BLUE MARINE FOUNDATION

The Lyme Bay experimental potting study

A collaborative programme to assess the ecological effects of increasing potting density in the Lyme Bay Marine Protected Area

Final report

Submitted by:

University of Plymouth Marine Institute in collaboration with the Blue Marine Foundation and local inshore fishing community

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Foreword by Charles Clover, Executive Director, Blue Marine Foundation:

It was some time in the early 1990s people that began to speak about the need to protect "England's coral garden" - the reefs of Lyme Bay. Newspapers carried images of the rich habitats for fish, shellfish and rare species of coral and sea fan revealed below the waves by divers and local fishermen, conservationists, divers and anglers, among others, found themselves part of a rising chorus of concern about evidence of damage caused to the reef habitat by trawls and scallop dredges. Eventually the many local and national expressions of concern prevailed and the government chose finally to close 60 square miles of the bay to mobile fishing gears in 2008. I was privileged to be involved in a minor way in documenting that dramatic first chapter of the story, a milestone in nature conservation and the management of inshore fisheries in Britain, in my former role as environment editor of the Daily Telegraph, in consultation with its many protagonists. What I will call second chapter of the story, documented here, began shortly after the formation of our new charity, the Blue Marine Foundation in 2011, when we at BLUE came to Lyme Bay to hear how things were going in what had become, in effect, Britain's largest multi-use marine national park. Though by then there was evidence that the reef habitats were recovering, all was not going as well as expected for the environment or for the static-gear fishermen still entitled to fish there. Despite the original statutory instrument and the subsequent designation of some 90 square miles as an EU Special Area of Conservation the place didn't yet appear to be being managed to the satisfaction of either fishermen or conservationists. The prohibition of dredging and bottom-trawling had the unexpected effect of making the reefs a magnet for a concentration of static gear - pots and nets – because the static gear no longer got towed away by the mobile gear, so the closed area was a safe place to leave it to work. Was there was an impact from this over-concentration of fishing gear upon some local fishermen's landings? Some had expressed their landings had halved in recent times. We were concerned that as this was happening, there might also be an impact upon the corals, sea fans and other benthic life that was supposed to have been protected by the closure to mobile gears. This report confirms that our suspicions were correct that unregulated, high levels of sustained potting effort could impact some of the marine life. Importantly however, in addition fishermen were insistent that their small-boat methods were sustainable, but larger boats from outside the area were not and these results provide evidence the current way of life for small-boat pot fishermen operating in the Lyme Bay MPA is entirely viable. A maintenance of the status quo should ensure long term sustainability of this fishery.

Back in 2012, BLUE and the fishermen agreed to set up a Consultative Committee and to try to achieve three "wins" for fishing and conservation.

1) A win for the fishermen to provide them and their heirs with a sustainable living;

2) A win for conservation in the protection of the Lyme Bay ecosystem and its stocks of seafood;

3) A win for the communities around the bay.

But how were we to measure success? Particularly in achieving the crucial second aim, on which everything else depended? We wanted to guarantee the fishermen from the four local ports what they wanted, a right of access to the resource as long as it could be proved that what they were doing was sustainable. Nobody could tell us, however, what density of potting that was and what level would impact not only the target species of lobster and crab but damage the reefs and their corals. Luckily, Dr Bob Watson was then chief scientist at Defra and was persuaded that this was precisely the kind of information that would be valuable as Britain developed its network of marine protected areas, most of which would continue to be fished. So the potting study began – with a secondary aim of seeing if there were any "overspill" effects beneficial to fishing from the small 500 x 500 m areas where potting had been removed, necessary to the experiment. (Something it has not been possible to prove.) The study has had its challenges: nobody anticipated all the pots and markers being washed away in the storms of the winter of 2013/14 with an impact on the seabed and data comparisons which necessitated a year's extension to the project, but we are delighted that it has had some clear results. These show a "threshold" at which fishing effort begins to be damaging to crustacean populations and the reef environment. We did not anticipate the other fascinating finding: that lower effort would result in a higher quality of catch. This completely vindicates the "high quality, low volume" fishery the Lyme Bay Fisheries and Conservation Reserve has tried to encourage in its voluntary code of conduct. We did not anticipate such clear findings and we thank Adam Rees and all at the University of Plymouth for their analyses, and the funders at Defra for their commitment to the science. These results will enable the Lyme Bay Fisheries and Conservation Reserve consultative committee to manage the reserve with confidence into the future. These results provide invaluable advice for the managers of marine protected areas, both around Britain's coasts and elsewhere.

1.1 **Introduction**

As attitudes towards marine management in the UK become more ecosystem-based, more holistic, approaches that favour the conservation of multiple marine resources are being championed. Ecosystem-based management focusses on protecting entire marine environments while unsustainable and damaging practices that compromise protection are removed (Pikitch *et al*. 2004). This approach recognises 'humans are an integral component of ecosystems', and so economic and social factors are considered alongside ecological factors, with the aim of benefitting fisheries by managing and protecting resources at the ecosystem level rather than at the species level (Gaines *et al.* 2010). Marine Protected Areas (MPAs) are considered as key tools for implementing an ecosystem-based approach and have demonstrated their efficacy at providing dual-benefits to both conservation and to fisheries, by protecting our seas and promoting the sustainable use of marine environments and resources. This type of approach can lead to increased economic income contributing to 'blue growth', which aims to drive economic growth from our marine resources, with fisheries contributing substantially, while concurrently increasing environmental protection (Roberts and Hawkins 2000; Shears *et al.* 2006; Vaughan 2017; World Bank 2017). The UK is committed to introducing a network of well-managed MPAs in addition to achieving Good Environmental Status (GES) of its regional seas by 2020, and protect the economic and social benefits of these seas (European Commission 2008; Marine Strategy Framework Directive 2008). In addition, the Marine and Coastal Access Act (MCAA) requires a network of Marine Conservation Zones (MCZs), a type of MPA, to be developed in order to manage and protect marine and coastal environments in the UK, at the ecosystem level (Fletcher *et al.* 2014).

At present the UK has introduced 275 statutory MPAs, which cumulatively cover 16% of UK waters (JNCC 2014), while 127 MCZs have been identified and are being phased in throughout England over coming years. The majority of UK MPAs are multi-use meaning they allow certain activities to continue, while excluding others. These multi-use MPAs offer partial protection and typically exclude damaging activities which compromise the objectives of the MPA (Read 2010). For commercial fisheries, fishing practices/methods that are known to negatively impact a protected feature or habitat are often managed or excluded from MPAs, while commercial fishing practices considered to be compatible with the conversation objectives are typically permitted to continue. For all types of commercial fishing activity comprehensive assessments are required to ensure that they do not compromise any obligations to protect sites, in accordance with both EU and UK directives. Evidence-based assessments should evaluate the potential ecological impacts of different commercial fishing methods in order to determine their requirement for management based on the risk they pose to designated features. Appropriate management action should be taken in light of these assessments. For multi-use MPAs in the UK evidence and understanding of the impacts and compatibility of all UK commercial fisheries with MPAs has been carried out by local Inshore Fisheries and Conservation Authorities (IFCAs) in the form of Habitat Risk Assessments as part of DEFRA's revised approach, however these assessments consider current effort levels of commercial fishing overlooking any future potential increases in effort.

1.1.2 **Fishing in the UK**

Mobile methods of commercial fishing, such as trawling, are the dominant methods used in UK commercial fisheries (MMO 2015). However some mobile methods, in particular bottom towed fishing methods, negatively impact ecosystems both directly and indirectly (Hall 1999; Jennings and Kaiser 1998). As a result bottom towed fishing methods have been removed from many UK MPAs, in order to halt degradation, and promote the recovery and protection of sensitive habitats and species.

