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Lyme Bay - A case study

Response of the benthos to the zoned exclusion of towed demersal fishing gear in Lyme Bay; 5 years after the closure

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

In July 2008 the Department for Environment, Food and Rural Affairs (Defra) closed a 60 nm^2 area to bottom towed fishing gear. The main reason for this was to protect the benthic biodiversity in the bay, eg the species at the bottom, in particular to maintain the structure of the reef system and to enable the recovery of the bottom living invertebrates.

The closure was specific to the use of bottom towed fishing gear and the area remained open to sea anglers, scuba divers, other recreational users and fishers using static gear such as pots and nets.

From 2008-2011 the monitoring of the ecological and socio-economic changes that occurred following the closure was undertaken by a consortium led by Plymouth University and funded by Defra.

From 2012 to 2014 Natural England and Plymouth University jointly supported the continuation of the ecological component of the monitoring, enabling it to be done annually for a 4^{th}, 5^{th} and 6^{th} year.

Natural England will use the findings from this study as part of our work to monitor the recovery of the Lyme Bay site and where appropriate to guide site management.

This case study may also be of interest to other relevant stakeholders such as the Association of Inshore Fisheries and Conservation Authorities (IFCAs), Cefas, Wildlife Trusts, Seasearch, local authorities and fisheries.

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Further information
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Lyme Bay - A case study: Response of the benthos to the zoned exclusion of towed demersal fishing gear in Lyme Bay; 5 years after the closure

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Executive Summary

In July 2008 the UK Government (Defra) closed a 60 nm^2 area through a Statutory Instrument (SI) (The Lyme Bay Designated Area (Fishing Restrictions) Order 2008) to bottom towed fishing gear. The primary aim of the closure was the protection of benthic biodiversity, namely to ensure the structure of the reef system was maintained and to aid the recovery of the benthos. This closure was specific to the use of bottom towed fishing gear; however, the area inside the closure remained open to sea anglers, scuba divers, other recreational users and fishers using static gear such as pots and nets. The bay was then put forward as a candidate Special Area of Conservation (cSAC) by Natural England in August 2010 under the EC Habitats Directive.

Monitoring the ecological and socio-economic changes that occurred following the closure was undertaken by a Plymouth University led consortium and was funded by the Department for Environment, Food and Rural Affairs (Defra) from 2008-2011 (see Attrill et al. 2011; Mangi et al. 2011; Attrill et al. 2012 ; Mangi et al. 2012). Natural England and Plymouth University jointly supported the continuation of the ecological monitoring component in 2012 and 2013 enabling a 4th and 5th year of annual monitoring following the closure of the area and baseline study in 2008. Here we present the benthic data from 2008-2013. The 2013 data have been used to compare the assemblages in the cSAC and sites which continue to be fished, two years after the cSAC was implemented.

To remotely sample the epibenthic reef fauna, two methods were employed using High Definition (HD) video. Firstly, a towed flying array was developed to fly the camera over the seabed to sample the sessile and sedentary taxa (Sheehan et al., 2010. Secondly, cameras were deployed on baited, static frames to sample the reef nekton and mobile benthic fauna.

For the towed video analysis, four treatment levels (or experimental units) were used: the Statutory Instrument (SI), Pre-existing Voluntary Closure (PVC), Open Control (OC) and Sensitive Area (SA), (Table 2.1). Within each treatment there were five or six areas, each comprising 3 sites (200 m video transect), which were sampled in the summers of 2008, 2009, 2010, 2011, 2012 and 2013 (Figure 2.3). The same design principles were used for the baited video as the towed sampling, however, there were less sites due to logistical constraints. Sampling was carried out in summer 2009, 2010, 2011, 2012 and 2013.

Species counts were made from each entire video transect for infrequent organisms (all mobile taxa) and conspicuous sessile fauna. Frame grabs were extracted from the video to quantify the encrusting, sessile species, some abundant and free-living fauna. Taxa were recorded as density for the species counts and either density or percentage cover as appropriate for the frame grabs. Quantitative data were extracted from the baited video samples by counting the maximum number of each taxon seen in the field of view within 1 minute slices of video (to prevent counting mobile species swimming in and out of the frame several times). The resulting data were then analysed for differences between treatments for number of taxa, relative abundance, and assemblage composition. Analyses of the abundance and distribution of pre-determined indicator species were undertaken. Indicator species were identified as a result of Objective 1 in the 2009 report (Jackson et al., 2008) and representatives selected from the range of species of differing biological traits present in Lyme Bay (Jackson et al., 2008).

Overall, in 2013 9 out of 16 indicator species increased in abundance in the SI relative to the OC. Of the sessile indicator species, *Chaetopterus variopedatus*, hydroids and branching sponges increased in the SI. The abundance of four taxa had their greatest abundances in 2013 including *Phallusia mammillata* which is considered to have a medium potential for recovery.

Species showing evidence of recovery are *Phallusia mammillata* and *Pentapora fascialis.* Taxa showing a positive towards recovery are *Pecten maximus* and branching sponges. In this study, ‘recovery’ is defined as results showing a statistically significant interaction between Year and Treatment where SI increases relative to OC and approaches PVC. ‘positive response’ refers to when SI increases relative to OC, but does not necessarily converge with PVC, in that PVC may also increase, or show wide variability.

The baited video results show a significant Year x Treatment interaction for number of taxa and assemblage composition from 2009-2013. Abundance increased in all treatments after a dip in 2012 but number of taxa has decreased from 2012-2013.

The results of the 2011 and 2012 surveys showed a significant difference in abundance between the PVC and SA and also the PVC and OC but the SA was not significantly different to the OC. It is possible that the protection of the SA had not been in effect long enough to see alterations in the assemblage. The 2013 results however show that assemblage composition within sites in the SA was significantly different to PVC and OC sites for the first time. It is expected that over time the SA sites will become more similar to the PVC and less similar to the OC sites that continue to be fished.

It is hoped that annual sampling of the benthos in Lyme Bay will continue with a view to establishing conclusive signs of recovery in the SI for key indicator species within the ecosystem.

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1 Introduction

Lyme Bay, located off the south west coast of England is host to some of the UK's most important reef habitat and is considered to be both nationally and internationally important in ecological and conservation terms. The reef habitat in Lyme bay is unique due to its complex strata comprising a variety of bedrock with locally occurring stony reef (Natural England 2013). The priority Biodiversity Action Plan (BAP) species Pink Sea Fans *Eunicella verrucosa* and the nationally rare sunset cup coral *Leptopsammia pruvoti* are both known to occur in Lyme Bay (Cork et al 2008). It is also an important area for commercial fishing and has a substantial number of recreational users.

In July 2008, the UK Government (Defra 2008) implemented a Statutory Instrument (SI) - The Lyme Bay Designated Area (Fishing Restrictions) Order 2008, which closed a 60 nm^2 area of Lyme Bay to towed demersal fishing gear.

In 2010, a candidate Special Area of conservation (cSAC) was proposed to the EU which enveloped the SI extending to the east, south and west due to the presence of extended Annex 1 reef habitat (Natural England, 2010) (Figure 1.1). The cSAC was accepted by the EU in 2011 so that it is now designated as a Site of Community Interest (SCI). The cSAC complicated the study in that some of the 'open to fishing' controls became protected and some became part of a fishing monitoring trial (iVMS). Fishers involved in the trial were permitted to continue fishing inside the cSAC over ground that was away from 'Sensitive Areas' (Figure 1.2). Figure 1.2 shows the Marine Management Organisation (MMO) chart of management strategies in Lyme Bay.

The primary aim of the SI closure was the protection of benthic biodiversity, namely to ensure that the reef structure was maintained and to allow the recovery of the benthos. The reefs of Lyme Bay are defined under Annex 1 of the Habitats Directive and include outcropping bedrock, cobbles and boulders, which are characterised by species such as the sea squirt *Phallusia mammillata*, corals *Alcyonium digitatum* and *Eunicella verrucosa*, and bryozoan *Pentapora fascialis* (Figure 1.3).

Monitoring the ecological and socio-economic changes that occurred following the closure was undertaken by a Plymouth University led consortium and was funded by the Department for Environment, Food and Rural Affairs (Defra) from 2008-2011 (see Attrill et al. 2011; Mangi et al. 2011; Attrill et al. 2012). Natural England and Plymouth University jointly supported the continuation of the ecological monitoring component in 2013 enabling a 5th year of annual monitoring following the closure of the area in 2008. Here we present the benthic data from 2008-2013.

The objectives of this study were:

i. Quantification of sessile and sedentary benthic taxa using high definition video on a towed flying array at sites within and outside protected areas
ii. Quantification of reef-associated nekton and mobile benthic fauna using baited, static frames at sites within and outside protected areas.

The report should be read in conjunction with those from the 2010 and 2012 survey periods (Attrill et al. 2011, and 2013 *in press*). The results from last year can be found in the 2013 report and full details and methods for the work conducted can be found in the 2011 report. In the interest of brevity the full details of the methods have not been repeated.

The focus of the surveys was to measure the 'recovery' of epibenthic reef fauna. Recovery cannot be truly measured due to the absence of pristine sites for comparison. Recovery was, therefore, defined as:

Table 1.1 Definition of treatments showing time since protection for different management areas of Lyme Bay

Treatment	Code	Previous code	Definition
Pre-existing Voluntary Closure	PVC	CC	Closed to towed demersal fishing under voluntary agreements before SI implemented in 2008
Statutory Instrument	SI	NC	Towed demersal fishing gear excluded since July 2008.
Open Control	OC	NOC/FOC	Open to towed demersal fishing gear.
Sensitive Area	SA	NOC/FOC	Towed demersal fishing gear excluded since 2011. These sites were OC from 2008-2010.
Vessel Monitoring System	VMS	NOC	Towed demersal fishing gear excluded since 2011 except vessels with Lyme Bay Trial Vessel Monitoring System. These sites were OC from 2008-2010.

'newly protected areas becoming more similar to previously protected areas and less similar to areas which remained open to towed demersal fishing'.

As a result of the implementation of the cSAC and four years passing since the SI was instigated a rebranding for treatments and some sites was called for in 2012. This rebranding continues into the 2013 dataset. Inside the cSAC there are three treatment levels. The old Closed Controls are now referred to as Pre-existing Voluntary Closures PVC. The new closure sites are no longer new and are referred to by their legal designation which is Statutory Instrument SI. Areas in the cSAC, which are outside the SI and comprise reef are called Sensitive Areas SA. The areas that were previously fished and are now protected under the cSAC will be treated for analysis as OC from 2008-2010 (as they were NOC and FOC before rebranding) and SA from their designation in 2011 onwards. Areas outside the SI but inside the cSAC that were being used as the VMS trial allowing a subset of fishers to tow over the ground are not included in this report. It was also necessary to add new Open Controls (OCs) in 2011 to compensate for those lost when the cSAC was established.

The ‘open to fishing’ controls comprise one treatment level Open Controls (OC). The focus of the study was to measure the recovery of those sites inside the SI. Using the new treatments the updated hypothesis was:

‘over time the SI will become less similar to the OC and more similar to the PVC’.

The response variables used were species richness, abundance of count organisms, abundance of cover organisms, assemblage composition, and abundance of the indicator species (Jackson et al 2008).

The same hypothesis was also used to evaluate the recovery of the Sensitive Areas (SAs) which have been protected since the introduction of the cSAC: ‘over time the SA will become less similar to the OC and more similar to the PVC’. For these recently protected areas, assemblage composition change was considered.

Sites were selected to monitor reef defined as hard substratum, including stony reef, as described in Irving (2009). The towed biodiversity survey methodology was designed to be cost effective, efficient and non-destructive so as to be appropriate for use in protected areas. High Definition (HD) video was used, firstly on a towed flying array designed to fly the camera over the seabed to sample sessile and sedentary taxa, and secondly on baited, static frames to sample reef-associated nekton and mobile benthic fauna. Full methods can be found in Sheehan et al. (2010) and Attrill et al. (2011).

It is important to note that this was an observational rather than experimental survey. It was not possible to manipulate the level of fishing in the different treatments or choose the starting condition of the Statutory Instrument sites. Due to the large size of the study area some spatial and temporal variation was expected within treatments. To quantify the magnitude and direction of changes that have occurred following the SI implementation, sites were located in treatment specific areas in 2008 and have been resampled every year since. The baited video survey was an addition made by Plymouth University in 2009 sampling the same sites as the towed video annually.

In addition to monitoring the indicator species as identified by Jackson et al. (2008), all species that could be identified using the video were counted. This meant that assessment of the impact of the closure at the assemblage level could also be made.

For each sampling methodology the following response variables were considered:

i. Towed HD video: Species richness, Overall abundance (count organisms), Overall abundance (cover organism), Assemblage composition, Abundance of indicator species
ii. Baited Remote Underwater Video (BRUV): Species richness, Overall abundance, Assemblage composition, Abundance of indicator species.

In 2013, we published two papers in peer reviewed journals on our findings from Lyme Bay. The first, Sheehan et al (2013b) discusses the results of the first four years of data from the towed video. In the second, Sheehan et al (2013a) we investigate the recovery of assemblages in the cSAC on pebbly-sand habitats.

One of the benefits of video data is that it can be revisited and analysed. We made use of this by analysing video from the pebbly-sand areas around the defined reefs in Lyme Bay comparing 2008 with 2011. This is not included in the feature designation as it is not hard physical reef and does not have reef organisms on it. It also has previously been heavily fished. We found that since the closure of the cSAC to towed gear, the classic reef organisms that define the feature have been spreading over this pebbly-sand region and thus increasing the functional size of the reef above and beyond the designated feature. Clearly these areas between the reefs can be fully functional reef communities if allowed to be freed from fishing pressure, but up to now we have not known this due to the impact of fishing around the actual defined reefs.

If MPAs are managed on a feature basis, then (for example) scallop dredging could potentially be possible in such areas between reefs which are not the designated “feature”. However, we have shown that given time these also recover to support a reef community and thus the actual functional reef is much bigger than that physically designated. The only way to discover the true size of such features is therefore to manage the whole at the site level, not just protect individual features as that initial designation may be incorrect.

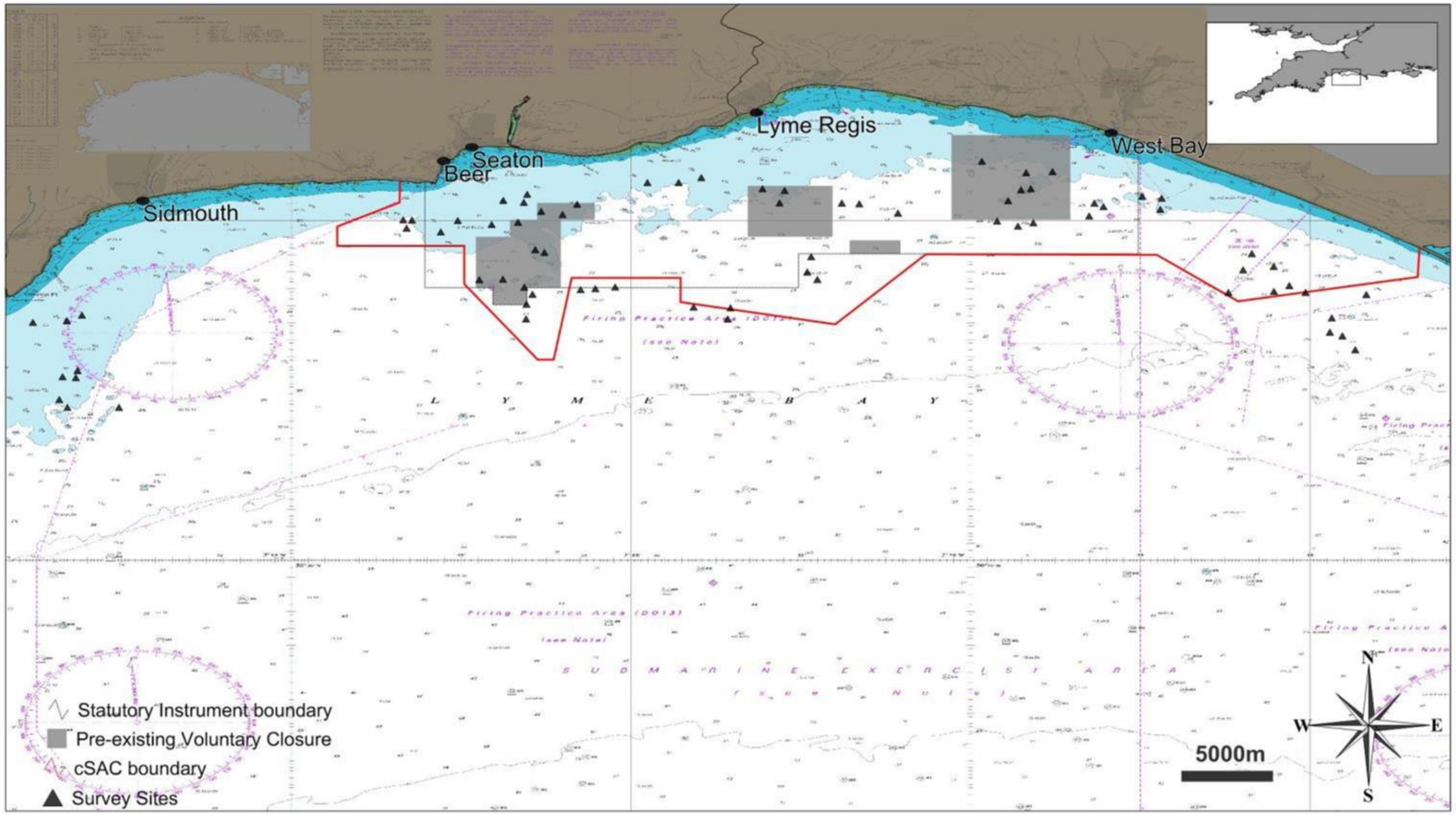

Figure 1.1 Lyme Bay showing the Statutory Instrument and cSAC boundaries. Survey sites are indicated by a black triangle.

