Natural England Commissioned Report NECR295

PLYMOUTH SOUND AND ESTUARIES SPECIAL AREA OF CONSERVATION: SUBTIDAL REEF COMMUNITIES SURVEY 2017/18

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Foreword

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

Background

The use of sentinel condition monitoring of Marine Protected Areas (MPAs) has been recommended as an option to deliver more in-depth information for a small number of MPAs that can guide condition monitoring in other MPAs. Natural England has set up the first English sentinel monitoring site as a trial of the diving survey method. This information will inform the future development of other sentinel monitoring sites as well as the condition assessment for Plymouth Sound and Estuaries SAC.

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Further information
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Summary

Scientific diving surveys of subtidal benthic reef communities were undertaken within Plymouth Sound and Estuaries Special Area of Conservation (SAC) in July 2017 and again in July 2018. The survey aimed to collect data to inform condition monitoring of the SAC 'reef' feature.

The two surveys were led by Natural England staff. The survey methodology was specifically designed by Natural England to establish a monitoring programme which would provide time-series data that could be collected consistently from selected sites representing a range of subtidal reef communities. The survey was designed to assess the attribute *species composition of subtidal reef communities*. Sites were selected at five discrete locations, representing four circalittoral communities and one infralittoral community. There were two open coast (moderately exposed) sites, a sheltered site on the landward side of Plymouth Breakwater and two further sites at the entrance to the River Tamar, which were sheltered from wave exposure but subject to accelerated tidal streams. Thus the array of sites represented a range of communities across a variety of environmental conditions within the SAC.

At the aforementioned five locations, targeted subtidal reef communities were surveyed using

0.25 m^2 quadrats along transect lines. As surveyors were limited to 10 minutes recording per quadrat the priority was to first record characterising species using estimates of percentage cover and also the presence of Priority Species and invasive non-native species.

The data collected on the 2017 and 2018 surveys have been analysed using PRIMER and the results are presented in this report. The primary purpose of this document is to report on the data analysis and determine whether the data show that similar communities were surveyed each year and that the methods used are robust and repeatable enough to provide meaningful data pertaining to the biological communities at each site.

The survey methodology is reported and the robustness of the collected data assessed in order to determine if the monitoring programme should continue in its present form.

Key findings:

The data analysis differentiated the distinct communities found at each of the five monitoring sites. Although there was overlap between data points of the two open coast sites, this is understandable as they both represent the same circalittoral community (CR.HCR.XFa.ByErSp.Eun). While differences were detected within the species composition of communities between years the communities remained the same at each site. In general, it was the differences in relative abundances of most of the taxa causing the differences between year groups rather than the presence or absence of different taxa recorded between years. There is also commonly known to be a combination of diver recording variability and natural fluctuations which can be considered to account for the observed differences.

It was concluded the repeatability of the survey methods validates a continuation of the survey techniques for future monitoring years, thereby establishing an initial monitoring time- series dataset which will contribute to the process of assessing whether the subtidal rock community of the 'reefs' feature is (or is not) in Favourable Condition.

There are recommendations to be considered for future surveys following the monitoring programme of subtidal reef communities within Plymouth Sound and Estuaries SAC.

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1 Introduction

Plymouth Sound and Estuaries was designated as a Special Area of Conservation (SAC) on 1st April 2005 and contributes to the UK's suite of Natura 2000 sites and overall Marine Protected Area network. The Annex I 'reefs' is one of six habitat features for which the site was designated.

The SAC was designated (under the EC Habitats Directive) for the following Annex I habitats:

- Sandbanks which are slightly covered by sea water all the time
- Estuaries
- Mudflats and sandflats not covered by seawater at low tide
- Large shallow inlets and bays
- Reefs
- Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)

The EC Habitats Directive requires Member States of the European Union to report on implementation of the Habitats Directive, every six years, under Article 17 of the Directive. As the statutory nature conservation body for England, Natural England must report an assessment of the condition of the Annex I habitat types, so it may be established if the features are in Favourable Condition or not.

