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Evaluating the impacts of integrating fisheries and conservation management

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EVALUATING THE IMPACTS OF INTEGRATING FISHERIES AND CONSERVATION MANAGEMENT

by

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Abstract

Historically, the governance streams of fisheries and conservation management have run separately to one another, with little attempt at integration despite their similar goals. Efforts to integrate the two have increased as a result of their similarities and the potential benefits that may arise, but a requirement for additional research was identified to determine the effectiveness of this approach. This thesis therefore took an interdisciplinary approach, seeking to combine knowledge and methods from ecological, social and economic disciplines to provide a holistic evaluation of the potential for success. Marine Protected Areas (MPAs) were chosen as a management tool to evaluate for this purpose. Ecological research used underwater video methods to show that potting may be compatible with the conservation objectives of a multi-use MPA, but that this will depend on the level of impact and what is deemed 'acceptable' by regulators. An evaluation of social acceptance of MPAs using Q methodology stressed the importance of stakeholder engagement and transparency in decision making. Stakeholder acceptance can be facilitated by provision of clear evidence of the need for management, and of the benefits it may bring. Economic research evaluated the potential economic benefits of multi-use MPAs through quantification of change in quantity and value of landings for potting fisheries finding landings increased following MPA implementation. Finally, the thesis considered the effectiveness of ecosystem based fisheries management using a questionnaire designed to gather the opinions of stakeholders. This highlighted the potential role of co-management and the value of the ecosystem approach and emphasised the need for responsive, adaptive management which considers all stakeholders and all three disciplines.

Overall the thesis highlighted the strength of taking an interdisciplinary approach, finding that whilst there is evidence for successful integration seen through designation of well managed multi-use MPAs, success may be limited by fundamental differences in the goals of the two streams. Further success may be facilitated by increased evidence for the benefits of integration for both governance streams, and provision of adequate resources to ensure management measures are reactive and adaptive.

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Author's declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award and work submitted for this research degree has not formed part of any other degree either at Plymouth University or at another establishment.

The work described in this thesis was conducted by the author, under the supervision of Dr Lynda Rodwell, Dr Emma Sheehan, Prof. Martin Attrill and Tim Robbins. This study was financed with the aid of a studentship from Devon and Severn Inshore Fisheries and Conservation Authority (D&SIFCA) and carried out in collaboration with D&SIFCA, the Marine Biology and Ecology Research Centre and the Centre for Marine and Coastal Policy Research at Plymouth University.

Relevant scientific seminars and conferences were regularly attended at which work was often presented. One paper has been published from the work from this thesis (Chapter 3) and five further papers are in preparation (from work in chapters 2, 4, 5 and 6). Knowledge and skills gained during the thesis have been applied to research projects and scientific papers and these are detailed below.

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Posters and conference presentations

Conference: Oceans of Potential, Plymouth, 10th – 12th September 2012. Poster: 'Evaluating the impacts of Integrating Fisheries and Conservation Management'.

Conference: Plymouth Marine Science & Education Foundation (PlyMSEF) Annual Student Conference, Plymouth, 18th December 2012. Presentation: 'Developing methods for evaluating the impacts of integrating fisheries and conservation management'

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Conference: 3rd International Marine Protected Areas Congress, Marseille, France, 21st – 27th October, 2013. Poster: 'Multi-use marine protected areas and the integration of fisheries and conservation management'.

Meeting: Crustacea Committee of the Shellfish Association of Great Britain, Fishmongers Hall, London, 13th June 2014. Presentation: 'Gathering evidence on potting to inform MPA management'.

Conference: 2nd Marine and Coastal Policy Forum, Plymouth, 18th – 20th June, 2014. Presentation: 'A day in the life of a crab pot: Quantifying the impacts of potting on benthic environments'. Poster: 'How to conduct a Q survey: a novel approach to assessing stakeholder attitudes'.

Conference: 3rd International Marine Conservation Congress, Glasgow, 14th – 18th August 2014. Presentations: 'A novel approach to assessing stakeholder acceptance and social impacts of Marine Protected Areas' and 'Impact of anthropogenic debris on marine life'.

Conference: Plymouth Marine Science & Education Foundation (PlyMSEF) Annual Student Conference, Plymouth, 12th February 2015. Presentation: 'Q methodology: a novel approach to assessing stakeholder acceptance and social impacts of MPAs'.

Workshop: Evidence for management of potting impacts on designated features. Wednesday 25th February 2015, London, hosted by ABPMer. Presentation: 'A method to evaluate the impacts of potting on rocky reef habitats'.

Conference: 31st Annual Q Conference, 14th – 17th September, Ancona, Italy. Presentation: 'Q methodology: a novel approach to assessing stakeholder acceptance and social impacts of Marine Protected Areas'

Conference: 3rd Marine and Coastal Policy Forum, Brest, France, 27th – 28th October, 2015. Presentation: 'UK MPAs conservation and management of our marine resources'.

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Chapter one: Introduction

1.1. Background

Coastal and marine environments provide ecosystem goods and services vital to human wellbeing (Costanza et al. 1997; Covich et al. 2004; MEA 2005). They provide a source of food, aid with the regulation of climate and the cycling of nutrients and waste, provide raw materials and are important for recreation and culture (Costanza et al. 1997; MEA 2005; Remoundou et al. 2009). Ensuring the provision of these goods and services relies on the health and functionality of marine ecosystems, and whilst the oceans were once thought of as vast, resilient and homogenous, it has become increasingly apparent that human impacts are causing destruction and undermining their resilience (Agardy 1994; Neubauer et al. 2013).

Threats to the marine environment come from a variety of sources such as habitat loss, climate change, overexploitation and pollution (Dayton et al. 1995; Gray 1997). These threats are the result of the expansion of human populations coupled with increasing industrialisation, where exploitation may reach levels that are considered unsustainable (Gray 1997). Exploitation through fisheries in particular has been highlighted as a substantial threat to the marine environment, where impacts on target species are readily observable, evident mainly through a reduction in landings (Dayton et al. 1995). Pauly and Zeller (2016) determined that globally, catch rates increased to a peak in 1996, but have since been declining at a mean rate of 1.22 mt per year, and the latest FAO statistics show that the number of stocks fished beyond biologically sustainable levels is increasing, with 28.8 % overfished, and 61.3 % fished to capacity (FAO 2014). In some cases the level of disturbance may result in large scale changes, from which it may not be possible for ecosystems to recover (Howarth et al. 2014; Mangel and Levin 2005).

1.2. The impact of fisheries on marine biodiversity

Fishing activities can affect the marine environment in many ways, depending on the scale (spatial and temporal) of the activity and the type of gear used (Auster and Langton 1999). The extent of the impact will also vary depending on species composition and resilience of the existing benthic community, the stability of the ecosystem, and the life histories of the species concerned (Auster and Langton 1999). Impacts occur both for target and non-target species and their supporting habitats through creation of an imbalance in ecosystem function and community structure and alteration of habitat complexity (Blyth et al. 2004; Dayton et al. 1995; de Groot and Lindeboom 1994; Hiddink et al. 2006; Jennings and Kaiser 1998; Kaiser et al. 2006; Kaiser and Spencer 1996).

1.2.1 The impacts of bottom towed fishing gear

The majority of research on the impacts of fishing gear on benthic marine ecosystems focusses on bottom towed fishing gear, with studies dating back to the 1970s (e.g. Caddy 1973), consequently impacts are relatively well understood. Some studies have suggested that bottom towed fishing gear is the most disruptive and widespread means of anthropogenic disturbance to benthic communities (Bradshaw et al. 2002; Engel and Kvitek 1998; Hiddink et al. 2006; Thrush et al. 1998; Watling and Norse 1998). Gear types include otter trawls, beam trawls and scallop dredges which are towed behind the fishing vessel, and the design of the gear means that it penetrates the sediment to disturb target species and increase the likelihood of their capture (Bergman and Hup 1992).

Bottom towed fishing gear is known to cause major and immediate effects to both infauna and epifauna (Caddy 1973; Collie et al. 1997; Currie and Parry 1996; de Groot 1984; Hall-Spencer and Moore 2000; Jones 1992; Thrush et al. 1995). Furthermore, it has the potential to cause extensive damage to complex benthic ecosystems which are crucial for the provision of shelter, provide a refuge for benthic organisms and juvenile fish species, and also provide of a source of food for demersal fish, including those of commercial importance (Auster et al. 1996; Collie et al. 1997). These impacts may cause shifts in community composition, a reduction in heterogeneity and a decrease in habitat complexity (e.g. Bradshaw et al. 2002; Collie et al. 2000; Hill et al. 1999; Kaiser et al. 2000; Lambert et al. 2011).

The vulnerability of areas to changes caused by bottom towed fishing gear will depend on factors such as duration, intensity and type of fishing activity, with impacts varying correspondingly. Under intensive fishing, communities are commonly observed to shift from those characterised by longer lived and slower growing species towards those composed of smaller, short-lived and fast growing species (Auster et al. 1996; Collie et al. 1997; Collie et al. 2000; Jennings et al. 2001; Kaiser et al. 2000; Kaiser and Spencer 1996; Tillin et al. 2006; Watling and Norse 1998). These shifts can 'simplify' the ecosystem, compromising its functionality, resilience and ability to support species of commercial importance and provision of ecosystem services (Howarth et al. 2014; Worm et al. 2006).

1.2.2 The impacts of static gear

The effect of static gear on benthic marine ecosystems is often regarded as minor in comparison with the impact of mobile benthic gear (Jennings and Kaiser 1998), and consequently, research efforts have been focussed on more damaging activities leaving the impact of static gear poorly understood. Static gear types include nets and baited pots, deployed and left on the seabed for a period of time before being hauled and the catch removed. Jennings and Kaiser (1998) identified that the impacts of repeated hauling and deploying of these gear types may be cause for concern in areas of long lived sessile epifauna where fishing effort is relatively high. The focus of research has therefore shifted from a sole focus on bottom towed gear where understanding is relatively well developed to include static gear in order to increase our understanding of these gear types (Jennings and Kaiser 1998).

In the UK, quantifying impacts is important as the number of vessels fishing using static gear has increased in the last 20 years. Seafish statistics reported 1,273 active fishing vessels using pots and traps as their main or sole gear type in 2014 compared to only 687 in 2005 (Seafish 2015). Pots are commonly deployed on a string, with the number of pots per string varying depending on location, vessel size and number of crew (Seafish 2009). Numbers can range from single pots up to approximately 100, with pots arranged off a central line. The strings are usually weighted at either end to give stability and secure the string in place and are marked on the surface using buoys. Nets are lightweight and therefore, with the exception of the weighted ends may not have much impact on the benthos. Ghost fishing is thought to be their main impact however, with studies suggesting that the ghost fishing potential of nets is substantial. Both Kaiser et al. (1996a) and Erzini et al. (1997) found that catch rates of target and non-target species were high, reducing over time but concluded that ghost fishing nets had the potential to remove substantial numbers of individuals from the ecosystem.

Studies to date considering the impacts of potting include the work of Eno et al. (2001) who concluded that potting causes little or no immediate impact to benthic organisms in a study considering the impacts of experimental potting on rocky reefs and soft sediment habitats in the UK. Similarly, Kinnear et al. (1996) determined that seapens were fairly resilient to smothering, dragging and uprooting by creels in Scottish sea lochs, and Coleman et al. (2013) found no significant differences in a suite of benthic indicator species at sites within and outside an MPA in Lundy, UK. They concluded that these species were insensitive to commercial potting effort and that it may be possible to permit limited potting within MPAs. In addition to the impact of the pots themselves, the ecosystem effects of pot fisheries may be substantial due to removal of target species. This was the case in the Gulf of Alaska, where Armstrong et al. (1998) reported that rapid expansion of crab fisheries between 1960 and 1980 resulted in subsequent stock collapses, highlighting the need for effective management.

Pots are, however, considered to be a relatively sustainable fishing method as their impact on non-target species and the seabed is thought to be minimal (e.g. Coleman et al. 2013; Eno et al. 2001; Kinnear et al. 1996). But further quantification is needed to determine the impact of potting on areas of long lived sessile epifauna such as rocky reefs, as static gear commonly targets these areas (Jennings and Kaiser 1998).

1.3. Fisheries & conservation management

In recognition of the potentially damaging impacts of fishing gears, some form of fisheries management has been in place since the 17th century (Garcia et al. 2014). Restrictions were minimal until industrialisation led to increasing pressure on fish stocks and concerns were raised about the growth of landings which increased from 5 to 15 million tonnes between 1901 and 1945 (Garcia et al. 2014). An Overfishing Committee was established within the International Council for the Exploration of the Sea (ICES) in 1903, marking the first attempt at international science based management. Historically, however, the focus of fisheries scientists was on single species and how to sustain stocks whilst fishing to Maximum Sustainable Yield (Pikitch et al. 2004). It was not until 1972 that the UN Conference on the Human Environment resulted in a focus on sustainable development, with the principles of integrating fisheries management with conservation emerging through the United Nations Law of the Sea Convention (UNCLOS), (1982), Convention on Biodiversity (CBD), (1992), United Nations Fish Stocks Agreement (1995) and the FAO Code of Conduct for Responsible Fisheries (1995), (FAO 2003).

Despite these international conventions and increasing concern over the effects of overfishing it was not until ICES established a working group on the Ecosystem Effects of Fishing in 1990 that fisheries management began to address the need for conservation. The historic focus on single stock management was recognised as having been largely unsuccessful (Botsford et al. 1997; Christensen et al. 2003; Lotze et al. 2006; Pikitch et al. 2004), and this led to a shift in focus to how to achieve human and ecosystem wellbeing through governance which effectively combined it with biodiversity conservation (Garcia et al. 2015). The FAO guidelines for implementing an ecosystem approach to fisheries (EAF), (FAO 2003) marked the beginning of this process, which has attempted to incorporate conservation and environmental considerations with social and economic concerns (FAO 2003; Garcia et al. 2014).

Incorporating these two streams is a substantial development as fisheries and conservation management have historically run parallel to one another (Garcia et al. 2014). Historically, as with fisheries management, conservation was achieved through a 'wise use' attitude, but industrialisation and increasing populations resulted in conflict between conservation and resource use (Brown 2002; Garcia et al. 2014). Marine conservation has lagged behind conservation in terrestrial systems due to the late recognition of the impact of human activities (Agardy 1994; Garcia et al. 2014; Pinnegar et al. 2000), and when it did emerge in the late 1960s, protection initially focussed on iconic, vulnerable habitats and species and was largely implemented through designation of marine protected areas (MPAs), (Garcia et al. 2014). Similarly to fisheries management, the adoption of UNCLOS and the establishment of the CBD were the main drivers behind marine conservation, providing the legal, institutional and policy frameworks required (Garcia et al. 2014).

1.3.1 Fisheries management, conservation management & the ecosystem approach

Management that combines fisheries and conservation goals is encompassed by the ecosystem approach which was first outlined at the Rio +20 summit of the Convention on Biological Diversity (CBD) in 1992. This approach is now seen as the key for delivering sustainable development (Laffoley et al. 2004) increasing the need for methods which effectively integrate the two streams. The ecosystem approach is a strategy for integrating management which promotes conservation and sustainable use in an equitable way and was formally adopted as the primary framework for action under the CBD at the Conference of Parties meeting in 2002, and endorsed by the World Summit on Sustainable Development in 2002 (Laffoley et al. 2004; Secretariat of the Convention on Biological Diversity 2004).

The ecosystem approach requires a shift from a sectoral approach to one which coherently addresses the relevant social, economic and environmental sectors to optimise long term benefits (Laffoley et al. 2004). When considered in a fisheries context, its objective is to sustain a healthy marine ecosystem, which will in turn support fisheries, and it requires the management of human activities to ensure that destructive practises do not compromise ecosystem resilience (Pikitch et al. 2004). The principles behind this approach were present within many of the international conventions already in place; hence, it was not a new concept, but rather a new phase in fisheries management which acknowledged the need for continuous evolution of fisheries related institutions (Garcia 2003). One term used to define the ecosystem approach to fisheries management is ecosystem based fisheries management (EBFM).

EBFM is defined as:

'an approach that takes major ecosystem components and services – both structural and functional – into account in managing fisheries. It values habitat, embraces a multispecies perspective, and is committed to understanding ecosystem processes… Its goal is to rebuild and sustain populations, species, biological communities and

marine ecosystems at high levels of productivity and biological diversity so as not to jeopardize a wide range of goods and services from marine ecosystems while providing food, revenues and recreation for humans' (US National Research Council 1998)

Consequently, EBFM has a focus on management and on the provision of ecosystem services, and is considered to be relevant to the topic of this thesis. Hence, where the ecosystem approach to fisheries management is discussed it will be with a focus on EBFM.

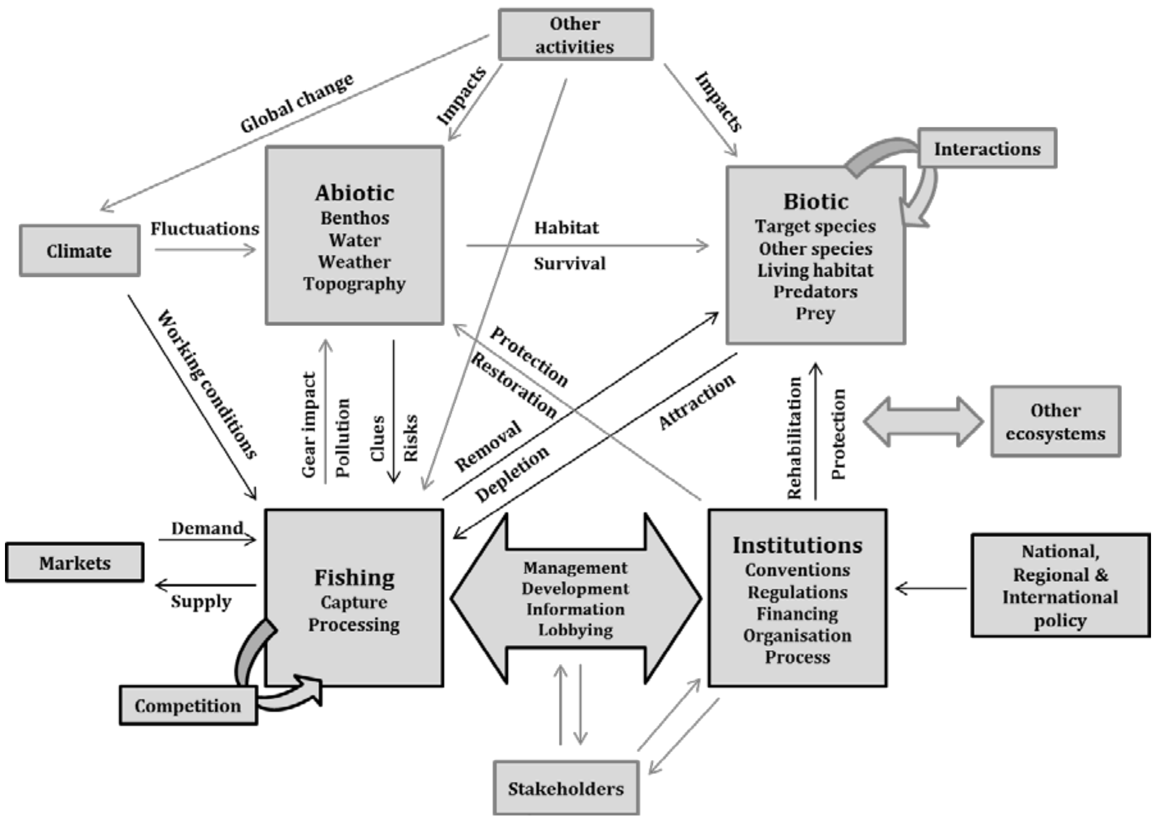

Figure 1.1: Framework for the ecosystem approach to fisheries. Black outlines represent elements of a traditional approach to fisheries management; grey the additional elements for an ecosystem approach. Adapted from Garcia and Cochrane (2005)

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Garcia (2003) considered the application of the ecosystem approach to fisheries management and identified four main ecosystem compartments when describing fisher's interactions with the ecosystem: biotic, abiotic, fishery and institutional (Figure 1.1). Humans were identified as part of the biotic compartment and also the fishery compartment where they were the key drivers, and they determined that the compartments interact and are affected by various factors, including non-fishing activities, climate, other ecosystems and the socio-economic environment (Garcia 2003), (Figure 1.1). Figure 1.1 clearly shows the interactions between compartments, and that many additional factors are incorporated under the ecosystem approach, compared to the traditional approach to fisheries management, one important element of which being stakeholder engagement.

1.4. Marine Protected Areas

Integration of fisheries and conservation governance strands via the ecosystem approach is commonly facilitated through the use of MPAs. MPAs are defined by the IUCN as:

> '*A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values'* (Kelleher and Kenchington 1992)

They can vary in size from one to 1000s kms and range from those where management prohibits all extractive and non-extractive uses to multi-use areas where restrictions are only placed on uses perceived to be counter to the aims and objectives of the site (Lester and Halpern 2008).

Initially tools for conservation management, MPAs are increasingly recognised for their potential to meet both fisheries and conservation goals (Hilborn et al. 2004; Kenchington et al. 2014). They are often implemented with the expectation that they can bring benefits through the protection of important or fragile areas, the prevention of overfishing, and the enhancement of fisheries (Allison et al. 1998; Murawski et al. 2000; Roberts et al. 2005). In the case of conservation, these benefits may include the recovery of habitats and species which were threatened by extractive activities and provide important economic goods and services, and for fisheries this may be through protection of vital habitat for target species, including feeding grounds, spawning grounds and nursery area (Bohnsack 1993; Gell and Roberts 2003; Halpern 2003).

Despite some conflicts, MPA designation addresses the common ground between the two governance streams of fisheries and conservation, namely the maintenance of ecosystem function, the sustainability of habitats and resources, the capacity to manage the footprint of all activities occurring in the marine environment, and the downstream consequences of land and freshwater activities (Kenchington et al. 2014; Rice et al. 2012). Rice et al. (2012) determined that implementing MPAs to address both fisheries and conservation goals was likely to result in 50 % of fisheries and 40 % of conservation objectives being met, whilst 25 % of fisheries and 30 % of conservation objectives were likely to be conflicting. MPAs are therefore not a panacea for the integration of fisheries and conservation management but do provide an opportunity to facilitate the integration of the two governance streams, especially though implementation of multi-use MPAs which do not have the conflicts associated with no take areas from which fisheries users are excluded (Kenchington et al. 2014).

MPA designation under management which follows the principles of the ecosystem approach requires consideration of ecological, economic and social factors. The selection of sites as MPAs has historically been driven by their ecological characteristics, with socio-economic concerns coming second to conservation. More recently, however, socio-economic factors have been recognised as key to MPA success. MPAs can be considered the product of social institutions, relying on changes in human behaviour to succeed (Pomeroy et al. 2007), and support from stakeholders is essential to generate compliance with regulations and ultimately allow conservation objectives to be realised (Arias et al. 2015; FAO 2003). Furthermore, support is more likely to be generated where stakeholders perceive the MPA will bring them direct benefits, highlighting the key link between ecological and socio-economic aspects of designation (Pollnac et al. 2010).

A review of the factors that make an MPA successful by Rossiter and Levine (2014) revealed four key characteristics:

1. Increased abundance of species of conservation importance, increased biodiversity or an improvement in the ecological condition of the site
2. Compliance with management measures by user groups through legal enforcement or social acceptance
3. Perceived success of the MPA at providing its intended benefits by the majority of stakeholders
4. No significant economic losses or loss of livelihood for local stakeholders or an offset of losses by other benefits arising from the designation

All four, or a combination of the four were present at sites said to be experiencing success according to their review of the literature, highlighting the importance of considering ecological, economic and social factors in site designation; an approach which is increasingly commonly advocated.

Due to their suitability as a marine management tool to address the integration of fisheries management with conservation management, MPAs have been used throughout this thesis as a proxy for evaluating the ecological, economic and social implications of the integration of these two governance streams.

1.4.1 MPA policy framework

Designation of MPAs is required through numerous international agreements to protect biodiversity such as the CBD, where Aichi Biodiversity Target 11 calls for the designation of 10 % of coastal and marine waters as protected areas by 2020 (Convention on Biological Diversity 2011). To ensure these targets are met, requirements for the creation of MPAs are increasingly incorporated into regional and national legislation (Figure 1.2) and with only 3.4 % of global waters currently protected this number will continue to increase (Juffe-Bignoli et al. 2014).

Internationally, MPA designation is driven by frameworks such as the CBD, OSPAR, Bern, Bonn and Ramsar Conventions (Figure 1.2), and the commitments established under these conventions are then commonly addressed at a regional and national level, where countries translate them into legal requirements (see Figure 1.2 for an example from English waters).

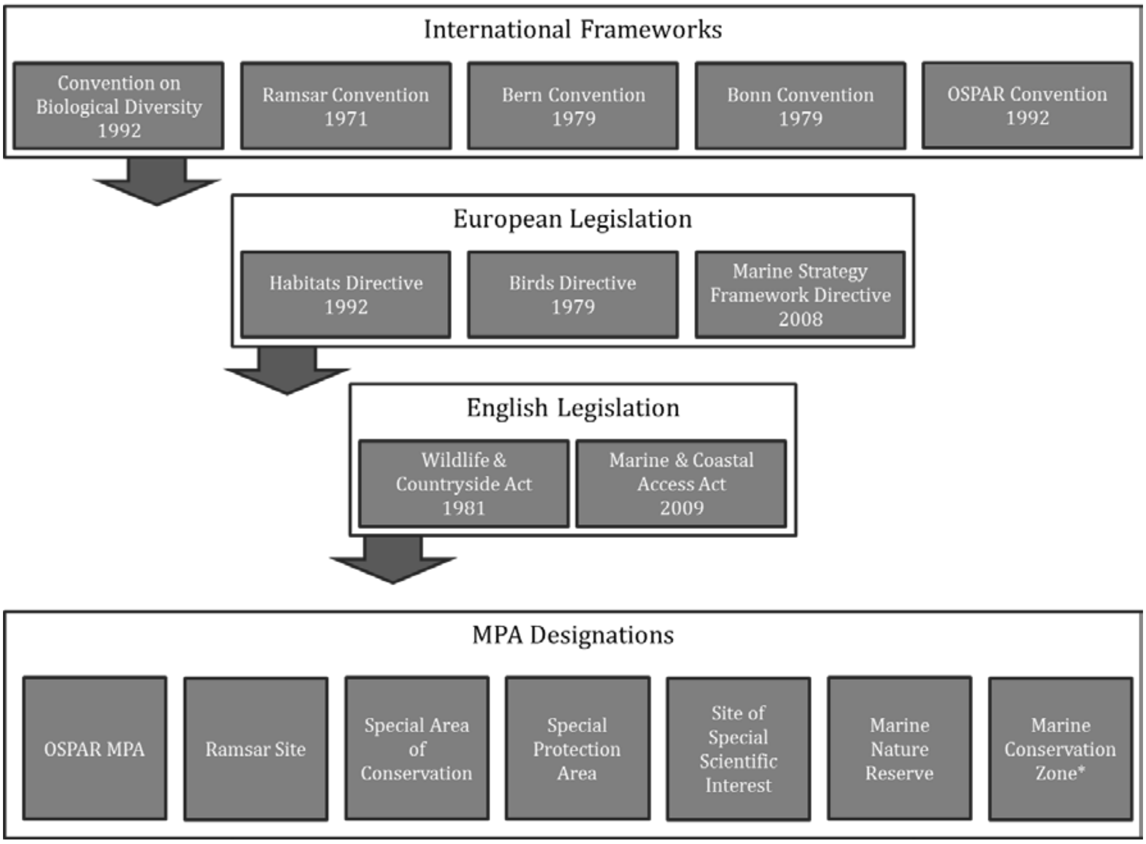


Figure 1.2: International frameworks, European and UK legislation leading to the designation of marine protected areas in English waters

Despite increasing recognition of the benefits of incorporating fisheries management with conservation through the designation of MPAs, however, the majority are designated for conservation purposes and therefore have conservation rather than fisheries objectives.

1.4.2 MPAs in a UK context

The UK has commitments through international, European and national legislation to establish an ecologically coherent network of MPAs comprising OSPAR MPAs, Ramsar sites, Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs), Marine Nature Reserves (MNRs) and Marine Conservation Zones (MCZs), (JNCC 2013), (Figure 2). The goal of the network is '*to develop an ecologically coherent and well-managed network of MPAs that is well understood and supported by sea-users and other stakeholders*' (Defra 2010). Its objectives are set out in the Marine Strategy Framework Directive which calls for Good Environmental Status (GES) in European Seas by 2020. Defined as '*the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive*', GES requires appropriate management of activities by all European countries (Lassen et al. 2013). Of the types of MPA contributing to the network, MCZs, SACs and SPAs (collectively European Marine Sites (EMS)) are the most numerous and contribute the greatest area and they are discussed in more detail below.

Marine Conservation Zones

MCZs are designated under Section 116 of the UK Marine and Coastal Access Act 2009 (MCAA) for the protection of habitats and features of conservation importance. Designation is devolved, with MCZs designated in English and Welsh territorial and offshore waters under the MCAA, and in Northern Ireland under the Marine Act (Northern Ireland) 2013, and Scottish MPAs designated in Scottish waters under the MCAA and the Marine (Scotland) Act.

In England, an initial planning phase conducted by four regional projects identified 127 recommended MCZ sites which were put forward to UK government in 2011 (Balanced Seas 2011; Irish Sea Conservation Zones 2011; Lieberknecht et al. 2011; Net Gain 2011). Tranche one of 27 sites was designated in November 2013 and tranche two of 23 sites in January 2016. A third tranche is planned for designation in 2018 but it is not known whether the full set of 127 sites will be designated.

Management for the sites is not yet in place as management decisions were not included in the planning phase, but these are being developed in line with the management of European Marine Sites under the Habitats and Birds Directives and management for these sites is expected to be in place by the end of 2016.

European Marine Sites

The Habitats Directive calls for member states to establish a network of MPAs under Natura 2000 *'a coherent European ecological network of Special Areas of Conservation'*. These, combined with SPAs designated under the Birds Directive are termed European Marine Sites (EMS). SACs are designated for the protection of habitats or species listed in Annexes I & II of the Habitats Directive and SPAs are for the protection of birds listed in Annex I.

Licenced activities which are deemed to be damaging to the habitats and species for which a site is designated require management or must be excluded from the site under Article 6(2) of the Habitats Directive, and these have historically included activities such as oil and gas installations and aggregate dredging, but not fishing activities. This was because the UK government took the view that fishing activity came under the public right to fish, was not under licence and therefore the Habitats Directive did not apply to most UK commercial fishing activities (Appleby 2015). This view was challenged by the Marine Conservation Society (MCS) and Client Earth who stated that if a licence is given for fishing activity under section 4 of the Sea Fish (Conservation) Act 1967, then that amounted to a licence to fish and activities occurring in SACs and SPAs required management under Article 6(2) or appropriate assessment under Article 6(3) of the Habitats

Directive (Appleby 2015). This view was accepted by Defra and resulted in a review of fisheries management in 2013 that led to the implementation of a change in approach to how fisheries were managed within these sites (Defra 2013).

To facilitate the change in approach, an extensive data gathering period was required as detailed knowledge of the impacts of fishing activities on the features for which SACs could be designated was lacking. This was led by Defra, with partners, the Marine Management Organisation (MMO), the Association of Inshore Fisheries and Conservation Authorities (AIFCA), Natural England (NE) and the Joint Nature Conservation Committee (JNCC). A matrix was produced which used existing research to code different fishing activities depending on the intensity of their impact on habitats and features for which sites were designated and identified knowledge gaps for further research. These knowledge gaps included the impacts of potting activities on features such as rocky reefs (Defra 2013).

Shortly prior to the completion of this thesis, the UK voted to leave the European Union. At the time of writing, the consequences of this decision for European Marine Sites is unknown, consequently this thesis is written based on the assumption that there will be no change.

1.4.3 The implications of multi-use MPAs

Research suggests that recovery of benthic ecosystems within an MPA occurs on decadal timescales (Babcock et al. 1999; Watling and Norse 1998), but that it can occur in multi-use MPAs where some fishing activity is permitted (Blyth et al. 2004; Sciberras et al. 2015; Sheehan et al. 2015; Sheehan et al. 2013b). In the UK, permitted activities commonly include static gear such as pots and nets, while bottom towed fishing gear is restricted or excluded completely. Permitting fishing activities within MPAs can be contentious. As highlighted by Rossiter and Levine (2014), for MPAs to succeed, increased abundance of species of conservation importance, increased biodiversity or an improvement in the ecological condition of the site is required. It is well recognised that no take MPAs are more successful at achieving improvements in ecological criteria (Edgar et al. 2014; Halpern 2014), but the exclusion of all fishing activities can have negative social and economic consequences which may be detrimental to the overall success of an MPA (Rossiter and Levine 2014). Consideration of ecological, social, and economic factors is therefore crucial both in the planning, and in the ongoing management of MPA sites, with an understanding of the implications of designation crucial to effective management and planning for future sites.

Ecological implications

The bulk of the literature to date has focussed on no take MPAs, with early studies mostly limited to tropical locations (e.g. Chiappone et al. 2000; Gell and Roberts 2003; Halpern 2003; McClanahan 1996; Polunin and Roberts 1993) and fewer studies have considered the ecological implications of designating multi-use MPAs to meet both fisheries and conservation goals. In the UK, studies have focussed on the impacts of bottom towed fishing gear, the benefits of MPAs which exclude them, and the recovery of benthic biodiversity post designation (Blyth-Skyrme et al. 2006; Blyth et al. 2004; Bradshaw et al. 2001; Hiddink et al. 2006; Kaiser et al. 1998a; Lambert et al. 2014; Sheehan et al. 2013a; Sheehan et al. 2013b). Some of these studies can, however, be used to determine whether recovery of benthic biodiversity occurs despite the ongoing presence of static gear fisheries (e.g. Blyth et al. 2004; Sheehan et al. 2015; Sheehan et al. 2013b).

This is the case in Lyme Bay, where Sheehan et al. (2013b) monitored recovery of benthic habitats following the exclusion of bottom towed fishing gear from a 60 nm^2 MPA where potting and netting was permitted to continue. Initial results showed that four years after designation early signs of successful recruitment were evident for some benthic species, and after 6 years signs of recovery were identified suggesting that the presence of static gear fisheries had not prevented recovery from occurring (Sheehan et al. 2015). Similarly, Blyth et al. (2004) compared benthic biodiversity at sites in the Inshore Potting Agreement in South Devon where zoned fisheries management has been in place since 1978 (a *de facto* MPA), finding that species richness and biomass were significantly greater in areas fished using static gear than in those fished with bottom towed fishing gear.

Other studies have, however, shown that the impacts of permitting some fishing activity can be damaging to the goals of an MPA. Lloret et al. (2012) for example, concluded that the sex and size specific nature of artisanal fisheries within an MPA in France was changing the sex composition of populations of target fish species and exacerbating rather than reducing the pressures on fish stocks in the area. Care therefore needs to be taken to ensure that activities permitted within MPAs do not compromise their ability to meet their conservation objectives, requiring assessment of the likely impact of fishing activities and monitoring of MPA success.

The main limitation of these studies and with many applied studies into the impact of fisheries is that there are no ‘pristine’ areas available for use as control sites where fishing impacts have never occurred. This poses a problem for traditional ecological survey design such as Before, After, Control, Impact (BACI) where control sites should be those free from impact (Underwood 1991). However, studies directly quantifying impact of fishing activities (e.g. Eno et al. 2001; Kaiser et al. 1996b; Kinnear et al. 1996; Tillin et al. 2006) can be used to overcome some of these limitations by assessing the potential for damage to occur.

Understanding the ecological impacts of activities permitted within multi-use MPAs is of particular importance in the UK following the change in approach to the management of fisheries within EMS as the impacts of all gear types are not fully understood (Defra 2013). For activities such as potting which occurs predominantly on rocky reef habitats, this may be particularly important as reef is a feature for which SACs are designated in 59 of 99 existing sites (JNCC 2016), and the UK has obligations to meet the conservation objectives of these sites under the European Habitats Directive. Management must therefore be implemented where activities are deemed to be damaging, and the likelihood of multi-use MPAs coinciding with areas of rocky reef is high, meaning that there could be substantial social and economic consequences for fisheries operating within these areas.

Social implications

The greatest social impacts of MPA designation stem from the process of resource and property right reallocation (Mascia 2004; Pomeroy et al. 2007). Positive impacts can include improved recreational activities such as diving or angling, whereas negative impacts may include displacement of fishing effort and conflict between users (Agardy et al. 2011; Sanchirico et al. 2002). It is important that these impacts are recognised and addressed in order to ensure social acceptability as this influences compliance with MPA restrictions and ultimately MPA success (Arias et al. 2015; Hattam et al. 2014).

Social acceptability has been defined by Thomassin et al. (2010) as *'a measure of support towards a set of regulations, management tools or towards an organisation by an individual or a group of individuals based on geographic, social, economic or cultural criteria'*. Furthermore, they state that it is composed of a set of individual perspectives and is complex, depending on multiple opinions and perceptions, with driving factors linked to the world view held by the stakeholders. Where social acceptability is high, compliance with MPA regulations should be greater, and therefore MPA success should increase. Achieving social acceptance amongst all stakeholders is, however, difficult, especially for those whose activities are negatively impacted by an MPA designation (Hattam et al. 2014; Sanchirico et al. 2002.).

To date, as with the ecological implications of MPA designation, the majority of research has focussed on the impacts of no take MPAs and stakeholders whose activities are negatively impacted by designation. It can be argued that fishers are those for which the implications of MPA designation may be most undesirable, especially in the short term, with the greatest impacts occurring for those whose fishing gear is incompatible with the conservation objectives of a site, requiring them to be excluded. The main impacts include displacement of effort, gear conflicts, increased fishing pressure, increased personal risk, increased costs and a loss of opportunity and employment (Rees et al. 2013b). This may cause conflict between fisheries and conservation governance streams where the impacts are thought to outweigh the benefits, especially where management measures are perceived to fail (e.g. Gómez et al. 2006; Suuronen et al. 2010). However, where fishers understand the implications of designation, feel that the restrictions placed on their activities are fair, and can find a way to maintain profitability, support may be stronger (e.g. Cadiou et al. 2009; Rees et al. 2013b).

The social implications of designating multi-use MPAs are therefore varied, with impacts dependent on stakeholder groups. The nature of the impacts can also change over time, with potential short term costs being outweighed by long term benefits. Fishers whose activities are permitted within a multi-use MPA often show the greatest level of support for the site due to a reduction in conflict between gear types and the potential for economic benefit to arise from increased access to fisheries resources (e.g. Hattam et al. 2014; Mangi et al. 2011). Stakeholders whose activities are not likely to be negatively impacted by MPA designation are also more likely to show support for site implementation. For example, benefits may be more readily obvious to those such as recreational sea anglers, charter boat operators and fishers whose activities are permitted within the MPA.

Hattam et al. (2014) found that opinions regarding the MPA in Lyme Bay varied between stakeholder groups, with the main opponents being mobile gear fishers who had been excluded from the area and static gear fishers who fished outside of the MPA. The main proponents were largely recreational users and static gear fishermen who fished within the MPA as they perceived the closure to be of benefit to their activities. As suggested by Rossiter and Levine (2014), MPA success may be greater where benefits arising from the designation are clear and tangible. This was also highlighted by Mangi and Austen (2008) who found that support of fishers decreased over time in southern European MPAs due to their failure to identify the expected benefits from the designation, thus having possible knock on effects for compliance with management measures (Arias et al. 2015).

Stakeholder support, and therefore social acceptance, has been seen to increase where there has been successful engagement throughout the MPA planning process (Gleason et al. 2010; Voyer et al. 2012). Engagement has been particularly successful at increasing social acceptance of MPAs in Australia and California, where zoned MPA schemes have been implemented and engagement has been strongly linked to acceptability (Gleason et al. 2010; Sutton and Tobin 2009). In the UK, engagement during the MCZ process was largely successful, however, concerns were raised by Lieberknecht et al. (2013) who found that the exclusion of stakeholders following the end of the planning process had resulted in disillusionment and disengagement from the process and therefore loss of social capital which may compromise the social acceptance of sites.

It is therefore important that the level of social acceptance amongst stakeholders is understood during both the planning and designation of MPAs. Clear links exist between social acceptance and MPA success (Arias et al. 2015; Rossiter and Levine 2014), but to date the focus of the literature has been on the success of planning stages (e.g. Gleason et al. 2010; Lieberknecht et al. 2013; Sutton and Tobin 2009). As MPA numbers are set to increase to meet global targets, and as many sites are now designated, it is important to increase the volume of literature that looks at social acceptance of MPAs post designation, both to inform ongoing management and for the future planning and implementation of additional sites.

Economic implications

The economic implications of MPA designation on fisheries stem from the same factors that influence the social impacts, i.e. displacement of fishing activities, increased access to fishing grounds for fishers permitted within the MPA, improved ecological quality for recreational users, and reduced conflict for resources and space (Agardy 1994; Hattam et al. 2014; Rees et al. 2013a; Sanchirico et al. 2002.). Impacts on other stakeholders may also be quantified in terms of economic costs and benefits, with stakeholders such as recreational sea anglers, recreational dive businesses and charter boat operators likely to directly benefit through profits arising from increased visitor numbers (Mangi et al. 2012; Rees et al. 2014; Rees et al. 2010; Roncin et al. 2008).

From a fisheries perspective, research has commonly focussed on fisheries which are excluded from an MPA as these individuals often disproportionately bear the costs of management strategies that place restrictions on resource use (e.g. Mangi et al. 2011; McClanahan and Mangi 2000; Murawski et al. 2000; Roberts et al. 2001; Russ and Alcala 1996; Russ et al. 2004). Studies have quantified the impact of displacement which may increase operating costs and reduce profits and the potential benefits of spillover from the export of biomass and larvae using landings and sightings data (e.g. Mangi et al. 2011; McClanahan and Mangi 2000; Murawski et al. 2000; Roberts et al. 2001; Russ and Alcala 1996; Russ et al. 2004). Fewer studies have focussed on the economic implications for fisheries permitted to operate within an MPA (but see Cadiou et al. 2009; Gómez et al. 2006; Mangi et al. 2012; Mangi et al. 2011; Rife et al. 2013; Vandeperre et al. 2011), especially in regard to shellfish (but see Mangi et al. 2012; Mangi et al. 2011). Potential benefits for these fishers may include increased catch per unit effort (CPUE) due to stock replenishment or increased area available to fish through reduction in gear conflict.

Research conducted to date on multi-use MPAs shows mixed results, with some studies finding an increase in CPUE within MPAs (Mangi et al. 2012; Vandeperre et al. 2011; Whitmarsh et al. 2002) and others finding that it remained stable (Cadiou et al. 2009) or decreased following MPA implementation (Rife et al. 2013). These differences arise in part from differences in management plans between sites; Vandeperre et al. (2011) concluded that increased CPUE was a direct result of spillover from a no take area within an MPA in France providing a steady increase in the abundance of target species, while Rife et al. (2013) concluded that larger no take areas and better enforcement were required to promote increased CPUE within a Mexican MPA. In France however, Cadiou et al. (2009) concluded that vessel numbers, fishing effort and CPUE had remained stable following the MPA designation, and fishing did not appear to impact the marine environment, leading them to question whether there was any reason to ban commercial fishing in MPAs.

Consequently, there is no clear pattern, with economic impacts dependent on location and management plans. Understanding the economic implications of multi-use MPAs is, however, important, not only to assess the benefits that designations can bring to fisheries and local economies, but also when considering acceptance and success of MPAs being linked to a clear demonstration of the benefits of designation (Rossiter and Levine 2014). In the UK context further research is needed to develop understanding of the economic costs and benefits of multi-use MPAs as all those recently designated or likely to be designated in the future are multi-use. Whilst management measures are not yet in place for the majority of sites in English waters, it is likely that static gear fisheries will be permitted to operate. Determining whether benefits arise for these fisheries is important, both to inform future planning and management of sites, and also for the generation of social acceptance.

1.5. Thesis aim & outline

As discussed, integrating fisheries and conservation management is complex. As although the two governance strands have common roots they are diverse and have some conflicting objectives (Garcia et al. 2014). Integration can however, be facilitated by taking an ecosystem approach to fisheries management, and MPAs are a management tool that is commonly used to achieve this. Despite their wide use, understanding the success of MPAs at achieving an integrated and holistic approach to fisheries and conservation management is limited as the majority of studies have focussed on individual aspects of designation. The numbers of MPAs are growing, however, and due to international, regional and national targets, numbers will continue to increase over time which makes developing an understanding of their potential for success important to ensure that sites are appropriately and effectively implemented in future.

Whilst the costs of MPA designation are more fully understood, there are clear gaps in our understanding of the potential benefits of multi-use MPAs. This is particularly important in the assessment of whether MPAs can successfully be used for conservation and fisheries management. If no economic benefits arise from multi-use MPAs they are unlikely to receive support from fishing industries and the ecological success of the MPA may be compromised.

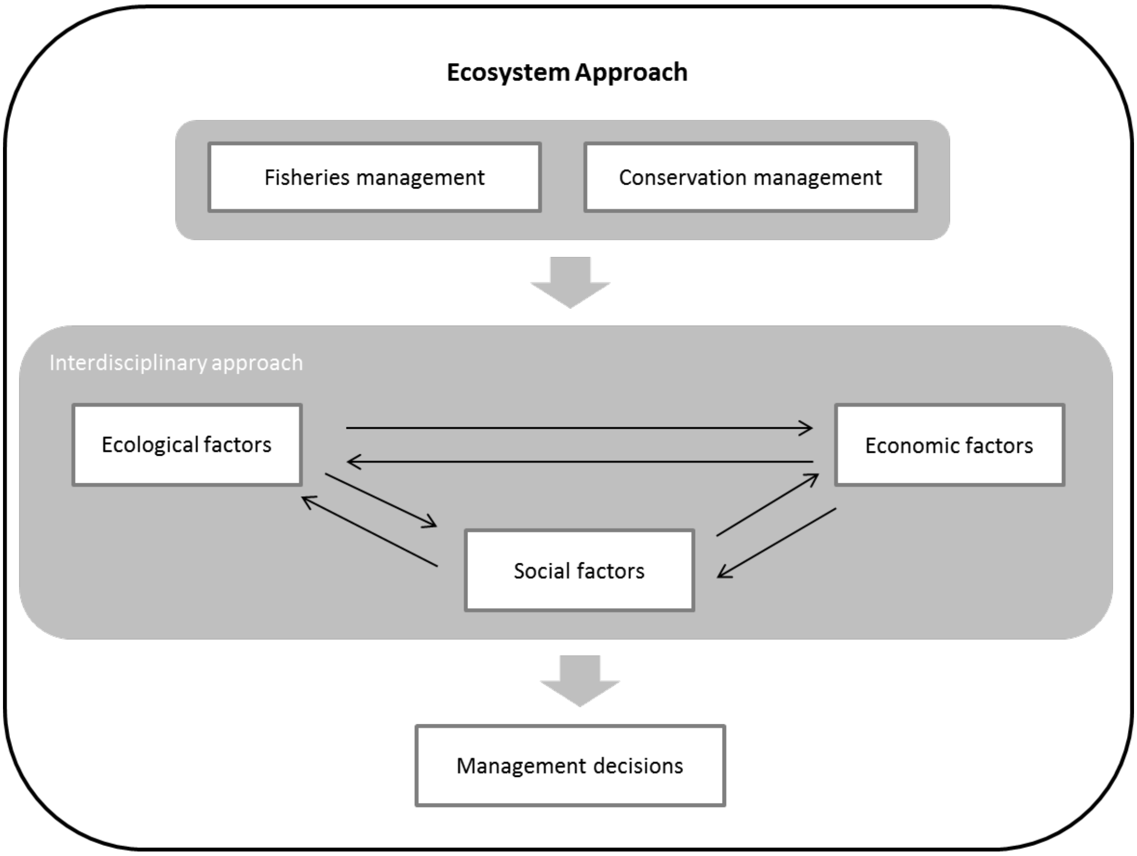


Figure 1.3: Schematic showing the interdisciplinary nature of research into the integration of fisheries and conservation management

To date, the majority of studies have addressed either the ecological, social or economic implications of MPA designation (e.g. Blyth et al. 2004; Hattam et al. 2014; Murawski et al. 2000; Roberts et al. 2005; Sanchirico et al. 2002.), and few have taken an interdisciplinary approach. It is argued however, that the disciplines are intrinsically linked, as the ecological condition of an MPA will affect both social and economic factors and vice versa (Figure 1.3). Where activities are permitted within a multi-use MPA there are likely to be benefits for most stakeholders, but the ecological state of the site might be compromised if extractive activities are not correctly managed. Increased understanding of the relationship between all aspects of MPA designation is crucial to ensure that sites are planned, designated, and managed appropriately to maximise their chance of success.

An interdisciplinary approach can be defined as one which *'facilitates the integration and synthesis of knowledge toward a more complete understanding of the whole'* (Stember 1991) and is considered to be a suitable method by which to provide a holistic overview of the factors which influence the successful integration of the fisheries and conservation governance strands. Furthermore, this approach mirrors that of the ecosystem approach and is an integral part of the remit and vision of the Inshore Fisheries & Conservation Authorities, making it appropriate here.

The aim of this thesis is to evaluate the effectiveness of integrating fisheries and conservation management. Based on the reviewed literature which identifies the importance of taking an ecosystem approach to management, and the interdisciplinary nature of the topic, this is achieved by considering the implementation of MPAs from an ecological, economic and social perspective, and assessing the effectiveness of current management of the marine environment via ecosystem based fisheries management.

1.5.1 Outline

This thesis is presented as a compendium of research chapters that are designed to be stand alone. The research pathway and thesis structure reflect the need for an interdisciplinary study to address the identified research question (Figure 1.4). The schematic of the research pathway (Figure 1.4) is reproduced in each chapter break to guide the reader through the stages of the thesis. Each chapter provides the aim and objectives of the study, a literature review, methods, results, and a discussion.

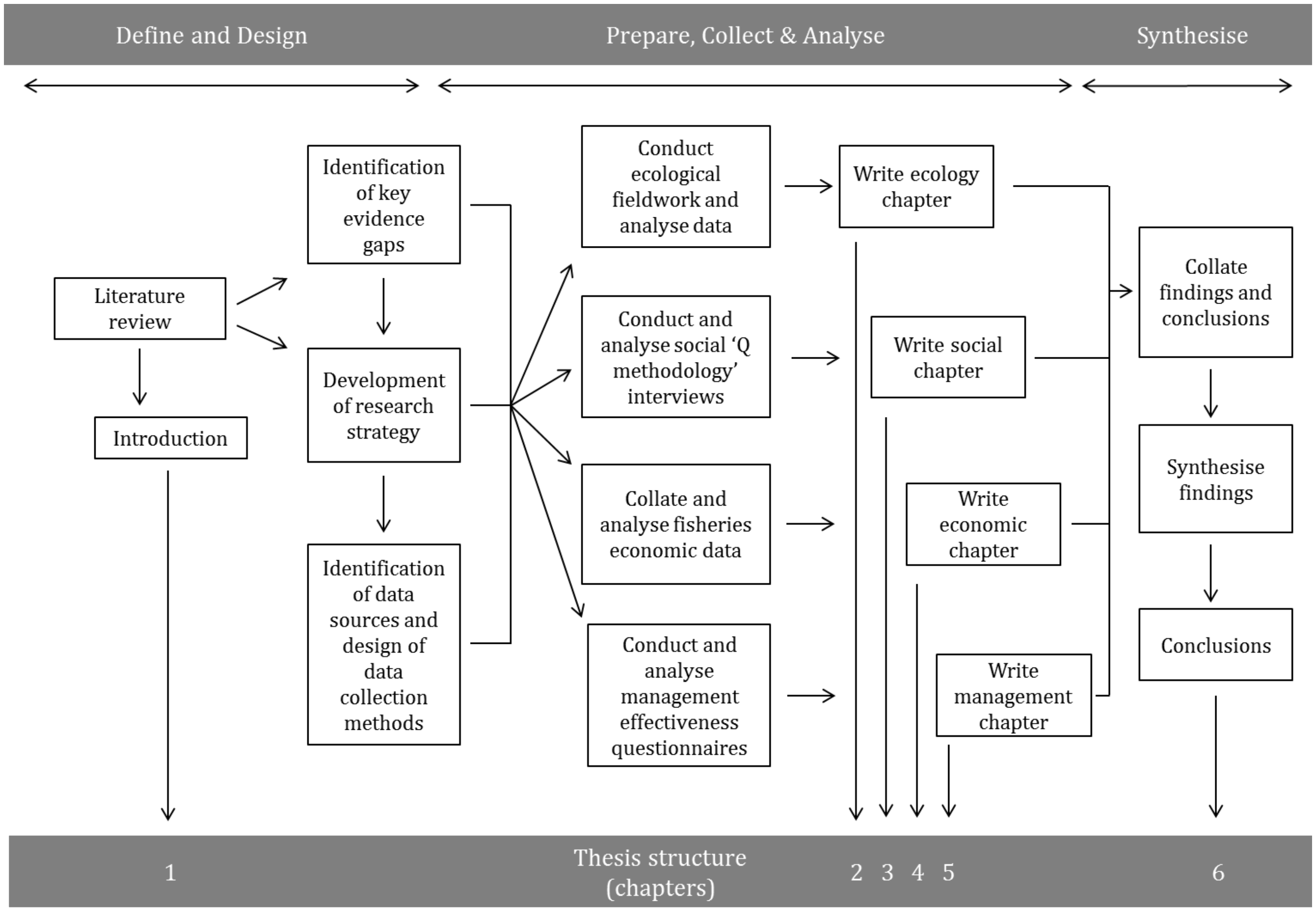


Figure 1.4: Schematic of research pathway undertaken to address the research question

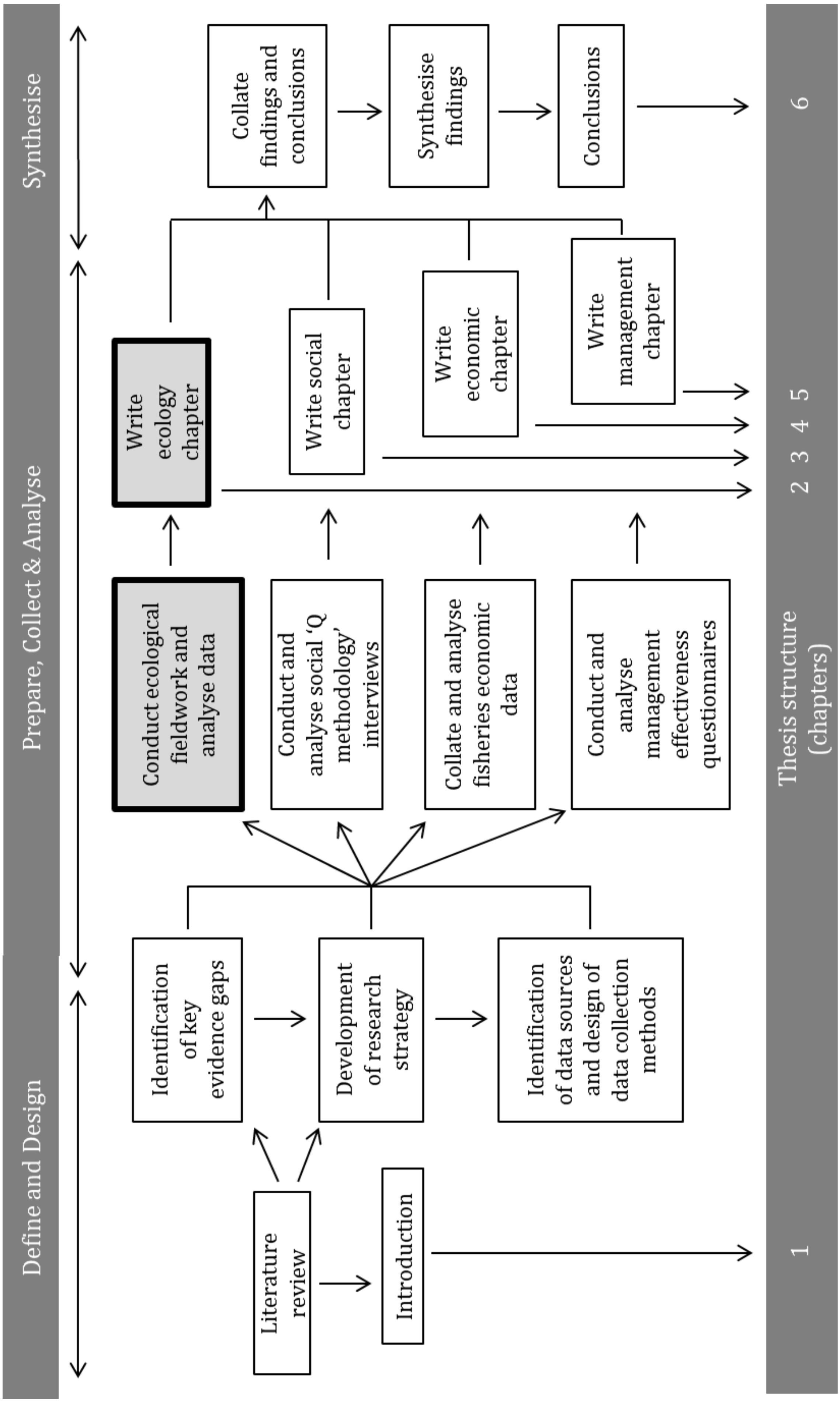
In **chapter two** I consider the ecological implications of designating multi-use MPAs and quantify the direct impacts of potting on benthic assemblages. This is achieved by determining 1) whether the exclusion of trawling from an MPA where potting is still permitted can result in the recovery of benthic systems and the provision of ecosystem services and 2) the mechanisms of physical potting impact on the benthos and the true footprint of potting.

In **chapter three** I evaluate the social acceptability of MPAs in the Devon & Severn region, UK. To achieve this, I use Q methodology, a quali-quantitative technique to quantify the perceptions and attitudes of stakeholders to the designation of MPAs through factor and discourse analysis.

In **chapter four** I determine whether the designation of multi-use MPAs provides economic benefit to fishers whose activities are permitted within them. This is achieved by using landings data to examine change over time in catch per unit effort, value of landings and number of active vessels targeting edible crab (*C. pagurus)*, European lobster (*H. gammarus*) and whelk (*B. undatum*); species of commercial importance to the shellfish fisheries in the UK and which commonly target rocky reef areas that may also be designated as MPAs.

In **chapter five** I consider the effectiveness of implementing ecosystem based fisheries management in UK waters using a case study of Devon & Severn IFCA. This is achieved through analysis of questionnaires completed by D&SIFCA stakeholders designed to elicit their perceptions of the D&SIFCA in regard to the Authority membership, goals and vision and aspects of their work.

Finally, in **chapter six** I provide a synthesis and general discussion where I draw together the findings of the different threads of the thesis to determine the implications of integrating fisheries and conservation management. I also outline directions for future research and make recommendation for future management.



Define and Design
Prepare, Collect & Analyse
Synthesise
Literature review
Introduction
Identification of key evidence gaps
Development of research strategy
Identification of data sources and design of data collection methods
Conduct ecological fieldwork and analyse data
Conduct and analyse social 'Q methodology' interviews
Collate and analyse fisheries economic data
Conduct and analyse management effectiveness questionnaires
Write ecology chapter
Write social chapter
Write economic chapter
Write management chapter
Collate findings and conclusions
Synthesise findings
Conclusions
Thesis structure (chapters)
1
2 3 4 5
6

Chapter two: Assessing the impact of potting on benthic habitats

The aim of this chapter was to quantify the impact of potting on benthic assemblages by determining 1) whether the exclusion of trawling from an MPA where potting is still permitted can result in the recovery of benthic systems and the provision of ecosystem services and 2) the mechanisms of physical potting interaction on the benthos and the true footprint of potting.

2.1 Introduction

Coastal and marine environments provide ecosystem goods and services vital to human wellbeing (Costanza et al. 1997; Covich et al. 2004; MEA 2005). They provide a source of food, aid with the regulation of climate and the cycling of nutrients and waste, provide raw materials and are important for recreation and culture (Costanza et al. 1997; MEA 2005; Remoundou et al. 2009). Biodiversity has been identified as one of the key drivers for the provision of ecosystem services, and the diversity of marine ecosystems means that they play a vital role in the provision of ecosystem services on a global level (Cardinale et al. 2012; Worm et al. 2006).

Benthic marine habitats vary from soft sediment to rocky reefs, and benthic communities include species of commercial importance such as flatfish and shellfish, and sessile colonial fauna such as bryozoans, sponges and soft corals (Garthe et al. 1996; Hiddink et al. 2008; Saila et al. 2002). The structural complexity of such habitats increases with the density and richness of species, providing the basis for many ecosystem processes (Crain and Bertness 2006).

Rocky reefs are characterised by sessile epifauna such as sponges, soft corals, hydroids, tunicates and bryozoans, and these species provide important biogenic structure, functioning as nursery areas, refuges from predators and habitat for the settlement of invertebrate spat such as scallops (Beck et al. 2001; Beukers-Stewart and Beukers-Stewart 2009; Dayton et al. 1995; Jennings and Kaiser 1998; Jennings et al. 2001; Monteiro et al. 2002; Ryer et al. 2004). They are also important for bentho-pelagic coupling, with sessile species recycling water and nutrients

(Beaumont 2009) and producing planktonic larvae that support higher trophic levels including commercially important fishes, birds and pelagic species (Grecian et al. 2010; Hiddink et al. 2011). Studies have suggested that the more complex and biodiverse an ecosystem, the more resilient it may be to external impacts making the maintenance and recovery of biodiversity and complexity in these habitats of key relevance to marine conservation and human wellbeing (Cardinale et al. 2012; Howarth et al. 2014).