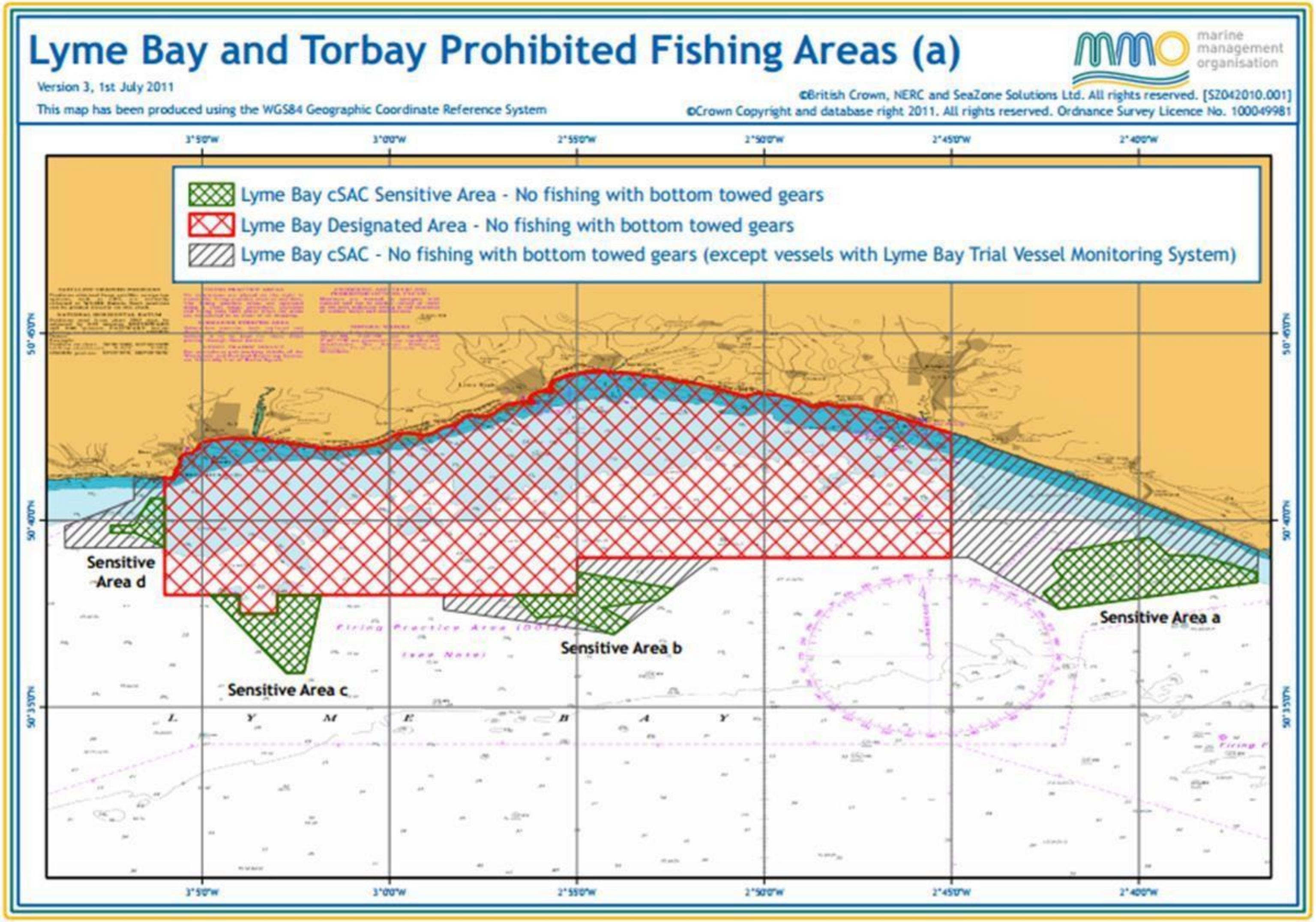

Figure 1.2 Chart showing management regimes in Lyme Bay

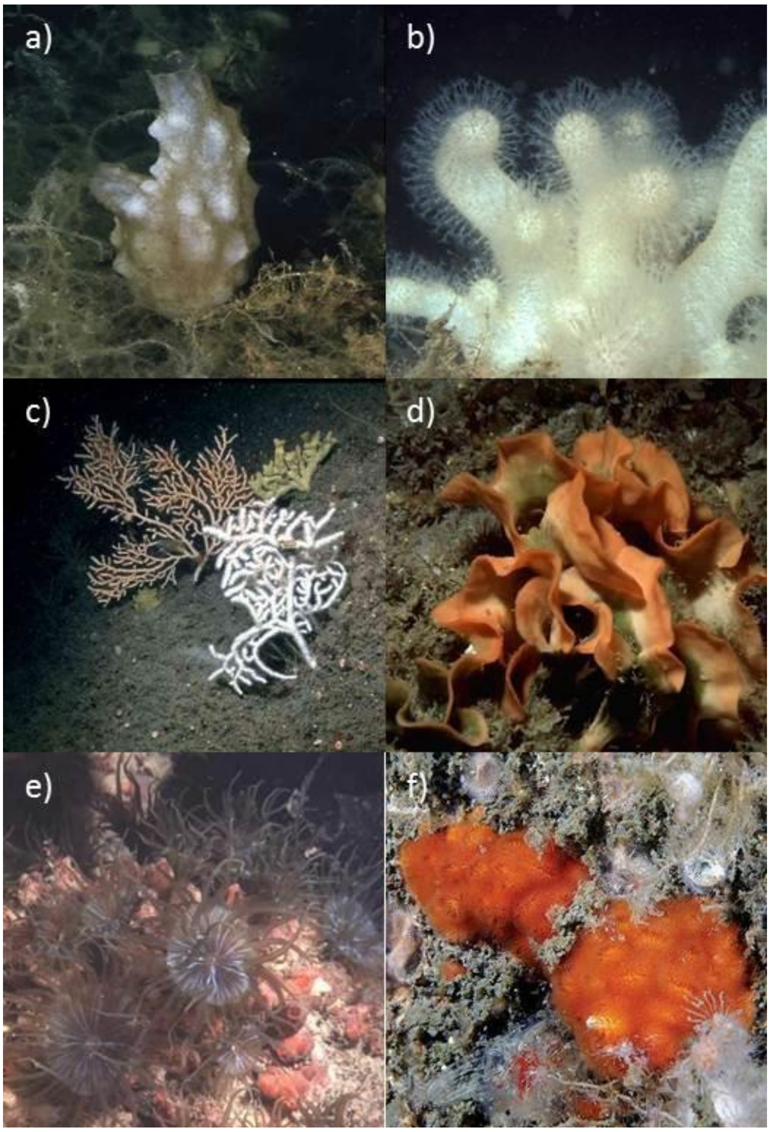

Figure 1.3 Examples of indicator Lyme Bay reef species; a) *Phallusia mammillata*, b) *Alcyonium digitatum*, c) *Eunicella verrucosa*, d) *Pentapora fascialis,* e) *Aiptasia mutabalis*, f) *Cellepora pumicosa* (Photos: Keith Hiscock)

2 Methods

2.1 Sampling methods

Methods for the 2013 survey period were consistent with previous years; these methods are briefly outlined below. Please refer to Sheehan et al. (2010) and Attrill et al. (2011) for details of the towed video and for details of both towed and BRUV respectively. As in previous years, all fieldwork was carried out from the vessel 'Miss Pattie', a 10 m displacement trawler. Sampling took place from the 15th of July 2013 to 7th of August 2013.

For each sampling methodology the following response variables were considered:

iii. A High Definition (HD) Towed video: Species richness, Overall abundance (count organisms), Overall abundance (cover organism), Assemblage composition, Abundance of indicator species

iv. Baited Remote Underwater Video (BRUV): Species richness, Overall abundance, Assemblage composition, Abundance of indicator species.

2.1.1 Towed video

To quantify changes in the abundance of sessile and sedentary benthic species, a HD video camera was mounted on a flying array (Figure 2.1). This method is particularly suitable for rapidly surveying large areas and is relatively low impact, which is necessary in a recovery study to avoid confounding assessments of change over time with impacts associated with the sampling method. It is also very applicable when sampling in areas of high conservation importance.

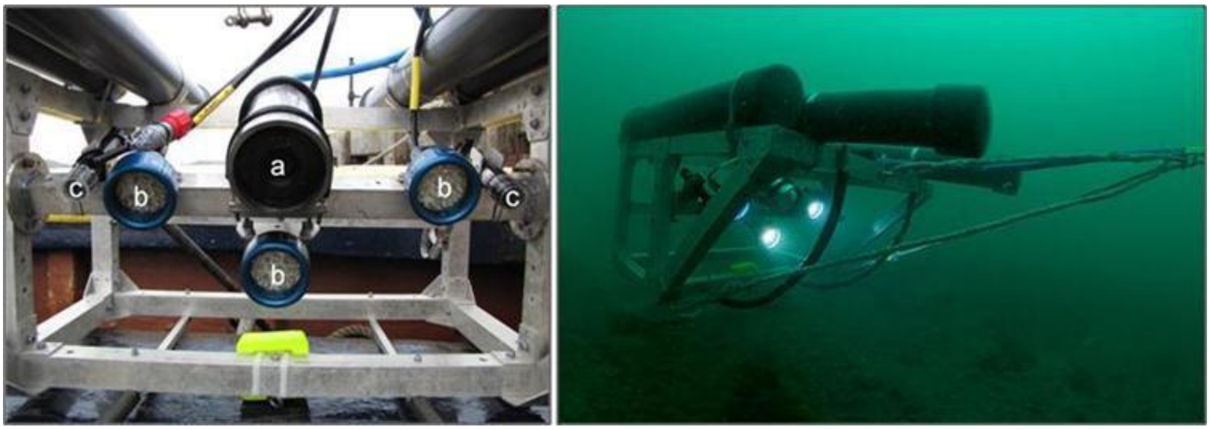

Figure 2.1 Flying array used for the towed video survey. a = high definition video camera, b = LED lights, c = lasers

2.1.2 Baited remote underwater video (BRUV)

To determine whether the closure affected reef-associated nekton species and mobile benthic fauna, BRUV was used. Methods were identical to those employed in 2011 as outlined in Attrill et al. (2011). The remote deployment of cameras on static frames increased sampling efficiency and statistical independence (Figure 2.2).

Figure 2.2 BRUV static frame with bait box developed for the 2011 survey

2.2 Sampling design (Towed and BRUV)

Species assemblages within the Statutory Instrument (SI) were surveyed at sites in treatment specific areas across Lyme Bay (Table 2.1, Figure 2.3, 2.4). The three treatments for towed and BRUV were Statutory Instrument, Pre-existing Voluntary Closure and Open to fishing Controls (Table 2.2). For the towed video each treatment comprised six or seven areas. Three replicate sites (200 m transect) were surveyed in each area in each year where possible. For BRUV there were six sites per treatment, selected as a smaller supplementary version of the towed survey. Survey locations were selected in 2008 before the baseline survey to control for habitat and fishing effort variability (Attrill et al. 2009).

New treatments arose as a result of changing management regimes in Lyme Bay in areas where sites were originally located (see introduction section 1.9). This allowed the conditions in the newly closed sites to be documented and the magnitude and direction of any changes to be determined (Figures 2.3, 2.4). Sites that are now in the area where the iVMS trial is taking place were not analysed as the level of fishing pressure has not been consistent.

Table 2.1 Definitions of survey units

Term	Definition
Site	A 200m transect (towed) or 3 camera drops (baited).
Area	A group of 3 sites that are averaged for statistics.
Treatment	An experimental unit with differing pressures e.g. PVC, SI or OC.

Table 2.2 Definitions and codes of survey treatments.

Treatment	Code	Definition
Pre-existing Voluntary Closure	PVC	Previously closed to towed demersal fishing under voluntary agreements in 2001.
Statutory Instrument	SI	Towed demersal fishing gear excluded since July 2008.
Open Control	OC	Open to towed demersal fishing gear.
Sensitive Area	SA	Towed demersal fishing gear excluded since 2011. These sites were OC from 2008-2010.
Vessel Monitoring System	VMS	Towed demersal fishing gear excluded since 2011 except vessels with Lyme Bay Trial Vessel Monitoring System. These sites were OC from 2008-2010.

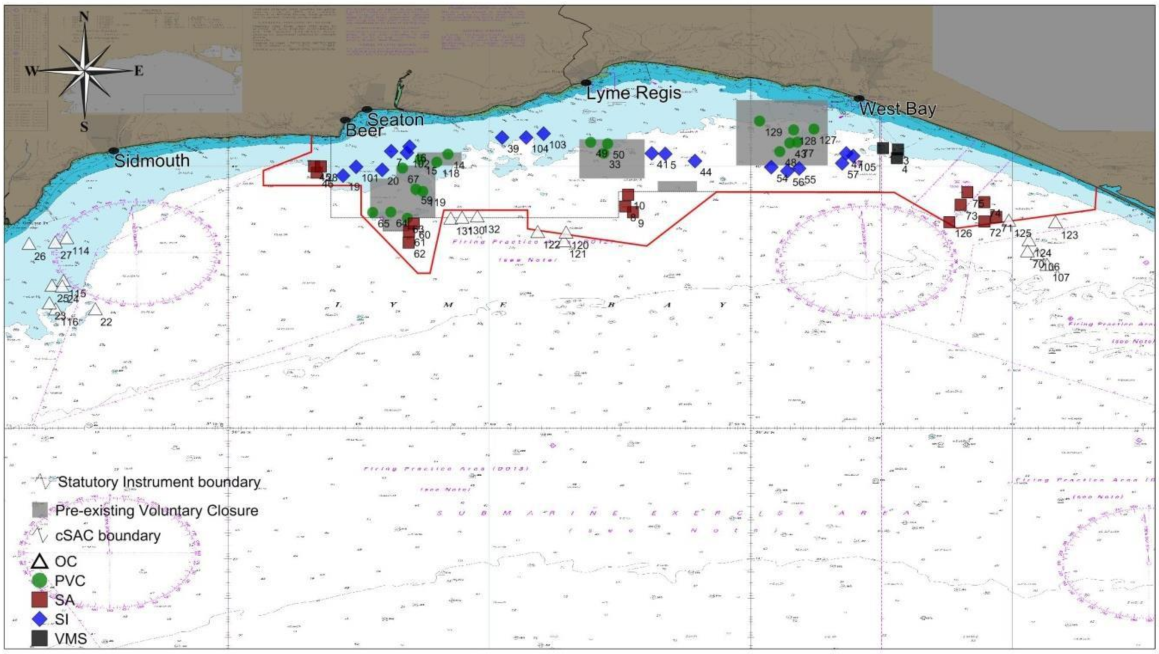

Figure 2.3 Locations of towed video transects in Lyme Bay coded by treatment (SI = Statutory Instrument, PVC = Pre-existing Voluntary Closure, OC = Open Control, SA = Sensitive Area, iVMS = inshore Vessel Monitoring System). Some symbols overlap at this scale

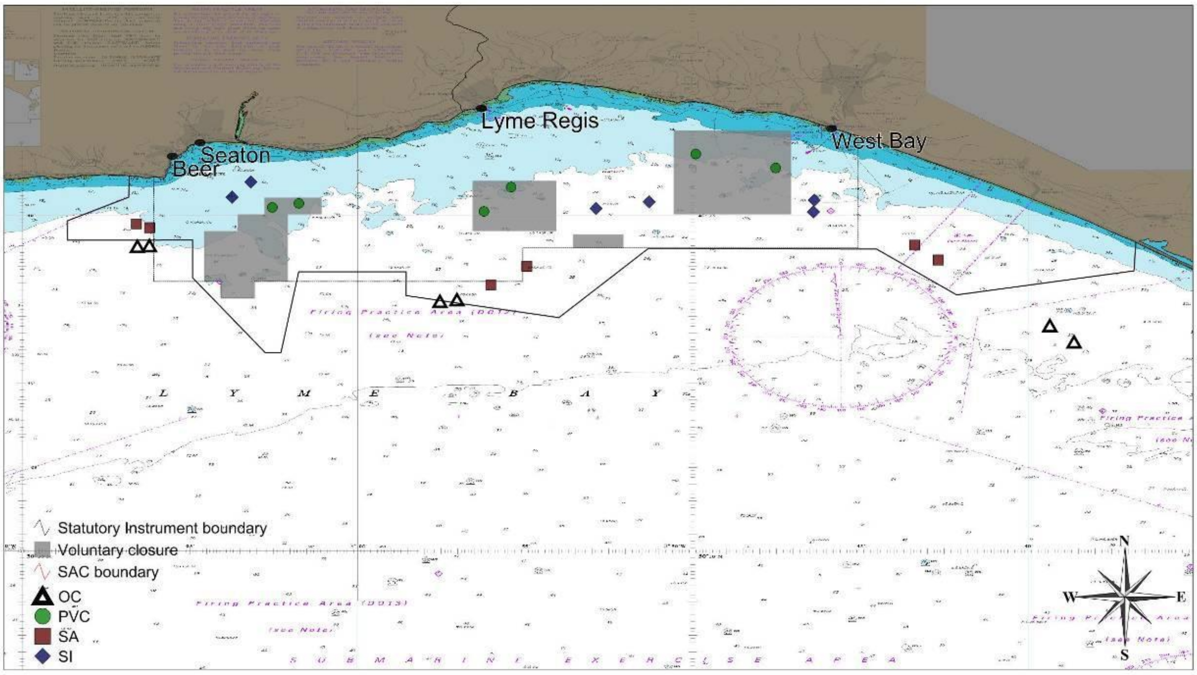

Figure 2.4 Locations of BRUV video sites in Lyme Bay coded by treatment (SI = Statutory Instrument, PVC = Pre-existing Voluntary Closure, OC = Open Control, SA = Sensitive Area). The boundaries of the SI (closure boundary), voluntary closures and the new cSAC are also shown. Some symbols overlap at this scale

2.3 Indicator species

Analyses of the abundance and distribution of 17 pre-determined indicator taxa as identified by Jackson et al. (2008) was undertaken (Annex A, Table A2). These were grouped into three categories; 'Key' species selected by Defra, 'Sessile' and 'Free living' by Jackson et al. (2008) and are presented in the same format here.

2.4 Video Analysis

For each analysis, all taxa present were identified and their abundance recorded. Identification was to the highest taxonomic level deemed possible although some groupings occurred due to between-species similarities, as outlined below. A full species list is presented in Annex A, Table A1.

Taxonomically similar species which could not be easily distinguished from each other were grouped:

i. All branching sponges, such as *Axinella dissimilis, Haliclona oculata, Raspailia hispida* and *Stelligera stuposa* were grouped as Branching sponges;
ii. The hydroid species *Halecium halicinium*, *Hydrallmania falcata* and unidentified hydroids excepting *Nemertesia antennina, Nemertesia ramosa* and *Gymnangium montagui*;
iii. The goby species *Gobius niger*, *Thorogobius ephippiatus* and unidentified gobies;
iv. The anemones *Aiptasia mutabilis*, *Cerianthus* spp. and *Peachia cylindrica* were grouped as Anemones because they were not differentiated in the 2008 survey;
v. The anemones Actinia spp. were identified to genus level;
vi. Flustridae spp. were identified to genus level;
vii. All red algae species;
viii. The sponges *Amphilectus fucorum* and *Iophon* spp. as *A. fucorum* is currently under taxonomic review (Ackers et al. 2007) and both genera are similar in appearance and have been classed as taxonomically difficult (Ackers et al. 2007).
ix. *Inachus* spp. and *Macropodia* spp. were identified to genus level. Additionally, for the baited video, and *Ophiura* spp. were identified to genus level, and *Triakidae* spp., was identified to family level.
x. Sponges that were not identifiable to species level were described and then identified as e.g. encrusting sponge 1, massive sponge 2 (Annex A, Table A1), ensuring taxonomic resolution was maximised.
xi. The term "turf" incorporated hydroid and bryozoan turf which projected less than 1 cm above the seabed surface.
xii. An organism which may be an alternative morph of the species *Cellepora pumicosa* was observed in 2012 and 2013. However these individuals could not be identified as such with confidence and so are excluded from the

indicator species abundance for *Cellepora pumicosa* and recorded as 'Bryozoan sp.'

2.4.1 Extraction of quantitative data from the HD video transect

Analysis of the video transects was conducted in two stages:

xiii. Species counts were made from each entire video transect by counting individuals that passed through the 'gate' formed by the two laser dots for infrequent organisms (all mobile taxa), and conspicuous sessile fauna (Annex A, Table A1).

xiv. 30 frame grabs were extracted from each video transect and overlaid with a calibrated grid to quantify the encrusting, sessile species, some abundant, free-living fauna and metrics of infaunal density and bioturbation such as burrow densities.

Taxa were recorded as density for the species counts and either density or percentage cover as appropriate for the frame grabs (Annex A, Table A1).

2.4.2 Extraction of quantitative data from Baited Remote Underwater Video

Quantitative data were extracted from the baited video samples by counting the number of mobile taxa in the field of view within one minute slices of video. These data were pooled to give relative abundance (mean min^{-1}) per species per replicate. This method ensures that species swimming in and out of the frame multiple times are not over represented.

For full details of these methods used please see Attrill et al. (2011).

2.5 Data analysis

Univariate and multivariate analyses were conducted using Permutational Multivariate Analysis of Variance (PERMANOVA, Anderson, 2001; Clarke, 2001) based on similarity matrices (univariate = Euclidean distance, multivariate = Bray Curtis similarity). Univariate data were Log (x+1) transformed and multivariate were dispersion weighted and fourth root transformed for towed video analysis and square root transformed for baited video (Anderson and Millar, 2004). The null hypothesis of no difference among species assemblages (see response variables, paragraph 1.10) between protected and fished treatments that is consistent over temporal and spatial scales was examined. Analyses were done using PRIMER 6 (Clarke & Warwick, 2001), with PERMANOVA + For PRIMER.

The factors used to test for recovery inside the SI relative to controls for towed video were Year (fixed: 2008, 2009, 2010, 2011, 2012, 2013), Treatment (fixed: PVC, SI, OC), Area (random and nested in Treatment: 6 or 7 within each Treatment), and Site (random and nested in Treatment and Area; 3 per Area). The 30 frame grabs per site were averaged to avoid pseudo replication. To test for recovery in the SA the factors used were Year (fixed: 2011, 2012, 2013), Treatment (fixed; PVC, OC, SA), Area (random and nested in Treatment) and Site (random and nested in Treatment and Area).

