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Spatially explicit economic assessment of cultural ecosystem services: Non-extractive recreational uses of the coastal environment related to marine biodiversity

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ABSTRACT

The adoption of comprehensive marine spatial plans (MSP) requires that all aspects of value associated with marine biodiversity are considered in their development. Therefore, a holistic approach to MSP needs to include the ecological, social and economic aspects related to the range of goods and services provided by marine biodiversity. In temperate coastal areas however, extractive uses of marine biodiversity (i.e., fisheries) tend to receive more consideration than other non-extractive uses such as certain forms of recreation. This is primarily due to its economic and social importance and a lack of information on non-extractive uses of marine biodiversity. This study presents an assessment of the economic importance and spatial distribution of non-extractive uses of marine biodiversity (diving, kayaking, wildlife watching from boats and seabird watching) in the coastal temperate area of Wales and its application to MSP. The assessment of the economic importance and spatial distribution of these uses was ascertained through questionnaires with relevant users. Results indicated that the economic importance of non-extractive recreational uses of marine biodiversity in Wales is comparable to that of commercial fisheries for the same region. Spatially there was a significant degree of overlap among areas used by the different recreational groups studied here and the distribution of uses could be linked to different aspects of marine biodiversity, such as the presence of particular habitats in the case of divers. The integration of spatially explicit socioeconomic data for a range of different uses of marine biodiversity enables policy makers to gain useful insight into the potential consequences of implementing a spatial management regime, as certain uses can be sometimes overlooked but are still essential if we are to consider the impact of spatial planning on all economically relevant activities. Such data provide a balanced overview of the value of marine biodiversity to different sectors of society and contributes to the process of developing comprehensive marine spatial plans.

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 [1]. 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 [2].

Over the past decade, the economic assessment of the services provided by ecosystems has become increasingly important in a policy context [3–8]. Although some of the approaches used in the assessment of the economic importance of biodiversity have been controversial [9], 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 [2], are among those provided by marine biodiversity. Thus far however, studies on the assessment of the economic importance of cultural services have mainly focused on iconic marine habitats (e.g., coral reefs) and species (e.g., whales) [10–14]. 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 [15]. In contrast, the importance

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of economic inputs derived from cultural services in temperate systems has received less attention perhaps as a consequence of a lower prevalence of iconic species and habitats (but see [7,16]).

Highlighting the economic importance of non-extractive uses associated with marine biodiversity in temperate areas can have benefits in promoting conservation as these uses are more easily regulated and their effects are less likely to contribute to biodiversity degradation than industrial scale activities (e.g., fishing and aggregate extraction), which generally makes them more compatible with conservation objectives. Furthermore, the assessment of the economic inputs 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) [17]. 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.

The aim of this paper was to provide a measure of the importance of the economic inputs of marine biodiversity in temperate coastal areas in terms of the provision of recreational services and to highlight the significance of mapping the distribution of these services to inform comprehensive spatial management. This study concentrates on the assessment of the economic importance and geographic distribution of four non-extractive recreational 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 define the characteristics of their activities and to 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 [18], a comparison of the relative importance and overlap of these activities is possible. The results of this study provide policy-makers and managers with a more objective means of assessing the relative importance of different activities that occur in the marine environment in the context of marine management plans.

Material and methods

Study area

The present study focused on Wales, United Kingdom (UK). The coastal area of Wales encompasses 1300 km of coastline and it is a popular tourist destination (Fig. 1). In 2007, Wales hosted a total of 8.85 million UK domestic trips, of which approximately 48% occurred at seaside destinations [19], it was estimated that domestic tourists spent approximately £742.6 million at Welsh seaside destinations.

Survey design

The present study provides a measure of the economic importance of those non-extractive recreational 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 [20]. 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

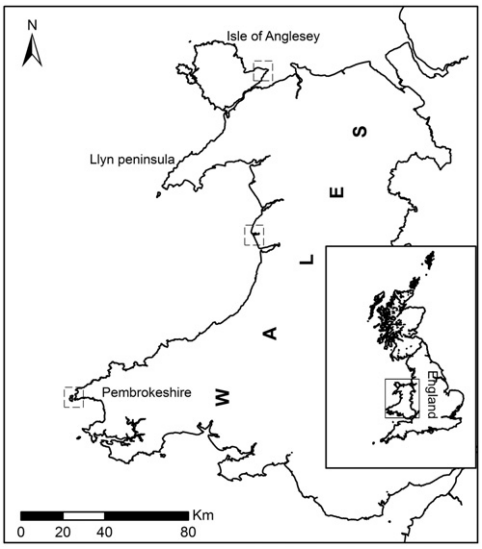

Fig. 1. Overview map of the study area. Dashed squares indicate interview locations with wildlife viewing trips customers.

