**Abstract**

Marine Protected Areas (MPAs) are an important tool for the maintenance of marine ecosystem functionality and health and ensuring the onward flow of beneficial ecosystem services that support human well-being. Social and economic factors influence whether and how stakeholders exploit resources or cooperate to conserve them. Environmental managers are now turning from designating MPAs to monitoring their effectiveness. Combining spatial analysis with quantitative and qualitative survey methods this research shows that an MPA (Lyme Bay, SW England) has had varying effects on the delivery of the beneficial ecosystem service of leisure and recreation. In the survey years 2008-2011 dive businesses have increased their frequency of activity inside and outside the MPA and report an increase in turnover; though they perceive little or no effect of the MPA on business. Charter boat operators have seen an overall decline in the frequency of activity outside the MPA and an increase inside the MPA. They perceive that the MPA has increasingly had a positive effect on their business. Sea angling activity has declined at sites outside the MPA and increased at sites within the MPA, suggesting a redistribution of spatial activity. Diving activity has increased both inside and outside the MPA. Divers report that the MPA has influenced where they choose to dive. This corresponds to a potential increase in value of the MPA resource (represented as the proportional expenditure and associated turnover by these groups) of £2.2 million. This research demonstrates that the use of the resource has changed following designation and that MPAs can attract a greater proportion of the leisure and recreation expenditure and associated turnover to sites within the MPA boundary. Moving forward it is important to assess effects both inside and outside MPAs. Integrating high quality social science at MPA sites to track effectiveness can help to adapt and refine management strategies to reflect the needs of the stakeholders and support effective conservation.

**Key words:** marine spatial planning, monitoring, recreation, impact, socio-economic, economics, conservation, temperate reef, fisheries closure

1. **Introduction**

Marine ecosystems provide a wide range of resources and services that contribute to human well-being and life on Earth [1]. The Millennium Ecosystem Assessment (MEA) established the concept of ecosystem services on the global agenda as “the benefits people obtain from ecosystems” [2] and although ecosystem services are defined in a variety of ways [3-5] the common theme is the translation of ecosystem functions and processes into direct or indirect benefits for human wellbeing [6]. By enabling the conservation of significant species, habitats, or entire ecosystems, Marine Protected Areas (MPAs), are an important tool for the maintenance of marine ecosystem functionality and health [7, 8]. MPAs can also have a wider ecological significance in supporting goals for the sustainable use of marine resources in a marine spatial planning context [9, 10].

Driven forward by global targets introduced under the Convention on Biological Diversity, the number of MPAs is rapidly increasing [11]. In the UK, this international policy driver is supported by European and national conservation policies to designate MPAs [11-14]. Given this rapid expansion of MPAs, the current conservation debate in the UK is moving towards questions of how to enforce and manage MPAs and then monitor them to determine if they are effective [15]. Currently, the legislative requirements for the monitoring of MPAs is driven by indicators linked to ecological goals [11-13, 16]. There are no specific legislative requirements to monitor the socio-economic effects of MPAs or set socio-economic goals for an MPA though the conservation policy. Nevertheless the EU Marine Strategy Framework Directive (MSFD) recognises that both socio-economic and biological factors can potentially influence the success of an MPA in meeting its ecological goals [17]. At a UK level, socio-economic factors must be taken into account in the MPA designation process [16].

Where the socio-economic effects of MPAs are considered, it is usually to provide information to support conservation initiatives or to provide information regarding potential trade-offs under different MPA management scenarios. There is traditionally a focus on fisheries and the provision of seafood as a beneficial ecosystem service [18, 19], particularly the spillover of target species into adjacent fisheries [20-23]. However, there is also a growing body of research that focusses on the non-fisheries benefits of MPAs namely the beneficial ecosystem service of “recreation, leisure and tourism”, assessing its economic value by using a combination of direct market valuations [24-27]; travel cost methods [28-31]; contingent valuation methods [32-40]; and choice modelling experiments [41-43]. In these contexts, valuing the beneficial ecosystem service of recreation and leisure in relation to MPAs is primarily used to take a single snapshot of the value and use of that activity in a particular MPA site. This information is often used to demonstrate the value of recreational activities to local economies, particularly to highlight the importance of recreational and leisure activities that make use of natural resource in comparison to that of commercial fishing.