Human impacts can compromise the ability of an ecosystem to provide goods and services (Cardinale et al. 2012; Halpern et al. 2008). Impacts from fishing include both direct impacts through the removal of target species, and indirect impacts through bycatch and damage to supporting benthic ecosystems (Jennings and Kaiser 1998). Where fisheries impacts are severe, broad scale assemblage level changes may occur, with changes in species composition, a reduction in biomass, diversity and productivity and the removal of key species compromising its resilience and its role in providing habitat to support species of commercial importance (Auster et al. 1996; Bradshaw et al. 2002; Collie et al. 1997; Jennings and Kaiser 1998; Roberts and Polunin 1991). In order to maintain the ecosystem services provided by the benthos it may be necessary for management measures to be implemented to reduce the impact of damaging fishing activities on sensitive habitats and species (Worm et al. 2006).

2.1.1 Fisheries management and marine protected areas

Fisheries are managed through international, regional and local legislation. Historically the focus was on management of single species and target stocks to maximise yield, but with time, and in line with international agreements such as the UN Conference on the Human Environment (1972) and the Convention on Biodiversity (1992) awareness of the need to manage via a process that incorporated conservation and environmental considerations with social and economic concerns grew (FAO 2003; Garcia et al. 2014).

In the current climate, fisheries management is increasingly combined with conservation management. This is primarily a result of international summits such as Rio + 20 with Principle 15 on the Precautionary Principle and Agenda 21 instrumental in setting guidance for fisheries and conservation management leading to the wide adoption of an ecosystem approach to management (Garcia et al. 2014). The overall objective of this approach is to sustain a healthy marine ecosystem, which will in turn support fisheries, thus, human activities must be managed to ensure that destructive practises do not compromise ecosystem resilience (Pikitch et al. 2004).

In Europe, fisheries management is encompassed by the Common Fisheries Policy (CFP), Regulation (EU) 2015/812, which is designed to manage fish stocks by setting restrictions on fishing activity across European waters. Incorporation of the ecosystem approach to fisheries management has however, been most apparent in the Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC).

The MSFD aims to achieve Good Environmental Status (GES) in European seas by 2020. Defined as '*the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive'*, GES has four descriptors which relate to fisheries; biological diversity, populations of commercially exploited fish and shellfish, the marine food webs and seabed integrity (Lassen et al. 2013). Currently the indicators for GES are under development, and will vary between regions due to differences in climate and ecological setting, but appropriate management of fishing activities will be required across European seas to ensure that GES can be achieved (Lassen et al. 2013).

Despite increasing recognition of the benefits of incorporating fisheries management with conservation through the designation of MPAs, the majority are designated for conservation purposes and therefore have conservation rather than fisheries objectives. In Europe, the European Union Habitats Directive (92/43/EEC) and Birds Directive (2009/147/EC), are legislation under which MPAs are most commonly designated, with sites often restricting fishing activities. The Habitats Directive calls for member states to establish a network of MPAs under Natura 2000 *'a coherent European ecological network of Special Areas of Conservation'*. These, combined with Special Protection Areas (SPAs) designated under the Birds Directive are termed European Marine Sites (EMS). SACs are designated for the protection of habitats or species listed in Annexes I & II of the Habitats Directive and SPAs are for the protection of birds listed in Annex I.

Article 6(2) of the Habitats Directive creates a duty that member states must avoid disturbance to the habitats and species listed in the Directive, and Article 6(3) states that activities can only occur in EMS if they have no impact on site integrity (Rees et al. 2013c). Site integrity can be defined as *'the maintenance of ecological processes and functions that support the wider delivery of ecosystem services'* (Rees et al. 2013c). Sites must also achieve favourable conservation status of Annex I habitats and Annex II species. Favourable conservation status for habitats and species requires that the site supports the natural habitat and species present within it without compromising their long term survival (The Council of the European Communities 1992). Favourable condition can be measured through a) extent of habitat, b) diversity of the habitat and its component species, c) community structure of the habitat, d) natural environmental quality, and e) natural environmental processes (Natural England 2013b). Member states must therefore manage licenced activities within these sites to ensure that both site integrity and favourable conservation status are achieved.

SACs and SPAs are types of marine protected area (MPA). MPAs are the most common tool currently used to combine fisheries management with conservation through the ecosystem approach. They are increasingly implemented to address conservation goals, which require the restriction or exclusion of some extractive activities within the site. MPAs are defined by the IUCN as:

> '*A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values*' (Kelleher and Kenchington 1992)

They can vary in size from one to 1000s kms and range from those where management prohibits all extractive and non-extractive uses to multi-use areas where restrictions are only placed on uses perceived to be counter to the aims and objectives of the site (Lester and Halpern 2008). It is often intended that MPAs will bring both conservation and fisheries benefit through the recovery of habitats and species, and the enhancement and replenishment of target stocks (Bohnsack 1993; Gell and Roberts 2003; Halpern 2003).

One challenge faced when developing targets for recovery is the identification of a baseline against which to measure success or GES (Duarte et al. 2013), with the interpretation of ‘good’ of key importance (Mee et al. 2008). Within Europe, adoption of a baseline in the 1980s is favoured (varying depending on the availability of data) as sufficient records exist for this to be measureable, and although adoption of a baseline when human activity was minimal is preferable this is not possible due to the lack of data against which to develop targets (HM Government 2012). Development of strong targets is necessary as studies are susceptible to ‘shifting baseline syndrome’ Pauly (1995) where inter-generational changes occur in the perception of the state of the environment and therefore what the natural state ‘baseline’ of an ecosystem is, resulting in a shifting of baselines through time (Sáenz-Arroyo et al. 2005).

2.1.2 The UK context

In the UK, statutory MPAs include SACs and SPAs (EMS), Marine Conservation Zones (MCZs), (England & Wales), Nature Conservation MPAs (Scotland), Ramsar sites for the protection of wetlands and Sites of Special Scientific Interest (SSSIs). This chapter will focus on SACs and MCZs.

Marine Conservation Zones

MCZs are designated under the UK Marine and Coastal Access Act 2009 for the protection of habitats and features of conservation importance in English and Welsh territorial and UK offshore waters. An initial planning phase identified 127 recommended sites which were put forward to UK government in 2011. Tranche one of 27 sites was designated in November 2013 and tranche two of 23 sites in January 2016, a third tranche is planned for the future but it is not expected that the full set of 127 sites will be designated.

Conservation objectives were assigned to features for which the site was designated depending on whether the feature was in a desirable state meaning that it should be 'maintained', or whether it fell below that state and should therefore be 'recovered to favourable condition' (JNCC and Natural England 2011). Extractive activities within MCZs must therefore ensure that they do not compromise the ability of the site to 'maintain' or 'recover' the features for which it has been designated (JNCC and Natural England 2011). Management for the sites is not yet in place as management decisions were not included in the planning phase, but they are being developed in line with the management of EMS (outlined below) which is expected to be in place by the end of 2016.

Special Areas of Conservation

Until 2013, the UK government took the view that fishing activity came under the public right to fish, was not under licence and therefore the Habitats Directive did not apply to most UK commercial fishing (Appleby 2015). This was challenged by the Marine Conservation Society (MCS) and Client Earth who stated that if a licence is given for fishing activity under section 4 of the Sea Fish (Conservation) Act 1967, then that amounted to a licence to fish and activities occurring in SACs and SPAs required management under Article 6(2) or appropriate assessment under Article 6(3) of the Habitats Directive (Appleby 2015). This view was accepted by Defra and was the driving force behind the change in approach to management of EMS, resulting in a need to manage fisheries within these areas.

Change in approach to management of fisheries within EMS

Management of EMS takes the form of feature based rather than site based management meaning that protection is only required for the periphery of the features for which the site has been designated rather than the whole site, relying on human ability to define the extent of the features (Sheehan et al. 2013a). Feature based management also requires extensive knowledge of the potential impact of fishing activities on the features for which the site has been designated. In the UK, this resulted in an extensive data gathering period as comprehensive knowledge of fisheries impacts was lacking (Defra 2013). This was led by Defra, with partners; the Marine Management Organisation (MMO), the Association of Inshore Fisheries and Conservation Authorities (AIFCA), Natural England (NE) and the Joint Nature Conservation Committee (JNCC).

An implementation group comprising the project partners and representatives from the fishing industry and NGOs was established, which produced a matrix of the impact of different types of fishing activities on all possible features and species of conservation importance. This coded different fishing activities depending on the intensity of their impact on habitats and features for which sites could be designated according to existing research (Table 2.1), (Defra 2013). Whilst there was some certainty relating to the impact of fishing activities such as bottom towed fishing gear on benthic habitats (e.g. Auster et al. 1996; Beukers-Stewart et al. 2005; Kaiser et al. 1998b; Kaiser et al. 1996b; Kaiser and Spencer 1996; Watling and Norse 1998), uncertainty remained relating to the impact of other fishing activities, which necessitated more research. These were coded amber activities and research was prioritised in order to fill the knowledge gaps (Defra 2013), (Table 2.1). One of these amber activities was potting targeting crab and lobster, as despite research to date suggesting that the negative impacts of potting on benthic habitats are limited (e.g. Coleman et al. 2013; Eno et al. 2001; Kinnear et al. 1996) more research was required to fully understand its impacts.

	Explanation
Red	Where it is clear that the conservation objectives for a feature (or sub-feature) will not be achieved because of its sensitivity to a type of fishing, - irrespective of feature condition, level of pressure, or background environmental conditions in all EMSs where that feature occurs - suitable management measures will be identified and introduced as a priority to protect those features from that fishing activity or activities.
Amber	Where there is doubt as to whether conservation objectives for a feature (or sub-feature) will be achieved because of its sensitivity to a type of fishing, in all EMSs where that feature occurs, the effect of that activity or activities on such features will need to be assessed in detail at a site specific level. Appropriate management action should then be taken based on that assessment.
Green	Where it is clear that the achievement of the conservation objectives for a feature is highly unlikely to be affected by a type of fishing activity or activities, in all EMSs where that feature occurs, further action is not likely to be required, unless there is the potential for in combination effects.
Blue	For gear types where there can be no feasible interaction between the gear types and habitat features, a fourth categorisation of blue is used, and no management action should be necessary.

Table 2.1: Explanation of the risk rating categories used to determine how likely it is that different fishing gear types would damage protected features of European Marine Sites (Defra 2013)

The change in approach required management to be implemented where there was doubt that the conservation objective for a feature or sub-feature would be met due to its sensitivity to the fishing activity. Management was in place for activities coded red by the end of 2013, and a detailed assessment of the impact of amber activities was instigated at a site specific level with appropriate management to follow by the end of 2016 (Defra 2013).

Responsibility for management of EMS within the six nautical mile limit lies with the Inshore Fisheries and Conservation Authorities (IFCAs). Their remit includes fisheries regulation and enforcement, stock enhancement, and monitoring, and they implement regulations through the use of byelaws and fishing orders. They were the lead relevant authority within inshore waters (inside 6 nm) and were responsible for conducting appropriate assessments of any activities whose impact on a feature was coded amber in the matrix.

In the context of potting, a need was identified for research to inform the management of potting activities on habitats such as subtidal sandbanks, lagoons and reefs. In UK SACs, reef is listed as a qualifying feature in 59 of the 99 sites, and is the most common feature for which a site is designated (JNCC 2016). Understanding the impacts of potting was therefore of priority to ensure that appropriate management measures could be implemented if required. This work falls within the remit of the IFCAs, who are required to complete Habitat Regulations Assessments for all SACs within their district detailing the extent of interaction between fishing gear and features for which the site is designated. These are then used as the evidence base for decisions regarding the management measures of fishing activities within the sites.

2.1.3 UK potting fisheries

Whilst the UK fishing fleet in general has decreased in size over recent years, the UK potting fleet has increased, with Seafish statistics reporting 1,273 active fishing vessels using pots and traps as their main or sole gear type in 2014 compared to only 687 in 2005 (Seafish 2015). Target species for these vessels are brown crab, whelk, lobster and nephrops, with pots of different design used to target different species. Potting vessels are commonly day boats of less than 12 m in length, with the majority falling into the under 10 m category (Bannister 2009). Due to their size, most vessels are restricted to inshore waters, but a number of large vessels equipped with vivier tanks exist which means that they can keep the crab alive and remain at sea for days at a time (Edwards 1989). The fisheries targeting these species are important to the UK economy, accounting for 31 % of all shellfish, and 69 % of all fisheries landings into the UK from UK vessels in 2014.

Different pot types are used across the fishery, including parlour and inkwell pots (Edwards 1989). Parlour pots are made in the traditional D shape and have either a hard or soft 'eye'; an opening for the crab and lobster to enter (Figure 2.6). Hard eyes are plastic funnels that taper to reduce the likelihood of escape, and soft eyes are made from netting and act as a non-return valve (Galbraith et al. 2004). Inkwell pots, shaped like inkwells have a 'bucket' entrance similar to a hard eye in a parlour pot (Galbraith et al. 2004), (Figure 2.6). The type of pots fished is based on personal preference, but parlour pots are more commonly used in English waters to target lobster as their design makes it harder for individuals to escape once they have entered, and inkwells are commonly used where brown crab are targeted (Galbraith et al. 2004).

Strings of pots are set and left to fish for a period of 24-72 hours before being hauled, emptied, re-baited and re-deployed (Coleman et al. 2013). The number of pots in a string varies widely, dependent on location and boat size, with small under 10 m boats fishing strings of 10-20, boats over 12 m able to fish strings of 60-100 pots and the largest vessels fishing strings of 100 or more, (commercial fishermen, pers. comm). Typically, a vessel will set a string of pots evenly spaced along a 'backline' which they are attached to via a 'leg' (see Figure 2.5 for details). They are deployed from the vessel by the first pot and buoy being thrown over the side, and the rest following as the vessel steams ahead slowly, usually through a door in the side of the vessel or off the back (commercial fishermen, pers. comm). Each end of the string is marked by a buoy line and in areas where there are strong currents or tides anchor weights may be used at either end to keep the pots stationary on the ground (Coleman et al. 2013).

2.1.4 Potential impacts of potting on benthic habitats

As discussed, for potting activity to be permitted to occur within EMS and MCZs, it must not compromise site integrity, and the sites must be able to maintain or recover to favourable conservation status. Managers must consider not only the direct impacts of potting on benthic habitats, but also indirect impacts where appropriate, such as the removal of target species from the ecosystem, removal of non-target species for use as bait in the pots, the addition of bait as a food source into the ecosystem, the impacts of ghost fishing when gear is lost, and any potential abiotic physical seabed impacts from pots contacting the reef structure (e.g. Armstrong et al. 1998; Bullimore et al. 2001; Kaiser et al. 1996a; Saila et al. 2002).

Research into these additional factors is beyond the scope of this study, which focusses on the direct impacts of potting on benthic rocky reef communities.

Studies on MPAs where bottom towed fishing gear has been prohibited suggest that recovery occurs on decadal timescales (Babcock et al. 1999; Watling and Norse 1998), but that it can occur whilst activities such as potting are permitted to continue (Blyth et al. 2004; Sheehan et al. 2015; Sheehan et al. 2013b). What is not clear, however, is what impact potting activity has on the recovery of these systems and whether they are able to reach a fully functional state (Tett et al. 2013) whilst activities are permitted, thus achieving GES and favourable conservation status.

Benthic impacts from potting activity may occur from the impact of the pot and/or end weight hitting the benthos on deployment, from the pot and/or end weight dragging across the benthos during the haul, or from scour caused by the backline and/or leg ropes. There may also be impacts during the soak if the weather or tidal conditions cause the pots to move across the ground.

Rocky reefs may be at risk from damage from potting activities due to the impact to long lived, slow growing sessile epifauna (Coleman et al. 2013; Jennings and Kaiser 1998). Species such as *Eunicella verrucosa* (pink sea fan), *Pentapora foliacea* (Ross coral), *Alcyonium digitatum* (Dead Man's Fingers) and erect branching sponges may be particularly vulnerable due to their erect body-forms, and the life histories of such species mean that they may not be very resilient to impacts (Coleman et al. 2013; Langmead et al. 2010).

Research on potting impacts on rocky reefs has been limited, but has shown some damage does occur. Casement and Svane (1999) concluded that shallow subtidal reef biota appeared to be physically unaffected by deployment and haul of rock lobster traps in South Australia, while Shester and Micheli (2011) found in their study in the Gulf of Mexico that lobster traps had minimal impacts on gorgonian corals. They did however report that damage caused removal of a maximum of five percent of tissue, and the implications of this were not known.

Eno et al. (2001) assessed the impact of potting on key species on rocky reef habitats, including *E. verrucosa*, and *P. foliacea*, finding some damage to colonies of *P. foliacea* but no sign of immediate detrimental effects. They observed *E. verrucosa* bending under the weight of the pots but returning to normal once the pots were lifted. Their study concluded that rocky reef habitats and their communities were relatively unaffected by potting activities, but these conclusions were compromised by issues of low power due to sampling replication and analysis, with only ten replicate pot deployments over the space of one month.

Coleman et al. (2013) assessed the impact of potting in the Lundy MPA by comparing abundance of a suite of benthic indicator species at sites within the no take zone (NTZ) to those outside where potting occurred. They found no significant differences and concluded that these species were insensitive to commercial potting effort and that potting had no detectable effect over the timescale of their study. However, they used diver surveys and sampled areas known to be potted rather than looking at direct impacts of the pots during the soak and haul. Their experimental potting study looked at the impact of potting within an NTZ from annual experimental potting activity, meaning that potting effort was very low. It may be that they would have detected impacts had potting levels been more representative of those in areas potted year round.

Research currently being conducted includes a study looking at the impact of potting on faunal turf communities with simulated potting intensities of 80, 000 pots km^{-2}, orders of magnitude greater than current levels of fishing activity. No significant impact has been detected, but work is ongoing (Fitzsimmons (2015), cited in Walmsley et al. (2015)). Work is also underway to determine the impact of potting of different intensities on benthic rocky reef communities through the establishment of experimental potting areas with no potting areas compared to low, mid and high density of pots (Rees In prep).

2.1.5 Study aims

Research to date has provided a useful and important background to the development of this study, but studies were limited in their scope and limited by issues of statistical power and survey design. The work of Eno et al. (2001) and (Coleman et al. 2013) are most relevant here, but both focussed their assessments on indicator species and did not consider the impacts of potting on wider benthic assemblages. It is important to facilitate the combination of data on potting interactions with benthic habitats with data relating to metrics that were beyond the scope of this study such as ghost fishing and the implications of the addition of bait as an artificial food source. These data could be incorporated into ecosystem models considering the impacts of fishing activities at different spatial and temporal scales in order to develop appropriate management measures and mitigation for any impacts identified.

MSFD requires GES to be achieved across European Seas, and the Habitats Directive and Marine and Coastal Access Act require fishing activities, which compromise the integrity and conservation objectives of an MPA to be managed. In the absence of indicators for GES, the work of Tett et al. (2013) may be considered where ecosystem health was defined as:

> *'The condition of a system that is self-maintaining vigorous, resilient to externally imposed pressures, and able to sustain services to humans. It contains healthy organisms and populations, and adequate functional diversity and functional response diversity. All expected trophic levels are present and well interconnected and there is good spatial connectivity amongst subsystems'* (Tett et al. 2013)

Consequently it is possible to develop a measure of ecosystem health using univariate metrics such as number of individuals (individuals m^{-2}), number of taxa (taxa m^{-2}), diversity (Simpson's 1-λ), and the number of individuals of selected indicator taxa known to be sensitive to fisheries impacts, such as, *Alcyonidium diaphanum, Alcyonium digitatum*, branching sponges, *Cliona celata, Eunicella verrucosa, Metridium senile, Pentapora foliacea* and *Urticina felina* (individuals m^{-2}), (see section 2.2.1.3), and multivariate metrics such as assemblage composition. Such assessments can aid the determination of whether potting interactions are compromising GES and the ability of a site to achieve or maintain favourable conservation status.

This study therefore aimed to quantify:

1. Whether the exclusion of trawling from an MPA where potting is still permitted can result in the recovery of benthic systems and the provision of ecosystem services, and;
2. The mechanisms of physical potting interaction with the benthos and the true footprint of potting

For ease of understanding, these are termed 1) benthic condition, and 2) mechanisms and true footprint throughout the chapter.

The Inshore Potting Agreement area in South Devon, UK, provides a test case study site for this work. Although not initially designated as an MPA, the site can be considered a *de facto* MPA as bottom towed fishing gear was excluded in 1978 from large areas to reduce conflict between mobile and static gear types. This led to the establishment of a zoned fisheries management scheme which was incorporated into statutory legislation in 2002 (Hart et al. 2003) and has provided ecological benefits to areas where bottom towed fishing gear was excluded (Blyth et al. 2004). The IPA covers an area approximately 500 km^2 and includes zones where static gear (pots and static nets) is exclusively allowed, areas where towed gear is exclusively allowed and areas where gear types are managed seasonally (Figure 1). The area is very important both locally and nationally for its brown crab (*Cancer pagurus*) fishery, with landings from boats into the ports of Dartmouth and Salcombe the largest in England, totalling almost £3.4 million in 2014 (Marine Management Organisation 2015).

The IPA area is overlain by the Start Point to Plymouth Sound and Eddystone SAC, designated for the protection of reef habitat and from which bottom towed fishing gear was excluded in 2014 (Figure 2.1), (Natural England 2013b). The site also overlaps the Skerries Bank and Surrounds Marine Conservation Zone, but as management plans are under development this has not been considered here. Production of HRAs for fishing activity within the SCI falls to D&SIFCA, and the need for this research was identified to inform their assessments.

Due to the long history of management within the IPA it is possible to test whether, following approximately 35 years of exclusion of bottom towed fishing gear, the ecosystem is in a healthy state by considering the metrics defined above. In the absence of pristine control sites, this method can help determine whether the presence of potting activity has allowed the ecosystem to recover and deliver ecosystem services, or whether the functionality of the site is compromised. Similar work was conducted by Blyth et al. (2004) at sites in and around the IPA. They used a scallop dredge to sample the benthos at sites fished using static gear and those fished using bottom towed fishing gear and found species richness and biomass were significantly greater in the static gear areas. Whilst this study provides useful data for comparison it did not share the same aims as this work, sampling methods differed and each site was only sampled once meaning that temporal variation could not be accounted for.

To assess the mechanisms responsible for potting interactions the following metrics were quantified: settle duration (seconds from point of first contact to becoming stationary) pot stability during the soak, haul duration (seconds from first movement to clearing the reef) and pot footprint (area impacted by the pot moving across the reef during the haul, m^2) to determine spatial impact. Pot footprint could be calculated by measuring the area of the pot base and the area of the haul corridor (the distance a pot travels during the haul before lifting off the seabed). A 10 cm buffer was added to the area of the pot base as the pots were often unstable as they moved across the ground during the haul, resulting in some slight rolling onto their sides. Observation of fishing methods and discussion with members of the fishing community suggested that the area of a haul corridor may not be equivalent to the estimated haul area as the impact on the reef is not uniform. The uneven topography dictates that pots are unlikely to maintain contact with the reef throughout the haul. Estimation of impact based on length of haul corridor would therefore result in an overestimation.

From here onwards, the estimated area impacted will be referred to as the assumed corridor (defined as the area (m^2) that could have been impacted during the haul and all taxa within it), and the true area will be referred to as the realised corridor (defined as the area (m^2) actually impacted and the taxa within it). Biotic metrics were also considered: number of individuals ((not damaged, damaged, removed), (number of individuals m^{-2})) and for selected indicator taxa known to be sensitive to fishing impact, *Alcyonium digitatum*, branching sponges, *Cliona celata, Eunicella verrucosa and Pentapora foliacea*, number of individuals ((not damaged, damaged, removed), (m^{-2})) was also calculated. Damage was defined as 'abrasion' where visible rubbing commonly resulted in clouding of the water suggesting tissue removal, and/or 'sections removed' where injury occurred resulting in clouding of the water and the presence of small sections of tissue.

Using the metrics outlined above, the study therefore examined the hypotheses that:

Benthic condition

H1 = number of taxa, number of individuals and diversity are statistically significantly greater in potted areas where bottom towed fishing is not permitted, than in areas open to bottom towed fishing

H2 = assemblage composition is statistically significantly different in potted areas where bottom towed fishing is not permitted, than in areas open to bottom towed fishing

Mechanisms and true footprint

H3 = during pot hauls the area of the realised corridor is statistically significantly smaller than the assumed corridor

H4 = considering the biotic metrics, during pot hauls statistically significantly more benthic fauna are not damaged than are damaged or removed within the realised corridor

H1 and H2 were tested across ten areas and over three years, and H3 and H4 were tested for two gear types (parlour and inkwell pots) across three areas and two years.

2.2 Methods

2.2.1 Benthic condition

2.2.1.1 Study site & survey design

The survey was conducted in South Devon UK, in the Inshore Potting Agreement (IPA) area, with the majority of sites also within the Start Point to Plymouth Sound and Eddystone SCI (Figure 2.1). The survey area differed in topography and exposure to tidal streams, with the west more sheltered and rugose and the east flatter and exposed to tidal streams around Start Point. Water depth ranged from 30-60 m with the majority of sites at approximately 50 m depth.

Two treatments were selected, Static where only static gear (mainly pots) had been fished since the IPA was established in 1978, and Mixed, where areas are open to both mobile and static gear. In January 2014, nine Mixed sites were awarded protection from bottom towed fishing gear. As this only came into effect five months before the 2014 and 17 months before the 2015 sampling event, and Sheehan et al. (2013b) showed that recovery at a comparable reef site was not detectable within two years of protection, samples are still considered here as Mixed.

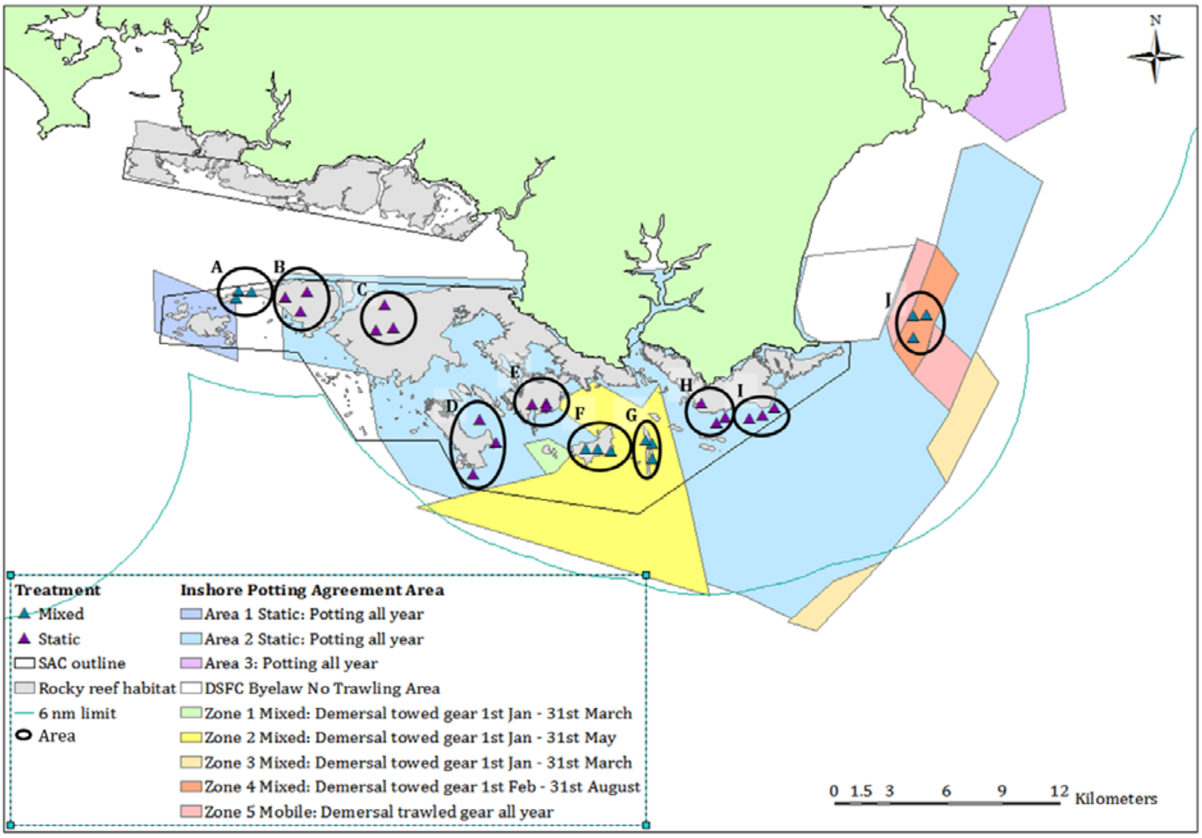


Figure 2.1: Survey sites for the towed video survey showing Mixed (purple triangles) and Static (blue triangles) gear sites grouped into Locations (A-J). Map created using ArcGIS, 2016

A total of 30 sites were sampled from late May to early September in 2013, 2014 and 2015. Sites were distributed across the survey area in groups of three, "Locations" (A-J see Figure 2.1) to account for any effects resulting from the known differences in topography and exposure to tidal streams. Eighteen sites were sampled in the Static treatment, and 12 in the Mixed (Figure 2.1). At each site a 20-minute video tow was recorded to sample sessile and sedentary taxa using drop down video with a HD camera mounted on a flying array towed behind the boat at a speed of approximately 0.4 knots, equating to approximately 200 m per tow (Figure 2.2). The method followed that developed by Sheehan et al. (2010) to ensure that sampling was cost-effective, relatively non-destructive and to minimise the risk of snagging on uneven rocky reef or boulders (Sheehan et al. 2016). Seasonal effects due to the length of the sampling season were discounted as observations and comparison of data from May and September revealed no differences in species composition that could be attributed to seasonal changes. The majority of sampling occurred in June and July.

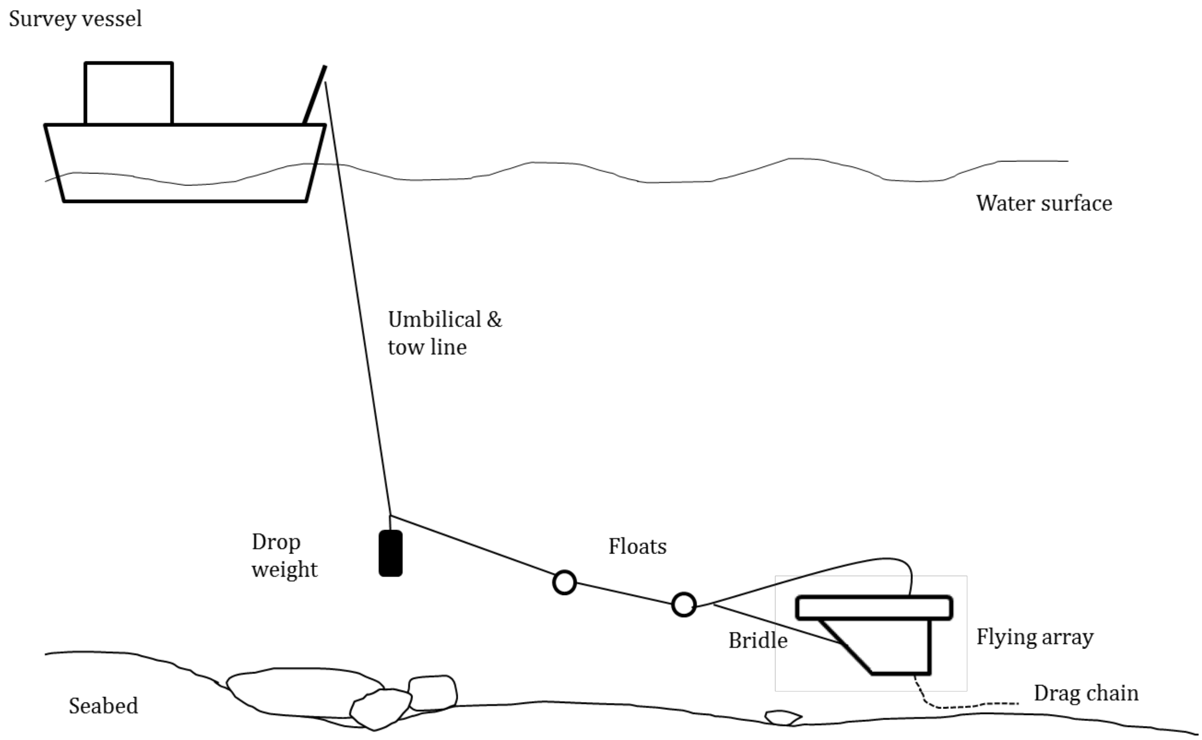


Figure 2.2: Diagrammatic representation of the equipment during the deployment of the towed flying array. Not to scale. Adapted from Sheehan et al. (2010)

Sampling aimed to quantify differences in the univariate metrics: number of individuals (m^{-2}), number of taxa (m^{-2}), diversity (Simpson's 1-λ) and number of selected indicator taxa (m^{-2}) *Alcyonidium diaphanum, Alcyonium digitatum*, branching sponges, *Cliona celata, Eunicella verrucosa, Metridium senile, Pentapora foliacea* and *Urticina felina;* and the multivariate metric: assemblage composition to determine whether, following the exclusion of bottom towed fishing gear in 1978, a healthy ecosystem is achieved whilst potting activities continue.

The target habitat type was rocky reef, which was considered to be bedrock reef, boulders and cobbles > 64 mm diameter. Suitable habitat was identified using sidescan data provided to Devon & Severn IFCA by Cefas (Figure 2.1). No data on frequency of fishing activity was available, but potters fish specific areas and there is known to be little additional space available (Blyth et al. 2002) giving confidence that sites within the static treatment would have been regularly fished. Where fishing gear was in the way of a planned transect, it was started at the next nearest position.

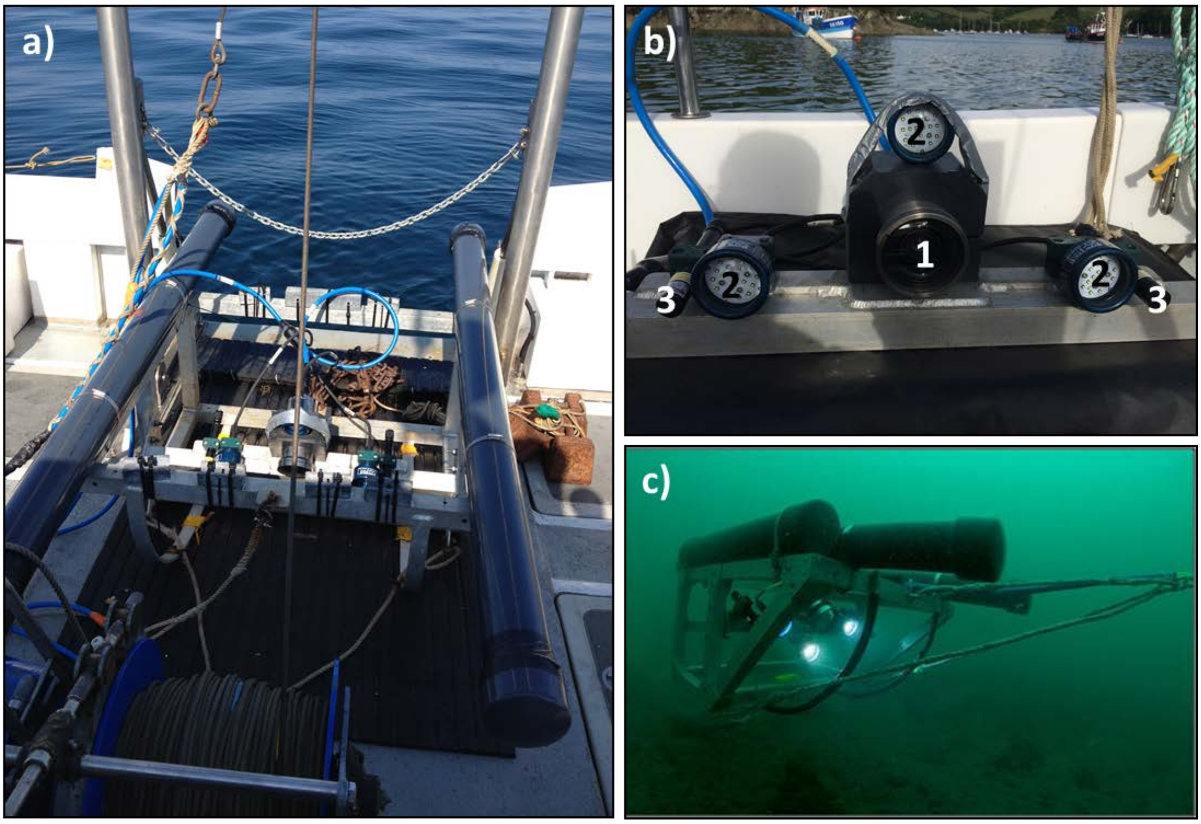


Figure 2.3: a) flying array on the deck of the Black Jack, b) HD camera (1), LED lights (2) and lasers (3), c) flying array underwater (image from Sheehan et al. (2010) of a virtually identical flying array that the flying array used here was based on).

The video system included an HD camera (Bowtech Products Limited, Surveyor-HD High Definition Underwater Colour Zoom Video Camera, 1080i/720p), LED lights (Bowtech Products Limited, LED-K-Series Underwater LED Light), and two laser pointers to allow the field of view to be calibrated (Apinex Inc. BALP-LG05-B105). The camera was positioned at an oblique angle to the seabed with the LED lights mounted on either side and above the camera, and the lasers fixed outside of the lights 30 cm apart (Figure 2.3). The camera was connected via an umbilical to a Bowtech System power and control unit, which gave topside control of the focus, zoom and aperture of the camera and the intensity of the lights. The vessels used for this work were the RV Drumbeat, RV Blackjack and fishing vessel Miss Pattie.

2.2.1.2 Video analysis

Data were extracted by examination of individual HD video frames taken at two second intervals to avoid overlap using 3Dive Frame Extraction software (Cybertronix). Images were overlain with a 0.25 m^2 counting grid calibrated using the position of the lasers which allowed extraction of density and percentage cover information for each taxon. Strict criteria were adhered to during the selection of frame grabs suitable for analysis (Sheehan et al. 2013b), (Annex A, Figure A1). Following Stevens et al. (2014), 30 frames were selected from each transect as this was deemed the optimum number for rocky reef habitat which could be sampled without loss of accuracy compared to sampling all frames.

All taxa present in each frame were identified, with identification to the highest taxonomic level possible. Organisms that fell on the edge of the overlain grid and were therefore partly in and partly out of the frame were deemed to be 'in' and counted as present within the frame. Number of individuals were enumerated using count (m^{-2}) or cover (% m^{-2}) as appropriate. Taxonomically similar species were grouped to avoid misidentification:

- All unidentified hydroids, excluding *Aglaophenia tubulifera*, *Gymnangium montagui*, *Halecium halicinium*, *Nemertesia antennina* and *Nemertesia ramosa*
- Flustridae spp. due to the similarity in appearance of species such as *Flustra foliacea* and *Securiflustra securifrons*
- Red algae species were grouped as 'unidentified macroalgae'
- The spider crabs Inachus spp. and Macropodia spp. were identified to genus level
- Due to the difficulties associated with identifying sponges from video (Ackers et al. 2007), those that were not identifiable were described and identified as e.g. massive sponge 1, encrusting sponge 1 to maintain taxonomic diversity
- 'Turf' described hydroid and bryozoan turf that projected less than 1 cm from the seabed
- Cup corals were grouped as 'cup corals'

2.2.1.3 Indicator taxa

Long lived and slow growing taxa with a range of life histories were selected from the species data as indicators that were expected to be susceptible to damage from fishing impacts (Coleman et al. 2013; Langmead et al. 2010). Jackson et al. (2008) and Langmead et al. (2010) identified a suite of indicator species for monitoring recovery of benthic habitats following the removal of bottom towed fishing gear in Lyme Bay that represented different levels of recoverability. Of these species, the majority were not observed or seen only rarely, such that analysis was not possible. Therefore, seven indicator species from the original list were used here. Branching sponges (grouped) were selected in addition, due to their erect structure and therefore potential fragility when considering the impact of potting (Coleman et al. 2013). The life history traits of those identified by Langmead et al. (2010) are presented in Table 2.2. No life history traits are given for branching sponges as these are dependent on individual species.

	Fragility	Regeneration	Maturity	Fecundity	Larval dispersal potential	Lifespan	Growth
Alcyonidium diaphanum	Intermediate	No	1-2 years	2-200 k	< 0.1 km	6-10 years	≤ 1cm/yr
Alcyonium digitatum	Fragile	Yes	3-5 years	2-200 k	> 10 km	≥ 11 years	≤ 1cm/yr
Cliona celata	Intermediate	Yes	3-5 years	2-200 k	0.1-1 km	≥ 11 years	> 5cm/yr
Eunicella verrucosa	Intermediate	No	3-5 years	2-200 k	0.1-1 km	≥ 11 years	≤ 1cm/yr
Metridium senile	Intermediate	No	-	-	> 10 km	≥ 11 years	> 5 cm/yr
Pentapora foliacea	Fragile	No	1-2 years	2-200 k	0.1-1 km	6-10 years	1-3 cm/yr
Urticina felina	Intermediate	No	1-2 years	2-200 k	< 0.1 km	≥ 11 years	1-3 cm/yr

Definitions
Fragility = the propensity to suffer damage from a physical impact
Regeneration = the capacity for partial or whole regrowth or regeneration
Maturity = the time taken to reach reproductive maturity from birth
Fecundity = the average number of offspring per reproductive episode
Larval dispersal potential = the potential horizontal distance larvae may travel before settling
Lifespan = the potential maximum time from birth to death
Growth rate = the average increase in width/length per unit time over the whole lifespan

Table 2.2: Life history traits for the long lived and slow growing species identified from the video analysis. Trait information taken from Langmead et al. (2010)

2.2.1.4 Data analysis

Multivariate and univariate analyses were conducted using Permutational Multivariate Analysis of Variance (PERMANOVA, Anderson (2001); Clarke and Warwick (2001)) based on similarity matrices using PERMANOVA+ for Primer in PRIMER 6 (Clarke and Warwick 2001). Multivariate data were dispersion weighted and fourth root transformed to down weight species with large and erratic abundances and allow rarer species to contribute to the outcome (Clarke et al. 2006) and Bray-Curtis similarity indices were used to construct similarity matrices.

Univariate data were also fourth root transformed and Euclidean dissimilarity indices were used to construct similarity matrices (Clarke and Warwick 2001). Each term in the analyses used 9999 permutations of the appropriate units (Anderson and Braak 2003).

Data were pooled by tow prior to analysis to avoid pseudo-replication. Four factors were used in the analyses, these were Year (random: 2013, 2014, 2015), Treatment (fixed: Static, Mixed), Location (random and nested in Treatment: 6 Static, 4 Mixed) and Site (random, nested in Location: 3 per Location). The lowest significant effect was interpreted for each test ($P < 0.05$) and significant interactions involving fixed factors were interpreted using pairwise tests. Data were visualised using Non-metric Multi-Dimensional Scaling (nMDS).

2.2.2 Mechanisms and true footprint

2.2.2.1 Study site & survey design

The survey was conducted in the Start Point to Plymouth Sound and Eddystone SAC. A total of 27 sites were selected, in 3 different areas, Start Point (SP), Mewstone Ledges (ML) and Hillsea Point (HP), (Figure 2.4). Sampling took place between late April and early September in 2014 and 2015. For logistical reasons one site at Start Point was unable to be sampled in 2015. At each site one string of inkwell pots and one string of parlour pots were deployed approximately 200 m apart, with four pots per string, and cameras fitted to alternate pots, each giving a different view of the reef.

Sampling aimed to quantify the mechanisms of potting interaction and the true footprint of a pot through quantification of the following metrics: settle duration (seconds from point of first contact to becoming stationary) pot stability during the soak, haul duration (seconds from first movement to clearing the reef), assumed corridor (defined as the area (m^2) that could have been impacted during the haul and all taxa within it), and realised corridor (defined as the area (m^{-2}) actually impacted and the taxa within it). In addition, biotic metrics were also used: number of individuals ((not damaged, damaged, removed), (number of individuals m^{-2})), and for selected indicator taxa known to be sensitive to fishing impact, *Alcyonium digitatum*, branching sponges, *Cliona celata, Eunicella verrucosa and Pentapora foliacea*, number of individuals ((not damaged, damaged, removed), (m^{-2})) was also calculated.

Local knowledge from the fishers and sidescan sonar from Cefas showing reef extent (Figure 2.4) were used to aid site selection, with the requirement that sites were on rocky reef (considered to be bedrock reef, boulders and cobbles > 64 mm diameter) and in approximately 20-30 m of water (dictated by the depth rating on the GoPro cameras). Reef habitat in the three survey locations was comparable, comprising bedrock, boulders and cobbles. Topographical differences were apparent, however, with reef at Start Point flatter and more tide swept than that at Mewstone Ledges and Hillsea Point where rugosity was greater.

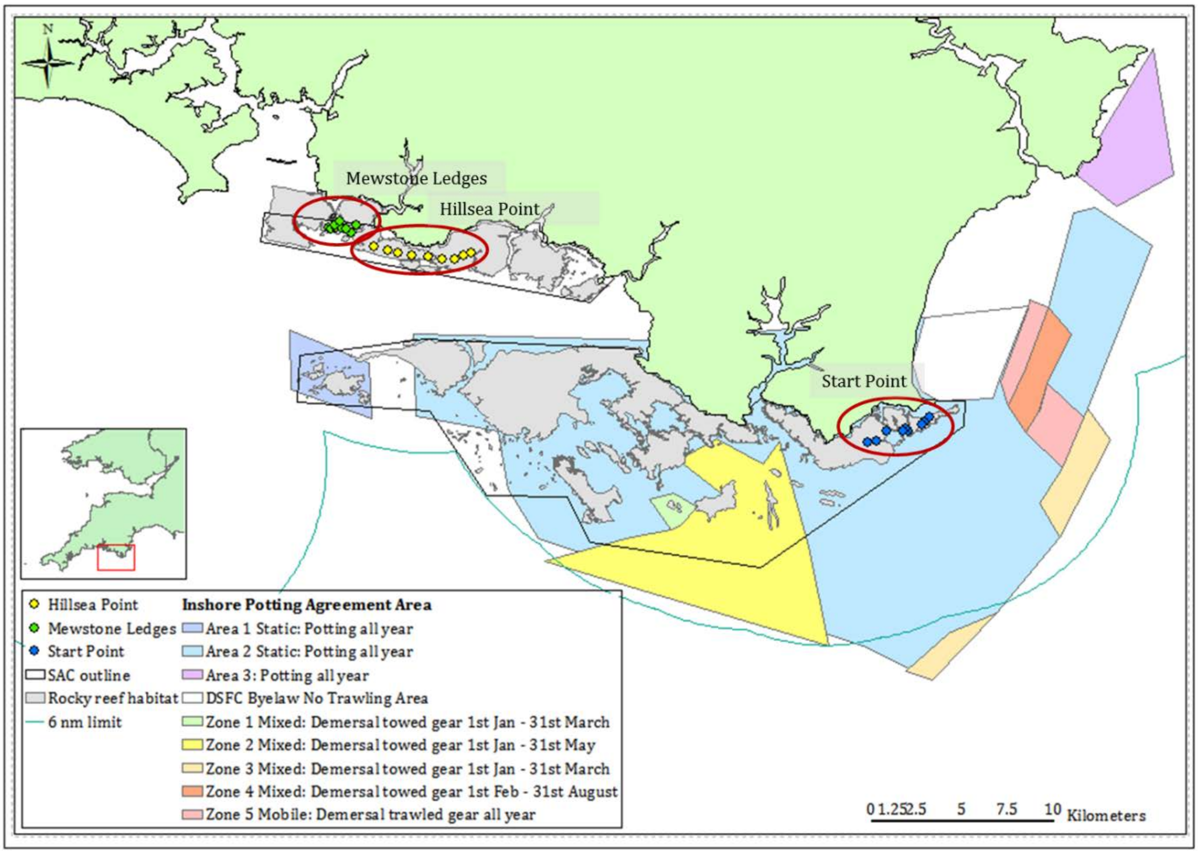


Figure 2.4: Map of the survey site showing the locations for the potting fieldwork showing sites at Mewstone Ledges, Hillsea Point and Start Point. Map created using ArcGIS, 2016

At each survey location, different vessels were used, at Start Point, work was conducted from the fishing vessels Superb-Us, a 12 m trawler, and at Mewstone Ledges and Hillsea Point the fishing vessel Violet-May a 6.5 m Cygnus GM and a University research vessel, Aquatay an 11.5 m Aquastar were used. Surveys were conducted in a variety of sea states and over the tidal cycle to be representative of true fishing conditions.

The strings of pots were set up as they would be under normal fishing conditions. End weights were used to anchor each end of the string, and a leaded line joined the string to the dahn on the surface (Figure 2.5). Leaded line was also used between the pots with the exception of the Violet May where buoyant line was used for logistical reasons. Pots were deployed for 25 minutes, allowing sufficient time for the pots to settle and were then hauled and redeployed at the next site.

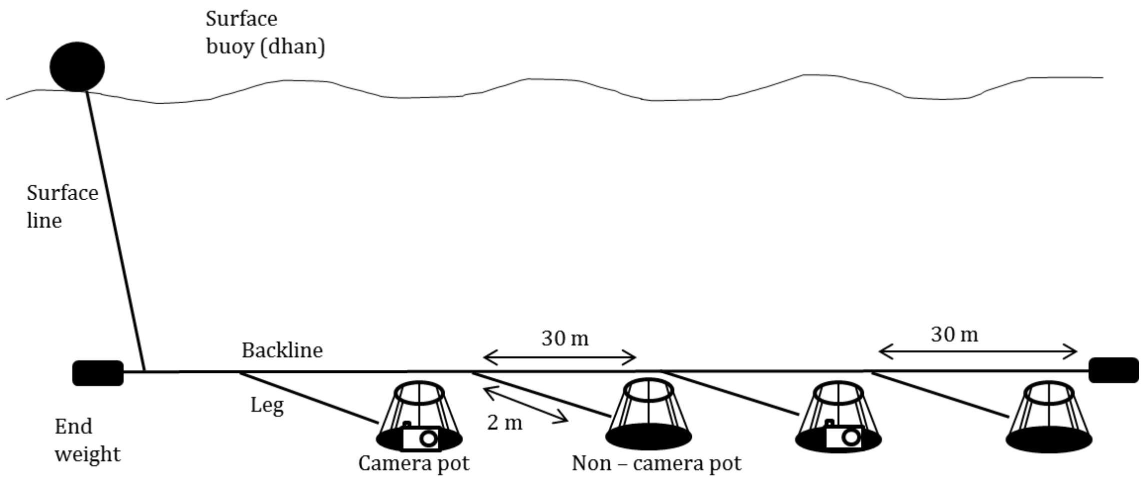


Figure 2.5: Set up of pots showing that pots 1 and 3 on the string had camera attachments and pots 2 and 4 did not. Set up of both parlour and inkwell pots on the string was identical

Each camera pot had 5 cameras mounted using Go Pro mounts and a system designed by Plymouth University technicians with help and advice from the fishers who were involved in the project. The cameras were mounted to give:

a. A bird's eye view: a view from above looking down over the pot providing a view down over the reef on descent and haul and an overview of the pot during the soak (Figure 2.6 1d & 2d and Figure 2.7f, g & h).
b. An inside view: mounted inside the pot looking in. To aid quantification of damage during the haul (Figure 2.6 1b & 2b and Figure 2.7a, b, c & d)
c. A down view: mounted inside the pot looking down through the base. To aid quantification of damage during the haul (Figure 2.6 1c & 2c)
d. A rope view: mounted on the outside of the pot where the leg attaches. To quantify damage caused by rope movement during the soak and to aid

quantification of damage during the haul (Figure 2.6 1a & 2a and Figure 2.7e)

e. A back view: in 2015 an additional camera was added looking back through the side of the pot at the opposite end to where the rope attaches to the pot. This was to aid quantification of damage during the haul (Figure 2.6 1b & 2b).

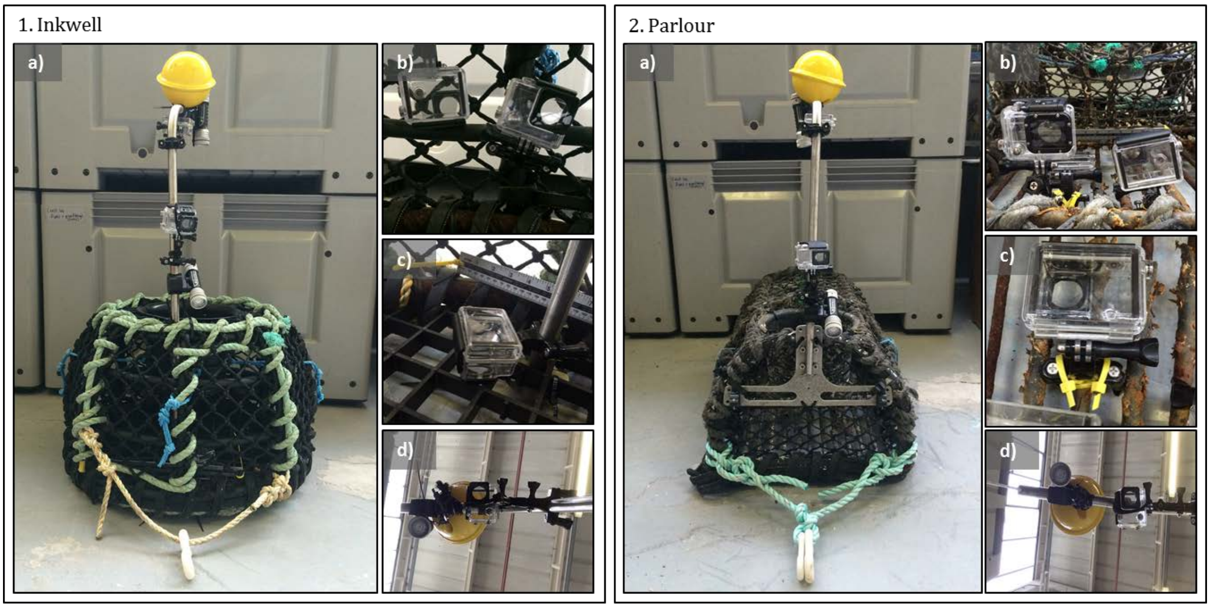


Figure 2.6: Set up of the cameras mounted on 1) an inkwell pot and 2) a parlour pot showing a) the full pot and the rope view camera, b) the back view camera (left hand side) and the inside view camera (right hand side) (for the parlour pot the door has been opened to take the photo), c) the down view camera, and d) the birds eye view camera (photo taken from the pot looking up)

The cameras used were Go Pro Hero 2, Go Pro Hero 3 and Go Pro Hero 4 Silver and Black editions (Go Pro Inc). All cameras were set to record in the 1080p, 30 frames per second mode, giving high quality footage while conserving battery life. Two Underwater Kinetics Aqualite torches were also mounted on each pot, one under the rope view camera and the other by the bird's eye camera to counteract poor light conditions (Figure 2.6 1a & 2a).

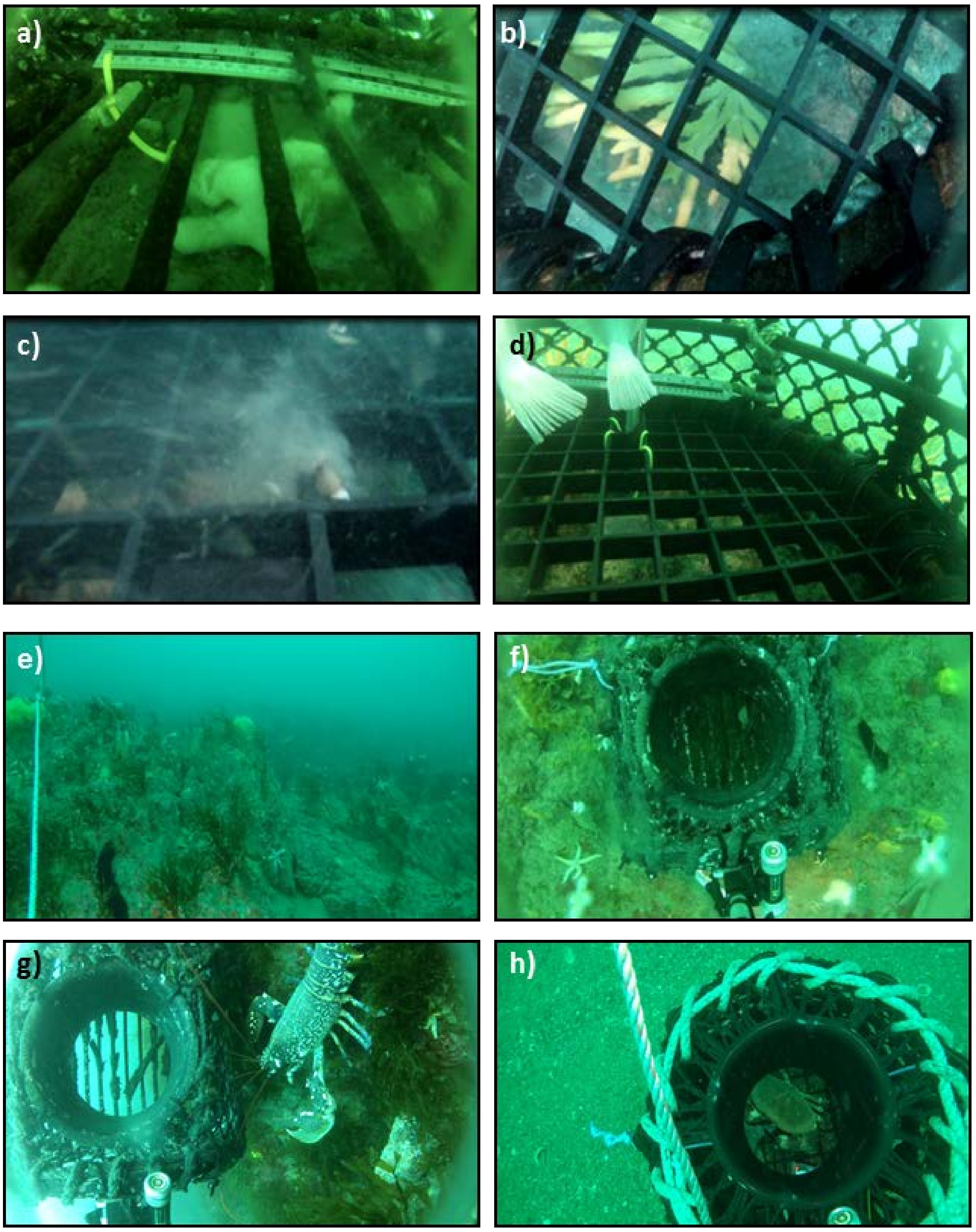


Figure 2.7: Stills taken from potting video a-c) showing benthic assemblage impacts, d) the inside view from an inkwell, e) the rope view, f) birds eye view over a parlour pot, g) *Hommarus gammarus* attracted to the pot as the haul begins, h) *Cancer pagurus* caught by an inkwell pot as the haul begins

2.2.2.2 Video analysis

HD video was watched from each camera view for each haul. Data were extracted for the metrics described in Table 2.3 (see Annex B for pot area calculations). A 10 cm buffer was added to the pot area to calculate the assumed and realised corridors as video analysis revealed that pots were often unstable as they moved across the ground during the haul, resulting in some slight rolling onto their sides.

Metric	Quantitative or qualitative	Description
Settle duration	Quantitative	Seconds from point of first contact to becoming stationary
Pot landing	Qualitative	Upright, side/end, changeable throughout soak (percentage occurrence)
Pot stability	Qualitative	No movement, occasional movement, movement throughout soak (percentage occurrence)
Haul duration	Quantitative	Seconds from first movement to clearing the reef
Assumed corridor	Quantitative	Number of 'pot distances' travelled during haul multiplied by pot area plus 10 cm buffer
Realised corridor	Quantitative	Number of pot distances travelled whilst contacting the benthos multiplied by pot area plus 10 cm buffer
Number of individuals	Quantitative	Not damaged, damaged, removed. Individuals m^{-2} in assumed corridor
Rope movement	Qualitative	No movement, minimal movement (with the tide), definite movement (percentage occurrence)

Table 2.3: metrics used to test the hypotheses relating to the mechanisms of impact and specific footprint of potting

Taxa were identified to the highest taxonomic level possible, although taxonomically similar species were grouped to avoid misidentification:

- Flustridae spp. were grouped due to the similarity in appearance of species such as *Flustra foliacea* and *Securiflustra securifrons*
- Red algae species were grouped as 'unidentified macroalgae'
- Branching sponges and massive sponges
- 'Turf' described hydroid and bryozoan turf that projected less than 1 cm from the seabed
- Hydroid and bryozoan turf - projecting > 1 cm from the seabed and forming a carpet like covering on the reef

In the case of turf and hydroid and bryozoan turf, quantification of removal and damage following pot interaction was not possible due to the difficulty of assessing the quantity of each following impact. These were therefore excluded from the analyses. Description of taxa damage is given in Table 2.4, where 'abrasion' is visible rubbing commonly resulting in clouding of the water suggesting tissue removal, and 'sections removed' where injury occurred resulting in clouding of the water and the presence of small sections of tissue in the water column. The implications of these were considered comparable and the definitions apply to interactions from both the pots and the ropes.

Species name	Common name	Phyla	Damage description
Alcyonidium diaphanum	Sea chervil	Bryozoa	Abrasion
Alcyonium digitatum	Dead Man's Fingers	Cnidaria	Abrasion and/or sections removed
Asterias rubens	Common starfish	Echinodermata	-
	Branching sponges	Porifera	Abrasion and/or sections removed
Cliona celata	Boring sponge	Porifera	Abrasion and/or sections removed
Dendrodoa grossularia	Baked bean ascidian	Chordata	Abrasion
Diazona violacea	Football ascidian	Chordata	-
Echinus esculentus	Edible sea urchin	Echinodermata	-
Eunicella verrucosa	Pink sea fan	Cnidaria	Abrasion
Flustridae	Bryozoans	Bryozoa	Abrasion and/or sections removed
Gymnangium montagui	Yellow feathers	Cnidaria	Abrasion and/or sections removed
Holothuria forskali	Cotton spinner	Echinodermata	-
Laminaria digitate	Kelp	Algae	Abrasion and/or sections removed
	Macroalgae	Algae	Abrasion and/or sections removed
Mathasterias glacialis	Spiny starfish	Echinodermata	Abrasion and/or damage to a leg
	Massive sponges	Porifera	Abrasion and/or sections removed
Nemertesia antennina	Sea beard	Cnidaria	Abrasion and/or sections removed
Pentapora fascialis	Ross coral	Bryozoa	Abrasion and/or sections removed

Table 2.4: Description of the damage caused to the taxa present in the haul corridor during pot hauling. No description is given for the species which suffered no damage.