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., [21–23]).

Customers of wildlife viewing trips were surveyed by means of face-to-face questionnaires. Twenty-one boat operators were identified along the Welsh coastline. Due to logistical limitations it was not possible to carry out a meaningful number of questionnaires at each of the 21 boat operators sites. Therefore, in order to obtain a good geographical survey coverage, the coast of Wales was divided into three areas, namely North, Mid and West Wales, where three locations were selected to undertake questionnaires (Fig. 1).

The information sought through the questionnaires focused on the characteristics of the user's trip, the expenditure incurred, the reasons for choosing a particular activity area and demographic information. The spatial distribution of activities was also assessed (Section 2.4).

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 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 ascertained as outlined in Section 2.3.

Estimation of total number of activity days

Scuba diving

No previous information existed on the number of diving activity days in Wales. The estimation of diving activity days was undertaken as follows. 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 [24].

Second, preliminary analysis of the questionnaire data from the present study indicated that respondents' residence distance to the coast of Wales was likely to influence the number of visits to Wales, therefore the diver population was estimated separately for different regions of the UK. To do this, the regional membership distribution for the British Sub Aqua Club (BSAC) was used to estimate the spatial distribution of the total diving population, BSAC holds information on the distribution of their membership across 10 different regions. As a high proportion of divers in the UK are BSAC members, for the purpose of the study it was assumed 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, which gave the total diving population for each of the 10 regions.

Third, only a portion of the divers estimated through the Watersports and Leisure participation 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 to ascertain what percentage of their days out had the Welsh coast as destination. A short questionnaire was e-mailed to diving clubs that 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.

Fourth, 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 population number obtained at the second step of the calculation process. Thus, the total number of diving activity days for Wales was estimated at approximately 110,000 day.

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 [25]. 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 played a very important role, [26]).

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 assess the relationship between popularity and level of kayaking activity. This relationship was then applied to the areas of Mid and West Wales in order to estimate activity levels for the entire Welsh coast.

Wildlife viewing cruises

The total number of passengers undertaking wildlife viewing trips was estimated using information from 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 for each of the 21 boat operators. Generally, companies operate from the 1st of April to the 31st of October; activity levels throughout the season were obtained by means of phone interviews with company owners. 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. To obtain the spatial distribution of the activity for the entire Welsh coast, information on the company's boat routes were obtained from available marketing information and/or through phone conversations with the company.

Seabird watchers

No information was available on the total 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 population estimate cannot account for the number of 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 cf. walking.

Spatial distribution of activities and related expenditure

All questionnaires included a map of Wales with an overlaid 10×10 km 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.

Additionally, in the case of diving it was possible 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 visited by divers and those that were not visited. Detailed habitat mapping information [27] 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 Government. The 12 nm limit was chosen as this was the maximum distance from the coast where divers in this survey had been diving. Multivariate analysis software, PRIMER 6 [28], 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 any 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 those cells that were utilised and those cells that were not utilised by divers.

Results

A total of 558 questionnaires were carried out among the different user 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.

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. 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 [29], however some divers might be attracted to them due to alternative reasons. Travel time and travel 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 ($\pm$S.D.) cost of a diving trip was estimated at £71 $\pm$ 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, the costs incurred by those divers staying overnight, £87 $\pm$ 46, were significantly higher than those that undertook day trips, £52 $\pm$ 32 ($t(1\,4\,6)=5.6$, $p<0.001$). The average expenditure on accommodation for divers staying away from home was estimated at £20 $\pm$ 13 per person per night.