To test for recovery in the SI using the baited video, the factors were Year (fixed: 2009, 2010, 2011, 2012, 2013), Treatment (fixed: PVC, SI, OC), and Site (random: six per treatment) with three replicates per site. The three replicates were averaged as with the frame grabs to avoid pseudo replication and to increase the measured precision of the mobile fauna assemblage. To test for recovery in the SA the factors used were Year (fixed: 2011, 2012, 2013), Treatment (fixed; PVC, OC, SA) and Site (random and nested in Treatment).

The life history of each indicator species dictated which sampling method dataset was used (see Tables 3.3, 3.4, 3.5) for each species specific univariate analysis.

Measures of abundance presented in the results appear with different units depending on the survey method from which they were derived. The units were not mixed within any single analysis. Individual or discrete colonial organisms counted within entire video transects (video transect data) are expressed as incidence per linear metre of each transect, (m^{-2}) with standard error of the mean (± SE). Individual or discrete colonial organisms counted within the 30 frames sub-sampled from each video transect are expressed as densities (m^{-2} ± SE). Cover-forming colonial taxa quantified from the frame grabs are expressed as percentage cover (% ± SE). Counts of benthic-associated nekton derived from the BRUV surveys are expressed as the mean number of fish appearing within a one minute segment of video (min^{-1} ± SE).

Ophiothrix fragilis was excluded from the analysis as their abundance could not be recorded reliably from video, and their density did not allow identification of habitat type.

3 Results

The visibility in the 2013 towed video and baited survey was excellent (Figure 3.1 and 3.2). A total of 182 taxa from 11 phyla were recorded in the surveys; 136 count taxa and 20 cover taxa were recorded in the frame grab analysis, 60 in the video analysis and 53 in the baited video (Annex A, Table A1). Of the species recorded through counts from the quadrat data, hydroids had the greatest mean abundance (80.02 m^{-2} ± 1.2), followed by bryozoan *Cellepora pumicosa* (6.50 m^{-2} ±0.17) and hermit crab *Pagurus bernhardus* (4.7 m^{-2} ± 0.16). “Turf” had the greatest mean percentage cover (18.41 m^{-2} % ± 0.24), and out of the cover taxa identified to species *Lithophyllum incrustans* had the greatest mean percentage cover (0.12 m^{-2} % ± 0.01). For conspicuous sessile and mobile species quantified in the video transects, *A. digitatum* was the most abundant sessile species (0.98 m^{-2} ± 0.09), branching sponges second (0.22 m^{-2} ± 0.03), followed by *Eunicella verrucosa* (0.20 m^{-2} ± 0.03) and *Pentapora fascialis* (0.14 m^{-2} ± 0.02). Of the free living species, abundance of *Pagurus spp.* (1.03 m^{-2} ± 0.20) was greatest, followed by *Aequipecten opercularis* (0.88 m^{-2} ± 0.09), *Asterias rubens* (0.41 m^{-2} ± 0.03) and *Pecten maximus* (0.25 m^{-2} ± 0.01).

The species that were observed in the towed video survey for the first time in 2013 include anemones *Actinia* spp., sea mouse *Aphrodita aculeata,* the colonial ascidian *Polyclinidae* sp.*,* the erect bryozoan *Bugula* sp.*,* live maerl fragments and the sea fan nudibranch *Tritonia nilsodhneri.*

From the baited data, *Trisopterus minutus* had the highest abundance of all nektonic taxa min^{-1} ± 0.39), followed by Gobies spp. (0.83 min^{-1} ± 0.10) and of the cryptic species *Pagurus bernhardus* had the greatest mean abundance (3.17 min^{-1} ± 0.52), followed by *Ophiura* spp. (2.49 min^{-1} ± 0.47).

For each PERMANOVA table (Annex B), significant low level spatial or temporal differences were not further interpreted as the hypotheses did not relate to spatial differences between areas in the bay or overall differences between years. While significant Treatment differences were further interpreted, the main focus for further interpretation was if there was significant Year x Treatment interaction that could indicate recovery.

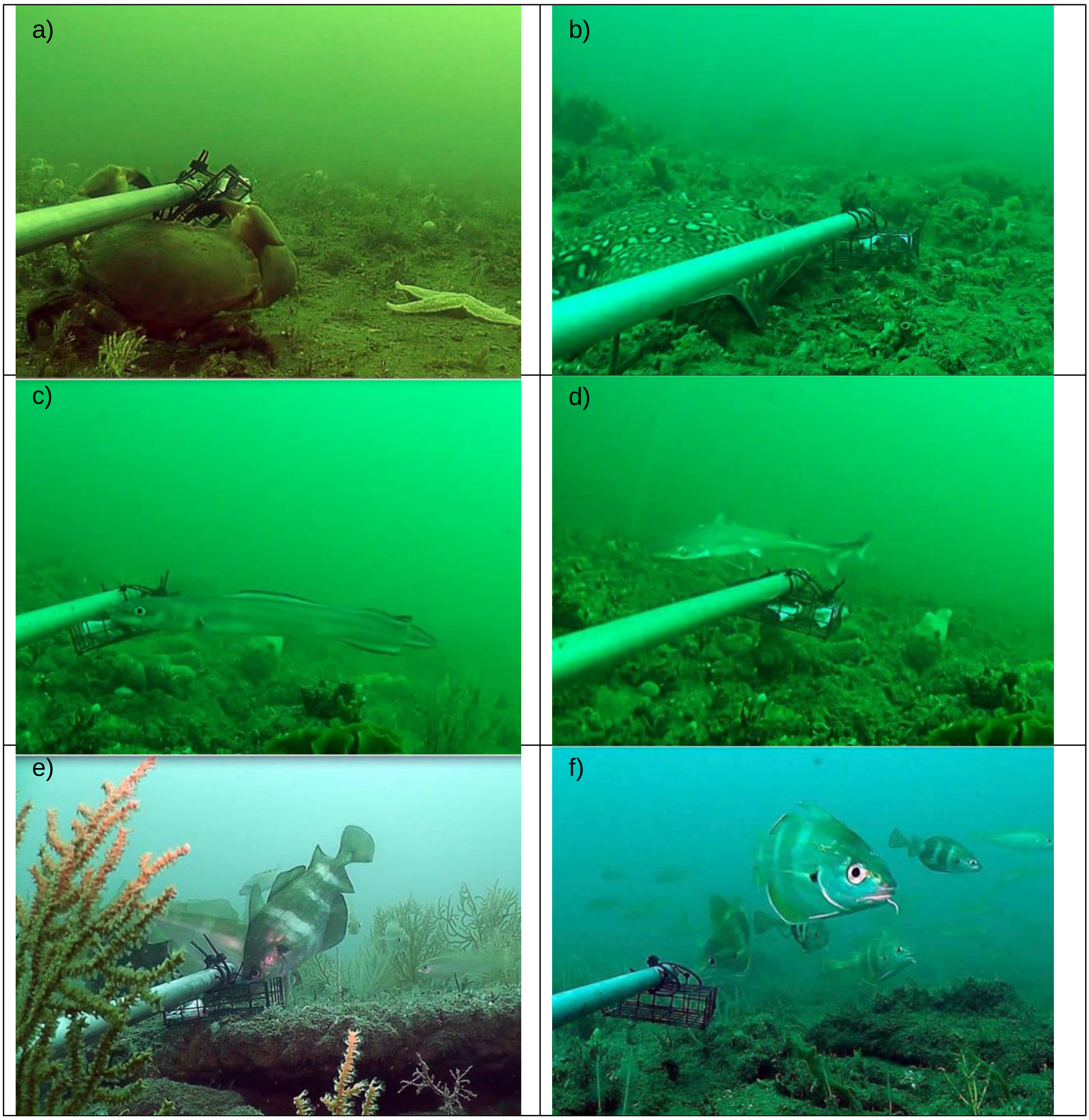

Figure 3.1 Images from the baited video survey 2013; a) *Cancer pagurus*, b) *Raja clavata*, c) *Conger conger*, d) *Galeorhinus galeus* (recorded as part of the Blue Marine Foundation project in the PVC) and e & f) *Trisopterus luscus*

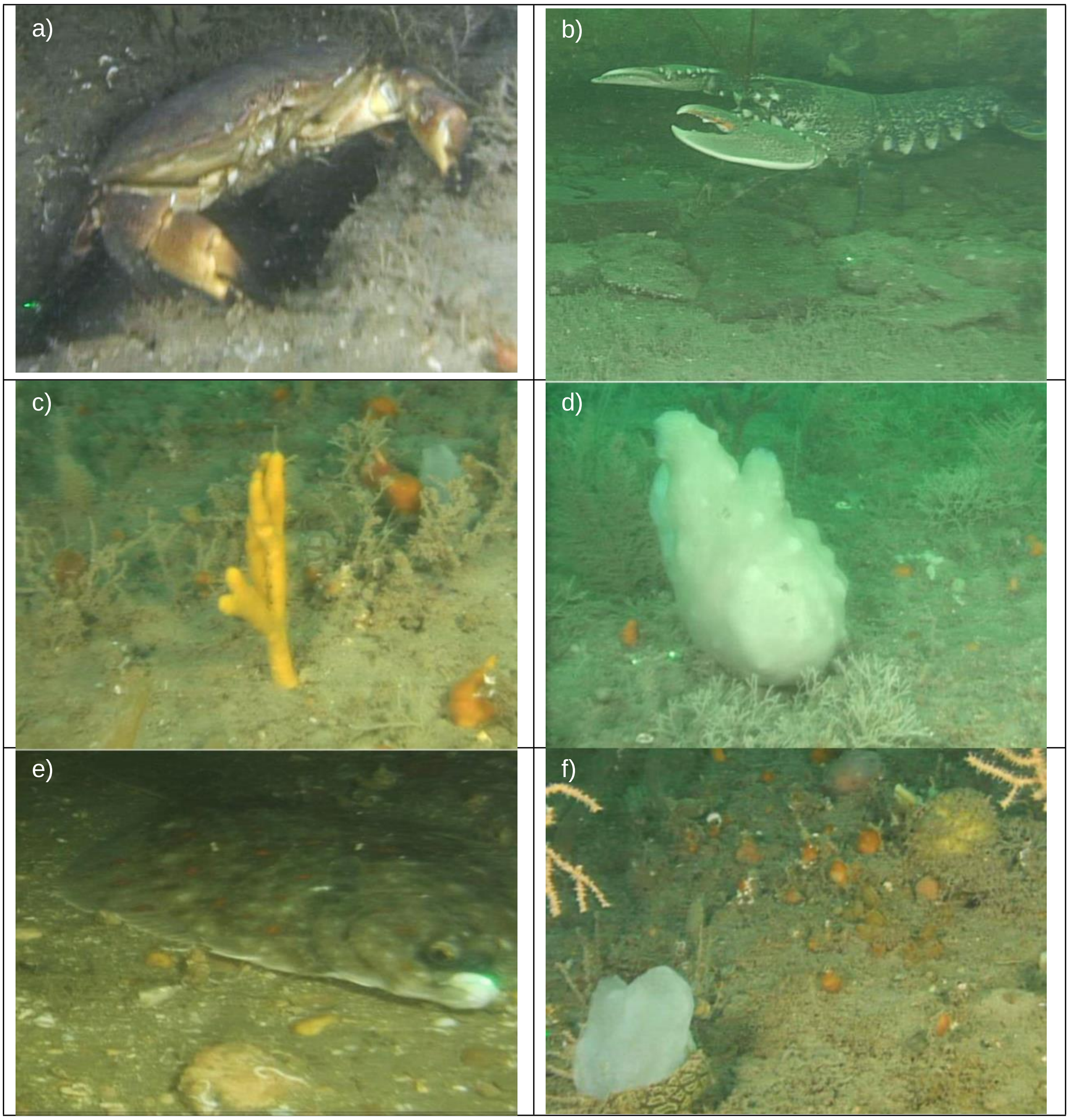

Figure 3.2 Images from the towed video survey 2013; a) *Cancer pagurus*, b) *Homarus gammarus*, c) Branching sponge, d) *Phallusia mammillata*, e) *Pleuronectes platessa* and f) reef assemblage.

3.1 Frame grab data

3.1.1 Overall Abundance

Abundance of count taxa (number of individuals) increased in the SI from 2012-2013 (116 m^{-2} ± 10.04 and 301.09 m^{-2} ± 42.38 respectively). From 2008-2013 abundance was greatest in the PVC in 2011 (381.12 m^{-2} ± 58.62) and lowest in the OC in 2008 (43.78 m^{-2} ± 6.65) (Figure 3.3). Significant Year ($P < 0.01$) and Treatment ($P < 0.01$) effects were identified. No significant Year x Treatment interaction was found (Annex B, Table B1).

Abundance of cover taxa (percentage cover) increased from 2012-2013 (24.64 % m^{-2} ± 4.04 and 31.03 % m^{-2} ± 7.32). From 2008-2013 abundance was greatest in the SI in 2011 (53.38 % m^{-2} ± 5.92) and lowest in the OC in 2013 (3.22 % m^{-2} ± 1.16) (Figure 3.4). Significant Year and Treatment effects were identified (both $P < 0.01$). No significant Year x Treatment interaction was found (Annex B, Table B2).

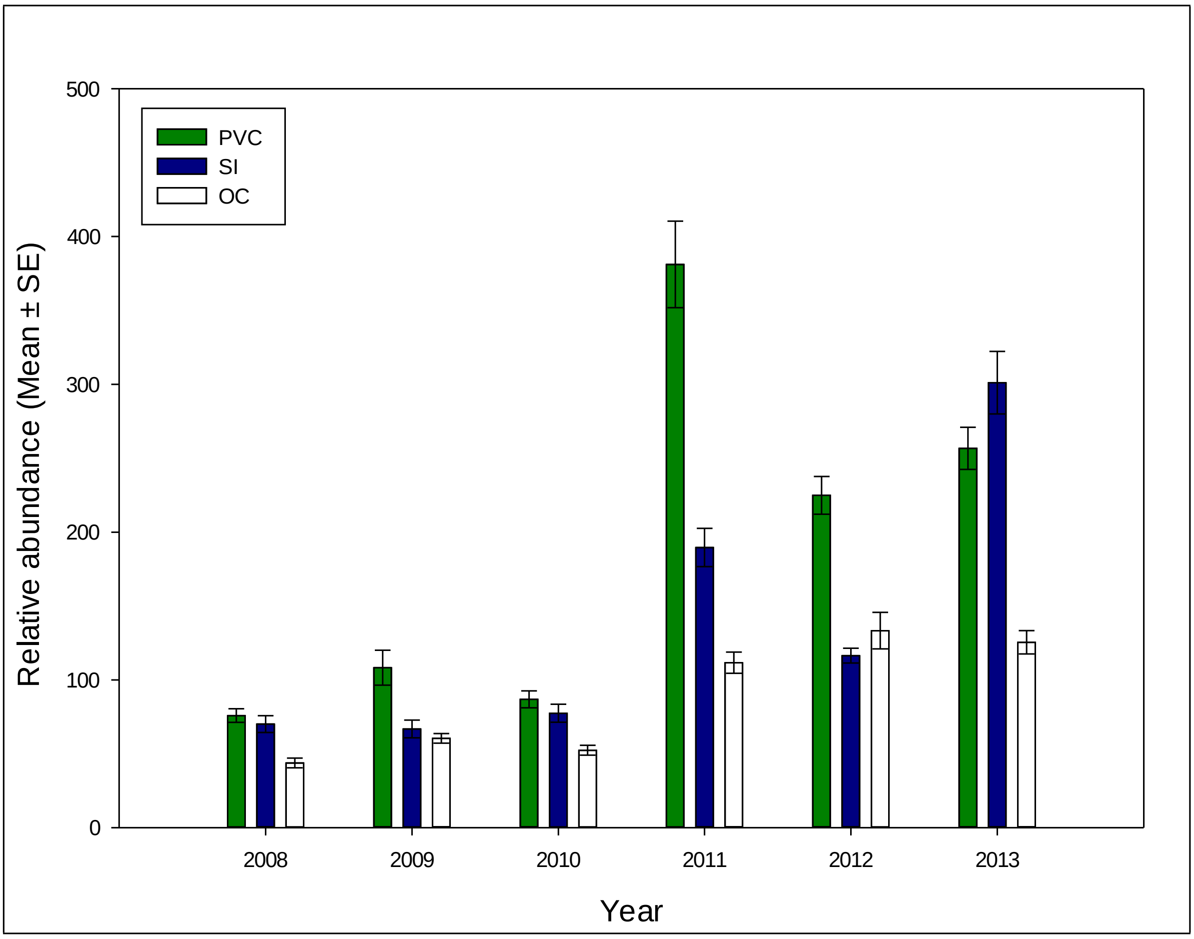

Figure 3.3 Abundance (mean m^{-2} ± SE) of count fauna (N) for each treatment (PVC = Pre-existing Voluntary Closure, SI = Statutory Instrument, OC = Open Control) in 2009, 2010, 2011, 2012 and 2013

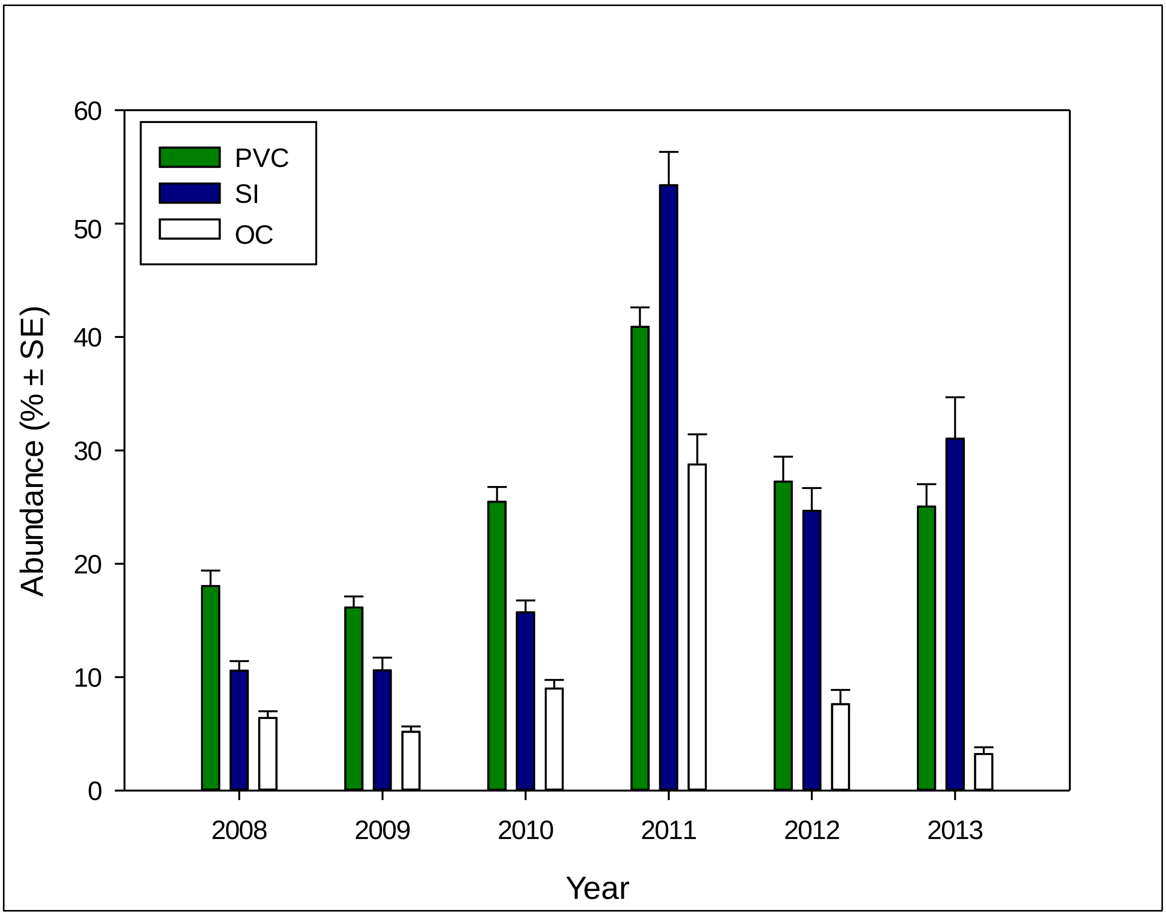

Figure 3.4 Abundance (% ± SE) of cover fauna (N) for each treatment (PVC = Pre-existing Voluntary Closure, SI = Statutory Instrument, OC = Open Control) in 2009, 2010, 2011, 2012 and 2013

3.1.2 Number of taxa

Both Year and Treatment had a significant effect on the mean number of taxa (both P < 0.01), although no Year x Treatment interaction was found (Annex B, Table B3). Mean species richness was greatest in the SI in 2013 (32.28 m^{-2} ± 1.35) and lowest in the OC in 2010 (13.86 m^{-2} ± 0.66), (Figure 3.5).

