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# Assessing the Impacts of Establishing MPAs on Fishermen and Fish Merchants: The Case of Lyme Bay, UK

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**Abstract** Shortly after the implementation of a marine protected area (MPA) in Lyme Bay in 2008, inside which scallop dredging and bottom trawling is prohibited, a socio-economic impact assessment was initiated. This article presents the initial findings from this study. The aim was to understand the costs and benefits to fishermen and fish merchants of establishing the MPA. These were assessed using a combination of primary and secondary data. The results indicate that the impacts of the closure differ according to the gear type and the fishing location used by the fishermen. Static gear fishermen who fish inside the closed area have seen changes in terms of increased fishing effort, mostly because they have been able to increase the number of crab and whelk pots they deploy. The effects of the closure on static gear fishermen who fish outside the closed area has been reported in terms of increased conflicts with towed gear fishermen who now fish regularly in their traditional grounds. Fishermen using towed gear on the other hand have been impacted through displacement effects as they have been forced to look for other fishing grounds outside the closed area. Most fish merchants and processors initially claimed that they were heavily impacted by the closure but when they were interviewed 1 year after the closure they suggested a more stable picture. Preliminary analyses of landings data indicate that the introduction of the MPA has so far had minimal impacts on the average incomes and financial profits of fishermen and fish merchants. This conclusion, however, reflects a short-term view as the impacts of the closure of Lyme Bay are likely to be felt for a long time to come.

**Keywords** Costs and benefits · Conservation-people conflicts · Perceptions · Resource users · Socio-economics

## INTRODUCTION

The socio-economic impact of marine protected areas (MPAs) is currently of particular interest in the United Kingdom (UK) where the Marine and Coastal Access Act commits the UK Government to deliver an ecologically coherent network of MPAs in English and Welsh territorial waters and UK offshore waters by 2012 (Marine and Coastal Access Act 2009). MPAs are considered an essential means of delivering an ecosystem-based approach to management, being able to protect and conserve species, habitats, ecosystems and ecological processes (Goni et al. 2000; Garcia-Charton et al. 2000; Gell and Roberts 2003; Roberts et al. 2005). Following concerns about the damage caused by mobile fishing gear on the structure and complexity of ecosystems, and the increase in scientific evidence of such damage (e.g., Currie and Parry 1996; Watling and Norse 1998; McConnaughey et al. 2000; Kaiser et al. 2000; Kaiser et al. 2002; Kaiser et al. 2006; Tillin et al. 2006), the UK Government took advice from its conservation advisors (Natural England) and in July 2008, closed part of the Lyme Bay reefs to scallop dredging and demersal trawling gear to protect marine biodiversity against damage incurred as a result of towed benthic gear. This statutory closure represents a major attempt on the south coast of the UK to implement an MPA as a tool to protect marine life.

Closing the Lyme Bay reefs to scallop dredgers and demersal trawlers has led to considerable attention because of the significant, and sometimes conflicting, interests of conservation bodies, fisheries and recreation sectors in the area. The reefs in Lyme Bay contain a highly diverse community of erect sponges, gorgonian corals and bryozoans, many of which are highly sensitive to physical disturbance such as that caused by demersal trawled fishing

gear (Jackson 2007; Hiscock and Breckles 2007). Lyme Bay is also an important fishing area, particularly for towed gears, such as scallop dredges, and for static gear, such as pots for crab, lobster, and whelks. Local vessels that fished in the area prior to the closure include approximately 25 >10 m trawlers and scallopers, 25 <10 m trawlers and scallopers, and 90 vessels involved in netting, potting or whelking activities (Andrews 2008). The fisheries within the Bay area are highly mixed and seasonal, with annual variations in activities being driven by a number of factors, including weather conditions, the varying availability of stocks and the financial returns available on different species (Stevens et al. 2007).

The Lyme Bay reefs are also popular for sea angling and diving among other recreational uses. Stevens et al. (2007) identified nine active dive businesses that used the Lyme Bay area generating a total turnover of ~£980,000 per annum. Similarly, Rees et al. (2010a) estimated the annual value of recreational activities in Lyme Bay to be over £3.9 million. The closure of the reefs therefore has immediate and long-term social and economic impacts for a wide range of user groups that need to be understood and quantified. Understanding these impacts is important because it provides the context necessary to analyze the level of support that the closure of Lyme Bay will receive from the local communities (Sanchirico 2002; Carter 2003; Pomeroy et al. 2004).

Surveys indicate that primary stakeholders living adjacent to protected areas often disproportionately bear the costs of conservation management strategies, particularly those associated with the type of restrictions on the use of resources (Hough 1988; McClanahan and Mangi 2000). For instance, commercial fishermen who are displaced by closures arguably bear most of the costs in the short run when a protected area is established, as improvements in catch may only be realized in the distant future (Sanchirico 2002). In fact, displacement of effort both across the fishing grounds and into other fisheries is arguably a fundamental driver in determining the distribution, type and magnitude of the costs and benefits from MPAs. Such fishing effort displacements have knock on effects to fish processors and merchants down the supply chain. In their environmental impact assessment, Andrews (2008) estimated that the costs to fishing fleets due to the closure of Lyme Bay area would be ~£230,000 for the first year alone, mainly as a result of decreased landings. Curtis and Anderson (2008) on the other hand, estimated that closing Lyme Bay to scallop dredging and benthic trawling would result in losses to annual scallop landings of £1.4 million per year. Both these studies assumed that establishing the MPA would result in a 50% reduction in total landings by scallop fishermen, the difference being Andrews (2008) used average landings from vessels recorded in the ICES

rectangles 30E6 and 30E7 between 1997 and 2007, while Curtis and Anderson (2008) used average landings from vessels recorded between 2005 and 2006. Since scallop landings in 2005 and 2006 were particularly high (i.e., 1.2 times higher than in 2007 and ~3 times higher than the previous 8 years), the estimate by Curtis and Anderson (2008) is much higher than that of Andrews (2008).