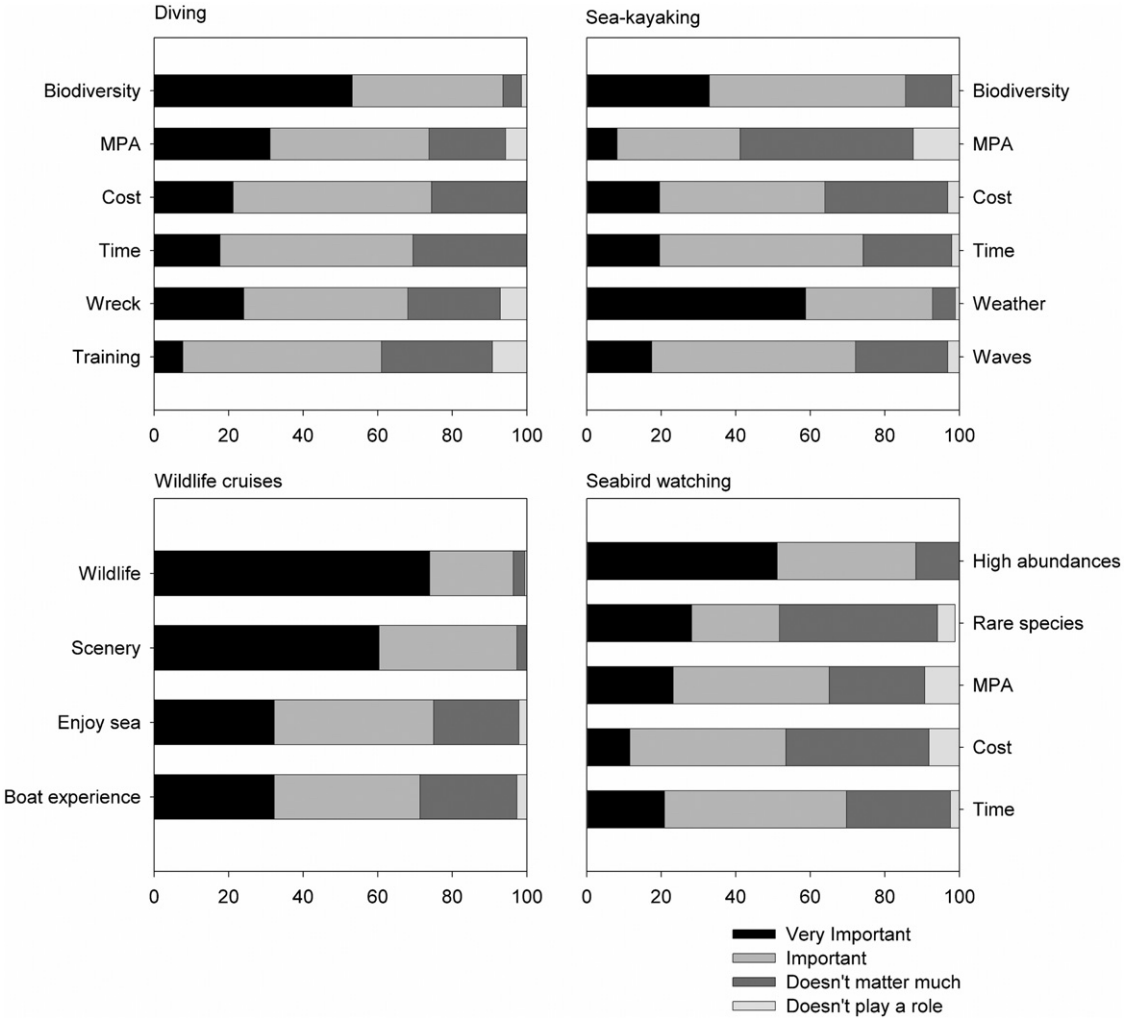

Fig. 2. Respondent's rating of the factors that influence the selection of activity location for each of the activities covered in the study in response to the question "*Please, rate the importance of the following elements when planning a diving/kayaking/wildlife cruise/seabird watching trip*". Respondent percentage is indicated on the *X*-axis, factors appear on the *Y*-axis (MPA=marine protected area).

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. £4.7 M, £10.9 M).