The commercial shellfish sector is consistently the second largest fishing sector contributing to total UK commercial landings (by UK vessels) in recent history, averaging around 35% (2010-2014) of all UK landings (MMO 2015); while contributing to 45% of the total value of UK landings (by UK vessels) averaging around £271 million (2010-2014) (MMO 2015). Scallops, Crabs and *Nephrops* contribute to over 70% of all shellfish landings in the UK; however, European lobsters are consistently the most economically valuable of all shellfish species landed (MMO 2015). 40% of the total quantity of shellfish and 50% of the total value of shellfish landed in the UK in 2014 was caught through the commercial fishing method of potting.

Commercial potting is a 'passive' or 'static' fishing method (Nédélec and Prado 1990; Seafish 2015), where pots are often baited and typically deployed to the seabed and left stationary for a period of time, allowing target animals to enter and be caught once hauled. The advantages of potting allow for more control over the size and species of the mobile species caught. Pot entrances can be altered to control the maximum size of the organisms that enter, while mesh size and escape routes can be altered to control the minimum size of the species retained and the type. The model or shape of the pot can be changed in order to target different species (Slack- Smith 2001). Pots are weighted to help maintain their position on the seabed over long time periods. Ecological damage could occur as a result of both direct contact and from abrasion/scour from the movement of potting gear (ground lines and anchors) on the seabed, particularly during periods of adverse weather and/or across spring tidal cycles (Eno *et al.* 2001; Lewis *et al.* 2009; Gall *In press*). In addition, it has previously been suggested that damage to sensitive habitats is likely to occur during both the setting and hauling of pots (Hartnoll 1998; Eno *et al.* 2001).

However, the impacts associated with commercial potting have always been considered as benign, causing little damage to marine environments (Eno *et al*. 2001; Coleman *et al.* 2013). There are currently very few empirical studies that have looked at the direct and indirect physical impacts of pot fishing on temperate benthic communities and habitats. In Defra's revised approach to managing European Marine Sites, 'Static –

pots' are considered to pose an 'Amber' risk to 27 habitats, including: subtidal gravel and sand, subtidal mixed sediments and subtidal bedrock, boulders and cobble reefs (Defra 2013). By 2016 the impacts associated with static pots had to be assessed, with necessary management measures in place. This target was not met, however, Amber risks continue to be assessed, as it is imperative to understand the environmental impacts associated with all commercial fishing activities.

In the UK, a number of technical measures are mandatory for commercial potting under European legislation, which include size limits (Minimum Conservation Reference Sizes (MCRS)) and the fitting of escape gaps in some areas; this is the case in Devon and Severn IFCAs district. However, there are very few examples of effort based management for commercial potting.

1.1.3 **The problem?**

Areas of the UK are currently seeing increases in potting activity in inshore waters (Mangi *et al.* 2011; Newman *et al.* 2012; Cefas 2014, Öndes 2017). The number of UK vessels that class pot fishing as their main gear type has been exacerbated by the widespread use of mechanical haulers (Munro *et al.* 1987) and commercial pot associated landings have steadily increased over the past 25 years. Local examples of this have been seen around the UK (Bannister 2009) including in the northeast of England (Turner 2009; Cefas 2014) and in Skomer, Wales (Newman *et al.* 2012). Increases have been seen in some areas in response to restrictions placed on bottom towed fishing gear (Mangi *et al.* 2011). It is believed that this unrestricted fishery could see a dramatic increase in effort, both in terms of quantity of gear and numbers of vessels, before the impacts of current levels are fully understood.

If sustainable levels of potting are to be permitted within an MPA without compromising fisheries or biodiversity, then an assessments need to be made in order to determine what level of commercial potting activity is sustainable.

1.1.4 **Lyme Bay: a case study**

Lyme Bay is a 2460 km^2 area of English Channel coastline located in Southwest England, encompassing approximately 120 km of coastline and numerous fishing ports (Rees *et al.* 2010) (Fig. 1.1). The area hosts important submerged geological features encouraging a mosaic of habitat including sandstone, mudstone and limestone reefs (Black 2007). These mixed ground reefs comprise of bedrock, stony and biogenic reef (Cork *et al.* 2008; Attrill *et al.* 2011; Ross 2011; Munro and Baldock, 2012) on which rich, complex, sensitive reefs have developed (Black 2007). Lyme Bay is home to a prosperous fishing industry, with numerous vessels involved in scallop dredging, trawling, netting, potting and whelk fishing (prior recent management measures) (Andrews 2008). Commercial potting has a long history in Southwest England, during which brown crab has been the dominant fishery (MMO 2015). Parlour pots, Inkwell pots, cuttlefish pots, and whelk pots are all commonly used throughout the region (Stevens *et al.* 2007).

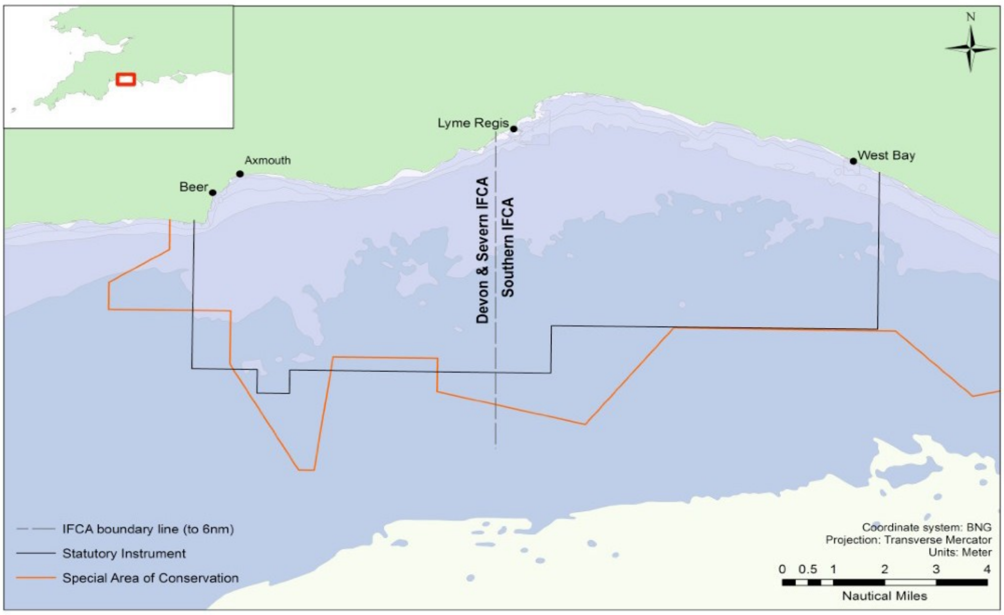

Figure 1.1 Lyme Bay MPA boundaries and associated ports, with Inshore Fisheries and Conservation Authority (IFCA) boundary line between Devon and Severn and Southern IFCA out to 6 nm highlighted.

Scallop dredging was a lucrative industry within Lyme Bay, however, repetitive dredging removed some of the sensitive reefs and degraded the local habitat forming geology (Devon Wildlife Trust 2007). As a result, in 2008 a 'Statutory Instrument' (SI) (a governmental regulation) was legally implemented by Defra, which excluded all bottom towed fishing from a 206 km^2 (60 nm^2) area of Lyme Bay seabed (Black line Fig.1.1) (Defra 2008). Static forms of fishing are permitted to continue within the Lyme Bay MPA, including potting, netting, rod and line fishing and hand-diving for scallops plus recreational fishing activities.