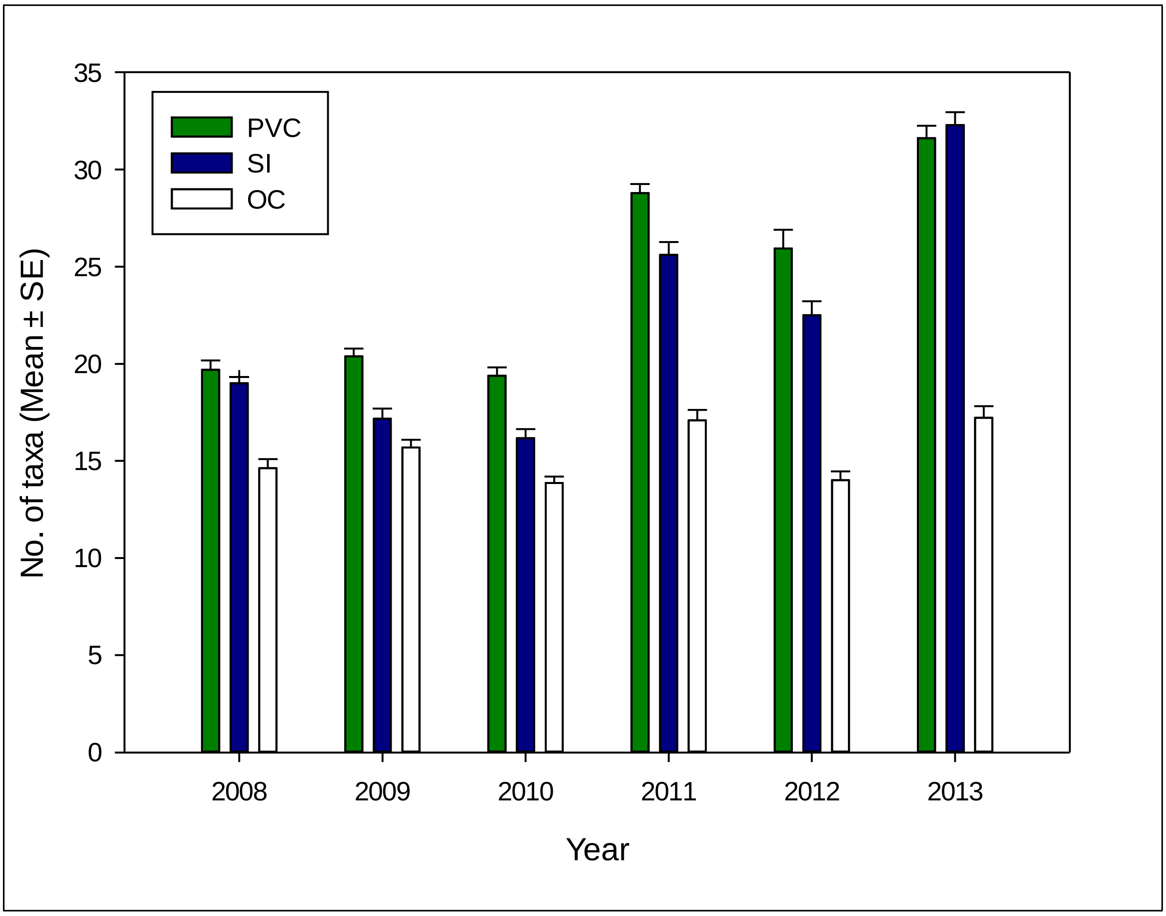

Figure 3.5 Number of taxa (Mean^{-2} ± SE) for each treatment (PVC = Pre-existing Voluntary Closure, SI = Statutory Instrument, OC = Open Control) in 2009, 2010, 2011, 2012 and 2013

3.1.3 Assemblage composition

Assemblage composition was significantly different for every factor tested (all $P = 0.0001$) (Table 3.1). Pairwise tests for Year x Treatment interaction showed that across all years the PVC and the SI were significantly different from the OC for assemblage composition (all $P < 0.05$). In addition in 2011 and 2013, the assemblage composition of the PVC and SI were significantly different to one another (all $P < 0.05$) (Annex B, Table B4).

The results from SIMPER analysis show that hydroids, turf, Alcyonidium diaphanum, Ocnus planci and Cellepora pumicosa contributed most towards the differences in assemblage between the OC and SI in 2013.

Table 3.1 PERMANOVA results for the relative abundance of the main assemblage count species identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were dispersion weighted and forth root transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference

Source	***df***	**SS**	**MS**	***F***	**P**
Year Ye	5	70953	14191	10.581	**0.0001**
Treatment Tr	2	82801	41400	7.2148	**0.0001**
Area Ar(Tr)	23	103760	4511.4	4.6985	**0.0001**
YexTr	10	19171	1917.1	1.8392	**0.0001**
Site (Ar(Tr))	67	60442	902.12	1.6791	**0.0001**
YexAr(Tr)	72	68361	949.46	1.7672	**0.0001**
Residual	167	89725	537.28		
Total	346	495220			

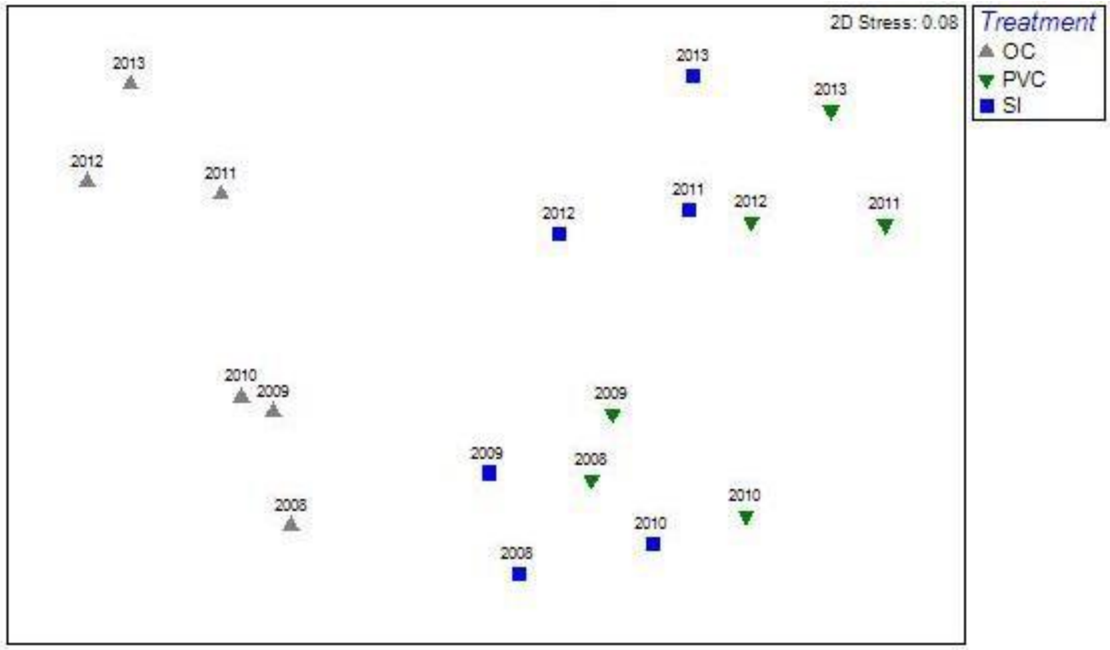

Figure 3.6 nMDS plot illustrating similarities in assemblage composition between Treatments (averaged for site within treatment), (Pre-existing Voluntary Closure = green triangles, Statutory Instrument = blue squares, Open Control = grey triangles), over time (2008, 2009, 2010, 2011, 2012, 2013)

The SI is moving in a similar direction to the PVC, away from the OC. In 2012 they moved back towards the OCs but in 2013 the PVC and SI paths are again on a trajectory away from the OCs (Figure 3.6).

3.2 Baited Remote Underwater Video data

A total of 53 taxa from six phyla were recorded during the BRUV surveys, consisting of 28 fishes, 12 crustaceans, four echinoderms, one echiura, one hydrozoan and seven molluscs (see Annex A, Table A1 for details).

The species that were observed in the baited video for the first time in 2013 were the rockling *Gaidropsarus* spp., Pollack *Pollachinus pollachius* and the seven armed starfish *Luidia ciliaris*.

3.2.1 Abundance

Mobile species abundance was greatest in the OC in 2011 (19.05 min^{-1} ± 3.49) and lowest in the PVC in 2009 (3.67 min^{-1} ± 0.72) (Figure 3.7). A significant difference was identified between Years ($P < 0.001$) but no Year x Treatment interaction was identified (Annex B, Table B5).

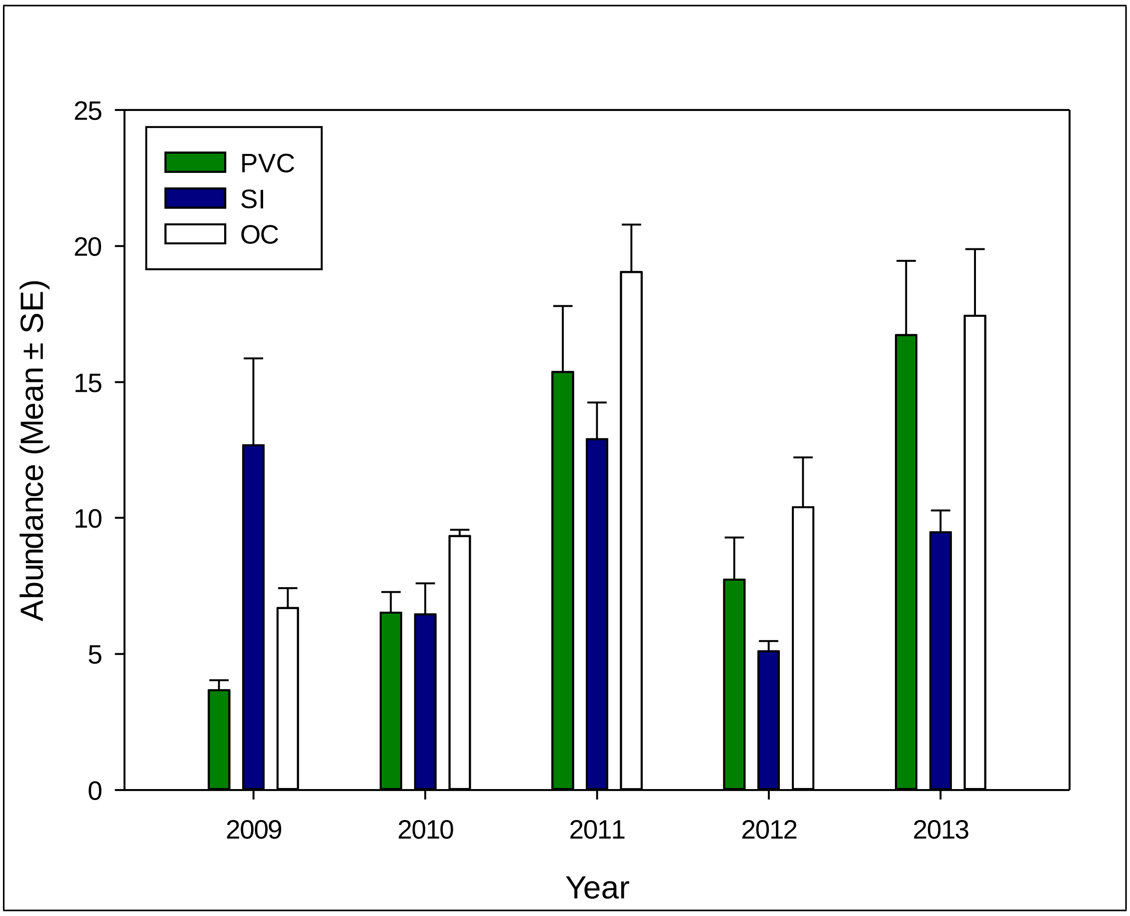

Figure 3.7 Abundance (Mean min^{-1} ± SE) of mobile fauna (N) for each treatment (PVC = Pre-existing Voluntary Closure, SI = Statutory Instrument, OC = Open Control) in 2009, 2010, 2011, 2012 and 2013

3.2.2 Number of taxa

Mean number of taxa was greatest in the SI in 2011 (11.0 min^{-1} ± 1.90) and lowest in the PVC in 2009 (5.67 min^{-1} ± 0.56) (Figure 3.8). A significant difference was identified between Years, and a significant Year x Treatment interaction was identified (both $P < 0.05$; Annex B, Table B6).

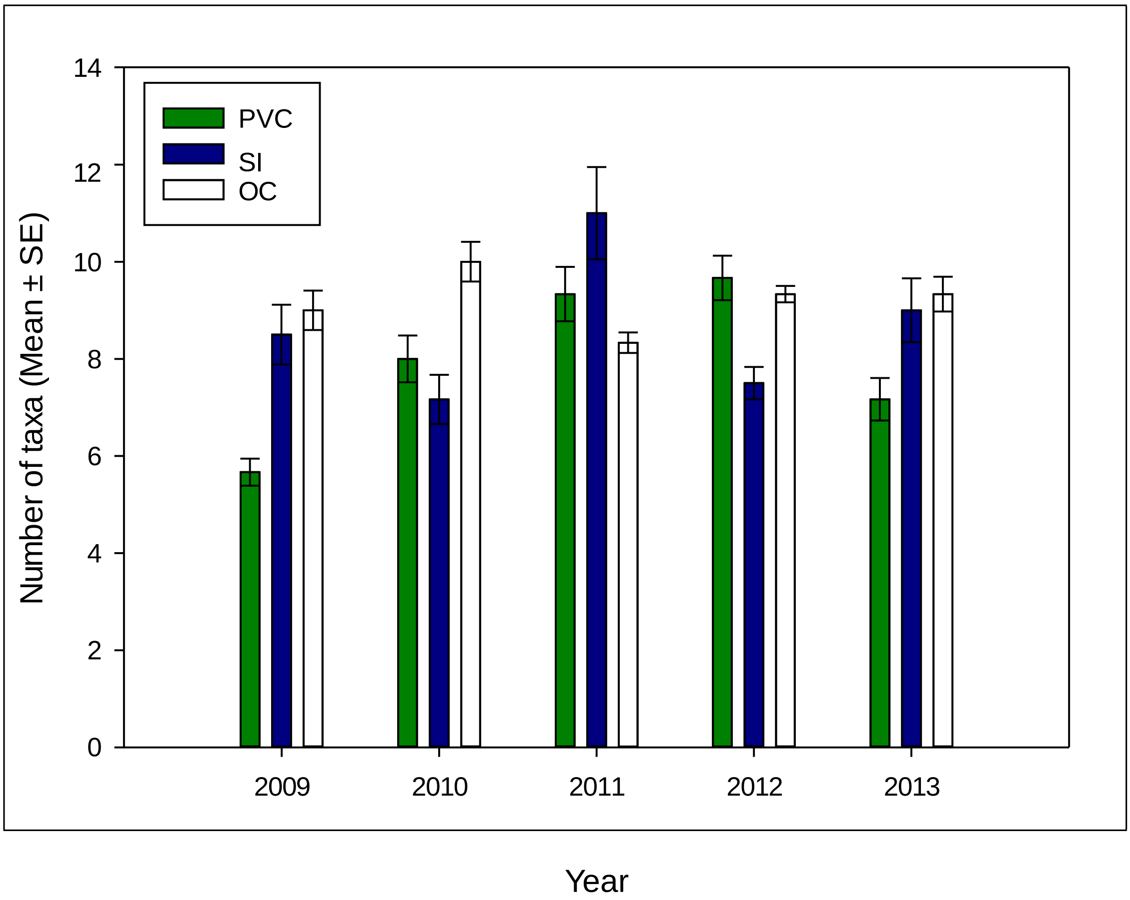

Figure 3.8 Number of mobile taxa (Mean min^{-1} ± SE) for each treatment (PVC = Pre-existing Voluntary Closure, SI = Statutory Instrument, OC = Open Control) in 2009, 2010, 2011, 2012 and 2013

3.2.3 Assemblage composition

A significant Year x Treatment interaction was identified for assemblage composition ($P < 0.05$) as illustrated in Figure 3.9 using non-metric multidimensional scaling (nMDS). The MDS plot shows that in 2013 the SI is on a trajectory away from the OCs and towards the PVCs.

Pairwise tests for the Year x Treatment interaction showed that in 2009, all Treatments were significantly different from each other (all $P < 0.05$). Also, in 2011, the assemblage composition was significantly different in the PVC and the SI to the OC (both $P < 0.05$). In 2012, assemblage composition was significantly different in the PVC to the OC ($P < 0.01$) and in 2013 assemblage composition was significantly different in the PVC and SI to the OC ($P < 0.05$; Annex B, Table B7) (Figure 3.10).

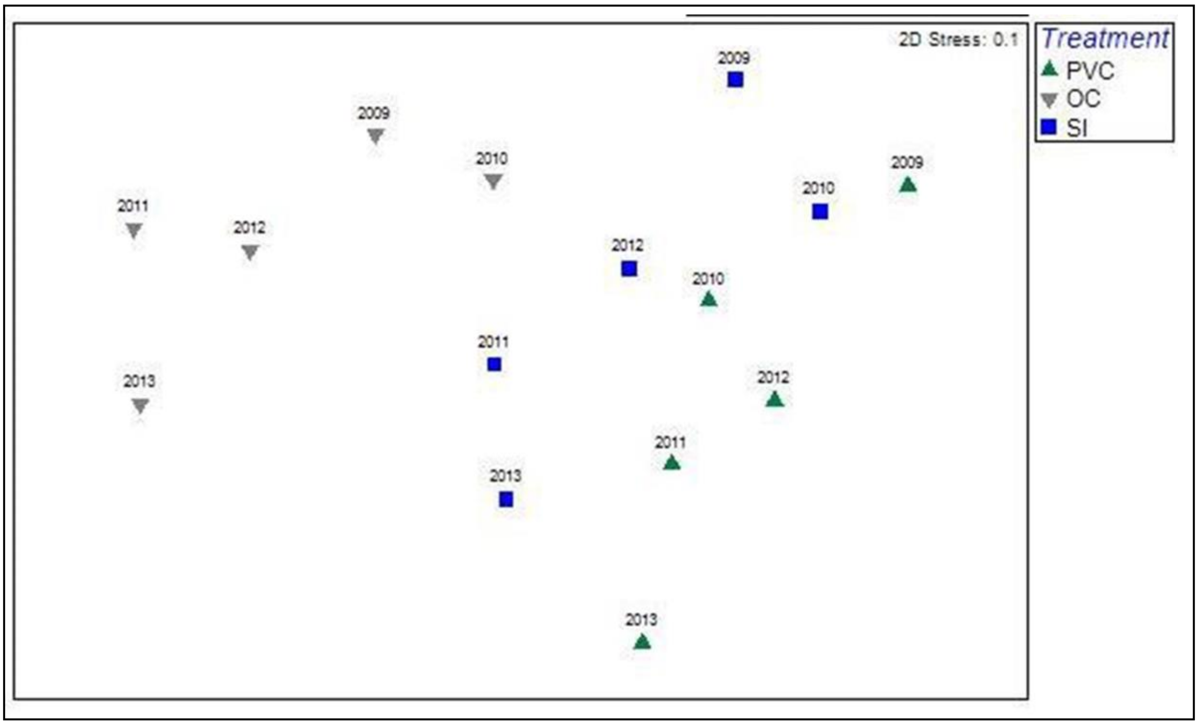

Figure 3.9 nMDS plot illustrating similarities in mobile fauna assemblage composition between Treatments (averaged for site within treatment), (Pre-existing Voluntary Closure = green triangles, Statutory Instrument = blue squares, Open Control = grey triangles), over time (2009, 2010, 2011, 2012, 2013)

