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Marine Matters

Marine Monitoring Framework

Plymouth Sound and Estuaries SAC: Sub-tidal and Mixed Gravel Sub-feature and Sub-tidal Rocky Reefs Sub-feature Condition Assessment

Version 1.2

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Solutions for Sustainable Seas

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1 Executive Summary

This report describes the findings of a sub-tidal diving survey of benthic habitats in Plymouth Sound, a SAC designated area. The overall aim of the survey was to ascertain the condition status of habitats designated as "of special conservation interest" by the EU Habitats Directive.

Two of the four survey sites, Eastern Kings and Duke Rock South have been surveyed previously. Results from the present survey are compared with historical results in an effort to detect change in assemblage composition that might indicate a change in habitat condition.

The methods used in the present study are designed to establish habitat condition using cost effective and statistically robust sampling techniques that can be repeated in future survey programmes.

In general the habitat condition was considered good in all sites. The assemblages encountered were diverse, included long lived organisms such as large sponges and branching hydroids, and showed very little obvious sign of anthropogenic disturbance despite their proximity to densely populated urban areas and exposure to the discharge of a large catchment area via the River Tamar.

Changes in species distribution and abundance between current and historical data are interpreted with caution and discussed in context of the variables associated with diving surveys. Lastly, suggestions are made to maximise the value gained from future sampling efforts.

2 Introduction

Plymouth Sound and its associated tributaries hold a number of national and international designations. The areas within European Sites (Special Area of Conservation and Special Protection Area), which are covered by tidal waters at any time are collectively referred to as a European Marine Site (EMS).

The Plymouth Sound and Estuaries SAC has a rich diversity of southern flora and fauna and a variety of different habitats due to the variations in wave exposure, water depth, rock and sediment types, salinity and tidal streams. Plymouth Sound and Estuaries qualifies as a SAC for the following Annex 1 habitats as listed in the EU Habitats Directive:

- Large shallow inlets and bays
- Estuaries
- Sandbanks which are slightly covered by seawater all the time.
- Reefs
- Intertidal mudflats and sandflats
- Atlantic salt meadows;
- and the species *Alosa alosa*, the Allis shad.

Two important sub-features of the Reef feature are:
1. 'Sub-tidal rocky reef communities' – specifically *SubSoAs, AlcByH.Hia* and *AlcTub* biotopes

and,

2. 'Sub-tidal mixed cobble and gravel communities' of Ephemeral red algae specifically, *MIR.SedK.EphR* which are often a sub-feature of large shallow inlets and bays.

The 'Sub-tidal rocky reef communities' sub-feature last underwent condition assessment in 2003 (Howson, Bunker & Mercer, 2005). The 'Sub-tidal mixed cobble and gravel communities' sub-feature was more recently assessed using remote video and still photography in 2011 (Ware, S. and Meadows, B., 2011)., However, Howson, Bunker & Mercer (2005) provides the last diver survey reference point.

Moore (2000) reported on the repeatability of using diver survey methods to monitor the sub-tidal reef communities in Plymouth Sound specifically to:

- Identify significant temporal changes in the data, distinguish real changes from artificial factors and describe the level of natural fluctuation in the sub-tidal reef communities
- To compare quadrat versus whole transect methods
- To calculate number of quadrat records required to detect 'significant' change
- To assess the reliability of diver records of species and abundance estimates
- To assess the use of different analytical techniques

The report shows answers to specific questions on:

- Temporal changes in populations/ communities
- Data analysis techniques
- Number of records required
- Reliability of diver records
- Ephemeral species and surrogacy
- Development of protocols for future monitoring.

Howson, Bunker & Mercer (2005) looked at the extent and diversity of the infra-littoral and circa-littoral biotopes within Plymouth Sound including sub-tidal rock and boulder and mixed cobble and gravel communities, with a view to initiate a repeatable monitoring programme, against which the condition of the site could be measured.

The project was designed to enable the condition of the Plymouth Sound SAC to be assessed against the targets for the features. This required diving fieldwork to establish a baseline of information against which the site condition could be assessed in the future and which could also be used in a comparison with extant data sets.

The methods used broadly followed those outlined in the Procedural Guidelines 3-7 in the Marine Monitoring Handbook (Davies *et al*. 2001). Fieldwork was carried out during 2003, with the data collected establishing a quantitative baseline of information for the site. Comparisons were made between these data and other data from various surveys since 1985, including quantitative data from monitoring trials carried out in 1998 and 1999.

The Howson, Bunker & Mercer (2005) study is viewed as the main reference point for the current study.

3 Aims and Objectives

Natural England commissioned ecological survey work through PML Applications Ltd during August of 2013 in order to obtain standardised biological information for the 'Sub-tidal mixed cobble and gravel', and 'Sub-tidal rock and boulder communities' sub-features of the Plymouth Sound and Estuaries SAC to assess the condition of these sub-features of the SAC against previous survey data.

The information gathered was required to be of sufficient quality to provide a comparison with previous surveys, in particular Howson *et al*. (2005) and to provide comprehensive baseline data for any new sites relating to the condition of the SAC 'Sub-tidal mixed cobble and gravel', and 'Sub-tidal rock and boulder communities' sub-features. Methodologies were required to follow guidance outlined in JNCC Common Standards Monitoring (CSM) guidance available at http://jncc.defra.gov.uk/page-2236. Survey work was undertaken as close as possible to the time when Howson *et al.* (2005) conducted their survey to allow comparison of results.

Natural England required PML Applications to pay particular attention to survey design so that quantitatively robust data are acquired which will permit rigorous statistical analysis of future survey work and support robust condition assessment judgements of SAC components of the EMS.

3.1 Objectives

The objectives of this survey are

A. To follow recommendations and methods developed in previous surveys (i.e. Moore 2001 and Howson *et al.* 2005) to develop a cost effective sampling strategy to allow condition of the 'Sub-tidal mixed cobble and gravel' and 'Sub-tidal rock and boulder communities' to be assessed against the relevant attributes and compared with previous survey data using the Common Standards Monitoring Guidance.

   These attributes are:
   - Sub-tidal mixed cobble and gravel communities
   - Species composition of characteristic biotope ***MIR.SedK.EphR*** Ephemeral red seaweeds and kelps on tide-swept mobile infra-littoral cobbles (now ***S.SMp.KSwSS.LsacR.CbPb*** Red seaweeds and kelps on tide-swept mobile infra-littoral cobbles and pebbles)

   - Sub-tidal rocky reef communities
   - Distribution of characteristic habitats
   - Species composition of characteristic habitats

B. Provide an assessment of the direction of ecological change by the integration of previously obtained relevant data.

C. Provide ecological baseline for attribute condition (from which to assess future change) where this is not identified in the supplementary information provided by Natural England. In particular to provide a baseline for the *IR.MIR.KR.HiaSw (previously AlcByH.Hia)*, if possible, See Section 3.2 below.

D. Where possible, ensure that any newly collected data is compatible (analytically) with historical survey data, but at the very least will make reference to and utilise such historical data.

E. Where possible replicate and build on existing survey design to maintain/increase statistical robustness of data and to enable the collection of compatible future data permitting quantitative long term trend analysis.

F. Allow anthropogenic influences, impacting on the ability of the sub-feature to achieve Favourable Condition, to be identified and where possible quantified.

G. Records of any non-native species and their abundances are recorded throughout the survey for example *Undaria pinnafida*, *Sargassum muticum, Crassostrea gigas, Styela clava, Crepidula fornicata.*

This survey work and subsequent analysis will contribute to Natural England's statutory duty to monitor and report on a range of features and attributes for the SAC.

3.2 Sub-feature Biotopes

There are a number of specific objectives to note with respect to the sub-features' representative biotopes:

I. Biotope classifications were revised in 2004. Table 1 below shows the revised biotope classifications which are considered the best equivalents of biotopes contained in the Regulation 33 document (as determined using JNCC translation table (http://jncc.defra.gov.uk/page-1645).

Table 1: Biotope codes

Biotope code 1997 (Marine Biotope Classification for Britain and Ireland Version 97.06)	***Biotope code 2004 (suggested conversion)*** Marine Habitat Classification for Britain and Ireland Version 04.05	***Biotope name 2004***
EphR	*SS.SMp.KSwSS.LsacR.CbPb*	Red seaweeds and kelps on tide-swept mobile infra-littoral cobbles and pebbles
SubSoAs	*CR.MCR.CFaVS.CuSpH.As*	Cushion sponges, hydroids and ascidians on turbid tide-swept sheltered circa-littoral rock.
AlcByH.Hia	*IR.MIR.KR.HiaSw*	*Hiatella arctica* and seaweeds on vertical limestone/chalk
AlcTub	*CR.HCR.FaT.CTub*	*Tubularia indivisa* on tide-swept circa-littoral rock
ErS.Eun	*CR.HCR.XFa.ByErSp.Eun*	*Eunicella verrucosa* and *Pentapora foliacea* on wave-exposed circa-littoral rock.

II. Where possible Natural England required an indication of condition with respect to prior data for the habitats previously monitored, in particular by Howson *et al*. 2005. In particular this was required for:
   a. *EphR*
   b. *SubSoAs*
   c. *AlcTub*

III. The biotope *AlcByH.Hia (IR.MIR.KR.HiaSw)* was not reported on by Howson *et al*. (2005) and Natural England ideally aimed to establish a baseline for this biotope.

IV. Previous monitoring (Howson *et al*. 2005) found it difficult to find good examples of the ErS.Eun biotope within the SAC. Natural England suggested removing this biotope from 2013 monitoring. Natural England requested suggestions and recommendations on reallocation of resources to meet overall monitoring objectives.

4 Site Selection

Site selection for this survey was predetermined by Natural England to correspond with previous survey efforts described in Section 3.1 and to achieve coverage of the habitats of interest described in section 3.2. All survey sites are shown in Figure 1 and are located within Plymouth Sound, to the North of the Breakwater.

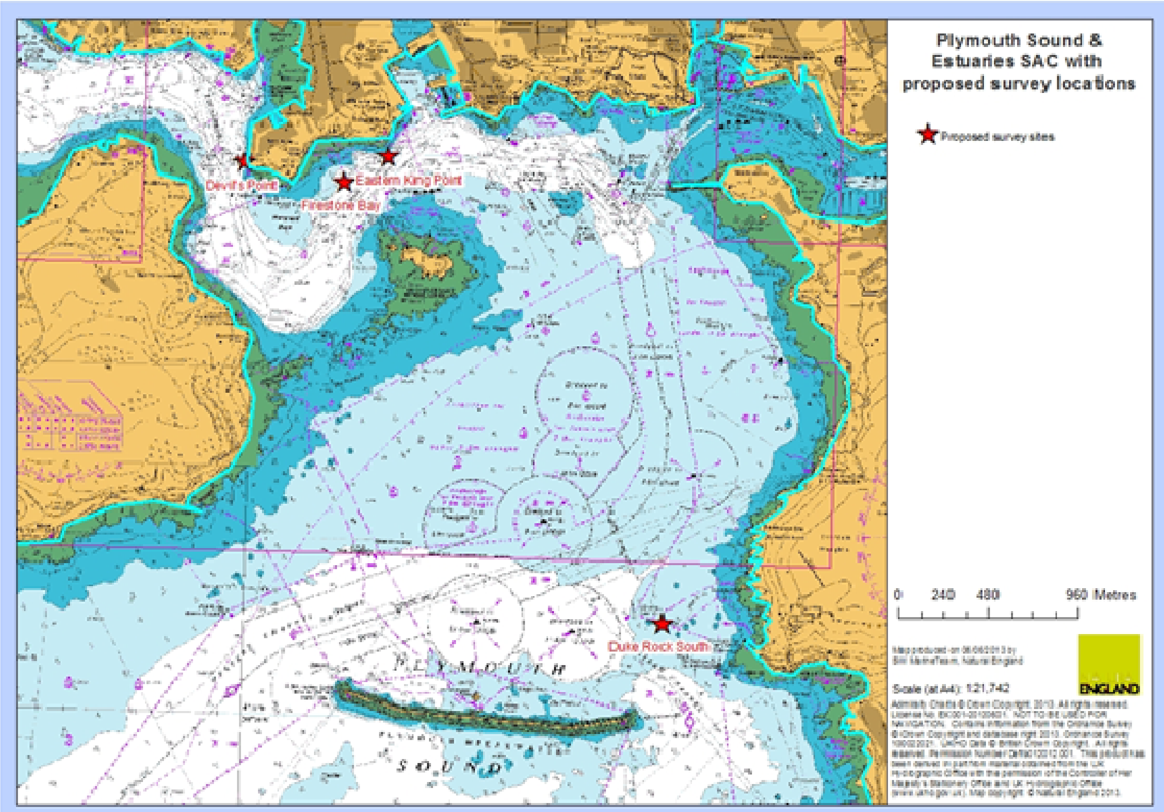

Figure 1: Chart showing the position of survey sites relative to Plymouth Sound, the Breakwater and Tamar Estuary.

One of the principal aims of this work is to build on previous surveys conducted in the area, so efforts were made to relocate the previous survey sites and confirm their current habitat type using dropdown video prior to undertaking the diving work. This confirmation step ensured that costly diving activities are used most effectively and only the habitats of interest were visited.

The GPS marks provided by Natural England for each site were used as starting points for site selection. The supplied marks were supplemented by local knowledge of the sites from PML Applications staff together with Dr Keith Hiscock and Dr Dan Smale from the Marine Biological Association.The proposed marks were investigated using dropdown video and either confirmed as being suitable for survey or rejected. Sites were considered suitable for survey if clear signs of the specified substrate type or Biotope defining species were visible. If the original marks were rejected, the drop down footage was used with GPS to confirm alternative survey areas within the vicinity of the previous surveys. The revised survey sites were discussed with Natural England prior to commencing work.

4.1 Results: Drop Down Video

The drop-down video footage was extremely useful as it allowed us to check the GPS marks supplied by Natural England to confirm they were in suitable habitats. The drop down footage also allowed us to identify the health and safety threat posed by lost and discarded monofilament fishing line at the proposed survey site at Devils Point.

4.1.1 Eastern Kings - Confirmed as Upward Facing Rock Assemblages

The drop-down video footage allowed us to confirm that the GPS marks provided by Natural England for Eastern Kings were indeed upward facing rock assemblages and the proximity to the underwater cables that provided the fixed reference point used by the previous survey.

4.1.2 Devils Point – New Site Suggested

The drop down video footage at Devils Point confirmed that the habitat type discovered was a sub-tidal rock reef as anticipated by natural England. However, there was a significant threat to divers posed by the presence of large amounts of thick, discarded monofilament fishing line. The extent of this was such that the drop down video camera itself became entangled. Consequently a new survey site was suggested as described in section 4.2.2

4.1.3 Firestone Bay – New Site Suggested

Drop-down footage at Firestone Bay showed that the habitat at the marks provided by Natural England was sandy seabed, and not a sub-tidal rocky reef habitat specified for condition assessment. Additionally, the GPS marks supplied by natural England were a considerable distance from any suitable fixed reference point to allow repeated survey of the same area. Consequently a new survey site was suggested as described in section 4.2

4.1.4 Duke Rock South - Confirmed

Drop down footage was not collected for Duke Rock South as PML Applications was confident from previous experience at this site that the habit type would support sub-tidal mixed cobble and gravel assemblages.

4.2 Adjustment of Survey Sites

The drop-down-camera footage suggested that GPS marks at some sites were ideal for survey, such as Eastern Kings, yet other sites would need adjustment to ensure that suitable habitat types were encountered (Firestone Bay) and that no health and safety risks were present (Devils Point). The following text provides a summary of the new survey sites in relation to the old survey sites.

Note: The two sites where historical data are present from previous surveys (Eastern Kings and Duke Rock) were relocated with a high degree of confidence.

4.2.1 Position - Eastern Kings

This site was surveyed at the exact marks provided by Natural England. Sub-sea cables were encountered at the same tide corrected depth as described by the previous survey (Moore *et al*, 2000). The initial inspection showed a high abundance of feather stars also described by Moore *et al* (2000)providing further confidence that the current survey was conducted in very close proximity to the previous survey.

4.2.2 Position – Devils Point

Due to the presence of large amounts of discarded monofilament fishing line, the actual site surveyed at Devils point was relocated to be as close as possible to the original GPS marks provided by Natural England, while keeping far enough away from the fishing activity so that the risk of diver entanglement was greatly reduced.

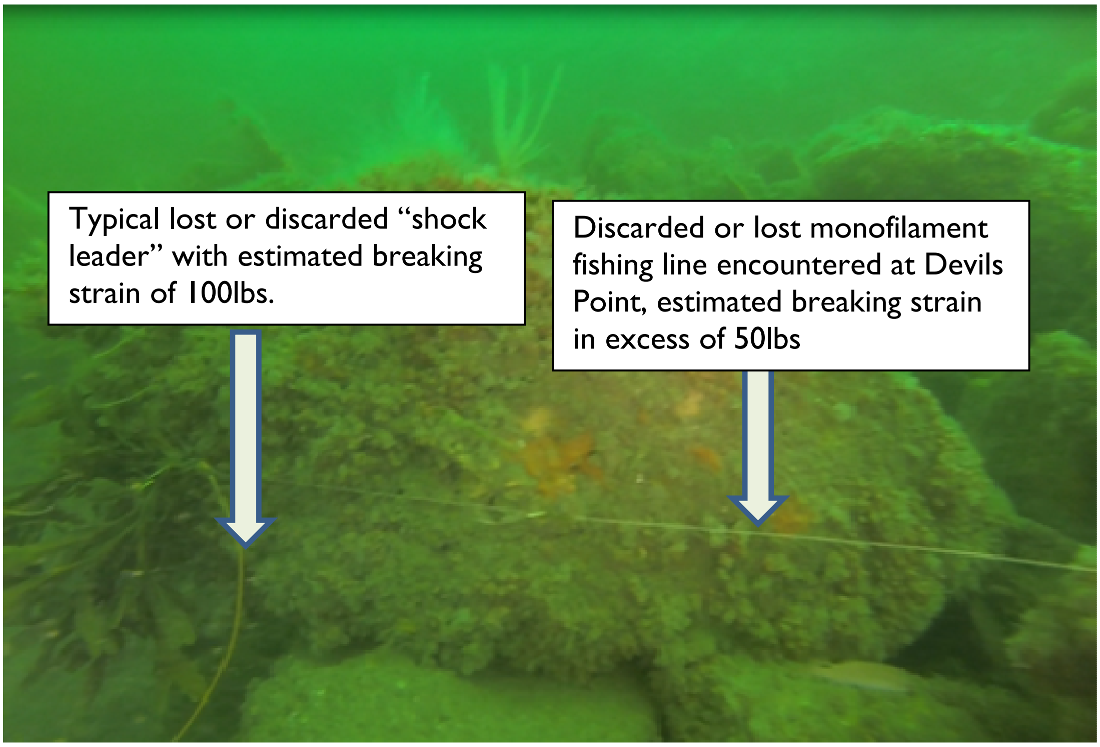

Figure 2: Image to show typical lost or discarded monofilament fishing line encountered at Devils Point.

