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An evaluation framework to determine the impact of the Lyme Bay Fisheries and Conservation Reserve and the activities of the Lyme Bay Consultative Committee on ecosystem services and human wellbeing.

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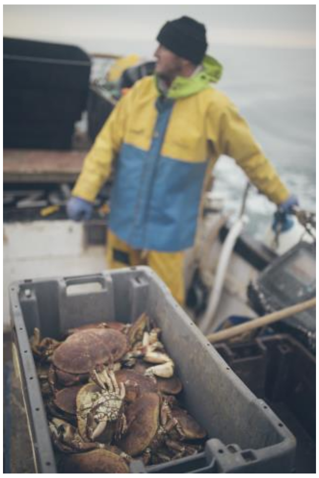

An evaluation framework to determine the impact of the Lyme Bay Fisheries and Conservation Reserve and the activities of the Lyme Bay Consultative Committee on ecosystem services and human wellbeing

Final Report

Submitted by

DISCOVER WITH PLYMOUTH UNIVERSITY
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To the

BLUE MARINE FOUNDATION

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Foreword

The development and success of the Lyme Bay Fisheries and Conservation Reserve has been achieved through a combination of statutory and voluntary management measures over the last decade or so. The initial statutory closure of 60 square miles of Lyme Bay to bottom-towed gear in 2008 was successful in preventing fishing practices destructive to the extensive reef habitats within the designated area but did initially result in a significant increase in the use of static gear by inshore vessels within the closed area.

The Blue Marine Foundation (BLUE) became involved in Lyme Bay in 2011 and set about to address the levels of static gear fishing within the reserve through the formation of the inclusive 'Lyme Bay Consultative Committee' to develop a series of voluntary best-practice management measures that fishermen could sign up to and also benefit from. In addition, collaborative research projects with Plymouth University and Succorfish have investigated the levels of potting that are sustainable within the reserve and successfully trialled the use of a 'fully documented fishery' for inshore vessels.

The evaluation framework presented within this report sets out to show whether the management measures implemented in Lyme Bay have had an effect on the provision of ecosystem services and the well-being of local fishermen. Overall it is clear that closure of the area to mobile fishing gear has enabled important habitats to recover which in turn has supported increased catches of shellfish. Further management and support measures agreed through the Consultative Committee have clearly been successful in improving the well-being for those fishermen directly involved in the project. Measures such as installing chiller units in ports for maintaining fresh catches and the development of 'Reserve Seafood' to sell sustainably-sourced fish and shellfish at a premium have both been very successful and popular with the local fishers involved. Indeed fishermen interviewed for this study strongly agreed that these two measures have benefitted their livelihoods.

The success of the voluntary management measures has continued to grow since the information was collected for this study in autumn 2015. Support from local fishermen and other stakeholders who have participated in the project has been high. Indeed one local environment group has stated that the Lyme Bay Fisheries and Conservation Reserve is a 'vital flagship project for marine conservation in the UK as a whole'. It is therefore important that the initiative is maintained and can continue to provide benefits for the local marine environment and the people that rely on it. Equally the successful approach developed for Lyme Bay can be used as a model for marine conservation and sustainable fishing for other parts of the UK's coastline. This is now being planned as part of BLUE's UK strategy and work programme.

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1 Executive Summary

In this study we present an evaluation framework that integrates ecosystem services and human wellbeing indicators to measure the impacts of: 1) management measures directly associated with the Lyme Bay Fisheries and Conservation Reserve and 2) partnership activities associated more broadly with the Lyme Bay Consultative Committee on Lyme Bay resource users.

Lyme Bay has been noted as being an area of 'high species richness that includes rare and threatened species'(Hiscock, 2007). Habitats of conservation importance include reefs, seagrass beds and subtidal muds. Species of conservation importance in Lyme Bay such as the Pink Sea Fan *Eunicella verrucosa,* are indicators of a structurally complex ecosystem, free from physical disturbance. These habitats and species interact to support the delivery of several ecosystem processes (e.g. primary and secondary production, formation of species habitat) and ecosystem services (e.g. fish for food) within Lyme Bay.

The protection of the reef habitat from bottom towed gear, firstly via voluntary management measures (10km^2) then via a 206km^2 Statutory Instrument (SI closure or closed area), from central government (Defra) in 2008; and finally via byelaws implemented by the Southern Inshore Fisheries and Conservation Authority (IFCA) and Devon and Severn IFCA to protect 236km^2 of Habitats Directive 92/43/EEC Annex I reef features in Lyme Bay, within a 312km Site of Community Interest (SCI) that aims to conserve the reef and associated reef species. Such conservation measures are underpinned by a motive to ensure security of supply for linked ecosystem services. The combination of the SI closure and the SCI form the boundary of the Lyme Bay Fisheries and Conservation Reserve, termed in this report as the Lyme Bay Reserve.

In 2011, a non-governmental organisation (NGO), the Blue Marine Foundation, formed a pro-active working group for the Lyme Bay Reserve, which led to the implementation of more specific MPA management measures. An initial Memorandum of Understanding (MoU) was developed, to be signed by all parties involved in the Lyme Bay Fisheries and Conservation Reserve, including local fishermen, conservation agencies, scientists, IFCAs and MMO representatives. The MoU established the basis for the Working Group (now the Lyme Bay Consultative Committee (LBCC)) for members to promote and implement best practice in fishery and conservation management. Fishery and conservation management actions included a voluntary Code of Conduct proposed as a means of achieving effective management to maintain sustainable fishing practices within the Lyme Bay Reserve. The code of conduct included voluntary measures including the fitting of iVMS (real-time monitoring) systems and caps on the volume of fishing gear deployed by vessels within the Lyme Bay

Reserve. Wider partnership activities by the LBCC included development of new markets and branding, investment in post-harvest icing infrastructure, and knowledge-sharing and training activities. A scientific research project, conducted by a PhD study at Plymouth University, has also been designed and undertaken with the input of fishermen to test the sustainability of potting techniques Many of the activities linked to the LBCC have involved public outreach with educational displays at public events and local fishermen providing talks to schools on fishing activities and commercial species.

Since the initial SI closure in 2008, ecological data have been collected annually by academics from Plymouth University. The results demonstrate that there have been positive responses for species richness, total abundance and assemblage composition for seven out of thirteen indicator taxa (Attrill et al, 2012, Sheehan et al., 2013). These species were found in greater abundance on reef habitat and pebbly-sand habitat in areas closed to bottom-towed fishing compared to those where such fishing continues. Collection of socio-economic data has been more limited, confined to the 3 years post SI closure. Initial results demonstrated that there had been displacement of the mobile (towed) gear fleet and permitted commercial fishing activities had proliferated within the SI closure (Mangi et al., 2011), and recreation participants and providers had increased their use of the area (Rees et al., 2010c, Rees et al., 2015).

This research, commissioned by the Blue Marine Foundation, aims to evaluate the impact of the management measures that form the Lyme Bay Reserve and the partnership activities of the LBCC on Lyme Bay resource users. An evaluation framework has been designed for the purposes of this project in the following parts:

- A review of published research to identify links between the ecology of the case study area and potential ecosystem services (e.g. food, recreation) and measures of human wellbeing;
- A multi-stakeholder workshop to identify key indicators of impact on important ecosystem services and aspects of human wellbeing;
- A synthesis of existing secondary data on fishing activity and landings in Lyme Bay from 2005-2014;
- Primary data collection involving a survey of fishermen to assess the impacts of the management measures associated with the Lyme Bay Reserve and the activities of the LBCC on human wellbeing; and
- An evaluation, providing a confidence rating to assess if each indicator and the wider agreement of evidence can accurately reflect the impact of management measures and the activities of the LBCC.

The results show that the habitats and species of Lyme Bay interact to support the delivery of several ecosystem processes (e.g. primary and secondary production, formation of species habitat) and ecosystem services (e.g. fisheries (for food) and provision of recreation opportunities). Given the short timescale of the project (6 months) it was agreed at a stakeholder workshop that the beneficial ecosystem service of 'commercial fisheries' would be the focus of this research. The stakeholder group agreed a set of indicators most suitable for assessing changes in delivery of ecosystem service benefits of commercial fisheries. These comprise both broad and fine scale indicators:

Broad scale indicators to evaluate the impacts of management measures and the activities of the LBCC inside and outside the Lyme Bay Reserve.

- Landings data from species which are associated with the reef habitat at some point in their life history. Landings data from ICES rectangles 30E6 and 30E7.
- Catch per Unit Effort (CPUE) of commercial species and fisheries supported by reef ecosystem[1].
- Composition of the fishing fleet.
- Fisher employment and new entrants to the industry.

Fine scale indicators to evaluate the impacts of management measures and the activities of the LBCC on fishermen who either fish in the Lyme Bay Reserve (static gear) or have been displaced from the Lyme Bay Reserve (mobile gear).

- Income/profit.
- Past and future investment in the industry.
- Existing and preferred sales strategies.
- Subjective economic wellbeing (income satisfaction).
- Subjective social wellbeing (job satisfaction, conflict).
- Subjective health and wellbeing (stress).
- Number of prosecutions (IFCA patrol time)
- Self-reported compliance.
- Support for the MPA.
- Support for the LBCC and perceptions on whether specific activities had delivered benefits.
- Indicators of outside events (wider influences), including;
    - Fuel prices changes
    - Quota changes
    - Weather events (frequency of storms and adverse weather)

To evaluate whether the broadscale and fine scale indicators accurately reflect the impact of management measures and the activities of the LBCC, a confidence rating is applied which combines

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[1] Calculation of CPUE was not possible due to sensitivity regarding landings linked to the vessel Port Letter and Number (PLN). Changes in effort linked to management measures and the Lyme Bay Consultative Committee have been analysed from the landings data and interpreted as the mean number of vessels per month and the mean number of trips per month from vessels making landings from inside and outside the Reserve from ICES Statistical rectangles 30E6 and 30E7.

an assessment of the quality of the indicator based on the data source and known limitations of the data, with the level of agreement in the evidence e.g. statistical analysis, divergent perspectives in qualitative data.

Analysis of the broadscale indicators demonstrates that, in the UK as a whole, there is a national trend of decline in the number of both under and over 10 metre vessels registered. The number of under 10 metre vessels registered to ports in the wider Lyme Bay region has declined in the 10 year period, from 201 vessels in 2005 to 191 vessels in 2014, supporting this national trend. The number of under 10 metre boats registered to ports within the Reserve boundary has not declined, nor has the number of over 10 metre boats registered to ports both inside and outside the Reserve. There is however, low confidence that this indicator reflects impact that can be attributed directly to management or partnership activities.

Between 2005 and 2014 there has been a significant increase in fishing effort for both vessels using mobile gear (outside) and vessels using static gear types (inside and outside). This indicator is supported by on the ground observations from local fishermen. Landings of whelk *Buccinum undatum* dominate the catch for static gear fishermen operating both inside and outside the Reserve though weight of landings appears to be declining. High whelk *Buccinum undatum* landings may reflect changes in static fishing effort due to the Reserve management measures, but are also influenced by the presence of market demand and related value. Declining weight of landings may also reflect the impact of growth overfishing rather than effort overfishing.

The management measures associated with the Reserve have had significant impacts on static gear fishermen operating inside the Reserve in terms of increases in mean monthly landings (weight and value, mean per vessel per month) for crab *Cancer pagarus* and scallops *Pecten maximus* (SCUBA dive caught). *Cancer pagarus* and *Pecten maximus* are both species that are associated with the protected reef habitat (Annex 1 bedrock reef and stony reef) suggesting that management measures may be beneficial for the associated fishery. Thus, there is higher confidence that these indicators accurately reflect the impact of management measures introduced since 2005. Values of *Cancer pagarus* and *Pecten maximus* (diver caught) landed from vessels using static gear inside the Lyme Bay Reserve are also significantly higher between 2011- 2014 when compared to the years preceding and immediately following the 2008 SI closure. This suggests that a significant change in catch value has been achieved in these latter years as a result of increased landings and the potential influence of the LBCC on the local fishery. There is greater confidence in this relationship for *Pecten maximus* than for *Cancer pagarus* as national fisheries statistics show landings (weight and value) of crab to ports in England by UK vessels have increased between 2009 and 2015, suggesting changes in Lyme

Bay may be within this national trend (Elliott, 2014). Landings (weight and value) of scallops into England by UK vessels have, however, decreased between 2009 and 2014, the period when the greatest increase in landings from within Lyme Bay Reserve (mean per vessel per month) occurred (Elliott, 2014).

Mobile gear fishermen who were displaced from the original SI closure have experienced negative effects of the management measures to create the Reserve. There has been a significant increase in effort required from this fleet to achieve comparable (pre Reserve) landings and value. There is only a medium confidence in this indicator as the limitations of the data from the ICES statistical rectangles do not show where the displaced vessels have gone to replace their income. The significant increase in landing of species associated with static fishing methods by fishermen who predominantly use mobile gear suggests increasing diversification of this fleet.

Analysis of fine scale indicators show changes in key aspects of well-being over time (2005-2015) and differences among static fishermen (those involved in the LBCC or not) and between static and mobile gear fishermen. For static gear fishermen involved in the LBCC partnership activities, job and income satisfaction were high and have increased marginally in the last ten years. Perceived levels of stress and conflict were low and have decreased over the last ten years. This group of static gear fishermen identified the SI closure and LBCC activities as the two most beneficial events, with gear conflicts prior to 2008 and poor weather in 2014-2015 as the two most negative events. This group were strongly supportive of the SI closure and the LBCC, and ranked the perceived benefits of partnership activities very highly, in particular the additional icing infrastructure and the 'Reserve Seafood' brand. Data on existing and preferred sale strategies showed that: 1) between 18-38% of the catch of static fishermen is sold locally, compared to only 5% of the catch of mobile vessels; ii), on average 15% of the catch of static fishermen involved in LBCC partnership activities is now sold as 'Reserve Seafood' at a premium directly to London, and; iii) that fishermen are interested in expanding local and 'Reserve Seafood' sales as, according to fisher testimony, these improve prices.

For static gear fishermen not involved in the LBCC partnership activities, job and income satisfaction are also high but have decreased or remained steady over the last ten years. Perceived levels of stress are moderate and have increased marginally over the last ten years. Perceived levels of conflict were moderate but have decreased to low levels in the last ten years. Many of these fishermen were initially negatively impacted by the SI closure in 2008 but, having fully converted to static gears, now experience the benefits of the Reserve. Poor weather in 2014-2015 and low quotas were the two most important negative events. This group of fishermen were only moderately supportive of SI closure and showed very low support for the LBCC, although there was large variation within the group. Fishermen explained these results by the loss of trust during the implementation of the 2008 SI closure and continued reservations over a lack of broad representation in the LBCC and concerns over its role relative to other recognised management authorities, namely the Inshore Fisheries and Conservation Authorities.

For mobile gear fishermen job and income satisfaction are moderate and have decreased in the last ten years. Fishermen experienced a sharp decline into negative wellbeing in 2008 but have had steadily rising levels of job and income satisfaction since. Perceived levels of stress and conflict are also moderate and have increased over the last ten years, primarily in 2008 with a steady decline since. On average across the ten year period mobile gear fishermen had lower levels of job and income satisfaction and higher levels of perceived stress and conflict than the static gear fishermen. This group of fishermen showed very low levels of support for the both the SI closure and the LBCC largely due to a perception that the consultation process to establish the 2008 SI closure was flawed and the outcome unfair for the mobile sector, particularly in the context of ever declining quota. Given low levels of support from some static and mobile fishermen, perceived non-compliance was reported to be lower than expected and on a downward trend.

The annual income of static gear fishermen from fishing is on average £15,000. The annual income of mobile gear fishermen from fishing is on average £22,500 for half the group and £100,000+ for the other half of the group revealing large income disparities within the sector. Over the last ten years most fishermen across all sectors have invested in their fishing business, and over a third of those we sampled plan to invest further in the near future, with high confidence that future investments will be sufficiently profitable. This investment is encouraging for the fishing industry in Lyme Bay given a wider national context of declining fisheries.

When considered against the much broader UK picture of fleet reduction, quota changes and increased storminess that can reduce time at sea and/or increase ‘risk’ associated with fishing. There are a number of key recommendations for future management of the Lyme Bay Reserve:

- Monitoring and management of the whelk fishery including continued consultation on best management practices to protect income related benefits.
- Monitoring and management of fishing effort for species which are associated with the (protected) reef habitat (e.g. scallop and crab) with consultation on sustainable limits to ensure security of future supply.
- Management and support for fishermen who wish to take advantage of the high value (non-quota) species that are associated with the reef habitat.
- Monitoring and management of scallop landings within the Reserve. Combined with research on the “spill-over” effect of the Reserve.

- Attend to ‘hidden’ aspects of wellbeing, such as stress, anxiety and associated ill-health during times of significant regulatory change, particularly in the context of widespread conservation and marine planning in the UK.
- Strengthen existing structures and develop further opportunities to support fisher involvement in future management across all gear types in Lyme Bay to mainstream collaborative management with the IFCAs at the local level.
- Develop initiatives to further boost income and tackle income inequality in the Lyme Bay fishery, including expanding local markets and the ‘Reserve Seafood’ brand, and tackling the buying up and leasing of quota by corporations rather than owner-operators.
- Consider expanding the breadth of engagement of the LBCC across both static and mobile sectors to include fishermen outside of the main focal ports of Lyme Regis, Beer, Axmouth and West Bay.

Contents

2 Introduction

2.1 Marine ecosystems and human wellbeing

Marine ecosystems provide a number of essential functions, such as primary production and climate regulation, which underpin life on earth (Millennium Ecosystem Assessment, 2005). The Millennium Ecosystem Assessment identified four categories of ecosystem services that flow from these ecosystem functions: Provisioning services that supply material resources; regulating services that control ecological systems; cultural services that provide non-material aesthetic, spiritual and recreational benefits; and supporting services that provide the basic ecological functions and structures that underpin all other services, such as primary production, biodiversity, oxygen production, soil formation and nutrient cycling (Millennium Ecosystem Assessment, 2005). The Economics of Ecosystems and Biodiversity (TEEB) project builds upon the MEA classification, distinguishing between the core ecosystem processes that support beneficial ecosystem processes, which in turn deliver beneficial ecosystem services in the form of material or non-material benefits for human well-being (Figure 1) (Balmford et al., 2008). These ecosystem services form the constituent parts essential to maintain human wellbeing (e.g. food and nutritional security). As such, these services benefit humankind. The development of conceptual models (Figure 1) to translate the complexity of ecosystem functions into beneficial ecosystem services has made it possible to explicitly link society and human wellbeing with ecological systems (Balmford et al., 2008). This explicit linkage between the two parts is often referred to as the social-ecological system (Armsworth et al., 2007, Curtin and Prellezo, 2010).

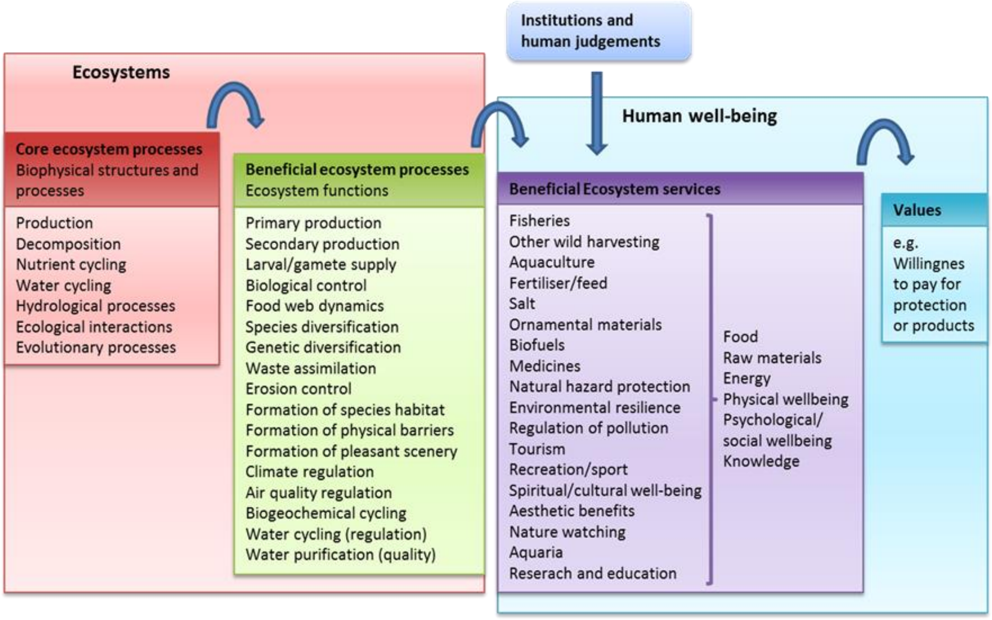

Figure 1 Links between ecosystems and human well-being (adapted from Balmford et al. (2005) and TEEB (2008)

Human wellbeing approaches measure “how we are doing as individuals, as communities and as a nation” in terms of what matters to us (OECD, 2013). The approach offers a broader set of impact indicators than conventional socio-economic frameworks, and so can capture important but intangible issues like trust, equality and lifestyle values (e.g., fishers see fishing “as a way of life” which is motivated by more than income benefits) in addition to valuing benefits from ecosystem services in economic terms (Britton and Coulthard, 2013, Pollnac and Poggie, 2008). Furthermore, wellbeing indicators can be compared across different groups (e.g. groups of fishers according to metrics such as age, vessel size, gear and level of engagement in decision-making), so capturing differential impacts and potential inequalities. There are objective (what people have), relational (what people do) and subjective (how people feel) dimensions to wellbeing. For example, wellbeing is affected by a person’s real income and whether or not they perceive that income to be adequate and fair relative to others. There is no single set of wellbeing indicators; instead, the choice of appropriate indicators can be suited to particular contexts.

2.2 Marine Protected Areas

Marine Protected Areas (MPAs) are an important tool for the maintenance of the functional integrity and health of marine ecosystems through the conservation of significant species, habitats, and ecosystems (Sobel and Dahlgren, 2004). MPAs are widely considered to be the most significant conservation management strategy for halting the loss of global marine biodiversity (Lubchenco et al., 2003), with recent research demonstrating that effectively designed and managed MPAs can have measureable conservation benefits (Edgar et al., 2014). MPAs help maintain and enhance flows of ecosystem services that support human wellbeing, for example, by supporting sustainable food provision and opportunities for recreation (Arkema et al., 2015, McCook et al., 2010, Rees et al., 2015, Roberts et al., 2001). It follows that once an MPA is identified and designated then there is a need to effectively manage the site to achieve the desired conservation objectives/biodiversity targets. Even though there has been a dramatic increase in the number of MPAs designated, at a global level, biodiversity continues to decline for some marine habitats and indicator species (Butchart et al., 2010, Pimm et al., 2014) and is predicted to continue to decline due to the persistent pressures on marine ecosystems exerted by patterns of consumption, pollution, invasive species and climate change (Butchart et al., 2010, Tittensor et al., 2014). There is growing evidence that areas that have effective management in place can have positive effects for biodiversity (Edgar et al., 2014, Sciberras et al., 2015, Sheehan et al., 2013). MPA management is typically challenging and complex. The establishment of an MPA can potentially touch upon numerous socially charged issues which, if ignored or compartmentalised, can result in the failure of the MPA to meet the ecological objectives for which it was primarily designed. Indeed, research shows that because MPAs are at the interface between social and ecological systems, short term biological gains associated with MPA designation may be compromised unless social issues, specifically notions of equity resulting from the impact of the MPA designation, are addressed in the planning and management process (Rees et al., 2013).

2.3 Evaluation frameworks

Evaluation is the assessment of the effectiveness and efficiency of a policy or management measure during and after implementation. It seeks to measure outcomes and impacts in order to assess whether the anticipated benefits have been realised (HM Treasury, 2011). Evaluation frameworks provide a structure to the evaluation process. Each evaluation framework needs to be tailored to the type of policy or management measure being considered and the types of questions it is hoped to answer (HM Treasury, 2011). Applying an evaluation framework to assess impact is the systematic process of assessing the causal effects of a project policy or programme (Gertler et al., 2011, Rosenbaum, 2010). An evaluation framework provides evidence on if and how an intervention affects (or has an impact upon) variables of interest, allowing statistical or observational analysis of ‘change’ that underlies an intervention. Evaluation within the continually evolving UK marine and coastal policy context is vital to identify learning and good practice to support improved marine management (Carneiro, 2013).

2.4 Indicators

Indicators provide measures of ecosystem processes and ecosystem service benefits, allowing for study of the linkages between ecological, social and economic systems and changes in relationships over time (Bohnke-Henrichs et al., 2013, Hattam et al., 2015). The selection and analysis of indicators can contribute to the development of a more detailed understanding of the social-ecological system as a whole, potentially leading to more informed management plans and a transparent decision making process (Hattam et al., 2015). The identification and analysis of changes in indicators following an intervention, such as an MPA designation, can also aid evaluation of impact upon ecosystem service delivery and related wellbeing. Potential indicators may be linked to environmental and socio economic indicators (Figure 2).

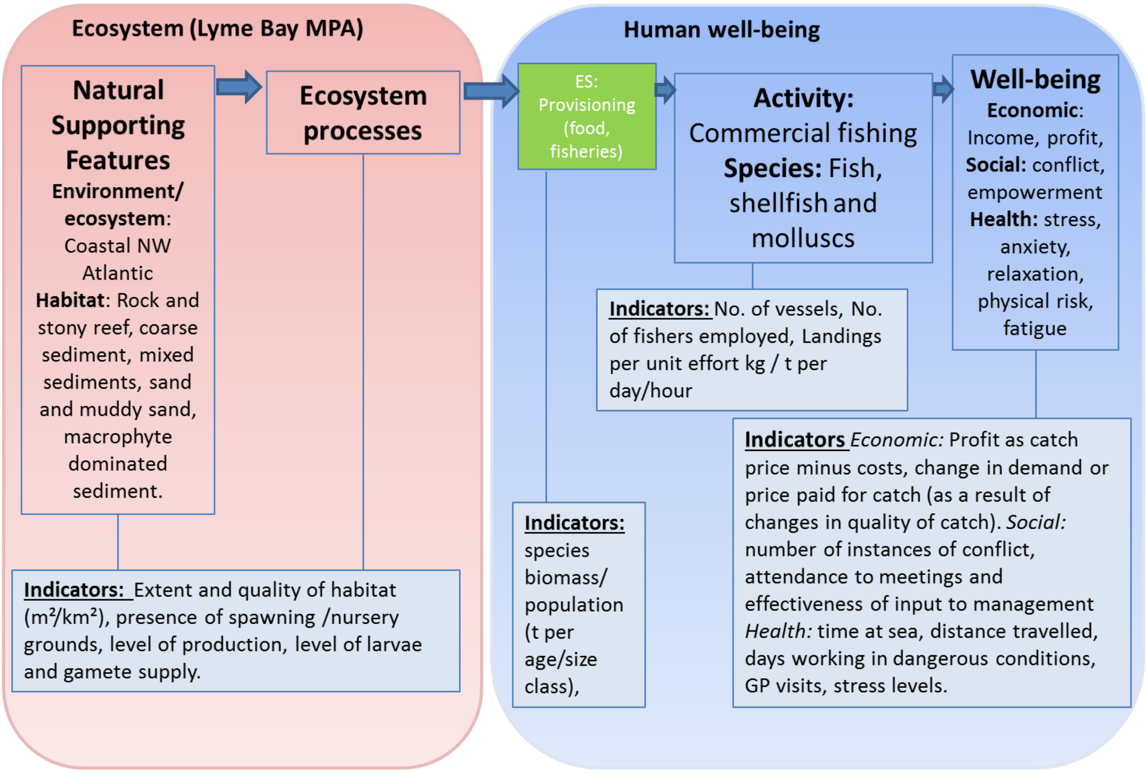

Figure 2 Application of potential indicators to evaluate change over time in relation to commercial fishing activity in an MPA. This example was presented to workshop participants at the project stakeholder workshop

3 Lyme Bay

Lyme Bay is located in south-west England, UK (Figure 3). The Bay comprises of a mosaic of substrates from sand, mud and gravel to rock and mixed ground. The entire bay has been defined as an area of ‘high species richness that includes rare and threatened species’(Hiscock, 2007). Traditionally within Lyme Bay, fishermen towing bottom-fishing gear (otter trawls, beam trawls, scallop dredging) avoid the rocky areas and fish on the mixed sediment areas (sands, gravels, cobbles). Static gear fishermen place pots in the rocky areas to catch crabs and lobster. Diving, angling and charter boats operate around the reefs and wrecks of Lyme Bay (Rees et al., 2010c). Along with the diversity of wreck sites, species such as the pink sea fan *Eunicella verrucosa* which is nationally uncommon (Hiscock, 2007) and the sunset cup coral *Leptopsammia pruvoti* which is nationally rare (Jackson et al., 2008) attract divers to the area. Charter boat operators run wildlife watching trips throughout the Bay to take people birdwatching or further offshore to see dolphins. Several small fishing boats (6-10 metres long) supplement their income by chartering boats to anglers (Rees et al., 2015). Recreational mackerel *Scomber scombrus* fishing trips are increasingly popular. There are currently several different MPA designation types in Lyme Bay (Figure 3).

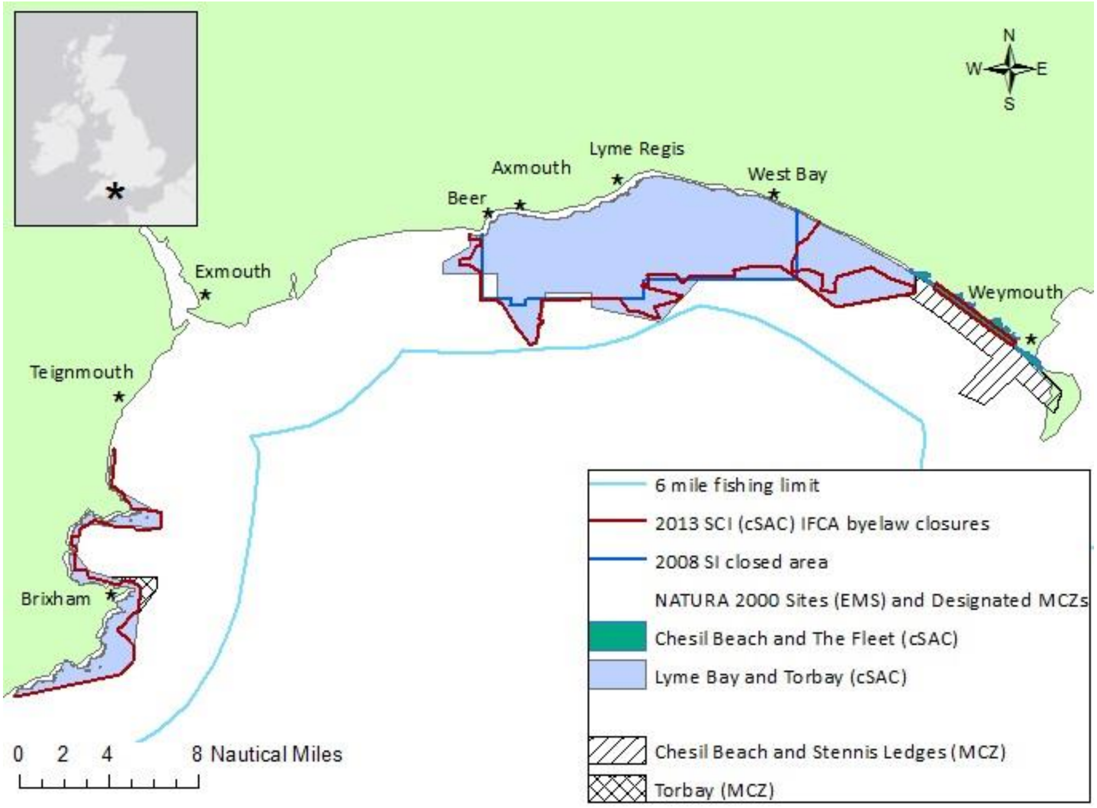

Figure 3: Lyme Bay MPAs, excluding transitional waters (candidate SACs, designated Marine Conservation Zones (MCZs), IFCA byelaws and the 2008 SI closure).

3.1 Voluntary Closures

In 2001, two voluntary closed areas for the reefs at Saw Tooth Ledges and Lanes Ground encompassing 10.3 km^2 were agreed by local stakeholders. A feasibility study on a third closed area, Beer Home Ground, was initiated by the Beer Home Ground Management Group comprising of a stakeholders from Devon Sea Fisheries Committee, East Devon District Council, Devon Wildlife Trust and local fishermen (Rees et al., 2010b). This third voluntary closure could not be agreed due to the economic importance of the site to local mobile gear fishermen (Davis, 2001).

3.2 The Statutory Instrument (SI) closed area

The statutory instrument (SI), 'Lyme Bay Designated Area (Fishing Restrictions) Order 2008' in Lyme Bay entered into force on the 11 July 2008 to protect 206km^2 of reef substrate and the associated biodiversity from the impacts of trawling and dredging with heavy demersal fishing gear (Defra, 2008) (Figure 4). Enforcement of the SI was principally the responsibility of the Devon Sea Fisheries Committee and Southern Sea Fisheries Committee working with Defra, The Marine and Fisheries Agency (MFA also renamed as M&FA) and, following the UK Marine and Costal Access Act 2009, the Marine Management Organisation (MMO). Following the abolishment of the Sea Fisheries Committees in 2011, under the UK Marine and Costal Access Act 2009, enforcement of the SI is now the responsibility of the Inshore Fisheries and Conservation Authorities (IFCAs). Since that time the IFCAs have supported the enforcement of the SI and established a joint compliance and enforcement tasking coordination group for the area. The group coordinates tactical deployment of IFCA patrol vessels, Royal Navy and Boarder force activity in the area, founded on a risk-based intelligence-led approach.

3.3 The Habitats Directive 92/43/EEC

In 2010, a slightly larger area of reef (312km^2) was put forward as a candidate Special Area of Conservation (cSAC), to meet (in part) UK commitments under the European Habitats Directive 92/43/EEC (Natural England, 2013b) (Figure 4). cSACs are sites that have been submitted to the European Commission, but not yet formally adopted by the member state. The Lyme Bay portion of the site contributes to a wider European Marine Site, the Lyme Bay and Torbay cSAC, which also includes sub tidal reef – bedrock, stony and biogenic and sea caves features immediately offshore of Brixham and Torbay (Figure 3). In 2011, Europe adopted the cSAC as a Site of Community Interest (SCI) (providing until 2017 for the UK government to formally designate the site as an SAC) (Natural England, 2015). Protection within the SCI is feature based, focusing on the features supporting habitats and species of conservation importance (Natural England 2015) (Table 1). Within the Lyme

Bay and Torbay SCI the qualifying features (natural habitats and/or species for which the site has been designated) are Reefs (H1170) and Submerged or partially submerged sea caves (H8330). The conservation objectives for the site are to 'ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the Favourable Conservation Status of its Qualifying Features, by maintaining or restoring:

- The extent and distribution of qualifying natural habitats;
- The structure and function (including typical species) of qualifying natural habitats; and
- The supporting processes on which the qualifying natural habitats rely.' (Natural England, 2014)

In 2014, byelaws were enacted by the Southern Inshore Fisheries and Conservation IFCA and Devon and Severn IFCA, protecting 236km² of the reef features in Lyme Bay, from bottom towed fishing gears (prohibition order) (Southern IFCA, Devon and Severn IFCA 2014). The IFCA bylaws are not yet properly described, they are a consequence of 'the revised approach' to the management of commercial fisheries in EMS ' and follow a habitats regulation assessment of high risk activities in sensitive features. As such they represent an evidence led approach to the achieve the requirements of Article 6 of the Habitats Directive

3.4 Marine Conservation Zones

A region of reef and intertidal coarse sediment, to the south-east of Lyme Bay MPA was also designated as a Marine Conservation Zone (MCZ) in 2013, the Chesil Beach and Stennis Ledges MCZ (38 km²), under the UK Marine and Coastal Access Act 2009 (Figure 3) (Natural England, 2013a). Existing restrictions under Southern IFCA include seasonal closures and restrictions on gear for oyster fisheries; Stennis Ledge reef features are protected by a voluntary agreement on dredging (Natural England, 2013a). The fleet, a lagoon area adjacent to the Chesil Beach and Stennis Ledges MCZ, containing seagrass habitats, is also protected by a byelaw, created by Southern IFCA, banning towed fishing gears and prohibiting digging for, fishing for, or taking of any sea fisheries resources. The Torbay MCZ protects intertidal habitats including rock, sand, coarse and mixed sediments. The most sensitive features designated under the Torbay MCZ are sea grass and subtidal mud (Figure 3).

The focus of this report is the group of MPA designations in the northern part of Lyme Bay which comprises of the boundaries created by the SI and the SCI (which areas closed under the IFCA bylaws to protect sensitive reef features within the SCI) (Figure 4). The area is commonly known as the Lyme Bay Fisheries and Conservation Reserve (Lyme Bay Reserve).

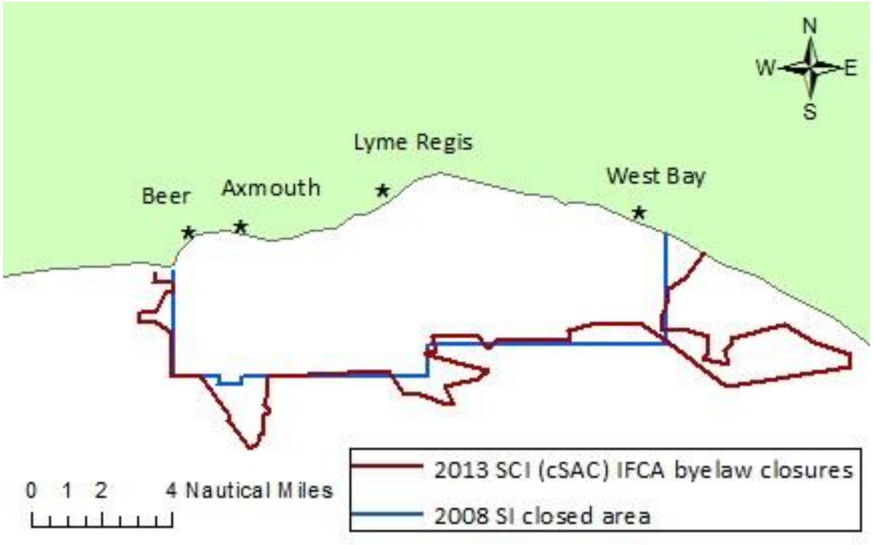

Figure 4 Map of the designations protecting reef habitat, forming the Lyme Bay Reserve.