Whilst these studies are useful to determine the value of a particular recreation and leisure activity in order to inform resource use management, most commentators agree that MPA designation and management creates ‘winners’ and ‘losers’ [44, 45]. It is known that the establishment of an MPA can potentially ignite socially charged issues [46] which, if compartmentalised or dismissed can result in the failure of the MPA to meet the primary ecological objectives for which it was initially designed [47]. To gain a more thorough understanding of how MPAs effect recreation and leisure and to feed into environmental management processes this research aimed to: 1) develop a method to monitor how recreation and leisure activity associated with an MPA changes in the years following designation and; 2) use a baseline study and methodology [27] to demonstrate changes in the frequency of activity and indicate potential increases or decreases in the expenditure or turnover of these recreation groups inside and outside the MPA.

1. **Methodology**

**2.1 Study Area**

Located in south-west England, UK, Lyme Bay encompasses a sea area of 2460 km2 (Figure. 1) and contains marine habitats that are important for conservation on both a national and international scale. The offshore reef areas are Annex 1 habitat designated as a Special Area of Conservation (SAC) under the European Union’s Habitats Directive (92/43/EEC). The reef substratum additionally hosts species such as the sunset cup coral (*Leptopsammia pruvoti*), which is nationally rare [48] and the pink sea fan (*Eunicella verrucosa*), which is nationally uncommon [49]. The Bay supports both a fishing and recreation and leisure industry [27, 50]. Following concerns that bottom towed fishing gear was damaging the structure and complexity of marine ecosystems within the Bay, the UK Government’s Department for Environment, Food and Rural Affairs (Defra) implemented a Statutory Instrument (SI) - The Lyme Bay Designated Area (Fishing Restrictions) Order 2008 - which closed a 206km2 area of Lyme Bay (Fig. 1) to bottom towed fishing gear [51].

[insert Figure 1]

**2.2 Questionnaire design and delivery**

Four questionnaires were developed to collect data on the spatial and economic activity of four different recreation groups that directly rely on the quality of the Lyme Bay conservation features for their activity (dive businesses, dive clubs, sea anglers and charter boat operators). The questionnaires were piloted on sample groups. Three of these questionnaires (dive clubs, sea anglers and charter boat operators) were further developed with an interactive map for use on-line. Dive businesses were approached in person each year with a paper version of the map and recreation sites to encourage their participation. Questionnaires were repeated each year for the four year duration of this project 2008 - 2011. A combination of methods were deployed to gather the data (e-mail, postal surveys, web forums, face to face interviews and telephone interviews), with every effort made to contact stakeholders in the Lyme Bay area. An approximate number of stakeholders that are known to undertake the activity in the vicinity of the MPA is provided in Table 1 (N) along with the number of stakeholders who took part each year in the research (n) provided as a number and as a percentage to demonstrate sample size.

[insert table 1]

**2.3 Setting the Baseline**

The Rees et al [27] survey provides the economic and spatial baseline for this study. The frequency of visits to recreation sites was determined using a map of Lyme Bay populated with 171 known reef, wreck and shore sites known to be used by these recreation groups (Fig 1). Respondents were asked to identify the sites they visited each year and also give an indication of the frequency of visits to each site on a scale of 1–5 where 1=a site rarely visited in 2008 and 5=a site frequently visited in 2008. Respondents were invited to add further sites to the map. To maintain consistency with previous economic studies in Lyme Bay [50, 52, 53] monetary values were elicited by asking questions designed to determine expenditure (diver and anglers) and business turnover (charter boats and dive businesses) [27]. This baseline is considered to be the monetary value of the marine resource in Lyme Bay for the beneficial ecosystem service of leisure and recreation.

**2.4 Evaluating Change: Spatial and Economic Data**

For each subsequent year 2009-2011, the frequency count for each site was summed for each recreational group and averaged by the number of respondents who provided spatial data. This provided an average frequency count per recreation site that could be compared with other years. To show the spatial change in the frequency of activity at recreation sites in Lyme Bay, the frequency count across all stakeholder groups was divided into 11 categories using Jenks natural breaks in ArcGIS, which classifies natural breaks in the data. This resulted in five negative frequency categories, five positive frequency categories and a category representing 0, symbolising no change in the frequency of activity between years. The data were then mapped, for each recreational group and year, using ArcGIS graduated symbols, which indicates the size of the frequency change, both positive and negative, by the size of the symbol. The same eleven categories were used for all maps so that each can be directly compared.