Sea-kayaking

A high proportion of kayakers (59%) considered that weather conditions were 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. 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 ($\pm$S.D.) of £27 $\pm$ 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 $\pm$ 16 pppd, overnight=£36 $\pm$ 27 pppd; $t(94)=4.37$, $p<0.001$). On average kayakers who stayed overnight spent £13 $\pm$ 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. £2.1 M, £2.9 M).

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. 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).

The mean ($\pm$S.D.) expenditure of a passenger taking a wildlife viewing trip was estimated at £44 $\pm$ 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 $\pm$ 6). Accommodation for those staying overnight was estimated at approximately £22 $\pm$ 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. £12.1 M, £14.7 M). 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.

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 ($\pm$S.D.) of £28 $\pm$ 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 $\pm$ 33, 95% C.I. £31, £55) were significantly higher than costs incurred by day trippers (£15 $\pm$ 21, 95% C.I. £9, £21). The average expenditure on accommodation was estimated at £22 $\pm$ 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., £2.9 M, £4.5 M).

Spatial distribution of activities

In the case of diving, approximately 50% of the activity was concentrated in 5% of the cells that covered the area between the coast and the 12 nm 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). ANOSIM results indicated that biotope characteristics differed significantly among areas either with or without recorded diving activity (Global $R=0.38$, $p=0.001$). The average dissimilarity between areas either with or without diving activity 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 substratum areas.

The distribution of sea-kayaking activity was estimated from the experts' questionnaire. Approximately, 50% of the activity was

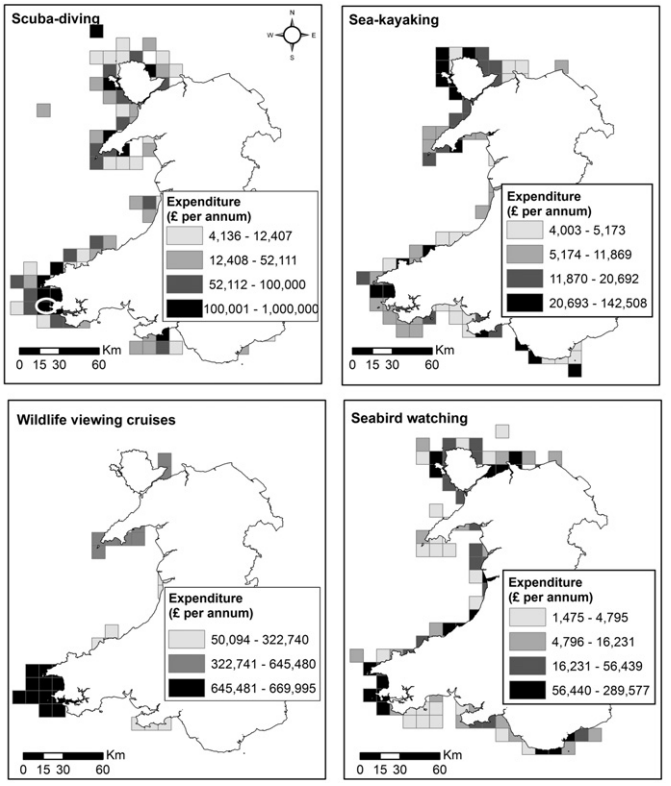

Fig. 3. Activity distribution and annual expenditure in 2008 in Wales for scuba-diving, sea-kayaking, wildlife viewing cruises and seabird watching. The location of the marine nature reserve in South West Wales is indicated on the top-left map with a white circle.

concentrated in 11% of the map cells (Fig. 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, Pearson $=0.6$, $p<0.001$ (Fig. 4).

In the case of wildlife watching the analysis of the geographical distribution revealed that this activity was concentrated around a small percentage of coastal waters, as approximately 50% of the activity was undertaken in 7% of the map cells.

The distribution of seabird watching activity was assessed through the survey (Fig. 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.

The activity distribution maps suggested 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. 1). This was further supported by significant correlations between cell use frequencies for the different activities (Pearson $_{\text{diving-kayaking}}=0.39$; Pearson $_{\text{diving-seabird watching}}=0.49$; Pearson $_{\text{kayaking-seabird watching}}=0.34$, all significant at the 0.01 level). Accordingly, these shared areas were the most important in economic terms (Fig. 5a and b). Furthermore, the spatial overlap between activities was high for most pairs of activities (Table 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%).