3.5 Management and Research Activities in the Lyme Bay Reserve 2008-2015

Under the Marine and Coastal Access Act 2009, the Marine Management Organisation (MMO) are responsible for the management of MCZs and European Marine Sites (EMSs). IFCAs are the lead regulators for fisheries within their Districts. They have duties under the Marine and Coastal Act (s.154) to 'further the conservation objectives of MCZs' and The Conservation of Habitats and Species (Amendment) Regulations 2012 which requires the competent authority (in this case IFCAs) to exercise their functions which are relevant to nature conservation, including marine conservation, so as to secure compliance with the requirements of the Directives. The MMO and IFCAs coordinate enforcement roles.

As part of the 'revised approach' to fisheries management within EMS, the management of fisheries within European Marine Sites is based on the level of risk that a fishing activity presents to protected features, either habitat or species, to conserve important habitats and species in line with the EU Habitats and Birds Directives (Marine Management Organisation, 2014). When the cSAC was formally recognised as an SCI, byelaws to restrict bottom towed fishing gear over Annex 1 reef habitat were announced by the IFCA in December 2013.

In addition to the organisations with statutory responsibilities wider groups have been involved in the Lyme Bay Reserve. From the outset, the SI closure was highly contentious and impacted heavily on sectors of the local fishing community, in particular as it followed voluntary closures of reef areas to scallop dredging and demersal trawling, agreed between environmental groups and local fishermen since 2001 (Hattam et al., 2014, Mangi et al., 2011, Rees et al., 2010a).

Following the 2008 SI closure, the UK Government invested in research that annually monitored the ecological and social-economic impact of the Lyme Bay Reserve (Attrill et al, 2012, Mangi et al, 2012). The presentation of non-biased, evidence-based research results were used to instigate discussions with local stakeholders and ease local tensions in the years following the closure (Mangi et al., 2011, Rees et al., 2013, Rees et al., 2010c, Sheehan et al., 2013, Attrill et al, 2012). In 2011, a non-governmental organisation (NGO), the Blue Marine Foundation, formed a pro-active working group for the Lyme Bay Reserve (now called the Lyme Bay Consultative Committee), which led to the implementation of more specific MPA management measures. An initial *Memorandum of Understanding* (MoU) was developed, to be signed by all parties involved in the Lyme Bay Fisheries and Conservation Reserve Project, including local fishermen, IFCAs and MMO representatives. The MoU established the basis for the Working Group (now the Lyme Bay Consultative Committee) for members to promote and implement best practice in fishery and conservation management. Fishery and conservation management actions included a voluntary Code of Conduct (Annex I) proposed as a means of achieving effective management to maintain sustainable fishing practices within the Lyme Bay Reserve. The code of conduct involved voluntary measures including the fitting of Integrated Vessel Monitoring Systems (iVMS)[2] (real-time monitoring) systems and caps on the volume of fishing gear deployed by vessels within the Lyme Bay Reserve (

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[2] Integrated vessel monitoring system (iVMS) incorporates dual Iridium satellite and GPS/GPRS/GSM mobile technology and e-log capability for vessel owners or fleet managers to access accurate location and catch data. http://succorfish.com/fisheries/

Annex I). Wider partnership activities by the LBCC included development of new markets and branding, investment in post-harvest icing infrastructure, and knowledge-sharing and training activities. A scientific research project, conducted by a PhD study at Plymouth University, has also been designed and undertaken with the input of fishermen to test the sustainability of potting techniques. Many of the activities linked to the LBCC have involved public outreach with educational displays at public events and local fishermen providing talks to schools on fishing activities and commercial species.

In addition to providing supporting technologies, these partnership activities have enabled participation of fishers in decisions that affect them and may have enhanced voluntary compliance to Lyme Bay Reserve management measures and built trust among Lyme Bay stakeholders. The ecological monitoring studies, results of which have been shared with the local fishing community, demonstrate that there have been positive responses for species richness, total abundance and assemblage composition for seven out of thirteen indicator taxa (Attrill et al, 2012, Sheehan et al., 2013). These indicator species were found in greater abundance on reef habitat and pebbly-sand habitat in areas closed to bottom towed fishing compared to those where these fishing practices continue (Attrill et al, 2012, Sheehan et al., 2013). The SI closure in Lyme Bay Reserve has also had profound effects within the social and economic system as the removal of bottom towed fishing gear in the Lyme Bay Reserve has resulted in a redistribution of benefits from ecosystem services that can be accessed in Lyme Bay. Permitted commercial fishing activities have proliferated within the closed area (Mangi et al., 2011), and recreation participants and providers have increased their use of the MPA (Rees et al., 2010c, Rees et al., 2015). However, mobile (towed) gear fishermen were displaced from areas they had previously had access.

4 Aim and Objectives

The aim of this work is to evaluate the impact of the management measures in place for the Lyme Bay Reserve and the impact of voluntary management measures and partnership activities of the Lyme Bay Consultative Committee on ecosystem services and human wellbeing.

The objectives of the project are to:

- Clarify the drivers of successful partnership and management and, thereby, enable promotion of the 'Lyme Bay model' for MPA management;
- Enable an assessment of the value-added by management measures and partnership activities on ecosystem services and indicators of human well-being;
- Identify future options for MPA management and investment that supports human well-being via conservation;
- Identify marginalised groups; and
- Test a transferable framework for evaluating impact in the MPA context.

An evaluation framework has been designed for the purposes of this project in the following parts:

- A review of published research and grey literature to identify the links in the ecology of the case study area to potential ecosystem services (e.g. food, recreation) and measures of human wellbeing;
- A multi-stakeholder workshop to identify key indicators of impact on important ecosystem services and aspects of human wellbeing.
- A synthesis of existing secondary data on fishing activity and landings in Lyme Bay from 2005-2015;
- Primary data collection involving a survey of fishermen to assess the impacts of the management measures associated with the Lyme Bay Reserve and the activities of the Lyme Bay Consultative Committee on human wellbeing; and
- Indicator evaluation.

5 A review to identify the links in the ecology of the case study area to potential ecosystem services (e.g. food, recreation) and measures of human wellbeing.

5.1 Methods

The environmental features, habitats and species present within the wider Lyme Bay region were derived from habitat map data available for the region on the European Marine Observation and Data Network (EMODnet) database. EMODnet is an online resource, funded by the European Commission, providing best available data and modelling outputs to support the requirements of the Marine Strategy Framework Directive (MSFD) across Europe (EMODnet Seabed Habitats 2016). Data sets were downloaded as ARC GIS shapefiles and entered into a geodatabase constructed within ARC GIS 10 (ESRI 2012). Spatial habitat data were mapped and the presence of habitats recorded.

Spatial habitat data were mapped using the European Nature Information System (EUNIS) habitat classification, which is a European system that classifies habitats into a common framework. Broad scale habitat data were available across the Lyme Bay region to a minimum of EUNIS level 3 (biological zone, hard or soft substrata, energy exposure, sediment type). Maps that delineate the extent of the EUNIS level three habitats in Lyme Bay must be interpreted with caution as the data is combined from bespoke field surveys and broadscale predictive mapping. The map presented in Figure 5 is illustrative of the broadscale habitats (EUNIS level 3) in Lyme Bay.

A matrix table was constructed to demonstrate the relationship between broadscale habitats at EUNIS level 3 and beneficial ecosystem processes and ecosystem services using evidence from key papers; Potts et al. (2014) and Fletcher et al. (2012). Wider relevant literature from both peer and grey sources was identified to support the discussion of the results. To provide further clarity of the relationship between other conservation features in Lyme Bay and broadscale habitats, a correlation table was constructed that cross referenced habitats in Lyme Bay at EUNIS level 3 with features of conservation interest listed for conservation in the Bay (Table 1).

Table 1 Subtidal habitats and species listed for conservation in Lyme Bay and the correlation with broadscale habitats at EUNIS level 3.

	Habitats of conservation importance in Lyme Bay					Species of conservation importance		
Habitats in Lyme Bay (EUNIS level 3)	European Union Habitats Directive (Annex 1)	MCZ Broadscale habitats	MCZ Habitats of conservation importance	OSPAR Threatened and declining	BAP Priority Habitats	MCZ Species of conservation importance	OSPAR Threatened and declining	UK BAP
High Energy Infralittoral Rock (A3.1)	Reefs 1170 Bedrock reef and Stony reef Submerged or partially submerged sea caves 8830 (associated with A3 and A4 Torbay section)	High energy infralittoral rock				Pink sea fan *Eunicella verracosa*		Pink sea fan *Eunicella verracosa* Sunset cup coral *Leptopsammia pruvoti* Sponge *Adreus fascicularis* (nationally scarce)
Moderate Energy Infralittoral Rock (A3.2)								
Low Energy Infralittoral Rock (A3.3)								
High Energy Circalittoral Rock (A4.1)					Fragile sponge and anthozoan communities			
Moderate Energy Circalittoral Rock (A4.2)								
Sublittoral Coarse Sediment (A5.1)						Native oyster *Ostrea edulis*		
Sublittoral Sand (A5.2)								
Sublittoral mud (A5.3)		Subtidal mud		Seapens and burrowing megafauna communities				
Sublittoral mixed sediments (A5.4)				Native oyster beds *Ostrea edulis*		Native oyster *Ostrea edulis*	Native oyster *Ostrea edulis*	
Sublittoral macrophyte-dominated sediment (A5.5)			Seagrass beds	Maerl beds, *Zostera* beds		Long snouted seahorse *Hippocampus guttulatus*		Long snouted seahorse *Hippocampus guttulatus*

5.2 Results and Discussion

At EUNIS level 3 there are ten broadscale habitats in Lyme Bay (Figure 5, Table 2 and Table 3). The EUNIS Habitat classification system is a comprehensive pan-European system to facilitate the harmonised description and collection of data across Europe through the use of criteria for habitat identification; it covers all types of habitats from natural to artificial, from terrestrial to freshwater and marine (EUNIS, 2014).

In addition to the sublittoral macrophyte dominated sediment located on the map, there have since been extensive subtidal surveys of the sublittoral mud in Torbay which also supports seagrass *Zostera marina* beds (broadscale habitat A5.5, sublittoral macrophyte dominated sediment). Additionally, Annex I habitat 'submerged or partially submerged sea caves' (8330) have been identified within the Torbay section of the Lyme Bay and Torbay cSAC. These broadscale habitats present in Lyme Bay were identified in the literature as potentially supporting several beneficial ecosystem processes and beneficial ecosystem services (Table 2 and Table 3).

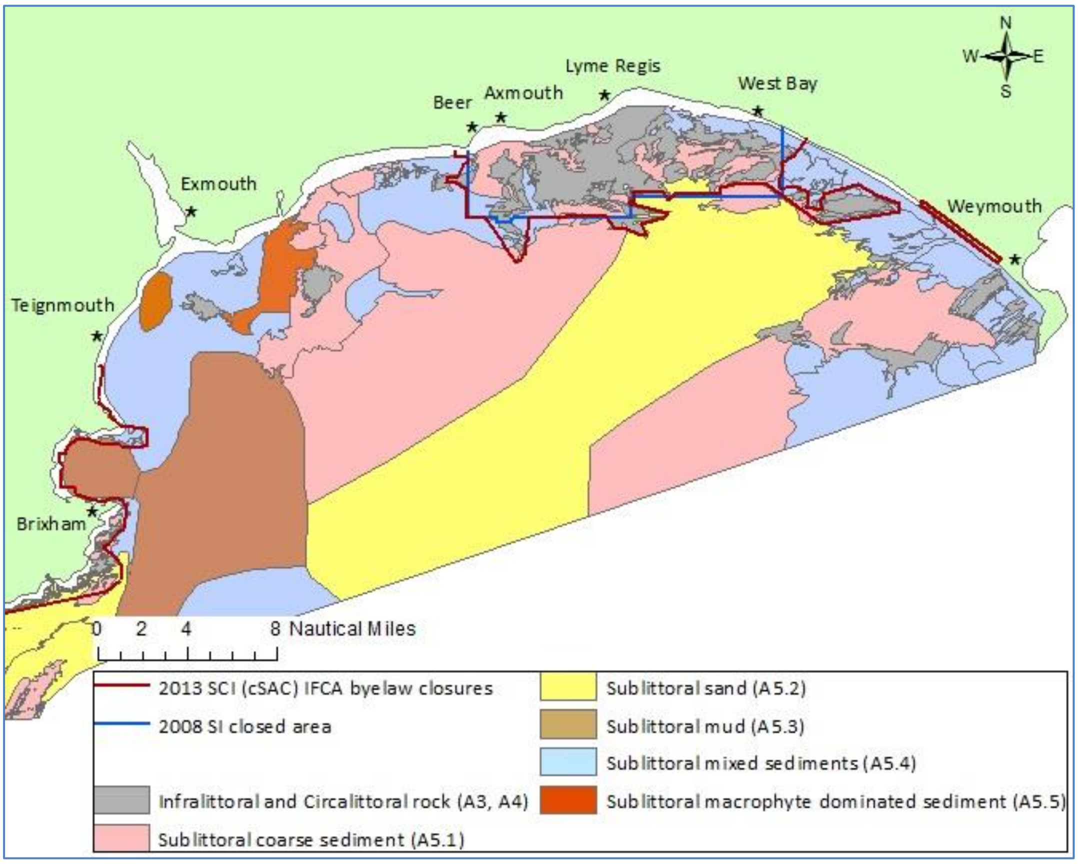
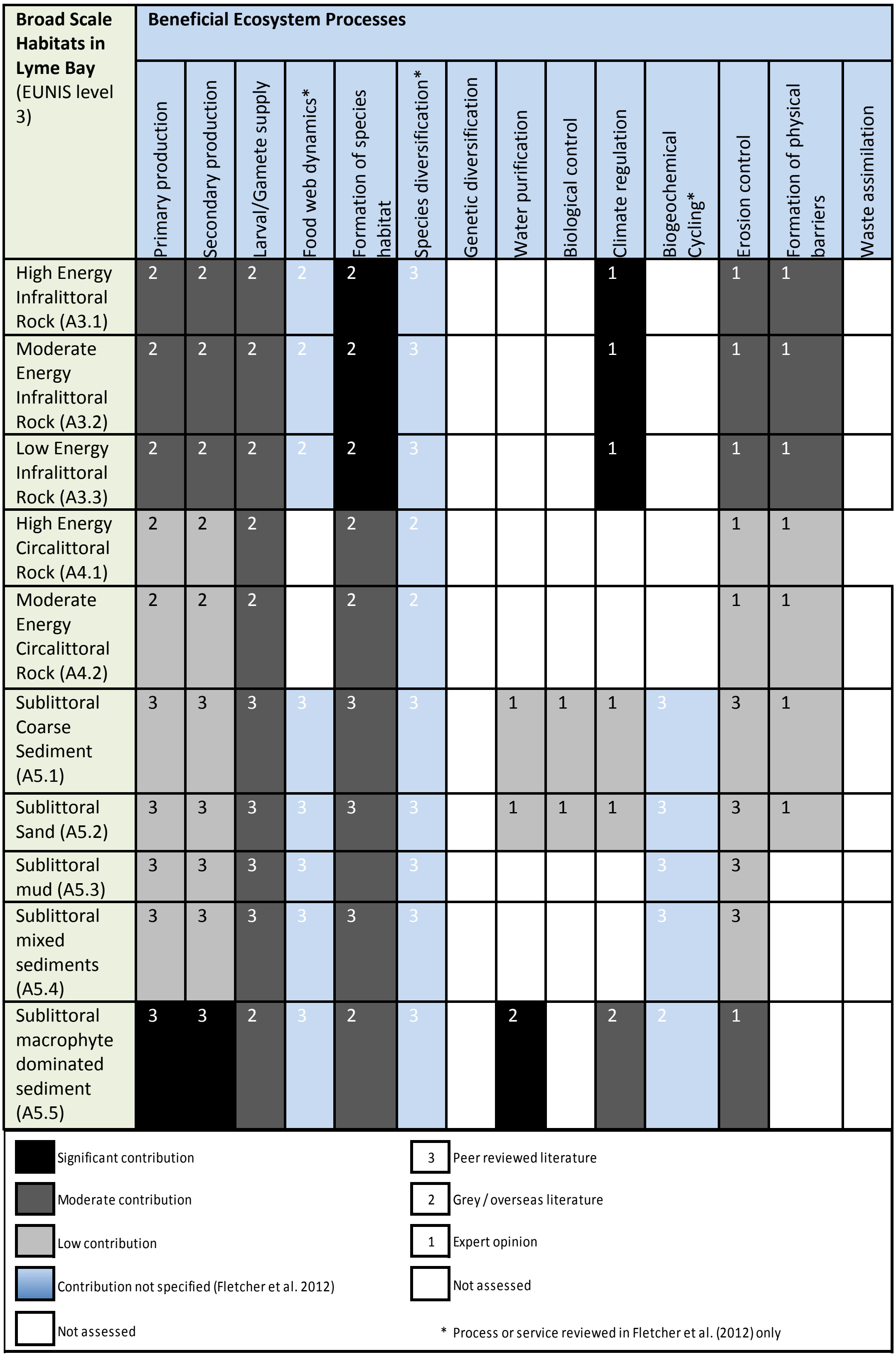


Figure 5 Map of broad scale habitat types (EUNIS level 3) within the wider Lyme Bay region (infralittoral and circalittoral rock have been combined, these habitats represent Annex 1 'reef' habitat). Habitat data is derived from both survey and broadscale predictive mapping, habitat boundaries must be interpreted as illustrative.

Table 2 Matrix of ecosystem processes provided by broad scale habitats in Lyme Bay, including level of delivery and confidence in associated literature, adapted from Potts et al. (2014) and Fletcher et al. 2012b).



Broad Scale Habitats in Lyme Bay (EUNIS level 3)	**Beneficial Ecosystem Processes**													
	Primary production	Secondary production	Larval/Gamete supply	Food web dynamics*	Formation of species habitat	Species diversification*	Genetic diversification	Water purification	Biological control	Climate regulation	Biogeochemical Cycling*	Erosion control	Formation of physical barriers	Waste assimilation
High Energy Infralittoral Rock (A3.1)	2	2	2	2	2	3				1		1	1	
Moderate Energy Infralittoral Rock (A3.2)	2	2	2	2	2	3				1		1	1	
Low Energy Infralittoral Rock (A3.3)	2	2	2	2	2	3				1		1	1	
High Energy Circalittoral Rock (A4.1)	2	2	2		2	2						1	1	
Moderate Energy Circalittoral Rock (A4.2)	2	2	2		2	2						1	1	
Sublittoral Coarse Sediment (A5.1)	3	3	3	3	3	3		1	1	1	3	3	1	
Sublittoral Sand (A5.2)	3	3	3	3	3	3		1	1	1	3	3	1	
Sublittoral mud (A5.3)	3	3	3	3		3					3	3		
Sublittoral mixed sediments (A5.4)	3	3	3	3	3	3					3	3		
Sublittoral macrophyte dominated sediment (A5.5)	3	3	2	3	2	3		2		2	2	1		

■ Significant contribution

▩ Moderate contribution

▒ Low contribution

🟦 Contribution not specified (Fletcher et al. 2012)

□ Not assessed

3 Peer reviewed literature

2 Grey / overseas literature

1 Expert opinion

□ Not assessed

* Process or service reviewed in Fletcher et al. (2012) only

Table 3 Matrix of ecosystem services provided by broad scale habitats in Lyme Bay, including level of delivery and confidence in associated literature, adapted from Potts et al. (2014) and Fletcher et al. 2012b).

Broad Scale Habitats in Lyme Bay (EUNIS level 3)	**Beneficial Ecosystem Services**												
	Fisheries and wild food	Nature watching	Aquaculture	Recreation/sport*	Fertiliser/feed	Medicines	Natural hazard protection	Regulation of pollution	Environmental resilience*	Research and education	Tourism	Spiritual/cultural wellbeing	Aesthetic benefits
High Energy Infralittoral Rock (A3.1)	■ 3	▩ 1	□	□	□	□	□	□	🟦 1	▨ 1	▩ 1	▨ 1	□
Moderate Energy Infralittoral Rock (A3.2)	■ 3	▩ 1	□	□	□	□	□	□	🟦 1	▨ 1	▩ 1	▨ 1	□
Low Energy Infralittoral Rock (A3.3)	■ 3	▩ 1	□	□	□	□	□	□	🟦 1	▨ 1	▩ 1	▨ 1	□
High Energy Circalittoral Rock (A4.1)	■ 1	▩ 1	□	🟦 1	□	□	□	□	□	▨ 1	▩ 1	▨ 1	□
Moderate Energy Circalittoral Rock (A4.2)	■ 1	▩ 1	□	🟦 1	□	□	□	□	□	▨ 1	▩ 1	▨ 1	□
Sublittoral Coarse Sediment (A5.1)	▩ 2	▨ 1	□	□	□	▩ 1	▨ 3	▩ 3	🟦 3	▨ 1	▨ 1	▨ 1	□
Sublittoral Sand (A5.2)	▩ 2	▨ 1	□	□	□	▩ 1	▨ 3	▩ 3	🟦 3	▨ 1	▨ 1	▨ 1	□
Sublittoral mud (A5.3)	▩ 2	□	□	□	□	□	▨ 3	▩ 3	🟦 3	▨ 1	□	▨ 1	□
Sublittoral mixed sediments (A5.4)	▩ 2	□	□	□	□	□	▨ 3	▩ 3	🟦 3	▨ 1	□	▨ 1	□
Sublittoral macrophyte dominated sediment (A5.5)	■ 3	▩ 1	□	□	□	□	▩ 1	■ 2	🟦 1	▨ 1	▩ 1	▨ 1	□

■	Significant contribution	3	Peer reviewed literature
▩	Moderate contribution	2	Grey / overseas literature
▨	Low contribution	1	Expert opinion
🟦	Contribution not specified (Fletcher et al. 2012)	□	Not assessed
□	Not assessed	*	Process or service reviewed in Fletcher et al. (2012) only

5.2.1 *Beneficial Ecological Processes*

Primary Productivity

Primary production, the process of pelagic and benthic fixation of carbon through photosynthesis, is supported by all the broadscale habitats in Lyme Bay (Table 2). In the infralittoral zone, between the mean low water mark to the depth where only 1% of light reaches the seabed, (e.g. the maximum depth of kelp biotopes) (JNCC, 2010), reef habitats (broadscale habitats A3.1 and A3.2 (Table 1)) contribute the most to production, relative to the surrounding habitats. Important primary producers associated with shallow reefs are algae species such as kelp *Laminaria spp.* (Smale et al., 2013, Smale, 2015). In the circalittoral zone, between the depth where only 1% of light reaches the seabed to the maximum depth at which the seabed is influenced by waves (JNCC, 2010), primary production is driven by phytoplankton in the surrounding water masses facilitating the transfer of energy to higher trophic level organisms (Jones, 2000). High abundance or blooms of phytoplankton in coastal regions, are linked to levels of organic nutrients (often related to run off from land), sunlight levels and mixing in the water column (Shutler et al., 2012, Shutler et al., 2015). Physical processes such as water circulation, development of fronts between water masses, persistence and strength of fronts and rainfall and river runoff therefore influence levels of phytoplankton within Lyme Bay (Shutler et al., 2015, Southward et al., 1995, Gowen et al., 1998, Pingree, 1977). Subtidal sediment (associated with broadscale habitats A5.1, A5.2, A5.3, A5.4 and A5.5) provides a sink for primary production. Research has indicated that the amount of primary production occurring in these systems is dependent on the assimilation of organic matter occurring following algal blooms (Denis and Desroy, 2008).

Macrophyte dominated sediment (broadscale habitat A5.5, Table 1) also makes a significant contribution to primary production (Table 2). Seagrass *Zostera marina* beds (associated with broadscale habitats A5.3) cover 0.80 km^2 (4.02 %) of the total Torbay rMCZ area and are known to be important for primary production with recorded annual production rates of between 69 g C $m^{-2}yr^{-1}$ (Borum and Wiumandersen, 1980) and 814 g C $m^{-2}yr^{-1}$ (Borum et al., 1984).

Secondary production

Secondary production is the generation of biomass though the consumption of organic material. The water column and water masses within Lyme Bay support zooplankton populations, whilst mixed substratum in-between the reef features supports benthic infauna communities. Secondary production is supported by all the broadscale habitats in Lyme Bay (Table 2) with the reef habitats (broadscale habitats A3.1 and A3.2 (Table 1)) and the sublittoral macrophyte dominated sediment (broadscale habitat A5.5 (Table 1)) contributing the most to this ecological process relative to the surrounding habitats (Table 2). From studies elsewhere in Europe it has been demonstrated that biomass from epibenthic colonisation of reef habitats were significantly greater than biomass within soft substratum habitat (Moura et al., 2011, Ricciardi and Bourget, 1999). Subtidally, a large proportion of the biomass is mobile and sessile epifauna, with species of starfish, brittlestar, crab, sponge and tunicate known to be particularly abundant in such areas (Jones et al., 2000). Rapid turnover of *Zostera marina* blades (associated with broadscale habitat A5.5 and A5.3 (Table 1)) and of the epiphytic algae on the leaf surfaces means that large amounts of seagrass primary production is transferred to consumers (secondary production) (Cebrian et al., 1997), critical for supporting the food chain.

Formation of species habitat

Formation of species habitat can be described as the contribution of habitat formed by one species but providing suitable niches for other species, including the production and maintenance of complex structure providing suitable habitat including shelter from predators. All broadscale habitats in Lyme Bay contribute to the beneficial ecological process of the formation of species habitat (Table 2). Native oyster beds *Ostrea edulis* have an important role in providing habitat for other species (Beck et al., 2011). The broadscale habitats that characterise ‘reef’ have a significant contribution relative to the surrounding habitats (Table 1). For example, kelp habitats associated with infralittoral reef provide a three-dimensional habitat structure for a diverse array of marine organisms, many of which are commercially important (Smale et al., 2013, Smale, 2015, Smale et al., 2011). Kelp communities also provide shelter for juvenile stages of commercially targeted fishes, crustaceans and bivalve molluscs (Gonzalez-Gurriaran and Freire, 1994). Canopy-forming kelps influence their environment and other organisms, thereby functioning as “ecosystem engineers” (Smale et al., 2013, Smale et al., 2011). Kelp holdfasts, the attachment between kelp and reef features, provide food resources for flatfish, sea bass and gadoid species (Snelgrove, 1999, Jones, 2000). By altering light levels (Connell, 2003), water flow (Rosman et al., 2007), physical disturbance and sedimentation rates (Eckman et al., 1989, Wernberg and Thomsen, 2005), kelps modify the local environment for other organisms. Moreover, through direct provision of food and structural habitat, kelp forests support higher levels of biodiversity and biomass than simple, unstructured habitats (Dayton, 1985, Dayton et al., 1999, Steneck et al., 2002).

Broad scale habitats associated with reef features (Table 1) provide surfaces for epibiota such as corals and sponges to attach, providing complexity and shelter resources for commercially targeted fish and shellfish (Lindholm et al., 2004, Lindholm et al., 2001, Bradshaw et al., 2003). Sessile epifauna, that colonise reef features, capture and recycle water column nutrients through filter feeding and produce planktonic larvae (Beaumont et al., 2007), further supporting higher trophic levels, which includes fish and shellfish species (Sheehan et al., 2013).

In the subtidal, formation of species habitat is strongly influenced by sediment type, with particle size distribution, organic content and chemical composition of importance to species distribution. Stability is provided by the presence of species such as Sand mason *Lanice conchilega* (Van Hoey et al., 2008), and habitat complexity is increased where benthic fauna are diverse and abundant due to the presence of tubes and burrows (Paramour, 2006). Intensive bottom fishing using towed nets and dredges has been shown to alter species composition in soft substratum seabed habitats, removing high biomass species contributing to topographic complexity (Kaiser et al., 2000). Experimental trawling has shown *Lanice conchilega* in particular are impacted by bottom towed fishing gears (Rabaut et al., 2008). Ross worm *Sabellaria spinulosa,* observed in patches by survey divers within the Reserve provides greater complexity and habitat resources for juvenile fish and crustaceans (Pearce, 2014, Jackson, 2008). In the wider Lyme Bay region presence of Maerl *Phymatolithin calcareum* (associated with broadscale habitat A5.5 (Table 1)) is recorded in OSPAR Threatened and Declining species data sets and has been observed in survey dives (in limited abundance from records in 2007), offshore of Exmouth (Wood, 2007). Maerl has been shown to provide significant habitat for juvenile scallops and may provide habitat complexity, increasing survivability of juvenile fish (Kamenos et al., 2004b, Howarth et al., 2011, Lindholm et al., 2001).

Climate regulation

The ability of the marine ecosystem to assimilate and store atmospheric gases contributes to the regulation of the climate. This service is supported by a range of broadscale habitats in Lyme Bay (Table 2). Reef habitats (broadscale habitats A3.1 and A3.2 9 (Table 1)) supporting kelp *Laminaria spp.* communities provide a significant contribution, while sublittoral macrophyte dominated sediment (broadscale habitat A5.5 and A5.3 (Table 1)) provide a moderate contribution to this ecological process, relative to the wider surrounding broadscale habitats.

Kelp communities *Laminaria spp.* associated with reef habitats (Table 1) are hugely important as fuels for marine food webs through the capture and export of carbon (Krumhansl and Scheibling, 2012, Dayton, 1985). Seagrasses (associated with broad scale habitat A5.5 and A5.3 (Table 1)) have the ability to baffle water currents and stabilize sediments, resulting in organic matter and nutrients becoming stored within the accreting sediments, sequestering carbon, nitrogen and phosphorous, while the remaining organic material is recycled or exported (Duarte, 2011, Nellemann, 2009, Kennedy, 2009).

Erosion Control

Erosion control is supported by several broadscale habitats in Lyme Bay (Table 2) with the reef habitats (broadscale habitats A3.1 and A3.2 (Table 1)) and sublittoral macrophyte dominated sediment (broadscale habitat A5.5 and A5.3 (Table 1)) contributing the most to this ecological process relative to the surrounding habitats. Physical features in the shallow inshore zone, such as infralittoral reefs (A3.1, A3.2) and vegetation such as seagrass, present in broadscale habitat A5 (Table 1), reduce sheer stress, slow water currents and reduce wave heights, thus reducing erosion in coastal regions (Jacobs, 2013, Potts et al, 2014).

5.2.2 Beneficial Ecosystem Services

The broadscale habitats of Lyme Bay support a range of beneficial ecosystem services including recreation opportunities, research and education, nature watching, medicines, natural hazard protection, regulation of pollution, environmental resilience, research and education, tourism, spiritual and cultural wellbeing and aesthetic benefits (Table 3). In terms of the broadscale habitats linked to the Lyme Bay Reserve the main beneficiaries of the flows of ecosystem services are the fisheries and recreation industry (Table 3).

Fisheries and wild food

At a regional scale habitats across Lyme Bay, associated with fisheries and wild food benefits, identified by Fletcher et al. (2012a, 2012b) and Potts et al. (2014) are important to the adult and juvenile stages of species supporting commercial and recreational activities (Potts et al, 2014, Fletcher, 2012a, Fletcher, 2012b). All broadscale habitats have a moderate or significant contribution towards this beneficial ecosystem service (Table 3). Each fishery in Lyme Bay is considered here in more detail.

Static trap fisheries are supported by brown crab *Cancer pagarus*, spider crab *Maja squinado*, European lobster *Homarus gammarus*, whelk *Buccinum undatum* and cuttlefish *Sepia officinalis.* The commercial shellfish species supporting activities in Lyme Bay have similar, broad habitat and prey preferences. The diversity of habitats found in Lyme Bay (Table 1,Table 4), interspersed with coarse substratum and mixed substrata benefits these crustacean species while *B.undatum* prefer sand and mud habitats (Galparsoro et al., 2009, Lawton, 1989, Hayward, 1998, Hancock, 1967, Freire et al., 2009, Gonzalez-Gurriaran and Freire, 1994).

Table 4 Matrix of links between habitats within Lyme Bay and commercially targeted species. Dark shading represents high importance, light shading represents lesser importance, 'jv.' indicates importance to juvenile stage (from peer reviewed and grey literature).

Habitat interactions		Key commercial species of the Lyme Bay fishery (MPC 2014)										
		Buccinum undatum	*Cancer pagarus*	*Homarus gammarus*	*Sepia officinalis*	*Maja squinado*	*Dicentrarchus labrax*	*Gadus morhua*	*Solea solea*	*Pleuronectes platessa*	*Raja clavata*	*Pecten maximus*
Broadscale habitats (EUNIS level 3) present in Lyme Bay	High Energy, Moderate Energy and Low Energy Infralittoral Rock (A3.1, 3.2, 3.3)	░	▓	▓		▓	▓	▓ jv.		▓	░ jv.	░ jv.
	High Energy, Moderate Energy, Circalittoral Rock (A4.1, 4.2.)	░	▓	▓		▓	▓	▓ jv.		▓	▓	░ jv.
	Sublittoral Coarse Sediment (A5.1)	▓	▓	▓ jv.	▓	▓	▓	▓	░	░	▓	▓
	Sublittoral Sand (A5.2)	▓	▓	▓ jv.	▓	▓	▓	░	▓	▓	▓	▓
	Sublittoral Mud (A5.3)	░		▓ jv.	░		▓	▓	▓	░	▓	
	Sublittoral Mixed Sediments (A5.4)	▓	░	▓	░		▓	░	▓		▓	▓
	Sublittoral Macrophyte-Dominated Sediment (A5.5)	▓	░	░	▓	▓	▓	▓	░	░	░ jv.	▓ jv.
Prey resources supporting commercial species (food web interactions)												
Food web interactions (bottom up)	Phytoplankton											▓
	Zooplankton							▓ jv.				▓
	benthic fauna (polychaeta)	▓		▓	▓		▓			▓		
	benthic fauna (crustacea)			▓	▓		▓	▓		▓	▓	
	benthic fauna (mollusc)	▓	▓	▓	▓	▓				▓		
	benthic fauna (fish)	▓	▓	▓	▓		▓	▓		▓	▓	
Seasonal presence of species within Lyme Bay												
Season	Winter	▓	░	░			░	▓	░	░	░	▓
	Spring	▓	▓	▓	▓	▓	▓	░	▓	▓	▓	▓
	Summer	▓	▓	▓	▓	▓	▓	░	▓	▓	▓	▓
	Autumn	▓	▓	▓	░		▓	▓	░	▓	▓	▓

Edible Crab *(Cancer pagarus)* utilise the range of broadscale habitats found in Lyme Bay (Table 4). This species makes use of crevices in reefs and space under boulders to shelter, whilst also utilising mixed coarse ground and muddy sand habitats where individuals dig into the sediment (Table 4) (Hayward, 1998, Pawson, 1995). Larger adults utilise offshore muddy sand habitats as well as mixed coarse ground and reefs, whilst juveniles predominantly occur in sublittoral rocky habitats. Habitat utilisation patterns are noted to be different between sexes, larger males are often caught on rocky substrates whilst females are more abundant on sand and gravel (Hayward, 1998, Pawson, 1995). Brown crab tend to move into shallower water at night to feed, scavenging on carrion and predating on molluscs such as whelks, mussels and cockles (Neal, 2008, Lawton, 1989) (Table 4).

Spider Crab *(Maja squinado)* are a less important commercial species that utilise reef habitats, coarse sand and mixed gravel but utilise seaweeds and sponges for shelter rather than crevices or boulders favoured by *Cancer pagarus* (Gonzalez-Gurriaran and Freire, 1994, Freire et al., 2009) (Table 4). Juveniles display habitat preference for kelp communities (associated with broadscale habitats A3.1 and A3.2) (Gonzalez-Gurriaran and Freire, 1994, Freire et al., 2009). Spider crab feed on a range of prey, including seaweeds, molluscs and echinoderms (Gonzalez-Gurriaran and Freire, 1994, Freire et al., 2009). Tracking of *Maja* spp. in North Western Spain revealed individuals spent a greater proportion of time in coarse sand substrates but isotope analyses showed that over 60% of diet originated from rocky substrates (Freire et al., 2009). In the south west UK and Ireland *M.squinado* move inshore in spring and summer and move offshore in winter (Fahy and Carroll, 2009) (Table 4).

Common lobster *(Homarus gammarus)* utilise similar habitats and food resources as *Maja squinado* and *Cancer pagarus*, displaying preference for the boundary between sedimentary and rock habitats with medium to high wave conditions (Galparsoro et al., 2009). Juveniles burrow into fine sediments and mud (associated with broadscale habitats 5.1, 5.2, 5.3 (Table 4)), while adults will form tunnels under boulders to avoid predation in sedimentary habitats (Galparsoro et al. 2009). Both juveniles and adults utilise crevices and holes to shelter in rock habitats (Linnane et al., 2000). *H.gammarus* feed on annelids, echinoderms and molluscs while juveniles. As adults, *H.gammarus* feed on smaller lobsters, crabs and larger molluscs (Hayward, 1998, Van der Meeren, 2005).

Common Whelk *(Buccinum undatum)* naturally occur on all broadscale habitats present in Lyme Bay (Table 4). *B. undatum* are scavengers and carnivorous predators feeding on polychaetes, bivalves and carrion, feeding across the range of habitats present in Lyme Bay (Hancock, 1967, Scolding et al., 2007). *B. undatum* may also bury in soft substrate with their siphon protruding (Hancock, 1967, Scolding et al., 2007).

Common cuttlefish (*Sepia officinalis*) are a short lived species, with a 2 year life span. Within the English Channel current research suggests cuttlefish spend the winter months in deeper offshore waters, where the water temperatures remain above 9 °C (Bloor et al., 2013a, Bloor et al., 2013b). Both adults and sub-adults are then assumed to undertake an inshore migration to shallow water areas during the spring (Bloor et al., 2013a, Bloor et al., 2013b). Sexually mature adults are currently thought to arrive earlier, followed by sexually immature sub-adults, with both age –classes making offshore migrations again in the autumn (Bloor et al., 2013a, Bloor et al., 2013b). *S. officinalis* tagged with continuous acoustic transmitters and released in comparable inshore waters in the south west UK to Lyme Bay displayed differing spatial movement patterns, with some individuals displaying short term site fidelity while others moved over greater distances (>35km) (Bloor et al., 2013b). Within Lyme Bay *S. officinalis* will inhabit sandy or muddy substrates (Table 4), whereby, both adults and young bury themselves in the sand during the day (Wilson, 2008). *S. officinalis* are ambush predators, feeding on a wide variety of prey including crustaceans, molluscs, polychaetes, small demersal fish as well as other cuttlefish (Wilson, 2008) (Table 4). They are preyed upon by elasmobranch species, demersal fishes and other cephalopods (Wilson, 2008). The eggs are attached to a range of substrates, including seaweed and shells (Wilson, 2008). The reef features within Lyme Bay, in particular the colonising algae and epifauna, thereby provide structures for egg attachment, while the high biomass of molluscs, crustaceans and small demersal fish, enhanced by the presence of reef features provides significant food resources (Jones, 2000, Smale, 2015).