Drop-down-camera footage at the proposed new survey site confirmed that the habitat was made up of sub-tidal rocky reef and mixed cobbles as specified by Natural England. The proposed survey site was less than 100m away from the original site proposed by Natural England and was also at the same tide corrected depth.

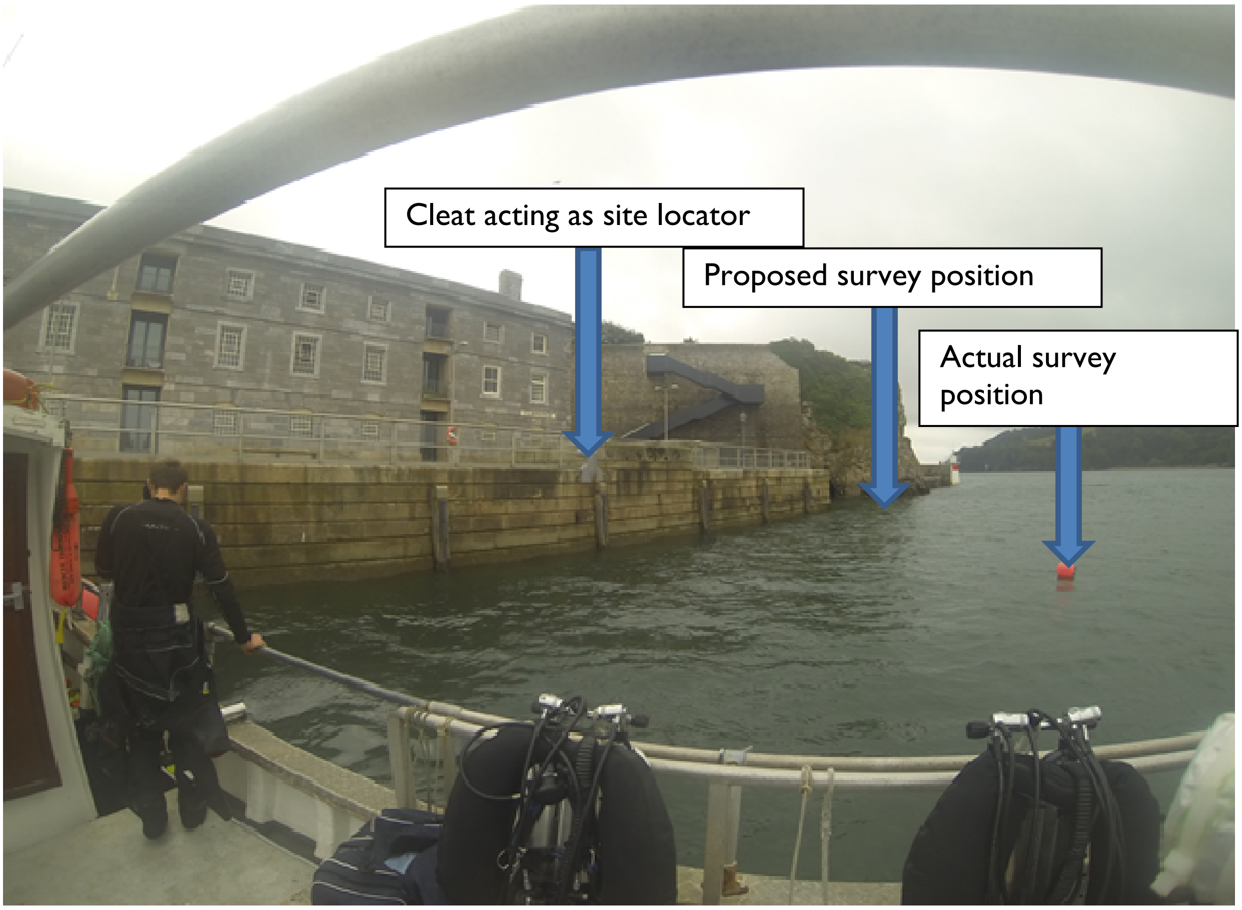

Figure 3: Image to show proposed survey location at Devils Point, the actual survey location and the cleat which provides a permanent locator for repeated surveys at the site.

4.2.3 Position – Firestone Bay

Drop-down video footage at Firestone Bay allowed PML Applications to find a site very close to the GPS position provided by Natural England that supported sub-tidal rocky reefs. The new site also provided fixed reference points in the form of sub-sea cables that can be used as site locators for subsequent surveys.

4.2.4 Position - Duke Rock

This site was surveyed using the exact marks provided by Natural England. We encountered what may have been part of the previous transect line established by Moore *et al.* (2000). An old length of rope was found partially buried in the sand, stretched out on the same cardinal point as described by Moore et al. (2000), at the same tide corrected depth.

Table 2: GPS marks suggested by Natural England and GPS marks actually surveyed by PML Applications. All GPS marks in WG-S84 projection.

Site	GPS Mark Suggested by Natural England	GPS Mark Actually Surveyed
Eastern Kings	50°21.627' N, 004° 09.404' W	50°21.627' N, 004° 09.397' W
Devils Point	50°21.6' N 004°10.05' W	50°21.634' N 004°10.041' W
Firestone Bay	50° 21.6' N 004° 09.6' W	50° 21.605' N 004° 09.634' W
Duke Rock South	50° 20.298' N 004° 08.099' W	50° 20.298' N 004° 08.099' W

5 Methods

To meet with the objectives of Natural England, PML Applications collected data in such a way as to build on previous survey work. This involved identifying the exact previous survey site where possible (Duke Rock South and Eastern Kings) and ensuring all new data were collected in comparable habitat types.

5.1 Survey Team

The scientific team consisted of four HSE qualified divers working in two pairs. The scientific divers were supported by a team consisting of a dive supervisor, dressed-in standby diver, skipper and a member of staff for surface support in accordance with the U.K. HSE Scientific and Archaeological ACOP (http://www.hse.gov.uk/pubns/priced/l107.pdf). Each diver also carried a red and yellow SMB to provide a failsafe pre-arranged form of communication with the dive vessel in the event of separation or equipment failure.

Port authorities were made aware of our intentions in the weeks before the survey and the only stipulation given was to notify The Longroom on arrival on-site and after the last dive team was back on board. Prior to starting work, permissions were sought from Flag Port Control and The Longroom on VHF radio channel 14. Permission to dive was granted on each survey day and diving work proceeded as planned.

5.2 Survey Dates

The survey sites experience strong tides and the survey times were chosen to coincide with high tide slack water conditions in daylight hours to give the best chance of suitable under water visibility.

Table 3: Time plan for Plymouth Sound diver surveys

Date	Site	Task
09.08.13	Devils Point Firestone Bay Eastern Kings	Drop-down video verification of survey locations
14.08.13	Eastern Kings	Diver Survey
15.08.13	Devils Point Duke Rock South	Diver Survey
16.08.13	Firestone Bay	Diver Survey

5.3 Site Locator

At each site, a prominent feature such as a position on an underwater cable or obvious feature was chosen as a site locator. This feature was either GPS marked and or suitably photographed to enable it to be used as a fixed reference point to easily identify the site for all future survey work.

Table 4: Description of site locators at each site.

Site	Site Locator
Eastern Kings	Sub-sea cable running North -South
Devils Point	Large metal cleat on dockside wall
Firestone Bay	Sub-sea cable running North -South
Duke Rock South	No locator was used as GPS mark appeared to be sufficient to relocate the previous survey area

5.4 Transect Position

To ensure that all data collected for this survey are independent and suitable for robust statistical analysis, a random distance between 0-3m from the Site Locator was determined prior to the dive from which all transects started from.

From the Transect Starting Point, a random bearing was chosen which fell within the habitat type, and depth range of interest. This was determined by selecting random bearings between 60 and 120 degrees in an Easterly direction and random bearings between 240 and 300 degrees in Westerly direction. This ensured that the transects did not run due North/South which would of resulted in steep depth gradients and depth related assemblage change. See Figure 4.

Each dive team finned from the transect starting point and laid out a 20m transect line, whilst using video to record the features of the wider area around the transect line. Once at the opposite end of the transect from the starting point, the quadrat survey began and each pair of divers worked back toward the transect start point, each surveying 5 quadrats along one side the transect. This approach was repeated at all sites but with transects running at different bearings and with different spacing between quadrats.

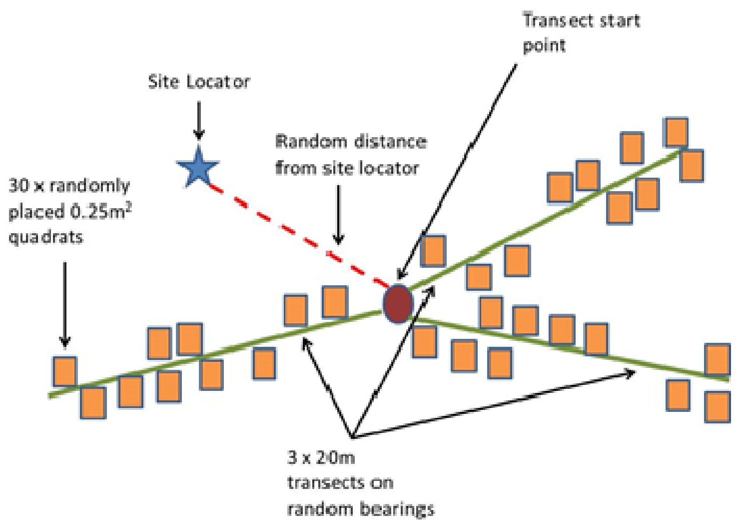

Figure 4: Diagram to show typical layout of the diving survey.

6 Site Location

The survey site at Firestone Bay is easily located by following the cable that runs south off the beach down to a depth of 11.2 meters below chart datum. The site and depth was chosen to be comparable to the previous survey work at Eastern Kings and because the drop-down camera footage had shown the required sub-tidal rocky reef sub-feature to be present at this depth.

6.1 Firestone bay

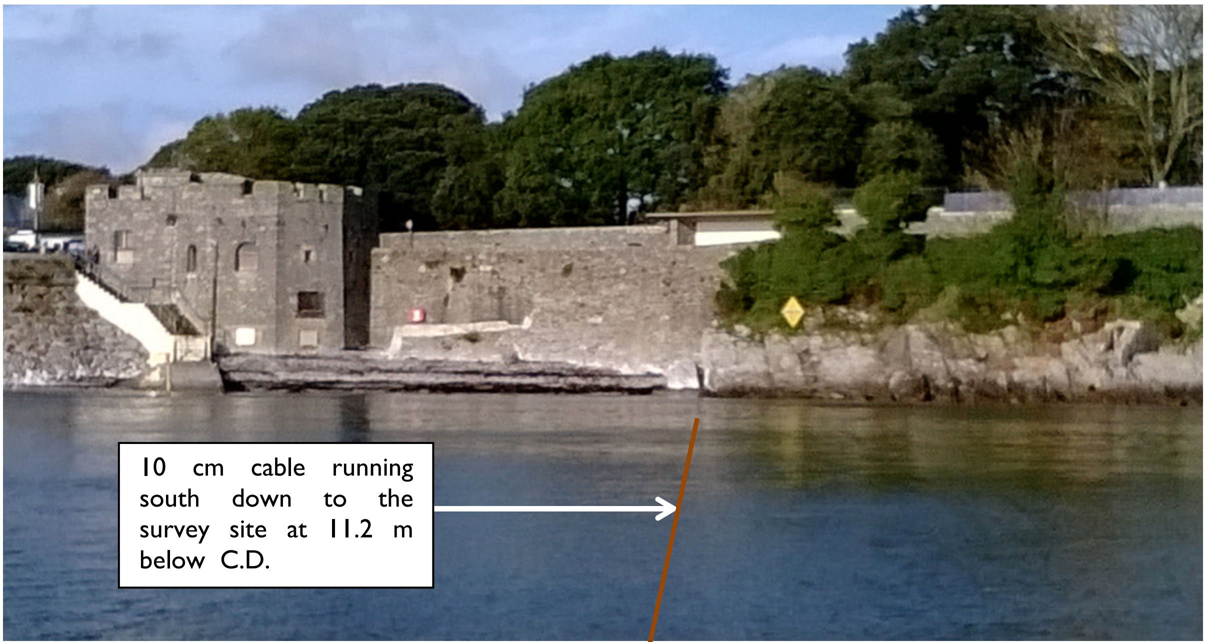

Figure 5: Survey site location at Firestone Bay. Cable running south runs South off the beach down to the survey site as described below.

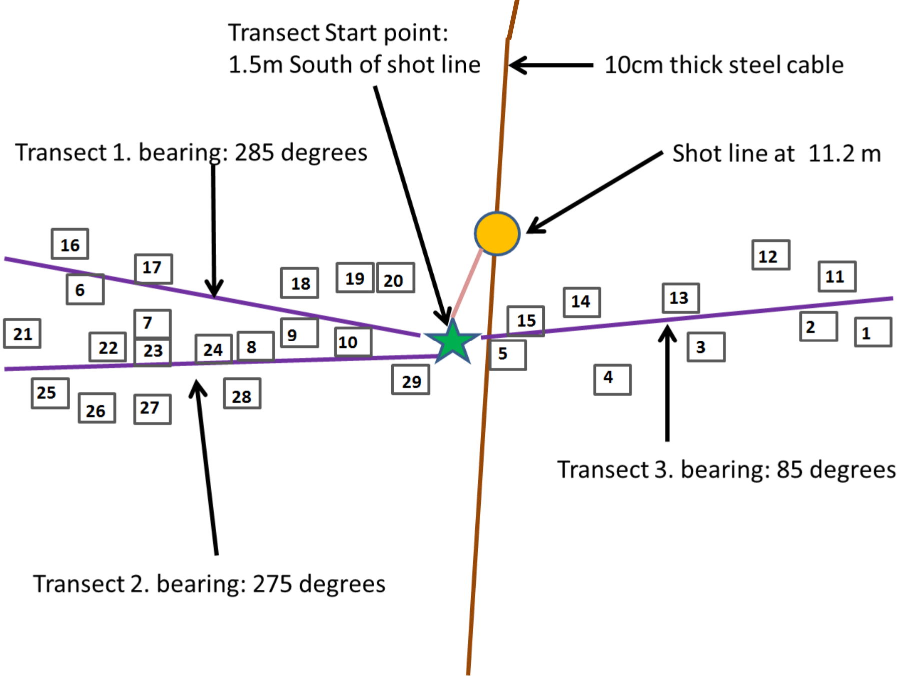

Figure 6: Survey site at Firestone Bay. Shot line depth below chart datum.

6.2 Eastern Kings

The survey site at Eastern Kings is easily located by following the cable that runs South West out of the stone building pictured below. The cable is insulated with black plastic for the first few meters. Further down the cable is thinner in diameter and insulated in bright blue plastic. The cable divides at one point and the survey site can be found by following the Western most divide down to a depth of 13.7 meters below chart datum.

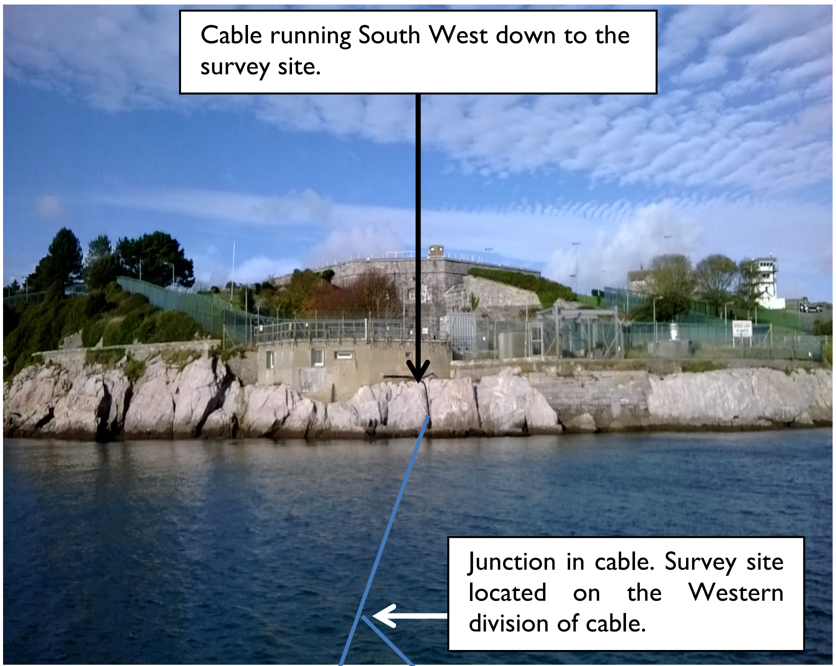

Figure 7: Site location at Eastern Kings. Cable running South West runs south off the beach down to the survey site as described below.