The Lyme Bay MPA falls on the border between two managing IFCAs, Devon & Severn to the West and Southern IFCA to the east (Fig. 1.1). Protection increased to protect offshore reef areas and these additional sites were designated a European Special Area of Conservation (SAC) in 2011, under the Habitats Directive (92/43/EEC), assigning the protected areas with European Marine Sites status (Red line Fig.1.1) (Rees *et al.* 2010; Natural England 2012). The conservation objectives of this SAC were to 'ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying reef features'. These qualifying reef features included, Circalittoral rock, Infralittoral rock and Subtidal stony reef of which their extent, structure, function and supported populations should be 'maintained or restored' (Natural England 2008) The designation of the SAC led to a subsequent assessment of bottom towed fishing across the site by both Southern and Devon and Severn IFCAs, ultimately resulting in further bottom towed fishing closures across the site through the introduction of bottom towed fishing byelaws by both IFCAs. Although introduced through two separate byelaws, the end management result for bottom towed fishing is the same both sides of the Devon/Dorset border. However management measures for individuals species caught using static gear in each of these two districts can be different, for example the Minimum Conservation Reference Size (MCRS) of European lobster.

To assess the efficacy of this Lyme Bay MPA, long-term monitoring of the recovery of the protected reefs began in 2008, by the University of Plymouth. Results have shown that a number of species, including key indictor species showed positive recovery within the MPA in comparison to those areas that continue to remain open to bottom towed fishing (Sheehan *et al*. 2013a). It is clear from these results that this site is still recovering and that the management of activities permitted continue within the Lyme Bay multi-use MPA should be routinely monitored.

Since 2008 IFCA and Marine Management Organisation (MMO) sightings data have shown an increase in the number of vessels using static gear inside the MPA. These increases included static pots targeting crab and lobsters, but also pots targeting whelks as well as static set nets. For crab and lobster both value and weight of landings have both increased within the Lyme Bay area, with number of trips into the Lyme Bay MPA significantly increasing (Mangi *et al*. 2011; Vanstaen and Breen 2014; Rees *et al.* 2016). While the increases in commercial potting effort targeting crab and lobster is not fully understood the economic upturn of this fishery, in conjunction with anecdotal reports from local fishermen, suggests that effort within this sector could continue to increase unregulated within the Lyme Bay MPA. An increase in commercial potting effort potentially threatens the livelihoods of many local Lyme Bay static gear fishermen (Clover *et al.* 2012).

1.1.5 **Lyme Bay and the Blue Marine Foundation**

In 2012 the Blue Marine Foundation developed a conservation proposal with the aim to achieve a 'win, win, win' outcome; for conservation, fisheries and fishing communities. (Blue Marine Foundation 2012). In order to achieve the desired 'wins', a 'bottom-up' approach was considered imperative. A key component in the approach has been the development of the Lyme Bay Consultative Committee. This assembly includes all local fishermen from ports encompassed by the MPA (Beer, Axmouth, Lyme Regis, West Bay),

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local and national stakeholders, funding bodies and policy makers; importantly the local IFCAs and the MMO, aiming for Lyme Bay management to represent:

1. Best practice in protecting biodiversity within a European Special Area of Conservation.
2. Best practice in managing fish and shellfish stocks.
3. Creating maximum long-term benefits for coastal communities by adopting best practice.

A Memorandum of Understanding (MOU) was also signed by all Consultative Committee members, an important step in improving collaboration between fishermen, conservation bodies, scientists and marine management bodies. In return, fishermen who adopt best practice and demonstrate sustainable fishing methods should be rewarded. All of these initiatives are part of a wide reaching proposal set out by the Blue Marine Foundation to meet its desired 'wins'.

Consultative Committee meeting in Lyme Regis

The Consultative Committee initially focussed on improving the management of the closed area in regards to increasing commercial potting efforts. It was decided that for the immediate future, voluntary measures should be adopted and were outlined within a Lyme Bay Commercial Fishermen's Voluntary Code of Conduct. This voluntary code is an attempt to reduce the immediate impact of static gear, and to principally develop a sustainable and well-managed inshore commercial pot fishery within Lyme Bay, and stated:

- *Fishermen will not fish more than 250 crab/lobster pots.*
- *Strings will not exceed a maximum of 10 pots in each.*
- *Escape hatches will be fitted to all parlour pots and creels, aligning the area that falls under Southern IFCAs district with that of Devon and Severn IFCA where escape hatches are already mandatory*
- *Voluntary V-notching (Tail mutilation in female lobsters undersize or carrying eggs (berried) will be carried out at the individual fisherman's discretion.*

In addition, it was clear that the impacts associated with current and increasing levels of commercial potting lacked appropriate evidence, thus a pioneering management-based project was developed by the

University of Plymouth, funded by the Blue Marine Foundation, and was designed with direct input from local fishermen.

1.2 **The Lyme Bay Experimental Potting Study**

The purpose of this study was to gather evidence on the ecological impacts of potting by controlling potting densities within a number of experimental units in the Lyme Bay MPA. This created a gradient of increasing potting effort from areas of no potting through to areas where potting effort was considered at a maximum, and above current levels of potting effort in Lyme Bay. Data were then collected over multiple years, in order to assess the impact of an increase in potting density on the seabed and its associated species, including populations of commercially targeted species. The potential for spillover from areas protected from potting was also evaluated. The evidence and conclusions of this project could then be used in future evidence-based management recommendations. The study ran from 2014-2017.

1.2.1 **Outline of the study methodology**

Each experimental unit measured 500 x 500 m and homogenous mixed ground or rocky reef substrata between depths of 25 m – 31 m were selected for the siting of the experimental units. Static gear fishermen from each port (Beer, Axmouth, Lyme Regis, West Bay) helped designate sets of four different experimental potting treatment units, 'Control' (no potting) units, 'Low potting' density units, 'Medium potting' density units and 'High potting' density units (Fig. 1.2). Potting densities and a regular potting regime were then maintained within each unit by the fishermen themselves, replicating episodic fishing close to 'normal' levels. Normal levels are considered to equate to potting hauls of between two and three times per week during periods of stable weather, typical during summer months, and one haul per week during periods of unsettled weather, typically winter months. Experimental potting treatment units (Fig. 1.2) consisted of the following densities per 500 x 500 m area: Control (no potting) = 0 pots, Low potting = 5-10 pots, Medium potting = 15-25 pots, High potting = 30 pots and higher.

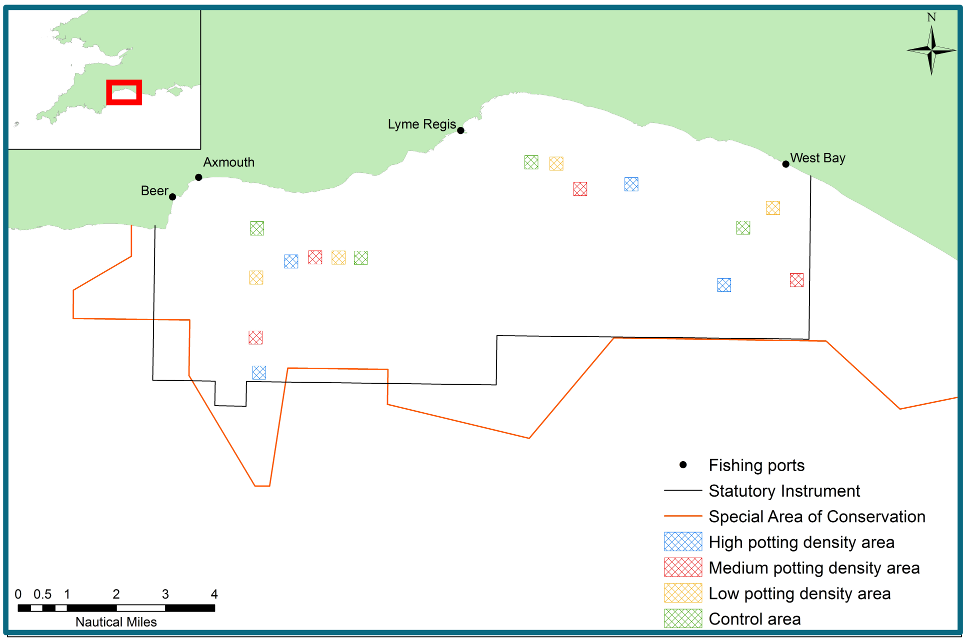


Figure 1.2. Distribution of experimental potting density units throughout the Lyme Bay MPA.