To provide an equivalent change in the monetary value of the resource which corresponds to the change in frequency of visits to sites inside and outside the Lyme Bay MPA, the sum of all frequency counts for recreation sites inside and outside the MPA was calculated each year. This frequency count was averaged by the number of respondents who provided spatial data (2008-2011). The change in monetary value was calculated annually by converting the average change in frequency counts inside and outside the Lyme Bay MPA into an equivalent percentage change in activity (increase or decrease). This percentage change was converted into a monetary value by calculating 1% of the 2008 baseline value and multiplying by the annual percentage change, thus providing an annual adjusted value. This process was repeated annually with the monetary value of the resource calculated as the sum of the percentage change in the frequency of activity multiplied by the annual adjusted value.

Spatial and economic data were verified with the stakeholders via a series of quantitative and qualitative questions. Respondents to the questionnaires were asked to scale their responses on a five-point Likert-type scale (1= no effect and 5 = a strong effect) to the following questions.

1. To what extent has the closed area affected your decision to conduct your recreation activity in Lyme Bay OR to what extent has the closed area affected your business this year?
2. How much has the closed area affected your decision as to *where* you conduct your activity/take clients in Lyme Bay?

The scores from respondents were used to calculate the mean and standard deviation to show the average response and how much an individual respondent differed from the overall average. To test whether the Likert type responses changed significantly across years the data were firstly tested for normality using the Shapiro-Wilks test. None of the data fitted the normal distribution and therefore the degree to which opinions vary within stakeholder groups by year was analysed using a non-parametric independent samples Kruskal-Wallis test. Additionally, each year every diver and angler was asked the number of dives/angling trips they had undertaken nationwide, the average expenditure per dive/angling trip and the number of dives/angling trips undertaken in Lyme Bay. Dives and angling trips in Lyme Bay were expressed as a percentage of overall activity. Businesses were asked to comment on any increase or decrease in turnover and number of clients.

**3. Results**

**3.1 Spatial Activity and Changes to the Economic Value of Recreation Sites**

Angling activity predominantly declined at sites both inside and outside the Lyme Bay MPA in the 2008-2009 period, though there is an increase in activity at a few sites within the MPA (Figure 2). In the 2009-2010 period, there was a decline in angling activity around reef and wreck sites within the Lyme Bay MPA, but there were noticeable increases in angling activity in the western part of the Bay and at a few sites within the closed area. Between 2010-2011 there was an increase in angling activity at sites within the Lyme Bay MPA (Figure 2). Overall in the 2008-2011 period angling activity has increased within the MPA and decreased outside the MPA. In terms of the proportionate changes in the economic value of the resource, this outside MPA decrease corresponds to a potential fall in the frequency of activity between 2008 and 2011 of 27% amounting to a loss in the expenditure associated with recreation sites of £3,680,264 (Figure 3a). At sites within the Lyme Bay MPA an increase in the frequency of visits between 2008 and 2011 of 51% corresponds to a potential £1,544,068 increase in the proportion of anglers’ total expenditure associated with sites within the MPA (Figure 3b).

[insert figure 2 and figure 3]

Charter boat operators consistently make use of sites both inside and outside the Lyme Bay MPA with annual increases and decreases in activity varying across sites (Figure 2). Activity across the majority of sites outside the MPA decreased between 2008 and 2011 representing a potential decrease in turnover associated with these sites of £644,067 a 33% decrease (Figure 3a). Charter boat activity increased by 19% within the MPA between 2008 and 2011 representing a potential increase of £108,427 in turnover associated with these sites within the MPA (Figure 3b).

As documented by Rees et al [27] dive business generally operate in the western section of Lyme Bay and make consistent use of recreation sites that suit the needs of their clients (e.g. novice divers). Spatially, between 2008 and 2011 dive business activity increased at sites inside and outside the MPA (Figure 2). The increase in activity outside the MPA has raised the value of the resource by £1,342,576. Overall, the original baseline value of sites outside the MPA has been elevated by 89% (Figure 3a). Dive businesses turnover that could be potentially attributed to the Lyme Bay MPA increased by 35% between 2008 and 2011 representing an increase in potential associated turnover at these MPA sites of £39,864. (Figure 3b).

Diver activity increased at sites outside the Lyme Bay MPA between 2008 and 2011 despite a decrease in activity between 2009 and 2010 (Figure 2). This 2008-2011 increase of 87% represents a potential increase in the expenditure of divers associated with these sites of £909,151 since the 2008 baseline (Figure 3a). Diving activity inside the MPA has increased between 2008 and 2011 even more dramatically, leading to a 210% increase in the frequency of activity by divers and a potential elevation in associated expenditure at these sites of £488,613 (Figure 3b).