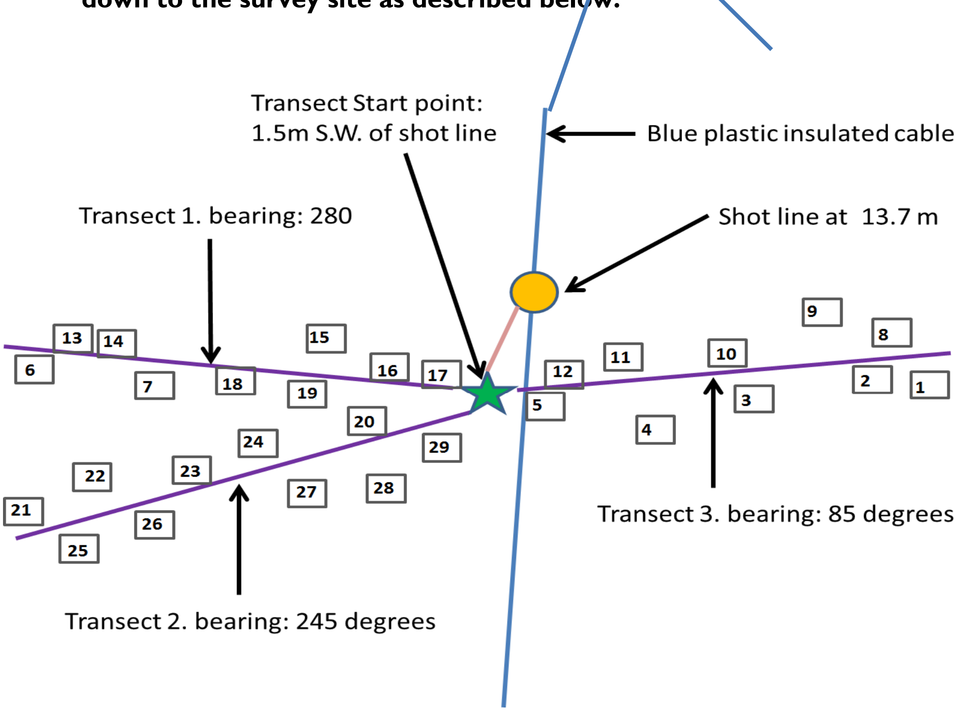

Figure 8: Survey site at Eastern Kings. Shot line depth below chart datum.

6.3 Site Location: Devils Point

The survey site at Devils Point can be easily located by deploying a shot line in line with the first large metal cleat (looking right to left as shown in the photograph below) along the Victualing wall at 9.7m below chart datum.

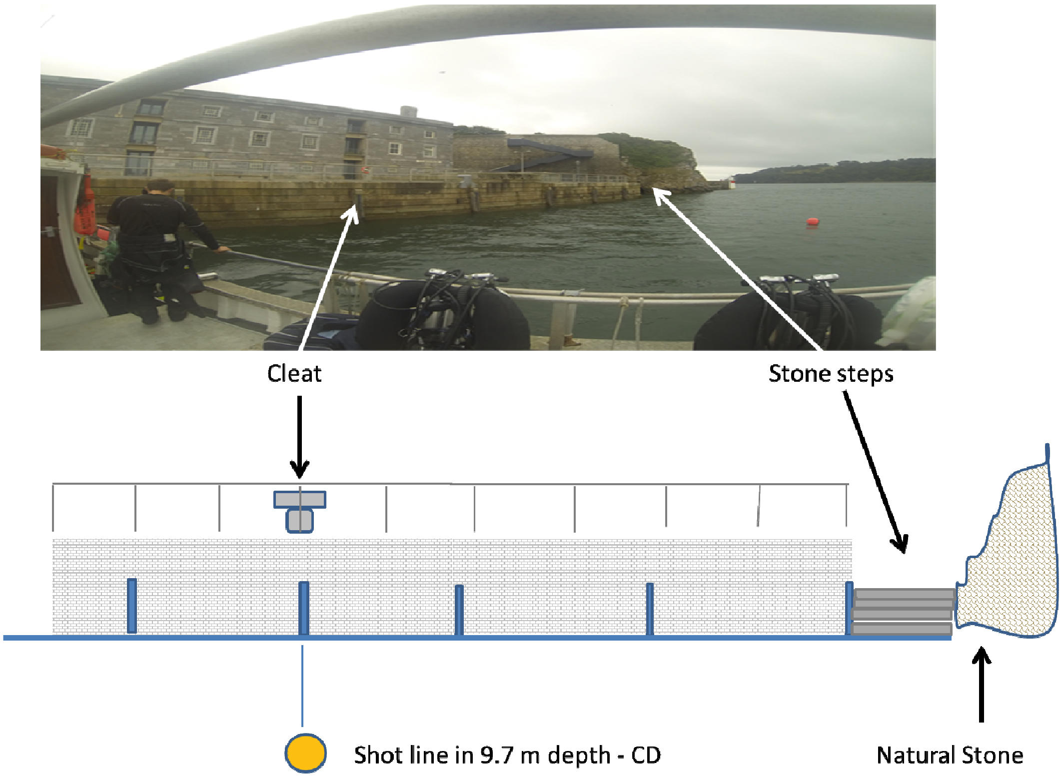

Figure 9: Image to show location of Devils Point survey site.

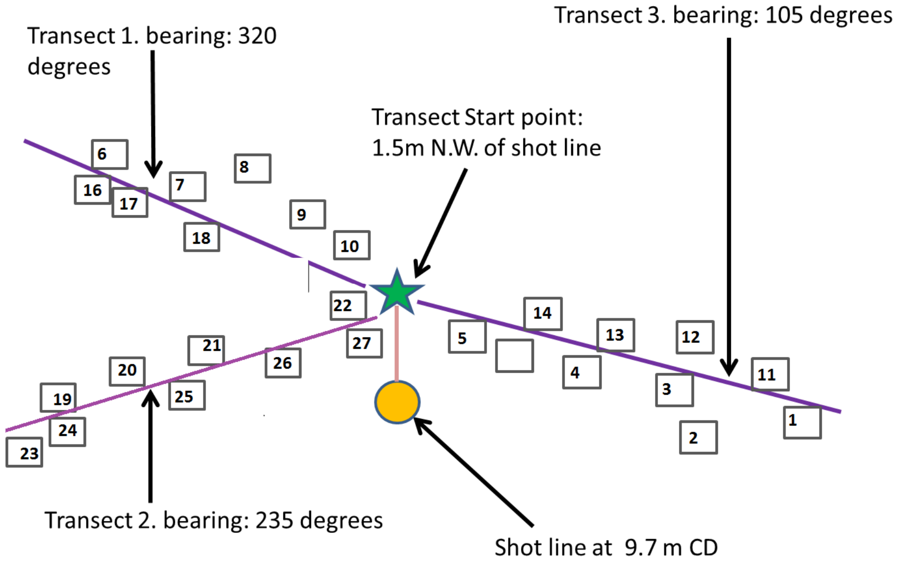

Figure 10: Image to show layout of survey transects at Devils Point.

6.4 Site Location: Duke Rock South

The survey site at Duke Rock South is easily located by dropping a shot line at the coordinates described in Table 2, ensuring the shot is dropped at 5.6m below chart datum. The layout of the transects and quadrats used in this survey are described below.

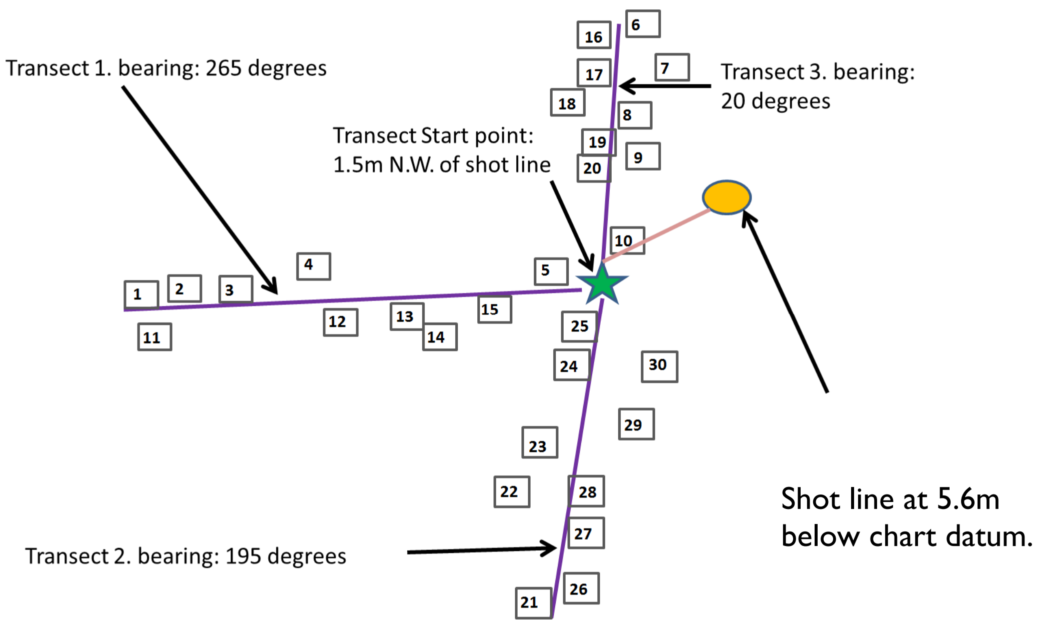

Figure 11: Image to show layout of survey transects at Duke Rock South.

6.5 Quadrat Survey

Each individual diver placed 5 x 0.25^2m quadrats along one side of the transect line. The distances between the quadrats and the distances away from the transect line (0-3m) were randomly determined before the dive.

6.5.1 Note on Quadrat Size:

Previous diver surveys within the Plymouth Sound SAC have used a variety of quadrat sizes, sometimes even within the same survey. This leads to confusion over different levels of sampling effort, with the potential for misleading trends in the survey data. While one of the goals of this study was to collect data that could be comparable to previous surveys, this was not always going to be possible when a variety of quadrat sizes had been used historically.

Our view was to select the most appropriate quadrat size to provide a representative measure of the habitat, based on the size and distribution of the individuals within the habitat, and stick to that size throughout the survey. The 0.25m quadrat size was considered the best compromise that would work across all sites (see discussion in Moore *et al,* 2000) and was approved by Natural England during the planning stage.

6.5.2 Quadrat Placement

In all cases, the random bearings and distances from the quadrat line were sufficiently different between transects to ensure they did not overlap and the same area was not surveyed twice. This was repeated until three transects and approximately 30 quadrats have been surveyed at each site.

To avoid diver bias, quadrat placement was not altered in the event of encountering heterogeneous habitats. This was not an issue except at Duke Rock South where the habitat was so variable, some degree of variability between substratum types was inevitable, which is a true representation of the site.

At some sites the long dive times of up to 60 minutes meant that not all of the planned quadrats were surveyed. Only a few quadrats were missed per site and we are confident that this will not have any measurable effect on the abundance data. Table 5 shows the number of quadrats successfully surveyed at each site.

Table 5: Number of quadrats successfully surveyed at each site

Site	Planned number of quadrats	Actual number of quadrats surveyed.
Eastern Kings	30	30
Devils Point	30	26
Firestone Bay	30	30
Duke Rock South	30	30

6.6 Inter-diver Calibration

Inter-diver calibration was achieved both prior to and during the survey.

- Prior to the survey the scientific divers examined photographs taken from the survey sites from previous expeditions.
- The team compared their individual identification results from the images and also compared estimates of percentage cover.
- After repeating this exercise several times, both species identification and estimates of percentage cover were found to be highly consistent between divers.

This preparative work was very valuable and allowed the dive team to refresh their identification skills, decrease the time required for in-water identification, and adequately prepare species lists to attach to survey slates.

After each dive, slates were compared and any unknown or unidentified species were standardised within the group to ensure consistency in taxonomy.

6.7 Data Collection - Quadrats

The percentage cover of macrofauna and macroalgae were recorded within each quadrat. Colonial and solitary species were both recorded with estimates of percentage coverage due to time constraints. Only sessile species were recorded with motile species only noted as being present. If a species occurred in very low percentage coverage it was noted as <1%.

Species were only recorded where they were obvious without manipulation of the benthos. Cryptic species or those not easily visible during diver survey conditions were not recorded. If identification was not clear in the field, a specimen was collected from outside the quadrats for analysis in the laboratory.

Divers recorded quadrat data on slates and also photographed each quadrat to provide an extra record of the conditions encountered that could be used to validate the slate data.

Any invasive non-native species or species suspected as residing outside their normal distribution range were noted and photographed with GPS location data. Examples of prominent macroalgal species in good condition (with the exception of large kelp) were collected for inclusion in a reference collection.

6.8 Data Collection – Photography

Still images were collected using an Olympus Tough TG-810 cameras in Olympus PT-051 housings. Video Images were taken using a GoPro Black Edition camera with dual mounted diffused LED video lights. Each individual diver was equipped with a stills camera. One diver from each working pair was equipped with a video camera.

6.9 Biotope Classification

Biotope codes were not assigned in the field but immediately upon return to the laboratory in order that all of the species information collected could be incorporated into selecting the most appropriate Biotope code.

Biotope classifications were first determined using the National Marine Habitat Classification for Britain and Ireland: Version 04.05 (Connor et al. 2004) to allow comparisons with existing SACs, SSSIs and EMS in the UK MPA network. Biotopes were then classified (usually level 5) using the EUNIS classification system following the JNCC conversion table (http://jncc.defra.gov.uk/pdf/EUNIS_Correlation_2007-11_20101206v2.pdf).

6.10 GIS

Digital GIS maps following the MESH ROG's have been produced from the polygon maps created immediately after the field surveys using the biotope classification data. Biotope polygons were digitised from 'neat' field maps and attributed to field data cleaned and transferred to excel spreadsheet using ArcGIS 10.0 (compatible with 9.3). All maps were produced at very high resolution for ease of use and are supplied as supplementary electronic files.

6.11 Statistical Analysis

All statistical analysis was carried out in PRIMER (V6) software. Bray Curtis similarity matrixes were calculated representing the percentage cover of all sessile invertebrates and algae species measured in the quadrat survey. The resemblance matrixes were analysed using Non Metric Multidimensional Scaling (NMDS) and Analysis of Similarity (ANOSIM) to test for similarity in assemblage composition between sites. If significant differences were detected by the ANOSIM test, further analysis was conducted with Similarity Percentages (SIMPER) to determine the rank percentage contribution of the different species to the total dissimilarity. n=30 for Eastern Kings, 26 for Devils Point, 30 Firestone Bay for and 30 for Duke Rock South respectively.

7 Results

The survey went according plan and was completed on time according to the schedule described by section 5.2. Dive operations proceeded safely without incident.

7.1 General Survey Conditions

Due to the fierce tides and frequently low visibility at Eastern Kings, Devils Point and Firestone Bay, these sites were surveyed at high water slack water windows during the daylight to maximise the chance of achieving good visibility for the quadrat survey.

This approach worked very well and the team was lucky to experience good weather conditions throughout the survey. Underwater visibility was excellent for the area and was in excess of 6 horizontal meters most of time.

Duke Rock South was surveyed at halfway down a falling tide and although visibility was not excellent, it was more than sufficient to conduct the survey work.

7.2 General Site Description

In general, the sites supported distinctly different assemblages despite being located at similar depths and being relatively close together. All sites appeared relatively undisturbed, diverse and in good condition. The following section describes representative assemblages from the different Biotopes encountered during the survey.

7.2.1 Firestone Bay – Detailed Site description

Classification / Physical Description	Characteristic features
Previous code: SCR.SubSoAs *Suberites* sp. and other sponges with solitary ascidians on very sheltered circa-littoral rock **Suggested new code: CR.MCR.CFaVS.CuSpH.As** Cushion sponges, hydroids and ascidians on turbid tide-swept sheltered circa-littoral rock **Location**: Firestone Bay 50° 21.605' N 004° 09.634' W **Wave exposure:** Sheltered **Tidal streams:** Moderately strong **Substratum:** Limestone bedrock **Zone:** Cira-littoral **Depth:** 10 – 20 m bcd	• Steep slope of silty limestone bedrock in tide-swept, wave-sheltered conditions; • Diverse fauna with a wide range of sponges, ascidians, anemones and bryozoans present; • Faunal turf dominated by the sponges *Esperiopsis fucorum*, *Halichondria bowerbanki* and *Cliona celata*, the hydroids, *Nemertesia antennina, Nemertesia ramosa.* The sponge *Suberites ficus* was also common • Rock beneath the turf bored by the sponge *Cliona celata* and the bivalve mollusc *Hiatella acrtica;* • Several fish species present; Conger Eel (*Conger conger),* Goldsinny-wrasse *(Ctenolabrus rupestris*), Tompot Blenny (*Parablennius gattorugine),* Rock Cook *(Centrolabrus exoletus),* Shore rockling *(Gaidropsarus mediterraneus),* Tadpole Fish (*Raniceps raninus),* Pollack (*Pollachius pollachius*) and Bib (*Gadus, luscus).*

Biotope description

This Biotope was recorded in Firestone Bay, which is a wave-sheltered location near the entrance to the Tamar in Plymouth Sound, directly behind Drakes Island. The site consists of a steep slope of limestone which is exposed to moderately strong tides from the Tamar flowing between Drake Island and the mainland. The rock surfaces were generally silty.

The Biotope was recorded in a zone between 10 to 20 m below chart datum but extended below this depth on the rock slope. The sessile fauna was diverse with a wide range of sponge, hydroid and ascidian species present. The rock surface was covered by a dense faunal turf dominated by a mixture of the sponges *Esperiopsis fucorum*, *Halichondria bowerbanki*. The sponge *Cliona celata* was also present both on top of the rock and also burrowing through the rock in large areas. The sponge *Suberites ficus* was also common.

The hydroids *Nemertesia antennina*, *Nemertesia ramosa*, and *Halecium halecinum* were characteristic of the habitat. The ascidian fauna included colonies of individual *Styela clava*, *Polycarpa scuba*, *Dendrodoa grossularia* and *Botryllus schlosseri*. There were odd specimens of algae with the most abundant being *Kallymenia reniformis* and *Cryptopleura ramosa*.