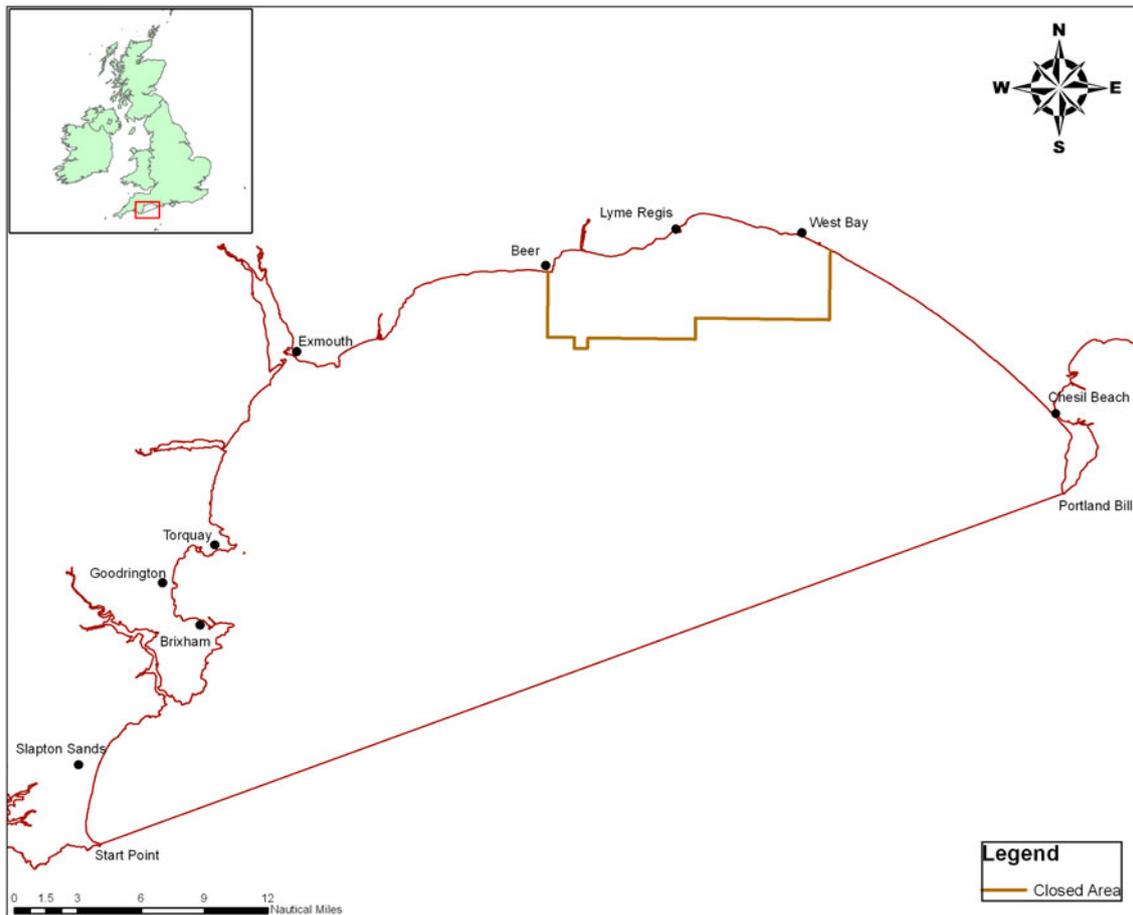
In this article, we explore the initial socio-economic impacts of closing Lyme Bay to scallop dredging and trawling on commercial fishermen and fish merchants, examining their perceived changes to fishing income and costs. Social impacts and perceptions of local communities towards increased marine protection are dynamic and change rapidly over time. The main purpose is, therefore, to analyze the changes that have occurred 1 year after the introduction of the closure to establish a baseline upon which future changes could be assessed. Consequently, we examine changes that have occurred associated with the implementation of the closure on four main areas: (1) diversification and gear changes; (2) changes in areas fished and distribution of fishing effort; (3) changes in wet weight and value of landings; and (4) changes in incomes and profitability.

## MATERIALS AND METHODS

### Study Site

Lyme Bay is situated on the south west coast of England (Fig. 1). The reef areas comprise rock and mixed ground (sand, gravel, pebbles, cobbles, and boulders) that support colonies of nationally important marine features including sponge (*Axinella dissimilis*), ross coral (*Pentapora fascialis*) and dead man's fingers (*Alcyonium digitatum*). The Lyme Bay reefs are considered to be both nationally and internationally important in conservation terms as they are home to pink sea fans (*Eunicella verrucosa*) and the sunset cup coral (*Leptopsammia pruvoti*) which are listed for conservation under the Wildlife and Countryside Act 1981, the UK Biodiversity Action Plan 1995, and included in the IUCN Red List (Hirst and Attrill 2008).

In 1991, conservation charity, Devon Wildlife Trust, together with Natural England called for a greater protection of the reefs in Lyme Bay. In 1992, 1998 and 2001, Devon Wildlife Trust conducted dive surveys that provided evidence of the damage caused by scallop dredging to the reefs (DWT 2007). The surveys showed that an area of reef locally known as The Exeters had been completely destroyed, and, in using data on known pink sea fan locations, three other areas (Lanes Ground, Beer Home Ground and Saw tooth Ledges) were in need of urgent protection (Rees et al. 2010b). Results from these surveys



**Fig. 1** Map of Lyme Bay showing the area that is closed to scallop dredging and demersal trawling

led to an agreement in 2001 between local fishermen and the environmental groups to voluntarily close two reefs (Saw tooth Ledges and Lanes Ground) to scallop dredging and demersal trawlers. As the closure was voluntary rather than statutory, enforcement of rules was conducted by the local community. However, as a result of increases in prices of scallops on the market and the absence of quota for this species, the number of fishing boats increased dramatically leading to increased infringements. In 2006, it was agreed that the local community was not in a position to enforce the closure (English Nature 2006) leading to a breakdown of the voluntary closure.

