Socioeconomic valuation of the marine environment in Wales: implications for coastal management

A thesis presented to Bangor University for the Degree of Doctor in Philosophy

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Summary

The present study identified and quantified the value of the marine environment to different users and non-users of the coast around Wales. Previous studies have tended to focus on the value of extractive activities only, whereas the present study investigated the implications of integrating a broader range of values and how this impacted the development of comprehensive marine spatial plans for the area.

The study identified data inadequacies relating to non-extractive recreational activities in the area. The economic importance and spatial distribution of the activities (i.e. diving, kayaking, wildlife cruises and bird watching) were investigated using questionnaires. The study revealed that non-extractive recreational users spent between £21.8 and £33 million in 2008 in Wales. The integration of this information with existing fine scale fisheries data in the design of marine reserves was investigated using a site-selection algorithm. The incorporation of spatially explicit economic data for recreation resulted in reserves that were considerably less costly to the recreational sector than reserves designed without the consideration of recreational interests without any extra costs to the fisheries sector.

The perceived distribution of values and benefits derived from the marine environment according to different stakeholder groups and their preferences for the location of marine reserves were assessed and mapped through interviews. The study suggested the existence of similar spatial distributions for certain benefits of the marine environment and particular areas were identified as providers of multiple benefits. Such data can be used to identify areas better suited for specific uses or management regulations. The integration of data on stakeholders' priority areas for conservation in a site-selection algorithm suggested that in the case of Wales it is possible to integrate stakeholders' preferences for the location of reserves without compromising conservation needs, potentially avoiding unnecessary conflicts between conservation and stakeholders' interests.

Society's support for marine reserves in Wales was assessed through the use of a choice experiment survey. Findings identified generalised support for reserves with heterogeneous views on the size and management of the reserve. Results suggested that society is willing to pay for the conservation of the marine environment and that this willingness to pay is likely to be greater than the associated economic costs of protection. The integration of valuation techniques, survey methods and systematic conservation tools established herein should further the development of comprehensive marine spatial plans for the area.

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I als meus pares, els millors, que m’han fet costat durant tots aquest anys. Mil grasis

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Chapter 1

General Introduction

1.1 Overview

For centuries human societies have utilised a range of goods and services that have been derived directly or indirectly from the marine environment. Historically, humans have exploited marine resources without the implementation of adequate management strategies that aimed to ensure the long term sustainability of these systems and their associated benefits. On the contrary, many resources have been exploited without any limits or considerations for future generations. This lack of adequate management has led in many instances to the degradation of marine ecosystems with global consequences such as the collapse or decline of some major fish stocks in the world (Jackson et al. 2001, Roberts 2007), high levels of pollution derived from the by-products of agricultural and industrial processes or the loss of marine biodiversity (Sala and Knowlton 2006). The decline in biodiversity levels has been highlighted as a particularly important problem as it has been shown that high levels of biodiversity are crucial for the maintenance and resilience of services provided by marine ecosystems (Worm et al. 2006, Duffy 2009).

The lack of adequate management strategies that ensure the sustainable use of the marine environment is partly related to the open-access nature of the goods and services provided by the oceans. In the marine environment the lack of property rights for most goods, the public nature of marine benefits and the fact that there are no market prices attached to most benefits have led to what has been described as the "tragedy of the commons" which refers to the conflicts associated to open access or free resources in which multiple individuals acting individually and for their own self-interest will ultimately deplete a shared resource (Hardin 1968). As most marine services, such as the cycling of nutrients, the contribution to the mitigation of climate change or the provision of cultural, recreational and aesthetic benefits, have no market prices attached to them most of these services are not explicitly included into management processes as they are considered to be free. Therefore, in order to design and implement efficient management policies that prevent the excessive degradation of marine resources and their services it is necessary to establish the full value of those services and to incorporate their values into appropriate decision-making processes (Birol et al. 2006b). In a world that is largely regulated by monetary decision making, the economic valuation of ecosystem services (ES) has been suggested as a way of integrating these services into management plans, as through economic valuation the different services provided by the ecosystems can be compared through the use of a common monetary metric (Liu et al. 2010). Although the economic valuation of ES remains an issue of debate, as some argue that nature should only be valued for its intrinsic value and not for the benefits it provides to humans (McCauley 2006), it allows for a more holistic approach to the management of the oceans, as through valuation all the different services derived from ecosystems can be included in decision-making processes. Besides, the arguments derived from economic valuations should be used in combination with, not in place of, scientific or ethical arguments (Turner et al. 2000, MEA 2003, Costanza 2006).

The valuation of ES can contribute to the adoption of a more holistic approach towards the management of marine ecosystems and that is precisely what is currently being advocated as the way forward to achieve the sustainable management of the oceans (World Summit on Sustainable Development 2002). This holistic concept has been termed the ecosystem based management (EBM) approach. The EBM was initiated from the recognition of the increasing diversity and intensity of marine ecosystem uses and their associated impacts, and the acknowledgement of the need to implicitly include human aspects in the management of the oceans (World Summit on Sustainable Development 2002). The overarching goal of EBM is to sustain the capacity of marine ecosystems to deliver ES by considering the range of services that are essential for humans and the range of factors that affect the production and delivery of those services (McLeod and Leslie 2009). However, the application of the EBM is complex as it involves a focus on the functional relationships and processes within ecosystems, the distribution of the benefits that stem from ES and the development of management plans at multiple scales (Douvere and Ehler 2009). Therefore, due to the difficulties and complexities associated to the EBM approach, and despite its broad acceptance, EBM remains more of a concept than a practice (Douvere and Ehler 2009). As a result, different variations of the EBM concept have emerged (Halpern et al. 2010). For example, within the practice of marine spatial planning (MSP) different areas of the sea are allocated to specific uses to achieve ecological, economic and social objectives usually specified through a political process (Douvere 2008).

Within a framework of MSP, marine protected areas (MPAs) have been advocated as an important tool for achieving global conservation targets. The importance of establishing MPAs has been recognised both at a European and global levels. In Europe, there is a growing interest in designating MPAs in the waters of member states. Countries of the European Union (EU) are already committed to the development of a network of MPAs as part of the EU Habitats and Birds Directive (EU 1979, EU 1992), and recently these obligations have been further reinforced by the EU Marine Strategy Framework which requires each member state to establish a coherent and representative network of MPAs by 2020 (MSFD 2008). These initiatives contribute to the fulfilment of international commitments such as the Protected Area Programme of the World Conservation Union (IUCN), which promotes the establishment of a global network of protected areas (IUCN 2000), the OSPAR Biological Diversity and Ecosystems Strategy, which recommended a coherent network of MPAs to be in place by 2010 (OSPAR 2003) and the Convention on Biological Diversity (CBD) and the World Summit on Sustainable Development (2002) which aim is to establish an effectively managed, representative, global system of MPAs by 2012 (CBD 2008).

1.2 Introducing the Welsh case study

In Wales UK, the Welsh Assembly Government (WAG) has recently adopted a Marine and Coastal Access Act (DEFRA November 2009) which aims to meet their conservation commitments established by the aforementioned international agreements. Through the Marine and Coastal Access Act, WAG commits to the establishment of an “ecologically coherent, representative and well managed network of marine protected areas” taking into account “environmental, social and economic criteria” by 2012. According to the Act, the Government will consider social and economic benefits to ensure that MPA sites are, as far as possible, chosen to maximise ecological, social and economic benefits while minimising any unnecessary conflicts with the different uses of the area. However, while in Wales comprehensive information is available for the distribution of biophysical and ecological factors and for the distribution and economic value of certain consumptive uses of the marine environment such as fisheries (Richardson 2006), there is very little information on other non-consumptive uses of the coast. Failing to integrate a more comprehensive set of uses and values into conservation management plans due to a lack of available information may result in less than optimal outcomes with avoidable financial compromises and conflicts amongst affected users.

As Wales is currently only beginning to develop the planning strategy for the establishment of a network of MPAs, it poses an ideal case study to investigate the value of a range of marine benefits and to integrate these different values into marine spatial plans. The aim of this thesis therefore will be to ascertain and capture some of the ES values provided by the coastal[1] marine environment in Wales. Furthermore, the thesis will investigate the incorporation of this information into marine spatial plans in order to achieve a more socially balanced process in the designation of MPAs, as it has been widely acknowledged that the establishment of protected areas is generally a complex process that involves the integration of multiple interests.

1.3 Establishment of MPAs

Despite the international recognition of the need and the will to establish MPAs, their planning and implementation is challenging for several reasons. While the positive benefits derived from the implementation of MPAs for habitat restoration and biodiversity conservation have been clearly established within the boundaries of MPAs (Halpern and Warner 2002, Blyth-Skyrme et al. 2006, Stewart et al. 2009), the role of MPAs in the recovery of fish stocks remains an issue of debate (Kaiser 2005, Stefansson and Rosenberg 2006). Additionally, the establishment of MPAs is often controversial as the closure of portions of the sea to human activities can have associated negative impacts on those sectors of society affected by the closures (Stump and Kriwoken 2006). However, if designed carefully MPAs can achieve a balance between ecological conservation and socioeconomic needs (Klein et al. 2008a). This may be achieved by using biological principles as primary design criteria (Roberts et al. 2003) and including relevant socioeconomic aspects to ensure community support and compliance (Walmsley and White 2003, Moore et al. 2004). Nevertheless, despite the acknowledgement of the importance of incorporating socioeconomic aspects into the design of MPAs, stakeholders' needs and preferences are not always included in the MPA design process, and even when they are included

[1] Coastal waters are defined as those within 12 nautical miles of the shore, i.e. UK Territorial Waters

it is often done so *a posteriori* (Stewart and Possingham 2005), which can lead to unanticipated socioeconomic impacts on certain stakeholder groups.

In order to minimize socioeconomic impacts and to achieve conservation objectives efficiently, the socioeconomic costs associated with the establishment of protected areas should be integrated at the onset of the planning process (Carwardine et al. 2008). It has been shown that the incorporation of spatially resolved socioeconomic costs into conservation planning can minimize impacts on resource users (Richardson et al. 2006, Klein et al. 2008a), and thereby reduce the potential conflicts between stakeholder and managers (Crawford et al. 2006), resulting in a cost-effective implementation of protected areas through reduced costs to society (Naidoo et al. 2006). However, despite the marine environment being used by a wide collective of stakeholders with commercial and non-commercial, or consumptive and non-consumptive interests, the inclusion of socioeconomic aspects in the design process of MPAs tends to be mostly dominated by the incorporation of commercial fisheries interests (Ban and Klein 2009). In most cases, the failure to incorporate a wider set of interests is generally caused by the scarcity or lack of data on the spatial distribution and value of other uses.

On the other hand, MPAs can provide economically valuable activities (Farrow 1996) such as tourism (Agardy 1993) or benefits that can contribute to the generation of economic revenues such as the protection of the natural resources that support fisheries (Russ and Alcala 1996). Additionally, MPAs may also possess an economic value that is unrelated to any actual expenditure or revenue associated to their use, this situation is likely to occur when people are willing to pay for the preservation of the marine environment due to existence or bequest reasons. For this reason it may be said that MPAs have associated non-use values (Wallmo and Edwards 2008) and the capture of these values could be used as support for conservation management plans. However, although important issues such as the value of non-consumptive uses or non-uses associated with the marine environment may play an important role in the planning of MPAs, these factors are not always taken into account. In this context, valuation studies can offer new essential information for the design of MPAs.

Within the general context of ecosystem conservation which includes tools such as MPAs, it has been acknowledged that the integration of economic and ecological sciences into decision support systems is a crucial step in achieving global conservation and sustainability (MEA 2003) since the capability of capturing the value of ecosystems can lead to better informed decisions and better management (TEEB 2008). Findings from economic valuation studies have revealed that there are substantial positive economic values attached to marketed and non-marketed services provided by ecosystems that justify their sustainable use and management (Mendelsohn and Olmstead 2009, Remoundou et al. 2009). Additionally, valuation studies offer useful economic information to policy and decision-makers in the design and development of efficient and effective environmental policies (Boyle et al. 1987, Loomis 1995, Loomis and Feldman 1995). They also provide useful data on societal preferences and attitudes towards the environment and potential environmental policies, offering an insight into whether new environmental measures would be willingly accepted by society (Remoundou et al. 2009).

However, ES valuation is a complex field as several types of services are derived from marine ecosystems, each of the services has a range of associated values and the quantification of each value type can be established using one or more of several valuation techniques. To clarify some of the concepts used in the subsequent chapters of this thesis, a brief introduction to the types of ES, their associated values and existing methodology for their valuation is presented in the following sections.

1.4 Type of ES and associated values

The range of services derived from marine ecosystems can be classified into several categories. The most widely accepted classification was established in 2003 by the Millennium Ecosystem Assessment (MEA 2003). The MEA represents the first attempt to fully interpret, understand and assess the interrelations between ecosystems and human well-being. According to MEA, ecosystem services (ES) are divided into four major classes: provisioning services, such as the production of food; regulating services, like flood and storm protection; supporting services, such as nutrient cycling; and cultural services, like recreation (MEA 2003). A detailed description of the different ES is shown in table 1.1.

A wide range of values is associated with the different ES, these values are dependent upon their absolute size and who benefits from them, thus the value of ES depends upon the views and needs of stakeholders (Vermeulen and Koziell 2002) (here the word 'stakeholders' refers to any group or individual who can affect or is affected by ES). The values that stakeholders attach to ES can be classified into two main groups, namely use values (UV) and non-use values (NUV). Use values refer to the benefits stakeholders derive from the use of the resource while non-use values reflect the values stakeholders attach to the resource even if they might not use it. Use values can be further divided into direct use values, indirect use values and option values; non-use values can be divided into existence values and bequest values (Hein et al. 2006):

(a) Direct use values. Direct use values arise from human direct utilization of ES. They include the value of consumptive uses such as harvesting of food products; and the value of non-consumptive uses such as recreational activities.

(b) Indirect use values. Indirect use values stem from the indirect utilization of marine ecosystems; these are values associated to benefits provided outside the ecosystem itself. Examples include nutrient cycling and gas and climate regulation.

(c) Option use values. Values derived from preserving the option to use ES that are not being used presently but that they might be used in the future. Option values can be attributed to all ES.

(d) Non-use values. Non-use values are derived from the enjoyment people may experience by knowing that a resource exist (existence value) or that a resource will be there for the use and enjoyment of future generations (bequest value).

The sum of all economic values that result from an environmental resource is known as the Total Economic Value (Fig. 1.1).

Table 1.1. A general classification of ecosystems goods and services of marine ecosystems. Source: Drawn from MEA (2003) and adjusted for marine environment based on Beaumont et al. (2007)

Category	Good or Service
Production services	Food provision The extraction of marine organisms for human consumption
	Raw materials The extraction of marine organisms for all purposes, except human consumption
Regulation services	Gas and Climate regulation The balance and maintenance of the chemical composition of the atmosphere and oceans by marine living organisms
	Disturbance prevention (Flood and storm protection) The dampening of environmental disturbances by biogenic structures
	Bioremediation of Waste Removal of pollutants through storage, dilution, transformation and burial
Cultural services	Cultural Heritage and Identity The value associated with marine ecosystems e.g. for religion, folklore, painting, cultural and spiritual traditions
	Cognitive values Cognitive development, including education and research, resulting from marine ecosystems
	Leisure and human recreation The refreshment and stimulation of the human body and mind through the engagement with the marine environment
	Non-use values Value which we derive from marine ecosystems organisms without using them
Option value use	Future unknown and speculative benefits Currently unknown potential future uses of marine ecosystems
Supporting services	Nutrient cycling The storage, cycling and maintenance of availability of nutrients by marine ecosystems
	Resilience / Resistance The extent to which ecosystems can absorb recurrent natural and human disturbances and continue to regenerate without slowly degrading or unexpectedly shifting to alternate states
	Biologically mediated habitat Habitat provided by marine organisms (e.g. coral reefs)

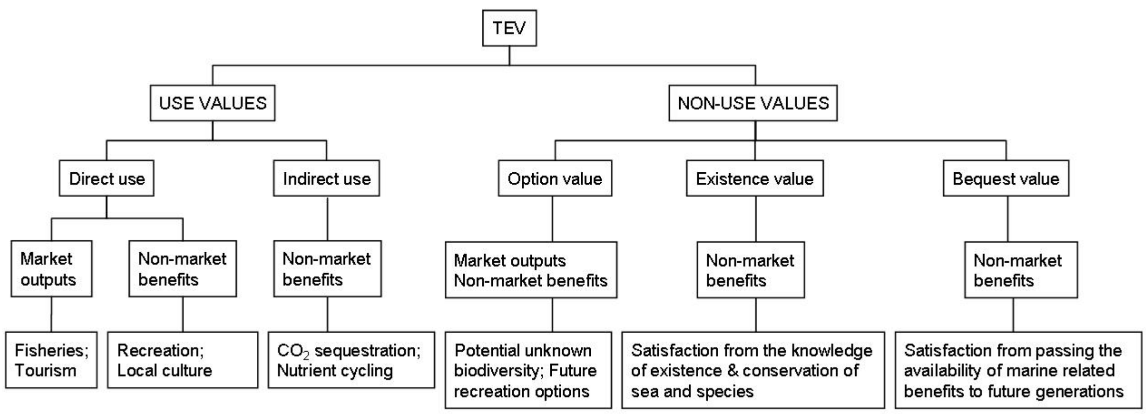


Figure 1.1. Category of the total economic value (TEV) of marine ecosystems. (Source: modified from Pearce and Moran 1994).

1.5 Economic Valuation Methods

The wide diversity of values associated to ES has generated a range of methods for the valuation of the different services and their associated values. These methods can be broadly divided into market valuation methods and non-market valuation methods. Market valuation methods are used to estimate the direct use value of services, these methods can only be used for those services that have a "market price" attached to them. In market valuations observations of market prices are used to estimate the economic value related to the service, this can include the value of contracts signed by pharmaceutical industries to exploit a particular resource or the value of the financial revenues related to tourism focused on visits to areas of high outdoor recreational demand (Nunes and van den Bergh 2001). Non-market valuation methods are used to value those services that are un-priced and for which there is no existing market. Non-market valuation techniques are used to estimate non-use values and some direct use values. Non-market valuation methods are further divided into two different approaches, namely the 'Revealed Preferences' approach (RP) and the 'Stated Preferences' (SP) approach. In revealed preferences techniques the valuation of the good or service under scrutiny is performed on the basis of consumer behaviour, values are indirectly deducted from people's behaviour in surrogate markets, which are hypothesized to be related to the ES of interest. RP techniques include the Travel Cost method, Hedonic Pricing, Replacement Cost and the Production Function method. In stated preference approaches a value is given to ES by asking individuals to place explicit monetary values on that ES. Stated preferences approaches are survey-based methodologies that use hypothetical markets in which respondents are asked to state their willingness to pay for a certain service. They include the Contingent Valuation method (CVM) and the Choice Experiment method (CE) (Liu et al. 2010). Details for each method, their applications and limitations are shown in table 1.2.

Table 1.2. Main economic valuation techniques (adapted from (IUCN 2004)

Method	Approach	Applications	Requirements	Limitations
Revealed Preferences				
Production function	Trace impact of change in ES on produced goods	Any impact that affects produced goods	Change in service; impact on production; net value of produced goods	Data on change in service and consequent impact on production often lacking
Replacement cost	Use cost of replacing the lost good or service	Any loss of goods or services	Extent of loss of goods or services, cost of replacing them	Tends to over-estimate actual value; should be used with extreme caution
Travel cost	Derive demand curve from data on actual travel costs	Recreation	Survey to collect monetary and time costs of travel to destination, distance travelled	Limited to recreational benefits; hard to use when trips are to multiple destinations
Hedonic pricing	Extract effect of environmental factors on price of good that influenced by those factors	Air quality, scenic beauty, cultural benefits House prices	Prices and characteristics of goods	Requires vast quantities of data; very sensitive to specification
Stated Preferences				
Contingent valuation	Ask respondents directly their WTP[2] for a specified service	Any service or good	Survey that presents scenario and elicits WTP for specified service	Many potential sources of bias in responses; guidelines exists for reliable application
Choice experiments	Ask respondents to choose their preferred option from a set of alternatives with particular attributes	Any service or good	Survey of respondents	Hypothetical valuation, analysis of the data generated is complex

The application of RP methods is limited as they can only be used to value a restricted number of ES; SP methods on the other hand can be used for the valuation of the full spectrum of use and non-use values (Nunes and van den Bergh 2001). However, SP suffer from two main lines of criticism, the principal criticism stems from the hypothetical nature of valuation as it is established that there is a difference between what people state they are willing to pay for an ES and how this is revealed in practice (Murphy et al. 2005). Additionally, it is argued that it is difficult for

[2] WTP, Willingness to pay

people to attach an economic value to an ES when in general people may be ill informed or unfamiliar with the subject (Jones-Walters and Mulder 2009).

1.5.1 Contingent valuation vs. Choice Experiments

As choice experiments have been used in Chapter 3 of this thesis to perform a social valuation of MPAs, a brief overview on stated preference techniques is presented here to provide some relevant information on the technique.

Contingent valuation (CVM) and choice experiment (CE) methods can be used to assess all use and non-use values for the whole set of environmental goods and services. In CVM studies respondents are asked to state how much they would be willing to pay to avoid a loss in a particular ES through carefully designed questionnaires. The method is said to be contingent because people are asked to state their Willingness to Pay (WTP) for a service, or what they would be willing to accept (WTA) to forego that service (Bateman and Turner 1992). There has been controversy regarding CVM as errors and biases are easily introduced (Table 1.3) (Venkatachalam 2004). The concerns about the reliability of the method led the National Oceanic and Atmospheric Administration (NOAA) to convene a panel of experts to examine the issue, and as a result a set of guidelines were established (Arrow et al. 1993).

The controversy surrounding CVM led to the rise in popularity of the CE approach over the last decade, and as a result CE has become a popular SP method for environmental valuation (Hoyos 2010). Choice experiments allow the identification of the marginal value of changes in the characteristics of an ES. Respondents are asked to choose their most preferred alternative among a set of hypothetical alternatives, each alternative shows the same bundle of environmental attributes, the alternatives differ in the levels displayed by the attributes. Through the analysis of responses the marginal rate of substitution between any pair of attributes that differentiate the alternatives can be determined. If one of the attributes has a monetary price attached to it, it is then possible to compute the respondent's WTP for the other attributes (Hanley et al. 1998). As with CVM, CE is subject to the same concerns about hypothetical bias, however it offers some advantages, for instance it creates the opportunity to determine trade-offs between environmental attributes since it is focused on the discovery of whole preference structures and not just monetary valuation (Liu et al. 2010).

Table 1.3. Potential bias incurred during contingent valuation

Bias	**Description**
Information bias	Attributed to respondents confusion of the valuation scenario
Design bias	The validity of results depends on the level and nature of the information provided to the respondents through the scenarios
Hypothetical bias	Disparity between respondent stated and actual WTP
Yea-saying bias	Tendency of respondents to agree with the interviewers requests, therefore not stating their own valuation
Strategic bias	Two forms Free-riding: occurs when individuals understate their true WTP on the expectation that others would pay enough for that good, so they don't have to pay Overpledging: it occurs when an individual assumes that his/her WTP would influence the provision of the ES under question
Substitute bias	If the service under valuation has a substitute then the WTP tends to be lower than those without substitutes
Embedding effects	Disparity between the value assigned to a group of services and the sum of the values assigned to the services individually

1.6 Aims and thesis structure

The overall aim of this thesis is to identify and quantify the value of the marine environment around the Welsh coast to different stakeholders and to integrate this information with already existing high quality economic fisheries valuation data (Richardson et al. 2006). This information will be used to model various scenarios for the implementation of MPAs. This study thus represents a unique opportunity to progress spatial planning and management for the Welsh coast beyond the focus of fisheries and to further the development of marine spatial planning for marine resource management.

Furthermore, this study will attempt to clarify the social, cultural and economic importance of the marine environment, and as such will be beneficial to support and influence future marine environmental policies. The objectives of the study are:

- Identification of stakeholder groups and examination of which areas of the sea have the highest value according to these different groups.
- Promote the inclusion of the different stakeholder groups in marine spatial planning processes.
- Identification of the social and cultural values attached to the marine environment.
- Optimisation of biodiversity conservation while reducing economic impacts on the stakeholders.
- Integration of economic, social and cultural values into a spatial planning framework.

These aims were addressed by the different chapters as summarized below. The thesis is presented in the form of papers prepared for scientific publication, as such some overlap is inevitable when common methodologies have been used for the different components of this thesis.

Chapter 2 focuses on the assessment of non-use values of the marine environment (i.e. bequest and existence values) by performing a stated preference valuation of a marine environmental conservation policy directed towards the establishment of a network of MPAs in Wales. Besides establishing the non-use values of the area, the aim is to ascertain society's economic support for the implementation of MPAs and to further understand preferences regarding the management regime and type of MPAs to be implemented.

Chapter 3 aims at filling in some of the information gaps in Wales regarding the value and distribution of some of the uses of the marine environment besides fisheries. In particular, this chapter reports on the findings of an economic market valuation and assessment of the spatial distribution of non-consumptive recreational services provided by marine biodiversity in Wales. Findings from this chapter provide a measure of the economic importance of marine biodiversity in terms of the provision of recreational services and highlight the importance of mapping the distribution of these services in relation to marine spatial planning.

Chapter 4 provides an assessment of the range of social values associated with the marine environment in Wales. This was achieved by gathering information on the values and benefits derived from the marine environment ascertained by different interest groups and by defining the spatial distribution of those values such that they could be incorporated into marine spatial management plans. Additionally, stakeholders views on the preferred location and design of MPAs was also investigated.

In Chapter 5 and Chapter 6 data collected over the course of the research are incorporated in the systematic design of marine protected areas for Wales. In Chapter 5, the site selection algorithm MARXAN is used to assess the potential benefits of integrating consumptive and non-consumptive interests in the design of MPAs in order to balance conservation needs and the interests of multiple stakeholders. Finally, Chapter 6 delivers an assessment, comparison and integration of two different approaches to the planning process of MPAs, namely a science-based approach and a stakeholder-based approach.

In Chapter 7 the general findings of this thesis are summarized and discussed.

Chapter 2

Valuing society's desire for marine protected areas

2.1 Abstract

Marine protected areas (MPAs) are increasingly being used as conservation tools in the marine environment. The success of MPAs depends upon a sound scientific design and societal support. However, societal preferences rarely have been acknowledged during the MPA design process. This study has quantified societal preferences and economic support regarding MPAs in Wales (United Kingdom) in terms of their size and management using a stated preference technique; the choice experiment method. Results indicated that there was general support for the establishment of MPAs among the general public (81%) and that society is willing to bear the additional economic costs derived from marine conservation. Respondents in favour of MPAs could be divided into two groups with distinct preferences for different degrees of protection. These different groups were characterized by those respondents who wanted smaller reserves with more restrictive policies (32%) versus those supporting bigger more liberally managed areas (49%). The recognition of heterogeneous preferences will be fundamental in the evaluation and success of marine protection policies. Based on our findings, marine reserves which combine areas with differing levels of user-access would appear to be the solution that would have the greatest level of public support while still ensuring effective conservation. In addition to characterizing preferences for different marine protected areas, the study was also able to establish that the economic benefits arising from establishing the MPAs will probably be greater than their costs.

2.2 Introduction

The marine environment provides society with a wide range of goods and services that are essential for the maintenance of our economic and social well being (Costanza et al. 1997). However, during the last century marine ecosystems have been subject to increasing human and environmental pressure with wide ranging consequences such as the collapse of fish stocks, decreases in biodiversity and increasing water temperatures (Pauly et al. 1998, Worm et al. 2009).

The current recognition of the effects of anthropogenic activities on marine ecosystems has led to stronger conservation initiatives globally. Marine protected areas (MPAs) are among the most important tools available for achieving global marine conservation targets, which are recognised at both an international and European level. In 1992, the OSPAR Convention (Convention for the Protection of the Marine Environment of the North Atlantic) recommended a "coherent network" of MPAs to be in place by 2010 (OSPAR 2003). In 2002, the World Summit on Sustainable Development issued a call for a "representative network" to be implemented by the year 2012, developed as an international binding treaty within the Convention on Biological Diversity (CBD 2008). More recently at a European level, the European Union Marine Strategy Framework Directive required each member state to establish a "coherent and representative network" of MPAs by 2020 (MSFD 2008).

Although the role of MPAs in the recovery of fish stocks and fisheries management remains an issue of debate (Kaiser 2005, Stefansson and Rosenberg 2006), it is clear that the establishment of MPAs has positive benefits for habitat restoration and biodiversity conservation within the boundaries of the MPA (Halpern 2003, Blyth-Skyrme et al. 2006). However, the creation and enforcement of MPAs is economically costly (Balmford et al. 2004) and despite their potential benefits, their designation is often complex both legally and socially. This is because the closure of portions of the sea to human activities has impacts on those sectors of society directly affected by the closures, and not all of these impacts are perceived as positive. However, if designed carefully MPAs can achieve a balance between marine conservation and socioeconomic objectives (Klein et al. 2008a). Consequently, the design of MPAs is better addressed from an interdisciplinary perspective that is able to provide insights into the range of potential consequences of implementation. If MPAs are to successfully achieve their conservation objectives, then the biological principles of good reserve design need to have a strong influence on the designation process (Roberts et al. 2003). However, conservation objectives cannot be met without support from members of local communities, resource users and policy makers (Moore et al. 2004). There is therefore a strong case for actively involving stakeholders in the designation process. However, although the importance involving stakeholders in conservation programmes is well documented at a general level (Lundquist and Granek 2005, Knight et al. 2006, Richardson 2006), societal issues are rarely considered during the MPA design process which remains dominated by biological issues.

Several studies have analysed stakeholders' perceptions towards MPAs (Himes 2007, Mangi and Austen 2008, Thomassin et al. 2010), however none of them have formally quantified the value provided to society from the establishment of MPAs, and its subsequent associated conservation benefits. Such studies have been undertaken in terrestrial systems, and they reveal that society is willing to pay for the establishment of protected areas (White and Lovett 1999, Walpole et al. 2001, Adams et al. 2008), however no such information is available for the marine environment. Although some valuation studies exist on the commercial and recreational uses of MPAs (Bhat 2003, Roncin et al. 2008) or on the willingness to pay for visiting protected areas (Arin and Kramer 2002, Mathieu et al. 2003, Peters and Hawkins 2009) there is no evidence for the intrinsic value society attaches to the conservation of the marine environment itself or on their economic support for the establishment of protected areas (but see Wallmo and Edwards 2008). Since oceans cover 71% of the earth's surface this is a surprising gap in our knowledge.

The present study focuses on Wales in the United Kingdom (UK), where Government has developed a Marine and Coastal Access Bill in which it commits to "establishing an ecologically coherent, representative and well-managed network of marine protected areas" taking into account "environmental, social and economic criteria" by 2012 (DEFRA November 2009). In Wales, comprehensive information is available for the distribution of biophysical and ecological factors, however no information exists on either how much the public values the conservation of the marine environment, or on the support for MPAs in the area. This case study therefore offers the opportunity to evaluate societal demand and support for MPAs.

In order to fill these knowledge gaps a non-market valuation exercise for a network of MPAs in terms of its size and management strategies was undertaken. The study adopts a stated preference technique, termed a choice experiment, as the method for ascertaining society's willingness to pay for the network of MPAs. Choice experiments (CEs) are survey-based methodologies where respondents are asked to choose their most preferred alternative among a set of hypothetical alternatives, each alternative is characterised by the same bundle of attributes, however the alternatives differ in the levels displayed by the attributes. Through the analysis of responses the marginal rate of substitution between any pair of attributes that differentiate the alternatives can be determined. If one of the attributes has a monetary price attached to it, it is then possible to compute the respondent's willingness to pay (WTP) for the other attributes (Hanley et al. 1998, Liu et al. 2010). Within the context of environmental valuation, CEs have been mostly used to measure the effects of changes in environmental attributes (Hanley et al. 1998, Birol et al. 2006a, Christie et al. 2006, Milon and Scrogin 2006, Christie et al. 2007, Yoo et al. 2008). Recently however, the CE approach has been used to measure the marginal value of the attributes of policies rather than environmental goods. Instead of defining the attributes in terms of the characteristics of the environmental good, the attributes are defined in terms of the characteristics of the policy itself (Christie et al. 2006, Ruto and Garrod 2009).

In the present study the CE approach is used to perform a valuation of an environmental policy directed towards the establishment of a network of MPAs in Wales, UK. The aim was to ascertain society's economic support for the establishment of MPAs and to further understand preferences regarding the management regime and type of MPAs to be implemented. This study provides policy-makers and managers with an essential insight into societal preferences with respect to MPAs and the economic benefits generated by the sustainable management of the marine environment.