Areas of flat rock were interspersed with numerous deep crack and depressions, many of which were home to crustaceans such as the Velvet Swimming Crab (*Necora puber),* Brown Crab *(Cancer pagurus)* and fishes including Conger Eel (*Conger conger),* Goldsinny-wrasse *(Ctenolabrus rupestris)*, Tompot Blenny (*Parablennius gattorugine),* Rock Cook *(Centrolabrus exoletus),* Shore rockling *(Gaidropsarus mediterraneus),* Tadpole Fish (*Raniceps raninus),* Pollack (*Pollachius pollachius*) and Bib (*Gadus, luscus).*

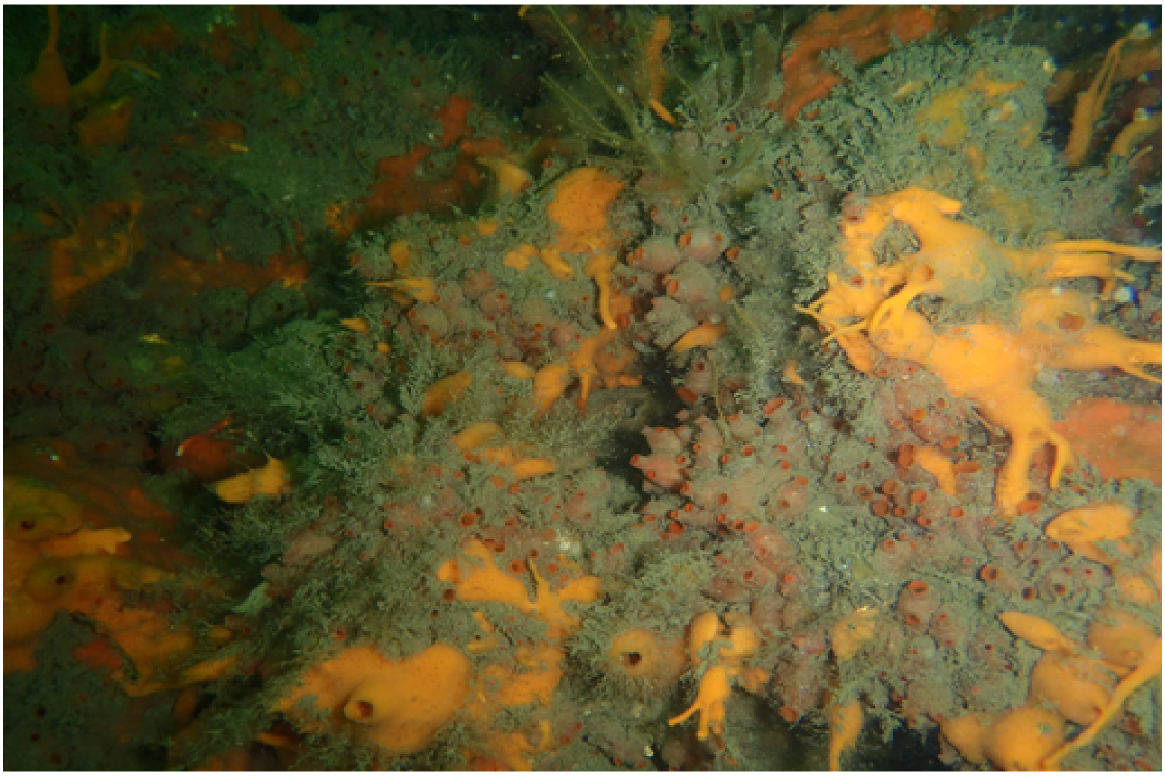

Figure 12: Typical assemblage at Firestone Bay dominated by sponges (*Esperiopsis fucorum*), tunicates and hydroids.

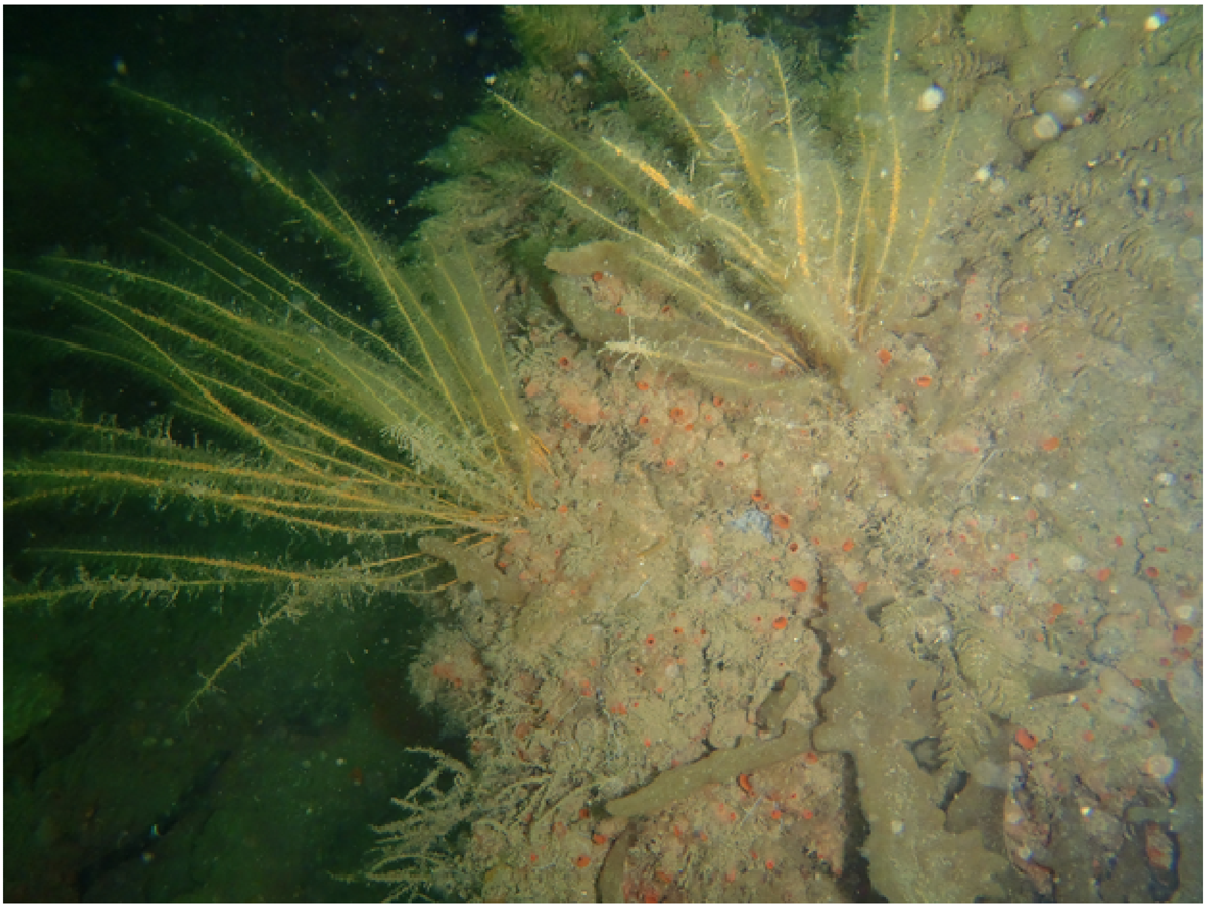

Figure 13: Typical tunicates, hydroids and bryozoans at Firestone Bay.

7.2.2 Eastern Kings – Adapted from Howson, Bunker and Mercer (2005)

Classification / Physical Description	Characteristic features
Previous code: SCR.SubSoAs *Suberites* sp. and other sponges with solitary ascidians on very sheltered circa-littoral rock **Suggested most suitable new code: CR.LCR.BrAs.AntAsH** Antedon spp., solitary ascidians and fine hydroids on sheltered circa-littoral rock **Notes : Biotope classification:** Based on our observations the code above is most representative of the site. However, this Biotope code does not refer to *Alcyonium digitatum* which is characteristic of the site, as were anemones, in particular *Urticina felina* **Location** Eastern King Point 50°21.627' N, 004° 09.397' W **Wave exposure** Sheltered **Tidal streams** Strong **Substratum** Limestone bedrock **Zone** Circa-littoral **Depth** 10 – 17 m bcd	• Steep slope of limestone bedrock in tide-swept, wave-sheltered conditions; • Diverse fauna with a wide range of ascidians, anemones and bryozoans present; Faunal turf dominated by the feather star *Antedon bifida,* the ascidian *Distomus variolosus*, the anemones *Sagartia elegans* and *Corynactis viridis*, the bryozoan *Scrupocellaria* spp., the hydroid *Nemertesia antennina*. The anemone *Urticina felina* and soft coral *Alcyonium digitatum* were common • Rock beneath the turf bored the sponge *Cliona celata*; • Fish species include: Goldsinny-wrasse *(Ctenolabrus rupestris)*, Tompot Blenny (*Parablennius gattorugine),* Rock Cook *(Centrolabrus exoletus),* Shore rockling *(Gaidropsarus mediterraneus),* Pollack (*Pollachius pollachius*) and Bib (*Gadus, luscus).*

Biotope description

This Biotope was recorded from Eastern King Point which lies in a wave-sheltered location near the entrance to the Tamar in Plymouth Sound. The site consists of a steep (estimated 45 degree) slope of limestone which is exposed to moderately strong tides from the Tamar flowing between Drakes Island and the mainland. The biotope was recorded in a zone between 10 to 20 m below chart datum.

The fauna was diverse with a wide range of sponge, hydroid and ascidian species present. The rock surface was covered by a dense faunal turf dominated by dominated by the feather star *Antedon bifida,* a mixture of the ascidian *Distomus variolosus*, the bryozoan *Scrupocellaria* spp., the worms *Salmacina dysteri* and small sandy sabellids, anemones *Sagartia elegans, Corynactis viridis* and hydroids *Halecium beanii* and *Nemertesia antennina*. The rock was also heavily burrowed by the sponge *Cliona celata* with the worms *Polydora* sp. and *Myxicola aesthetica* occupying holes in the rock.

The dahlia anemone *Urticina felina* and soft coral *Alcyonium digitatum* were common. Several species of sponge were present although in relatively small amounts. These included *Suberites ficus*, *Polymastia mamillaris*, *Axinella dissimilis*, *Raspailia ramosa* and *Halichondria bowerbanki*. The ascidian fauna included colonies of *Morchellium argus*, *Aplidium punctum*, individual *Styela clava*, *Polycarpa scuba*, *Dendrodoa grossularia* and *Botryllus schlosseri*. There were small amounts of a few species of algae with the most abundant being *Kallymenia reniformis* and *Cryptopleura ramosa*.

There were relatively few mobile species recorded with only occasional crabs *Cancer pagurus* and the gastropod mollusc, *Calliostoma zizyphinum. Several species of fish were noticed including*, Goldsinny-wrasse *(Ctenolabrus rupestris)*, Tompot Blenny (*Parablennius gattorugine),* Rock Cook *(Centrolabrus exoletus),* Shore rockling *(Gaidropsarus mediterraneus),* Pollack (*Pollachius pollachius*) and Bib (*Gadus, luscus).*

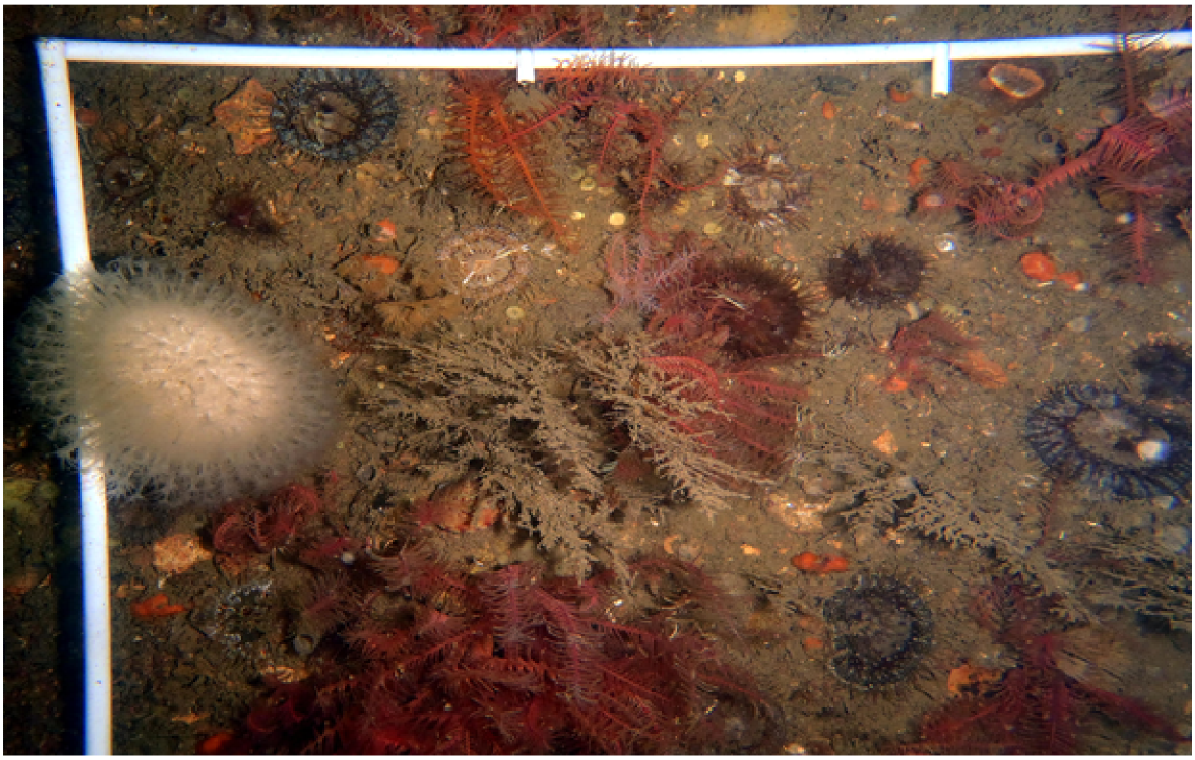

Figure 14: typical assemblage at eastern Kings which experiences the strongest tidal currents. Note the high abundance of the common feather star *Antendon bifida* which characterises this site.

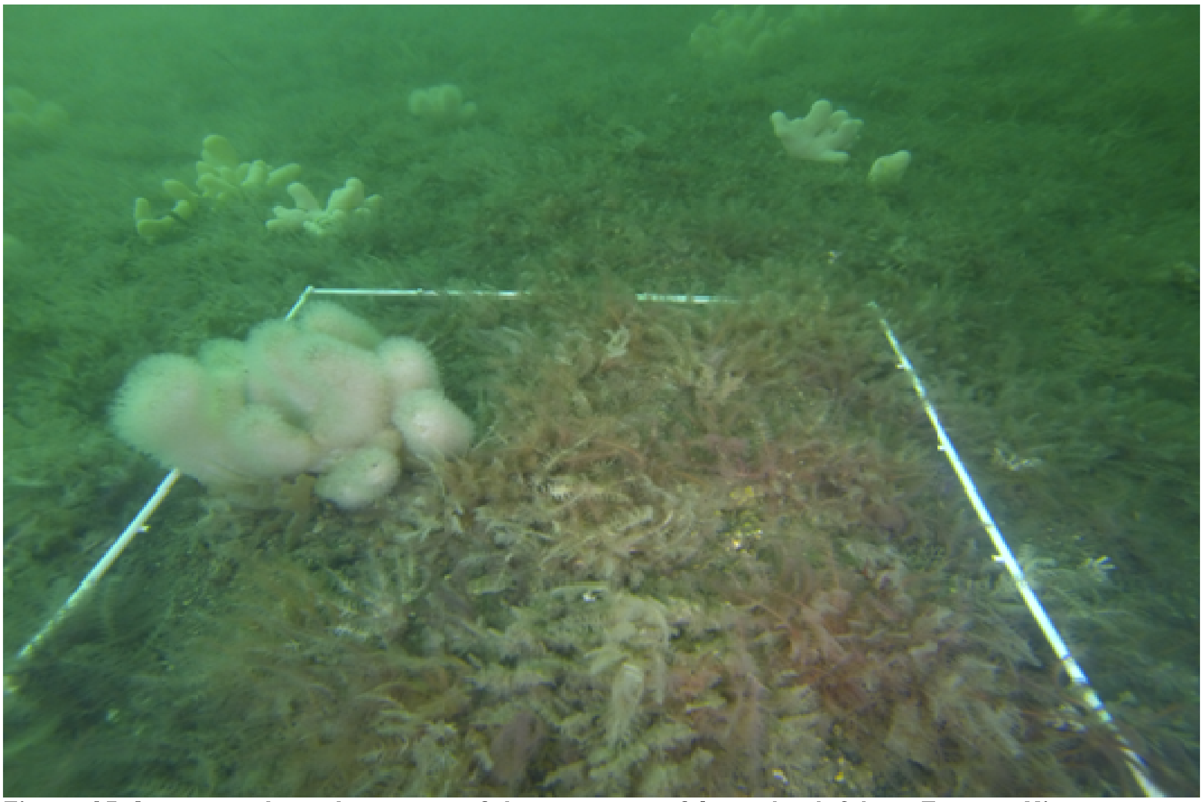

Figure 15: Image to show the extent of the coverage of *Antendon bifida* at Eastern Kings.