Overall, recreation stakeholders make use of a variety of sites across Lyme Bay. Dive businesses and diving activity has increased at sites outside the Lyme Bay MPA. Though with the fall in angler and charter boat activity there has been an overall £2,251,727 decline in associated turnover and expenditure at these sites, largely influenced by a reported 27% decline in angling activity since 2008. At sites within the Lyme Bay MPA all groups have increased the frequency of their activity. This corresponds to a potential overall increase in the proportional turnover and expenditure by these groups of £2,180,974 at sites within the MPA.

**3.2 Changes to Business and Recreation Activity 2008-2011**

In terms of actual changes in local businesses in the period 2008 to 2011, the majority of dive businesses have either seen their businesses turnover remain the same or grow (although two dive businesses closed in 2010). This is demonstrated by turnover, the number of students learning to dive, the number of divers on dive trips and the number of staff employed either staying the same or increasing over this 4 year period (Figure 4). Similarly, the majority of charter boat operators have seen their turnover stay the same or increase over this four year period, although they have seen fluctuations in the number of anglers and divers that they take on trips each year (Figure 4).

[insert figure 4]

From the anglers surveyed, trips to Lyme Bay as a percentage of the total number of trips have remained consistent over the 4 year period (aside from a drop in angling trips to Lyme Bay in 2009) (Table 2). For divers, between 2009 and 2011 there has been a small but progressive increase in the number of dive trips to Lyme Bay as a percentage of the total of dive trips taken in a year, though it remains lower than the original baseline in 2008. The average expenditure per dive and the average expenditure per angling trip show no significant differences over time (Table 2).

[insert table 2]

3.3 Perceptions of change

Each year stakeholders were asked questions as to the influence of the Lyme Bay MPA on their decision to conduct their recreational activity in Lyme Bay (divers and anglers) and the effect on their business (dive businesses and charter boat operators). Divers and anglers registered a small to moderate effect of the Lyme Bay MPA on activity (Table 3) while dive businesses and charter boat operators perceive that the Lyme Bay MPA has had little to no effect on their business. Dive Businesses are the most unified in their response (demonstrated by the lowest standard deviation, Table 3). In testing whether the distribution of stakeholder responses has been the same across years, the significant results in the Kruskal Wallis test demonstrate that there have been no obvious changes in opinion.

[insert table 3]

In terms of whether the Lyme Bay MPA has affected their decision as to where they go/take clients in Lyme Bay, only dive businesses indicate that the MPA has little or no effect on their decision (Table 3). Divers, anglers and charter boat operators all indicate that the Lyme Bay MPA has had a small to moderate effect on their decision as to where they go in Lyme Bay (Table 3). Across all stakeholder groups there has been an increase in the mean response between 2008 and 2011, indicating over time the MPA is having an increasing effect on their activity. However, when tested as to whether the distribution of results are the same across years, the results are significant for all groups thus demonstrating that there has been no significant variation in opinions from these stakeholder groups in the 2008-2011 period.

1. Discussion

The Lyme Bay MPA has had varying effects on recreation and leisure activities. Dive businesses report that they have increased their frequency of activity inside and outside the MPA. In 2008 the sites within the MPA accounted for less than 10% of their annual diving activity. Dive businesses make little or no use of the dive sites inside the MPA, and consequently little turnover can be associated with those sites [27]. This lack of use is attributed to the distance of the MPA from their business premises and the close proximity of good dive sites elsewhere in the Bay. Overall dive business owners report an increase in turnover during this period though they perceive little or no effect of the MPA on their business or where they take clients in Lyme Bay. Charter boat operators have seen an overall decline in the frequency of activity outside Lyme Bay MPA and an increase inside the MPA between 2008 and 2011. During this period 12 charter boat operators had either retired or gone out of business, perhaps reflecting the overall decline in the frequency of activity but supporting the fact that charter boat operators report that their business turnover has either stayed the same or increased. Charter boat operators perceive that the MPA has increasingly influenced their business. Between 2010 and 2011 they report that it has influenced where they take clients in Lyme Bay, a finding supported by an increase in charter boat frequency of activity within the MPA during this same period.

