you would be happy to participate in the next round of surveys, please could you supply a telephone number and e-mail address for future correspondence. Please be assured that your details will remain completely confidential.

Name:

E-mail:

Telephone:

Please could you recommend another fisher to contact?

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Do you have any comments on the survey?

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Thank you for your cooperation

Appendix 2: Statement of contribution to co-authored papers

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

Siân E. Rees[a], Martin J. Attrill[a], Melanie C. Austen[b], Stephen C. Mangi[b], Jo P. Richards[a], Lynda D. Rodwell[a]

[a] Marine Institute, Plymouth University (UoP), Portland Square, Drake Circus, Plymouth, PL4 8AA, U.K.

[b]Plymouth Marine Laboratory (PML), Prospect Place, The Hoe, Plymouth, PL1 3DH, U.K

This paper is a literature review which defines the process by which a decision was made to close an area of Lyme Bay, UK to fishermen using benthic trawls and dredges. This chapter was written by me under the supervision of Dr Lynda Rodwell, Professor Martin Attrill and Dr Melanie Austen. Dr Stephen Mangi and Dr Jo Richards (Plymouth University) and Charlotte Marshall (Plymouth University) also provided comments on drafts of this paper. This paper was published in the journal of Ocean and Coastal Management in 2010.

The value of marine biodiversity to the leisure and recreation industry and its application to marine spatial planning.

Siân E. Rees[a], Lynda D. Rodwell[a], Martin J. Attrill[a], Melanie C. Austen[b] and Stephen C. Mangi[b].

This paper provides both a monetary and non monetary valuation of the leisure and recreation industry in Lyme Bay. This paper was written by me under the supervision of Dr Lynda Rodwell, Professor Martin Attrill and Dr Melanie Austin. Questionnaires were developed for use on all stakeholder groups in the Defra

Lyme Bay project (MB0101) by a team that included myself, Dr Lynda Rodwell, Dr Stephen Mangi, Dr Caroline Hattam (PML) and Dr Melanie Austen. The GIS element of the questionnaire was programmed by Mike Gormley (PML). Data from the recreation industry was collected by me with help from Dr Lynda Rodwell and Samantha Fowell (Plymouth University) who was employed as a Research Assistant on the Defra Lyme Bay project (MB0101). My supervisory team plus Dr Stephen Mangi and Dr Caroline Hattam provided comments of drafts of this paper. This paper was published in the journal Marine Policy in 2010

Chapter three: Incorporating indirect ecosystem services into marine protected area planning.

Siân E. Rees[a], Melanie C. Austen[b] , Martin J. Attrill[a] and Lynda D. Rodwell[a],

This paper is a methods development paper for spatially valuing benthic ecological function and the delivery of indirect ecosystem services in the case study area. This paper was written by me under the supervision of Dr Lynda Rodwell, Professor Martin Attrill and Dr Melanie Austin. The development of the idea for this paper was supported by supervisory team and also Dr Olivia Langmead (Marine Biological Association (MBA) and Plymouth University), Dr Harvey Tyler-Walters (MBA) and Dr Emma Jackson (MBA/Plymouth University). Data for this chapter was accessed from a number of sources. Dr Tim Stevens (Griffiths University, Australia) provided pre-complied presence data for species and habitats in Lyme Bay. Help in converting this data for a Biological Traits Analysis was provided by Dan Lear and Becky Sealy from the Marine Biological Association. Comments on a draft paper were provided by my supervisory team, Dr Emma Jackson (MBA) and Charlotte Marshall (Plymouth University).

This chapter has been published in the International Journal for Ecosystem Services, Biodiversity Science and Management.

A thematic cost-benefit analysis of a Marine Protected Area.

Siân E. Rees[a], Lynda D. Rodwell[a], Martin J. Attrill[a], Melanie C. Austen[b], Stephen C. Mangi[b], Caroline Hattam[b]

Using qualitative data collected from key stakeholder groups affected by the MPA in Lyme Bay this paper develops a thematic framework methodology for a cost-benefit analysis of the impacts of the policy instrument. This paper was written by me under the supervision of Dr Lynda Rodwell, Professor Martin Attrill and Dr Melanie Austin. Data collection was carried out as part of the Defra Lyme Bay (MB0101) between 2008 and 2010. Dr Lynda Rodwell, Dr Stephen Mangi, Dr Caroline Hattam, Samantha Fowell (Plymouth University), Sarah Gall (Plymouth University) and I all conducted interviews with stakeholders during this three year period. My supervisory team plus Dr Stephen Mangi and Dr Caroline Hattam provided comments on drafts of this paper. This paper was submitted to the journal Conservation Biology in October 2011.

Appendix 3: Accepted papers.