2.3 Materials and Methods

The economic value associated with changes in the size and uses allowed within the boundaries of an MPA network were estimated using choice experiments (CE). CE data were collected using questionnaires. Societal preferences for MPAs were estimated with a latent class choice experiment model (Train 2009).

2.3.1 Area of study

The study focused on the establishment of a network of MPAs around the coastal waters of Wales, UK (Fig. 2.1) prior to the initiation of formal Government consultation in late 2009. In 2009, 32% of Welsh territorial waters were protected under a range of European designations (Marine Nature Reserve, Special Area of Conservation, Special Protection Area and Site of Special Scientific Interest). However, existing designations are limited in terms of the species, habitats or areas that are afforded protection and also the level of protection they offer. At the time of writing, no area of the Welsh coast was fully protected from all potentially harmful activities.

In the UK, the Marine and Coastal Access Bill provides the legislative powers necessary for the implementation of Marine Conservation Zones (MCZs). In Wales, the MCZ designation will be primarily used to establish Highly Protected Marine Reserves (HPMRs), these are sites that are generally protected from extraction and deposition of living and non-living resources, and all other damaging or disturbing activities. The establishment of HPMRs will complement the existing network of protected areas, resulting in a network of MPAs with varying levels of protection.

2.3.2 Study design

Choice experiments (CE) were used to perform a valuation of an environmental policy directed towards the establishment of a network of MPAs in the UK. The first step in any CE is to define the good to be valued in terms of its attributes and levels. This study focuses on those aspects of MPA network design that are most likely to have an impact on society. Initially, the attributes considered for the CE were the location, total size of the network, level of protection, proportion of areas with different levels of protection, and the economic cost associated with enforcing protection. A focus group was carried out with 15 members of the general public to define the final list of attributes to be included in the survey. During the meeting the list of attributes, possible associated levels and alternative formats of the CE survey were discussed. The focus-group exercise revealed that the full set of attributes was too complex to enable respondents to make meaningful trade-offs during the CEs. The final set of attributes was reduced to include only size, level of protection and cost.

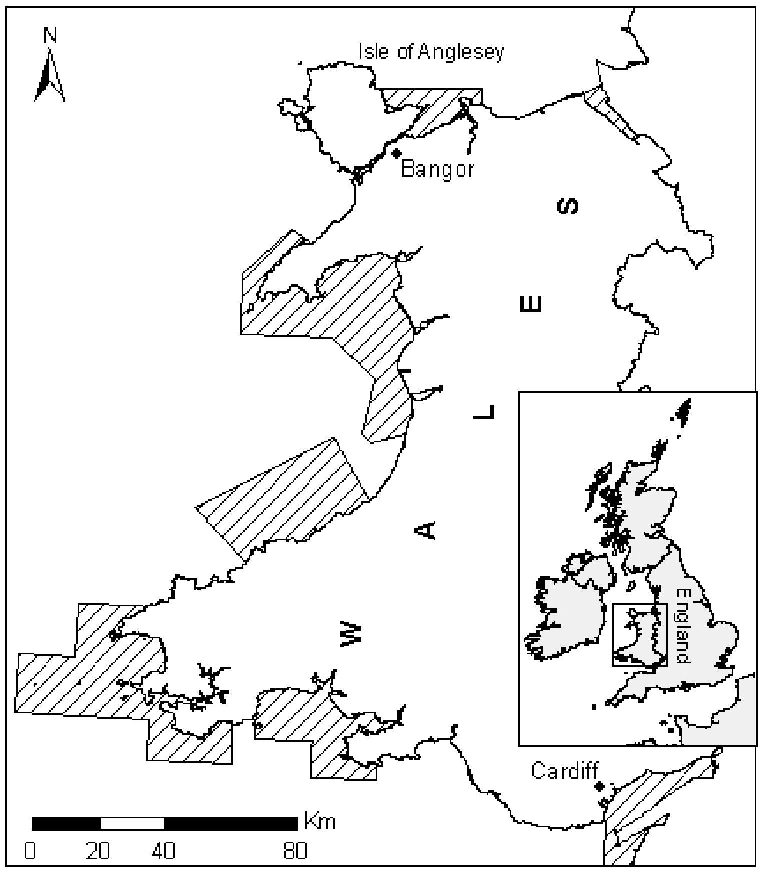


Figure 2.1. Map of Wales, hatched areas indicate the location of conservation designation areas in 2009 (none of these areas are fully protected from all potentially harmful activities).

To set the levels for the size attribute, the current situation in Wales was taken as a baseline. According to the statutory Governmental conservation advisory body (Countryside Council for Wales), it is unlikely that the area of the new network of MPAs will exceed that of the existing protected areas (32% of territorial waters). Thus, the highest level for attribute size was set to 30% of Welsh territorial waters (equivalent to 4,826 km^2), 20% and 10% were chosen as the alternate levels.

To define the different levels of network protection for the CE, management plans for marine reserves worldwide were reviewed. In this study four levels of protection were selected for the CE as a representation of the most common management alternatives around the world: (1) no take zones in which no activities were allowed, (2) areas in which only scientific research and educational activities were allowed, (3) non-extractive recreational activities allowed (e.g. scuba-diving, sailing, kayaking) and (4) recreational and commercial fishing using non-damaging equipment to the sea floor allowed.

The third attribute included in the CE was a monetary one, which is required to estimate welfare changes of respondents. The range chosen for the monetary attribute and the payment vehicle were determined during preliminary interviews. The final set of selected attributes, their levels and definition are reported in table 2.1.

Table 2.1. Attributes and levels used in the choice experiment

Attribute	Definition	Levels
Network size	Percentage of territorial waters to be protected	10%, 20%, 30%
Uses permitted	Uses permitted within the boundaries of the network	- All activities prohibited - Only scientific research and educational activities - Non-extractive activities (i.e. sailing, diving, kayaking, wildlife watching) allowed - Recreational and commercial fishing using non-damaging equipment to the sea floor allowed (previous level included)
Cost	Annual contribution to a neutral charity. The charity works with the government to negotiate, monitor and manage the MPAs	Payment levels: £5, £10, £25, £50, £100

The final questionnaire contained general information on the relevance of the marine environment from a societal perspective, information on MPAs and on the current situation and future plans for Wales. CE tasks were located subsequently after. Additionally, data on societal views and attitudes towards MPAs and the environment were collected.

This study aimed to collect a representative sample for the areas of Wales and England, thus demographic data were collected in order to assess the representativeness of the sample. Average questionnaire completion time was 15 minutes (Appendix 1).

2.3.3 Experimental design and data collection

SPSS Orthoplan was used to generate a (3^1 x 4^1 x 5^1) fractional factorial experimental design, which created 25 choice options. A blocking procedure was used to assign the options to five bundles of five choice sets, thus five versions of the choice experiments were produced. Each version contained a different combination of five CE tasks and each choice task consisted of three alternatives (A, B and Current situation in Wales, Fig. 2.2).

Data were collected between May-July 2008 using self-completion questionnaires. Questionnaires were administered to consenting passengers on several train routes covering the entire area of Wales. Since the completion time of the questionnaire was high and required the full attention of the respondent it was felt that trains would offer a receptive audience willing to participate in the study. Also, within the UK trains are widely used by a cross section of society including businessmen, students, retired people and families. Any potential bias that occurred as a consequence of sampling on trains could be assessed through the socio-demographic data collected in the questionnaires (Table 2.2).

Two consecutive pilot phases were conducted on seventy-three respondents prior to the final administration of the survey. Minor corrections to the questionnaires were implemented after the pilots. As the structure of the CEs tasks did not change during the pilot phases, all pilot questionnaires were included in the final CE analysis.

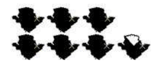
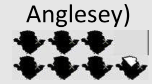
	Option A	Option B	Current Situation
Size of the network of MPAs	20% of coastal waters (equivalent to 4½times the area of Anglesey) 	30% of coastal waters (equivalent to 6¾ times the area of Anglesey) 	30% of coast as SAC (equivalent to 6¾ times the area of Anglesey) 
Level of Protection	Only scientific research and educational activities allowed	Non-extractive activities (i.e. sailing, diving, kayaking, wildlife watching) allowed	Minimum level of protection Most activities including commercial fishing allowed
Cost to you **each year**	£25	£5	No additional cost to you
Which of the three options do you most prefer?	I prefer Option A ☐	I prefer Option B ☐	I prefer the Current Situation ☐

Figure 2.2. Choice task example

A total of 448 people were approached to take part in the study of which 78 declined to participate. Of the 368 questionnaires handed out, 14 were incompletely answered, leaving a total sample of 354 respondents. Each version of the CE tasks was allocated approximately 71 times.

Table 2.2. Comparison of respondents' socio-demographic characteristics vs. census data for England and Wales

	Sample average	Census average[a] (England & Wales)
Gender (% male)	49	49
Median age range	45-59	45-59
University degree & above (%)	63	19
Household size	2.6	2.4
Number of children	0.5	1.6
Annual income x capita[b] (£)	15,248	16,100

[a]Source: 2001 UK Census: Standard Area Statistics (England and Wales)
[b]Source: StatsWales 2006-2007

2.3.4 Choice Experiments Econometrics

The economic framework for CE lies in Lancaster's theory of consumer choices (Lancaster 1966), which assumes that the utility of a good can be decomposed into the utilities of the characteristics of that good and as a result consumers' decisions are determined by the utility of the attributes rather than by the good itself. The econometric basis for CE is provided by the random utility theory framework which describes consumers' choices as utility maximization behaviours. Through the analysis of CE data, marginal values for the attributes of a good or individual's willingness to pay (WTP) can be calculated (Hensher et al. 2007).

CEs can be analysed using different models. Due to its simplicity, the multinomial logit model (MNL) is the most widely used. This model has important limitations; specifically, it assumes independence of irrelevant alternatives (IIA) and it assumes homogeneous preferences for all respondents (Hausman and Mcfadden 1984). However, within society preferences are heterogeneous and the ability to account for this variation allows the estimation of unbiased models that provide a better representation of reality. Random parameter logit models (RPL) and latent class logit models (LC) relax the limitations of standard logit by allowing random taste variation and unrestricted substitution patterns in their estimation. The RPL allows utility parameters to vary randomly across individuals while in the LC formulation parameter heterogeneity across individuals is modelled with a discrete distribution, or a set of "classes". The situation can be viewed as one in which the individual resides in a "latent" class which is not revealed to the analyst (Hensher et al. 2007).

The utility (U) of a good consists of a known or systematic component (V) and a random component (ε) which is not observable by the researcher. The systematic component of utility can be further decomposed into the specific attributes of the good (βX), which in this case is a policy for the establishment of MPAs. Thus, the utility that respondent n derives from a certain MPA alternative i is given by:

$$U_{in} = \beta_{in} + \varepsilon_{in} \quad (1)$$

The probability that an individual *n* will choose MPA alternative *i* from a set of *J* alternatives is equal to the probability that the utility derived from *i* is greater than the utility derived from any other alternative:

$$\Pr ob_{in} = \Pr ob(U_{in} > U_{jn}) \qquad \forall j \in J \qquad (2)$$

Assuming the random term to be independent and identically distributed (IID) according to a type I extreme value distribution, the probability that respondent chooses alternative *i* in choice occasion *q* is a standard MNL (McFadden, 1974):

$$L_n(i,q \mid \beta_n) = \frac{\exp(\beta_n X_{inq})}{\sum_j^J \exp(\beta_n X_{jnq})} \qquad (3)$$

If z_{nt} is the respondent's chosen alternative in choice occasion *q* and $z_n = (z_{n1}, z_{n2},..., z_{nQ})$ is the sequence of choices in Q choice occasions then the joint probability of the respondent's choices is the product of the standard logits:

$$\Pr ob(z_n \mid \beta_n) = L(z_{n1}, 1 \mid \beta_n)....L(z_{nQ}, Q \mid \beta_n) \qquad (4)$$

The term β_n is not directly observable, only its density $f(\beta \mid \theta)$ is assumed to be known, where θ represents the parameters of the distribution. In RPL and LC models the unconditional probability of the respondent's sequence of choices is the integral of equation (4) over all possible values of β_n determined by the population density of β_n:

$$\Pr ob(z_n \mid \theta) = \int \Pr ob(z_n \mid \beta_n) f(\beta_n \mid \theta) d\beta_n \qquad (5)$$

The distribution of β will determine the type of model to be used. If β is continually distributed it will result in a RPL (McFadden and Train, 2000) while if the coefficients are discretely distributed and class membership is homogeneous it results on a LCM, where β takes values for each class.

The log-likelihoods for both specifications are determined by:

$$L(\theta) = \sum_{n}^{N} \ln \Pr ob(z_n) \qquad (6)$$

Since the choice probability in the RPL does not have a closed form the expression has to be approximated using simulation (Train, 2003). Repeated draws of β are taken from its density $f(\beta \mid \theta)$. For each draw, the product of logits is calculated and the results are averaged across draws. In this study Halton intelligent draws have been used for the simulation since they have been found to provide greater accuracy than independent random draws in the estimation of RPL models (Train 2009).

$$L_{RPL}(\theta) = \sum_{n=1}^{N} \ln\left[\frac{1}{D} \Pr ob(z_n \mid \beta^d)\right] \qquad (7)$$

where D is the number of draws and β^d is the d^{th} draw. For a LCM with C latent classes, the log-likelihood function is given by:

$$L_{LCM}(\theta) = \sum_{n}^{N} \ln\left[\sum_{c=1}^{C} \Pr ob(c) \Pr ob(z_n \mid \beta_c)\right] \qquad (8)$$

where Prob(c) has a MNL form and is the probability of respondent *n* belonging to class *c* and β_c represents a vector of class specific coefficients.

Welfare estimates can be derived from the models, they are calculated in the form of willingness to pay (WTP) using the formula

$$WTP = \frac{\beta_a}{\beta_c} \qquad (9)$$

where β_a is the coefficient of the attribute of interest and β_c is the negative of the coefficient of the monetary variable.

2.3.5 Model specification

In this study, RPL and LCM models were used to determine society's WTP for alternative designs of networks of MPAs. MNL was estimated for comparative purposes.

All models in the study were estimated using LIMDEP 9.0 (NLOGIT 4.0., Econometric software). Only the results for the best fitting model are presented. CE models were designed under the assumption that the observable utility function would follow a strictly additive form. Models were specified so that the probability of selecting a particular MPA configuration scenario was a function of the attributes of that scenario and a constant, which was specified to equal 1 when either alternative A or B was selected, and 0 when the current situation scenario was selected. Attributes size and cost were treated as continuous variables while effects-coding (Hensher et al. 2007) was used for the allowed uses attribute.

Focus groups carried out as part of a similar study have suggested that there is a diminishing marginal utility for increasing the size of an MPA network (Wallmo and Edwards 2008) and therefore an additional quadratic term for size was included in the models. Interaction terms between the type of use and size were also included in the models to evaluate how size affected utility for the different uses.

Socio-demographic and attitudinal variables were included in the models. Respondent's knowledge on MPAs was also considered. Knowledge was assessed with a four point Likert scale with anchor points "I've never heard of MPAs" and "I consider I've got a good knowledge of MPAs" and on the basis of their responses they were divided into two groups, namely Low and High knowledge level.

2.3.6 Latent Class segmentation

In order to define the number of classes to be used in the LC model specification a principal component analysis (PCA) was carried out on the attitudinal statements and socio-demographic data collected on the survey. A PCA with varimax rotation extracted 9 factors with eigen-values greater than 1. In order to simplify the model specification only the three factors with the highest eigen-values (3.7, 2.3 and 1.8) were used in the model, these components accounted for approximately 30% of the variance. The first component was composed of statements relating to general attitudes towards the protection of the environment and was called "Environmental values" (factor 1). The second factor was labelled "Use/protection of the sea" (factor 2) because statements related to the use and protection of the marine environment loaded highly in this factor. The third factor was composed of socio-demographic characteristics.

Scores for the first two factors were calculated for each respondent resulting in two variables to be used in the definition of the latent classes. Factor values ranged from 1 to 4, 1 indicating higher degree of environmental consciousness. The socio-demographic variables selected on the third factor were also included in the model. In total six variables were used in the latent class model specification.

Information criterion measures, AIC and BIC, were used to ascertain the suitability of models with 2, 3, 4 and 5 segments. After examination of their respective log likelihoods, pseudo-R^2, AICs and BICs it was concluded that the 3-segment solution provided the best fit to the data.

2.4 Results

2.4.1 Public attitudes towards marine conservation

Results from the attitudinal study revealed that public knowledge regarding MPAs was very low. On a scale of 1 to 4 (1 = "*Never heard of MPAs*" and 4 = "*I consider I've got a good knowledge of MPAs*") 79% of respondents chose either options 1 or 2.

Despite the lack of knowledge on marine protected areas the questionnaire showed that the general public had a positive and supportive attitude towards marine reserves. Over 66% of respondents thought that current levels of protection of the sea were insufficient and the vast majority (90% of the sample) liked knowing that certain areas of the sea were fully protected, and agreed with the principle of protection of the Welsh marine environment even if they might never make use of it. Seventy-five percent of respondents agreed that MPAs can provide a good balance between conservation and human activities and a high proportion (86%) thought that there are conservation benefits related to protected areas.

Fifty percent of respondents believed that the benefits associated with the establishment of protected areas would most likely be greater than its costs. However, in general, it was considered that those who are affected by the establishment of MPAs should receive compensation for any financial losses and the public might be willing to pay higher prices for marine-related products or services in order to facilitate the preservation of areas of the sea around Wales. It is worth noting that the percentage of respondents willing to pay higher prices was very similar for Welsh and non-Welsh residents (66% and 60% respectively). Public opinion was equally divided regarding the proposition that no-one should be restricted from using the sea. Fifty percent of the respondents considered that there was no need to restrict uses that do not cause damage to the seafloor, this percentage however dropped to 38% when the specific use under consideration was fishing.

2.4.2 Choice experiments results

The majority of respondents were able to make a choice between the three alternatives offered in the CE and only 2% of the sample did not complete the total number of choice tasks. About 76% of respondents were completely, mostly or somewhat certain of the choices they made. One of the two MPA alternatives was chosen 69% of the times and there is evidence that respondents compared the alternatives, as in 84% of the cases respondents varied their choice across the five choice tasks. Only 3% of the sample consistently chose either alternative A or B. Approximately 18% of respondents selected the current situation constantly across the tasks, the main reasons for selecting the status quo were that they "*support the conservation of the marine environment but can't afford the costs*", "*I need more information to make a choice*" and "*no one should be restricted from using the sea*".

2.4.3 Best fitting model. The Latent Class Model

Results for the RPL, RPL with interactions and LCM indicated that the LCM significantly improved the fit of the model ($RPL_{\text{log-likelihood (LL)}}$ = -1441, RPL_{AIC} = 1.7, $RPL_{\text{pseudo-R}}{}^2$ = 0.24; LC_{LL} = -1271, LC_{AIC} = 1.5, $LC_{\text{pseudo-R}}{}^2$ = 0.33). Additionally, a test on non-nested choice models based on AIC (Ben-Akiva and Swait 1985) was applied to help determine which model, LC or RPL with interactions, was superior. The test rejected the null hypothesis that the RPL with interactions was the true model and therefore it was concluded that the LC was superior.

Results for the 3-segment LCM are given in table 2.3, where the upper part displays the utility coefficients for MPAs attributes, while the lower part reports segment membership coefficients. The membership coefficients for the third segment are normalized to zero in order to identify the remaining coefficients and all other coefficients are interpreted relative to this normalised segment.

Coefficients for the different segments suggest that preferences among classes differed substantially. None of the coefficients except $size^2$ and cost were significant for the first segment suggesting an indifference to MPA attributes.

Respondents in segment 2 experienced a positive utility impact when moving away from the current situation as indicated by the positive sign of the constant. They were in favour of bigger MPAs with diminishing marginal utility for the size of the MPA as indicated by the significance and sign of the $size^2$ coefficient. Respondents belonging to this class preferred protected areas where recreational uses are permitted but fishing is not.

Finally, respondents in segment 3 also experienced a positive utility impact when moving away from the status quo. Respondents were not concerned with the size of the network as long as recreational and controlled fishing activities were allowed within the boundaries of the MPA.

The relative size of each class was estimated and each respondent assigned a probability for belonging to each of the three classes. Class membership was determined by the highest probability score. To assist the understanding of the differences between classes, attitudinal and socio-demographic variables were calculated for each class (Table 2.4). The majority of respondents belonged to class 3 (49%), followed by class 2 (32%) and class 1 (19%).

Table 2.3. Parameter estimates for three segments latent class model, coefficient (SE)

	Segment 1	Segment 2	Segment 3
Utility function parameters			
Constant	-4.763	2.630*** (0.704)	1.053** (0.507)
Size	-0.530 (688.056)	0.142*** (0.047)	0.007 (0.055)
Size^2	0.020* (0.012)	-0.003*** (0.001)	0.0002 (0.001)
HPMR[a]	-23.208	-0.024 (0.425)	-0.222 (0.464)
Research	--	--	--
Recreation	8.345	-0.548 (0.423)	-0.325 (0.404)
Restricted fishing	7.456	0.532 (0.418)	0.952** (0.402)
HPMR*Size	0.720	-0.012 (0.531)	-0.063***
Recreation*Size	-0.277 (688.066)	0.037* (0.020)	0.047** (0.020)
Rest. fishing*Size	-0.200 (688.065)	-0.039* (0.021)	0.015 (0.019)
Cost	-0.016* (0.011)	-0.008*** (0.002)	-0.042***
Segment membership function			
Knowledge	-0.206 (0.288)	0.313 (0.222)	--
Income x capita	-0.001* (0.001)	0.034* (0.019)	--
Higher education	-0.184 (0.203)	0.302 (0.246)	--
Resident	0.246 (0.193)	0.321 (0.196)	--
Factor 1	0.469 (0.302)	-2.867*** (0.642)	--
Factor 2	0.950***	-0.756*** (0.287)	--
LC probability	0.188	0.325	0.487
Log-likelihood	-1270.564		
AIC	1.52413		
McFadden's	0.3295555		
Sample size	1725		

***1% significance level, **5% significance level, *10% significance level
[a]HPMR: Highly Protected Marine Reserve

Table 2.4. Respondents' profiles for each latent class segment

	Segment 1	Segment 2	Segment 3	Differences
Within 10 miles %	53.1	55.5	39.9	2&3
High MPA knowledge %	11.1	38.5	14.9	1&2, 2&3
Factor 1 (SE)	2.25 (0.11)	1.45 (0.03)	1.99 (0.04)	1&2, 1&3, 2&3
Factor 2 (SE)	2.88 (0.87)	1.64 (0.68)	2.14 (0.06)	1&2, 1&3, 2&3
Gender % males	61.3	53.2	40.5	1&3, 2&3
Age (SE)	44.5 (2.3)	45.9 (1.5)	44.3 (1.30)	--
Household size (SE)	2.4 (0.2)	2.7 (0.1)	2.7 (0.1)	--
Children (SE)	0.51 (0.13)	0.52 (0.09)	0.53 (0.07)	--
High Education %	50	78.8	58.6	1&2, 2&3
Income x capita (SE)	10.7 (1.3)	17.7 (1.4)	15.1 (1.01)	1&2, 1&3
Country (% Wales)	54	58.9	46	--

Values located on the second half of table 2.3 and on table 2.4 indicate that besides the level of environmental awareness, the only significant difference between supporters and non-supporters of MPAs was the level of income, which was significantly lower for non-supporters. Members of the second segment, who experienced the greatest positive utility from the move away from the status quo and would like to see MPAs where no fishing is allowed, had higher knowledge on MPAs, higher level of education and had a more positive attitude towards conservation and the restriction of uses on the marine environment when compared to classes 1 and 2.

2.4.4 Welfare measures

Welfare measures were calculated in the form of marginal willingness to pay (WTP) for the best fitting model. WTP was determined by estimating the marginal rate of substitution between the change in the attribute under scrutiny and the marginal utility of the cost attribute using the Delta method. Due to the non significance of the great majority of coefficients in class 1, this segment was omitted from the calculation of welfare measures.

In class 2 the WTP for recreational uses and fishing activities was influenced by the size of the protected area. The bigger the area destined for recreation the more respondents were willing to pay, conversely the bigger the area for fishing the greater the negative WTP became (Table 2.5). The same was true in class 3 for the HPMR and recreational use, however for fishing uses, respondents in this group were willing to pay £22.8 regardless of the size of the protected area.

A weighted average WTP for the total sample was calculated using the relative size of each class. Results suggest that overall the sample population was willing to pay for bigger MPAs, however only up to a certain size as indicated by the negative WTP for $size^2$. The sample was willing to pay more for those MPAs in which recreational activities are allowed, followed by those where restricted fishing is permitted. A negative WTP was attached to those MPAs that are totally restricted to the public.

Table 2.5. Marginal willingness to pay (WTP) derived from the latent class model for the attributes. WTP (95% CI)

	Class 1	Class 2	Class 3	Weighted
Size	--	16.88 (4.82, 28.94)	--	5.49 (1.57, 9.41)
$Size^2$	--	-0.35 (-0.64, -0.07)	--	-0.11 (-0.21, -0.02)
HPMR[a]	--	--	--	--
Research	--	--	--	--
Recreation	--	--	--	--
Rest. fishing[b]	--	--	22.75 (4.54, 40.97)	11.08 (2.21, 19.95)
HPMR*Size	--	--	-1.51 (-2.49, -0.53)	-0.74 (-1.21, -0.26)
Recreation*Size	--	4.44 (0.31, 8.58)	1.12 (0.24, 1.99)	1.99 (0.22, 3.76)
Rest. fishing*Size	--	-4.65 (-8.87, -0.44)	--	-1.51 (-2.88, -0.14)

[a]HPMRs: highly protected marine reserves
[b]Rest.fishing: restricted fishing

2.4.5 The costs and WTP for MPAs in Wales

Balmford et al (2004) estimated the global economic costs of MPAs through models that used MPA size, distance to inhabited areas and purchasing power parity as model predictors. Using Balmford's model, the economic costs for current MPAs in Wales in 2009 was estimated at approximately £10 million, equivalent to £1,797/km^2 per annum.

Willingness to pay for different management scenarios in Wales was calculated for the average sample respondent, results were then extrapolated to the total Welsh income tax payer population (Table 2.6). The mean WTP for the nine potential scenarios presented here was estimated at £28,737/ km^2 per annum.

Table 2.6. Willingness to pay (WTP) for different management scenarios for the average respondent and for the total Welsh income tax payer population per annum.

Scenarios (% of coastal waters)	WTP (£/person)	WTP (£ million) Welsh population[1]	WTP (£/km2)
10% HPMR	36.5	49.2	30,584
20% HPMR	51	68.8	21,374
30% HPMR	43.5	58.6	12,152
10% Recreation	63.8	86	53,459
20% Recreation	105.6	142.4	44,256
30% Recreation	125.4	169.1	35,032
10% Fishing	39.9	53.8	33,416
20% Fishing	46.7	62.9	19,563
30% Fishing	31.5	42.4	8,794
Average	60.4	81.5	28,737

[1]Total Welsh income tax payer population estimated at 1,348,215 people in 2007, includes employed Welsh residents aged 16-65. Source: StatsWales

2.5 Discussion

This study provides evidence that the majority of the general public in Wales and England support the establishment of an enhanced network of MPAs in Welsh waters. Our findings suggest that societal preferences for MPAs are not homogeneous and that different opinion groups exist. This is in agreement with findings from a similar study carried out in the Northeast United States in which three groups with different preferences for MPAs were identified (Wallmo and Edwards 2008). Our results also indicate that the lack of interest in MPAs can be related to lower income levels, as this was the only significant difference between MPA supporters and non-supporters. The sample collected during the study was considered to be a good representation of the populations of England and Wales as the comparison of demographic parameters did not show any major differences between sample and population. The gap registered between the level of education of the sample and the population was likely to be smaller than what data showed, as the only census data available dates from 10 years ago and since then it is estimated that a greater number of people go into higher education, the percentage now reaching almost 50% of the population (National Statistics 2010).

The respondents in favour of the establishment of MPAs could be divided into two classes. The first class preferred MPAs with a size limit and in which recreational activities were allowed but no fishing was permitted. The combination of size limitation and the restriction of fishing activities indicated that respondents were aware of the necessity to protect the marine environment while at the same time they were conscious of the impacts that a closure with no spatial limitations would have on the affected users. The second group of MPA supporters was indifferent to the size of the protected area but disliked the idea of highly protected marine reserves (HPMRs) and wanted both recreational uses and restricted fishing to be permitted within the boundaries of the network. Permitting fishing activities within the limits of the MPA is therefore controversial.

The model of Balmford et al (2004) suggests the annual costs for managing and enforcing MPAs in Welsh waters is much lower than the WTP for Welsh MPAs per annum. It should be noted however that the Balmford et al (2004) model is only concerned with the costs of establishment and monitoring. It does not consider the losses or gains in overall economic activity that may be associated with the establishment of MPAs (e.g. loss of income fishing, increase in tourism and their associated multiplier effects). It has been acknowledged that choice experiments can suffer from hypothetical bias, where individuals tend to overstate their economic valuations (Hensher 2010). However, even if the results of this study over estimated real WTP by 1.35 times, which has been shown to be the median ratio of hypothetical to actual value (Murphy et al. 2005), WTP for Welsh MPAs is still greater than Balmford’s estimated costs.

The study suggests that the support for MPAs in Welsh waters was similar for Welsh and non-Welsh residents and for coastal and non-coastal population (those living further than 10 miles from the coast). This contrasts with the “decay factor” found in other studies where support decreases with distance to the site under scrutiny (Bateman et al.

1995), it also suggests positive altruistic and existence values from those that do not benefit directly from the management policy.

Results indicate that the great majority of the public were not supportive of the idea of MPAs as HPMRs. However, it is possible that the level of support for HPMRs would have increased if respondents had been offered a CE including MPAs with different use zones that offered different levels of protection. This is supported by the fact that the majority of respondents in the study (90%) indicated that they "*like knowing that certain areas of the sea are fully protected*" thus, showing their support for areas where no activities are allowed and biodiversity is fully protected. This result is in line with a survey carried out among users of MPAs in southern Europe which showed a strong preference for having MPAs with different use zonations, including areas designated for restricted fishing, non-damaging recreational activities and the full protection of species and ecosystems (Mangi and Austen 2008). At the onset of the study consideration was given to the inclusion of a set of attributes that would have reflected the establishment of a multi-zoned MPA, however the adoption of such design would have considerably increased the number of attributes in the experiment. This increase in attributes and associated number of levels would have resulted in a design too complex to enable respondents to make meaningful trade-offs between the alternatives and therefore the multi-zoned MPA scenario was rejected.

The attitudes and preferences of resource users of MPAs are a key issue for the management of protected areas (Jones 2008). It has been widely acknowledged that for the management of MPAs to be successful and to ensure compliance it is necessary that users have positive attitudes towards MPAs and their associated regulations (White et al. 2000, Himes 2007). Previous studies have investigated the design of MPAs taking into account influential stakeholder groups preferences such as fishermen (Richardson et al. 2006), however little information has been gathered on societal preferences for MPAs. This study shows a general support for the protection of the marine environment in the form of MPAs, nevertheless the heterogeneity in respondents' preferences should be taken into account when designing any network of MPAs. HPMRs combined with adjacent areas with differing levels of user-access would appear to be the solution that would have the greatest level of public support, while also ensuring effective conservation. More importantly, results suggest that society is willing to bear the additional economic costs derived from the protection of the marine environment.

Chapter 3

Spatially explicit valuation of cultural ecosystem services: non-consumptive marine recreational activities in temperate coastal areas

3.1 Abstract

The valuation of the goods and services provided by marine biodiversity and the assessment of their spatial distribution is essential if policy makers are to make informed decisions about spatial management in the marine environment. Unfortunately there is a relatively sparse literature on the economic value of marine biodiversity, and many studies have focused on "iconic" species and habitats which probably results in a biased evidence base being available to decision-makers. An economic valuation and assessment of the spatial distribution of non-consumptive recreational services provided by marine biodiversity in Wales was undertaken. Results indicated that the economic importance of recreational services provided by marine biodiversity is comparable to that of the provision of goods from commercial fisheries for the same region. Spatially there was a significant degree of correlation among areas used by the different recreational groups studied here. There was an overlap between areas identified as biodiversity hotspots and provisioning areas of recreational services, suggesting that higher levels of marine biodiversity offer more satisfactory experiences to some users of the marine environment. The integration of spatially explicit biological and socioeconomic data enables policy makers to gain useful insight into the potential consequences of implementing a spatial management regime. Such data provide a balanced overview of the value of marine biodiversity to different sectors of society, and through demonstrating overlaps in recreational and conservation value they provide policy makers with the opportunity to devise management win-win scenarios which can safeguard biodiversity and provide benefits through recreational services.