Netting, trawling and handline fisheries in Lyme Bay are supported by sole *Solea solea*, plaice *Pleuronectes platessa*, skate and rays (primarily thornback ray *Raja clavata*), bass *Dicentrarchus labrax* and cod *Gadus morhua* (species contributing greatest landings weight and value to fisheries within Lyme Bay, as indicated by; Marine Planning Consultants 2014 (Pearce, 2014). Habitats of importance to the fish and elasmobranch species of commercial importance to fisheries in Lyme Bay can be separated into species groups with similar habitat preferences. The diversity of habitats provided in Lyme Bay by rocky reefs and stony reefs, interspersed with coarse sediments and mixed sediments provide benefits across these species groups: (i) *Flatfish species, (ii) other demersal fish (roundfish)*, *(iii) Elasmobranch*s.

(i) Flatfish species, plaice *Pleuronectes platessa* and sole *Solea solea* are the principal flatfish species targeted by fisheries and share similar habitat preferences (Table 4). Soft substratum with bottom living prey animals, such as, shellfish, cockles, razor shells, polycheates, crustaceans and sand eels is required by both species (Reeve, 2007, Ruiz, 2007, Hinz et al., 2006) (Table 4). Plaice use sight to hunt and utilise clearer habitat with less disturbance, with a preference for sandy patches in rocky areas, such as the soft substratum in between reef features (Hinz *et al.* 2006). *S. solea* have a broader prey preference than plaice; like *P. platessa*, *S. solea* avoid gravelly sediment but use tactile and chemo sensory senses to hunt and so occur in muddier sediments or regions with greater disturbance (Hinz *et al.* 2006) (Table 4).

(ii) Demersal fish species, principally cod *Gadus morhua* and bass *Dicentrarchus labrax* are also targeted by static net fisheries (Pearce, 2014). *D. labrax* occur in a range of habitats from rock to soft sediments, including sand, shingle and mud, migrating into south western UK coastal regions in spring and often displaying site fidelity for long periods (Pawson et al., 2008, Pawson et al., 2007) (Table 4). A carnivorous species, *D. labrax* require smaller fish, crustaceans, squid and polychaete prey to be present (Miller, 1997).

G. morhua range to a depth of 600m. Juvenile (up to 5 years) *G. morhua* prefer coarser or rocky ground (Table 3). As shown by Lindholm et al. (1999) the complex habitats provided by reefs and sessile epifauna reduce predation rates of juvenile *G. morhua. G. morhua* feed on crustaceans and other fish as adults and during juvenile stages will eat zooplankton, particularly copepods (Frose, 2015) (Table 4). As adults and juveniles *G. morhua* are present close to the shore in autumn and winter while adults move offshore in early spring (Righton et al., 2007).

(iii) **Elasmobranchii species**, principally thornback ray *Raja clavata* and small-eyed ray *Raja microocellata* are caught by net fisheries. *Raja clavata* contribute greatest landings and migrate to inshore coastal waters in spring. Shallow regions are used as nursery areas (including low usage in Lyme Bay) (Ellis and Taylor, 2012). Both ray species prefer sand or mud although *Raja clavata* will occur over rock and gravel (Holden, 1974, Rae, 1982, Ellis, 1996). *Raja microocellata* prefer softer sand substratum (Table 4), in which to bury (Kaiser et al. 2004). *Raja clavata* and *Raja microcellata* feed on a range of species, including crustaceans, shrimp and smaller fish including sand eels (Holden, 1974, Rae, 1982, Ellis, 1996, Kaiser et al., 2004) (Table 4).

Scallop diving and ***scallop dredging*** fisheries are supported by scallop species (with dredging occurring outside the SI and away from the reef areas within the SCI), primarily king scallop *Pecten maximus*. Queen scallops *Aequipecten opercularis*, are a less important commercial species although fisheries exist in other UK regions (Howarth et al., 2011).

Adult scallops generally prefer clean, full salinity sea water. They are found on a variety of bottom substrates including rock, stones and mixed sand and gravel substrata. The highest abundance has been noted where rocky outcrops or boulders occur on a substrate of mixed silty sand with gravel or shell (Franklin, 1980). *Pecten maximus* are often found in shallow depressions in the sea bed and commonly bury into the substratum, *A. opercularis* are commonly more mobile and found above the substratum (Marshall, 2009). Juvenile *A. opercularis* have shown attachment to maerl beds (associated with broadscale habitat 5.5) under mesocosm conditions and in field surveys, suggesting these habitats contribute to nursery areas (Kamenos et al., 2004b, Kamenos et al., 2004a, Kamenos et al., 2004c, Howarth et al., 2011). Greater habitat complexity, through higher presence of macro algae was also related to increased abundance of juvenile *A. opercularis* within a Scottish marine reserve (Howarth et al., 2011). Complexity provided by areas of sessile epifauna such as ross coral *Pentapora fascialis,* dead man's fingers *A.digitatum*, pink sea fan *E.verrucosa* and presence of mussel beds also provide shelter and resources benefitting juvenile scallops (Howarth et al., 2011, Sheehan et al., 2013).

Natural hazard protection/regulation of pollution/resilience

There is a body of peer reviewed evidence that demonstrates that sediment habitats (characterised by broadscale habitats A5.1, A5.2, A5.3, A5.4, and A5.5 (Table 3)) have a role in supporting these beneficial ecosystem services. Intertidal sediment plays an important role in coastal protection, and it is thought that intertidal boulders also afford a degree of protection through the formation of a physical barrier which dissipates wave energy and therefore reduces erosion (Jacobs, 2013). Seagrass leaves (associated with broadscale habitats A5.5 and A5.3 (Table 1) baffle water currents and attenuate waves, reducing erosion and promoting sediment accretion. At the same time roots and rhizomes of the seagrass beds bind sediment (Madsen et al., 2001). As such seagrass may not only stabilise sediments but in some cases have been shown to provide shoreline stabilisation and protection from erosion (Madsen et al., 2001, Cabaco et al., 2008). Native Oysters *Ostrea edulis* can remove suspended solids from surrounding waters and improve water clarity (Beck et al., 2011).

Nature watching/tourism/recreation

Local club diving and independent angling are particularly popular activities in Lyme Bay, and with numerous boat and beach access points throughout. These activities make use of the natural marine resources that stem from wider biological diversity in the region. High levels of subtidal biomass on reefs, including corals, sponges, anemones and large predators such as lobsters and large fish (associated with broadscale habitats A3.1, A3.2, A4.1 and A4.2 (Table 2)) are of interest to divers (Jones et al. 2000). In the west, Torbay is sheltered from the prevailing weather fronts which allows year round access to both shore and reef sites including Morris Rouge, Orestone, Goodrington sands and Brixham Breakwater. In the north of the Bay there are well established reef diving sites (e.g. Saw tooth ledges). Non club diving and angling activities are supported by a dive business industry (which offer services to divers including gear and training) and a charter boat industry whose skippers take sea anglers/divers (who are not using their own boats) to suitable sites (Rees et al., 2010c).

6 The identification of ecosystem service and human wellbeing indicators that can be used to measure impact.

6.1 Methods

A literature review was undertaken to identify the full list of relevant indicators that could be used to measure impact of the identified beneficial ecosystem process and services. The review also identified previous studies and potential data sources for which time series data may be available. The full set of indicators was reviewed by a select stakeholder group at a workshop held in Charmouth on the 13th of October 2016 (workshop agenda: Annex II). To define appropriate indicators that are linked to wellbeing in the Lyme Bay context the select stakeholder group also identified and prioritised indicators for economic wellbeing, social wellbeing and health and psychological wellbeing.

In order to give context to any changes in the ecosystem service and wellbeing indicators a final group exercise at the workshop was used to create a collective timeline of how key events/interventions shaped activities and influenced outcomes in Lyme Bay. Participants were asked to identify significant events that have affected their activities within the Lyme Bay region. Although focused on the Lyme Bay MPA the discussion was open ended to identify the main events that had affected fishermen in the region. As a result events raised were both related to MPA management and partnership activities and other outside events, such as adverse weather and national and European level fisheries management (Timeline: Annex III).

A summary of the full range of indicators that can be used to study changes in ecosystem service delivery in the marine environment in relation to the key beneficiaries (fisheries and recreation) are included in Annex IV. The stakeholder group agreed a set of indicators most suitable for assessing changes in delivery of ecosystem service benefits of commercial fisheries and include both broad scale and fine scale indicators. These comprise:

Broad scale indicators to evaluate the impacts of management measures and the activities of the LBCC inside and outside the Lyme Bay Reserve.

- Landings data from species which are associated with the reef habitat at some point in their life history. Landings data from ICES rectangles 30E6 and 30E7;
- Catch per Unit Effort (CPUE) of commercial species and fisheries supported by reef ecosystem;
- Composition of the fishing fleet; and
- Fisher employment.

Fine scale indicators to evaluate the impacts of management measures and the activities of the LBCC on fishermen who either fish in the Lyme Bay Reserve (static gear) or have been displaced from the Lyme Bay Reserve (mobile gear).

- Income/profit;
- Past and future investment in the industry;
- Existing and preferred sales strategies;
- Subjective economic wellbeing (related to fishing activity, income satisfaction and confidence in future investments);
- Subjective social wellbeing (related to fishing activity, job satisfaction and conflict);
- Subjective health and psychological wellbeing (related to fishing activity, stress and physical risk);
- Number of prosecutions (IFCA patrol time);
- Self-reported compliance;
- Acceptance of the MPA; and
- Perceptions and benefits from the LBCC (perceptions of the LBCC and perceptions on whether specific activities had delivered benefits).

Indicators of wider influence (outside events)

- Fuel prices;
- Quota; and
- Weather (storm and adverse weather frequency).

Data were sought on all these relevant indicators from the recommended available data sources. Data for calculating CPUE were not made available for this project due to commercial sensitivity restrictions regarding combined landings and sightings data linked to the individual vessels Port Letter and Number (PLN). Changes in effort linked to management measures and the LBCC have been analysed from the aggregated landings data and anonymised vessel identifiers.

7 A synthesis of fishing activity and landings in Lyme Bay from 2005-2015

7.1 Methods

7.1.1 Composition of fishing fleet and employment data: data collection and analyses

Registered vessel lists for September in each year for 2005-2015 were obtained from the UK Government Statistical Data Sets collection. Data from September was used for each year as the study commenced in September 2015 and interviews (primary data collection) commenced in autumn 2015. Lists were separated into 'registered and licensed vessels under 10 metres,' and 'registered and licensed vessels over 10 metres'. For each vessel length category, vessels relevant to the study were selected by home ports within the wider Lyme Bay region: Brixham, Exmouth, Teignmouth, Beer, Axmouth, Lyme Regis, West Bay and Weymouth. The Devon and Severn, and Southern IFCAs were consulted to verify which vessels actively fished within Lyme Bay and approximate crew numbers for each vessel.

Changes in registered vessels under 10 metres and vessels over 10 metres, within Lyme Bay were then plotted for each year from 2005 to 2015. Data were also plotted on the change in registered under and over 10 metre vessels for ports within the boundary of Lyme Bay Reserve (Beer, Axmouth, Lyme Regis and West Bay) between 2005 and 2015. To assess changes in employment (at sea jobs), the approximate number of crew in relation to registered under 10 vessels from ports within the Lyme Bay Reserve boundary were calculated. Changes in employment opportunities related to over 10 metre vessels in the wider Lyme Bay were not assessed as many of these vessels fish outside of the 6 mile limit (e.g. the larger mobile (towed) gear vessels based in Brixham).

Numbers of attendees on Seafish Basic Health and Safety training courses were identified during the project workshop as an indicator for new entrants to the fishing industry in the Lyme Bay Reserve area, as this course is the basic requirement for new entrants to the industry. Data on numbers attending courses run by the Southern Fish Industry Training Association (the Seafish approved training provider in the Lyme Bay area) were obtained from Seafish. Data were provided for all courses run at locations between Poole and Lyme Regis. Data were extracted on numbers attending courses between Weymouth and Lyme Regis as these courses were closest to new entrants to the industry with home ports within the Lyme Bay Reserve, as these courses were within 20 miles of Lyme Bay Reserve. Since 2012 courses were hosted at Lyme Regis and numbers attending these courses were also plotted separately as well as included in the 'all ports' data set as these courses were run at a location adjacent to the Lyme Bay Reserve.

7.1.2 Fishing activity and landings: data collection and analysis

Data on the volume of species landed by different gear types were obtained from the Marine Management Organisation (MMO) for each vessel that has fished in Lyme Bay (ICES statistical rectangles 30E6 and 30E7) from 2005 to 2014 (Figure 6).

As data pre-dated the December 2013 IFCA byelaws, the term 'Reserve' represents the 2008 SI closed area boundary until the December 2013 IFCA byelaws came into effect, after December 2013 the term 'Reserve' represents the combined boundary of the 2008 SI and the SCI (IFCA byelaws) (Figure 6). Demersal mobile gear is not permitted for use within the SI. Some areas within the SCI can be accessed with demersal mobile gear.

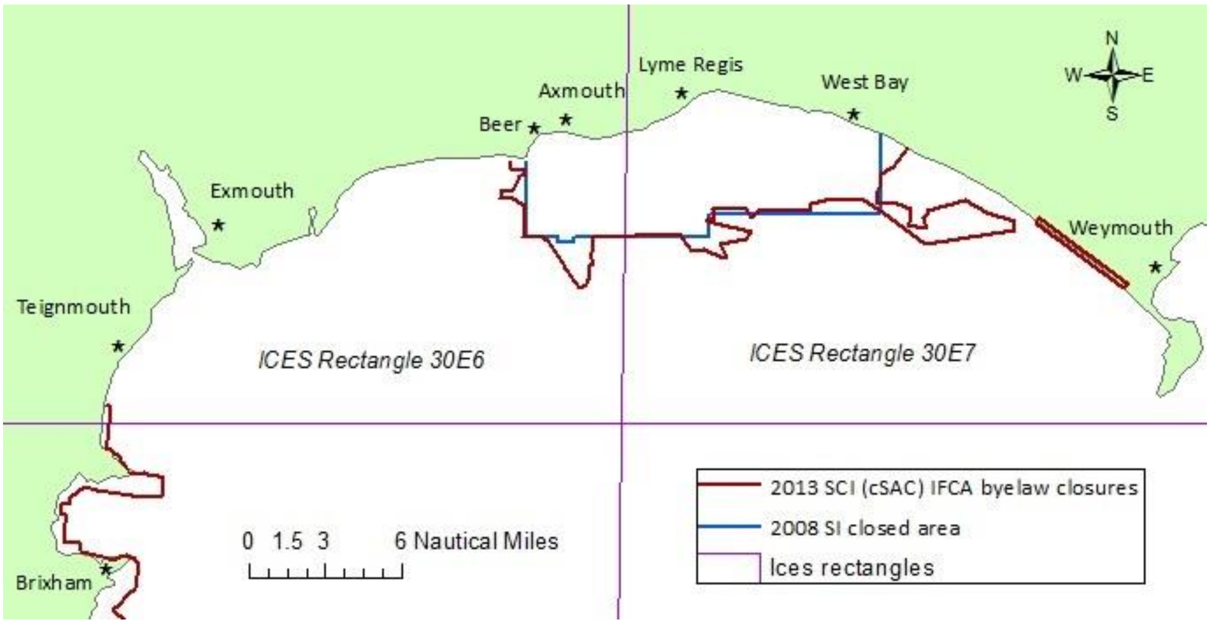


Figure 6 Spatial extent of ICES statistical rectangles 30E6 and 30E7.

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 Lyme Bay. The data set included the date the fishing took place, species caught, ICES rectangle fished, and the gear type used. We understand that these data could be underestimating the actual landings and fishing effort as there is no statutory requirement for fishermen to declare their catches for 10 metre and under vessels. Landings records for 10 metre and under vessels are therefore collated from log sheets and landings declarations supplied by fishermen and sales notes from buyers and sellers (MMO, 2016). We have, however, used this data set as it presents the official landings and provides a proxy indicator for fishing effort.

Information from enforcement agencies and data on sightings were used to match locations of where (inside or outside of the Reserve) fishing was being undertaken. This assumed that the catch of each vessel came from the location at which the vessel had been sighted. This is not true for all vessels especially the large vessels (over 10m) and therefore was only applied to vessels that were sighted and those that the Devon and Severn IFCA could confirm would only fish in certain areas. This underestimates the value of catches coming from the various areas but because we could not obtain disaggregated data due to data protection laws, the combination of expert judgements, the sightings data together with the landings data has allowed us to make inferences on whether the vessel fished inside or outside of the Reserve.

To assess changes in fishing effort, changes in the number of static gear and mobile gear vessels fishing inside and outside the Reserve were calculated as mean number of vessels fishing in each area (inside and outside the Reserve) per year and mean number of trips to each area per year. Due to data confidentiality, sightings data was not available at the vessel level. The data covering 2005 to 2014 were split into years from July to June as the initial 2008 SI closure commenced in July 2008. The process was repeated to analyse weight (kg) (mean kg per vessel per month for each year 2005-2014) and value of total landings (£) (mean £ per vessel per month for each year 2005-2014). Fishing activities were separated as static or mobile gear types fishing inside or outside the Reserve. This separation reflects activities that were still permitted and those that are no longer allowed. Landings data were further interrogated to analyse mean landings per month per vessel for 8 of the key commercial species identified in Section 5.2.2 (review of beneficial ecosystem services): Whelk, Scallop, Crab, Lobster, Cuttlefish, Lemon Sole, Sole and Plaice.

In order to test for changes in effort and landings data over time, one-way analysis of variance (ANOVA) was used. This was to determine whether there are any significant differences between the means of the 12 year groups between 2005 and 2014. Where a significant difference was found, Tukey's HSD *post hoc* analysis was used to compare all pairs of means for the different years. The ANOVA procedure requires data to be normally distributed and variance to be homogeneous, therefore data were first tested for normality of distributions using the Shapiro-Wilk test and homogeneity of variance was tested using Levene’s test. For activity or landings data sets where Levene's test for homogeneity of variance was significant, Welch's ANOVA was used followed by Games-Howell *post hoc* analysis. Welch’s ANOVA (Welch’s *F* test) was used as this procedure does not assume that the variances of the groups being compared are equal (Tomarken and Serlin, 1986).

The *p*-value provided by the statistical test can range from 1.00 to 0 and indicates the probability of random sampling resulting in the means (of values in fishing activity and landings each month

2005/06-2013/14) as far apart as observed in the data set being tested. A small *p*-value indicates that the differences in the data are unlikely to be due to random sampling. If the *p* value returned is below 0.05 the difference is considered significant as the statistical test indicates there is only a 5% or lower probability that the differences observed in means could have been returned by random sampling and 95% probability that the annual activity and landings data do not have identical means. As this test compares the means across all years, it does not indicate which years are different and therefore the post hoc tests were used to identify which years differed.

7.2 Results

7.2.1 Changes in composition of the Lyme Bay fishing fleet

Fishing within the Lyme Bay Reserve is dominated by smaller under 10 m (inshore) vessels that mainly fish within the 6 mile limit. Under 10 metre vessels comprise approximately 74% of the total number of vessels registered to ports within the Lyme Bay study region and 96% of vessels registered to ports within the boundary of the reserve. In the study period (Between 2005 and 2015), the number of under 10 metre vessels registered to ports within Lyme Bay Reserve has remained stable between 38 to 44 vessels (Figure 7). A similar stable pattern was evident in the number of over 10 metre vessels registered to ports within the Reserve boundaries. Over 10 metre vessels registered to ports within the reserve boundaries have ranged between 2 in 2008 to 3 in 2015, with a peak of 4 registered vessels in 2011 (Figure 7). Since 2012, registered vessel data from MMO included scallop licenses related to each vessel. These data show that 2 of the 3 over 10 metre vessels in 2012 and all 3 registered vessels in 2013-2015 (with home ports within the Reserve) held scallop licenses, and would therefore have to undertake this activity outside of the Reserve boundary.

In the wider Lyme Bay region there has been an overall decline in the number of under 10 metre vessels between 2005 and 2015. The highest number of vessels was registered in 2012/13 (213 vessels), while the lowest in 2015 (191 vessels). The overall number of vessels in this 10 year period show a range of plus or minus 22 vessels. Conversely, there has been an increase in the number of over 10 metre vessels in the 2005-2015 period (68 vessels in 2005 and 69 vessels in 2015). The highest number of vessels were registered in 2007 (73 vessels). The lowest number of vessels were registered in 2011 (58 vessels). The overall range of data in this 10 year period representing additions or losses of 15 vessels (Figure 7).

In terms of links to the timescale of significant management measures (the 2008 closed area and the introduction of IFCA byelaws December 2013) and activities of the LBCC, no causal links can be made as there are wider environmental or social and economic factors influencing the number of registered vessels e.g. retirement, decommissioning schemes. Additionally, registered boat lists are not truly representative of vessel numbers as a boat may fish in Lyme Bay but be registered elsewhere in the region. However, it can be observed that the peak in under 10 metre vessel numbers between 2008 and 2009 registered to Lyme Bay Reserve ports and a small increase (2 vessels) in over 10 metre vessels between 2008 and 2011 correspond to the years the SI closure was established. Additionally, it must be noted that in the UK as a whole there is a national trend of decline in the number of under and over 10 metre vessels registered (Elliot et al. 2014). Whilst the number of under 10 metre vessels registered to ports in the wider Lyme Bay region has declined in the 10 year period, supporting this national trend, the number of under 10 metre boats registered to ports within the Reserve boundary has not declined, nor has the number of over 10 metre boats registered to ports both inside and outside the Reserve. It is possible that the presence of a large port and related shore based service industries at Brixham may continue to support larger vessels in the wider Lyme Bay region. Additionally, the management and opportunities presented by the LBCC may provide some resilience to the under 10 metre fleet registered to the Reserve ports against a national picture of decline.

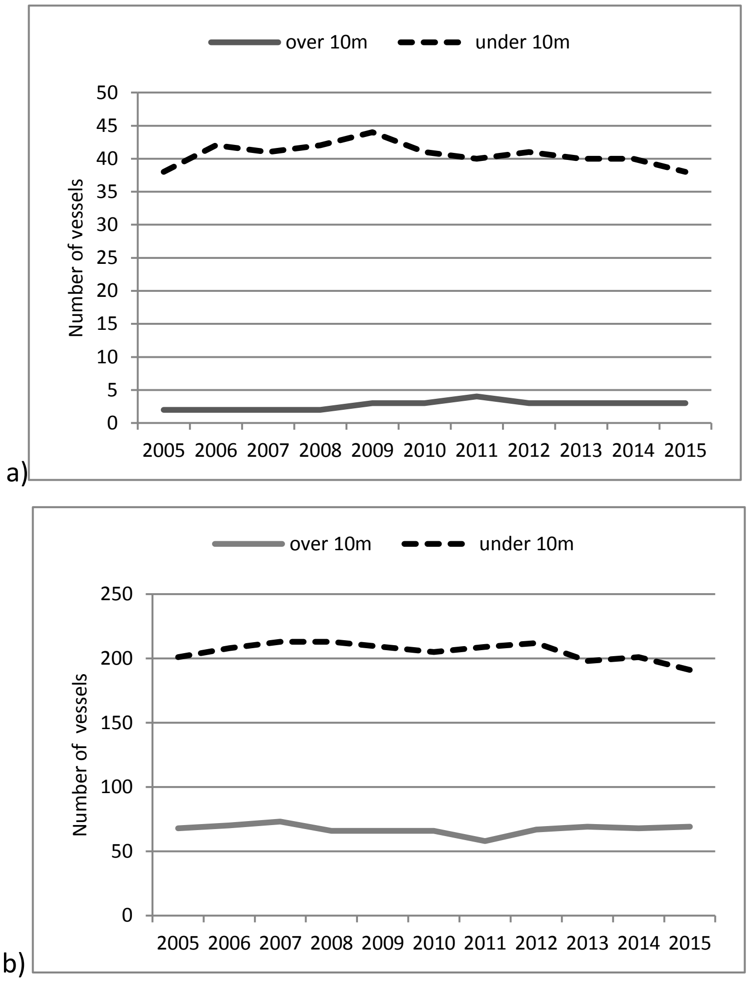


Figure 7 Numbers of vessels between 2005-2015 with; a) registered home ports within the boundaries of Lyme Bay Reserve; b) registered home ports across all Lyme Bay study region

7.2.2 Changes in fishing industry employment related to active vessels

At the time of the study individual under 10 metre vessels operating from ports within the boundary of the Reserve supported employment for between 1 and 3 crew (only 3 vessels, all in West Bay, were identified by IFCA representatives as being operated by a crew of up to 3 fishermen, including the skipper). The majority of under 10 metre vessels from the major ports in the wider study area, Weymouth and Brixham, were also operated by up to 3 crew (indicated by consultation with regional IFCAs) per vessel. Larger over 10 metre vessels operating from ports in the study region are operated by between 2 and 4 crew (including the skipper).

Between 2005 and 2015, under 10m vessels from ports within the Reserve boundary supported a minimum of 38 and a maximum of 76 at sea jobs. There has been no net increase in the number of at sea jobs linked to the under 10 m fleet registered to vessels in Reserve ports between 2005 and 2015. Given the range in the number of vessels registered during this 10 year period, between 6 and 8 at sea jobs have been created and lost in this timescale. A decrease in registered under 10 metre vessels since a peak of 44 vessels in 2009 to 38 vessels in 2015 was spread between Axmouth (1 vessel less), Lyme Regis (2 less vessels) and West Bay (3 less vessels). This represented an approximate reduction in a minimum of 6 and maximum of 18 at sea jobs (consultation with regional IFCAs).

Over 10 metre vessels registered to ports within the boundaries of the Reserve supported between 4 and 8 at sea jobs in 2005 and between 6 and 12 at sea jobs in 2015. The reduction of 22 under 10 metre vessels registered with home ports across the wider Lyme Bay region, from a peak of 213 vessels in 2008 to 191 vessels in 2015, represents a potential decrease of a minimum of 22 at sea jobs (and maximum of 66 jobs).

These results must be interpreted with caution as the data on registered vessels does not indicate actual crew numbers (employment) even though verification on numbers has been sought through consultation with regional IFCAs. The information on vessel and crew numbers also does not indicate the level of activity. Additionally, it is important to consider that some inshore fishermen are part-time or near retirement age. Fishermen may also have sought other employment on other vessels and therefore jobs are not necessarily lost.

7.2.3 Changes in numbers of new entrants to the industry

Numbers of attendees of the Seafish Basic Health and Safety training course for all ports in proximity to Lyme Bay Reserve (under 20 miles) remained within a range of between 0-21 between 2005 and

2011 (Figure 8). Peaks were seen in 2005 (15 attendees) and 2009 (21 attendees). Since 2012 the range of numbers attending the Seafish Basic Health and Safety Training course has been higher than previous years, from 2012 to 2015 between 20 and 40 people attended the training courses). Peaks were seen in 2012 (40 attendees) and 2015 (33 attendees). Since 2012 the course has been held in Lyme Regis as well as Weymouth and Portland. The high numbers of attendees for courses in Lyme Regis (within a range of between 20 and 30 attendees between 2012 and 2015) account for the higher overall number of attendees between 2012 and 2015.

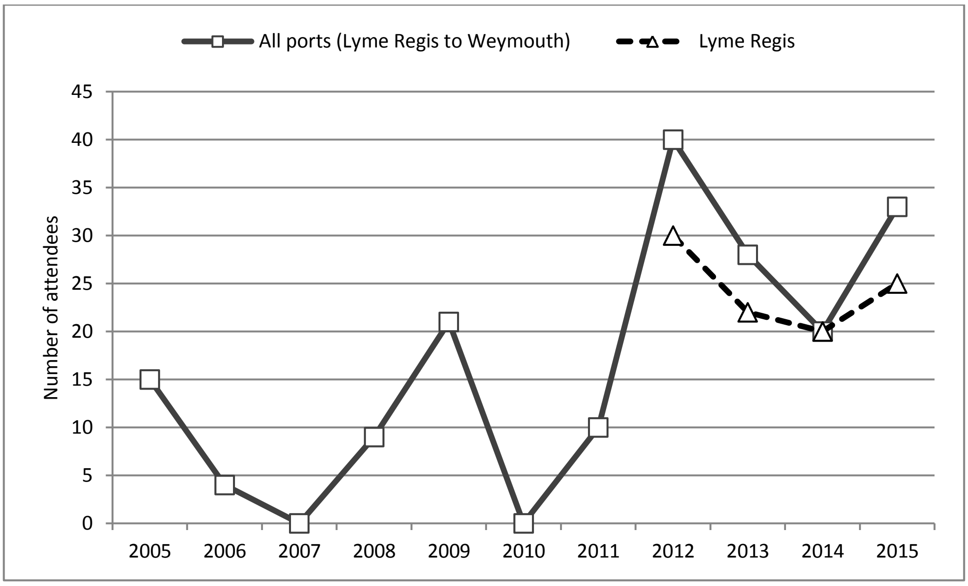


Figure 8 Number of attendees on the Basic Health and Safety courses delivered by the Southern Fish Industry Training Association in ports between Lyme Regis and Weymouth between 2005 and 2015 and just in Lyme Regis 2005-2015.

It is unknown if the high attendance for courses in Lyme Regis may be due to decreases in courses run in other ports in the South Devon and Dorset regions, resulting in attendees travelling from the wider region. Therefore, confidence in these results reflecting an increase in new entrants to the fishing industry in the local region, surrounding Lyme Bay Reserve (under 20 miles) has been treated with caution and considered low. However, the data suggest that there has been an increase in new entrants to the industry in the region immediately surrounding Lyme Bay Reserve between 2012 and 2015.

7.2.4 Changes in fishing activity

The number of vessels actively fishing inside and outside the Lyme Bay Reserve and reporting landings from ICES statistical rectangles 30E6 and 30E7 per month has increased over the 9 year period from 63 in 2005/2006 to 105 vessels in 2013/2014 (mean number of vessels per month) (Figure 9 a, b). The number of vessels using static gear, fishing inside the Reserve has shown the smallest increase (from 27 vessels in 2005/2006 to 28 vessels in 2013/2014), while the number of vessels using static gear fishing outside of the Reserve has shown the greatest increase from 29 vessels in 2005/06 to 61 vessels in 2013/2014 (an increase of 32 vessels).

Numbers of vessels using towed gear fishing outside the Reserve increased from 10 vessels in 2005/2006 to 17 vessels in 2006/2007. The number of vessels then declined to the lowest point between 2009 and 2011 (13 vessels) (Figure 9, a, b). In the 9 year period (2005 to 2014), the number of mobile gear vessels actively fishing per month has increased overall from 10 vessels in 2005/2006 to 16 vessels in 2013-14.

Data on mean number of trips per month for all vessels indicates that total fishing effort (mean monthly trips for all vessels, combined for all fishing practices) across Lyme Bay had increased significantly between 2005 (199 trips) and 2014 (722 trips) (Welch's $F = 39.37$, $P < 0.01$). A significant increase in the number of trips conducted by those fishing inside and outside of the Reserve with static gear, from 124 trips (mean number of trips per month for all vessels) in 2005 to 637 trips in 2014, accounts for much of this increase (Figure 10a) (inside, Welch's $F = 30.9$, $P < 0.01$, outside, Welch's $F = 41.3$, $P < 0.01$). It is important to consider when interpreting this result that mean monthly trips in each year were calculated from available landings and relevant sightings data and corroboration from regional IFCAs. As there is no statutory requirement for fishermen to declare their catches for 10 metre and under vessels and level of voluntary declarations may have increased or decreased over the years, the data may not reflect actual landings and spatial effort. Similarly sightings data is dependent upon patrol effort, which also changes over time. As such, results should be interpreted with caution. As discussed, we have used this data set as it presents the official landings and provides a proxy indicator for fishing effort.

In terms of links to the timescale of significant management measures (the 2008 SI closed area and the introduction of IFCA byelaws December 2013) and activities of the LBCC no definitive causal links can be made as there are wider environmental or social and economic factors influencing fishing effort e.g. weather. Additionally, the interpretation of the data is limited by the available data which only relates to the ICES statistical rectangles 30E6 and 30E7 and does not take into account wider fishing activity, nor does it truly capture displacement of fishing activity. However, a number of observations can be made from the data. Overall there has been a significant increase in effort from vessels using static gear inside the Reserve (Welch's $F = 30.9$, $P < 0.01$). Following the initial SI closure the number of trips per month within the Reserve for vessels using static gear increased from 36 in 2005 to 173 in 2009/2010 (Games- Howell pair wise comparison, number of trips, 2005/2006 and 2009/2010 $P = 0.03$). This suggests that there was a significant increase in effort in the years following the initial closure. The mean number of fishing trips per month for static gear vessels fishing inside the Reserve continued to rise between 2009/2010 and 2010/2011 to a peak of 282 trips per month. Fishing effort from vessels using static gear then declined slightly between 2010/2011 and 2012/2013 to 223 mean trips per month to grounds inside the Reserve. The number of trips per month within the Reserve for all vessels using static gear increased again in 2013-2014 (Figure 10a). It can be noted that fishing effort for static gear boats inside the Reserve increases during the period the LBCC has been active and IFCA byelaws have been announced for the SCI (candidate SAC).

Overall the data suggests there has been a significant increase in effort from vessels using static gear outside the Reserve (Welch's $F = 41.3$, $P < 0.01$). The mean number of fishing trips for all vessels using static gear outside the Reserve increased year on year apart from 2011/2012 to 2012/2013 (Figure 10a). Fishing effort rose from 88 mean trips per month (all static gear vessels) in 2005/2006 to a peak of 395 trips in 2013/2014 (Figure 10a). The greatest increase in mean trips per month outside the Reserve was between 2005/2006 (88 trips) and 2007/2008 (246 trips) (Figure 10a), reflecting the increase in the number of vessels fishing with static gear outside the Reserve during this period (Figure 9a), and corresponding to the original SI closure. Although fishing effort of vessels using static gear outside the Reserve decreased from 370 trips in 2011/2012 to 340 trips in 2012/2013 effort increased again in 2013/2014 to a peak of 395 trips. The range of effort in these years was high (340-395 trips) in relation to the range in previous years (88-355 trips, 2005 to 2011). These years correspond to the period the LBCC were active and IFCA byelaws were introduced. Given the significant increase in effort from vessels using static gear both inside and outside the Reserve it is likely that there are other factors supporting static gear fisheries in the Lyme Bay region, such as availability of species or markets, as well as the influence of selective gear spatial management measures. It can also be considered that the spatial measures that comprise the Reserve may have been influencing where static gear fishermen choose to fish and may have attracted fishermen from other areas.

Before the SI closure, the number of fishing trips per month made by fishermen using mobile (towed) gear was slightly higher inside the closed area than those made to outside the closed area (41 trips per month (mean) inside compared to 35 outside), suggesting the area was an important fishing ground. This however changed from July 2008 when all bottom towed (mobile) fishing activities were banned from fishing inside the closed area (Figure 10b). Fishing effort for vessels with mobile (bottom towed) gears increased significantly in the remaining open grounds following the 2008 SI closure (number of trips per month for all mobile gear vessels in the years after the closure, compared to the years before the closure, $t = -7.45$, $P < 0.001$). This effort outside the Reserve has continued to increase throughout the 10 year time period (from 53 trips in 2005/2006 to 85 trips in 2013/2014).

Of interest for the mobile fleet is that the number of vessels fishing with mobile gear outside the closure did not increase but remained stable and then decreased following the closure (16 vessels in 2008/2009 and 2009/2010, and then decreased to 13 vessels in 2009/2010 and 2010/2011), despite displacement of between 4 and 9 vessels that had been fishing with mobile gear inside the closure in the 3 years prior to the 2008 SI closure (Figure 9b). It is possible that the results of the mean number of trips per month for mobile vessels inside the Reserve, in the years prior to the SI closure was high due to presence of visiting mobile gear vessels from outside the region, prior to the SI closure. The lack of direct transfer from inside to outside the Reserve also suggests that vessels may have been displaced to fishing grounds outside of these ICES areas.

Mean trips per month by vessels using mobile gears to locations outside the Reserve increased significantly over the period of the study from 53 (2005) to 85 trips 2013/2014 (Welch's $F = 4.5$, $P < 0.03$). An initial increase occurred from 53 trips in 2005 to 76 trips between 2008/2009 and 2009/2010, also indicating displacement of effort following the initial closure**.** Fishing effort from vessels using mobile gear (mean number of trips per month for all mobile gear vessels) continued to increase each year outside the Reserve, reaching a peak of 101 trips in 2012/2013 (Figure 10b). Effort decreased in 2013/2014 to 85 (mean number of trips per month for all mobile gear vessels) outside Lyme Bay Reserve. However, this change was not significant (Games-Howell pair wise comparison 2012/2013 and 2013/2014, $P = 0.9$) and was still within the range of values seen between 2008/2009 to 2010/2011 (76 to 85 trips). It can be observed that mobile gear effort has increased outside of the Reserve throughout changes in management during this time period. A slight decline in effort can be observed between 2012/2013 and 2013/2014, after December 2013 when IFCA byelaws were introduced, preventing towed (mobile) gear in some further areas of Annex I reef habitat. There was also a period of intense storminess in the winter of 2014 which may have limited time at sea.