Perhaps due to the different nature of the activities reviewed here, users from the different groups placed varying degrees of importance on the different categories of marine wildlife. 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. 6). Therefore, the geographic distribution of marine biodiversity is likely to be among one of the factors that influence the distribution of human activities in terms of recreational use of the marine environment.

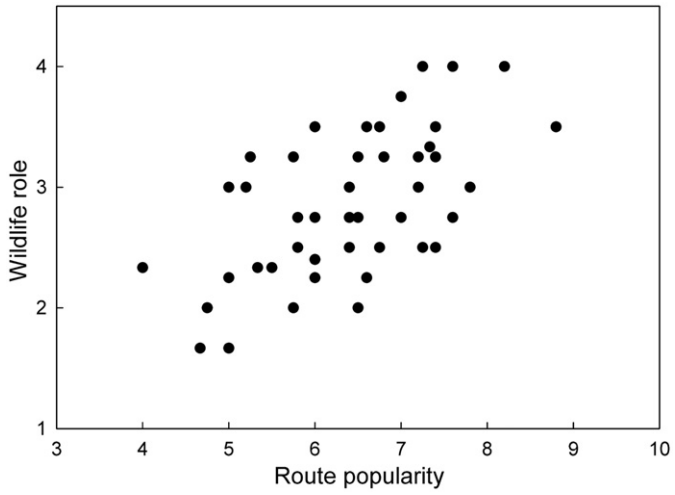

Fig. 4. Correlation between kayaking route popularity (rated on a 10-point scale) vs. the role played by the presence of wildlife on the popularity of the route (rated on a 4-point Likert scale). Pearson's correlation coefficient $=0.6$, $p<0.001$.

The comparison of the distribution of recreational activities and commercial fisheries revealed that popular areas for recreation frequently coincided with some of the most profitable areas for commercial fishing (Fig. 5c and d). The analysis of the average fishing revenues in cells with 4, 3, 2 or 1 recreational activities showed that the cells with 4 activities taking place in them also coincided with the highest fishing revenues areas (Avg $_{\text{revenue in cells with 4 activities}}=$£321,905; Avg $_{\text{revenue, 3 acts}}=$£197,048; Avg $_{\text{revenue, 2 acts}}=$£95,161; Avg $_{\text{revenue, 1 act}}=$£57,399).

Discussion

The total annual expenditure associated with non-extractive 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 (£742 million) attributed to coastal domestic tourism in Wales in 2007 [19]. In tropical and sub-tropical areas of the world non-extractive activities play an important economic role at both national and local levels [30]. 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 [31,32]. 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 [18]. 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 t in 2005 to 3836 t in 2008 (written statement by the Welsh 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 Government. Examples such as this emphasise the importance that non-extractive 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 a rural economy and 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 [33]. 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 economic assessment presented in this study underestimates the economic importance of non-extractive benefits provided by the marine environment in general as other activities less reliant on marine biodiversity but