In 2006, English Nature (now Natural England), the UK Government’s conservation advisors, applied for a stop order under the Sea Fisheries Act 1967 to prohibit demersal fishing across an area of 206 km<sup>2</sup>. The fishermen responded by forming the South West Inshore Scallopers Association (SWISA) and put forward a compromise proposal to increase the number of voluntary closed areas to four, adding Beer Home Ground and East Tennant’s Reef (Rees et al.2010b). This proposal was accepted by the Fisheries Minister, under the condition that a full public consultation would be

undertaken. In September 2006, the issue went to public consultation, with three options: Option A, continue to rely on the areas of protection agreed in which towed gear is excluded; Option B, exclude the use of all towed gear, by either sea fisheries committee (SFC) byelaw or order, in an area of 86 km<sup>2</sup>; and Option C, exclude the use of all towed gear, by either SFC byelaw or order in an area of 206 km<sup>2</sup>. The result of which was an announcement in June 2008 by the Fisheries Minister that the Government had reached a decision to close the full 206 km<sup>2</sup> of Lyme Bay reefs. From the 11th July 2008 the use of dredges and demersal trawls became prohibited through a Statutory Instrument 1584 (Defra 2008). The Lyme Bay closure does not include a no-take zone; it only restricts the use of scallop dredgers and bottom trawlers in the protected area while fishing using pots and nets, sea angling, scuba diving for submerged collection of scallops, and other recreational uses are allowed.

**Primary Data**

Fishermen extract resources while fish merchants and processors buy these resources and sell them at the market.

This initial study focused on these two stakeholder groups because they were expected to bear the immediate costs of the closed area. To evaluate their perceived changes to income, fishing costs and businesses as a result of the closure, a questionnaire was developed for the fishermen, while fish merchants were surveyed using semi-structured interviews. Both the fishermen's questionnaire and the questions used in the semi-structured interviews with fish merchants were designed to elicit the impacts that the closed area was having on the respondents' costs and incomes. The fishermen's questionnaire was pilot-tested, face-to-face with four fishermen and later revised based on the comments received from respondents. A postal survey was then conducted immediately after the closure and then 1 year later using the same questions to ensure that results are comparable. Follow-up telephone calls were used to encourage those who had not responded to complete the questionnaire and to clarify ambiguities in responses in completed questionnaires. In order to explore changes that the respondents perceived to be due to the closed area, two surveys were conducted: one immediately after the closure between September and December 2008, and the other 1 year after the closure, between December 2009 and March 2010.

The questionnaires included closed-ended questions to gather specific information about changes in fishing activities. The questions were divided into three broad categories. The first section required basic information of the respondent including: (1) the gear type they currently used; (2) how long they had been using that gear; (3) whether it was the same gear they used before the closure; and (4) whether it was their preferred gear type. The length of time they had been fishing in general and the specific number of years fishing in Lyme Bay was also recorded. The second section of the questionnaires focused on costs due to the closure, with questions asking respondents to relate costs before and after the closure. The third section focused on the incomes derived from fishing, including their perception of whether these had increased, decreased or stayed the same, and any additional incomes sources that the fishermen had. Fishermen were also asked to express their opinion about the reasons for any perceived changes to costs and incomes.

Names and addresses of 157 vessel owners who use Lyme Bay were acquired through the local Marine Management Organization (MMO) office and were contacted to take part in the survey. Of these, 16 declined to participate in the survey because they had not fished in the Lyme Bay area and they did not want to compromise the views of their colleagues. A total of 43 responses (30%) were received in the first survey, and 31 responses (21%) in the second survey.

Fish merchants and fish processors from Devon and Dorset were identified through records held by the local MMO office and the Yellow Pages. Each merchant was contacted by telephone to ascertain their previous level of involvement in the processing of scallops from Lyme Bay. They were also asked to identify other fish merchants involved in the scallop trade who may have been affected by the closure of Lyme Bay. This initial search identified seven key processors, six of whom were subsequently interviewed twice, by telephone and follow-up e-mails. The semi-structured interviews with the fish processors and merchants used a mixture of open and closed-ended questions that focused on the previous involvement of the merchants in buying scallops from Lyme Bay, the volume they processed before and after the closure, quality and price of scallops bought from Lyme Bay, the perceived impacts on their business that could be attributed to the closure and what they were doing to overcome any difficulties arising.

### Secondary Data

Data on the volume of species landed by different gear types were obtained from the MMO for each vessel that has fished in ICES statistical rectangles 30E6 and 30E7 from 2005 to 2009. Catch data from these two ICES rectangles were used since the closed area is located within these two rectangles. The catch data included the wet weight and value of landings reported by fishermen and fish merchants to the MMO landed at various ports around the South West of England. The dataset included the date the fishing took place, the length and registration number of the vessel, the ICES rectangle fished, and the gear type used.

### Data Analyses

Given that it is only benthic mobile gear types that are restricted in the closed area, analyses were completed with data pooled together into either towed or static gear types. Data on the perceptions of fishermen towards changes in income, costs, travel time to fishing sites, and fishing duration were reported, based on the proportion of fishermen who participated in the survey. The responses are presented for the first survey, which was conducted immediately after the closure, and the second survey, which was conducted 1 year after the closure was introduced. Changes in fishing gear types used and whether fishermen have diversified their incomes as a consequence of the closure were analyzed based on data collected directly from the fishermen. Responses of the fish merchants and processors are summarized from the two rounds of interviews.