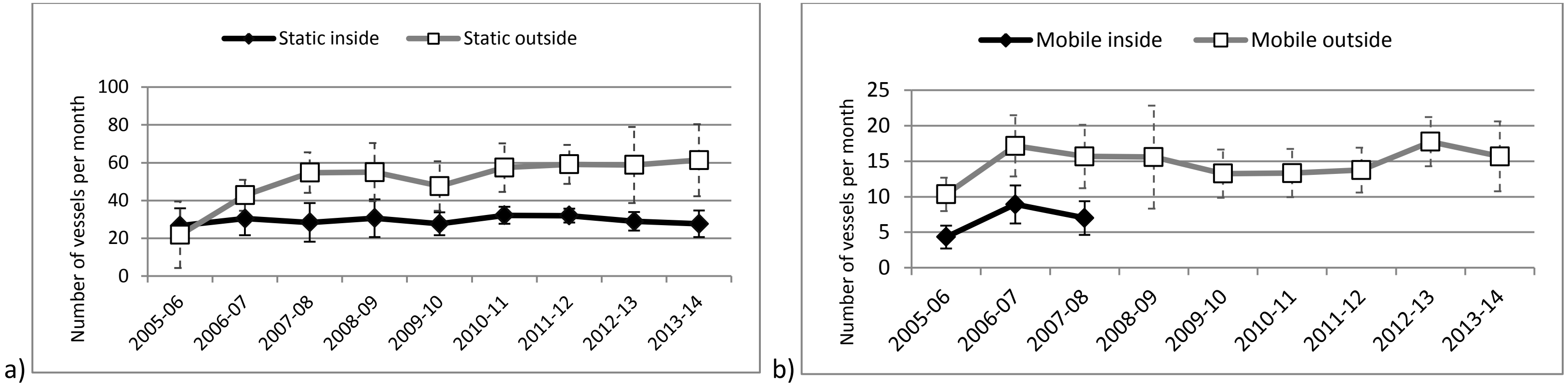


Figure 9 Number of vessels per month (mean) actively fishing inside and outside the closure/ Lyme Bay Reserve post 2013) for a) static and b) mobile gear categories.

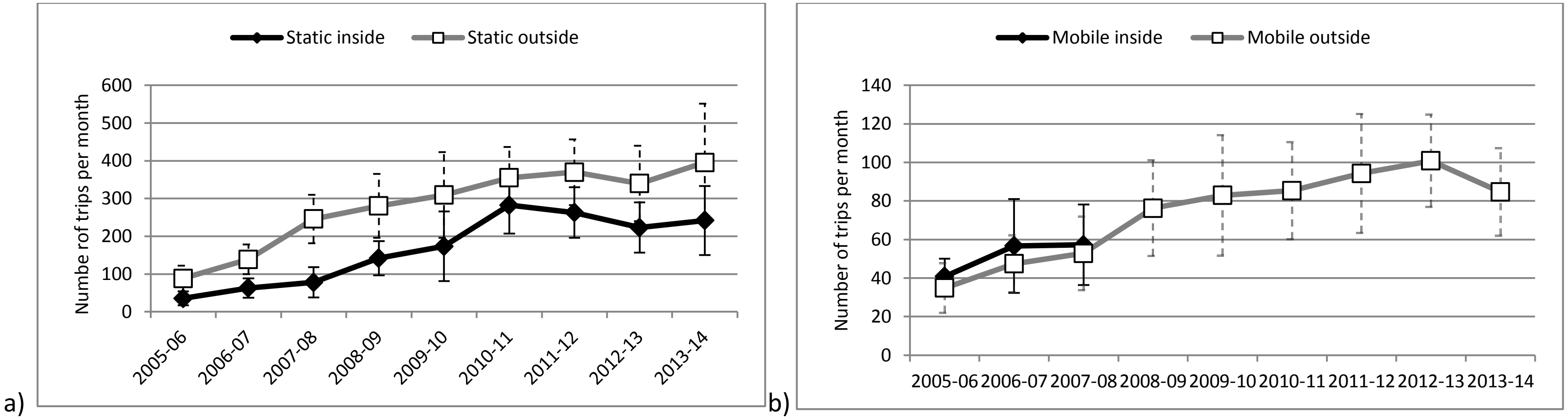


Figure 10 Number of trips per month (mean) conducted by vessels to locations inside and outside the closure closure/ Lyme Bay Reserve post 2013 for a) static and b) mobile gear categories.

7.2.5 Changes in landings

Comparisons of data on weight of landings (mean kg per vessel per month) from 2005 to 2014 show that the volume for all species landed by static gear fishermen, from trips within the Reserve, significantly increased from 2.6 tonnes in 2005/2006 to 3.5 tonnes per vessel per month in 2013/2014 (Welch's *F* 2.1*, P* = 0.05), (Figure 11a). The value of landings also significantly increased over the 9 year period (Welch's *F* 3.6, *P* = 0.03). Between 2005/2006 and 2009/2010 there was a steady rise of between £102 and £386 each year in mean monthly landings value per vessel. The largest rise (£500) occurred between 2009/2010 and 2010/2011 (Figure 11a). Static gear landings peaked in 2010/2011 (3.8 tonnes per vessel per month). Landings weight (mean kg per vessel per month) sharply declined between 2010/2011 and 2011/2012 to 2.2 tonnes, before recovering to 3.5 tonnes in 2013/2014 (Figure 11a). However, value of landings show a much smaller decline in relation to the decrease in landings weight in 2011/2012, falling to £2918 in 2011/2012 and recovering steadily to £3501 in 2013/2014. This suggests that from 2010-2011 a higher value is achieved for less weight landed, which could be caused by a decrease in landings weight for lower value species, changes in market prices or catch composition and static gear fishermen targeting higher value/lower weight species.

Overall, landings weight from vessels operating static gear outside the Reserve decreased slightly from 3.3 tonnes (mean per month) in 2005/2006 to 2.4 tonnes (mean per month) in 2013/2014, despite the evidence that static gear fishing effort outside the Reserve had increased. Landings values, however, slightly increased, (from a mean of £3456 in 2005/06 to £3470 per vessel per month in 2013-14).

The total weight of landings from all static gear fishing outside the Reserve initially showed a significant decrease from 3.3 tonnes (mean per vessel per month) in 2005/2006 to 1.3 tonnes in 2007/2008 (Games-Howell pair wise comparison 2005/2006 and 2007/2008 *P* = 0.05). A gradual increase to 2.4 tonnes in 2010/2011 (Figure 12a) corresponds to the increase in effort (no. trips and vessels) occurring after the 2008 SI closure (Section 7.2.4). Landings from outside the Reserve by static gear vessels followed a similar trend to landings from inside the Reserve, decreasing in 2011/2012 and 2012/2013 (to 1.6 tonnes and 1.4 tonnes respectively), before recovering in 2014 (to 2.4 tonnes) (Figure 12a). Value of landings from outside the Reserve also showed a smaller decline during this period compared to weight of landings, suggesting similar factors have affected the static gear fisheries inside and outside the Reserve in these years.

The landings achieved per vessel (kg) and the value received (£) are greater for static gear vessels operating inside the Reserve compared to vessels outside the Reserve (Figure 11, Figure 12). Landings from static gear fisherman operating outside the Reserve are dominated by landings of whelk.

Landings for mobile (towed) gear fishermen sharply declined within the area that was closed by the 2008 SI closure, from 11 tonnes (mean per vessel per month) in 2005/2006 to 3.7 tonnes in 2007/2008. This decline preceding the SI closure is supported by the evidence for a decrease in effort (section 7.2.4) during this period, possibly linked to the voluntary closures that were agreed during this time period (Section 7.2.4; Figure 11). Landings for mobile gear fishermen fishing outside the Reserve also declined from 26 tonnes (mean per vessel per month) in 2005/2006 to 3.7 tonnes in 2007/2008, although the high landings weight in 2005/2006 was due to a small number of very high volume landings of mussels which are (at this point) unexplained. Changes in landings of the mobile fleet and value achieved are linked to management measures associated with the Reserve as fishing vessels and effort have been displaced. Other influences include composition of species landed, market prices, quota and weather.

Changes in value of landings (mean £ per vessel per month), pooled for fishing locations both inside and outside the Reserve, shows landings values for mobile (towed) gear fishermen decreased significantly, from a peak of approximately £24561 (mean per vessel per month) in 2005/2006 to approximately £6056 (mean per vessel per month) in 2013/2014 (Welch's $F = 13.5$, $P < 0.01$). Meanwhile, landings for static gear vessels increased significantly from £5411 (mean per vessel per month) in 2005/2006 to £7267 (mean per vessel per month) in 2013/2014 (Welch's $F = 2.6$, $P = 0.02$). This indicates there has been a decrease in landings value for mobile (towed) gear fishermen, despite increased effort in remaining open grounds in Lyme Bay. The reduced fishing grounds in ICES rectangles 30E6 and 30E7 for mobile gear, combined with the fact that the most productive grounds for scallops (DSFC 2008) are in the areas that were closed to towed gears by the 2008 SI closure and 2013 IFCA byelaws will have had an impact on landings. As Mangi et al. (2012) identify, this may explain the decline in fishing income for towed gear fishermen from these two rectangles. Conversely, annual sea fisheries statistics published by the MMO show that at a national level, the value of landings from fishermen using mobile gears rose from 2006 to 2012 and remained higher than 2006 in 2013 and 2014 (Elliot et al. 2014). It is possible that mobile gear fishermen who have been displaced as a result of management measures within the ICES rectangles 30E6 and 30E7 have sought other fishing grounds.

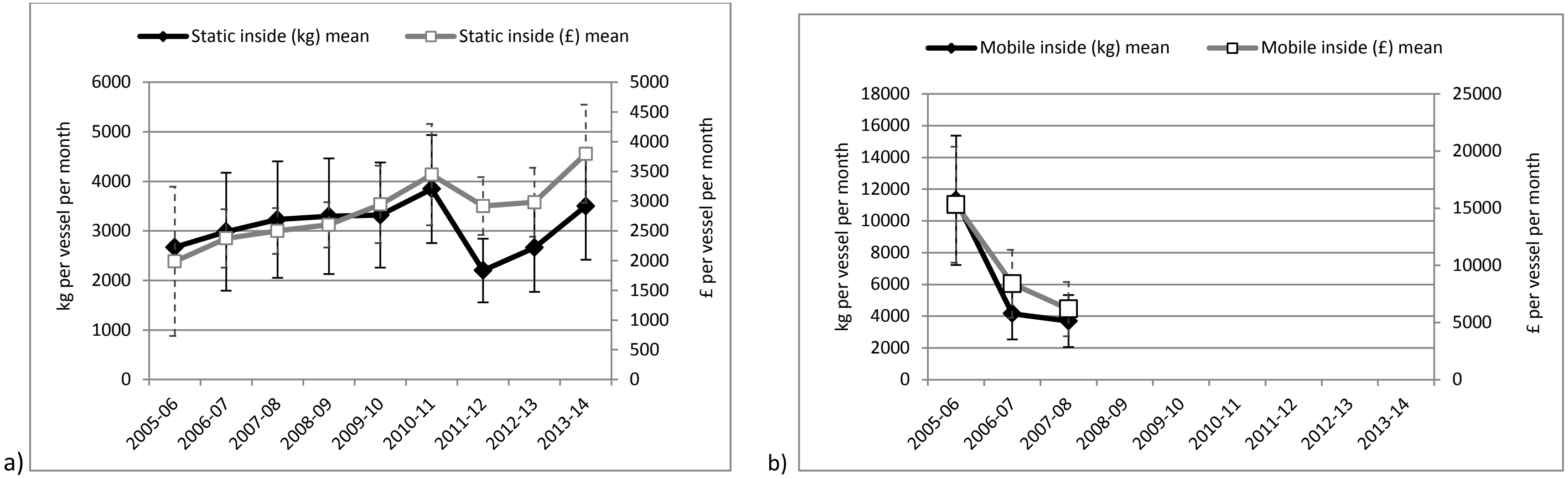


Figure 11 Wet weight of landings and value of landings per vessel per month for a) static gear vessels and b) mobile gear vessels fishing inside the Reserve.

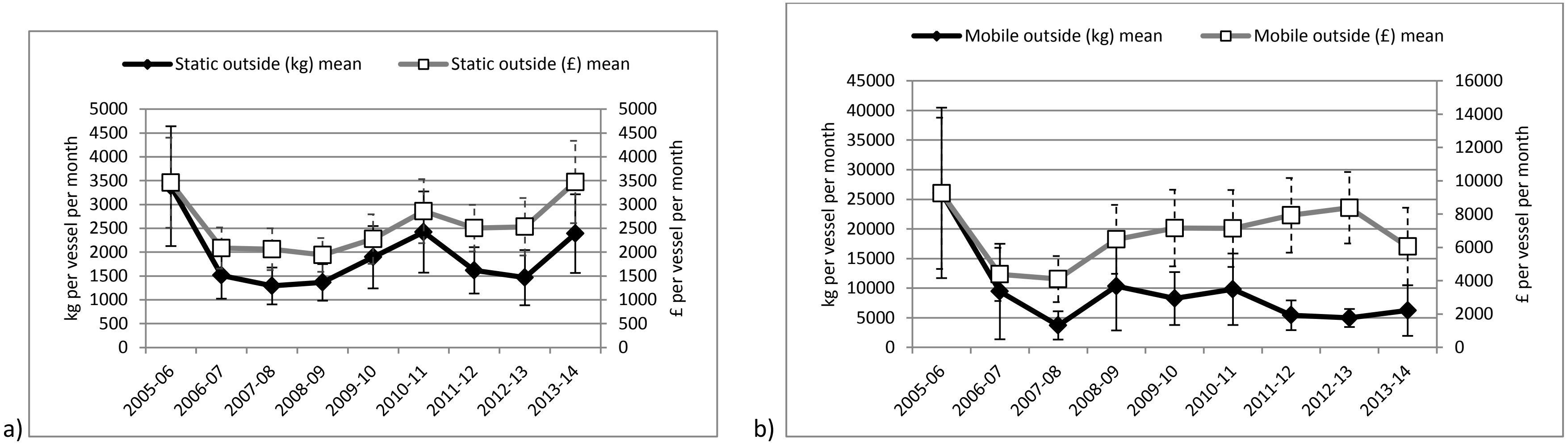


Figure 12 Wet weight of landings and value of landings per vessel per month for a) static gear vessels and b) mobile gear vessels fishing outside the Reserve.

7.3 Landings and values of selected species

A number of species (crabs, scallops, whelk, cuttlefish, lobster and lemon sole) have been selected for further enquiry as they comprise non-quota species that are important landings associated with the Lyme Bay Reserve and the wider Lyme Bay region. Landings data for sole and plaice are also included as, although they are quota restricted species, they provide high value landings (when quota allows) and therefore contribute to value of fisheries benefits. For the purpose of this evaluation, data have been divided into vessels that are predominantly set up for either mobile (towed) or static gear fishing. However, it must be noted that individual fishermen may (at different times of year) switch to an alternate form of fishing to take advantage of available stocks e.g. predominantly mobile gear vessels also setting pots for whelks. Each species is addressed in further detail in individual sub-sections. Landings data for individual species, from ICES rectangles 30E6 and 30E7, between 2005 and 2014 show the non-quota species whelk and scallops provided the greatest contribution to total landings volume and value, combined for all vessels and fishing locations (Figure 13, Figure 14, Figure 15, Figure 16). Full tables can be viewed in Annex V.

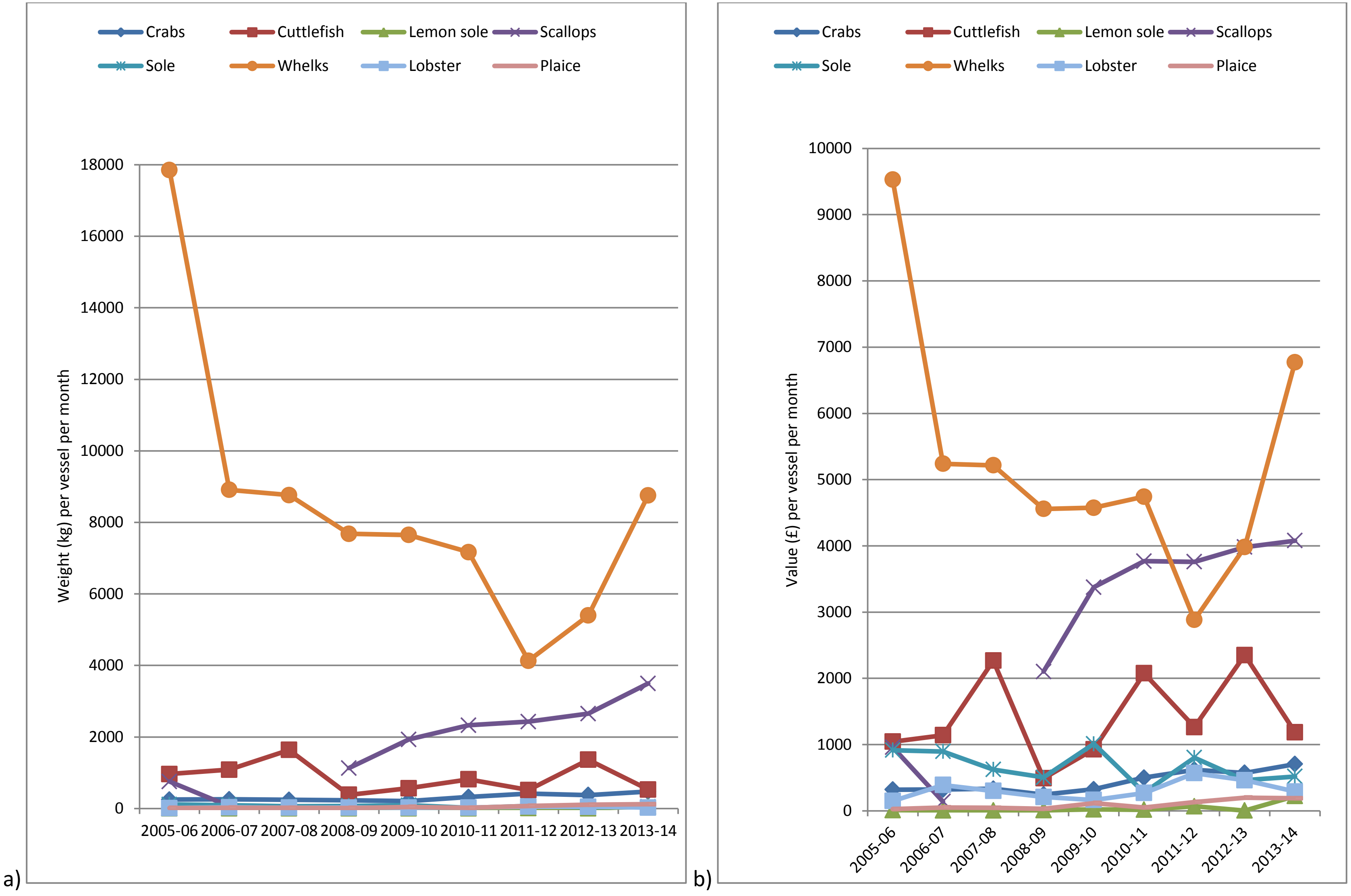


Figure 13 Species landings from inside the Lyme Bay Reserve by vessels operating static gears a) mean weight (kg) per vessel per month, b) mean value (£) per vessel per month.

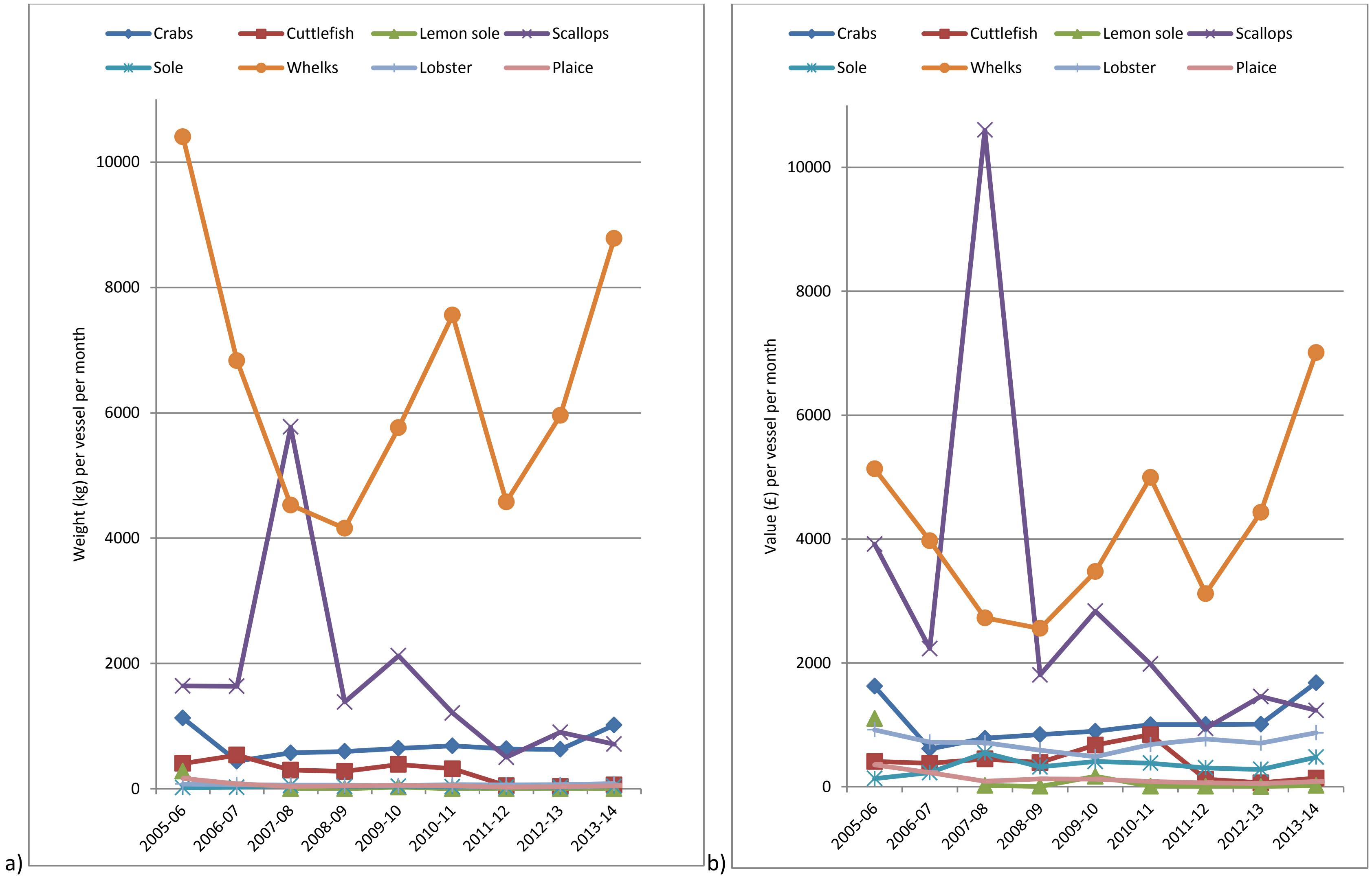


Figure 14 Species landings from outside the Lyme Bay Reserve by vessels operating static gears a) mean weight (kg) per vessel per month, b) mean value (£) per vessel per month.

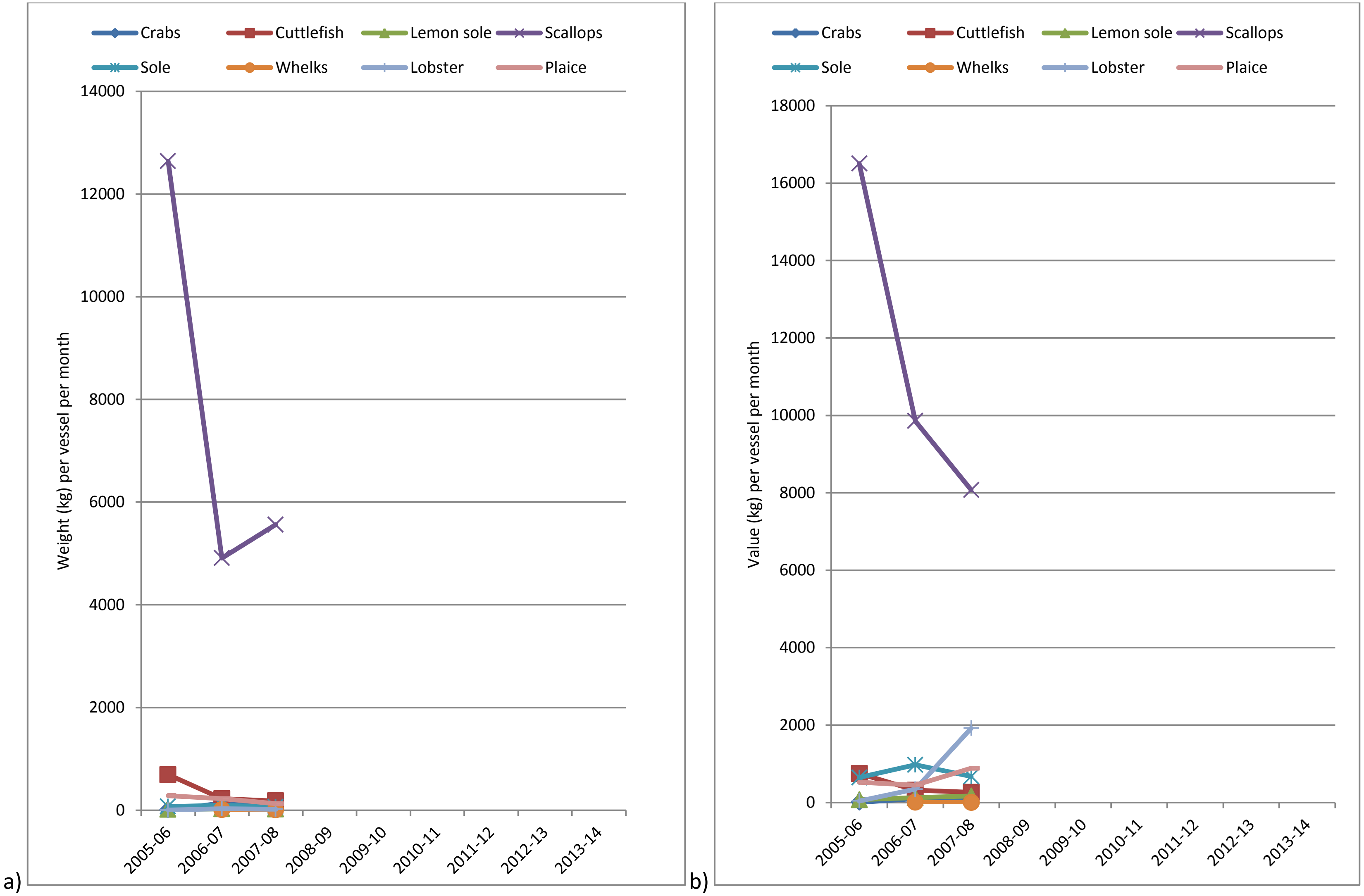


Figure 15 Species landings from inside the Lyme Bay Reserve by vessels operating mobile gears a) mean weight (kg) per vessel per month, b) mean value (£) per vessel per month.

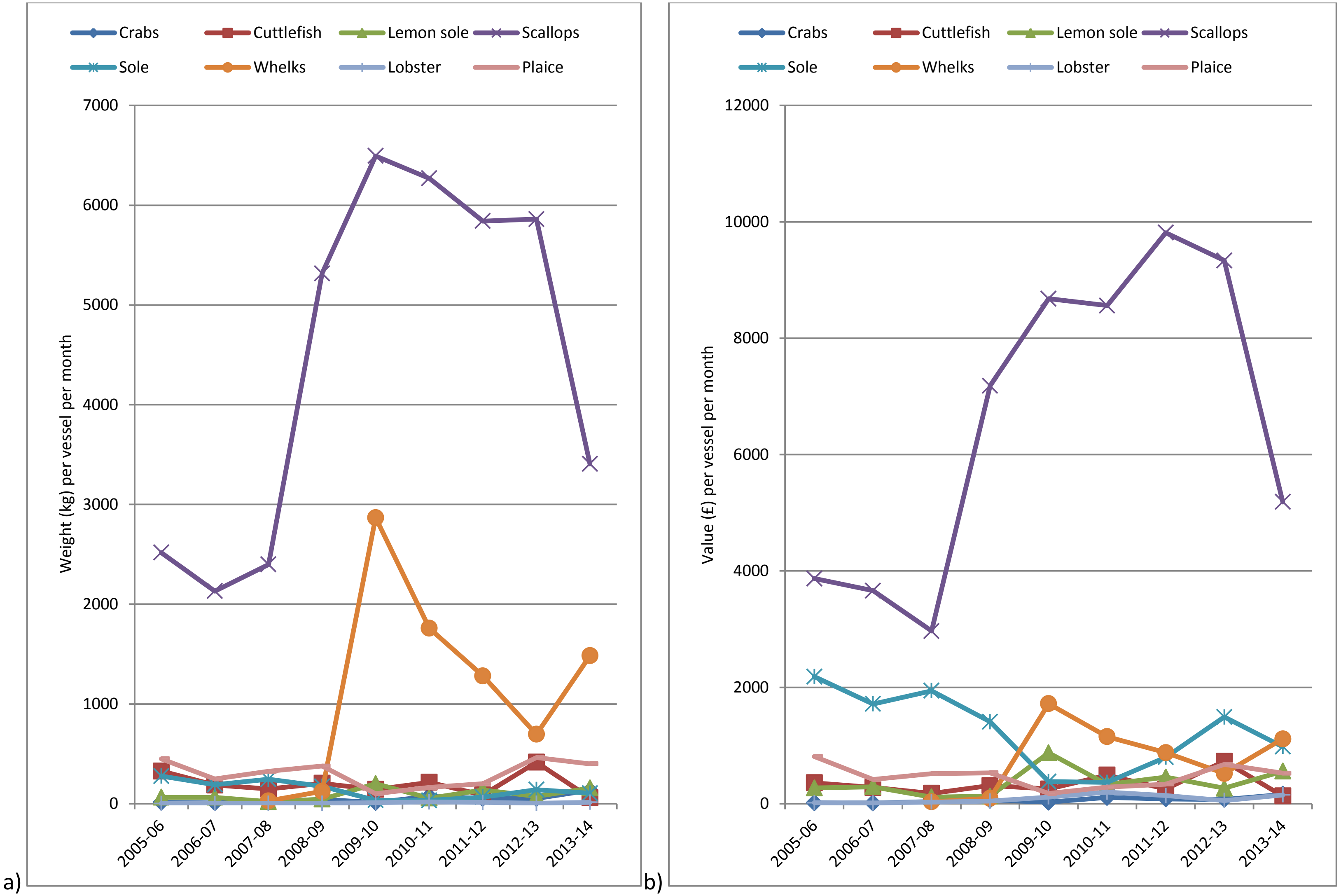


Figure 16 Species landings from outside the Lyme Bay Reserve by vessels operating mobile gears a) mean weight (kg) per vessel per month, b) mean value (£) per vessel per month.

7.3.1 Whelk (*Buccinum undatum*)

Whelks are a static gear fishery. Between 2005 – 2014 landings of whelks by static gear fishermen operating inside the Reserve declined by half from ~18 to ~9 tonnes (mean per vessel per month) (Welch's $F = 3.7$, $P = 0.04$) (Figure 13a). A similar decline was observed in the whelk landings for static gear fishermen fishing outside the Reserve (Figure 14a). Landings (mean vessel kg per vessel per month) between 2006/2007 and 2013/2014 were within similar ranges for static gear fishermen operating inside and outside the Reserve. In terms of catch value there had been a corresponding decline in value of approximately £2755 (mean per vessel per month) operating inside the Reserve, but an increase in value of £1874 (mean per vessel per month) outside the Reserve. These opposing trends could possibly be related to a very high volume of landings of whelk caught in 2005 from within the area that now forms the Reserve (17.9 tonnes). As data were not obtained from MMO on landings before 2005 it is unknown if similar high volumes of whelk were landed in earlier years. Additionally the Registration of Buyers and Sellers (RBS) Scheme has been fully operational in England since 2005 under the Registration of Fish Buyers and Sellers and Designation of Fish Auction Sites Regulations 2005 (England). The legislation requires that all buyers and sellers of first sale fish are registered and that all auction sites of first sale fish are designated. Before 2005 there was no obligation for commercial fishers to release so much information about their catch – thus making the data available for the years before 2005 subject to bias.

For fishermen using mobile gear data suggest that no further pots were set for whelks following the SI closure in 2008-2009. For vessels predominantly using mobile gear outside of the Reserve there is a significant increase in the volume of whelks landed from 0.032 tonnes (32kg) (mean per vessel per month) in 2007/08 to approximately 1.1 tonnes landed (mean per vessel per month) in 2013-14 (2007/2008 to 2013/2014, Welch's $F = 7.1$, $P < 0.01$) (Figure 16a). This corresponds to the SI closure in 2008/2009 and signals a potential shift (diversification) in gear types to either take advantage of the market or supplement income due to displacement effects.

Significant changes in value and landings for whelk (mean £ per vessel per month) for the mobile sector, for the years over the study period were only identified when data from 2005/2006, 2006/2007 and 2007/2008 were excluded from analyses, as whelk catches were recorded in less than 3 months out of the 12 months in each of these years, preventing analyses using ANOVA tests. In pair-wise comparisons of years between 2008/2009 and 2013/2014, significant increases were present in tests between 2008/2009 and 2009/2010 and between 2008/2009 and 2010/2011 (Games-Howell $P = 0.05$ and $P = 0.03$ respectively) suggesting significant changes in effort in these years. Mobile gear fishermen, potentially supplementing income by using pots do not land the quantity of whelks that the static boats do but it is possible that the use of additional static gear has been in response to the presence of a market for whelks and the SI as a management measure.

Overall, whelks are not associated solely with the reef ecosystem but naturally occur on all broadscale habitats present in Lyme Bay. In the UK fishing effort has generally increased on whelk stocks due to displacement of effort from whitefish and trap fisheries and the development of improved markets. In recent years whelks have become increasing valuable, ranking 5th to 6th in a list of the most valuable shellfish species by total English & Welsh first sale landings value (£7-9 million p.a. over the last 5 years)(Lawler, 2013).It is unknown in Lyme Bay whether increased landings relate to there being a high abundance of whelks or whether the new market for whelks has further opened up the fishery. However, it is clear that there is an overall decline in landings since the volume recorded in 2005. The broader evidence suggests that it is fishing issues relating to 'size of maturity', indicative of growth overfishing rather than issues of effort overfishing that is causing the decline in landings (Lawler, 2013). Discussions regarding future fisheries management plans for the south west UK have been undertaken within Project Inshore (a collaborative project between Seafish, the Marine Stewardship Council and the Shellfish Association of Great Britain) (Huntington, 2012). Within Lyme Bay discussions of potential management measures considered by regional IFCAs to maintain sustainability in this non-quota fishery, such as, introducing closed seasons, an increase in minimum conservation reference size and/or standardising riddle sizes, are reported in the minutes of Lyme Bay Reserve Consultative Committee meetings (Blue Marine Foundation, 2015).

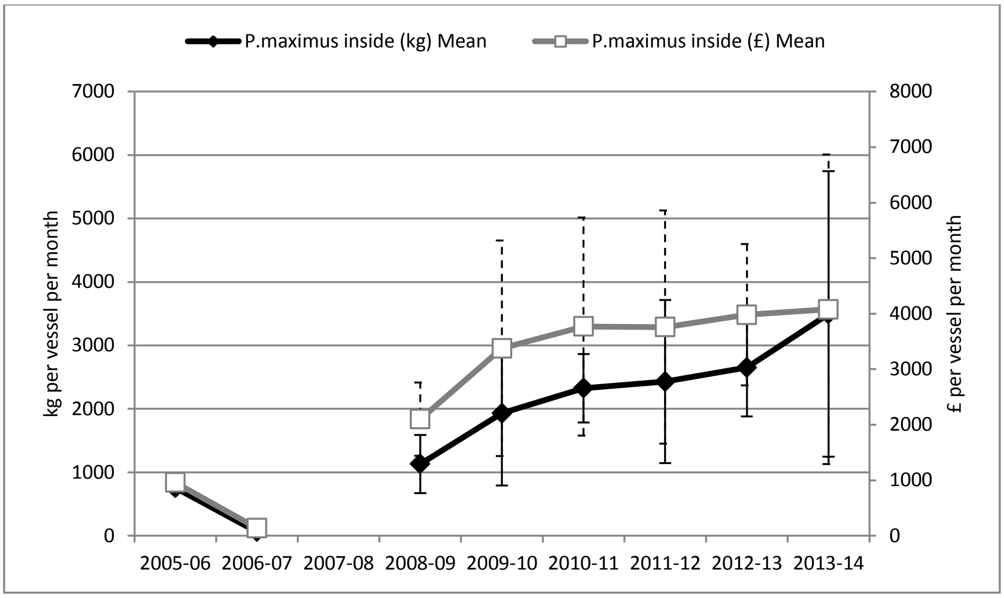
7.3.2 Scallop (Pecten maximus)

Scallops are landed in greatest volume by mobile (towed) gear vessels using dredges. A smaller scale scallop fishery also exists within the static gear category for collection of scallops by hand using SCUBA diving equipment. Scallops therefore provide the greatest contribution to landings by mobile gear fishermen, both in the Reserve, before the 2008 SI closure and outside in all years (Figure 15, Figure 16). A significant decrease occurred in the volume of scallops landed by mobile gear vessels fishing within the Reserve, prior to the 2008 SI closure, from 12.6 tonnes (mean per vessel per month) in 2005/2006 to 5.6 tonnes in 2007/2008 (F = 18.4, P = <0.01). The SI closure in 2008 then prevented any further landings from bottom towed (mobile) fishing gears. A significant increase occurs between 2005 and 2014 in the volume of scallops landed from outside the Reserve by vessels using mobile gears (F = 9.3, P = <0.01), corresponding to the displacement of vessels (Figure 16, Section 7.2.4). Weight of scallops landed by mobile vessels fishing outside the Reserve rose from 2.4 tonnes (mean per vessel per month) in 2007/2008 to a peak of 6.5 tonnes in 2009/2010. Landings from outside the Reserve remained close to the 2009/2010 peak until falling in 2013/2014 to 3.4 tonnes.

Landings of scallops from the area outside the Reserve increased from 2.4 tonnes (mean per vessel per month) in 2007/2008 to 6.5 tonnes in 2009/2010 and remain at a similar level. The data indicate increase in landings weight returned from mobile fishing activity outside the Reserve between 2007/2008 and 2009/2010 was approximately 4.1 tonnes (mean per vessel per month). This was very similar to the weight of landings from within the closed area site in 2007/2008 (5.6 tonnes), suggesting that the loss of landings from grounds within the 2008 SI closure (5.6 tonnes in 2007/2008) were potentially being made up in grounds outside the closure. However, fishing effort data (mean number of trips per vessel per month) indicate that greater effort is required in remaining areas by mobile gear vessels to return similar weight and value of catches between 2008/2009 and 2013/2014, in comparison with years before 2008/2009 (Section 7.2.4). Some vessels using mobile gear that targeted scallops were known to have spent some time fishing in other UK locations at the time of initial monitoring of the 2008 SI closure (Mangi et al. 2011). The landings of these vessels have not been analysed in this study and therefore the full extent of changes in scallop landings between 2005 and 2014 for Lyme Bay vessels may differ from the results discussed for these ICES rectangles.