2.2.2.3 Indicator taxa

Long lived and slow growing taxa were selected from the species data as indicator taxa as they would be most susceptible to damage from pot interaction.

Information was gathered from the work of Jackson et al. (2008) and Langmead et al. (2010) who assessed the potential long-term effects of fisheries closures on the recoverability of long lived, sessile species found on rocky reefs. Four species were identified from this work that were present here, *Alcyonium digitatum* (Dead Man's Fingers), *Cliona celata* (boring sponge), *Eunicella verrucosa* (Pink Sea Fan), and *Pentapora foliacea* (Ross coral), (Table 2.5). These taxa were selected as indicators, along with grouped branching sponges due to their erect structure and potential fragility when considering the impact of potting (Coleman et al. 2013).

	Fragility	Regeneration	Maturity	Fecundity	Larval dispersal potential	Lifespan	Growth
Alcyonium digitatum	Fragile	Yes	3-5 years	2-200 k	> 10 km	> 11 years	< 1cm/yr
Cliona celata	Intermediate	Yes	3-5 years	2-200 k	0.1-1 km	> 11 years	> 5cm/yr
Eunicella verrucosa	Intermediate	No	3-5 years	2-200 k	0.1-1 km	> 11 years	< 1cm/yr
Pentapora foliacea	Fragile	No	1-2 years	2-200 k	0.1-1 km	6-10 years	1-3 cm/yr

Definitions
Fragility = the propensity to suffer damage from a physical impact
Regeneration = the capacity for partial or whole regrowth or regeneration
Maturity = the time taken to reach reproductive maturity from birth
Fecundity = the average number of offspring per reproductive episode
Larval dispersal potential = the potential horizontal distance larvae may travel before settling
Lifespan = the potential maximum time from birth to death
Growth rate = the average increase in width/length per unit time over the whole lifespan

Table 2.5: Life history traits for the long lived and slow growing species identified from the video analysis. Trait information and definitions taken from Langmead et al. (2010). No life history traits are available for grouped branching sponges

2.2.2.4 Data analysis

Multivariate and univariate analyses were conducted using Permutational Multivariate Analysis of Variance (PERMANOVA+, (Anderson 2001; Clarke and Warwick 2001)) based on similarity matrices using PERMANOVA+ for Primer in PRIMER 6 (Clarke and Warwick 2001). Multivariate data were square root transformed and Bray Curtis similarity indices were used to construct similarity matrices. Univariate data were untransformed and Euclidean dissimilarity indices were used to conduct similarity matrices (Clarke and Warwick 2001). Each term in the analyses used 9999 permutations of the appropriate units (Anderson and Braak 2003).

Three random factors, Year (2014, 2015), Location (Start Point (SP), Mewstone Ledges (ML), Hillsea Point (HP)), and Site (1-9 nested in Location) and one fixed factor Pot Type (Parlour (P), Inkwell (I)) were used in the analysis. To test whether the number of individuals not damaged was significantly greater than the number of individuals damaged or removed in the assumed corridor, a repeated measures approach to ANOVA was used with the additional random factor Corridor (1-102), nested in Year, Pot type and Site (added as the measures of individuals not damaged, damaged and removed were taken from the same impact corridor (Bob Clarke, pers. comm.)), and the fixed factor Response (No Damage (ND), Damaged (D) and Removed (R). The lowest significant effect was interpreted for each test ($P < 0.05$) and significant interactions involving fixed factors were interpreted using pairwise tests.

2.3 Results

2.3.1 Benthic condition

Thirty tows were completed successfully in 2013 and 2015, but in 2014 survey conditions resulted in 3 tows being unusable and therefore only 27 were analysed. A total of 91 taxa were recorded from nine phyla. Hydroids had the greatest mean abundance (181.72 ind. m^{-2} ± 12.32) followed by the brittlestar *Ophiothrix fragilis* (121.77 ind. m^{-2} ± 38.36), the ascidian *Dendrodoa grossularia* (26.73 ind. m^{-2} ± 10.26) and the soft coral, *Alcyonium digitatum* (24.93 ind. m^{-2} ± 3.49). The taxon with the greatest cover was turf (13.44 m^{-2} % ± 1.38).

2.3.1.1 Abundance of count and cover individuals

Abundance of count individuals was consistently greater in the Static than the Mixed treatment (Static = 549.41 ind. m^{-2} ± 54.86, Mixed = 260.45 ind. m^{-2} ± 16.24). It was greatest in the Static treatment in 2015 (618.58 ind. m^{-2} ± 70.66) and lowest in the Mixed treatment in 2013 (223.13 ind. m^{-2} ± 39.51), (Figure 2.8a).

A significant Treatment effect was identified for the abundance of cover individuals $P < 0.05$, Annex A, Table A2). Similarly, the abundance of cover individuals was significantly greater in the Static than Mixed treatment (Static = 16.88 m^{-2} % ± 1.75, Mixed = 8.73 m^{-2} % ± 2.16). It was greatest in the Static treatment in 2015 (18.99 m^{-2} % ± 3.50) and lowest in the Mixed treatment in 2015 (3.58 m^{-2} % ± 1.13) (Figure 2.8b).

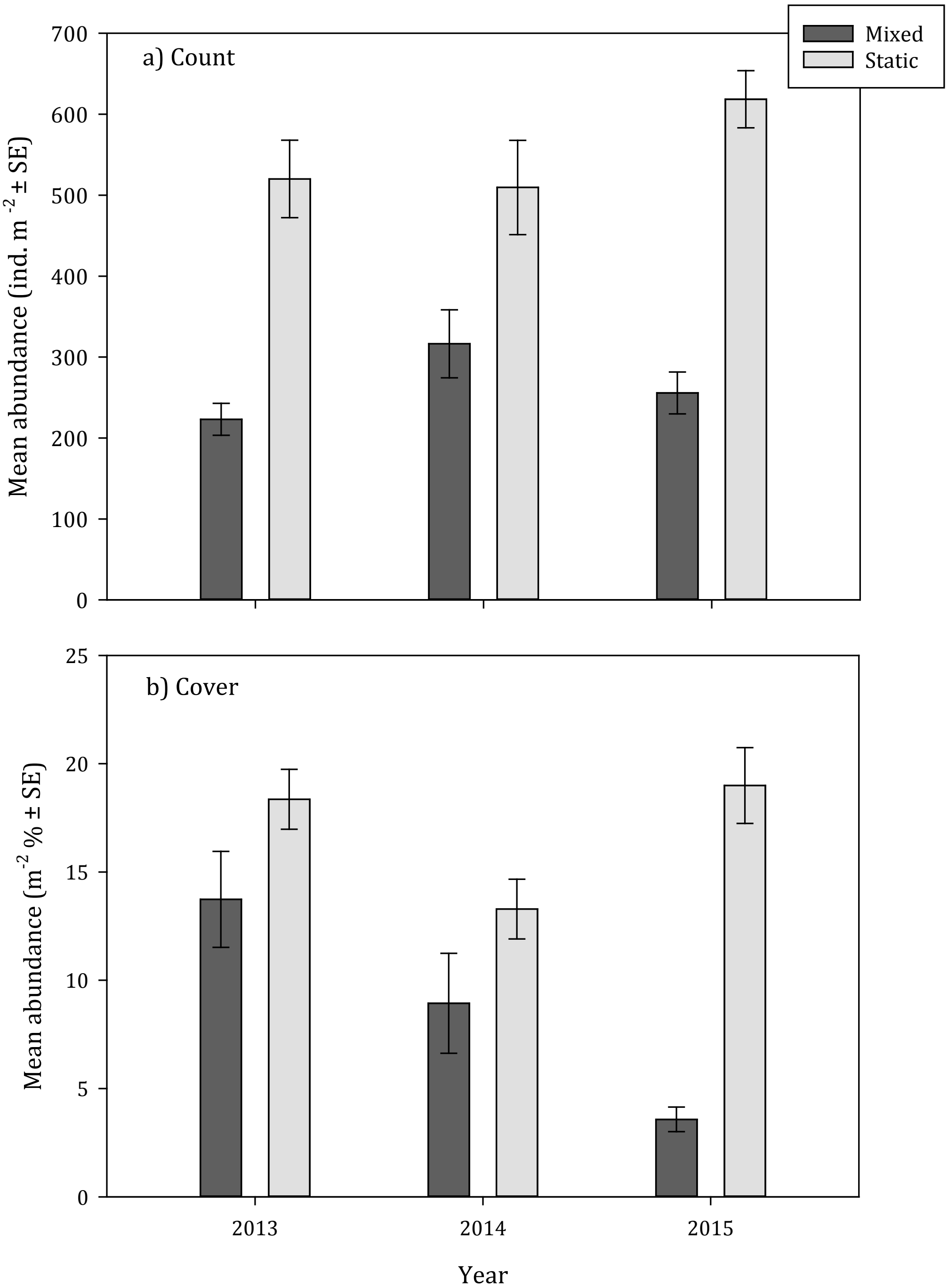


Figure 2.8: Mean abundance of a) Count (individuals m^{-2} ± SE) and b) Cover (m^{-2} % ± SE) individuals in the Static and Mixed treatments per year (2013, 2014, 2015).

2.3.1.2 Number of taxa

Number of taxa was consistently greater in the Static treatment (Static = 20.37 m^{-2} ± 0.35, Mixed = 17.00 m^{-2} ± 0.49), (Figure 2.9) (Annex A, Table A3).

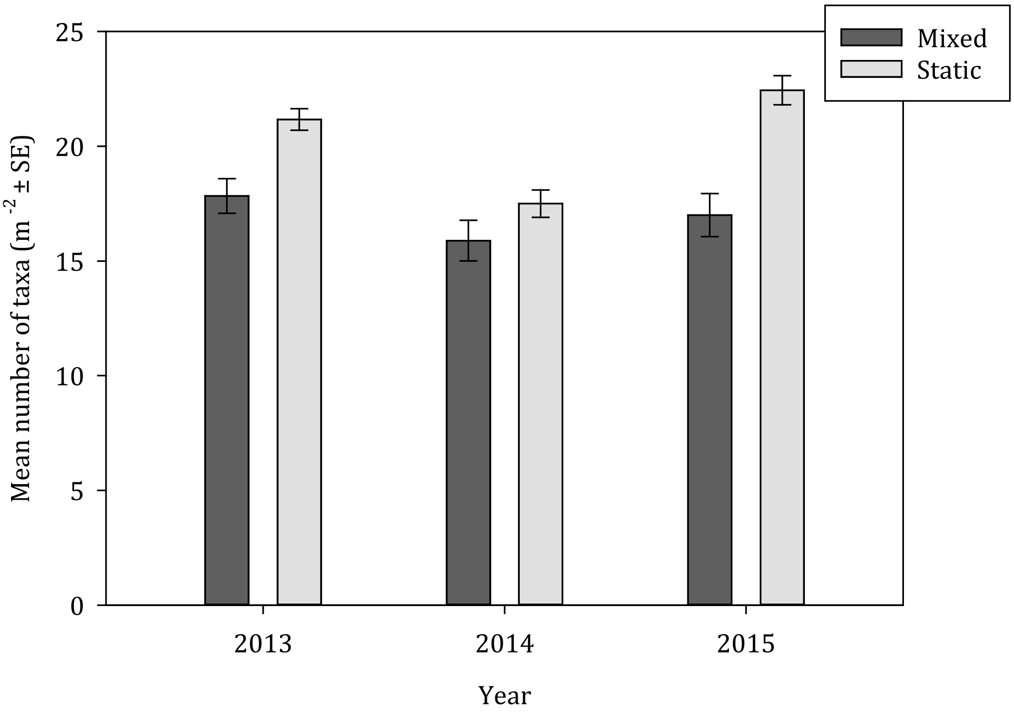


Figure 2.9: Mean number of taxa (m^{-2} ± SE) in the Static and Mixed treatments by year (2013, 2014, 2015).

2.3.1.3 Diversity

Diversity was greater in the Static than the Mixed treatment (Static = 0.54, Mixed = 0.49), but no Treatment effect was identified (Annex A, Table A3).

2.3.1.4 Assemblage composition

Despite significant temporal and spatial variation, a significant treatment effect was identified for assemblage composition ($P < 0.05$, Table 2.6, Figure 2.10).

Source	df			
		MS	Pseudo-F	P(perm)
Ye	2	3812.80	3.16	**0.0002**
Tr	1	13717.00	1.82	**0.04**
Lo(Tr)	8	6373.50	2.80	**0.0001**
YexTr	2	1833.80	1.55	0.07
Si(Lo(Tr))	20	1326.90	1.68	**0.0001**
YexLo(Tr)	16	1178.60	1.50	**0.0004**
Res	37	787.55		
Total	86			

Table 2.6: PERMANOVA to test the differences in assemblage composition between Years (2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in Location) and Treatments (Static, Mixed). Data were dispersion weighted and fourth root transformed prior to the construction of a Bray Curtis resemblance matrix. Bold values indicate significant differences.

Figure 2.10 shows two distinct groupings, sites in the static treatment were more similar to each other than to the sites in the mixed treatment, although some overlap occurred between them.

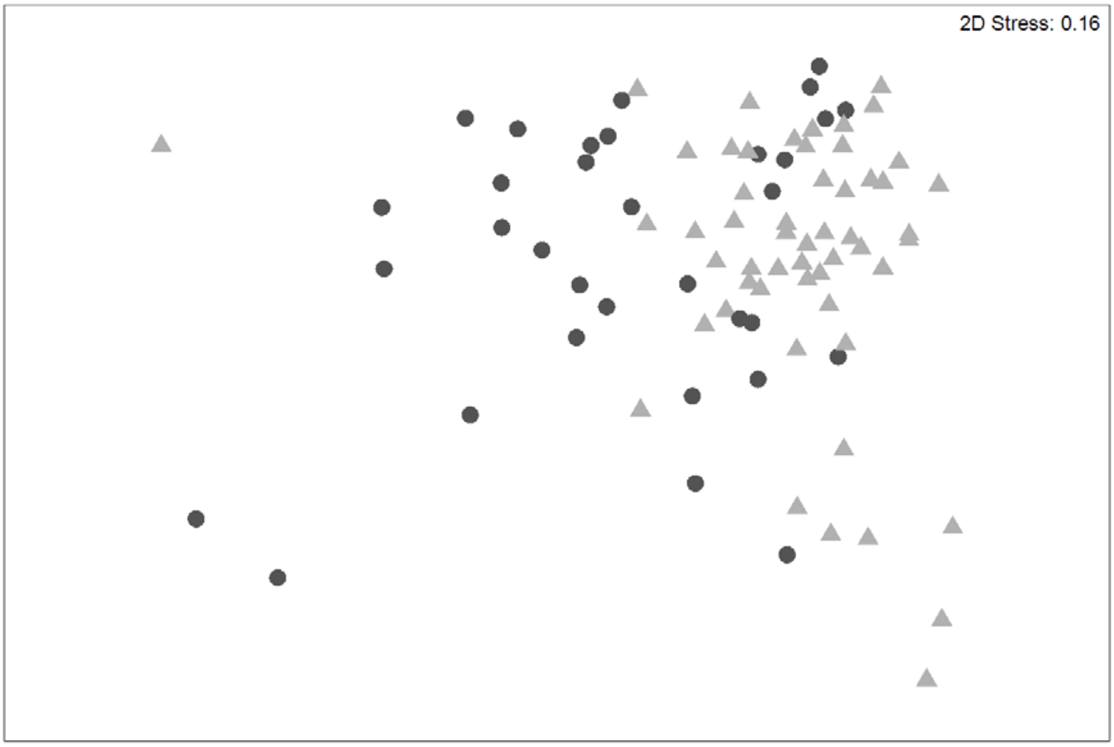


Figure 2.10: nMDS ordination illustrating similarities in assemblage composition between Treatments (Static = triangles, Mixed = circles)

Results of SIMPER showed the distinction between Treatments was driven by differences in the abundance of hydroid and bryozoan turf, *A. digitaum (*Dead Man’s fingers), hydroids, and *Alcyonidium diaphanum* (Sea chervil).

Static		Mixed	
Unidentified hydroid species	**205.38 ± 16.28**	Unidentified hydroid species	143.01 ± 16.80
Ophiothrix fragilis	**166.86** ± 59.42	*Ophiothrix fragilis*	47.98 ± 24.17
Dendrodoa grossularia	**41.95 ± 16.23**	*Alcyonidium diaphanum*	**16.85 ± 7.79**
Alcyonium digitatum	**36.31 ± 4.95**	Unidentified bryozoan species	**12.53 ± 3.58**
Corynactis viridis	**19.25 ± 7.12**	Turf	8.64 ± 2.14
Turf	**16.37 ± 1.70**	*Alcyonium digitatum*	6.30 ± 1.72
Alcyonidium diaphanum	15.76 ± 2.69	*Ophiocomina nigra*	3.80 ± 1.38
Ophiocomina nigra	**14.50 ± 3.29**	*Nemertesia antennina*	3.78 ± 0.89
Unidentified bryozoan species	11.84 ± 2.74	*Cellepora pumicosa*	**3.04 ± 1.36**
Nemertesia antennina	**7.16 ± 1.02**	*Metridium senile*	**2.67 ± 1.38**

Table 2.7: Summary table showing the top ten most abundant taxa (ind. m^{-2} ± SE) in the Static and Mixed treatments. Bold type denotes greater abundance

Assemblages in the Static treatment varied across the study area, but were characterised by sessile benthic species such as *D. grossularia*, *A. digitatum* and *C. viridis* (Table 2.7, Figure 2.11). By contrast, assemblages in the Mixed treatment were characterised by species such as *A. diaphanum*, *O. fragilis* and unidentified hydoids, while abundance of brittlestars *Ophiothrix fragilis* and *Ophiocomina nigra* were high across both treatments. (Table 2.7, Figure 2.11).

Figure 2.11: a), b), c) frames taken from towed video in the Static treatment and d), e), f) frames taken from towed video filmed in the Mixed treatment, showing differences in assemblage composition

Taxa present in a greater abundance in the Mixed treatment tended to be scavenging, mobile species, such as *Pagurus bernhardus*, *Asterias rubens*, *Inachus* spp. and *Macropodia* spp. When considering the top ten taxa, individuals were more abundant in the Static treatment (Table 2.7).

2.3.1.5 Indicator taxa

Abundance of indicator species was greatest for *A. digitatum* (24.93 ind. m^{-2} ± 3.50) and *A. diaphanum* (16.17 ind. m^{-2} ± 3.37) and lowest for *P. foliacea* (0.25 ind.

m^{-2} ± 0.05). Abundance was greatest in the Static treatment for all but one indicator, *M. senile* (Table 2.8, Figure 2.12). Treatment effects were identified for *A. digitatum*, *C. celata* and *M. senile* and as with assemblage composition some variation was observed between random factors for most indicators.

	Mixed	Static
Alcyonidium diaphanum	16.85 ind. m^{-2} ± 7.79	15.76 ind. m^{-2} ± 2.69
Alcyonium digitatum	6.30 ind. m^{-2} ± 1.72	**36.31 ind. m^{-2} ± 4.95**
Branching sponges	0.33 ind. m^{-2} ± 0.12	1.35 ind. m^{-2} ± 0.29
Cliona celata	0.02 ind. m^{-2} ± 0.02	**0.47 ind. m^{-2} ± 0.10**
Eunicella verrucosa	1.58 ind. m^{-2} ± 0.69	2.21 ind. m^{-2} ± 0.72
Metridium senile	**2.67 ind. m^{-2} ± 1.38**	0.01 ind. m^{-2} ± 0.01
Pentapora foliacea	0.18 ind. m^{-2} ± 0.09	0.29 ind. m^{-2} ± 0.06
Urticina felina	0.85 ind. m^{-2} ± 0.38	1.29 ind. m^{-2} ± 0.32

Table 2.8: Summary table showing number of individuals (ind. m^{-2} ± SE) for indicator species in Mixed and Static treatments. Bold type denotes where this is significantly greater

Alcyonidium diaphanum

Abundance of *A. diaphanum* was slightly greater in the Mixed (16.85 ind. m^{-2} ±7.79) than the Static treatment (15.76 ind. m^{-2} ± 2.69), (Table 2.8), but no significant treatment effects were identified (Annex A, Table A4).

Alcyonium digitatum

Abundance of *A. digitatum* was significantly greater in the Static (36.61 ind. m^{-2} ± 4.95) than the Mixed (6.30 ind. m^{-2} ± 1.72) treatment (Table 2.8), ($P < 0.05$, Annex A, Table A4).

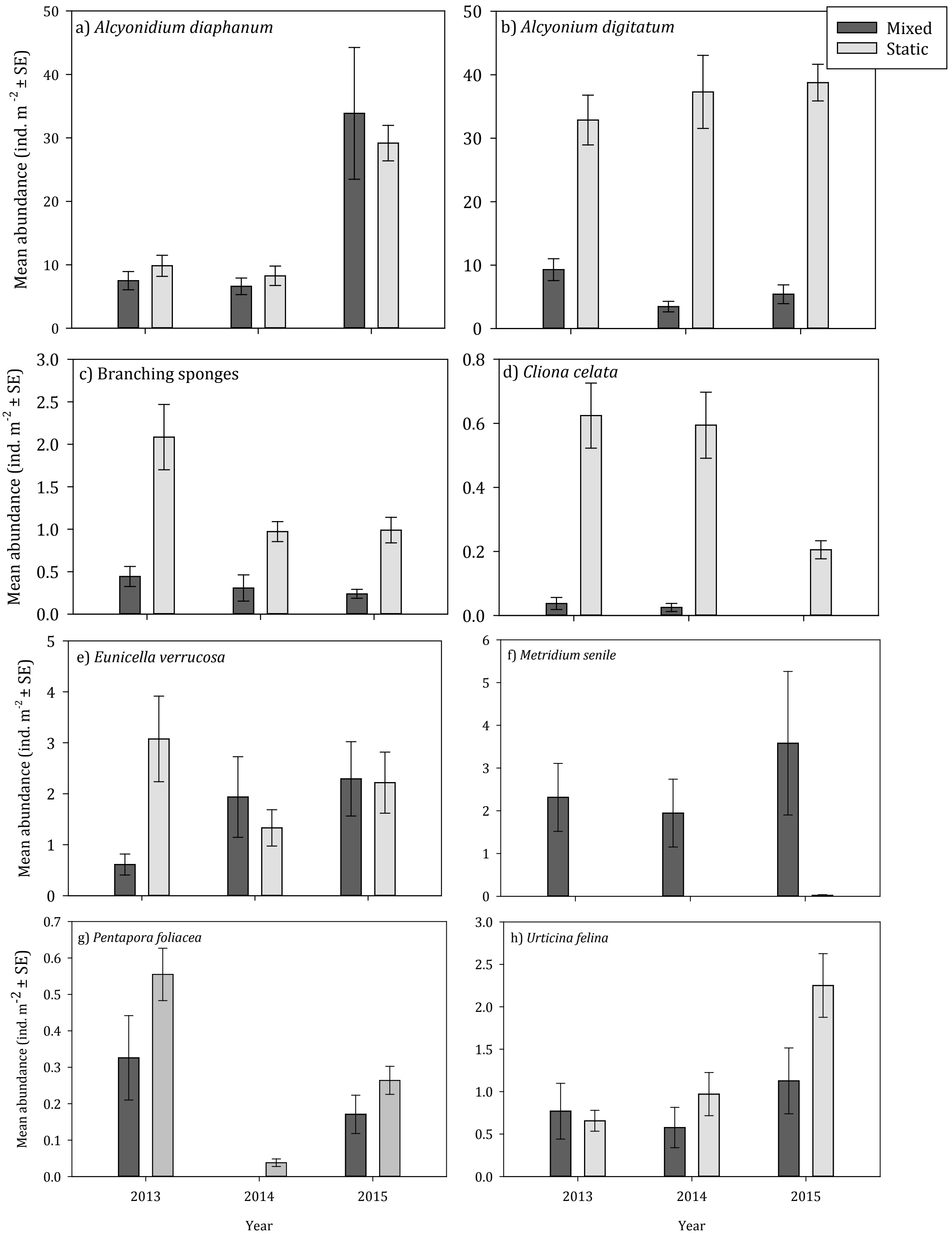


Figure 2.12: Mean number of individuals (individuals m^{-2} ± SE) of indicator species a) *Alcyonidium diaphanum*, b) *Alcyconium digitatum*, c) Branching sponges, d) *Cliona celata*, e) *Eunicella verrucosa*, f) *Metridium senile*, g) *Pentapora foliacea* and h) *Urticina felina* by Treatment (Mixed, Static) and Year (2013, 2014, 2015).

Branching sponges

Abundance of branching sponges was greater in the Static treatment than the Mixed treatment (Static = 1.35 ind. m^{-2} ± 0.29; Mixed = 0.33 ind. m^{-2} ± 0.12) although this difference was not significant (Table 2.8), (Annex A, Table A4).

Cliona celata

Abundance of *C. celata* was significantly greater in the Static treatment than the Mixed treatment (Static = 0.47 ind. m^{-2} ± 0.10; Mixed = 0.02 ind. m^{-2} ± 0.02), (Table 2.8), ($P < 0.05$, Annex A, Table A4).

Eunicella verrucosa

No significant treatment effects were identified for *E. verrucosa*, but abundance was greater in the Static treatment than the Mixed (Static = 2.21 ind. m^{-2} ± 0.72; Mixed = 1.58 ind. m^{-2} ± 0.69, Table 2.8, Annex A, Table A4).

Metridium senile

Abundance of *M. senile* was significantly greater in the Mixed treatment, with very few individuals present in the Static treatment (Static = 0.01 ind. m^{-2} ± 0.01; Mixed = 2.67 ind. m^{-2} ± 1.38, Table 2.8), ($P < 0.05$, Annex A, Table A4).

Pentapora foliacea

Abundance of *P. foliacea* was low across the study area, but was greatest in the Static treatment (Static = 0.29 ind. m^{-2} ± 0.06; Mixed = 0.18 ind. m^{-2} ± 0.09, Table 2.8). No significant treatment effects were identified (Annex A, Table A4).

Urticina felina

Abundance of *U. felina* was greater in the Static treatment than the Mixed (Static = 1.29 ind. m^{-2} ± 0.32, Mixed = 0.85 ind. m^{-2} ± 0.38, Table 2.8), but no significant treatment effects were identified (Annex A, Table A4).

2.3.2 Mechanisms and true footprint

Pots took an average of 3.46 seconds (± 0.27) to settle, with Inkwell pots taking 3.29 seconds (± 0.35) and Parlour pots taking 3.63 seconds (± 0.42). The majority of pots (82.5 %) landed upright, with more parlour than inkwell pots landing on end (Parlour = 17.82 %, Inkwell = 4.04 %), as would be expected due to their design. Pots were relatively stable (No movement = 86.36 % of soaks), with some occasional movements (8.08 % of soaks), which were very sporadic and small. Only one pot made large movements throughout the soak.

The pots took 41 seconds (± 3.24) to haul. The total time that the pots moved across the seabed (rather than being stationary or off the seabed), however, was 20.71 seconds (±1.36), meaning that they were in contact with the seabed for approximately half the time it took for them to be lifted clear. Rope movement during the soak was observed for 51.02 % of soaks, although 45.91 % of the time this movement was described as minimal; where the rope moved slightly with the tide but no scour or species impacts were observed. In 4 of the 5 instances where movement occurred, the rope was in full contact with the substratum, impact where this occurred was, however, limited to abrasion of *A. digitatum* and *E. verrucosa*. No individuals of *A. digitatum* and *E. verrucosa* were removed from the reef by the rope. Five instances occurred where damage was evident from rope contact during the haul, including four occasions (3.70 % of hauls) where rope caught on *A. digitatum* causing abrasion, and removal of 2 individuals from the reef.

Despite having five cameras mounted on the pots, it became apparent that all metrics except for the rope movement were best quantified using the video from the birds eye camera. The rope view camera was used for assessing rope movement. Whilst the other three cameras provided useful observational information and contributed to the understanding of the pot movements and impacts, they were not used for data analysis.

2.3.2.1 Area of the assumed and realised corridors

The assumed haul corridor (area that could have been impacted during the haul and all taxa within it) was 6.56 m^2 ± 0.62, and the length of the realised haul corridor (area actually impacted and the taxa within it) was 3.22 m^2 ± 0.24 (49.07 % of the assumed corridor).

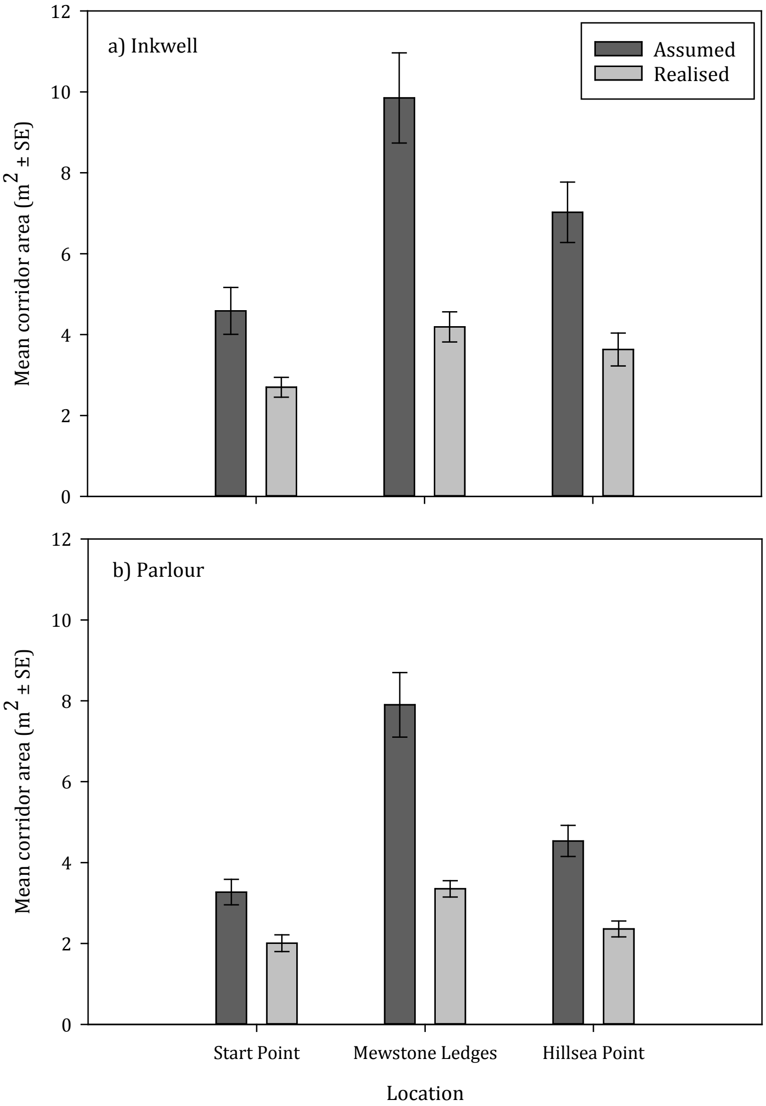


Figure 2.13: Mean assumed and realised corridor areas (m^{-2} ± SE) for a) Inkwell and b) Parlour pots on rocky reef habitat at sites in Start Point, Mewstone Ledges and Hillsea Point

Differences between pot types were apparent (Figure 2.13) with a significant Pot x Site(Location) interaction identified; assumed corridors were significantly larger than realised corridors, and these differences were greater for inkwell pots than for parlour pots (inkwell, assumed = 3.65 m^2 ± 0.80, realised = 3.51 m^2 ±0.40, parlour, assumed = 2.66 m^2 ± 0.51, realised = 2.57 m^2 ±0.24, $P < 0.05$) and were consistent between areas (Table 2.9).

Source	**df**	**MS**	**Pseudo-F**	**P(perm)**
Ye	1	3994.70	2.17	0.28
Lo	2	867.56	0.70	0.71
Po	1	962.86	1.39	0.38
Si(Lo)	24	641.58	0.77	0.74
YexLo	2	1778.10	2.14	0.14
YexPo	1	616.41	3.43	0.21
LoxPo	2	143.23	0.57	0.81
YexSi(Lo)**	23	816.47	2.63	**0.02**
PoxSi(Lo)	24	697.27	2.26	**0.04**
YexLoxPo	2	140.14	0.45	0.65
Res	19	310.21		
Total	101			

	SP	**ML**	**HP**
1			
I & P	0.48	0.25	0.25
2			
I & P	0.25	0.24	0.24
3			
I & P	-	0.49	-
4			
I & P	0.24	-	0.49
5			
I & P	0.23	0.50	0.24
6			
I & P	0.25	0.25	0.24
7			
I & P	0.52	0.50	0.26
8			
I & P	-	0.27	0.22
9			
I & P	-	0.52	0.23

Table 2.9: ANOVA to test the differences between assumed and realised corridor areas between Years (Yr, 2014, 2015), Locations (Lo, Start Point, Mewstone Ledges, Hillsea Point), Sites (1-9, nested in Location) and Pot Types (Po, Inkwell, Parlour). Pairwise tests are used to examine significant relationships between fixed factors. Data were untransformed and a Euclidean Distance resemblance matrix constructed. Bold values indicate significant differences.

2.3.2.2 Benthic impacts

A total of 18 taxa were identified from the videos, from six phyla (Table 2.10). Abundance across all sites was greatest for the solitary baked bean ascidian *Dendrodoa grossulaira* (8.46 ind. m^{-2} ± 2.95), macroalgae (2.20 ind. m^{-2} ± 0.40) and the soft coral *A. digitatum* (1.75 ind. m^{-2} ± 0.28), (Table 2.10).

	Total	Inkwell			Parlour		
		ND	D	R	ND	D	R
Alcyonidium diaphanum	0.33 ± 0.11	0.09 ±0.04	0.04 ± 0.02	0.00	0.39 ± 0.15	0.15 ± 0.06	0.003 ± 0.003
**Alcyonium digitatum*	1.75 ± 0.28	0.76 ±0.16	0.32 ± 0.09	0.11 ± 0.03	1.53 ± 0.32	0.48 ± 0.10	0.28 ± 0.11
Asterias rubens	0.11 ± 0.03	0.06 ± 0.02	0.00	0.00	0.16 ± 0.05	0.00	0.00
*Branching sponges	0.18 ± 0.06	0.06 ± 0.02	0.06 ± 0.02	0.00	0.19 ±0.10	0.04 ± 0.02	0.00
**Cliona celata*	0.10 ± 0.02	0.04 ± 0.01	0.05 ± 0.02	0.001 ± 0.001	0.08 ± 0.04	0.02 ± 0.01	0.001 ± 0.001
Dendrodoa grossularia	8.46 ± 2.95	6.34 ± 3.39	3.88 ± 2.24	0.01 ± 0.01	4.43 ± 1.16	2.10 ± 0.97	0.15 ± 0.14
Diazona violacea	0.003 ± 0.002	0.00	0.00	0.00	0.01 ± 0.00	0.00	0.00
Echinus esculentus	0.03 ± 0.01	0.02 ±0.01	0.00	0.00	0.04 ± 0.02	0.00	0.00
**Eunicella verrucosa*	0.12 ± 0.03	0.06 ± 0.02	0.07 ± 0.02	0.00	0.08 ± 0.03	0.04 ± 0.02	0.00
Flustra foliacea	0.22 ± 0.10	0.07 ± 0.04	0.05 ± 0.03	0.00	0.22 ± 0.14	0.10 ± 0.05	0.00
Gymnangium montagui	0.005 ± 0.005	0.00	0.00	0.00	0.00	0.01 ± 0.01	0.00
Holothuria forskali	0.09 ± 0.02	0.08 ±0.03	0.00	0.00	0.10 ± 0.03	0.00	0.00
Laminaria digitate	0.003 ± 0.003	0.01 ± 0.01	0.001 ± 0.001	0.00	0.00	0.00	0.00
Macroalgae	2.20 ± 0.40	1.56 ± 0.33	0.59 ± 0.21	0.02 ± 0.02	2.01 ± 0.62	0.22 ± 0.08	0.00
Marthasterias glacialis	0.26 ± 0.04	0.26 ±0.06	0.00	0.00	0.26 ± 0.07	0.01 ± 0.01	0.00
Massive sponges	0.13 ± 0.04	0.07 ±0.04	0.04 ± 0.02	0.00	0.11 ± 0.07	0.04 ± 0.02	0.00
Nemertesia antennina	0.23 ± 0.09	0.15 ± 0.10	0.02 ± 0.02	0.00	0.24 ± 0.14	0.05 ± 0.03	0.00
**Pentapora foliacea*	0.07 ± 0.02	0.01 ± 0.01	0.05 ± 0.02	0.002 ± 0.002	0.06 ± 0.03	0.03 ± 0.02	0.002 ± 0.002

Table 2.10: Total number of individuals (individuals m^{-2}) and number of individuals (individuals m^{-2}) Not Damaged (ND), Damaged (D) and Removed (R) during the haul. An asterix (*) denotes indicator taxa

Of the 22 taxa identified, 14 suffered damaged from pot impacts, including all five indicator taxa, and individuals of six were removed from the reef, including one indicator taxa (Table 2.10). Only four species suffered no damage or removal; the common starfish *Asterias rubens*, the football ascidian *Diazona violacea*, the edible sea urchin *Echinus esculentus* and the sea cucumber *Holothuria forskali*. Individuals of *E. esculentus*, *H. forskali* and *A. rubens* were observed to roll (*E. esculentus*) or be moved out of the way by the pressure wave from a pot. No damage was observed suggesting they may be able to withstand the gentle movement caused. During the survey no instances of direct impact were observed however. No direct contact was made with *D. violacea* and therefore no damage was caused.

Source	df	MS	Pseudo-F	P(perm)
Ye	1	16052.00	2.45	0.12
Lo	2	19696.00	1.99	**0.02**
Po	1	4754.30	1.48	0.24
Re	2	84028.00	7.33	**0.0002**
Si(Lo)	25	4963.70	1.46	**0.04**
YexLo	2	6235.00	1.80	0.09
YexPo	1	3826.90	1.07	0.43
YexRe	2	5651.70	1.64	0.16
LoxPo	2	1546.70	0.65	0.90
LoxRe	4	6123.20	1.54	**0.03**
PoxRe	2	606.50	1.06	0.45
YexSi(Lo)**	23	3397.60	No test	
PoxSi(Lo)**	24	3930.30	1.27	0.12
Si(Lo)xRe**	48	1574.40	0.96	0.63
YexLoxPo	2	3402.90	1.10	0.36
YexLoxRe	4	3324.90	2.06	**0.01**
YexPoxRe	2	964.37	0.59	0.84
LoxPoxRe	4	1315.80	0.88	0.69
YexPoxSi(Lo)*	19	3079.60	No test	
YexSi(Lo)xRe*	46	1576.30	No test	
PoxSi(Lo)xRe*	48	1286.20	0.94	0.69
YexLoxPoxRe	4	1721.90	1.26	0.21
Co(YexPoxSi(I	0		No test	
YexPoxSi(Lo)x	37	1370.20	No test	
Total	305			

** Term has one or more empty cells

	SP	ML	HP
2014			
ND & D	0.68	**0.002**	**0.003**
ND & R	**0.02**	**0.000**	**0.000**
D & R	**0.01**	**0.001**	**0.005**
2015			
ND & D	0.17	**0.001**	**0.002**
ND & R	**0.002**	**0.0002**	**0.0003**
D & R	**0.002**	**0.005**	0.06

Table 2.11: PERMANOVA to test the differences in number of individuals between Years (2014, 2015), Locations (Start Point, Mewstone Ledges, Hillsea Point) Sites (1-9), nested in Location, Corridors (1-102), nested in Year, Pot type and Site, Pot Types (Inkwell, Parlour) and Response (No Damage, Damaged and Removed. Pairwise tests are used to examine significant interactions between fixed factors. Data were square root transformed prior to the construction of a Bray-Curtis resemblance matrix. Bold values indicate significant differences

The taxa removed from the reef included two upright, branching taxa, *Alcyonidium diaphanum* and *A. digitatum*, two taxa with massive forms projecting from the reef, *C. celata* and *P. foliacea*, *D. grossularia* which attaches to the reef at its base and has a lifespan of 1-2 years (BIOTIC) and macroalgae which was observed in dense clumps at some sites and whose growth is annual.

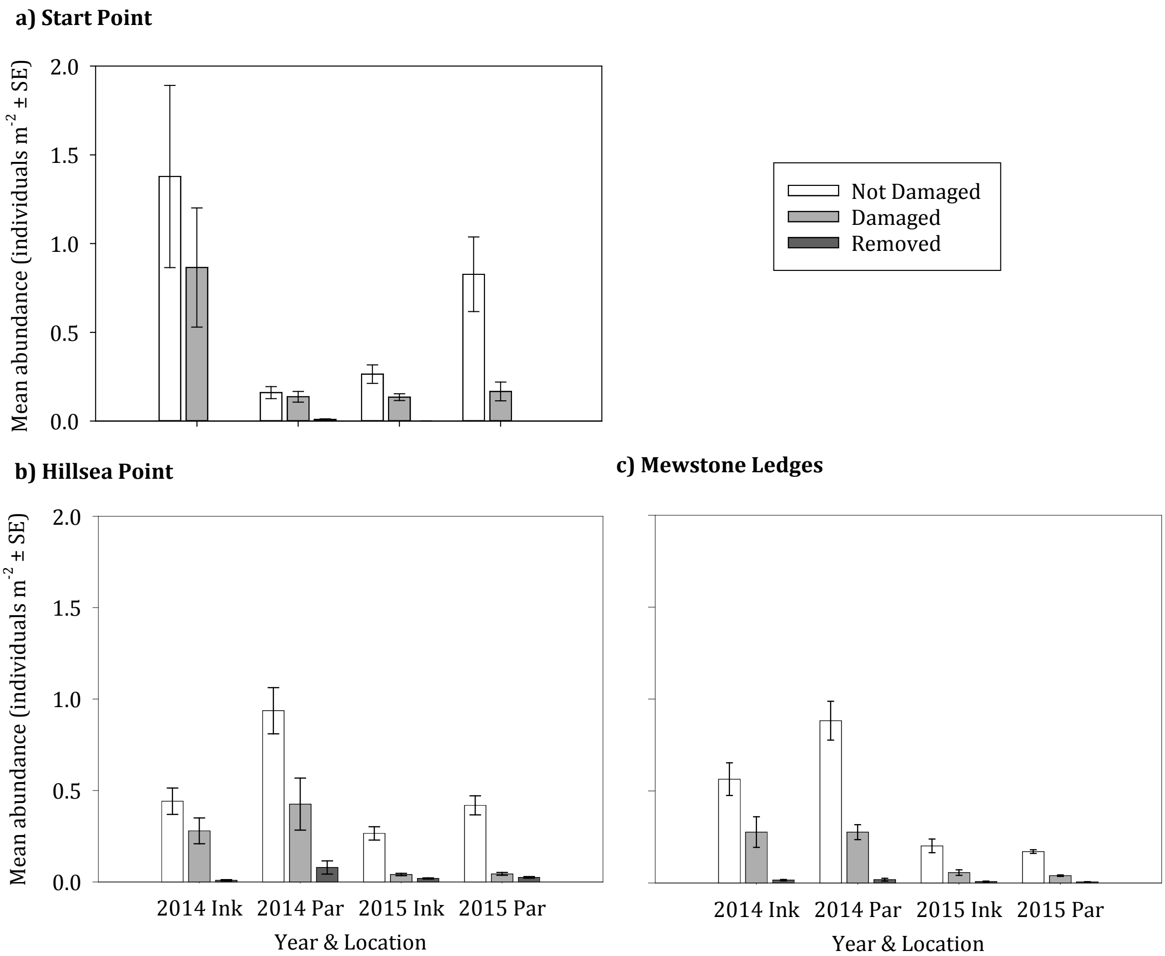


Figure 2.14: Mean number of individuals (individuals m^{-2} ± SE) Not Damaged, Damaged and Removed within assumed corridors at a) Start Point, b) Hillsea Point and c) Mewstone Ledges) in different Years (2014, 2015) and for different Pot types (Inkwell, Parlour).

The mean number of individuals was 0.79 ind. m^{-2} ± 0.17. A significant Year x Location x Response interaction was identified, and despite some spatial variation there were significantly more individuals not damaged (0.54 ind. m^{-2} ± 0.05 (68.35 %)) than damaged (0.23 ind. m^{-2} ± 0.03 (29.11 %)), not damaged than removed (removed = 0.02 ind. m^{-2} ± 0.00 (2.53 %)) and damaged than removed (Table 2.11, Figure 2.14).

2.3.2.3 Indicator taxa

Abundance of indicator taxa was greatest for *A. digitatum* (1.15 ind. m^{-2} ± 0.18) and lowest for *P. foliacea* (0.03 ± 0.01 m^{-2}) but varied between sites and years for all species (Figure 2.15). All indicator taxa were damaged during the haul, but only individuals of *A. digitatum*, *C. celata* and *P. foliacea* were removed (Table 2.11, Figure 2.15).

Alyconium digitatum

A significant Pot Type x Site(Location) interaction was identified for the response of *A. digitatum* to potting impact ($P < 0.05$, Annex B, Table B1), but no significant pairings were identified. On average, number of individuals not damaged (1.15 m^{-2} (±0.18)) exceeded the number damaged (D = 0.40 m^{-2} (± 0.07)) or removed (R = 0.20 m^{-2} (± 0.06)), (Figure 2.15).

Branching sponges

No significant differences or interactions were identified for the response of branching sponges to potting activity (Annex B, Table B1). On average, more branching sponges were damaged than not damaged (ND = 0.13 m^{-2} (± 0.05), D = 0.15 m^{-2} (± 0.01)) and none were removed. When considering the impact at different locations, variation was identified between years and locations (Figure 2.15).

Cliona celata

No significant Treatment effect was identified for the impact of potting activity on *C. celata* (Annex B, Table B1). Some damage was observed, however, with the same number of individuals damaged as not damaged (Damaged = 0.11 m^{-2} (± .22), Not damaged = 0.11 (± 0.11)), but few Removed (0.001 (± 0.01)), (and see Figure 2.15). Damage was observed where the pot caused abrasion against the sponge tissue, and where portions were removed due to the impact and movement of the pot.

Eunicella verrucosa

No significant Treatment effect was identified for the response of *E. verrucosa* to potting activity (Annex B, Table B1). Some damage was observed, however, with more individuals damaged than not (Damaged = 0.15 m^{-2} (±0.02), Not damaged = 0.07 m^{-2} ± (0.01)), but no individuals removed. Impacts were patchy with no *E. verrucosa* present at Start Point, and impacts at the other two sites mixed (Figure 2.15). Damage was limited to abrasion as the pot went past and some individuals were bent under the pot during the soak. These did not appear to be damaged however, as they righted themselves once the pot lifted clear.

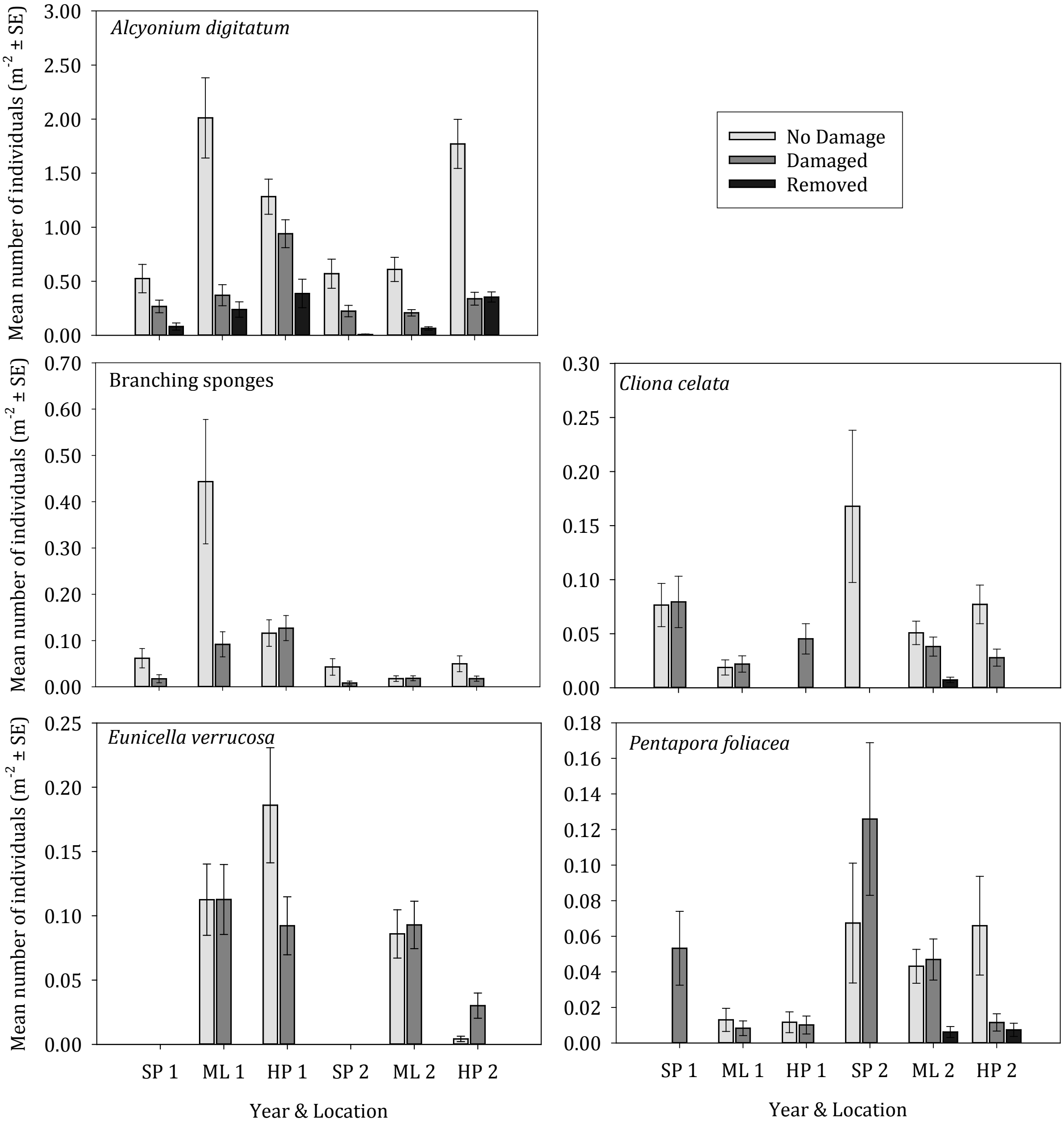


Figure 2.15: Number of individuals (individuals m^{-2} ± SE) of the 5 indicator species, *Alcyonium digitatum*, Branching sponges, *Cliona celata*, *Eunicella verrucosa*, and *Pentapora foliacea* at the different Locations (SP = Start Point, ML = Mewstone Ledges, HP = Hillsea Point) and different Year (1 = 2014, 2 = 2015). Note the scales on the Y axis vary.

Pentapora foliacea

No significant Treatment effects were identified for *P. foliacea* (Annex B, Table B1), but some damage was observed with 0.04 m^{-2} (± 0.01) damaged and 0.002 m^{-2} (±0.02) (1 individual) removed compared to 0.03 m^{-2} (±0.01) not damaged (Figure

2.15). Due to the brittle nature of *P. foliacea*, damage commonly took the form of some bits being broken off rather than abrasion.

Despite significant differences being apparent for some indicator taxa, Response was only significantly different for *A. digitatum* where there were significantly more individuals not damaged than damaged. The distribution of all indicator taxa was patchy, but it is important to note that pots were not damaging all individuals that fell within the area of impact, and instances of removal were uncommon.

2.4 Discussion

This study aimed to determine whether with the removal of trawling, potting allows for a healthy ecosystem, and to quantify the direct mechanisms and true footprint of potting. The results were intended to provide quantitative data relating to the impact of potting to aid discussions and management decisions regarding the compatibility of potting activities with achieving GES in European seas and favourable conservation status of designated habitats within MPAs. Initially they were intended to support the Habitat Regulation Assessments conducted by D&SIFCA in line with the change in approach to the management of fisheries within EMS.

Following the removal of trawling from areas within the Inshore Potting Agreement in South Devon, potting activity has continued over the last 35 years. The study found that whilst areas fished with static gear (predominantly pots) had consistently greater abundance, species richness and diversity than those open to bottom towed fishing gear, significant differences were only identified for abundance of cover taxa, with significantly greater abundance in static treatments. Spatial and temporal variation was apparent for indicator species but despite this, abundance was significantly greater at static sites for *A. digitatum* and *C. celata*. Although not significant, abundance of all other indicator species was also greater in the static treatment with the exception of *M. senile* which was limited to Location F in the Mixed treatment suggesting it may be related to factors not considered by this study.

Significant differences were identified in assemblage composition between the two treatments. Static gear areas were characterised by sessile species such as *D. grossularia*, *A. digitatum* and *C. virids* while areas open to bottom towed gear were characterised by mobile species and those that could be considered scavengers such as *P. bernhardus*, *A. rubens*, *Inachus* sp. and *Macropodia* sp.

These results are in partial agreement with those of others studies considering potting impacts (Coleman et al. 2013; Eno et al. 2001), as differences in assemblage composition were identified, but significantly greater numbers of individuals, numbers of taxa and diversity in these areas compared with those fished with mobile gear would be expected in a system that was fully functional (Tett et al. 2013). The finding of a significant difference in assemblage composition was, however, important; species characterising areas fished with static gear were more representative of fully functional benthic rocky reef areas (Beck et al. 2001; Beukers-Stewart and Beukers-Stewart 2009; Dayton et al. 1995; Jennings and Kaiser 1998; Jennings et al. 2001; Monteiro et al. 2002; Ryer et al. 2004), than those present in areas fished with bottom towed fishing gear.

Blyth et al. (2004) surveyed the IPA area in 2002 and concluded that areas fished using static gear had significantly greater species richness and biomass than sites open to bottom towed fishing gear, and Sheehan et al. (2015) identified recovery in the Lyme Bay MPA despite the continuation of potting activity. Differences in methodology and in metrics must be acknowledged when comparing results of these studies (Sheehan et al. 2016), but they suggest that external factors may be contributing to the results presented here.

When considering the mechanisms of potting interaction, it was found that the area of the assumed corridor was significantly greater than the realised corridor, and that the realised corridor was significantly greater for inkwell than for parlour pots. On average, one pot had a footprint of 3.22 $m^2 \pm 0.24$. The majority of pots landed upright and remained stationary throughout the soak, with the haul period the time where there was greatest potential for impact to taxa present on the reef. Using the assumed corridor as a metric for pot impact would therefore be inappropriate on rocky reef habitat as the area where impact occurs is significantly smaller.

Significant spatial and temporal variation was apparent, but despite this, significantly more species were not damaged within the assumed haul corridor than were damaged or removed. Damage occurred to 14 of the 22 identified taxa, and removal of individuals occurred for five taxa. With the exception of *D. violacea* which was not directly contacted by the pots, the species not damaged were sedentary but mobile. Similarly to the observations made by Eno et al. (2001) about sea pens in soft sediment, it was noted that mobile taxa were moved out of the way of the pot by the pressure wave caused as it neared the seabed, suggesting that they are less susceptible to damage than sessile species.

Damage included abrasion, and impacts such as removal of sections of the individual. In the majority of cases, few individuals were damaged, with the number not damaged outweighing that of damaged taxa. All five indicator species were damaged in some way, however; long-lived and slow growing species that were thought to be most susceptible to potting impacts and would take the longest to recover (Langmead et al. 2010).

Impacts of abrasion are not well studied, but species such as sponges and soft corals are known to be susceptible to it which may leave them vulnerable to disease (Bavestrello et al. 1997; Hiscock 2007; Shester and Micheli 2011; Wassenberg et al. 2002). Abrasion was observed for *E. verrucosa*, and research to date suggests that colonies are able to re-grow over a period of about 1 week if damaged (Hiscock 2007), but if areas of the coenenchyme covering the skeleton are scraped off and recovery does not occur promptly they may be vulnerable to colonisation by epibiota (Bavestrello et al. 1997). This could cause mechanical stress through increased resistance to water movement, and susceptibility to weakening from the burrowing activities of epibiota.

Abundance of *E. verrucosa* across the study site was patchy, but it was generally greater in the static treatment. The work of Ocean Ecology Limited (2015) who conducted a condition assessment of *E. verrucosa* in the Start Point to Plymouth and Eddystone SCI found colonies to be in good condition. This is important due to the protected nature of *E. verrucosa*, their low recoverability (Langmead et al.

2010), their listing as a UK BAP species and as vulnerable on the IUCN red list. They are important for ecosystem function, creating complex elevated surfaces available for the settlement of spat and as habitat for other organisms (Howarth et al. 2011; Jones et al. 1994). Few cases occurred where a pot landed directly on top of an individual, but where this did the results were similar to the findings of Eno et al. (2001) who found that *E. verrucosa* 'bounced back' once the pot had passed and to Shester and Micheli (2011) who found no incidence of removal of gorgonians as a result of lobster trap impact in the Gulf of Mexico.

Pots contacting ross coral *Pentapora foliacea* caused pieces to break off. This is a key species on rocky reefs with a low recoverability (Langmead et al. 2010) and is a functionally important bio-constructor playing a role in the formation of biogenic reefs (Cocito and Ferdeghini 2001; McKinney and Jackson 1989) and providing structurally complex habitat which acts as a nursery habitat for juvenile fish (Bradshaw et al. 2003). Of the 16 colonies observed, only one was removed from the reef, but their fragile and brittle structure meant that more individuals were damaged than not damaged. The longer term implications of damage are unknown, and due to the low abundance of *P. foliacea* across the study site, conclusions were not possible. Abundance was greater in the static treatment, however, suggesting that the impact of potting has a lesser effect than the impact of trawling on this species. Results from Sheehan et al. (2015) who also used *P. foliacea* as an indicator species showed increased abundance in potted areas following the exclusion of bottom towed fishing gear, suggesting that impacts from potting should be less than those from trawling.

2.4.1 Implications of the results

A significant difference was identified in assemblage composition between areas fished with pots and those fished with bottom towed fishing gear, but although numbers of individuals were greater, number of taxa and diversity were not significantly different. The intermediate disturbance hypothesis predicts that number of taxa could increase in areas open to bottom towed fishing gear as the abundance of some dominant species is reduced and there is opportunity for new species to become established, increasing the overall number of taxa present (Gray et al. 2006). This may be the case here, as more opportunistic scavengers were found in the areas open to bottom towed fishing gear than in areas where only static gear can be used. Therefore, despite there being no significant difference between treatments for some metrics, the differences in assemblage composition are important indicators of change in the areas where potting occurs, showing that they are different to the areas open to bottom towed fishing gear and suggesting that the ecosystem has reached a more healthy state (Tett et al. 2013).

The results have also shown that the area of the realised corridor was smaller than that of the assumed corridor during a pot haul, and significantly more individuals remained not damaged than were damaged or removed within the realised corridor. Furthermore, despite the footprint of an inkwell pot being greater than that of a parlour pot, no significant differences were found between pot types for the majority of other metrics. In the case of this study, inkwells did not remove or damage significantly more taxa than parlour pots.

It is apparent, however, that there are mechanisms preventing the ecosystem from reaching a fully functional state, as significant differences in number of taxa, number of individuals and diversity would be expected if this were the case (Tett et al. 2013). This is thought most likely to be due to external factors, such as natural variation, or fishing pressure at a local or regional scale altering trophic structure (Babcock et al. 1999). It is thought that the most likely impact would be from the winter storms of 2013/2014, however; with wave height in the study area reaching 5.25 m in February compared to an average annual wave height for the period 2007 – 2013 of 3.69 m (Channel Coastal Observatory 2014). The storm season prevented fishers from going to sea to retrieve their gear, so pots were left on the ground (in water depth of approximately 60 m) with many losses suffered (South Devon & Channel Shellfishermen Ltd, Pers comm.).

Whilst temporal variation was not considered by this study, it was apparent that abundance, diversity and richness were lower in 2014 than in 2013 or 2015, and whilst lacking sufficient 'before' data to test hypotheses it was thought that the storm might have contributed to these differences. In a study of Caribbean lobster traps, Lewis et al. (2009) found that movement during storms and hurricanes caused abrasion, fragmentation and removal of corals and sponges with a reduction in benthic species cover. Furthermore, a study carried out in Lyme Bay on comparable habitat into the impacts of the 2013/2014 storms which compared pre-storm data from 2008 – 2013 to post storm data from 2014 found significant reductions in abundance, diversity and richness and for selected indicator species within the MPA, with sites becoming more similar to those open to bottom towed fishing gear outside the MPA (Sheehan et al, unpublished data). It is therefore thought that impacts from the storm may have masked true differences between the treatments.