Total catches from ICES rectangles 30E6 and 30E7 were plotted for four periods: from July 2005 to June 2006; July 2006 to June 2007; July 2007 to June 2008; and July 2008 to June 2009. Data were analyzed for all species landed by static gear, all species landed by towed gear and then for scallops landings alone. Based on information from enforcement agencies and data on sightings, daily catches for each vessel were matched to the corresponding location of the vessel on the date when fishing was undertaken. The assumption was that the catch of each vessel came from the location at which the vessel had been sighted. The fishing locations were categorized as either inside or outside of closed area. The value of landings from each of these two fishing locations were then plotted and compared based on the gear types used. To study changes in fishing effort following the closure, the number of vessels and number of trips made in each month was used. Data were tested for normality (Shapiro–Wilk test) and homogeneity of variance. Data were normally distributed and therefore one-way analysis of variance (ANOVA) on the value of catches and number of trips taken was used to examine changes in landings for fishermen that had used static or towed gear, and where a significant difference was found, Tukey's post hoc test was used to compare the differences between pairs of years. The value of catches from 2005 to 2008 was converted into 2009 prices using retail price index.

To determine the average cost a fisherman incurs each day, data were gathered from questionnaires with the fishing vessel owners. Each respondent was asked to state the average cost per day for fishing trips made to Lyme Bay including costs for fuel, crew share and licenses. Given that the questionnaires were conducted in 2008 and 2009, costs data for earlier years were obtained from Seafish Economic Survey report (Anderson 2007). The cost per day for each gear type was then estimated from these data. Income data focused primarily on the vessel's income from fishing and was estimated based on the landings recorded for the vessel. Once the costs and incomes for each vessel were calculated, financial profit was obtained by subtracting the costs from the income for each vessel.

## RESULTS

### Perceived Changes to Income and Costs

The majority of the respondents (73%) who use towed gear stated that their income had decreased immediately after the closure (Table 1). This is a view shared by almost half (40%) of static gear fishermen, while 52% of static gear fishermen stated that fishing incomes have remained at similar levels to before the closure. Seventy one percent of all fishermen from the first survey and 81% from the second survey stated that

total costs have increased. The reasons provided for the increased costs include increased fuel costs (56% of respondents); and longer fishing duration (43% of respondents). Static gear fishermen fishing outside the closed area stated that the fall in income is due to the displacement of towed gear fishermen into fishing grounds traditionally used by static gear fishermen. Another reason given was that the quality of scallops harvested from outside the closed area is lower, and hence they fetched lower prices. Over 80% of towed gear fishermen have seen increases in the time they take to travel to fishing sites, while most of the static gear fishermen have seen no change, as their fishing grounds have remained the same.

Most of the fishermen (74%) stated that they had no other income source and attributed 98 to 100% of their monthly income to fishing in Lyme Bay. Results also indicate that only four fishermen (6%) have changed gear as a result of the closure. The majority are still using their preferred gear type while two fishermen have changed gear type, but not as a consequence of the closure. For example, one sold his fishing vessel because of restrictions to catch quotas.

During the first round of interviews, fish processors and merchants claimed that they had been heavily impacted by the closure. The main impacts they felt included a decrease in number of boats landing scallops hence sourcing fewer scallops from Brixham market, and decrease in quality of scallops and subsequent decrease in customer satisfaction (Table 2). During the second survey, however, most fish merchants seemed to claim that there were no major impacts that they could attribute to the closure. The majority claimed that the closure has had little effect on their businesses. They had seen no change in the quality of scallops purchased and felt that the reduced volumes of purchases are part of seasonal cycles and not necessarily due to the closure. Most are still sourcing scallops from the same boats that now fish in more distant areas. Most fish processors and merchants claimed that they were not experiencing major impacts but they were concerned that the fishermen were being heavily impacted by the closure.

### Changes in Value of Landings

The value of landings for static gear fishermen significantly increased ( $F = 5.4$ ,  $P < 0.01$ ,  $n = 48$ ) between 2005 and 2009, while catches for towed gear show a significant decrease ( $F = 9.1$ ,  $P < 0.01$ ,  $n = 48$ ) during the same period (Fig. 2). Changes in landings for all species caught by static gear fishermen indicate that catches in 2005 were significantly lower ( $P < 0.01$ ) than in other years, while catches for towed gear fishermen indicate that landings in 2005 were significantly higher ( $P < 0.01$ ) than in the other years (Table 3). The total value of landings of all gear

**Table 1** Percentage of towed and static gear fishermen and their perceived changes to income, total costs, travel time to fishing sites, number of fishing trips and fishing duration showing responses (a) immediately after the closure, and (b) 1 year after the closure of Lyme Bay

Perceived changes to	Gear	Increased (%)	Decreased (%)	Same (%)	No response (%)
(a) Immediately after closure					
Income	Towed	0	73	20	7
	Static	4	40	52	4
Total costs	Towed	73	0	7	20
	Static	68	0	28	4
Travel time to fishing sites	Towed	80	0	13	7
	Static	16	4	76	4
Number of trips per month	Towed	13	0	87	0
	Static	4	4	76	16
Fishing duration	Towed	67	0	20	13
	Static	28	4	64	4
(b) 1 Year after closure					
Income	Towed	0	83	8	8
	Static	6	44	39	11
Total costs	Towed	83	8	0	8
	Static	78	0	11	11
Travel time to fishing sites	Towed	75	0	8	17
	Static	17	0	50	33
Number of trips per month	Towed	0	17	75	8
	Static	0	11	89	0
Fishing duration	Towed	50	25	8	17
	Static	28	6	50	17

A total of 15 towed gear fishermen and 25 static gear fishermen responded to the surveys immediately after the closure, while 12 towed gear fishermen and 18 static gear fishermen responded 1 year after closure. *Source of data:* questionnaire responses from fishermen