7.2.3 Devils Point

Classification / Physical Description	Characteristic features
Previous code: SCR.SubSoAs *Suberites* sp. and other sponges with solitary ascidians on very sheltered circa-littoral rock **Suggested new code: CR.MCR.CFaVS.CuSpH.VS** Cushion sponges and hydroids on turbid tide-swept variable salinity sheltered circa-littoral rock. **Notes : Biotope classification:** Based on our observations the code above is most representative of the site. However, the Biotope code refers to sheltered circa-littoral rock, whereas this Biotope is better characterised as limestone bedrock and rubble. Our understanding is that a Biotope code does not exist that accurately describes both the characteristic faunal and physical features of this site so the CR.MCR.CFaVS.CuSpH.VS is considered the best compromise at present. **Location** : Devils Point 50° 21.595' N 004° 09.964' W **Wave exposure** Sheltered **Tidal streams** Moderately strong **Substratum** Limestone bedrock and rubble. **Zone** Circa-littoral **Depth** 10 – 20 m bcd	• Steep slope of limestone bedrock and rubble in tide-swept, wave-sheltered conditions; • Diverse fauna with a wide range of sponges, hydroids and bryozoans present; • Faunal turf dominated by the sponges *Esperiopsis fucorum*, *Halichondria bowerbanki* the hydroids, *Nemertesia antennina, Nemertesia antennina,* • The sponge *Suberites ficus* is common; • The bryozoan *Alcyonidium diaphanium* was existing almost as a mono-culture in 4m^2 patches, particularly in the shallower areas of the biotope. • Several fish species present, including: Goldsinny-wrasse *(Ctenolabrus rupestris)*, Tompot Blenny (*Parablennius gattorugine),* Rock Cook *(Centrolabrus exoletus),*

Biotope description

This biotope was recorded in near Devils Point alongside the Victualing Wall, which is a wave-sheltered location on the eastern entrance to the River Tamar in Plymouth Sound. The site consists of a steep slope of limestone which is exposed to very strong tides from the mouth of the Tamar. The natural bedrock is covered in many areas by rubble and cobbles, presumably discarded during the construction process of the adjacent Royal William Yard in 1825 – 1831.The biotope was recorded in a zone between 10 to 20 m below chart datum but extended below this depth on the rock slope.

The sessile fauna was diverse with a wide range of sponge, hydroid and ascidian species present. The rock and boulder surface was covered by a dense faunal turf dominated by a mixture of the sponge *Esperiopsis fucorum*, *Halichondria bowerbanki*. The hydroids *Nemertesia antennina, Nemertesia antennina*, and *Halecium halecinum* were also characteristic of the habitat.

The ascidian fauna included colonies of *Dendrodoa grossularia* and *Botryllus schlosseri*. The bryozoan *Alcyonidium diaphanium* was present throughout the biotope with occasional areas (approx. $4m^2$) where it was almost entirely dominant. There were small amounts of a few species of algae with the most abundant being *Kallymenia reniformis* and *Cryptopleura ramosa*.

Gaps beneath and between boulders were often inhabited by crustaceans such as Crabs (*Necora puber, Cancer pagurus),* and Lobsters (*Homarus gammarus).* Fishes observed included Goldsinny-wrasse *(Ctenolabrus rupestris)*, Tompot Blenny (*Parablennius gattorugine),* and Rock Cook *(Centrolabrus exoletus),*

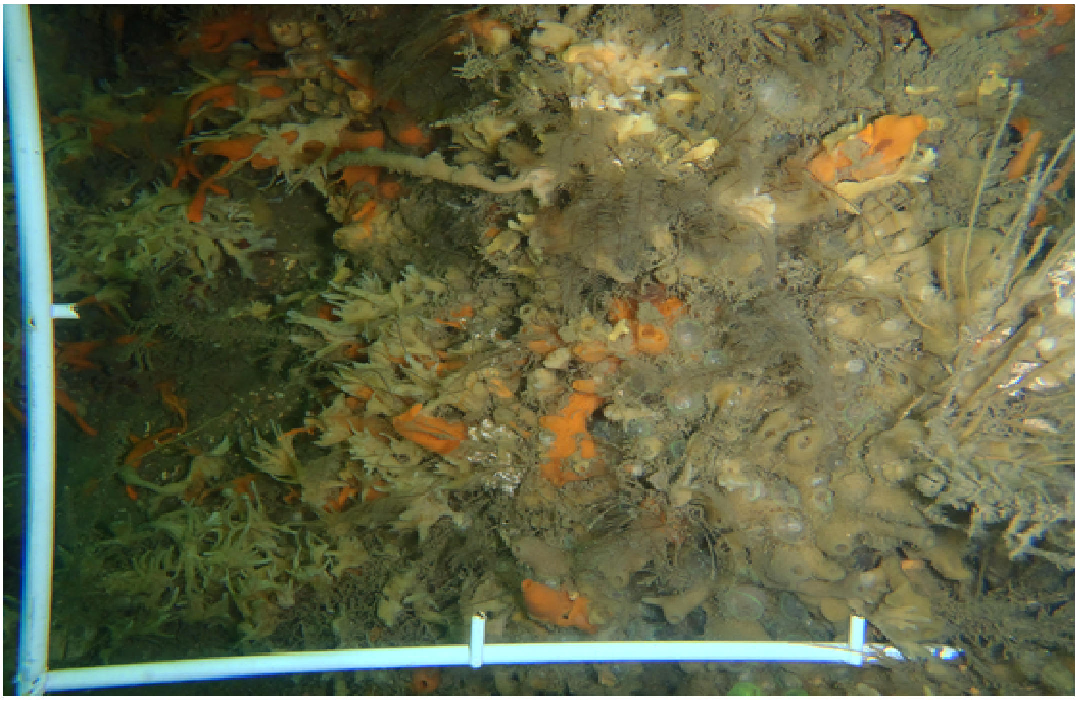

Figure 16: Typical Assemblage at Devils Point dominated by sponges, bryozoans and hydroids. Note the exceptional clarity of the water which aided identification in the field.

Figure 17: Image to show extent of patches of the bryozoan *Alcyonidium diaphanium encountered* at Devils Point in approximately 8 meters of water.

7.2.4 Duke Rock South - Adapted from Howson, Bunker and Mercer (2005)

Classification / Physical Description	Characteristic features
Ephemeral and scour-tolerant seaweeds on cobbles and sand **Previous code: MIR.EphR** Ephemeral red seaweeds and kelps on tide-swept mobile infra-littoral cobbles **Suggested new code: SS.SMp.KSwSS.LsacR.CbPb** Red seaweeds and kelps on tide-swept mobile infra-littoral cobbles and pebbles **Location** Duke Rock South 50° 20.298' N 004° 08.099' W **Wave exposure** Moderately exposed **Tidal streams** Moderately strong **Substratum** Cobbles, pebbles, gravel, sand, interspersed by outcrops of bedrock **Zone** Infra-littoral **Depth** 7 – 7.5 m bcd	• broad gullies between kelp-covered bedrock ridges. • weak or moderate tidal flow in this area • moderate covering of benthic sediment • mixed substratum of pebbles, gravel, sand and scattered cobbles, interspersed by outcrops of bedrock. • The cobbles and pebbles supported a diverse assemblage of scour-tolerant red algae, with *Stenogramme interrupta* dominant • Brown algae were common including kelp. • Very few motile animals were present,

Biotope description

This biotope was recorded at Duke Rock South, inside the eastern end of the breakwater. The area is characterised by broad gullies between kelp-covered bedrock ridges. There is a weak or moderate tidal flow in this area through the gap between the breakwater and the mainland. The seabed consisted of a clean mixed substratum of pebbles, gravel, sand and scattered cobbles, interspersed by outcrops of bedrock.

The cobbles and pebbles supported a diverse assemblage of scour-tolerant red algae, with *Stenogramme interrupta* dominant but with other species present in relatively low abundances. Conspicuous algae included *Callophyllis laciniata*, *Cryptopleura ramose, Dilsea carnosa,* and *Dellesseria sanguinea*. Brown algae were common including *Dictyota dichotoma*, *Laminaria saccharina*, *Laminaria ochroleuca, Saccharina latissima, Saccorhiza polyschides* and with *Laminaria* sporelings and *Cystoseira* sp. attached to stones.

Very few motile animals were present, with the gastropod mollusc *Gibbula magus*, bivalve mollusc, *Pecten maximus*, and crabs Crabs (*Necora puber, Cancer pagurus)* all rare or occasional.

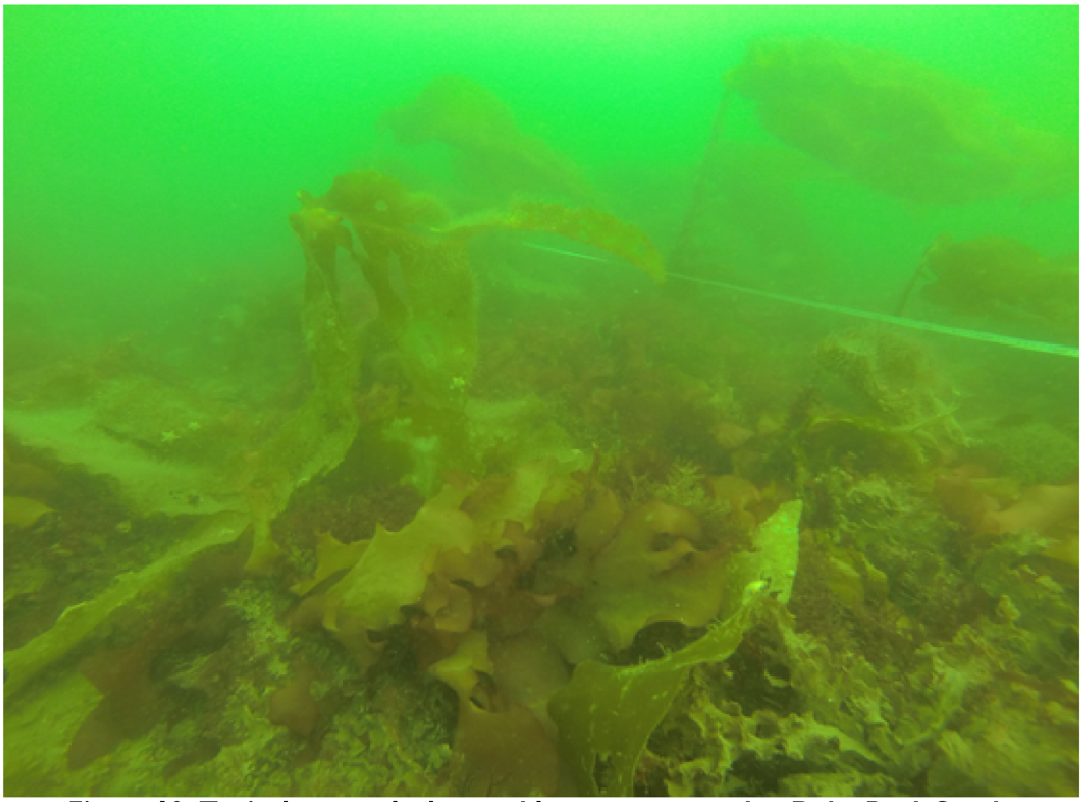

Figure 18: Typical macroalgal assemblage encountered at Duke Rock South.

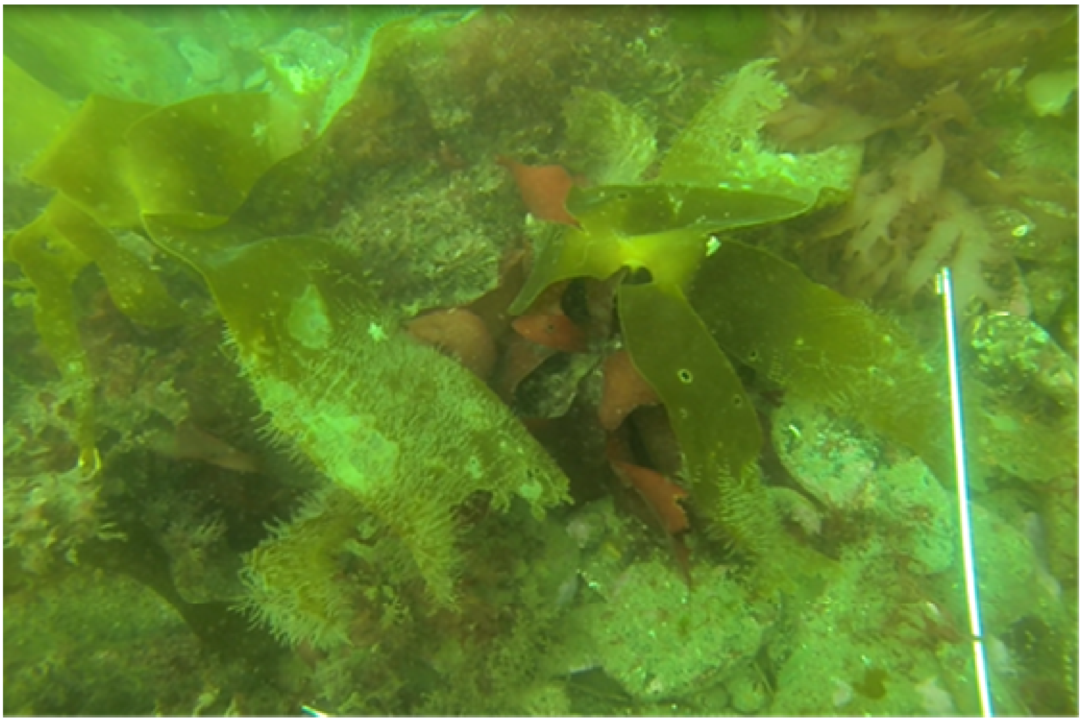

Figure 19: Image showing a typical area of seabed at Duke Rock South including a variety of variety of kelp species interspersed with red algae growing on cobbles.

7.3 Assess Anthropogenic Influences, Impacting on Identified Features.

Any signs of anthropogenic influences on the habitat types were recorded during drop down video and diver surveys. It was notable that very little human influence on the habitats other than monofilament fishing line was recorded in the sites, despite very good visibility.

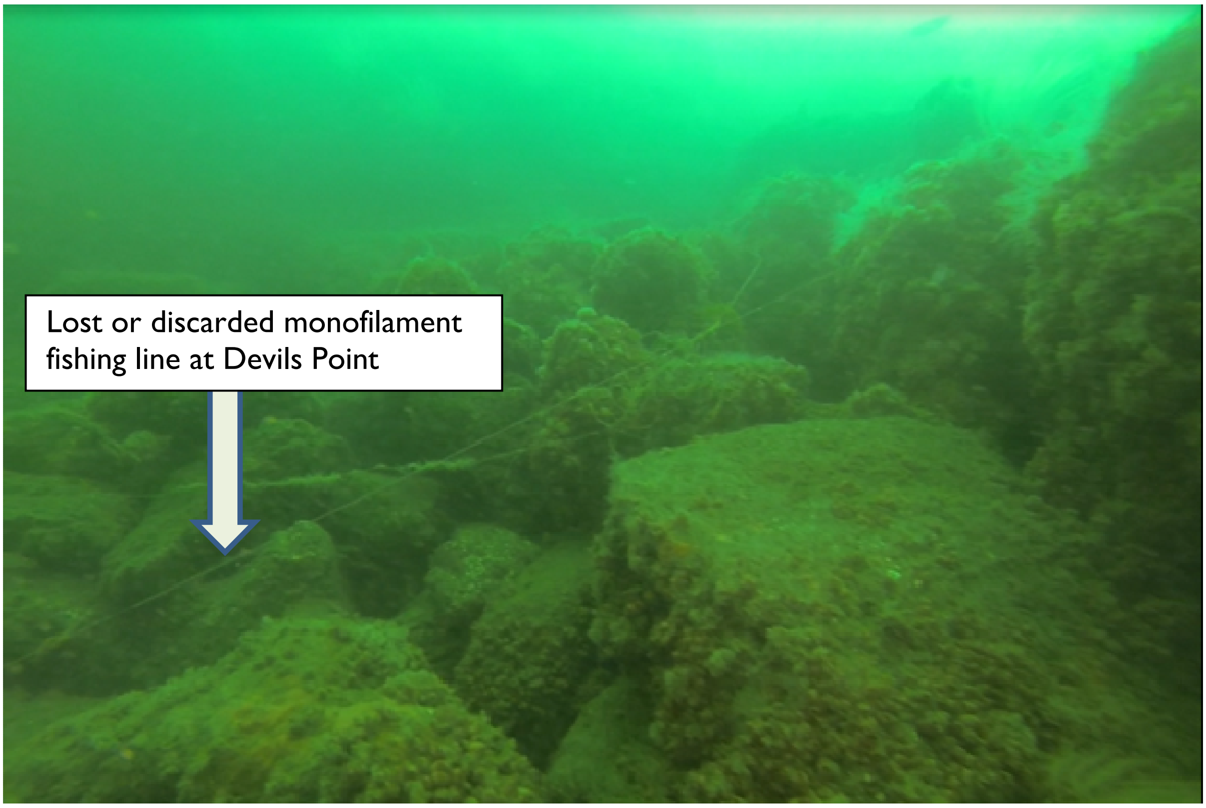

Figure 20: Image to show the only notable impact of anthropogenic activity which was lost or discarded fishing line at Devils Point. Note also the exceptional underwater visibility at the site.

7.4 Biotope Maps – GIS

Biotope maps to support the findings of this survey were supplied to Natural England in digital format.

7.5 Invasive Non-native Species

Non-native species discovered during the survey were limited to the tunicate *Styela clava* at Firestone Bay and Eastern Kings. This species was rare but consistently distributed throughout both sites.

Previous survey work conducted by PML Applications recorded the kelp *Undaria pinnatifida* growing in the infer-littoral zones at Firestone Bay and Eastern Kings. This species was not encountered during the current survey work that was focussing mainly on the circa-littoral zone.

7.6 Key Data Comparisons

PML Applications understands that Natural England requires this study to build on existing data where possible to:

- assess the condition of particular sub-features and assemblages specified in section 3.1.particular habitats; and
- provide a means by which change in habitat condition can be assessed in the future.

The previous studies undertaken in this area, particularly Moore *et al.* (2000) and Howson, Bunker and Mercer (2005) are very useful in terms of providing baseline data describing the relative abundances and diversity within the specified habitats. These data, irrespective of the specifics of the methods used to collect them, provide this study with a baseline to compare assemblage condition criteria such as abundance of dominant species. However, because the specifics of the methods used to collect the data for these different studies varied, direct statistical comparisons can't always be made with confidence.