3.2 Introduction

Marine biodiversity provides society with a wide range of goods and services that are essential for the maintenance of our social and economic wellbeing (Costanza et al. 1997). The benefits provided by marine biodiversity, in terms of ecosystem goods and services, can be divided into four main categories: provisioning services, regulating services, cultural services and supporting services (MEA 2003).

Over the past decade, the economic valuation of the services provided by ecosystems has become increasingly important in a policy context (Beaumont et al. 2006, Birol et al. 2006b, Christie et al. 2006, Beaumont et al. 2007, Bartczak et al. 2008, Remoundou et al. 2009). Although the approaches used in the valuation of biodiversity have been controversial (Nunes and van den Bergh 2001), in the absence of monetary valuation some biodiversity services might be overlooked during decision making. This may lead to inappropriate decisions that in some instances may result in the degradation of the marine environment and the services it provides.

Cultural services, defined as the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences (MEA 2003), are among those provided by marine biodiversity. Thus far however, valuation studies of cultural services have mainly focused on iconic marine habitats (e.g. coral reefs) and species (e.g. whales) (Cesar et al. 1997, Berg et al. 1998, Parsons et al. 2003, Turpie et al. 2003, Richardson and Loomis 2009). Activities such as whale-watching or scuba-diving on coral reefs attract high numbers of visitors and generate significant economic revenues both at a local and national scale (Hoyt 2001). In contrast, the valuation of cultural services in temperate systems has received less attention perhaps as a consequence of a lower prevalence of iconic species and habitats (but see Beaumont et al. 2007).

Highlighting the economic importance of non-consumptive uses associated with marine biodiversity can have benefits in promoting conservation as these uses are more easily regulated and their effects are less likely to contribute to biodiversity degradation, which generally makes them compatible with conservation objectives. Furthermore, the valuation of the services provided by marine biodiversity facilitates their incorporation into management plans, particularly if the geographic distribution of these services can be integrated into marine spatial planning (i.e. such as the implementation of marine protected areas) (Richardson et al. 2006). Such information can be used to facilitate stakeholder engagement and can help in conflict resolution when designing networks of marine protected areas from which some activities may be excluded or more strictly regulated. Mapping ecosystem services can also highlight the existence of spatial correlations between areas of high biodiversity and areas which provide particular ecosystem services. If these areas overlap it could provide policy win-win situations where strategies introduced to safeguard biodiversity would also provide benefits for other ecosystem services (Anderson et al. 2009).

The aim of this paper is to provide a measure of the economic importance of marine biodiversity in temperate coastal areas in terms of the provision of recreational services and to highlight the importance of mapping the distribution of these services to inform comprehensive spatial management. This study concentrates on the economic valuation and geographic distribution of four non-consumptive uses of the marine environment for which marine biodiversity may have an important role. Recreational scuba-divers, sea-kayakers, customers of wildlife viewing boat trips and seabird watchers were surveyed in Wales (United Kingdom) in order to characterize their activities and obtain information on their economic significance. As this study builds on a previous assessment of the economic value of provisioning services (fisheries) in the same area (Richardson 2006), a comparison of the relative importance and overlap of these activities is possible. The results of this study will provide policy-makers and managers with much needed data on the economic value of some of the benefits generated by marine biodiversity that will potentially allow for their integration into marine management plans.

3.3 Materials and methods

3.3.1 Study area

The present study focused on Wales, United Kingdom (UK). The coastal area of Wales encompasses 1,300 km of coastline and it is a popular tourist destination (Fig. 3.1). In 2007, Wales hosted a total of 8.85 million UK domestic trips, of which approximately 48% occurred at seaside destinations (Visit Wales 2008). It was estimated that domestic tourists spent approximately £742.6 million at Welsh seaside destinations and part of this expenditure was associated with marine-related activities.

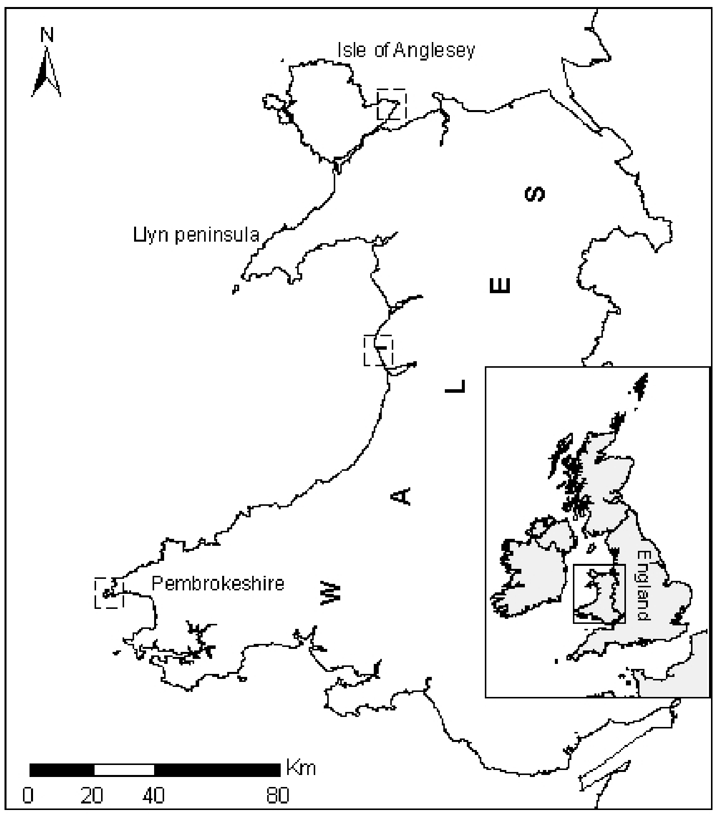


Figure 3.1. Overview map of the study area. Dashed squares indicate interview locations with wildlife viewing trips customers.

3.3.2 Survey design

The present study provides a measure of the economic importance of those non-extractive activities that are dependent to some degree on marine biodiversity and which do not impinge on its integrity if adequately managed. The assessment of the economic importance and geographic distribution of diving, kayaking, wildlife viewing cruises and seabird watching was undertaken using questionnaire surveys. Two different approaches were adopted to survey the various user groups. Divers, kayakers and seabird watchers were surveyed using an on-line questionnaire (Dillman et al. 2008). This survey method was chosen due to the impracticality of intercepting a representative sample of such a wide-spread population using face-to-face questionnaires. The survey was promoted through diving, kayaking and birding clubs and associations in Wales and England. Additionally, in order to reach those users who might not have belonged to any clubs or associations, flyers and posters promoting the study were distributed among watersports retailers throughout Wales and England. Press releases were also published in several relevant magazines and fora in both paper and electronic formats (e.g. Divernet 2008; Dive magazine 2008; Canoe & Kayak 2008).

Customers of wildlife viewing trips were surveyed by means of face-to-face questionnaires. Twenty-one boat operators were identified along the Welsh coastline, and three representative locations were selected to undertake the surveys in the areas of North, Mid and West Wales (Fig. 3.1).

The information sought through the questionnaires (Appendix 2) focused on the characteristics of the user’s trip, the expenditure incurred, the reasons for choosing a particular activity area and demographic information. Additionally, questionnaires for divers, kayakers and seabird watchers included a map of Wales with an overlaid 10x10km grid which enabled the estimation of the geographic distribution of the activities. Respondents were asked to indicate the three cells of the map they had visited most frequently in the previous year.

In order to obtain the total revenues produced through the activities included in the study it was necessary to estimate the average expenditure per person per day for each of the activities and to scale the results obtained to the population level.

The average spend per person per day for each activity was calculated using information collected for the expenditure incurred on food and drink, accommodation, travel costs and the total duration of the activity visit. Additionally, boat-use related expenditures, air tank refills and equipment hire were included for divers. Equipment rental was included for kayakers and in the case of wildlife-cruise customers the cost of the boat ride was also included in the calculations. Estimates for the total number of activity days in Wales for each user-group were obtained as outlined below.

3.3.2.1 Scuba diving

No previous information existed on the number of diving activity days in Wales. The estimation of diving activity days was undertaken using a three step process. First, in 2007 the Watersports and Leisure participation survey, a survey carried out each year by the Marine British Federation on the number of water sports' participants in the UK, estimated the total number of diving participants in the UK at approximately 270,000 people (BMF 2008).

Second, preliminary analysis of the questionnaire data indicated that residence distance to the coast of Wales was likely to influence the number of visits to Wales, therefore the diver population was estimated for 10 different regions of the UK. Regional membership distribution for the British Sub Aqua Club (BSAC) was used to estimate the spatial distribution of the total diving population. As a high proportion of divers in the UK are BSAC members, it was thought that BSAC's regional/national membership ratio was representative of the proportional distribution of divers in the UK. Thus, the number of BSAC memberships per region was divided by the total BSAC membership in order to obtain the proportional distribution of divers in the UK. These percentages were then applied to the total UK diving population estimated in 2007 through the Watersports and Leisure participation survey.

Third, only a portion of the divers estimated through the watersports survey would have dived in Wales, therefore in order to estimate the level of activity in Wales a second survey was carried out among diving clubs across England and Wales. A short questionnaire was e-mailed to diving clubs which belonged to the main diving associations in the UK (British Sub Aqua Club BSAC, the Sub-Aqua Association SAA and the Professional Association of Diving Instructors PADI). For each club, information was sought on the number of diving trips made to Wales during the previous 12 months, the average number of people participating in the trips, trip duration, club membership size and the number of active club members (those diving more than 3-4 times a year). From this survey the percentage of active divers and the number of activity days per active diver were estimated. Finally, to obtain the total number of activity days in Wales, activity days per active diver for each of the regions were multiplied by the regional active-diver population number. Thus, the total number of diving activity days for Wales was estimated at approximately 110,000 days.

To study some of the factors that influenced the distribution of diving activity in Wales, the relationship between diving sites and habitat characteristics was investigated. A comparison was carried out between those cells of the map frequently visited by divers and those that were not visited. Detailed habitat mapping information (Robinson et al. 2007) was obtained for those cells within 12 nautical miles (nm) off the coast where a total of 33 different biotopes were identified. Biotope data for seabed habitats was obtained from the Countryside Council for Wales which is the statutory nature conservation agency that advises the Welsh Assembly Government. The 12 nm limit was chosen as this was the maximum distance from the coast where divers in this survey had been diving and this also coincides with the territorial limit of waters under the jurisdiction of the Welsh Assembly Government for the purposes of fisheries management.

Multivariate analysis software, PRIMER 6 (Clarke and Gorley 2006), was used to compare the presence/absence of biotopes between those cells used/not used by divers. A Bray-Curtis similarity matrix was calculated and the ANOSIM procedure was used to assess for significant differences between those cells used/not used by divers. The

SIMPER procedure was subsequently used to discern which biotopes contributed to the differentiation between used and not used sites.

3.3.2.2 Sea-kayaking

Information on the number of sea-kayaker activity days in Wales was available through Canoe Wales (the national governing body for paddle sports) which estimated the number of activity days at 93,000 sea-kayaking days per annum. No information was available on the number of sea-kayakers that visited Wales from different regions of the UK.

Due to logistic constraints during the survey, areas in Mid and South Wales were undersampled, thus the spatial distribution of kayaking activity could only be assessed reliably for the North Wales area. In order to overcome this problem and to obtain a reliable proxy for the distribution of sea kayaking across Wales, a panel of seven experts was interviewed. All panel members were well-known experienced sea-kayakers within the kayaking community with extensive knowledge of the Welsh coast. Activity distribution was ascertained through a questionnaire containing a map with 46 kayaking routes covering the whole of the Welsh coast. Experts were asked to rate each route in popularity (on a scale from 1 to 10), and to state the reasons why they thought the route was popular. Additionally, respondents were asked to estimate the role that marine wildlife played in the popularity of the route (on a Likert scale from 1 to 4 with 4 indicating that wildlife had a very important role, (Likert 1932)).

The combination of results from the first survey for North Wales (for which reliable data was collected) and information about route popularity as assessed by experts for the same area was used to asses the relationship between popularity and level of kayaking activity. This relationship was used to estimate activity levels for the entire Welsh coastal territory.

3.3.2.3 Wildlife viewing cruises

The total number of passengers on board wildlife viewing trips was estimated using information regarding wildlife viewing operators in Wales. This information included the total number of boats, passenger capacity, number of trips per day and the length of the tourist season. Generally, companies operate from the 1st of April to the 31st of October; activity levels throughout the season were obtained by means of interviews with company owners and the researcher's personal observations. It was estimated that during high activity periods (weekends, bank holidays, school breaks) companies operated at 90% of their capacity while during the rest of the season activity levels were maintained at around 60% of the total capacity. The total number of passengers per annum was estimated at approximately 304,000 people.

3.3.2.4 Seabird watchers

No information was available on the number of people visiting Wales on seabird watching trips. Instead the annual number of visitors to RSPB (Royal Society for the Protection of Birds) marine reserves in Wales was used as a proxy for the total seabird watching population. From 2008 to 2009, 131,746 people visited the three RSPB marine reserves located around Wales. This estimate cannot account for visits made to other areas of the coast of Wales outside the reserves and implicitly assumes that every person visiting the reserve did so for the purpose of viewing birds c.f. walking.

3.3.3 Spatial distribution of activities and related expenditure

All questionnaires included a map of Wales with an overlaid 10km^2 grid. Respondents were asked to select the three cells of the map they had visited the most during the previous 12 months to the survey and state the number of times they had undertaken activities (as defined in this paper) in those cells. For each activity, the percentage of total activity days in the sample was calculated for each cell. These percentages were then applied to the total number of population activity days for each activity and thus the total number of activity days per cell was estimated accordingly. In order to obtain the economic expenditure per cell, the average expenditure per person per day was multiplied by the number of activity days for each cell.

The spatial overlap between recreational activities, commercial fisheries and recreation and biodiversity hotspots was also investigated. Biodiversity hotspots areas in Wales were previously identified by a study carried out by the World Wide Fund for Nature in 2007 (Hiscock and Breckels 2007).

3.4 Results

A total of 558 questionnaires were carried out among the stakeholder groups. Between May and November 2008, 156 divers, 110 kayakers and 198 wildlife cruise customers were interviewed. One hundred seabird watchers were surveyed between June and October 2009.

3.4.1 Scuba Diving

Several factors influenced the distribution of diving activity. Different aspects such as the cost and travel time or the environmental quality of the diving location played an important role in the choice of diving site (Fig. 3.2). Results from the study suggested that the level of marine biodiversity at the dive location is one of the most important factors in determining diving location as 53% of the respondents considered it to be "very important" on a four point Likert scale. The presence of a marine protected area, which in many cases can be associated with high levels of habitat quality, was also considered as a "very important" aspect by 31% of the sample, as was the presence of wrecks (24%). Wrecks are also areas of high biodiversity as the structures create a habitat that enables the settlement of reef species (Zintzen et al. 2008), however some divers might be attracted to them due to alternative reasons. Travel time and the associated costs were considered as "very important" by 18% and 21% of the respondents respectively, suggesting that divers put dive quality ahead of cost.

The mean (± S.D.) cost of a diving trip was estimated at £71 ± 44 (95% C.I. £64, £78) per person per day (pppd), this figure included costs associated with food and drink, travel, accommodation and auxiliary costs such as boat fees, air tank refills and gear rental. This estimation represents the costs of a diving trip regardless of whether the diver was spending the night away from home. Approximately, 54% of respondents stayed overnight and as expected the costs incurred by those divers staying overnight, £87 ± 46 were significantly higher than those that undertook day trips, £52 ± 32 ($t_{(146)}$ =

5.6, p < 0.001). The average expenditure on accommodation for divers staying away from home was estimated at £20 ± 13 per person per night. The average cost of a trip increased with distance to the diving location. Therefore, in order to estimate the total expenditure of diving in Wales, the average cost of a diving trip was estimated for different regions in the UK. The combination of these costs with regional activity levels in Wales resulted in an estimate of the total expenditure incurred by divers in Wales of £7.8 million per annum (95% C.I. £4.7M, £10.9M).

The geographical distribution of diving activity and associated costs were also investigated. Approximately, 50% of the activity was concentrated in 5% of the cells that covered the area between the coast and the 12nm limit, indicating a very high usage of particular areas. The most popular area for diving coincided with the location of the only Marine Nature Reserve in Wales (Fig. 3.3).

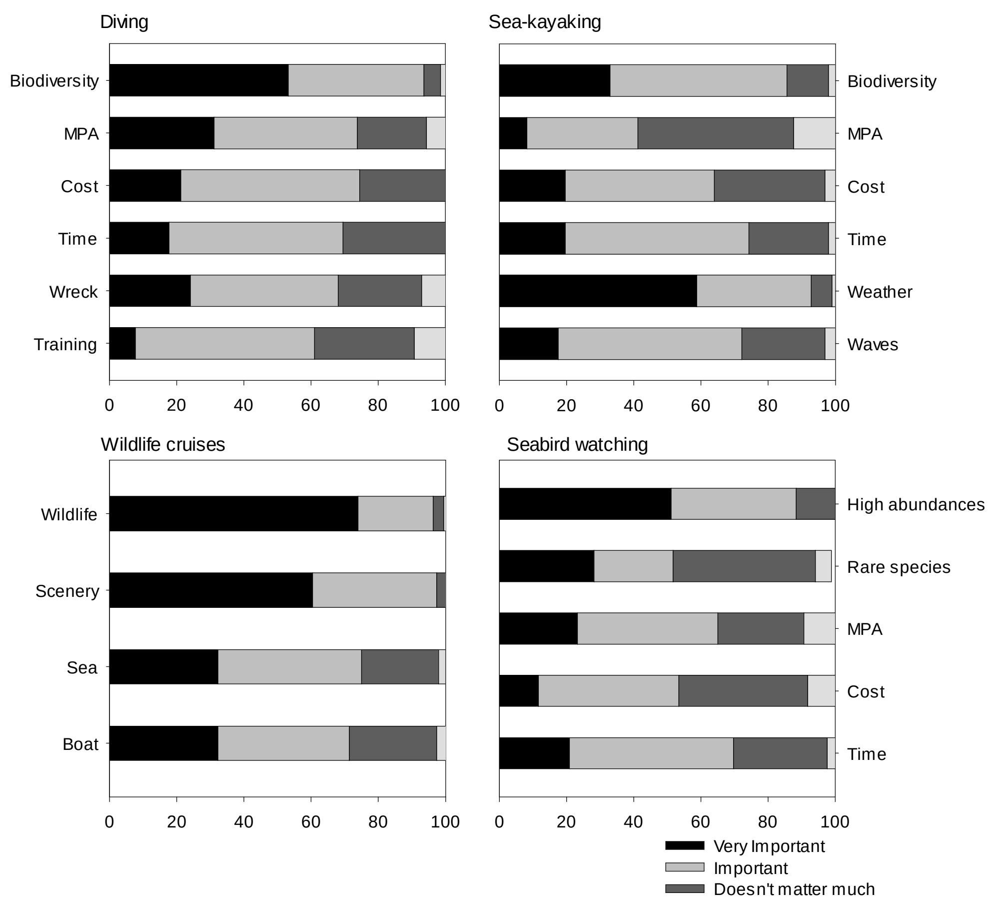


Figure 3.2. Respondent's rating of the factors that influence the selection of activity location for each of the activities covered in the study. Respondent percentage is indicated on the X-axis, factors appear on the Y-axis (MPA = marine protected area)

ANOSIM results indicated that biotope characteristics between areas with and without recorded diving activity differed significantly (Global $R = 0.38$, $p = 0.1\%$). The average dissimilarity between both areas was estimated at approximately 64%. The SIMPER procedure indicated that the presence of hard substrata biotopes in areas with recorded diving activity contributed to 31% of the total dissimilarity. These findings are consistent with anticipated diver's preferences, as divers will most likely choose visually attractive areas (i.e. those with emergent structural flora and fauna) which in turn will mostly coincide with hard substrate areas.

3.4.2 Sea-kayaking

A high proportion of kayakers (59%) considered that weather conditions are a "very important" determinant in their choice of kayaking location. In comparison to divers a lower percentage of kayakers (33%) viewed marine biodiversity as a "very important" factor in their selection of site and the presence of a protected area did not play a "very important" role in their decisions. Travel time and costs were considered equally important as 20% of the sample considered them to be "very important" in the choice of kayaking location (Fig. 3.2).

The average cost for a sea-kayaking trip was estimated to be approximately 40% of the cost of a diving trip, with a mean (± S.D.) of £27 ± 24 (95% C.I. £23, £32) pppd. Around 54% of respondents spent the night away from home. Kayakers that undertook day trips spent significantly less than those staying overnight (day trip = £18 ± 16 pppd, overnight = £36 ± 27 pppd; $t_{(94)} = 4.37$, $p < 0.001$). On average kayakers who stayed overnight spent £13 ± 11 pppd on accommodation.

Using the average cost of a kayaking trip and the estimated number of activity days in Wales the annual expenditure associated to sea-kayaking in Wales was estimated at £2.5 million (95% C.I. £2.1M, £2.9M).

The distribution of sea-kayaking activity was estimated from the experts' questionnaire. Approximately, 50% of the activity was concentrated around 11% of the map cells. At a large scale, areas popular for kayaking generally coincided with areas that were also popular for diving (Fig. 3.3). Common traits were identified among the most popular kayaking routes (popularity rating ≥ 7). For all of these popular routes the presence of marine wildlife, challenging waters (i.e. tidal races), the opportunity to practice navigational skills, sea/landscape and easy access to the water were identified as the most important traits that contributed to the popularity of the route. A Pearson's correlation was conducted on the responses from the experts' questionnaire, which indicated that the most popular routes had also the strongest association with the presence of wildlife (Fig. 3.4).

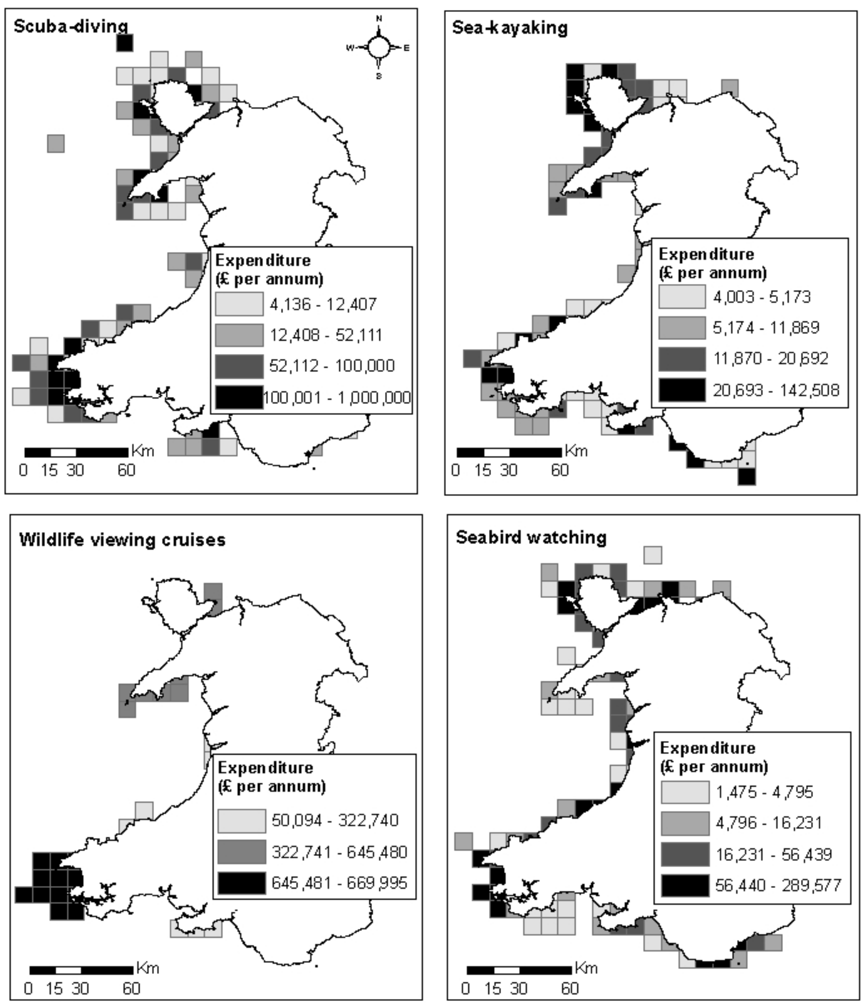


Figure 3.3. Activity distribution and annual expenditure in 2008 in Wales for scuba-diving, sea-kayaking, wildlife viewing cruises and seabird watching.

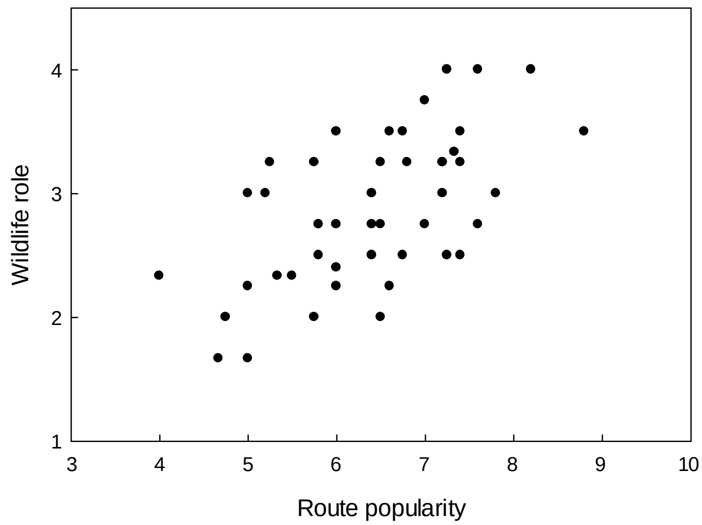


Figure 3.4. Correlation between kayaking route popularity (rated on a 10-point scale) vs. the role played by the presence of wildlife on the popularity of the route (rated on a 4-point Likert scale). Pearson's correlation coefficient = 0.6, $p < 0.001$

3.4.3 Wildlife watching boat trips

As expected, one of the main reasons for boat customers to go on wildlife viewing trips was to be able to observe marine wildlife (as opposed to simply enjoying the experience of being on a boat on the sea), and accordingly 74% of respondents considered viewing marine wildlife to be a "very important" part of their experience (Fig. 3.2). Approximately 60% of the sample thought the enjoyment of the scenery was also of great importance. Respondents assigned high importance to the ability to see marine mammals and particular species of seabirds (i.e. gannets, *Morus bassanus* Linnaeus or puffins, *Fratercula artica* Linnaeus).

Wildlife watching from boats was concentrated around a small percentage of coastal waters, as approximately 50% of the activity was undertaken in 7% of the map cells. The mean (±S.D.) expenditure of a passenger taking a wildlife viewing trip was estimated at £44 ± 27 pppd (95% C.I. £39.7, £48.5) on the day of the trip. The boat trip accounted for approximately a quarter of the daily expenditure (£11 ± 6). Accommodation for those staying overnight was estimated at approximately £22 ± 18.

The total expenditure incurred by boat passengers in Wales in 2008 on the day of the trip was estimated at £13.4 million per annum (95% C.I. £12.1M, £14.7M). As this expenditure was incurred on the day of the trip it can be considered that marine wildlife viewing was responsible for the majority of these costs. The geographic distribution of the expenditure on day trips was estimated by plotting cruise routes and their associated numbers of passengers per annum within a GIS (Fig. 3.3).

3.4.4 Seabird watching

A high proportion of seabird watchers (51%) considered the presence of high abundances of seabirds to be a "very important" determinant when planning a trip. The presence of rare species of seabirds and the presence of a marine protected area were considered as "very important" factors by 28% and 23% of the sample respectively. Travel time was considered a more important factor than travel costs (21% and 12% respectively).

The average cost of a seabird watching day out was estimated at a mean (± S.D.) of £28 ± 30 (95% C.I. £22, £34) pppd regardless of whether the respondent spent the night away. Approximately 48% of respondents spent the night away; costs for those staying overnight (£41 ± 33, 95% C.I. £31, £55) were significantly higher than costs incurred by day trippers (£15 ± 21, 95% C.I. £9, £21). The average expenditure on accommodation was estimated at £22 ± 20 (95% C.I. £16, £28) per person per night.

The total economic expenditure derived from seabird watching activity in Wales was estimated at approximately £3.7 million per annum (95% C.I., £2.9M, £4.5M).

The distribution of seabird watching activity was assessed through the survey (Fig. 3.3), and revealed that the most popular areas for seabird watching coincided with the location of reserves set up by the Royal Society for the Protection of Birds (RSPB). Sea bird watching activity tends to concentrate around a small portion of the coast as approximately 50% of the activity was focussed around 5% of the map cells.

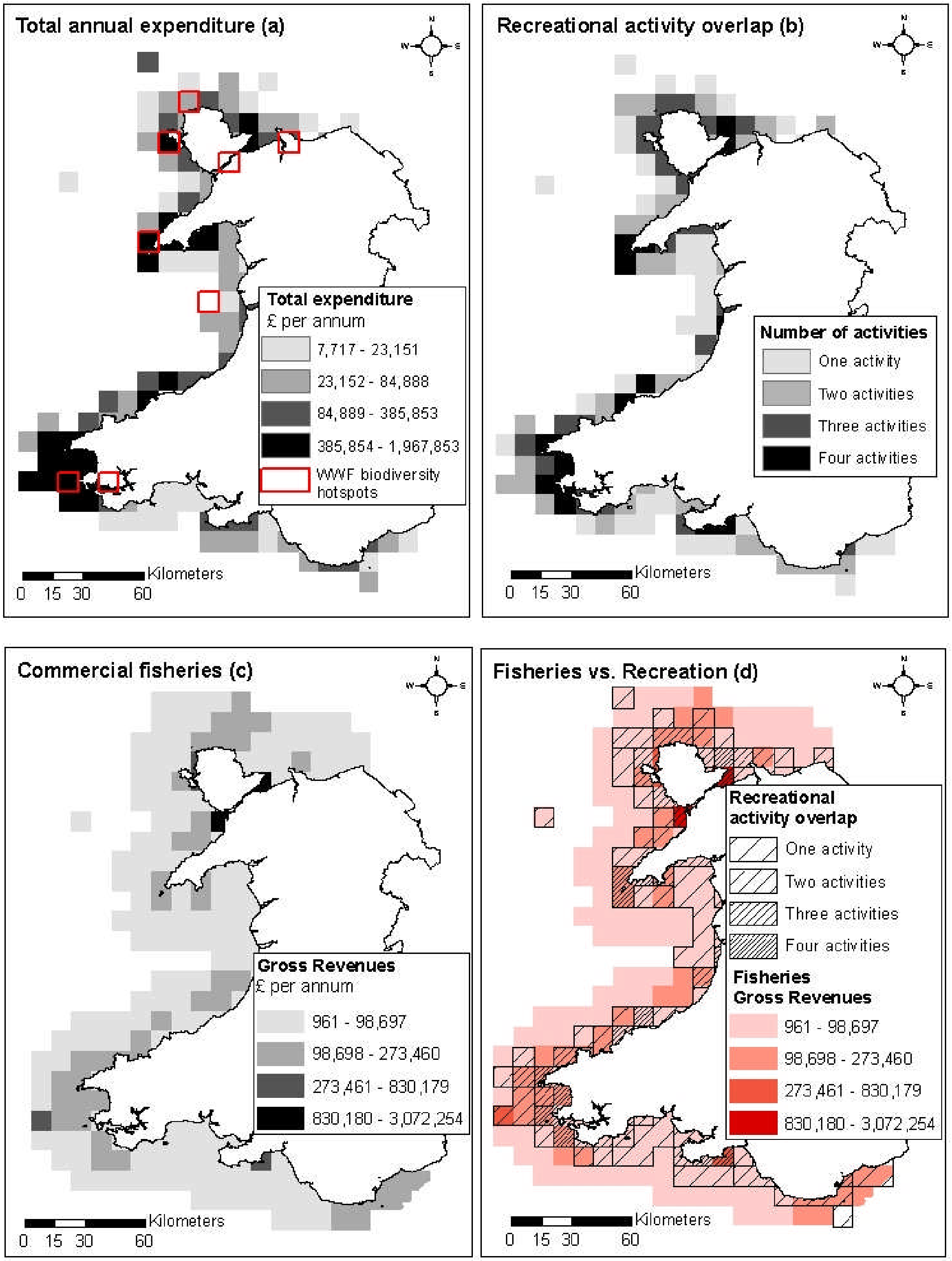


Figure 3.5. (a) Total annual expenditure and (b) spatial overlap of the recreational activities studied (diving, kayaking, seabird watching and wildlife watching cruises) in 2008 in Wales. (c) Aggregate gross revenues for the commercial fisheries in Wales in 2003 (d) Spatial overlap of recreational and commercial fisheries activities: recreation; greater hatch densities indicate greater recreational activity overlap, fisheries; darker colours indicate more profitable areas

3.4.5 Spatial distribution of activities

The activity distribution maps suggest that there was a co-occurrence in the location of the most popular areas between the activities. Three areas were highlighted as the most popular for all the activities, namely the area around the Isle of Anglesey, the Llyn Peninsula and the coast around Pembrokeshire (for area location, see Fig. 3.1). This was further supported by significant correlations between cell use frequencies for the different activities ($Pearson_{diving\text{-}kayaking} = 0.39$; $Pearson_{diving\text{-}seabird\ watching} = 0.49$; $Pearson_{kayaking\text{-}seabird\ watching} = 0.34$, all significant at the 0.01 level). Accordingly, these shared areas were the most important in economic terms (Figs 3.5a & 3.5b). Furthermore, the spatial overlap between activities was high for most pairs of activities (table 3.1), the highest overlap occurred between kayakers and birdwatchers who shared the use of 61% of the total number of cells used by both activities. Diving and kayaking also presented a high degree of spatial overlap (44%).