2.4.2 Limitations

This study has been able to draw conclusions about the impact of potting and whether, with the removal of bottom towed fishing gear the ecosystem is able to reach a fully functioning state, but the following limitations must be noted:

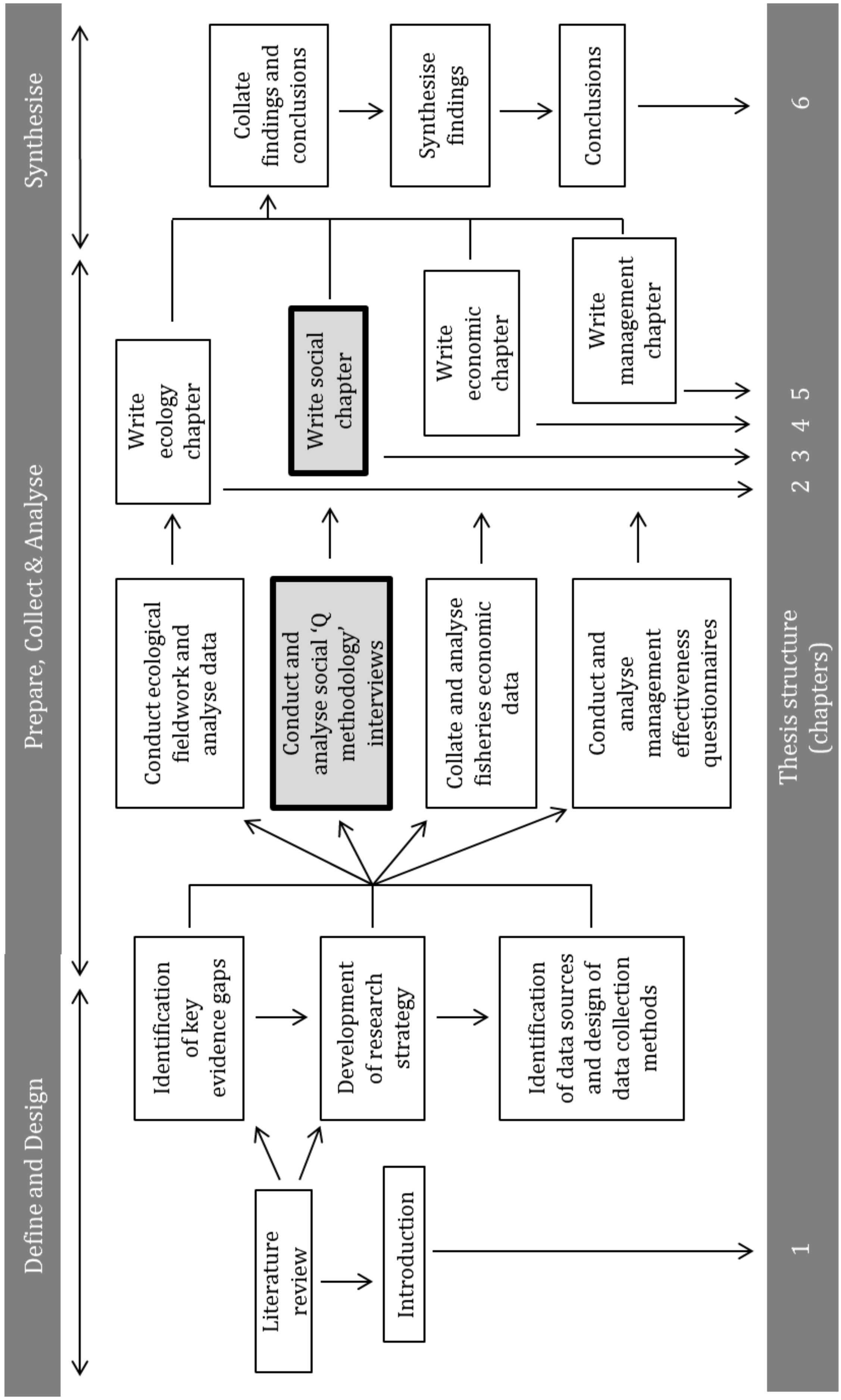
- Any application of these results to similar rocky reef habitat must take into account site by site variation and the influence of external variables.
- In order to fully understand the impacts of pot fisheries these results should be combined with other factors such as the impacts of ghost fishing, the consequences removing the target species from the ecosystem, the consequences of introducing an artificial food source to the environment, and the removal of species from the ecosystem for use as bait in the pots (e.g. Armstrong et al. 1998; Bullimore et al. 2001; Kaiser et al. 1996a; Saila et al. 2002).
- The study assumed that fishing effort was consistent across the study site and that all sites were subject either to fishing with bottom towed fishing gear or potting on a regular basis.
- The finding of no significant difference in abundance, richness and diversity of taxa in sites open to bottom towed fishing gear and those open to static gear only may be confounded by the impact of the winter storms of 2013/2014 and due to annual variation, the survey period would need to be extended to determine if this was the case.

- The pots were left to soak for 25 minutes here compared to the usual 48 hours in the study area. It is not known what the impacts may be if pots were left for this time, especially for species such as branching sponges and *E. verrucosa* which were seen to 'bounce back' following the removal of a pot.
- The catch was very limited, and pots often came up empty. It is not known whether the extra weight caused by a full catch following a 48 hours soak would increase the impacts seen.
- The length of time taken to haul the pots was slightly longer than it would be under normal fishing conditions due to the bird's eye camera arm which made recovery of the pot into the boat more difficult. It is unclear whether this would result in a difference in contact time with the seabed and this may have implications (either positive or negative) for taxa.
- This study is unable to make further assessment regarding the impact of potting at densities greater than that present within the study area or the cumulative impacts of potting. It is unknown whether the first impact would have the greatest effect or whether consecutive impacts would increase the effects identified (e.g. Collie et al. 2000; Hiddink et al. 2006). The work of Rees (In prep) regarding the impact of potting at different densities should, however, provide relevant data.

2.4.3 Conclusion

Regulators must decide what they consider to be an 'acceptable' level of impact when making decisions regarding management of fishing activities. Despite its limitations, this work has substantial policy relevance. It has provided quantitative, robust data which can be used, in combination with data on additional metrics to reach decisions regarding whether potting activity is compatible with GES and will allow MPAs to reach or maintain favourable conservation status. In the case of SCIs in the UK this is achieved through the use of Habitat Regulations Assessments (HRAs), and initially this work will support the conclusions of HRAs that have been conducted by D&SIFCA. It suggests that in the absence of bottom towed fishing gear, where potting is still permitted, ecosystems are able to recover towards a fully functional state (Tett et al. 2013). In the case of the Start Point to Plymouth Sound & Eddystone SCI, it suggests that the reef is being maintained in favourable conservation status, as required by the conservation objectives of the site despite the presence of potting activity.

Providing robust evidence is key to making well informed management decisions, and this is particularly important under the evidence based approach to decision making currently favoured by the UK government. This work has demonstrated that whilst potting does have some negative impact on some individual taxa, overall it should not negatively impact assemblage composition, and if a system is resilient then it will still be able to provide ecosystem goods and services essential to human wellbeing. This is key to ensuring that MPAs designated as multi-use can produce ecological benefits, but also that they are able to support viable fisheries providing social and economic benefits to local communities. Globally, this work is transferable to other temperate rocky reef habitats where potting pressure exists, and, with appropriate site specific considerations it can be used to inform management of fisheries in these areas. Decisions regarding future management of potting activities in MPAs must however, recognise the issue of shifting baselines in determining what characterises a fully functional ecosystem (Tett et al. 2013).



Define and Design
Prepare, Collect & Analyse
Synthesise
Literature review
Introduction
Identification of key evidence gaps
Development of research strategy
Identification of data sources and design of data collection methods
Conduct ecological fieldwork and analyse data
Conduct and analyse social 'Q methodology' interviews
Collate and analyse fisheries economic data
Conduct and analyse management effectiveness questionnaires
Write ecology chapter
Write social chapter
Write economic chapter
Write management chapter
Collate findings and conclusions
Synthesise findings
Conclusions
Thesis structure (chapters)
1
2 3 4 5
6

Chapter three: Evaluating the social acceptability of Marine Protected Areas

The aim of this chapter was to evaluate the social acceptability of Marine Protected Areas using the Devon & Severn region of the UK as a case study site.

This chapter is also published as:

Gall, S.C. & Rodwell, L.D. (2016). Evaluating the social acceptability of Marine Protected Areas. Marine Policy, 65, 30-38

3.1 Introduction

The number of Marine Protected Areas (MPAs) is growing globally, with 3.4 % of the global oceans currently protected (Juffe-Bignoli et al. 2014), and further increases required to meet the Convention on Biodiversity (CBD) Aichi Biodiversity Target 11 which calls for 10 % of coastal and marine areas to be protected through *'effectively and equitably managed, ecologically representative and well-connected systems of protected areas'* by 2020 (Convention on Biological Diversity 2011). It is not just a matter of designation though; the success of protected areas in meeting their conservation and socio-economic objectives is dependent on their effective management and enforcement which may be strongly influenced by the social acceptability of the designation.

Rossiter and Levine (2014) identified six themes that were consistently associated with MPA success, namely, level of community engagement, socio-economic characteristics, ecological factors, MPA design, governance and enforcement. It has been shown that social, cultural, economic and political factors can be more influential in shaping success than biological or physical factors (Fiske 1992; Mascia 2004; Pomeroy et al. 2007), and positive attitudes towards MPAs are necessary for successful management (Dahl 1997; Himes 2007). Considerable reliance is therefore placed on human behaviours and compliance with regulations with a clear need to promote understanding of the purpose of designation and intended site benefits; the stakeholders must 'buy-in' to the concept of the MPA and feel some ownership towards the site.

In the context of MPAs, social acceptability has been defined by Thomassin et al. (2010) as *'a measure of support towards a set of regulations, management tools or towards an organisation by an individual or a group of individuals based on geographic, social, economic or cultural criteria'*. Furthermore, they state that it is composed of a set of individual perspectives and is complex, depending on multiple opinions and perceptions, with driving factors linked to the world view held by the stakeholders. Whilst studies have evaluated the success of stakeholder participation in the planning phase (e.g. Brody 2003; Gleason et al. 2010; Voyer et al. 2012), few have looked at the attitudes of stakeholders to MPAs once they are a reality (but see Hamilton 2012; Thomassin et al. 2010). This is a key part of the ongoing monitoring of MPAs; to understand stakeholder attitudes and opinions post designation will aid the evaluation of MPA success and effective management.

3.1.1 Stakeholder impacts

It can be argued that fishers are those for which the implications of MPA designation may be most undesirable, especially where their fishing gear is incompatible with the conservation objectives of a site and they are excluded. The main impacts include displacement of effort, gear conflicts, increased fishing pressure, increased personal risk, increased costs and a loss of opportunity and employment (Rees et al. 2013b). This may cause conflict between fisheries and conservation governance streams where the impacts of MPA designation are thought to outweigh the benefits, especially where management measures are perceived to fail (e.g. Gómez et al. 2006; Suuronen et al. 2010). However, where fishers understand the implications of designation, feel that the restrictions placed on their activities are fair, and can find a way to maintain profitability, support may be stronger (e.g. Cadiou et al. 2009; Rees et al. 2013b). In multi-use MPAs, fishers whose activities are permitted within the MPA often show the greatest level of support for the site due to a reduction in conflict between gear types and the potential for economic benefit to arise from increased access to fisheries resources (e.g. Hattam et al. 2014; Mangi et al. 2011).

Other stakeholders are less likely to be negatively impacted by MPA designation and are therefore more likely to be supportive. For example, benefits may be more readily obvious to recreational sea anglers, charter boat operators and fishers whose activities are permitted within the MPA. Hattam et al. (2014) found that opinions regarding an MPA in Lyme Bay, UK varied between stakeholder groups, with the main opponents being mobile gear fishers who had been excluded from the area and static gear fishers who fished outside of the MPA and the proponents largely recreational users and static gear fishermen who fished within the MPA as they perceived the closure to be of benefit to their activities. A study by Mangi and Austen (2008) highlighted the importance of clear benefits being apparent from MPAs, as they found that support of fishers decreased over time in southern European MPAs as the expected benefits were not realised.

3.1.2 UK MPA history

The UK has a history of insufficient marine planning, with no statutory provision for the creation of MPAs in existence until 1981, and Lundy designated as the first statutory Marine Nature Reserve in 1986 (Fletcher et al. 2014; Jones 2008). Since that time, European Marine Sites (Special Areas of Conservation and Special Protection Areas) have been designated under the Natura 2000 agreement, but no framework for the development of a network of MPAs existed until the Marine and Coastal Access Act, 2009 (MCAA). Since 2009, England, Wales, Northern Ireland and Scotland have begun their own independent processes to establish MPAs within their waters.

In England, the MCAA led to the formalisation of the English Marine Conservation Zone (MCZ) project which was established in 2008. This involved a combination of top down and bottom up approaches, with guidance provided by the UK Government, Defra (Department for Food and Rural Affairs), the Statutory Nature Conservation Bodies (SNCBs) and the involvement of multi-sectoral stakeholder collaboration under four Regional Projects (Figure 1). The aim was *'to develop an ecologically coherent and well-managed network of MPAs that is well understood and supported by sea-users and other stakeholders'* (Defra 2010). Extensive stakeholder consultation and engagement was incorporated into the process, intended to bring a strategic, regional approach to marine conservation planning and increase stakeholder participation (Lieberknecht et al. 2013).

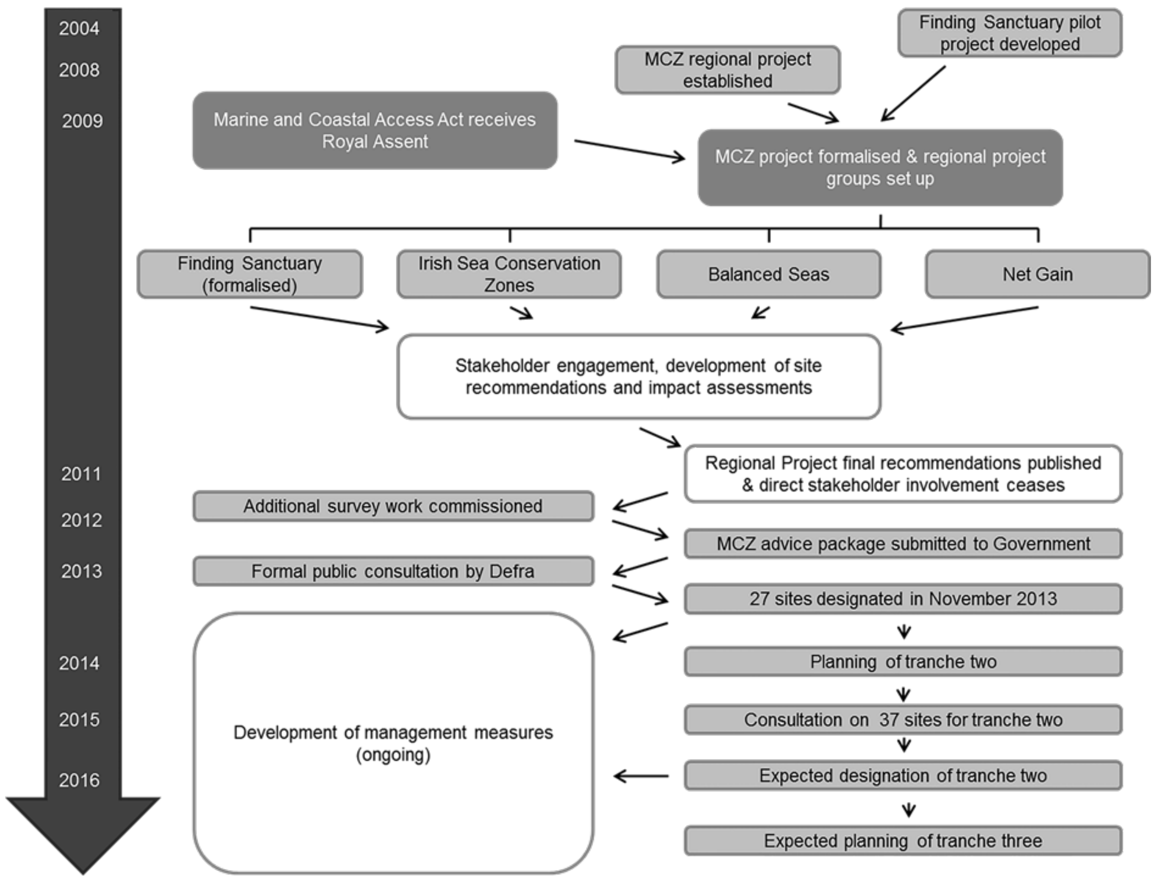


Figure 3.1: Time line for the UK Marine Conservation Zone project. Data source: Natural England and JNCC (2012)

MCZs are multi-use MPAs, which should have management in place for activities that are deemed to be damaging to the features for which the site is designated. The regional projects recommended 127 MCZs; a first tranche of 27 was designated in November 2013 and consultation ended in April 2015 for a second tranche of 23 with a date for designation as yet unknown (correct at time of writing, Figure 3.1, Figure 3.2). As MCZs are a type of MPA the two terms are used throughout this study; MCZ is used for sites designated under the MCZ project, and MPA is used as an umbrella term or when referring to sites designated outside of this project.

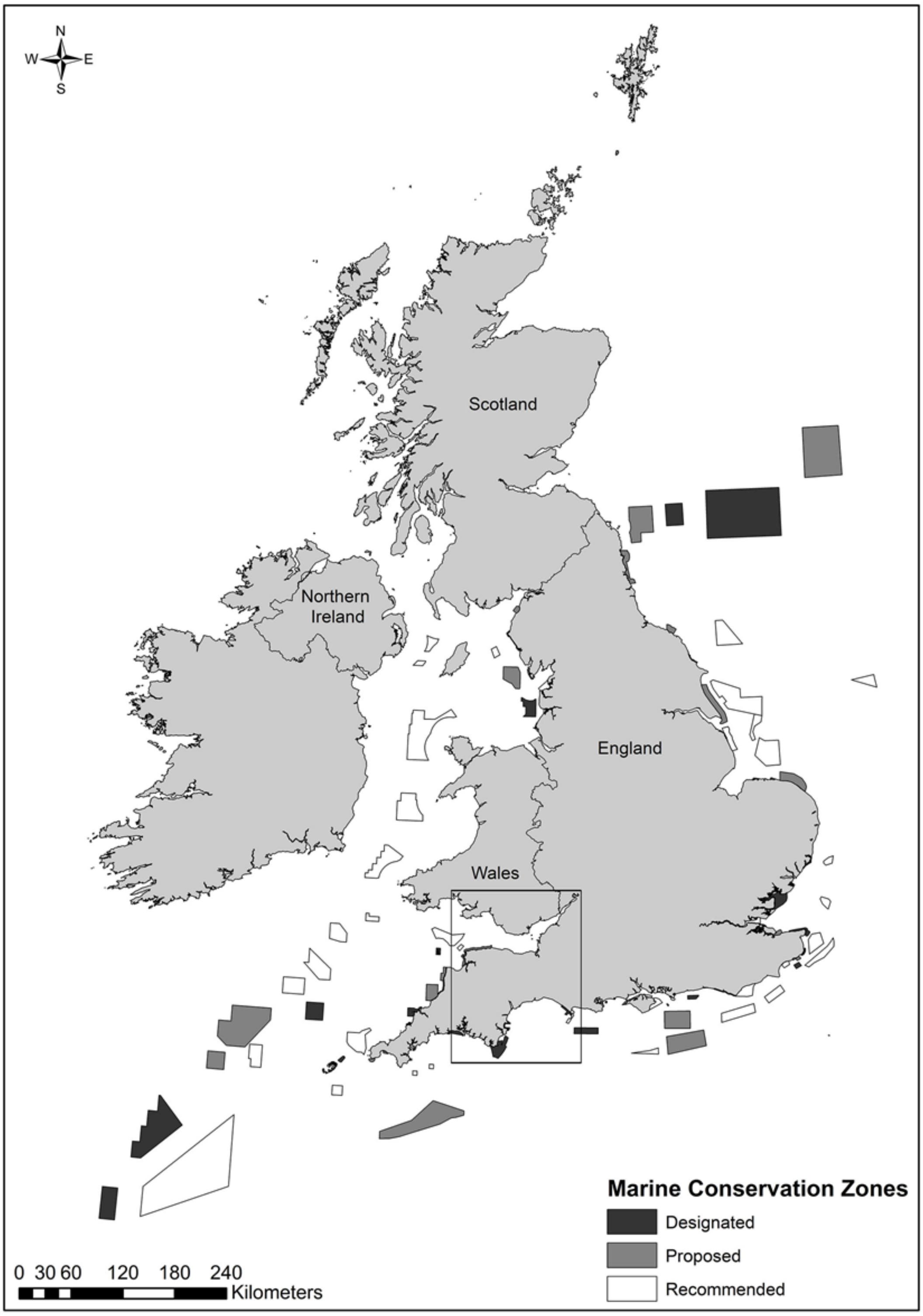


Figure 3.2: Map of the UK showing the Marine Conservation Zones that have been designated, proposed and recommended. The black box shows the study area, the Devon & Severn area of England. (MCZ data source: © Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right [2015]). Map created using ArcGIS, 2016

Initially, the approach taken by Defra and the SNCBs was systematic; planning a network of sites based on best available evidence, including strong participative incentives for stakeholder engagement and providing clarity about site management. However, with time it changed, becoming more focussed on specific features and individuals sites, with strong top down elements and a requirement for scientific evidence rather than being driven by stakeholders (Jones 2012; Lieberknecht et al. 2013). The management decisions were also postponed until after site designation. Stakeholder engagement ceased at the end of the regional project period in 2011 when the final recommended MCZs were delivered to Defra, and from this point forwards the process was Government led with stakeholder inclusion limited to public consultation periods. Concerns were raised by the regional projects that this might lead to a loss of the social capital that had been generated through the extensive stakeholder engagement process, and they felt that continuing active stakeholder engagement throughout the implementation period would be beneficial (Lieberknecht et al. 2013).

3.1.3 Study aims

Lieberknecht et al. (2013) conducted a governance analysis of the MCZ regional project Finding Sanctuary in the south-west UK, finding considerable support for the MCZ generated through the initial project period. Stakeholders appreciated the chance for open discussion and for their voices to be heard, but with time, the changes made to how the process was conducted led to considerable uncertainty leaving them feeling disempowered, disenfranchised and excluded from what they perceived to be the important process of site implementation and decisions regarding their management. Furthermore, the change from an approach of using 'best available evidence' to a process which required strong scientific evidence for each site was perceived to undermine the work of the stakeholder groups.

This work provides context and background for the current study, but was completed prior to the first set of MCZs being designated, and as identified, few studies have assessed the social acceptability of MPAs following designation (but see Hamilton 2012; Thomassin et al. 2010). This study therefore aimed to assess social acceptance of MPAs once the first tranche had been designated, focussing on the perspectives of stakeholders that had been involved with, or were very familiar with the process, and represented their local stakeholder group's views. The Devon & Severn region of south-west England was used as a case study site, with work building on that of (Lieberknecht et al. 2013).

The objectives of this study were to:

a) Understand the discourses relating to MPAs
b) Determine whether MPAs are considered socially acceptable
c) Reflect upon and develop recommendations for current and future MPA processes in order to promote best practice

Interviews were conducted with stakeholders using Q methodology; an innovative method to understand the discourses relating to MCZs and the opinions and attitudes of stakeholders.

3.2 Methods

Previous studies on social acceptability of MPAs have used a range of survey-based methods, including attitudinal surveys with the general public, surveys with specific stakeholder groups and multi-criteria analysis (e.g. Hamilton 2012; Himes

2007; Leleu et al. 2012; Read et al. 2011; Sant 1996; Suman et al. 1999; Thomassin et al. 2010; Voyer et al. 2012). Q is a well-established method developed by Stephenson (1935) which uses factor analysis to explore the subjective viewpoints of participants (Watts and Stenner 2012). It aims to analyse subjectivity in a way that is systematic, rigorous and statistically interpretable (Barry and Proops 1999; Brown 1996) and can be described as a quali-quantitative technique to explore viewpoints or discourses about a topic that can be debated or is socially contentious (Cairns et al. 2014). It was selected here as, unlike other survey methods which result in a statistical analysis of categories defined in advance by the researcher, Q methodology results in a set of discourses explaining the perceptions that exist amongst people, allowing them to develop their own topics rather than having them pre-defined (Addams and Proops 2000). The method was considered appropriate for a study of social acceptance.

Q methodology originated in psychology, but has been increasingly used in other disciplines such as social science and ecological economics where it has been applied to examine the way in which people think about issues such as policy, governance and management (e.g. Ellis et al. 2007; Frantzi et al. 2009; Pike et al. 2014; Steelman and Maguire 1998; Webler et al. 2009). Whilst Q has been advocated as an appropriate tool to study the social and political acceptability of environmental policy (Barry and Proops 1999) its use to date has focussed mainly on terrestrial environmental policies (Steelman and Maguire 1998) and its application to the marine environment has been limited (but see Bacher et al. 2014; Bischof 2010; Pike et al. 2014; Tuler and Webler 2009). It was therefore proposed to use Q methodology to explore the social acceptability of marine environmental policy in the form of MPAs; a subject that is often socially contentious and about which stakeholders have strong opinions.

3.2.1 Conducting Q Methodology

Q methodology uses a set of pre-determined statements about the topic of interest, and the participants are required to rank these statements in order from those which they most strongly agree with to those they least agree with. The ranking is done using a forced-choice frequency distribution (see Figure 3), which ensures that each statement is ranked relative to the individual, and provides the required standardisation. The necessary steps are detailed below:

3.2.1.1 Identify the research question

For the purpose of this study, the research aimed to understand stakeholder attitudes towards MPAs in the Devon & Severn region.

3.2.1.2 Generate the Q set

Initially, the generation of the Q set required the concourse (breadth of the debate) to be established. Statements were collated from a number of sources that represent the concourse to ensure that all topics and viewpoints are represented. This was done using previous research, where interviews had been conducted relevant to the topic (Hattam et al. 2014; Mangi et al. 2012; Rees and Rodwell 2012), media sources (The Western Morning News, The Times, The Guardian, The

Telegraph) and their online comments sections, and social media (e.g. Facebook and Twitter).

To identify statements from media sources, searches were conducted using the key words ‘marine protected area’. Articles resulting from the search were read and any key statements occurring within the article or the comments section were recorded. For Twitter, the hashtags #MPA, #marineprotectedarea, #MCZ, #marineconservationzone, #marinereserve were searched and also the key words ‘marine protected area’, ‘marine conservation zone’ and ‘marine reserve’. For Facebook, the post and comments of groups such as Hugh’s Fish Fight and The Real Fish Fight were searched.

Once identified, statements were lifted verbatim from the source and compiled in an Excel spreadsheet along with information on when and where they had been published. A total of 180 statements were gathered. The statements were then condensed, with duplicate statements and those not considered relevant removed. Where statements were similar only the most relevant was reserved. This left 139 statements which were then sorted into broad theme categories, and streamlined into three main themes:

- Management and the use of MPAs
- Conservation
- Economic and social considerations

A range of statements was maintained within each theme to ensure that the range of viewpoints was included. This meant that each theme could be divided into statements that were positive towards MPAs, those which were negative, and some which were neutral. This process was used to ensure that the key topics and a representative range of opinions were included in the Q set. The final set of 42 statements is presented in Table 3.1. The statements were printed on card and assigned numbers. These were randomly assigned and were for use in the analysis process rather than being of relevance to the statements themselves.

3.2.1.3 Select a P set

The P set is the set of stakeholders that take part in the Q study. As Q does not attempt to generalise across the population it does not require a large sample size from which to draw its conclusions, only that the participants are knowledgeable, informed and have a defined viewpoint (Brown 1980). The key is that sufficient participants are interviewed to ensure that there is strength in the generated factors, with 20-40 participants considered suitable (Brown 1980).

Twenty-four key stakeholders were identified and interviewed from the following broad groups: commercial fishermen, recreational users, Non-Governmental Organisations, managers, charter boat operators, academics and statutory bodies. All stakeholders were from the Devon & Severn region of the UK (Figure 2.2), and were well informed about the MCZ process either through their occupation or through voluntary involvement in MPA planning or management.

3.2.1.4 Q sorting

The Q sort was conducted in stages. Initially, participants were given the entire set of 42 statements, and asked to sort them into 3 piles, one for the statements that were ‘most like I think’ one for ‘least like I think’ and one for those that they had no strong opinion for and so could be termed ‘neutral’ (Figure 3.3). Following this, the distribution grid was laid out and the participant asked to sort the statements into it, starting with the two statements that were ‘most like I think’ and the two that were ‘least like I think’, and working in towards the centre where their feelings towards the statements were neutral (Figure 3.4).

Most like I think **Least like I think**

+4	**+3**	**+2**	**+1**	**0**	**-1**	**-2**	**-3**	**-4**

Figure 3.3: Q sort grid. Participants were asked to allocate two statements to the +4 and -4 columns, four to the +3 and -3 columns, and 6 to the +2, +1, 0, -1 and -2 columns

Participants were asked additional questions about their sort including reasons for their choice of the two statements that were ‘most like I think’ and the two that were ‘least like I think’. Additional open and closed questions were asked providing useful context to the Q sorts. Closed questions included ‘On a scale of 1-10 where 1 is not at all happy and 10 is extremely happy, how happy are you with the current management of the UK marine environment?’ and the answer to this was averaged across participants.

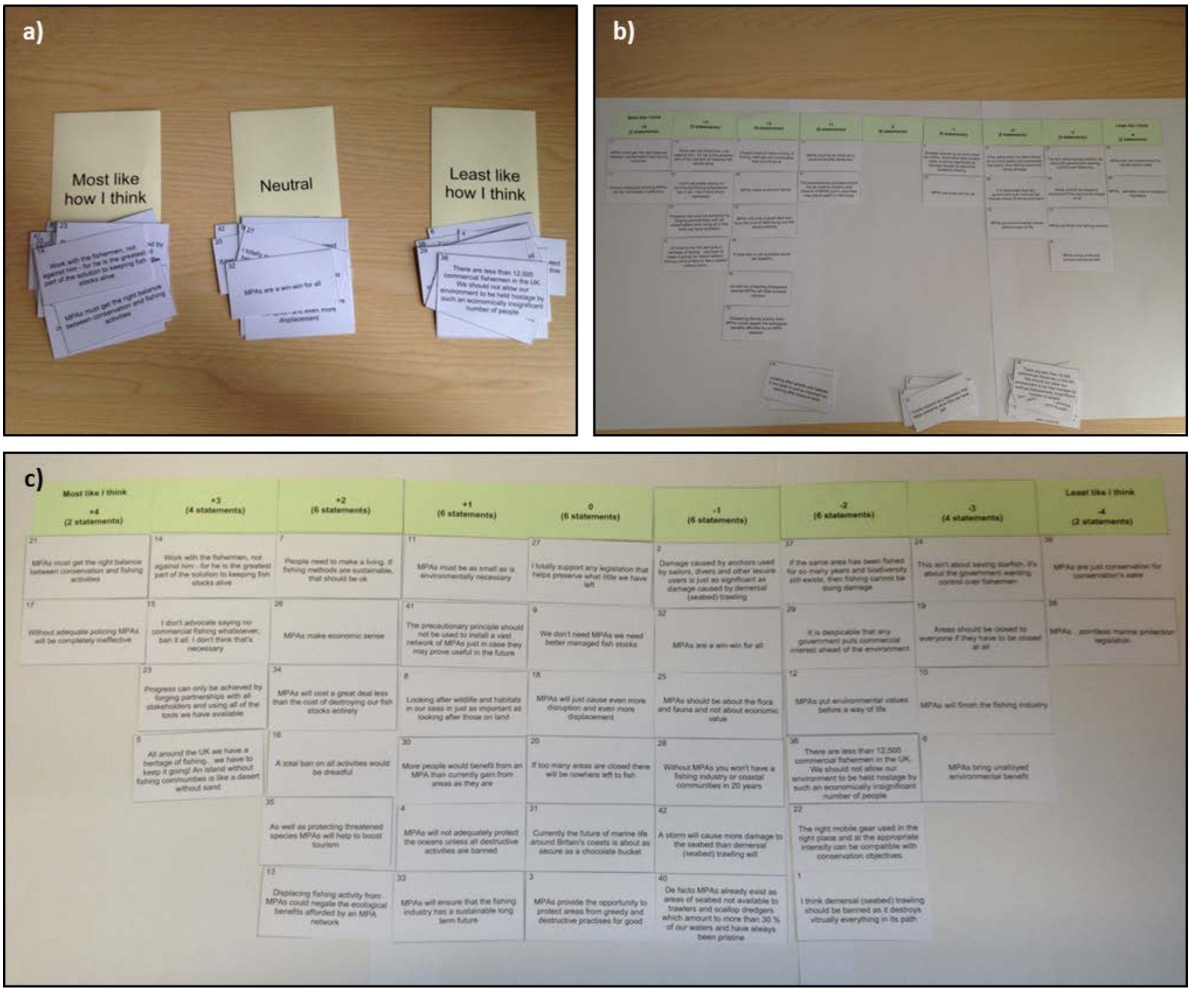


Figure 3.4: a) step one of the Q sort where the participant is asked to sort the statements into 3 piles, those that are 'most like I think', those that are 'least like I think' and those that are 'neutral'. b) a Q sort in progress, and c) a completed Q sort where the participant has allocated all their statements to the grid.

3.2.1.5 Q analysis

Q analysis was conducted using PQMethod (Schmolk 2002) and following established methods (Brown 1980; Watts and Stenner 2012) to reveal factors, or clusters of opinions which could be interpreted as viewpoints, or discourses. Centroid analysis was run from a correlation matrix where each sort was correlated with ever other to identify clusters of similar Q sorts (similar opinions). Factors were selected where eigenvalues were greater than 1 following the Kaiser-Guttman criterion (Guttman 1954; Kaiser 1960, 1970), (Table 3.2) as this meant that each factor was defined by at least one significantly loading sort (Brown 1980). Factor loading expresses the degree to which a sort agrees with the viewpoint of the factor (Brown 2004), and significantly loading factors were identified (± 0.40 or above, $p < 0.01$, for equation see Brown (1980)). The analysis revealed a three factor solution to be most appropriate, based on their eigenvalues and as this maximised the stability, clarity and distinctness of the emerging discourses (Watts and Stenner 2005; Webler et al. 2009). These were termed 'pro-conservation', 'pro-fisheries' and 'win-win' and discourses were developed for each. Statements that were statistically distinguishing for each factor ($p < 0.05$) were used in the development of the discourses, and consensus statements were those where all factors agreed.

3.3 Results

The survey aimed to identify discourses of opinion and the social acceptability of MPAs. Twenty-four Q sorts were completed by participants between April 2014 – March 2015, and three discourses were identified; 'Pro-conservation', 'Pro-fisheries' and 'Win-win'. The significantly loading discourses accounted for 62 % of the study variance, incorporating the views of 13 participants. The remaining 38 % of the variance was accounted for by the 11 remaining participants who had views which were shared among the discourses and were not significantly loaded on one alone. For sorts to contribute to a factor they had to be significantly loading ($p < 0.01$), (see Brown 1980). These sorts and the answers given by the participants to the additional open questions formed the basis for the discourse. The idealised sorts for each discourse are given in Table 3.1, showing the differences and similarities between them.

Statement		A	B	C
1	I think demersal (seabed) trawling should be banned as it destroys virtually everything in its path	-4	-4	0**
2	MPAs will finish the fishing industry	-2	-2	-4**
3	Damage caused by anchors used by leisure users is just as significant as damage caused by demersal (seabed) trawling	-1	-2	-1
4	MPAs must be as small as is environmentally necessary	-2	2**	-2
5	Areas should be closed to everyone if they have to be closed at all	-3	-1	-2
6	MPAs make economic sense	0	-1	3**
7	MPAs provide the opportunity to protect areas from greedy and destructive practises for good	0	-2*	1
8	MPAs put environmental values before a way of life	0	0	-3**
9	If too many areas are closed there will be nowhere left to fish	-1	2**	-1
10	I totally support any legislation that helps preserve what little we have left	-2	-2	2**
11	MPAs will ensure that the fishing industry has a sustainable long term future	1	0	4**
12	MPAs…pointless marine protection legislation	-4	-1	-3
13	MPAs will not adequately protect the oceans unless all destructive activities are banned	1	0	0
14	I'm not against MPAs, I'm just against the way they are being implemented	2	2	0**
15	MPAs must get the right balance between conservation and fishing activities	1**	3	2
16	Without MPAs you won't have a fishing industry or coastal communities in twenty years	-2*	-4*	1**
17	MPAs will cost a great deal less than the cost of destroying our fish stocks entirely	2	1*	2
18	MPAs are just conservation for conservation's sake	-3	-2	-4
19	All around the UK we have a heritage of fishing…we have to keep it going! An island without fishing communities is like a desert without sand	1	1	1
20	Work with the fishermen, not against him - for he is the greatest part of the solution to keeping fish stocks alive	2	3	2
21	The right mobile gear used in the right place and at the appropriate intensity can be compatible with conservation objectives	3	1	0
22	It is despicable that any government puts commercial interest ahead of the environment	2**	-3**	-1**
23	The creation of an MPA is the start of an effective conservation effort, not the end	3	1*	3
24	De facto MPAs already exist as areas of seabed not available to trawlers and scallop dredgers	-1	3**	-2
25	MPAs bring unalloyed environmental benefit	-1	-3**	1
26	I don't advocate saying no commercial fishing whatsoever, ban it all. I don't think that's necessary	3*	1*	-1*
27	Progress can only be achieved by forging partnerships with all stakeholders and using all of the tools we have available	4	4	4
28	More people would benefit from an MPA than currently gain from areas as they are	0	-1	2**

29	There are less than twelve thousand five hundred UK commercial fishers. We should not allow our environment to be held hostage by such an economically insignificant number of people	1**	-3*	-1*
30	The precautionary principle should not be used to install a vast network of MPAs just in case they may prove useful in the future	-2	1**	-3
31	People need to make a living. If fishing methods are sustainable, that should be ok	1	3	1
32	A total ban on all activities would be dreadful	2	2	1*
33	This isn't about saving starfish, it's about the government wanting control over fishermen	-2	-1*	-3
34	Currently the future of marine life around Britain's coasts is about as secure as a chocolate bucket	0	-3**	0
35	If the same area has been fished for so many years and biodiversity still exists, then fishing cannot be doing damage	-3	2**	-2
36	A storm will cause more damage to the seabed than demersal (seabed) trawling will	-1	0	-2*
37	Looking after wildlife and habitats in our seas in just as important as looking after those on land	3	1**	3
38	Without adequate policing MPAs will be completely ineffective	4	4	3
39	MPAs should be about the flora and fauna and not about economic value	2**	-1	0
40	MPAs are a win-win for all	-1	-2	2**
41	We don't need MPAs we need better managed fish stocks	-3*	0	-1
42	MPAs will just cause even more disruption and even more displacement	0	0	-2**

Table 3.1: Q statements with score for each of the extracted discourses, A = Pro-conservation, B = Pro-fisheries and C = 'win-win', listed in descending order from statements with most consensus to those with most disagreement between factors. Scores represent the level of agreement with each statement from -4 'least like I think' to +4 'most like I think'. Statements that are defining statements are noted for each factor, ** denotes a significance of $p < 0.01$, *denotes a significance of $p < 0.05$.

3.3.1 Discourse A – Pro-conservation

This discourse accounted for 49 % of the study variance, and had 3 significantly loading sorts (Table 3.2). It is characterised by pro-conservation views, and those that think conservation interests should be prioritised over fishing interests in MPAs. They see the value of MPAs (Statement (S) 12, -4) and feel that the environment should be given priority over economic and commercial interests (S22, +2; S39, +2). Despite their pro-conservation views, they recognise the importance of commercial fishing and are against a complete ban on all activities

(S26, +3), and also strongly disagree with a ban on demersal trawling (S1, -4). Their opinion is that a ban would be unnecessary, *'commercial trawling can be very damaging on certain habitats – on reefs and sediment that are very stable, but in other areas, if it's very mobile sands and things then it can go ahead'*, and they show a preference instead for management of activities they perceive to be damaging. Pro-conservationists also recognise the importance of partnerships between stakeholders (S27, +4) and the need for effective management and policing (S38, +4) for MPAs to be effective.

3.3.2 Discourse B – Pro-fisheries

This discourse accounted for 8 % of the study variance, with three significantly loading Q sorts (Table 3.2). It was characterised by pro-fisheries opinions, and the feeling that conservation should come second to fisheries interests. Concern was evident for access to fisheries (S9, +2) with feelings that MPAs should be as small as possible (S4, +2) to ensure that disturbance is minimal. The discourse was of the opinion that there are already areas of the sea that are inaccessible to fisheries and are therefore *de facto* MPAs (S24, -1; S3, -2) negating the need for large quantities of new MPAs. They felt very strongly that fishing activities should not be banned (S1, -4; S26, +1) and that MPAs are not necessary as a means of ensuring the future of the fishing industry (S16, -4) *'we've effectively had an MPA out there more or less since the end of the war…that has existed, the coastal communities have existed, the fishermen in Brixham…Salcombe and Dartmouth are still there, so clearly the situation can exist if its handled properly'*. Their opinions were more focussed on economics, with commercial interests more important than environmental (S22, -3; S29, -3) and a strong disbelief that MPAs bring limitless environmental benefits

(S25, -3). Despite their doubts about the need for increasing numbers of MPAs, this discourse seemed to accept the underlying principles for MPA creation and that they are a reality and will be expanding, and, as with the pro-conservationists felt that partnerships between all stakeholders and effective policing are essential to their success (S27, +4; S38, +4).

3.3.3 Discourse C – 'win-win'

This discourse accounted for 5 % of the study variance, and had 7 significantly loading sorts (Table 3.2). It was characterised by views that MPAs can be used to achieve both conservation and fisheries goals, and therefore present a 'win-win' solution to fisheries and conservation management. The discourse sees MPAs as bringing security to both fisheries management and conservation management goals (S11, +4; S10 +2) and long term sustainability to the fishing industry (SS11, +4; S2, -4). They feel that MPAs will not cause disruption and displacement or put environmental values first, but will work to benefit everyone (S40, +2; S28, +2). There is a strong economic case for MPAs (S6, +3), and certainty that they will not be detrimental to the fishing industry (S2, -4). They also feel that management and government intervention should be balanced between fisheries and conservation goals and that neither should be prioritised above the other (S22, -1; S29, -2). As with the previous two discourses they put an emphasis on the need for stakeholder participation (S27, +4) and effective management and enforcement for MPA success (S38, +3).

Q sorts		A	B	C
Discourse A Pro-conservation				
Stakeholder 1	Statutory agency	**0.72**	0.17	0.35
Stakeholder 16	Marine Professional	**0.69**	0.17	0.34
Stakeholder 23	Marine Professional	**0.62**	0.29	0.19
Discourse B Pro-fisheries				
Stakeholder 6	Commercial fishermen	0.03	**0.69**	0.05
Stakeholder 19	Commercial fishermen	0.2	**0.84**	0.15
Stakeholder 22	Commercial fishermen	0.17	**0.64**	0.03
Discourse C win-win				
Stakeholder 10	Recreational angler	0.28	0.07	**0.68**
Stakeholder 12	Statutory agency	0.15	0.33	**0.79**
Stakeholder 14	NGO	0.29	-0.01	**0.77**
Stakeholder 18	NGO	0.32	-0.1	**0.69**
Stakeholder 20	Local authority	0.3	0.15	**0.53**
Stakeholder 24	Statutory agency	0.37	0.11	**0.68**
Confounded sorts				
Stakeholder 02	Recreational angler	0.51	-0.02	0.59
Stakeholder 03	Management Group	0.56	-0.03	0.58
Stakeholder 04	Recreational angler	0.48	0.04	0.76
Stakeholder 05	Charter boat operator	0.34	-0.28	0.75
Stakeholder 07	NGO	0.43	0.12	0.44
Stakeholder 08	NGO	0.63	0.21	0.45
Stakeholder 09	Research Scientist	0.59	0.11	0.56
Stakeholder 11	Research Scientist	0.52	0.09	0.53
Stakeholder 13	Research Scientist	0.44	-0.47	0.33
Stakeholder 15	Research Scientist	0.68	-0.08	0.46
Stakeholder 17	NGO	0.65	0.02	0.58
Stakeholder 21	Local authority	0.42	0.15	0.69
% explained variance		**49**	**8**	**5**
Eigenvalues		**11.65**	**2.03**	**1.12**
Total defining Q sorts		**3**	**3**	**6**

Table 3.2: Factor loadings for each sort, ranging from complete disagreement (-1) to complete agreement (1) with the perceptions of each factor

3.3.4 Consensus and disagreement statements

It was evident that despite their differences, all discourses were accepting of MPAs, agreeing that they were the start of an effective conservation effort (S23, +3, +1, +3) and that protecting our seas is as important as protecting the land (S37, +3, +1, +3). They also agreed that there was more to MPAs than conservation (S18, -3, -2, -4), *'it's partly for conservation, but it's also for just trying to get things better'*.

All discourses placed importance on partnerships between stakeholders (S27, +4, +4, +4) showing the value of stakeholder engagement and consultation, with comments that *'it's important to be democratic, inclusive, transparent in the way that decisions are taken'; 'if the stakeholders are all in agreement you get a much better buy in from the industry and other stakeholders'*, and *'there are so many examples of where not using partnerships and not involving stakeholders means that you don't meet your objectives'.* All discourses also placed importance on the need for enforcement within protected areas (S38, +4, +4, +3), with a fear that *'if there is no way of policing or controlling them they are a pointless waste of money'*.

Disagreement was apparent between the pro-conservation and win-win discourses and the pro-fisheries discourse. This related mainly to issues regarding fishing impacts and the need for management measures to counteract these. Differences were most pronounced when considering the de facto MPAs, with pro-conservation and win-win discourses unwilling to accept that areas unavailable to scallop dredgers and trawlers can be considered MPAs (S24, -1, 3, -2), and also that the existence of biodiversity in areas that have been fished for many years means that fishing cannot be doing any damage (S35, -3, 2, -2). Therefore, despite their win-win attitude, it is clear that the win-win are slightly less pro-fisheries than pro-conservation.

Disagreement was also apparent in relation to the banning of demersal trawling within protected areas, with the pro-conservation and pro-fisheries discourses strongly in disagreement (-4, -4) and the 'win-win' expressing ambivalence (0) which may be surprising given their viewpoints. It is thought, however that there was some hesitance surrounding this statement, with respondents in this category unwilling to commit to a strong opinion as they felt that trawling may need to be banned in some areas but not others, so this statement was not one that they felt that they could comment on.

3.3.5 Additional questions

In addition to the Q sort, participants were asked questions which helped guide development of the discourses. On average, respondents were relatively unhappy with the current management of the marine environment (mean 4.54/10) citing reasons such as *'I think we are getting there…there is more work to do'*; *'could do better; improve awareness – it's dreadful'*; *'the tools exist, but for a variety of reasons, either capacity of willingness they aren't being introduced or used for fear of upsetting sea users'*. Eighty-three percent of respondents felt that the number of MPAs in UK waters should be increased *'we've done all that work, and that was trying to achieve something and that isn't finished yet'*; *'would have been very happy if the whole network had been there as we were given a formula…which said you need to have a certain proportion of different seabed habitats protected. We actually got it to those percentages'*. The remaining 17 % did not know whether the amount should remain the same, be increased or be decreased due to a perceived lack of information with which to make the decision. Respondents felt that until there was clear evidence of the success of MPAs they were unable to determine whether more were justified or required: *'unsure without further evidence of the value of what is around us - scientific evidence. I wouldn't like to call it too little or too much. I would want to have an informed opinion before committing myself'*.

Finally, participants were asked whether they would have liked their involvement to continue past the end of the regional project period. All respondents agreed that continued involvement would have been beneficial; keeping the momentum and support going and allowing local, well informed input to the implementation of sites and development of management plans; *'there had been something built up over the couple of years that it ran for that that could have been used as a building block for developing the management of the sites'*. The regional projects had generated a sense of shared ownership, and had bought different stakeholder groups together; *'I think if that process had continued people could have discussed the management options...they may not necessarily have agreed with the decisions made, but at least they would have felt that they had an input and had been listened to'.* Despite this, some participants felt that the final decisions needed to be top down and government led due to the legislative aspects, but that locals should be involved in the development of the management plans as they would *'bear the biggest proportion of the costs'*.

3.4 Discussion

This chapter aimed to determine whether MPAs are considered socially acceptable by investigating the discourses on their use for fisheries and conservation management. Understanding social acceptability is a crucial part of MPA monitoring and can be used as a measure of MPA success. Where MPAs are not found to be socially acceptable, adaptive management may be required to ensure that activities are managed in a way that allows them to reach their goals.

Three discourses were identified, 'pro-conservation' who felt that conservation should be prioritised over commercial and economic interests; 'pro-fisheries' who saw fishing to be the priority and expressed concerns over the uncertainty of management measures and the number of planned MPAs; and 'win-win' who felt that the current approach to marine management using MPAs would allow both fisheries and conservation goals to be met. Despite some differences in opinion, the discourses had some strong similarities, with social acceptability of MPAs identified across all three.

The views of the win-win and pro-conservation discourses were most similar, with both feeling that the environment should be prioritised over economic and commercial interests. The stakeholders forming these two discourses were from a diverse mix of stakeholder groups, with representatives from management bodies, statutory bodies, recreational users, NGOs and academic institutions. The pro-fisheries group was, however, comprised entirely of commercial fishers, highlighting an important difference in opinion between this stakeholder group and the others. This difference is apparent elsewhere, with Mangi and Austen

(2008) finding that most stakeholders thought conservation was the most important MPA objective for southern European sites, whilst fishers prioritised fisheries management. It is thought to arise as commercial fishers are often the only stakeholders who stand to lose directly from the establishment of an MPA due to restrictions placed on extractive uses. As seen here, however, they are not always completely anti-MPA, a finding supported by that of Jones (2008) who found what is perhaps a surprising level of support (23 % of respondents) for NTZs in a study of the fishing industry in the south-west UK. He also found that 36 % of respondents thought NTZs could bring both fisheries and conservation benefits, and 20 % thought that they should be purely for biodiversity. This last group were of the opinion that a 'win-win' approach was unrealistic as the fisheries benefits were too uncertain, and they would rather have a clear and honest approach to the areas.

Social acceptability of MPAs does come with some limitations. Acceptability was greatest within the win-win and pro-conservation discourses and was apparent to a lesser degree within the pro-fisheries discourse. The main limitations were due to uncertainty over whether MPAs will bring their intended benefits, due to scepticism that they will work, and due to limited availability of resources with which to implement effective management and enforcement. This uncertainty is inherent in the process of establishing MPAs, and, despite an ever increasing volume of literature from tropical locations showing MPA success at increasing the biodiversity of sessile and mobile reef species (e.g. Aburto-Oropeza et al. 2011; Gell and Roberts 2003; Polunin and Roberts 1993; Rife et al. 2013) evidence from temperate locations has been slower to emerge (but see Horta e Costa et al. 2013; Sheehan et al. 2013b).

It is expected that with time, and once management measures are established, attitudes may become more positive as users begin to see the benefits of designation, become familiar with management and adapt their activities accordingly (Taylor and Buckenham 2003. p. 58). This is corroborated by the findings of Hamilton (2012) who compared fishers perceptions of MPAs in the Philippines where MPAs had been established for 10 years to Cambodia where MPAs were a novel idea. He found 85 % of fishers were supportive of MPAs in the Philippines compared to 61 % in Cambodia, and this result positively correlated with perceived changes in abundance of reef fish, where Filipino fishers had noticed a positive change in fish landings attributed to the MPA and Cambodian fishers had noticed a decline.

Another fundamental concern limiting social acceptability was the lack of inclusivity and transparency in the MCZ process. The switch to a process that was almost entirely top-down resulted in the exclusion of local stakeholders, the cessation of local level involvement at the end of the planning period and a loss of social capital which had been accumulated during the planning phase. All participants expressed a wish for their involvement to have continued into the MCZ implementation period and felt that their exclusion from the development of management plans for the sites was a mistake, confirming that opinions identified by Lieberknecht et al. (2013) persist 18 months on and highlighting a key shortfall in the MCZ project. It is thought that continued stakeholder involvement would have increased social acceptance of MPAs, as found in the Philippines where a change from top down government led management to co-management between the government and locals was found to be very successful (Alcala and Russ 2006). Inclusion has also been found to increase compliance with MPA regulations, with

Arias et al. (2015) finding compliance levels perceived by resource users to be higher in MPAs where locals had been involved in the decision making process than where they had not.

Had the engagement process been continued, with local level inclusivity and dialogue channels between local and governmental groups, it is thought that social acceptability would be greater. In a study of commercial fishers in southern France, Leleu et al. (2012) attributed high social acceptability of MPAs to the involvement of fishing guilds throughout the process of establishment and management of the MPAs. They also found that the process had been supported by successful communication between managers and users about the direct and indirect benefits of the sites which alleviated concerns and increased the transparency of the process. This result provides an interesting comparison for our study, where commercial fishers were those that expressed the lowest level of acceptance of MPAs. They stated that they were in support of MPAs but only when they felt that they were being implemented for the right reasons and when they could see a clear scientific case for them. Had better education and communication existed relating to the need for and benefits of MPAs it is thought that social acceptance within this group may have increased. Education and communication are therefore aspects of key importance within the process of MPA planning, and must continue into the implementation period. If the stakeholders are well informed and can see clear benefits from the existence of an MPA they are more likely to support it.

Transparency and honesty in the design and implementation of MPAs is key to their social acceptability, irrespective of their location. Stakeholder expectations must be managed and the engagement process must work to alleviate the concerns of those whose livelihoods are likely to be directly impacted in a way that allows them to fully understand the costs and benefits of the designation. Without this, and with ongoing uncertainty and a lack of appropriate management measures, MPAs are at risk from decreasing social acceptability, as identified by Mangi and Austen (2008) who showed decreasing support for MPAs from fishermen who failed to identify any benefit to their activity arising from the designation of sites in Southern Europe.

Understanding social acceptability is key for the ongoing MPA process, promoting stakeholder engagement and introducing adaptive management where appropriate, and it should form a key part of any monitoring programme for MPA success.

3.4.1 Conclusion

By analysing the views and attitudes of stakeholders to MPAs three separate discourses have been developed providing an insight into social acceptability. Social acceptability was identified across all discourses, and is believed to have resulted in part from the well-developed and thorough process of stakeholder engagement during the MPA planning period. Acceptance has however, been limited by the cessation of stakeholder engagement in the implementation period and the exclusion of stakeholders from the development of management measures, resulting in disenfranchisement and uncertainty of the future of their activities within the proposed sites.

These results show that social acceptability of MPAs is generated by effective and ongoing stakeholder engagement, transparency and honesty relating to the costs and benefits of designations and a certainty that once sites are in place the resources exist for their effective management. It will also be increased where evidence exists that suggests the MPAs will be successful in meeting their goals, and should increase over time if this is seen to be the case.

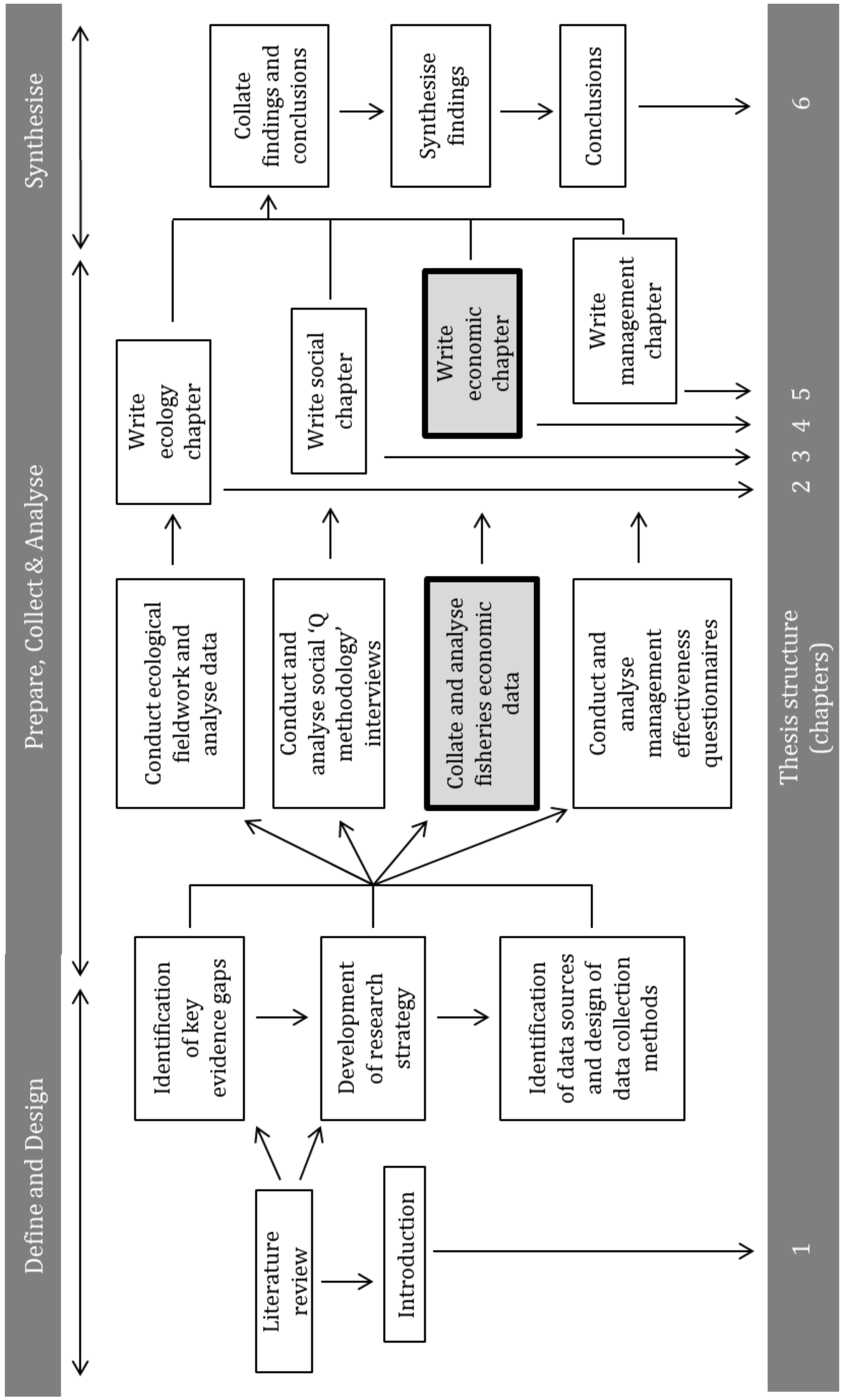
From this study, the following recommendations are made:

1. That stakeholder engagement should take place through the duration of any MPA process, from the design of sites, to implementation and development of management measures, thus incorporating both top down and bottom up approaches.
2. That stakeholder engagement should have defined parameters that are clear and transparent so that stakeholder expectations are managed and the risk of lost support minimised.
3. That communication with and education of stakeholders continues throughout the process ensuring that they are well informed about the process and its justification

Whilst the results of this study cannot be extrapolated to the wider population it is thought that they are likely to be representative of views in other locations across the globe where similar MPA designation processes are occurring. Research is required in areas where the MPA process has been different in order to determine the best practice for MPA designation to generate social acceptability and aid MPA success. Although social acceptability is one of numerous factors that can influence

MPA success, it is argued that it is of key importance as a measure of support for MPAs, and stakeholder support is crucial for their success.

At the time of writing, no monitoring had been undertaken into the success of the MCZs designated in 2013 at meeting their objectives, limiting the ability to determine whether social acceptability has contributed to MPA success and providing an opportunity for further research. Understanding how social acceptability changes with MPA age will help in the development of best practice for MPA planning. Ongoing monitoring is also required to ensure that stakeholder support is maintained, and in the hope that it increases, with results from Mangi and Austen (2008) highlighting the risk of decreased support if management fails to bring positive change. Understanding social acceptability will guide adaptive management and increase the chances of MPA success and the meeting of global targets.



Define and Design
Prepare, Collect & Analyse
Synthesise
Literature review
Introduction
Identification of key evidence gaps
Development of research strategy
Identification of data sources and design of data collection methods
Conduct ecological fieldwork and analyse data
Conduct and analyse social 'Q methodology' interviews
Collate and analyse fisheries economic data
Conduct and analyse management effectiveness questionnaires
Write ecology chapter
Write social chapter
Write economic chapter
Write management chapter
Collate findings and conclusions
Synthesise findings
Conclusions
Thesis structure (chapters)
1
2 3 4 5
6

Chapter four: Assessing the implications of multi-use marine protected areas for fisheries

The aim of this chapter was to determine whether multi-use MPAs provide economic benefit for fishers whose activities are permitted within them.

4.1 Introduction

Marine ecosystems provide a range of resources and services that contribute to human health and wellbeing (UNEP 2006). The Millennium Ecosystem Assessment established ecosystem services on the global agenda; defined in a variety of ways, with the common theme that they are 'the translation of ecosystem functions and processes into direct or indirect benefits for human wellbeing' (MEA 2005; Potschin and Haines-Young 2011). The ability of ecosystems to provide these services depends on their health and the maintenance of ecosystem functions and processes (MEA 2005; TEEB 2010). Marine resources are, however, common property; no one stakeholder has rights to them, and this can result in exploitation of resources beyond their economic or biologically sustainable yield (Carter 2003). This is a common occurrence for fisheries resources, with industrialisation leading to global landings increasing from five million tonnes in 1900 to 80 million tonnes by 2012 (Garcia et al. 2014). Despite fisheries management aiming to achieve sustainability over this period, the latest statistics report an estimated 28.8 % of global fisheries are overfished and 61.3 % are fully fished causing concern for the future of fish stocks (FAO 2014) and compromising the ability of ecosystems to provide ecosystems services crucial for human wellbeing (Chapin III et al. 2000; Halpern et al. 2008; Worm et al. 2006).

Concerns over the future of fisheries have led to management measures being advocated that focus on achieving human and ecosystem wellbeing through governance which effectively combines fisheries management with conservation (Garcia et al. 2014). This encompasses the ecosystem approach which was first outlined at the Rio +20 summit of the Convention on Biological Diversity (CBD) in

1992. It is a strategy for integrating management which promotes conservation and sustainable use in an equitable way and was formally adopted as the primary framework for action under the CBD at the Conference of Parties meeting in Jakarta, 1995 (Secretariat of the Convention on Biological Diversity 2004).