For example, Moore *et al.* (2000) did not collect data using a randomised placement of quadrats. This means that an artificial sampling bias could have been introduced during the data collection stage which prevents rigorous statistical analysis of the data. Howson, Bunker and Mercer (2005) did collect data using a randomised sampling strategy, but the number and size of the quadrats differed during the survey, and the survey did not cover all the sites that the current survey was required to assess.

Consequently, it seems logical to benefit from these previous data in as far as possible, i.e. by comparing overall diversity in different habitats across the surveys and comparing abundances of dominant species. The results of statistical comparison between the current survey and the previous surveys should be treated with caution for the following reasons:

- different methods have been used during different surveys
- not all the site have been historically surveyed to the same extent
- previous sampling strategies don't meet assumptions required for many statistical techniques.

It is worth highlighting that the current survey used a fully randomised, consistent and well replicated sampling strategy. This will enable all subsequent surveys to undertake rigorous statistical comparison of new data with data collected for this study, assuming that the straightforward methods described in this report are repeated at the same sites.

7.7 Comparison Between Sites

To our knowledge, this is the first time that Eastern Kings, Firestone Bay, Devils Point and Duke Rock South have all been surveyed during the same operation. Therefore, a logical first step was to compare the algal and invertebrate assemblages between all sites do understand if indeed the sites are different. The objective of this comparison was to understand:

- Are the sites different enough to warrant individual survey attention?
- Could one or more sites be replaced with other sites that support different habitats of high importance to increase the cost benefit value of the sampling work?
- Did the current study involve sufficient replication to allow distinctions between sites to be made?

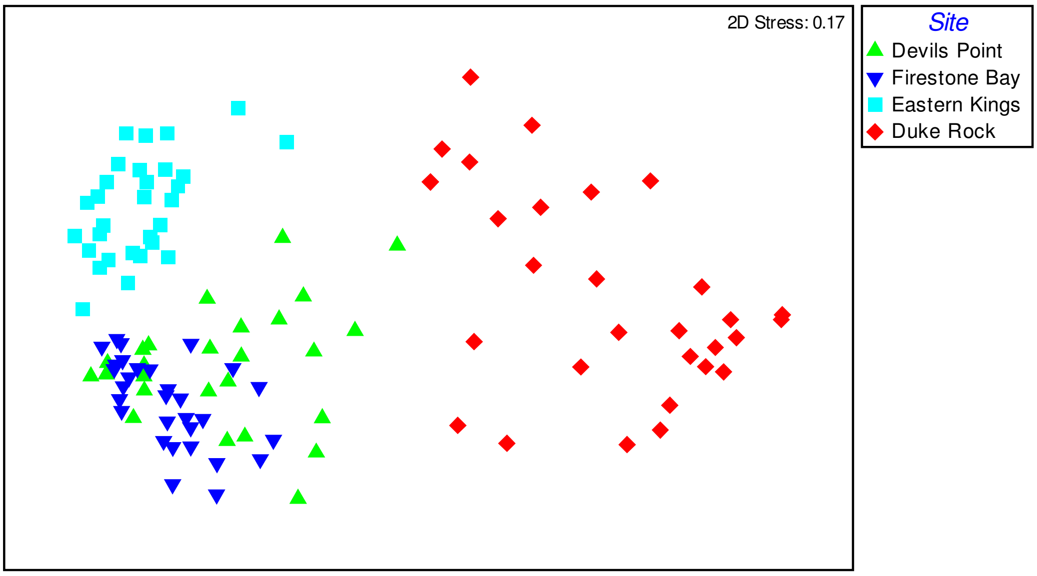

Figure 21: MDS plot to show the difference in sessile assemblage composition between survey sites based on percentage coverage data obtained during the quadrat survey. n=30 for Eastern Kings, 26 for Devils Point, 30 Firestone Bay for and 30 for Duke Rock South respectively.

Figure 21 clearly shows there are differences between survey sites in terms of assemblage composition. This finding is supported by ANOSIM result of (Global R): 0.694, p=0.1.
As expected, Duke Rock South clearly supports a different assemblage compared to the other sites. Figure 21 also shows that the within site variability in assemblage composition appears to be higher at Duke Rock South than at the other sites which show a tighter grouping of data points indicating more within site similarity.

SIMPER analysis confirms this observation. The results in Table 6 show the rank order of site in terms of their within-site similarity.

Table 6: Table to show the within site similarity between survey sites indicating variability of assemblage structure at each site

Site Name	Within Site Average Percentage Similarity
Firestone bay	49.06
Eastern Kings	47.99
Devils Point	37.47
Duke Rock South	18.96

Duke Rock South is more variable in terms of within-site assemblage composition that any of the other sites. This is likely to be a result of the combination of very different substratum types at this site compared to the other sites which are largely homogeneous. Duke Rock South contains areas of sand, gravel, cobbles and boulders as well as limestone reef and kelp forests, as shown in Section 7.

Only a limited number of algal specimens were discovered at Eastern Kings, Firestone Bay and Devils Point, whereas invertebrates dominated these sites. Kelp species were also not recorded at these sites in the quadrat survey, even though kelp is present in the shallower water at all these sites.

As expected, the different ratio of sessile invertebrates to algae at Eastern Kings, Firestone Bay and Devils Point, compared to Duke Rock South, together with the variability of substratum type at Duke Rock South, is responsible for the difference is assemblage structure seen in Figure 21.

7.8 Site Differences excluding Duke Rock South

While it is clear that there are differences between Duke Rock South and the other sites, the relationship between Eastern Kings, Firestone Bay and Devils Point, is not easily understood by examination of the MDS plot in Figure 21. The relationship between these sites becomes much clearer when Duke Rock South is excluded from the analysis as described by Figure 22 below.

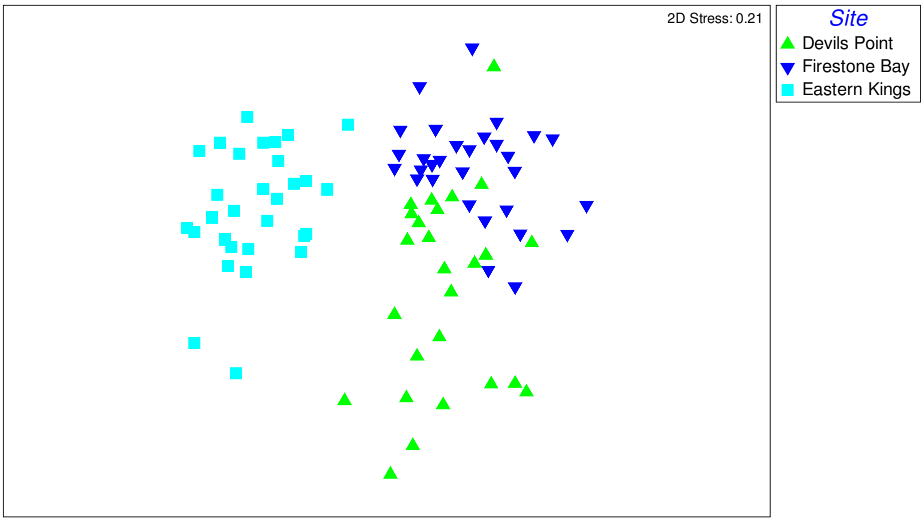

Figure 22: MDS plot to show the difference in sessile assemblage composition between survey sites at Eastern Kings, Firestone Bay and Devils Point excluding Duke Rock South based on percentage coverage data obtained during the quadrat survey. n=30 for Eastern Kings, 26 for Devils Point, 30 Firestone Bay for and 30 for Duke Rock South respectively.

Figure 22 shows that Eastern Kings, Firestone Bay and Devils Point are indeed different from one another, with discreet groupings of data described for each site.

7.8.1 ANOSIM – Site difference Excluding Duke Rock South

The significant difference between Eastern Kings, Firestone Bay and Devils Point in terms of community composition is further described by the ANOSIM result Sample statistic (Global R): 0.64 with a significance level of sample statistic: 0.1%. The average dissimilarity between sites is described by Table 7.

Table 7: Table to show average dissimilarity between Eastern Kings, Firestone Bay and Devils Point based on percentage coverage percentage coverage data obtained during the quadrat survey.

Survey Site	Av. Dissimilarity
Devils Point & Firestone Bay	66.21
Devils Point & Eastern Kings	79.51
Firestone Bay & Eastern Kings	77.16

Table 8: Ranked Average Abundance of Species (up to 1%) at Devils Point, Eastern Kings and Firestone Bay. Colour Coding Identifies Species Common Across Sites.

Devils Point	Average Abundance	Eastern Kings	Average Abundance	Firestone Bay	Average Abundance
Alcyonidium diaphanium	**13.85**	***Antedon bifida***	**48.67**	***Esperiopsis fucorum***	**12.07**
Nemertesia antennina	12.35	*Polydora* sp	17.10	*Nemertesia antennina*	9.67
Esperiopsis fucorum	10.38	*Cliona celata*	8.43	*Halichondria bowerbanki*	9.67
Dendrodoa grossularia	8.46	***Alcyonium digitatum***	**5.03**	*Corynactis viridus*	6.67
Amphipod tubes indet	6.19	*Cereus pedunculatus*	3.63	*Halichondria panicea*	6.67
Halecium sp.	5.85	*Distomus variolosus*	2.67	Amphipod tubes indet	4.43
Cliona celata	5.46	*Encrusting orange*	2.27	*Raspailia ramosa*	3.83
Halichondria panicea	4.00	*Nemertesia antennina*	2.23	*Halecium halecinum*	3.20
Salmacina dysteri	3.62	*Halecium halecinum*	2.21	*Salmacina dysteri*	3.10
Raspailia ramosa	3.35	*Sagartia elegans*	1.63	Encrusting orange sponge	2.73
Halichondria bowerbanki	2.73	*Scrupocellaria scruposa*	1.63	*Halecium sp.*	2.53
Halecium halecinum	2.42	*Salmacina dysteri*	1.58	*Alcyonidium diaphanium*	2.53
Encrusting orange sponge	2.31	*Cellaria sp.*	1.43	*Aglaophenia tubulifera*	2.33
Antho inconstans	2.15	*Urticina felina*	1.37	*Nemertesia ramosa*	2.17
Bugula Flabalata	1.92	Indet tubes	1.30	*Kirchenpaueria pinnata*	2.00
Plumularia setacea	1.92	*Botryllus schlosseri*	1.03	*Botryllus schlosseri*	1.67
Bispira volutacornis	1.42	*Suberites sp.*	1.00	*Haliclona viscosa*	1.33
Kirchenpaueria pinnata	1.35			*Cliona celata*	1.23
Indet tubes	1.04				

Table 8 shows that although Devils Point, Eastern Kings and Firestone Bay do support different assemblages, many species are common across sites. The key difference between the sites comes not from their species richness, but from the difference in relative abundances of key species which define the sites. This is especially true for Firestone Bay and Devils Point.

7.9 Historical Comparison

Howson, Bunker and Mercer (2005) discuss on page 26 and 27 of their report how the differences between quadrat surveys during years 1999 – 2003 at Eastern Kings resulted in distinct groupings of data for each time point. The authors continue to suggest that despite statistical difference between the time points, they actually felt that comparisons between the abundance of the most dominant species was a more valuable measure of habitat condition, and therefore concluded that little change in terms of condition had occurred between time periods.

We agree with this view, especially in this case where any formal analysis of historical data would involve not only data collected by different survey teams, but also data collected with different numbers of quadrats, and sometimes with quadrats of different sizes.

It would be more surprising if change was not measured between time points given that data had been collected in different ways by different people.

It is our view that genuine patterns in time-series data sets can be detected by formal analysis techniques if sufficient trends in the data are available to outweigh the effect of uncontrolled variables such as different sampling methods. However in this case, four time points with low numbers of replicate samples at each point, does not meet the criteria.

The analysis described in this section should be interpreted with caution resulting from the different methods of data collection and sampling effort used throughout the different surveys.

7.10 Historical Comparison: SS.SMp.KSwSS.LsacR.CbPb - Duke Rock South

Previous quadrat survey data collected by Howson, Bunker and Mercer (2005) and Moore *et al.* (2000) were compared to data collected during the current survey in an attempt to identify which species were playing a key role in characterising the site by contributing most to the similarity between quadrats within the site.

Table 9: Table to show species (excluding kelp) contributing to 90% of similarity within site during the four survey years at Duke Rock South

	2013		2003		1998		1999	
Species	**% contribn to similarity**	**Av. abundance**	**% contribn to similarity**	**Av. abundance**	**% contribn to similarity**	**Av. abundance**	**% contribn to similarity**	**Av. abundance**
Heterosiphonia plumosa	7.75	0.71	10.14	5.75	9.06	6.81	9.93	9.13
Dictyota dichotoma	5.76	0.59	7.13	1.59	7.05	3.05	7.98	4.13
Delesseria sanguinea	11.42	0.86	6.72	2.86	1.03	2.05	6.55	6.98
Polyneura bonnemaisonii	10.45	0.62	5.21	2.18	0.34	1.14	0.37	0.48
Cryptopleura ramosa	5.98	0.62	2.11	0.27			0.02	0.04
Cryptonemia hibernica	N/A	N/A	2.02	3.32	15.93	14.62	8.23	4.27
Rhodymenia pseudopalmata	N/A	N/A	1.91	1.45	2	0.57	0.37	0.21
Phyllophora pseudoceranoides	N/A	N/A	1.46	0.32	2.51	1.48	3.09	0.58
Callophyllis laciniata	1.79	0.27	1.25	2.36			0.09	0.09
Phyllophora crispa	N/A	N/A	1.2	0.13	N/A	N/A	N/A	N/A
Dilsea carnosa	24.01	1.32	1.2	0.36	0.78	0.74	1.96	1.22
Kallymenia reniformis	N/A	N/A	0.31	0.09	4.55	4.57	4.1	3.5

Table 9 shows that as would be expected from a Biotope characterised by ephemeral species, there is considerable change in abundance of different species over the different survey years. It is also clear that the algal community (excluding kelp) is made up of many species, each with relatively low respective abundance within the Biotope.

The species *C. hibernica, P. pseudoceranoides, P. crispa,* and *K. reniformis* were all undetected during the current survey although had occurred in previous years. Several species that had historically been relatively dominant in the site such as *H. plumosea* and *D. dichotoma* appear to be less abundant in the current survey year, whereas *C. ramosa,* and *D. carnosa* have increased in relative abundance in comparison to previous years.

Table 10: Total number of algal species (excluding kelp) recorded at the SS.SMp.KSwSS.LsacR.CbPb Biotope at Duke Rock South.

Year / number of replicate quadrats sampled	2013/ n=30	2003/ n=14	1999/ n=28	1998/ n=21
Total number of species	51	62	74	49

Table 10 shows that the total number of species recorded in the Biotope has fluctuated considerably over the previous survey years. The sampling effort is not consistent throughout the survey years which may account for some of the variation seen. Usually, an increased sampling effort would result in a greater number of species recorded, which is not the case here.

Natural variability in ephemeral assemblage structure and variability within the survey team are likely to be responsible for the changes in total number of recorded species. Despite this apparent change, 60% of the species most responsible for characterising the Biotope were recorded during the previous and current survey, although their respective abundances appear to have shifted.

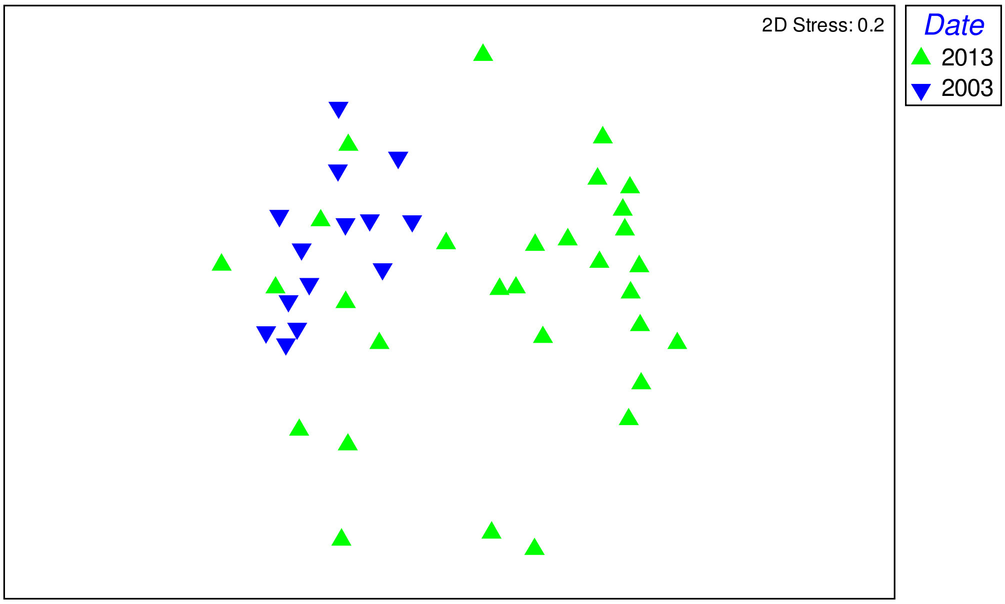

Figure 23: MDS plot to show historical comparison of algal assemblage (excluding kelp) at Duke Rock South between 2013 and 2003.

Figure 23 shows that the current survey discovered a much more variable algal assemblage that in the previous survey in 2003. This change is likely to be caused by in part by the highly variable substrate type encountered at the GPS position suggested for survey. Some quadrats were recorded on highly mobile sediments and gravel which supported very low abundances of algae. These low abundance areas were immediately adjacent to areas of high algal abundance (red algae and kelp) which is likely to explain some of that variability.

The decision was made not to relocate quadrats during the survey if they fell on different substrate types as a result of the random sampling design. This decision was made as the variable substratum type is a true reflection of the Biotope and diver selection of quadrat positions during the survey was likely to introduce a sampling bias.