Table 3.1. Percentage of map cell use overlap between recreational users

% Overlap	Diving	Kayaking	Cruises	Bird watching
Diving	--	44.2	30.7	35.1
Kayaking		--	28.4	60.8
Cruises			--	21.3
Bird watching				--

Spatially, areas identified as biodiversity hotspots by a report from the World Wide Fund for Nature (Hiscock and Breckels 2007) coincided with some of the most popular areas for recreation. Six out of the eight biodiversity hotspots identified in Wales coincided with some of the most economically valuable areas and similarly, six out the eight biodiversity hotspots were used by at least 3 of the activities investigated here (Figs 3.5a & 3.5b).

Perhaps due to the different nature of the activities reviewed here, users from the different groups placed varying degrees of importance on different marine wildlife classes. Sea-kayakers considered that it was very important to be able to see animals such as sea-mammals and seabirds whilst divers were more interested in those groups of species that could be observed underwater. Customers of wildlife cruises had a particular desire to observe cetaceans, seals and charismatic species of seabirds such as puffins or gannets (Fig. 3.6). Therefore, the distribution of marine biodiversity is likely to be among the factors that influence the distribution of human activities in terms of recreational use of the marine environment.

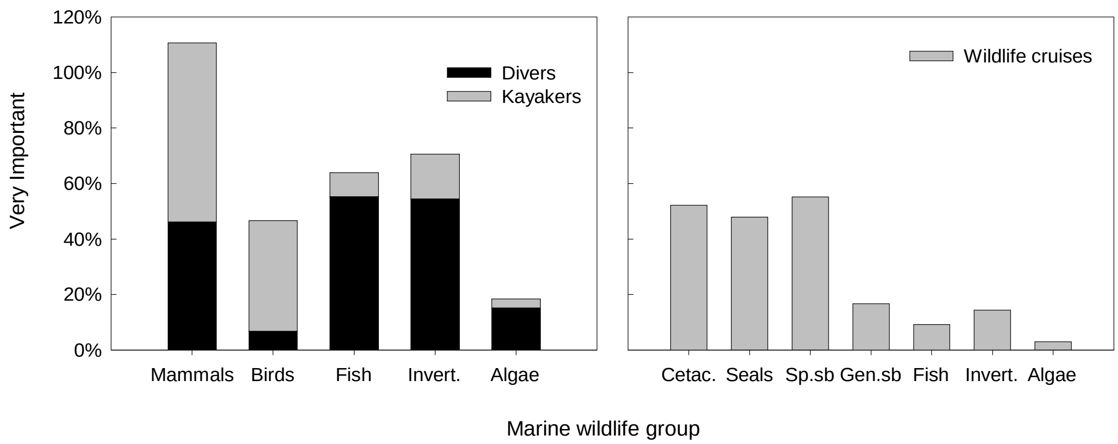


Figure 3.6. Percentage of respondents that thought as "very important" being able to observe certain groups of marine wildlife (invert. = invertebrates, cetac. = cetaceans, Sp. Sb = special seabirds, i.e. puffins, gannets, Gen.sb = general seabirds, i.e. seagulls)

3.5 Discussion

The total annual expenditure associated with non-consumptive recreational uses of marine biodiversity in Wales (diving, kayaking, wildlife viewing cruises and seabird watching) was estimated to be between £21.8 and £33 million in 2008. This represents between 3 to 5% of the total expenditure (£742million) attributed to coastal domestic tourism in Wales in 2007 (Visit Wales 2008). In tropical and sub-tropical areas of the world non-extractive activities play an important economic role at both national and local levels (Brander et al. 2007). High numbers of visitors are attracted to certain places due to the presence of iconic species or habitats such as coral reefs and in some cases revenues from those non-extractive uses of marine biodiversity can surpass the value of some of the consumptive uses (Hoyt and Hvenegaard 2002, Troëng and Drews 2004). Generally however, in temperate locations where marine biodiversity is not the main attraction for visitors, the economic importance of this type of activity is often assumed to be of less importance than commercial extractive activities such as fishing. However, in the context of Wales, a comparison of the two types of uses of the marine environment reveals that revenues from both are similarly important since in 2003 the total first value of fisheries landings in Wales was estimated at £27.9 million (Richardson 2006). This figure is likely to have increased in recent years as landings for some shellfish species such as scallops (*Pecten maximus* Linnaeus) increased from 248 tonnes in 2005 to 3,836 tonnes in 2008 (written statement by the Welsh Assembly Government). However, this short term economic gain did not last long as concerns about diminishing scallop stocks and the condition of the sea bed led to the temporary closure of the fishery in 2009 by the Welsh Assembly Government. Examples such as this emphasize the importance that non-consumptive uses have for local communities as extractive uses like fishing become more prone to unpredictable fluctuations.

If adequately managed the uses of the marine environment addressed in this study should be compatible with biodiversity conservation. This is important as the value of recreational activities to local communities should provide an economic incentive to conserve marine biodiversity. Furthermore, Wales is one of the poorest regions within the UK with high unemployment rates, lower income per capita and more people dependent on fishing and agriculture than the UK average (StatsWales 2009). This situation highlights the importance of maintaining a high quality marine environmental status in rural areas in order to preserve the additional revenues and local employment opportunities that depend on the marine environment.

It should be noted that the valuation presented in this study underestimates the economic importance of non-consumptive benefits provided by the marine environment in general as other activities less reliant on marine biodiversity but still dependent on the marine environment (i.e. surfing, sailing, yachting, shipping) were not included in the valuation. Equally, other recreational uses of marine biodiversity that fell into the category of extractive uses such as recreational angling were not included despite their economic importance. For example, in 2003 the total expenditure made by Welsh anglers in Wales was estimated at £46.3 million (Richardson 2006). Additionally, the valuation undertaken here cannot represent the total value associated to the uses covered in this study, as the term value encompasses much more than just expenditure. For instance, this study did not have the scope to ascertain consumer surplus (i.e. the difference between the maximum price a consumer is willing to pay and the actual price they do pay), therefore the value reported here reflects the market value of these uses at a particular moment in time. This is not to say that the estimates presented here are of no importance, as market valuation approaches for the estimation of the economic expenditure of recreational activities are often used as indicators of economic value (Nunes and van den Bergh 2001).

Spatial information on the distribution of the uses and services provided by marine biodiversity is crucial for an adequate management of the marine environment. Geographic data on the distribution of activities is particularly relevant in marine spatial planning (MSP) where portions of the sea are allocated to different uses to achieve ecological, economic and social objectives (Douvere 2008). Successful MSP requires an understanding of the spatial heterogeneity of the different ecosystem components including both ecological and human elements. Extensive data are available for the distribution of ecological components in the study area (i.e. Habmap, Robinson et al. 2007), however, no information exists on the spatial heterogeneity of coastal human activities. This study has contributed to fill in the existing information gap by revealing the spatial heterogeneity of non-consumptive recreational uses that are dependent upon marine biodiversity.

Different factors play a role in the distribution of human activities, therefore a thorough understanding of the distribution of activities should also include the study of the factors affecting that distribution. The distribution of marine activities is partially determined by the distribution of ecological components but also by the facilities and uses of the adjacent coastline. Clearly, factors such as ease of access and proximity to shore side facilities and amenities will play an important role in determining popularity levels. Additionally, the distribution of ecological elements is also fundamental in determining human use patterns. For instance, results show that the distribution of scuba-diving is influenced among other things by the location of hard subtidal substrata as these habitats will harbour more visually attractive communities than those characteristic of soft sediments (Di Franco et al. 2009). In the case of sea-kayaking it is also clear that the distribution of the activity is influenced by the presence of marine wildlife, as results suggest that this is an important factor in the popularity of an area (Fig. 3.4). The spatial distribution of the different wildlife groups will influence human activity patterns, as results indicate that preferences to observe different wildlife groups differ between user groups.

Within the study zone, some of the high use areas coincide with areas identified as biodiversity hotspots in Wales in a study carried out by the World Wide Fund for Nature in 2007 (Hiscock and Breckels 2007) suggesting that higher levels of marine biodiversity offer more satisfactory experiences to certain users of the marine environment, and in turn create higher economic revenues. Furthermore, the spatial overlap of locations that are most valuable for recreational services with areas that host the most diversity could offer the opportunity for win-win situations as management strategies introduced to safeguard biodiversity will also offer benefits for maintaining recreational services (Anderson et al. 2009).

An understanding of the distribution of human activities can highlight areas of intense use or areas where multiple uses occur. Additionally, it provides information on how people interact with the marine environment and it can contribute to balancing the needs of different users. In Wales, the areas of Anglesey and the Llyn peninsula in the north and Pembrokeshire in the west have been identified as popular zones for the uses covered in this study. Some of these areas coincide with those identified in 2003 as some of the most profitable areas for commercial fishing (Figs 2.5c & 2.5d) (Richardson 2006). This comparison highlights areas where potential user conflicts can occur. Furthermore, the integration of existing ecological information with human patterns of activity can contribute to the identification of pressures on the marine environment by highlighting areas of high levels of activity on sensitive environments thus allowing for adequate management to be implemented on a zone by zone basis. The mapping of activities therefore provides essential information for the development of suitable zoning systems for the sustainable management of human interactions within the marine environment.

At a time when the valuation of ecosystem services is becoming increasingly important this study shows the economic importance of non-consumptive uses of marine biodiversity and places the revenues generated by these uses to be on the same level as previously thought more economically important activities such as commercial fishing. Additionally, as marine spatial planning is being progressively incorporated into management plans these results highlight human patterns of activity along the coast and the importance that different factors play in their spatial distribution.

Although this study focuses on the coast of Wales the approach adopted here to evaluate and characterize patterns of non-consumptive uses of marine biodiversity could be applied to other uses and coastal systems elsewhere. Such studies can contribute with invaluable data to inform suitable management decisions.

Chapter 4

Mapping stakeholder values for coastal zone management

4.1 Abstract

There is a growing recognition of the need to incorporate multiple values in environmental management plans. While biological and increasingly economic values are considered in the design of management strategies, community or stakeholder's values are not often taken into account.

This study has mapped stakeholders' values for marine ecosystems and assessed their preferences for the location and type of marine protected areas (MPAs) around the coast of Wales (UK).

Stakeholders were chosen to represent a comprehensive range of interests in the marine environment. Fourteen different types of value were identified by stakeholders. The spatial distribution of the different values attached to the marine environment was ascertained; this revealed the existence of areas where multiple values overlapped. Results indicated that areas perceived as ecologically important also possessed high heritage and leisure values.

When locating MPAs, stakeholders balanced conservation needs with societal demands by protecting areas identified as ecologically important while avoiding those areas where restrictions could have a considerable impact on society. Data suggested a preference for MPAs that permitted a range of adequately regulated anthropogenic activities.

The distribution of stakeholders' values and the identification of areas of multiple value help managers to understand the potential consequences of particular management strategies, and allow them to be aware of the location of areas where greater consideration is required when designing management plans as multiple interests may overlap. Thus, mapping stakeholders' values in the marine environment provides a useful tool for identifying areas better suited for specific management regulations and for the development of comprehensive marine spatial plans, as these require the understanding of the spatial heterogeneity of the different ecosystem components including both ecological and human elements.

4.2 Introduction

There is an increasing need to incorporate multiple values (i.e. economic, social and cultural values) into conservation and environmental management plans (Cowling and others 2008; Naidoo and others 2008). Strategy documents such as the Millennium Ecosystem Assessment have highlighted the necessity to take into account the intrinsic values associated with ecosystems and also to adopt a comprehensive approach that encompasses a wider range of values, including the local, cultural and economic values that stem from the relationship between people and nature (MEA 2005). However, whilst ecological, and latterly economic values (Naidoo and others 2008), are considered in the definition and design of environmental management plans, community or stakeholders' values are not always considered (Alessa, Kliskey, Brown 2008; Bryan and others 2010; Raymond and others 2009). If these values are to be incorporated into spatial management plans it is essential that they possess a spatial component so that they can be integrated with spatially defined biophysical, ecological and economic data. In addition to facilitating the integration of information Zube (1987) suggested several advantages associated with mapping community values; firstly it permits the identification of places people value and the reasons why they value them, thus allowing managers to become aware of the need to give particular areas extra consideration when designing management plans. Secondly, it identifies areas of potential conflict between user groups in cases where multiple user groups value an area for potentially conflicting reasons; and thirdly, it helps managers understand the potential consequences that alternative management scenarios can have on the wider environment and on society.

In terrestrial systems, several studies have mapped community values of the natural environment using different approaches. For example, values associated with urban natural areas, such as parks and green areas, have been mapped in Finland (Tyrvainen, Makinen, Schipperijn 2007), while other studies have elucidated the values people ascribe to publicly owned lands (Alessa, Kliskey, Brown 2008; Brown and Reed 2000; McIntyre, Moore, Yuan 2008). A variety of value typologies have been utilized in these studies, however some of the typologies used focused only on particular sets of values, such as recreational values, and thus did not have the scope to capture the wider array of values that can be associated with the natural environment (McIntyre, Moore, Yuan 2008). In 2005, Brown developed a landscape value methodology to map and measure a wider range of landscape values which included recreational, aesthetic, economic, cultural and biodiversity values (Brown 2005). Whilst this methodology sought to understand a range of values from the social perspective, it failed to capture the biophysical aspects of value. Raymond and others (2009) provided a potential framework for understanding this broader set of values by integrating Brown's (2005) typology with the concept of natural capital and ecosystem services established by the Millennium Ecosystem Assessment (MEA) (2005), thereby offering the possibility to value other aspects of the environment such as the provision of regulating or supporting services.

Such an approach to mapping community values is lacking in the marine environment despite its potential value to accomplish successful marine spatial planning (MSP). The development of comprehensive MSP requires an understanding of the spatial heterogeneity of different ecosystem components including both ecological and human elements. Marine protected areas (MPAs) are among the most important management and conservation tools available within a framework of MSP and have been advocated as an essential part for achieving global marine conservation targets (CBD 2008; OSPAR 2003; UN 2002). For MPAs to be successful in achieving their conservation objectives they need to be designed with biological principles as a primary design criterion (Roberts and others 2003), but they also need to have community support in order to ensure user compliance (Moore and others 2004). Despite having recognised the latter as an important factor for success, community values are not always considered during an MPA design process that remains dominated by biological issues.

The aim of this study was to elicit and spatially define community values for the marine environment. This was achieved by adapting Raymond and others' (2009) value typology to the marine environment. Whilst Raymond and others (2009) used MEA's classification for ecosystems goods and services (EGS), this study utilized Beaumont's adaptation of MEA's EGS to the marine environment (Beaumont and others 2007). This study focuses on Wales, UK, where the Welsh Assembly Government has adopted a

Marine and Coastal Access Act through which it is committed to “establishing an ecologically coherent, representative and well-managed network of marine protected areas” taking into account “environmental, social and economic criteria” by 2012 (DEFRA November 2009). Although comprehensive information is available for the distribution of biophysical and ecological factors, no information exists on the social values associated with the marine environment in Wales. The present study seeks to inform the decision making process regarding the design of MPAs in Wales by providing key insights into the values held by different stakeholder groups with an interest in the marine environment. This was achieved by gathering information on the values and benefits derived from the marine environment by different stakeholder groups and by defining the spatial distribution of those values such that they could be incorporated into marine spatial management plans. Stakeholder views on the preferred location and design of MPAs and their associated management was also investigated.

4.3 Materials and Methods

4.3.1 Study Area

Wales has a coastline of around 1,300 km and an area of approximately 16,000 km^2 lies within Welsh territorial waters (Fig. 4.1). In Wales the majority of the population is concentrated in coastal areas, where the marine environment offers the opportunity for a wide range of uses such as commercial fisheries, tourism, energy provision, recreation or shipping. Therefore, a variety of stakeholder groups exists with a wide range of interests and values attached to the marine environment.

4.3.2 Stakeholder sample

Representatives of various stakeholder groups were interviewed during the study. In order to achieve a comprehensive representation of groups with different interests in the marine environment members of the Wales Maritime and Coastal Partnership (WMCP) were approached in the study. The WMCP is formed of representatives of maritime and coastal interests in Wales encompassing 26 organizations drawn from the public, private and voluntary sector. The aim of the WMCP is to provide integrated and co-ordinated advice to the Welsh Assembly Government on a range of policy areas including the development of an Integrated Coastal Zone Management plan. For the purpose of the study only those organizations with direct involvement in the marine environment were approached (20 organizations). Of the remaining twenty organizations, four declined to participate in the study and no response was received from six other organizations after several attempts to contact them, thus a total of 14 organizations took part in the study. Whenever possible, two members from each organization were interviewed separately (total number of individuals interviewed = 22).

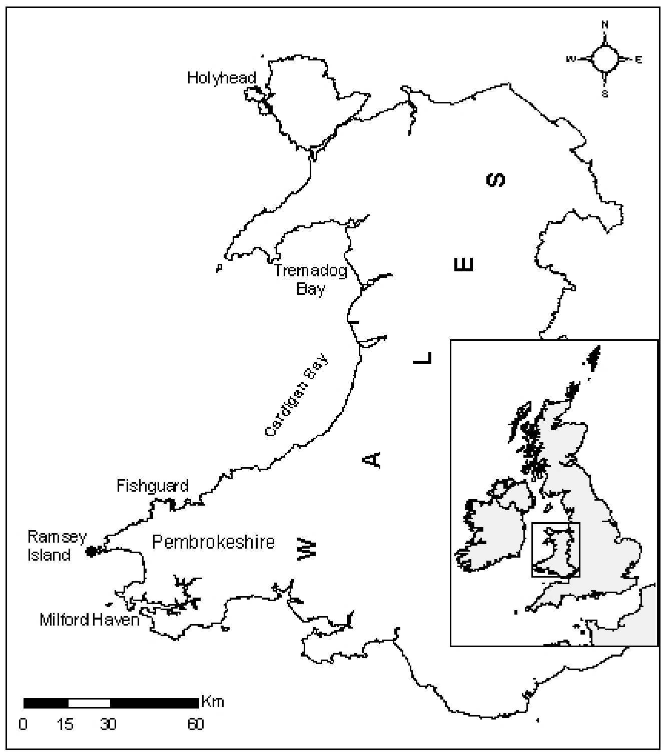


Figure 4.1. Overview map of the study region showing the location of the main ports (Holyhead, Fishguard, Milford Haven), bays and islands in Wales.

Table 4.1. Organization type, number of interviewees and approximate membership representation, NA = not applicable

Organization type	No of participants	Representation
Business & industry	4	NA
Academic research	3	NA
Commercial fisheries	3	435[‡]
Heritage	1	100,000
NGO & voluntary sector	2	1,000
Environmental public bodies	5	NA
Recreational sector	4	26,000

The organizations interviewed here represent the interests of substantial numbers of people with a range of interests in the marine environment (Table 4.1). Face-to-face interviews were carried out with representatives of the business and industry sector (4 participants), academic research (3), commercial fisheries (3), heritage (1), non-governmental organizations and voluntary sectors (2), environmental public bodies (5) and recreational sector (4 participants).

4.3.3 Interview design

In-depth interviews were conducted with the participants between January and June 2010. Interviews followed an open-ended format with full probing, meetings generally occurred in people's work place and lasted for around one hour. All interviews focused around two main questions: (i) which areas of the Welsh marine environment the participant thought provided the most important benefits to society and why?; and (ii) which areas of the Welsh marine environment would the participant like to see protected from certain human uses?

4.3.4 Stakeholder perceptions

The interview was divided into two parts. In the first part respondents were asked to indicate places of value to them by arranging 1cm wooden cubes on a 1:500,000 A3 map of Wales, each cube covered an area of 100 km^2 on the map. The map had a superimposed 10x10 km grid and respondents were requested to fit the cubes on the grid cells. In order to qualitatively estimate "value" respondents were given a maximum of

[‡] No of vessels represented by the Welsh Federation of Fishermen's Association Ltd.

30 cubes, equivalent to 14% of the total available cells. Before arranging the cubes on the map, participants were introduced to the benefits society obtains from the marine environment according to the classification established by the Millennium Ecosystem Assessment (MEA 2003). The interviewees were given a laminated card with the MEA classification for them to use as reference (Table 4.2).

Participants were then asked to place the cubes on those cells of the map where they thought nature provided the most important benefits to society. Once the cubes were arranged on the map respondents were asked to indicate the reasons why they considered the selected cells to be important and the type of benefits or values they thought society obtained from those areas.

The second part of the exercise was concerned with the establishment and location of marine protected areas in Wales. Respondents were briefed on the current conservation policy situation in Wales. Participants were asked to indicate those cells where they would like to see some type of protection or restriction in the marine environment. To create priority in the selection of areas, the exercise was divided into three sub-tasks; first respondents were given 10 cubes to place on the map, so that only 10 cells could be selected for protection. Once the cubes were arranged on the map, participants were then given another 10 cubes and once these were arranged an extra 10 cubes were given. To be able to identify the cells selected through the different subtasks each of the three sets of cubes had a different colour.

After each sub-task respondents were asked to indicate the reasons behind their selection and to state the type of protection they would like to see in place for each of the selected cells. Respondents could choose among three levels of protection: (1) closed access areas, where no human activities were allowed, (2) areas where non-extractive recreational activities were allowed, and (3) areas where restricted recreational and commercial fishing were permitted.

Table 4.2. Goods and services provided by marine biodiversity adapted from Beaumont et al. (2007).

Production services	**Food provision** *The extraction of marine organisms for human consumption*
	Raw materials *extraction of marine organisms for all purposes, except human consumption*
Cultural services	**Identity / cultural heritage** *The value associated with the marine environment e.g. for religion, folklore, painting, cultural and spiritual traditions*
	Leisure and recreation *The refreshment and stimulation of the human body and mind through the observation of, and engagement with marine organisms in their natural environment*
	Cognitive value *Cognitive development, including education and research*
	Non-use value *Value which we derive from marine organisms without using them*
Option use value	**Future unknown and speculative benefits** *Currently unknown potential future uses of marine biodiversity*
Regulation services	**Gas and Climate Regulation** *The balance and maintenance of the chemical composition of the atmosphere and oceans by marine living organisms*
	Flood and Storm protection *The dampening of environmental disturbances by biogenic structures*
	Bioremediation of waste *Removal of pollutants through storage, dilution, transformation and burial*
Supporting services	**Nutrient cycling** *The storage, cycling and maintenance of availability of nutrients by living marine organisms*
	Resilience/Resistance *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*
	Biologically mediated habitat *Habitat which is provided by marine organisms*

4.3.5 Data analysis

Digital pictures of the participant's maps were taken after each exercise and the results were digitized using a geographic information system (GIS) software (ArcGIS 9.2, ESRI, Redlands, California). Additionally, a database was created with the attribute information associated to each of the cells of the map, this database was linked to the spatial information stored in the GIS. The percentage of respondents and the number of times each cell was identified as important provider of a particular benefit or selected for protection was recorded and used in subsequent spatial analyses.

The assessment of potential spatial relationships was undertaken using two different types of analyses. First, Pearson's correlations were used to identify geographic relationships between pairs of benefits (Mitchell 2005). Second, the level of spatial aggregation for each of the benefits was analysed using Local Moran's I, this method allows for the identification of clusterings of similar values (high or low) by analysing how much each cell is similar or dissimilar to its neighbours (Mitchell 2005). The statistical significance of Moran's I at a certain confidence level is calculated using the Z-score. High values of Moran's I indicate high clustering, values around zero indicate no clustering and negative values indicate dispersion. Three maps were produced for each of the perceived benefits. Local Moran's I was mapped to show the location of clusters of similar values, Z-score maps were produced to indicate which of the clusters were significant at a 95% confidence level and a third map showing the percentage of times each cell was selected for a particular benefit was produced to indicate whether the clusters were comprised of high or low values.

4.4 Results

4.4.1 Perceived spatial distribution of values

The nature of stakeholders' values and their spatial distribution were examined for the coast of Wales. Respondents identified fourteen different types of societal benefits or values derived from the marine environment. The majority of participants identified tourism and recreation, food provision, industrial opportunities and ecological importance as some of the most important values derived from the marine environment (Table 4.3).

Table 4.3. List of stakeholders' perceived values, number of cubes allocated to the different values and number of participants who mentioned each of them

Values	N cubes	N respondents
Tourism / Recreation	416	20
Ecological value	332	19
Food provision (fisheries)	124	16
Industrial value	96	16
Identity / heritage	96	9
Existing conservation designations	44	3
Supporting services	44	3
Cognitive value	30	4
Energy provision	21	7
Geological value	18	2
Regulation services	16	3
Option value	12	2
Aggregate extraction	8	1
High population	4	1
Aesthetic value	3	1
Total	637	22

The opportunities offered by the marine environment for recreation and tourism were perceived as the most important benefit for society, as "tourism and recreation" values were assigned the greatest number of cubes when compared to the rest of values. "Ecological value" was the derived benefit that received the second highest number of cubes and was mentioned by 83% of respondents. Only those respondents from the academic research sector or the environmental public bodies specifically mentioned the supporting and regulating benefits provided by the marine environment, this may relate to the level of expertise of the interviewees. However, it became clear from the interviews that the rest of participants included these benefits under the broader term of "ecological value". Benefits derived from marinas and from the three main commercial ports in Wales (Holyhead, Fishguard and Milford Haven, Fig. 4.1) were perceived as "industrial values" and were mentioned by a high proportion of respondents, approximately 70% of the participants referred to them during the interviews. Respondents also viewed the marine environment as an important source of energy supply, areas off the north coast of Wales were mentioned as important for wind energy and areas in the south and south west coast were pointed out as potential suppliers of tidal energy.

GIS maps were created for the perceived spatial distribution of the benefits most frequently mentioned by participants (Fig. 4.2). The mapping of Z-scores indicated the existence of significant clusters of high values for several of the perceived benefits (i.e. areas selected by a high percentage of respondents). For most of the benefits significant clusters tended to be located around the same areas (Pembrokeshire coast, Cardigan Bay and Tremadog Bay, Fig. 4.1) suggesting that certain areas were perceived as providers of multiple benefits. The similarity of the perceived spatial distribution for some of the benefits was further confirmed by strong positive spatial correlations between some pairs of benefits (Table 4.4), for instance the distribution of areas with an associated ecological value was strongly correlated with the distribution of areas with associated recreational benefits (Pearson = 0.904), identity values (0.815) or fisheries benefits (0.72). The overlay of the perceived distribution for the different ecosystem values further confirmed that particular areas of the coast provided multiple values. A map showing the total number of different perceived values assigned to each cell was created and the presence of significant clusters was identified (Fig. 4.3a). This map makes it possible to identify "hotspot areas" for the provision of values.