The High potting treatments denote a level of potting that is substantially higher than the present level of potting and is considered here as close to maximum effort possible for the defined treatment area. This is to replicate the effects of a maximum increase in potting effort. The densities used in the High potting treatment are confidently considered to represent maximum fishing effort per 500 x 500 m area as similar assessments of potting effort throughout Devon and Severn IFCA district in 2008 observed that 36 pots seemed to be the maximum number of pots that can viably and economically be placed in the areas that individuals work (Sarah Clark, Deputy Chief Officer D&SIFCA *pers comm*.). Current levels of potting effort for Lyme Bay is characterised by the Medium density treatments. Low potting densities are also considered to replicate potting levels in some areas of the MPA and is considered to be a level of potting more similar to those pre closure. Control units where potting was removed to simulate a 'no potting' treatment were incorporated into the studies design to act as a reference point to determine any measurable changes, as well to as assess the potential local spillover benefits no potting areas may induce in surrounding areas.

A parlour pot

A set of four experimental treatment units were introduced for each port, totalling in 16 areas across the MPA (Fig. 1.2). To aid potting density manipulation experimental sets of 30 experimental pots were assigned to each port to supplement density manipulation. Parlour pots were purchased from a local supplier that supplies the local fishing community. Pots were industry standard measuring 28 inches x 21 inches x 15 inches, with a mesh (net) size of 40 mm and 10 inch entrances or 'mouths'. All pots were also fitted with escape gaps of 84 mm wide by 46 mm high and 100 mm long to meet Devon and Severn IFCA technical permit requirements for commercial potting (D&S IFCA 2011). Potting areas were spatially and temporally replicable and started from similar ecological baselines which allowed for changes over time to be confidently attributed changes in potting effort.

The scale and duration of this experiment makes it novel, yet the direct collaboration between scientists and fishermen is considered particularly poignant.

1.2.2 **Aims of the study**

The experimental potting project assessed potting impacts on both the ecosystem and on the local fishery. Multiple data were collected in order to answer different hypothesis driven questions that set out better understand the impacts of potting on the ecosystem and local fishery.

Four research questions:

Ecosystem

• *Assess the impacts of increasing potting density on sessile and sedentary reef species and assemblages*

• *Assess the impacts of increasing potting density on benthic macro-mobile species and assemblages*

Fishery

• *Assess the impacts of increasing potting density on target fishery species and associated bycatch*

• *Assess potential spillover benefits to fisheries of 'No potting' areas*

A detailed description of objective methodologies and results are presented in the form of a PhD thesis entitled 'The ecological effects of increasing potting density in the Lyme Bay Marine Protected Area' (Rees unpublished doctoral thesis, University of Plymouth, 2017). Results from this thesis will be published in relevant scientific journals for reference. A brief summary is provided here. Figures (1.3 - 1.6) show results from the final year of 2016 collection (2016), after a three year gradient had been established. Each with significance testing (full results see thesis).

1.3 **Summary of results**

1.3.1 **Ecosystem: Study 1:**

• *sessile and sedentary reef species and assemblages*

It was firstly considered important to assess the impact of increasing potting density on the benthic reef ecosystem in Lyme Bay, by quantifying the responses of large, sessile (fixed) reef species, in the different areas of potting density (Control - High) over time.

The total number of sessile reef species increased over time in areas of No potting and Low density potting, the number of these species decreased in areas of High potting density. It is concluded that at least some sessile species respond negatively to High levels of potting intensity (Fig.1.3). Importantly, these trends were only clear after three years of potting density manipulation (Fig 1.3).

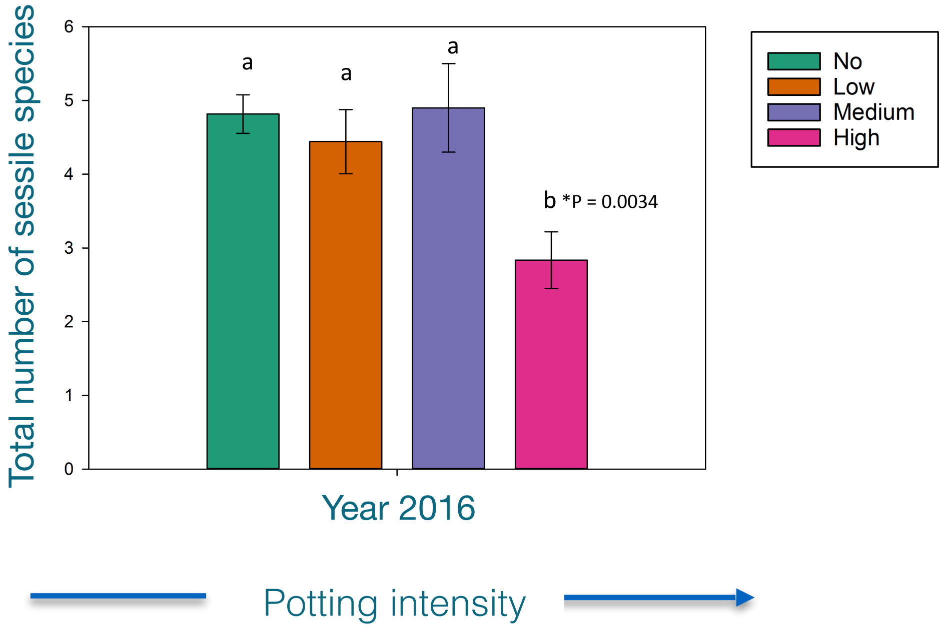


Figure 1.3 Total number of sessile species in each potting density area in 2016, quantified in Study 1. Letters above bars denote significant differences.

To provide greater insight into potting impacts at the species level, pre-selected sessile indicator species (six in total, see Rees unpublished doctoral thesis, University of Plymouth, 2017 for description of indicator species selection) were then analysed to aid greater understanding. Two of these indicator species showed a positive response to reduced potting density and are thus considered to be driving the pattern seen above. These indicator species were the Ross coral *(Pentapora folicacea)*, which was observed to show