7.11 Kelp Abundance – Duke Rock South

Natural England conducted a detailed kelp survey in Plymouth Sound in 2012. The current survey did not set out to specifically survey kelp, but as kelp were found at the GPS marks provided by Natural England, and by the previous Moore *et al.* (2000) survey, kelp were measured where they were encountered. Kelp count data was compared between the current survey and the *Moore et al.* (2000) survey in an attempt to identify any change in abundance of kelp species at the site.

The sub-tidal reef and surveyed 0.25m^2 quadrats (*n* = 30) along the same transect length and bearing as the Moore *et al.* (2000) study. As with the original survey, the abundance of all kelp species was recorded *in situ*.

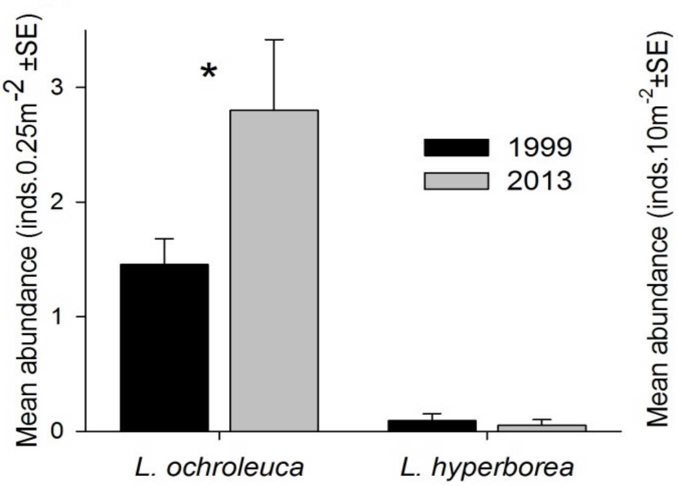

Figure 24: Abundance of kelp species at Duke Rock South between 1999 and 2013.

The abundance of *L. ochroleuca* significantly increased at Duke Rock South between 1999 and 2013 ($F_{1,40}$ = 4.49, P = 0.04, Fig. 24), but we recorded no change in the abundance of *L. hyperborea* ($F_{1,40}$ = 0.25, P = 1.00, Fig. 24). *L. ochroleuca* was the most abundant kelp species on bedrock with approximately 10 individuals per square meter. This is possibly because Duke Rock South is sheltered from wave action by the breakwater, and the reef is subjected to relatively high sediment loading which allows *L. ochroleuca* to out-compete *L. hyperborea.*

7.12 Historical Comparison: CR.LCR.BrAs.AntAsH - Eastern Kings

Previous quadrat survey data collected by Moore *et al.* (2000) and Howson, Bunker and Mercer (2005) were compared to data collected during the current survey in an attempt to identify which species were playing a key role in characterising the site by contributing most to the similarity between quadrats within the site.

Table 11: Table to show species contributing to 90% of similarity the CR.LCR.BrAs.AntAsH Biotope at Eastern Kings. (based on transect 2 data from 1998, 1999)

Species	Average abundance			
	2013	**2003**	**1999**	**1998**
Antedon bifida	48.67	43.29	28.5	47.5
Distomus variolosus	2.67	13.65	54.0	17.5
Urticina felina	1.37	3.35	4.5	5.1
Cereus pedunculatus	3.63	2.26	3.0	6.0
Scrupocellaria scruposa	1.63	2.69	0.1	0.5
Hiatella arctica	0.57	0.79	2.0	3.5
Polydora sp	17.10	1.25	N/A	N/A
Cliona celata	8.43	3.1	2.3	7.0
Sagartia elegans	1.63	1.06	6.0	15
Cellepora pumicosa	0.20	0.26	N/A	N/A
Sabellidae indet.	0.70	0.18	0.1	11.0
Chaetopterus variopedatus	0.33	0.28	N/A	N/A

Table 11 shows that the vast majority of species contributing most to the within site similarity are recorded at each time point, with broadly similar abundances, indicating a lack of major assemblage structural change. There are notable exceptions to this, including the marked drop in abundance of the tunicate *D. variolosus* and *H. arctica* during the current survey compared with previous years. In contrast, the abundance of *Polydora sp* and *C. celata* are noted as increasing considerably in abundance as measured in 2013 compared to previous years.

The spread of species in terms of their occurrence in each sample is further described in Table 11. It is critical to consider the difference in sample size (0.1m^2 quadrat in 1998 and 1999 Vs. 0.25m^2 in 2013) when interpreting this table. Given the size in individual organisms at this site such as *A. digitatum,* we suggest that use of the larger quadrat (0.25^{2}m) as used in 2013 is preferable.

Table 12:Table showing the spread of the most abundant species at the CR.LCR.BrAs.AntAsH Biotope at Eastern Kings.

Species Contributing to 90% of similarity within site during 1998, 1999 and 2013 at Eastern Kings	Percentage of samples where species occurred		
	2013 n=30 0.25m^2	1999 n=32 0.1m^2	1998 n=32 0.1m^2
Antedon bifida	100	83.7	80.6
Distomus variolosus	56.1	83.7	77.5
Urticina felina	46.2	68.2	74.4
Cereus pedunculatus	62.7	46.5	15.5
Scrupocellaria scruposa	26.4	15.5	15.5
Hiatella arctica	16.5	55.8	46.5
Polydora sp	89.1	80.6	74.4
Cliona celata	69.3	52.7	52.7
Sagartia elegans	46.2	65.1	52.7
Cellepora pumicosa	9.9	N/A	N/A
Sabellidae indet.	16.5	49.6	9.3
Chaetopterus variopedatus	16.5	18.6	6.4

Table 12 shows that in broad terms the spread of species within samples is fairly consistent thought the survey years, despite the marked difference in sampling effort due to the different quadrat sizes.

Table 13: Table showing total number of different sessile species recorded during the previous surveys at the CR.LCR.BrAs.AntAsH Biotope at Eastern Kings.

Year / number of replicate quadrats sampled	2013/ n=30	2003/ n=14	1999/ n=28	1998/ n=21
Total number of different sessile species sampled	42	40	77	56

Table 13 shows that the total number of species encountered during the current survey is very similar to the previous survey in 2003, although the 2003 and 2013 surveys both recorded nearly 50% fewer different tax compared with 1999.

The assemblage structure at Eastern kings was compared based on quadrat survey data collected during the current survey and the Howson, Bunker and Mercer (2005) data. The results are shown in Figure 25 below.

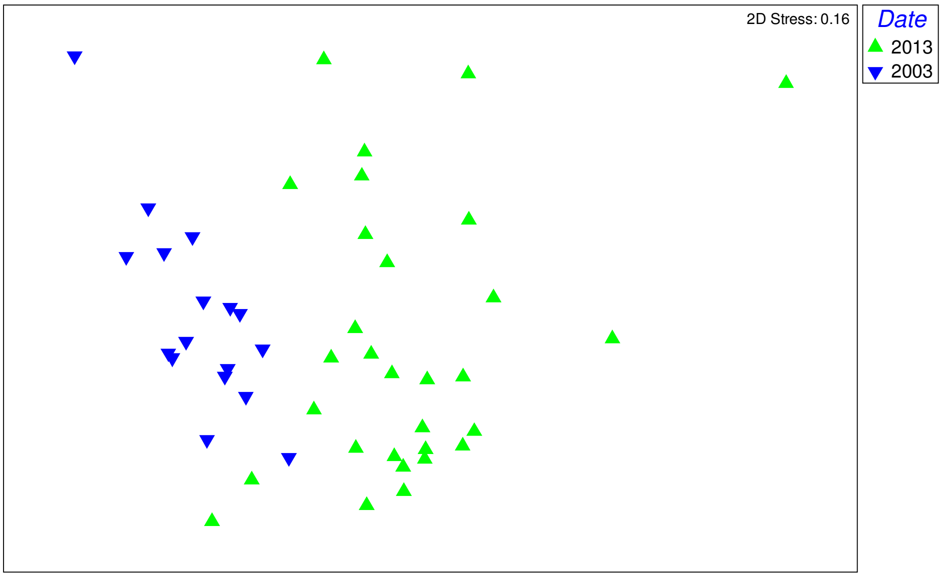

Figure 25: MDS plot showing historical comparison of assemblage structure at Eastern Kings based on diver quadrat data. n=17 for 2003 and 30 for 2013.

Figure 25 clearly shows a difference between assemblage structure between sampling points. As demonstrated by previous analysis in this section, we believe the major influence of the difference assemblage structure between the survey years to result from the decrease in abundance of *D. variolosus* and *H. arctica* during the current survey compared with previous years, and the increase in abundance of *Polydora* sp. and *C. celata.* The ecological significance of these findings is discussed in Section 8.3 of this report.

8 Discussion

Although differences in abundance and distribution of benthic invertebrates and algae are apparent between current and historical data sets, these differences should be treated with caution as described in Section 7.9. We believe this difference between current and historic data sets is likely to represent a natural change in benthic assemblage structure rather than a loss of habitat condition.

The following section aims to explain this view by reviewing the condition assessment for each separate attribute encountered during the survey to meet the specific objectives outlined by Natural England in Section 3.1 of this report.

8.1 Condition Assessment

Providing a full condition assessment of a habitat normally requires the collection of data describing range of biotic, ecological, physical and chemical aspects. The only parameters available to base the following condition assessment on are the abundance and distribution of invertebrates and algae encountered in approximately 30 quadrats in each of four different survey sites, with historic data available for only two of those sites.

As such, the scope of this condition assessment is somewhat restricted, but it can provide an indication of the relative condition of the habitats encountered which can be substantiated by further surveys of the area.

8.1.1 General Assessment Across Sites.

The condition of the habitats surveyed for the current study is considered to be good in general terms. This is based on the discovery of diverse habitats with little evidence of human interaction, and the presence of long-lived and slow growing species like large sponges and hydroids.

Established indicators of poor habitat condition such as obvious anthropogenic influence, litter, low diversity or dominance by a disturbance or pollution resistant organisms were not recorded. In contrast, all sites were diverse with approximately 120 different species being identifiable.

8.2 Condition Assessment – Sub-tidal Mixed Cobble and Gravel Communities

This section is based on the findings from the survey work conducted at Duke Rock South.

The abundance on sessile or indeed mobile invertebrates at this SS.SMp.KSwSS.LsacR.CbPb Biotope at Duke Rock South were considered too low to be used as an indicator of sub-feature condition, as would be expected in an area characterised by mobile substratum. Consequently, the focus here will be on the ephemeral algal assemblage.

Change in the distribution and abundance of ephemeral algae was detected at the sub-tidal mixed cobble and gravel communities. Consideration of Table 10 and Figure 23 in Section 7.1 of this report suggest that it is likely that a measurable shift in ephemeral algal assemblage structure was encountered during the current survey in comparison to the previous survey in 2003. However by definition, this ephemeral assemblage is subject to change on short time scales and it would be more surprising if no significant change was detected in this highly dynamic assemblage. It is our view that this finding this does not directly imply an increase or loss of condition, but reflects normal, natural change.

The total number of different species of ephemeral recorded by the current survey encountered during the current survey was lower than in the previous survey in 2003. However the current survey encountered more different species than the first survey in 2008. This variation, as discussed in Section 7.1, suggests either that the total number of different ephemeral algal species is subject to considerable natural variation or there are other factors involved such as small but significant differences in survey location and inter-survey team variation.

Even if major shifts in the distribution or abundance of ephemeral algal species had occurred, the likely ecological impact of such a shift is considered low due to the assumed functional redundancy of the organisms.

8.2.1 Kelp

As discussed in Section 7.12, Natural England conducted a detailed assessment of kelp beds in the Plymouth Sound SAC in 2012. That report provides a more complete indication of kelp community condition in the area. However, it is interesting to note that the abundance of *L. ochroleuca* has changed significantly since 1999.

This species is thought to be increasing its poleward distribution as average sea surface temperatures increase. The kelp is known to directly compete for reef space with the native *L. hyperborea* which supports a much greater assemblage of epibionts which grow on its stipe. In contrast, the stipe of *L. ochroleuca* is almost completely bare of epibiotic growth.

It is possible that if *L. ochroleuca* is becoming more dominant across broad scales in sub-tidal reef systems there could be measurable changes in understory and epibiotic assemblages in future years. At present, the difference between grazing rates and carbon sequestration and cycling between the two kelp species is also not fully understood and could also present a driver for sub-tidal assemblage change within in the Plymouth Sound SAC and beyond.

8.2.2 Condition assessment summary – Sub-tidal mixed cobble and gravel communities

It is our conclusion is that no ecologically important change in condition has occurred in this Biotope since the previous survey, with the exception of the possible change in dominance of the kelp communicates as described above. However, as this study did not set out to conduct a survey of kelp dominated areas, full guidance of the kelp habitat condition should be taken from the Natural England Plymouth Sound Kelp Habitat Report from 2012.

This conclusion is based on the following findings:

- Approximately 60% of the same species responsible for characterising the biotope were recorded during the previous and current survey, despite a change in sampling effort and survey team, and the survey being conducted on a largely ephemeral assemblage.

- The following species have been consistently high in abundance and contributing to the within-site similarity throughout the historical surveys: *H. plumosa, D. dichotoma, D. sanguinea, P. bonnemaisonii*

- Changes in the relative abundance of non-dominant, ephemeral and functionally redundant algal species is unlikely to significantly alter habitat condition.

8.3 Condition assessment - Sub-tidal rocky reef communities

This section is based on the findings from the survey work conducted at Devils, Point, Firestone Bay and Eastern Kings.

As no historical data were present to describe Devils, Point or Firestone Bay, the scope of a condition assessment here is limited. However, as described previously, indicators of poor habitat condition such as obvious anthropogenic influence like litter, low diversity or dominance by a disturbance or pollution resistant organisms were not recorded.

By contrast, over 40 species of sessile macro invertebrates were discovered at these sites from a wide range of groups including soft corals, sponges, hydroids, tube worms, tunicates, echinoderms and molluscs, in addition to mobile invertebrates and fishes. Many structurally fragile species such as they hydroids; *N. antennina,* and *N. ramosa* were encountered at both these sites which suggest that disturbance at the site is minimal.

Considering these sites are less that 1km away from a major Naval dockyard, subject to the catchment area of the Tamar Valley, and in close proximity to treated sewerage discharge points, the condition of the sub-tidal rocky reef communities at Devils, Point and Firestone Bay appear to be surprisingly good. As mentioned previously, discarded fishing line was present at Devils Point, but across all sites, there was very little evidence of litter and human debris.

High numbers of commercial and pleasure craft in the area also have the potential to cause a change in condition as a result of the introduction of invasive non-native marine species from hull fouling and ballast water discharge, together with disturbance from anchoring and prop-wash. However, despite the occasional occurrence of the non-native tunicate *S. clava* which has been recorded in Plymouth Sound for over 60 years, no evidence of these potential impacts was found.

For the majority of the species recorded in Devils, Point and Firestone Bay, very little information exists describing life history traits and susceptibility to waterborne pollution. This lack of information makes it difficult to make a condition assessment based on the presence and distribution data from one point in time. However, it is hoped that the data collected by the current survey can be used as a benchmark to measure change if it occurs, in subsequent years.

8.3.1 Condition Assessment - CR.LCR.BrAs.AntAsH

The results in Section 6.12 of this report show how the abundance and distribution of the feather star *A. bifida* appears to have increased since the last survey in 2003. This is likely be a genuine finding as the species is obvious in the field and easy to identify. This increase is important because *A. bifida* is the most dominant space occupying species in the CR.LCR.BrAs.AntAsH Biotope. Although technically mobile, any increases in the abundance of this species will reduce the available space for other competitors resulting in potential loss of diversity or condition within the Biotope.

A decline in the abundance and distribution of the anemone *U. felina* was recorded in the current survey compared to previous surveys at this site. This finding may partially be result of an increase in the dominance of *A. bifida* at the site, causing the abundance of most other species to decrease. Alternatively, Howson, Bunker and Mercer (2005) describe how the feeding behaviour of anemones in general can have a measureable affect their visibility during diver surveys, and so this change is not regarded as being indicative of significant ecological change.

One of the key differences in assemblage structure at the CR.LCR.BrAs.AntAsH Biotope encountered at Eastern kings was the marked reduction in abundance and distribution of the tunicate *D. variolosus.* If this is a true finding, it could be considered as being ecologically important as it represents a significant change in assemblage structure. However, in terms of assemblage function, it is unlikely to be important due the occurrence of other functionally similar species at the site including *D. grossularia* and *P. scuba*.

D. variolosus, is understood to live for relatively short periods of time (approx. 2 years) and therefore could be subject to relatively rapid but natural changes in abundance resulting from normal patterns in reproductive success etc. It should also be noted that this change in *D. variolosus* abundance and distribution could also relate from confusion with other species, (particularly *D. grossularia*) throughout the different survey years.

The abundance and distribution of *Polydora* sp. was also noted to have increased in the current survey compared to previous years. The ecological significance of this finding is difficult to interpret due to the lack of information describing the sensitivity of *Polydora* sp. in general to pollution and other pressures, and a lack of understanding about their full functional role in benthic systems.

It should also be noted that this type of organism is often overlooked during surveys as only the tubes themselves are visible, which are the same colour as the surrounding sediment. Therefore, it is likely that this group was simply overlooked during previous surveys. It is also possible that the reduced abundance of *H. arctica* during the current survey is also partly a result of sampling error resulting from the challenge of recording cryptic species in the field.

8.3.2 Condition Assessment Summary- Sub-tidal Rocky Reef Communities

It is our conclusion is that no ecologically important change in condition assessment as occurred in this Biotope since the previous survey,

This conclusion is based on the following findings:

- The dominant species responsible for characterising the Biotope that exist at this site were relocated with similar abundances during the current and historical surveys.

- Where changes in distribution and abundance of species or groups were encountered, such as (*U. felinea, A. bifida*, *H. arctica* and *Polydora* sp.) these changes are either likely to result from a sampling issue between surveys or a behavioural aspect of the organism.