Landings weight and value for scallops landed by vessels using mobile gear outside of the Lyme Bay Reserve have remained stable throughout periods of management activities since the 2008 SI closure. However, a decline in landings can be observed between 2012/2013 and 2013/2014 (Figure 16). This decline corresponds to when the IFCA byelaws are introduced, preventing towed (mobile) gear in some further areas of Annex I reef habitat. Periods of intense storminess in the winter of 2014 may have also limited time at sea and related landings.

Collection of scallops using Self-Contained Underwater Breathing Apparatus (SCUBA) diving equipment provided landings of between 1.7 tonnes (mean per vessel per month) and 2.4 tonnes of scallops (combined for landings from inside and outside the Reserve) between 2005 and 2007. From July 2008 to 2014 weight of scallops collected by SCUBA diving within the Reserve increased significantly from 0.8 tonnes (mean per vessel per month) (2005/2006) to 3.5 tonnes (2013/2014) ($F = 2.7$, $P = 0.04$) (Figure 13a, Figure 17). During the same period landings weights of scallop collected by SCUBA diving from outside the Reserve have decreased significantly, from 1.6 tonnes (mean per vessel per month) (in 2005/2006) to 713kg in 2013/2014 (Welch $F = 3.1$, $P = 0.01$), possibly indicating a shift in effort into the Reserve following the implementation of spatial management measures (Figure 17).

a) 

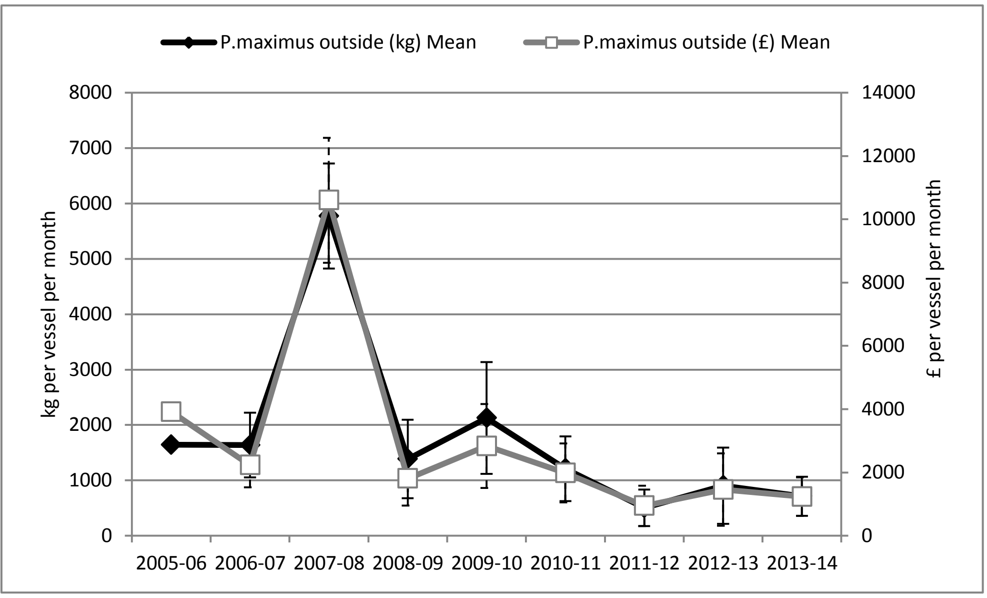
b) 

Figure 17 Wet weight (kg) of landings of hand collected scallops *Pecten maximus* and value (£) per vessel per month a) inside the closure, b) outside the closure 2005-2014.

Increases in landings (weight and value) of scallops collected by SCUBA diving and decreases in landings from outside the Reserve both started at the time of the 2008 SI closure (2008/2009). The trends have persisted throughout management measures, with a mean value returned of between £3769 and £4079 per vessel, per month in relation to landings between 2010/2011 and 2013/2014. Between 2012/2013 and 2013/2014 there has been a slightly larger increase from 2.7 tonnes to 3.5 tonnes (an increase of 0.8 tonnes, mean per vessel per month) than previous values for mean landings weight per vessel per month. The fishery has been resilient despite an extended period of storms during the winter of 2013-2014.

At a national level, scallop landings (weight and value) into England by UK vessels has declined in the 2010-2014 time period (Elliott, 2014). The decrease in landings for scallop collected by SCUBA diving outside the Reserve and for scallops landed by vessels using mobile (towed dredge) gear reflect the national trend. The increase in landings weight (mean per vessel per month) for diver collected scallops inside the Reserve goes against this national trend. It must be noted that any changes in landings by fishermen using different gear must be also considered against factors affecting fishing site preferences, rather than simple assumptions of increased abundance. Additionally, IFCA byelaws were announced in December 2013, increasing the area of reef features where towed fishing gears are excluded. Increased landings may also be due to additional fishermen entering the fishery using SCUBA diving to collect scallops over time. Concurrently, the landings values have increased during the time the 2008 SI closure and IFCA byelaws have been present, and during the period the Consultative Committee has been active.

The coarse substratum between reef features within the Lyme Bay Reserve and associated sessile epifauna provide habitats for both juvenile and adult life stages of scallops. Between 2008/2009 and 2010/2011 the fishery based around SCUBA diving to collect scallops has returned increasing landings during a period when great scallop *P.maximus* populations (and sessile epifauna species) within Lyme Bay Reserve have shown recovery trends (Sheehan et al., 2013).

7.3.3 Cuttlefish *(Sepia officinalis)*

Cuttlefish can also be caught in static nets or mobile otter trawls. Cuttlefish landings show large changes between years, for instance, from peaks of 1.6 tonnes (mean per vessel per month) (2007/2008) to a low of 0.4 tonnes a year later (2008/2009) but no significant change in combined landings across years 2005-2014, inside or outside the Reserve (inside, Welch's $F = 0.9$, $P = 0.66$, outside Welch's $F = 2.1$, $P = 0.1$). Inside the Reserve, landings have decreased slightly over this time period (Figure 13). This occurred during a period when fishing effort within the Reserve increased for all species (Section 7.2.4). However, landings are dependent upon the abundance of cuttlefish migrating to the region each spring as well as fishing effort. A peak in landings in 2012/2013 to 1.4 tonnes (mean per vessel per month) from vessels fishing inside the Reserve displays high variability in annual landings weight.

Despite variable landings by volume (weight) cuttlefish provide high value landings to static fishermen operating inside the Reserve (Figure 13b). Landings inside the Reserve during 2005-2014 have provided between £491 and £2352 per vessel per month. Landings weight and value have been lower for vessels outside the Lyme Bay Reserve over the same time period, between £64 and £843 per vessel per month.

Landings of cuttlefish from vessels using mobile gears outside the Reserve are low in most years and did not significantly change between 2005/2006 and 2013/2014. Small peaks in landings weight and landings value occurred in 2010/2011 (214kg, £489 per vessel per month) and 2012/2013 (415kg, £728 per vessel per month), increasing the contribution of cuttlefish landings to the overall weight and value of landings from mobile gear vessels in those years. The peak in 2012/2013 is also shown in landings from static gear vessels (inside the Reserve), suggesting a high abundance of cuttlefish in this year.

Fishing effort from vessels using static gears has increased both inside and outside the Reserve over time. It is not possible to infer from the data available if the greater landings weight and value returned from inside the Reserve from cuttlefish are due to greater numbers of cuttlefish traps being deployed within the Reserve, a greater abundance of cuttlefish within the Reserve or a combination of both factors. The cuttlefish fishery within Lyme Bay, and within the Reserve in particular, was variable but within a similar broad range across years while management measures have been in place. The fishery provides a noticeable bonus income in spring months, between April and June each year, with largest catches (e.g. 3.9 tonnes (mean per vessel per month) in May 2008, providing a value of £5613 (mean per vessel per month)) occurring when adults migrate into the Lyme Bay region.

Cuttlefish feed within the habitats present within the Reserve and attach eggs to sessile epifauna and kelp habitats associated with Lyme Bay Reefs. Landings of cuttlefish within the Reserve had decreased from a peak in 2007/2008, until a small increase, although not significant, in 2012/2013. During this time some sessile epifauna species have been shown to displayed recovery trends since the 2008 SI closure (Sheehan et al., 2013). These links are not considered to be causal.

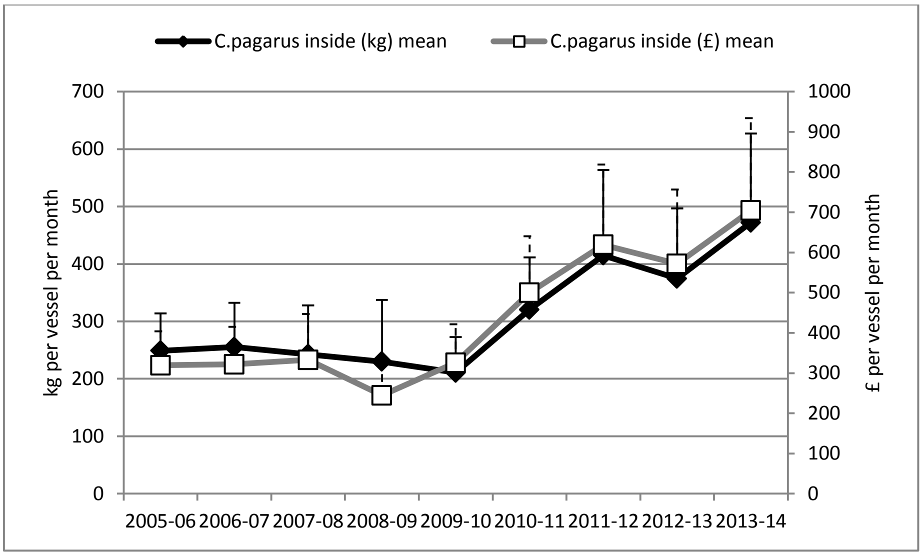
7.3.4 Crab (Cancer pagarus)

Crabs are a static fishery species. Landings of crabs by static gear fishermen operating inside and outside the Reserve have significantly increased over time (Figure 13, Figure 14, Figure 18) (inside Welch $F = 3.7$, P 0.04, outside Welch $F = 2.5$, $P = 0.03$). Landings of crabs from inside the Reserve increased significantly in mean weight and value per vessel per month between 2009/2010 (211kg, £326) and 2010/2011 (321kg, £500) (Games-Howell pair wise comparison $P = 0.03$) (Figure 9a). Values of crabs (mean per vessel per month) landed from vessels using static gear inside the Reserve are also significantly higher in 2011/2012, 2012/2013 and 2013/2014 than they were in 2006/2007

(Games-Howell pair wise comparisons, *P* = 0.01, *P* = 0.11 and *P* = < 0.01 respectively).This suggests that a significant change in value returned from the fishery within the Reserve has been achieved in these latter years.

Landings of crabs from outside the Reserve by vessels using static gears show a decrease between 2005/2006 and 2006/2007 from 1.1 tonnes (£1623) (mean per vessel per month), to 0.4 tonnes (£613). Landings increased from 0.4 tonnes (mean per vessel per month) in 2006/2007 to 0.6 tonnes in 2007/2008 and then remained stable (within a small range of between 0.6 tonnes and 0.7 tonnes between 2007/2008 and 2012/2013). A large increase in landings occurred between 2012/2013 and 2013/2014 to 1 tonne (mean per vessel per month) (Figure 14, Figure 18). Large changes between years only occur in the first and last years of the time series, providing a consistent mean value per vessel per month from catches between 2007/2008 and 2012/2013 of between £784 and £1011 (Figure 18b). During years of peak catches, 2005/2006 and 2013/2014, mean landings value per vessel per month increased to £1623 and £1680 respectively.

a)



b)

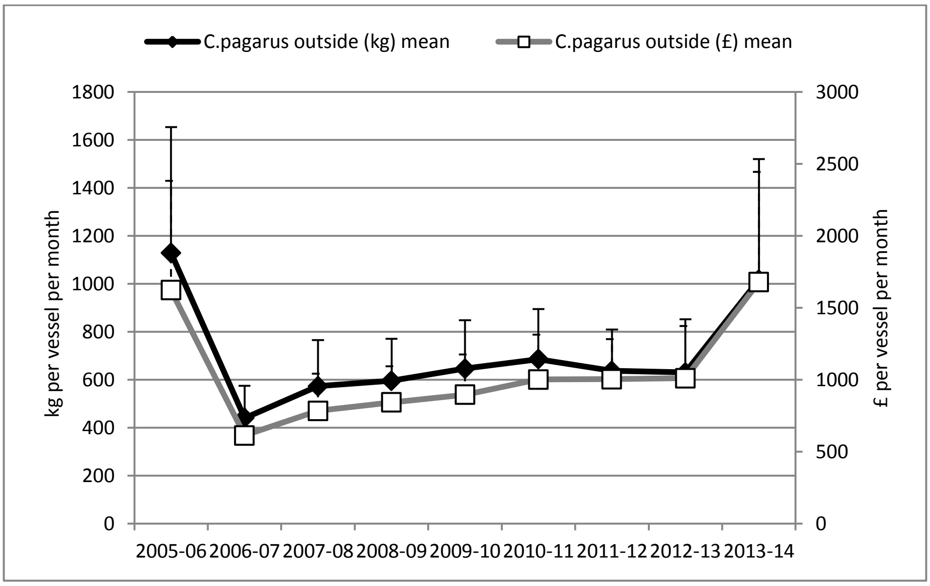


Figure 18 Wet weight (kg) of landings of brown crab *C. pagarus* and value (£) per vessel per month a) inside the closure, b) outside the closure.

Landings of crabs have continued to increase up to 2013/2014, even though the number of trips has declined. From the data available it is unknown if this is due to increasing abundance of crab or due to more gear being deployed by individual vessels. However, smaller inshore vessels are limited by the amount of pots that can be effectively baited, deployed and retrieved from a small vessel with limited range operating single handed or with only 1 extra crew. During the same period brown crab *Cancer pagarus* had shown recovery between 2008 and 2011 in benthic monitoring studies in regions outside the Reserve but close to the boundary, despite peaks in fishing effort occurring during this time.

Landings both inside and outside the closure have provided a more stable income for static gear fishermen in comparison to species with more variable landings weights between years, such as whelk and cuttlefish, or species with limited quota allocations such as sole.

The increased landings and associated value from the crab fishery within the Reserve supported increased income of fishermen using vessels with static gears. Increased landings have occurred since 2010/2011, peaking in 2013/2014. This corresponds to the period the LBCC have been active and IFCA byelaws have been introduced, protecting further areas of reef habitat. Increased landings of crab also reflects national trends between 2009 and 2014 where landings into England by UK vessels have increased from 10 000 tonnes in 2009 to 15 800 tonnes in 2014 (Elliott et al. 2014).

7.3.5 Lobster (*Homarus gammarus*)

Lobster are a static gear fishery, caught using the same methods as crab but providing greater value in relation to landings weight. A small but significant increase in lobster landings from vessels fishing inside the Reserve with static gears has had a relatively large, and significant, contribution to overall value (Welch's F 3.9, P = <0.01) (Figure 13b).

Value of landings from vessels using static gear outside the Lyme Bay Reserve declined from £919 (mean per vessel per month) in 2005/2006 to £487 in 2010/2011, before slowly increasing again to £871 in 2013/2014. Highest values from lobster landings have been maintained within a range of between £682 (per vessel per month) and £871 from 2011/2012 to 2013/2014 (Figure 14b).

Vessels using mobile gear inside and outside the Reserve also landed smaller quantities of lobster (from between £39 and £342 inside the closure, before 2008 and between £12 and £197, mean per vessel per month outside the closure). Although landings values were much smaller than for vessels using static gears there was a significant increase across 2005-2014 in value of landings for vessels predominantly using mobile gears outside the Lyme Bay Reserve (Welch's F = 6.4, P = < 0.01) (Figure 16b).

7.3.1 Lemon sole (*Microtomus kitt*)

Lemon sole are a flatfish species that are not regulated by quotas in the Lyme Bay area and return high values for catches. Both static and mobile gear fisheries catch lemon sole, using either static nets or mobile trawl methods. The highest landings volumes are between June and November.

Lemon sole landings from vessels using static gear within the Reserve increased over time from 2kg (mean per vessel per month) in 2005/2006 to 54kg in 2013/2014. Although changes in landings weight were not significant over time (Welch's *F* = 2.9, *P* = 0.109), associated changes in landings value were significant (Welch's *F* = 2.8, *P* = 0.05) (increase from £9 per vessel per month in 2005/2006 to £221 per vessel per month in 2013/2014) (Figure 13a, b). Landings from vessels using static gear within the Reserve were very low, ranging from 1kg to 3kg (mean per vessel per month) between 2005/2006 and 2010/2011. In 2011/2012 and 2013/2014 greater volume of landings (14kg and 69kg respectively) provided large increases in value per vessel per month (from under £20 in previous years to £68 and £221 respectively) (Figure 13).

Landings from vessels using static gear outside the closed area displayed a similar pattern of low landings in all but two years, 2005/2006 when 284kg were landed and 2009/2010 when 29kg were landed (mean per vessel per month). The higher catches outside the Reserve occurred before the initial SI was designated (2008) and within the first 1-2 years it was present (2008-2010) (Figure 14a). From 2011/2012 onwards sole landings display a similar pattern to plaice landings, whereby landings from outside the Reserve decrease but landings from inside the Reserve increase. Without individual vessels spatial effort data it cannot be confidently assessed whether this change is due to change in spatial distribution of static netting effort (increasing in the Reserve and decreasing outside), or changes in abundance of species within Reserve.

Landings of lemon sole from vessels using mobile gear within the site of the Reserve before closure were between 17kg and 23kg. Landings from outside the Reserve were between 20kg and 200kg (Figure 16a). There was a significant increase in weight and value of landings outside the Reserve over time (weight, Welch's *F* = 2.6, *P*=0.02, value, Welch's *F* = 2.4, *P* = 0.03), all peaks occurred from 2009/2010 or later (2009/2010, 200kg, 2011/2012, 138kg, 2013/2014, 157kg). The peaks in landings weight also provided increased value of £872 per vessel per month in 2009/2010, £456 in 2011/2012 and £557 in 2013/2014 (Figure 16).

The increased landings from outside the Reserve occurred during a period (2008/2009 to 2013/2014) when effort (number of trips) from vessels using mobile gears increased outside the Reserve.

7.3.2 Sole (*Solea solea*)

Sole are caught in both static net fisheries and mobile trawl fisheries. Sole are a quota species and therefore landings weight is regulated each month by the quota allowance in each ICES area. Analyses for changes in landings weight and value are limited as results will only reflect quota allowance over the year. However, sole are a valuable species in terms of providing high value in relation to weight and therefore presenting changes in landings over time will aid interpretation of changes in total value of the fishery in Lyme Bay to fishermen using static or mobile gears.

Sole provide low landings by weight in comparison to other species for vessels using static gear within the Lyme Bay Reserve. These small landings by weight, however, provide high values, within a range across all years of between £277 and £1010 (per vessel per month) (Figure 13). There was a decrease in weight of landings of sole between 2011/2012 and 2013/2014 from 70kg to 46kg mean per vessel per month. Although this suggests quota allowances decreased in each of these years this decrease represents a decrease in value of landings from £802 mean per vessel per month in 2011/2012 to £518 per vessel per month in 2013/2014 (Figure 13b).

Vessels using mobile gears outside the Reserve show a similar trend in landed weight and value of sole (Figure 16). A significant decrease occurred for value of sole catches between 2005/2006 and 2013/2014 (Welch $F = 10.2$, $P = <0.01$). Between 2005/2006 and 2008/2009 sole provided the second highest landings value for mobile gear fisheries outside of the Reserve (second to scallops), within a range of between £1408 and £2183 (mean per vessel per month). This decreased from 2009/2010 to 2013/2014 to a range of between £379 and £1489 (Figure 16b). As quota allowance influences these landings values causal links cannot be suggested, however, as with static fisheries the decreased landings and associated value are likely to have affected the total value of landings from Lyme Bay for vessels fishing with mobile gears.

7.3.3 Plaice (*Pleuronectes platessa*)

Plaice are landed in small volume by mobile and static gear vessels, using static nets or mobile otter trawl. Like sole, plaice landings are regulated by quotas and analyses of landings cannot indicate changes in abundance in Lyme Bay. A significant increase in landings weight and value (mean per vessel per month) occurred for plaice landed by vessels using static gears inside the Reserve (weight, Welch $F = 4.1$, $P = < 0.01$, value, Welch $F = 3.8$, $P = 0.01$). Vessels using static gear within the Reserve landed small volumes of plaice (between 13kg and 71kg) between 2005/2006 and 2011/2012. From 2012/2013 there is an increase in the volume of plaice landed, within a range of 106kg to 121kg (mean per vessel per month) (Figure 13). The increase in landings weight provided an increase of value with the highest landings occurred between summer and autumn months June to November.

Plaice landings from vessels using static gear outside the Reserve declined between 2005/2006 to 2013/2014 (from 168kg to 47kg) (Figure 14a). Across Lyme Bay as a whole (inside and outside the Reserve) between 2005 and 2014 increased landings from within the Reserve and decreased landings outside suggest plaice quota is primarily being landed from within the Reserve between 2012 and 2014.

Landings of plaice by vessels using mobile (towed) gears within the Reserve before the initial 2008 SI closure (between 2005/2006 and 2007/2008) were decreased from 284kg and 126kg (Figure 15a). Landings weight from outside the Reserve changed significantly between years from 2005/2006 to 2013/2014 (Welch's $F = 8.6$, $P = <0.01$). Landings decreased from 450kg in 2005/2006 to 100kg in 2009/2010 and then increased again to 461kg in 2012/2013 (Figure 15a). Significant changes between years occurred in pair wise comparison between 2005/06 and 2009/10 (Games-Howell $P =$ 0.05*)* and in comparison between 2009/10 and 2012/13 (Games-Howell $P = 0.02$).

Although landings weights are closely linked to quota allowance, the results display that in years with greater quota, plaice landings have a high contribution to the total value from all species other than scallops landed in Lyme Bay. For instance the significant increase in landings for mobile gear vessels between 2009/10, 2012/2013 also provided a significant increase in value from £175 to £674 per vessel per month (Games-Howell $P = 0.05$) (Figure 16).

Plaice, in particular larger adults show preference for gravel and sand habitats in between rock and reef habitats. These habitats occur between the reef features protected within the 2008 SI closed area, and habitats comprising 'Annex 1 reef' habitat protected within the 2013 IFCA byelaws.

8 The impacts of the management measures associated with the Lyme Bay Reserve and the activities of the Lyme Bay Consultative Committee on human wellbeing

8.1 Methods

8.1.1 Data collection.

Data were collated in relation to each of the indicators that were identified as a priority by workshop participants to best represent changes in ecosystem service delivery and aspects of wellbeing important to stakeholders in Lyme Bay (Section 6.1). Data on compliance were obtained using records of successful prosecutions for infringement of the IFCA byelaws, obtained from Southern IFCA. However, it was not possible to relate this data to patrol effort as patrol effort data were only available for individual regions (e.g. Lyme Bay Reserve) for 2015 onwards. Where data were not available in pre-existing formats (for instance in relation to changes in specific aspects of subjective wellbeing) primary data collection was conducted through a face to face interview questionnaire, the full questionnaire is provided in Annex VI.

8.1.2 Questionnaire

The questionnaire contained 10 sections (A-J), accessing changes in levels of indicators over time. These were; A) Description of fishing activity; B) Job satisfaction; C) Income and income satisfaction; D) Investment; E) Demand and sales; F) Conflict; G) Health and wellbeing; H) Support and trust (for MPA management and partnership activities); I) Undocumented levels of compliance (with management regulations); J) Benefit of partnership activities.

Each section contained both closed and open questions, using a mixed methods approach to combine quantitative and qualitative data collection. Closed ended questions gathered information on the age and experience of fishers, details of vessel and gear type, patterns of fishing activity (gears used and species targeted through the year), income as turnover and profit, and levels of investment. Scales between 0 (no confidence) – 10 (complete confidence) were used to gather information on fishermen’s level of confidence in profitability of investments in their business such as purchase of new vessels or new gear types. Similar scales, between 0 (no support) – 10 (complete support), were used to gauge fishermen’s level of support for management measures, partnership activities and, for those involved, specific partnership activities such as the ‘Reserve Seafood’ brand.

To measure subjective wellbeing over time we used an integrated timeline and ranking approach. We focused on four indicators that were prioritised in the workshop: ‘job satisfaction,’ ‘income satisfaction,’ ‘health’ and ‘conflict’. Along a timeline between 2005 and 2015, fishermen were asked to identify a year when that specific aspect of wellbeing, such as job satisfaction, was highest. They were then asked to rank on a scale of 0 (none) to 10 (complete/extremely high) how they perceived their wellbeing at that time. They repeated this for the time of lowest and current (2015) wellbeing. Respondents were then asked to identify key events that explained the highest, lowest and current levels of wellbeing, i.e. changes in wellbeing over time. The events identified by selected stakeholders in the Charmouth workshop were available on a separate sheet as a prompt for respondents if required.

Fishermen were interviewed individually face to face in pre-arranged meetings by authors MA and LE. They were initially contacted by email and phone or approached on the quayside in local harbours. We also used snowball sampling after each interview to get further contacts. Interviews lasted between 30 and 60 minutes and were recorded where permitted by the respondent. Prior to each interview, respondents were assured that the data would be reported anonymously and they had the right to withdraw their information from the study following the interview. They gave verbal informed consent. Prior to conducting interviews ethical clearance had been sought through Plymouth University’s research ethics review committee (Science and Environment Ethics Review Committee) and the University of Exeter’s research ethics committee in Geography.

Our target sample was between 20-30 respondents to provide a fair representation of fishermen in Lyme Bay. We aimed to include representatives of mobile and static gears, all ports inside and outside the Reserve and fishermen who did and did not participate in the Lyme Bay Consultative Committee (LBCC).

8.2 Data analysis

Data from each interview were entered into a shared spreadsheet by authors MA and LE. Values from closed ended questions and scaled questions were entered directly, and key points from open ended questions were detailed in the same spreadsheet. If key points from survey notes were unclear the voice recording was referred to. All data were analysed using Microsoft Excel.

For all survey analyses fishermen were categorised into three groups: static gear fishermen involved in the LBCC or partnership activities (Static Y), static gear fishermen not involved in the LBCC or partnership activities (Static N) and mobile gear fishermen all of whom, bar one, were not involved in the LBCC or partnership activities (mobile). For most questions frequency or average scores were calculated across the three groups, whether for numerical (e.g., income) or ranking data (e.g., 0-10 level of support). For the wellbeing timeline questions an intermediate step was taken before calculating mean scores across the ten-year timeline. Table 5A below illustrates hypothetical raw data for three respondents. It demonstrates that before extrapolation mean scores show large variability between 2006 -2009, fluctuating between 5 to 10 to 5 to 8.3 in the space of 4 years. This variability reflects the different years respondents identified as significant, rather than potential changes to average wellbeing. The extrapolation process assumed that fishermen did not experience dramatic changes in wellbeing in-between the years they nominated as significant. So, for instance, respondent A retained a score of 10 from 2007 until the key event in 2009 when they specified a decline to 5, while respondent B retained a score of 5 from 2006 until they experienced significant improvements in 2009. For each respondent we extrapolated from each data point they nominated to the next using the same score, as shown in (Table 5B). This provides a mean ranking that better reflects the average scores of all respondents across the years

Table 5 Hypothetical data for three respondents to demonstrate the high variability between years (A) before data were extrapolated (B).

A)

A			10		5						5
B		5			10						5
C				5	10						10
Mean		5	10	5	8.3						6.7
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

B)

A			**10**	10	**5**	5	5	5	5	5	**5**
B		**5**	5	5	**10**	10	10	10	10	10	**5**
C				**5**	**10**	10	10	10	10	10	**10**
Mean		5	7.5	6.7	8.3	8.3	8.3	8.3	8.3	8.3	6.7
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

Finally, the event data for all wellbeing questions was combined and the number of fishermen that identified a key event as important was counted.

8.3 Results

8.3.1 Summary statistics from survey

A total of 28 fishermen were interviewed, representing the main ports in the study region, inside (n=19) and outside the Reserve (n=9) (Figure 19). The majority of the respondents (24, 86%) were aged 45 or over. A representative sample was sought of mobile (towed) and static gear fishermen, who currently, or prior to July 2008 fished within the region of Lyme Bay containing the Reserve. A greater number of static gear fishermen operated inshore vessels (under 10 metre) that predominantly fished closer to shore from ports within the study region. The smaller sample of mobile (towed) gear fishermen also reflected the smaller number of under 10 metre vessels using mobile gears in the region (Section 7.2.1). Fishermen operating larger (over 10 metre) mobile gear vessels (such as those based in Brixham) were approached but many declined interviews based on their fishing grounds being further offshore. Two mobile gear fishermen expressed interest in the survey but did not have time to complete the interview, either when approached at quayside and in follow up calls. Fishermen who did and did not participate in the LBCC were interviewed, a sample of 10 fishermen participating in the LBCC (all using static gear fishing methods primarily) provided for categorisation of the 3 groups; a) static involved in the LBCC (Static Y), b) static not involved in the LBCC (Static N) and c) Mobile gear fishermen. Despite this separation it is recognised that fishermen may operate multiple gear types throughout the year in response to available species, or may have changed between mobile and static gears in response to management events and other factors. Therefore, the primary gear type used in the most recent years was used for categorisation.

	Home Port							**Age category**						**Gear type category**		**Involved in Consultative Committee**		**Total**
	Brixham	Exmouth	Beer	Axmouth	Lyme Regis	West Bay	Weymouth	18-24	25-34	35-44	45-54	55-64	65+	Mobile	Static	Yes	No	
No. of respondents	5	3	3	2	8	6	1	1	1	2	12	8	4	9	19	10	18	28

Figure 19 Summary statistics for interview survey, including all fishermen interviewed, respective home ports, gear types and involvement with the Lyme Bay Consultative Committee.

8.3.2 Job satisfaction

Fishermen were asked to identify and rank when they were *most and least satisfied with their fishing (i.e. using preferred gears and targeting preferred species)*. The average level of job satisfaction across all fishermen interviewed for 2005-2015 was 6.2 (Figure 20).Static fishermen not involved in Lyme Bay partnership activities (Static N) had the highest average level of job satisfaction (Static N = 7.1) compared to static fishermen who were involved in the partnership (Static Y = 6.7) and Mobile fishermen (5.4). In 2015 job satisfaction was much higher than the ten-year average for Static Y fishermen (8.3) but was lower than average for Static N fishermen (5.9) and Mobile fishermen (5.0). The job satisfaction of Static Y fishermen declined until 2009-2010 due to gear conflicts and a perception that fisheries were declining, then steadily increased as a result of the SI closure and introduction of Lyme Bay partnership activities to a peak in 2015. The job satisfaction of Static N fishermen began higher than Static Y fishermen but declined in 2009 due to some fishermen having to transition to fully static fisheries in response to the SI closure. Job satisfaction rose and remained steady from 2010 due to reduced gear conflict and a perception of improved fisheries but remained at a lower level than pre-2009. From 2013-2015 the job satisfaction of Static N fishermen has declined partly due to pressure from quota and, more recently, weather conditions. Mobile fishermen had a high level of job satisfaction until 2008 when it declined dramatically as a result of the SI closure and its expansion through SAC bi-laws (from 8.3 – 3.4). It has remained at low levels, exacerbated by ever declining quota and concern over the state of the scallop fishery post the 2014 storms, rising only slightly from 2012-2015 due to improved stocks (e.g., Sole) and good catches in some species (e.g., Cuttlefish).

8.3.3 Income and income satisfaction

Fishermen were asked to identify and rank when they were *most and least satisfied with their net income or profit from their fishing activities*. The average level of income satisfaction across all fishermen interviewed for 2005-2015 was 6.8 (Figure 20). Static Y fishermen had the highest average level of income satisfaction (7.7) compared to Static N fishermen (7.3) and Mobile fishermen (5.8). In 2015 income satisfaction was slightly higher than the ten-year average for all groups: Static Y (7.9), Static N (7.5) and Mobile (6.6). The income satisfaction of Static Y fishermen increased steadily from 2007 to a peak in 2010-2011 as a result of the perceived benefits of the SI closure, followed by a decline in 2014 following the winter storms with some recovery in 2015 attributed mostly to the introduction of the ‘Reserve Seafood’ brand. The income satisfaction of Static N fishermen was steady until 2009 when it began to decrease slightly due to the cost of investment in transitioning to fully static gear to a low in 2011, rising again to a peak in 2013 as fishermen became more established, and a slight decline in 2014-2015 due to the impacts of rough weather. Mobile fishermen had a high level of income satisfaction until 2008 when it declined to a low of 3.4 following their exclusion from the SI closure. It has since risen steadily though remains below that of other groups, explained primarily by low quota.

Fishermen were asked to provide an estimated turnover for 2015. Figure 21 shows that Static fishermen's turn-over varies from <£10,000 to £100,000+ as does the turn-over of the Mobile fishermen interviewed, though a higher proportion of Mobile fishermen have a turnover of £100,000+. Ten fishermen selected not to answer this question, and two did not know. Fishermen that had provided their approximate annual turnover were then asked to estimate their percentage of profit. Three static fishermen replied that they made no profit, just enough to cover costs and the minimum wage, two more made up to £10,000 and two made between £20-30,000. Of the figures provided the average profit for Static fishermen in 2015 for fishing alone is ~£15,000 per annum. The estimated average profit for Mobile fishermen was £22,500 for four fishermen, and over £100,000 for another four operators. Unfortunately, as fishermen did not consistently answer this question in a 2009 survey we are unable to compare changes in turn-over and profit between 2009 and 2015. However, the fisheries landings value data above shows trends in value over time (Figure 11, Figure 12).

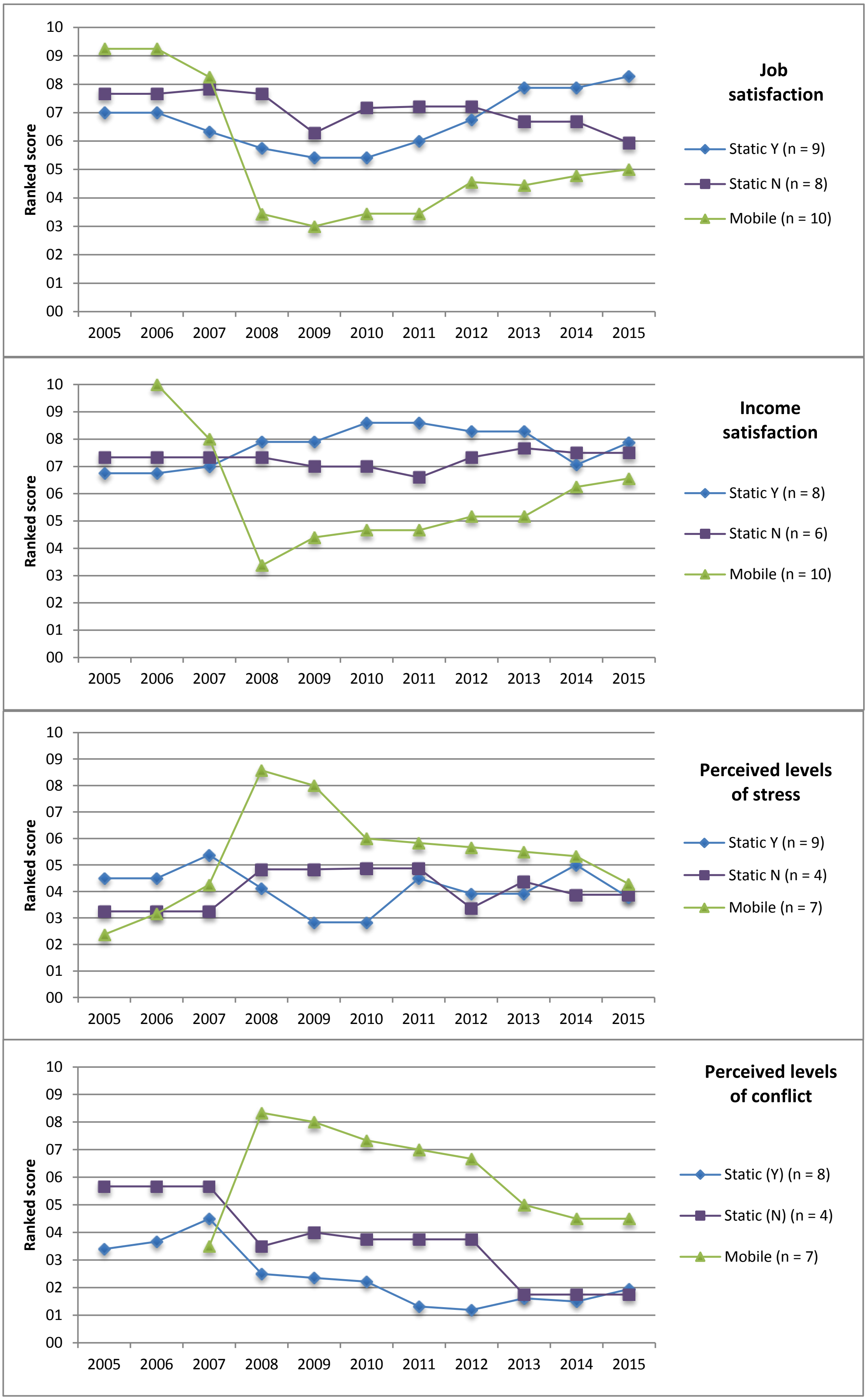


Figure 20 Fishermen’s subjective wellbeing in Lyme Bay from 2005-2015

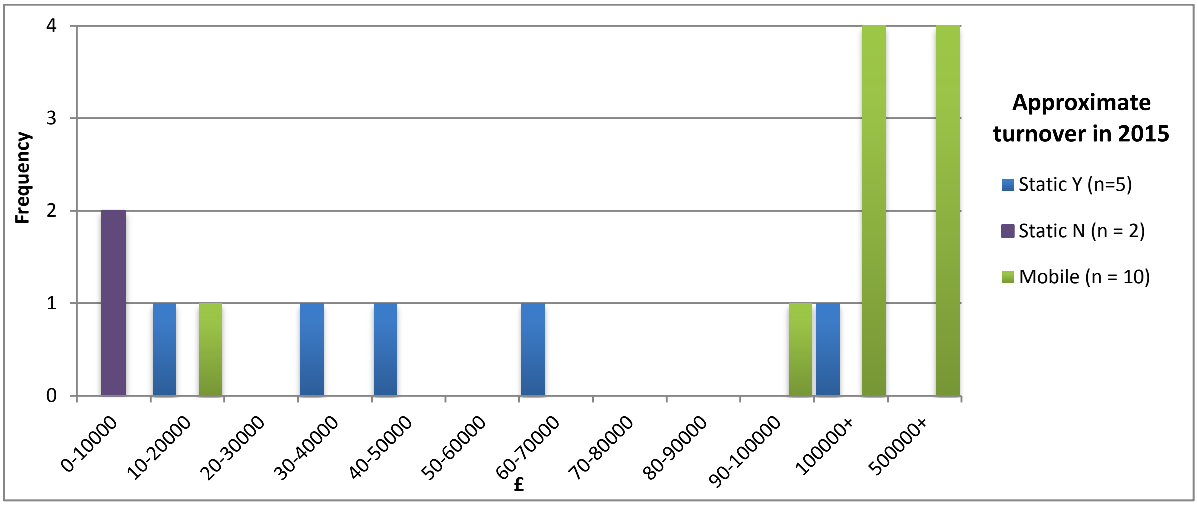


Figure 21 Estimated turnover for fishing businesses in 2015. Static Y = fishermen involved in the Lyme Bay partnership activities; Static N = fishermen not involved in the partnership activities; Mobile = fishermen using mobile gear.