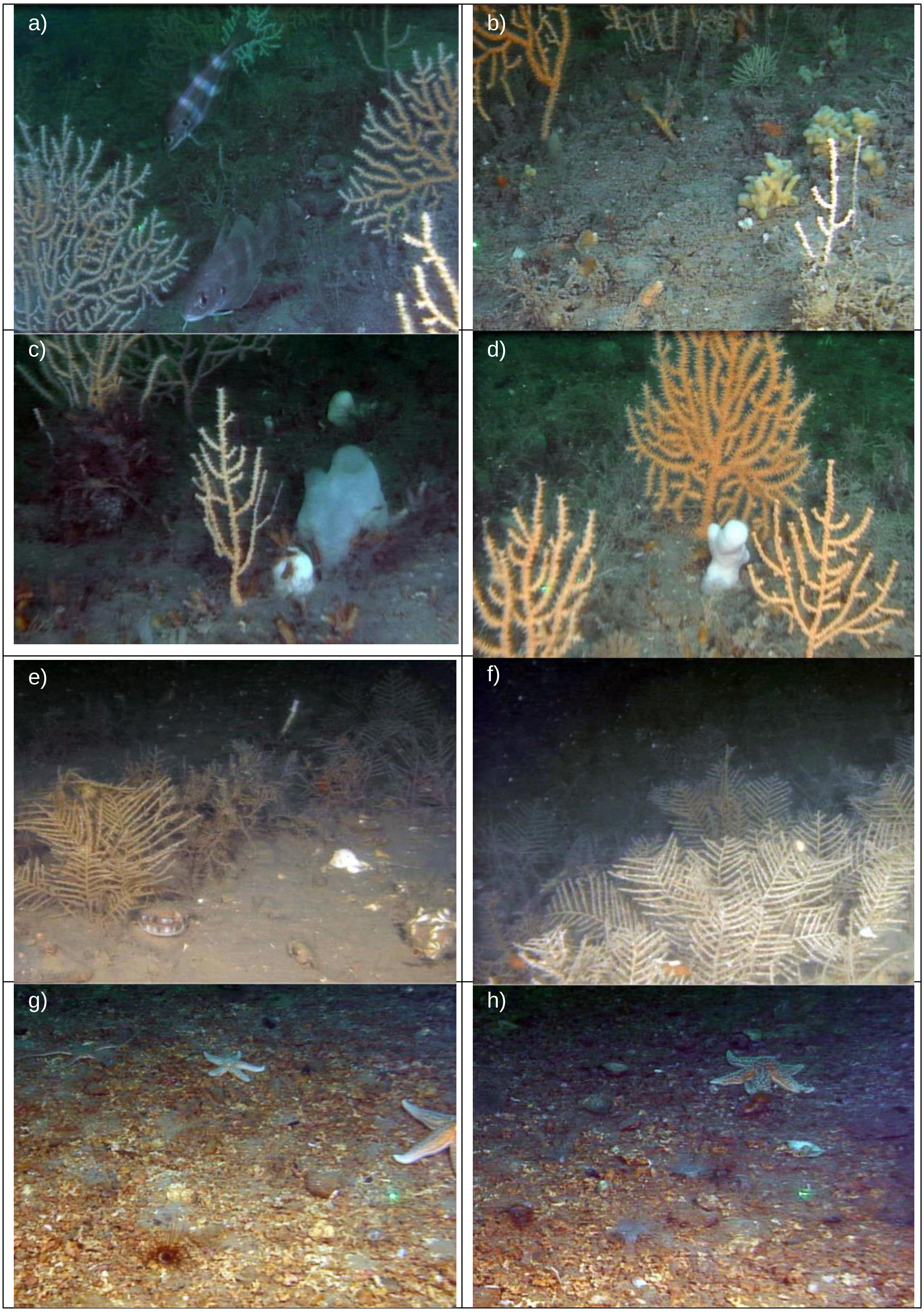

Figure 3.10 Images from the towed video survey 2013 showing typical assemblages in each treatment; a & b) PVC, c & d) SI, e & f) SA and g & h) OC

3.3 Analysis of indicator species

The indicator species' univariate analyses were based on data from one of the three video datasets, either video transect, frame grab or baited (as indicated in Table 3.2). They are presented here in three categories (Jackson et al. 2008): Key species that were preselected by Defra, sessile species, and free living species. A summary table is included detailing the results per species which relate to evidence for recovery (Table 3.2), along with graphs summarising abundance by Treatment and Year (Figures 3.11, 3.12, 3.13). For clarity and readability, full results of pairwise tests are given in Annex B, Tables B8 – B23.

Table 3.2 Summary of recovery status with evidence from pairwise statistical tests. *Data type* refers to data quantified from the 30-frame subsample (*Frames*), counts over the entire video transect (*Video*) or baited video (*Baited*). *Recovery* is used in the narrow sense where SI increases relative to OC and approaches PVC. *Positive response* indicates that SI increases relative to OC, but does not necessarily converge with PVC, in that PVC may also increase, or show wide variability.

Response metric	Data type	Recovery	Positive response
Pecten maximus	Video	No	Yes
Phallusia mammillata	Video	Yes	Yes
Cellepora pumicosa	Frames	No	No
Pentapora fascialis	Frames	Yes	Yes
Anemones	Frames	No	No
Alcyonium digitatum	Video	No	No
Eunicella verrucosa	Video	No	No
Chaetopterus variopedatus	Frames	No	No
Tethya auratium	-	-	-
Hydroids	Frames	No	No
Cliona celata	-	-	-
Branching sponges	Video	No	Yes
Asterias rubens	Video	No	No
Trisopterus minutus	Baited	No	No
Necora puber	Video	No	No
Cancer pagurus	Video	No	No
Ctenolabrus rupestris	Baited	No	No
Gobies	Baited	No	No

3.3.1 Key Species

***Pecten maximus* – King scallop (V)**

Abundance of *Pecten maximus* increased by 260 % in the SI from 2008 to 2011 (mean abundance 2008 = 0.29 m^{-2} ± 0.04, 2011 = 0.76 m^{-2} ± 0.13) (Figure 3.11) relative to the controls indicated by a Treatment x Year interaction ($P < 0.001$). By 2010, *P. maximus* was significantly more abundant in the SI than the OC ($P < 0.01$). *P. maximus* abundance in the SI decreased in 2012 and then increased in 2013 so that the abundance in 2013 is greater than in 2010 (mean abundance 2012 = 0.39 m^{-2} ± 0.07, 2013 = 0.58 m^{-2} ± 0.09). In 2013, *P. maximus* is now significantly more abundant in the SI than the PVC and OC (both $P < 0.01$) (Annex B, Table B8).

***Phallusia mammillata* – A sea squirt (V)**

Abundance of *Phallusia mammillata* increased in the SI relative to the Open Controls from 2008-2009 (mean abundance 2008 = 0.08 m^{-2} ± 0.04, 2009 = 0.25 m^{-2} ± 0.09) (Figure 3.8). A Year x Treatment interaction was identified (P < 0.05) and from 2009-2013 *P. mammillata* was significantly more abundant in both the SI and PVC than the OC (both P < 0.05; Annex B, Table B9).

***Cellepora pumicosa* – A sea mat (F)**

After a decrease in abundance of *Cellepora pumicosa* in both the SI and PVC in 2012, the abundance in the SI and PVC 2013 has once again surpassed that of 2008 (mean abundance SI 2008 = 11.97 m^{-2} ± 1.15, 2013 = 13.0 m^{-2} ± 0.94, mean abundance PVC 2008 = 10.77 m^{-2} ± 0.95, 2013 = 14.98 m^{-2} ± 1.20) (Figure 3.11). There was a significant Year and Treatment effect on the abundance of *Cellepora pumicosa* (both P = 0.0001) but no Year x Treatment interaction was identified (Annex B, Table B10).

***Pentapora fascialis* – Ross coral (F)**

Abundance of *Pentapora fascialis* in the SI was steady from 2008-2010 (mean abundance 2008 = 0.32 m^{-2} ± 0.15, 2010 = 0.45 m^{-2} ±0.21), increased in 2011 (mean abundance 2011 = 1.81 m^{-2} ± 0.58), decreased in 2012 (mean abundance 2012 = 0.54 m^{-2} ± 0.25) and remained steady in 2013 (mean abundance 2013 = 0.52 m^{-2} ± 0.13) (Figure 3.11). Abundance was significantly greater in the PVC and SI compared to the OC from 2008-2013 (all P < 0.05), identified by a Year x Treatment interaction (P < 0.001; Annex B, Table B11).

Anemones (F)

Abundance of grouped anemones in the SI remained steady from 2008-2011 then increased in 2012 and decreased in 2013 (mean abundance = 2012 = 2.39 m^{-2} ± 1.76, 2013 = 0.21 m^{-2} ± 0.08) (Figure 3.11). Abundance showed a significant Year and Treatment effect (P < 0.05) but no Year x Treatment effect (Annex B, Table B12).

***Alcyonium digitatum* – Dead man's fingers (V)**

Abundance of *Alcyonium digitatum* decreased in all treatments in 2013. Abundance in the SI remains greater in 2013 than 2011 (mean abundance 2012 = 2.63 m^{-2} ± 0.71, 2013 = 1.50 m^{-2} ± 0.46) (Figure 3.11). A significant Year effect was identified (P < 0.01), but there was no Year x Treatment effect (Annex B, Table B13).

***Eunicella verrucosa* – Pink sea fan (V)**

Abundance of *Eunicella verrucosa* decreased in the SI in 2013 (mean abundance 2012 = 0.54 m^{-2} ± 0.19, 2013 = 0.50 m^{-2} ± 0.19) (Figure 3.11). However, abundance in the SI and PVC have increased relative to the OC in 2013 compared to 2008 (mean abundance SI 2008 = 0.14 m^{-2} ± 0.09, 2013 = 0.50 m^{-2} ± 0.19, mean abundance PVC 2008 = 0.19 m^{-2} ± 0.08, 2013 = 0.45 m^{-2} ± 0.2, mean abundance OC 2008 = 0.003 m^{-2} ± 0.002, 2013 = 0.0005 m^{-2} ± 0.0005). No Year x Treatment interaction was identified (Annex B, Table B14).

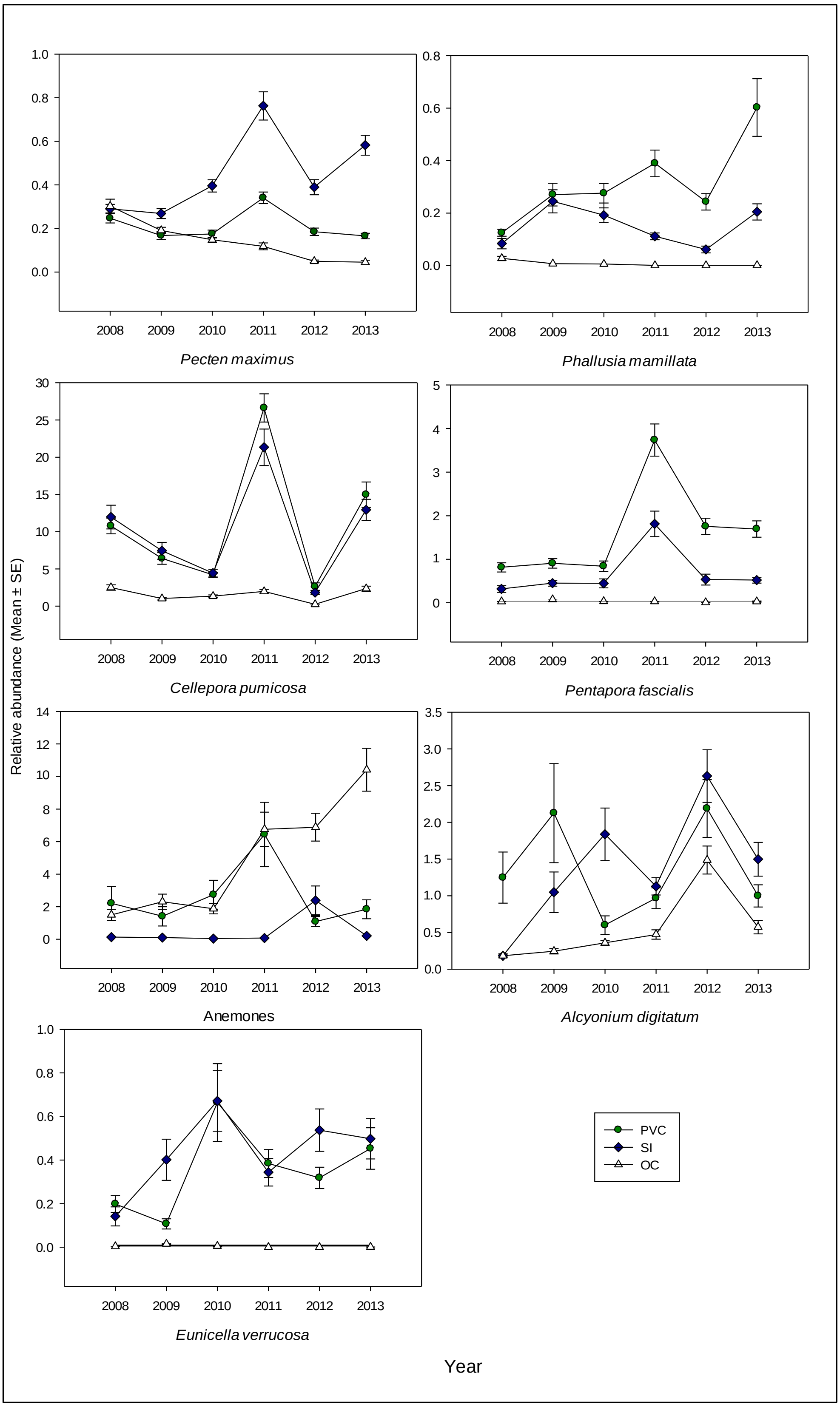

Figure 3.11 Relative abundance of key indicator species (Mean m-^{2} ± SE) per treatment (PVC = Pre-existing Voluntary Closure, SI = Statutory Instrument, OC = Open Control), per year (2008, 2009, 2010, 2011, 2012, 2013). Scales on the y-axes vary

3.3.2 Remaining sessile species

***Chaetopterus variopedatus* – Parchment worm (F)**

Abundance of *Chaetopterus variopedatus* increased in the SI in 2013 (mean abundance 2012 = 0.21 m^{-2} ± 0.08, 2013 = 1.04 m^{-2} ± 0.29). However, abundance has decreased in all treatments from 2008-2013 (mean abundance SI 2008 = 1.22 m^{-2} ± 0.47, 2013 = 1.04 m^{-2} ± 0.29, mean abundance PVC 2008 = 1.53 m^{-2} ± 0.92, 2013 = 0.59 m^{-2} ± 0.2, mean abundance OC 2008 = 0.52 m^{-2} ± 0.24, 2013 = 0.29 m^{-2} ± 0.12) (Figure 3.12). No Year x Treatment interaction has been identified for the abundance of *Chaetopterus variopedatus* (Annex B, Table B15).

***Tethya citrina* – Golf ball sponge**

Abundance of *Tethya* citrina was too low to be interpreted or analysed.

Hydroids (F)

Abundance of Hydroids increased in the SI from 2008-2011 (mean abundance 2008 = 30.37 m^{-2} ± 10.02, 2011 = 106.65 m^{-2} ± 13.53), decreased in 2012 (mean abundance 68.92 m^{-2} ± 9.9) and increased in 2013 (mean abundance 195.18 m^{-2} ± 34.72) (Figure 3.12). No Year x Treatment interaction has been identified (Annex B, Table B16).

***Cliona celata* – Boring sponge**

Abundance of Cliona celata was too low to be interpreted or analysed.

Branching sponges (V)

Abundance of branching sponges decreased in the SI from 2008 to 2009 (mean abundance 2008 = 0.17 m^{-2} ± 0.09, 2009 = 0.02 m^{-2} ± 0.01) but has increased from 2009 to 2013 (mean abundance 2013 = 0.45 m^{-2} ± 0.10), indicated by a significant Year x Treatment interaction ($P < 0.001$) (Figure 3.12). Abundance in the SI has been significantly greater than Open Controls since 2010 (all $P < 0.05$; Annex B, Table B17).

Abundance has increased in the SI and PVC relative to OC from 2009-2013 (PVC mean abundance 2008 = 0.36 m^{-2} ± 0.08, 2013 = 1.57 m^{-2} ± 0.46, SI mean abundance 2008 = 0.17 m^{-2} ± 0.08, 2013 = 0.44 m^{-2} ± 0.1, OC mean abundance 2008 = 0.07 m^{-2} ± 0.03, 2013 = 0.03 m^{-2} ± 0.01).

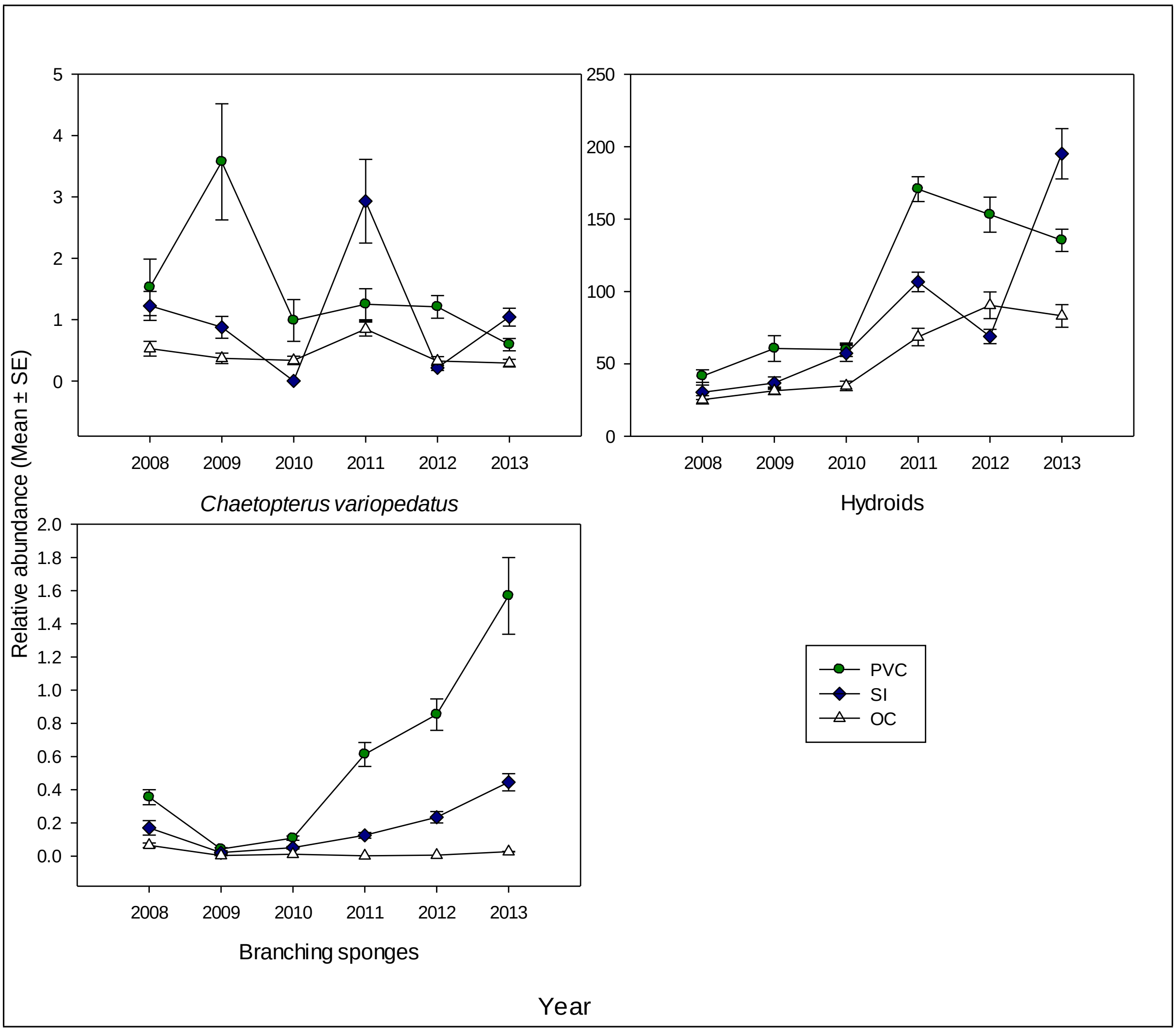

Figure 3.12 Relative abundance of sessile indicator species (Mean m^{-2} ± SE) per treatment (PVC = pre-existing voluntary closure, SI = Statutory Instrument, OC = Open Control), per year (2008, 2009, 2010, 2011, 2012, 2013) Scales on the y-axes vary

3.3.3 Free living species

***Asterias rubens* – Common starfish (V)**

Abundance of *Asterias rubens* increased in the SI from 2008-2012 but decreased from 2012-2013 (mean abundance 2012 = 0.33 m^{-2} ± 0.08, 2013 = 0.28 m^{-2} ± 0.06) (Figure 3.13) No Year x Treatment interaction has been identified (Annex B, Table B18).