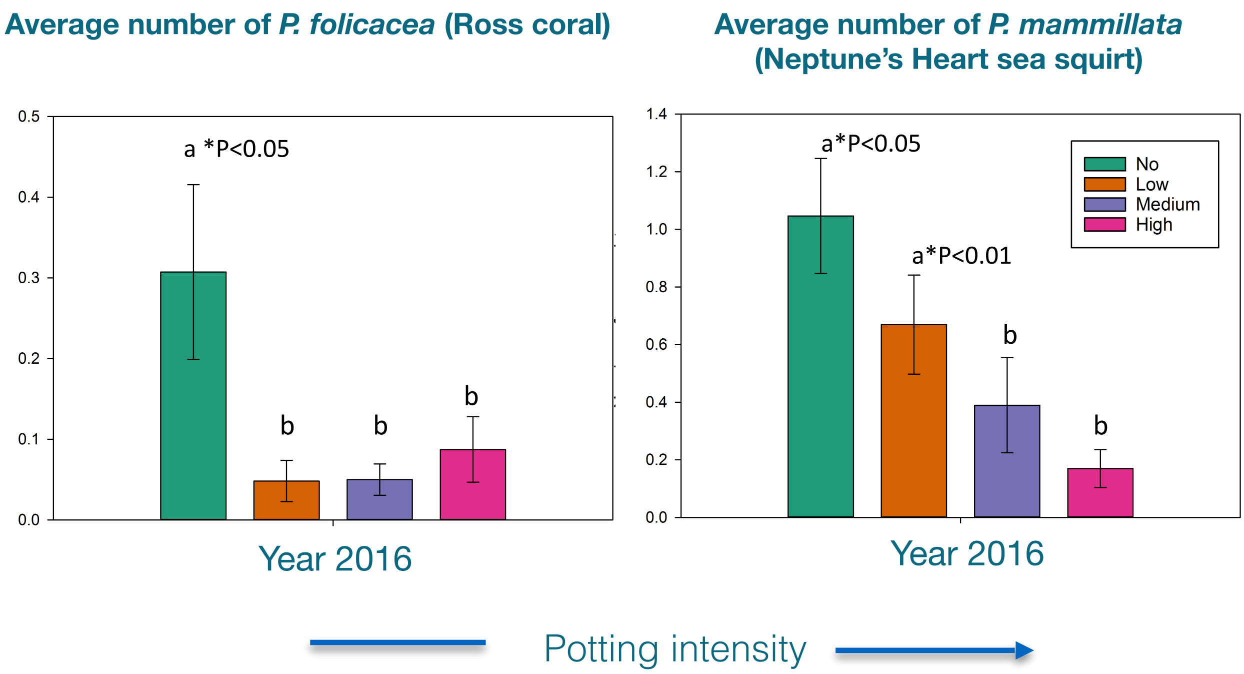


Figure 1.4 Total number of indicator species *Pentapora folicacea* and *Phallusia mammillata* with increasing potting intensity in 2016, quantified in study 1. Letters above bars denote significant differences.

recovery in the no potting areas only, and the white Neptune's Heart sea squirt (*Phallusia mammillata)* that showed positive recovery in the Low potting density and No potting areas (Fig 1.4).

Over time, it has been shown that *P. mammillata* recovery rate decreased with increasing potting density and a significantly lower abundance was observed in areas of Medium and High potting density. For *P. folicacea* all levels of potting activity (Low-High) impacted the recovery rate of this species, as significantly lower abundances were observed in these treatments.

Both of these key species are known to be impacted by bottom towed fishing, yet not considered to be impacted by commercial potting, as their populations have been recovering throughout Lyme Bay since 2008 (Sheehan *et al. 2*015). Results from this current study highlight that in a recovering system, where commercial potting is permitted, potting can impact the recovery of these species. Damage associated with potting activity on *P. folicacea* have been highlighted in previous studies, but observations of damage were from single or short term potting episodes. This damage has not been quantified until now and it is concluded here that over time repetitive damage from sustained potting activity on recovering populations of *P. folicacea* explain the decline in abundance seen within the potted treatments (Low, Medium, High) of this study.

image taken from www.google.co.uk

P. folicacea is a large erect bryozoan with low recoverability, which plays an important role in the formation of biogenic reef (Cocito and Ferdeghini 2001). This species forms an enveloping honeycomb structure, and is noted for being extremely slow growing, with some estimates at around 2 cm a year (MarLIN 2006; Jackson *et al.* 2008). *P. folicacea* is important for providing structurally complex habitat through the provision of interstitial spaces that form as part of its honeycomb. It is extremely functionally important to flora and fauna that use it as nursery habitat, for example juvenile fish species (Cocito and Ferdeghini 2001; Bradshaw *et al.* 2003). It also provides physical habitat which encourages the settlement of larvae, and provides structure for nest building reef associated fauna (Rodriguez *et al.* 1993; Pirtle *et al*. 2012), and if removed could impact the ecological function of reef habitat (Patzold *et al.* 1987).

image taken from www.google.co.uk

Phallusia mammillata is the largest solitary marine tunicate (seasquirt) inhabiting waters of the British Isles (Picton and Morrow 2016). It is a fast growing suspension feeder with low fecundity that can reach around 12 cm tall, growing at between

3-5 cm a year (Jackson *et al.* 2008). Typically found growing on hard substratum, this species has medium recoverability due to its medium survivability to disturbance and high repopulation ability (Langmead *et al.* 2010). This species again provides erect structure for the settlement of larvae, nursery for juvenile mobile species and laying of eggs or nests; much like the functional role *P.folicacea* occupies. The cellulose test of *P. mammillata* is tough, but the weight and tension of pots and their ropes would be enough to remove this species; as noted by Eno *et al.* (2001) ('evidence of some detachment of ascidians and sponges'), in the same way removal of sea whips (Hall *et al.* 2008) or sea fans (Eno *et al*. 1996, 2001) has also been observed.

More subtle impacts of potting were noted on the other indicator species but were not significant. During the study, populations of *E. verrucosa* and *A. digitatum* showed decreasing trends in both Medium and High potting treatments, while abundance stayed the same or increased in the lower density treatments however, these effects were marginal. These species have been observed growing within sediment on underlying hard substratum (Sheehan *et al.* 2013b), and this attachment potentially reduces the threat of being removed from the seabed (Newman *et al.* 2012), despite their survivability being considered as low (Jackson *et al.* 2008). Here, results suggest that susceptibility of these species to potting impacts is low.

Both of the impacted species form part of the associated Annex I reef communities of reef habitats in Lyme Bay, and are classified as indicators for recovery from in response to the exclusion of bottom towed fishing (Sheehan *et al.* 2013a). However these results should be considered in the context of the conservation objectives of the Lyme Bay MPA. The objectives state that the extent, structure and function of the reef species assemblage should be maintained or restored. The results from this project can provide fisheries managers with information assess the sustainability of this fishery when assessing the conservation objectives of the Lyme Bay MPA.

This study is the first of its kind, quantifying the impact of commercial potting on sessile reef habitats over multiple years; and has shown evidence of the first known ecological impacts associated with commercial potting.

1.3.2 **Ecosystem: <u>Study 2:</u>**

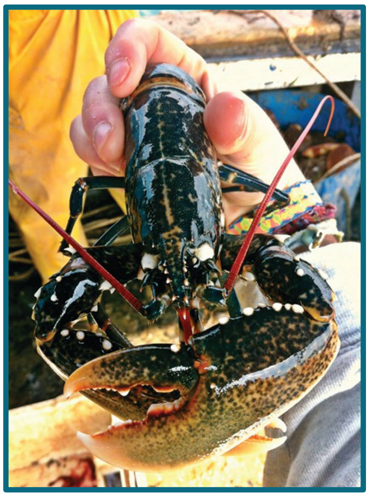
- *benthic macro-mobile species and assemblages*

In order to meet holistic assessment objectives the ecological changes to the mobile species associated with Lyme Bay reef habitats in response to increasing commercial potting density were additionally quantified. It has previously been shown that reef habitats and mobile communities are highly ecologically associated with each other (Bradshaw *et* *al.* 2003). Although not shown here, it is believed that there could be knock-on ecological impacts on mobile communities if a breakdown in the availability of key biogenic reef species was to occur. This is of particular interest in the context of a recovering MPA, and where biogenic reef species are theorised to play a valuable role in increasing the ecological resilience of MPAs (Howarth *et al.* 2014).