The ecosystem approach has been implemented through management tools such as Marine Protected Areas (MPAs) and has been a key driver in their implementation at a global scale. MPAs allow a holistic approach to management to be taken, incorporating ecological, social and economic factors and are often advertised as a win-win for both conservation and fisheries goals and an investment in natural capital (Alban et al. 2006; Hilborn et al. 2004). MPAs can be defined as '*a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values*' (Kelleher and Kenchington 1999). They can vary in size from one to 1000s kms and range from no take areas where management prohibits all extractive and non-extractive uses to multi-use areas where restrictions are only placed on uses perceived to be counter to the aims and objectives of the site (Lester and Halpern 2008).

Despite increasing recognition of the benefits of incorporating fisheries management with conservation through the designation of MPAs, the majority are designated for conservation purposes and therefore have conservation rather than fisheries objectives. Currently, 3.4 % of marine areas are protected globally, and of this, only 0.1 % are fully protected in no take zones meaning the majority of MPAs are multi-use (Juffe-Bignoli et al. 2014). This amount is set to increase, however, through CDB agreements, with 192 countries signed up to Aichi Biodiversity

Target 11 which states that by 2020 at least 10 % of coastal and marine areas should be protected.

MPAs have been implemented in Europe under the ecosystem approach through the Habitats & Birds Directives which call for member states to establish a network of MPAs under Natura 2000. These are either Special Areas of Conservation (SACs), (Habitats Directive) or Special Protection Areas (SPAs), (Birds Directive) and are collectively termed European Marine Sites (EMS). SACs are designated for the protection of habitats or species listed in Annexes I & II of the Habitats Directive and SPAs are for the protection of birds listed in Annex I. Article 6(2) of the Habitats Directive creates a duty that member states must avoid disturbance to the habitats and species listed in the Directive, and Article 6(3) states that activities can only occur in EMS if they have no impact on site integrity (Rees et al. 2013c). Sites must also achieve favourable conservation status of Annex I habitats and Annex II species which requires that the site supports the natural habitat and species present within it without compromising their long term survival (The Council of the European Communities 1992).

The UK Marine and Coastal Access Act 2009 (MCAA) established guidelines for the implementation of MPAs in the UK as well as instigating the modernisation of fisheries management. In English and Welsh territorial waters and UK offshore waters, MPAs designated through the MCAA are termed Marine Conservation Zones (MCZs) and are multi-use, aiming to protect habitats and features of conservation importance (JNCC and Natural England 2011). Management of extractive activities in both MCZs and EMS is currently under development, with the same approach being taken for both types of MPA: fishing activities that are deemed contrary to the objectives of the site require management and those proven to have no adverse effect are permitted to continue (Defra 2013).

4.1.1 Fisheries management and MPAs

It is intended that MPAs will bring economic benefit through the protection and enhancement of marine resources which in turn ensures the provision of ecosystem services (Potschin and Haines-Young 2011; Sobel and Dahlgren 2004. p. 220). In the case of conservation this may be through the recovery of habitats and species which were threatened by extractive activities and provide important economic goods and services. Despite MPAs rarely being designated with fisheries objectives written into their management plans, fisheries benefits may be expected through enhanced and replenished populations which can then 'spill over' the boundaries of the MPA allowing landings to be maintained even where fishing effort is displaced (Bohnsack 1993; Gell and Roberts 2003; Halpern 2003).

The selection of sites as MPAs has historically been driven by their ecological characteristics, with socio-economic concerns coming second to conservation. More recently, however, socio-economic factors have been recognised as key to MPA success; MPAs can be considered the product of social institutions, relying on changes in human behaviour to succeed (Pomeroy et al. 2007). Support from stakeholders is essential to generate compliance with regulations and ultimately allow conservation objectives to be realised (Arias et al. 2015; FAO 2003). Support is more likely to be generated where stakeholders perceive the MPA will bring them direct benefits, highlighting the key link between ecological and socio-economic aspects of MPAs (Pollnac et al. 2010). This recognition has increased efforts to value the goods and services provided by MPAs such that the costs and benefits of designation can be determined and effectively communicated to stakeholders and policy makers.

Valuation can be achieved through quantification of ecosystem services, with services including food provision, climate regulation, recreation, nutrient cycling and flood protection (Defra 2007; Remoundou et al. 2009). Following The Economics of Ecosystems and Biodiversity Project (TEEB), these have been classified to distinguish between ecosystem processes and services (TEEB 2010). The principle is that core ecosystem processes support beneficial ecosystem processes and these in turn deliver beneficial ecosystem services (BES). The BES of fisheries may rely on beneficial ecosystem processes such as primary production, food web dynamics and formation of species habitat, which are in turn dependent on core ecosystem processes such as production and ecological interactions (Fletcher et al. 2012b). Human activities occurring within the ecosystem such as fishing can provide benefits through improved food provision, but may also result in costs though negative impacts on beneficial ecosystem processes such as food web dynamics or formation of species habitat (Balmford et al. 2008). Management measures such as MPAs can therefore be implemented to restrict activities damaging to the provision of BES and where they are well designed and enforced they may enhance ecosystem service provision (Halpern et al. 2010).

Quantification of BES can provide both monetary and non-monetary values relating to their value in supporting human wellbeing, and in the context of MPAs this can be used to quantify the costs and benefits of designation in order to inform adaptive management of existing sites and designation of additional sites in the future (Fletcher et al. 2012a).

4.1.2 Economic implications of multi-use MPA designation

For fisheries, MPAs can bring short term costs from restrictions on fishing activity (Sanchirico et al. 2002.). These arise mainly from displacement, where vessels are no longer permitted access to their usual fishing grounds and have to travel further afield. This can increase operating costs and time at sea and increase competition for resources outside the MPA which can result in increased operating costs and may result in decreased landings (Hattam et al. 2014; Mangi et al. 2011; Suuronen et al. 2010). Benefits are often less obvious than costs, and may only become evident over the longer timescale. Benefits can include increased landings and profit arising from spillover of stock from within the MPA (Gell and Roberts 2003; Russ 2002). Where the MPA is multi-use additional benefits may be available to fishers permitted to continue their fishing activities within the MPA, through reduced competition and increased access to resources resulting from reduced competition between gear types (e.g. Vandeperre et al. 2011).

Whilst no take MPAs exclude all fishers and therefore can be expected to cause similar impacts regardless of gear type, the impacts of multi-use MPAs depend on the management measures implemented. Restrictions are most common for bottom towed fishing gear which may cause broad scale assemblage level changes such as altered species composition, a reduction in biomass, diversity and productivity and the removal of key species, compromising resilience and the ability of an ecosystem to provide habitat to support species of commercial importance (Auster et al. 1996; Bradshaw et al. 2002; Collie et al. 1997; Jennings and Kaiser 1998; Roberts and Polunin 1991). Commonly, management measures to be implemented in multi-use MPAs may exclude bottom towed fishing gear but permit static gear to continue as its impacts as thought to be less substantial (Coleman et al. 2013; Eno et al. 2001; Jennings and Kaiser 1998).

The economic costs and benefits to fishers resulting from MPA designation will therefore vary depending on gear type. Research has commonly focussed on fisheries which are excluded from an MPA as these individuals often disproportionately bear the costs of management strategies that place restrictions on resource use (e.g. Mangi et al. 2011; McClanahan and Mangi 2000; Murawski et al. 2000; Roberts et al. 2001; Russ and Alcala 1996; Russ et al. 2004). Studies have quantified the impact of displacement and the potential benefits of spillover from the export of biomass and larvae using landings and sightings data (e.g. Mangi et al. 2011; McClanahan and Mangi 2000; Murawski et al. 2000; Roberts et al. 2001; Russ and Alcala 1996; Russ et al. 2004). Fewer studies have focussed on the economic implications for fisheries permitted to operate within an MPA (but see Cadiou et al. 2009; Gómez et al. 2006; Mangi et al. 2012; Mangi et al. 2011; Rife et al. 2013; Vandeperre et al. 2011), especially in regard to shellfish (but see Mangi et al. 2012; Mangi et al. 2011). Potential benefits for these fishers may include increased catch per unit effort (CPUE) due to stock replenishment or increased area available to fish due to reduced gear conflicts.

For fisheries, direct market valuation can be achieved using a cost based approach where fisheries landings data provide the value of each fishery, and this can then be used as a proxy for the value of the fisheries within the MPA (Kettunen et al.

2013). Metrics such as number of active vessels within the fishery, catch per unit effort (CPUE) e.g. landings per vessel per day/month/year, and value of landings are commonly used, allowing assessment of change over time and changes resulting from the implementation of management measures (e.g. Cadiou et al. 2009; Mangi et al. 2011; Rife et al. 2013; Vandeperre et al. 2011).

Research conducted to date shows mixed results, with some studies finding an increase in CPUE within MPAs (Mangi et al. 2012; Vandeperre et al. 2011) and others finding that it remained stable (Cadiou et al. 2009) or decreased following MPA implementation (Rife et al. 2013). These differences stem from differences in the management plans between sites; Vandeperre et al. (2011) concluded that increased CPUE was a direct result of spillover from a no take area within an MPA in France providing a steady increase in the abundance of target species, while Rife et al. (2013) concluded that larger no take areas and better enforcement were required to promote increased CPUE within a Mexican MPA. In France meanwhile, Cadiou et al. (2009) concluded that vessel numbers, fishing effort and CPUE had remained stable following the designation of an MPA, and that artisanal static gear fishing did not appear to impact the marine environment within it. This led them to question whether there was any reason to ban commercial fishing in MPAs.

Of the identified studies, the work of Mangi et al. (2012) was the only one which considered the impact of a multi-use MPA on shellfish fisheries. Their work formed part of a larger project funded by the UK Government (Defra) which documented the recovery of habitats from fishing impacts and the socio-economic impacts of an MPA in Lyme Bay, UK from 2008-2011 (see Attrill et al. 2012; Mangi et al. 2012). The Lyme Bay Designated Area (Fishing Restrictions) Order 2008 banned demersal towed fishing gear from a 60 nm^2 area of Lyme Bay, UK (Figure 1) and was implemented due to concerns that fishing was damaging habitats and species within the bay. The restrictions did not apply to static gear, however, and pots and nets were still permitted within the closed area.

Following this, in August 2010, a larger area of the bay was designated as a candidate Special Area of Conservation (cSAC) under the EC Habitats Directive (Figure 1), and was adopted by the European Commission in November 2011, becoming a Site of Community Importance (SCI) ahead of becoming a fully designated SAC (Natural England 2013a). Management measures for the SCI were introduced by the Devon & Severn and Southern Inshore Fisheries & Conservation Authorities (IFCAs) who share management responsibility across the site, and in line with management of fisheries within SACs, trawling access to reef areas was removed in January 2014, increasing the area accessible only to vessels using static gear.

Mangi et al. (2012) conducted annual monitoring to document the socio-economic impacts of the MPA from 2008 – 2011 using a combination of primary data from interviews and secondary data from landings to evaluate the changes to CPUE, income, fishing costs and businesses occurring as result of the MPA. Initial results immediately following designation and one year later were reported by Mangi et al. (2011) who concluded that static gear fishers who fished within the MPA saw a benefit as they were able to increase the number of pots deployed within the area. Subsequently Mangi et al. (2012) found that landings had increased after MPA implementation, suggesting economic benefit to fishers active within the MPA.

They were, however, unable to draw firm conclusions about the impact of the MPA after only three years.

4.1.3 Aims and objectives

These studies show that the impact of MPAs on fisheries permitted within their boundaries are mixed and dependent on location and management measures. Studies conducted to date have mostly focussed on fish rather than shellfish species, but in the UK, shellfish landings (predominantly edible crab (*Cancer pagurus)*, European lobster (Homarus gammarus), Norway lobster (*Nephrops norvegicus*), squid, cuttlefish, king scallop (*Pecten maximus*) and whelk (*Buccinum undatum*)) account for more than one third of total landings, and had a value of £278.8 million in 2014 (Marine Management Organisation 2015). Of these, *N. norvegicus* and *P. maximus* are targeted primarily by bottom towed fishing gear accounting for 56 % of shellfish landings into the UK in 2014, and *H. gammarus*, *C. pagurus* and *B. undatum*, are key species targeted by static gear vessels and accounting for 34 % of landings in 2014 (Marine Management Organisation 2015).

Static gear fishers targeting these species may benefit from the designation of MPAs in the UK through a reduction in competition, an increase in available ground and a reduction in gear conflicts. UK MPAs are likely to encompass preferred habitats for *H. gammarus*, *C. pagurus* and *B. undatum*. *C. pagurus* and *H. gammarus* favour rocky reef habitats, and reef is a listed feature for which both MCZs and SACs are designated, and is a qualifying feature in 59 of the 99 SAC sites in the UK (JNCC 2016). *B. undatum* are known to favour softer sediment habitats, but may occur on areas between rocky reefs which provide important habitat for them as well as juvenile *H. gammarus* (Howard and Bennett 1979; Martel et al.). There is likely to be considerable overlap therefore, between MPAs and ground targeted by *H. gammarus*, *C. pagurus* and *B. undatum* fishers, potentially leading to economic benefits for these vessels. Multiuse MPAs may therefore bring economic benefits to fishers targeting these species, and quantification of the benefits may enhance understanding of the role of MPAs in fisheries management. Increasing understanding may also aid interpretation and communication of the benefits of MPAs to fishers, an aspect which is crucial to promoting compliance with management measures and acceptance of MPA designations (Arias et al. 2015; Rossiter and Levine 2014).

Using the Lyme Bay MPA, this study therefore built on the work of Mangi et al. (2012) to determine the impact of multi-use MPA designation on landings of *C. pagurus*, *H. gammarus* and *B. undatum*; species that are of key importance to the livelihoods of fishers operating in the area. Using the metrics: number of active vessels (mean number of active vessels per month), CPUE (mean number of tonnes per vessel per month) and value of landings (mean £ per vessel per month), the study aimed to determine whether multi-use MPAs provide economic benefit for fishers whose activities are permitted within them.

Following the cessation of the initial MPA monitoring project, in October 2011 the Blue Marine Foundation established the Lyme Bay Working Group which aimed to *'develop, promote and implement best practise in fishery and conservation management…in order to maximise socio-economic benefits for local coastal communities'* (Lyme Bay Fisheries and Conservation Reserve). The working group comprised regulators, fishers, conservationists and scientists and a voluntary code of conduct for fishers operating within the MPA was developed. The code of conduct included a cap on the number of pots per vessel, limiting this to 250, although all vessels were thought to be fishing well within this limit (Lyme Bay Fisheries and Conservation Reserve). The work of Mangi et al. (2012); (2011) and the discussions of the working group suggested that use of static gear had increased within the MPA since designation. This was thought to be a result of the reduction in conflict between fishers using static gear and those using bottom towed fishing gear, with economic benefits expected for fishers targeting *C. pagurus*, *H. gammarus* and *B. undatum*.

To provide a control site enabling exclusion of confounding variables external to the MPA, data were compared to vessels fishing within the Inshore Potting Agreement (IPA) area in South Devon. The IPA was established as a voluntary zoned fisheries management system in 1978 primarily to reduce conflict between mobile and static gear types and the agreement was incorporated into legislation in 2002 (Hart et al. 2003). It covers an area approximately 500 km^2 and as well as zones where static gear (pots and static nets) is exclusively allowed and areas where towed gear is exclusively allowed there are also areas where gear types are managed seasonally (Figure 4.1), and is managed by the Devon & Severn IFCA (D&SIFCA). This site provides an appropriate control for Lyme Bay as any changes seen in landings can be expected to be the result of external factors and market fluctuations rather than site specific factors. Fluctuations in landings from boats fishing for *C. pagurus*, *H. gammarus* and *B. undatum* are unlikely to result from management measures as these have been static for so long. Furthermore, static gear fishers operate independently in set areas that are historic in origin and the ground is perceived to be fished to capacity (D&SIFCA, pers. comm.).

The study therefore examined the hypotheses that:

H1 = numbers of active vessels statistically significantly increased with time in the Lyme Bay MPA whilst remaining static in the IPA

H2 = CPUE statistically significantly increased with time in the Lyme Bay MPA whilst remaining static in the IPA

H3 = the value of landings statistically significantly increased with time in the Lyme Bay MPA whilst remaining static in the IPA

These were tested over nine years, covering the period from two years before the Lyme Bay MPA came into effect until seven years after.

4.2 Methods

To determine whether a change in the metrics: number of active vessels (mean number of active vessels per month), CPUE (mean number of tonnes per vessel per month) and value of landings (mean £ per vessel per month) occurred following the implementation of an MPA in Lyme Bay, UK, landings data were analysed. Data were provided by the Marine Management Organisation and covered the period from two years before the Lyme Bay MPA was implemented until seven years after it came into effect. Data were provided per vessel for ICES rectangles 30E6 and 30E7 for Lyme Bay, and 29E5 and 29E6 for the IPA (Figure 4.1).

Data were refined using the following criteria: 1) vessels must fish within the Lyme Bay MPA/IPA, determined through consultation with D&SIFCA, Southern IFCA and the Blue Marine Foundation (identified using Port Letters and Numbers), 2) data must only include landings of target species; *C. pagurus*, *H. gammarus* and *B. undatum*. Consultation with D&SIFCA, Southern IFCA and the Blue Marine Foundation also confirmed that the assumption that landings from all vessels came from within the Lyme Bay MPA or IPA could be made, based on their known fishing patterns. Landings were plotted using a July to June year, reflecting the implementation of the Lyme Bay MPA in July 2008. Due to availability of data at the time of writing, data for 2015 was only available until May.

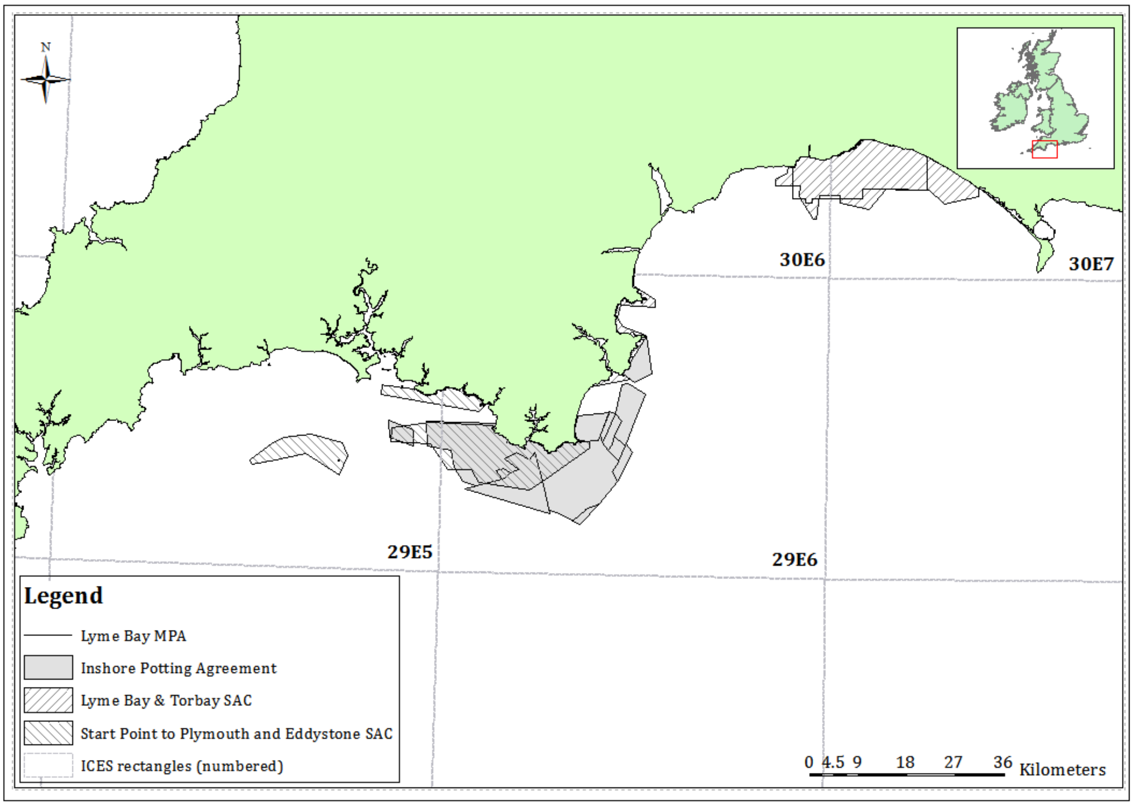


Figure 4.1: Location of the Lyme Bay MPA and Inshore Potting Agreement, showing the Lyme Bay & Torbay and Start Point to Plymouth Sound & Eddystone Special Areas of Conservation and relevant ICES rectangles. Map created using ArcGIS, 2016

Differences before and after MPA designation in Lyme Bay were calculated for each metric by subtracting the average before designation (2006/2007 – 2007/2008) from the average measure after designation (2008/2009 – 2014/2015) to give a positive (increase following designation) or negative (decrease following designation) value. These differences were also calculated as a percentage to enable direct comparison between case study sites.

4.2.1 Data analysis

Analysis of Variance (ANOVA) was conducted to test for differences for each metric between Years (fixed: 2006/2007 – 2014/2015) using PRIMER 6 (Clarke and Warwick 2001) with PERMANOVA+ for PRIMER, chosen as it is robust to unbalanced designs and makes no assumptions about underlying data distributions (Walters and Coen 2006). Data were untransformed and Euclidean distance similarity indices were used to conduct resemblance matrices (Clarke and Warwick 2001). Each term in the analyses used 9999 permutations of the appropriate units (Anderson and Braak 2003). Differences were considered significant where $P < 0.05$.

4.3 Results

Over the period of study, 43 active vessels were known to be fishing within the MPA in Lyme Bay. Of these, 41 targeted *C. pagurus*, 42 *H. gammarus*, and 29 *B. undatum*, with all except two vessels targeting two or more species (Table 4.1). Landings were greatest for *B. undatum* (mean = 65.49 tonnes per month ± 5.15), followed by *C. pagurus* (mean = 10.48 tonnes per month ± 0.93) and *H. gammarus* (mean = 0.71 tonnes per month ± 0.05) and combined totals were greatest in the year 2013/2014 averaging 137.16 tonnes per month ± 24.10 and lowest in 2007/2008 averaging 42.63 tonnes per month ± 9.50.

	Lyme Bay MPA	IPA
Total	**43**	**34**
C. pagurus, H. gammarus & B. undatum	27	5
C. pagurus & H. gammarus	11	26
C. pagurus & B. undatum	1	0
H. gammarus & B. undatum	0	0
C. pagarus only	0	1
H. gammarus only	1	2
B. undatum only	2	0

Table 4.1: Number of active vessels targeting *Cancer pagurus*, *Hommarus gammarus* and *Buccinum undatum* in the Lyme Bay MPA and the IPA

Over the same period 34 vessels were actively fishing within the IPA, 32 targeting *C. pagurus*, 33 *H. gammarus* and five *B. undatum* (Table 4.1). Landings were greatest for *C. pagurus* (mean = 98.66 tonnes per month ± 6.97) followed by *B. undatum* (7.58 tonnes per month ± 0.75) and *H. gammarus* (0.73 tonnes per month ± 0.06) and combined totals were greatest in the year 2014/2015, averaging 159.12 tonnes per month ± 26.33 and lowest in 2009/2010 averaging 77.50 tonnes per month ± 15.13.

4.3.1 Number of active vessels

The number of active vessels targeting *C. pagurus*, *H. gammarus* and *B. undatum* within both the Lyme Bay MPA and the IPA fluctuated over the period 2006 to 2015. In both locations, trends showed an initial decrease was followed by a steady increase over time (Figure 4.2), with similar numbers of vessels targeting *C. pagurus* and *H. gammarus* and fewer targeting *B. undatum* (Figure 4.2).

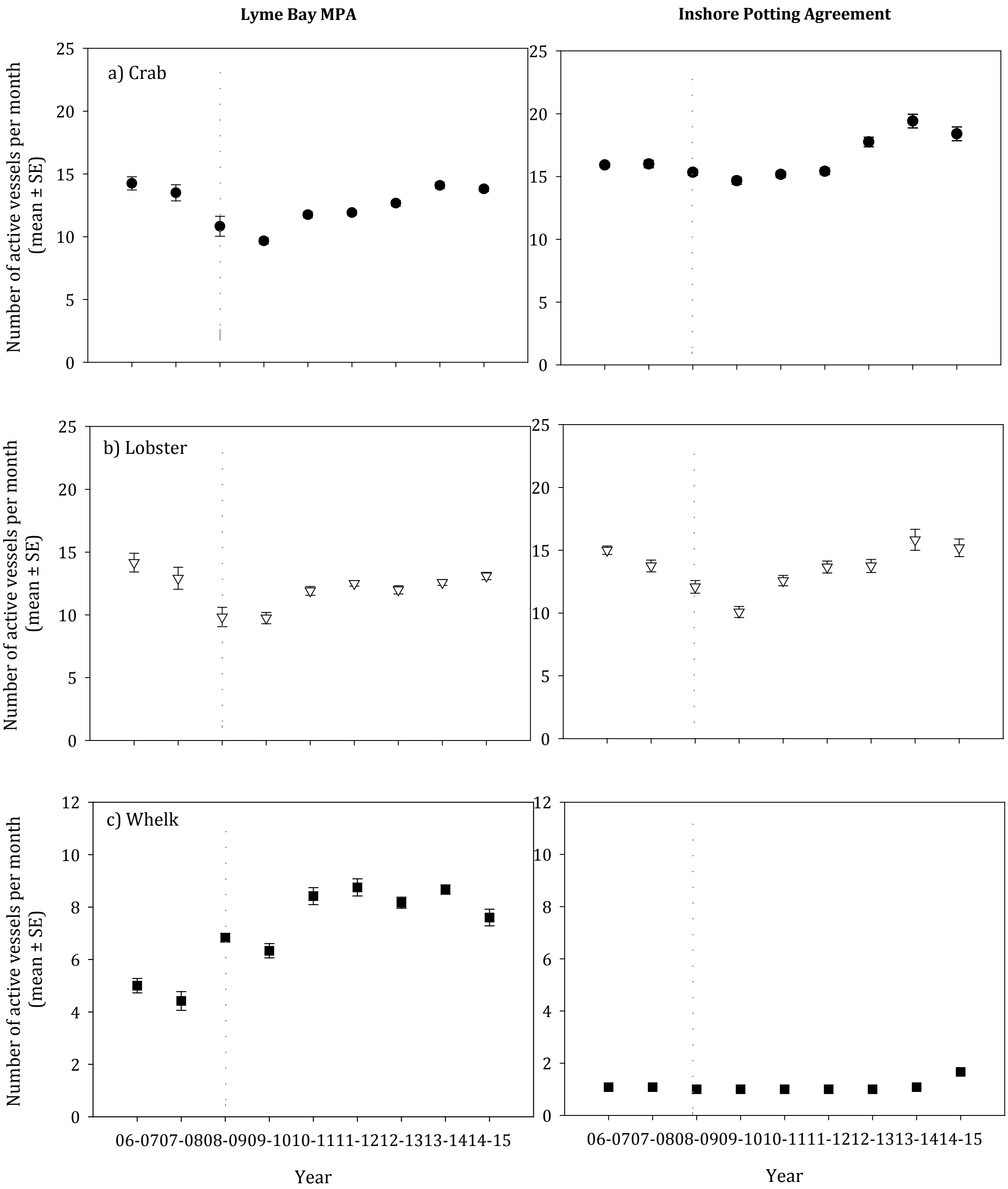


Figure 4.2: Mean number of active vessels per month landing a) *C. pagurus*, b) *H. gammarus* and c) *B. undatum* over time in the Lyme Bay MPA and the Inshore Potting Agreement MPA (July – June, 2006 – 2015). The dotted line represents when the MPA was implemented in Lyme Bay in July 2008.

Following MPA implementation, numbers of active vessels targeting all three species rose in Lyme Bay, with a significant difference identified between Years for *B. undatum* and *C. pagurus*, but not *H. gammarus*. For *C. pagurus*, significantly fewer vessels were active in 2009/2010 than all other years (P < 0.05, Table 2, Annex Table B1), but despite trends showing an increase with time since the MPA (Figure 2), numbers remained lower following its establishment, and overall a decrease of 13 % was seen post MPA (Table 4.2).

No significant differences were identified in number of active vessels targeting *H. gammarus* over time (Table 4.2, Annex Table B1), and although numbers were similar before and after MPA implementation (Figure 4.2), they decreased on average by 14 % (Table 4.2). For *B. undatum* the years before the MPA significantly differed to those after the MPA was designated in the majority of cases (P < 0.05, Table 4.2, Annex Table B1), with number of vessels significantly greater between 2011/2012 and 2014/2015 (after MPA implementation) than between 2006/2007 and 2007/2008 (before MPA implementation). On average the number of active vessels increased by 67 % following the MPA (Table 4.2).

By comparison, in the IPA, significant differences were identified between Years for *C. pagurus* and *H. gammarus*, but not for *B. undatum* (Table 4.2, Annex A2). Significantly more vessels were active in 2012/2013, 2013/2014 and 2014/2015 than in all other years for *C. pagurus* (excluding 2006/2007 and 2007/2008 for 2012/2013), (P < 0.05, Table 4.2, Annex Table B2), with an increase of 4 % observed in vessel numbers following MPA implementation in Lyme Bay (Table 4.2). For *H. gammarus*, significantly fewer vessels were active in 2009/2010 than in all other years except 2010/2011 (P < 0.05, Table 4.2, Annex Table B2) and numbers before and after Lyme Bay MPA implementation fluctuated, with an average decrease in vessels of 7 % (Table 4.2). The number of vessels actively targeting *B. undatum* was low, with only one vessel consistently fishing throughout the study period and no significant differences identified (Table 4.2, Annex Table B2). On average, a decrease of 8 % was observed, but this only represented 1 vessel (Table 4.2).

	Sig. dif. Before vs After MPA	Sig. > after MPA	Difference (No. active vessels per month)	% Difference
Lyme Bay MPA				
Crab	Yes	No	-1.79	-12.91
Lobster	-	-	-1.90	-14.05
Whelk	Yes	Yes	3.14	66.58
IPA				
Crab	Yes	Yes	0.64	4.04
Lobster	Yes	No	-1.03	-7.13
Whelk	-	-	-0.08	-7.69

Table 4.2: Summary table showing results for differences before and after the MPA was implemented in Lyme Bay in number of active vessels operating within the Lyme Bay MPA and the IPA.

4.3.2 Catch per Unit Effort

CPUE varied across the study period in Lyme Bay, with general trends showing an increase following MPA implementation for *C. pagurus* and *H. gammarus* and variation for *B. undatum* (Figure 4.3).

A significant increase in CPUE was seen for *C. pagurus* over time, with CPUE in 2013/2014 and 2014/2015 significantly greater than in all other years ($P < 0.05$, Table 3, Annex Table B3). On average, CPUE increased by 60 % after implementation, with a gradual increase followed by a sharp rise (Table 4.3, Figure 4.3).

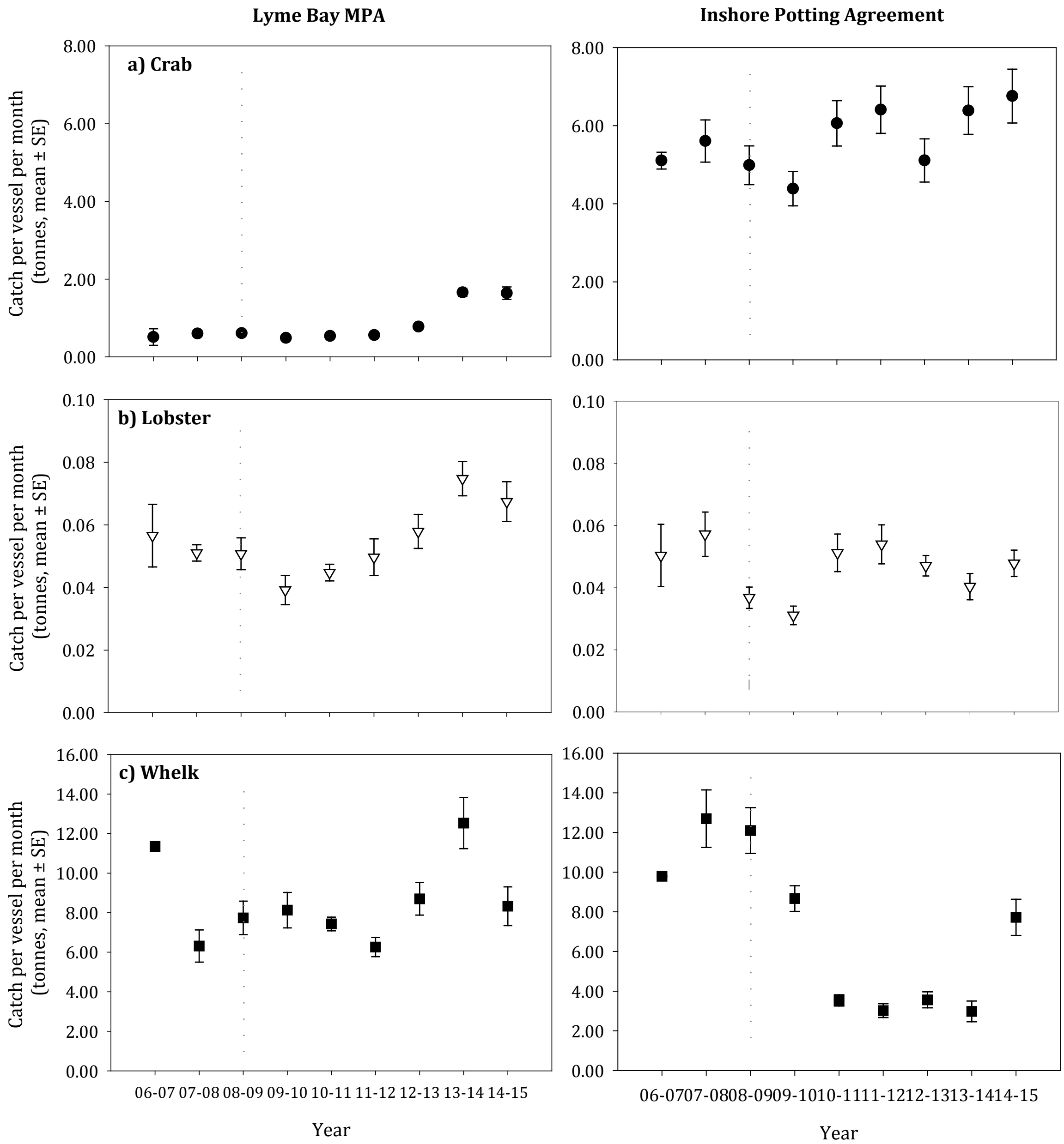


Figure 4.3: CPUE (catch per vessel per month) of a) *C. pagurus*, b) *H. gammarus* and c) *B. undatum* per year (July – June, 2006 – 2015) for the Lyme Bay and Inshore Potting Agreement MPAs. The dotted line represents when the MPA was implemented in Lyme Bay in July 2008.

No significant differences were found between Years for *H. gammarus*, but CPUE showed an increasing trend from 2009/2010 to 2013/2014 (Figure 4.3), although on average, CPUE only increased by 2 % after MPA designation (Table 4.3). *B. undatum* CPUE fluctuated with time and was greatest in 2013/2014 but appeared to go through cycles of increased CPUE followed by decreased CPUE (Figure 4.3).

No significant differences were identified over time, but on average, CPUE decreased by 4 % (Table 4.3, Annex Table B3).

In the IPA, CPUE fluctuated for all three species, and did not follow the trends identified for *C. pagurus* and *H. gammarus* in Lyme Bay. No significant differences were identified over time for *C. pagurus*, but following Lyme Bay MPA designation, CPUE increased by 7 % and as with the Lyme Bay MPA it was greatest in 2013/2014 and 2014/2015 (Figure 4.3, Table 3, Annex Table B4). CPUE for *H. gammarus* also fluctuated, but no significant differences were identified and on average it decreased by 18 % following Lyme Bay MPA implementation (Figure 4.3, Table 4.3, Annex Table B4). CPUE for *B. undatum* was significantly greater between 2006/2007-2009/2010 than 2010/2011-2013/2014 and increased significantly in 2014/2015 ($P < 0.05$, Table 4.3, Figure 4.3). On average it decreased by 47 % following Lyme Bay MPA implementation (Table 4.3).

	Sig. dif. Before vs After MPA	**Sig. > after MPA**	**Difference (tonnes per vessel per month)**	**% Difference**
Lyme Bay MPA				
Crab	Yes	Yes	0.33	59.80
Lobster	-	-	0.001	1.79
Whelk	-	-	-0.39	-4.36
IPA				
Crab	-	-	0.36	6.71
Lobster	-	-	-0.01	-18.20
Whelk	Yes	No	-5.32	-47.35

Table 4.3: Summary table showing results for differences before and after the MPA was implemented in Lyme Bay in CPUE for vessels operating within the Lyme Bay MPA and the IPA

4.3.3 Value of Landings

Fluctuations in value of landings per vessel per month in Lyme Bay were similar to fluctuation in CPUE, with a trend of increasing value after MPA designation (Figure 4.4). A significant difference in value of landings was identified for *C. pagurus*, *H. gammarus* and *B. undatum* in Lyme Bay (Table 4.4, Annex Table B5). For *C. pagurus*, landings value was significantly greater in 2013/2014 and 2014/2015 than all other years, and significantly greater in 2012/2013 than in 2006/2007, 2008/2009, 2009/2010 and 2010/2011 ($P < 0.05$, Table 4.4, Annex Table B5). On average, value of landings increased by 73 % following MPA designation (Table 4.4).

Value of landings for *H. gammarus* were significantly lower in 2009/2010 and 2010/2011 than in 2006/2007 and 2007/2008, significantly greater in 2013/2014 than the period from 2008/2009 – 2011/2012 and significantly greater in 2014/2015 than 2009/2010 and 2010/2011 ($P < 0.05$, Table 4.4, Annex Table B5). On average, value of landings decreased by 13 % following MPA implementation (Table 4.4), but peaked in 2013/2014 at £839.95 per vessel per month ± £245.39.

For *B. undatum*, landings had a significantly greater value in 2013/2014 than between 2007/2008 – 2011/2012 ($P < 0.05$, Table 4.4, Annex Table B5). Trends were inconsistent, with two cycles of increased followed by decreased landings apparent, and whilst value of landings did increase overall by an average of 16 % (Table 4.4) they decreased in 2014/2015 to a level similar to that seen in 2006/2007 (Figure 4.4).

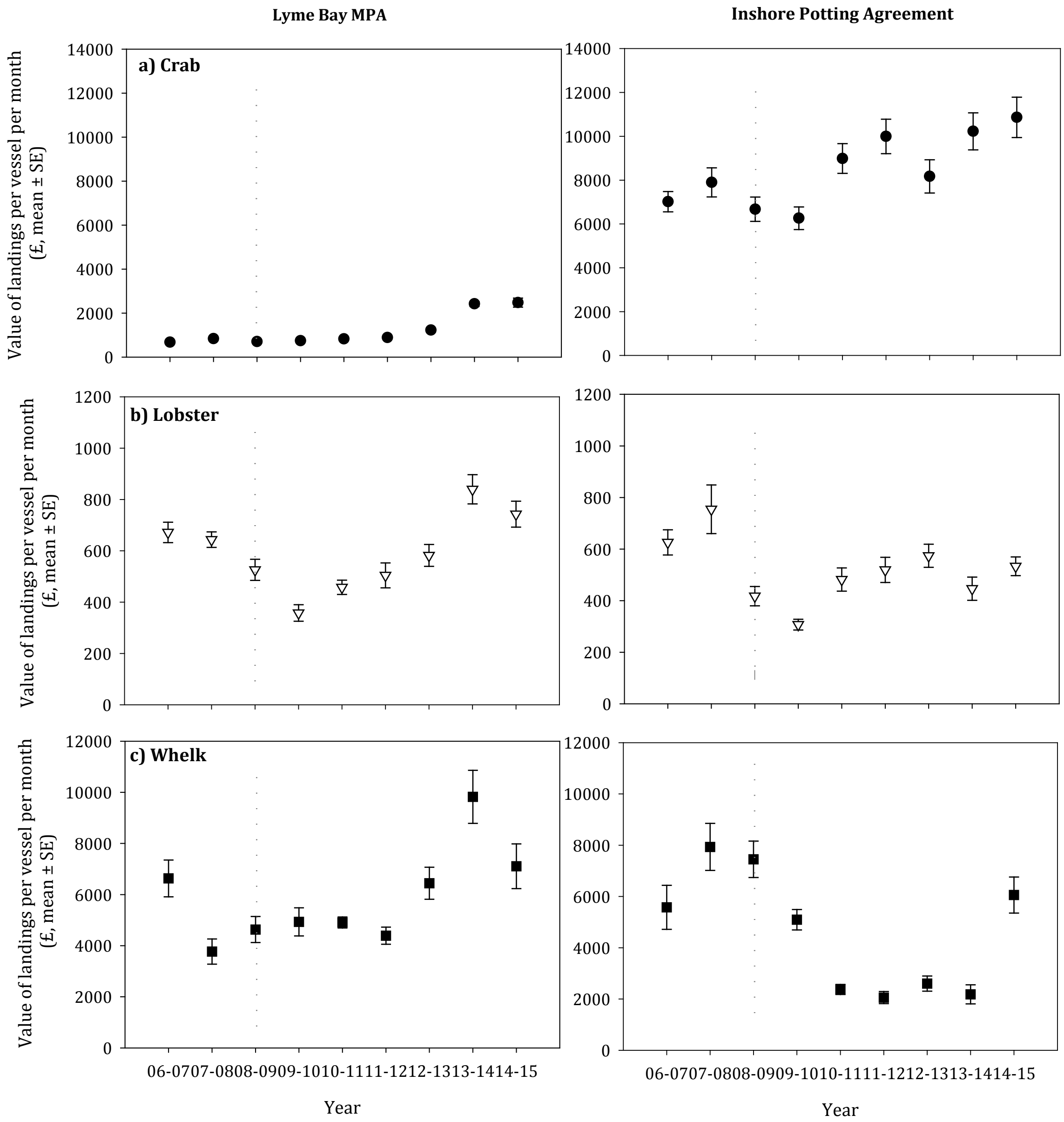


Figure 4.4: Value of landings per vessel per month for a) *C. pagurus*, b) *H. gammarus* and c) *B. undatum* per year (July – June, 2006 – 2015) for the Lyme Bay and Inshore Potting Agreement MPAs. The dotted line represents when the MPA was implemented in Lyme Bay in July 2008.

Value of landings in the IPA fluctuated over time. For *C. pagurus*, an increasing trend was observed from 2009/2010 onwards, but no significant differences were identified (Table 4.4, Annex Table B6). Value of landings was 17 % greater after Lyme Bay MPA designation than before (Table 4.4), and similarly to Lyme Bay, value of landings was greatest in 2013/2014 and 2014/2015. No significant differences were observed for value of landings for *H. gammarus* over time (Annex Table B6).

On average, landings decreased by 32 % following Lyme Bay MPA designation (Table 4.4). Value of landings for *B. undatum* were however significantly lower from 2010/2011 – 2013/2014 than from 2007/2008-2009/2010 and significantly greater in 2014/2015 than from 2010/2011 – 2013/2014. On average, landings decreased in value by 42 % following Lyme Bay MPA implementation (Table 4.4, Annex Table B6).

Overall, for vessels targeting all three species, value of landings increased by £1,287.95 per vessel per month in the Lyme Bay MPA and decreased by £1,772.96 in the IPA.

	Sig. dif. Before vs After MPA	Sig. > after MPA	Difference (£ per vessel per month)	% Difference
Lyme Bay MPA				
Crab	Yes	Yes	£554.71	72.79
Lobster	Yes	No	-£86.76	-13.19
Whelk	Yes	Varied	£820.00	15.77
IPA				
Crab	-	-	£1,257.21	16.86
Lobster	-	-	-£222.44	-32.23
Whelk	Yes	No	-£2,807.73	-41.57

Table 4.4: Summary table showing results for differences before and after the MPA was implemented in Lyme Bay in value of landings for vessels operating within the Lyme Bay MPA and the IPA

4.4 Discussion

This study aimed to determine whether multi-use marine protected areas increase benefits for fishers whose activities are permitted within them by assessing the changes occurring in number of active vessels, CPUE and value of landings over time in the Lyme Bay MPA. Previous work conducted by Mangi et al. (2012) and observations made by the Lyme Bay Working Group suggested that effort had increased within the MPA following its designation, but this had not been quantified following the cessation of the work of Mangi et al. (2012) which considered the impacts of the MPA up to 2011. The study hypothesised that all three metrics would increase significantly after the implementation of the MPA in Lyme Bay but remain static in the IPA (a control site) where zoned management had been in place since 1978 and the fishery was relatively static. It is clear, however, that variation occurred in the IPA as well as the Lyme Bay MPA, suggesting that external factors have affected both sites. Despite this, comparison has enabled differences to be identified and where a significant increase was seen in the Lyme Bay MPA following designation and not in the IPA, it was assumed that MPA designation may have influenced the results.

The results in Lyme Bay show variation between target species, but overall no increase in the number of vessels operating within the MPA. They do, however, indicate economic benefit for fishers targeting *C. pagurus* within the MPA as CPUE and value of landings were significantly greater following MPA implementation. This suggests that designation may be increasing the provision of economic benefits for fisheries.

Despite the observed benefits, however, an initial decline was seen in the number of vessels targeting all three species and in CPUE for *C. pagurus* and *H. gammarus* immediately following the closure. This was the continuation of a decline that pre-dated the MPA, and similar patterns were observed in the IPA over this period suggesting that it may be related to external factors and not MPA implementation. In the majority of cases, increases were seen following designation of the MPA from 2010/2011 onwards in number of active vessels, CPUE and value of landings (with variation between species), but, despite a similar increase in number of active vessels, CPUE and value of landings were much more variable within the IPA. The work of Mangi et al. (2012) showed that vessels operating within the MPA experience no, or limited costs from designation and perceived the implemented management measures to be of benefit to their activities (Hattam et al. 2014; Mangi et al. 2012; Mangi et al. 2011). The benefits identified in this study where vessels targeting *C. pagurus* landed an additional 0.33 tonnes per vessel per month providing an increase in value of landings of £554.71 per vessel per month, suggest that they have benefitted from the designation of the MPA. Similar benefits from MPA designation were identified in a review of Southern European MPAs by Vandeperre et al. (2011) who found that CPUE increased gradually by 2-4 % over a 30 year period.

Vandeperre et al. (2011) attributed this benefit to the presence of no take zones within the MPA, and whilst there are no designated no take areas within the Lyme Bay MPA there are a number of factors which may have contributed to the increases seen. Firstly, although not related to MPA designation, the decrease in number of active vessels over the study period may have reduced competition for fishing grounds, and secondly, the management measures implemented at the time of designation would have reduced conflict and increased gear security and ground available to fish. The further restrictions put in place to manage fishing activities within the SAC would have increased the ground available to static gear fishers alone, and whilst bottom towed fishing gear was only excluded in January 2014, this may contribute to the increased landings seen in 2013/2014 and 2014/2015.

Mangi et al. (2011) identified an increase in the number of pots deployed by fishers within the MPA immediately following its implementation and it is thought that the increased opportunity to fish may have resulted in some vessels increasing the quantity of gear used, intending to increase their catch rates. Data relating to pot numbers and how they changed over time was unavailable to this study, so it was not possible to determine whether this was the cause of the increased CPUE, but 62 of the 66 boats targeting *C. pagurus* were signed up to the Lyme Bay Working Group's voluntary Code of Conduct limiting them to 250 pots per vessel (Lyme Bay Fisheries and Conservation Reserve). This was established in recognition of the need to manage effort within the fishery, and the majority of the vessels that signed up to the code are thought to fish well within these limits (A. Rees, pers. comm). The Lyme Bay Experimental Potting Study which is assessing the impacts of potting at different intensities within the MPA should provide additional data to allow sustainable limits to be determined within the bay, and it is thought that the Lyme Bay Working Group would amend their voluntary codes where necessary if current fishing efforts were thought to be compromising future sustainability of target species (Rees In prep).

Benefits to vessels targeting *C. pagurus* could also be due to increased availability of *C. pagurus* within the MPA. This might be expected as a result of the exclusion of bottom towed fishing gear through recovery of habitat and decreased disturbance. Studies have shown *C. pagurus* to be sensitive to damage from the impacts of fishing gear such as beam trawls and scallop dredges which may cause loss of limb, carapace damage and mortality (Jenkins et al. 2001; Kaiser and Spencer 1995). Where this fishing pressure is removed number of individuals as well as numbers of undamaged *C. pagurus* may be expected, leading to increased value of landings as fewer individuals would be discarded or damaged, increasing the proportion of high quality catch retained for sale.

No studies have been conducted which have specifically quantified the abundance of crustaceans in Lyme Bay following the implementation of the MPA, but Sheehan et al. (2015) used *C. pagurus* as an indicator species in a study monitoring benthic recovery and therefore quantified its abundance on an annual basis using baited remote underwater video from 2008 - 2014. No significant differences in abundance between sites inside and outside the MPA were identified over time, but trends showed abundance increasing from 2008-2010, then decreasing from 2010-2013 and increasing slightly from 2013-2014. Data from 2015 are not yet available, but the data up to 2014 suggests that whilst CPUE of *C. pagurus* has increased, abundance may have decreased, with the significant increase in CPUE in 2013/2014 identified by this study not matched by a significant increase in abundance (Sheehan et al. 2015). The *C. pagurus* fishery in the south-west is thought to be sustainable and well managed; the latest stock assessment conducted by Cefas in the western English Chanel concluded that the stock was in good condition with exploitation rates close to the levels required to produce Maximum Sustainable Yield (Cefas 2014). It is possible, however, that current exploitation rates within the MPA may be masking the potential for the species to increase in abundance, or, as the population is exploited across the bay both within and outside the MPA no increase in abundance was detectable.

Evidence for the MPA providing economic benefit to fishers targeting *H. gammarus* and *B. undatum* is less evident. No significant difference was identified in CPUE across the study period for *H. gammarus*, and value of landings significantly decreased. Similar trends were observed in the IPA, although the reduction in value of landings was not significant, and this is thought to reflect a reduction in market price for the species rather than an effect of the MPA. *B. undatum* was seen to vary in both the Lyme Bay MPA and the IPA throughout the study period, and despite a significant increase in number of vessels with time in the MPA, CPUE did not increase significantly, and value of landings varied between years. Overall economic benefit realised from the increased landings of *C. pagurus* may therefore have been undermined by insecurities in *B. undatum* stocks, and loss of value of landings of *H. gammarus*. Despite this, value of landings for vessels targeting all three species in Lyme Bay still increased, showing that the increased value of *C. pagurus* and *B. undatum* was sufficient to counteract the reduction in value of *H. gammarus*.

The work of the Blue Marine Foundation means that additional economic benefit may be generated from the MPA. They helped to establish a 'Reserve Seafood' brand in 2015, where fishers who are signed up to the voluntary Code of Conduct and accredited under the Seafish Responsible Fishing Scheme can sell their fish at a price which is inflated by 25 % (Lyme Bay Fisheries and Conservation Reserve). This accounts for approximately 15 % of all landings from static gear vessels (Rees et al, in prep) and, along with the identified increases in value of landings and

CPUE should result in a greater economic benefit arising from the MPA, and help to counteract the reduction in market price seen for lobster. The work of Rees et al (in prep) also identifies social and wellbeing benefits for all static gear fishers operating within the MPA through reduction in stress and conflict since designation, suggesting that benefits are not just monetary.

4.4.1 Limitations of the study

This study has provided a mechanism by which to assess the impact of implementing MPAs on fisheries permitted to continue within their waters. It has been able to provide an initial measure of the benefits, identifying increased CPUE and value of landings for fishers targeting *C. pagurus* within the MPA. Whilst the designation may have increased the provision of ecosystem services for fishers operating within its waters, additional data are required to fully determine the increased economic benefit that can be directly attributed to the MPA as external factors were identified which were not able to be quantified. These include monitoring of pot numbers per vessel to determine whether landings increased due to fishers increasing the number of pots deployed, and stock assessments to quantify the abundance of target species within the MPA. The Blue Marine Foundation funded study 'The Lyme Bay Experimental Potting Study' (Rees In prep) should provide data that will enable a more detailed assessment to be conducted.

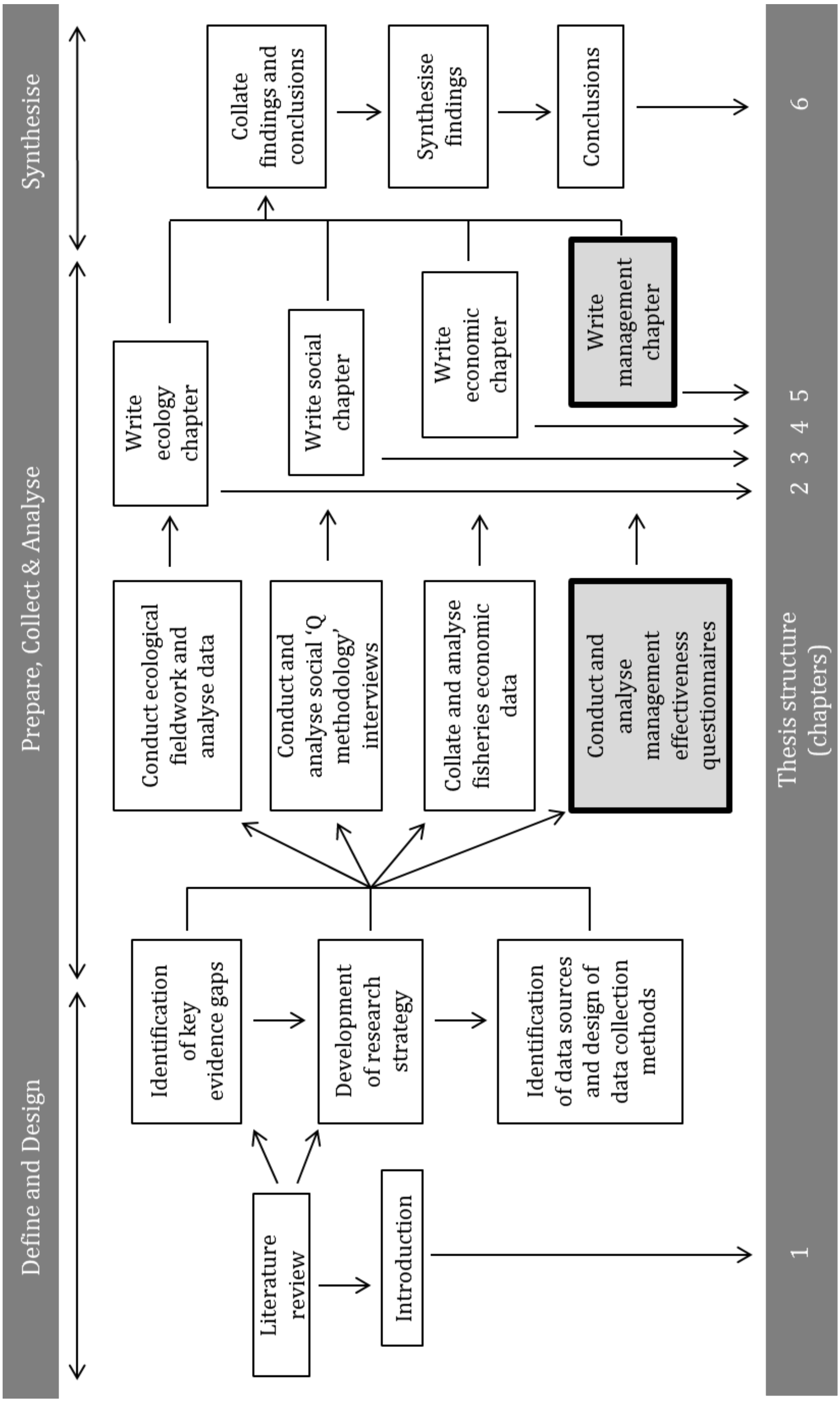
Data relating to vessel fishing locations such as VMS and sightings data would also be useful, providing information on how vessels fishing locations have changed over time. All vessels included in this study were assumed to fish entirely within the Lyme Bay MPA/IPA respectively, which may put some extra weighting on the landings from the closure. Quantifying changes such as vessels moving to fish within the MPA from outside as a result of the closure would aid interpretation of the results.

4.4.2 Conclusion

This study has shown that the implementation of a multi-use MPA in Lyme Bay where bottom towed fishing gear was prohibited, but static fishing gear permitted, has contributed to economic benefits and may consequently have increased ecosystem service provision for fishers, primarily since 2010/2011. In particular, this was realised through increased CPUE and value of landings for *C. pagurus*. Whist the benefits cannot be conclusively attributed to the designation of the MPA it is thought to have contributed, both directly through provision of ground, reduction in gear conflict and increased opportunity to fish, and indirectly through the establishment of the Lyme Bay Working Group and the brand Reserve Seafood. It is hoped that these benefits will be maintained, and that local management via the Lyme Bay Working Group will ensure sustainability of landings in the future, this will, however, be dependent on appropriate and adaptive management to ensure stocks are maintained and not over fished.

Quantification of the impacts of multi-use MPAs is important on the global scale as their implementation is increasing under national, regional and international legislation, with many countries aiming to protect 10 % of their coastal and marine waters by 2020 under CBD targets. Studies have shown that stakeholder support is greatest where benefits of designation are clearly visible, and acceptance is linked to compliance and MPA success (Arias et al. 2015; Rossiter and Levine 2014). Case studies quantifying the benefits arising from MPA designation are therefore important, both for increasing understanding of what the benefits might be, and in terms of ensuring MPAs are designed and managed to facilitate their generation. Economic benefits are known to be dependent on location and protection level (Rife et al. 2013; Rossiter and Levine 2014; Vandeperre et al. 2011), and this study has shown that benefits can arise for fishers within a multi-use MPA in the absence of no take areas.

The Lyme Bay case study site provides opportunity for long term monitoring of MPA implementation, which would provide a detailed assessment of the socio-economic implications of designating a multi-use MPA. Evidence to date suggests that the ecological benefits of MPAs are evident on the long timescale rather than in the short term (Babcock et al. 1999; Watling and Norse 1998), and whilst this study provides a case study covering 6 years post designation, it is hoped that, as in the case of the MPAs reviewed by Vandeperre et al. (2011), the MPA is managed effectively so that the ecosystem services provided by the site increase over time.



Define and Design
Prepare, Collect & Analyse
Synthesise
Literature review
Introduction
Identification of key evidence gaps
Development of research strategy
Identification of data sources and design of data collection methods
Conduct ecological fieldwork and analyse data
Conduct and analyse social 'Q methodology' interviews
Collate and analyse fisheries economic data
Conduct and analyse management effectiveness questionnaires
Write ecology chapter
Write social chapter
Write economic chapter
Write management chapter
Collate findings and conclusions
Synthesise findings
Conclusions
Thesis structure (chapters)
1
2 3 4 5
6

Chapter five: Perspectives on the success of ecosystem based fisheries management in inshore waters

The aim of this chapter is to evaluate how effective the implementation of ecosystem based fisheries management has been in inshore waters.

5.1 Introduction

Historically, fisheries management focussed on single species and how to sustain stocks whilst fishing to Maximum Sustainable Yield (Pikitch et al. 2004). This approach was however, largely unsuccessful, resulting in the degradation of both fish stocks and their supporting ecosystems (Botsford et al. 1997; Christensen et al. 2003; Lotze et al. 2006; Pikitch et al. 2004). FAO statistics show that the number of commercial stocks fished beyond biologically sustainable levels has increased since 1974 with the latest statistics reporting an estimated 28.8 % of global fisheries are overfished and 61.3 % fully fished (FAO 2014). In recognition of this, and as a result of an increasing need to address management of the whole system including the ecosystems supporting fisheries, the focus of fisheries management is now how to achieve human and ecosystem wellbeing through governance, which effectively combines it with biodiversity conservation (Garcia et al. 2015). This approach is termed ecosystem based management (US National Research Council 1998).

Taking an ecosystem approach to management is a substantial development as fisheries and conservation management have historically run parallel to one another (Garcia et al. 2014). They shared common roots through a 'wise use' attitude, but industrialisation and population growth resulted in conflict (Brown 2002; Garcia et al. 2014) and there was little overlap until the UN Law of the Sea Convention (1972) provided a mechanism to unify the two, causing them to converge (Garcia et al. 2014). More recently, international summits such as the Convention on Biological Diversity (CBD) Rio + 20 summit have been instrumental in setting guidance for fisheries and conservation management leading to an ecosystem approach being widely adopted through mechanisms such as ecosystem based fisheries management (EBFM), (Garcia et al. 2014).

In Europe the Marine Strategy Framework Directive (MSFD) calls for *'an ecosystem based approach to the management of human activities'* and, in line with the CBD guidance has provided a legal framework for the ecosystem approach to be incorporated into marine management (Farmer et al. 2012). It is also evident in the EU Common Fisheries Policy, which was reformed in 2002 allowing a shift from a narrow focus on fish stock management to a more holistic approach encompassing sustainable use of resource and their supporting ecosystems (Pope and Symes 2000. p. 33). In the case of the UK it is also incorporated into the Marine and Coastal Access Act (2009) that set out an ecosystem based plan for marine activities aiming to achieve sustainable development (Fletcher et al. 2014).

5.1.1 Ecosystem based fisheries management

Link (2002) defined an ecosystem as '*an ecological community together with its environment, considered as a unit'* and argued that as it is not possible to manage an ecosystem, EBFM is fisheries management in an ecosystem context rather than ecosystem management in a fisheries context. The overall objective of EBFM is to sustain a healthy marine ecosystem, which will in turn support fisheries, requiring management of human activities to ensure that destructive practises do not compromise ecosystem resilience (Pikitch et al. 2004).