8.3.4 Demand and sales

Fishermen were asked to explain where they sold their catch (Table 6). The highest proportion of all catch is sold to processors or auctions in Brixham or Plymouth harbours. Static fishermen involved in LBCC partnership activities, however, sold more than 50% of their catch to local markets or through the Reserve Seafood brand direct to London. When asked *what is your preferred sales strategy*, ten fishermen stated that they would not change their strategy and ten fishermen across all gears types would prefer more local or direct sales. Few respondents commented on *what needed to happen to make their preferred strategy a reality* except to highlight the limitations of time after fishing, the potential risk in terms of maintaining a good price of selling to one or a few buyers, and the challenges of infrastructure or transport requirements.

Table 6 Proportion of catch sold to different markets for static fishermen involved in the Lyme Bay partnership activities (Static Y), static fishermen not involved in the partnership activities (Static N) and mobile gear fishermen.

	Reserve Seafood	Local	Processors / auctions	Total
Static Y (n = 9)	15%	38%	47%	100%
Static N (n = 7)		18%	81%	100%
Mobile (n = 10)		5%	95%	100%

8.3.5 Investment in fishing businesses

In the Charmouth workshop, investment in the industry was identified as a good potential indicator of fishermen's economic wellbeing. In the survey fishermen were asked to describe past and expected investment in their fishing activities, other than routine maintenance, and to rank their *confidence that future investment would be sufficiently profitable.* Over the past ten years fishermen had made considerable investments in new boats (n=11), boat upgrades or renovations (n=7) and new gears (n=11) as well as processing or selling facilities (n=3) across all fishing groups. There were no major trends distinguishing Static Y, Static N or Mobile fishermen in terms of how many fishermen invested in the industry in the last yen years. Only two static fishermen provided an estimate of how much they had invested financially (average ~£7,500). For mobile fishermen average investments in boats and gears cost ~£320,000 (n=4) and the main reason, where given (only n=3), was to get a bigger boat that was safer and could fish further for longer. Fishermen that didn't invest stated that they couldn't afford to. When asked if there were actively planning to invest in their fishing business in the near future (1-5 yrs) fifteen fishermen responded negatively with nine fishermen responding positively (five static gear fishermen, four mobile gear fishermen). Of these nine, most investments would be self-funded, with a few gear investments hoping to access European Fisheries Fund support. The average level of confidence (0-10) that such investments would be sufficiently profitable was 7.3 across all fishermen, and slightly higher for Static Y fishermen (8) than for Static N (6.5) and Mobile fishermen (7.1).

Fishermen were also asked if they sought other means to obtain an income. The majority of fishermen did not have additional livelihoods (n=11). Those that did, invested in processing or selling facilities (n=3), engaged with tourists or researchers (n=3) or did 'odd jobs' in construction, for example (n=3). Additional livelihoods were most common across the Static Y fishermen and rare in the mobile sector.

8.3.6 Health

In the Charmouth workshop, key representatives identified stress and anxiety as important aspects of health. In the survey, fishermen were asked to identify and rank when they *experienced the highest and lowest levels of stress and anxiety related to their fishing activities*. The average level of stress across all fishermen interviewed for 2005-2015 was 4.7 (Figure 20). Static fishermen had the lowest levels of stress (Static Y = 4.1; Static N = 4.1) compared to Mobile fishermen (5.4). In 2015, the stress levels for all fishermen were similar and lower than the ten-year average (Static Y = 3.8; Static N = 3.9; Mobile = 4.3). The perceived levels of stress for Static Y fishermen was rising slightly prior to 2008 and the introduction of the SI closure when it dropped to a low in 2009-2010, it then fluctuated between 2010-2015 with a spike in 2014 due to the stress of extreme and uncertain weather conditions. The perceived level of stress for Static N fishermen was lower than that of Static Y fishermen prior to 2008 but rose between 2008-2011 as a result of the closure. It then fluctuated slightly from 2011-2015 at levels that were slightly higher than those reported for before 2008, due largely to the stress of weather conditions, but also to low quota for some operators and the perception that the static fishery was increasingly crowded. The perceived levels of stress for Mobile fishermen was also low prior to 2008 but rose very sharply in 2008-2009 as a result of the SI closure. For some individuals clear symptoms of psychological and physical ill health were reported. The perceived level of stress has then declined steadily between 2009-2015 due to increased experience, ‘just getting on with things’, and good catches for some species.

We also asked fishermen about physical risk, specifically, whether they felt pressure to fish in more dangerous sea conditions (“pushed more weather”). The majority of fishermen responded that they do feel pressure to go out in bad weather (n=11) particularly when the weather has been bad for a while, or in order to avoid debt or use up quota. Another three responded that they did in the past to clear debt but no longer do. Another four fishermen responded that they generally don’t risk bad weather due to the safety of launching off a beach or their responsibilities to their crew. ‘Pushing the weather’ was common across all fishing types. While static gear fishers need not go as far out as mobile gear vessels, they tend to have smaller boats that are vulnerable to weather conditions so appear to be as exposed to physical risk as the mobile sector.

8.3.7 Conflict

Fishermen were asked to identify and rank when they experienced the most and least incidences of conflict with other fishermen (such as arguments with other fishermen, damage to gear, loss of gear, or other instances of conflict). The average level of perceived conflict experienced across all fishermen interviewed for 2005-2015 was low (3.5) (Figure 20). Static Y fishermen perceived the lowest average level of conflict (2.4) compared to Static N fishermen (3.7) and Mobile fishermen (6.1). In 2015, perceived conflict was very low for both Static Y (1.9) and Static N fishermen (1.8) and was lower than the ten-year average for Mobile fishermen (4.5). For Static Y fishermen perceived conflict, particularly between static and mobile gear vessels, rose slightly up until 2007 then declined from 2008 onwards to very low levels. For Static N fishermen conflict levels began at higher levels than for Static Y fishermen but steadily declined from 2008 onwards also as a result of the SI closure. For Mobile fishermen perceived conflict was lower than for Static fishermen prior to 2008 but rose dramatically in 2008 as they were displaced from the SI closure and concentrated in remaining areas. Perceived conflict has declined steadily since, though remains more than twice as high as that perceived by static fishermen due to gear conflicts with European vessels.

8.3.8 Compliance

Fishermen were asked to identify and rank times when they had *witnessed or knew personally of fishing vessels undertaking activities prohibited by fisheries by-laws, statutory instruments or voluntary guidelines*. The average level of perceived non-compliance to legal and voluntary regulation in Lyme Bay across all fishermen interviewed for 2005-2015 was low (3.3). Perceived non-compliance in 2015 was at its lowest in ten years (0.9), having peaked in 2008 and declined steadily since. Increases in non-compliance were explained as fishermen not knowing the position of the SI closure (n=5), particularly visiting vessels or vessels 'fishing the line'. Most fishermen stated that they were unaware of instances of non-compliance bar those that were prosecuted and reported or that it was much less than they had expected (n=10). The reasons given for most boats complying included increasing awareness of the boundaries of the SI closure, improvements in enforcement by the IFCAs (n=8) and tracking through electronic VMS and iVMS.

Fishermen were also asked to explain their own *motivations for complying with the current regulations and codes of conduct in Lyme Bay in the last 12 months* (Figure 22). Fishermen stated that they complied with the law because they don't want the fines or embarrassment of being prosecuted (n=8), with some noting the particular effectiveness of penalties against a boat license. Fishermen complied with voluntary guidelines primarily because they were set by fishermen and did not require a reduction in effort at the time; i.e., the voluntary code aims to limit future rises in effort (n=4). Respondents also said that they wanted to look after their future (n=3) and were not against the principle of conservation. Nevertheless, some fishermen argued that motivations for not complying included disagreement over what forms of conservation were appropriate and how they were implemented (n=4).

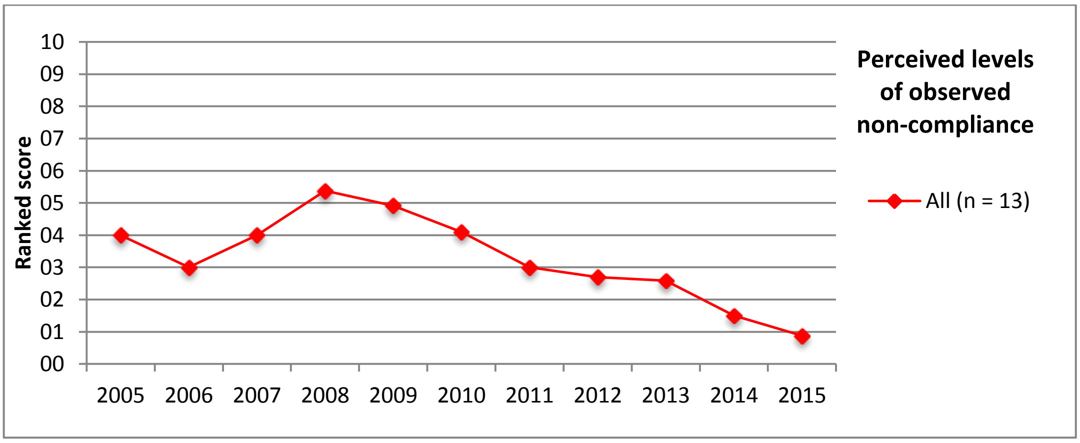


Figure 22 Perceived levels of non-compliance.

8.3.9 Events

Fishermen were asked to identify the key events that *explained their highest, lowest and current levels of wellbeing across job satisfaction, income satisfaction, health and conflict*. Many of the events identified were common across the different aspects of wellbeing, so here event data are combined and the number of fishermen that identified a particular event as having a positive or negative impact was counted. For presentation purposes, only those events mentioned by more than five fishermen are presented in Figure 23 (data are also presented in table form in Annex VI). Where a particular event had both a positive and negative impact on fishermen in a single year, the difference in scores is noted (e.g., +10 -5 = +5). A number of fishermen stated that they were always satisfied with fishing and their income from fishing (n=7), while others mentioned that their satisfaction had improved or their stress levels decreased as a result of being older, having cleared debts and generally being more experienced (n=5). Events that had a consistently negative impact on fishermen over time in Lyme Bay included quota limitations (n=11), loans (n=5), fuel and insurance costs (n=5) and general concerns about future changes to regulation or the industry (n=5). In addition to these general impacts, fishermen identified 2007-2008 and 2014-2015 as the years in which they experienced the greatest positive and negative impacts on their fishing activities and wellbeing.

In 2007, fishermen either argued that they were most satisfied because they were fishing their preferred gears (n=8) or that they were dissatisfied because of gear conflicts, primarily between fishermen using static and mobile gears (n=7). A few static fishermen also noted a decline in fishing and habitat up to 2007 (n=4). The establishment of the Statutory Instrument (SI) in 2008 was identified as positive for some (n=7) but negative for many fishermen (n=19) including those that now use static gear in the Reserve but who had to change or adjust gears when the SI closed area was established. The SI was, overall, the event mentioned by the most number of fishermen in Lyme Bay. The Lyme Bay partnership activities backed by the BLUE Marine Foundation were mentioned as important by static fishermen from 2010, with some mentioning specifically the benefits of the recent Seafood Reserve brand (n=5, estimated by one fisher to improve his income by 25%). In the latter few years, winter storms (n=7) and general bad weather (n=13) were identified as the events that had the greatest negative impact on fishermen's wellbeing. A number of fishermen had invested in new boats specifically to deal better with the requirements to travel further out in rough weather following the introduction of the SI (n=4). Fishermen also mentioned the challenge of bad weather combined with monthly quota allocations. Where the SI reduced gear conflicts for many static fishermen (n=7), it increased gear conflicts outside of the SI area (n=6), particularly when extended through the SAC by-laws in 2013 (n=3). Finally, fishermen noted that following the introduction of the SI and the rising value of some static species, particularly Whelks, that the static gear fishery was now over-crowded (n=6).

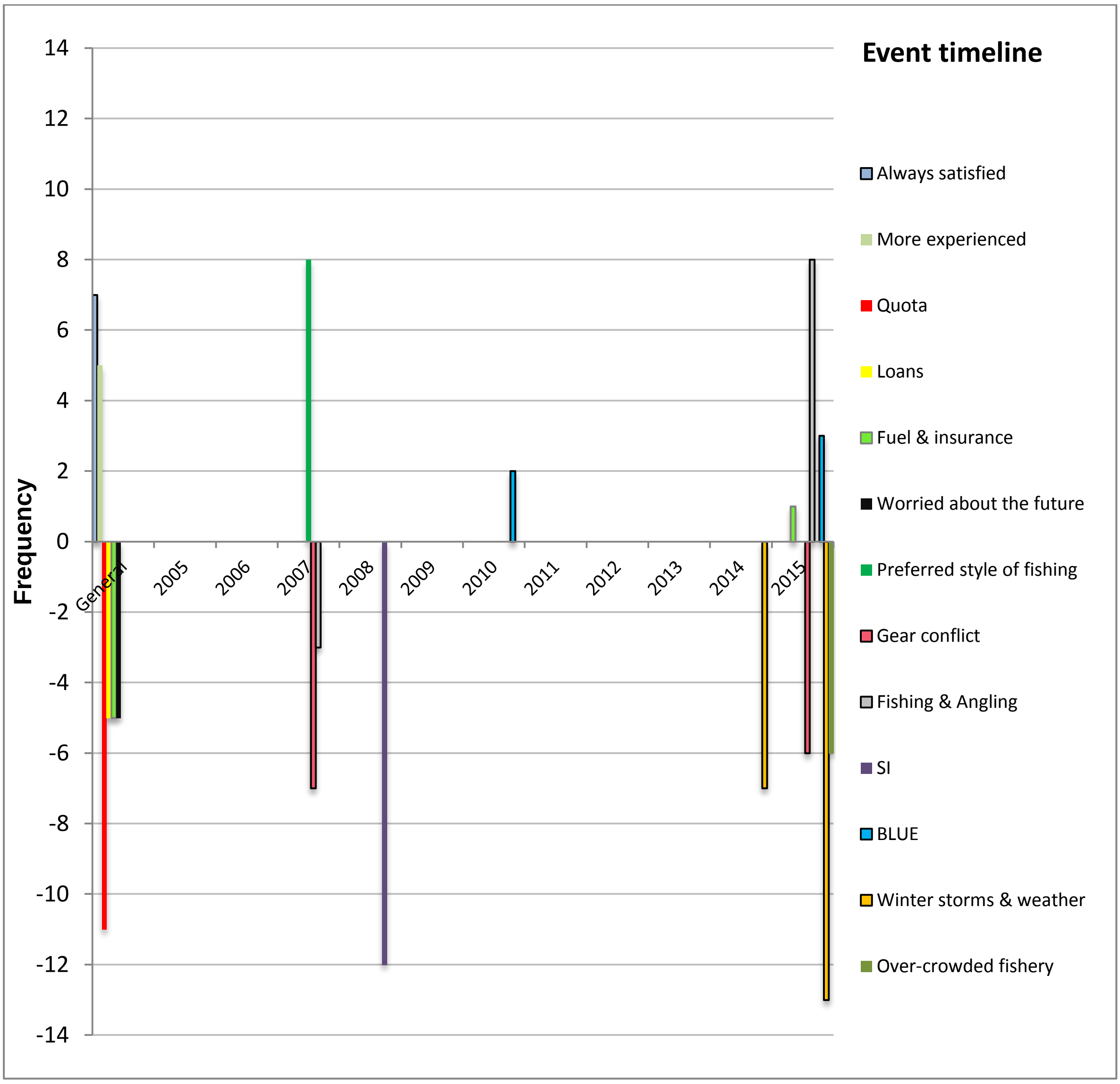


Figure 23 Event timeline for static and mobile fishermen in Lyme Bay over the past ten years. Events include all those with a positive or negative impact that were mentioned by more than five fishermen.

8.3.10 Support and trust

All fishermen were asked to rank (0 = completely against and 10 = completely support) the extent to which they supported or not the: a) *closed area (SI) policy in Lyme Bay*, and; b) *Lyme Bay Consultative Committee*. For the question on support of the SI closed area we have compared our 2015 data with perception data collected previously from Lyme Bay (Figure 24). Average support for the Lyme Bay SI closure across all fishermen interviewed in 2015 was 5.5. Support was higher for static fishermen (7.6) than for mobile fishermen (1.3), and also differed between static fishermen who are and are not involved in the Lyme Bay partnership activities (Static Y = 9.5; Static N = 5.3 though there was large variation within the Static N group). Compared with previous years, support by mobile fishermen has declined from an average of 6.6 in 2008 to a mean of 2.2 across 2009, 2010 and 2015. Support by static fishermen began low in 2008 at 3.4, but rose substantially from 2009-2015. Support was particularly high for static fishermen directly involved in the partnership activities in 2015.

Average support for the LBCC across all fishermen interviewed in 2015 was 4.1 (Figure 25). Support was higher for static fishermen (5.3) than for mobile fishermen (1.6), but differed substantially between static fishermen who are and are not involved in the Lyme Bay partnership activities (Static Y = 7.9; Static N = 1.7). Mobile and Static N fishermen have similarly low levels of support for the LBCC. The lack of support among Static N and Mobile gear fishermen appears to stem from a loss of trust in consultation processes in general following what was perceived as a fishermen's agreement to voluntary close three areas prior to 2008 followed by a seemingly unilateral decision by government (influenced by influential conservation agencies) to blanket close a much larger area (n=9). Fishermen also highlighted a few concerns with the Blue Marine Foundation's involvement in the consultative committee, and the perception that the organisation has primarily engaged smaller-scale (part-time or retired) fishermen that are already perceived to be low impact e.g. static gear) and, by extension, has neglected many other static and mobile fishermen who also use Lyme Bay (n=5). Any benefits from the Consultative Committee and partnership activities are perceived to be concentrated to a small number of fishermen.

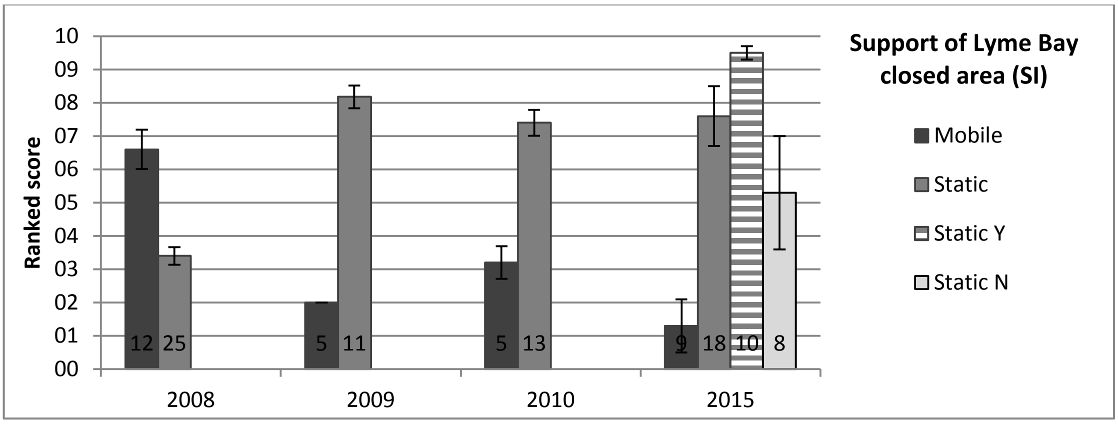


Figure 24 Fishermen's perceived support of the Lyme Bay closed area (SI) from 2008 to 2015. Static Y = static gear fishermen involved in Lyme Bay partnership activities. Static N = static gear fishermen not involved in Lyme Bay partnership activities.

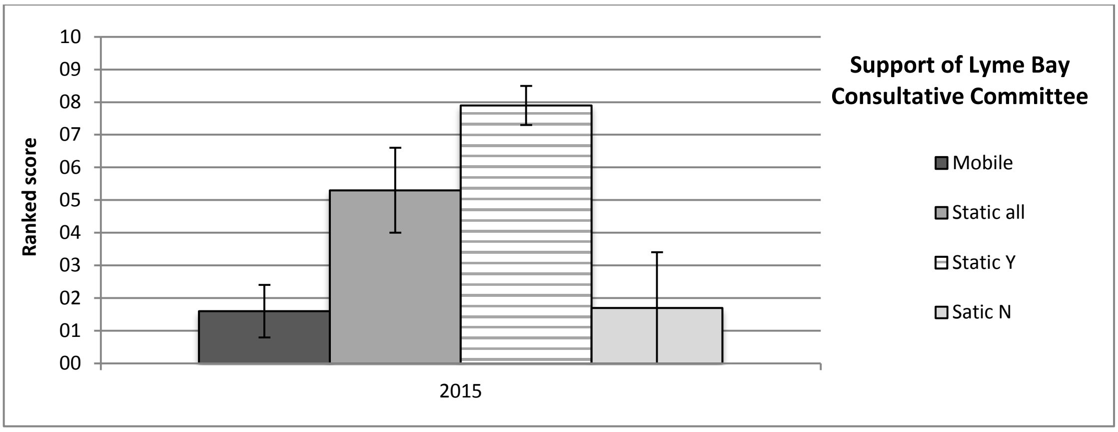


Figure 25 Fishermen's perceived support of the LBCC in 2015. Static Y = static gear fishermen involved in Lyme Bay partnership activities. Static N = static gear fishermen not involved in Lyme Bay partnership activities.

Static fishermen who stated that they were involved in Lyme Bay partnership activities (Static Y), which involves collaboration with the Blue Marine Foundation, were asked to further rank (0 = completely disagree and 10 = completely agree) whether specific partnership activities had *benefitted their fishing activity in Lyme Bay*. The specific partnership activities included the: a) voluntary code of conduct; b) fully monitored and documented fisheries project[3]; c) additional storage and icing facilities, and; d) Reserve Seafood brand. Fishermen were also asked to rank their agreement with the statement: *I feel I am more actively engaged in managing the Lyme Bay area as a result of the Lyme Bay Consultative Committee*. Static Y fishermen agreed that most of the partnership activities had benefitted their fishing activities, in particular the additional storage and icing facilities (9.8) and the Reserve Seafood brand (8.0) but also the voluntary code of conduct (6.8). They were more ambivalent about whether the fully monitored and documented fisheries project had benefited their fishing activities (4.9) (Figure 26). Responses to an open-ended question asking respondents to comment on their ranked scores suggested that fishermen generally support the voluntary code of conduct because most Static Y fishermen already fish within the limits set. Note however that in other general comments a few Static N fishermen voiced concern over voluntary agreements being made without the involvement of all static fishermen using Lyme Bay as they might set a precedent for future regulation. Static Y fishermen were also very supportive of and see great future potential in the Reserve Seafood brand despite a few 'teething problems'. Specifically, fishermen noted the success of detailed invoicing by size and quality of fish that was provided by Direct Seafood buyers. The fully documented fishery project was seen by some as complementary to the Reserve Seafood initiative as it provided the necessary traceability of product. On the other hand,

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[3] Lyme Bay Fisheries and Conservation Reserve Fully Monitored and Documented Fisheries Project sees the Succorfish SC2 inshore Vessel Monitoring Systems (iVMS) voluntarily installed on board vessels to monitor and manage fishing activity in and around the marine protected area in Lyme Bay http://www.bluemarinefoundation.com/film/fully-monitored-and-documented-fisheries-in-lyme-bay/

some concerns over the inshore vessel monitoring systems (iVMS) were highlighted including issues with the technology breaking down or running down the boat battery. Concerns over iVMS also included that fishermen were being asked to pay for the technology or pay for repairs to the technology despite it primarily benefiting managers, and further concerns over who owned the data and how it would be used in the future. Nevertheless, fishermen were on the whole supportive of the partnership activities and agreed on average that they felt more actively engaged in managing the Lyme Bay area as a result of the Consultative Committee (6.6). To quote one of the respondents:

> *Blue [Marine Foundation's] work in the Reserve made an enormous difference to the fishing and fishing grounds. We're aware of how lucky we are. They helped to get us in a position where we can influence what goes on, the ice machine and new markets raised income, and prosecutions through the MMO [Marine Management Organisation] improved after Blue as we previously reported instances [of non-compliance] but they didn't enforce it.*
> (November 2015)

Other respondents were more tentative in their support explaining that 'whether the partnership activities were actually commercially beneficial was still uncertain' and that 'time would tell whether there would be benefits in the long-term'.

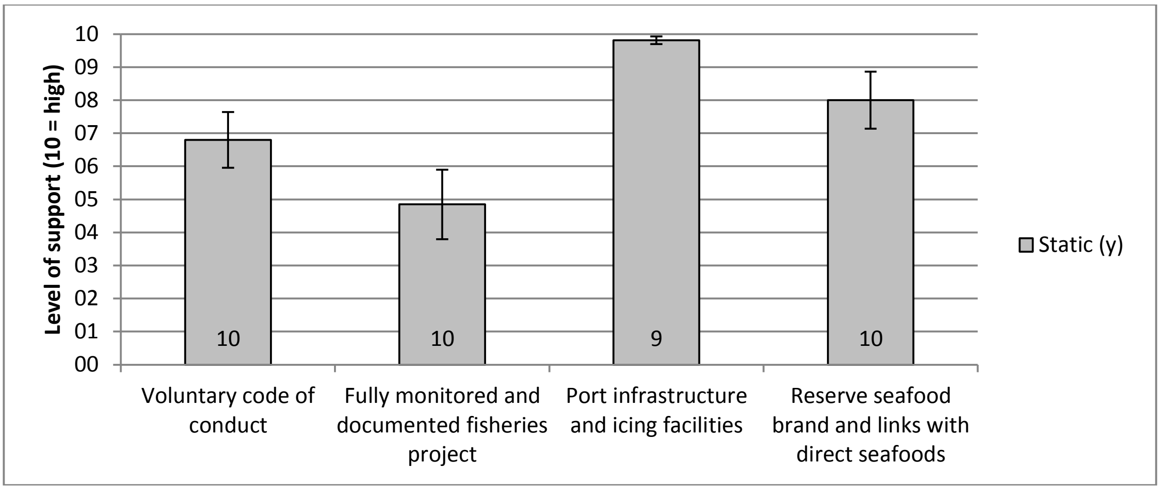

Figure 26 Fishermen's perceived support of Lyme Bay partnership activities in collaboration with the Blue Marine Foundation in 2015.

8.3.11 Change in number of successful prosecutions from IFCA enforcement activity.

Southern IFCA and Devon and Severn IFCA provided records that showed prosecutions had increased in relation to prohibited fishing activity in Lyme Bay Reserve, from two prosecutions in 2013 to three prosecutions in 2014. Of these prosecutions one of those in 2013 was for scallop dredging within a closed area (the Reserve) and one was for undersized scallops. In 2014, two prosecutions were for dredging within a closed area (the Reserve) and one prosecution was for undersized lobster and spider crabs. This reflects fishermen's perceptions that enforcement had increased in recent years (Section 8.3.8).

8.3.12 Changes in outside events (influencing factors) impacting fishing businesses: 2005-2015

Certain outside events or influences, not directly related to MPA management and LBCC partnership activities were identified by workshop participants as having an effect on fishermen's wellbeing in Lyme Bay. These were adverse weather events, fuel cost and quota levels for relevant quota restricted species (Annex III). Of these, adverse weather events, in particular storms in February 2014 and consistent stormy weather at the time of the interview survey, between November and January 2015 and low quotas, in particular low sole quotas were raised by multiple fishermen in face to face interviews (weather events n=13, quota n=11) (Figure 23).

In interviews two under 10 metre static gear fishermen mentioned that they would consider not going to sea in wind speeds of force 6 (38km/h and over) (although wind direction and local conditions would ultimately dictate decisions). To assess the potential impact of weather events across the 2005-2015 timeline the total number of days within each year 2005 -2015 and the mean days per month annually 2005-2015, when wind speeds exceeded force 6 (38km/h) were plotted from data for the nearest location with a historical data source (Exeter airport) (weather underground historical records) (Figure 27). Years with greater than 40 days per year with wind speeds in excess of 38km/h recorded at Exeter airport were 2007-2009 and 2013-2015 (Figure 27). As Exeter airport is inland of Lyme Bay, wind speeds are likely to be stronger on the coast and therefore these data provide a conservative estimate of days lost at sea due to poor weather. The highest total number of days above force 6 within a year between 2005 and 2015 had occurred in the most recent years, 2013-2015 (45 to 64 days) (Figure 27).

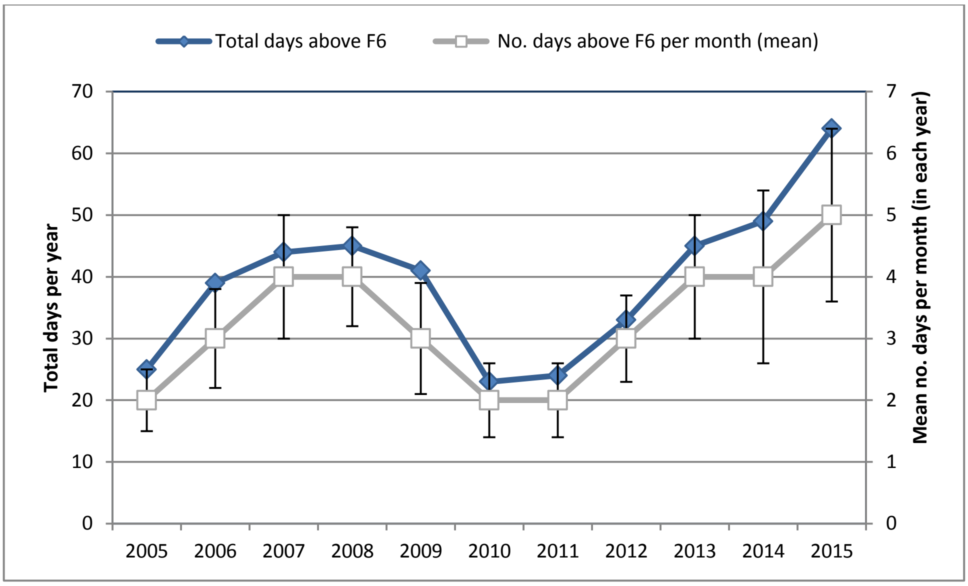

Figure 27 Total days per year and mean days per month per year when wind speeds exceeded Force 6 at Exeter airport (2005-2015).

The plot of mean days per month (within each year) where wind speeds were above force 6 displays peaks of 4-5 days per month (annual mean) occurring in two periods, 2013-2015, and 2007-2008 (Figure 27). However the number of days with wind speeds above force 6 within individual winter months (November to March) have been higher between 2013/2014 and 2015/2016 than any previous years (with peaks of 17 days in February 2014, 12 days in February 2015 and 14 days in December 2015) (Figure 28). Previous to 2013 only one month, over the course of 8 years (2005-2012) had more than 10 days with wind speeds of force 6 or over (November 2009, 11 days) (Figure 28).

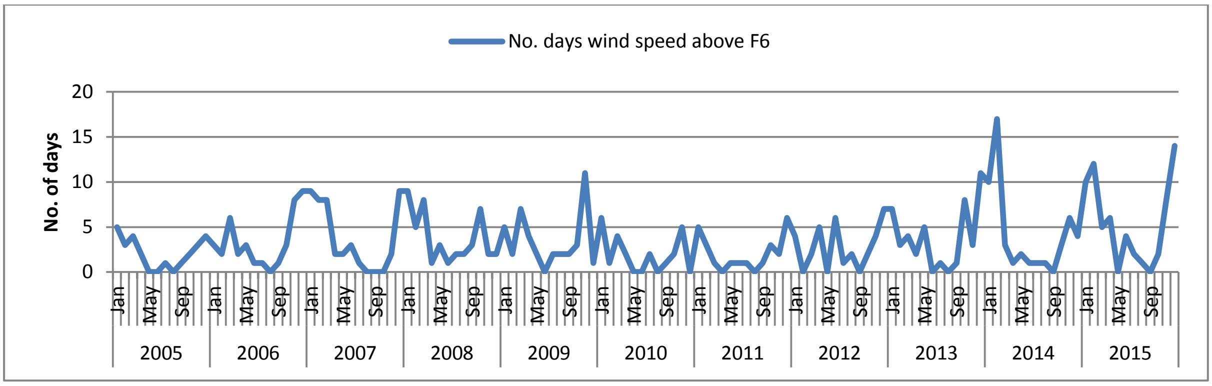

Figure 28 Number of days per month in each year 2005-2015 when wind speeds exceeded Force 6 at Exeter airport.

Low quotas (for the 10 metre and under vessel pool, within ICES area VIIe (western English Channel) that includes Lyme Bay) were raised by fishermen as events or factors that have a continual impact on wellbeing. Low sole quota were raised by 11 fishermen as having a specific influence on income satisfaction and wellbeing, as this high value species has low quotas during winter months when many under 10 metre vessel static gear fishermen were netting (for instance, 60kg in November 2015 at the time interviews were conducted). The monthly sole and plaice quota allowance for the 10 metre and under vessel pool, within ICES area VIIe, available from the MMO between 2010 – 2015 shows sole quota levels are low each year between January and May (within a range of 30-60kg), compared to a peak of 250kg in December 2010 (Figure 29). Plaice quota levels had also remained low between November 2014 and September 2015 (between 0 and 275kg) (Figure 29).

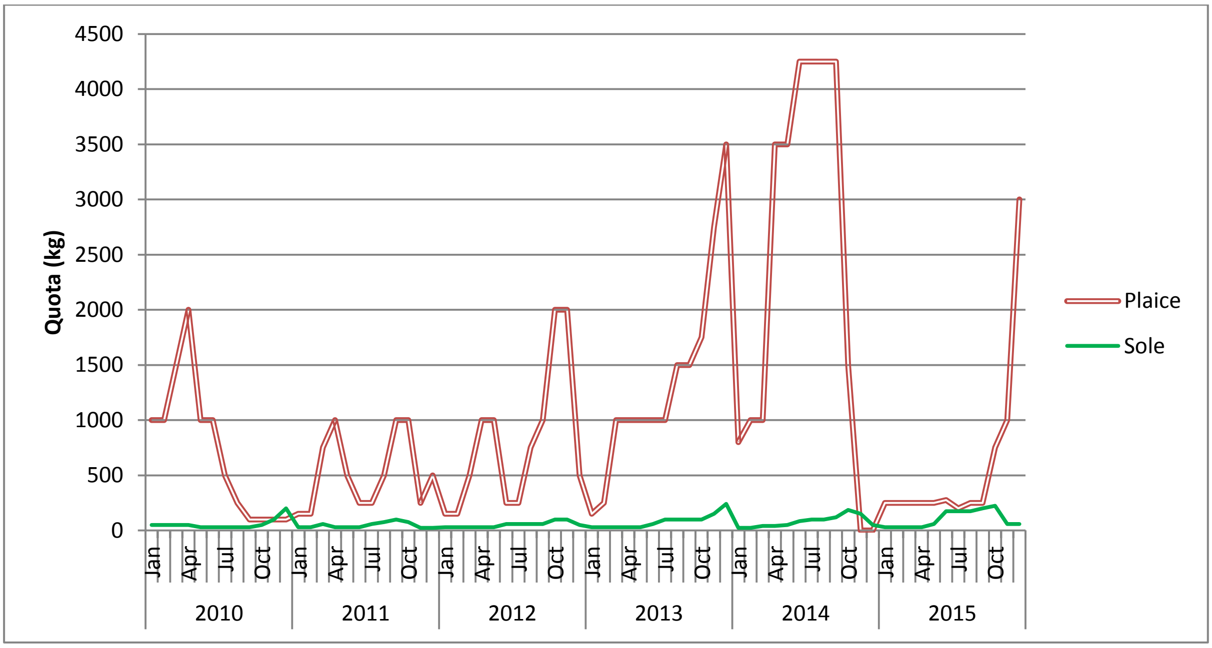

Figure 29 Quota for the 10 metre and under pool within ICES area VIIe for sole and plaice 2010-2015.

The low quotas of higher value fish have coincided in recent years (2014-2015) with periods of intense storminess and thus an increase in days at sea lost to adverse weather. The combination of these factors is likely to have reduced the opportunity for inshore (under10 metre vessel) fishermen to generate income in winter months. Fuel price was only raised by 5 fishermen in interviews as an event or factor affecting wellbeing (Figure 23). However, an increase in total days with wind speeds over force 6, during periods when quotas have been low for higher value species, had also occurred during a period 2012-2014/2015 when fuel prices had peaked (to between 48 and 59.8 pence per litre, for diesel pre-tax) (Figure 30).