Table 4.4. Pearson's correlation between pairs of benefits, *correlation is significant at the 0.01 level

	Ecological	Leisure	Fisheries	Identity	Industrial	Energy
Ecological	--	0.904*	0.702*	0.815*	0.422*	0.111
Leisure		--	0.720*	0.801*	0.394*	0.120
Fisheries			--	0.526*	0.354*	-0.309
Identity				--	0.413*	0.072
Industrial					--	0.019
Energy						--

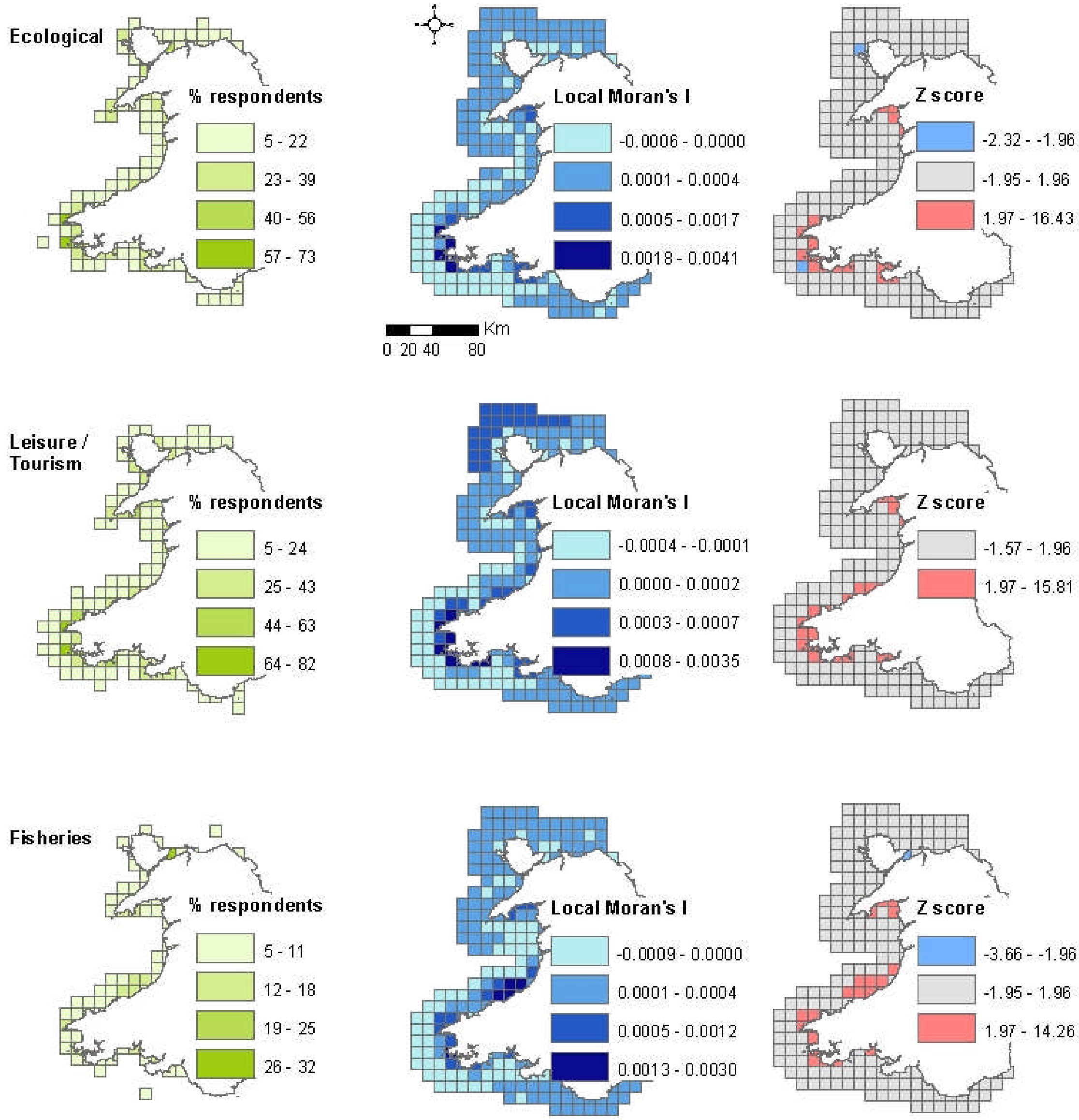


Figure 4.2. Spatial distribution of ecological, leisure and fisheries benefits identified by stakeholders around the Welsh coast. Left: % of respondents who identified a particular cell as provider of a particular benefit; middle: Local Moran's I, high values indicate clustering of similar values; right: Z-score, pink cells indicate significant clusters of similar values at the 0.05 significance level, blue cells indicate dispersion of values

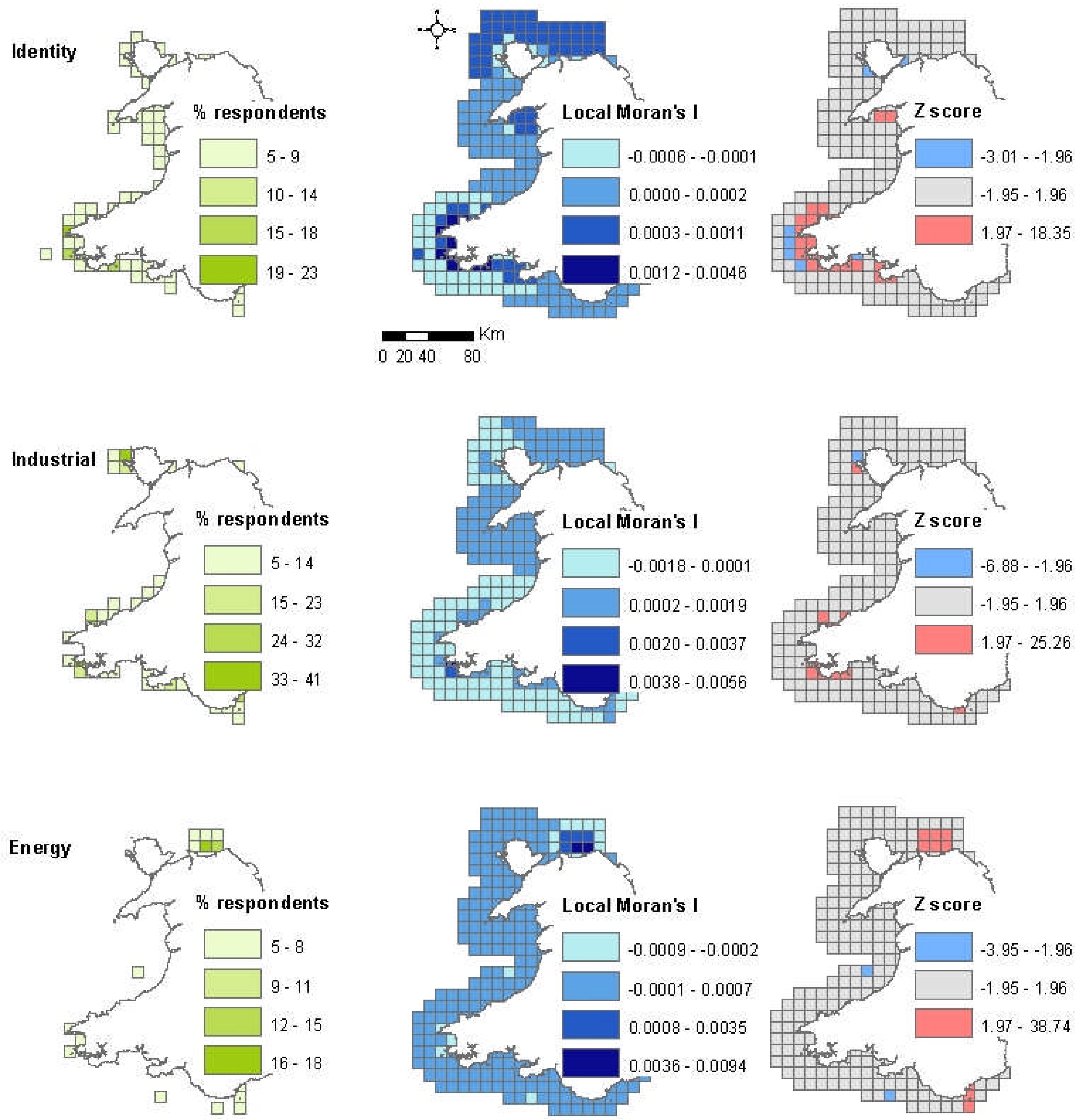


Figure 4.2 (cont.). Spatial distribution of identity, industrial and energy benefits identified by stakeholders around the Welsh coast. Left: % of respondents who identified a particular cell as provider of a particular benefit; middle: Local Moran's I, high values indicate clustering of similar values; right: Z-score, pink cells indicate significant clusters of similar values at a 0.05 significance level, blue cells indicate dispersion of values

4.4.2 Location of marine protected areas

The majority of participants (74%) used the 30 available cubes for the selection of protected areas. In general, participants supported less restrictive marine protected areas where controlled commercial and recreational fishing were allowed. Seventy-four percent of respondents chose to protect areas using this type of management (lowest level of protection), on average participants allocated 66% (± 7.8 SE) of their cubes to this level of protection. Similarly, 74% of participants chose to protect some areas of the coast using the second level of protection where only non-extractive recreational activities were allowed, however the average number of cubes allocated to this type of protection was lower than in the previous case as participants on average allocated 30% (± 7.5 SE) of the cubes to this level of management. Generally, respondents did not support the full protection of areas of the marine environment where no anthropogenic activities were permitted. Only four participants chose to implement the highest form of protection in certain areas of the coast. Interestingly, these areas were of very restricted size as on average those respondents who chose the highest level of protection allocated only 2 cubes to this type of management.

Digital maps that represented the distribution of high, medium and low protection areas as chosen by the respondents were created (Fig. 4.4). According to participants, the locations of areas of high protection were selected due to the "uniqueness" of the ecological environment in the case of north Wales and due to the permanent presence of cetacean populations in the west coast of Wales. Some of the most frequently selected areas under medium protection were located in estuarine areas, which were perceived to be unique and important environments. Ramsey Island was also considered unique as it is home to hundreds of breeding pairs of seabirds and is also an important seal breeding colony (Fig. 4.1). Areas of low protection were mainly located around areas perceived as both ecologically important and popular tourism destinations. In these areas participants wanted to see some type of low levels of restriction or codes of conduct that would mitigate the potential impacts derived from the presence of high densities of people.

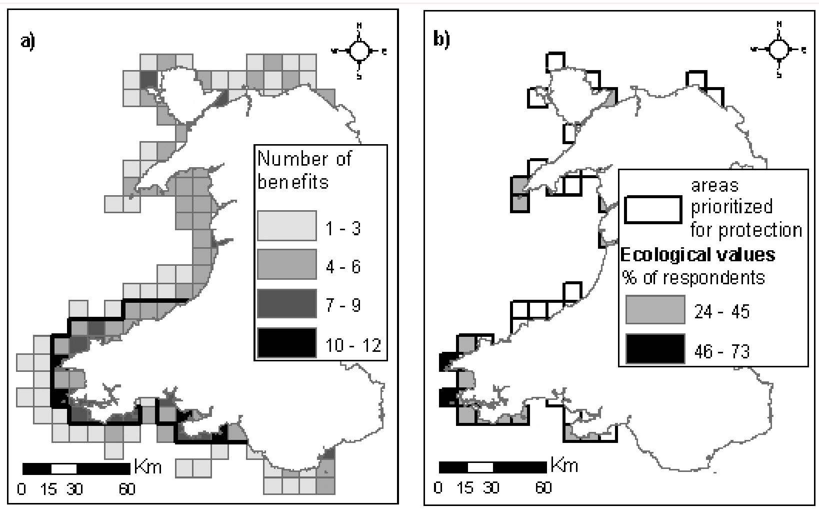


Figure 4.3. a) Total number of types of benefits allocated to each cell, solid black line indicates significant clusters of similar values; b) Spatial overlap between cells allocated high ecological value and those cells consistently selected for protection (>25% of respondents)

Analysis of the data from the prioritization exercise revealed that when respondents were given the choice to select only 10 cells for protection, they mostly selected those cells with the highest ecological values (Fig. 4.5a) while they tended to avoid those with associated industrial values (Fig. 4.5b). Cells selected for protection during the second and third subtasks had a lower ecological value than the first 10 selected cells. No differences were detected between the total number of values assigned to the cells selected in the first, second and third subtask (Fig 4.5a). Therefore, on the basis of this exercise it is possible to conclude that ecological value was prioritised over other values.

4.4.3 Spatial overlap between protected areas and values

Areas that were consistently selected for having "ecological value" by at least 25% of the respondents were overlaid over areas that were also consistently selected for protection; the spatial overlap between these areas was very high, as all the ecologically important areas were selected for protection (Fig. 4.3b). Furthermore, a strong positive correlation was found between the number of times a cell had been selected for its "ecological value" and the number of times it had been selected for protection (Pearson = 0.91, $p < 0.001$). The high degree of spatial correlation between areas of protection and ecological importance suggests that respondents did not allocate areas for protection at random.

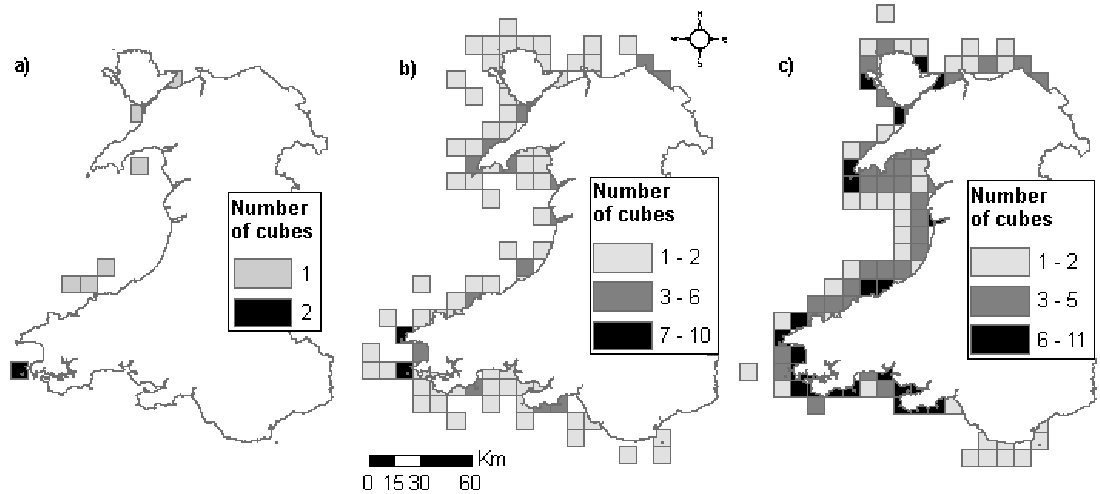


Figure 4.4. Aggregated data for areas selected under different management regimes; a) high level of protection, b) medium, c) low.

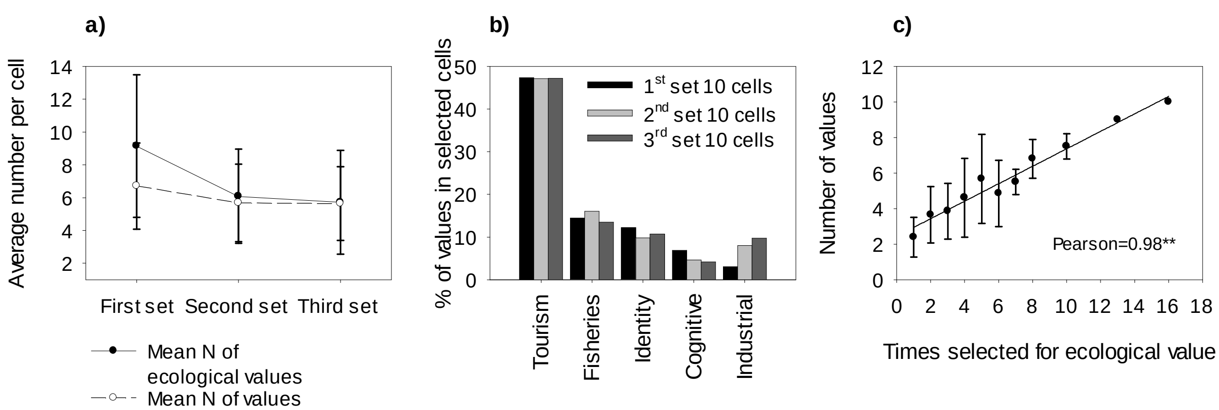


Figure 4.5. a) Solid circles represent the average no of times the cells selected in the first, second and third subtasks had been allocated "ecological value"; open circles indicate the average no of benefits associated to the cells selected in the first, second and third subtasks. b) Percentage of times the cells selected in the first, second and third subtasks had been allocated a particular "value". c) Scatter plot showing the relationship between the no of times a cell had been selected due to its "ecological value" and the total no of different "values" allocated to that same cell.

Analysis of the data revealed that there was a positive relationship between the number of times a cell had been assigned to a "low" or "medium" protection management regime and the number of times it had been chosen for its ecological value (Fig. 4.6 top). Similarly, a positive relationship was detected between the number of times a cell was given a "low" or "medium" protection status and the total number of values recorded in that particular cell (Fig. 4.6 bottom). The reason for the similarity of both relationships can be found in the positive correlation between the number of times a cell had been allocated "ecological value" and the total number of values assigned to that same cell (Fig. 4.5c), this suggests that areas of perceived high ecological value were also perceived to be important providers of other benefits. No such apparent relationships were detected in the cells selected for "high" protection, this is possibly due to the fact that only 2% of the total number of cubes were assigned to this type of management regime.

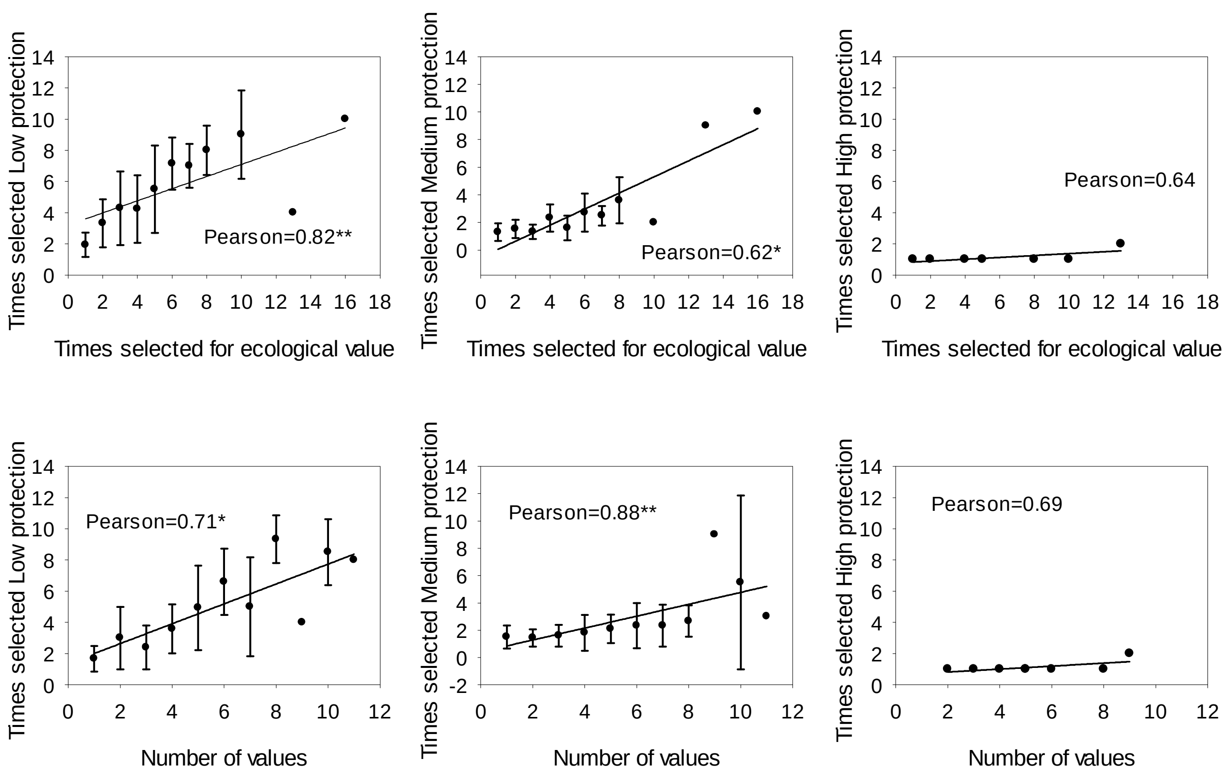


Figure 4.6. **Top:** No of times a particular cell had been allocated "ecological value" vs. no of times the cell had been selected under a particular management regime (left: low protection, middle: medium protection, right: high protection). **Bottom:** Total number of values per cell (excluding ecological value) vs. no of times selected under different management regimes. Pearson correlation indices *significant at 0.01 level, **significant at 0.001 level.

4.5 Discussion

4.5.1 Stakeholders' perceptions of value distribution

Results from the study provide an insight into the perceived range of values offered by the marine environment in the area of Wales. The results indicated that stakeholders' representatives valued the Welsh coast for a variety of reasons. It is unlikely that the values identified here are unique to Wales and hence the findings are likely to be applicable to other rural coastal economies. Fourteen different types of "values" were perceived to be found in the study region. All the ecosystem benefits (hereafter referred to as values) included in the Millennium Ecosystem Assessment (MEA) (MEA 2003) were mentioned by the study participants. Additionally, respondents expanded on the MEA based typology of values and included extra aspects such as geological values or more anthropogenic orientated aspects such as values related to areas of high population densities.

The spatial distribution of values varied across the study region, data suggests that particular benefits followed a similar spatial distribution along the coast, as indicated by the strong positive correlations found for some pairs of benefits. Furthermore, it was apparent that some areas were perceived as more valuable than others in terms of the societal benefits derived from the marine environment. The spatial analysis of the distribution of benefits highlighted the presence of clear clusters of areas that were perceived as providers of multiple benefits. From a societal perspective these zones or "hotspot areas" are important locations where multiple interests overlap and will require higher levels of stakeholder involvement in prospective spatial management plans. Additionally, from a managerial point of view the superimposition of these layers of information allows for the creation of multiple decision criteria maps which facilitate the identification of areas better suited for specific uses or management regulations. A similar methodology was used on a land-based case study to identify areas of agreement and disagreement in perceived stakeholder landscape values and a system was developed to rank potential land use for consistency with stakeholders' values (Brown 2005). Another example of the application of suitability maps can be found in the planning process of a national forest in Canada where a suitability analysis method was developed to map landscape values to determine the consistency of potential forest management strategies with community held landscape values (Reed and Brown 2003).

Care has to be taken however when interpreting the outcomes of this type of exercise as place valuations are strongly influenced by the subjective judgment and personal views of the respondent, which will depend on the understanding of the respondents' definition of value, their experiences, familiarity with the area and their map literacy among others (Zhu et al. 2010). Further limitations of this type of analysis include the ambiguous placement on the map of the cubes used in the exercise, where the area being mapped is actually smaller or bigger than the cube area used here, and the erroneous arrangement or incomplete placement of cubes by participants who are less familiar with the study area (Brown 2005). Particularly, in our study concerns were initially raised regarding participants familiarity with the study area, as some respondents stated that they were more knowledgeable about their surrounding area of residence than about the rest of the study region. However, the comparison of the spatial distribution of stakeholders' perceived values with some ecosystem services which distribution was known (i.e. tourism, recreation, food and energy provision) confirmed the validity of stakeholders' perceptions. Further evidence backing the soundness of stakeholders' views comes from other studies which have previously confirmed the agreement between perceived values and the assessment of geographic features (Brown 2005), conservation priorities (Raymond and Brown 2006) and measures of ecological richness (Alessa et al. 2008). Additionally, the correspondence between perceptions and actual distributions validates the methodology used in the study as it indicates that participants understood the mechanics of the exercise and that responses were not random but thought through.

4.5.2 Location and management of marine protected areas

The vast majority of stakeholders' representatives were not in favour of the establishment of marine protected areas (MPAs) which would completely exclude anthropogenic activities from within their boundaries. Conversely, most participants supported the implementation of MPAs with low levels of restriction where most activities would be allowed but would be adequately regulated. However, it is likely that a higher number of more restrictive areas would have been chosen during the exercise if the method of area selection would have allowed for the selection of smaller areas, as it was mentioned by participants that the methodology used in the study forced them to choose highly protected MPAs of a minimum size patch of 100 km^2 which they thought would significantly impact certain sectors of society. It is therefore advised that in future studies a different approach which enables respondents to delineate their selected areas more accurately is used.

The selection frequency map for the location of MPAs provides an extra layer of information to managers and decision-makers in terms of which areas stakeholders consider should be protected. It is unquestionable that for MPAs to be successful in achieving their conservation goals it is paramount that they are designed with biological principles as primary design criterion (Roberts et al. 2003). However, information derived from the perceived distribution of values and stakeholders' views on the preferred location of MPAs could provide practical input in cases where decisions have to be made between two or more equally ecologically important sites, as stakeholder information could help discerning which site would be less controversial to protect from a societal point of view. Additionally, it has been suggested that the involvement of stakeholders' perceptions in management plans is likely to increase the quality and durability of environmental decisions (Beierle 2002, Reed 2008) as well as increasing the likelihood that decisions are perceived to be more holistic and fairer, as they account for a wide range of different values and needs (Richards et al. 2004).

In Wales, the Welsh Assembly Government is currently identifying and designating a network of marine conservation zones (MCZs) taking into account social, economic and ecological criteria. Whilst some areas of the MCZs will have management regimes that will be directed towards the maintenance of conservation status by allowing existing activities to continue if do not cause site condition to deteriorate; other areas will be designated as Highly Restricted MCZs which will include a general presumption against fishing of all kinds, all constructive, destructive and disturbing activities. Therefore, the methodology and information provided in this study can contribute towards the identification of areas better suited for particular management regimes from a social perspective.

Graphical representation of value, including maps, can have powerful influence in decision-making thus care is needed to ensure that their use reflects the quality of information they represent. The present study investigated the values of different stakeholder groups through interviews with two representatives of each group. Although the resulting maps appear to be sensible, it is recommended that future studies include higher numbers of people in the interviews to allow the investigation of opinion variation within and between the different groups. Furthermore, attention has to be paid to the potential disproportional representation of interest sectors, in which case weightings might need to be applied to the final valuation maps.

Although some concerns have been raised regarding the quality of stakeholder based environmental decisions, a review carried out in 2002 on the effects of stakeholder participation on the quality of environmental decisions determined that there is evidence that stakeholders contribute with new information and ideas to the decision process (Beierle 2002). Therefore, stakeholder participation can enhance the quality of environmental decisions by considering more comprehensive information inputs. Similar conclusions can be drawn from this study as results indicate that participants tended to protect ecologically important areas while at the same time avoiding areas where restrictions could have an impact on society, such as important areas for industrial activities. This suggests that stakeholders tried to balance conservation needs with social demands.

This study has adapted a methodology previously used on terrestrial environments (Brown 2005, Raymond et al. 2009) to map stakeholders' values of the marine environment. The mapping exercise has provided key insight information on the distribution of stakeholders' perceived values and the preferred distribution of MPAs for the area of Wales while at the same time validating the soundness of stakeholders' perceptions and decisions. The outcomes of this study will facilitate the integration of social values with environmental and economic data to provide a more comprehensive understanding of the complexities and dynamics of socio-ecological systems. Although this study focuses on the Welsh coast the approach used here to map stakeholders' values could be used in coastal systems elsewhere to provide practical data to inform successful marine spatial planning which takes into account social, ecological and economic aspects.

Chapter 5

Balancing use and conservation objectives in marine protected area design

5.1 Abstract

Socioeconomic considerations are crucial in the design of marine protected areas (MPAs). Most systematic planning processes that incorporate socioeconomic aspects mainly concentrate on consumptive user interests by integrating spatial data on fisheries, thus overlooking other interests such as the non-consumptive sector. Additionally, most theory on systematic spatial conservation planning is focused on the design of single zone reserves. The present study evaluates the benefits of integrating consumptive and non-consumptive interests in the planning process of MPAs and assesses whether the socioeconomic impacts on users of the marine environment of an MPA with multiple management zones are different to those of a single zone MPA. Results indicate that protected areas designed with consideration of non-consumptive interests reduced the potential economic impacts on this sector by c.50% more than MPAs designed without that consideration, without extra cost to the consumptive sector. The design of a multiple-zone MPA outperformed that of a single-zone MPA by reducing and generating more equitable impacts for both consumptive and non-consumptive interests. Additionally, a multi-zone MPA allows for the reduction in the size of the no-take zone without compromising conservation objectives.

5.2 Introduction

The positive ecological effects of marine protected areas (MPAs) are well documented (Blyth-Skyrme et al. 2006, Lester et al. 2009, Stewart et al. 2009), however their designation is often controversial as their implementation usually entails the removal of certain human activities from specific areas of the marine environment with associated negative socioeconomic impacts for the affected user groups. The success of MPAs in achieving their conservation goals depends on two main factors; firstly, MPAs need to be designed with biological principles as the primary design criteria to ensure biodiversity conservation (Roberts et al. 2003), secondly, their success is also dependant on user compliance (White et al. 2000, Moore et al. 2004). However, stakeholders' needs are not always included in the MPA design process or are considered *a posteriori* (Stewart and Possingham 2005), which can lead to unanticipated socioeconomic impacts on certain stakeholder groups.

In order to minimize socioeconomic impacts and to achieve conservation objectives efficiently, the socioeconomic costs associated with the establishment of protected areas should be integrated at the onset of the planning process (Carwardine et al. 2008). The incorporation of spatially resolved socioeconomic costs into conservation planning can minimize impacts on resource users (Richardson et al. 2006, Klein et al. 2008a), and thereby reduce the potential conflicts between stakeholders and managers (Crawford et al. 2006), resulting in a cost-effective implementation of protected areas through reduced costs to society (Naidoo et al. 2006).

However, to date most published studies (77%) that have accounted for socioeconomic costs in MPA design have only considered the opportunity costs for fisheries (i.e. the foregone revenues or value to fisheries) (Ban, Klein 2009). In all these studies the integration of fisheries socioeconomic data into the marine reserve design significantly reduced unnecessary socioeconomic impacts for the commercial fishing sectors. For instance, Richardson et al (2006) showed that the incorporation of fine-scale fisheries economic data into the design of protected areas considerably decreased (between 76% and > 300%) the losses incurred by the fishing industry when compared with reserves designed using coarse-scale resolution data. Although these studies have produced insights into the importance of including socioeconomic data into marine reserve planning they remained limited in scope whereas the marine environment is used by a much wider collective of stakeholders with commercial and non-commercial interests that are seldom taken into account in the planning process of protected areas. Attempts have been made to incorporate a wider range of users of the marine environment in systematic MPA planning by using proxies for non-consumptive interests (Klein et al. 2008a), however, the effectiveness of socioeconomic data surrogates remains an issue of debate (Weeks et al. 2010). Furthermore, most of the studies published on the cost-effective planning of MPAs have focused on the design of protected areas at the two extremes of management options (closed vs. open areas) with no consideration for different use-zones within the planning area. The recent release of a new multizone optimization tool (Marxan with Zones (Watts et al. 2009)), enables the definition of areas with a range of different management constraints. However, although it has been shown that the establishment of use-zonation in MPAs can be used to reduce and obtain a more equitable socioeconomic impact on the different fishing sectors operating within an area (Klein 2010), no studies have assessed the potential impacts of incorporating non-consumptive interests in the planning process of a multizoned MPA.

The present study had two main aims. First, to assess the socioeconomic impacts of incorporating fine resolution data of non-consumptive uses of the marine environment in the design of an MPA network that balances conservation needs with multiple stakeholder interests. Second, to ascertain whether the socioeconomic impacts on consumptive and non-consumptive uses of the marine environment of an MPA with zonation are different to those of an open / closed MPA.

5.3 Materials and Methods

5.3.1 Policy context and area of study

The Welsh Assembly Government (UK) has adopted a Marine and Coastal Access Act in which it commits to "establishing an ecologically coherent, representative and well-managed network of marine protected areas" taking into account "environmental, social and economic criteria" by 2012 (DEFRA November 2009). The Government will consider social and economic issues to ensure that MPA sites are, as far as possible, chosen to maximise ecological, social and economic benefits while minimising any unnecessary conflicts with the different uses of the sea.

The planning region used in this study was defined by the Welsh Territorial Sea, that is, the marine area extending to 12 nautical miles (nm) offshore from the midline of the Dee Estuary in the northeast and the midline of the Severn Estuary in the south. The area lying to the east of Worm's Head, however, had to be excluded from the planning exercise as insufficient ecological data was available for the region (Fig 5.1).

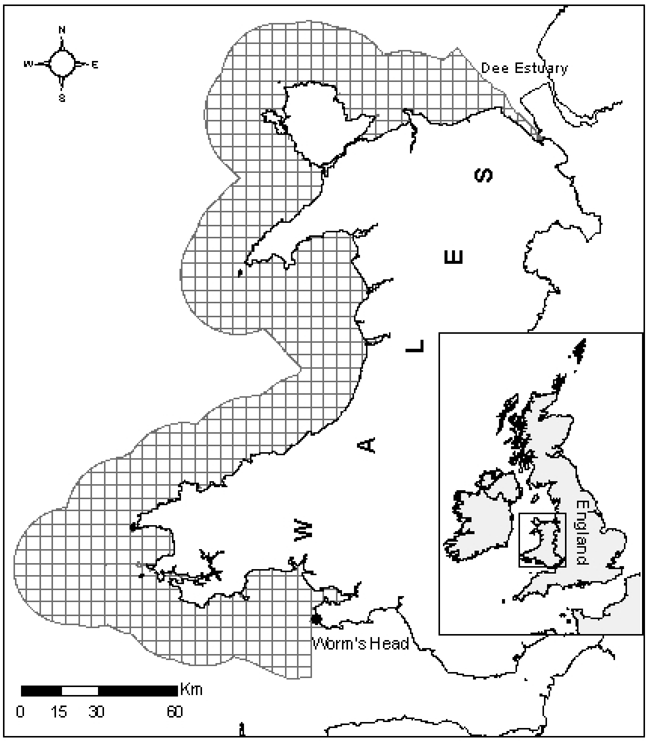


Figure 5.1. Overview map of the planning region showing the distribution of the 5x5 km planning units

A grid covering the entire study area was created, this process delineated 779 square cells or "planning units", each planning unit had an area of 5x5 km. This particular size of planning unit has been suggested to be adequate for coastal management (Watts and Kircher 2009) and has been used previously in other planning exercises (Stewart and Possingham 2003). Due to the irregular shape of the study area, a number of planning units were truncated at the coastline and near shore islands, which created some size variation across the planning region (Fig 5.1). Each planning unit contained information on the amount of each of the socioeconomic and conservation features considered in the design of the MPA network (see below). ArcGIS (ESRI, Redlands, California) was used to calculate the amount of each feature in each planning unit.

5.3.2 Biodiversity considerations

The Countryside Council for Wales (CCW), which is the statutory nature conservation agency that advises the Welsh Assembly Government in environmental matters, has recommended the inclusion of both representative habitats and special conservation features within the network of MPAs (CCW 2010).

A network of MPAs that encompasses representative proportions of all ecologically relevant habitats is considered to have the greatest chance of including all species, life stages and ecological linkages that exist in a particular area (Roberts et al. 2003). International (OSPAR[4]) and national (JNCC[5]) guidance suggests that level 3 of the EUNIS classification (European Nature Information System, a pan-European habitat classification system) is an appropriate level at which to represent habitats in an MPA network. Habitat distribution data attained through surveys were obtained from CCW. However, as the spatial coverage of the survey data was limited, modelled habitat information was incorporated from HABMAP (Robinson et al. 2007) and was also used in the planning exercise.

The inclusion of special conservation features such as species and habitats that are particularly threatened, declining or sensitive to damage by anthropogenic activities is a common approach in MPA design. Therefore, habitats suggested by CCW and listed under the Wales Section 42 (Biodiversity Action Plan) list were included in the network design. Section 42 habitats are those habitats considered to be of priority importance for conservation because they are either threatened or declining (DEFRA 2006). For a full list of the conservation features included in the exercise see table 5.1.