Baited Remote Underwater Video (BRUV) techniques were used to quantify the number and diversity of mobile species associated with the benthos in areas of different potting density. All mobile species were assessed, commercially targeted and non commercially targeted. Results showed there were no impacts of commercial potting, at both current and increased levels, on mobile communities as the number of individuals and species diversity remained consistent between all the potting densities. Considering the results from Study 1, which only showed impacts of potting on key indicator species after three years, this result could be interpreted as a lag between the impact on the sessile benthic habitat and the detection of consequent impacts on associated mobile species and communities. It is also possible that the extent of impact from elevated potting density on sessile benthic species is not enough to negatively impact associated mobile species. It is, again, noteworthy that the data collected here represents first example of quantification of the responses of reef associated mobile species to increases in commercial potting density.

1.3.3 **Fisheries: Study 3:**

- *impacts of increasing potting density on target fishery species and associated bycatch*



The impacts of increasing in commercial potting effort on target commercial fishery responses were also assessed. In Lyme Bay, predominant high value crustacean species targeted by potting are the brown crab (*Cancer pagurus*) and European Lobster (*Homarus gammarus*). Landings of these species have increased since the removal of bottom towed fishing pressures (Sheehan *et al.* 2013a; Rees *et al.* 2016), plus increased space and decreased conflict and competition between commercial potters, has contributed to the rise in commercial potting effort in the Lyme Bay MPA. Like the Studies 1 and 2, the effects of increasing potting on target fishery species were assessed against post storm baseline of 2014 for comparability. Results from the final year of the study (2016) are presented below for clarity. The behaviours of brown crab and European lobster make them inconspicuous in rocky reef habitats, and so the video survey techniques used in Studies 1 and 2 were unsuitable to collect necessary data for fisheries assessment, so a quantitative potting methodology was employed.

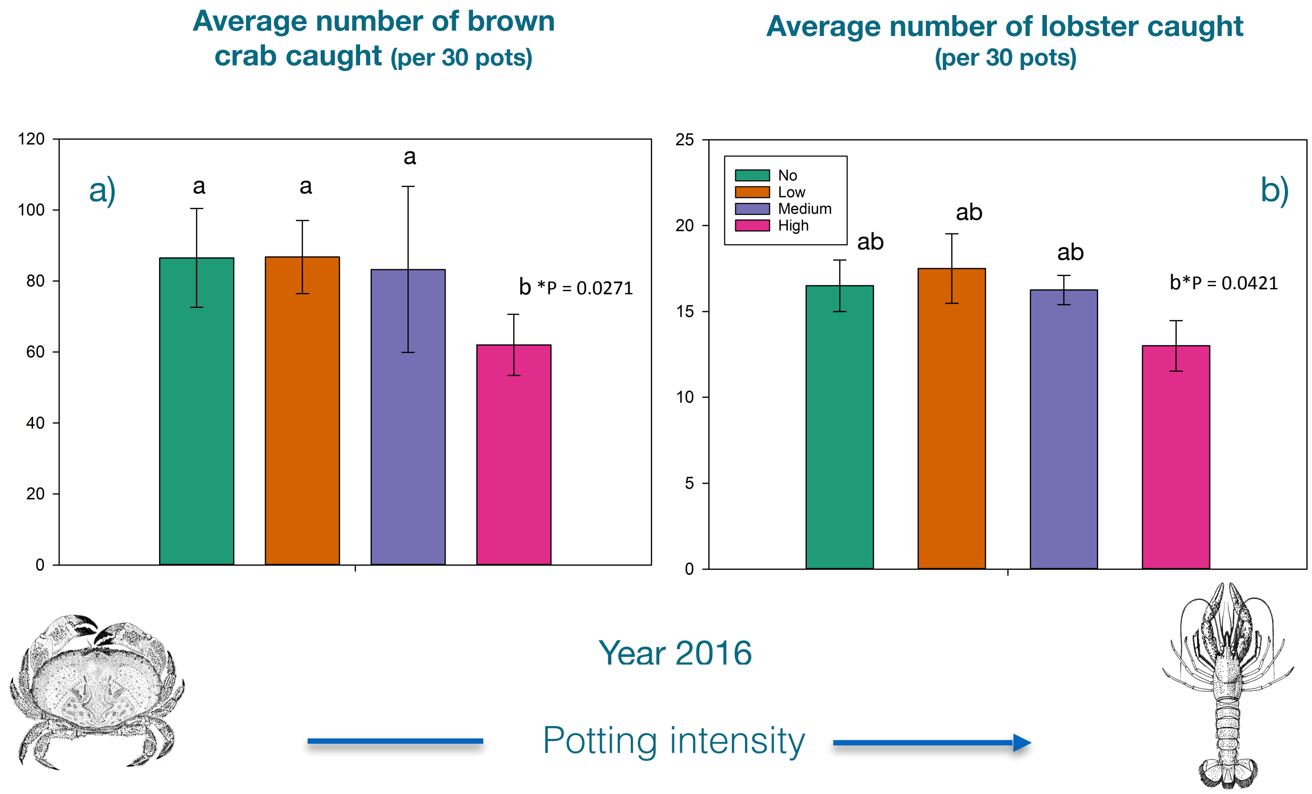


Figure 1.5 Average number of (a) brown crab and (b) European lobster caught (per 30 pots)in each potting density area in 2016. Letters above bars denote significant differences.

The research found that after three years a high density of commercial potting can impact these both of these target species. For brown crab (*C. pagurus*) a decline of almost 20% in the average number of crabs caught (per 30 pots) was observed in areas of high potting density (Fig.1.5a), while a similar decline (approx. 12%) was seen in lobster, *H. gammarus* (Fig.1.5b).

In addition, carapace size/weight analyses revealed the average individual crab weights in Medium and High potting areas were lower (approx. 9% ≈ 50 grams) than in Low potting density and areas on no potting, after three years (Fig. 1.6b). This change in weight is not being driven by a change in the carapace size of crabs being caught as this was not observed to change in response to an increase in potting (Fig. 1.6b).