Monitoring fieldwork was undertaken by eight scientific divers during five-day periods over two survey seasons; 3rd to 7th July in 2017 and 2nd to 6th July in 2018. The two surveys were led by Natural England staff and supplemented by two additional external consultant marine biologists.

The data collected during these two field seasons have been analysed and the results are discussed later in this report.

The primary aim of this report is to make an initial assessment of the survey methodologies to determine if the data derived from the surveys are statistically robust, for the following purposes:

- Is the methodology delivering data that will be able to detect any significant future changes in the community composition, the diversity and abundance of species?
- Is it reliably repeatable?
- Are the sites distinguishable in the data analysis?

1.1 Site overview and reef feature description

(Taken from Plymouth Sound and Estuaries SAC UK0013111 Compilation date: May 2005 Version: 1 Designation citation).

Plymouth Sound and Estuaries SAC is located on the south coast of England and straddles the border between Devon and Cornwall. Plymouth Sound and its associated tributaries comprise a complex site of marine inlets. The high diversity of reef and sedimentary habitats, and salinity conditions, give rise to diverse communities representative of ria systems and some unusual features.

The site is of particular importance for its reef communities which are home to a number of species of note. The Devonian limestone reef is of particular importance because this is one of only two sites in the south west with coastal Devonian limestone. The limestone reef is heavily bored by marine worms and bivalves. The nationally rare sponge (*Dysidea pallescens*) and the Weymouth carpet coral (*Hoplangia durotrix*) are found on sublittoral reefs in the site. Nationally scarce species; pink sea fan

(*Eunicella verrucosa*), trumpet anemone (*Aiptasia mutabilis*), latticed corklet anemone (*Cataphellia brodricii*), scarlet and gold star coral (*Balanophyllia regia*) and orange light seasquirt (*Pycnoclavella aurilucens*) have all been recorded on reefs in the site. The nationally scarce hydroid (*Hartlaubella gelatinosa*) forms clumps on mixed substrata in the upper Tamar estuary.

1.2 Monitoring aim and objectives

The monitoring programme for Plymouth Sound and Estuaries SAC was designed to assess the condition of the subtidal reef communities, one of the component habitats of the Annex I 'reef' feature. Natural England have identified attributes for each feature and set measurable targets against them in order to determine if each feature (Annex I habitat type) is in Favourable Condition. In 2017, the survey programme commenced gathering data on the species composition of a range of subtidal reef communities. The data would provide evidence to contribute to future condition assessment by allowing Natural England to monitor any changes in the species composition which would contribute towards making an assessment of the overall site condition.

The survey programme was designed primarily to monitor the attribute

- *Maintain the species composition of subtidal reef communities*

The survey will also provide data to support the assessment of the following attributes

- Reduce the introduction and spread of non-native species and pathogens, and their impacts.
- Maintain the presence and spatial distribution of reef communities

The targets identified for attributes of the 'reef' feature can be viewed online at:
https://designatedsites.naturalengland.org.uk/Marine/MarineFeatureCondition.aspx?SiteCode=UK0013111&SiteName=Plymouth Sound and Estuaries SAC&SiteNameDisplay=Plymouth+Sound+and+Estuaries+SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=

1.3 Site selection

All survey sites were located within the Plymouth Sound and Estuaries SAC. The seaward boundary of this SAC extends from Rame Head, east across Wembury Bay to the entrance to the Yealm Estuary.

The sites selected are based on historical data from previous surveys (Appendix 1) and are known to be representative of the range of subtidal reef communities found within Plymouth Sound and Estuaries SAC. The monitoring programme aimed to record the species composition of subtidal reef communities at sites representing a range of physiographic conditions (wave exposure, tidal streams, turbidity) across the SAC.