**Table 2** Relative importance (%) of the main impacts reported by fish merchants

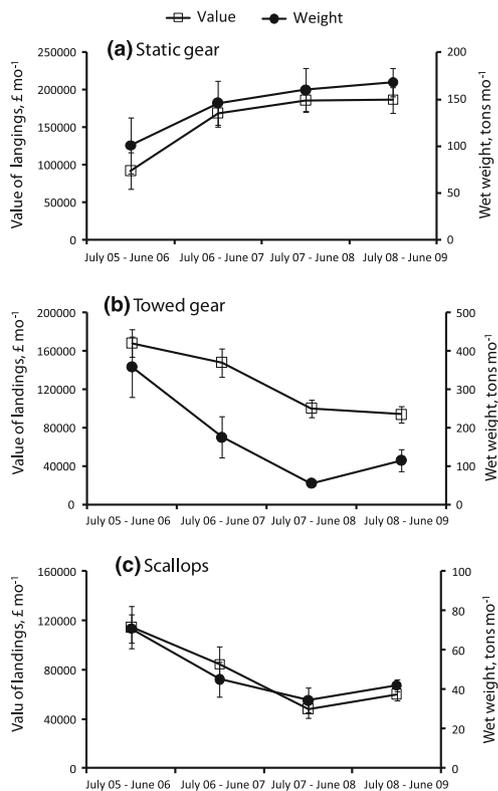
Main impacts felt	Immediately after closure	1 Year after closure
Decline in number of boats landing scallops hence sourcing fewer scallops from Brixham market	27	
Decrease in quality of scallops and subsequent decrease in customer satisfaction	20	
Increase in haulage costs from sourcing scallops from more distant areas	7	10
Loss of trade	13	
Buying scallops from bigger boats that fish further places	7	10
Closure has had no effect on business	13	25
No change in quality of scallops		20
Fishing boats are fishing in other areas such that the volume of scallops reaching the market has not changed		15
Sourcing scallops from same boats as before the closure	13	20
Our main concern is for the fishermen as we source scallops from other areas they cannot		35

Respondents belonged to six key fish merchants from Devon and Dorset immediately after the closure, and seven fish merchants 1 year after the closure. *Source of data:* questionnaire responses from fish merchants

types from July 2007 to June 2008 (1 year before the closure) was not statistically different to the value of landings from July 2008 to July 2009 (1 year after the closure). These landings data reveal that the majority of the

catches for static gear fishermen have been coming from outside the closed area (Fig. 3a).

Landings data show that the number of fishing vessels fishing inside the closed area using static gear ranged

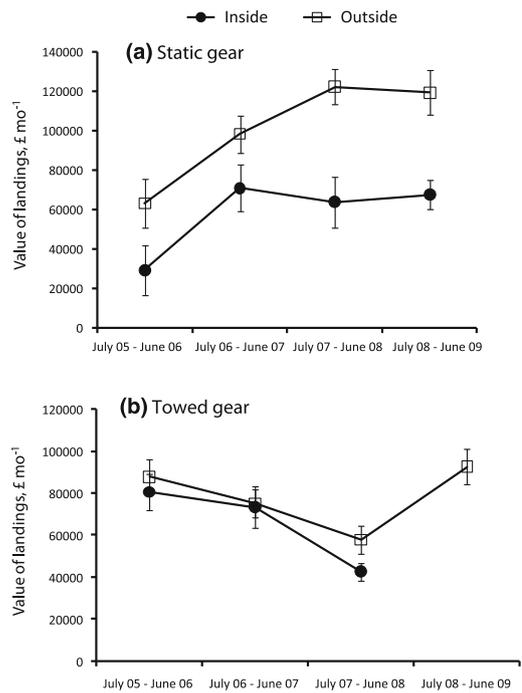


**Fig. 2** Value and wet weight of landings from 2005 to 2009 for **a** all species landed by static gear, **b** all species landed by towed gear, and **c** scallops only from vessels that had fished in the ICES rectangles 30E6 and 30E7. Error bars are SEM. Source of data: MMO landings data 2005–2009

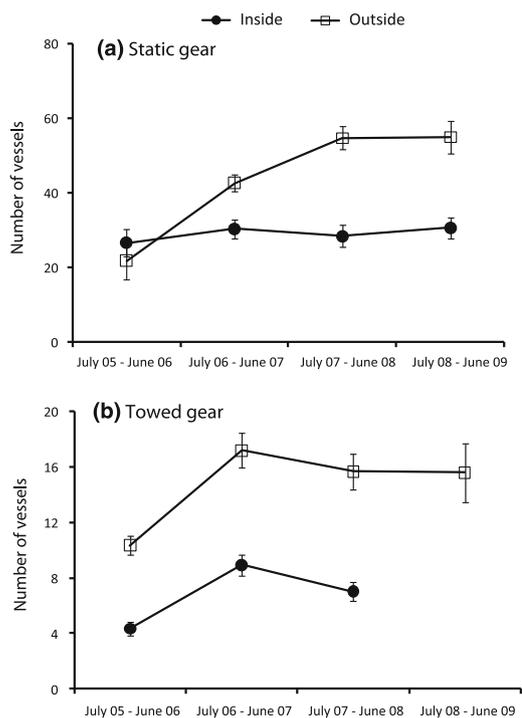
**Table 3** Results of the post hoc Tukey’s test for differences between years on the value of catches from landings data for the gear types shown on Fig. 2

	July 05–June 06	July 06–June 07	July 07–June 08	July 08–June 09
(a) Value of landings using static gear $F = 5.4, P < 0.01$				
July 06–June 07	+			
July 07–June 08	+	NS		
July 08–June 09	+	NS	NS	
(b) Value of landings using towed gear $F = 9.1, P < 0.01$				
July 06–June 07	NS			
July 07–June 08	+	+		
July 08–June 09	+	+	NS	
(c) Value of scallops $F = 5.9, P < 0.01$				
July 06–June 07	NS			
July 07–June 08	+	NS		
July 08–June 09	+	NS	NS	