[4] Administrator of the Oslo and Paris Conventions for the protection of the marine environment of the North-East Atlantic
[5] UK's Government wildlife advisor

Table 5.1. List of conservation features included in the planning exercise

Representative habitats
Atlantic and Mediterranean high energy infralittoral rock
Coastal saltmarshes and saline reedbeds
Features of littoral rock
Features of littoral sediment
High energy circalittoral rock
High energy infralittoral rock
High energy littoral rock
Littoral biogenic reefs
Littoral coarse sediment
Littoral mixed sediments
Littoral mud
Littoral sand and muddy sand
Low energy infralittoral rock
Low energy littoral rock
Moderate energy circalittoral rock
Moderate energy infralittoral rock
Moderate energy littoral rock
Sublittoral biogenic reefs on sediment
Sublittoral coarse sediment
Sublittoral cohesive mud and sandy mud communities
Sublittoral macrophyte-dominated communities on sediments
Sublittoral mixed sediment
Sublittoral sand
Sublittoral sands and muddy sands
Biodiversity Action Plan habitats
Sabellaria alveolata reefs
Coastal saltmarsh
Intertidal mudflats*
Seagrass beds* (*Zostera* beds)
Sheltered muddy gravels
Fragile sponge & anthozoan communities on subtidal rocky habitats
Subtidal sands and gravels
Subtidal mixed muddy sediments
Mud habitats in deep water
Blue mussel beds* (Intertidal *Mytilus edulis* beds on mixed and sandy sediments)
Horse mussel beds*
Maerl beds*
Ostrea edulis beds**

* Indicates habitats that are on both the Section 42 list and the OSPAR list of Threatened and/or Declining Habitats (OSPAR, 2008) occurring in Welsh waters.
** *Ostrea edulis* beds are listed as a threatened species under the Section 42 species but have been added here to the habitats list as they are on the OSPAR list of Threatened and/or Declining Habitats.

At the time of writing, the Welsh Assembly Government had not yet decided on how much of each conservation feature should be included in the network of MPAs. For the purpose of this study and following international recommendations for protected areas (IUCN 2005), the protection of a minimum of 30% of each conservation feature was targeted in this planning exercise.

5.3.3 Socioeconomic considerations

Extractive uses

To minimize socioeconomic impacts on consumptive activities, data on the spatial distribution and economic importance of commercial and recreational fisheries were included in the planning exercise. Fine scale resolution data on the spatial distribution of gross revenues for the mobile and static fishing fleet and recreational fisheries in Wales was available from Richardson et al. (2006). Data were collected between 2003 and 2004 through face-to-face interviews with commercial and recreational charter boat skippers (recreational fishing is defined here as the fishing undertaken from charter boats), who delineated their fishing grounds on maps and provided information on their profitability.

Non-extractive uses

To analyse the influence of non-consumptive recreational data in driving network design, spatial data on the economic expenditure of some of the most popular recreational activities in Wales were included in the planning process. Data on the spatial distribution and economic expenditure of scuba-diving, sea-kayaking, wildlife watching boat trips and seabird watching were available (Chapter 3). Data were obtained through the administration of five hundred and fifty-eight questionnaires among the different user groups from which the spatial distribution and economic expenditure of the different activities were estimated (Chapter 3). The total economic expenditure for each of the activities was derived from expenditures such as food and drink, travel, accommodation, equipment hire or the cost of boat trip.

5.3.4 Design of marine protected areas

The planning exercise had two main objectives: (i) to analyse the benefits associated with the incorporation of multiple stakeholders' interests in the reserve design process by minimizing the economic impact or "cost" to both consumptive and non-consumptive users while ensuring the achievement of the conservation goals set for the exercise and (ii) to evaluate the potential socioeconomic advantages associated with the design of multi-zoned protected areas as opposed to single protection areas.

An extension of Marxan software, Marxan with Zones, was used to design cost-effective networks of MPAs incorporating conservation and socioeconomic principles (Watts et al. 2009). The software was used to design two types of protected areas, one with multiple zones and the other with an open/closed access configuration. Marxan uses a simulated annealing algorithm to minimize a linear combination of planning unit costs and MPA boundary length while ensuring that conservation targets are met (Watts et al. 2009). The level of fragmentation of the network can be controlled by indicating the relative importance of minimizing the boundary of the protected areas relative to the planning cost by adjusting a parameter called the “zone boundary cost”. The most suitable boundary cost was identified by using the method developed by Stewart and Possingham (2005). In order to minimize socioeconomic impacts, costs were defined as the gross revenues for each of the fishery sectors and the economic importance associated to the different recreational activities. As described in Matts et al (2009) the cost of placing a planning unit (i = 1,…,M) in a zone (j = 1,…,N) is given by c_{ij}, which is the sum of the value for all the uses (k = 1,…,P) that are not permitted in that particular zone:

$$c_{ij} = \sum_{k=1}^{P} a_{ik} b_{kj}$$

where a_{ik} is the value of the i^{th} planning unit to the k^{th} use, and b_{kj} represents if the k^{th} use is not allowed in the j^{th} zone. If the k^{th} use is not allowed in the j^{th} zone, $b_{kj} = 1$, otherwise b_{kj} equals 0. Marxan with Zones minimizes the following cost objective function:

$$C = \sum_{i=1}^{M} \sum_{j=1}^{N} c_{ij} x_{ij}$$

where $x_{ij} = 1$ if the i^{th} planning unit is included in the j^{th} zone, subject to the limitation that a planning unit and a set of zone specific targets can only be placed in one zone:

$$\sum_{j=1}^{N} x_{ij} = 1$$

Three different planning scenarios were run using Marxan's simulated annealing algorithm with iterative improvement. Each scenario was run 100 times using 1,000,000 iterations per run. This generated 100 possible solutions for each scenario thus producing many spatial configurations for each scenario that satisfied both conservation and socioeconomic goals. Due to the impracticality of displaying each of the solutions generated by Marxan, maps showing the selection frequency of each planning unit were presented here. These maps represent how often a particular planning unit contributed to the efficient design of the network.

5.3.5 Planning scenarios

Three different planning configurations were compared in this exercise. The first two scenarios were used to establish the potential benefits of using non-consumptive recreational data in the establishment of protected areas. Both scenarios consisted of a network of MPAs with two management zones: a zone completely closed to any type of anthropogenic activity and an open area where all uses were allowed. In the first scenario (A), 30% of conservation features were targeted in the closed area while trying to safeguard 90% of the gross revenues for each fisheries sector. In the second scenario (B), 30% of conservation features were targeted while seeking to safeguard 90% of the economic value of both consumptive and non-consumptive uses. The third scenario (C) was designed to have three different management zones: (i) areas closed to all activities, (ii) areas where only non-extractive recreational activities were allowed and (iii) open areas. In this scenario, 30% of conservation features were targeted from which at least 10% had to be located within the closed area and the rest within the partial protection area, socioeconomic considerations were the same as for scenario B (table 5.2).

To compare network solutions, Cohen's Kappa coefficient was used for the best solutions of each scenario (Fielding and Bell 1997). Kappa coefficient provides a measure of spatial agreement of the networks after removing overlap due to chance, kappa values range from +1, indicating complete agreement, to -1 indicating complete disagreement (K= 0 indicates overlap due to chance, poor K < 0.4, good 0.4 < K < 0.75, excellent K > 0.75 (Landis and Koch 1977)).

Table 5.2. Details for the different Marxan scenarios (A, B, C), the percentage target of conservation features and consumptive and non-consumptive interests within each zone (open zone, partial closure, closed zone) are indicated (na = not applicable)

Scenario	Features	% target for each zone		
		Open	Partial	Closed
A	Conservation	--	na	≥30
	Consumptive	≥90	na	--
	Non-consumptive	--	na	--
B	Conservation	--	na	≥30
	Consumptive	≥90	na	--
	Non-consumptive	≥90	na	--
C	Conservation	--	≥20	≥10
	Consumptive	≥90	--	--
	Non-consumptive	≥90*		--

*the overall percentage target for non-consumptive interests in scenario C was distributed between the open and partial closure zones

5.4 Results

5.4.1 Consideration of non-consumptive interests

The selection of areas for protection was assessed either including (scenario B) or excluding (scenario A) the consideration of spatial data on the economic importance of non-consumptive recreational activities. Importantly, both planning scenarios met the targets set for all the conservation features within a 2% margin (table 5.3). The analysis of the best solutions generated including or excluding recreational data indicated that those protected areas designed with consideration of recreational data reduced the potential economic impact on the recreational industry by 31% when compared to the economic impact of protected areas designed excluding recreational data (Fig 5.2). The total area of the network of protected areas that included recreational activity data was 12% smaller than the network designed with no recreational consideration, the perimeter of the MPA network, however, was 16% bigger, indicating that scenario A produced a solution that was slightly more spatially compact than scenario B (table 5.4).

Protected areas designed with the inclusion or exclusion of the recreational industry were analysed in terms of the economic losses for the different sectors of the recreational industry. The comparison of the best solutions generated by scenarios A and B revealed that the design of a network of MPAs without consideration of the recreational industry could have important economic impacts on the diving, wildlife boat cruises and seabird watching sectors in Wales, as they could be excluded from areas from which c. 45% of their economic expenditure is derived. The MPA network solution generated under the consideration of recreational data was very close to meeting the 90% target set for the different sectors of the recreational industry, resulting in economic losses from this scenario that ranged between 11% to 14% of the total economic importance of the activities (Fig 5.2). Socioeconomic impacts on sea-kayaking were similar in both scenarios.

Table 5.4. Area (km^2), perimeter (km) of the MPA network and economic losses for the best solutions for scenarios A (no recreational data, 2 zones), B (inclusion of recreational data, 2 zones) and C (recreational data, 3 zones)

Scenarios	**A**	**B**	**C**	
			Closed area	Recreational area
Area (km^2)	4,780	4,185	1,441	2,799
Perimeter (km)	1,724	2,050	1,095	1,691
No planning units	281	250	100	159

The inclusion of non-consumptive activities in the planning process did not affect the interests of the commercial and recreational fishing sector, as both scenarios were able to retain 90% of the overall gross profits generated by the fishing industry. Additionally, the impacts on the different fishing sectors were equitable as the economic effects on the mobile, static and recreational fishing industry were similar (Fig 5.2).

Priority areas selected in scenarios A and B are illustrated using the summed solution of all the solutions generated by the 100 runs (Fig 5.3a, 5.3b). The summed solution represents the percentage of times each planning unit was selected for inclusion in the protected area. Maps indicate that the solutions generated including recreational considerations tended to avoid the selection of planning units located close to the coastline in comparison to scenario A, as most recreational activities in the area take place within the first 6 nm off the coast. Figure 5.3c shows the differences in the selection frequencies of scenarios A and B relative to each other, indicating that protected areas designed under the considerations of scenario A tended to include those planning units located around the areas of Mid and West Wales, while in scenario B these areas tended to be avoided due to their high recreational importance. Despite these differences, the spatial agreement between networks was good as indicated by the high value of the kappa coefficient (K = 0.52, $p < 0.001$).

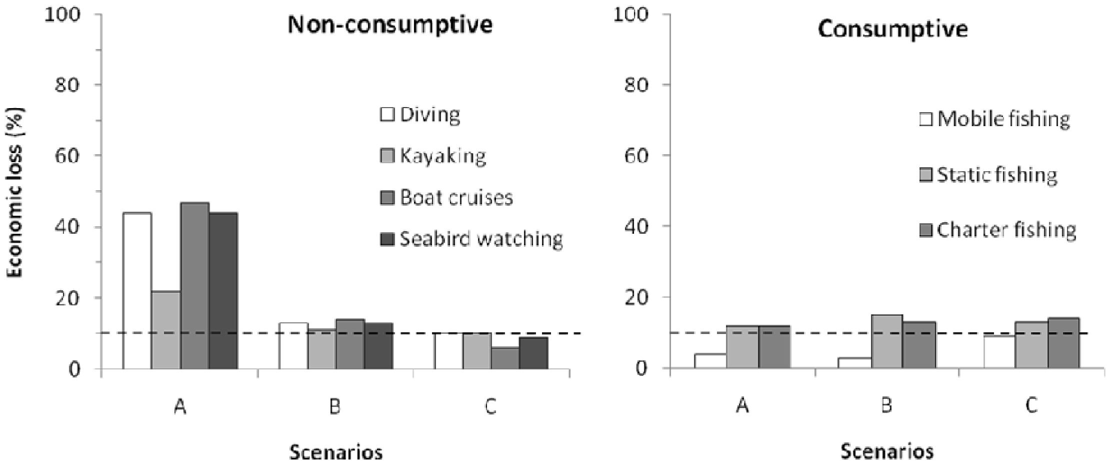


Figure 5.2. Percentage of potential economic losses associated with non-consumptive and consumptive activities for the best solutions generated by scenarios A (no recreational data, 2 zones), B (inclusion of recreational data, 2 zones) and C (recreational data, 3 zones). Dashed line indicates the 10% target for economic losses

5.4.2 Impacts of Zonation

The selection of areas for protection with the consideration of both consumptive and non-consumptive interests was assessed with (scenario C) and without zonation (scenario B). The addition of a third management area contributed to further reduce the economic losses to the recreational industry (reduction of 16% relative to scenario B). No substantial changes were detected on the economic impacts to the fishing industry (Fig 5.2).

Conservation targets of 10% in the closed area and 20% in the partial protection area were met for almost all of the conservation features. The 10% target could not be achieved in the closed area for four of the conservation features, however over 30% of the spatial coverage of those features was included in the partial protection zone (table 5.3).

The comparison of the spatial coverage of the closed zones (no activities allowed) for both scenarios indicated that the design adopted in scenario C reduced the total area of the closed zone by 66% in comparison to scenario B, while the no-fisheries zone was only increased by 1%. The location of the closed areas appeared to be more spatially dispersed than in scenario B (Fig 5.3d).

Table 5.3. Percentage of conservation and socioeconomic features for the best MPA solutions for scenarios A, B and C

	Scenario A		**Scenario B**		**Scenario C**		
Features (%)	Full protection	Open access	Full protection	Open access	Full protection	Medium protection	Open access
Surveyed habitats							
Atlantic and Mediterranean high energy infralittoral rock	50	--	50	--	50	50	--
Coastal saltmarshes and saline reedbeds	56	--	38	--	38	25	--
Features of littoral rock	100	--	100	--	0	100	--
Features of littoral sediment	100	--	100	--	0	100	--
High energy circalittoral rock	30	--	32	--	12	21	--
High energy infralittoral rock	28	--	30	--	17	21	--
High energy littoral rock	43	--	43	--	14	29	--
Littoral biogenic reefs	44	--	33	--	11	22	--
Littoral coarse sediment	67	--	33	--	33	33	--
Littoral mixed sediments	100	--	100	--	100	0	--
Littoral mud	67	--	33	--	25	50	--
Littoral sand and muddy sand	29	--	30	--	10	24	--
Low energy littoral rock	50	--	50	--	25	25	--
Moderate energy circalittoral rock	27	--	36	--	18	27	--
Moderate energy infralittoral rock	75	--	75	--	12	75	--
Moderate energy littoral rock	67	--	33	--	17	50	--
Sublittoral biogenic reefs on sediment	55	--	48	--	12	42	--
Sublittoral coarse sediment	28	--	30	--	10	20	--
Sublittoral cohesive mud and sandy mud communities	54	--	31	--	12	31	--
Sublittoral macrophyte-dominated on sediment	100	--	100	--	100	0	--
Sublittoral mixed sediment	28	--	38	--	9	20	--
Sublittoral sand	29	--	29	--	10	20	--
Sublittoral sands and muddy sands	30	--	33	--	14	14	--
Supralittoral rock (lichen or splash zone)	40	--	40	--	20	20	--
Predicted habitats							
High energy circalittoral rock	30	--	29	--	12	21	--
High energy infralittoral rock	29	--	30	--	12	18	--

	Scenario A		Scenario B		Scenario C		
Features (%)	Full protection	Open access	Full protection	Open access	Full protection	Medium protection	Open access
Low energy infralittoral rock	50	--	50	--	50	0	--
Moderate energy circalittoral rock	61	--	39	--	29	46	--
Moderate energy infralittoral rock	47	--	31	--	10	27	--
Sublittoral biogenic reefs on sediment	31	--	31	--	14	21	--
Sublittoral coarse sediment	40	--	31	--	14	20	--
Sublittoral cohesive mud and sandy mud communities	49	--	30	--	11	19	--
Sublittoral macrophyte-dominated communities on sediments	80	--	80	--	0	80	--
Sublittoral mixed sediment	30	--	30	--	10	19	--
Sublittoral sands and muddy sands	29	--	30	--	10	20	--
Biodiversity Action Plan habitats							
Blue mussel beds (*Mytilus edulis*)	30	--	30	--	14	20	--
Fragile sponge & anthozoan communities on subtidal rocky habitat	30	--	30	--	13	30	--
Horse mussel beds (*Modiolus modiolus*)	43	--	43	--	29	14	--
Intertidal mudflats	37	--	30	--	17	29	--
Maerl beds	100	--	50	--	50	50	--
Mud habitats in deep water	100	--	100	--	0	100	--
Ostrea edulis beds	100	--	50	--	50	50	--
Sabellaria alveolata reefs	80	--	30	--	20	30	--
Sheltered muddy gravels	73	--	33	--	20	53	--
Subtidal mixed muddy sediments	48	--	32	--	23	26	--
Subtidal sands and gravels	31	--	30	--	10	22	--
Zoostera beds	56	--	44	--	19	50	--
Socioeconomic data							
Gross revenues for mobile fisheries	--	96	--	97	--	--	91
Gross revenues for static fisheries	--	88	--	85	--	--	87
Gross revenues for charter fisheries	--	88	--	87	--	--	86
Economic expenditure scuba-diving	--	56	--	87	--	45	45
Economic expenditure sea-kayaking	--	78	--	89	--	27	63
Economic expenditure wildlife watching cruises	--	53	--	86	--	46	48
Economic expenditure seabird-watching	--	56	--	87	--	45	46

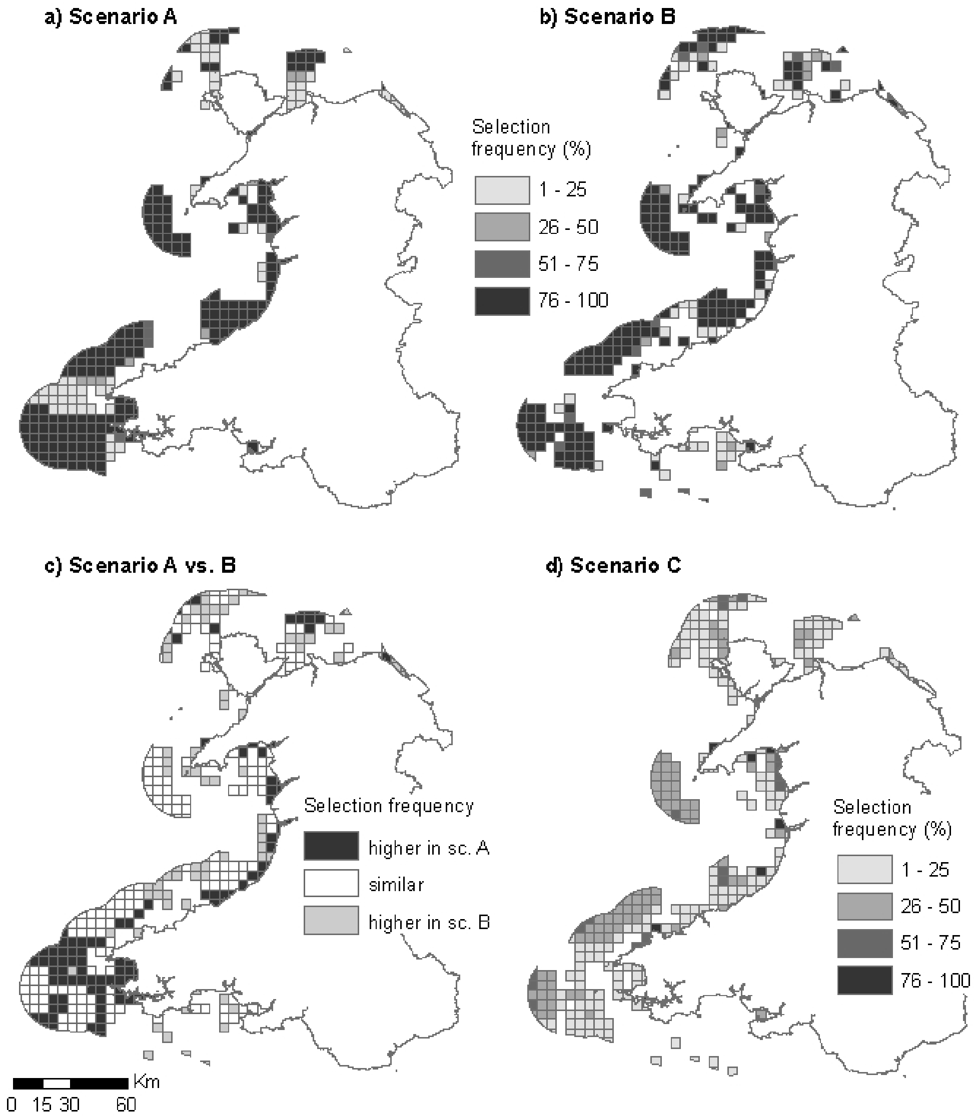


Figure 5.3. a) b) d) Selection frequency of each planning unit in scenarios A, B and C measured as the percentage of times each planning unit was selected to be part of the protected area in 100 solutions. c) Difference in the spatial distribution of selected frequencies for the protected area in scenarios A and B

5.5 Discussion

To date, mostly only consumptive interests have been considered in the establishment process of marine reserves. However, the lack of consideration of a wider set of interests, such as non-consumptive recreational users, could result in important socioeconomic consequences for this sector. The incorporation of recreational uses in the planning process is generally rare, partly because data on the spatial distribution of recreational uses is seldom available and partly because it is often assumed that the fishing industry is economically more important than recreational sectors. Data collected for Wales showed that while the gross revenues for the fishing industry were estimated at approximately £23 million (approximately £3M profits) in 2006 (Richardson et al. 2006), the total economic expenditure on non-consumptive recreational activities dependant on marine biodiversity was estimated at approximately £25M in 2008 (Chapter 3). In the present case study, networks of marine protected areas that did not consider non-consumptive interests caused the loss of important areas of economic activity for the recreational industry, areas where almost 50% of their expenditure occurred. Conversely, the incorporation of both consumptive and non-consumptive interests in the reserve design process had positive outcomes for the two sectors under consideration, as both sectors were able to retain access to areas that generated almost 90% of their economic value. Nevertheless, it should be mentioned that the establishment of MPAs could also have associated socioeconomic benefits for both sectors, such as benefits associated to increases in fish stocks or in wildlife numbers, however at present there are no models that can predict such associated socioeconomic effects.

This study uses spatially explicit information on a range of non-consumptive activities at resolutions comparable to the consumptive and biophysical data. The use of biological and socioeconomic data that is consistent in extent and resolution across the planning region is essential to avoid data-driven bias in site selection (Grand et al. 2007). The availability of such fine scale data on the distribution of non-consumptive uses of the marine environment is rare, such that to date most studies have used proxies for the inclusion of non-consumptive interests in the design of protected areas. The majority of studies have used the proximity to key localities (such as residential areas, ports, ship wrecks, terrestrial parks or marine laboratories) as proxies for the socioeconomic importance of these areas, as these sites are likely to have greater social or economic value (Banks et al. 2005, Crossman et al. 2007, Klein et al. 2008a) . However, although such approaches might contribute to the avoidance of some particularly important social areas, they do not contain information on the explicit spatial distribution of non-consumptive uses and nor do they account for the differences in use intensity across the planning region. In the case of consumptive activities, it has been shown that the use of socioeconomic surrogates does not provide an accurate representation of resource use at fine spatial scales (Weeks et al. 2010). Thus it is also likely that the use of a surrogate approach for non-consumptive uses will overlook relevant socioeconomic areas.

Previously, due to the unavailability of more flexible systematic conservation planning tools, studies on the cost-efficient design of marine protected areas focused on the design of marine reserves with a single no-take protected area and an open zone (Alpine and Hobday 2007, Grantham et al. 2008, Ban et al. 2009). However, most marine conservation areas involve some sort of zonation with different levels of protection, ranging from areas where only non-consumptive activities are allowed, to areas where only certain forms of extractive activities are permitted, to strictly no-take zones. Findings from this study indicate that the use of a multizone optimization numerical tool outperforms tools that can only identify one zone by reducing and generating more equitable impacts for both consumptive and non-consumptive interests. These results are in accordance with those of Klein (2010) who used a multizone tool to generate networks of MPAs that simultaneously considered the impacts on several fisheries; however, Klein's study did not have the scope to incorporate the needs of a wider set of interests in the marine environment and thus the balance between different interest sectors could not be assessed. Additionally, outcomes from the present study indicate that the incorporation of consumptive and non-consumptive interests in the planning process of a multi-zoned network of protected areas with different levels of protection allows for a considerable reduction in the size of the no-take zone without compromising conservation objectives. Furthermore, this reduction in size had associated benefits for the non-consumptive recreational sector as their use-area increased while their economic losses decreased in comparison to a protected area with a single zone. The addition of an extra zone did not have negative implications for the fishing industry as the economic impacts and the extent of the no-fishing area remained the same as with the open vs. closed area scenario.

The estimation of the socioeconomic impacts on the consumptive and non-consumptive sectors presented here assumes that the designed network of MPAs eliminates opportunities for fisheries and / or recreation in the areas closed to those activities and that users are unable to mitigate the impacts in other ways, such as re-distributing the lost fishing effort or recreational activities. The scenarios presented here thus overestimate the impact to the fisheries and recreational industries. The incorporation of models that predict the impact of protected areas on the different interest sectors by considering the redistribution of the consumptive and non-consumptive activities, such as the model developed by Hutton et al. (2004) on the choice of fishing location, would contribute important information to the design of protected areas.

The approach presented here is intended to support the decision making process of designing and establishing marine protected areas. Marine reserves designed using Marxan are not suggested to represent the final design of a network as this will need to be fine-tuned with the input of a full-range of ecological, political, socio-economic and practical considerations. Therefore, the use of planning tools is intended to complement, but not replace, a process in which stakeholders groups need to have substantial inputs (Klein et al. 2008b).

Chapter 6

Assessment and integration of a stakeholder driven and a science-based approach in the prioritization of marine protected areas

6.1 Abstract

The present study aimed to assess, compare and integrate two different approaches to the planning process of marine protected areas (MPAs) in Wales (UK). A stakeholder-based approach and a science-based systematic approach were compared. Stakeholder priorities for the establishment of MPAs were identified during individual interviews with relevant stakeholders' representatives. Science-based solutions were developed using biological and socioeconomic spatial data in the decision support tool Marxan. The comparison of approaches revealed that although the spatial configuration of the resulting MPAs differed, stakeholders performed well at including representative proportions of relevant marine habitats and species. The extent of stakeholders' knowledge of their surrounding marine environment was identified as a key factor in the quality of their decisions. The integration of the stakeholder driven approach with the science-based solution revealed that an integrated approach could be used as a tool to achieve conservation targets while simultaneously accounting for stakeholder's preferences, as the resulting integrated solution met all conservation targets and was only slightly bigger than the science-based solution alone. Results also revealed the potential utility of using stakeholders' knowledge as a proxy for identifying ecologically important areas when spatial data on conservation features is sparse.

6.2 Introduction

Marine protected areas (MPAs) have been recognised among the most important tools to achieve global marine conservation targets (Agardy 1994). Their planning and implementation is, however, challenging for several reasons. While the positive benefits derived from the implementation of MPAs for habitat restoration and biodiversity conservation have been clearly established within the boundaries of MPAs (Halpern and Warner 2002, Blyth-Skyrme et al. 2006, Stewart et al. 2009), the role of MPAs in the recovery of fish stocks remains an issue of debate (Kaiser 2005, Stefansson and Rosenberg 2006). Additionally, the establishment of MPAs is often controversial as the closure of portions of the sea to human activities can have associated negative impacts on those sectors of society affected by the closures (Stump and Kriwoken 2006). However, if designed carefully MPAs can achieve a balance between ecological conservation and socioeconomic needs (Klein et al. 2008a) by using biological principles as primary design criterion (Roberts et al. 2003) and including relevant socioeconomic aspects to ensure community support and compliance (Walmsley and White 2003, Moore et al. 2004).

Different approaches exist for the site selection process of MPAs, with stakeholder-based site selection at one end of the spectrum (e.g. Rodriguez-Martinez (2008)) and science-based systematic selection at the other (e.g. Leslie et al. (2003)). Although in most cases a combination of both approaches is adopted, in general the designation process of MPAs tends to be dominated by one aspect or the other. Processes based on stakeholder decisions have often been criticised for being *ad hoc* or driven by political interests and are frequently questioned in terms of their conservation effectiveness (Pressey 1994, Stewart et al. 2003). On the other hand, MPA designations solely based on ecological criteria, although effective from a conservation perspective often fail to achieve the support of the people affected by the establishment of the protected area (Walmsley and White 2003).

Conservationists, resource managers and social scientists frequently disagree on whether it is possible to achieve a balance between social and ecological benefits in environmental management (Grumbine 1994), as some argue that in a multiple objective process it is impossible to maximize more than one variable at a time (Stanley 1995). Recent studies, however, indicate that it is possible to balance social and ecological factors in natural resource management (Keough and Blahna 2006, Klein et al. 2008a). In the marine environment, the use of optimization site selection algorithms in systematic conservation planning as decision support tools for the designation of MPAs has facilitated the integration of spatially explicit biological and socioeconomic information (Richardson et al. 2006). The types of socioeconomic data used in the designation process of MPAs typically include those data that are relatively easily available, such as fisheries revenues, fishing effort or the spatial distribution of other marine activities that could be affected by the establishment of an MPA (Alpine and Hobday 2007, Ban and Klein 2009, Klein et al. 2010, Weeks et al. 2010). These types of data are crucial for the identification of areas that are valuable from a socioeconomic perspective, thus allowing the inclusion of some stakeholder’s needs in the process (Klein et al. 2008a, Klein et al. 2008b). However, while this information is paramount for the consideration of the interests of certain stakeholder groups, i.e. commercial fishers, it cannot account for all stakeholders’ preferences regarding the location of MPAs, as these might not be adequately reflected in the information available for use in the optimisation algorithms.

The present study attempts to compare the outcomes of a science-based approach using biological and socioeconomic variables and a stakeholder-based approach regarding the spatial planning of MPAs in Wales (UK), where the Welsh Assembly Government has committed to the establishment of an ecologically coherent and well managed network on MPAs by 2012 taking into account ecological, social and economic criteria whenever possible (DEFRA November 2009). The aims of the study are to (i) assess the conservation performance of a stakeholder-based MPA, (ii) to compare the spatial distribution and extent of MPAs produced as result of a stakeholder-based and a scientific-based process and (iii) to attempt to integrate both approaches in order to achieve solutions that meet conservation objectives and consider stakeholder preferences simultaneously.

6.3 Materials and Methods

6.3.1 Planning region

The planning region was defined by Wales' Territorial Sea, that is, the marine area extending to 12 nautical miles (nm) offshore from the midline of the Dee Estuary in the northeast and the midline of the Severn Estuary in the south. The area laying to the east of Worm's Head was excluded from the planning exercise as not enough biological data were available for the region (Fig 6.1). A grid covering the entire study area was created, this process delineated 182 square cells or "planning units", each planning unit had an extent of 10x10 km. Due to the irregular shape of the study area, a number of planning units were truncated at the coastline and near shore islands, therefore creating some size variation across the planning region (Fig 6.1).

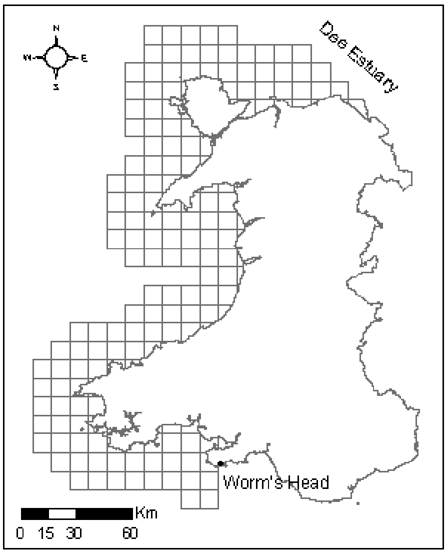


Figure 6.1. Overview map of the planning region showing the distribution of the 10x10 km planning units

6.3.2 Stakeholder-based approach

A mapping exercise was undertaken with various stakeholders' representatives with an interest in the Welsh marine environment (Chapter 4). In order to achieve a comprehensive representation of groups with different interests in the marine environment, members of the Wales Maritime and Coastal Partnership (WMCP) were approached in the study. The WMCP is formed of representatives of maritime and coastal interests in Wales encompassing 26 organizations drawn from the public, private and voluntary sector. The aim of the WMCP is to provide integrated and co-ordinated advice to the Welsh Assembly Government on a range of policy areas including the development of an Integrated Coastal Zone Management plan. For the purpose of the study only those organizations with direct involvement in the marine environment were approached (20 organizations). Of the remaining twenty organizations, four declined to participate in the study and no response was received from six other organizations after several attempts to contact them, thus a total of 14 organizations took part in the study. Whenever possible, two members from each organization were interviewed separately (total number of individuals interviewed = 22). Face-to-face interviews were carried out with representatives of the business and industry sector (4 participants), academic research (3), commercial fisheries (3), heritage (1), non-governmental organizations and voluntary sectors (2), environmental public bodies (5) and recreational sector (4 participants) (Chapter 4).