The four main principles, as defined by Pikitch et al. (2004) are: to avoid ecosystem degradation; to minimize the risk of causing damage to species and ecosystem processes that could be irreversible; to obtain and maintain socio-economic benefits over the long timescale that do not compromise the ecosystem; and to increase the knowledge base for an ecosystem such that the likely consequences of human actions are understood. A key principle of the ecosystem approach is that it incorporates ecological, economic and social factors (Laffoley et al. 2004), and this can be seen within the principles of EBFM (Figure 1).

The engagement of stakeholders has been recognised as crucial to successful EBFM as its goals cannot be met by top-down approaches to management alone (Gray and Hatchard 2008; Valdimarsson and Metzner 2005). In a review of the relationship between stakeholder participation and EBFM, Gray and Hatchard (2008) found that in the majority of cases it is mutually beneficial, with stakeholder participation providing knowledge, legitimacy, practical support and contributing to adaptive management.

5.1.2 Fisheries management and stakeholder participation

Stakeholder participation in fisheries management has been facilitated by the development of co-management practises. Co-management can be defined as '*the collaborative and participatory process of regulatory decision making among representatives of user groups, government agencies and research institutions*' (Jentoft et al. 1998). It requires a broad stakeholder base and is recognised to be central to the development and implementation of management using an ecosystem approach (Costanza et al. 1998; FAO 2003; Ostrom 2009; Pomeroy and Berkes 1997; Pretty 2003; Royal Commission on Environmental Pollution 2004; WWF 2002), (Figure 1).

Research has shown that co-management can bring advantages such as an enhanced sense of ownership, empowerment, improvements in management through incorporation of local knowledge, increased sensitivity to local socio-economic and ecological constraints, increased compliance with regulations and greater involvement of fishers in monitoring, control and surveillance (Berkes 2007; Jentoft 2005; Pomeroy and Williams 1994). Furthermore, environmental outcomes can be improved through compliance with regulations (Sandström et al. 2014). For co-management to be effective, Gutierrez et al. (2011) concluded through a review of 130 fisheries that attributes such as strong leadership, social cohesion, individual or community quotas and clear incentives to stakeholders (e.g. through benefits from protected areas) were required, with success enhanced where both local community and strong central governance existed.

Examples of successful co-management are apparent in the literature from a variety of locations globally (e.g. Castilla and Defeo 2001; Österblom et al. 2011; Pinkerton 1994; Pomeroy 1995; Sen and Raakjaer Nielsen 1996). Management is often focussed on fisheries goals, such as in the Lofoten Islands, Norway, where committees of fisheries representatives were established to reduce conflict and promote sustainability of fish stocks in the area (Jentoft and Kristoffersen 1989). Literature relating to examples where the management committee is extended to include stakeholders with wider interests and expertise is less common, but this approach is increasing in popularity in countries such as the USA where the stakeholder base was widened following recognition that for conservation to be achieved, inclusion of stakeholders whose interests are in restoration and sustainability of ecosystems is necessary (Okey 2003). This is also important for increasing the social acceptability of management measures, and to increase compliance with regulations (Arias et al. 2015). It is hoped that support may increase with time in areas where benefits of co-management are evident.

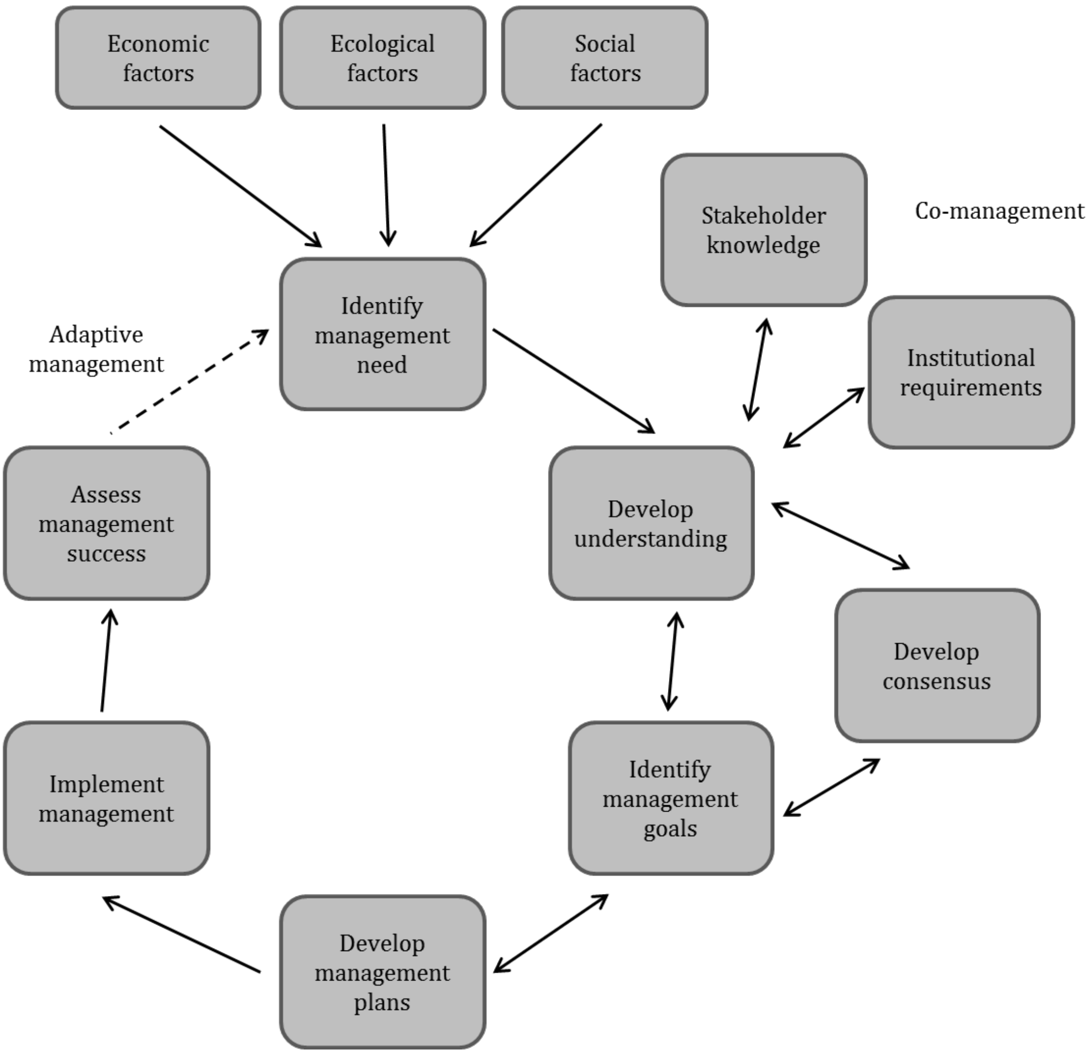


Figure 5.1: Schematic diagram showing the ecosystem based management process and how it can incorporate co-management and adaptive management. Adapted from: Slocombe (1998)

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Emphasis has been put on the need for management to be adaptive, allowing rapid response to changes in policy ideas to achieve sustainability, especially where knowledge of ecosystems is incomplete (Christensen et al. 1996; Costanza et al.

1998), (Figure 5.1). Olsson et al. (2004a) related adaptive management to the building of resilience in socio-ecological systems, emphasising the need for support from a diverse range of stakeholders to produce '*flexible community based systems of resource management*', and Armitage et al. (2009) identified it as important especially where complex socio-ecological systems are present.

5.1.3 Fisheries management in the UK context

UK inshore fisheries are dominated by vessels of ten metres and under, the majority of which have close ties with their home ports as they are unable to travel far to fish and return to port every evening (Seafish 2015). These vessels represent only one tenth of UK fishing capacity and one third of fleet power, but are very valuable to the social fabric, cultural identities and economies of coastal areas (Phillipson and Symes 2010; Seafish 2015).

Fisheries management in the UK faced a need for reform at the beginning of the 21st century; systems were thought to be fatigued and struggling to cope with the pressure of combining fisheries management with environmental management without a clear structure under which to do so (Phillipson and Symes 2010). The ecosystem approach was first introduced to marine policy in 2002 through a document entitled 'Safeguarding our Seas' (Defra 2002), which required effective marine spatial planning and a coherent and informed approach to both involve and empower stakeholders (Rodwell et al. 2014). It was addressed by the Marine and Coastal Access Act in 2009 that provided a coordinated regulatory system for management, setting out a rationale that included the principles of precaution and sustainable development and promoted economic, social and environmental objectives. This was seen as an opportunity for major changes to be made to fisheries management in the UK, with the incorporation of conservation of key importance (Rodwell et al. 2014). Support for the reform of fisheries management was strong, and a key driver for MCAA, but there were concerns that it could result in environmental management obscuring the issues of social and economic sustainability within inshore fisheries (Phillipson and Symes 2010).

Prior to the MCAA, inshore fisheries management in England and Wales was conducted by Sea Fisheries Committees (SFCs). These were predominantly fisheries management bodies however, and to address the need for inclusion of conservation in their remit, the MCAA established Inshore Fisheries and Conservation Authorities (IFCAs) in England to replace the SFC as statutory regulators in April 2011. Ten IFCAs were established around the coast of England and had responsibility for inshore waters out to 6 nautical miles from the coast. Their vision was to '*lead, champion and manage a sustainable marine environment and inshore fisheries, by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry'*. They also developed goals, which related to enforcement, conservation, fisheries productivity, employment opportunities, stakeholder communication and recreational activities. They were given responsibilities for fisheries regulation and enforcement, stock enhancement, and monitoring, and implemented regulations through the use of byelaws and fishing orders.

A key part of the IFCA remit, and one of the main differences to that of the SFCs was the inclusion of environmental management; in particular, this includes management of marine protected areas and evaluation of whether fishing activities are compatible with their conservation objectives. The current workload of the IFCAs includes assessment of fishing activities within European Marine Sites under the change in approach to their management introduced by the UK government (Defra 2013) and a review of the historic byelaws inherited from the SFCs and the introduction of new ones where necessary.

Both the SFCs and the IFCAs can be considered co-management bodies, with EBFM evident in the approach of the MCAA and the role of the IFCAs. The inclusion of conservation in the IFCA remit facilitated a change in the structure of the management committee (termed the Authority), and inclusion of a broader range of stakeholders widening representation and lessening the focus on the fishing industry (Defra 2015). Consequently, IFCAs are managed by committees of Authority members with representatives including local authorities, commercial fishermen, recreational sea anglers, scientists, managers, conservation bodies and statutory agencies.

5.1.4 Study aims

The establishment of the IFCAs can be seen as a positive step towards EBFM in England, and towards meeting obligations within international, regional and national legislation to take an ecosystem approach to management. Identification of effective mechanisms for implementation of EBFM are essential, and the success of the IFCAs at achieving this has not been fully evaluated (but see Defra 2015; Pieraccini and Cardwell 2015; Rodwell et al. 2014). This study therefore provides a case study of how EBFM has been incorporated into marine management in

England. Determining the success of EBFM is fundamental so that management measures can be adapted where necessary to ensure their effectiveness.

The IFCA remit appears to address the key factors identified by Gutierrez et al. (2011), but in a preliminary assessment of the perceptions of IFCA members, Rodwell et al. (2014) concluded that the IFCAs faced challenges such as inadequate resources, which may compromise their ability to succeed. This conclusion was supported by a report by Defra (2015) into the conduct and operation of the IFCAs up to 2014, which highlighted areas that may require consideration. Areas included the size of IFCA committees and the knowledge of their members (Defra 2015), but the Defra report did not use a structured interview process so it did not gather opinion on all areas. It is clear however, that whilst IFCAs may have the necessary attributes for success, there may be factors constraining this, and identification of these is key to ensuring that management can be adapted where necessary to increase its effectiveness.

Prior to this study, Rodwell et al. (2014) conducted a survey of the perceptions of IFCA members from all ten IFCAs in English waters immediately following their establishment. Their aim was to provide an initial assessment of the potential role of the IFCA in achieving both fisheries and conservation goals, and the objectives of their study were: *'to assess whether members (1) are positive about the balance of membership of the IFCAs; (2) agree on common goals of the IFCAs; (3) perceive that there are specific obstacles to success of the IFCAs; (4) are optimistic or pessimistic about whether IFCAs can achieve their goals; (5) have opinions on legal and regulatory issues regarding the IFCAs; and (6) agree with specific perception statements about IFCA functionality'* (Rodwell et al. 2014).

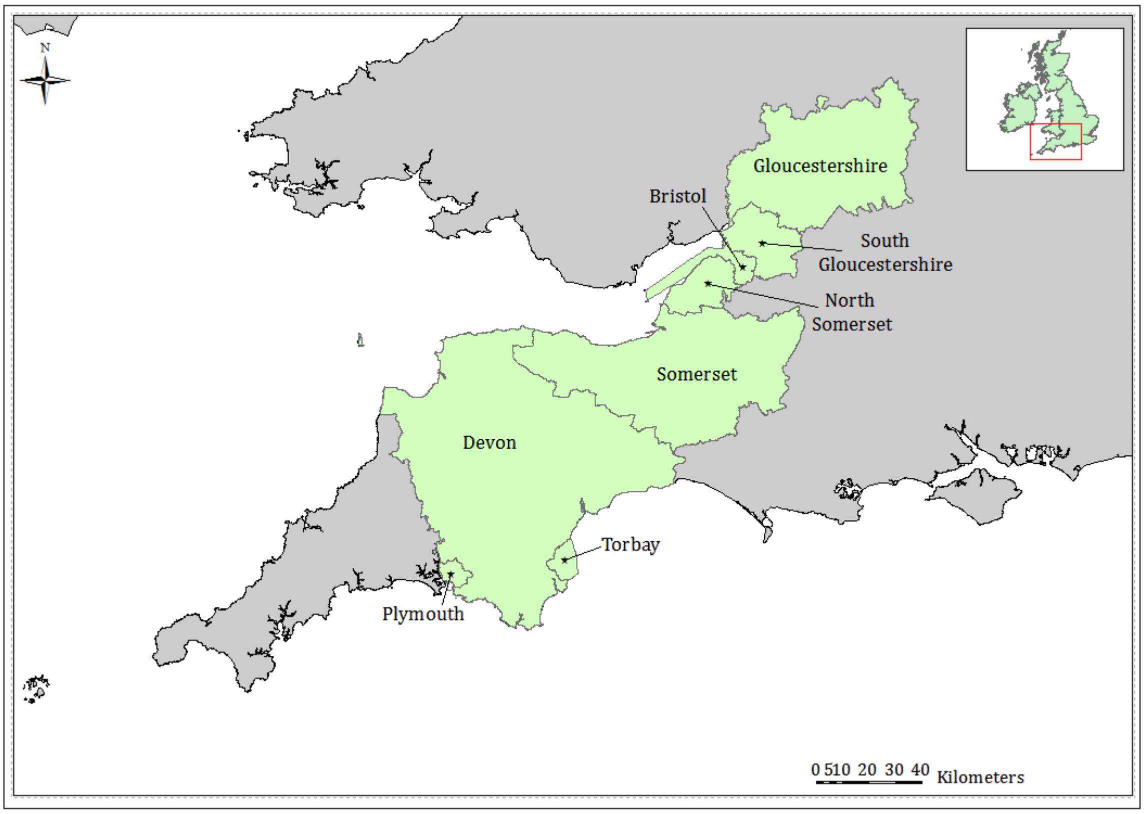


Figure 5.2: Devon & Severn Inshore Fisheries & Conservation Authority District showing County (Devon, Somerset, North Somerset, South Gloucestershire, and Gloucestershire) and District (Plymouth, Torbay, and Bristol) boundaries. Source: Ordnance Survey Data © Crown Copyright and database right 2010. Map created using ArcGIS, 2016

This study built on the work of Rodwell et al. (2014), and aimed to assess the effectiveness of integrating EBFM into marine management to address fisheries and conservation goals in England. This was achieved by evaluating the ability of Devon and Severn IFCA (D&SIFCA) to meet their objectives in their first five years of existence through interviews with Authority members and the wider stakeholder group. The D&SIFCA was established in April 2011 replacing the Devon Sea Fisheries Committee (DSFC). In addition to Devon, the new district covered the tidal areas of Somerset, North Somerset, Bristol, Gloucestershire and South Gloucestershire (Figure 5.2); areas which did not previously fall within a SFC as their commercial fisheries are minimal, but which are now included due to the conservation remit of the Authority.

The D&SIFCA is funded by the eight local authorities within its district and New Burdens funding from the Defra (UK Government). Thirty Authority members make up the D&SIFCA Authority, including 12 Local Authority members, Statutory Appointees from Natural England (NE), the Marine Management Organisation (MMO) and the Environment Agency (EA) and 15 general members such as recreational sea anglers, researchers, commercial fishermen and conservation organisations (Defra 2015).

Stakeholder engagement has been identified as a key component of the ecosystem approach, apparent in both EBFM and fisheries co-management. The perceptions of D&SIFCA stakeholders were therefore considered key to an evaluation of their success. In order to evaluate how effective the implementation of ecosystem based fisheries management has been in inshore waters in England, the following objectives were developed in order to determine whether D&SIFCA stakeholders:

1. Are optimistic about the membership of the D&SIFCA and the way it is run
2. Agree on the goals and the vision of the D&SIFCA and perceive that they are being achieved
3. Perceive there to be obstacles restricting the ability of D&SIFCA to achieve its goals
4. Feel that the fisheries and conservation management is succeeding
5. Are optimistic about the IFCAs being an improvement on the SFCs

5.2 Methods

A questionnaire was developed to address the aims and objectives of the study (Table 5.1). As discussed, this built on the work of Rodwell et al. (2014) with amendments and additions made to the questionnaire following initial consultation with D&SIFCA staff to ensure questions were relevant and addressed areas perceived to be of importance. The questionnaire developed by Rodwell et al. (2014) contained 24 questions, of which 9 were used/amended for the new questionnaire.

Objectives	Example questions
1. Are stakeholders optimistic about the membership of the D&SIFCA and the way it is run?	- To what extent do you agree with the statement 'The IFCA membership is allowing the IFCA to work effectively' - To what extent do you agree with the statement 'The IFCA membership is allowing decision making to be more participative and democratic'
2. Do stakeholders agree on the goals and vision of the D&SIFCA and perceive that they are being achieved?	- Which goals do you think should be most important for the D&SIFCA? Please rank them in order of importance - Since its inception in 2011, to what extent do you think the D&SIFCA has been successful in achieving (a) Healthy seas
3. Do stakeholders perceive there to be obstacles restricting the ability of D&SIFCA to achieve its goals?	- What (if any) do you think are the main obstacles the D&SIFCA faces in achieving these goals and how do you think they might be overcome?
4. Do stakeholders feel that fisheries and conservation management is succeeding?	- In your opinion, how effective is the current management of fishing activities within marine protected areas in the D&SIFCA district? - Do you expect future byelaw reviews to impact your use of the marine environment within the D&SIFCA district? (2016 only)
5. Are stakeholders optimistic about the IFCAs being an improvement on the SFCs?	- How would you describe your current feelings about the IFCAs being an improvement on the previous regulatory structure (Sea Fisheries Committees)

Table 5.1: Objectives of the study and examples of questions asked under each objective

The questions were designed to elicit the perceptions of stakeholders and were arranged under broad sub headings (Table 5.2). Initially questions used multiple choice, long answers and answers using the Likert scale to explore stakeholder perceptions of the D&SIFCA and the membership of the Authority. Questions then used the same methods to consider management of marine protected areas and the byelaw review, and finally, they considered the vision and goals of the D&SIFCA, with respondents asked to select and rank the goals in order of importance. Where the Likert scale was used, responses were sought on a five-point scale from 1 = strongly disagree to 5 = strongly agree.

Subheading	Description	Year(s) included
Introductory questions	Questions to set the scene, e.g. which stakeholder group do you belong to	2012, 2013, 2016
Your experience with the D&SIFCA	Contact with D&SIFCA officers, their efficiency, professionalism and conduct	2012, 2013, 2016
Your opinions	Questions regarding the D&SIFCA membership, its suitability and effectiveness, and whether stakeholders views are being heard	2012, 2013, 2016
Funding	Whether stakeholders think the way the D&SIFCA is funded is the correct way	2013, 2016
Management of Marine Protected Areas	Impact of EMS fisheries restrictions, effectiveness of current management	2013, 2016
Byelaw review	Impact of byelaw review. In 2016 this section was expanded to include current and potential future impacts & success of consultation	2013, 2016
Goals & potential impacts of the D&SIFCA	Ranking of IFCA goals	2012, 2013, 2016
IFCA vision statement	Success of D&SIFCA in meeting the vision statement, degree of optimism on IFCA being an improvement on SFCs	2012, 2013, 2016
IFCA communication	Opinions about the D&SIFCA website	2013, 2016

Table 5.2: Section headings and descriptions showing how these changed over time from 2012, to 2013 and 2016

Some amendments were made to the questionnaire in 2013 and 2016, guided by the work of the D&SIFCA and the issues that had arisen since the previous questionnaire was administered. This resulted in the addition of questions relating to the management of marine protected areas, the byelaw review, and communication (Table 5.2). Full copies of the questionnaire from each year are given in Annex C. Respondents were also asked whether they had heard of the D&SIFCA prior to completing the questionnaire, and analyses include only those who had heard of them.

Data collection was carried out between May and August in 2012 and 2013 and in January and February 2016. The questionnaire was administered as an online survey using Google forms. Online survey methods have advantages such as being cheaper and quicker to administer, convenient for the respondent to complete in their own time, and having a lack of interviewer effects (e.g. social desirability bias), (Bryman 2016). There are also, however, disadvantages, such as not knowing who has completed the questionnaire, the interviewer being unable to prompt and probe for more detailed/relevant answers to the questions, and the possibility that the respondent will become bored and won't fully complete the questionnaire (Bryman 2016). On balance, however, an online method was chosen as a cost effective way of conducting the research, allowing a range of individuals to be targeted from a range of stakeholder groups. The number of questions and their complexity was kept to a minimum in order to overcome some of the limitations of this method.

All D&SIFCA Authority members were invited to complete the questionnaire, and in addition, a database developed by D&SIFCA was used to identify other interest groups. This contained contact details for stakeholders known to them who could be invited to complete the questionnaire (n = 105) and included representatives from management groups, non-governmental organisations, funding bodies, fishermen's associations, sea angling groups, dive clubs, and charter boat operators. A snowball sampling technique was then implemented, where those contacted were asked to recommend others they thought might be interested in participating. Representatives of stakeholder organisations e.g. dive clubs and sea angling clubs were asked to circulate the questionnaire to their members. Stakeholders were also targeted using Twitter, with an initial tweet containing a link to the questionnaire re-tweeted by D&SIFCA to their followers and then subsequently by others to their followers. Invitations were also placed on recreational diving and sea angling forums: www.fishing-forum.info, www.anglinguk.org and www.ukdiving.co.uk. Due to the sampling strategy it was not possible to determine whether the respondents differed between years, but it was expected that there would be some repeat respondents and some new.

5.2.1 Data analysis

Once responses had been collated, descriptive statistics were used for analysis. Where answers were given as 'yes', 'no', 'don't know' or used the Likert scale, results were calculated as percentages. Where the same question had been asked in each year, data were pooled as multivariate analysis failed to identify any between year differences (see methods explanation below and section 5.3.6).

The qualitative responses gathered from respondents were imported into NVivo 10 (QSR International 2012) text analysis software and coded into a thematic framework of statements to reflect the respondents perceptions. Themes were only coded if they were repeated by more than one respondent, and were ranked depending on the number of statements.

To determine whether the stakeholder group respondents belonged to were the drivers for their perceptions, and to identify temporal trends, data from opinion questions where answers were given using multiple choice or used the Likert scale were extracted e.g. The IFCA membership is allowing the IFCA to work effectively, I am satisfied that my views are being heard, over the past year to what extent do you think the D&SIFCA have been successful in achieving sustainable fisheries. Based on the common perception that the attitude of fishers towards marine management differs from that of other stakeholders (e.g. Helvey 2004), the hypothesis to be tested was:

H1 = the perceptions of commercial fishers regarding the D&SIFCA Authority membership, vision, goals and management will significantly differ from those of all other stakeholder groups

Permutational Multivariate Analysis of Variance (PERMANOVA) (Anderson (2001)) using PRIMER 6 (Clarke and Warwick 2001) with PERMANOVA+ for PRIMER. was selected for analysis as it is robust to unbalanced designs and makes no assumptions about underlying data distributions (Walters and Coen 2006). Much debate exists in the literature regarding the appropriateness of using parametric statistics for analysis of Likert data (e.g. Norman 2010; Sullivan and Artino Jr 2013). There is, however, a strong and conclusive argument in favour, with Norman (2010) concluding that parametric statistics are suitable for analysis of Likert data, data with unequal variance, and data with non-normal distributions, making this approach valid here. Furthermore, many studies have used multivariate methods in PRIMER for the analysis of data from questionnaires and interviews to determine stakeholder perceptions in the marine environment, adding weight to the appropriateness of this approach (Cárcamo et al. 2014; Mangi and Austen 2008; Pajaro et al. 2010).

Two factors were used in the analyses, Year (fixed: 2012, 2013, 2016) and Stakeholder Group (fixed: commercial fisher, management organisation, funding authorities, statutory agencies, non-governmental organisations, recreational sea anglers, charter boat operators, recreational divers, other). Data were square root transformed and Euclidean distance indices were used to construct similarity matrices (Clarke and Warwick 2001). Each term in the analysis used 9999 permutations and the lowest significant effect was interpreted for each analysis ($P < 0.05$).

5.3 Results

A total of 105 questionnaires were completed over the three years of study (2012 = 47, 2013 = 30, 2016 = 28). Respondents came from throughout the D&SIFCA district, with the greatest proportion from South Devon (40 %), Torbay (12 %), Plymouth (9 %) and North Devon (9 %). The number of respondents from Gloucestershire, South Gloucestershire, Somerset and Bristol was low, with each accounting for a maximum of 4 % of the total.

The greatest number of responses came from commercial fishermen (n = 29), funding authorities (n = 19), recreational sea anglers (n = 17) and statutory agencies (n = 14), (Table 5.3). The category 'other' included conservationists and those who did not specify a group.

Stakeholder group	2012	2013	2016	Total
Commercial fishermen	12	6	11	29
Recreational sea anglers	6	4	7	17
Funding authorities	8	6	5	19
Recreational divers	4	3	0	7
Non-governmental organisations	4	6	0	10
Statutory agencies	6	4	4	14
Management organisations	3	1	2	6
Charter boat operators	1	2	0	3
Scientific communities	1	1	1	3
Other	5	1	1	7
No response	1	0	0	1

Table 5.3: Number of respondents from each stakeholder group. Total number of stakeholders here exceeds 95 to account for those that fall within multiple stakeholder categories.

Of those who had direct contact with the D&SIFCA, 98 % thought that they were professional, and 80 % felt that their enquiry was dealt with effectively. Instances where this was not the case related mainly to matters of enforcement and where stakeholders felt that more could be done to support their stakeholder group (this is discussed in more detail below). Overall, however, respondents were supportive of the D&SIFCA, '*officers very good and efficient*' (Recreational sea angler, 2016) and felt they were helpful and polite.

5.3.1 IFCA membership

Respondents were asked their opinions about aspects of Authority membership relating to the effectiveness of working, decision making, stakeholder representation, and expertise (Figure 5.3). Responses showed that more people agreed or strongly agreed with all statements than those that disagreed or strongly disagreed, (all strongly agree & agree ≥ 48 %, all strongly disagree & disagree ≤ 33 %), (Figure 5.3).

Variation was apparent between questions, however. Greatest support was seen in response to the statement *'IFCA membership is inclusive of individuals with the expertise to advise the effective management of a sustainable marine environment and inshore fisheries industry'* (Strongly agree & agree = 52 %). Greatest disagreement was seen for the statement *'IFCA membership is ensuring adequate representation of my stakeholder group'* (Strongly disagree & disagree = 33 %). This statement had the greatest number of respondents who strongly disagreed with it (20 %), but it also had the greatest number who strongly agreed with it out of all the statements (17 %).

Uncertainty was greatest for the statements: *'IFCA membership is allowing the IFCA to work effectively'* (neither agree nor disagree = 21 %) and *'IFCA membership is inclusive of individuals with the expertise to advise the effective management of a sustainable marine environment and inshore fisheries industry'* (neither agree nor disagree = 21 %), and was smallest for the statement *'IFCA membership is ensuring adequate representation of my stakeholder group'* (neither agree nor disagree = 11 %).

51 % of all stakeholders felt that their views were being heard (strongly agree, agree = 53 %, strongly disagree, disagree = 26 %). Those who did not feel that they were being heard included individuals from almost all stakeholder groups, including funding authorities, commercial fishermen and recreational sea anglers.

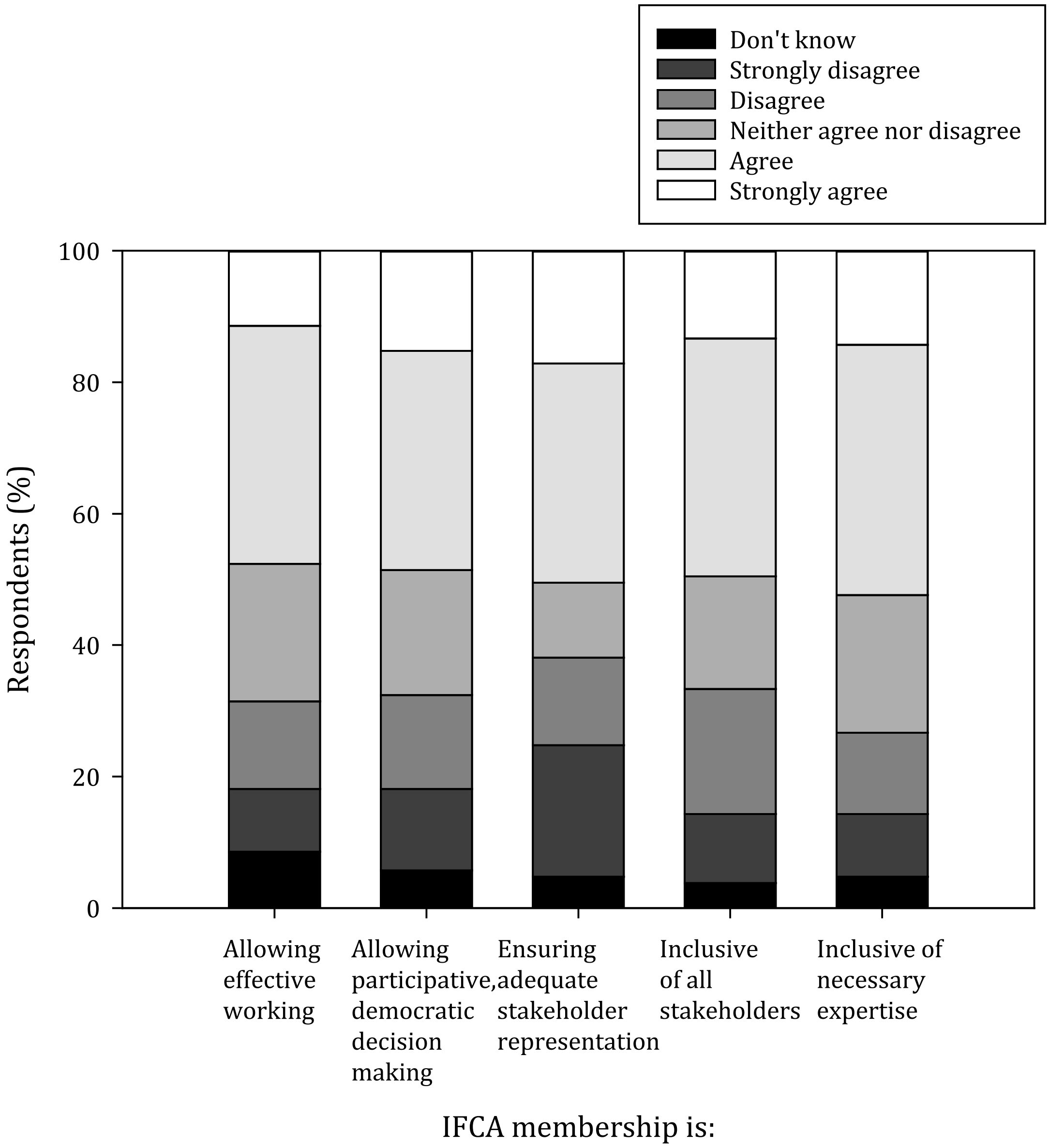


Figure 5.3: Level of agreement with statements regarding the IFCA membership – the IFCA membership is: (a) Allowing the IFCA to work effectively, (b) Allowing decision making to be more participative and democratic, (c) Ensuring adequate representation of my stakeholder group, (d) Inclusive of all stakeholders with an interest in ensuring healthy seas and a sustainable and viable fisheries industry, (e) Inclusive of individuals with the expertise to advise the effective management of a sustainable marine environment and inshore fisheries industry.

Themed analysis showed that of the comments made relating to IFCA Authority membership, 12 were positive and 60 were negative. Individuals who were positive felt that the membership allowed the inclusion of a wide range of stakeholders and a more holistic approach to management e.g. '*the structure of the* *committee with a better balance between fisheries and conservation is to be welcomed*' (Recreational sea angler, 2012).

Negative statements were made by those who disagreed/strongly disagreed/neither agreed nor disagreed with statements relating to the D&SIFCA membership as well as those who agreed but felt that improvements could be made. Comments revealed that the majority of stakeholders felt the balance of membership was not quite right with some feeling that the change had resulted in too many members, and that councillors from funding authorities lacked the expert knowledge required to be effective. These concerns were apparent throughout the study e.g. '*I feel the IFCA is overrepresented by councillors and their assistants, often well exceeding those with more expert knowledge around the table*' (Commercial fisherman, 2012), '*Local Authority representatives show very little interest, are not engaged and have little or no understanding of the policies, law or environmental principles; they are a major impediment to the working of the IFCA*' (MMO appointee, 2016).

Stakeholders who felt that they were insufficiently represented included recreational boaters, commercial fishers (due to the diversity within the industry), recreational sea anglers, divers, and ports and harbours. Concerns were also raised by some funding authorities who did not feel that they should be included on the D&SIFCA as it was not able to serve their needs.

5.3.2 IFCA vision and goals

The majority of respondents agreed that the D&SIFCA vision was the correct vision (Yes = 66 %, No = 13 %, Don't know = 21 %). Those who did not agree suggested that it should include stakeholder engagement and that it was too ambitious, attempting to achieve things that were outside the control of the D&SIFCA; *'should state a clear purpose that is within IFCA ability to control'* (Commercial fishermen, 2016).

When considering the different aspects of the vision statement, respondents felt that D&SIFCA had been most successful at achieving stakeholder engagement across the three years of study, (Very successful = 21 %, Successful = 44 %), (Figure 5.4). Uncertainty was, however, high for the success of the D&SIFCA at meeting the other aspects of their vision statement, with 48 % of respondents feeling they had been neither successful nor unsuccessful at achieving healthy seas or a viable industry, and 37 % that they had been neither successful nor unsuccessful at achieving sustainable fisheries. Despite this, however, a greater percentage of respondents felt that they had been either very successful or successful (Healthy seas = 29 %, sustainable fisheries = 36 %, a viable industry = 30%) than unsuccessful or very unsuccessful (Healthy seas = 19 %, sustainable fisheries = 19 %, a viable industry = 13 %).

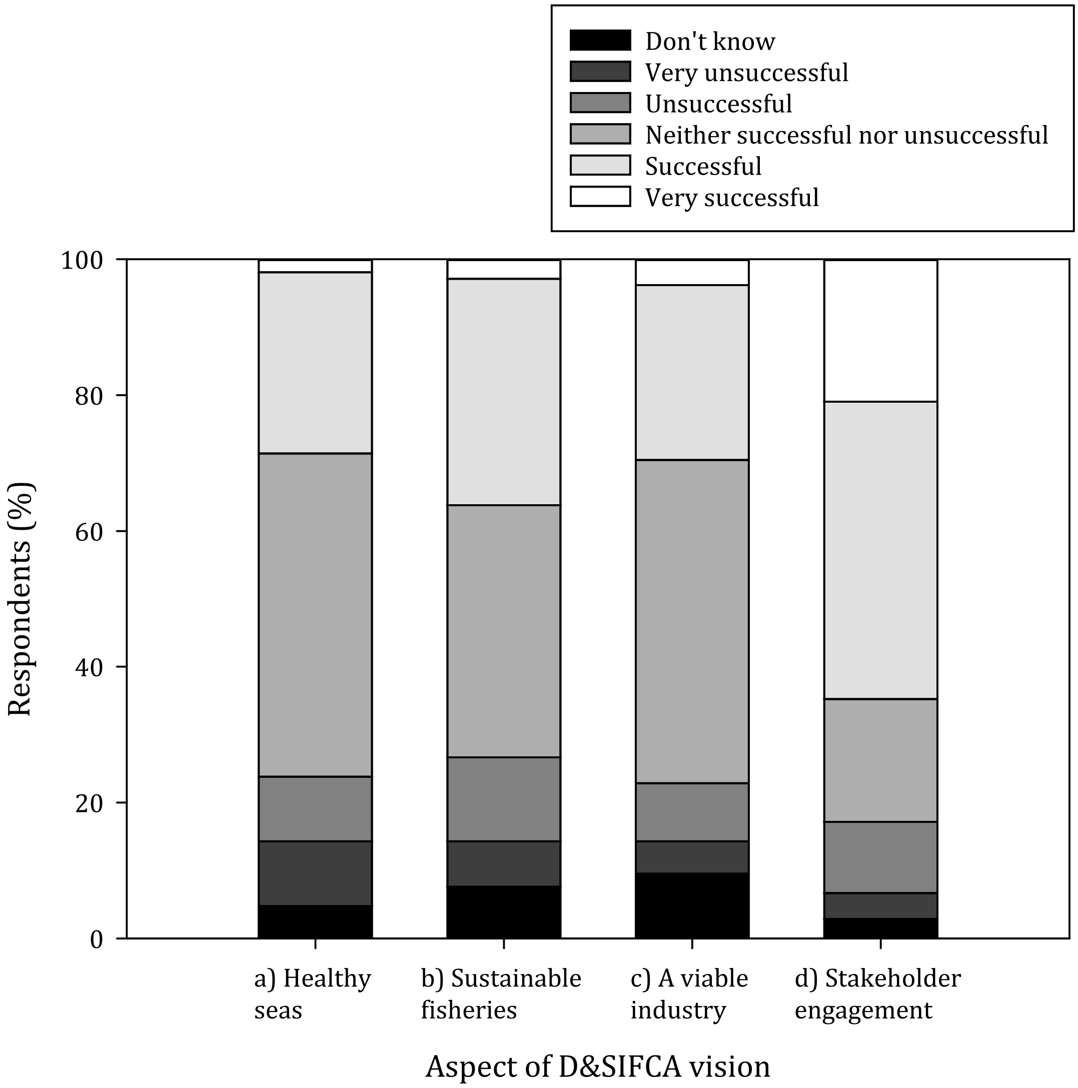


Figure 5.4: Opinions of respondents in response to the question: Since its inception in 2011, to what extent do you think the D&SIFCA has been successful in achieving: a) Healthy seas, b) Sustainable fisheries, c) A viable industry, d) Stakeholder engagement?

Where support was lacking, stakeholders most commonly recognised that despite their best efforts, healthy seas, a viable industry and sustainable fisheries were influenced by factors outside of the control of the D&SIFCA e.g. *'suffice it to say that we may not be happy, but appreciate that the D&SIFCA staff have a difficult job, with limited resources, to control all the tasks for which they are responsible'* (Commercial fishermen, 2012), and most were of the opinion that more time was needed to achieve the vision and that it was still early days.

Alongside the vision statement, D&SIFCA set out goals and respondents were asked which they thought were most important. Responses showed that '*ensuring effective fisheries enforcement*' was the top ranking goal overall (56 %), (Table 5.2). '*Conservation of marine ecosystems for (direct) economic purposes e.g. tourism and fisheries*' (48 %), '*conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation*' (44 %) and '*sustaining/improving fisheries productivity*' (44 %) were also ranked highly (Table 5.2). The goal which was ranked the lowest by respondents was *'sustaining/improving recreational opportunities'* (17 %). A high level of agreement was seen between stakeholder groups, with no obvious differences apparent. Comments received again related to limitations caused by outside influences, and that the IFCAs were too new to have had time to make a real difference, e.g. *'some of these are a bit above the IFCAs 'pay grade' but they are doing their best to reconcile the different interests'* (Recreational sea angler, 2012).

Rank	IFCA goal	Total votes	% of possible vote
1	Ensuring effective fisheries enforcement	73	56
2	Conservation of marine ecosystems for (direct) economic purposes e.g. tourism and fisheries	63	48
3=	Conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation	57	44
3=	Sustaining / improving fisheries productivity	57	44
5	Sustaining employment opportunities in the commercial fisheries sector	43	33
6=	Facilitating a dialogue across sectors of community	24	18
6=	Inclusion of a broad range of marine resource users	24	18
8	Sustaining / improving recreational opportunities	22	17

Table 5.4: Ranking of importance of D&SIFCA goals showing total votes and the percentage of possible vote achieved (n = 130).

5.3.3 Obstacles to success

Themed analysis highlighted that stakeholders perceived a lack of funding and resources, communication and education and conflicts between stakeholder interests to be the greatest impediments to the D&SIFCA achieving its goals (Table 5.3).

Theme (number of statements)	Reference	Example quote
Funding and resources (33)	Commercial fishermen, 2016	*Budget restraints can be a major obstacle.*
	Statutory agency, 2016	*The size of the patch and the limited resources make it difficult to enforce byelaws, even if they are well administered and planned.*
Communication & education (10)	Statutory agency, 2012	*Be more proactive and consultative*
	Recreational sea angler, 2012	*Communication of their activities and actions with ALL stakeholders*
Conflicts between stakeholder interests (9)	Recreational sea angler, 2012	*Entrenched views and behaviours of commercial fishing*
	Commercial fishermen, 2016	*I think their scared to upset the greens*
Factors beyond D&SIFCA control (8)	Management organisation, 2012	*European and national politicians over-riding the findings and recommendations of fisheries scientists*
	Recreational sea angler, 2012	*(Lack of) good grounding awareness in marine matters for wider community*
D&SIFCA membership (7)	Other stakeholder, 2012	*The reluctance of certain stakeholders to engage proactively.*
	Funding authority, 2016	*A more relevant and less geographically expansive membership is needed*
Other (7)	Commercial fishermen, 2012	*IFCA need clear unambiguous targets which can be used to measure their success; simplify things.*
	Statutory agency, 2013	*Absence of an overall, integrated management regime for their inshore waters*
Devon/Severn divide (2)	Funding authority 2013	*The Devon / Severn issues are very different.*

Table 5.5: Themes relating to obstacles to the D&SIFCA achieving their goals (listed in rank order) with examples of supporting quotes

A total of 33 of the 76 comments made related to lack of funding and resources, showing this to be a major concern for D&SIFCA stakeholders. Comments related to the size of the district and the restricted budget assigned to the D&SIFCA which was perceived to compromise their ability to work effectively e.g. *'doing their best during times of extreme financial pressure'* (Recreational sea angler, 2016). Particular concern was expressed for the lack of resources for effective enforcement e.g. *'not enough man power to enforce the area, and the people who are* *breaking the laws know this, and are using it to their advantage'* (Commercial fishermen, 2015), particularly in light of new fisheries management measures implemented between 2012 and 2016.

In total, 46 % of respondents thought that the current arrangement was the best way to fund the D&SIFCA, 32 % did not think it was, and 23 % did not know. Whilst those in favour of the current funding balance felt it was shared fairly between the local authorities comprising the D&SIFCA, the majority of those not in favour felt the inclusion of the Severn district in the D&SIFCA was resulting in ineffective working.

5.3.4 Conservation and fisheries management measures

The introduction of management of fishing activities within EMS and the byelaw review bought about changes to the management of fisheries within the D&SIFCA district. 30 % of respondents who were aware of the change in approach to management of fisheries within EMS said that it had already impacted their activities in 2016, with commercial fishers being the most impacted. 43 % thought that their activities would be impacted once all the assessments had been completed, with a further 25 % unsure of the likely impacts. Commercial fishers were those who had already experienced the greatest impacts, with restrictions placed on some activities and ongoing reviews of other activities which caused some concern for the future e.g. *'stopping people doing what they have done all their lives and taking away their livelihoods is never a good thing'* (Commercial fishermen, 2013). Recreational anglers also expected impacts, with bag limits reducing the amount they could take home. These were seen by some as positive steps, but concern remained regarding unknown further restrictions. Attitudes to the change were mostly positive, although split by stakeholder group, with a noticeable difference in opinion between commercial fishers and recreational anglers as anglers perceived the restrictions placed on commercial activity had been reduced from what was originally planned e.g. *'main obstacle perceived to be a commercial fleet used to doing what it likes and resistant to change…commercials feel very threatened…therefore it is going to take a great deal of time to change things'* (Recreational sea anglers, 2016).

When asked how effective they felt current management of fisheries was within MPAs, the majority of respondents thought that it was effective (45 %) however, only 3 % thought that it was very effective. In addition, 10 % thought that it was ineffective, and a further 7 % thought it to be very ineffective. Themed analysis again showed that lack of funding and resources were perceived to be restricting the success of D&SIFCA management e.g. *'I have some severe doubts as to whether the IFCAs can deliver their statutory functions, yet alone 'add value' on their present finding resource'* (Non-Governmental Organisation, 2013), but there was a feeling that they were working to the best of their abilities, and no clear differences were apparent between stakeholder groups.

Questions regarding the byelaw review consultation were added in 2016, and showed that of the 96 % of respondents who were aware of the review, 54 % were involved in the consultation, and 11 % of respondents were not involved. The reasons for being uninvolved included that they did not think it was worthwhile, or felt that it was only applicable to commercial fishers. Sixty percent of those involved were satisfied or very satisfied with the process; they had been able to communicate their views effectively, and thought that the process had been successful at engaging all stakeholders. 27 % were dissatisfied or very dissatisfied, with the main reasons for this were mostly related to the perceived impacts of the review on their activities. Some did feel, however, that they had been unable to contribute and the process had been unnecessarily complicated.

Themed analysis identified future uncertainty surrounding changes in management. Commercial fishers expressed the greatest concern, with some worried about future viability, especially due to the netting byelaw review which was ongoing at the time of the 2016 questionnaire. Other stakeholders felt that changes would be positive due to the increased focus on conservation and the importance they assigned to management of fishing activities. Uncertainty was also apparent in the response of some recreational sea anglers who thought there may be management of their activities in future. They were, however, largely supportive of restrictions on commercial activity, feeling that it would be of benefit to angling in the future.

5.3.5 D&SIFCA as an improvement on DSFC

Respondents were asked whether they were optimistic or pessimistic about the D&SIFCA being an improvement on the DSFC. Responses were all neutral, although respondents were most optimistic in 2012 (3.38 ± 0.18), (Figure 5.5). Optimism reduced in 2013 (3.17 ± 0.25) but increased again in 2016 (3.25 ± 0.25), although it did not reach the level it was in 2012 (Figure 5.5). Stakeholder groups were split across the scale, but more representatives from commercial fishers and funding authorities were pessimistic or very pessimistic than optimistic or very optimistic.

Themed analysis showed that optimism was felt where respondents saw that a more holistic approach was being taken to management of the marine environment and felt that the inclusion of conservation in the remit of the D&SIFCA was a positive change e.g. 'the IFCA appears to be embracing a new paradigm that sees conservation actually working for the majority of fishers' (Non-Governmental Organisation, 2013). Tentative optimism was experienced by those who felt that things had improved but that it was either too early to be certain that it was for the better, or were cautious due to scepticism about resource availability for enforcement. Those that were pessimistic or very pessimistic felt that there were pressures from the increased size of the district without an appropriate increase in resources, expressed concern over the Authority membership or felt that there had not been much change from the DSFC. A total of 11 comments were made from those who were very pessimistic, and of these, 8 related to the inclusion of the Severn authorities in the district, highlighting the strength of feeling relating to this issue e.g. *'it has introduced a whole layer of bureaucracy and cost to the Severn area that did not have an SFC or even has an inshore fisheries industry'* (Funding authority, 2012).

5.3.6 Overall perceptions

Response of stakeholders to opinion questions (Likert scale) regarding the D&SIFCA Authority membership, vision, goals and management were analysed to identify change over time and differences between stakeholder groups. This showed that responses were not significantly different between years, but revealed differences between stakeholder groups ($P < 0.05$, Table 5).

a)

Source	df	MS	Pseudo-F	P(perm)
Ye	2	9.593	1.4328	0.1074
St	8	10.933	1.6328	**0.0023**
YexSt**	13	5.8564	0.87469	0.7975
Res	81	6.6954		
Total	104			

b)

	C.F	M.O	F.A	S.A	N.G.O	R.S.A	C.B.O	R.D	O
Commercial fishers									
Management organisations	**0.022**								
Funding agencies	**0.016**	0.380							
Statutory agencies	**0.010**	0.467	0.149						
Non-governmental organisations	**0.012**	0.375	0.179	0.178					
Recreational sea anglers	**0.001**	0.141	0.331	0.609	0.335				
Charter boat operators	0.231	0.296	0.433	0.090	0.090	**0.029**			
Recreational divers	0.135	0.688	0.833	0.335	0.152	0.612	0.825		
Other	**0.011**	0.206	0.215	0.263	0.264	**0.042**	**0.048**	0.224	

Table 5.6: Results of PERMANOVA for a) stakeholder opinion relating to D&SIFCA Authority membership, vision, goals and management in response to the fixed factors Year (Ye) and Stakeholder group (St) and b) pairwise testing for stakeholder group (Commercial fishers (C.F.), Management organisations (M.O.), Funding Authorities (F.A.), Statutory Agencies (S.A.), Non-Governmental Organisations (N.G.O), Recreational Sea Angler (R.S.A.), Charter Boat Operators (C.B.O), Recreational Divers (R.D) and Other (O). Data were square root transformed and similarity matrices were conducted using Euclidean Distance. Bold type denotes a statistically significant result

Commercial fishers were found to have statistically different opinions regarding D&SIFCA Authority membership, vision, goals and management to all stakeholder groups with the exception of charter boat operators and recreational divers ($P < 0.05$, Table 5.4). The only other group to have statistically different opinions to each other were charter boat operators and recreational sea anglers, and both these groups differed from 'other' stakeholders.

The differences in opinion between commercial fishers and recreational anglers were most pronounced ($P < 0.01$, Table 5.4), with themed analysis revealing that recreational anglers perceived that the strength of conservation measures and the designation of MPAs had been diminished by the strength of voice of the commercial fishing industry. They were also disappointed that the D&SIFCA attempts to establish designated areas for recreational sea anglers where commercial fishers would be excluded had not succeeded at delivering what was originally proposed e.g. *'the initial proposals by the IFCA were very different to those that were finally agreed…proposals in the north were being implemented because of minimal commercial activity whereas in the south there was much stronger opposition from the inshore fleet'* (Recreational sea angler, 2016). Commercial fishers felt that the viability of their livelihoods was being compromised by the increasing focus on conservation e.g. *'I expect to be forced out of areas I've fished all my life because the greens think the pink sea fan and a bit of sea grass is more important than me earning a living'* (Commercial fishermen, 2016), with concern for the future and scepticism about the ability of the D&SIFCA to enforce effectively driving their opinions.

5.4 Discussion

This study aimed to assess the effectiveness of using ecosystem based fisheries management to address fisheries and conservation goals by evaluating the ability of D&SIFCA to meet their objectives in their first five years of operation. Initial optimism of stakeholders towards the IFCAs was identified by Rodwell et al. (2014), and it was considered important to understand whether this has been maintained now that the D&SIFCA has been established and working for five years. EBFM requires a broad stakeholder base, strong leadership, social cohesion and clear incentives for stakeholders (Gray and Hatchard 2008; Gutierrez et al. 2011; Royal Commission on Environmental Pollution 2004), and these results show that whilst these attributes are present, they are not yet fully established.

The work of Pieraccini and Cardwell (2015) suggests that despite some issues of transparency in the selection process, the structure of IFCA membership should bring diversity and empowerment which are important for successful co-management, and hence EBFM. It appears that membership of the D&SIFCA has been partially successful in this regard, bringing diversity through the mix of stakeholders on the Authority and allowing a more holistic approach to management and decision making. Similar success at following this approach has been identified in the USA where a diverse range of stakeholder groups from commercial fishers to conservation scientists and recreational users are included in management bodies (Okey 2003). In Canada, similar results have been seen, with management of the Salmon fishery in British Columbia including multiple interest groups and recognising the rights of aboriginal communities leading to successful resolution of biological, economic and political problems (Pinkerton 1994).

Despite this, there were concerns that some members had insufficient knowledge to contribute effectively to the management of the D&SIFCA, with concerns particularly evident in relation to local authority members who may have had no prior experience of fisheries and conservation management. Rodwell et al. (2014) had expected that having a diversity of stakeholders would increase the knowledge base and allow informed decision making due to the combined expertise of local councillors, fishers and those with expertise in environmental management and conservation.

Whilst this represents the ideal outcome it is clear that the composition of Authority members has not been entirely successful at allowing this to happen, but progress has been made suggesting that it is not a severely limiting factor. During their first five years of existence the D&SIFCA have introduced new byelaws and management for fisheries within MPAs, and it is expected that the diversity of stakeholder groups within the Authority has facilitated this. It may be that the fears of Phillipson and Symes (2010), that some stakeholders would feel the changes from the DSFC have been too radical are being realised, and it is hoped that with time these problems will be overcome. One solution, proposed in the Defra (2015) report, was that training should be provided to Authority members where needed. This may help to increase trust in the ability of the Authority membership, an element that is important for generating social capital (Gutierrez et al. 2011).

In agreement with the findings of Rodwell et al. (2014), stakeholders felt that the vision is the correct vision for the D&SIFCA. The goals identified as most important related to enforcement, conservation for direct and indirect purposes and fisheries productivity. This suggests that stakeholders are supportive of the change from the DSFC and the widening of the remit to include both fisheries and conservation management in line with the ecosystem approach (Laffoley et al. 2004). Support was based on a belief that this should help to bring long term sustainability and economic benefits to fisheries, with acceptance thought to have increased since inception (Rodwell et al. 2014) as positive comments showed that fishers recognise that conservation is necessary for sustainability and that this may require changes to their fishing behaviour. Case studies exist in support of this (e.g. Jones 2008) but care must be taken to manage stakeholder expectations, as where management is not successful in bringing expected benefits stakeholder support and associated social capital may be lost (Mangi and Austen 2008).

Currently, the ongoing byelaw review and the change in approach to management of fisheries within EMS is bringing uncertainty, but the majority of stakeholders were more positive than negative about the effectiveness of management within MPAs. Concerns were raised as they did not know whether their activities would be negatively impacted or not, and this was coupled with a perception that resources are insufficient for the effective enforcement of new management measures. Enforcement is known to be essential for effective management, especially within MPAs (Rossiter and Levine 2014) and where there are clear benefits it can also increase compliance with regulations and stakeholder support (Arias et al. 2015; Gutierrez et al. 2011; Taylor and Buckenham 2003. p. 58). This has been identified in case studies in the Philippines and Cambodia, where Hamilton (2012) found that fishers were more supportive of MPAs where they had been established for ten years than where they were a novel idea and therefore had associated uncertainty. Comments from some stakeholders showed that they felt there was little point in implementing numerous new regulations unless the capacity existed with which to ensure they were complied with, but it is hoped that once decisions are reached there will be more certainty and therefore the potential for greater support. This could be facilitated by regular communication, dissemination of information and the management of stakeholder expectations.

Differences in opinions were apparent between stakeholder groups, with commercial fishers seen to be the most different. These differences were not apparent in the initial study conducted by Rodwell et al. (2014) who found that opinions were similar between all stakeholder groups, and they were found to relate to changes that have been made since the D&SIFCA were established. Fishers are commonly expected to differ in opinion from other stakeholders as their livelihoods are directly reliant on access to fishing grounds and they have historically been sceptical about introduction of management measures (Helvey 2004). The differences in opinion here related to concerns over the future of fisheries due to uncertainties associated with management being implemented, but also related to conflict with recreational sea anglers. This is due to the efforts of D&SIFCA to promote recreational sea angling, and the creation of zones closed to commercial fishers and designated for anglers only (D&SIFCA 2014). It is hoped that this conflict will reduce with time, and that if management measures bring long term benefits to fishers that outweigh the short term costs the opinions of fishers should become more similar to other stakeholder groups.

The issues identified here relating to the inclusion of the Severn area in the D&SIFCA have also been highlighted by Thompson Ecology (2014) and Defra (2015). To date this has caused problems relating to Authority membership and funding. The IFCAs are financed by the local authorities within the district and in part by new burdens funding from the UK government which was allocated to local authorities to compensate for the new duties of the IFCAs. This money is however, not ring-fenced and this has been a cause of contention between local authorities and the D&SIFCA as they may allocate the money to higher priority issues. Despite the size of its district, the D&SIFCA has the second smallest budget (Defra 2015), and resources are therefore very valuable which is expected to heighten the issue. These concerns were only raised by Authority members, but the comments received show that it is a serious issue and may be a current constraint on the functioning of the D&SIFCA.

Stakeholders perceived the D&SIFCA staff to be professional and competent and the majority of queries were dealt with effectively, showing that good relationships exist. Strong leadership was an element identified by Gutierrez et al. (2011) as important for successful co-management, generating resilience to change in governance, enhancing conflict resolution and increasing compliance (Olsson et al. 2004b), and this can be facilitated by a strong chief officer coordinating the IFCA (Rodwell et al. 2014). The characteristics of a strong leader included someone who was well respected and highly motivated, and the comments made relating to the D&SIFCA staff here suggest this is the case, with the entire staff and not just the chief officer playing an important leadership role.

Tentative optimism was identified with regard to the D&SIFCA being an improvement on the DSFC. They appear to have the components required for successful integration of social and ecological factors which is crucial for EBFM (Österblom et al. 2011), but it seems that their success has been constrained by outside influences. Whilst they have generated social capital across their stakeholder base, issues within the Authority itself have limited their effectiveness. The matters relating to the inclusion of the Severn authorities in the D&SIFCA are thought to be a primary reason for this, and this needs to be fully resolved before trust and understanding can be realised. This may require time and resources (Gutierrez et al. 2011), as ultimately decisions relating to the district boundaries and funding rest with UK Government and not individual IFCAs.

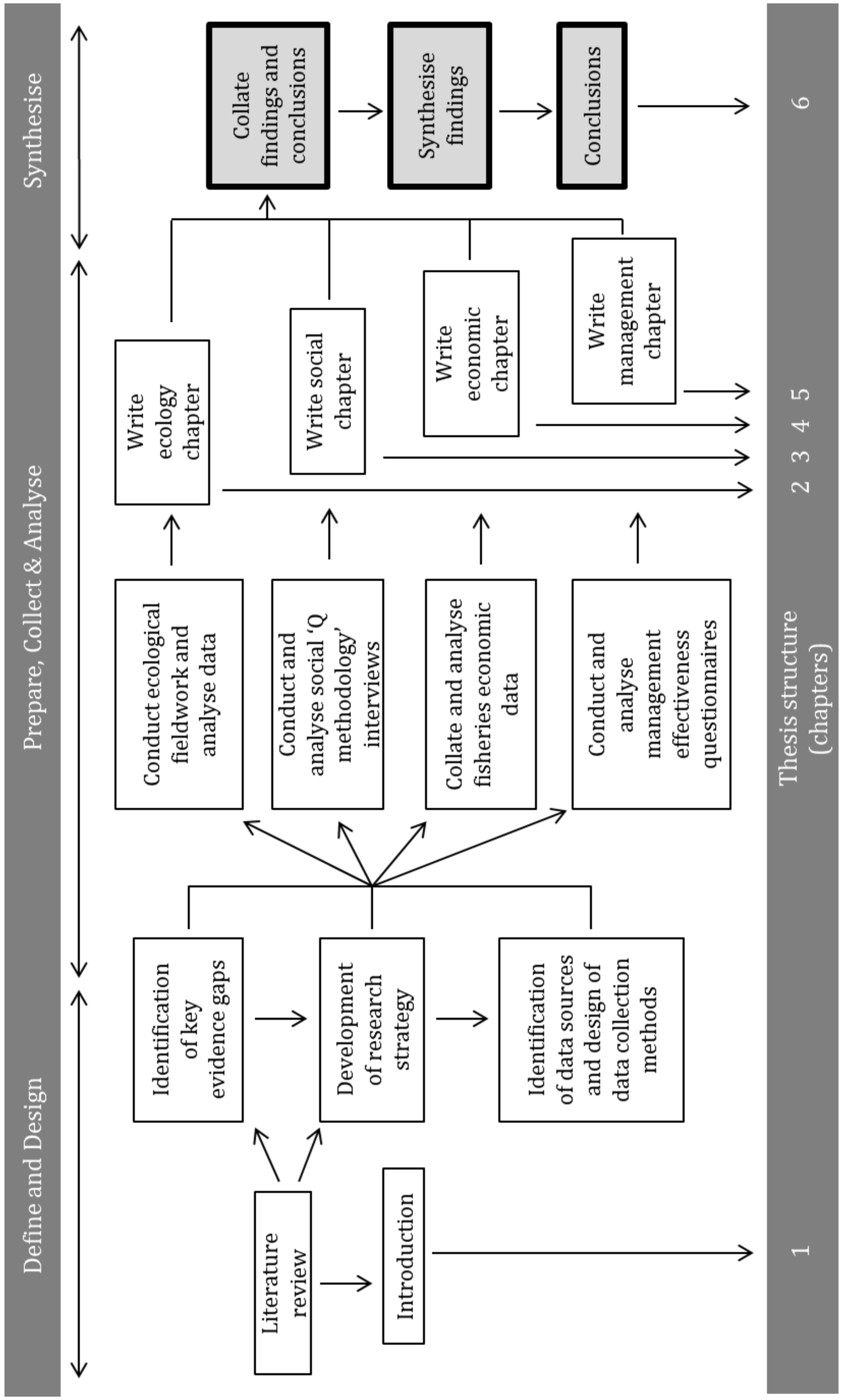
Case studies from the USA, Canada and Norway show that success in co-management approaches can be greatest where decision making is at a regional rather than national level with a high degree of stakeholder input (BalticSea 2020

2009). The IFCAs may therefore benefit from increased devolution of power. Currently they only have the ability to create local byelaws, and whilst this is an improvement from the powers of the SFCs (Rodwell et al. 2014), their success may be increased if they could solve some of the issues identified here which currently fall within the control of the UK government. Results from the USA, Canada and Norway show that whilst none of the systems are perfect (Dell'Apa et al. 2012; Holm et al. 2000; Okey 2003), they have had some success at generating trust and legitimacy in fisheries management procedures, improving the rate of compliance (Österblom et al. 2011).