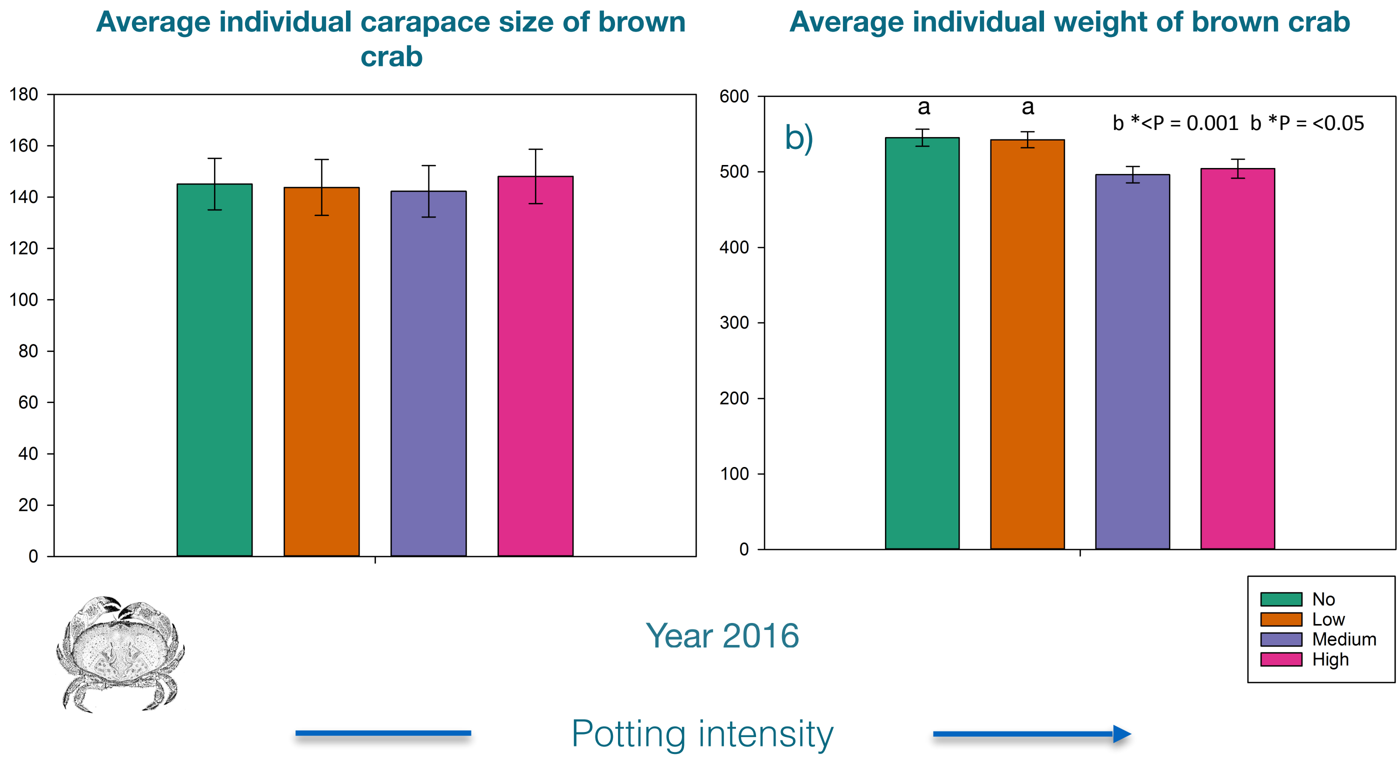
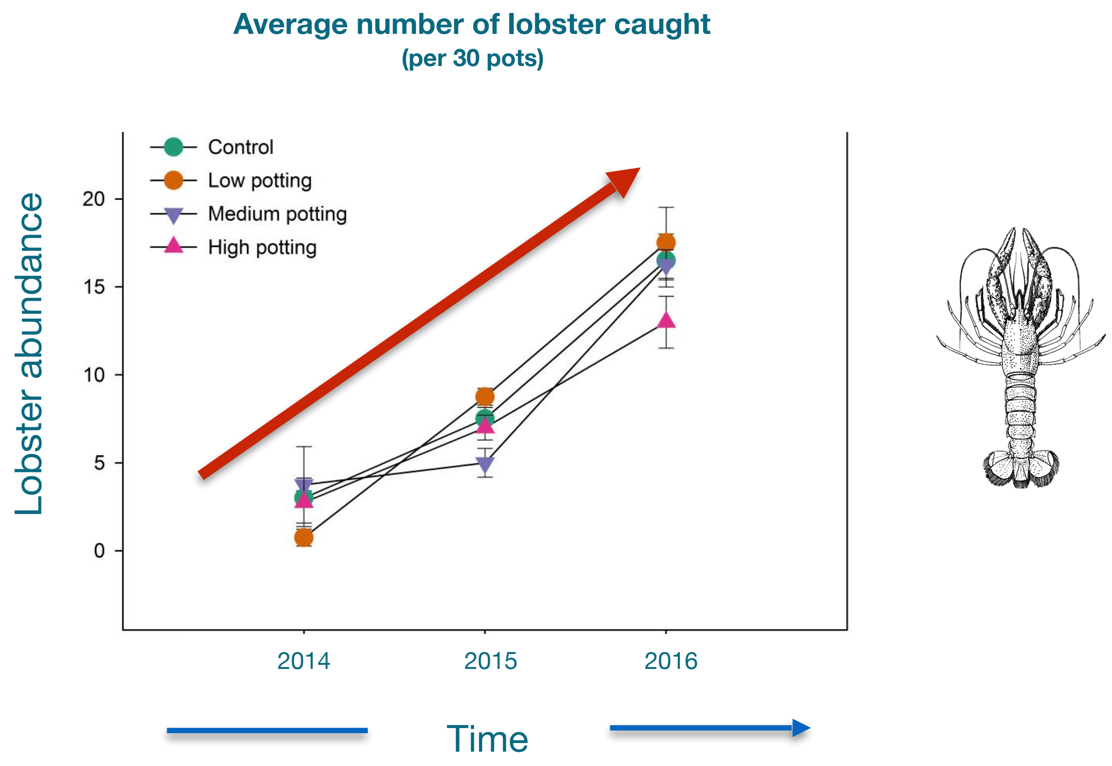


Figure 1.6 Average individual (a) carapace width (size) and (b) weight of brown crab caught in each potting density area in 2016. Letters above bars denote significant differences.

It is therefore concluded here that brown crab being caught in areas exposed to a Medium and High level of potting on average weigh less, and so overall *condition* of brown crab in these areas in concluded to be have decreased over time. It is suggested here that this could be due to a selective fishing pressure is being placed on adult brown crab driven by an economic incentive for commercial fishermen to select for heavier individuals of legally-sized brown crab, on account of their increased meat content leading to greater economic return at market (MMO 2015). The ecological consequences of this shift in overall condition are not known, however weight can be considered a proxy for muscle quality on account of blood protein content which increases with muscle content (ICES SGCRAB Report 2004). The energetic demands of growth and reproduction in brown crab are reliant on internal body composition. A reduction in average individual weight, and thus condition, among the brown crab population of highly potted areas could potentially impact the ecological processes of this species, including reproductive success and productivity (Levitan 1991).

For European lobster, *condition* was not impacted by increasing potting density and average individual weights and carapace lengths remained consistent. This suggests that commercial potting is not negatively impacting lobster condition after three years. However, it should be highlighted that, although outside the scope of this study, the number of lobsters and particularly juvenile lobsters has increased substantially during this study (Fig.1.7). This is representative of anecdotal conversations and comments made by the local fishermen, while highlights an increase in the health and productivity of the lobster fishery in Lyme

Bay. This is likely to be due to the protection from bottom towed fishing in Lyme Bay MPA, indicating the benefits this MPA is providing.



In conclusion, impacts on the average number of brown crab caught during experimental sampling were

Figure 1.7 Average total number of European lobster caught per 30 pots during sampling in each potting density from years 2014 - 2016.

seen in the areas exposed to commercial potting effort **above** current levels. It is important to consider these results in the context of the study, which artificially increased potting to a level beyond that of current levels in Lyme Bay, which represented a spatial maximum of potting effort (density of pots per 500 x 500 m area). While a decline in the *condition* of brown crab was observed in areas exposed to both **current** levels and **above** current levels of commercial potting in the Lyme Bay MPA, again it should be noted that this was observed in areas exposed to potting activity sustained over three years. While this may not be representative of the commercial potting activities in the Lyme Bay MPA, it does highlight potential impacts if potting effort if density and duration is replicated. If commercial potting is allowed to reach High levels for comparable lengths of time to this study then brown crab quality, and subsequently economic return for fishers, may decline over time. There was no observed impact on the quality of European lobster caught during the study, but the number of caught also declined in areas of High potting, again above current levels of potting in the Lyme Bay MPA.

This study is again the first of its kind, demonstrating impacts to target fisheries in response to increasing commercial potting.