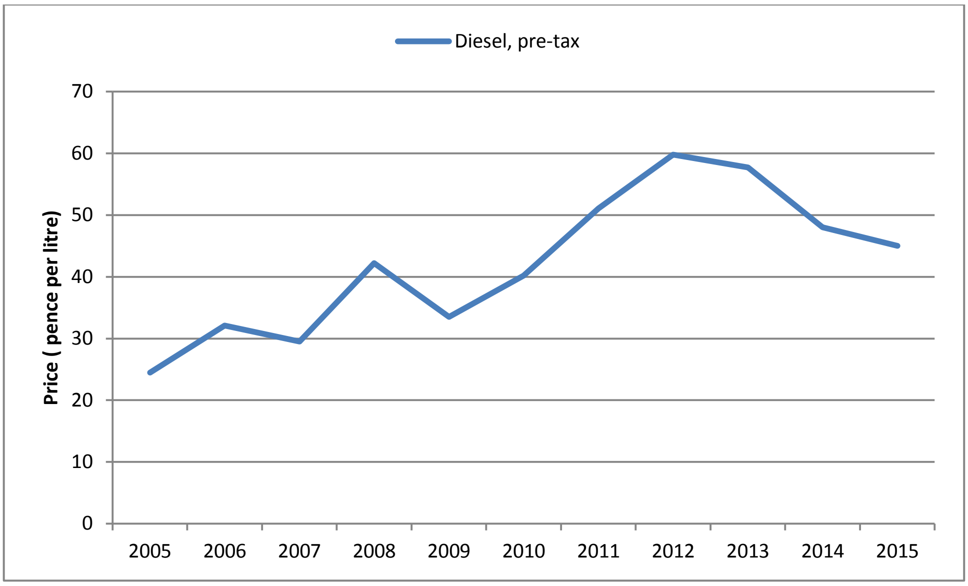

Figure 30 Diesel price (pre-tax) between 2005 and 2015.

The adverse weather conditions at the time interviews were conducted and low quota for sole may have influenced the high rate that adverse weather and quota restrictions were raised by interview respondents. However, increased frequency and severity of winter storms has been predicted as a potential future scenario in relation to climate change (although uncertainty currently exists over links between sequences of severe storms in winter 2014 and 2015 and a warming climate changing atmospheric circulations) (Met Office 2014).

If sequences of severe storms in winter months persist this factor may become increasingly relevant to future management decisions. Increased adverse weather events are likely to have negative economic impacts on fishermen in Lyme Bay, and in ports within the Reserve boundaries in particular. For instance, fishermen in West Bay mentioned being limited as the harbour faces into prevailing south westerly winds, preventing safe entry and exit in adverse weather (n=5). Fishermen using mobile gear with home ports within the Reserve also mentioned increased lost days at sea/fishing opportunities since the 2008 SI closure (n=3) as prior to the closure they could still fish in more sheltered waters in Lyme Bay in adverse weather. One fisherman who had changed from mobile to static gear since the 2008 SI closure mentioned they had concern for the fishermen still fishing with mobile gears in adverse weather (from ports within the Reserve) as they now have to take increased safety risks, fishing outside the Reserve, or lose further days at sea.

Although weather events and regional quota restrictions occur regardless of MPA management and LBCC partnership activities, increasing frequency and severity of winter storms may put further financial pressure on Lyme Bay fishermen and the objective of providing ‘wins’ for the environment, for fisheries and for coastal communities may become increasingly challenging.

8.3.13 Reflections on management of Lyme Bay

To finish the questionnaire fishermen were asked to reflect on *what they would like to see change to improve best practice management*. Static Y fishermen raised two primary issues. They requested more involvement with the IFCA’s in fisheries management, in order to retain and/or gain fisheries management influence at the local level. They also raised the potential of strengthening the voluntary code of conduct so that it would have control over external boats that were not signed up to the agreement (note previous text reporting concerns from Static N fishermen that voluntary agreements developed by a sub-section of the static sector could be formalised). Static N fishermen also called for greater involvement of the IFCAs in local fisheries management (n=5). Some also recommended opening up some parts of the SI closed area (n=3), and limiting either the number of boats or gears that can be used in the area. Similarly, mobile gear fishermen supported the call for closer collaboration between the IFCAs and fishermen in local fisheries management (n=6), and suggested that parts of the SI closure should be re-opened under the agreement that vessels are tracked with VMS or iVMS, that gear limits for both static and mobile vessels are introduced in that area specifically, and that new ‘lighter touch’ technologies are developed and trialled. The mobile sector referred to a perceived lack of fairness in how only they were excluded from the SI closure, and in terms of unequal quota allocations for the owner-operator vessels compared to corporate or European vessels (n=6).

9 Evaluation

Table 7 provides a summary of all the ecosystem service and human wellbeing indicators evaluated as part of this project, where appropriate a statistical analysis of the significance of change across the 10 year period is included. A confidence rating to assess if the indicator and the wider agreement of evidence can accurately reflect the impact of management measures and the activities of the LBCC is included (Figure 31).

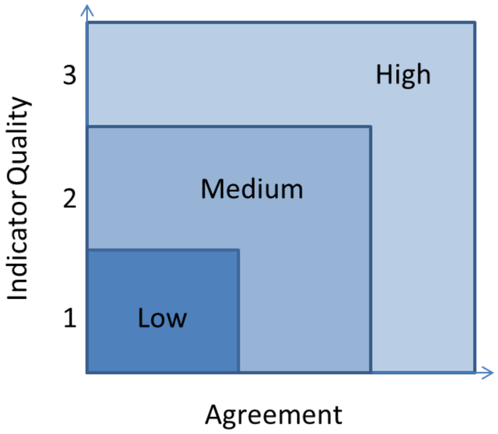

Figure 31 Criteria applied to provide a confidence rating for each indicator, based on each indicators level of data quality and the agreement of the evidence provided to reflect the impact of management measures and activities of LBCC.

Table 7 Summary of all the ecosystem service and human wellbeing indicators evaluated as part of this project, A) Broad scale indicators and B) Fine scale indicators

A) Broad scale indicators

Indicators	Lyme Bay Reserve (under 10m)	Lyme Bay Reserve (over 10m)	Lyme Bay (under 10m)	Lyme Bay (over 10m)	Indicator quality	Comments
Registered vessels	38 -38 (Range = 4 vessels)	2-3 (Range= 2 vessels)	201 – 191 (Range =22 vessels)	68-69 (Range =58 vessels)	1	There are wider environmental or social and economic factors influencing the number of registered vessels e.g. retirement. Registered boat lists are not truly representative of vessel numbers as a boat may fish in Lyme Bay but be registered elsewhere in the region. A vessel may also be registered but that does not represent the number of days (if any) it is working and providing employment
	+/-	+	-	+		
Employment	Approx. number 38-76 to 38-76	Approx. number 2-8 to 6-12	402-804 to 382-764	Approx. number 136-272 to 138-276	1	
	+/-	+	-	+		
New entrants to the fishing industry	Attendees of courses within 20 miles of LBR Range increases from 0-21 in 2005-2011 to 20-40 in 2012-2015	Attendees of courses within 20 miles of LBR Range increases from 0-21 in 2005-2011 to 20-40 in 2012-2015	No data for wider region	No data for wider region	1	Attendees of Seafish Basic Health and Safety courses within 20 miles of the Lyme Bay Reserve area may not represent solely new entrants from home ports within 20 miles of Lyme Bay Reserve, as attendees could feasibly travel from any location. New entrants may, likewise have also completed training in other UK locations and then fished in Lyme Bay. No separation of inside / outside the Reserve and under 10 metre or over 10 metre vessels can be provided. Data were only obtained for courses run within 20 miles of the Lyme Bay Reserve and therefore data cannot confidently be presented for the wider Lyme Bay region
	+	+				

Indicators	LBR (static)	LBR (mobile) No towed gear from 2007-2008)	LB (static)	LB (mobile)	Indicator quality	Comments
Number of vessels	27-28, Range = 4	4-7, Range = 3	22-61, Range = 39	10-18, Range = 8	1-2	The data is based on the ICES statistical rectangles 30E6 /30E7. These rectangles cover the Lyme Bay Reserve but only a partial area of the wider Lyme Bay region. Therefore the quality of the indicator is higher for inside the Reserve compared to outside the Reserve. Large assumptions are made as to which vessels operate inside and outside the Reserve when, in reality, the lines are not so clear cut. Data could be underestimating the actual fishing effort as effort is calculated here from landings data. There is no statutory requirement for fishermen to declare their catches for 10 metre and under vessels. There are also wider environmental or social and economic factors influencing fishing effort and landings e.g. weather, market prices.
	+/- not statistically significant	- (Welch's *F* = 14.1, *P* < 0.01)	+ (Welch's *F* = 7.1, *P* < 0.01) (32)	+ (Welch's *F* = 6.1, *P* < 0.01)		
Mean Monthly trips	36-242, Range = 246	41-57, Range = 6	88-395, Range = 307	35-101, Range = 66	1-2	
	+ (Welch's *F* = 30.9, *P* < 0.01)	- not statistically significant	+ (Welch's *F* = 41.3, *P* < 0.01)	+ (Welch's *F* = 4.5, *P* = 0.03)		
Landings (kg)	2670-3501, Range = 1645	(11304-3684, Range = 7620	(3384-1292, Range = 2092	26084-6224, Range = 22378	1-2	
	+ (Welch's *F* = 2.1, P = 0.05)	- (Welch's *F* = 19.5, *P* <0.01)	- (Welch's *F* = 2.65, *P* = 0.02)	- (Welch's *F* = 2.55, *P* = 0.03)		
Landings (£)	1988-3797, Range = 1809	15311-6179, Range =9132	3456-3470, Range = 1529	9250-6056, Range = 5149	1-2	
	+ (Welch's *F* = 3.6, *P* = 0.03)	- (Welch's *F* = 15.7, *P* <0.01)	+ (Welch's *F* = 3.6, *P* < 0.01)	- (Welch's *F* = 8.0, *P* < 0.01)		

Indicators	LBR (static)	LBR (mobile) No towed gear from 2007-2008)	LB (static)	LB (mobile)	Indicator quality	Comments
Whelk	17850-8755, Range = 13720	12-5, Range 7	10404-8784, Range = 6284	0-1484, Range = 2867	2	As above for effort and landings though a slightly higher quality as an indicator (compared to combined landings data) as static gear is used and there is a LBCC voluntary code of conduct. D&S IFCA is considering increasing Minimum Conservation Reference Size (MCRS) for whelks to ensure 50% of the population reaches sexual maturity and prevents the boom and bust fisheries seen. D&S IFCA potting permit byelaw introduced in 2015
	- (Welch's *F* = 3.7, *P* = 0.04)	- not caught in sufficient quantity to test with ANOVA	- (Welch's *F* = 2.5, *P* = 0.03)	+ 2008-2014 (Welch's *F* = 7.1, *P* < 0.01)		
Whelk (£)	9528-6773, Range = 6645	7-3, Range =7	5134-7008, Range = 4451	0-1113, Range = 1782	2	
	- (Welch's *F* = 2.8, *P* = 0.02)	- not statistically significant	+ Welch's *F* = 2.4, *P* = 0.03)	+ not statistically significant		
Cuttlefish	963-531, Range =1285	693-179, Range = 514	404-63, Range = 322	327-59, Range = 268	1	As above for effort and landings though a lower quality in this species as an indicator as landings are dependent upon the abundance of cuttlefish migrating to the region each spring as well as fishing effort. Caches of cuttlefish are highly variable between years. IFCA Voluntary code on the protection of cuttlefish eggs introduced during the period of study.
	- not statistically significant	- not statistically significant	- (Welch's *F* = 2.4, *P* = 0.03)	- not statistically significant		
Cuttlefish (£)	1043-1185, Range = 1775	746-262, Range = 484	409-139, Range = 779	357-132, Range = 357	1	
	+ not statistically significant	- not statistically significant	- not statistically significant	- not statistically significant		
Scallops (dredge) (kg)	n/a	12641-5563, Range = 7732	n/a	2518-3405, Range = 4363	2	As above for effort and landings. Some vessels using mobile gear that targeted scallops were known to have spent some time fishing in other UK locations at the time of initial monitoring of the 2008 SI closure (Mangi et al. 2011). The landings of these vessels have not been analysed in this study and therefore the full extent of changes in scallop landings between 2005 and 2014 for Lyme Bay vessels may be greater or smaller than the results discussed for these ICES rectangles.
		- (*F* = 18.4, *P* <0.01)		+ (*F* = 9.3, *P* <0.01)		
Scallops (dredge) (£)	n/a	16507-8077, Range = 8430		3869-5186, Range = 6847	2	
		- (*F* = 11.5, *P* <0.01)		+ (*F* = 10.6, *P* <0.01)		

Indicators	LBR (static)	LBR (mobile) No towed gear from 2007-2008)	LB (static)	LB (mobile)	Indicator quality	Comments
Scallop (diver) (kg)	756-3495, Range =3432		1643-713, Range = 5252		2-3	As above for effort and landings though a higher quality of indicator as effort of this fishery is highest inside the Reserve. Scallops are a reef associated species and have been monitored as an indicator species for studies between 2008 and 2012 of benthic species recovery. Shucked scallops required for public sale means landings recorded through processors in recent years. Considered by the LBCC Voluntary Code of Conduct though no data on whether effort has been limited or enforced. D&S IFCA Diving Permit Byelaw introduced in 2015 with restriction on recreational fishers
	+ (Welch's *F* = 2.67, *P* = 0.04)		- (Welch's *F* = 3.1, *P* = 0.01)			
Scallop (diver) (£)	960-4079, Range = 3940		3918-1235, Range = 9118		2-3	
	+ (Welch's *F* = 15.3, *P* <0.01)		- not statistically significant			
Crabs (kg)	249-472, Range = 261	4-73, Range = 133	1129-1017, Range = 689	13-133, Range = 125	2-3	As above for effort and landings though a higher quality of indicator as crabs are a reef associated species. Crabs were also an indicator species for studies between 2008 and 2012 of benthic species recovery. Considered by the LBCC Voluntary Code of Conduct though no data on whether effort has been limited or enforced. A species under detailed study in Lyme Bay (potting experiments). IFCA minimum landings sizes present for the fishery. D&S IFCA Potting Byelaw introduced in 2015 – increase in females crab MCRS, increase in Spider crab MCRS, increase in crawfish MCRS. Limit on catch for recreational fishers. The EU Western Waters Regime places a limit upon the number of kilowatt days that the >15m potting fleet can use within ICES area VII. From 2013 active management has been introduced leading to reductions in the number of days fished within this stock area.
	+ (Welch's *F* = 3.7, *P* = 0.04)	- not statistically significant	+ (Welch's *F* = 2.5, *P* = 0.03)	+ (Welch's *F* = 3.4, *P* = <0.01)		
Crabs (£)	319-704, Range = 460	6-111, Range = 105	1623-1680, Range = 1067	17-158, Range = 147	2-3	
	+ (Welch's *F* = 13.1, *P* <0.01)	- not statistically significant	+ (Welch's *F* = 7.4, *P* <0.01)	+ (Welch's *F* = 3.5, *P* <0.06)		
Lemon Sole (kg)	2-54, Range = 52	17-23, Range = 8	284-4, Range =284	64-157, Range = 180)	2	As above for effort and landings though a though a medium quality indicator as an off quota high value flatfish species in Lyme Bay region targeted by fisheries inside and outside. Relevant to the LBCC voluntary Code of Conduct IFCA minimum landings sizes are present for the fishery
	+ not statistically significant	+ not statistically significant	- not statistically significant	+ (Welch's *F* = 2.6, *P* = 0.02)		
Lemon Sole (£)	9-221, Range = 218	72-165, Range = 93	1101-19, Range = 1096	270-557, Range = 759	2	
	+ (Welch's *F* = 2.8, *P* = 0.05)	- not statistically significant	- not statistically significant	+ (Welch's *F* = 2.4, *P* = 0.03)		

Indicators	LBR (static)	LBR (mobile) No towed gear from 2007-2008)	LB (static)	LB (mobile)	Indicator quality	Comments
Sole (kg)	113-46, Range = 91	73-63, Range = 34	18-41, Range = 36	276-105, Range =243	1	As above for effort and landings though a though a low quality indicator as sole landings are regulated by quotas and analysis of landings cannot indicate changes of abundance in Lyme Bay Relevant to the LBCC voluntary Code of Conduct IFCA minimum landings sizes are present for the fishery
	- (Welch's *F* = 3.1, *P* = 0.01)	+ not statistically significant	+ not statistically significant	- (Welch's *F* = 8.6, *P* = <0.01)		
Sole (£)	915-518 Range = 733	646-672, Range = 326	133-478, Range = 416)	2183-979, Range = 1817	1	
	- (Welch's *F* = 4.5, *P* <0.01)	+ not statistically significant	+ not statistically significant	- (Welch's *F* = 10.2, *P* = 0.01)		
Lobster (kg)	11-24, Range = 11	3-20, Range = 29	76-83, Range = 31	1-13, Range = 16	2	As above for effort and landings though a though a medium quality indicator as lobster is a reef associated species. A species under detailed study in Lyme Bay (potting experiments) Considered by the LBCC voluntary Code of Conduct IFCA minimum landings sizes are present for the fishery D&S IFCA Potting byelaw introduced 2015 – ban on berried lobsters, escape gaps fitted, limit on catch for recreational fishers
	+ not statistically significant	+ not statistically significant	+ not statistically significant	+ not statistically significant		
Lobster (£)	147-290, Range = 422	39-216, Range =330	920-872, Range =433	17-150, Range =186	2	
	+ (Welch's *F* = 3.9, *P* <0.01)	+ not statistically significant	- not statistically significant	+ (Welch's *F* = 6.4, *P* = < 0.01)		
Plaice (kg)	13-121, Range = 108	284-126, Range = 158	168-47, Range = 144	450-399, Range = 361	1	As above for effort and landings though a though a low quality indicator as Plaice landings are regulated by quotas and analyses of landings cannot indicate changes in abundance in Lyme Bay Relevant to the LBCC voluntary Code of Conduct IFCA minimum landings sizes are present for the fishery
	+ (Welch's *F* = 4.1, *P* <0.01)	- not statistically significant	- not statistically significant	- (Welch's *F* = 8.6, *P* <0.01)		
Plaice (£)	25-188, Range =173	524-866, Range = 437	356-75, Range = 304	811-523, Range = 635	1	
	+ (Welch's *F* = 3.8, *P* <0.01)	+ not statistically significant	- not statistically significant	- (Welch's *F* = 7.8, *P* <0.01)		

B) Fine scale indicators

Indicator	Static (Y) gear fishermen involved in the LBCC	Static (N) gear fishermen not involved in the LBCC	Mobile gear fishermen	Indicator quality	Comments
Average annual income in 2015	£15,000		£22,500 / £100,000+	1-2	Respondents estimated their turnover and what proportion would be income (rather than checking their financial records). Respondents were reluctant to answer the question.Data from 2009 were not available to allow a comparison over time.
Income satisfaction	Increased (6.8 to 7.9)	Remained the same (7.3 to 7.5)	Decreased (10.0 to 6.6)	2-3	Satisfaction is a subjective measure that is well captured by a 0-10 scoring approach Respondents were asked to recall past levels of satisfaction which can introduce some recall bias.
Job satisfaction	Increased (7.0 to 8.3)	Decreased (7.7 to 5.9)	Decreased (9.3 to 5.0)	2-3	
Levels of stress	Decreased (4.5 to 3.8)	Increased (3.3 to 3.9)	Increased (2.4 to 4.3)	2	The indicator uses a subjective measure of perceptions of lived experiences of stress / conflict. A high confidence measure would also use objective data (e.g., medical records or number of incidences of conflict). Respondents were asked to recall past levels of stress/conflict which can introduce some recall bias
Levels of conflict	Decreased (3.4 to 1.9)	Decreased (5.7 to 1.8)	Increased (3.5 to 4.5)	2	
Unreported non-compliance	Decreased (4.0 to 0.9)			1	Compliance is a sensitive issue to investigate through survey tools. Some respondents were reluctant to answer the question.
Past investment	Over 70% of fishermen have invested in fishing in the last ten years across all gear types.			3	Respondents could easily recall the number of investments in their business.
Past investment amount	£7,500		£320,000	2	Respondents estimated the value of their investments (rather than checking their financial records). Some static gear fishermen were reluctant to answer the question
Confidence in future investment	8.0	6.5	7.1	3	Confidence is a subjective measure that is well captured by a 0-10 scoring approach
Sales strategy	38% local + 15% Reserve Seafood	18% local	5% local	2	Respondents estimated the proportion of their catch that they sell through different channels (rather than consulting their sales records).
Influential events	+ SI reduced gear conflict, LBCC activities - weather	+ Don't really worry; - SI related gear changes, weather, quota	+ More experienced, good cuttlefish catch; - SI displacement, quota, gear conflict with EU trawlers	2-3	The number of respondents identifying an event as significant was quantified. Respondents were asked to recall past events which can introduce some recall bias.
Support for SI closure	9.5	5.3	1.3	2-3	Support is a subjective measure that is well captured by a 0-10 scoring approach. Static N fishermen showed wide variation in response.
Support for LBCC	7.9	1.7	1.6		
Benefit from voluntary Code of Conduct	6.8			2	The indicator uses a subjective measure of perceptions of benefits experienced. Kinds and amounts of benefits related to precise partnership activities are not quantified in this question.
Benefit from the Fully Documented Fisheries project	4.9				
Benefit from additional icing infrastructure	9.8				
Benefit from Reserve Seafood brand	8.0				

9.1 Observed changes in the broad scale indicators

Low confidence

- Between 2005-2015 the number of under 10 metre boats registered to ports within the Reserve has stayed the same whilst the number of boats registered to ports in the wider Lyme Bay region has declined, in agreement with the national trend. It is possible that management measures and the actions of the LBCC have provided some resilience to the fleet against a decline in numbers.
- Numbers of people attending Seafish Basic Health and Safety Courses, a potential indicator of new entrants to the industry, increased for courses run within 20 miles of Lyme Bay Reserve.
- A significant increase in landings weight and value occurred for plaice landed by vessels using static gears inside Lyme Bay Reserve. Plaice landings are regulated by quotas and analyses of landings cannot indicate changes in abundance in Lyme Bay nor reflect the impact of management measures.

Medium confidence

- Between 2005-2014 static gear boats operating within the Reserve and in the wider Lyme Bay region have increased fishing effort (mean number of vessels per month, mean monthly trips per month). The increase in the number of trips per month is significant. This increase in effort within the Reserve during this timescale has also been observed by local fishermen.
- Fishing effort (number of trips) for static gear boats inside the Reserve reached a peak in 2010-11 and has remained high during the period the LBCC has been active and IFCA byelaws have been announced for the SCI. This increase in effort inside the Reserve is potentially linked to the management measures that form the Lyme Bay Reserve as they reduced gear conflict between mobile and static gear fishermen and created space for more static gears. However, the dominance of whelks (landings and value) as a non-quota species in catches suggests that wider changes in this fishery are likely to have had a strong effect on effort in Lyme Bay.
- Between 2005-2014 mobile gear boats operating outside the Reserve have significantly increased fishing effort (mean number of vessels per month, mean monthly trips per month). This increase in effort during this timescale may signal displacement of effort following the SI closure in 2008.

- A slight decline in effort for mobile gear fishermen operating outside the Reserve can be observed between 2012-2013 and 2013-2014, after December 2013 when IFCA byelaws are introduced, preventing towed (mobile) gear in some further areas of Annex I reef habitat. There was also a period of intense storminess in the winter of 2014 which may have limited time at sea.
- Between 2005-2014 the mean landings per boat per month (kg and £) has significantly increased for static gear fishermen operating inside the Reserve. Landings of whelk dominate the catch but the weight and value of landings have declined for this species during this period. It is unknown whether there has been a decline in whelk stocks or if fishermen are switching to more preferred methods of fishing. Whelk fisheries are known to go through what is a 'boom and bust' cycle. Futures changes in management such as an increase in MCRS might help ensure sustainability so that the long term decline does not continue.
- Between 2005-2014 there has been a decrease in the mean landings value per vessel for mobile (towed) gear fishermen (combined across all areas), despite increased effort in remaining open grounds in Lyme Bay. The reduced fishing grounds in ICES rectangles 30E6 and 30E7 for mobile gear, combined with the fact that the most productive grounds for scallops are in the areas that were closed to towed gears by the 2008 SI closure and 2013 IFCA byelaws will have had an impact on landings. Large peaks in scallop landings by mobile vessels in 2005/06 and 2006/07 (from inside the Reserve) and a very large volume of mussels landed by mobile gear vessels from outside the Reserve in 2005/2006 had a strong influence on this result.
- Between 2006/2007 and 2013/2014 mean value per vessel for mobile (towed) gear fishermen operating outside the Reserve increased but did not reach the values obtained in landings from all areas between 2005 and 2007. It is also possible that mobile gear fishermen who have been displaced from the ICES rectangles 30E6 and 30E7 have sought other fishing grounds, outside Lyme Bay for all or part of the year, or have targeted different (lower value) species.
- Between 2005-2014 landings data from outside the Reserve by mobile gear boats showed a significant increase in landings of scallops. This increase is likely to have been initially driven by displacement of vessels from the Reserve in 2008. The continued significant increase in the mean weight and value of scallops landed per vessel from mobile gear fishermen operating outside the Reserve suggests that the management measures that protect the resource may have a beneficial impact for this fishery and/or that boats are concentrating

more effort in remaining grounds or employing more efficient technologies. It must be noted that there has also been a significant increase in fishing effort during this timescale.

- Between 2005-2014 mobile gear fishermen in Lyme Bay are increasingly diversifying fishing practices with significant increases in landings of whelk and crab.

High confidence

- Following the SI closure in 2007 mobile gear fishing effort and landings inside the Reserve significantly declined as they were banned using bottom towed gear.
- Between 2005-2014 landings (kg and value) of scallops caught inside the Reserve has increased. During the same period landings weights of scallop collected by SCUBA diving from outside the closed area have decreased significantly, possible indicating a shift in effort from outside to inside the Reserve area due to the spatial management measures.
- Between 2005-2014 landings (kg and value) of crabs caught inside the Reserve has increased. Effort may have shifted as a result of the management measures. The close association of these species to the reef habitat and the evidence of recovery of the reef habitat suggest that management measures may be beneficial for the associated fishery. In 2006 and 2008 there was a change in the way official fishery data (shellfish) were recorded leading to an increase in records, particularly effort. It is believed that the higher levels recorded in this period represent a more accurate magnitude of activity than previously recorded in the 1990s (Cefas, 2014).
- Corresponding with increased landings, values of crabs landed from vessels using static gear inside the Lyme Bay Reserve are also significantly higher in 2011-2012, 2012-2013 and 2013-2014 than they were in 2006-2007. This suggests that a significant change the value returned by the fishery has been achieved in these latter years and corresponds to the period the LBCC have been active and IFCA byelaws have been introduced, protecting further areas of reef habitat.

9.2 Observed changes in the fine scale indicators and confidence in the indicator to reflect impact of management measures and the actions of the LBCC.

Low confidence

- Perceived levels of unreported non-compliance were very low on average over the ten years and extremely low in 2015 due to improvements in vessel monitoring and enforcement.

Questions of compliance are highly sensitive and difficult to research through survey tools. We designed the survey question in a sensitive manner, nevertheless less than half of all research participants answered.

Low/Medium confidence

- The income from fishing for static fishermen is substantially less than for half the mobile gear operators who responded. Respondents estimated their turnover and what proportion would be income (rather than checking their financial records). Many respondents were reluctant to answer the question, and data from 2009 were not available to allow a comparison over time so we have only low/medium confidence in our result on income disparities between the static and mobile sector, and within the mobile section between operators. Values data for both static and mobile fishermen actually suggests an increase in landings value between 2005-2014 for static fishermen (detailed above).

Medium confidence

- A majority of fishermen across the static and mobile fishing sectors have invested in their fishing business in the last ten years. Over a third of our sample plan to invest further in the near future with high confidence that future investments will be sufficiently profitable. Respondents could easily recall the number of investments in their business. However, respondents estimated the value of their investments (rather than checking their financial records), with some static gear fishermen reluctant to answer the question hence the exact value of investments is less certain. Nevertheless, this result is encouraging for the fishing industry in Lyme Bay as a whole given a wider national context of declining fisheries.
- Between 18-38% of the catch of static fishermen is sold locally, compared to only 5% of the catch of mobile vessels fishing in Lyme Bay. Fishermen’s testimony suggests that local sales have price benefits for static fishermen and contribute to the local economy (local retailers, restaurants and hotels). Respondents estimated the proportion of their catch that they sell through different channels (rather than consulting their sales records).
- A recent and important change in the sales strategies of static fishermen is the introduction of the Reserve Seafood brand with links to Direct Seafood, London. On average 15% of the catch of static fishermen involved in LBCC partnership activities is now sold at a premium directly to London. There is capacity in terms of available catch and interest in expanding this initiative.

- The perceived stress and conflict levels for static fishermen involved in the LBCC partnership activities were generally very low since the SI closure, although stress was experienced in times of consistent and extreme bad weather. Static fishermen not involved in LBCC partnership activities reported low average and 2015 stress levels, though they experienced elevated stress at the time of the SI closure. They also reported low levels of conflict, particularly after the closure with the removal of mobile gear. Mobile gear fishermen revealed higher average stress levels compared to static fishermen. Perceived stress levels in the mobile sector were extremely high in 2008-2009 with some individuals reporting symptoms of psychological and physical ill health. Perceived conflict was also high at this time, and has remained higher for mobile fishermen on average over ten years and in 2015 than for static fishermen. The wellbeing indicator for stress and conflict uses a subjective measure of perceptions of lived experiences of stress / conflict. A high confidence measure would also use objective data (e.g., medical records or number of incidences of conflict). Respondents were asked to recall past levels of stress/conflict which can introduce some recall bias.

Medium/High confidence

- Between 2005-2015 static fishermen involved in LBCC partnership activities had the highest average income satisfaction of any group, and the highest job and income satisfaction in 2015 of any group. Job satisfaction in 2015 was starkly different from the other groups. Job satisfaction was at a ten-year high for this fishing group in 2015, and income satisfaction had risen since 2008 with a slight dip in 2014 due to weather but an important boost in 2015 associated with the introduction of the Reserve Seafood brand. Fishermen credited the reduction in gear conflicts and improvements in fish availability as a result of the SI closure, and the more recent involvement of the Blue Marine Foundation and associated partnership activities for their high wellbeing. Static fishermen involved in the LBCC partnership activities showed extremely high levels of support for the SI closure (9.5) and high levels of support for the LBCC. In particular, they perceived high benefits to their fishing business from the additional icing facilities, the Reserve Seafood brand, and more moderate benefits from the voluntary Code of Conduct and Fully Documented fisheries projects. Satisfaction and support are subjective measures that are well captured by a 0-10 scoring approach. Perceived benefits were also captured through a subjective indicator and are not quantified in this question. Respondents were asked to recall past levels of wellbeing which can introduce some recall bias. This group of fishermen were the most straightforward to engage in the research, and respondents provided comprehensive answers to survey questions.

- Between 2005-2015 static fishermen not involved in LBCC partnership activities had the highest average job satisfaction of all groups, although in 2015 job satisfaction was lower than average and much lower than for static fishermen involved with LBCC partnership activities. Income satisfaction, however, was also high on average and remained slightly higher than average in 2015 despite a dip due to rough weather in 2014-2015. This high income satisfaction may reflect the increase in the landings and value of target species reported above. Somewhat surprisingly, static fishermen not involved in the LBCC partnership activities were only moderately supportive of the SI closure, and showed very low levels of support for the LBCC. While the wellbeing and support indicators in this case provide high confidence, this group of fishermen were reluctant to answer all the survey questions, and at times revealed quite divergent perspectives reducing confidence in their averaged data.
- Between 2005-2015 mobile gear fishermen had lower average levels of job and income satisfaction than static gear fishermen. By 2015 job and income satisfaction were higher than average but still lowest for mobile fishermen compared to other groups. Between 2008-2013 mobile fishermen were more dissatisfied than satisfied (negative wellbeing), an experience that did not occur in the static gear groups. Mobile gear fishermen revealed very low levels of support for the SI closure (despite moderate levels of support in 2008) and for the LBCC. Every effort was made to recruit mobile fishermen as participants in this research and mobile gear respondents provided data for most of the survey questions. However, our sample likely represents a relatively limited proportion of the total population of mobile fleets using Lyme Bay for all or part of the year.
- Southern IFCA and Devon and Severn IFCA records showed prosecutions had increased in relation to prohibited fishing activity in Lyme Bay Reserve. From 2 prosecutions in 2013 to 5 prosecutions in 2014.

10 Conclusions

The habitats and species of Lyme Bay interact to support the delivery of several ecosystem processes (e.g. primary and secondary production, formation of species habitat) and ecosystem services (e.g. fisheries (for food) and providing recreation opportunities). Ecological data that have been annually collected demonstrate that there have been positive responses for species richness, total abundance and assemblage composition for seven out of thirteen indicator taxa inside the Lyme Bay Reserve since 2008 (Attrill et al, 2012, Sheehan et al., 2013). These indicator species were found in greater abundance on reef habitat and pebbly-sand habitat in areas closed to bottom towed fishing compared to those where bottom towed fishing continues (Attrill et al, 2012, Sheehan et al., 2013).

Landings of whelks *Buccinum undatum* dominate the catch for static gear fishermen operating both inside and outside the Reserve. Catches of crab and scallop (dive caught) have also significantly increased from within the Reserve during this time period. This evaluation demonstrates that the management measures associated with the Reserve have had significant benefits for static gear fishermen operating inside the Reserve in terms of providing spatial separation of gear types. The link between increased catches and stock abundance within the Reserve is slightly more tenuous as there are multiple factors that affect the volume and value of landings. Though, it must be noted that both species (crab and scallop) are associated with the reef ecosystem and any recovery of the reef habitats will benefit these species. Primary data on subjective wellbeing suggests that these improvements in ecosystem service provision have had positive impacts on static fishermen's well-being. For those static gear fishermen working with the LBCC these wellbeing effects are even more pronounced, suggesting clear added value of the LBCC for those fishermen who are directly involved. The evidence that multiple ecosystem service and well-being indicators have increased across the years, especially for those involved with the LBCC, potentially signals that it is the combination of the management measures and the influence of the LBCC that benefit static fishermen.

Mobile gear fishermen who were displaced from the original SI closure have suffered significant effects from the management measures to create the Reserve. There has been a significant increase in effort required from this fleet to achieve comparable (pre Reserve) landings and value. The significant increase in landing of species associated with static fishing methods by fishermen who predominantly use mobile gear suggests increasing diversification of this fleet. The significant increase in the mean weight and value of scallops landed per vessel from vessels using mobile gear outside the reserve, since the 2008 SI closure may relate to increased effort (mean trips per month or gear efficiency) outside the Reserve and / or spill-over the scallop *Pecten maximus* following a recovery in *P.maximus* abundance inside the Reserve between 2008 and 2012 (Sheehan et al., 2013).

However, at this time no direct causal link can be made between recovery of *P.maximus* populations inside the reserve and landings outside the Reserve from the available data.

Mobile gear fishermen report lower levels of average job and income satisfaction and higher levels of average stress, and levels of conflict than static fishermen. Average job and income satisfaction remain above the neutral score of five but dip into negative wellbeing between 2008-2012. Levels of stress and conflict reflect negative wellbeing on average over ten years, and particularly between 2008-2013. Mobile fishermen explain these lower levels of wellbeing by the 'imposition' of the SI closure in 2008, the associated concentration of the mobile fleet into a smaller space, and the constant challenge of relying on quota species. Saying this, at least a third of the mobile vessels interviewed report very high turn-over and income from fishing. In addition to the impacts of management activities, lower levels of wellbeing in the mobile sector may also be linked to the method of fishing which is notoriously high risk (physically and financially). The evidence that some mobile gear fishermen have switched to deploying some static gear to maintain income demonstrates the resilience of these fishermen to take advantage of emerging markets (whelks) and increased abundance (crabs).

As previously stated, interpretation of results based on landings data has been cautious due to the limitations of landings and effort data, particularly from the under 10 metre vessel fleet as there is no statutory obligation for fishermen to report landings. This data was used as it presents the official landings and provides a proxy indicator for historical fishing effort (between 2005 and 2014). The need for caution in interpreting results from this data displays the importance in the future for data with greater spatial accuracy, such as iVMS to inform research and management activities.

Overall these results must be considered against the much broader UK picture of fleet reduction, quota changes and increased storminess that can reduce time at sea and/or increase 'risk' associated with fishing. Future management of the Lyme Bay Reserve may benefit by considering the following recommendations:

- Whelks dominate the landings for static gear fishermen. The decline in landings is largely thought to be attribute to growth overfishing rather than effort overfishing. There is an urgent need to monitor and manage this fishery to safeguard the stock and support the future income of these fishermen. Recent research conducted by D&S IFCA into the size of sexual maturity of whelks supports this aim.
- Increases in effort to target those species which are associated with the recovery of the reef habitat (scallop and crab) need to be managed within sustainable limits to ensure security of future supply.

- Monitoring and management of, and support for, fishermen who wish to take advantage of the high value (non-quota) species that are associated with the reef habitat.
- Management of scallop catch from within the Reserve. Combined with research on the potential for a “spill-over” effect from the Reserve.
- For those fishermen who benefit from the LBCC there is a need to provide ongoing logistical support to maintain access to the new markets that have been opened.
- The perceived lack of legitimacy in the implementation of the original SI closure continues to affect fishermen who call for more collaborative management between fishermen and government going forward. There is a need to strengthen existing structures and develop further opportunities to support all fishermen’s involvement in future management of the marine resource.
- Across all groups of fishermen the decision-making authority of the IFCAs is better recognised than that of the LBCC (of which the IFCAs are a member), which is not well supported by mobile fishermen and static fishermen not directly involved. Fishermen called for greater involvement with the IFCAs to retain or gain decision-making power for fisheries management at the local level.
- While static fishermen report being satisfied with their income, the data they provided suggest that this sector earns just over half the national average income. The mobile sector appears to have a two-tier model whereby some operators make less than the national average income while others make substantially more. Fishermen are unlikely to significantly increase catch volumes in the future given vessel, weather and quota constraints. Income rises will therefore likely rely on improved prices and post-harvest processing. Initiatives to boost income and encourage income equality in the sector may be beneficial.
- The LBCC has delivered clear benefits for the static fishermen involved in the initiative, particularly through the investments in infrastructure and new markets. However, static fishermen not directly involved feel marginalised by the relatively narrow focus of the LBCC on a few ports directly adjacent to the Reserve. There appears to be potential to expand the breadth of LBCC engagement across Lyme Bay.
- The establishment of the SI closure had clear negative impacts on the wellbeing of both mobile and static fishermen who are not involved in the LBCC. Though it has ultimately benefitted static fishermen who are involved with the LBCC. In particular, stress, anxiety and associated ill-health were substantially elevated for mobile fishermen in 2008. More attention to these ‘hidden’ aspects of wellbeing during times of significant regulatory change are recommended in the context of widespread conservation and marine planning in the UK.
- The commercial fisheries in Lyme Bay need to be managed and supported to remain resilient to wider influences, such as climate change effects on weather conditions , which can reduce days at sea and increase the risk to personal safety.
- This evaluation framework did not include other beneficiaries of ecosystem services in Lyme Bay such as recreational anglers or divers. A broader focus to consider these groups in future assessment of the Reserve may be beneficial.