5.4.1 Conclusion

This work provides an insight into the views of D&SIFCA stakeholders about the success of D&SIFCA management in the first five years of their existence. Whilst there are likely to be similarities between the D&SIFCA and other IFCAs it does not attempt to generalise across them; this study has identified that the D&SIFCA faces unique challenges and evaluation must therefore be done on a case by case basis. The findings of the study build on the work of Rodwell et al. (2014), identifying support and a degree of optimism for marine management and the role of the D&SIFCA. It has also, however, identified constraints on this which may be overcome through devolved decision making, resolution of issues regarding the Severn area, and increased resources and funding. Whilst these constraints exist, management of stakeholder expectations is necessary to maintain social capital and avoid disenfranchisement.

The establishment of the IFCAs marked the first step in a long term goal of meeting social, environmental and economic objectives through implementing an ecosystem approach to management in England (Rodwell et al. 2014). Whilst it is still early days, this study has found that the correct attributes are contained within the vision, goals and workings of the D&SIFCA and if resolution of some of the identified obstacles can be achieved then they should see increased success at meeting their goals. Agreement has been identified with Gutierrez et al. (2011), as the success seen here is built on strong leadership and social capital. Incentives to stakeholders have not been fully realised, however, despite the presence of MPAs, management decisions have not yet been made regarding fishing activities that may occur within them. It is hoped that with time this will increase as uncertainty reduces and management measures are implemented. Future monitoring is recommended, and expansion of the survey to the other IFCAs in English waters to determine whether this has been the case, and to evaluate the ongoing success of EBFM in English waters.


Define and Design
Prepare, Collect & Analyse
Synthesise
Literature review
Introduction
Identification of key evidence gaps
Development of research strategy
Identification of data sources and design of data collection methods
Conduct ecological fieldwork and analyse data
Conduct and analyse social 'Q methodology' interviews
Collate and analyse fisheries economic data
Conduct and analyse management effectiveness questionnaires
Write ecology chapter
Write social chapter
Write economic chapter
Write management chapter
Collate findings and conclusions
Synthesise findings
Conclusions
Thesis structure (chapters)
1
2 3 4 5
6

Chapter six: Synthesis

6.1 Introduction

This thesis has taken an interdisciplinary approach to investigate the effectiveness of integrating fisheries and conservation management. These two governance streams have historically run separately from one another, and despite having similar goals, stem from different roots (Rice et al. 2012). In recent years, however, there have been efforts to integrate the two to facilitate a holistic approach to management (Garcia et al. 2014). The degree of overlap between the two streams has increased because neither can achieve its objectives alone, and each relies on cooperation from, and impacts on the other (Charles et al. 2014). The introduction of the ecosystem approach via the Rio +20 summit of the Convention on Biological Diversity (1992) marked the beginning of formal efforts to achieve integration, but due to their different roots it is unclear whether full integration will be possible (Charles et al. 2014).

Regulators commonly rely on tools such as Marine Protected Areas (MPAs) to facilitate the integration of fisheries and conservation management following recognition that sites can be established to meet goals from both governance streams (Hilborn et al. 2004; Kenchington et al. 2014). MPA success was initially thought to depend on effective management of ecological factors alone, but with time, the importance of the human dimension has been realised, with socio-economic concerns increasingly seen as key drivers for success (Arias et al. 2015; Mascia 2004; Pomeroy et al. 2007).

Recognition of the interdisciplinary nature of the research question led this thesis to take an interdisciplinary approach (Stember 1991), seeking to integrate knowledge and methods from ecological, social and economic disciplines to produce a holistic evaluation of whether fisheries and conservation management may be effectively integrated (Figure 6.1). This approach recognised the influence of ecological, social and economic factors together with the remit and vision of the Inshore Fisheries and Conservation Authorities in England.

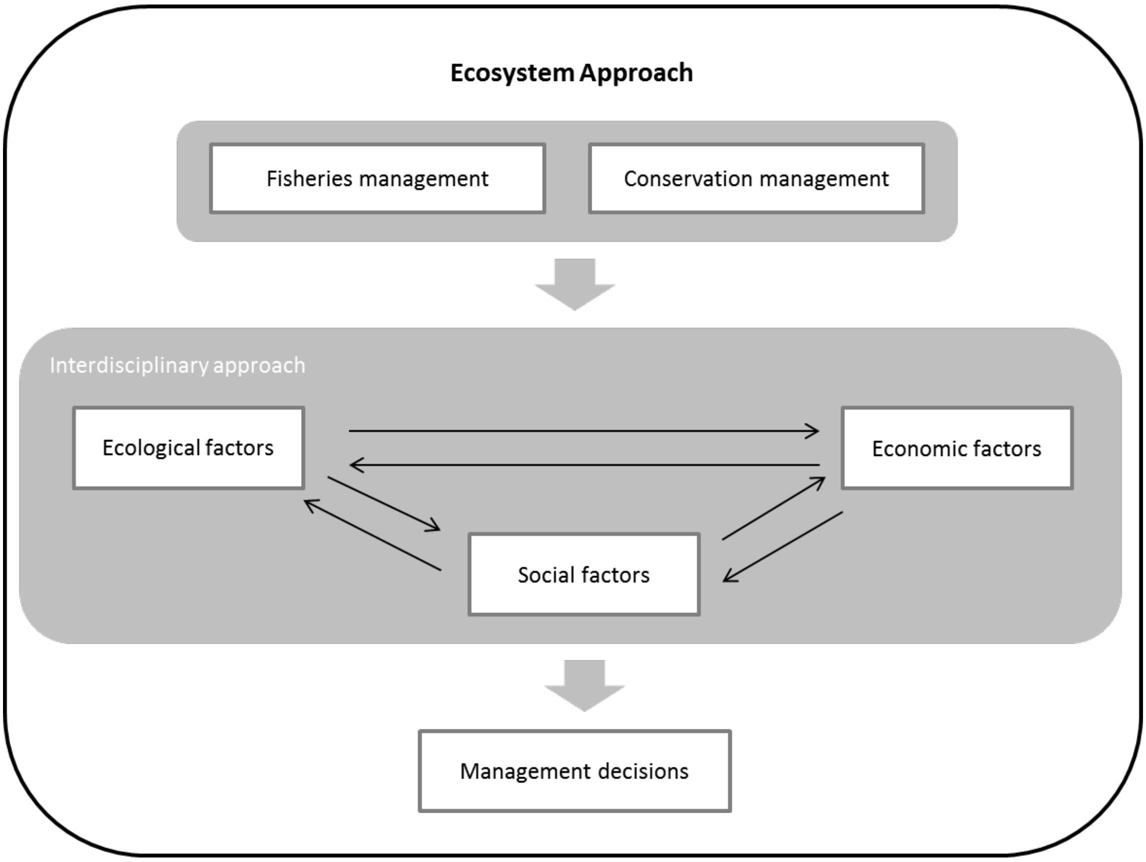


Figure 6.1: Schematic showing the interdisciplinary nature of research into the integration of fisheries and conservation management

Primarily the thesis has investigated the effectiveness of integrating these two governance streams using the example of MPAs. It has evaluated the ecological and economic impacts of designation, the perceptions of stakeholders on their success and the effectiveness of management measures. The four data chapters considered:

- Chapter two: the ecological implications of designating multi-use MPAs,
- Chapter three: the social acceptability of MPAs,

- Chapter four: the implications of designating multi-use MPAs for fisheries, and,
- Chapter five: the perceptions on success of EBFM

Upon completion of this thesis, chapter three has been published, and additional publications are planned from chapters two, four and five, with chapter six forming a discussion paper; a synthesis addressing the overall research questions of the thesis: 'what are the impacts of integrating fisheries and conservation management?'.

This chapter aims to synthesise how the main findings relate to the research questions of this thesis. It will also highlight the wider application of this work, the importance of the interdisciplinary approach, and discuss ideas for future studies.

6.2 Ecological implications

This research **(chapter two)** provided robust, quantitative evidence of the impact of potting on rocky reef ecosystems. Few studies had considered potting impact previously, and those that had drew conclusions that suggested potting should be compatible with conservation objectives (Coleman et al. 2013; Eno et al. 2001; Kinnear et al. 1996). Potting activities are commonly permitted within multi-use MPAs based on the assumption that they are compatible with the conservation objectives of the site, and with designations increasing, it was deemed important to quantify the impact of potting on rocky reef ecosystems.

Results have shown some impact, namely that areas fished with static gear were more representative of a well-functioning rocky reef ecosystem (Tett et al. 2013) than those fished with bottom towed fishing gear. The research also developed a method for assessing the mechanisms of potting using a system of GoPro cameras mounted on crab pots to give views of the deployment, soak time and haul, therefore to enable quantification of interaction. This work showed that it is inappropriate to use the entire length of the assumed haul corridor as a metric for area of reef impacted as contact was only made with the reef approximately 50 % of the time during the haul. Where damage occurred from pot impact this included abrasion, and removal of sections of the individual. In the majority of cases, few individuals were damaged, however, with the number not damaged outweighing that of damaged taxa.

It was concluded that there were mechanisms preventing the ecosystem from reaching a fully functioning state, as significant differences in number of taxa, number of individuals and diversity would be expected if this were the case (Tett et al. 2013). It was thought that the winter storms of 2013/2014 were the most likely contributor, with research in Lyme Bay finding that sites within an MPA became more similar to sites open to bottom towed fishing gear outside it following the storms (Sheehan et al. unpublished data). It was thought that due to the proximity of the study site to Lyme Bay and the similarities between the reef environments, similar impacts would have occurred in the study area which may have masked true differences between the treatments.

This research has been able to quantify the direct mechanisms of potting interaction and provide quantitative, robust evidence that should be used in conjunction with data on additional metrics to reach decisions regarding whether potting activity is compatible with GES. It should therefore allow MPAs to reach or maintain favourable conservation status. It has also been used as evidence to support the Habitat Regulations Assessments (HRAs) conducted by D&SIFCA, thereby aiding policy decisions regarding management of fisheries within European Marine Sites.

These results are important as benthic ecosystems play a vital role in supporting fisheries activities through the provision of ecosystem services. Species such as sponges, soft corals, tunicates and bryozoans provide important biogenic structure and function including nursery areas, refuges from predators and habitat for the settlement of invertebrate spat such as scallops (Beck et al. 2001; Beukers-Stewart and Beukers-Stewart 2009; Dayton et al. 1995; Jennings and Kaiser 1998; Jennings et al. 2001; Monteiro et al. 2002; Ryer et al. 2004). The condition of benthic ecosystems is therefore vital to fisheries activities, not only through provision of target species, but also maintenance of their supporting ecosystems. A well-functioning reef system should underpin the provision of ecosystem services, and ensure the sustainability of both social and economic benefits associated with the presence of a viable industry.

When considering the implications of this work more widely, issues of shifting baselines (Pauly 1995; Sáenz-Arroyo et al. 2005) and the scale of the fishery, intensity and effort must be acknowledged. Management decisions must be made in combination with data on social and economic factors as any management measures introduced may have implications for the continuation of fishing activities in MPAs. Furthermore, it is vital that adequate ecological monitoring is conducted at sites where fishing activities are permitted to ensure that they continue to be compatible with conservation objectives and continue to provide ecosystem goods and services thereby ensuring sustainability.

6.3 Social acceptability

Through analysis of the views and attitudes of stakeholders, this research **(chapter three)** has provided an insight into the social acceptability of MPAs and their perception in the Devon & Severn region of the UK. Previous research identified that compliance with MPA regulations was linked to success, and was greater when stakeholders understood the reasons for designation and were supportive of it (Arias et al. 2015). Research was lacking, however, on whether and how acceptance changed over time following MPA establishment. This was considered important. With the increasing designation of MPAs to meet targets such as the CBD Aichi Biodiversity Target 11 calling for 10 % of coastal and marine areas to be protected areas by 2020, understanding the acceptance of MPAs and identifying limiting factors would help to ensure that future sites could be implemented appropriately, maximising their chances of success.

Despite its increasing use in environmental disciplines, Q methodology has not been widely used in marine research; however, it has been successfully applied here to analyse views and attitudes of stakeholders towards MPAs. It provides not only a robust methodology for quantifying viewpoints, but also a novel alternative to more traditional research methodologies which could help overcome stakeholder fatigue.

This research showed that social acceptance was achieved where engagement during the planning process was well-developed and thorough. In this case, it was limited by the cessation of engagement at the end of the planning phase and the exclusion of stakeholders from the ongoing process of site implementation and development of management plans. This suggests that in future, steps should be taken to ensure the ongoing involvement of stakeholders, or to manage expectations to ensure that support is maintained.

All discourses placed emphasis on the importance of working with partnerships between stakeholders, and acknowledged the value of cross table discussions involving multiple stakeholder groups. The importance of engagement during the planning process is well documented in the literature (e.g. Gleason et al. 2010; Leleu et al. 2012; Rossiter and Levine 2014; Sutton and Tobin 2009), but this research highlights the need for continued involvement throughout implementation and into the future management of the site. It was concluded that social acceptance of MPAs was likely to be greater where involvement was continued, and where there could be local input into management plans.

This research also highlighted that the majority of stakeholders think numbers of MPAs should be increased and that management of the marine environment needs to be improved. Concerns were raised over the availability of resources to enforce regulations and to monitor success. Without successful enforcement it is unlikely that MPAs will succeed at meeting their goals and to increase the chances of them doing so, compliance is essential (Arias et al. 2015; Rossiter and Levine 2014).

6.4 Fisheries implications

Through analysis of landings data, this research **(chapter four)** quantified the benefits to static gear fishers of the implementation of a multi-use MPA which permitted static gear but excluded bottom towed fishing gear. Research into the economic implications of MPA designation has commonly focussed on fisheries which are excluded from an MPA as these individuals may disproportionately bear the costs of management strategies that place restrictions on resource use (Mangi et al. 2011; McClanahan and Mangi 2000; Murawski et al. 2000; Roberts et al. 2001; Russ and Alcala 1996; Russ et al. 2004). Research has however, been limited on the potential benefits for fishers permitted to continue their activities within an MPA. These individuals are expected to benefit through increased area available to fish and decreased competition, but also from ecological benefits that may be expected from the MPA through recovery of stocks. Quantification of these may aid acceptance and subsequently, success of MPAs as where benefits are readily apparent, stakeholders are more likely to support management measures and compliance increase (Arias et al. 2015).

This research found that designation of multi-use MPAs may provide economic benefit for certain fishers. In the Lyme Bay case study this was primarily through increased landings of edible crab *Cancer pagurus*. Whilst the benefits could not be conclusively attributed to the designation of the MPA it was thought that direct benefits may have resulted from expansion of available ground, reduction in gear conflicts and increased opportunity to fish, and indirectly through the establishment of the Lyme Bay Working Group and the brand Reserve Seafood.

The establishment of the Lyme Bay Working Group resulted in a voluntary code of conduct and the direct involvement of fishers in the ongoing management of the MPA in which they fish. It is hoped that this co-management approach will help to ensure the economic benefits and long term sustainability of the site, however, this is not guaranteed. The finding from Sheehan et al. (2015) that abundance of *C. pagurus* may have decreased in the study area whilst CPUE increased may give cause for concern over the long term sustainability of the stock. Assessment of *C. pagurus* abundance does however, require dedicated stock assessment as this was outside the remit of the work of Sheehan et al. (2015). It is hoped that the existence of the Working Group will ensure an adaptive and responsive approach to management so that should a requirement arise for management of potting activity the relevant measures would be implemented. As identified in **chapter five**, co-management bodies such as this can aid in implementation of ecosystem based fisheries management and may be considered a positive step in the management of marine resources at a local level.

6.5 Perspectives of ecosystem based fisheries management

Using a questionnaire approach, this research **(chapter 5)** has assessed the effectiveness of Devon & Severn Inshore Fisheries and Conservation Authority (D&SIFCA) management in order to determine how ecosystem based fisheries management has been incorporated into marine management in England. This followed the establishment of IFCAs around the coast of England as a result of the Marine and Coastal Access Act (2009), marking a positive step towards an ecosystem approach to management and the meeting of obligations within international, regional and national legislation.

Previous work by Rodwell et al. (2014) concluded that the IFCAs had the necessary attributes for success, but expressed concerns that there may be limiting factors preventing them from working to the best of their abilities. This research therefore aimed to evaluate the ability of D&SIFCA to meet their objectives in their first five years of existence, and evaluate management effectiveness to inform adaptive co-management.

The research found that stakeholders expressed support for the work of the D&SIFCA and a degree of optimism for marine management, and in agreement with the work of Gutierrez et al. (2011), strong leadership and social capital was identified. They also, however, identified constraints which may be overcome through devolved decision making, resolution of issues regarding the inclusion of the Severn area in the D&SIFCA and increased resources and funding. One notable area of concern was the implementation of Marine Conservation Zones without any management plans in place at time of designation. This, combined with concern over the availability of resources to enable effective enforcement once plans are in place was highlighted as a current failing of marine management in England. It is hoped that uncertainty will reduce over time once plans are implemented, which in turn should increase social acceptance and success of management measures (Arias et al. 2015).

Parallels drawn with EBFM in the USA, Norway and Canada identified that the IFCAs may benefit from devolution of powers to enable greater decision making at a regional rather than a national level (BalticSea 2020 2009; Dell'Apa et al. 2012; Holm et al. 2000; Okey 2003). This is particularly because some of the issues which are specific to the D&SIFCA relate to issues which fall within the control of the UK government, and stakeholder support and management success could both be increased through resolution of these issues at a regional level.

6.6 Integrating fisheries and conservation management

Whilst the thesis is structured in stand-alone chapters with each considering a different discipline, the links between them are apparent throughout. **Chapter two** has shown that static fishing methods may be compatible with the conservation objectives of a multi-use MPA, but that this will depend on the level of impact and what is deemed 'acceptable' by regulators. Rocky reef ecosystems provide important ecosystem services for the maintenance of fisheries and bring social and economic benefits to fishers and coastal communities. It is therefore essential for long term sustainability of fisheries that activities are monitored and that management can be reactive. Ensuring compatibility of both fisheries and conservation goals is crucial for successful integration of the two governance strands.

Chapter three stressed the importance of stakeholder engagement and transparency in decision making to increase social acceptance of management measures and increase the likelihood of their success. Where management is required to enable the conservation objective of a site to be achieved, stakeholder acceptance can be facilitated by provision of clear evidence of the need for management, and of the benefits it may bring. Evidence of these benefits has been provided by chapters two and four, with **Chapter four** highlighting potential economic benefits through quantification of change in quantity and value of landings of target species for potting fisheries following implementation of a multi-use MPA. Results showed increased quantity and value of landings which were thought to stem in part from the MPA, but comparison with ecological data from Sheehan et al. (2015) suggested that the increased landings may be negatively impacting abundance of target species, which has negative implications for the sustainability of stocks and the ecology of the site. Thus, reiterating the importance of long term ecological monitoring and the value of taking an interdisciplinary approach when considering site success.

Finally, **Chapter five** provided an assessment of the perspectives of the D&SIFCA at implementing ecosystem based fisheries management, highlighting the potential role of co-management and the value of an ecosystem approach. It also emphasised the need for responsive, adaptive management which considers all stakeholders and all three disciplines and which has sufficient power to implement change at a local level.

Whilst this thesis has focussed on fisheries and conservation management in UK waters, it is envisaged that many of the conclusions will be applicable across the globe. It has been able to demonstrate that the elements required for successful integration of fisheries and conservation management include:

- Identification of fisheries which can operate within multi-use MPAs whilst allowing the conservation objectives of a site to be achieved;
- Inclusion of stakeholders in, and transparency of all stages of planning, designation and management of MPAs to facilitate site acceptance and compliance with regulations;

- Development of co-management groups e.g. IFCAs to facilitate cross-table discussions between stakeholder groups and provide a holistic approach to management;
- Implementation of management which is responsive and adaptive and which benefits from some devolved decision making power;
- Regular monitoring of ecological, social and economic aspects of MPAs to ensure that management is adequate and is permitting ecological, social and economic benefits to be realised;

It is also thought that the introduction of fisheries specific goals into MPA plans may facilitate the integration and success of MPAs at meeting both fisheries and conservation goals. Currently the majority of MPAs e.g. MCZs, SACs are designated for conservation alone which may restrict integration. The addition of some sites with both conservation and fisheries objectives may help to overcome this.

6.7 Conclusions

This thesis has highlighted the strength of taking an interdisciplinary approach to research into the implications of integrating fisheries and conservation management. It has been able to draw conclusions on ecological, social, economic and management aspects and has demonstrated the connections between them. The thesis is able to conclude that integration of these two governance streams could be possible within certain limitations: some fishing activities are likely to be compatible with the conservation objectives of MPAs, therefore they are able to address both fisheries and conservation goals. The success of these areas at meeting their goals will be influenced by social and economic factors, with success more likely where stakeholder acceptance is greater. Acceptance depends on the provision of adequate resources for management and enforcement to ensure that the ecological objectives of the site are not compromised. It can be enhanced by continued engagement of stakeholders through the planning, implementation and management process. Successful implementation and compliance with regulations would further benefit from provision of evidence that shows there can be economic benefits arising from MPA designation, as has been demonstrated for fishers active within multi-use sites.

It is thought that, as identified by Charles et al. (2014) and Rice et al. (2012) integration is limited by fundamental differences in the roots of the two governance streams. Whilst they have become more convergent with time, with multi-use MPAs in particular striving to meet conservation objectives whilst permitting some extractive activities which may bring social and economic benefits locally and nationally, success may be limited by fundamental differences in the goals of the two streams. The priority of conservationists will always primarily be the conservation of resources, whilst the priority of fishers will be maximising yields within sustainable limits. It is essential that multi-use MPAs work to bring benefits to both sectors if they are to be successful and that the potential benefits are effectively communicated to stakeholders. Furthermore, it is crucial that management measures are reactive and adaptive and that if the condition of a site changes, appropriate management measures are implemented to ensure the long term sustainability of ecosystem service provision.

Designation of MPAs is set to increase globally before 2020 in order to meet the CBD Aichi Biodiversity Target 11 which calls for 10 % of coastal and marine areas to be protected. This thesis has provided research which may be used in order to increase the effectiveness of site implementation in order to meet such targets. Research in this area would, however, benefit from ongoing efforts to develop an evidence base quantifying both the costs and benefits of integrating fisheries and conservation management in order to develop best practise, identify the potential limitations and establish methods to overcome them. In particular research would benefit from advances in some key areas:

- Long term monitoring of species within multi-use MPAs to quantify the impacts of any permitted fishing activity and ensure it is managed within sustainable limits.
- Long term monitoring of social acceptance in case study sites, particularly before and after the introduction of management measures to further understanding of whether acceptance increases once management measures are implemented and whether it would increase if management was implemented at the time of designation.
- Increasing examples of interdisciplinary research which considers the ecological, economic and social impacts of management measures to provide a holistic, robust approach to quantifying both the costs and benefits of management measures to directly inform governance.

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Annex A: Assessing the impact of potting on benthic habitats

A1: Benthic condition

1. Image is well focussed
2. Lasers in acceptable laser positions (-1, 0, 1, see diagram)
3. Image clear of obstructions eg. large fish
4. Frame must contain > 50 % hard substrata*

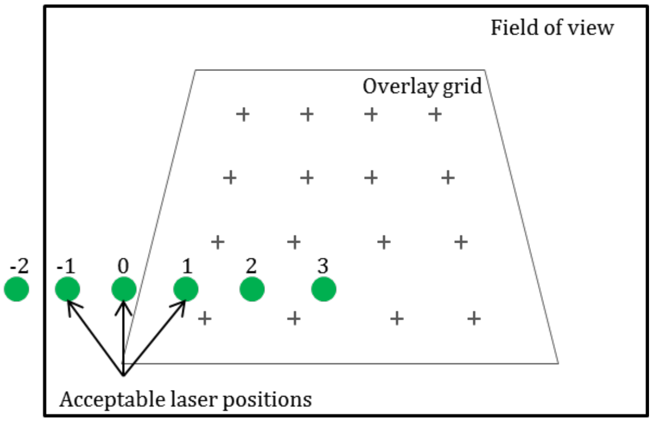

Figure A1: criteria for selection of frame grabs for analysis, adapted from (Sheehan et al. 2013b)

Source	df	MS	Pseudo-F	P(perm)
Count taxa				
Ye	2	3820.50	3.08	**0.001**
Tr	1	12338.00	1.57	0.08
Lo(Tr)	8	6756.80	2.89	**0.000**
YexTr	2	1925.50	1.58	0.07
Si(Lo(Tr))	20	1345.30	1.67	**0.0001**
YexLo(Tr)	16	1212.80	1.51	**0.0004**
Res	37	804.24		
Total	86			

Source	df	MS	Pseudo-F	P(perm)
Cover taxa				
Ye	2	3338.60	1.97	**0.07**
Tr	1	19842.00	3.41	**0.01**
Lo(Tr)	8	4890.30	1.79	**0.002**
YexTr	2	1429.70	0.86	0.51
Si(Lo(Tr))	20	1591.50	1.52	**0.02**
YexLo(Tr)	16	1656.80	1.59	**0.02**
Res	37	1045.20		
Total	86			

Table A1: PERMANOVA to test the differences in number of count and cover individuals between Years (2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in Location) and Treatments (Static, Mixed). Data were fourth root transformed prior to the construction of a Euclidean distance resemblance matrix. Bold values indicate significant differences.

Source	df	MS	Pseudo-F	P(perm)
Number of taxa				
Ye	2	0.10	7.55	**0.01**
Tr	1	0.26	3.44	0.07
Lo(Tr)	8	0.07	1.25	0.26
YexTr	2	0.01	0.91	0.43
Si(Lo(Tr))	20	0.05	4.97	**0.0001**
YexLo(Tr)	16	0.01	1.37	0.21
Res	37	0.01		
Total	86			

Source	df	MS	Pseudo-F	P(perm)
Diversity				
Ye	2	0.00	0.17	0.85
Tr	1	0.01	0.27	0.95
Lo(Tr)	8	0.04	1.72	0.06
YexTr	2	0.01	2.00	0.16
Si(Lo(Tr))	20	0.02	3.38	**0.0004**
YexLo(Tr)	16	0.01	1.28	0.27
Res	37	0.01		
Total	86			

Table A2: PERMANOVA to test the differences in number of taxa and diversity (Simpsons 1-λ) between Years (2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in Location) and Treatments (Static, Mixed). Data were fourth root transformed prior to the construction of a Euclidean distance similarity matrix. Bold values indicate significant differences

Source	df	MS	Pseudo-F	P(perm)
Alcyonidium diaphanum				
Ye	2	3.91	8.53	**0.003**
Tr	1	0.75	0.70	0.64
Lo(Tr)	8	1.56	2.31	**0.01**
YexTr	2	0.18	0.40	0.66
Si(Lo(Tr))	20	0.31	1.33	0.22
YexLo(Tr)	16	0.45	1.88	0.06
Res	37	0.24		
Total	86			
Branching sponges				
Ye	2	0.04	1.95	0.18
Tr	1	0.43	2.39	0.14
Lo(Tr)	8	0.18	3.55	**0.001**
YexTr	2	0.01	0.69	0.52
Si(Lo(Tr))	20	0.03	1.48	0.13
YexLo(Tr)	16	0.02	0.92	0.56
Res	37	0.02		
Total	86			
Eunicella verrucosa				
Ye	2	0.07	0.70	0.53
Tr	1	0.06	0.11	1.00
Lo(Tr)	8	1.30	8.54	**0.0001**
YexTr	2	0.11	1.12	0.36
Si(Lo(Tr))	20	0.05	2.79	**0.004**
YexLo(Tr)	16	0.10	5.17	**0.0001**
Res	37	0.02		
Total	86			
Pentapora foliacea				
Ye	2	0.03	5.17	**0.02**
Tr	1	0.01	1.25	0.36
Lo(Tr)	8	0.01	1.43	0.15
YexTr	2	0.00	0.23	0.79
Si(Lo(Tr))	20	0.00	1.34	0.20
YexLo(Tr)	16	0.01	2.08	**0.03**
Res	37	0.00		
Total	86			

Source	df	MS	Pseudo-F	P(perm)
Alcyonium digitatum				
Ye	2	0.35	2.57	0.11
Tr	1	19.09	6.56	**0.01**
Lo(Tr)	8	2.41	5.01	**0.0001**
YexTr	2	0.54	4.01	**0.04**
Si(Lo(Tr))	20	0.39	1.43	0.17
YexLo(Tr)	16	0.13	0.49	0.94
Res	37	0.27		
Total	86			
Cliona celata				
Ye	2	0.01	1.69	0.21
Tr	1	0.11	5.02	**0.02**
Lo(Tr)	8	0.02	1.48	0.13
YexTr	2	0.01	0.85	0.45
Si(Lo(Tr))	20	0.01	1.09	0.39
YexLo(Tr)	16	0.01	1.09	0.39
Res	37	0.01		
Total	86			
Metridium senile				
Ye	2	0.01	0.44	0.67
Tr	1	0.22	3.76	**0.05**
Lo(Tr)	8	0.05	1.54	0.11
YexTr	2	0.01	0.75	0.51
Si(Lo(Tr))	20	0.03	1.13	0.34
YexLo(Tr)	16	0.02	0.77	0.76
Res	37	0.03		
Total	86			
Urticina felina				
Ye	2	0.18	3.55	**0.04**
Tr	1	0.10	0.38	0.88
Lo(Tr)	8	0.39	4.75	**0.0001**
YexTr	2	0.03	0.52	0.62
Si(Lo(Tr))	20	0.04	1.16	0.33
YexLo(Tr)	16	0.05	1.65	0.10
Res	37	0.03		
Total	86			

	M&S
2013	0.073
2014	**0.017**
2015	**0.024**

Table A3: ANOVA to test the differences in number of individuals of the indicator taxa *Alcyonidium diaphanum, Alcyonium digitatum,* Branching sponges, *Cliona celata, Eunicella verrucosa, Metridium senile, Pentapora foliacea* and *Urticina felina* between Years (2013, 2014, 2015), Locations (A-J, nested in Treatment), Sites (1-30, nested in Location) and Treatments (Static, Mixed). Pairwise tests were used to examine significant interactions between fixed factors. Data were fourth root transformed prior to the construction of a Euclidean distance resemblance matrix. Bold values indicate significant differences.

A2: Mechanisms and true footprint

Pot area data

Base including buffer: inkwell = 0.61 m^2, parlour = 0.53 m^2
Side segment including buffer: inkwell = 0.23 m^2, parlour = 0.30 m^2
End of the parlour pot including buffer = 0.32 m^2
The side segment and end were calculated as there were some instances where these were the surfaces contacting the reef when the pot was hauled.

Source	df	MS	Pseudo-F	P(perm)
Alcyonium digitatum				
Ye	1	3.75	0.50	0.63
Lo	2	11.72	0.97	0.53
Po	1	15.08	4.83	**0.04**
Si(Lo)	25	7.30	2.43	**0.02**
YexLo	2	7.39	2.47	0.08
YexPo	1	1.37	0.85	0.46
LoxPo	2	1.66	0.59	0.84
YexSi(Lo)**	23	2.94	2.21	**0.03**
PoxSi(Lo)**	24	3.58	2.69	**0.01**
YexLoxPo	2	1.51	1.13	0.33
Res	18	1.33		
Total	101			
Branching sponges				
Ye	1	0.84	1.58	0.35
Lo	2	0.38	0.97	0.55
Po	1	0.42	2.81	0.14
Si(Lo)	55	0.24	0.73	0.71
YexLo	2	0.47	1.45	0.26
YexPo	1	0.42	1.31	0.31
LoxPo	2	0.06	0.20	0.71
YexSi(Lo)**	37	0.32	No test	
PoxSi(Lo)**	0		No test	
YexLoxPo	0		No test	
Total	101			

	SP	ML	HP
1			
I & P	0.49		0.50
2			
I & P	0.25	0.25	0.24
3			
I & P		0.25	
4			
I & P	0.51		0.25
5			
I & P	0.51	0.24	0.49
6			
I & P	0.50	0.25	0.25
7			
I & P	0.50	0.50	0.50
8			
I & P		0.25	0.50
9			
I & P		0.24	0.50

Source	df	MS	Pseudo-F	P(perm)
Cliona celata				
Ye	1	0.12	4.07	0.12
Lo	2	0.08	1.73	0.16
Po	1	0.07	1.25	0.39
Si(Lo)	25	0.06	0.84	0.69
YexLo	2	0.03	0.39	0.78
YexPo	1	0.09	0.86	0.45
LoxPo	2	0.05	0.60	0.84
YexSi(Lo)**	23	0.07	1.41	0.18
PoxSi(Lo)**	24	0.06	1.15	0.34
YexLoxPo	2	0.10	2.00	0.13
Res	18	0.05		
Total	101			
Eunicella verrucosa				
Ye	1	0.13	1.49	0.32
Lo	2	0.21	1.91	0.10
Po	1	0.03	1.16	0.43
Si(Lo)	25	0.05	0.82	0.74
YexLo	2	0.09	1.35	0.26
YexPo	1	0.07	0.60	0.60
LoxPo	2	0.07	0.75	0.72
YexSi(Lo)**	23	0.06	0.93	0.59
PoxSi(Lo)**	24	0.06	0.82	0.71
YexLoxPo	2	0.12	1.83	0.15
Res	18	0.07		
Total	101			
Pentapora foliacea				
Ye	1	0.09	2.24	0.20
Lo	2	0.05	1.28	0.32
Po	1	0.06	2.11	0.18
Si(Lo)	55	0.04	0.91	0.52
YexLo	2	0.04	0.83	0.53
YexPo	1	0.07	1.56	0.22
LoxPo	2	0.01	0.31	0.75
YexSi(Lo)**	37	0.04	No test	
PoxSi(Lo)**	0		No test	
YexLoxPo	0		No test	
Total	101			

Table A4: ANOVA to test the differences in number of individuals for the indicator taxa *Alcyonium digitatum,* Branching sponges, *Cliona celata, Eunicella verrucosa* and *Pentapora foliacea* between Years (Yr, 2014, 2015), Locations (Lo, Start Point, Mewstone Ledges, Hillsea Point), Sites (1-9, nested in Location) and Pot Types (Po, Inkwell, Parlour). Pairwise tests are used to examine significant interations between fixed factors. Data were untransformed prior to the construction of a Euclidean Distance resemblance matrix. Bold values indicate significant differences.

Annex B: Assessing the economic implications of multi-use marine protected areas for fisheries

	df	MS	Pseudo-F	P(perm)
Number of vessels targeting crab				
Ye	8	29.85	3.42	**0.002**
Res	98	8.71		
Total	106			
Number of vessels targeting lobster				
Ye	8	25.15	1.85	0.08
Res	98	13.59		
Total	106			
Number of vessels targeting whelk				
Ye	8	31.00	8.56	**0.0001**
Res	98	3.62		
Total	106			

	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
06/07		0.69	0.10	**0.001**	0.05	0.05	0.20	0.95	0.76
07/08			0.23	**0.01**	0.24	0.27	0.59	0.72	0.85
08/09				0.52	0.61	0.55	0.30	0.07	**0.10**
09/10					**0.01**	**0.003**	**0.001**	**0.0001**	**0.0002**
10/11						0.89	0.21	**0.004**	**0.01**
11/12							0.26	**0.004**	**0.01**
12/13								0.06	0.08
13/14									0.70
14/15									

	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
06/07		0.59	**0.01**	0.11	**0.001**	**0.001**	**0.0002**	**0.0002**	**0.01**
07/08			**0.01**	0.05	**0.001**	**0.001**	**0.0004**	**0.0001**	**0.004**
08/09				0.51	0.05	**0.02**	**0.03**	**0.002**	0.22
09/10					**0.03**	**0.01**	**0.02**	**0.002**	0.13
10/11						0.78	0.83	0.82	0.51
11/12							0.53	1.00	0.31
12/13								0.46	0.57
13/14									0.23
14/15									

Table B1: ANOVA to test the difference in number of active vessels between Years (2006/2007 – 2014/2015) for *C. pagurus*, *H. gammarus* and *B. undatum* in the Lyme Bay MPA. Data were untransformed and Bray Curtis resemblance matrices constructed. Bold values indicate significant differences. Pairwise tests are used to examine significant relationships. Bold type denotes a statistically significant result.

	df	MS	Pseudo-F	P(perm)
Number of vessels targeting crab				
Ye	8	33.75	5.86	**0.0001**
Res	98	5.76		
Total	106			

	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
06/07		1.00	0.41	0.09	0.28	0.51	0.05	**0.01**	**0.03**
07/08			0.45	0.14	0.34	0.53	0.11	**0.01**	**0.04**
08/09				0.43	0.90	1.00	**0.02**	**0.003**	**0.01**
09/10					0.57	0.39	**0.004**	**0.002**	**0.005**
10/11						0.81	**0.01**	**0.003**	**0.01**
11/12							**0.02**	**0.005**	**0.02**
12/13								0.25	0.52
13/14									0.66
14/15									

	df	MS	Pseudo-F	P(perm)
Number of vessels targeting lobster				
Ye	8	39.74	2.90	**0.01**
Res	98	13.72		
Total	106			

	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
06/07		0.32	**0.03**	**0.000**	**0.04**	0.29	0.35	0.68	0.69
07/08			0.27	**0.01**	0.39	1.00	-	0.31	0.28
08/09				0.17	0.75	0.29	0.29	0.08	0.05
09/10					0.06	**0.01**	**0.02**	**0.01**	**0.004**
10/11						0.43	0.41	0.11	0.07
11/12							1.00	0.29	0.26
12/13								0.32	0.30
13/14									0.94
14/15									

	df	MS	Pseudo-F	P(perm)
Number of vessels targeting whelk				
Ye	8	0.08	0.71	0.63
Res	98	0.12		
Total	106			

Table B2: ANOVA to test the difference in number of active vessels between Years (2006/2007 – 2014/2015) for *C. pagurus*, *H. gammarus* and *B. undatum* in the IPA. Data were untransformed and Bray Curtis resemblance matrices constructed. Bold values indicate significant differences. Pairwise tests are used to examine significant relationships. Bold type denotes a statistically significant result.

	df	MS	Pseudo-F	P(perm)		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
CPUE crab (tonnes per vessel per month)														
Ye	8	3	10.96	**0.0001**	06/07		0.48	0.50	0.77	0.72	0.63	**0.03**	**0.0001**	**0.002**
Res	98	0			07/08			0.95	0.38	0.63	0.77	0.24	**0.0005**	**0.01**
Total	106				08/09				0.41	0.63	0.75	0.33	**0.0005**	**0.01**
					09/10					0.53	0.49	**0.02**	**0.0002**	**0.001**
					10/11						0.83	**0.05**	**0.0001**	**0.002**
					11/12							0.12	**0.0002**	**0.002**
					12/13								**0.0008**	**0.02**
					13/14									0.96
					14/15									
CPUE lobster (tonnes per vessel per month)														
Ye	8	0	1.33	0.23										
Res	98	0												
Total	106													
CPUE whelk (tonnes per vessel per month)														
Ye	8	54	1.40	0.20										
Res	98	39												
Total	106													

Table B3: ANOVA to test the difference in CPUE between Years (2006/2007 – 2014/2015) for *C. pagurus*, *H. gammarus* and *B. undatum* in the Lyme Bay MPA. Data were untransformed and Bray Curtis resemblance matrices constructed. Bold values indicate significant differences. Pairwise tests are used to examine significant relationships. Bold type denotes a statistically significant result.

	df	**MS**	**Pseudo-F**	**P(perm)**		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
CPUE crab (tonnes per vessel per month)														
Ye	8	8	0.52	0.83										
Res	98	14												
Total	106													
CPUE lobster (tonnes per vessel per month)														
Ye	8	0	0.74	0.67										
Res	98	0												
Total	106													
CPUE whelk (tonnes per vessel per month)														
Ye	8	188	4.80	**0.0003**	06/07		0.48	0.54	0.74	**0.04**	**0.02**	**0.04**	**0.03**	0.56
Res	98	39			07/08			0.87	0.22	**0.004**	**0.002**	**0.01**	**0.004**	0.17
Total	106				08/09				0.22	**0.0003**	**0.0001**	**0.0004**	**0.001**	0.16
					09/10					**0.002**	**0.001**	**0.005**	**0.004**	0.66
					10/11						0.57	0.98	0.63	**0.03**
					11/12							0.61	0.98	**0.02**
					12/13								0.66	**0.04**
					13/14									**0.03**
					14/15									

Table B4: ANOVA to test the difference in CPUE between Years (2006/2007 – 2014/2015) for *C. pagurus*, *H. gammarus* and *B. undatum* in the IPA. Data were untransformed and Bray Curtis resemblance matrices constructed. Bold values indicate significant differences. Pairwise tests are used to examine significant relationships. Bold type denotes a statistically significant result.

	df	**MS**	**Pseudo-F**	**P(perm)**		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Value Crab (£ per vessel per month)														
Ye	8	6119900	16.25	**0.0001**	06/07		0.37	0.86	0.57	0.16	0.14	**0.004**	**0.0001**	**0.0001**
Res	98	376670			07/08			0.49	0.58	0.93	0.77	0.09	**0.0001**	**0.001**
Total	106				08/09				0.79	0.36	0.25	**0.01**	**0.0001**	**0.0003**
					09/10					0.37	0.28	**0.01**	**0.0001**	**0.0001**
					10/11						0.59	**0.02**	**0.0001**	**0.0003**
					11/12							0.11	**0.0002**	**0.001**
					12/13								**0.0004**	**0.01**
					13/14									0.90
					14/15									
Value Lobster (£ per vessel per month)						06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Ye	8	264370	3.15	**0.003**	06/07		0.79	0.22	**0.004**	**0.04**	0.19	0.45	0.24	0.58
Res	98	83838			07/08			0.26	**0.005**	**0.04**	0.24	0.56	0.14	0.40
Total	106				08/09				0.12	0.50	0.87	0.63	**0.04**	0.10
					09/10					0.26	0.23	0.05	**0.001**	**0.003**
					10/11						0.69	0.24	**0.01**	**0.02**
					11/12							0.56	**0.04**	0.10
					12/13								0.09	0.23
					13/14									0.53
					14/15									
Value Whelk (£ per vessel per month)						06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
Ye	8	41814000	2.16	**0.03**	06/07		0.12	0.28	0.36	0.28	0.17	0.92	0.22	0.84
Res	98	19329000			07/08			0.57	0.43	0.30	0.60	0.11	**0.02**	0.10
Total	106				08/09				0.85	0.85	0.87	0.27	**0.04**	0.23
					09/10					0.99	0.68	0.37	**0.05**	0.29
					10/11						0.52	0.26	**0.03**	0.22
					11/12							0.16	**0.02**	0.15
					12/13								0.17	0.75
					13/14									0.33
					14/15									

Table B5: ANOVA to test the difference in value of landings between Years (2006/2007 – 2014/2015) for *C. pagurus*, *H. gammarus* and *B. undatum* in the Lyme Bay MPA. Data were untransformed and Bray Curtis resemblance matrices constructed. Bold values indicate significant differences. Pairwise tests are used to examine significant relationships. Bold type denotes a statistically significant result.

	df	MS	Pseudo-F	P(perm)
Value Crab (£ per vessel per month)				
Ye	8	32331000	1.39	0.21
Res	98	23190000		
Total	106			
Value Lobster (£ per vessel per month)				
Ye	8	197860	1.62	0.12
Res	98	121960		
Total	106			
Value Whelk (£ per vessel per month)				
Ye	8	65489000	4.09	**0.0004**
Res	98	16017000		
Total	106			

	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15
06/07		0.35	0.41	0.81	0.07	0.05	0.11	0.08	0.84
07/08			0.83	0.17	**0.01**	**0.005**	**0.01**	**0.01**	0.43
08/09				0.17	**0.0002**	**0.001**	**0.001**	**0.001**	0.51
09/10					**0.01**	**0.005**	**0.02**	**0.02**	0.55
10/11						0.61	0.75	0.82	**0.02**
11/12							0.47	0.89	**0.01**
12/13								0.66	**0.03**
13/14									**0.02**
14/15									

Table B6: ANOVA to test the difference in value of landings between Years (2006/2007 – 2014/2015) for *C. pagurus*, *H. gammarus* and *B. undatum* in the IPA. Data were untransformed and Bray Curtis resemblance matrices constructed. Bold values indicate significant differences. Pairwise tests are used to examine significant relationships. Bold type denotes a statistically significant result.

Annex C

2012

Questionnaire to assess the effectiveness of the Devon & Severn Inshore Fisheries and Conservation Authority (D&SIFCA) from a stakeholder's perspective

The Inshore Fisheries and Conservation Authorities (IFCAs) were established in April 2011. They replaced the Sea Fisheries Committees following the Marine and Coastal Access Act (2009) which modernised inshore sea fisheries resource management in England. They are responsible for inshore waters up to 6 nautical miles.

The Devon & Severn IFCA (D&SIFCA) is working to strengthen its existing stakeholder relationships, and to develop new and more efficient ways of working. This questionnaire is part of a study being conducted by members of the Marine Institute, Plymouth University (Sarah Gall and Lynda Rodwell) and has been designed to assess the effectiveness of stakeholder engagement by D&SIFCA since its inception two years ago. This marks the second round of the study, with the first round being completed in 2012. It will be repeated again in subsequent years to provide both positive and negative feedback on an annual basis to improve and strengthen stakeholder relations. Your views are very important if future management and stakeholder engagement is to be effective.

The survey should take approximately 15 minutes to complete. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw from the survey at any time.

If you would like further information about this research or have concerns, please contact Sarah Gall (sarah.gall@plymouth.ac.uk) or Lynda Rodwell (lynda.rodwell@plymouth.ac.uk).

If you would like to provide additional comments directly to D&SIFCA or have questions then please contact them directly either by email - office@devonandsevernifca.gov.uk or by telephone on 01803 854648 or see their website - www.devonandsevernifca.gov.uk

Please tick the box below if you agree to participate in this study *

☐ I understand the aim of this study and agree to my responses being used anonymously for research purposes

1. Which area of the D&SIFCA district do you live in?

- ☐ Plymouth
- ☐ Torbay
- ☐ South Devon
- ☐ North Devon
- ☐ Mid Devon
- ☐ Somerset
- ☐ North Somerset
- ☐ Bristol
- ☐ South Gloucestershire
- ☐ Gloucestershire
- ☐ Other (please state): ________________________

2. Which stakeholder group do you belong to?

- ☐ Commercial fishermen
- ☐ Recreational sea anglers
- ☐ Recreational divers
- ☐ Charter boat operators
- ☐ Funding authorities
- ☐ Statutory agencies
- ☐ Non-governmental organisations
- ☐ Management groups
- ☐ Other (please state):

  ____

3. Before being asked to complete this questionnaire, were you aware of the existence of the D&SIFCA? *

☐ Yes　　　　No ☐

4. If yes, please give a brief outline of your understanding of their role

Your experience with the D&SIFCA

5. Before being asked to complete this questionnaire, did you know that the IFCAs replaced the Sea Fisheries Committees in April 2011?

☐ Yes　　　　☐ No

6. Over the past year have you had any contact with the D&SIFCA? *

For example, meetings, telephone conversations

☐ Yes　　　　☐ No

7. If yes, please give a brief outline of this contact
For example, what was the reason for the contact? What was the outcome?

8. Contact with D&SIFCA officers
If you have had multiple contact and different experiences with D&SIFCA officers then please complete this question and then provide any additional information in Question 9 below

	Yes	No	N/A
Over the past year have you had any direct contact with any IFCA officers?	☐	☐	☐
Were they professional in their approach to you?	☐	☐	☐
Were they able to deal with your enquiry effectively?	☐	☐	☐
If you have attended meetings where D&SIFCA officers have been present, do you think their presence was useful?	☐	☐	☐
If you have been to meetings organised by D&SIFCA, did you find them useful?	☐	☐	☐

9. Multiple contact: if any of your experiences differed from that you have outlined above then please provide details below

10. If you were not satisfied with your experience, please outline how you feel it could have been improved

11. Please provide any additional comments below

Your opinions

The formation of the IFCAs has strengthened their local/regional focus and led to a review of membership. The IFCAs are formed of representatives from statutory bodies (Natural England (NE), the Marine Management Organisation (MMO) and the Environment Agency (EA)), local authorities (e.g. Devon County Council) and other stakeholders that use, or are knowledgeable about inshore marine area such as commercial fishermen, environmental groups and marine researchers. These individuals form the IFCA membership and give their time voluntarily.
To what extent do you agree with the following statements:

12. The IFCA membership is:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Allowing the IFCA to work effectively	☐	☐	☐	☐	☐
Allowing decision making to be more participative and democratic	☐	☐	☐	☐	☐
Ensuring adequate representation of my stakeholder group	☐	☐	☐	☐	☐
Inclusive of all stakeholders with an interest in ensuring healthy seas and a sustainable and viable fisheries industry	☐	☐	☐	☐	☐
Inclusive of individuals with the expertise to advise the effective management of a sustainable marine environment and inshore fisheries industry	☐	☐	☐	☐	☐

13. I am satisfied that my views are being heard

	1	2	3	4	5	
Strongly disagree	☐	☐	☐	☐	☐	Strongly agree

14. Please provide any additional comments below

For example, if you are not satisfied that your views are being heard please outline why you think this is and provide suggestions for ways this can be improved

15. Over the past year, the D&SIFCA has helped to clarify to marine users the relationship between fisheries regulation and existing conservation measures such as special areas of conservation (SACs)

	1	2	3	4	5	
Strongly disagree	☐	☐	☐	☐	☐	Strongly agree

Goals and potential impacts of the D&SIFCA

22. Please select the three goals you think are most important for the D&SIFCA and rank them in order of importance:

	Rank 1 (most important)	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8 (least important)
Sustaining/improving fisheries productivity	☐	☐	☐	☐	☐	☐	☐	☐
Ensuring effective fisheries enforcement	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining employment opportunities in the commercial fisheries sector	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (direct) economic purposes e.g. tourism & fisheries	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining/improving recreational opportunities	☐	☐	☐	☐	☐	☐	☐	☐
Facilitating a dialogue across sectors of community	☐	☐	☐	☐	☐	☐	☐	☐
Inclusion of a broad range of marine resource users	☐	☐	☐	☐	☐	☐	☐	☐
Other, please specify below:	☐	☐	☐	☐	☐	☐	☐	☐

23. If you have selected 'Other' then please describe your goal and explain its importance

24. What (if any) do you think are the main obstacles the D&SIFCA faces in achieving these goals and how do you think they might be overcome?

IFCA Vision Statement

The IFCA vision statement is: 'IFCAs aim to lead, champion and manage a sustainable marine environment and inshore fisheries, by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry'

25. Over the past year, to what extent do you think the D&SIFCA has been successful in achieving:

	Very unsuccessful	Unsuccessful	Neither unsuccessful nor successful	Successful	Very successful
a) Healthy seas?	☐	☐	☐	☐	☐
b) Sustainable fisheries?	☐	☐	☐	☐	☐
c) A viable industry?	☐	☐	☐	☐	☐
d) Stakeholder engagement?	☐	☐	☐	☐	☐

26. Please outline the reasons for your answers

27. Do you think that this is the correct vision for the D&SIFCA?

☐ Yes ☐ No ☐ Don't know

28. If no, please provide details of what you think the D&SIFCA vision statement should include

29. How would you describe your current feelings about the IFCAs being an improvement on the previous regulatory structure (Sea Fisheries Committees)?

	1	2	3	4	5	
Very pessimistic	☐	☐	☐	☐	☐	Very optimistic

30. Please explain your degree of optimism or pessimism

Additional comments

31. Are you interested in finding out more about the IFCA?

☐ Yes ☐ No

32. If yes, which of the following topics are you most interested in learning more about?
Please select three of the following options

- [ ] IFCA byelaws
- [ ] Agendas for Authority meetings
- [ ] Conservation areas within the Devon & Severn IFCA district
- [ ] Advice for commercial fishermen
- [ ] Advice for non-commercial fishermen
- [ ] Advice for mariculture fishermen
- [ ] Advice on national legislation
- [ ] Opportunities for students
- [ ] Other (please specify):____

33. Please outline how you would like the D&SIFCA to communicate its aims to you?
For example, direct contact, through meetings, through information online

34. Please provide your contact details if you would like the D&SIFCA to contact you
Email address/contact telephone number. N.B. This information will be passed to D&SIFCA along with your answers to Questions 32 and 33. It will then be removed from your response to ensure anonymity

35. Please add any additional comments on the questionnaire, or on issues which have not been covered here

Thank you for taking the time to complete this questionnaire

You are reminded that by completing this questionnaire you give consent for the information provided to be used in analysis of the survey. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw your information at a later date, please provide your initials and the date that the survey was completed as an identifier and keep a note of this.
e.g. SCG01052012 represents Sarah C Gall 1st May 2012

If you have not heard about the D&SIFCA before

Your answers to the following questions will help the D&SIFCA to improve upon stakeholder engagement and outreach:

N6. Are you aware of the role that the Devon Sea Fisheries Committee played prior to the creation of the D&SIFCA?

☐ Yes ☐ No

N7. If yes, how successful do you think their management of the inshore fishery was?

	1	2	3	4	5	
Very successful	☐	☐	☐	☐	☐	Very unsuccessful

N8. Please select the three goals you think are most important for the management of inshore waters (inside 6 nautical miles) and rank them in order of importance:

	Rank 1 (1st in importance)	Rank 2 (2nd in importance)	Rank 3 (3rd in importance)
Sustaining/improving fisheries productivity	☐	☐	☐
Ensuring effective fisheries enforcement	☐	☐	☐
Sustaining employment opportunities in the commercial fisheries sector	☐	☐	☐
Conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation	☐	☐	☐
Conservation of marine ecosystems for (direct) economic purposes e.g. tourism & fisheries	☐	☐	☐
Sustaining/improving recreational opportunities	☐	☐	☐
Facilitating a dialogue across sectors of community	☐	☐	☐
Inclusion of a broad range of marine resource users	☐	☐	☐
Other, please specify below:	☐	☐	☐

N9. Are you interested in finding out more about the D&SIFCA?

☐ Yes ☐ No

N10. If yes, which of the following topics are you most interested in learning more about?

Please select three of the following options

- ☐ IFCA byelaws
- ☐ Agendas for Authority meetings
- ☐ Conservation areas within the Devon & Severn IFCA district
- ☐ Advice for commercial fishermen
- ☐ Advice for non-commercial fishermen
- ☐ Advice for mariculture fishermen
- ☐ Advice on national legislation
- ☐ Opportunities for students
- ☐ Other (please specify):____

N11. Please outline how you would like the D&SIFCA to communicate its aims to you?
For example, direct contact, through meetings, through information online

N12. Please provide your contact details if you would like the D&SIFCA to contact you
Email address/contact telephone number. N.B. This information will be passed to D&SIFCA along with your answers to Questions N11 and N12. It will then be removed from your response to ensure anonymity

N13. Please add any additional comments on the questionnaire, or on issues which have not been covered here

Thank you for taking the time to complete this questionnaire

You are reminded that by completing this questionnaire you give consent for the information provided to be used in analysis of the survey. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw your information at a later date, please provide your initials and the date that the survey was completed as an identifier and keep a note of this.
e.g. SCG01052012 represents Sarah C Gall 1st May 2012

Once the survey has closed, results will be published on the Devon & Severn Inshore Fisheries and Conservation Authority website (http://www.devonandsevernifca.gov.uk/)

Please contact either of the following if you require any information to be withdrawn:

Sarah Gall (sarah.gall@plymouth.ac.uk) Lynda Rodwell (lynda.rodwell@plymouth.ac.uk)

2013

Questionnaire to assess the effectiveness of the Devon & Severn Inshore Fisheries and Conservation Authority (D&SIFCA) from a stakeholder's perspective

The Inshore Fisheries and Conservation Authorities (IFCAs) were established in April 2011. They replaced the Sea Fisheries Committees following the Marine and Coastal Access Act (2009) which modernised inshore sea fisheries resource management in England. They are responsible for inshore waters up to 6 nautical miles.

The Devon & Severn IFCA (D&SIFCA) is working to strengthen its existing stakeholder relationships, and to develop new and more efficient ways of working. This questionnaire is part of a study being conducted by members of the Marine Institute, Plymouth University (Sarah Gall and Lynda Rodwell) and has been designed to assess the effectiveness of stakeholder engagement by D&SIFCA since its inception two years ago. This marks the second round of the study, with the first round being completed in 2012. It will be repeated again in subsequent years to provide both positive and negative feedback on an annual basis to improve and strengthen stakeholder relations. Your views are very important if future management and stakeholder engagement is to be effective.

The survey should take approximately 15 minutes to complete. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw from the survey at any time.

If you would like further information about this research or have concerns, please contact Sarah Gall (sarah.gall@plymouth.ac.uk) or Lynda Rodwell (lynda.rodwell@plymouth.ac.uk).

If you would like to provide additional comments directly to D&SIFCA or have questions then please contact them directly either by email - office@devonandsevernifca.gov.uk or by telephone on 01803 854648 or see their website - www.devonandsevernifca.gov.uk

Please tick the box below if you agree to participate in this study *

☐ I understand the aim of this study and agree to my responses being used anonymously for research purposes

1. Which area of the D&SIFCA district do you live in?

- ☐ Plymouth
- ☐ Torbay
- ☐ South Devon
- ☐ North Devon
- ☐ Mid Devon
- ☐ Somerset
- ☐ North Somerset
- ☐ Bristol
- ☐ South Gloucestershire
- ☐ Gloucestershire
- ☐ Other (please state): ____

2. Which stakeholder group do you belong to?

- ☐ Commercial fishermen
- ☐ Recreational sea anglers
- ☐ Recreational divers
- ☐ Charter boat operators
- ☐ Funding authorities
- ☐ Statutory agencies
- ☐ Non-governmental organisations
- ☐ Management groups
- ☐ Other (please state):

  ____

3. Before being asked to complete this questionnaire, were you aware of the existence of the D&SIFCA? *

☐ Yes ☐ No (If no, please go to Question N1, page 12)

4. If yes, please give a brief outline of your understanding of their role

Your experience with the D&SIFCA

5. Before being asked to complete this questionnaire, did you know that the IFCAs replaced the Sea Fisheries Committees in April 2011?

☐ Yes ☐ No

6. Over the past year have you had any contact with the D&SIFCA? *

For example, meetings, telephone conversations

☐ Yes ☐ No (please go to Question 12, page 4)

7. If yes, please give a brief outline of this contact

For example, what was the reason for the contact? What was the outcome?

8. Contact with D&SIFCA officers

If you have had multiple contact and different experiences with D&SIFCA officers then please complete this question and then provide any additional information in Question 9 below

	Yes	No	N/A
Over the past year have you had any direct contact with any IFCA officers?	☐	☐	☐
Were they professional in their approach to you?	☐	☐	☐
Were they able to deal with your enquiry effectively?	☐	☐	☐
If you have attended meetings where D&SIFCA officers have been present, do you think their presence was useful?	☐	☐	☐
If you have been to meetings organised by D&SIFCA, did you find them useful?	☐	☐	☐

9. Multiple contact: if any of your experiences differed from that you have outlined above then please provide details below

10. If you were not satisfied with your experience, please outline how you feel it could have been improved

11. Please provide any additional comments below

Your opinions

The formation of the IFCAs has strengthened their local/regional focus and led to a review of membership. The IFCAs are formed of representatives from statutory bodies (Natural England (NE), the Marine Management Organisation (MMO) and the Environment Agency (EA)), local authorities (e.g. Devon County Council) and other stakeholders that use, or are knowledgeable about inshore marine area such as commercial fishermen, environmental groups and marine researchers. These individuals form the IFCA membership and give their time voluntarily.

To what extent do you agree with the following statements:

12. The IFCA membership is:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Allowing the IFCA to work effectively	☐	☐	☐	☐	☐
Allowing decision making to be more participative and democratic	☐	☐	☐	☐	☐
Ensuring adequate representation of my stakeholder group	☐	☐	☐	☐	☐
Inclusive of all stakeholders with an interest in ensuring healthy seas and a sustainable and viable fisheries industry	☐	☐	☐	☐	☐
Inclusive of individuals with the expertise to advise the effective management of a sustainable marine environment and inshore fisheries industry	☐	☐	☐	☐	☐

13. I am satisfied that my views are being heard

	1	2	3	4	5	
Strongly disagree	☐	☐	☐	☐	☐	Strongly agree

14. Please provide any additional comments below

For example, if you are not satisfied that your views are being heard please outline why you think this is and provide suggestions for ways this can be improved

15. Over the past year, the D&SIFCA has helped to clarify to marine users the relationship between fisheries regulation and existing conservation measures such as special areas of conservation (SACs)

	1	2	3	4	5	
Strongly disagree	☐	☐	☐	☐	☐	Strongly agree

Funding

The role of the D&SIFCA is to address both fisheries and conservation objectives which means that all areas of the Devon & Severn must be managed. Currently the D&SIFCA is funded by 8 local authorities (Devon County Council, Plymouth City Council, Torbay Council, Somerset County Council, North Somerset Council, Bristol City Council, South Gloucestershire Council, and Gloucestershire County Council).