The mapping exercise focused on the establishment and location of marine protected areas along the coast of Wales. Participants were asked to indicate those areas of the Welsh coast which they would like to see protected in some way. Respondents were asked to arrange 1cm wooden cubes on a 1:500,000 A3 map of Wales, each cube covered an area of 100 km^2 on the map. The map had a superimposed 10x10 km grid, respondents were requested to fit the cubes on the planning units. Participants could identify a maximum of 30 planning units for protection (equivalent to 14% of the total available planning units). Subsequently, respondents were asked to indicate what type of protection they would like to see in place for each individual planning unit. Respondents could choose between three levels of protection: (1) closed access areas, where no anthropogenic activities were allowed, (2) areas where non-extractive recreational activities were allowed and (3) areas where restricted recreational and commercial fishing were permitted.

Digital pictures of the participant's maps were taken and results were digitised using a geographic information system software (ArcGIS, ESRI, Redlands, California). Through the analysis of data two sets of maps were produced: a map displaying the stakeholder planning unit selection frequency and a map displaying priority areas for conservation according to stakeholders. The latter was created by selecting those planning units with selection frequencies ≥ 25%.

6.3.3 Science-based approach

The optimisation site selection algorithm Marxan was used to identify priority areas for conservation (Watts et al. 2009). Marxan is a decision support tool that allows for the creation of protected areas that meet conservation goals while minimizing associated costs. Conservation targets can be species, habitats, biophysical factors or anything that the user wishes to set as conservation target. The associated cost can be any type of spatial measures, monetary or not. Frequently, area is used as cost but more specific measures such as fisheries revenues, fishing effort or the economic importance of other marine activities can also be used as costs. Marxan is run several times, with each run producing a potential spatial configuration that meets the set criteria. Marxan generates a summed solution that corresponds to the number of times each individual cell or "planning unit" is selected throughout the runs. This information provides an idea of how often a planning unit contributes to the efficient and systematic design of a protected area that satisfies conservation and costs criteria.

Marxan was used to identify conservation areas that would exclude all human activities. Four scenarios were run using four different costs. Following international recommendations (IUCN 2005) a conservation target of 30% for all biodiversity features was set. Fifty-one conservation features were considered in the planning exercise, these included representative habitats and special conservation features (Chapter 5). For the first cost scenario, area was used as cost, the assumption is that by minimizing the area, the impacts of conservation on people will be reduced (Beck and Odaya 2001). The second cost scenario used fine scale resolution data on the spatial distribution of gross revenues for the commercial and recreational fishing fleet in Wales (Richardson et al. 2006). The third scenario used data on the spatial distribution of recreational expenditure along the Welsh coast, data on the economic importance of recreational activities was derived from expenditures such as food and drink, travel or accommodation for some of the most popular activities around the Welsh coast (i.e. diving, kayaking, wildlife watching from boats and seabird watching) (Chapter 3). The fourth scenario used a combination of the previous two.

Each scenario was run 100 times using 1,000,000 iterations per run. This generated 100 possible solutions for each scenario that achieved the set targets.

6.3.4 Integrated approach

To produce an integrated solution, planning units identified through the stakeholder-based approach were “locked in” such that they were automatically included in each of the scenarios, each scenario was run to achieve the conservation targets set for the different science-based scenarios. Additional to the 30% conservation target, a scenario with a 10% target for all conservation features was also performed. This second target was incorporated as this was the recommended target established through the Convention of Biological Diversity (Convention on Biological Diversity 2006).

6.3.5 Analyses

The assessment of the performance and spatial similarity of the different approaches was carried out using four types of analyses. First, spatial overlap measures were used to calculate the proportion of convergently classified planning units divided by the total number of planning units (Fielding and Bell 1997), science-based scenarios were used as the basis for comparison. Second, Cohen’s kappa coefficient was used to examine the overlap of individual planning unit selection frequencies for the different scenarios. Cohen’s kappa coefficient is a chance corrected measure of spatial agreement, kappa values range from +1, indicating complete agreement, to -1 indicating complete disagreement ($K = 0$ indicates overlap due to chance, poor $K < 0.4$, good $0.4 < K < 0.75$, excellent $K > 0.75$ (Landis and Koch 1977)). Planning unit selection frequency was classified in five classes (0, <25%, 25%-50%, 50%-75% and >75%). Third, the selection frequency of planning units between scenarios was compared performing a hierarchical cluster analysis using Euclidean distances, results were presented using multi-dimensional scale plots (Clarke and Gorley 2006). Finally, the performance of the stakeholder-based scenario was carried out by assessing the percentage of conservation features included in the priority areas for conservation and by comparing the stakeholder-based configuration to the science-based scenarios in terms of their spatial extent.

6.4 Results

6.4.1 Systematic conservation-based maps vs. stakeholder-based maps

The comparison of the science-based approach map using area as cost and the stakeholder-based map indicated the existence of common areas selected for conservation through both solutions. Common planning units selected as priority areas in both solutions tended to be located close to the coast, as priority conservation areas selected by the stakeholders were generally located within the first 4 nm off the coast. Conversely, the science-based approach also identified priority areas for conservation lying outside the 4 nm line (Fig 6.2 A, C).

The assessment of the spatial overlap for both approaches revealed that approximately 50% of the planning units were convergently classified (protected vs. not protected) by the science-based best scenario and stakeholder-based method. However, Cohen's kappa coefficient based on planning unit selection frequency was low (0.12), indicating that the level of agreement in selection frequencies between both approaches was poor (table 6.1).

Table 6.1. Spatial overlap assessment of conservation prioritization approaches using Cohen's kappa coefficient

	Stakeholder-based	Science-based approach using cost as:			
		Area	Fisheries	Recreation	Fish + Rec
Stakeholders	--	0.115	-0.031	-0.110	-0.005
Area		--	0.086	-0.038	0.034
Fisheries			--	0.061	0.386
Recreation				--	0.322
Fish + Rec					--

The majority of respondents interviewed in the study were in favour of marine reserves that would permit certain level of human activity within their boundaries. During the mapping exercise, 67% of the cubes arranged on the map were allocated to "low" levels of protection (i.e. management that allowed recreational activities and certain types of commercial fishing within the reserve), 31% were allocated to a "medium" level of protection (i.e. only non-extractive recreational activities allowed) and only 2% of the cubes were allocated to zones completely closed to human activities.

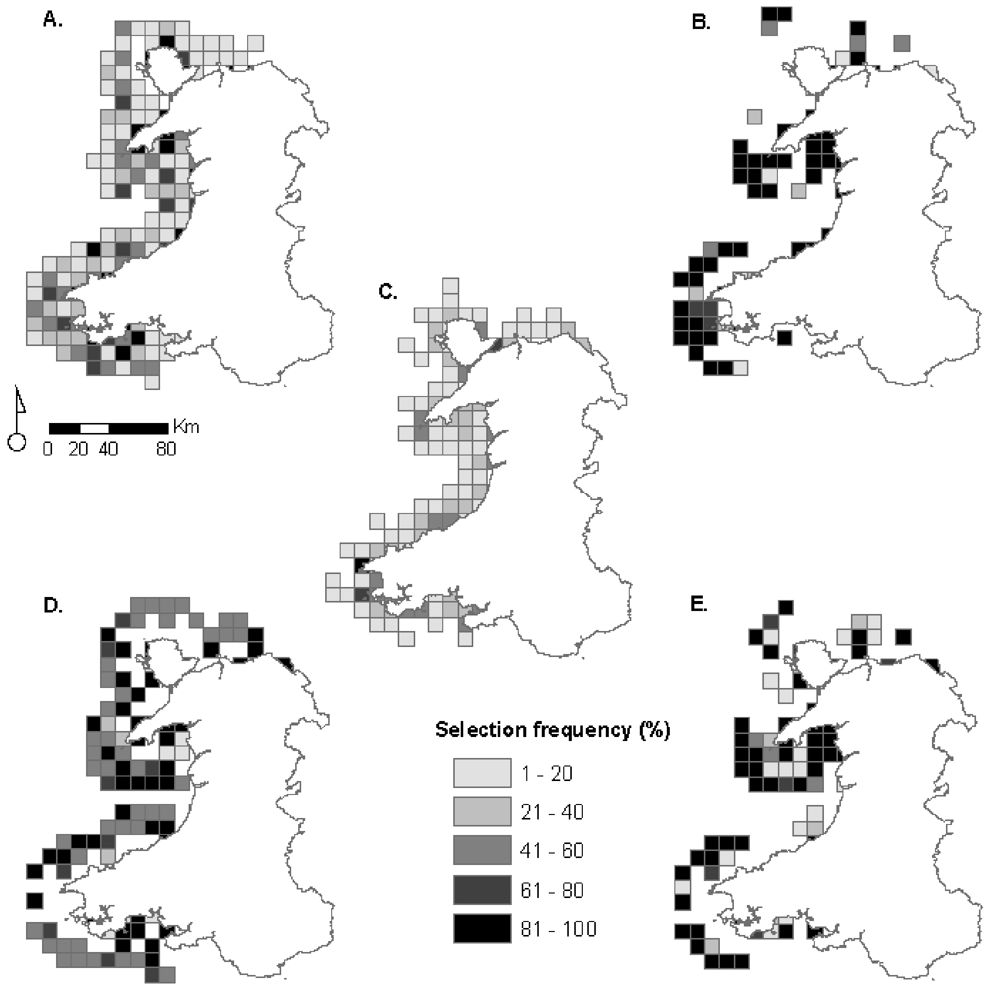


Figure 6.2. Selection frequency of planning units for the different approaches, A. Marxan using area as cost, B. Marxan using fisheries gross revenues as cost, C. Stakeholder-based approach, D. Marxan using recreation expenditure as cost, E. Marxan using fisheries gross revenues and recreation expenditure as combined cost.

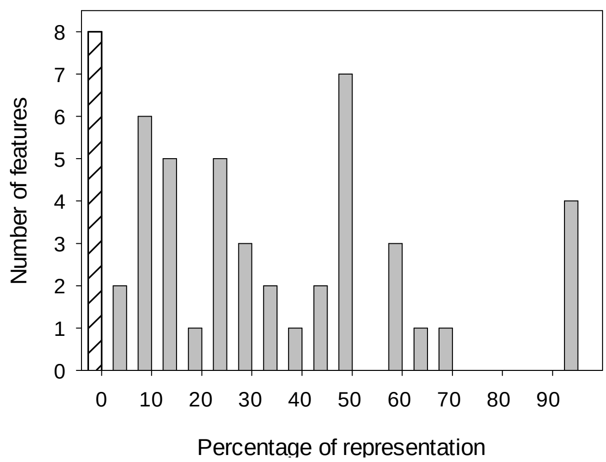


Figure 6.3. A: proportion of conservation features present in the stakeholder-based approach (e.g. seven features have between 45% to 50% of their spatial coverage included in the stakeholder reserve). Hatched bar represents the number of features that were not represented in the network of MPAs

The stakeholder-based reserve configuration included important conservation features, and 44 of the 51 conservation features were present in the priority area for conservation selected by the stakeholders. The average representation of the conservation features was 39% (± 4% SE). Under the consideration of the 10% conservation target scenario, 80% of conservation features achieved the target in the stakeholder-based reserve (Fig 6.3B). The number of conservation features that achieved the conservation goal under the 30% target scenario was reduced to 47%. In terms of spatial coverage, the stakeholder-based configuration covered 16% of the planning area, however, the reserve was still missing the inclusion of some of the conservation features. The integration of the stakeholder-based reserve with Marxan revealed that in order for the stakeholder configuration to protect 10% of all conservation features the area of the reserve would need to be increased by 2% and by 12% if it were to include 30% of all features (Fig 6.4). In terms of area, the extended 30% target stakeholder reserve was only slightly bigger than the science-based reserve, as the latter covered 23% of the study region, 5% less than the stakeholder reserve.

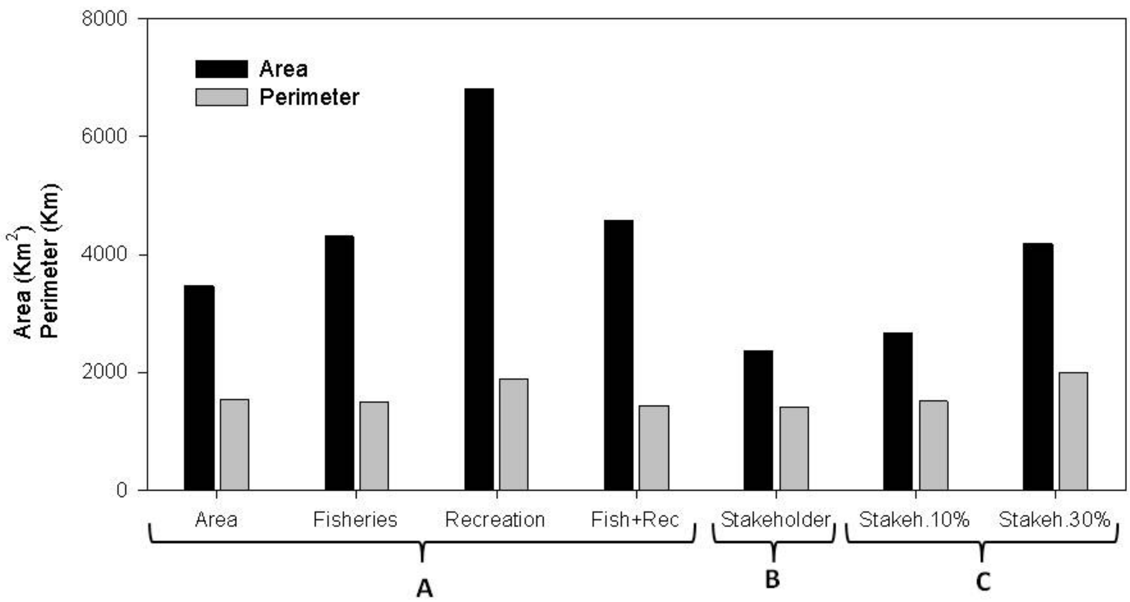


Figure 6.4. Area (km^2) and perimeter (km) of the reserves resulting from the different scenarios. A. Best solutions generated by Marxan using costs as: area, fisheries gross revenues, recreational expenditure and the combination of fisheries and recreation. B: Stakeholder-based approach. C: Integrated approach solutions for a 10% and 30% conservation target scenarios

The science-based approach, however, produced a more spatially compact reserve, as the perimeter of the stakeholder-based reserve was 29% greater than the perimeter of the science-based reserve (Figs 6.4 and 6.5).

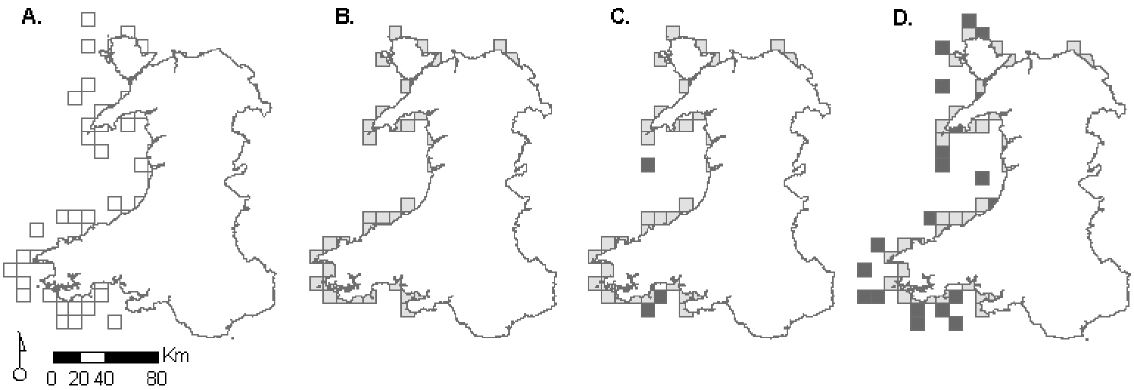


Figure 6.5. Marine reserve spatial configuration for different approaches, A. Best solution for Marxan using area as cost, B. Stakeholder-based configuration, C. Marxan and stakeholder-based integrated configuration for a 10% target of all conservation features (light grey cells indicate planning units chosen by stakeholders; dark grey cells indicated planning units selected by Marxan to achieve conservation targets) D. Marxan and stakeholder-based integrated configuration for a 30% target of all conservation features

6.4.2 Science- based maps taking socioeconomic costs into consideration vs. stakeholder-based maps

The comparison of stakeholder-based maps with the solutions obtained from the science-based scenarios taking socioeconomic costs into account indicated clear differences between the spatial configurations of the different solutions (Fig 6.2 C, D, E). Marxan solutions produced under socioeconomic considerations tended to avoid in-shore areas (< 4 nm) as these areas are economically important for both the fisheries and recreational sector. Stakeholder-based reserves on the contrary tended to be situated close to the coast, one of the reasons stakeholders might not have avoided in-shore areas was the assumption that the protected areas did not completely exclude human activities from within their boundaries, therefore not having such a negative socioeconomic impact. Another reason for stakeholders predominantly choosing areas close to the coast could lay in the fact that those were the areas about which they had most knowledge and / or valued the most. The comparison of the percentage of fisheries gross revenues and recreational expenditure occurring within the protected area for the different approaches revealed that under the assumption that protected areas were completely closed to human activities, Marxan solutions significantly minimized the economic impacts on fisheries and recreational interests (Fig 6.6). Conversely, the protected area designed under the stakeholder's approach encompassed a considerable proportion of areas where fisheries gross revenues and recreational expenditure occurred, however according to respondents 98% of areas selected for protection would have a "medium" or "low" level of protection, therefore revenues made within the protected areas would not be completely lost to the different interest sectors.

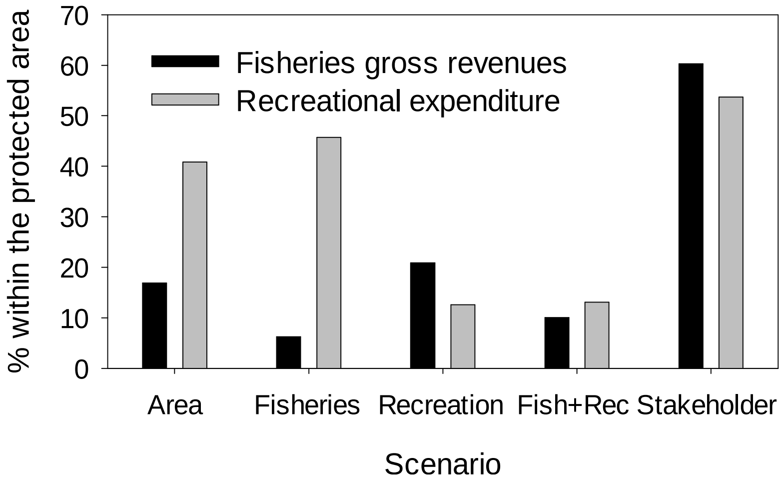


Figure 6.6. Percentages of fisheries gross revenues and recreational expenditure encompassed within the protected areas resulted from the different scenarios: Marxan defining cost as: area, fisheries gross revenues, recreational expenditure and a combination of fisheries and recreation; and the stakeholder configuration

The assessment of the spatial overlap between the best solutions for the different Marxan scenarios and the stakeholder-based approach revealed that approximately 44% of the planning units were convergently classified by the stakeholders vs. Marxan using fisheries gross revenues as minimizing cost, 36% between the stakeholder-based approach and Marxan using recreational expenditure as cost, and 39% between the stakeholder approach and Marxan using a combination of fisheries and recreation as minimizing cost. As with the science-based scenario using area as cost, Cohen's kappa statistic based on planning unit selection frequency was also low, however in this case values were negative which indicated a tendency towards disagreement, while in the former case the value was positive (table 6.1). The relative position of the different scenarios on the MDS plot based on Euclidean distances indicated that the spatial configuration of the stakeholder-based approach was more similar to the outcome generated by the science-based approach using area as cost, than to the science-based scenarios that used socio-economic factors as costs (Fig 6.7).

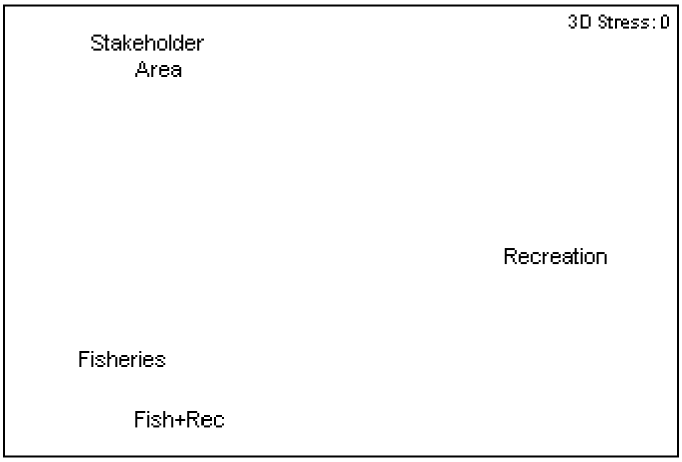


Figure 6.7. Two-dimensional ordination plot of planning unit selection frequency for the different approaches

6.5 Discussion

The comparison of the spatial configuration and conservation effectiveness of marine protected areas (MPAs) resulting from a stakeholder-based approach versus a systematic conservation approach revealed that although there were differences in the spatial configuration of both approaches the stakeholder solution performed well in conservation terms. Designated areas for protection by stakeholders included a significant proportion of the conservation features considered in the planning exercise, 80% of features achieved the 10% conservation target, while approximately 50% reached the 30% target.

Priority areas for conservation selected by stakeholders' representatives tended to be concentrated in areas lying close to the coastline while the science-based approach selected areas throughout the planning region. Similar patterns have been identified in other studies where community-based decisions prioritized areas for conservation located within the first few kilometres off the coast (Rodriguez-Martinez 2008, Ban et al. 2009). As indicated by the stakeholders' interviews carried out during the present study the bias towards prioritizing inshore areas for conservation can be attributed to a more extensive knowledge or familiarity of the stakeholders with areas situated closer to the coast, which are more easily accessible and more frequently used.

The spatial distribution of priority areas for conservation selected by stakeholders' displayed closer resemblance to the Marxan solutions that used area as associated uniform cost in comparison to those using socioeconomic variables. The explanation for this centres on the fact that participants selected areas based principally on their ecological importance and on their need for protection from human pressures and did not focus on the potential socioeconomic impacts. The reason participants concentrated on the ecological importance rather the associated socioeconomic impacts of implementation is that respondents generally opted for the establishment of protected areas that would regulate human activities rather than imposing a total ban on them, therefore not having such a high associated impact on activities. In contrast, Marxan solutions that used socioeconomic variables as cost were performed under the assumption that activities would not be allowed within the protected area and therefore solutions tended to avoid, whenever possible, those areas of the coast with an associated high socioeconomic value.

In systematic conservation planning most studies that take socioeconomic aspects into consideration do so in the form of spatial data on the distribution of various human activities (Alpine and Hobday 2007, Grantham et al. 2008, Ban et al. 2009). The solutions resulting from the incorporation of these types of data are more likely to obtain community support as they can potentially minimize the socioeconomic impacts derived from the establishment of an MPA. However the availability of such spatial data is generally limited to certain uses of the marine environment (e.g. mostly fisheries) and while its integration in planning processes is paramount, it cannot account for all stakeholders' preferences regarding the location of MPAs. Thus, in instances where no comprehensive spatial data is available, the approach used here offers the possibility to integrate the perceptions of a wider set of stakeholders in the planning processes of protected areas. Thus, as this approach can potentially encompass the interests of multiple stakeholders, it might contribute to avoid MPA design outcomes that are biased towards the interests of certain stakeholders groups.

Often, the quality of environmental decisions based on stakeholder processes has been questioned (Pressey 1994). However, a recent review on the effects of stakeholder participation on the quality of decisions indicated that there should be little concern that stakeholder processes result in low-quality outcomes. On the contrary, there is evidence that stakeholder participation can enhance the quality of environmental decisions by considering a more comprehensive set of inputs (Beierle 2002). As informative as the Beierle (2002) review was, it did not have the scope to address the quality of stakeholders' decisions in the case of MPAs, a topic that has been often criticised (Stewart et al. 2003). The present study indicates that in the case of Wales, stakeholders performed well at selecting areas for protection, since selected areas encompassed a significant proportion of the conservation features considered here. Further support regarding the conservation adequacy of stakeholders' solutions can be found in a similar study carried out in Canada which indicated that areas selected by indigenous communities for the establishment of MPAs were also of high ecological value (Ban et al. 2009). The present case study and the study carried out in Canada have an important factor in common, for both studies, participants had a solid understanding of their marine environment. In Canada, indigenous communities have extensive knowledge of the waters surrounding their territories and in Wales, there is extensive information on the ecological importance and extent of marine habitats and the respondents participating in the study had a considerable knowledge of the Welsh marine environment due to their involvement in marine related issues. Therefore, it appears that for community preferences to be meaningful, it is fundamental that the individuals involved in the process have a sound knowledge of their surrounding marine environment. Furthermore, the success of the stakeholders' approach at including a significant proportion of conservation features highlights the utility of including stakeholders' knowledge into resource management especially in the absence or scarcity of spatial data of biophysical variables.

The integration of the science-based and stakeholder-based approaches offers the possibility to reach balanced solutions that can provide a consensus between conservationists and stakeholders, as it allows for the consideration of stakeholders' interests while still meeting conservation needs. In the present case study, the integration of approaches allowed for the complementation of the stakeholder-based solution by incorporating off-shore areas to the design, which resulted in a reserve with a spatial extent only slightly greater than the science-based solution.

Systematic conservation planning in the marine environment using decision support tools such as optimization selection algorithms generally use the spatial distribution of socioeconomic variables to account for stakeholders' interests (Alpine and Hobday 2007, Grantham et al. 2008, Weeks et al. 2010), but see Ban et al. (2009). The present approach differs from previous ones in that it accounts for stakeholders' preferences regarding the location of protected areas, it allows for the assessment of the effectiveness of stakeholders' decisions and for the integration with a scientific-based approach that complements stakeholders' views. In terms of the implementation of MPAs, the integration of both approaches offers a useful tool for managers and decision-makers as stakeholders are more likely to support solutions generated by an integrated approach than solutions generated solely through a science based approach (Ban et al. 2009).

The results from this study provide evidence of the quality of stakeholders' decisions in the planning process of MPAs. The extent of the knowledge of stakeholders on their surrounding marine environment has been identified as a key factor in the quality of their decisions. The comparison of a stakeholder-driven approach with a science-based approach revealed that although the spatial configuration of the resulting MPAs differed, stakeholders performed well at including representative proportions of relevant habitats and species. Furthermore, findings from the study suggest that the integration of a stakeholder driven process with a science-based approach can be used to achieve conservation targets while simultaneously accounting for multiple stakeholder's preferences, therefore contributing to the avoidance of potential conflicts between conservation and stakeholders and among stakeholders groups.

Chapter 7

General discussion

Although it has been widely acknowledged that the participation and integration of stakeholders in the design of environmental conservation plans is fundamental to achieve successful outcomes (Leslie 2005, Lundquist and Granek 2005, Ritchie and Ellis 2010), the views, values and perceptions of stakeholders are not always considered in planning processes. Wales is currently beginning to develop plans to establish a network of marine protected areas (MPAs) as part of national and international conservation commitments (DEFRA November 2009). The Welsh Assembly Government has announced that besides biological aspects, it will consider social and economic benefits to ensure that MPA sites are chosen to maximise ecological, social and economic benefits while minimising any unnecessary conflicts with the different uses of the area. However, while in Wales comprehensive information is available for the distribution of biophysical and ecological factors and for the distribution and economic value of certain consumptive uses such as fisheries, there is very little information on other values and benefits associated to the marine environment. Wales has thus been used as a case study to investigate the value of a range of marine benefits and the results of these valuations have been subsequently integrated into marine spatial plans to achieve more socially inclusive and effective outcomes.

Economic support for MPAs in Wales

Community support is a crucial aspect in the success of MPAs as only with the support of and compliance by the community towards newly established conservation designations it will be possible to achieve conservation goals (Walmsley and White 2003). The research herein has provided useful insights for the future designation of MPAs in Wales. Findings from this thesis (Chapter 2) have established that there is a generalised support among the general public for the establishment of MPAs in Wales and moreover, that most people are willing to bear the additional economic costs associated with the conservation of the marine environment. Importantly, results indicated that societal preferences towards the management regime of protected areas were not homogeneous and that two groups with differing preferences could be established. These two groups were characterized by people who supported smaller reserves with more restrictive policies (32% of the sample) versus those supporting bigger more liberally managed areas (49%), similar findings have been reported by other studies (Wallmo and Edwards 2008). The recognition of heterogeneous preferences will be fundamental for the evaluation of alternative marine conservation plans in the area, as it provides important information for the assessment of the level of support for potential environmental policies. Several case studies, mainly in the US, provide evidence of the significance of stated preference studies (i.e. choice experiments and contingent valuation) in influencing the outcomes of environmental management policy plans (Boyle et al. 1987, Loomis 1995, Loomis and Feldman 1995) . As an illustration, in a National Estuary in the US a choice experiment (CE) survey was used to determine the relative preferences and economic values that people had for preserving and restoring key environmental resources, findings from the study were used to select adequate management plans for the estuary (Johnston et al. 2002).

The choice experiment (CE) design adopted in this thesis, however, was certainly not without limitation. Herein, willingness to pay (WTP) was estimated for the establishment of a network of MPAs with a single management zone, while most networks of MPAs that have been designed to date tend to adopt zoning plans in which different levels of protection are combined. At the onset of the CE study, consideration was given to the inclusion of a set of attributes that would reflect the establishment of a multi-zoned MPA, however the adoption of such design would have considerably increased the number of attributes in the experiment. This increase in attributes and associated number of levels would have resulted in a design too complex to enable respondents to make meaningful trade-offs between the alternatives and therefore the multi-zoned MPA scenario was rejected. However, one could suggest that the findings of the single zone CE study provide a lower bound estimate for the WTP for MPAs in Wales. The reasoning behind this argument is that it is unlikely that the outcome of a multi-zoned MPA CE would have resulted in lower WTP estimates for MPAs since it has been shown that stakeholders have stronger preferences for MPAs with different use zonations rather than for single zone MPAs (Mangi and Austen 2008).

Economic valuation of non-consumptive uses of the marine environment

Within a framework of MPA design, it has been widely recognised that in order to minimize socioeconomic impacts and to achieve conservation objectives effectively, the socioeconomic costs associated with the establishment of protected areas should be integrated in the planning process (Carwardine et al. 2008). However, it is often the case that when socioeconomic aspects are incorporated in planning processes these aspects tend to be dominated by certain interest-sectors. In the case of MPAs, commercial and consumptives uses of the marine environment such as fisheries tend to be given preference over non-consumptive uses such as recreation (Ban and Klein 2009). I suggest two main reasons for the bias towards the incorporation of commercial fisheries interests in planning processes. First, data on fisheries revenues or fishing effort are relatively easily available in comparison to data on the distribution and economic importance of non-consumptive uses. Second, in temperate waters, the opportunities for uses such as recreation are not considered to be particularly important sources of revenue (i.e. if it is compared to revenues generated by marine recreation in tropical areas), while in contrast commercial fisheries generate considerable economic revenues and it is apparent that livelihoods are dependent on this activity. Nevertheless, findings for this study (Chapter 3) indicate that the economic value of non-consumptive recreational activities in Wales is comparable to that of commercial and recreational fisheries in the area. Thus, indicating that the economic expenditure on recreational activities (consumptive and non-consumptive) in Wales is twice as much as the economic value of commercial landings (Richardson 2006). Furthermore, as the non-consumptive uses of the marine environment addressed in this study were largely dependent on the quality of the surrounding marine environment, the revelation of the economic importance of these uses could promote conservation initiatives to maintain high quality environmental status in order to preserve (or increase) the additional revenues that depend on the marine environment. Elsewhere, there is evidence that the assessment of the economic importance of consumptive and non-consumptive uses of a particular marine resource has influenced management decisions towards the adoption of conservation measures that would ensure the sustainability of that particular resource (Troëng and Drews 2004).