1.3.4 **Fisheries: Study 4:**

- *Potential spillover benefits to fisheries of 'No potting' areas*

In order to test the fisheries benefits of areas of no potting on the target fishery species *C. pagurus* and *H. gammarus* further*,* their potential for providing spillover effects was assessed. Data were collected from three representative potting density areas. 'No potting' areas where all commercial potting activity had been removed, 'Current potting' treatment was areas exposed to current levels of commercial potting ('Medium' potting density units from experimental potting study), and 'Spillover' areas where an 80 m zone immediately surrounding each No potting treatment area were used to test for a spillover effect and to determine local spillover extent.

No spillover effects were found from no potting areas, however data collected in this chapter provides important baselines for future assessments of spillover and no potting area benefits to brown crab fisheries in particular. In addition, it provides further evidence and agreement with previous studies (Lambert *et al.* 2000; McClanahan and Graham 2005) regarding the timescales necessary for the occurrence of spillover effects. Spillover effects typically only manifest after a number of years protection, and after a density gradient has been built up between protected and unprotected areas (Gell and Roberts 2003). Here, it is theorised that over time spillover benefits should increase and be detected from the no potting areas in Lyme Bay, but this requires more in depth study.

1.4 **Summary**

This collaborative study has successfully controlled commercial potting effort within experimental areas and exposed areas of protected rocky reef habitat to a sustained gradient of increasing potting density inside the Lyme Bay MPA. This gradient included areas where potting was removed, areas that represented current levels of potting in Lyme Bay (Low-Medium) and areas where potting effort was experimentally increased (High) to replicate a scenario that demonstrated the highest level of potting (density of pots per unit area) possible. Impacts of increasing potting effort on both the *ecosystem* (Study 1,2) and *fisheries* (Study 3,4) were both assessed in order to test the efficacy of the Lyme Bay multi-use MPA in providing benefits to both. This research was part of a collaborative project funded by the Blue Marine Foundation, the results of which can now be taken forward to inform appropriate management. This study demonstrates the first quantitative assessment of the ecological impacts associated with increasing potting density, over a duration of three years. A summary of findings is presented below:

Ecosystem impacts summary

• Potting areas were spatially and temporally replicable and started from similar ecological baselines which allowed for changes over time to be confidently attributed changes in potting effort.

•The total number of sessile reef species decreased over time within the High potting density areas - with significant differences only being observed in the last year of the study (2016).

• This decline was largely driven by decline in two key indicator species: the Ross coral *Pentapora folicacea* and the Neptune's Heart sea squirt *Phallusia mammillata.*

• The indicator species *Pentapora folicacea* decreased by approximately 80% between areas of No potting and all potted areas, while *Phallusia mammillata* decreased by an average of approximately 25% as potting density increased.

• **However** these declines were observed in areas of elevated potting effort, higher than current levels in the Lyme Bay MPA. Results demonstrate a threshold (density of pots) at which potting impacts begin to be detected, if sustained over a long periods of time, and do not represent current commercial potting efforts in Lyme Bay.

• Potting effort in Lyme Bay and other commercial fisheries is spatially variable in practice. Potting fisheries do follow the seasonal movement of lobster and crab, and areas of habitat will be exposed to different potting levels throughout the year as target fishery populations move; often during times of spawning.

• Mobile reef associated species did not show any responses to increasing potting density.

Fishery impacts

• Over time the average number of brown crab caught in areas of Medium and High potting density declined by almost 20% in comparison to areas of low potting and areas where commercial potting has been removed.

• Average individual weight of brown crab also declined in Medium and High potting density areas, while carapace widths remained consistent and similar between potting densities.

• Overall *condition* of brown crab was therefore shown to decline in response to increasing potting density.

• For European lobster, the number caught declined by around 12% in the High potting density area in comparison to the lower potting density areas, in the last year of the project.

• Average individual weights and carapace lengths did not show any response to increasing potting density, so it is concluded that *condition* of lobster is not impacted by increasing potting density.

• However, the overall number of European lobster being caught during sampling tripled over the duration of the study (in all potting density areas) which highlights the benefits the Lyme Bay MPA is having on local lobster populations.

• Again, results were observed in areas exposed sustained, spatially restricted, potting activity.

1.5 **Conclusions: What does this mean for local commercial pot fishermen and the Lyme Bay *Reserve*?**

- This demonstrates a successful collaboration between fishermen and scientists to assess the impact of potting activity in an MPA.
- The study has not only provided evidence that can be used in management, but should invoke a sense of pride by all that were involved; particularly the local fishermen.
- This is highly valuable for Lyme Bay Reserve Brand and for local fishermen that stand to benefit, by providing robust evidence that the small boat potting 'way of life' is entirely viable and sustainable within a Marine Protected Area (demonstrated by Low level potting density results).
- A low density of potting has minimal impact on environment or target species.
- The results provide fisheries managers with the confidence that existing levels of potting within the Lyme Bay MPA are compatible with the conservation objectives of the site.
- However at high densities, indicative of maximum potting effort (higher than current potting effort in the Lyme Bay MPA) and sustained over three years, potting can damage the seabed ecosystem and reduce quality and quantity of target species.
- Regardless, this is the first time a "threshold" has been demonstrated for commercial potting effort.

The results provide a way forward for how to manage the Reserve, its activities and its fisheries, in order to maximise catch (total catch and economic return) and minimise ecological damage. This has been demonstrated by evidence of a relationship existing between potting density and quality of catch. Based on these results and circumstances, *fewer* pots in an area can equate *better* catches (total catch and economic return). This work can be used to add conservation credentials to the Lyme Bay Reserve Brand and allows the reserve brand to retain a clear USP and approach to local inshore fisheries management.

1.6 **Moving forward**

In management:

- How can these results inform management regulations that preserve Reserve fisher livelihoods and the environment?

For any future management of commercial fisheries, lessons from this study can be learnt. The introduction of a voluntary Code of Conduct will initially encourage buy-in from local fishers and voluntary management of commercial potting may help mitigate against intensive commercial potting and encourage future sustainability of this fishery. For Lyme Bay the following key questions remain: At present, **how do local fishermen manage potting density and the number of pots are put down in some areas?** Can mitigation approaches be first made to the voluntary Code of Conduct, in order to avoid certain areas being exposed to high potting density? If these questions can be answered then a well managed commercial potting fishery can be main achieved in Lyme Bay.

The impacted species, observed in Study 1, should be considered in the context of the conservation objectives of the Lyme Bay MPA. The objectives state that the extent, structure and function of the reef species assemblage should be maintained or restored. The results from this project can provide fisheries managers with information assess the sustainability of this fishery when assessing the conservation objectives of the Lyme Bay MPA.

- How can these results be applied to other case study areas?

At present over half of the UK's MPAs are being introduced to protect seabed reef habitats and features. Such habitats are important for supporting commercial potting. Like in Lyme Bay, it is likely that if areas are protected against mobile forms of fishing then static fishing methods could increase. An increase in static gear effort has been anecdotally observed within other UK MPAs, and so the evidence presented here should be used for proactive management of commercial potting activities, as opposed to reactive management.

In application

- How can this work be continued to give positive legacy to Lyme Bay Reserve and remain UK-leading?

- Could the No potting areas introduced as part of the project ("Lobster Reserves") be kept in place? For further monitoring and to allow more informative conclusions to be made?

The areas of no potting have provided some of the highest levels of protection in Lyme Bay, as these areas have removed commercial potting activity, albeit voluntary, within a wider MPA that restricts bottom towed fishing. The efforts that have gone into introducing these areas should not be undermined and of possible these no potting areas should remain in place and continue to be monitored to improve the long term data set from these areas, for ongoing and future assessments of recovery within the Lyme Bay MPA. The feasibility of this continuation is currently being discussed with representatives from the local fishing community.

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