16. Do you think that this is the correct way to fund the D&SIFCA?

☐ Yes ☐ No ☐ Don’t know

17. Please outline the reasons for your answer below

Management of Marine Protected Areas

The UK Government (Defra) introduced a change of approach to the management of commercial fisheries within European Marine Sites (EMS), (Special Areas of Conservation and Special Protected Areas) last August. This requires an assessment of the potential impact of all fishing activities that could occur within EMS and will lead to management measures being introduced. The activities which are most damaging to the designated features of each EMS will be managed by the end of 2013, and all other activities will have management in place by 2016. D&SIFCA has six EMS in its district and is required to undertake extensive research to provide an evidence base on which to base these decisions. More details can be found at
http://www.marinemanagement.org.uk/protecting/conservation/ems_fisheries.htm

18. Were you aware of this change?

☐ Yes ☐ No

19. If yes, how did you hear about it?

20. If yes, do you expect it to have any impact on your current use of the marine environment within the D&SIFCA district?

☐ Yes ☐ No ☐ Don't know

21. If yes, please outline what impact you expect?

22. Do you expect this impact to be:

☐ Positive ☐ Negative ☐ Neither positive nor negative

23. Please provide any additional comments below

24. In your opinion, how effective is the current management of fishing activities within marine protected areas in the D&SIFCA district

	1	2	3	4	5		
Very effective	☐	☐	☐	☐	☐	Very ineffective	☐

Don't know

25. Please give the reasons for your answers below

Byelaw review

D&SIFCA are currently undergoing a review of all its byelaws inherited from the Devon Sea Fisheries Committee and the Environment Agency. This must be completed by 2015 and is intended to introduce better management and to make legislation more accessible and understandable. For more information, please see http://www.devonandsevernifca.gov.uk

26. Were you aware of the byelaw review?

☐ Yes ☐ No

27. If yes, how did you hear about it?

28. If yes, do you expect it to have any impact on your current use of the marine environment within the D&SIFCA district?

☐ Yes ☐ No ☐ Don't know

29. If yes, please outline what impact you expect?

30. Do you expect this impact to be:

☐ Positive ☐ Negative ☐ Neither positive nor negative

31. Please provide any additional comments below

Goals and potential impacts of the D&SIFCA

32. Please select the three goals you think are most important for the D&SIFCA and rank them in order of importance:

	Rank 1 (most important)	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8 (least important)
Sustaining/improving fisheries productivity	☐	☐	☐	☐	☐	☐	☐	☐
Ensuring effective fisheries enforcement	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining employment opportunities in the commercial fisheries sector	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (direct) economic purposes e.g. tourism & fisheries	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining/improving recreational opportunities	☐	☐	☐	☐	☐	☐	☐	☐
Facilitating a dialogue across sectors of community	☐	☐	☐	☐	☐	☐	☐	☐
Inclusion of a broad range of marine resource users	☐	☐	☐	☐	☐	☐	☐	☐
Other, please specify below:	☐	☐	☐	☐	☐	☐	☐	☐

33. If you have selected 'Other' then please describe your goal and explain its importance

34. What (if any) do you think are the main obstacles the D&SIFCA faces in achieving these goals and how do you think they might be overcome?

IFCA Vision Statement

The IFCA vision statement is: 'IFCAs aim to lead, champion and manage a sustainable marine environment and inshore fisheries, by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry'

35. Over the past year, to what extent do you think the D&SIFCA has been successful in achieving:

	Very unsuccessful	Unsuccessful	Neither unsuccessful nor successful	Successful	Very successful	Don't know
a) Healthy seas?	☐	☐	☐	☐	☐	☐
b) Sustainable fisheries?	☐	☐	☐	☐	☐	☐
c) A viable industry?	☐	☐	☐	☐	☐	☐
d) Stakeholder engagement?	☐	☐	☐	☐	☐	☐

36. Please outline the reasons for your answers

37. Do you think that the IFCA vision statement describes the correct vision for the D&SIFCA?

☐ Yes ☐ No ☐ Don't know

38. If no, please provide details of what you think the D&SIFCA vision statement should include

39. How would you describe your current feelings about the IFCAs being an improvement on the previous regulatory structure (Sea Fisheries Committees)?

	1	2	3	4	5	
Very pessimistic	☐	☐	☐	☐	☐	Very optimistic

40. Please explain your degree of optimism or pessimism

IFCA Communication

41. Have you visited the D&SIFCA website (http://www.devonandsevernifca.gov.uk)?

☐ Yes ☐ No

42. If yes, what was your purpose?
If you have visited the website multiple times please select all that apply

☐ To find out about D&SIFCA and the work they do
☐ To contact D&SIFCA
☐ To look up D&SIFCA byelaws
☐ To look at D&SIFCA environmental research reports
☐ To look at D&SIFCA authority reports
☐ Other (please specify): -

____

43. If yes, please indicate to what extent you agree with the following statements

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
The website is well designed	☐	☐	☐	☐	☐
It was easy to find the information I was looking for	☐	☐	☐	☐	☐

44. Please provide any additional comments below

45. Thank you for taking the time to complete this questionnaire, please provide any additional comments on the questionnaire, or on issues which have not been covered here

Thank you for taking the time to complete this questionnaire

You are reminded that by completing this questionnaire you give consent for the information provided to be used in analysis of the survey. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw your information at a later date, please provide your initials and the date that the survey was completed as an identifier and keep a note of this.

e.g. SCG01052013 represents Sarah C Gall 1st May 2013

If you have not heard about the D&SIFCA before

Your answers to the following questions will help the D&SIFCA to improve upon stakeholder engagement and outreach:

N1. Are you aware of the role that the Devon Sea Fisheries Committee played prior to the creation of the D&SIFCA?

☐ Yes ☐ No

N2. If yes, how successful do you think their management of the inshore fishery was?

	1	2	3	4	5	
Very unsuccessful	☐	☐	☐	☐	☐	Very successful

N3. Which goals do you think should be most important to D&SIFCA? Please rank them in order of importance:

	Rank 1 (most important)	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8 (least important)
Sustaining/improving fisheries productivity	☐	☐	☐	☐	☐	☐	☐	☐
Ensuring effective fisheries enforcement	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining employment opportunities in the commercial fisheries sector	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (direct) economic purposes e.g. tourism & fisheries	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining/improving recreational opportunities	☐	☐	☐	☐	☐	☐	☐	☐
Facilitating a dialogue across sectors of community	☐	☐	☐	☐	☐	☐	☐	☐
Inclusion of a broad range of marine resource users	☐	☐	☐	☐	☐	☐	☐	☐
Other, please specify below:	☐	☐	☐	☐	☐	☐	☐	☐

N4. Are you interested in finding out more about the D&SIFCA?

☐ Yes ☐ No

N5. If yes, which of the following topics are you most interested in learning more about?

☐ D&SIFCA byelaws
☐ Advice for commercial fishermen
☐ Advice for recreational fishermen
☐ Advice for mariculture fishermen
☐ Advice on national legislation
☐ Marine Protected Areas within the D&SIFCA district
☐ Agendas for authority meetings
☐ Opportunities for students
☐ Other (please specify):____

N6. Please outline how you would like the D&SIFCA to communicate with you

If you would like D&SIFCA to contact you directly then please provide your contact details (if provided, your contact details will be passes to D&SIFCA along with your response to questions N5 and N6 and then will be removed from your questionnaire to ensure your anonymity.

N7. Please add any additional comments on the questionnaire, or on issues which have not been covered here

Thank you for taking the time to complete this questionnaire

You are reminded that by completing this questionnaire you give consent for the information provided to be used in analysis of the survey. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw your information at a later date, please provide your initials and the date that the survey was completed as an identifier and keep a note of this.

e.g. SCG01052013 represents Sarah C Gall 1st May 2013

2016

Questionnaire to assess the effectiveness of the Devon & Severn Inshore Fisheries and Conservation Authority (D&SIFCA) from a stakeholder's perspective

The Inshore Fisheries and Conservation Authorities (IFCAs) were established in April 2011. They replaced the Sea Fisheries Committees following the Marine and Coastal Access Act (2009) which modernised inshore sea fisheries resource management in England. They are responsible for inshore waters up to 6 nautical miles.

The Devon & Severn IFCA (D&SIFCA) is working to strengthen its existing stakeholder relationships, and to develop new and more efficient ways of working. This questionnaire is part of a study being conducted by members of the Marine Institute, Plymouth University (Sarah Gall and Lynda Rodwell) and has been designed to assess the effectiveness of stakeholder engagement by D&SIFCA since its inception. This marks the third and final round of the study, with previous rounds being completed in 2012 and 2013. Its purpose is to provide both positive and negative feedback to improve and strengthen stakeholder relations. Your views are very important if future management and stakeholder engagement is to be effective.

The survey should take approximately 15 minutes to complete. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw from the survey at any time.

If you would like further information about this research or have concerns, please contact Sarah Gall (sarah.gall@plymouth.ac.uk) or Lynda Rodwell (lynda.rodwell@plymouth.ac.uk).

If you would like to provide additional comments directly to D&SIFCA or have questions then please contact them directly either by email - office@devonandsevernifca.gov.uk or by telephone on 01803 854648 or see their website - www.devonandsevernifca.gov.uk

Please tick the box below if you agree to participate in this study *

☐ I understand the aim of this study and agree to my responses being used anonymously for research purposes

1. Which area of the D&SIFCA district do you live in?

- ☐ Plymouth
- ☐ Torbay
- ☐ South Devon
- ☐ North Devon
- ☐ Mid Devon
- ☐ East Devon
- ☐ West Devon
- ☐ Somerset
- ☐ North Somerset
- ☐ Bristol
- ☐ South Gloucestershire
- ☐ Gloucestershire
- ☐ Other (please state): ____

2. Which stakeholder group do you belong to?

- ☐ Commercial fishermen
- ☐ Recreational sea anglers
- ☐ Recreational divers
- ☐ Charter boat operators
- ☐ Funding authorities
- ☐ Statutory agencies
- ☐ Non-governmental organisations
- ☐ Management groups
- ☐ Other (please state):

____

3. Before being asked to complete this questionnaire, were you aware of the existence of the D&SIFCA? *

☐ Yes ☐ No (If no, please go to Question N1, page 12)

4. If yes, please give a brief outline of your understanding of their role

Your experience with the D&SIFCA

5. Over the past year have you had any contact with the D&SIFCA? *

For example, meetings, telephone conversations

☐ Yes ☐ No (please go to Question 12, page 4)

6. If yes, please give a brief outline of this contact

For example, what was the reason for the contact? What was the outcome?

7. Contact with D&SIFCA officers

If you have had multiple contact and different experiences with D&SIFCA officers then please complete this question and then provide any additional information in Question 9 below

	Yes	No	N/A
Over the past year have you had any direct contact with any IFCA officers?	☐	☐	☐
Were they professional in their approach to you?	☐	☐	☐
Were they able to deal with your enquiry effectively?	☐	☐	☐
If you have attended meetings where D&SIFCA officers have been present, do you think their presence was useful?	☐	☐	☐
If you have been to meetings organised by D&SIFCA, did you find them useful?	☐	☐	☐

8. Multiple contact: if any of your experiences differed from that you have outlined above then please provide details below

9. If you were not satisfied with your experience, please outline how you feel it could have been improved

10. Please provide any additional comments below

Your opinions

The formation of the IFCAs has strengthened their local/regional focus and led to a review of membership. The IFCAs are formed of representatives from statutory bodies (Natural England (NE), the Marine Management Organisation (MMO) and the Environment Agency (EA)), local authorities (e.g. Devon County Council) and other stakeholders that use, or are knowledgeable about inshore marine area such as commercial fishermen, environmental groups and marine researchers. These individuals form the IFCA membership and give their time voluntarily.

To what extent do you agree with the following statements:

11. The IFCA membership is:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Allowing the IFCA to work effectively	☐	☐	☐	☐	☐
Allowing decision making to be more participative and democratic	☐	☐	☐	☐	☐
Ensuring adequate representation of my stakeholder group	☐	☐	☐	☐	☐
Inclusive of all stakeholders with an interest in ensuring healthy seas and a sustainable and viable fisheries industry	☐	☐	☐	☐	☐
Inclusive of individuals with the expertise to advise the effective management of a sustainable marine environment and inshore fisheries industry	☐	☐	☐	☐	☐

12. I am satisfied that my views are being heard

	1	2	3	4	5	
Strongly disagree	☐	☐	☐	☐	☐	Strongly agree

13. Please provide any additional comments below

For example, if you are not satisfied that your views are being heard please outline why you think this is and provide suggestions for ways this can be improved

14. Please state the extent to which you agree with the following statement: Since its inception in 2011, the D&SIFCA has helped to clarify to marine users the relationship between fisheries regulation and existing conservation measures such as special areas of conservation (SACs) and marine conservation zones (MCZs)

	1	2	3	4	5	
Strongly disagree	☐	☐	☐	☐	☐	Strongly agree

Funding

The role of the D&SIFCA is to address both fisheries and conservation objectives which means that all areas of the Devon & Severn must be managed. The D&SIFCA is funded by 8 local authorities (Devon County Council, Plymouth City Council, Torbay Council, Somerset County Council, North Somerset Council, Bristol City Council, South Gloucestershire Council, and Gloucestershire County Council) and New Burdens from Defra.

15. Do you think that this is the correct way to fund the D&SIFCA?

☐ Yes ☐ No ☐ Don't know

16. Please outline the reasons for your answer below

For example, if there are any other bodies that you think should help to fund D&SIFCA please state them below

Management of Marine Protected Areas

The UK Government (Defra) introduced a change of approach to the management of commercial fisheries within European Marine Sites (EMS), (Special Areas of Conservation and Special Protected Areas) in August 2012. This requires an assessment of the potential impact of all fishing activities that could occur within EMS, has led to restrictions on activities such as demersal trawling on rocky reef habitats and may lead to additional management measures being introduced for other activities. All management will be in place by the end of 2016. D&SIFCA has six EMS in its district and is required to undertake extensive research to provide an evidence base on which to base these decisions. More details can be found at
http://www.marinemanagement.org.uk/protecting/conservation/ems_fisheries.htm

17. Were you aware of this change?

☐ Yes ☐ No

18. If yes, how did you hear about it?

19. If yes, has it had any impact on your use of the marine environment within the D&SIFCA district?

☐ Yes ☐ No

20. If yes, please outline how below:

21. Has this impact been:

☐ Positive ☐ Negative ☐ Neither positive nor negative

22. Once all assessments are completed do you expect there to be any impact on your current use of the marine environment within the D&SIFCA district?

☐ Yes ☐ No ☐ Don't know

23. If yes, please outline what impact you expect

24. Do you expect this impact to be:

☐ Positive ☐ Negative ☐ Neither positive nor negative

25. Please provide any additional comments below

26. In your opinion, how effective is the current management of fishing activities within marine protected areas in the D&SIFCA district

	1	2	3	4	5		
Very effective	☐	☐	☐	☐	☐	Very ineffective	☐ Don't know

27. Please give the reasons for your answers below

Byelaw review

D&SIFCA are reviewing all the byelaws it inherited from the Devon Sea Fisheries Committee and the Environment Agency. This is intended to introduce better management and to make legislation more accessible and understandable. To date, revised byelaws have been introduced for potting activities, diving and mobile fishing activities, all of which require a permit. A netting byelaw review is currently underway and is in the pre-consultation phase. For more information, please see http://www.devonandsevernifca.gov.uk

28. Were you aware of the byelaw review?

☐ Yes ☐ No

29. Have you been involved in any consultations for the byelaw review?

☐ Yes ☐ No

30. If no, were there any reasons that you did not participate?

e.g. unaware of the consultation, decided not to take part

31. How satisfied were you with the consultation process?

	1	2	3	4	5	
Very satisfied	☐	☐	☐	☐	☐	Very dissatisfied

32. Please outline the reason for your answer below

Please include suggestions for ways the consultation process could have been improved

33. If yes, how easy did you find it to communicate your views to D&SIFCA?

	1	2	3	4	5		
Very easy	☐	☐	☐	☐	☐	Very difficult	☐ Didn't submit a response

34. Please outline the reason for your answer below

Please include suggestions for ways the process could have been improved

35. Have the changes to date had any impact on your use of the marine environment within the D&SIFCA district?

☐ Yes ☐ No

36. If yes, please outline what impact there has been

37. Is this impact:

☐ Positive ☐ Negative ☐ Don't know

38. Do you expect future byelaw reviews to impact your use of the marine environment within the D&SIFCA district?

☐ Yes ☐ No ☐ Don't know

39. If yes, please outline what impact you expect

40. Do you expect this impact to be:

☐ Positive ☐ Negative ☐ Neither positive nor negative

41. Please provide any additional comments below

Goals and potential impacts of the D&SIFCA

42. Which goals do you think should be most important for the D&SIFCA? Please rank them goals in order of importance:

	Rank 1 (most important)	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8 (least important)
Sustaining/improving fisheries productivity	☐	☐	☐	☐	☐	☐	☐	☐
Ensuring effective fisheries enforcement	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining employment opportunities in the commercial fisheries sector	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (direct) economic purposes e.g. tourism & fisheries	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining/improving recreational opportunities	☐	☐	☐	☐	☐	☐	☐	☐
Facilitating a dialogue across sectors of community	☐	☐	☐	☐	☐	☐	☐	☐
Inclusion of a broad range of marine resource users	☐	☐	☐	☐	☐	☐	☐	☐
Other, please specify below:	☐	☐	☐	☐	☐	☐	☐	☐

43. If you have selected 'Other' then please describe your goal and explain its importance

44. What (if any) do you think are the main obstacles the D&SIFCA faces in achieving these goals and how do you think they might be overcome?

IFCA Vision Statement

The IFCA vision statement is: 'IFCAs aim to lead, champion and manage a sustainable marine environment and inshore fisheries, by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry'

45. Since its inception in 2011, to what extent do you think the D&SIFCA has been successful in achieving:

	Very unsuccessful	Unsuccessful	Neither unsuccessful nor successful	Successful	Very successful	Don't know
a) Healthy seas?	☐	☐	☐	☐	☐	☐
b) Sustainable fisheries?	☐	☐	☐	☐	☐	☐
c) A viable industry?	☐	☐	☐	☐	☐	☐
d) Stakeholder engagement?	☐	☐	☐	☐	☐	☐

46. Please outline the reasons for your answers

47. Do you think the IFCA vision statement describes the correct vision for the D&SIFCA?

☐ Yes ☐ No ☐ Don't know

48. If no, please provide details of what you think the D&SIFCA vision statement should include

49. How would you describe your current feelings about the IFCAs being an improvement on the previous regulatory structure (Sea Fisheries Committees)?

	1	2	3	4	5	
Very pessimistic	☐	☐	☐	☐	☐	Very optimistic

50. Please explain your degree of optimism or pessimism

IFCA Communication

51. Have you visited the D&SIFCA website (http://www.devonandsevernifca.gov.uk)?

☐ Yes ☐ No

52. If yes, what was your purpose?
If you have visited the website multiple times please select all that apply

- ☐ To find out about D&SIFCA and the work they do
- ☐ To contact D&SIFCA
- ☐ To look up D&SIFCA byelaws
- ☐ To take part in consultations
- ☐ To look at D&SIFCA environmental research reports
- ☐ To look at D&SIFCA authority reports
- ☐ Other (please specify): - ____________________

53. If yes, please indicate to what extent you agree with the following statements

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
The website is well designed	☐	☐	☐	☐	☐
It was easy to find the information I was looking for	☐	☐	☐	☐	☐

54. Please provide any additional comments below

55. Thank you for taking the time to complete this questionnaire, please provide any additional comments on the questionnaire, or on issues which have not been covered here

Thank you for taking the time to complete this questionnaire

You are reminded that by completing this questionnaire you give consent for the information provided to be used in analysis of the survey. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw your information at a later date, please provide your initials and the date that the survey was completed as an identifier and keep a note of this.
e.g. SCG01022016 represents Sarah C Gall 1st February 2016

If you have not heard about the D&SIFCA before

Your answers to the following questions will help the D&SIFCA to improve upon stakeholder engagement and outreach:

N1. Are you aware of the role that the Devon Sea Fisheries Committee played prior to the creation of the D&SIFCA?

☐ Yes ☐ No

N2. If yes, how successful do you think their management of the inshore fishery was?

	1	2	3	4	5	
Very unsuccessful	☐	☐	☐	☐	☐	Very successful

N3. Which goals do you think should be most important to D&SIFCA? Please rank them in order of importance:

	Rank 1 (most important)	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7	Rank 8 (least important)
Sustaining/improving fisheries productivity	☐	☐	☐	☐	☐	☐	☐	☐
Ensuring effective fisheries enforcement	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining employment opportunities in the commercial fisheries sector	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (indirect) non-economic purposes e.g. conservation	☐	☐	☐	☐	☐	☐	☐	☐
Conservation of marine ecosystems for (direct) economic purposes e.g. tourism & fisheries	☐	☐	☐	☐	☐	☐	☐	☐
Sustaining/improving recreational opportunities	☐	☐	☐	☐	☐	☐	☐	☐
Facilitating a dialogue across sectors of community	☐	☐	☐	☐	☐	☐	☐	☐
Inclusion of a broad range of marine resource users	☐	☐	☐	☐	☐	☐	☐	☐
Other, please specify below:	☐	☐	☐	☐	☐	☐	☐	☐

N4. Are you interested in finding out more about the D&SIFCA?

☐ Yes ☐ No

N5. If yes, which of the following topics are you most interested in learning more about?

☐ D&SIFCA byelaws
☐ Advice for commercial fishermen
☐ Advice for recreational fishermen
☐ Advice for mariculture fishermen
☐ Advice on national legislation
☐ Marine Protected Areas within the D&SIFCA district
☐ Agendas for authority meetings
☐ Opportunities for students
☐ Other (please specify):____

N6. Please outline how you would like the D&SIFCA to communicate with you

If you would like D&SIFCA to contact you directly then please provide your contact details (if provided, your contact details will be passes to D&SIFCA along with your response to questions N5 and N6 and then will be removed from your questionnaire to ensure your anonymity.

N7. Please add any additional comments on the questionnaire, or on issues which have not been covered here

Thank you for taking the time to complete this questionnaire

You are reminded that by completing this questionnaire you give consent for the information provided to be used in analysis of the survey. All information provided will remain confidential and will be handled anonymously. Only aggregated data will be used in analysis and reporting. You have the right to withdraw your information at a later date, please provide your initials and the date that the survey was completed as an identifier and keep a note of this.

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Evaluating the social acceptability of Marine Protected Areas

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ABSTRACT

Q methodology provides a novel, quantitative approach to reveal stakeholder perspectives and was used to assess social acceptance of Marine Protected Areas (MPAs) with fisheries and conservation management goals using the Devon & Severn region, UK as a case study site. Participants sorted a set of statements ($n=42$) into a forced-choice frequency distribution and centroid analysis revealed three factors for interpretation: (1) 'pro-conservation', characterised by views that conservation should be prioritised over commercial and economic interests; (2) 'pro-fisheries' who saw fishing as the priority and expressed concerns over the uncertainty of management measures and the number of planned MPAs; and (3) 'win–win' who felt that the current approach to marine management using MPAs would allow both fisheries and conservation goals to be met. Despite some differences in opinion, social acceptability of MPAs was identified across all three discourses, but was limited by the knock-on effects of the exclusion of stakeholders from the implementation of MPAs and the development of management measures. This resulted in disenfranchisement and uncertainty over the future of their activities. The results suggest that social acceptability of MPAs is generated by effective and ongoing stakeholder engagement, transparency and honesty relating to the costs and benefits of designations and a certainty that once sites are in place the resources exist for their effective management. Understanding social acceptability will guide adaptive management and increase the chances of MPA success and the meeting of global targets.

1. Introduction

Marine ecosystems are threatened by a range of anthropogenic stressors and exploitative activities, bringing them under increasing pressure and threatening their resilience. Conservation efforts worldwide are addressing this, with Marine Protected Areas (MPAs) some of the most common tools to conserve biodiversity and manage extractive activities. The goals of MPAs vary with location, with some full no-take reserves and others multi-use. The Convention on Biodiversity (CBD), Aichi Biodiversity Target 11 calls for the conservation of at least 10% of coastal and marine areas through *'effectively and equitably managed, ecologically representative and well-connected systems of protected areas'* by 2020 [1]. MPA numbers are growing globally, with 3.4% of the global oceans currently protected [2], but further increases are required to meet these targets. It is not just a matter of designation though; the success of protected areas in meeting their conservation and socio-economic objectives is dependent on their effective management and enforcement which may be strongly influenced by the social acceptability of the designation.

Rossiter and Levine [3] identified six themes that were consistently associated with MPA success, namely, level of community engagement, socio-economic characteristics, ecological factors, MPA design, governance and enforcement. It has been shown that social, cultural, economic and political factors can be more influential in shaping success than biological or physical factors [4–6], and positive attitudes towards MPAs are necessary for successful management [7,8]. Considerable reliance is therefore placed on human behaviours and compliance with regulations with a clear need to promote understanding of the purpose of designation and intended site benefits; the stakeholders must 'buy-in' to the concept of the MPA and feel some ownership towards the site.

In the context of MPAs, social acceptability has been defined by Thomassin and White [9] as '*a measure of support towards a set of regulations, management tools or towards an organisation by an individual or a group of individuals based on geographic, social, economic or cultural criteria*'. Furthermore, they state that it is composed of a set of individual perspectives and is complex, depending on multiple opinions and perceptions, with driving factors linked to the world view held by the stakeholders. Whilst studies have evaluated the success of stakeholder participation in the planning phase e.g. [10,11,12], few have looked at the attitudes of stakeholders to MPAs once they are a reality but see [9,13]. This is a key part of the ongoing monitoring of MPAs; to understand stakeholder attitudes and opinions post designation will aid the

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evaluation of MPA success and effective management.

This study investigated the social acceptability of MPAs post designation in order to contribute to the understanding of the role social acceptability plays in MPA success. It focussed on the use of MPAs to address fisheries and conservation goals as these are two of the most common reasons for MPA creation and a cause for conflict in stakeholder opinion [14–16]. To facilitate this, the Devon & Severn region of south-west England was used as a case study site.

1.1. UK MPA history

The UK has a history of insufficient marine planning, with no statutory provision for the creation of MPAs in existence until 1981, and Lundy designated as the first statutory Marine Nature Reserve in 1986 [17,18]. Since that time, European Marine Sites (Special Areas of Conservation and Special Protection Areas) have been designated under the Natura 2000 agreement, but no framework for the development of a network of MPAs existed until the Marine and Coastal Access Act, 2009 (MCAA). Since 2009, England, Wales, Northern Ireland and Scotland have begun their own independent processes to establish MPAs within their waters.

In England, the MCAA led to the formalisation of the English Marine Conservation Zone (MCZ) project which was established in 2008. This involved a combination of top down and bottom up approaches, with guidance provided by the UK Government, Defra (Department for Food and Rural Affairs), the Statutory Nature Conservation Bodies (SNCBs) and the involvement of multi-sectoral stakeholder collaboration under four Regional Projects (Fig. 1). The aim was '*to develop an ecologically coherent and well-managed network of MPAs that is well understood and supported by sea-users and other stakeholders*' [19]. Extensive stakeholder consultation and engagement was incorporated into the process, intended to bring a strategic, regional approach to marine conservation planning and increase stakeholder participation [20].

MCZs are multi-use MPAs, which should have management in place for activities that are deemed to be damaging to the features for which the site is designated. The regional projects recommended 127 MCZs; a first tranche of 27 was designated in November 2013 and consultation ended in April 2015 for a second tranche of 23 with a date for designation as yet unknown (Figs. 1 and 2). As MCZs are a type of MPA the two terms are used throughout this study; MCZ is used for sites designated under the MCZ project, and MPA is used as an umbrella term or when referring to sites designated outside of this project.

Initially, the approach taken by Defra and the SNCBs was systematic; planning a network of sites based on best available evidence, including strong participative incentives for stakeholder engagement and providing clarity about site management. However, with time it changed, becoming more focussed on specific features and individuals sites, with strong top down elements and a requirement for scientific evidence rather than being driven by stakeholders [20,21]. The management decisions were also postponed until after site designation. Stakeholder engagement ceased at the end of the regional project period in 2011 when the final recommended MCZs were delivered to Defra, and from this point forwards the process was Government led with stakeholder inclusion limited to public consultation periods.

Lieberknecht and Qui [20] conducted a governance analysis of the MCZ regional project Finding Sanctuary in the south-west UK, finding considerable support for the MCZ generated through the initial project period. Stakeholders appreciated the chance for open discussion and for their voices to be heard, but with time, the changes made to how the process was conducted led to considerable uncertainty leaving them feeling disempowered, disenfranchised and excluded from what they perceived to be the important process of site implementation and decisions regarding their management. Furthermore, the change from an approach of using 'best available evidence' to a process which required strong scientific evidence for each site was perceived to undermine the work of the stakeholder groups.

This work provides context and background for the current study, but was completed prior to the first set of MCZs being designated. This paper therefore aimed to assess social acceptance of

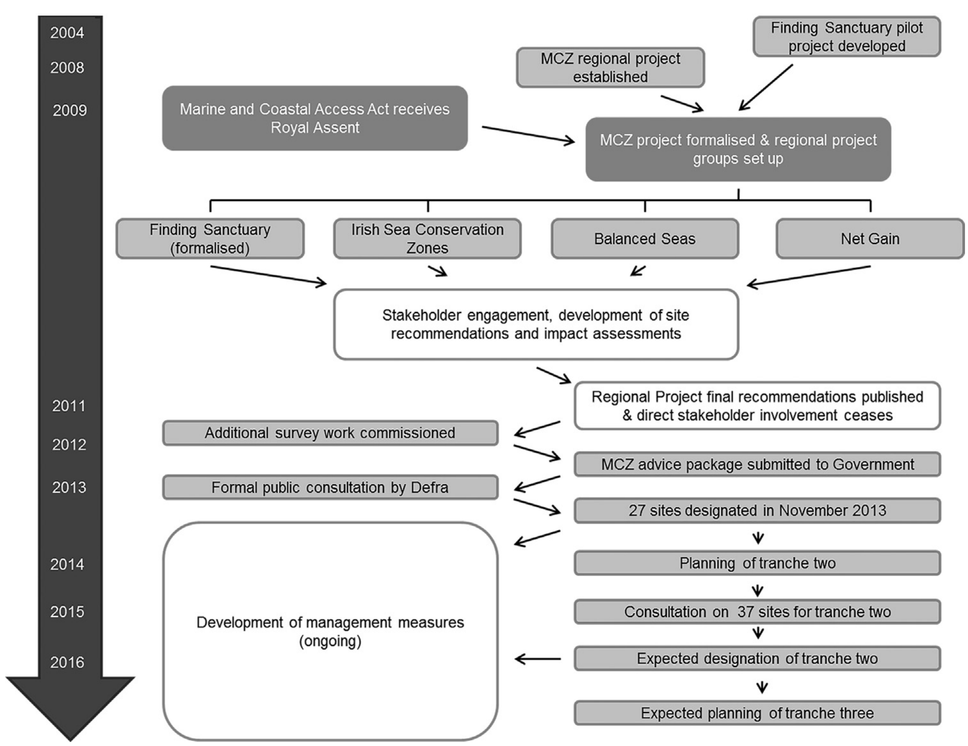

Fig. 1. Time line for the UK Marine Conservation Zone project. Adapted from Natural England and JNCC (2012).

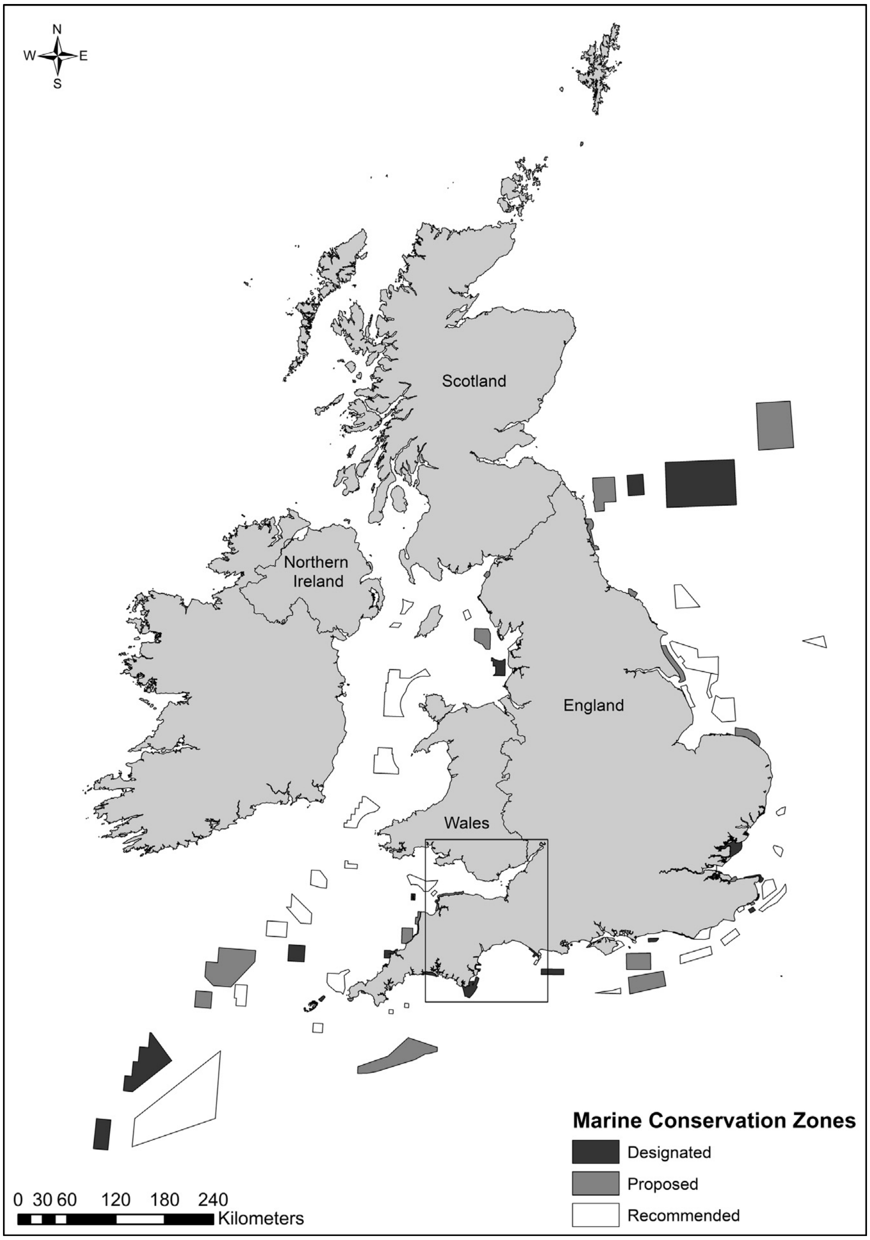

Fig. 2. Map of the UK showing the Marine Conservation Zones that have been designated, proposed and recommended. The black box shows the study area, the Devon & Severn area of England. (MCZ data source: ©Natural England copyright. Contains Ordnance Survey data ©Crown copyright and database right [2015]).

MPAs once the first tranche had been designated, focussing on the perspectives of stakeholders that had been involved with, or were very familiar with the process, and represented their local stakeholder groups views. The objectives of this study were to:

a) Understand the discourses relating to MPAs.
b) Determine whether MPAs are considered socially acceptable.
c) Reflect upon and develop recommendations for current and future MPA processes in order to promote best practice.

Interviews were conducted with stakeholders using Q methodology; an innovative method to understand the discourses relating to MCZs and the opinions and attitudes of stakeholders.

2. Methods

Previous studies on social acceptability of MPAs have used a range of survey-based methods, including attitudinal surveys with the general public, surveys with specific stakeholder groups and multi-criteria analysis e.g. [7,9,12,13,22–25]. Q is a well-established method developed by Stephenson [26] which uses factor analysis to explore the subjective viewpoints of participants [27]. It aims to analyse subjectivity in a way that is systematic, rigorous and statistically interpretable [28,29] and can be described as a quali-quantitative technique to explore viewpoints or discourses about a topic that can be debated or is socially contentious [30]. It was selected here as, unlike other survey methods which result in a statistical analysis of categories defined in advance by the researcher, Q methodology results in a set of discourses explaining the perceptions that exist amongst people, allowing them to develop their own topics rather than having them pre-defined [31]. The method was considered appropriate for a study of social acceptance.

Q methodology originated in psychology, but has been increasingly used in other disciplines such as social science and ecological economics where it has been applied to examine the way in which people think about issues such as policy, governance and management e.g. [32,33–36]. Whilst Q has been advocated as an appropriate tool to study the social and political acceptability of environmental policy [28] its use to date has focussed mainly on terrestrial environmental policies [35] and its application to the marine environment has been limited [but see 34,37–39]. It was therefore proposed to use Q methodology to explore the social acceptability of marine environmental policy in the form of MPAs; a subject that is often socially contentious and about which stakeholders have strong opinions.

2.1. Survey methods

Verbatim statements relating to opinions on UK MPAs from a fisheries and conservation perspective were collated through a review of appropriate sources, including previous work by the authors [40–42], newspaper articles and associated comments sections, social media such as Twitter and Facebook and existing literature on the topic. The statements were then reduced to form a representative set of 42 which reflected the breadth of opinion, for example: *'MPAs will finish the fishing industry'* ; *'MPAs must get the right balance between conservation and fishing activities'*, *'MPAs bring unalloyed environmental benefit'* (see Table 1).

As Q does not attempt to generalise across the population it does not require a large sample size from which to draw its conclusions, only that the participants are knowledgeable, informed and have a defined viewpoint [43]. The key is that sufficient participants are interviewed to ensure that there is strength in the generated factors, with 20–40 participants considered suitable [43].

Twenty-four key stakeholders were identified and interviewed from the following broad groups: commercial fishermen, recreational users, Non-Governmental Organisations, managers, charter boat operators, academics and statutory bodies. All stakeholders were from the Devon & Severn region of the UK (Fig. 2), were well informed about the MCZ process either through their occupation or through voluntary involvement in MPA planning or management. The proportion of stakeholders from each group was made as even as possible, but this was not considered essential as the study was concerned with the opinions of the respondents regardless of their stakeholder group.

Table 1
Q statements with score for each of the extracted discourses.

	Statement	A	B	C
1	I think demersal (seabed) trawling should be banned as it destroys virtually everything in its path	−4	−4	0**
2	MPAs will finish the fishing industry	−2	−2	−4**
3	Damage caused by anchors used by leisure users is just as significant as damage caused by demersal (seabed) trawling	−1	−2	−1
4	MPAs must be as small as is environmentally necessary	−2	2**	−2
5	Areas should be closed to everyone if they have to be closed at all	−3	−1	−2
6	MPAs make economic sense	0	−1	3**
7	MPAs provide the opportunity to protect areas from greedy and destructive practises for good	0	−2*	1
8	MPAs put environmental values before a way of life	0	0	−3**
9	If too many areas are closed there will be nowhere left to fish	−1	2**	−1
10	I totally support any legislation that helps preserve what little we have left	−2	−2	2**
11	MPAs will ensure that the fishing industry has a sustainable long term future	1	0	4**
12	MPAs…pointless marine protection legislation	−4	−1	−3
13	MPAs will not adequately protect the oceans unless all destructive activities are banned	1	0	0
14	I am not against MPAs, I am just against the way they are being implemented	2	2	0**
15	MPAs must get the right balance between conservation and fishing activities	1**	3	2
16	Without MPAs you won't have a fishing industry or coastal communities in twenty years	−2*	−4*	1**
17	MPAs will cost a great deal less than the cost of destroying our fish stocks entirely	2	1*	2
18	MPAs are just conservation for conservation's sake	−3	−2	−4
19	All around the UK we have a heritage of fishing…we have to keep it going! An island without fishing communities is like a desert without sand	1	1	1
20	Work with the fishermen, not against him – for he is the greatest part of the solution to keeping fish stocks alive	2	3	2
21	The right mobile gear used in the right place and at the appropriate intensity can be compatible with conservation objectives	3	1	0
22	It is despicable that any government puts commercial interest ahead of the environment	2**	−3**	−1**
23	The creation of an MPA is the start of an effective conservation effort, not the end	3	1*	3
24	De facto MPAs already exist as areas of seabed not available to trawlers and scallop dredgers	−1	3**	−2
25	MPAs bring unalloyed environmental benefit	−1	−3**	1
26	I do not advocate saying no commercial fishing whatsoever, ban it all. I do not think that is necessary	3*	1*	−1*
27	Progress can only be achieved by forging partnerships with all stakeholders and using all of the tools we have available	4	4	4
28	More people would benefit from an MPA than currently gain from areas as they are	0	−1	2**
29	There are less than twelve thousand five hundred UK commercial fishers. We should not allow our environment to be held hostage by such an economically insignificant number of people	1**	−3*	−1*
30	The precautionary principle should not be used to install a vast network of MPAs just in case they may prove useful in the future	−2	1**	−3
31	People need to make a living. If fishing methods are sustainable, that should be ok	1	3	1
32	A total ban on all activities would be dreadful	2	2	1*
33	This is not about saving starfish, it is about the government wanting control over fishermen	−2	−1*	−3
34	Currently the future of marine life around Britain's coasts is about as secure as a chocolate bucket	0	−3**	0
35	If the same area has been fished for so many years and biodiversity still exists, then fishing cannot be doing damage	−3	2**	−2
36	A storm will cause more damage to the seabed than demersal (seabed) trawling will	−1	0	−2*
37	Looking after wildlife and habitats in our seas in just as important as looking after those on land	3	1**	3
38	Without adequate policing MPAs will be completely ineffective	4	4	3
39	MPAs should be about the flora and fauna and not about economic value	2**	−1	0
40	MPAs are a win–win for all	−1	−2	2**
41	We do not need MPAs we need better managed fish stocks	−3*	0	−1
42	MPAs will just cause even more disruption and even more displacement	0	0	−2**

A = Pro-conservation, B = Pro-fisheries and C = 'win–win', listed in descending order from those statements with most consensus to those with most disagreement between factors. Scores represent the level of agreement with each statement from −4 'least like I think' to +4 'most like I think'. Statements that are defining statements are noted for each factor.

** Significance of $p < 0.01$.

* Significance of $p < 0.05$.

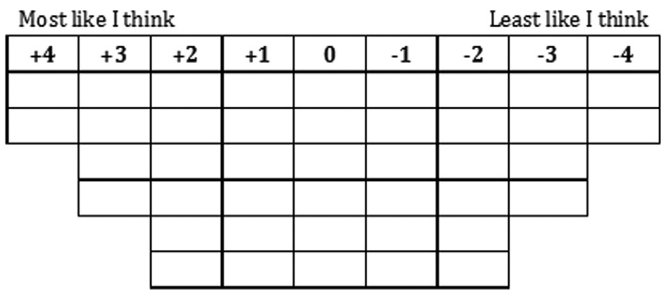

Fig. 3. Q sort grid. Participants were asked to allocate two statements to the +4 and −4 columns, four to the +3 and −3 columns, and 6 to the +2, +1, 0, −1 and −2 columns.

Interviews were conducted with each individual on a face-to-face basis. Participants were asked to sort the statement cards into a pre-determined forced choice frequency grid which ensured that each statement was ranked relative to the individual. The statements were sorted according to how like or unlike their thoughts they were using a nine point scale from +4 which were those 'most like I think' to −4 which were those 'least like I think' (Fig. 3).

Participants were asked additional questions about their sort including reasons for their choice of the two statements that were 'most like I think' and the two that were 'least like I think'. Additional open and closed questions were asked providing useful context to the Q sorts. Closed questions included 'On a scale of 1–10 where 1 is not at all happy and 10 is extremely happy, how happy are you with the current management of the UK marine environment?' and the answer to this was averaged across participants.

2.2. Q analysis

Q analysis was conducted using PQMethod [44] and following established methods [27,43] to reveal factors, or clusters of opinions which could be interpreted as viewpoints, or discourses. Centroid analysis was run from a correlation matrix where each sort was correlated with ever other to identify clusters of similar Q sorts (similar opinions). Factors were selected where eigenvalues were greater than 1 following the Kaiser–Guttman criterion [45–47], (Table 2) as this meant that each factor was defined by at least one significantly loading sort [43]. Factor loading expresses the degree to which a sort agrees with the viewpoint of the factor [48], and significantly loading factors were identified (±0.40 or above, $p<0.01$, for equation see Brown [43]). The analysis revealed a three factor solution to be most appropriate, based on their eigenvalues and as this maximised the stability, clarity and distinctness of the emerging discourses [36,49]. These were termed 'pro-conservation', 'pro-fisheries' and 'win–win' and discourses were developed for each. Statements that were statistically distinguishing for each factor ($p<0.05$) were used in the development of the discourses, and consensus statements were those where all factors agreed.

3. Results

The survey aimed to identify discourses of opinion and the social acceptability of MPAs. Twenty-four Q sorts were completed by participants between April 2014 and March 2015, and three discourses were identified; 'Pro-conservation', 'Pro-fisheries' and 'Win–win'. The significantly loading discourses accounted for 62% of the study variance, incorporating the views of 13 participants. The remaining 38% of the variance was accounted for by the 11

Table 2
Factor loadings for each sort, ranging from complete disagreement (−1) to complete agreement (1) with the perceptions of each factor.

Q sorts		A	B	C
Discourse A Pro-conservation				
Stakeholder 1	Statutory agency	**0.72**	0.17	0.35
Stakeholder 16	Marine professional	**0.69**	0.17	0.34
Stakeholder 23	Marine professional	**0.62**	0.29	0.19
Discourse B Pro-fisheries				
Stakeholder 6	Commercial fishermen	0.03	**0.69**	0.05
Stakeholder 19	Commercial fishermen	0.20	**0.84**	0.15
Stakeholder 22	Commercial fishermen	0.17	**0.64**	0.03
Discourse C win–win				
Stakeholder 10	Recreational angler	0.28	0.07	**0.68**
Stakeholder 12	Statutory agency	0.15	0.33	**0.79**
Stakeholder 14	NGO	0.29	−0.01	**0.77**
Stakeholder 18	NGO	0.32	−0.10	**0.69**
Stakeholder 20	Local authority	0.30	0.15	**0.53**
Stakeholder 24	Statutory agency	0.37	0.11	**0.68**
Confounded sorts				
Stakeholder 02	Recreational angler	0.51	−0.02	0.59
Stakeholder 03	Management group	0.56	−0.03	0.58
Stakeholder 04	Recreational angler	0.48	0.04	0.76
Stakeholder 05	Charter boat operator	0.34	−0.28	0.75
Stakeholder 07	NGO	0.43	0.12	0.44
Stakeholder 08	NGO	0.63	0.21	0.45
Stakeholder 09	Research scientist	0.59	0.11	0.56
Stakeholder 11	Research scientist	0.52	0.09	0.53
Stakeholder 13	Research scientist	0.44	−0.47	0.33
Stakeholder 15	Research scientist	0.68	−0.08	0.46
Stakeholder 17	NGO	0.65	0.02	0.58
Stakeholder 21	Local authority	0.42	0.15	0.69
% Explained variance		**49**	**8**	**5**
Eigenvalues		**11.65**	**2.03**	**1.12**
Total defining Q sorts		**3**	**3**	**6**

remaining participants who had views which were shared among the discourses and were not significantly loaded on one alone. For sorts to contribute to a factor they had to be significantly loading ($p<0.01$), see [43]. These sorts and the answers given by the participants to the additional open questions formed the basis for the discourse. The idealised sorts for each discourse are given in Table 1, showing the differences and similarities between them.

3.1. Discourse A – pro-conservation

This discourse accounted for 49% of the study variance, and had 3 significantly loading sorts (Table 2). It is characterised by pro-conservation views, and those that think conservation interests should be prioritised over fishing interests in MPAs. They see the value of MPAs (Statement (S) 12, −4) and feel that the environment should be given priority over economic and commercial interests (S22, +2; S39, +2). Despite their pro-conservation views, they recognise the importance of commercial fishing and are against a complete ban on all activities (S26, +3), and also strongly disagree with a ban on demersal trawling (S1, −4). Their opinion is that a ban would be unnecessary, *'commercial trawling can be very damaging on certain habitats – on reefs and sediment that are very stable, but in other areas, if it's very mobile sands and things then it can go ahead"* and they show a preference instead for management of activities they perceive to be damaging. Pro-conservationists also recognise the importance of partnerships between stakeholders (S27, +4) and the need for effective management and policing (S38, +4) for MPAs to be effective.

3.2. Discourse B – pro-fisheries

This discourse accounted for 8% of the study variance, with three significantly loading Q sorts (Table 2). It was characterised by pro-fisheries opinions, and the feeling that conservation should come second to fisheries interests. Concern was evident for access to fisheries (S9, +2) with feelings that MPAs should be as small as possible (S4, +2) to ensure that disturbance is minimal. The discourse was of the opinion that there are already areas of the sea that are inaccessible to fisheries and are therefore *de facto* MPAs (S24, −1; S3, −2) negating the need for large quantities of new MPAs. They felt very strongly that fishing activities should not be banned (S1, −4; S26, +1) and that MPAs are not necessary as a means of ensuring the future of the fishing industry (S16, −4) *'we've effectively had an MPA out there more or less since the end of the war…that has existed, the coastal communities have existed, the fishermen in Brixham…Salcombe and Dartmouth are still there, so clearly the situation can exist if its handled properly'*. Their opinions were more focussed on economics, with commercial interests more important than environmental (S22, −3; S29, −3) and a strong disbelief that MPAs bring limitless environmental benefits (S25, −3). Despite their doubts about the need for increasing numbers of MPAs, this discourse seemed to accept the underlying principles for MPA creation and that they are a reality and will be expanding, and, as with the pro-conservationists felt that partnerships between all stakeholders and effective policing are essential to their success (S27, +4; S38, +4).

3.3. Discourse C – 'win–win'

This discourse accounted for 5% of the study variance, and had 7 significantly loading sorts (Table 2). It was characterised by views that MPAs can be used to achieve both conservation and fisheries goals, and therefore present a 'win–win' solution to fisheries and conservation management. The discourse sees MPAs as bringing security to both fisheries management and conservation management goals (S11, +4; S10 +2) and long term sustainability to the fishing industry (SS11, +4; S2, −4). They feel that MPAs will not cause disruption and displacement or put environmental values first, but will work to benefit everyone (S40, +2; S28, +2). There is a strong economic case for MPAs (S6, +3), and certainty that they will not be detrimental to the fishing industry (S2, −4). They also feel that management and government intervention should be balanced between fisheries and conservation goals and that neither should be prioritised above the other (S22, 1; S29, −2). As with the previous two discourses they put an emphasis on the need for stakeholder participation (S27, +4) and effective management and enforcement for MPA success (S38, +3).

3.4. Consensus and disagreement statements

It was evident that despite their differences, all discourses were accepting of MPAs, agreeing that they were the start of an effective conservation effort (S23, +3, +1, +3) and that protecting our seas is as important as protecting the land (S37, +3, +1, +3). They also agreed that there was more to MPAs than conservation (S18, −3, −2, −4), *'it's partly for conservation, but it's also for just trying to get things better'*.

All discourses placed importance on partnerships between stakeholders (S27, +4, +4, +4) showing the value of stakeholder engagement and consultation, with comments that *'it's important to be democratic, inclusive, transparent in the way that decisions are taken'; 'if the stakeholders are all in agreement you get a much better buy in from the industry and other stakeholders'*, and *'there are so many examples of where not using partnerships and not involving stakeholders means that you don't meet your objectives'*. All discourses also placed importance on the need for enforcement within protected areas (S38, +4, +4, +3), with a fear that *'if there is no way of policing or controlling them they are a pointless waste of money'*.

Disagreement was apparent between the pro-conservation and win–win discourses and the pro-fisheries discourse. This related mainly to issues regarding fishing impacts and the need for management measures to counteract these. Differences were most pronounced when considering the de facto MPAs, with pro-conservation and win–win discourses unwilling to accept that areas unavailable to scallop dredgers and trawlers can be considered MPAs (S24, −1, 3, −2), and also that the existence of biodiversity in areas that have been fished for many years means that fishing cannot be doing any damage (S35, −3, 2, −2). Therefore, despite their win–win attitude, it is clear that the win–win are slightly less pro-fisheries than pro-conservation.

Disagreement was also apparent in relation to the banning of demersal trawling within protected areas, with the pro-conservation and pro-fisheries discourses strongly in disagreement (−4, −4) and the 'win–win' expressing ambivalence (0) which may be surprising given their viewpoints. It is thought, however that there was some hesitance surrounding this statement, with respondents in this category unwilling to commit to a strong opinion as they felt that trawling may need to be banned in some areas but not others, so this statement was not one that they felt that they could comment on.

3.5. Additional questions

In addition to the Q sort, participants were asked questions which helped guide development of the discourses. On average, respondents were relatively unhappy with the current management of the marine environment (mean 4.54/10) citing reasons such as *'I think we are getting there…there is more work to do'; 'could do better; improve awareness – it's dreadful'; 'the tools exist, but for a variety of reasons, either capacity of willingness they aren't being introduced or used for fear of upsetting sea users'*. Eighty-three percent of respondents felt that the number of MPAs in UK waters should be increased *'we've done all that work, and that was trying to achieve something and that isn't finished yet'; 'would have been very happy if the whole network had been there as we were given a formula…which said you need to have a certain proportion of different seabed habitats protected. We actually got it to those percentages'*. The remaining 17% did not know whether the amount should remain the same, be increased or be decreased due to a perceived lack of information with which to make the decision. Respondents felt that until there was clear evidence of the success of MPAs they were unable to determine whether more were justified or required: *'unsure without further evidence of the value of what is around us – scientific evidence. I wouldn't like to call it too little or too much. I would want to have an informed opinion before committing myself'*.

Finally, participants were asked whether they would have liked their involvement to continue past the end of the regional project period. All respondents agreed that continued involvement would have been beneficial; keeping the momentum and support going and allowing local, well informed input to the implementation of sites and development of management plans; *'there had been something built up over the couple of years that it ran for that that could have been used as a building block for developing the management of the sites'*. The regional projects had generated a sense of shared ownership, and had bought different stakeholder groups together; *'I think if that process had continued people could have discussed the management options…they may not necessarily have agreed with the decisions made, but at least they would have felt that* *they had an input and had been listened to'*. Despite this, some participants felt that the final decisions needed to be top down and government led due to the legislative aspects, but that locals should be involved in the development of the management plans as they would *'bear the biggest proportion of the costs'*.

4. Discussion

This study aimed to determine whether MPAs are considered socially acceptable by investigating the discourses on their use for fisheries and conservation management. Understanding social acceptability is a crucial part of MPA monitoring and can be used as a measure of MPA success. Where MPAs are not found to be socially acceptable, adaptive management may be required to ensure that activities are managed in a way that allows them to reach their goals.

Three discourses were identified, 'pro-conservation' who felt that conservation should be prioritised over commercial and economic interests; 'pro-fisheries' who saw fishing to be the priority and expressed concerns over the uncertainty of management measures and the number of planned MPAs; and 'win–win' who felt that the current approach to marine management using MPAs would allow both fisheries and conservation goals to be met. Despite some differences in opinion, the discourses had some strong similarities, with social acceptability of MPAs identified across all three.

The views of the win–win and pro-conservation discourses were most similar, with both feeling that the environment should be prioritised over economic and commercial interests. The stakeholders forming these two discourses were from a diverse mix of stakeholder groups, with representatives from management bodies, statutory bodies, recreational users, NGOs and academic institutions. The pro-fisheries group was, however, comprised entirely of commercial fishers, highlighting an important difference in opinion between this stakeholder group and the others. This difference is apparent elsewhere, with Mangi and Austen [14] finding that most stakeholders thought conservation was the most important MPA objective for southern European sites, whilst fishers prioritised fisheries management. It is thought to arise as commercial fishers are often the only stakeholders who stand to lose directly from the establishment of an MPA due to restrictions placed on extractive uses. As seen here, however, they are not always completely anti-MPA, a finding supported by that of Jones [17] who found what is perhaps a surprising level of support (23% of respondents) for NTZs in a study of the fishing industry in the south-west UK. He also found that 36% of respondents thought NTZs could bring both fisheries and conservation benefits, and 20% thought that they should be purely for biodiversity. This last group were of the opinion that a 'win–win' approach was unrealistic as the fisheries benefits were too uncertain, and they would rather have a clear and honest approach to the areas.

Social acceptability of MPAs does come with some limitations. Acceptability was greatest within the win–win and pro-conservation discourses and was apparent to a lesser degree within the pro-fisheries discourse. The main limitations were due to uncertainty over whether MPAs will bring their intended benefits, due to scepticism that they will work, and due to limited availability of resources with which to implement effective management and enforcement. This uncertainty is inherent in the process of establishing MPAs, and, despite an ever increasing volume of literature from tropical locations showing MPA success at increasing the biodiversity of sessile and mobile reef species e.g. [50,51–53] evidence from temperate locations has been slower to emerge but see [54,55].

It is expected that with time, and once management measures are established, attitudes may become more positive as users begin to see the benefits of designation, become familiar with management and adapt their activities accordingly [56]. This is corroborated by the findings of Hamilton [13] who compared fishers perceptions of MPAs in the Philippines where MPAs had been established for 10 years to Cambodia where MPAs were a novel idea. He found 85% of fishers were supportive of MPAs in the Philippines compared to 61% in Cambodia, and this result positively correlated with perceived changes in abundance of reef fish, where Filipino fishers had noticed a positive change in fish landings attributed to the MPA and Cambodian fishers had noticed a decline.

Another fundamental concern limiting social acceptability was the lack of inclusivity and transparency in the MCZ process. The switch to a process that was almost entirely top-down resulted in the exclusion of local stakeholders, the cessation of local level involvement at the end of the planning period and a loss of social capital which had been accumulated during the planning phase. All participants expressed a wish for their involvement to have continued into the MCZ implementation period and felt that their exclusion from the development of management plans for the sites was a mistake, confirming that opinions identified by Lieberknecht et al., [20] persist 18 months on and highlighting a key shortfall in the MCZ project. It is thought that continued stakeholder involvement would have increased social acceptance of MPAs, as found in the Philippines where a change from top down government led management to co-management between the government and locals was found to be very successful [57]. Inclusion has also been found to increase compliance with MPA regulations, with Arias et al., [58] finding compliance levels perceived by resource users to be higher in MPAs where locals had been involved in the decision making process than where they had not.

Had the engagement process been continued, with local level inclusivity and dialogue channels between local and governmental groups, it is thought that social acceptability would be greater. In a study of commercial fishers in southern France, Leleu et al., [25] attributed high social acceptability of MPAs to the involvement of fishing guilds throughout the process of establishment and management of the MPAs. They also found that the process had been supported by successful communication between managers and users about the direct and indirect benefits of the sites which alleviated concerns and increased the transparency of the process. This result provides an interesting comparison for our study, where commercial fishers were those that expressed the lowest level of acceptance of MPAs. They stated that they were in support of MPAs but only when they felt that they were being implemented for the right reasons and when they could see a clear scientific case for them. Had better education and communication existed relating to the need for and benefits of MPAs it is thought that social acceptance within this group may have increased. Education and communication are therefore aspects of key importance within the process of MPA planning, and must continue into the implementation period. If the stakeholders are well informed and can see clear benefits from the existence of an MPA they are more likely to support it.

Transparency and honesty in the design and implementation of MPAs is key to their social acceptability, irrespective of their location. Stakeholder expectations must be managed and the engagement process must work to alleviate the concerns of those whose livelihoods are likely to be directly impacted in a way that allows them to fully understand the costs and benefits of the designation. Without this, and with ongoing uncertainty and a lack of appropriate management measures, MPAs are at risk from decreasing social acceptability, as identified by Mangi and Austen [14] who showed decreasing support for MPAs from fishermen who failed to identify any benefit to their activity arising from the designation of sites in Southern Europe.

Understanding social acceptability is key for the ongoing MPA process, promoting stakeholder engagement and introducing adaptive management where appropriate, and it should form a key part of any monitoring programme for MPA success.

5. Conclusions

By analysing the views and attitudes of stakeholders to MPAs three separate discourses have been developed providing an insight into social acceptability. Social acceptability was identified across all discourses, and is believed to have resulted in part from the well-developed and thorough process of stakeholder engagement during the MPA planning period. Acceptance has however, been limited by the cessation of stakeholder engagement in the implementation period and the exclusion of stakeholders from the development of management measures, resulting in disenfranchisement and uncertainty of the future of their activities within the proposed sites.

These results show that social acceptability of MPAs is generated by effective and ongoing stakeholder engagement, transparency and honesty relating to the costs and benefits of designations and a certainty that once sites are in place the resources exist for their effective management. It will also be increased where evidence exists that suggests the MPAs will be successful in meeting their goals, and should increase over time if this is seen to be the case.

From this study, the following recommendations are made:

1. That stakeholder engagement should take place through the duration of any MPA process, from the design of sites, to implementation and development of management measures, thus incorporating both top down and bottom up approaches.
2. That stakeholder engagement should have defined parameters that are clear and transparent so that stakeholder expectations are managed and the risk of lost support minimised.
3. That communication with and education of stakeholders continues throughout the process ensuring that they are well informed about the process and its justification

Whilst the results of this study cannot be extrapolated to the wider population it is thought that they are likely to be representative of views in other locations across the globe where similar MPA designation processes are occurring. Research is required in areas where the MPA process has been different in order to determine the best practice for MPA designation to generate social acceptability and aid MPA success. Although social acceptability is one of numerous factors that can influence MPA success, it is argued that it is of key importance as a measure of support for MPAs, and stakeholder support is crucial for their success.

At the time of writing, no monitoring had been undertaken into the success of the MCZs designated in 2013 at meeting their objectives, limiting the ability to determine whether social acceptability has contributed to MPA success and providing an opportunity for further research. Understanding how social acceptability changes with MPA age will help in the development of best practice for MPA planning. Ongoing monitoring is also required to ensure that stakeholder support is maintained, and in the hope that it increases, with results from Mangi and Austen [14] highlighting the risk of decreased support if management fails to bring positive change. Understanding social acceptability will guide adaptive management and increase the chances of MPA success and the meeting of global targets.

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