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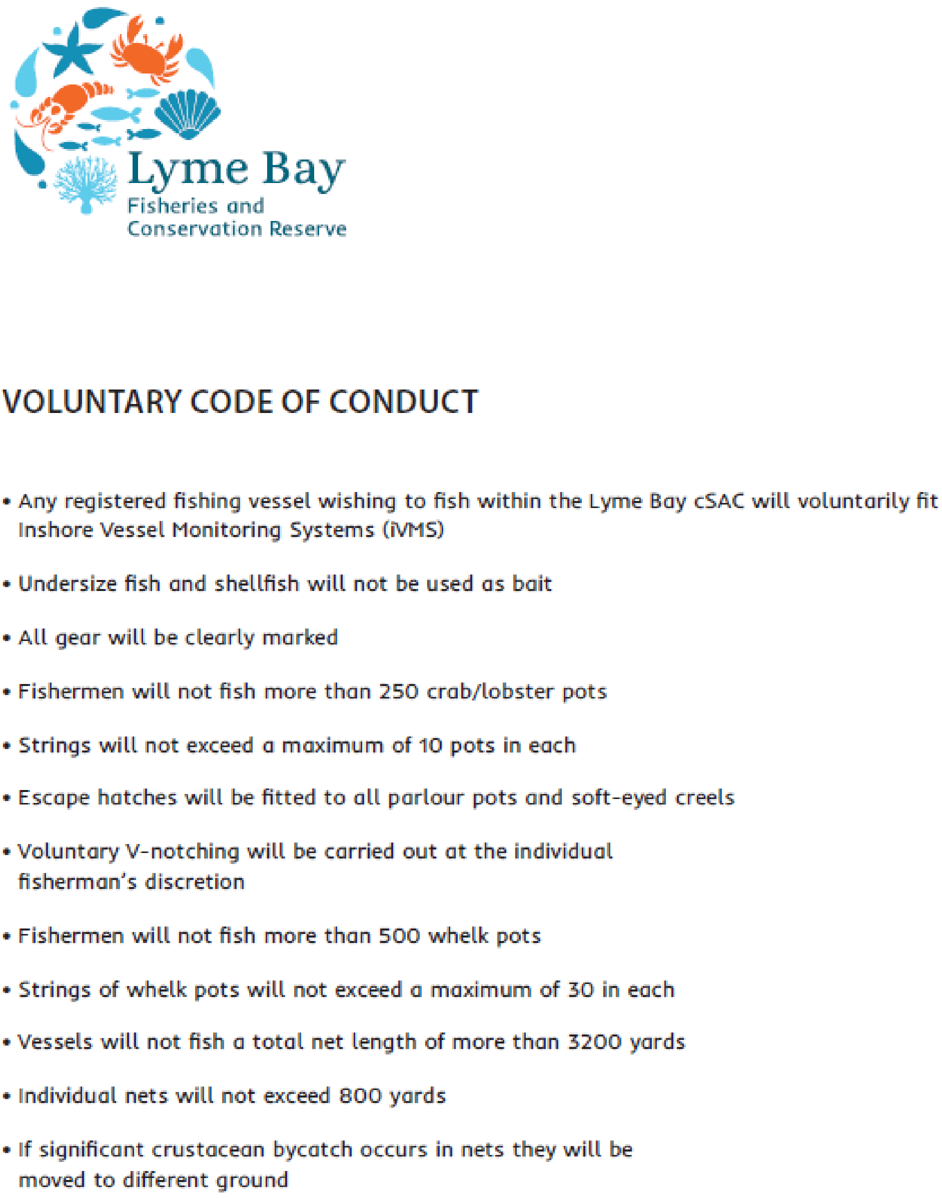
12 Annex I

Lyme Bay Fisheries and Conservation Reserve, Fishermen's Voluntary Code of Conduct



Lyme Bay
Fisheries and
Conservation Reserve

VOLUNTARY CODE OF CONDUCT

- Any registered fishing vessel wishing to fish within the Lyme Bay cSAC will voluntarily fit Inshore Vessel Monitoring Systems (iVMS)
- Undersize fish and shellfish will not be used as bait
- All gear will be clearly marked
- Fishermen will not fish more than 250 crab/lobster pots
- Strings will not exceed a maximum of 10 pots in each
- Escape hatches will be fitted to all parlour pots and soft-eyed creels
- Voluntary V-notching will be carried out at the individual fisherman's discretion
- Fishermen will not fish more than 500 whelk pots
- Strings of whelk pots will not exceed a maximum of 30 in each
- Vessels will not fish a total net length of more than 3200 yards
- Individual nets will not exceed 800 yards
- If significant crustacean bycatch occurs in nets they will be moved to different ground

13 Annex II

Detailed Agenda for the project workshop, held in Charmouth on the 13th October 2015

- ***Introduction to the day***. Lyme Bay: Framing ecology, ecosystem services and human wellbeing in Lyme Bay

Welcome: A brief introduction to the project, why we are here what we hope to achieve and an introduction to the research (15min).

- ***Indicators activity***. Group discussion based on indicators used in existing research to assess changes in delivery of ecosystem services and resulting benefits. The discussion focused on what we have, what we can measure, what's relevant, what's missing (in regard to indicators), based on an inventory / list of indicators commonly applied in ecosystem services research.

The group was divided into two or three smaller working groups around the room. Groups facilitated by project researchers. Each group worked though the list of proposed indicators to address the following questions:

Q1. Is this a relevant indicator to evaluate the impact/effect of management measures in Lyme Bay?

Q2. Is this a relevant indicator to evaluate the impact/effect of the activities of the Lyme Bay Consultative Committee?

Q3. Is there data available to assess this as an indicator in Lyme Bay, can it be scaled to the marine protected Area in Lyme Bay

Q4. On a scale of 1-10 where 1 in not important at all and 10 is really very important, how would you rate the importance of this indicator to evaluate the effect of management measures and partnership activities in Lyme Bay?

- ***What is wellbeing?*** Defining wellbeing. A power point presentation was provided introducing the wellbeing concept and why assessing wellbeing is of interest to the project.
- ***Timeline activity.*** Workshop participants provided events, either events specific to the Lyme Bay Reserve (for instance designations prohibiting certain fishing activities) and outside events, not directly related to marine protected area management or LBCC partnership activities (for instance, significant adverse weather events). The events suggested were discussed as a group.
- ***Wellbeing activity.*** Workshop participants provided aspects of wellbeing of importance to them in relation to the Lyme Bay Fisheries and Conservation Reserve and outside events, affecting their commercial or recreational activity within Lyme Bay. Aspects of wellbeing of importance to workshop participants were provided on an individual basis as questions posed on 'post it notes.'

14 Annex III

Key events identified during workshop, October, 2015

1990 - 2005	1	Registration of Buyers and Sellers Legislation (Sep.)	48. Processors demanding more quality over time ↓	47. Fuel Price over time ↓	46. Enforcement over time ↓	45. Decline in quota over time ↓
	2	Scallop dredging curfew, Voluntary agreements ongoing				
2006	3	Seafish Responsible Fishing Scheme launched				
	4	SWIFA formed				
2007	5	Fishermen’s gear conflict resolution agreement				
2008	6	VMS on over 15m vessels				
	7	**Statutory Instrument (SI) closure bottom towed gear 206Km^2** (Jul)				
	8	DEFRA/PU/PML monitoring starts 2008 – 2011/12				
2009	9	Finding Sanctuary MCZ project (July)				
	10	License capping (under 10s)				
	11	iVMS (mobile phone) trials (autumn-winter)				
2010	12	**Candidate SAC put forward, 312.48 Km^2 of reef features (Aug)**				
	13	Southern IFCA berried lobster bye-laws				
2011	14	**cSAC accepted as SCI, 312.48 Km^2 (until 2017 to establish as SAC)**				
	15	iVMS trials and instillation on vessels signing MOU				
	16	*First working group meeting (Oct 25th).*				
	17	Tasking of group to co-ordinate IFCA patrol assets				
	18	*Initial BLUE assessment responding to problems caused by unmanaged static gear (June-July).*				
2012	19	Revised approach to Habitats Directive. Policy change to risk-based assessment (December).				
	20	VMS for over 12m				
	21	*Lyme Bay Management Report and Plan (May)*				
	22	*Lyme Bay working group MoU signed (March)*				
	23	*BLUE Voluntary Code of Conduct (April)*				
	24	IFCA Byelaw: Prohibition on Undulate Rays				
2013	25	**2 IFCA Byelaws to protect features within SCI/cSAC, 236Km^2**				
	26	**MCZ designation of Chesil Beach and Stennis Ledges 38 Km^2** plus voluntary agreement (November)				
	27	Seafish Nation-wide Responsible Fishing Scheme				
	28	Southern IFCA purchase enforcement vessel (October)				
	29	*BLUE support RFS membership to WG members (May)*				
	30	*WG formalised as a Consultative Committee with a constitution (June).*				
	31	*16 Experimental potting areas established in the bay (PU-DEFRA-BLUE Potting study) (March). Contract begins (June)*				
2014	32	Responsible Fishing Scheme now ISO				
	33	*Beer Ice-Machine and chiller store installed (May)*				
	34	*Integrated Fisheries Management Assessment consultancy report (Sept)*				
	35	*Lyme Bay Fully Documented Fishery (March)*				
	36	Winter storms (February)				
	37	Scallop ASP toxin leads to shucked scallop sales only				
	38	Southern IFCA voluntary escape gaps (lobster)				
2015	39	Bass minimum size limit increased to 42cm				
	40	*Reserve Seafood Brand (July)*				
	41	*Axmouth Ice machine and chiller store installed (June)*				
	42	IFCA Byelaws on shellfish				
	43	Storms research (Plymouth University)				
	44	Results of Fully Documented Fisheries report to committee (Sep.)				
2016		End of the risk approach				

KEY

National Level Event	Regional Level Event	**MPA Designations**	*Blue Foundation Activities*

15 Annex IV

Ecosystem service indicators relevant to assessment of change in fisheries and wild food benefits, adapted from Hattam et al. 2015 and Bohnke-Henrichs et al. 2013.

Ecosystem service	**Activity**	**Generic marine ecosystem service indicators**	**Measurement** (Hattam et al. 2015; Bohnke-Henrichs et al. 2013)	**Units**
			Change over time 2005-2015	
Food provision - Fisheries (wild food)	Mobile and static fisheries	Natural resource	*Biomass of commercial species*	tonnes per km²
			Abundance of commercial species	*n* per km²
		Quality of resource	*Health of population*	Age profile, length profile, percentage affected by disease, mortality rates.
		Activitiy supported	*Spatial fishing effort*	Sightings per unit effort of aerial or vessel patrols.
			Catch or Landings from spatial locations	Catch or Landings from spatial locations.
		Level of value or benefit delivered	*Spatial catch or landings per unit effort*	Amount harvested (t/km²/yr).
			Income/profit	Market prices, income as turnover - expenses.
			Customer demand and distribution of sales	% sale to markets, processors and private customers.
			Employment in sector	No. of active vessels, no. of full/part time crew, no. of days worked per year, annual income from fishing.
Recreation / Sport	Recreational angling	Natural resource	*Biomass of fish and shellfish species*	tonnes per km²
			Abundance of fish and shellfish species	*n* per km²
		Quality of resource	*Health of population*	Age profile, length profile, percentage affected by disease, mortality rates.
			Diversity of species	Species richness, diversity measures.
		Activitiy supported	*No. of fishing marks*	Habitat and wreck features.
			Catch at spatial locations	Catch compostion, Number of fish within weight classes, No. of 'specimen' fish.
		Level of value or benefit delivered	*Proportion of time spent in Lyme Bay Reserve*	% time, No. of vistis to individual marks (charter vessels and/or private anglers)
			Spend per day	(£)
			Charter vessel % business from angling, Charter vessel turnover / profit from angling.	% business, (£)
			Travel or cost angling visitor prepared to undertake for angling in Lyme Bay.	distance (miles), cost (£)

Ecosystem service	**Activity**	**Generic marine ecosystem service indicators**	**Measurement** (Hattam et al. 2015; Bohnke-Henrichs et al. 2013)	**Units**
			Change over time 2005-2015	
Recreation / Sport	Recreational diving	Natural resource	*Biomass of species of interest*	tonnes per km²
			Abundance of species of interest.	*n* per km²
			Diversity of epifauna and mobile fauna of interest.	Species diversity measures
			Extent of features and habitats of interest.	*n* per km²
			No. of recognised sites.	*n* within area
		Quality of resource	*Sea space with safe water quality and reduced litter for diving.*	km²
			No. of pollution incidents.	*n* per month or year
			No. or area of features of interest in a recovered conservation state.	*n* or km²
		Activitiy supported	*No. of participants, No. of clubs in region and memberships.*	*n*
			No. of charter vessels and customers for charter trips,	*n*
			Proportion of time spent in Lyme Bay Reserve sites, Charter vessel visits to individual sites (n).	% or hrs, number of visits
		Level of value or benefit delivered	*Cost prepared to pay to travel to Lyme Bay sites, travel time.*	£, time hours/minutes
			Spend per day (£)	£
			Charter vessel % business from angling.	%
			Charter vessel turnover / profit from angling.	£

16 Annex V

Weight of landings for key species, kg per vessel per month																
Static inside																
	Crabs		Cuttlefish		Lemon sole		Scallops		Sole		Whelks		Lobster		Plaice	
	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem
2005-06	249	65	963	519	2	1	756		113	67	17850	4756	11	8	13	8
2006-07	255	77	1086	674	1		63		93	83	8912	3407	31	6	22	10
2007-08	243	85	1640	1033	0				61	27	8762	2837	22	4	20	11
2008-09	230	107	382	214	1	1	1130	457	72	38	7679	2799	26	7	16	4
2009-10	211	62	566	362	3	3	1932	1138	90	50	7649	2281	21	5	45	10
2010-11	321	91	817	479	2		2326	538	22	8	7167	1870	26	5	18	5
2011-12	415	148	515	303	13	14	2429	1286	70	52	4130	1423	52	11	71	18
2012-13	374	122	1365	314	1	1	2652	773	37	9	5396	1878	48	19	106	31
2013-14	472	155	531	509	54	69	3495	2250	46	11	8755	2316	25	4	121	32
Static outside																
2005-06	1129	524	404	420	284		1643		18	12	10404	4029	76	15	168	153
2006-07	440	134	538	543			1637	584	26	21	6832	2041	68	10	78	55
2007-08	573	193	300	204	1	2	5774	951	54	27	4528	1878	60	9	37	12
2008-09	596	176	279	213	1	0	1385	708	37	16	4156	1811	59	9	48	21
2009-10	646	202	389	376	29	1	2124	1009	41	28	5761	2396	52	10	54	21
2010-11	686	208	321	228	1	0	1210	586	32	20	7558	3539	67	13	47	20
2011-12	637	172	49	27	2	1	502	329	25	12	4579	1775	64	10	24	8
2012-13	631	222	36	22	1	2	903	691	25	11	5958	3641	66	10	36	13
2013-14	1017	503	63	53	4	4	713	354	41	22	8784	3648	83	15	47	11

Weight of landings for key species, kg per vessel per month																
Towed inside																
	Crabs		Cuttlefish		Lemon sole		Scallops		Sole		Whelks		Lobster		Plaice	
	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem
2005-06	4	3	693	460	17	8	12641	4505	73	63			3	1	284	110
2006-07	137	38	224	176	25	19	4909	1647	97	71	12		32	12	224	85
2007-08	73	73	179	154	23	11	5563	2554	63	44	5		20	5	126	26
Towed outside																
2005-06	13	5	327	199	64	48	2518	1553	276	117			1	1	450	66
2006-07	8	6	186	137	63	49	2131	1268	190	101			1	0	247	43
2007-08	27	21	147	65	20	9	2399	1350	244	127	28		2	0	324	66
2008-09	41	9	204	97	45	24	5315	2274	174	131	123		4	1	377	73
2009-10	12	8	142	71	200	130	6494	2460	35	17	2867	230	10	4	100	16
2010-11	74	36	214	172	56	47	6269	2322	33	17	1758	1306	17	5	163	40
2011-12	52	60	88	64	138	104	5841	2264	66	42	1281	1550	12	4	201	29
2012-13	52	42	415	205	72	52	5860	1842	140	74	695		4	2	461	79
2013-14	133	99	59	32	157	117	3405	1390	105	46	1484		13	3	399	79

Value of landings for key species, £ per vessel per month																
Static inside																
	Crabs		Cuttlefish		Lemon sole		Scallops		Sole		Whelks		Lobster		Plaice	
	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem
2005-06	319	85	1043	542	9	2	960		915	540	9528	2677	147	102	25	14
2006-07	322	93	1142	699	6		139		896	768	5239	1978	390	76	49	24
2007-08	333	114	2266	1397	3				623	271	5217	1754	300	45	45	26
2008-09	244	75	491	277	7	3	2101	661	505	206	4559	1657	208	42	31	8
2009-10	326	96	929	593	20	15	3376	1940	1010	594	4575	1378	163	25	116	24
2010-11	500	140	2077	1255	16		3769	1962	277	97	4743	1237	269	49	51	13
2011-12	619	199	1263	754	68	64	3758	2099	802	562	2883	1012	569	98	133	33
2012-13	572	184	2352	534	4	2	3981	1272	460	109	3980	1384	462	145	198	57
2013-14	704	230	1185	1151	221	249	4079	2787	518	120	6773	1779	290	39	188	49
Static outside																
2005-06	1623	760	409	426	1101		3918		133	104	5134	1953	920	182	356	419
2006-07	613	184	379	350			2230	706	227	185	3974	1235	722	101	229	143
2007-08	784	259	448	303	21	9	10602	1975	549	278	2728	1136	711	99	90	35
2008-09	843	252	392	298	7	2	1806	859	321	151	2557	1167	592	64	128	67
2009-10	896	281	674	659	170	19	2835	1321	408	286	3474	1462	487	63	126	47
2010-11	1002	311	843	630	9	2	1983	929	381	248	4993	2323	682	73	85	27
2011-12	1005	278	123	67	7	0	944	636	306	169	3119	1219	770	106	67	22
2012-13	1011	362	64	40	5	7	1456	1146	281	118	4431	2697	704	64	52	12
2013-14	1680	765	139	116	19	18	1235	607	478	265	7008	2926	872	120	85	23

Value of landings for key species, £ per vessel per month																
Towed inside																
	Crabs		Cuttlefish		Lemon sole		Scallops		Sole		Whelks		Lobster		Plaice	
	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem	Mean	Sem
2005-06	6	3	746	507	72	42	16507	5650	646	579			39	18	524	207
2006-07	102	57	318	277	125	93	9855	3073	972	717	7		343	124	449	184
2007-08	111	110	262	211	165	63	8077	3298	672	478	3		1920	972	886	337
Towed outside																
2005-06	17	11	357	230	270	195	3869	2375	2183	894			17	7	811	140
2006-07	11	6	279	214	291	228	3661	2335	1714	895			12	4	414	72
2007-08	34	28	177	88	113	51	2967	1702	1940	986	32		27	5	514	103
2008-09	60	12	310	147	129	68	7183	2659	1408	1026	94		43	12	531	77
2009-10	26	17	251	128	872	552	8679	3312	379	185	1718	133	113	39	176	24
2010-11	106	60	489	392	332	271	8560	3090	366	176	1152	851	198	48	284	68
2011-12	82	97	251	175	456	324	9814	3356	798	492	877	1070	137	37	334	49
2012-13	72	84	728	365	266	182	9335	2917	1489	773	520		54	14	674	129
2013-14	158	114	132	74	557	397	5186	1934	979	387	1113		150	36	523	103

17 Annex VI

The interview script used in face to face interview surveys with fishermen

Please make the interviewee aware of the following:

This interview forms part of a study being carried out by Plymouth University, Exeter University and Cefas to evaluate the impact of the Lyme Bay Reserve and the activities of the Lyme Bay Consultative Committee on ecosystem services and human wellbeing. This work is funded by the Blue Marine Foundation.

For the purpose of this project the Lyme Bay Reserve consists of the area where use of bottom towed fishing gear is prohibited within the 2008 Lyme Bay "Statutory Instrument" and within the 2013 IFCA byelaws (Lyme Bay zone of the Lyme Bay and Torbay European Marine Site).

The interview should last no longer than 45min -1hr. The interview will be recorded and notes taken. Answers given will **remain confidential** and only anonymised and grouped data will be used in the analysis and reporting. By taking part in this interview you are consenting to your data being used as part of this study. You have the right to withdraw from this interview or to request your data is removed from the project at any time. You do not have to answer any individual question if you do not wish to do so.

By ticking the following box, you indicate that you have read and understand the information provided above, that you willingly agree to participate and that you may withdraw your consent at any time and discontinue participation.

☐

Date:

Interview number*:*

(Please use your initials and a corresponding number to recording file)

1. Home port:
2. Vessel PLN:

A: Description of your fishing activity

3. How many years have you been fishing?
4. How many years fishing in Lyme Bay?
5. Age a) 18-24 d) 45-54

b) 25-34 e) 55-64

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

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

7. Are there any other boats you own? Yes/No
8. How many (PLN)?

9. In the last year please can you list your 3 top target species and main gear type(s) you use?

	Winter Dec-Feb	Spring March-May	Summer June-August	Autumn Sept- Nov
Target species				
Gear				

10. Are there other landing ports that you use? Yes / No
If **yes to Q11**, please name them:

11. Are you a member of any fishing organisations?
If **yes to Q12**, please name them:

13. Do you participate in any fishing related meetings/forums, or follow their updates through social media such as twitter?

If **yes to Q13**, please name them:

B: Job satisfaction

Completely satisfied	10											
	9											
	8											
	7											
	6											
	5											
	4											
	3											
	2											
	1											
Completely dissatisfied	0											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

14. Referring to the 10 year timeline above, at which point were you **most satisfied** with your fishing, (*i.e., using the gear you wanted, fishing where you wanted and catching plenty of fish*). What was your level of satisfaction with your fishing activities at this time? *Where 10 corresponds to completely satisfied and 0 corresponds to completely dissatisfied.*
15. Which species were you targeting and what gear were you using at this time?

16. Now, please can you indicate a point on the timeline when you were **least satisfied** with your fishing? *(prompts: gear used, catches, grounds fished)*. How would you score your level of satisfaction with your fishing activities at this time?

17. Finally, how would you score your **satisfaction** with fishing this year?.

SHOW TABLE 1. These events were identified in a workshop meeting by representatives of fishermen's organisations, IFCAs and the Blue Marine Foundation as potentially important national and local level events affecting Lyme Bay. They may or may not have impacted you.

Which of the events, if any, between (DATE OF FIRST/EARLIEST POINT) and (DATE OF SECOND POINT) contributed to the change in your satisfaction with fishing? Were there other events that also affected your satisfaction with fishing between FIRST POINT + SECOND POINT? Which one event had the most impact on you?

If none of the TABLE 1 EVENTS affected you, personally, please tell us how you explain this change (between FIRST POINT + SECOND POINT). Which one event had the most impact on you?

Which of the events between (DATE OF SECOND POINT) and (NOW) contributed to the IMPROVEMENT/DECLINE in your satisfaction with fishing shown in the timeline? Which one event had the most impact on you?

C: Income and income satisfaction. *Answers to these questions will remain strictly confidential. At no point will economic details be made available other than in an aggregated form.*

Completely satisfied	10											
	9											
	8											
	7											
	6											
	5											
	4											
	3											
	2											
	1											
Completely dissatisfied	0											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

18. In the last 10 years, when were you **most satisfied** with the net income / profit of your fishing activities? On the scale of 0-10, where **0 = completely dissatisfied** and **10 = completely satisfied,** how satisfied were you with your net fishing income at this time. (*income minus expenses*)
19. At what point in time were you **least satisfied** with the net income / profit of your fishing activities? On the scale of 0-10 how satisfied were you with your net fishing income at this time.
20. Finally, please can you rank your level of satisfaction with your net fishing income / profit **today**
21. Which of the events in TABLE 1, if any, between (DATE OF FIRST/EARLIEST POINT) and (DATE OF SECOND POINT) contributed to the change in your profit? Were there other events that also affected your profits between FIRST POINT + SECOND POINT? Which one event had the most impact on you? **If none of the TABLE 1 EVENTS affected you**, personally, please tell us how you explain this change (between FIRST POINT + SECOND POINT). Which one event had the most impact on you?

    Which of the events between (DATE OF SECOND POINT) and (NOW) contributed to the IMPROVEMENT/DECLINE in your profits shown in the timeline? Which one event had the most impact on you?
22. What is your approximate annual turnover from fishing currently? (*income before deduct costs*)

£0-£10,000	£10001-£20,000	£20,001-£30,000	£30,001-£40,000
£40,001-£50,000	£50,001-£60,000	£60,001-£70,000	£70,001-£80,000
£80,001-£90,000	£90,001-£100,000	£100,001-£110,000	£110,001-£120,000
£120,001-£130,000	£130,001-£140,000	£140,001-£150,000	£150,001-£160,000
£160,001-£170,000	£170,001-£180,000	£180,001-£190,000	£191,000-£200,000
£200,000 +	Please specify within £10,000		

Seek an approximate number. If this is not forthcoming then ask the interviewee to identify a bracket on the scale

23. What % of the figure in Q22 is profit (approximately)?
24. How does your income today compare to the income you received when you were most satisfied with the profit from your fishing activity? (% change). (*profit = income minus expenses*)

D: Investment

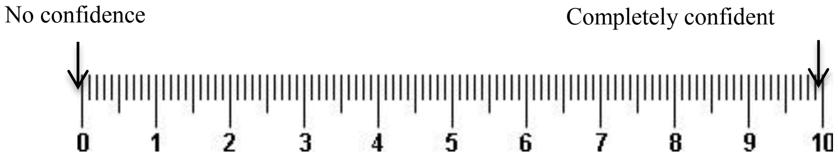
25. Have you made any investments in your fishing business over the last ten years, beyond routine repairs and gear replacement?

    If **yes to Q25,** please indicate when you made these investments, how much they were and for what purpose (*Prompt:* In addition to routine repairs and gear replacement) *Looking for boat renewals, investment in extra gear or new gears, engine changes, significant electronic or machinery upgrades (interviewer to add points to timeline).*

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

    If **no to Q25**, please explain briefly why you have not made any major in your fishing activities over this time period.

26. Are you actively planning to make any major investments in your fishing business in the near future? (*Prompt:* 1-5 years)
27. If **yes to Q26,** on a scale of 0-10, where **0 = no confidence and 10 = completely confident**, how confident are you that future investment will be sufficiently profitable? *(please place an arrow along the ruler scale to indicate your ranking)*



28. How would you look to fund this ? (i.e. *personal investment, European Maritime and Fisheries Fund*)

29. What feasible change would you like to see happen to help you achieve your preferred income from your fishing business? (open question)

30. Over this 10 year period have you sought other means to provide yourself with an income from sources other than directly fishing? (e.g.*Other employment, onshore services)?*

E. Demand and Sales

31. Where do you sell your catch? *(Prompt* e.g. *auction, direct to fish processor, direct to customer, other)*
    If you sell to more than one market, please indicate the proportion of your landings that you sell to each. *e.g. if the landings are 100%*

    → *90% to fish processor*

    → *10% direct sales to restaurants*

32. Has this changed in the last ten years?
    If yes to Q31: Please can you indicate key events/dates when your sales strategy changed (record as proportion of landings) and why?

e.g. if the landings are 100%

→ *90% to fish processor*

→ *10% direct sales to restaurants*

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

33. What is your preferred sales strategy for the future?

34. What needs to happen to make this a reality?

F: Conflict

Extremely high	10											
	9											
	8											
	7											
	6											
	5											
	4											
	3											
	2											
	1											
None at all	0											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

35. In the last 10 years, have you ever experienced **conflict with other fishermen?** (*such as arguments with other fishermen, damage to gear, loss of gear, or other instances of conflict*) Y/N

36. If Yes to Q35, in what year did you experience the highest level of conflict and on the scale of 0-10 where **0 is no conflict and 10 is extremely high levels of conflict** what level did you experience at this peak time? *(please also briefly indicate the type of conflict and context below, (i.e. for loss or damage could this have been accidental).*

37. If yes Q35 at what point in time did you experience the **lowest levels of conflict,** *(arguments, damage or loss of fishing assets)*? On the scale of 0-10, what level of conflict did you experience at this time?

38. If yes to Q35, finally, please can you rank the **current level of conflict that** you are experiencing?

39. Which of the events in TABLE 1, if any, between (DATE OF FIRST/EARLIEST POINT) and (DATE OF SECOND POINT) contributed to the change in the conflict you experienced? Were there other events that also affected conflict levels between FIRST POINT + SECOND POINT? Which one event had the most impact on you?

    If none of the TABLE 1 EVENTS affected you, personally, please tell us how you explain this change (between FIRST POINT + SECOND POINT). Which one event had the most impact on you?

    Which of the events between (DATE OF SECOND POINT) and (NOW) contributed to the IMPROVEMENT/DECLINE in the conflict you experienced shown in the timeline? Which one event had the most impact on you?

G: Health & Wellbeing

Extremely high	10											
	9											
	8											
	7											
	6											
	5											
	4											
	3											
	2											
	1											
None at all	0											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

40. In the last 10 years, in what year did you experience the **highest levels of stress** related to your fishing activities? (*prompts: resilience to highly stressful circumstances or actual experiences of stress, anxiety, anger, frustration*). On the scale of 0-10 where **0 is no to low stress and 10 is very high levels of stress**, how would you rank your level of stress at this peak time? *(please briefly indicate below the type of stress encountered for each year and the context)*

41. At what point in time did you experience the **lowest levels of stress** related to your fishing activities? On the scale of 1-10, what level of stress did you experience at this time?

42. Finally, please can you rank your **current level of stress**?

43. Which of the events in TABLE 1, if any, between (DATE OF FIRST/EARLIEST POINT) and (DATE OF SECOND POINT) contributed to the change in how much stress you experienced? Were there other events that also affected your stress levels between FIRST POINT + SECOND POINT? Which one event had the most impact on you?

    If none of the TABLE 1 EVENTS affected you, personally, please tell us how you explain this change (between FIRST POINT + SECOND POINT). Which one event had the most impact on you?

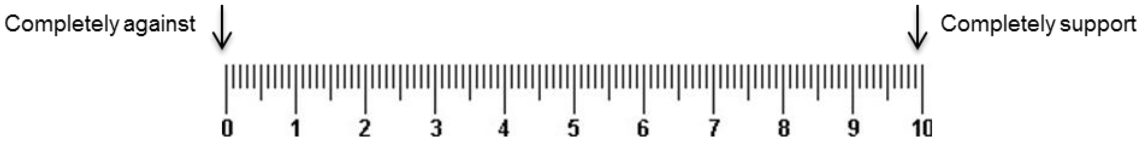
    Which of the events between (DATE OF SECOND POINT) and (NOW) contributed to the IMPROVEMENT/DECLINE in your levels of stress shown in the timeline? Which one event had the most impact on you?

H: Physical risk

44. Please also indicate on the timeline any periods when you have intentionally fished in more dangerous sea conditions (*i.e. 'pushed more weather'*) and indicate the reasons why?

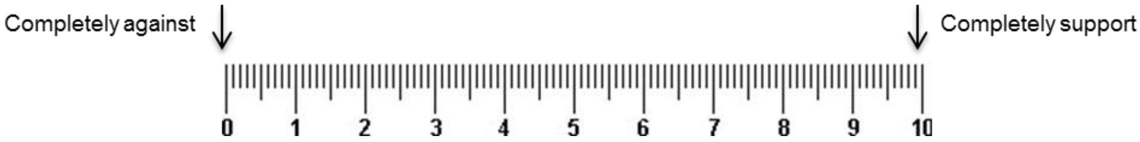
I: Support and trust

45. On a scale of 0-10, where **0 = completely against and 10 = completely support**, to what extent do you support or not support the closed area (SI) policy in Lyme Bay? *(please place an arrow along the ruler scale to indicate your ranking currently in 2015).*



Please also place a circle on the scale above to indicate your level of support 5 years ago (2010).

46. On a scale of 0-10, where **0 = completely against and 10 = completely support**, to what extent do you support or not support the Lyme Bay Consultative Committee? *(currently: Please circle one)*



47. Please feel free to comment on any of the statements above.

J: Compliance

Compliance was identified in a multi-stakeholder workshop as an important indicator of the performance of Lyme Bay Reserve. Compliance questions are somewhat sensitive so we have designed our question to minimise, to the extent possible, any direct questions on your own compliance or non-compliance. You are not obliged to answer any of these questions.

Complete non-compliance	10											
	9											
	8											
	7											
	6											
	5											
	4											
	3											
	2											
	1											
Complete compliance	0											
		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015

48. In the last 10 years, when were there the **highest levels of <u>non</u>-compliance** in your experience (*you witnessed or knew personally fishermen or fishing vessels undertaking activities prohibited by the fisheries bye-laws, SI or Voluntary guidelines*). On the scale of 0-10, where **0 = complete compliance** and **10 = complete noncompliance,** how would you rank levels of compliance at this time.
49. At what point in time was **<u>non</u>-compliance at the lowest level** in your experience? On the scale of 0-10 how would you rank compliance at this time?
50. Finally, please can you rank levels of compliance **today** on the scale of 0-10.
    Can you tell us **the number of instances of prohibited activity** you know of in the last 12 months, again, either because witnessed an event or know the fishermen personally.

51. In your opinion, which of the events in TABLE 1, if any, between (DATE OF FIRST/EARLIEST POINT) and (DATE OF SECOND POINT) contributed to changes in compliance? Were there other events that were important between FIRST POINT + SECOND POINT? Which one event do you think was the most significant? **If none of the TABLE 1 EVENTS** were important, please tell us how you explain this change (between FIRST POINT + SECOND POINT). Which one event had the most influence on compliance?
    Which of the events between (DATE OF SECOND POINT) and (NOW) contributed to the IMPROVEMENT/DECLINE in compliance shown in the timeline? Which one event had the most influence?

56. Please explain your own **key motivation for complying** with the current regulations and codes of conduct in Lyme Bay in the last 12 months.

K: Partnership Activities

57. Have you been involved in Lyme Bay Working Group Partnership Activities (prompt: *voluntary code of conduct, fully documented fisheries, use of additional port infrastructure, Reserve Seafood Brand*)? Yes/No. If YES please continue to question 50.

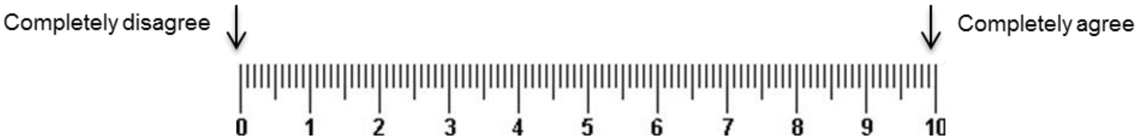
If NO please continue to question 62.

58. On a scale of 0-10, where **0 = completely disagree** and **10 = completely agree**, to what extent do you agree to the following statement: '*The **BLUE voluntary code of conduct** has benefitted my fishing activity in Lyme Bay'*

59. On a scale of 0-10, where **0 = completely disagree** and **10 = completely agree**, to what extent do you agree to the following statement: '*The **fully monitored and documented fisheries project** has benefitted my fishing activity in Lyme Bay'*

60. On a scale of 0-10, where **0 = completely disagree** and **10 = completely agree**, to what extent do you agree to the following statement: '*The **additional storage and icing facilities have** benefitted my fishing activity in Lyme Bay'*

On a scale of 0-10, where **0 = completely disagree** and **10 = completely agree**, to what extent do you agree to the following statement: '*The **Reserve Seafood Brand** will be beneficial to my fishing activity in Lyme Bay'*



61. On a scale of 0-10, where **0 = completely disagree** and **10 = completely agree**, to what extent do you agree to the following statement: 'I feel I am more **actively engaged in managing the Lyme Bay area** as a result of the **Lyme Bay Consultative Committee'**.

62. What would you like to see change to improve management in Lyme Bay *(balance Reserve goals/ sustainable fishing and benefits to fishing activities)*?

63. Please feel free to comment on any of the statements above

Thank you for taking part in this survey. Please be assured that your details will remain completely confidential. We would like to consult the fishing community as widely as possible. Please could you recommend another fisherman to contact?

Name…………………….

Telephone……………………..

Email………………………..

We are collecting data on a number of economic, social and health focused 'indicators'. The following table identifies which indicators we are seeking data for, some of which will be collected via this interview.

Indicators 2005-2015	Source
Landings data from species which are associated with the reef habitat at some point in their life history. Landings data from 30E6 and 30E7.	Cefas/MMO
Catch Per Unit Effort (CPUE) of commercial species and fisheries supported by reef ecosystem. CPUE of 'displaced' fishers	Cefas/MMO
Income/profit	Interview
Investment in the industry (renewal and replacement as well as new assets)	Interview
Sales strategies	Interview
Composition of the fishing fleet	IFCA Active Vessels Licence/MMO
Fisher employment	As above &/or Annual first Aid training records
Subjective economic wellbeing (relating to activity)	Interview
Number of prosecutions (IFCA patrol time)	IFCA
Self-reported compliance	Interview
Acceptance of the MPA	Interview
Subjective social wellbeing (relating to profit and income)	Interview
Subjective questions related to health and psychological wellbeing (relating to conflict and stress)	Interview

If you would like to receive a copy of the final report please provide an e-mail or postal address. Please be assured that your details will remain completely confidential.

Name:

E-mail:

Address:

Many thanks

18 Annex VII

Table of events between 2005 and 2015 perceived by interviewed fishermen as having positive and negative effects on wellbeing, (numbers represent number of fishermen identifying each event).

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Always satisfied	7											
More experienced	5											
Quota	-11											
Loans	-5											
Worried for future	-5											
Fuel & insurance	-5											1
Preferred style of fishing				8								
Gear conflict				-7								-6
Fishing & Angling				-3								8
SI closure					6,-19							
BLUE							2	2				3
Winter storms & weather											-7	-13
Over-crowded fishery												-6