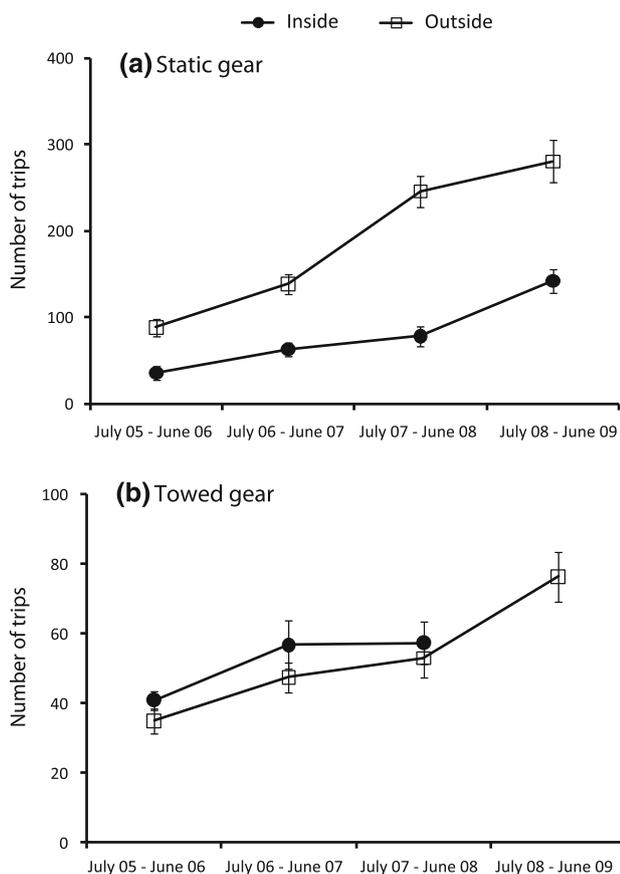
Tukey’s test: +, significant at  $P < 0.01$ ; NS, not significant;  $n = 48$ . Source of data: Marine Management Organization (MMO) landings data 2005–2009



**Fig. 3** Mean monthly value of landings (£) for fishing vessels that use **a** static gear, and **b** towed gear comparing the value of landings when fishing had been conducted inside or outside of the closed area. Error bars are SEM. Source of data: MMO landings data 2005–2009



**Fig. 4** Number of vessels from landings data from 2005 to 2009 using **a** static gear, and **b** towed gear showing the number of vessels fishing inside or outside of the closed area. Error bars are SEM. Source of data: MMO landings data 2005–2009



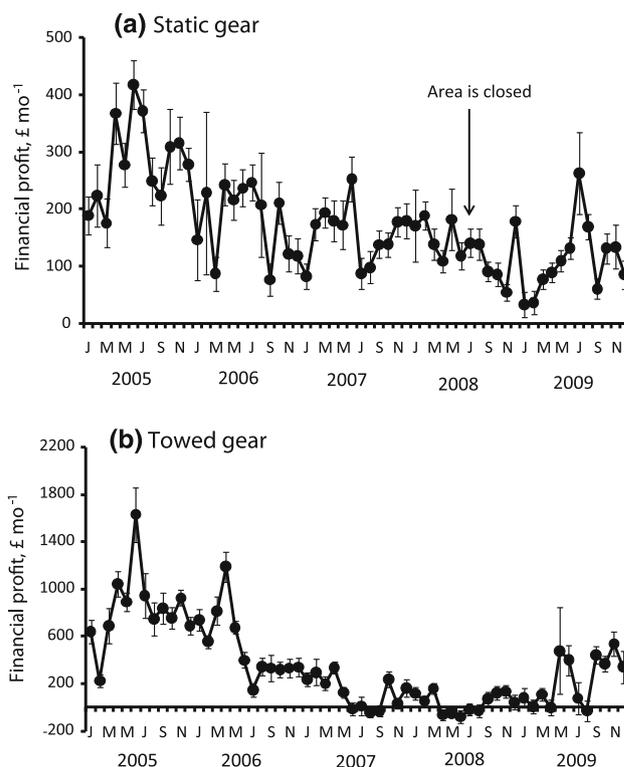
**Fig. 5** Number of trips based on landings data made by commercial fishermen using **a** static gear and **b** towed gear fishing either inside or outside of the closed area. Error bars are SEM. Source: MMO landings data 2005–2009

**Table 4** Results of the post hoc Tukey’s test from landings data for differences between years on the number of trips taken inside and outside of the closed area by static gear fishermen shown in Fig. 3

	July 05–June 06	July 06–June 07	July 07–June 08
(a) Number of trips into the closed area by static gear fishermen <i>F</i> = 15.6, <i>P</i> < 0.001			
July 06–June 07		NS	
July 07–June 08			NS
July 08–June 09	+	+	+
(b) Number of trips by static gear fishermen to areas outside of closed area <i>F</i> = 27.7, <i>P</i> < 0.001			
July 06–June 07		NS	
July 07–June 08	+	+	
July 08–June 09	+	+	NS

Tukey’s test: +, significant at *P* < 0.01; NS, not significant; *n* = 48. Source of data: Marine Management Organization (MMO) landings data 2005–2009

between 27 and 31 vessels per month from 2005 to 2009 (Fig. 4a). The number of vessels using static gear fishing outside of the closed area rose, although not significantly,



**Fig. 6** Financial profitability of fishing operations for **a** static gear and **b** towed gear fishermen from 2005 to 2009. Costs data were obtained directly from fishermen through questionnaires. Profit was calculated as value of landings (income) minus average costs. Error bars are SEM. Source of landings data: MMO 2005–2009

from 22 in 2005 to 55 vessels per month in 2008. The number of trips has, however, been rising significantly (*P* < 0.001, *n* = 48) for static gear fishermen fishing inside and outside of the closed area (Fig. 5; Table 4). Before the closure, fishing trips made by fishermen using towed gear were to both inside and outside of the closed area, however, this changed from July 2008, when all of the towed gear fishermen were banned from fishing inside the closed area.