***Trisopterus minutus* – Poor cod (B)**

Abundance of *Trisopterus minutus* in the SI decreased from 2009-2010 (mean abundance 2009 = 9.45 min^{-1} ± 5.87, 2010 = 0.90 min^{-1} ± 0.56), remained steady from 2010-2012 (mean abundance 2012 = 0.54 min^{-1} ± 0.27) and increased from 2012-2013 (mean abundance 2013 = 2.94 min^{-1} ± 1.73) (Figure 3.13), indicated by a significant Year x Treatment interaction ($P < 0.05$; Annex B, Table B19).

***Necora puber* – Velvet swimming crab (V)**

Abundance of *Necora puber* in the SI increased from 2008-2010 (mean abundance 2008 = 0.004 m^{-2} ± 0.002, 2010 = 0.03 m^{-2} ± 0.01), decreased from 2010-2012 (mean abundance 2012 = 0.005 m^{-2} ± 0.003) and increased in all treatments in 2013 (mean abundance SI 2013 = 0.009 m^{-2} ± 0.002, mean abundance PVC 2013 = 0.02 m^{-2} ± 0.006, mean abundance OC 2013 = 0.005 m^{-2} ± 0.002) (Figure 3.13), although no Year x Treatment interaction was identified (Annex B, Table B20).

***Cancer pagurus* – Edible crab (V)**

Abundance of *Cancer pagurus* in the SI remained steady from 2008-2011 (mean abundance 2008 = 0.004 m^{-2} ± 0.003, 2011 = 0.004 m^{-2} ± 0.002) and decreased from 2012-2013 (mean abundance 2012 = 0.0009 m^{-2} ± 0.0009, 2013 = 0.00 m^{-2} ± 0.00) (Figure 3.13). No Year x Treatment interaction was identified (Annex B, Table B21).

***Ctenolabrus rupestris* – Goldsinny wrasse (B)**

Abundance of *Ctenolabrus rupestris* in the SI increased from 2009-2011 (mean abundance 2009 = 0.06 min^{-1} ± 0.04, 2011 = 0.9 min^{-1} ± 0.31) and decreased in 2012 (mean abundance 2012 = 0.09 min^{-1} ± 0.05). It has increased once again in 2013 (mean abundance 2013 = 0.29 min^{-1} ± 0.2) (Figure 3.13). No Year x Treatment interaction was identified (Annex B, Table 22).

Gobies (B)

Abundance of Gobies in the SI has shown an overall decrease but has been variable from 2009 to 2013 (mean abundance 2009 = 1.09 min^{-1} ± 0.51, 2013 = 0.07 min^{-1} ± 0.05) (Figure 3.13). No Year x Treatment interaction has been identified (Annex B, Table B23).

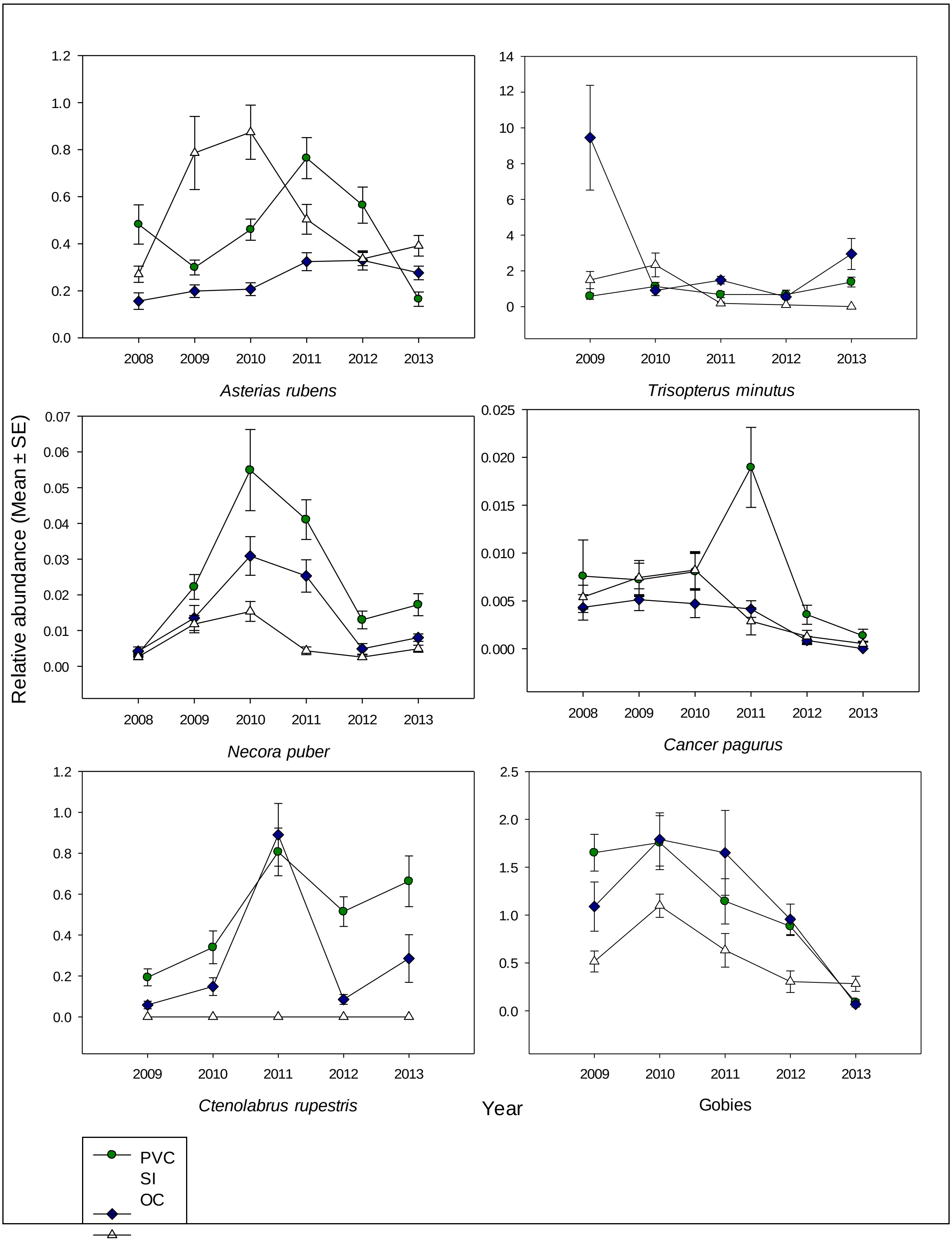

Figure 3.13 Relative abundance (Mean m^{-2} / min^{-1} ± SE) of free living indicator species per treatment (PVC = Pre-existing Voluntary Closure, SI = Statutory Instrument, OC = Open Control), per year (2008, 2009, 2010, 2011, 2012, 2013). Abundance of *Asterias rubens*, *Necora puber* and *Cancer pagurus* presented as mean m^{-2}. Abundance of *Trisopterus minutus*, *Ctenolabrus rupestris* and Gobies presented as mean min^{-1}. Scales on the y-axes vary

3.4 Sensitive Areas analysis

The data presented above consider the results for the SI, PVC and OC. The following analyses consider the assemblage composition results for the Sensitive Areas (SA) when compared with the OC, PVC and SI.

3.4.1 Frame grab data

Assemblage composition was significantly different for every factor tested. A significant Year x Treatment interaction was found (all $P = 0.0001$) with pairwise tests showing that in 2011, 2012 and 2013, the assemblage composition in the SA was significantly different from the PVC (all $P < 0.01$). For the first time in 2013, the assemblage composition in the SA was also significantly different to the OC ($P < 0.05$) (Annex B, Table B24).

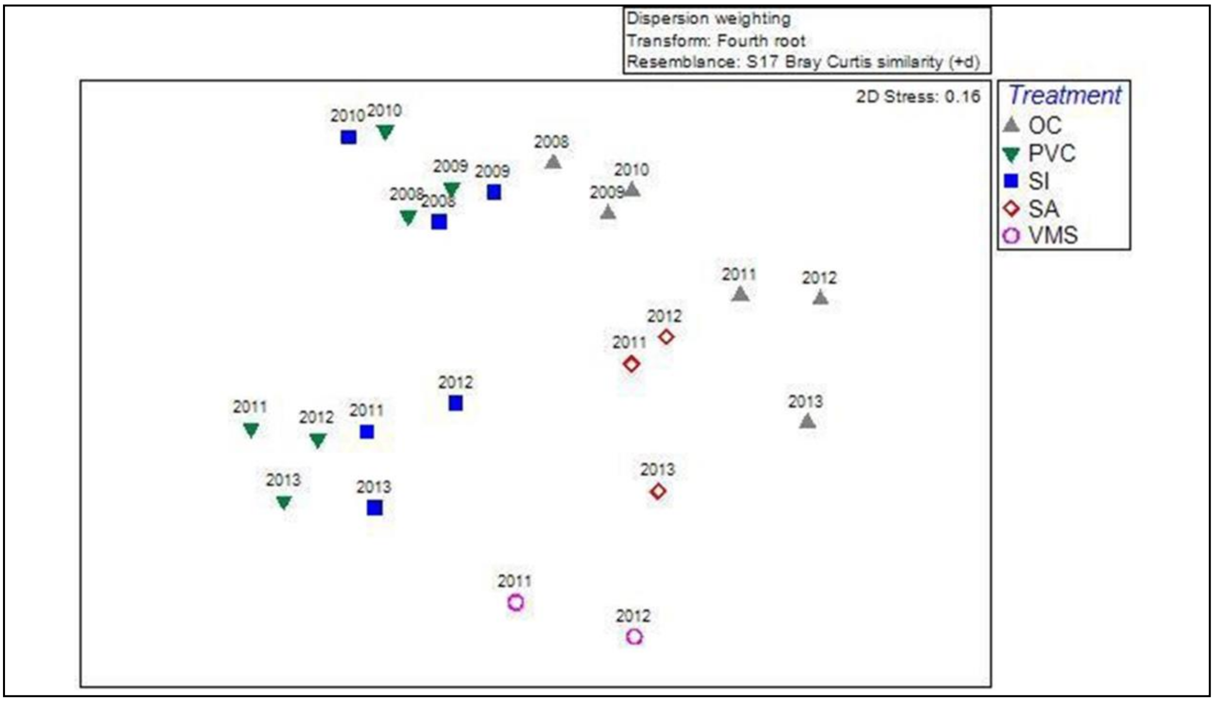

Figure 3.14 nMDS plot illustrating similarities in assemblage composition between Treatments (averaged for site within treatment), (Pre-existing Voluntary Closure = green triangles, Sensitive Area = red diamonds, Open Control = grey triangles, Vessel Monitoring System = pink circles), over time (2008, 2009, 2010, 2011, 2012, 2013)

In 2013 the assemblage composition of SA sites became less similar to the OC and PVC and SI sites (Figure 3.14).

3.4.2 Baited Remote Underwater Video data

Assemblage composition of mobile fauna from the baited video was significantly different for Year and Treatment (both P= 0.0001) but no Year x Treatment interaction was found (Annex B, Table B25). The nMDS plot shows that in
2013 the assemblage in the PVC is very different to the SA and OC (Figure 3.15).

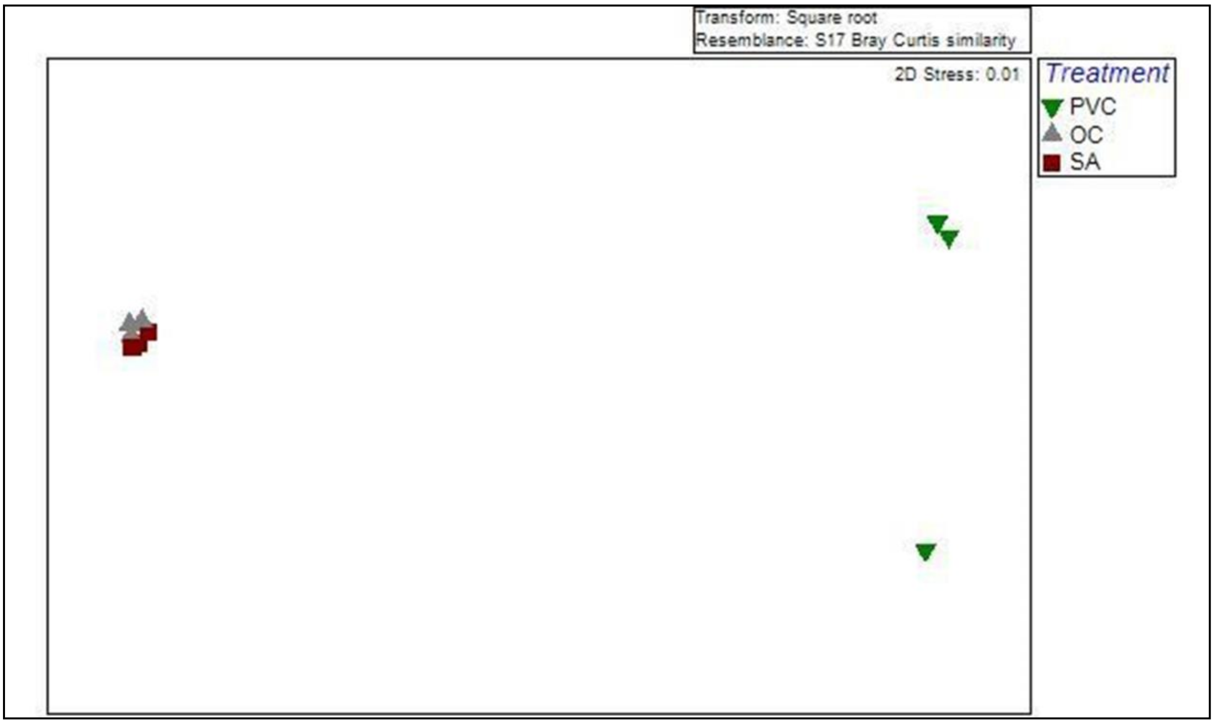

Figure 3.15 nMDS plot illustrating similarities in mobile fauna assemblage composition between Treatments (averaged for site within treatment), (Pre-existing Voluntary Closure = green triangles, Open Control = grey triangles, Sensitive Area = red squares), over time (2009, 2010, 2011, 2012, 2013)

4 Discussion

The 2013 sampling season marked the fifth year of survey since the SI came into force, and the sixth benthic survey. This annual monitoring of benthic assemblages and reef associated nekton has provided the first large scale recovery data set for temperate reef assemblages that is a valuable resource for the future monitoring of national, European and international habitats.

Early signs suggest that habitat forming, functionally important and commercially valuable species are beginning to recover in Lyme Bay. This report recommends the continuation of the current conservation measures.

To put this report into the context of the current scientific peer reviewed literature, in 2013, two papers were published on the findings from the Lyme Bay recovery study. The first, Sheehan et al (2013b) discusses the results of the first four years of data from the towed video. The second, Sheehan et al (2013a) investigates the recovery of assemblages in the SAC on pebbly-sand habitats.

One of the benefits of video data is that it can be revisited and analysed. Sheehan et al 2013a made use of this by reanalysing video from the pebbly-sand areas around the defined reefs in Lyme Bay, comparing video from 2008 with video from 2011.

Pebbly-sand areas are not considered to be designated Annex I reef features as they fail to satisfy the definition of hard substratum reef as per Irving (2009). Since the closure of the SAC to towed gear, classic reef organisms such as dead man's fingers (*Alcyonium digitatum*), branching sponges and ross coral (*Pentapora fascialis*) that define the reef feature significantly increased in abundance over this pebbly-sand region and thus increasing the functional size of the reef above and beyond the designated feature. This study suggested the potential of these areas between the reefs to become fully functional reef communities because of the cessation of fishing pressure. This potential has been previously unknown because of the impact of fishing around the actual defined reefs.

If MPAs are managed on a feature basis, then (for example) scallop dredging could potentially be possible in such areas between reefs which are not the designated "feature". However, it has been shown that given time these neighbouring substrates, although currently barren, might also recover to support a reef community and extend the size of the reef thus the actual functional reef is much bigger than that physically designated. One way to discover the true size of such features is to manage at the site level, not just protect individual features as that initial designation may be incorrect.

4.1 Towed video survey

From 2008 to 2011 positive trends were observed for number of taxa and overall abundance in the SI and PVC relative to the Open Controls (OC). 2011 stood out as a particularly good year for the benthos however the abundance decreased in 2012. The abundance of organisms from the count and cover measures increased from 2012-2013 in both the Statutory Instrument (SI) and Pre-existing Voluntary Closure (PVC) relative to the OC. The assemblage composition of SI and PVC sites also became less similar to OC sites, suggesting that the assemblages are still diverging. The reduced metrics in 2012 have been attributed to the extremely poor weather experienced that year, including an increased average rainfall in June and July (Met Office, 2012) and strong westerly winds that were responsible for bad visibility (Langmead et al. 2010). This poor visibility resulted in reduced quality images which affected our ability to observe benthic fauna from the video. However, temporal variability within marine reserves has been recorded previously (e.g. Francour, 1994, see review by García-Charton & Pérez-Ruzafa 1999). It is thought that this variability may exist partly because prevailing conditions affect ecological processes (Saether 1997) and therefore population dynamics are influenced by climate (McCarty 2001, Stenseth et al 2002, Walther et al 2002). The temporal variability in these Lyme Bay data may therefore be explained by the variable weather experienced from 2011, though recruitment and other ecosystem processes are also temporally variable (Sale et al 1984, Shugart and Urban, 1988).

The target species *Pecten maximus* showed a positive response, as are hydroids. The two may be interlinked with results from the Isle of Man scallop fishery closure attributing an increase in habitat complexity and enhanced scallop stocks to an increase in the abundance of hydroids (Bradshaw et al. 2003).

Other species which provide habitat complexity have increased in abundance including the low recoverability species *Eunicella verrucosa*, which is listed as vulnerable on the IUCN red list (IUCN 2013) and is a UK BAP species. In addition, Branching sponges have dramatically increased in the PVC (~400 %) and SI (~250 %) from 2008-2013 compared to fished controls where they have decreased in abundance in the same period.

The taxa which contributed most towards the differences in assemblage between the OC and SI in 2013 were Hydroids, Turf, *Alcyonidium diaphanum*, *Ocnus planci* and *Cellepora pumicosa.*

4.2 Baited video

The baited video data comprise five years of survey, 2009-2013. There is a significant Year x Treatment interaction for number of taxa and assemblage composition. This means that both Year and Treatment are significant factors alone but also in interaction with one another. Abundance has increased in all treatments after a dip in 2012 but number of taxa decreased from 2012-2013. The 2013 baited results however still do not conform to the theory that disturbed systems are often typified by high abundance and low species diversity compared to un-disturbed sites (Kaiser et al. 2000, Halpern, 2003, Hixon, 2007) as abundance is high in the PVC and OC compared to SI and the number of taxa is lower in the PVC compared to SI and OC.

The taxa which contributed most towards the differences in mobile species assemblage between the SI and OC in 2013 were *Pagurus bernhardus*, *Trisopterus minutus*, *Trisopterus luscus*, *Aequipecten opercularis* and Ophiura spp.

4.3 Indicator Species

Indicator species were selected to be representative of the range of species with differing biological traits present in Lyme Bay, and their recoverability (low, medium or high) was determined (Jackson et al. 2008). These indicator species have been used throughout the study to aid the explanation of the results provided by the towed and baited video and for comparison between these results and studies published in the literature (Langmead et al. 2010).