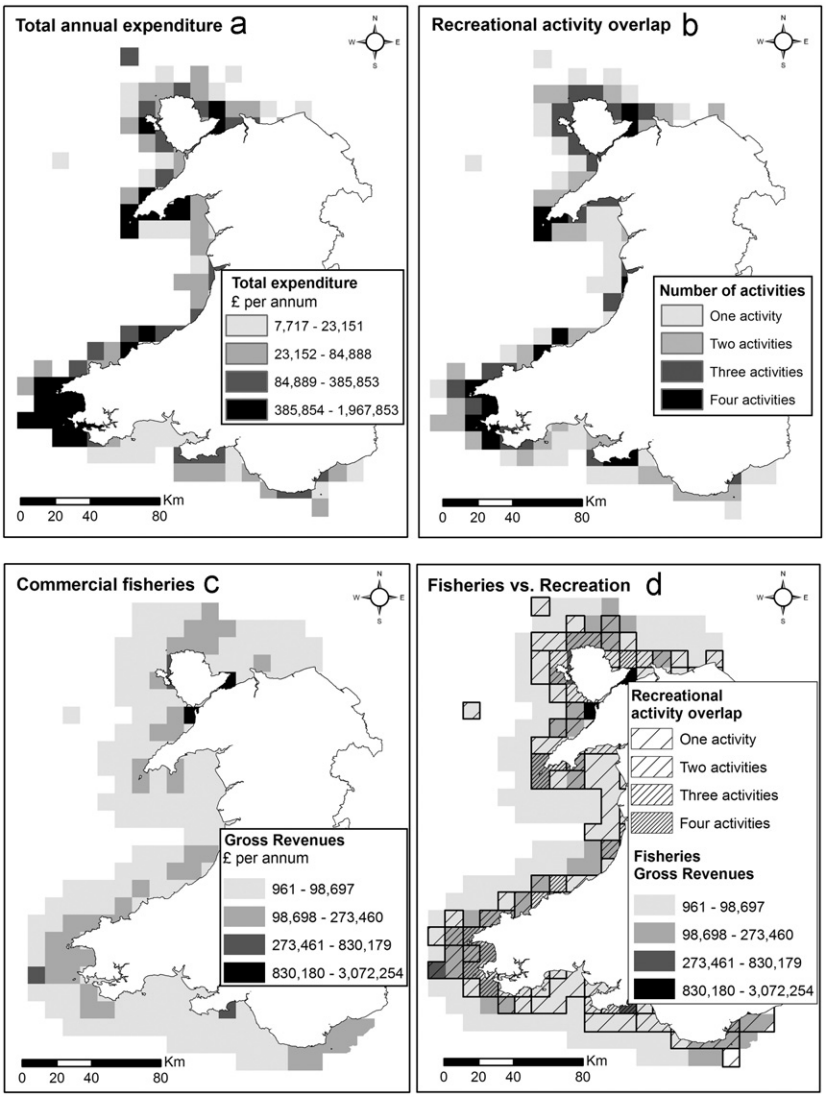

Fig. 5. (a) Total annual expenditure and (b) spatial overlap of the recreational activities studied (diving, kayaking, seabird watching and wildlife watching cruises) in 2008 in Wales. (c) Aggregate gross revenues for the commercial fisheries in Wales in 2003 (d) Spatial overlap of recreational and commercial fisheries activities: recreation; greater hatch densities indicate greater recreational activity overlap, fisheries; darker colours indicate more profitable areas.

Table 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				–

still dependent on the marine environment (i.e., surfing, sailing, yachting, shipping) were not included in the assessment. 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. Furthermore, the assessment undertaken here cannot represent the total value associated with 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 [9].

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 [34]. 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, [27]), however, little 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-extractive recreational uses that are dependent upon marine biodiversity (but see [16]).

Different factors play a role in the distribution of human activities, therefore a thorough understanding of the distribution

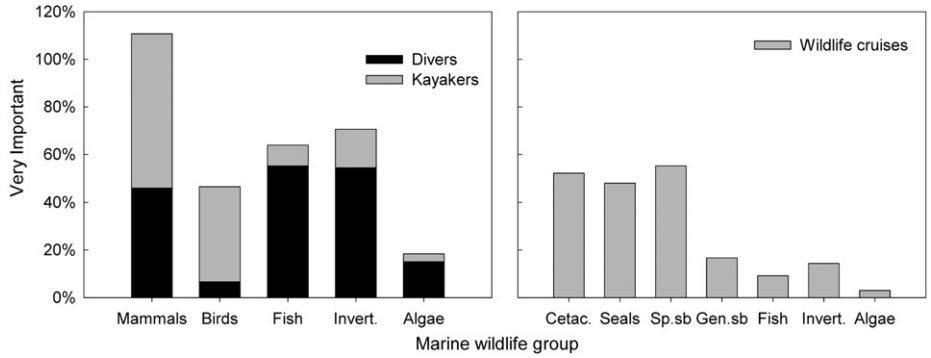

Fig. 6. Percentage of respondents that thought as "very important" being able to observe certain groups of marine wildlife (invert.=invertebrates, cetac.=cetaceans, Sp. Sb=special seabirds, i.e., puffins, gannets, Gen.sb=general seabirds, i.e., seagulls).

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 of an area. 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 [35]. 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. 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.

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. 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.

Conclusion

This study shows the economic importance of non-extractive 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 characterise patterns of non-extractive 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.

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