The sites comprise two relatively open coast sites (East of North degaussing buoy and West of Mew Stone), one site north-east of the breakwater (Duke Rock South) and two wave-sheltered sites near the Tamar River tributary which are subject to increased tidal streams (Eastern King Point and Devil's Point). Duke Rock South represents the only infralittoral community surveyed and whilst the other four sites are all upper circalittoral communities, all sites are in relatively shallow water, as much of the area within the SAC is barely deeper than 20m below chart datum (BCD). Therefore algal species remain a prominent feature of all sites.

2 Methods

2.1 Survey design

2.1.1 The sites

Table 1: Survey sites and positions (derived from GPS).

Site number	Name (abbreviation used in report)	Position (WGS 84)
1	East of Northern degaussing buoy (ENDG)	50.31701 -4.16188 50’ 19.0206’ (N) 4’ 9.7128’ (W)
2	Devil’s Point (DP)	50.3605 -4.16735 50 21.634'N -4 10.041' (W)
3	Duke Rock South (DR)	50.3383 - 4.134983 50’ 20.298’ (N) -4’ 8.0988’ (W)
4	West of Mew Stone (WMS)	50.30635 - 4.12567 50’ 18.381’ (N) -4’ 7.5402’ (W)
5	Eastern King Point (EK)	50.36045 - 4.15662 50’ 21.627’(N) -4’ 09.397’ (W)