Overall, in 2013 9 out of 16 indicator species increased in abundance in the SI relative to the OC. All of the sessile indicator species, *Chaetopterus variopedatus*, hydroids and branching sponges increased in the SI. The abundance of four taxa had their greatest abundances in 2013 including *Phallusia mammillata* which is considered to have a medium potential for recovery. A decrease in abundance of *P. fascialis* was seen in 2012 and no increase has been seen in 2013. A Year x Treatment interaction was found for this species though and abundance was greater in closed sites compared to the OC. This is encouraging for the recovery of closed sites *P. fascialis* is a species with low recoverability and is functionally important as a bioconstructor which plays a key role in the formation of biogenic reef (Cocito and Ferdeghini, 2001, McKinney and Jackson, 1989 in: Lombardi, 2007). The abundance increases in *P. mammillata*, hydroids and branching sponges are also promising as such species are known to improve survivorship of taxa such as juvenile fish through the provision of a structurally complex habitat (Bradshaw et al. 2003).

A positive response towards recovery of king scallop *P. maximus* populations in the SI had been apparent since 2009, with an increase in abundance apparent until 2011. A decrease in abundance in 2012 caused concern for the recovery of the population but the abundance has increased in the SI for 2013 whilst the PVC and OC continue to decline. The abundance increase in the SI is partially in line with the expectation from the literature as similar studies such as that of Stokesbury et al. (2004), who assessed the north-east American *Placopecten magellanicus* population, and identified a greater abundance of scallops within areas closed to mobile fishing gear. The slight decline in *P. maximus* in the PVC is so far not understood.

A significant Year x Treatment trend was found for *Trisopterus minutus* and abundance was found to be greater in the SI than the PVC and OC; however SI and OC are not significantly different so this species is not quite showing a positive response towards recovery. Abundance of *Ctenolabrus rupestris* increased in closed treatments in 2013 but a Year x Treatment interaction was not found. These increases could be attributed to increased survivorship of juvenile fishes as a result of the increased provision of structurally complex habitats as sessile species recover (Bradshaw et al. 2003).

The abundance of anemones (*Aiptasia mutabilis*, *Cerianthus* spp. and *Peachia cylindrica*) decreased in the SI in 2013 but has continued to increase in the OC. It is thought that *Cerianthus* spp. are likely driving the higher abundance in the OC as these are associated with soft sediment habitats and were therefore recorded in areas of cobble and boulder habitat with exposed sediment patches. In addition, in 2013 it was noted that high abundances of *Cerianthus* spp. were present in the OC sites on the west of the bay on habitats that looked less disturbed than in previous years.

There is still however considerable variation in the results for indicator species. For example, a Year x Treatment interaction was identified in 2012 for *Cellepora pumicosa*, but this trend is not apparent in 2013, although abundance in the SI and PVC sites increased relative to the control, highlighting the need for continued annual monitoring.

5 Sensitive Areas

The 2013 results show that assemblage composition within sites in the SA was significantly different to PVC and OC sites for the first time since 2011. This suggests that after two years the protection has allowed the assemblage to diverge away from the OC sites. It is expected that over time the SA sites will become more similar to the PVC and less similar to the OC which continues to be fished. The taxa which contributed the most towards the differences between the OC and SA in 2013 were hydroids, *Ophiura ophiura, Serpula vermicularis, Alcyonidium diaphanum* and anemones.

For the assemblage of mobile taxa recorded using baited video, there was no indication of recovery for SA sites. In all three years SA sites were more similar to OC sites and less similar to PVC sites.

6 Further notes of interest

It was noted that in 2011 the population of the sea cucumber *Ocnus planci* expanded dramatically from 2010. Individuals were again seen in large numbers in 2013, in sites 14, 15, 47, 57, 105 and 119, the east of the SI and PVC and the west of the SI, within communities growing on sediment with species including *Alcyonium digitatum*. We previously thought these individuals were *Cucumaria frondosa* but samples of this species have since been examined and it is now thought that it is likely these are large populations of *Ocnus planci,* a species less common in the UK. *Ocnus planci* is known to occur in large populations and has previously been misidentified as *Aslia lefeverei* (McKenzie, 1991). This discovery highlights the benefits of the towed array method, cost-effectively surveying large areas of benthic habitat. In 2012 a large increase in the numbers of brittlestars *Ophiothrix fragilis* was observed. Video from two sites in the 2012 survey could not be obtained because so many brittlestars were present that the seabed was obscured. In 2013 video was obtained from these sites but high numbers of brittlestars *Ophiothrix fragilis* were observed once again. *Ophiothrix fragilis* was not included in the overall abundance graphs for towed video data due our inability to identify rocky reef habitat. This phenomenon of extreme population density fluctuations has previously been observed in many species of echinoderm which could be attributed to their broadcast spawning and planktotrophic larval life history. The combination of these traits can result in positive feedback loops that can lead to rapid population increase once an ‘outbreak’ cycle has been initiated (Uthicke et al. 2009).

7 Conclusions and considerations

This study aimed to assess the recovery of Lyme Bay reefs following the cessation of towed demersal fishing gear within the SI. This report has provided the results from the baseline survey and five years post closure. It was understood from the outset that a short term study would not be sufficient to see the re-establishment of most species in the SI due to their life history traits, and the addition of a fifth year of sampling has shown that whilst some indicator species are showing positive responses towards recovery, variation within the results demonstrate that it is still too early for firm conclusions to be drawn.

The first (2008) sampling event constituted the 'before' element of the design. It is important to consider, however, that the closure had already been in place for six weeks when the towed video sampling program commenced, and therefore, unfortunately, the opportunity for a true 'before' sampling effort had passed. Changes in benthic species and community structure are however, expected to occur over annual or even decadal time spans, and consequently, if present, these changes would be detectable by the design implemented (Glasby, 1997).

Previous studies have shown that the speed of recovery of assemblages in Marine Protected Areas (MPA) varies. For some species, such as those previously targeted by fisheries, those undergoing rapid recovery or those subject to other trophic and structural changes can take in excess of 25 years (Ballantine and Langlois, 2008; Hoskin et al. 2011). It is therefore, anticipated that recovery in the Lyme Bay system will take time.

As of June 2013 the PVC sites had been protected for between 7 to 12 years and SI sites for five years. This report considers it reasonable to assume that both treatments are still in the early stages of a recovery scenario. Differing degrees of change have been identified across the SI. Some species are exhibiting recovery trends however there is still too much variance among other species to conclude that a trend towards recovery is evident, suggesting that the Lyme Bay system is recovering.

There is a paucity of quantitative comparable studies with which to compare the results of this study or make predictions regarding the likely recovery of epibenthic assemblages in the bay (Langmead et al. 2010). To date, the majority of the literature has focussed on tropical latitudes as MPAs were first established in these regions. The continuation of the Lyme Bay monitoring is therefore of importance, not only to quantify patterns and rates of recovery in a priority UK habitat, but also to add to the global body of knowledge relating to reef systems and their recovery from physical disturbance.

The Lyme Bay annual data could prove a valuable resource that managers can draw on to make informed decisions for the management of new Special Areas of Conservation and Marine Conservation Zones.

The suggestion that areas appearing to be soft sediment can support a range of reef species, between the reefs is also of importance for the understanding of temperate systems and for future management (Sheehan et al 2013 MPB).

The 2013 data shows that after two years the protection that the cSAC has afforded the sites in Sensitive Areas (SA) has allowed the assemblage to diverge away from the OC sites. It is expected that over time the SA sites will become more similar to the PVC and less similar to the OC, which continue to be fished. Ideally these sites will continue to be monitored in order to assess the level of recovery within the sites selected for protection within Lyme Bay.

It is hoped that annual sampling of the benthos in Lyme Bay will continue with a view to establishing conclusive signs of recovery in the SI for key indicator species within the ecosystem and to determine whether the early recovery identified to date is more than a short term phenomenon.

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10 Annexes

A. Species lists

Table A1 Species list detailing the taxa present and the survey method(s) that they were recorded by (F = Frames, V = Video, B = Baited)

Species name	Common name	F Count	F Cover	V	B
Actinia spp.	Actinia spp.	Y			
Actinothoe sphyrodeta	Sandalled anemone	Y			
Aequipecten opercularis	Queen scallop	Y		Y	Y
Alcyonidium diaphanum	Sea chervil	Y			
Alcyonium digitatum	Dead man's fingers	Y		Y	
Ammodytes marinus	Raitt's sand eel				Y
Amphilectus fucorum	Shredded carrot sponge		Y		
Anemones (grouped)	Anemones (grouped)	Y			
Anseropoda placenta	Goose foot starfish	Y		Y	
Aphrodita aculeata	Sea mouse	Y			
Aplidium elegans	Sea-strawberry	Y			
Archidoris pseudoargus	Sea lemon	Y			
Ascidia mentula	Red sea squirt	Y			
Ascidiella aspersa	Fluted Sea Squirt	Y			
Aslia lefevrii	Brown Sea Cucumber	Y			
Aspitrigla cuculus	Red Gurnard	Y			
Asterias rubens	Common starfish	Y		Y	Y
Astropecten irregularis	Sand star	Y		Y	
Atelecyclus rotundatus	Circular crab	Y		Y	
Bispira volutacornis	Twin fan worm	Y			
Blennius ocellaris	Butterfly blenny				Y
Botryllus schlosseri	Star ascidian		Y		
Branching sponges (grouped)	Branching sponges (grouped)	Y		Y	
Bryozoan sp.	Bryozoan sp.	Y			
Buccinum undatum	Common whelk	Y			Y
Bugula sp.	Erect bryozoan	Y			
Callionymus lyra	Common dragonet	Y		Y	Y
Calliostoma zizyphinum	Painted topshell	Y			Y
Cancer pagurus	Edible crab	Y		Y	Y
Caryophyllia smithii	Devonshire cup coral	Y			
Cellaria fistulosa	A bryozoan	Y			
Cellepora pumicosa	A bryozoan	Y			
Centrolabrus exoletus	Rock cook			Y	Y
Cereus pedunculatus	Daisy anemone	Y			
Chaetopterus variopedatus	Parchment worm	Y			
Chelidonichthys cuculus	Red Gurnard			Y	Y
Chrysaora hysoscella	Compass jellyfish				Y
Ciocalypta penicillus	A sponge	Y			
Ciona intestinalis	A sea squirt	Y		Y	

Clavelina lepadiformis	Light bulb ascidian	Y			
Clingfish spp.	Clingfish spp			Y	
Cliona celata	Boring sponge		Y		
Conger conger	European conger				Y
Corynactis viridis	Jewel anemone	Y			
Corystes cassivelanus	Masked crab			Y	
Crab	Crab			Y	
Crenilabrus melops	Corkwing wrasse	Y		Y	Y
Crepidula fornicata	Slipper limpet	Y		Y	
Ctenolabrus rupestris	Goldsinny wrasse	Y			Y
Dendrodoa grossularia	Baked bean ascidian	Y			
Dercitus bucklandi	An encrusting sponge		Y		
Diazona violacea	Football sea squirt	Y			
Dicentrarchus labrax	European seabass				Y
Didemnum coriaceum	A colonial ascidian		Y		
Diplosoma spongiforme	An encrusting sponge		Y		
Dysidea fragilis	A sponge	Y			
Ebalia granulosa	Crab	Y			
Echinus esculentus	Edible urchin	Y			
Encrusting sponge 1	Encrusting sponge 1		Y		
Encrusting sponge 2	Encrusting sponge 2		Y		
Encrusting sponge 3	Encrusting sponge 3		Y		
Encrusting sponge 4	Encrusting sponge 4		Y		
Encrusting sponge 6	Encrusting sponge 6		Y		
Encrusting sponge 7	Encrusting sponge 7		Y		
Encrusting sponge 8	Encrusting sponge 8		Y		
Encrusting sponge 9	Encrusting sponge 9		Y		
Epitonium clathrus	Common wentletrap	Y			
Eunicella verrucosa	Pink sea fan	Y		Y	
Fish spp.	Fish spp.	Y		Y	
Flustridae spp.	Flustridae spp.	Y			
Gadus morhua	Cod			Y	
Gaidropsarus spp.	Rockling spp.				Y
Gobies (grouped)	Gobies (grouped)	Y		Y	Y
Goneplax rhomboides	Mud Runner/Square Crab	Y		Y	Y
Grantia compressa	Purse Sponge	Y			
Gymnangium montagui	Yellow feathers	Y			
Halichondria spp.	A sponge		Y		
Hemimycale columella	Crater sponge		Y		
Henricia oculata	Bloody henry	Y			
Holothuria forskali	Cotton spinner	Y		Y	
Homarus gammarus	Common lobster	Y		Y	Y
Hyas coarctatus	Toad crab	Y		Y	
Hydroids (grouped)	Hydroids (grouped)	Y			
Inachus spp.	Scorpion spider crab	Y		Y	Y
Janolus cristatus	A nudibranch	Y			
Juvenile fish	Juvenile fish	Y			Y

Labrus bergylta	Ballan wrasse	Y		Y	Y
Labrus mixtus	Cuckoo wrasse	Y		Y	Y
Lanice conchilega	Sand mason	Y			
Limanda limanda	Dab				Y
Liocarcinus depurator	Harbour crab	Y		Y	Y
Lipophrys pholis	Shanny	Y		Y	
Lissoclinum perforatum	A colonial ascidian		Y		
Lithophyllum incrustans	An encrusting coralline alga		Y		
Luidia cilaris	Seven armed starfish	Y		Y	Y
Macropodia sp.	Long legged spider crab	Y		Y	Y
Maerl (sp not distinguished)	Maerl	Y			
Maja squinado	Spiny spider crab	Y		Y	Y
Massive Sponge 2	Massive Sponge 2	Y			
Massive sponge 3	Massive sponge 3	Y			
Massive sponge 4	Massive sponge 4	Y			
Massive sponge 5	Massive sponge 5	Y			
Massive sponge 6	Massive sponge 6	Y			
Massive sponge 7	Massive sponge 7	Y			
Massive sponge 8	Massive sponge 8	Y			
Megalomma vesiculosum	Fan worm	Y			
Metridium senile	Plumose anemone	Y			
Microstomus kitt	Lemon sole			Y	
Molgula manhattensis	Sea grapes	Y			
Myxicola infundibulum	A fanworm	Y			
Nassarius reticulatus	Netted dog whelk	Y			Y
Necora puber	Velvet swimming crab	Y		Y	Y
Nemertesia antennina	Sea beard	Y			
Nemertesia ramosa	A hydroid	Y			
Neopentadactyla mixta	Gravel sea cucumber	Y			
Nudibranch spp.	Nudibranch spp.	Y		Y	
Ocnus planci	Small sea cucumber	Y			
Ophiura ophiura	A brittlestar	Y			Y
Pachymatisma johnstonia	Elephant's ear sponge		Y		
Pagurus bernhardus	Common hermit crab	Y		Y	Y
Pagurus prideaux	Hermit crab	Y		Y	Y
Palaemon spp.	Palaemon spp.	Y		Y	
Parablennius gattorugine	Tompot blenny	Y		Y	Y
Pecten maximus	King scallop	Y		Y	Y
Pentapora fascialis	Ross coral	Y		Y	
Phallusia mammillata	White sea squirt	Y		Y	
Pholis gunnellus	Rock gunnel			Y	
Pisidia longicornis	Long-clawed porcelain crab	Y		Y	
Pleuronectes platessa	European Plaice	Y		Y	
Pollachius pollachius	Pollack	Y		Y	Y
Polyclinidae sp.	Colonial ascidian	Y			
Polymastia boletiformis	A massive sponge	Y			
Polymastia penicillus	Chimney sponge	Y			

Porcellana platycheles	Broad-clawed porcelain crab				Y
Psammechinus miliaris	Green Sea Urchin	Y			Y
Raja clavata	Thornback ray	Y		Y	Y
Red algae	Red algae	Y			
Sabella pavonina	Peacock worm	Y			
Sagartia elegans	A sea anemone	Y			
Salmacina dysteri	Coral worm	Y			
Sarcodictyon roseum	Star like polyps	Y			
Schooling fish spp.	Schooling fish spp.				Y
Scyliorhinus stellaris	Nursehound			Y	Y
Scyliorhinus canicula	Small spotted cat shark	Y		Y	Y
Sediment tube worm spp.	A tube worm	Y			
Sepia atlantica	Little cuttlefish			Y	
Sepia officinalis	Common cuttlefish	Y		Y	Y
Serpula vermicularis	A tube worm	Y			
Solea solea	Sole	Y		Y	
Solitary ascidian spp.	Solitary ascidian spp.	Y			
Spondyliosoma cantharus	Black seabream				Y
Stolonica socialis	Orange sea grapes	Y			
Styela clava	Leathery sea squirt	Y			
Suberites spp.	A massive sponge	Y			
Sycon ciliatum	A sponge	Y			
Syngnathus acus	Greater Pipefish			Y	
Tethya aurantium	Golf ball sponge	Y			
Thalassema thalassemum	Spoon worm				Y
Trachurus trachurus	Jack mackerel				Y
Triakidae spp.	Houndshark spp.				Y
Trigla lucerna	Tub gurnard				Y
Trisopterus luscus	Pouting	Y		Y	Y
Trisopterus minutus	Poor cod	Y		Y	Y
Tritonia nilsodhneri	Whip fan nudibranch	Y		Y	Y
Turf	Turf		Y		
Urticina felina	Dahlia anemone	Y			
Xantho incisus	Montagu's crab			Y	Y
Zeugopterus punctatus	Topknot	Y		Y	
Zeus faber	John dory	Y		Y	Y

Table A2 Indicator species as identified in Jackson et al. (2008) showing whether species were sighted in the biodiversity monitoring. Alterations in species used for analysis are noted and are fully explained in Attrill et al. (2011)

Original indicator species	Sighted?	Revised indicator species
Pecten maximus	Yes	
Phallusia mammillata	Yes	
Cellepora pumicosa	Yes	
Pentapora fascialis	Yes	
Aiptasia mutabilis	Yes	Anemones
Eunicella verrucosa	Yes	
Alcyonium digitatum	Yes	
Chaetopterus variopedatus	Yes	
Tethya citrina	Yes	Insufficient data. No suitable replacement
Halecium halecinum	Yes	Hydroids
Actinothoe sphyrodeta	No	None suitable
Hydrallmania falcata	Yes	Hydroids
Cliona celata	Yes	Insufficient data. No suitable replacement
Erect branching sponges	Yes	
Asterias rubens	Yes	
Hommarus gammarus	No	None suitable
Pollachius pollachius	No	*Trisopterus minutus*
Necora puber	Yes	
Cancer pagarus	Yes	
Labrus bergylta	Yes	Insufficient data. *Ctenolabrus rupestris*
Thorogobius ephippiatus	Yes	Gobies
Leptopsammia pruvoti	No	None suitable

B. PERMANOVA results

Frame grab Analysis

Abundance

Table B1 Results of Permanova for the relative abundance of the main assemblage count species identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were dispersion weighted and forth root transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference

Source	*df*	SS	MS	*F*	P
Year Ye	5	107.4	21.48	31.008	**0.0001**
Treatment Tr	2	33.546	16.773	5.9556	**0.0063**
Area Ar(Tr)	23	50.904	2.2132	5.9988	**0.0001**
YexTr	10	8.2816	0.82816	1.5269	0.15
Site (Ar(Tr))	67	23.167	0.34578	1.8297	**0.0018**
YexAr(Tr)	72	35.653	0.49517	2.6203	**0.0001**
Residual	167	31.559	0.18898		
Total	346	290.51			

Table B2 Results of Permanova for the relative abundance of the main assemblage cover species identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were dispersion weighted and forth root transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference

Source	*df*	SS	MS	*F*	P
Year Ye	5	76.805	15.361	12.528	**0.0001**
Treatment Tr	2	124.28	62.139	9.0572	**0.0002**
Area Ar(Tr)	23	123.84	5.3842	7.183	**0.0001**
YexTr	10	7.911	0.7911	0.93865	0.5024
Site (Ar(Tr))	67	47.077	0.70264	1.4846	**0.0255**
YexAr(Tr)	72	57.88	0.8039	1.6985	**0.0033**
Residual	167	79.041	0.4733		
Total	346	516.83			

Number of taxa

Table B3 Results of Permanova for the relative number of taxa of the benthic taxa identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference

Source	*df*	SS	MS	*F*	P
Year Ye	5	9.6196	1.9239	20.419	**0.0001**
Treatment Tr	2	12.552	6.276	11.617	**0.0003**
Area Ar(Tr)	23	9.7465	0.42376	7.0224	**0.0001**
YexTr	10	0.91216	0.091216	1.3866	0.2024
Site (Ar(Tr))	67	3.7896	0.056562	1.5352	**0.0176**
YexAr(Tr)	72	4.3923	0.061004	1.6558	**0.0056**
Residual	167	6.1528	0.036843		
Total	346	47.165			

Assemblage composition

Table B4 Results of a) Permanova for the relative abundance of the main assemblage cover species identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions, and b) Pairwise testing for the interaction Year x Treatment. Data were dispersion weighted and forth root transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference

a)

Source	*df*	SS	MS	*F*	P
Year Ye	5	70953	14191	10.581	**0.0001**
Treatment Tr	2	82801	41400	7.2148	**0.0001**
Area Ar(Tr)	23	103760	4511.4	4.6985	**0.0001**
YexTr	10	19171	1917.1	1.8392	**0.0001**
Site (Ar(Tr))	67	60442	902.12	1.6791	**0.0001**
YexAr(Tr)	72	68361	949.46	1.7672	**0.0001**
Residual	167	89725	537.28		
Total	346	495220			

b)

	2008		**2009**		**2010**		**2011**		**2012**		**2013**	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	0.84	0.7882	0.93	0.5677	1.10	0.2741	1.54	**0.031**	1.19	0.181	1.52	**0.0304**
PVC, OC	1.66	**0.0062**	2.01	**0.0042**	2.38	**0.0005**	3.41	**0.0006**	2.92	**0.0017**	3.65	**0.0002**
SI, OC	1.56	**0.0075**	1.72	**0.01**	2.28	**0.0001**	2.47	**0.0007**	2.44	**0.0022**	2.83	**0.0012**

Baited Video Analysis

Abundance

Table B5 Results of Permanova for the relative abundance of the reef associated nekton and mobile benthic fauna identified using baited video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factor Site (Si) and their interactions. Data were square root transformed. Analyses were conducted using Bray Curtis similarity. Bold type denotes a statistically significant difference

Source	*df*	SS	MS	*F*	P
Year Ye	4	9.853	2.4633	8.0323	**0.0001**
Treatment Tr	2	1.8481	0.92403	1.3513	0.2782
Site (Tr)	21	12.933	0.61584	2.1316	**0.0136**
YexTr	7	2.729	0.38986	1.3494	0.2475
Residual	53	15.312	0.28891		
Total	87	42.675			

Species Richness

Table B6 Results of a) Permanova for the relative species richness of the reef associated nekton and mobile benthic fauna identified using baited video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factor Site (Si) and their interactions and b) Pairwise testing for the interaction Year x Treatment. Data were square root transformed. Analyses were conducted using Bray Curtis similarity. Bold type denotes a statistically significant difference

a)

Source	*df*	SS	MS	*F*	P
Year Ye	4	0.4075	0.10188	2.5852	**0.0483**
Treatment Tr	2	0.32981	0.1649	0.96743	0.4009
Site (Tr)	21	3.1654	0.15073	4.5658	**0.0001**
YexTr	7	0.79721	0.11389	3.4497	**0.0041**
Residual	53	1.7497	0.033013		
Total	87	6.4496			

b)

	2009		**2010**		**2011**		**2012**		**2013**	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	2.08	0.0739	0.63	0.5585	0.61	0.5586	1.77	0.1223	1.04	0.326
PVC, OC	3.24	**0.0261**	1.47	0.1812	0.65	0.5426	0.13	0.9313	1.90	0.0971
SI, OC	0.48	0.6443	1.91	0.1079	1.19	0.2912	2.37	**0.0431**	0.43	0.6868

Assemblage composition

Table B7 Results of a) Permanova for the relative distribution of the reef associated nekton and mobile benthic fauna identified using baited video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factor Site (Si) and their interactions and b) Pairwise testing for the interaction Year x Treatment. Data were square root transformed. Analyses were conducted using Bray Curtis similarity. Bold type denotes a statistically significant difference

a)

Source	***df***	**SS**	**MS**	***F***	**P**
Year Ye	4	31436	7858.9	6.2399	**0.0001**
Treatment Tr	2	33027	16514	4.4903	**0.0003**
Site (Tr)	21	66835	3182.6	2.7699	**0.0001**
YexTr	7	10944	1563.5	1.3607	0.0351
Residual	53	60896	1149		
Total	87	203140			

b)

	2009		**2010**		**2011**		**2012**		**2013**	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	1.52	0.0244	0.69	0.9023	0.95	0.5072	0.91	0.5983	0.93	0.5494
PVC, OC	2.14	0.0018	1.45	0.0986	2.44	0.0025	2.09	**0.004**	2.52	**0.0027**
SI, OC	1.59	0.009	1.33	0.0982	2.04	0.0036	1.42	0.0664	1.77	**0.0077**

Indicator Species Analysis

Pecten maximus **– Great scallop (V)**

Table B8 Results of a) Permanova for the relative abundance of *Pecten maximus* identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions, and b) Pairwise testing for the interaction Year x Treatment. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

a)

Source	*df*	SS	MS	*F*	P
Year Ye	5	1.4958	0.29916	4.2611	**0.0014**
Treatment Tr	2	5.7241	2.862	6.7427	**0.0064**
Area Ar(Tr)	22	7.7372	0.35169	6.5878	**0.0001**
YexTr	10	1.846	0.1846	3.6175	**0.0005**
Site (Ar(Tr))	67	3.2184	0.048036	1.5857	**0.0265**
YexAr(Tr)	75	3.3805	0.045073	1.4879	**0.0258**
Residual	166	5.0287	0.030293		
Total	347	28.431			

b)

	2008		2009		2010		2011		2012		2013	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	0.81	0.5042	1.31	0.2159	2.07	0.0556	1.91	0.0877	2.29	**0.045**	2.72	**0.0021**
PVC, OC	0.73	0.5403	0.64	0.6314	0.54	0.6856	2.84	**0.0128**	3.26	**0.0061**	2.73	**0.0262**
SI, OC	0.46	0.8077	1.41	0.1746	3.31	**0.0043**	3.22	**0.0014**	4.47	**0.0007**	3.83	**0.0008**

Phallusia mammillata **– A sea squirt (V)**

Table B9 Results of a) Permanova for the relative abundance of *Phallusia mammillata* identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions, and b) Pairwise testing for the interaction Year x Treatment. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

a)

Source	*df*	SS	MS	*F*	P
Year Ye	5	1.2338	0.24677	2.2689	**0.0311**
Treatment Tr	2	5.7945	2.8973	8.5099	**0.0009**
Area Ar(Tr)	22	6.2158	0.28254	2.8273	**0.0035**
YexTr	10	2.006	0.2006	2.1397	**0.0278**
Site (Ar(Tr))	67	6.0804	0.090752	1.9824	**0.0343**
YexAr(Tr)	75	6.2669	0.083559	1.8253	**0.013**
Residual	166	7.5993	0.045779		
Total	347	35.197			

b)

	2008		2009		2010		2011		2012		2013	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	0.83	0.4943	0.45	0.8856	0.69	0.5901	2.04	0.0707	2.40	**0.0336**	1.32	0.2144
PVC, OC	3.73	**0.002**	3.02	**0.0071**	3.26	**0.0048**	3.25	**0.0006**	3.69	**0.004**	2.30	**0.0006**
SI, OC	1.32	0.2146	3.94	**0.0009**	3.80	**0.0015**	3.03	**0.0011**	2.71	**0.0008**	2.22	**0.0006**

***Cellepora pumicosa* – A sea mat (F)**

Table B10 Results of Permanova for the relative abundance of *Cellepora pumicosa* identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	5	93.961	18.792	17.471	**0.0001**
Treatment Tr	2	134.35	67.176	15.992	**0.0001**
Area Ar(Tr)	23	75.75	3.2935	5.887	**0.0001**
YexTr	10	15.46	1.546	1.8065	0.0734
Site (Ar(Tr))	67	35.14	0.52447	1.7857	**0.0012**
YexAr(Tr)	72	56.004	0.77783	2.6484	**0.0001**
Residual	167	49.048	0.2937		
Total	346	459.71			

***Pentapora fascialis* – Ross coral (F)**

Table B11 Results of a) Permanova for the relative abundance of *Pentapora fascialis* identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions, and b) Pairwise testing for the interaction Year x Treatment. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

a)

Source	*df*	SS	MS	*F*	P
Year Ye	5	9.3306	1.8661	11.821	**0.0001**
Treatment Tr	2	31.417	15.708	14.762	**0.0001**
Area Ar(Tr)	23	19.194	0.8345	6.1204	**0.0001**
YexTr	10	4.5678	0.45678	4.2199	**0.0001**
Site (Ar(Tr))	67	8.5698	0.12791	1.5608	**0.0204**
YexAr(Tr)	72	6.8995	0.095826	1.1694	0.2145
Residual	167	13.685	0.081948		
Total	346	93.663			

b)

	2008		2009		2010		2011		2012		2013	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	1.79	0.0947	1.13	0.2938	1.09	0.3102	1.83	0.0961	2.43	**0.0379**	1.98	0.072
PVC, OC	4.23	**0.0016**	3.84	**0.0025**	3.86	**0.0027**	5.05	**0.0001**	4.32	**0.0012**	4.47	**0.000**
SI, OC	2.79	**0.0076**	2.57	**0.0175**	2.66	**0.0146**	6.63	**0.001**	3.51	**0.0053**	2.92	**0.010**

Anemones (F)

Table B12 Results of Permanova for the relative abundance of Anemones identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	***df***	**SS**	**MS**	***F***	**P**
Year Ye	5	18.574	3.7148	4.3426	**0.0009**
Treatment Tr	2	51.721	25.86	4.1645	**0.0248**
Area Ar(Tr)	23	112.32	4.8836	5.6887	**0.0001**
YexTr	10	7.302	0.7302	1.3114	0.2471
Site (Ar(Tr))	67	53.812	0.80316	2.6738	**0.0001**
YexAr(Tr)	72	36.302	0.50419	1.6785	**0.0048**
Residual	167	50.163	0.30038		
Total	346	330.2			

Alcyonium digitatum – Dead man's fingers (V)

Table B13 Results of Permanova for the relative abundance of *Alcyonium digitatum* identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	***df***	**SS**	**MS**	***F***	**P**
Year Ye	5	85.516	17.103	3.3304	**0.0031**
Treatment Tr	2	56.892	28.446	0.86129	0.4529
Area Ar(Tr)	22	606.95	27.589	11.64	**0.0001**
YexTr	10	39.315	3.9315	1.1254	0.3415
Site (Ar(Tr))	67	142.16	2.1218	1.7324	**0.0216**
YexAr(Tr)	75	240.65	3.2087	2.6198	**0.0005**
Residual	166	203.31	1.2248		
Total	347	1374.8			

***Eunicella verrucosa* – Pink sea fan (V)**

Table B14 Results of Permanova for relative abundance of *Eunicella verrucosa* identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference

Source	***df***	**SS**	**MS**	***F***	**P**
Year Ye	5	2.8502	0.57004	1.4988	0.1651
Treatment Tr	2	13.105	6.5525	1.9036	0.1607
Area Ar(Tr)	22	62.794	2.8543	13.575	**0.0001**
YexTr	10	2.9312	0.29312	1.2975	0.2378
Site (Ar(Tr))	67	12.584	0.18782	2.4822	**0.0002**
YexAr(Tr)	75	15.272	0.20362	2.691	**0.0002**
Residual	166	12.561	0.075667		
Total	347	122.1			

***Chaetopterus variopedatus* –Parchment worm (F)**

Table B15 Results of Permanova for the relative abundance of *Chaetopterus variopedatus* identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	***df***	**SS**	**MS**	***F***	**P**
Year Ye	5	5.9508	1.1902	2.344	**0.039**
Treatment Tr	2	4.4535	2.2268	2.4149	0.106
Area Ar(Tr)	23	17.071	0.74223	3.2144	**0.0004**
YexTr	10	8.0724	0.80724	1.7551	0.0876
Site (Ar(Tr))	67	14.734	0.21991	0.96632	0.5553
YexAr(Tr)	72	30.675	0.42604	1.8721	**0.0004**
Residual	167	38.005	0.22758		
Total	346	118.96			

Hydroids (F)

Table B16 Results of Permanova for the relative abundance of Hydroids identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	5	130.51	26.102	15.744	**0.0001**
Treatment Tr	2	51.616	25.808	3.9457	**0.0293**
Area Ar(Tr)	23	118.55	5.1545	4.8972	**0.0001**
YexTr	10	17.743	1.7743	1.3615	0.218
Site (Ar(Tr))	67	66.145	0.98724	1.9939	**0.0003**
YexAr(Tr)	72	85.846	1.1923	2.4081	**0.0001**
Residual	167	82.687	0.49513		
Total	346	553.1			

Branching sponges (V)

Table B17 Results of a) Permanova for the relative abundance of branching sponges identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions, and b) Pairwise testing for the interaction Year x Treatment. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

a)

Source	*df*	SS	MS	*F*	P
Year Ye	5	15.401	3.0803	8.6896	**0.0001**
Treatment Tr	2	19.925	9.9627	8.7965	**0.0013**
Area Ar(Tr)	22	20.692	0.94055	3.5547	**0.0029**
YexTr	10	12.434	1.2434	4.1859	**0.0003**
Site (Ar(Tr))	67	16.251	0.24256	1.0729	0.3694
YexAr(Tr)	75	19.852	0.2647	1.1709	0.2497
Residual	166	37.528	0.22607		
Total	347	142.08			

b)

	2008		**2009**		**2010**		**2011**		**2012**		**2013**	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	1.06	0.3364	0.86	0.4787	1.49	0.16	3.29	**0.011**	1.97	0.0738	2.14	**0.0421**
PVC, OC	2.75	**0.0148**	2.62	**0.0165**	3.53	**0.0021**	4.78	**0.0005**	3.07	**0.0104**	3.28	**0.0005**
SI, OC	1.18	0.2622	1.30	0.2272	2.66	**0.0157**	2.59	**0.0039**	2.74	**0.0006**	3.58	**0.0017**

***Asterias rubens* – Common starfish (V)**

Table B18 Results of Permanova for the relative abundance of *Asterias rubens* identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	5	4.8601	0.97201	1.237	0.2765
Treatment Tr	2	5.1188	2.5594	0.88472	0.4437
Area Ar(Tr)	22	53.879	2.4491	4.8184	**0.0001**
YexTr	10	7.2825	0.72825	1.1163	0.3566
Site (Ar(Tr))	67	30.687	0.45802	1.904	**0.0184**
YexAr(Tr)	75	44.874	0.59832	2.4873	**0.0004**
Residual	166	39.932	0.24055		
Total	347	186.63			

***Trisopterus minutus* – Poor cod (B)**

Table B19 Results of Permanova for the relative abundance of *Trisopterus minutus* identified using baited video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factor Site (Si) and their interactions, and b) Pairwise testing for the interaction Year x Treatment. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

a)

Source	*df*	SS	MS	*F*	P
Year Ye	4	3.6809	0.92023	2.7597	**0.0317**
Treatment Tr	2	3.9857	1.9929	2.6371	0.0924
Site (Tr)	21	13.936	0.66363	2.1101	**0.0183**
YexTr	7	5.7119	0.81599	2.5946	**0.0237**
Residual	53	16.668	0.31449		
Total	87	43.983			

b)

	2009		**2010**		**2011**		**2012**		**2013**	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SI	2.34	**0.021**	0.43	0.6857	1.41	0.1936	0.01	1	0.29	0.7644
PVC, OC	0.81	0.4696	0.54	0.5988	1.49	0.1459	1.22	0.2406	2.88	**0.0273**
SI, OC	1.67	0.1418	0.82	0.4344	2.88	**0.0273**	1.58	0.2165	1.96	0.0609

***Necora puber* – Velvet swimming crab (V)**

Table B20 Results of Permanova for the relative abundance of *Necora puber* identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions and b) Pairwise testing for the term Treatment. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	5	0.029379	0.0058759	4.8773	**0.0001**
Treatment Tr	2	0.019753	0.0098765	3.9528	**0.027**
Area Ar(Tr)	22	0.046151	0.0020978	1.738	0.0534
YexTr	10	0.012718	0.0012718	1.2329	0.274
Site (Ar(Tr))	67	0.074627	0.0011138	1.795	**0.0172**
YexAr(Tr)	75	0.071451	0.00095268	1.5353	**0.0263**
Residual	166	0.10301	0.00062053		
Total	347	0.35709			

***Cancer pagurus* – Edible crab (V)**

Table B21 Results of Permanova for the relative abundance of *Cancer pagurus* identified using video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Area (Ar) and Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	5	0.0028016	0.00056033	2.3745	**0.0362**
Treatment Tr	2	0.0012279	0.00061397	1.5441	0.232
Area Ar(Tr)	22	0.0078165	0.0003553	1.2732	0.2176
YexTr	10	0.0016991	0.00016991	0.86778	0.5681
Site (Ar(Tr))	67	0.017956	0.000268	1.182	0.2183
YexAr(Tr)	75	0.015155	0.00020207	0.89119	0.6864
Residual	166	0.037639	0.00022674		
Total	347	0.084295			

***Ctenolabrus rupestris* – Goldsinny wrasse (B)**

Table B22 Results of a) Permanova for the relative abundance of *Ctenolabrus rupestris* identified using baited video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	4	0.92555	0.23139	5.3308	**0.0006**
Treatment Tr	2	1.9749	0.98744	11.371	**0.0012**
Site (Tr)	21	1.571	0.074807	1.7981	0.0514
YexTr	7	0.44806	0.064008	1.5386	0.1691
Residual	53	2.2049	0.041602		
Total	87	7.1244			

Gobies (B)

Table B23 Results of Permanova for the relative abundance of Gobies identified using baited video in response to the fixed factors Year (Ye) and Treatment (Tr), and random factors Site (Si) and their interactions. Data were Log (X+1) transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	4	5.0743	1.2686	9.1116	**0.0001**
Treatment Tr	2	0.97645	0.48822	1.2363	0.3121
Site (Tr)	21	7.4054	0.35264	2.7774	**0.002**
YexTr	7	0.87668	0.12524	0.98637	0.4497
Residual	53	6.7294	0.12697		
Total	87	21.062			

Sensitive Areas Analysis

Table B24 Results of Permanova for the relative abundance of the main assemblage count species identified using frame grabs in response to the fixed factors Year (Ye) and Treatment (Tr) including SA, and random factors Area (Ar) and Site (Si) and their interactions. Data were dispersion weighted and forth root transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

a)

Source	*df*	SS	MS	*F*	P
Year Ye	5	56623	11325	7.6731	**0.0001**
Treatment Tr	2	73908	36954	8.697	**0.0001**
Site (Tr)	22	84572	3844.2	4.2158	**0.0001**
YexTr	7	15090	2155.7	2.094	**0.0001**
Residual	75	60459	806.12	1.5125	**0.0001**
Total	51	47712	935.53	1.7553	**0.0001**

b)

	2008		**2009**		**2010**		**2011**		**2012**		**2013**	
Groups	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**	**t**	**P**
PVC, SA	-	-	-	-	-	-	3.20	**0.0021**	2.18	**0.0084**	2.73	**0.0039**
PVC, OC	1.66	**0.0057**	2.01	**0.0045**	2.38	**0.0007**	3.41	**0.0008**	2.92	**0.0013**	3.65	**0.0003**
SA, OC	-	-	-	-	-	**-**	1.17	0.2151	1.06	0.3391	1.63	**0.0212**

Table B25 Results of Permanova for the relative abundance of the mobile species assemblage identified using baited video in response to the fixed factors Year (Ye) and Treatment (Tr) including SA, and random factors Area (Ar) and Site (Si) and their interactions. Data were dispersion weighted and square root transformed. Analyses were conducted using Euclidean distance. Bold type denotes a statistically significant difference.

Source	*df*	SS	MS	*F*	P
Year Ye	2	10192	5096	5.6203	**0.0001**
Treatment Tr	2	28819	14409	5.7529	**0.0001**
Site (Tr)	15	37571	2504.7	2.7624	**0.0001**
YexTr	4	4321.6	1080.4	1.1916	0.2122
Residual	30	27201	906.71		
Total	53	108100			