Analyses of the profitability of the fishing operations illustrate that in general, financial profits for both towed and static gear fishermen have been declining from 2005 to 2009 (Fig. 6). Most of the fishing operations carried out by static gear fishermen were profitable throughout the study period, whereas towed gear fishermen made losses between July to September 2007, and between April and August 2008 (Fig. 6b). Results indicate that profit margins were very low immediately after the closure but started to rise 8 months afterwards. The profits between May and December 2009 (1 year after closure) were much higher than those of the last 2 years before the closure. This could be an indication that fishermen have adjusted to the initial disruption of the closure on their activities.

## DISCUSSION

The establishment of the closed area has affected various fishing activities in Lyme Bay and imposed a number of costs and benefits on the various stakeholders. In this study, we examined the initial impacts of the closure on commercial fishermen and fish merchants, in order to evaluate the changes that have occurred 1 year after its establishment. The results indicate that the impacts differ according to the gear type and the fishing location used by the fishermen. Most static gear fishermen who fish inside the closed area have seen changes in terms of increased fishing effort, mostly because they have been able to increase the number of crab and whelk pots they deploy. The effects of the closure on static gear fishermen who fish outside the closed area has been reported in terms of increased conflicts with towed gear fishermen who now fish regularly in their traditional grounds. Fishermen using towed gear on the other hand have been impacted through displacement effects as they have been forced to look for other fishing grounds outside the closed area. Despite the impacts felt by the fishermen, fishing in Lyme Bay has remained profitable 1 year after the closure implying that the loss of access to fishing grounds in the closed area has been compensated for by the remaining fishing grounds. This conclusion, however, is based on preliminary findings and reflects a short-term view as the impacts of the closure of Lyme Bay are likely to be felt for a long time to come. This is the view shared by most fishermen and fish merchants who informed us that the impacts of the closure are yet to be fully realized.

Fishermen using towed gear have had to look for other, often more distant, fishing grounds and so experienced increased costs associated with fishing time and location such as an increase in fuel consumption. Although they are making the same number of trips now as they did before the closure, most trips are to fishing grounds further afield, some of which are not as productive as those in the closed area. Out of the four most productive inshore areas for scallops that have been identified in South Devon coast, only one is outside the closed area (DSFC 2008). Vessels totally dependent on scallops, therefore, have to compete for space within this remaining area, that has seen increased congestion and anecdotal evidence indicates that there is increased conflict amongst towed gear fishermen and between towed and static gear fishermen. Our analysis indicates that fishermen using towed gear are working longer hours to compensate for the loss of the fishing grounds. This strategy seems to enable the fishermen to maintain similar income levels as before the closure. The question is whether this small area will be able to sustain the large number of vessels that will be dredging on full-time basis over the long term.

Due to increases in costs associated with displacement effects, towed gear fishermen may be able to change to static gear enabling them to continue to use their old fishing grounds or they may develop other fishing opportunities. However, this may not be possible for most of the fishing vessels, especially the small ones that fish in Lyme Bay. The size of vessel means that they cannot safely move to other, more distant areas or readily change methods of fishing without a large capital outlay. Furthermore, some vessels may not be capable of being used for alternative methods of fishing due to the specialized equipment used. For example, the opportunity for mobile fishing gear vessels to change over to potting for crustaceans is very difficult (DSFC 2008). Fisheries restrictions in neighboring areas may also be a constraint on relocation of effort. For example, the inshore potting agreement in Start Bay includes areas designated for exclusive static or towed gear use, and for seasonal static and towed gear use (Blyth et al. 2002); restrictions are now in place in Cardigan Bay for scallop dredging; and further MPAs are planned around SW England. The findings from our questionnaires have shown that four fishermen so far have changed gear as a result of the closure.

Fishermen using static gear fishing outside the closed area are concerned that their traditional fishing grounds are being put under increased fishing intensity as a result of the displaced towed gear fishermen. Some respondents said that they had experienced increases in damage to their nets and pots by vessels of towed gear fishermen. Although this was hard to verify with the present data, the increased intensity of use of the grounds outside the closure by towed gear fishermen means that it is very likely that static gear loss and damage is occurring. Conflicts between static and towed gears are not new (Blyth et al. 2002), but could have been intensified by the closure. This could be managed through the use of gentlemen's agreements or through the development of local fisheries management systems such as the inshore potting agreement that exists in Start Bay (Blyth et al. 2002). Such local inshore fisheries management systems have been shown to reduce conflicts between static and towed gear fishermen, but a number of factors are critical for their success including: (1) a limited number of organizations representing the fishermen; (2) a very high level of membership of those organizations; and (3) simple and clear rules (see Blyth et al. 2002).

Fishermen using static gear fishing inside the closed area have benefited from the closure by having more space to spread their pots and nets. As their fishing territories have expanded, most of them appear to have used the extra fishing space to double the number of pots they deploy. By doing this, static gear fishermen have enjoyed profitable fishing operations after the closure. Some static gear fishermen claimed that there is now very little space for

additional static gear in the closed area meaning that static gear fishermen can only create space for additional pot strings by moving existing strings closer together. If this is the case, then this perceived benefit of the closure may be short-term as the resultant trap aggregation may cause local overfishing (McClanahan and Kaunda-Arara 1996; Miller and Hunte 2000). McClanahan and Mangi (2000) found that by increasing the number of traps a fisherman deployed, fishermen fishing adjacent the Mombasa Marine Park experienced a reduction in the catch per trap. If so, then the MPA management may need to regulate the number of pots inside the closed area if they need to demonstrate that the closure has both conservation and fisheries benefits.