Sea angling activity declined at sites outside the MPA though it increased at sites within the MPA since 2008. This decline in overall frequency of activity is the most dramatic between 2008 and 2009 where angling activity is reported to have declined by 27%. This large decline is unexplained though the corresponding drop in the angling response rate between these same years may have influenced the results. Angling groups have largely supported the campaign for MPAs in the UK (e.g. The Angling Trust). It is possible that the 2008 results were skewed by this enthusiasm and that the 2009-2011 results may be more illustrative of annual angling use in Lyme Bay. In addition, the overall downturn in the UK economy and a series of summers with higher than average rainfall may also have influenced stakeholders angling activity in Lyme Bay [54].

Despite this overall decrease in activity, angling within the MPA has increased. The angling respondents did not demonstrate that they are increasing their number of trips to Lyme Bay. So it can be inferred that any increase in angling activity within the MPA, has an associated decrease in activity outside the MPA. As the expenditure (per day) has not significantly changed during this time then there is no additional expenditure, but potentially a transfer of expenditure by this stakeholder group that can be proportioned to the MPA. Anglers additionally perceive the MPA to have influenced whether they undertake their activity within Lyme Bay and report that the MPA has influenced where they go.

Divers as a stakeholder group have been the most affected by the Lyme Bay MPA. Diving activity has increased both inside and outside the MPA, despite a downturn in activity between 2009 and 2010. Divers have not reported that they have increased their number of visits to Lyme Bay so it is possible that diver numbers have increased (dive businesses report an increase in students learning to dive between 2008-2011) and/or there has been a transfer of activity away from other dive sites in the UK. This is supported by the perceptions of divers who report that the MPA has influenced whether they conduct their activity in Lyme Bay and where they go.

The 2008 baseline study [27] set a snapshot of the expenditure and turnover of the recreation groups that could be attributed to the marine resource, namely the reef, wreck and shore sites of Lyme Bay. This direct market valuation essentially values the presence of the natural resource in order to support socio-economic studies that require decision makers to understand the economic importance of different stakeholder groups in the MPA designation process. In Lyme Bay in particular there was much expectation from stakeholder groups that the MPA would have economic benefits [55]. This research demonstrates that the value of the resource has changed following designation and that MPAs can attract a greater proportion of the leisure and recreation expenditure and associated turnover to sites within the MPA boundary, thus increasing the value of the resource. This within MPA increase though is potentially drawing activity away from sites outside the MPA boundary. The effects of MPA designation cannot be separated from the wider activities occurring outside their boundaries. This wider influence of MPA designation must be considered within regional multi sector management planning [10].

So is the MPA effective? From an ecological perspective in the period 2008-2011 the results of the 4 year survey in Lyme Bay show that there has been some recovery of the reef community in areas where bottom towed fishing gear is no longer permitted. Recovery has also been observed for certain individual species such as the ross coral (*Pentapora fascialis*), sea squirt (*Phallusia mammillata*) and king scallop (*Pecten maximus*) [56]. Additionally research from Lyme Bay has determined that recovery of the reef habitat has not been restricted to those areas that are strictly defined as reef habitat for the purposes of Annex I of the EU Habitats Directive [57]. The results demonstrate that sessile taxa associated with reef habitats are also now present on pebbly sand habitats in Lyme Bay that have been protected from bottom towed fishing gear for three years. These sessile species are found in greater abundances on pebbly-sand habitat in areas closed to fishing compared to those where bottom towed fishing continues [57].

From a socio-economic perspective the restrictions on bottom towed gear within the Lyme Bay MPA has enabled the ecosystem to function and support the ongoing delivery of the ecosystem services. From a fishing perspective and the maintenance of the flow of the beneficial ecosystem service of food production, the static gear sector of the fishing industry are the main beneficiaries as the MPA provides a safe haven in which they can set their pots and nets [18]. For the beneficial ecosystem service of leisure and recreation, the MPA is attracting divers and anglers from sites outside the MPA (and potentially further afield for divers) to sites inside the MPA. Charter boat operators have, in the 2010-2011 period also increased their frequency of use of sites within the MPA. Additionally the MPA has increased the value of the resource which may have knock-on effects to local businesses and services onshore that benefit from the direct expenditure of divers and anglers (e.g. shops, car parks, hotels close to MPA access sites).