- It seems likely that *H. arctica* and *D. variolosus* have decreased in abundance over the last 10 years. The ecological significance of this assemblage change abundance is not clear. Given the lack of other evidence to suggest a loss of condition has occurred, it is likely that this change is simple a result of natural assemblage change. This could be confirmed during subsequent surveys.

8.4 Additional Objectives

This section provides our response to the sub-features objectives outlined by Natural England in Section 3.2 of this report. The objective from natural England is written in italic font and our response is below each objective in normal font.

H. *Provide ecological baseline for attribute condition (from which to assess future change) where this is not identified in the supplementary information provided by Natural England. In particular to provide a baseline for the IR.MIR.KR.HiaSw (previously AlcByH.Hia), if possible, See Section 3.2 below.*

The Biotope ***IR.MIR.KR.HiaSw*** *(Hiatella arctica* with seaweeds on vertical limestone / chalk) was not encountered at any of the sites surveyed for this study. We have some information that will help identify likely areas where this Biotope might exist outside the SAC and we would be pleased to discuss this further with Natural England.

V. *Where possible Natural England required an indication of condition with respect to prior data for the habitats previously monitored, in particular by Howson et al. 2005. In particular this was required for:*
    a. *EphR*
    b. *SubSoAs*
    c. *AlcTub*

The condition of the EphR habitats is described in detail in Section *8.2*

Where Natural England refer to *SubSoAs* in the specification above, we assume the reference is to the new Biotope *CR.MCR.CFaVS.CuSpH.As*. This is the new code that we suggest is assigned to the Biotope encountered in Firestone Bay and its condition is described in detail in section 8.3.

Where Natural England refers to *AlcTub* in the specification above, we assume the reference is to the new Biotope *CR.HCR.FaT.CTub (Tubularia indivisa* on tide-swept circalittoral rock*)*. This Biotope is only known to exist in a very discrete area near Devils Point. Unfortunately this was the same area that was deemed unsafe by our site specific diving risk assessment due to the existence of extensive heavy weight monofilament fishing line.

As described in this report, attempts were made to survey as close to this area as possible without comprising safety, but the extensive *Tubularia indivisa* beds characteristic of the *CR.HCR.FaT.CTub* Biotope were not encountered.

It should be noted that heavy grazing of the *Tubularia indivisa* beds is likely to have occurred during August when the current study was conducted making their presence less obvious. Future survey efforts targeting this Biotope might be more likely to discover the true distribution earlier in the year when the organism is more obvious during diver surveys.

VI. *The biotope AlcByH.Hia (IR.MIR.KR.HiaSw) was not reported on by Howson et al. (2005) and Natural England ideally aimed to establish a baseline for this biotope.*

The Biotope ***IR.MIR.KR.HiaSw*** *(Hiatella arctica* with seaweeds on vertical limestone / chalk) was not encountered at any of the sites surveyed for this study. We have some information that will help identify likely areas where this Biotope might exist and we would be pleased to discuss this further with Natural England.

VII. *Previous monitoring (Howson et al. 2005) found it difficult to find good examples of the ErS.Eun biotope within the SAC. Natural England suggested removing this biotope from 2013 monitoring. Natural England requested suggestions and recommendations on reallocation of resources to meet overall monitoring objectives.*

Eunicella verrucosa does occur within the SAC although its presence is patchy and we do not know of any areas within the SAC where it occurs in sufficient abundance to be used as a representative feature for habitat classification. It seems reasonable that if Howson *et al.* (2005) were tasked with mapping the distribution of Biotopes within the SAC, but did not find the ErS.Eun Biotope, it would make sense to remove it from further monitoring programmes.

Without knowing the full extent of Natural England monitoring programmes, it is our suggestion that mobile gravel, sand and soft sediment habitats are underrepresented in current monitoring schemes given their wide distribution within the SAC. If resources are to be re-distributed, these biologically and functionally active areas could warrant greater attention.

PML has already conducted extensive time series sampling of these habitats within the SAC (see Section 9.2) and we would be pleased to talk to Natural England about existing data and baseline variability in these sites. Further discussion on reallocation of resources is provided in Section 9.

9 Recommendations

The following recommendations are proposed to address Objective H as outlined in the requirements document supplied by Natural England:

A. *To follow recommendations and methods developed in previous surveys (i.e. Moore 2001 and Howson et al, 2005) to develop a cost effective sampling strategy to allow condition of the 'Sub-tidal mixed cobble and gravel' and 'Sub-tidal rock and boulder communities' to be assessed against the relevant attributes and compared with previous survey data using the Common Standards Monitoring Guidance.*

9.1 Sampling Strategy

This section aims to provide recommendations for sampling strategies based on our practical experience of sampling these sub-tidal mixed cobble and gravel and sub-tidal rock and boulder habitats.

9.1.1 Sampling Methods

Section 5 of this report outlines the sampling methods used in the current survey. This diving survey method was found to be highly successful in terms of being practically easy to implement and also allowed the survey team to collect good quality species abundance and distribution data describing each of the attributes we encountered within the habitats.

In particular we would recommend the value of obtaining photographic information describing the biological assemblages at proposed survey sites prior to undertaking the diving operation through the use of drop down video or similar methods. Careful examination of this information by the current team provided confidence in taxonomic capability and saved valuable time underwater as described fully in Section 6.

If subsequent surveys use site locators as described in Section 5, this will ensure that the same general area will be surveyed in subsequent years. However, the random placement of quadrats used during the current survey will ensure data can be considered independent and subject to full statistical examination.

We suggest that by following the methods described in Section 5 of this report, subsequent dive teams will be able to collect representative data from the sub-tidal mixed cobble and gravel' and sub-tidal rock and boulder communities within realistic timescale and budgets.

9.1.2 Number of Replicates for the Quadrat Survey

Diver surveys are never exhaustive due to the limitations of field conditions, yet the present survey was conducted with the benefit of hindsight from the previous survey attempts (at Eastern Kings and Duke Rock) and consequently was well informed in terms of species that were likely to be encountered.

The present survey also used a higher number of replicate quadrats than the previous studies at each site, increasing the chance of encountering the majority of the characteristic species within the habitat. The present study cannot be classed as a baseline as such, due to the existence of previous surveys in the area. However, the present study should be considered as currently the most representative assessment of habitat condition in the area for comparison with future studies.

The present survey planned 30 replicate quadrats at each site based on the power analysis conducted by Moore *et al.* 2000. This number of replicates was chosen to comfortably accommodate the within-site variation in distribution and abundance of sessile organisms at each site.

Following the field work, it is considered that 30 replicates per site is a good compromise between what is realistically achievable by a small dive team in the allocated time and the ability to adequately describe habitats which are prone to considerable patchiness.

A good example of the variable nature of these sites can be seen at Devils Point where *A. diaphanium* occurs in dense patches (Figure 17). Equally, at Duke Rock South, large areas of gravel and sand occur in between limestone outcrops. If less that 30 quadrats are surveyed at these sites, there is a good chance that an influential proportion of the quadrats would fall in one of these patches, with the potential to provide a false account of the true diversity and spread of species at the site.

9.1.3 Indicator Species Approach

Our experience of all four survey sites suggests to us that an indicator species based sampling strategy would be the best compromise between ability to detect change when it occurs, and limited resources. We suggest that suite of indicator species are carefully selected for each Biotope and are subsequently used to provide a rapid indication of Biotope condition assessment.

Appropriate selection of a limited number of indicator species will reduce the sampling effort and intensity required, but should still highlight if notable decline or improvement of habitat condition occurs. This approach could lead to a reduction in sampling resource required per site that could potentially be reallocated to other habitat types in the Plymouth Sound SAC to provide a more holistic habitat condition of a wider range of habitat types.

If habitat condition change is suspected based on a restricted indicator species survey, then a follow up survey with greater taxonomic assessment could be used to provide a better understanding of any shifts in community composition compared to existing baseline data from the Biotope. This provides a more cost effective approach that full assemblage assessment at each sampling event.

We believe that this approach is better suited to our understanding of Natural England's monitoring requirements. The indicator species approach also avoids the situation where complete assemblage assessment over repeated sampling events inevitably produces complex patterns of natural temporal and spatial change which are very difficult, if not impossible to disentangle from anthropogenically driven change in habitat condition.

9.1.4 Indicator Species Selection

If the indicator species approach is taken, species selection should be carefully considered in relation to aspects such as:

- Are the chosen indicator species ecologically important in terms of the structure and function of the habitat?
- Are the indicator species selected likely to show naturally highly variable abundance, presence or absence over time short time scales that could be misinterpreted as anthropogenic driven loss of habitat condition?
- Are the indicator species sufficiently susceptible to disturbance or pollution events etc. to enable change to be detected in sufficient time to mitigate where possible?
- Are the indicator species selected suitable for rapid monitoring techniques such as drop down video, coarse taxonomic resolution in rapid diver surveys?
- Is it possible to select a small enough number of indicator species to dramatically reduce the sampling effort compared to whole assemblage assessment?

9.1.5 Biotope Specific Approaches

Our analysis of the four sites surveyed for this study has shown that each of the different sites supports either a different distribution or diversity of organisms. Consequently, different indicator species are likely to be required at each site. This section provides suggestions of key species and that could be considered useful indicator species for each Biotope that was encountered at the different sites and suggests sampling approaches to monitor them.

The suggestions of indicator species and sampling approaches made here are suggestions based on our understanding of Natural England's monitoring requirements and would need separate consideration beyond the scope of this current study before implementing. We would be happy to discuss this with Natural England in more detail.

9.1.6 Justification for Sampling Strategy Suggestions

As described in Section 9.1.4, indicator species selection is critical and should be considered carefully beyond the scope of this study. Due to the positioning of theses Biotopes in relation to discharge from the Tamar and Plym Estuaries, susceptibility to chemical pollution (including nutrient run-off) should also be considered when selecting indicator species for these Biotopes.

The justification for the timing of the repeated survey is more difficult and is obviously largely dependent on available resource, previous monitoring frequency and over-arching monitoring obligations.

Based on the limited data available on the growth rates of species identified as being characteristic of the Biotopes described in the study (see http://www.marlin.ac.uk/biotic/), sampling invertebrate (and algal) dominated habitats every three years is a reasonable compromise between capturing the growth or die back of long lived species (>10 yrs) and capturing the occurrence of fast growing opportunistic species that characteristically increase in abundance as a result in loss of habitat condition or increase in disturbance. This aspect of sampling frequency also requires further discussion beyond the scope of this study.

Table 14: Table showing suggested indicator species and sampling approaches for Sub-tidal mixed cobble and gravel' and 'Sub-tidal rock and boulder Biotopes

Site Name	Suggested New Biotope Code	Possible Indicator Species & Justification	Sampling Approach
Firestone Bay	**CR.MCR.CFaVS.CuSpH.As** Cushion sponges, hydroids and ascidians on turbid tide-swept sheltered circa-littoral rock	• Sponges *Halichondria sp* (highly abundant) and *Cliona celata* (highly abundant and implicated in structure of reef) • Hydroids, *Nemertesia antennina, Nemertesia ramosa* (both species are characteristic of the Biotope and are structurally fragile) • Tunicates: *Polycarpa scuba, Dendrodoa grossularia* (both highly abundant and responsible for large proportion filtration capacity of Biotope)	Every 3 years - Diving quadrat survey for indicator species based on sampling methods used in present study (Section 5)
Eastern Kings	**CR.LCR.BrAs.AntAsH** Antedon spp., solitary ascidians and fine hydroids on sheltered circa-littoral rock	• The anemone, *Urticina felina* (highly abundant and visible with drop down video techniques) • Soft coral, *Alcyonium digitatum (*long lived, fragile and visible with drop down video techniques) • Feather star, *Antedon bifida* (Characteristic of Biotope, fragile, highly abundant and capable of small scale movement if unfavourable conditions are experienced)	Every 3 years – Drop down video assessment or diving quadrat survey for indicator species based on sampling methods used in present study (Section 5)

Devils Point	**CR.MCR.CFaVS.CuSpH.VS** Cushion sponges and hydroids on turbid tide-swept variable salinity sheltered circa-littoral rock.	• Sponge *Halichondria sp.* (highly abundant) • *Hydroids*, *Nemertesia antennina*, and *Nemertesia antennina*, (both species are characteristic of the Biotope and are structurally fragile) • Bryozoan, *Alcyonidium diaphanium* (relatively long lived (10 yrs), visible with drop down video techniques and characteristic of the biotope)	Every 3 years - Drop down video assessment or diving quadrat survey for indicator species based on sampling methods used in present study (Section 5)
Duke Rock	**SS.SMp.KSwSS.LsacR.CbPb** Red seaweeds and kelps on tide-swept mobile infra-littoral cobbles and pebbles	• Ephemeral red algae, only recording percentage cover at coarse taxonomic scale • Ratio of *Laminaria hypoborea* to *Laminaria ochrolueca* kelp species (support different epifloral and faunal assemblages and probably different carbon sequestration potential)	Every 5 years - Diving quadrat survey for indicator species based on sampling methods used in present study (Section 5)

9.2 Further Recommendations / Considerations for Future Work

9.2.1 Site Choice – Use of Resource

Survey work such as the current study is extremely valuable to determine the condition of valuable habitats. However, it is both costly, time consuming and requires consistent use of a specialist team to achieve best results. Consequently, site choice is critical to ensure that best use of available resources is achieved.

Analysis of the survey sites confirmed that they are all different, but Devils Point and Firestone Bay are similar in terms of key species but with differences in abundance separating the two sites. It could be considered that Devils Point (as surveyed by the current study) and Firestone Bay are not sufficiently different enough to warrant individual survey attention as they are similar in terms of diversity, and it is likely that if habitat condition changed enough to be detected, this would be measurable in both sites.

It could be considered that the addition of another site containing other sub-features included in the Favourable Condition Table (Table 1) would be a better use of resource that would provide a more holistic appraisal of the condition of Plymouth Sound SAC.

9.2.2 Interpretation

Care must be taken both with comparison of data from previous surveys and also with comparison of data collected during the current survey and future surveys. Changes in dominant species abundance or diversity can appear dramatic but can often be explained by one of the following artefacts which don't actually reflect a change in habitat condition.

Previous work undertaken at PML aimed at characterising infaunal sediment assemblage change over a five year time period in Plymouth Sound has shown that measureable changes in abundance and diversity can and do occur quite naturally as a result of normal shifts in dominance and competition for resources and space. (http://www.westernchannelobservatory.org.uk/benthic_survey.php)

Survey work is unlikely to be undertaken on a regular basis for the sites in the current survey, therefore it is highly likely that a degree of this natural variation will be measured between time points, which may appear to be quite dramatic.

It is easy to interpret a measurable shift in dominance of key species for example as a reaction to a loss of condition, where this may actually be attributed to a normal temporal shift in community dominance. Without regular repeated sampling of the same site (which in its self can result in assemblage change) it is very difficult to disentangle natural variation with loss of condition associated with anthropogenic activities.

9.2.3 Variation Between Survey Staff

Several guidelines have been described by the current study (Section 5.5) and previous studies (Moore *et al.* 2000 & Howson, Bunker and Mercer, 2005) which are aimed at standardising sampling technique and identification skills between divers to reduce sampling error. While these guidelines are without doubt very effective, there will inevitably be variation between sampling technique and identification quality between individuals.

This variation is impossible to remove completely, but the influence of a difference in survey technique can easily result in measureable differences between overall diversity measures of a habitat together with abundance over time. At Eastern Kings for example, the Moore *et al.* (2000) survey picked up approximately 15 species that that the current survey did not encounter. Equally, the current survey picked up approximately 10 species not encountered by the Moore *et al.* (2000) study. The influence of these species in terms of assessment criteria is probably low, as they were generally infrequently measured, and not broadly characteristic of the habitat.

These differences are much less likely to occur in relation to the abundance dominant species which all surveyors become accustomed to during the operation. Therefore minor changes if the abundance of rare or cryptic species should be treated with caution and the emphasis of assessing condition should be reserved for the most abundant and dominant organisms in each habitat.

9.2.4 Randomised sampling strategies

The advantage of randomised sampling strategies is that all data are independent and can be analysed as such to provide good power to measure change. The disadvantage of this method is that the exact same area is not surveyed on repeated sampling events.

Benthic organisms are notoriously heterogeneous in their distribution so using a randomised approach is very likely to produce differences in abundance of key species between sampling events. Only by adequate replication of suitably sized sample units can the true changes be detected. In summary, subtle changes in distribution and dominance in key species are to be expected when using randomised sampling approaches and most attention should be paid to strong and consistent trends that are detectable above the "noise" associated with repeated sampling of an area of habitat as opposed to the exact same area of seabed.

9.3 Timing of Survey

While it makes sense in broad terms to conduct repeated surveys of the same area at a similar time in the year, this is not the only issue controlling abundance and diversity of sessile algae and invertebrates in Plymouth Sound SAC.

Personal observations and those of the survey team indicate that the peculiarities of the season in terms of rainfall and temperature is likely to have a greater effect on benthic assemblage structure that the month during which the survey is completed. This is particularly the case in algal dominated habitats.

We suggest that planning of subsequent surveys is not restricted to exactly the same time as the current survey, but considered in terms of the weather patterns during that season. The survey could be brought forward during a hot spring and early summer or pushed back during a cold and wet winter accordingly although it would be difficult to parameterise this.

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11 References

Howson, C., Bunker, F., & Mercer, T., (2005). Plymouth Sound European Marine Site Sublittoral Monitoring 2003 Report. Aquatic Survey & Monitoring Ltd.

JNCC (2004), Common Standards Monitoring Guidance for Marine, Version August 2004, ISSN 1743-8160. Available online at: http://jncc.defra.gov.uk/page-2236

Moore, J. (2000), Development of a monitoring programme and methods in Plymouth Sound cSAC: application of diver techniques – 1999, English Nature

Moore, J.J., James, B., 2000. Development of a monitoring programme and methods in Plymouth Sound cSAC: application of diver and ROV techniques. *English Nature Research Report.*

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