Fish processors and merchants reported that they had experienced difficulties in finding alternative sources of scallops immediately after the closure and they considered the scallops that they were getting from outside the closed area to be of poorer quality, hence of lower value. Some merchants claimed that they had experienced increases in haulage costs from sourcing scallops from more distant areas, while some fish auctioneers reported loss in trade as some buyers were closing their accounts due to reduced supply of scallops. When these same processors and merchants were interviewed 1 year after the closure, they suggested a more stable picture. Most processors were still buying from the same local boats and the boats were catching enough to meet demand. The number of buyers at the Brixham market was still the same as before the closure and that there had been little change in volume or price of scallops sold through the market. Clearly some of these scallops were not coming from Lyme Bay; most were landed by bigger boats that fish further away. It is likely that this change in perceptions from deep pessimism immediately after closure to a moderate level of optimism one year after closure could be because fish processors and merchants were initially uncertain about the livelihoods of the fishermen and their potential to find new scallops grounds. The perceptions of fish merchants towards the closure are a sign that most fishermen might have adjusted to the closure. However, most agree that the full effects of the closure are yet to be felt. Fishing is a complex process that depends on many factors, including the type of vessel and gear used, target species, stock density, weather and time and areas fished (Sancharico 2002). The inputs into this process affect the costs associated with fishing and, therefore, impact the activity level. The fisheries within Lyme Bay are also highly seasonal, e.g. scallop harvesting follows known cycles (Stevens et al. 2007). Annual variations in fishing activities driven by these factors will continue to influence the total costs incurred by fishing fleets and compound the impacts of the closure.

The pessimistic views of fishermen and fish merchants towards the closure were not supported by the landings data, which showed that there have been minimal changes. Most of the variables analyzed through the landings data showed similar levels 1 year before and after the closure, albeit at higher levels of fishing effort. The fishermen's views may be a reflection of the contentious way in which the Lyme bay closure was established and their objection to the process. The decision to establish the MPA in Lyme Bay followed a series of resource use conflicts, mainly between conservation groups and commercial fishermen using dredges and trawlers (Rees et al. 2010b). It was evident from responses to open-ended survey questions that fishermen saw the decision to establish an MPA in Lyme Bay as a top-down intervention from Government, when discussions were still taking place on the best way to balance the various interests in Lyme Bay. The Government, however, argued that it had to intervene since a lengthy bottom up process had largely failed to provide the necessary protection for the reefs (Rees et al. 2010b). These views of fishermen can change in favour of MPAs, however. For example, establishing the Tonga Island Marine Reserve in New Zealand was contentious amongst local residents, holiday makers, recreational and commercial fishermen, who were concerned about its impacts on their activities. However, after 10 years the attitudes of local stakeholders had changed with most in favour of the reserve (Tylor 2003). Similarly, Joyce (1989) found the majority of commercial fishermen in favour of the Leigh Marine Reserve after two decades of its establishment. Fishermen around the Leigh Marine Reserve did not just support the marine reserve but also helped enforce rules by reporting poachers to the enforcement agencies. Given that many fishermen in Lyme Bay felt that the marine environment was a common resource and that rights of access should be granted to all, it is understandable that they find it difficult to accept that this is no longer the case. Overcoming this requires education and consultation if fishermen are to change their attitudes. However, the dilemma is still present whereby conservationists claim that access to the resources of the sea is a privilege, while recreational users believe it is their right to enjoy and fishermen their right to exploit. In exploring changing attitudes to MPAs, it is helpful to acknowledge and engage the diversity of stakeholder groups, each with a distinct perspective (Jones 2008).

Greater stakeholder involvement is required for the successful establishment and management of MPAs (Jones 1999; Jones and Burgess 2005; Beukers-Stewart et al. 2005). In the case of Lyme Bay, the multiplicity of direct and indirect interests means that there is a need to include more people in the decision making process, such as recreational users and local businesses. Ravetz (1999) refers to

this as an ‘extended peer community’. The inclusion of a wider stakeholder community is considered a key element in the adoption of the ecosystem approach (Jones 2001). However, stakeholder processes frequently result in conflict over what are commonly referred to as collective action problems (Jones 2006). Collective action problems are very common in areas of multiple use, where resource use interests are highly heterogeneous and perspectives commonly conflicting (Jones and Burgess 2005). There is therefore a need for advanced frameworks that include a clear weighting of the diverse values held by different stakeholders to ensure that the process of establishing MPA is not hijacked by a minority group, or a group with a disproportionately large voice, and that the distribution of costs and benefits are assessed, including related equity and justice (Jones 2009).

In the UK, a consultation is underway for a network of MCZs through the Marine and Coastal Access Act. This involves four regional partnerships projects that are identifying and recommending a network of sites to Government Ministers through collaboration amongst stakeholders. Information from stakeholders on the ecological, economic and social value of various areas of the sea and seabed is being used to inform the network design, objectives and management strategies. Such a partnership approach in establishing MPAs is welcomed by many stakeholders, and is considered an improvement to the many criticisms that were prevalent during the establishment of the Lyme Bay closure. It remains to be seen whether this collaborative approach reduces subsequent conflicts and objections.

In conclusion, preliminary findings indicate that the introduction of a closed area in Lyme Bay has so far had minimal impacts on the average incomes and profits of fishermen and fish merchants. Most fishermen and fish merchants initially claimed that they are heavily impacted by the closure but this may be a reflection of their objection to the top-down process leading to its introduction. The full social impacts of the closure, such as increased conflicts, longer fishing duration for some fishermen and changes in income distribution, have yet to be fully explored. Although the landings data reported here have been collected from official sources, they are conservative estimates. With respect to catch levels and fishing effort based on landings in UK ports, not all catches by inshore fishing fleet, fishing within 12 nm of the coast, are recorded at landing, although buyers and sellers must report their transactions to fisheries administrations. It is therefore possible that the landings data analyzed here are underestimates of the true level of catches and fishing effort. Assumptions were also made in relating specific landings to the actual location they were caught, and in calculating opportunity cost of the closure. This study has, however,

helped us understand the initial perceptions, costs and benefits to fishermen and fish merchants of the Lyme Bay closure. The findings will aid the facilitation and organization of the appropriate scientific and economic analyses for a long-term monitoring of the impacts of the Lyme Bay closure, as well as future marine conservation zones under the Marine and Coastal Access Act.

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