Caution must be exercised though as wider studies have demonstrated that diving can, for example, have adverse effects on benthic features [58-60]. Additionally angling can increase pressure on fish stocks that have both a recreational and commercial value [61]. With this in mind there is potentially a case for including wider business planning in MPA management (e.g. voluntary codes of conduct for divers and anglers) where MPA managers are the conduit for ensuring the outward flow of ecosystem services provided by the species and habitats within MPAs rather than the enforcers of rules and regulations [62]. Wider studies have demonstrated that any economic gains may not necessarily benefit local communities. At a case study targeting recreational fishermen in the NW Mediterranean, it was shown that though anglers spend approximately €600 a year on their activity, 95% of that expenditure did not occur within towns or villages within the MPA [63]. Within Lyme Bay there may be opportunities to raise levies to undertake recreation activities within MPAs via recreation permits that could further fund MPA management, scientific studies or support enforcement activities.

As stated, the monitoring of the Lyme Bay MPA in the period 2008-2011 has uniquely tracked both ecological and socio-economic effects of the closure. The inclusion of data related to the effect of the MPA on the recreation and leisure industry has informed local management actions and has ensured that those who represent recreation and leisure interests now have a central place in local decision making forums. What must not happen is that the economic advantages received by the recreation and leisure sector then serve to marginalise the fishing sector [45]. MPAs are known to be more successful in supporting ecological and socio-economic goals as long as a diversity of stakeholders are engaged in the management process [64]. If the Lyme Bay MPA is to continue to meet the primary ecological objectives for which it was initially designed then all stakeholders must remain participants in the decision making process and maintain their involvement in monitoring MPA performance from both inside and outside the MPA boundaries.

1. **Conclusion**

The ability of marine ecosystems to provide services for human wellbeing depends on the health and functionality of its physical and biological components [8]. In the case of Lyme Bay the removal of bottom towed gear has enabled the recovery of the reef habitat thus maintaining those ecosystem functions that support the ongoing delivery of the beneficial ecosystem service of leisure and recreation. For some recreation and leisure stakeholder groups, most notably divers and anglers, the Lyme Bay MPA has influenced where they undertake their activity. Whilst there has been an increase in value of the recreation and leisure sites within the MPA this does not necessarily translate to an increase in expenditure or turnover relating to their activity. Rather it signals a potential transfer in where recreational stakeholders are choosing to spend their time. It is possible that as the profile of the MPA grows nationally as place for a first class diving and angling experience then visitors may start to arrive from further afield or that divers and anglers who are new to the recreation activity choose to start out in Lyme Bay thus enabling dive businesses and charter boat operators to benefit from new business. The potential is clear as are the potential pitfalls of effects on the marine resource as a result of increasing recreation and leisure activity and an unbalancing of the stakeholder dynamics in the decision making process.

As the number of MPAs designated continues to increase it will become critical to monitor and assess MPA performance from both an ecological perspective and a socio-economic perspective [7]. Conservation theory and practice is moving away from excluding resource users and towards creating partnerships with them. It is becoming increasingly clear that conservation of marine ecosystems is as much about understanding people as it is about understanding ecological processes. Social and economic factors can influence whether and how individuals and communities exploit resources or cooperate to conserve them. Integrating high quality social science at conservation sites can help to adapt and refine management strategies to reflect the needs and desires of the stakeholders. It also enables the selection of strategies that are appropriate for local conditions, and ensures that scarce resources are used more wisely by targeting specific strategies at the segments of the population where they are most needed. It is essential that the broader socio-economic context of MPAs is monitored and used to inform onward management planning. This, if left unchecked may derail any aspiration that MPAs may hold in supporting goals for sustainable use of the marine resources.

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**Figures captions**

Figure 1 Lyme Bay

Figure 2. The spatial change in the frequency of activity at recreation sites in Lyme Bay. The frequency count across all stakeholder groups was divided into 11 categories using Jenks natural breaks in ArcGIS, which classifies natural breaks in the data. This resulted in five negative frequency categories, five positive frequency categories and a category representing 0, symbolising no change in the frequency of activity between years. The same eleven categories were used for all maps so that each can be directly compared.

Figure 3. The annual change in frequency of visits to recreation sites in a) Lyme Bay and b) the Lyme Bay MPA represented as a proportional change in total turnover/expenditure from the 2008 baseline.

Figure 4: Change in dive business a) turnover, b) the number of students learning to dive, c) the number of divers, Charter boat operators d) turnover, e) number of diver on trips and e) number of anglers on trips in the years 2008, 2009, 2010 and 2011. NB – in 2010 and 2011 two dive businesses had closed and by 2011 12 charter boat operators had either retired or gone out of business