Integration of valuation data within marine spatial plans

The economic significance of recreational uses provided by the marine environment as highlighted by this thesis further confirms the importance of considering recreational interests in marine spatial plans. In Wales, failure to incorporate spatial data on recreational activities in the planning process of protected areas could have important socioeconomic consequences for this sector. MPAs designed without consideration of the recreational sector could result in the loss of important areas of economic activity for the recreational industry (Chapter 5). Conversely, the integration of both consumptive and non-consumptives needs in the design process of MPAs allowed to balance the interests of multiple stakeholders while still achieving conservation targets. Previous studies have attempted to integrate the needs of multiple stakeholders through the use of surrogate data as a proxy for the distribution of non-consumptive uses of the marine environment (Crossman et al. 2007, Klein et al. 2008a). Generally, these studies use the proximity to key localities as proxies for the socioeconomic importance of these areas. However, it has been shown that the use of socioeconomic surrogates does not provide an accurate representation of resource use at fine spatial scales (Weeks et al. 2010) and that therefore stakeholders' interests cannot be adequately represented through the use of such proxies. To the author's knowledge, the study presented here represents the first attempt to incorporate fine scale data of consumptive and non-consumptive uses of the marine environment in the design of MPAs (but see Agostini et al. 2010). Furthermore, this study has also quantified the potential economic impacts derived from the failure to incorporate such data.

The collection of spatial data for non-consumptive uses and its integration with existing data on fisheries in a multizone site selection tool (i.e. Marxan with zones) allowed to ascertain whether the socioeconomic impacts on consumptive and non-consumptive uses of the marine environment of an MPA with zonation (i.e. three management zones: no-take zone, zone where only non-consumptive uses are permitted, zone where consumptive and non-consumptive uses are permitted) were different to those of an open / closed MPA (Chapter 5). Findings indicate that the adoption of the multizone design allowed for a considerable reduction in the size of the no-take zone without compromising conservation objectives. This reduction in size had associated benefits for the non-consumptive recreational sector as their use-area increased while their economic losses decreased in comparison to a protected area with a single zone. The implementation of a multizone conservation area did not have negative implications for the fishing industry as the economic impacts and the extent of the no-fishing area remained the same as with an open vs. closed area scenario. No studies have previously integrated spatial data on consumptive and non-consumptive uses in a multizone site selection tool. The only evidence currently available comes from a study that integrated spatial data on different fisheries in the design of a multizone MPA to obtain more equitable economic impacts on the different fishing sectors considered (Klein et al. 2010). However, this study only accounted for consumptive uses while most MPAs in the world adopt some sort of zonation that involve the regulation of both consumptive and non-consumptive uses within the protected area, therefore the example presented here represents a closer representation of the potential impacts associated with a multizone conservation area.

Chapters 3 and 5 make an important contribution towards the wider consideration of multiple uses of the marine environment through the valuation and integration of non-consumptive uses into marine spatial plans. However, as not all the uses of the marine environment could be addressed here, the study fell short to incorporate the interests of the full spectrum of stakeholders. One of the difficulties is that these types of studies rely on the collection of fine scale data which it is often very labour intensive and time consuming to undertake. Therefore, in situations where resources are limited other means of data collection might be more appropriate. The methodology presented in Chapter 4 offers an alternative way of collecting spatial data from a wider set of stakeholders by mapping their perceived distribution of values / benefits derived from the marine environment. The analysis of the spatial distribution of values revealed that particular values followed a similar distribution along the coast and that some areas were perceived as multiple providers of values. The identification of the location of these areas may provide useful information to managers and decision-makers as these are areas where multiple interests overlap and which will require a higher level of stakeholder involvement in the design of spatial management plans. Furthermore, the spatial distribution of values can inform the creation of multiple-decision-criteria maps which could facilitate the identification of areas better suited for specific uses or management regulations. There is no evidence for the practical application of such methods in marine environmental plans, however, examples of the adoption of suitability maps can be found in management strategies for conservation areas on land. For instance, in Canada suitability maps were used in the planning process of a national forest to map landscape values in order to determine the consistency of potential forest strategies with community held landscape values (Reed and Brown 2003).

Similarly, herein the same methodology was used to assess stakeholders' preferences for the location of MPAs in Wales (Chapter 4). The integration of the data collected through this exercise with systematic conservation support tools (Chapter 6) allowed for a wider set of interests to be included in the planning process of a network of MPAs in comparison to the outcomes achieved in Chapter 5, where only commercial fisheries and non-consumptive recreational interests could be integrated in the process. This is not to say that the collection of fine scale data is of no importance and the author advises to collect and integrate detailed data whenever possible, however, in instances where not enough resources are available it might be more suitable to use a different strategy such as the "stakeholder mapping" approach presented here. Findings from this study (Chapter 6) are particularly interesting for managers and decision-makers as results show that in the case of Wales it is possible to integrate stakeholders' preferences for the location of MPAs without compromising conservation needs, thus potentially allowing for the avoidance of unnecessary conflicts. Further improvements to this approach could be attained by increasing the number of interests sectors and associated number of representatives participating in the study. Additionally, a method that would allow stakeholders to delineate priority areas for conservation more accurately could be adopted.

The successful implementation of marine spatial plans is a complex process where all affected stakeholders should be adequately incorporated (Leslie 2005, Ritchie and Ellis 2010). The work presented here has made use of different methodologies to perform a detailed assessment of some of the values associated with the marine environment and has demonstrated the potential application of these type of data into the efficient design of marine protected areas for the area of Wales. The integration of revealed and stated valuation methods, stakeholders mapping exercises and site selection tools for protected areas presented herein should further the development of comprehensive marine spatial plans for the area.

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Appendices

Appendix 1

Choice Experiment questionnaire

Appendix 2

Non-consumptive recreational uses questionnaires

Appendix 3

Additional data on non-consumptive recreational users

Demographic characteristics of divers

The majority of respondents were male (69.2%) and were aged between 35 to 54 (62%). The mean age of respondents was 42.8 ± 10.5 years. The median household income class was £30,000 to 49,999 (table 1). The majority of the respondents were residents of England, from which most of them lived in neighbouring regions (23.1% in the North West and 7% in West Midlands). Over a third of the respondents (36.5%) were residents of Wales.

Table 1. Frequency distributions of selected demographic characteristics for respondents to the scuba-diving survey

	n	%
Gender		
male	108	69.2
female	31	19.9
missing	17	10.9
Age		
16 to 24	6	3.8
25 to 34	26	16.7
35 to 44	42	26.9
45 to 54	45	28.8
55 to 64	19	12.2
missing	18	11.5
Country of residence		
England	81	51.9
Wales	57	36.5
missing	18	11.5
Household income (£ p.a.)		
< 10,000	5	3.2
10,000 to 19,999	8	5.1
20,000 to 29,999	19	12.2
30,000 to 49,999	57	36.5
> 50,000	44	28.2
missing	23	14.7

Diving activity of respondents

Approximately, half of the respondents (57.7%) had taken part in the sport for 10 years or less (table 2). Around 67% of the sample dived from the shore during the preceding year, 55% undertook dives from club boats, 47% from charter boats and only 18% dived from private boats (table 3).

Table 2. Number of years of respondents' diving experience

Years diving	No of respondents	% of respondents
0 to 4 years	49	31.4
5 to 9 years	41	26.3
10 to 19 years	47	30.1
20 to 30 years	9	5.8
over 30 years	10	6.4
missing	0	0

Table 3. Frequency of diving trips undertaken from the shore, club, charter and private boat in 2008 by survey respondents.

No of	Shore		Club boat		Charter boat		Private boat	
diving trips	n	%	n	%	n	%	n	%
None	50	32.5	69	44.8	81	52.6	125	81.7
1 to 4	52	33.8	29	18.8	45	29.2	14	9.2
5 to 9	23	14.9	26	16.9	14	9.1	6	3.9
10 to 19	18	11.7	18	11.7	7	4.5	2	1.3
20 to 29	6	3.9	9	5.8	5	3.2	4	2.6
30 to 50	3	1.9	2	1.3	2	1.3	1	0.7
50 +	2	1.3	1	0.6	0	0	1	0.7

Characteristics of respondents' diving trips

To analyse the characteristics of respondents' diving trips respondents were divided into 6 groups according to the distance travelled to the diving site (50 miles intervals). The majority of the respondents lived within a 150 miles of the diving site (62.2% of respondents) (table 4).

There was a general trend towards an increase in expenditure with increasing distance to the diving site. Divers living within a 50 miles range of the diving site represented 11.5% of the sample and they mostly carried out day trips, not spending any money on accommodation. Their expenditure was mainly diverted towards travel costs (24.5% of the total expenditure) and boat club use (21.5%).

The number of respondents staying overnight in Wales increased for those living at increasing distances to the diving location. Approximately, half of those living between 101 to 150 miles from the diving site (56.4%) stayed overnight; the percentage went up to a 100% for those divers living further than 250 miles from the diving location. The number of nights spent away from home increased significantly with increasing distances to the diving site (table 4).

Expenditure on the usage of club boat followed a decreasing trend with increasing distance to the diving location. The lowest overall expenditure for a diving trip per person per day was done by divers living closest to the diving location (£27.9 ± 18.1 SD) while the greatest expenditure corresponded to those living furthest from the diving location (£138.3 ± 54 SD).

Table 4. Characteristics of diving trips for respondents living at different distances to the diving location (mean ± SD).

Distance to diving location (miles)	1-50	51-100	101-150	151-200	201-250	251-300
N	18	24	55	10	12	10
Respondents staying overnight	1	8	31	6	10	10
Activity days	1.1 ± 0.2	1.5 ± 1.2	1.6 ± 0.6	1.7 ± 0.7	2.2 ± 0.9	2.0 ± 0.5
Food	5.1 ± 6.2	14.6 ± 20.6	17.7 ± 15.5	17.8 ± 11.1	18.8 ± 14.3	29.7 ± 20.7
Accommodation	0	7.1 ± 13.4	10.8 ± 12.3	12.9 ± 13.3	13.1 ± 10	27.3 ± 21.5
Travel	5.8 ± 3.1	18.7 ± 6.9	24.4 ± 9.1	32.7 ± 12.2	37.1 ± 17.5	42.9 ± 15.4
Club boat	7.9 ± 9.3	6.9 ± 8.2	5.0 ± 8.3	8.0 ± 7.6	3.3 ± 8.1	4.0 ± 12.6
Charter boat	5.6 ± 13.1	2.9 ± 10.3	13.7 ± 18.7	5.0 ± 15.8	18.8 ± 23.3	26.0 ± 26.8
Private boat	0.7 ± 2	3.5 ± 8.4	1.9 ± 7.9	4.0 ± 12.7	3.8 ± 11.5	0
Air	2.8 ± 3	3.3 ± 2.3	4.3 ± 3.2	3.4 ± 2.2	4.3 ± 4.8	8.4 ± 5.1
Gear rental	0	2.0 ± 7	2.6 ± 14.1	0	0	0
Total expenditure	27.9 ± 18.1	58.9 ± 33.6	80.3 ± 31	83.8 ± 23.7	99.1 ±30.1	138.3 ± 54

Factors affecting diver expenditure

In order to explore whether the frequency of diving affected expenditure, respondents were divided in three activity groups: low (1 to 5 dives in Wales), medium (6 to 17 dives) and high (18 dives and over). Daily trip expenditure increased significantly with decreasing activity level with a median expenditure of £79.7 for those with a low activity level to £46.9 for those in the high activity group. A factor closely related to the diving frequency in Wales was the distance to the Welsh coast from the respondents' residence. Respondents living closer to the Welsh coast dived more frequently in Welsh waters, 57.5% of those allocated to the high activity group lived within 100 miles of the Welsh coast, thereby having the possibility to reduce travel and subsistence expenditures.

Divers carrying out day trips spent significantly less than those staying overnight in Wales even before taking accommodation costs into account. Day trip divers spent less in travel related expenditures as they lived closer to the diving site and in subsistence costs, as food and drink could be generally brought from home. Overnight accommodation for divers staying away from home averaged £20.49 ± 12.76 per person per night ($n = 83$). Some divers tried to reduce accommodation costs by staying at camp sites. Non-Wales residents were more likely to stay overnight (64.2% non-residents vs. 36.8% residents) and have higher expenditure on travel, food and drink. The median daily spent for a non-Wales resident was £70.1 versus £43.4 for a diver living in Wales. Furthermore, another important factor when evaluating the economic importance of diving to Wales is that residents in Wales undertook a median of 75% of their diving in Wales while the median for non-Wales residents was 25% (Mann-Whitney $U = 1118$, $Z = -5.159$, $p < 0.001$). Differences were expected between respondents with different income levels, as those with higher incomes had more money to invest in the sport, however no significant differences were detected on the daily expenditure.

Table 5. Test results for factors considered likely to influence respondents' trip expenditure. Kruskall-Wallis test results are reported for the respondent's activity level, Mann-Whitney test results are reported for the rest of the factors considered likely to influence trip expenditure

	Trip expenditure (£*day^{-1})				
Factor	N	median	Mean Rank	χ^2 / Z	p
Activity level					
High	41	46.9	48.2		
Medium	48	61.5	63.5		
Low	41	79.7	85.2	20.02[1]	p < 0.001
Country					
England	76	70.1	80.2		U = 1162
Wales	57	43.4	49.4	- 4.56[2]	p < 0.001
Household income p.a.					
≤ £29,999	26	52.9	57.7		U = 1113
≥ £30,000	87	60.8	56.8	-0.12[2]	p = 0.902
Trip length					
Day trip	65	51.8	55.5		U = 1465
Staying away	68	71.9	77.9	-3.35[2]	p = 0.001

[1] Kruskall-Wallis test
[2] Mann-Whitney test

Kayakers

Demographic characteristics of respondents

The majority of respondents were male (61%) and were aged between 35 to 54 (53%). The mean age of respondents was 41.4 ± 10.9 (SD) years. The median household income class was £30,000 to 49,999. The majority of the respondents were residents of Wales (43%), while 36% were residents of England. The majority of English residents lived in the North West neighbouring region (15%). An important proportion of respondents from non-UK territory (18%) chose Wales as a kayaking destination (table 6).

Table 6. Frequency distributions of selected demographic characteristics for respondents to the sea-kayaking survey

	n	%
Gender		
male	67	60.9
female	29	26.4
missing	14	12.7
Age		
16 to 24	6	5.5
25 to 34	20	18.2
35 to 44	32	29.1
45 to 54	27	24.5
55 to 64	9	8.2
Over 65	1	0.9
missing	15	13.6
Country of residence		
England	40	36.4
Wales	47	42.7
Scotland	4	3.6
Non-UK residents	19	17.3
missing		
Household income (£ p.a.)		
< 10,000	6	5.5
10,000 to 19,999	7	6.4
20,000 to 29,999	14	12.7
30,000 to 49,999	28	25.5
< 50,000	31	28.2
missing	24	21.8

Kayaking activity of respondents

Approximately, half of the respondents (55.6%) had taken part in the sport for 10 years or less (table 7).

Table 7. Number of years of respondents' sea-kayaking experience

Years kayaking	No of respondents	% of respondents
0 to 4 years	37	34.3
5 to 9 years	23	21.3
10 to 19 years	20	18.5
20 to 30 years	16	14.8
over 30 years	12	11.1
missing	2	0

On average residents in Wales undertook 88.9% ± 16.6 (SD) of their kayaking in Wales, respondents who lived in the neighbouring regions of West Midlands and the North West of England carried out 62.5% ± 17.7 (SD) and 68.2% ± 25.7 (SD) of their kayaking trips respectively in Welsh waters. Residents of Scotland and the North East of England were the groups that visited the Welsh coast least frequently (table 8).

Table 8. Area of residence and frequency of kayaking activity in Wales of respondents who participated in the kayaking survey. Number of survey respondents from each region is indicated, average kayaking frequency = (N times kayaked in Wales / Total number of kayaking trips in 2008)*100

Region	N	% Kayaked in Wales	
		Mean	SD
East England	2	20	0
East Midlands	4	10.3	32
London	4	35.3	23.8
North East	1	2	0
North West	17	68.2	25.7
South East	6	36.7	12.1
West Midlands	2	62.5	17.7
Yorkshire & the Humber	2	17.5	10.6
Wales	46	88.9	16.6
Scotland	4	5	3.6

Characteristics of respondents' kayaking trips

To analyse the characteristics of respondents' kayaking trips respondents were divided into 7 groups according to the distance travelled to the kayaking site (50 miles intervals).

The majority of respondents (49.1%) lived within a 100 miles radius of the chosen kayaking site. Kayakers living within 50 miles range of their kayaking site represented 36.1% of the sample and they mostly carried out day trips, only 12.8% stayed in Wales overnight. Their expenditure was instead mainly diverted towards travel costs (35.7% of the total expenditure) and food and drink expenses (53.1%) (table 9).

The number of days spent kayaking followed an upward trend with increasing distance to the kayaking point going from an average of 1.7 ± 1.6 (SD) days for those living within 200 miles, to 3.5 ± 1.2 (SD) days for those living further than 200 miles. With the exception of a few cases (5 respondents), most kayakers who took part in the survey had their own kayaking equipment and therefore barely any money was spent on gear / equipment rental.

Table 9. Characteristics of kayaking trips for respondents living at different distances to the kayaking location (mean ± SD).

Distance (miles)	1-50	51-100	101-150	151-200	201-250	251-300	> 301
N	39	14	9	4	8	6	6
Overnight stay (N respondents)	0.2 ± 0.62	1.9 ± 2.4	1.8 ± 1.2	6.3 ± 4.4	3.9 ± 8.3	6 ± 4.4	3.5 ± 1.9
Activity days	1.1 ± 0.4	2.5 ± 2.3	1.4 ± 0.7	4.8 ± 3.1	3.5 ± 1.2	3.7 ± 1.4	3.2 ± 1.2
Food	7.6 ± 7.9	11.6 ± 6.9	8.3 ± 5.2	10.3 ± 10.6	12.8 ± 8	21.1 ± 21.8	15.7 ± 8.1
Accommodation	0.6 ± 2.5	7.5 ± 10.6	8.1 ± 11.5	9 ± 5.2	11.6 ± 8.3	20.3 ± 13.6	18.7 ± 15.7
Travel	5.1 ± 3.7	14.7 ± 7.7	29.4 ± 11.1	14.6 ± 7.4	20.7 ± 7.2	25.7 ± 13.1	34.4 ± 11.2
Gear rental	0.9 ± 4.3	0 ± 0	0 ± 0	0 ± 0	0 ± 0	3.2 ± 7.8	0 ± 0
Total cost	14.3 ± 10.2	33.8 ± 11.3	45.8 ± 13.4	33.9 ± 11.3	45.1 ± 14.6	70.3 ± 34	68.4 ± 19
Cost without accommodation	13.6 ± 9.51	26.3 ± 10	37.7 ± 9	24.9 ± 12.9	33.5 ± 12.6	50 ± 26.5	49.8 ± 7.2

The overall expenditure per day increased with increasing distances to the kayaking point. The lowest expenditure corresponded to those kayakers living closest to the activity point (£13.6 ± 9.5 SD) while the highest corresponded to those living furthest (£49.8 ± 7.2 SD).

Factors affecting kayaker expenditure

In order to explore whether kayaking frequency affected expenditure, respondents were divided in three activity groups: low (1 to 10 trips in Wales), medium (11 to 25 trips) and high (26 trips and over).

Daily trip expenditure increased significantly with decreasing activity level. Respondents with a high and medium frequency of activity showed similar medians (£16.7 and £11.2, respectively), while kayakers with lower levels of activity spent more (median of £37.9) (table 10).

Table 10. Test results for factors considered likely to influence respondents' trip expenditure. Kruskall-Wallis test results are reported for the respondent's activity level, Mann-Whitney test results are reported for the rest of the factors considered likely to influence trip expenditure

	Trip expenditure (£*day^{-1})				
Factor	N	median	Mean Rank	χ^2 / Z	p
Activity level					
High	25	16.7	30.5		
Medium	26	11.2	31.7		
Low	36	37.9	62.2	31.9[1]	P<0.001
Country					
Wales	47	14.2	28.8		U = 227
Other	40	36.8	61.8	-6.1[2]	P<0.001
Household income p.a.					
≤ £29,999	25	18.2	35.8		U = 570
≥ £30,000	53	27.9	41.3	-0.99[2]	p = 0.322
Trip length					
Day trip	42	15.2	31.4		U = 414
Staying away	45	33	55.8	-4.51[2]	p < 0.001

[1] Kruskall-Wallis test
[2] Mann-Whitney test

A factor closely related to kayaking frequency in Wales was the distance to the Welsh coast from the respondents' residence. Respondents living closer to the Welsh coast kayaked more frequently in Welsh waters, 76% of those allocated to the high activity group lived within 50 miles of the Welsh coast and a 100% within 100 miles, thereby having the possibility to reduce travel and subsistence expenditures.

Kayakers carrying out day trips spent significantly less than those staying overnight in Wales even before taking accommodation costs into account ($U = 414$, $p < 0.001$). Day trip kayakers spent less in travel related expenditures as they lived closer to the kayaking site and in subsistence costs, as food and drink could be generally brought from home. Overnight accommodation for kayakers staying away from home averaged £13 ± 10.9 per person per night ($n = 58$).

Non-Wales residents were more likely to stay overnight (83.1% non-residents vs. 16.9% residents) and have higher expenditure on travel, food and drink. The median daily spent for a non-Wales resident was £36.8 versus £14.2 for a kayaker living in Wales. Furthermore, another important factor when evaluating the economic importance of kayaking to Wales is that residents in Wales undertook a median of 95% of their kayaking in Wales while the median for non-Wales residents was 40% (Mann-Whitney $U = 358$, $Z = -6.582$, $p < 0.001$).

Wildlife watching cruises

Demographic characteristics of respondents

There were a similar number of male and female respondents (46% vs. 54% respectively), the majority of respondents were aged between 35 to 54 (55%). The mean age of respondents was 47.3 ± 12.6 SD. The median household income class was £30,000to £49,999 (table 11). The majority of respondents were visitors from England (77%), only 16% of respondents were residents of Wales.

Table 11. Frequency distributions of selected demographic characteristics for respondents to the wildlife watching cruise survey (sample includes respondents from Beaumaris in north Wales, Aberdyfi in Mid Wales and St Davids in West Wales).

	n	%
Gender		
male	88	45.8
female	104	54.2
missing		
Age		
16 to 24	7	3.6
25 to 34	24	12.5
35 to 44	49	25.5
45 to 54	56	29.2
55 to 64	38	19.2
Over 65	17	8.9
missing	1	
Country of residence		
England	148	77.1
Wales	31	16.1
Other	10	5.2
missing	3	
Household income (£ p.a.)		
< 10,000	17	8.9
10,000 to 19,999	22	11.4
20,000 to 29,999	30	15.6
30,000 to 49,999	38	19.8
> 50,000	53	27.6
missing		

Separate information collected at the three sampling locations (Beaumaris, Aberdyfi and St Davids) is provided below.

Demographic characteristics of respondents

The sample of respondents surveyed at each of the study locations was evenly distributed among members of both genders; approximately 50% of respondents were males and 50% females (table 12) Most respondents at each of the locations (over 70%) were residents of England. Differences in income levels among locations were tested by assigning respondents to two income level groups (≥ £29,999 and < £30,000). Significant differences were found between locations ($\chi^2 = 21.2$, $p < 0.001$). The sampling location located in the north of Wales (Beaumaris) showed lower frequencies than expected of respondents belonging to the higher income level group.

Table 12. Frequency distributions of selected demographic characteristics for respondents to the wildlife watching cruise survey in Aberdyfi, Beaumaris and St Davids.

	Aberdyfi		Beaumaris		St Davids	
	n	%	n	%	n	%
Gender						
male	21	52.5	42	43.8	25	44.6
female	19	47.5	54	56.3	31	55.4
missing	0					
Age						
16 to 24	0	0	5	5.3	2	3.6
25 to 34	4	10	9	9.5	11	19.6
35 to 44	10	25	22	23.2	17	30.4
45 to 54	23	57.5	18	18.9	15	26.8
55 to 64	2	5	27	28.4	9	16.1
Over 65	1	2.5	14	14.7	2	3.6
missing			1			
Country of residence						
England	33	84.6	74	78.7	41	73.2
Wales	5	12.8	16	17	10	17.9
Other	1	2.6	4	4.3	5	8.9
missing	1					
Household income (£ p.a.)						
< 10,000	4	10.5	12	15.4	1	2.3
10,000 to 19,999	3	7.9	14	17.9	5	11.4
20,000 to 29,999	2	5.3	22	28.2	6	13.6
30,000 to 49,999	11	28.9	17	21.8	10	22.7
> 50,000	18	47.4	13	16.7	22	50
missing	2		18		12	

Characteristics of respondents visiting trips

Characteristics of visitor's trips undertaken at the three study locations were studied. Approximately half of the respondents interviewed in Beaumaris undertook single purpose trips; these respondents visited the town with the only intention of taking part in one of the boat trips on offer (table 13). Conversely, respondents interviewed in Mid and West Wales carried out multipurpose trips, the boat trip was one of the reasons for them to visit the area but was not the only reason to do so. In accordance to these findings, the number of day-trips was higher in Beaumaris in comparison to Aberdyfi and St Davids. Day-trippers were more likely to plan and prioritize their activities due to the limited amount of time available. All the respondents that undertook day-trips in Beaumaris were residents of Wales. The length of the stay for those respondents that stayed overnight was significantly shorter for those staying in Beaumaris in comparison with respondents staying in the areas of Mid and West Wales ($U_{North,\ Mid}$ = 966.5, $p < 0.001$; $U_{North,\ West}$ = 1765.5, $p < 0.001$; $U_{Mid,\ West}$ = 919, p = 0.18).

Table 13. Percentage of respondents who visited the boat tour location (with the sole purpose of taking the boat trip/the boat trip was one of the reasons for visiting the location/ took the boat trip by chance), percentage of day-trippers vs. Respondents staying overnight and average length of stay (±SD)

	N	Visit to location (%)			Trip Length (%)		Number of nights Mean ± SD
		Specific	Multi	Chance	Day trip	Overnight	
Aberdyfi	40	12.5	55	32.5	2.6	97.4	7.2 ± 3.5
Beaumaris	96	53.1	32.3	14.6	27.1	72.9	5.4 ± 3.2
St Davids	56	30.4	53.6	16.1	7.1	92.9	6.5 ± 3.4

On average, on the day of the boat trip respondents in Beaumaris and St Davids travelled longer distances than those in Aberdyfi ($U_{North,\ Mid}$ = 658.5, $p < 0.001$; $U_{North,\ West}$ = 2196.5, p = 0.06; $U_{Mid,\ West}$ = 580, $p < 0.0001$). In Beaumaris the frequency of day-trips was highest, day-trippers had to travel to the boat trip location from their residences, thus travelling longer distances than those respondents staying overnight in the area, approximately 30% of day trippers in Beaumaris lived between 50 to 150 miles away from the cruise location, while 75% of respondents staying overnight had their accommodation in a 25 miles radius (table 14). In Aberdyfi over 97% of respondents stayed overnight in the area, from those, 92% stayed within 25 miles of the boat location. In St Davids, the situation was very similar, 93% of respondents stayed overnight, from those, 77% stayed within 25 miles of the boat departure location.

The price of boat trips differed significantly between the three locations; Beaumaris offered the lowest of all, at approximately half the price offered in the other two locations. Expenditure on food and drink was similar between locations, significant differences were only found between St Davids and Beaumaris. In Beaumaris a high proportion of respondents, particularly those undertaking day trips, brought their own food for the day in order to reduce the cost of the trip. For those staying overnight, accommodation costs were significantly lower in the North Wales area compared to Mid and West Wales ($U_{North,\ Mid}$ = 616.5, p = 0.005; $U_{North,\ West}$ = 1426.5, p = 0.004; $U_{Mid,\ West}$ = 656.5, p = 0.64).

Overall, the costs incurred on the day of the boat trip were significantly lower in Beaumaris ($U_{North,\ Mid}$ = 723, $p < 0.001$; $U_{North,\ West}$ = 740, $p < 0.001$; $U_{Mid,\ West}$ = 782, p = 0.05). Accommodation costs were not taken into account in this particular analysis in order to make expenditure of day trippers and respondents staying overnight comparable.

Table 14. Mean expenditures and distances travelled by respondents (± standard deviation) surveyed in Aberdyfi, Beaumaris and St Davids. Significant differences among locations were tested using Chi-square.

	Aberdyfi		Beaumaris		St Davids		Chi-square		
	N	Mean ±SD	N	Mean ±SD	N	Mean ±SD	χ^2	df	p
Boat trip price	40	15.9 ± 3.2	96	6.1 ± 0.7	56	17.7 ± 2.4	147.9	2	<0.001
Dist travelled on the day	39	16.7 ± 35.7	96	51.5 ± 52.6	51	38.3 ± 41	34.9	2	<0.001
Total dist. residence	40	267.5 ± 112	96	232.9 ± 159.4	56	400.5 ± 200.9	29.9	2	<0.001
Food & drink	38	11.9 ± 8.4	95	11.4 ± 16.8	56	12.9 ± 8	7.6	2	0.02
Accommodation	26	20.7 ± 14.1	75	15.7 ± 22.4	54	18.6 ± 12.7	12.1	2	0.002
Expenditure on trip day	37	29.1 ± 10.9	95	20.4 ±17.2	56	32.6 ± 9.8	65.1	2	<0.001

Factors influencing trip expenditure

It was expected that several factors could affect visitors' expenditure. The choice of location had a significant influence on the expenditure; overall Beaumaris represented the most economic alternative.

It was expected that income levels would affect visitors expenditure. Those respondents with higher income levels paid on average a higher price for their boat trip experience and thus they mostly visited Aberdyfi and St Davids (76.35% and 72.7% of respondents in these locations had an income level over £30,000 p.a., respectively). Conversely, in Beaumaris 61.5% of respondents earned below £30,000 p.a.

The overall auxiliary expenditure (food and drink and travel cost) was equally influenced by respondents' income levels, those with higher purchasing power spent more per day than those with lower power. Overall expenditure was similarly influenced by the duration of the visiting trip, those staying overnight spent significantly more (£20.2 ± 16.4) than respondents undertaking day trips (£11 ± 10.9) even before taking accommodation costs into account. Day trip visitors spent less in travel related expenditures as they lived closer to the site and in subsistence costs, as food and drink could be generally brought from home (table 15).

Table 15. Mann-Whitney test for factors affecting boat trip expenditure [a]average expenditure on boat trip ticket, [b]total expenditure on the day of the boat trip (includes expenditure on food and drink and travel costs, excludes accommodation costs)

	Boat trip price[a]				Total cost of trip[b]			
	N	Mean±SD	Median	Mann-Whitney	N	Mean ± SD	Median	Mann-Whitney
Income								
≤ 29,999	69	9.3 ± 5.1	6.5	U=1999	69	17.1 ± 20.4	12.4	U=2428
> 30,000	91	13.2 ± 5.5	13.2	Z= -3.9	88	19.2 ± 13.4	16.9	Z=-2.2
missing	32			p <0.001	3			p=0.03
Trip length								
Day trip	33	8.5 ± 5.5	6	U =1626	31	11 ± 10.9	7.9	U=1129
Overnight	158	12.1 ± 5.7	13.5	Z=-3.4	157	20.2 ± 16.4	17.1	Z=-4.7
missing	1			p=0.001	4			p<0.001

Seabird watchers

Demographic characteristics of respondents

The number of male respondents was slightly greater than the number of female respondents (48% vs. 37%, respectively). The majority of respondents were aged between 45 to 64 (43%). The mean age of respondents was 52 ± 13 SD. The median household income class was £30,000 to £49,000. There were similar numbers of respondents from England (45%) and Wales (36%).

Table 16. Frequency distributions of selected demographic characteristics for respondents to the seabird watching survey

	n	%
Gender		
male	48	48
female	37	37
missing	15	15
Age		
16 to 24	1	1
25 to 34	8	8
35 to 44	19	19
45 to 54	14	14
55 to 64	29	29
Over 65	-	-
missing	29	29
Country of residence		
England	45	45
Wales	36	36
Other	3	3
missing	16	16
Household income (£ p.a.)		
< 10,000	1	1
10,000 to 19,999	11	11
20,000 to 29,999	16	16
30,000 to 49,999	30	30
> 50,000	23	23
missing	19	19

Appendix 4

Organizations interviewed in Chapter 4

List of organizations interviewed in Chapter 4.

Organization name	Number of participants
Welsh Water	2
British Wind Energy Association	1
Milford Haven Port Authority	1
Cardiff University	1
Bangor University	2
Federation of Welsh Anglers	2
Welsh Yachting Association	2
Welsh Federation of Fishermens' Association	2
North Western and North Wales Sea Fisheries Committee	2
National Trust	1
Environment Agency	2
Countryside Council for Wales	2
Pembrokeshire Coast National Park	1
Pembrokeshire Coastal Forum	2