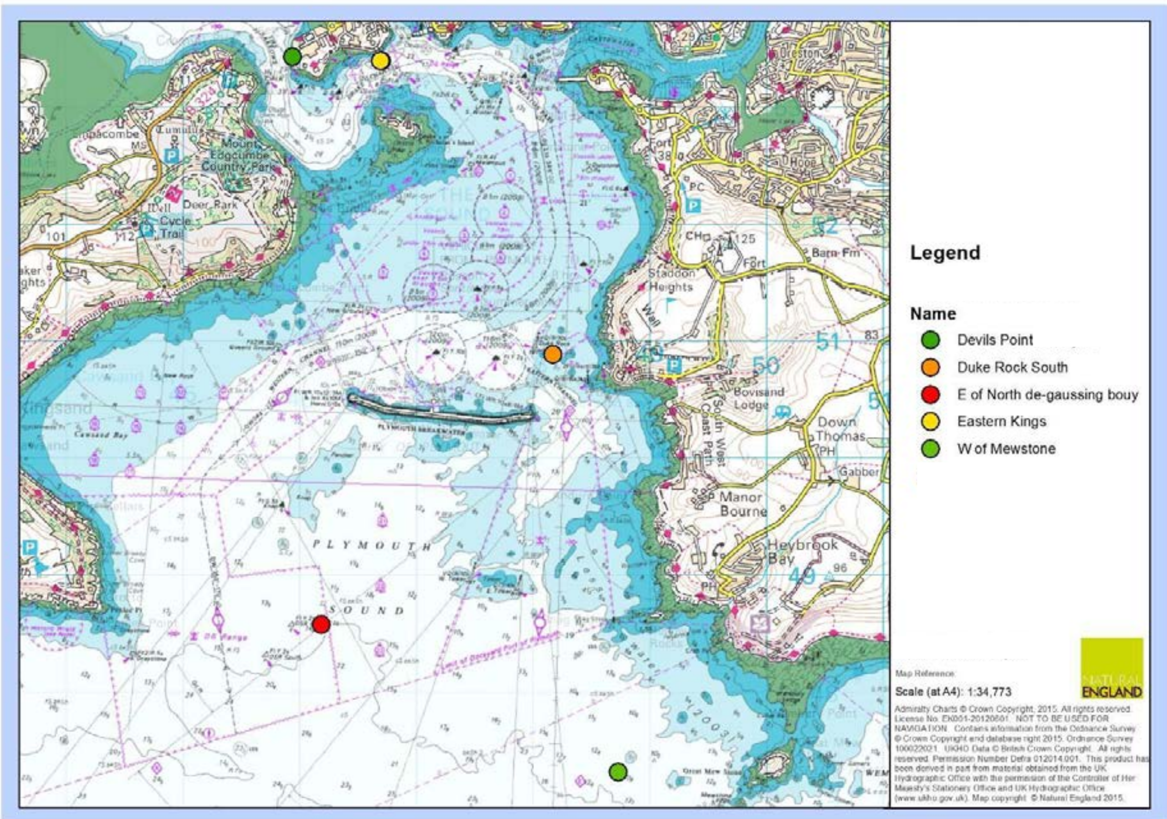


Figure 1: Map of all survey sites in Plymouth Sound and Estuaries SAC

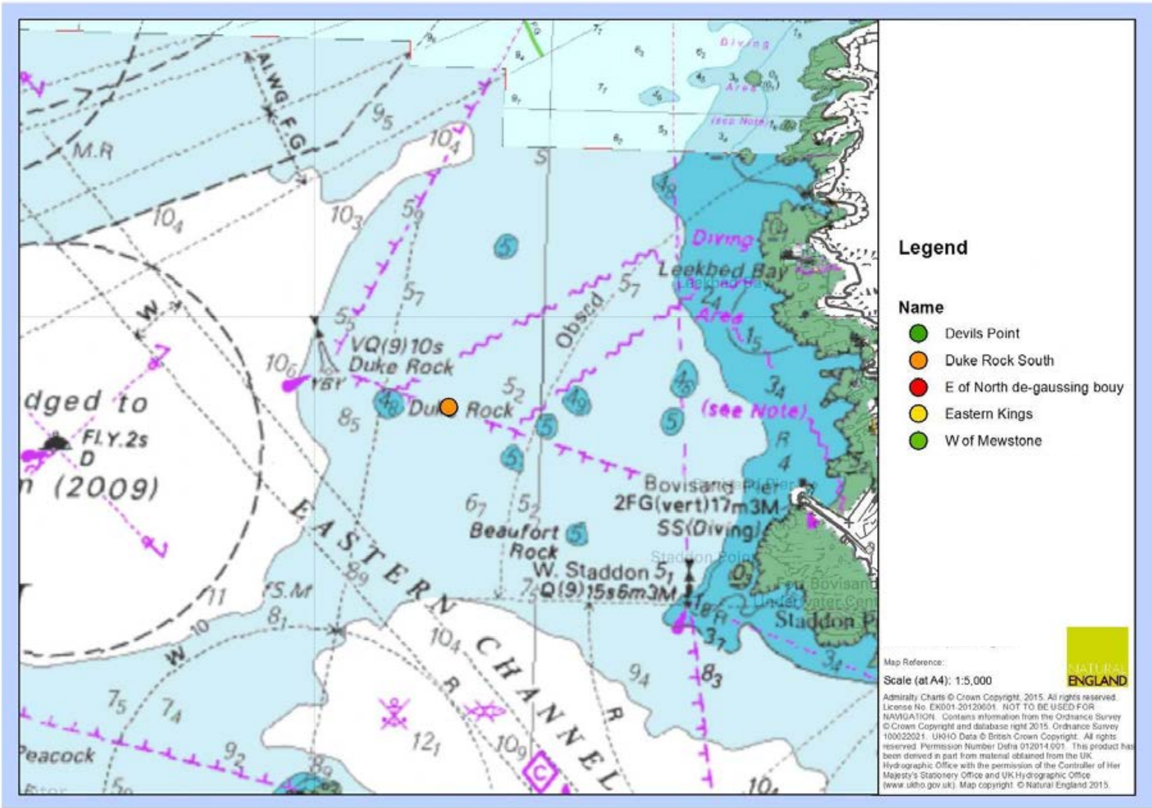


Figure 2: Map of Duke Rock South monitoring site

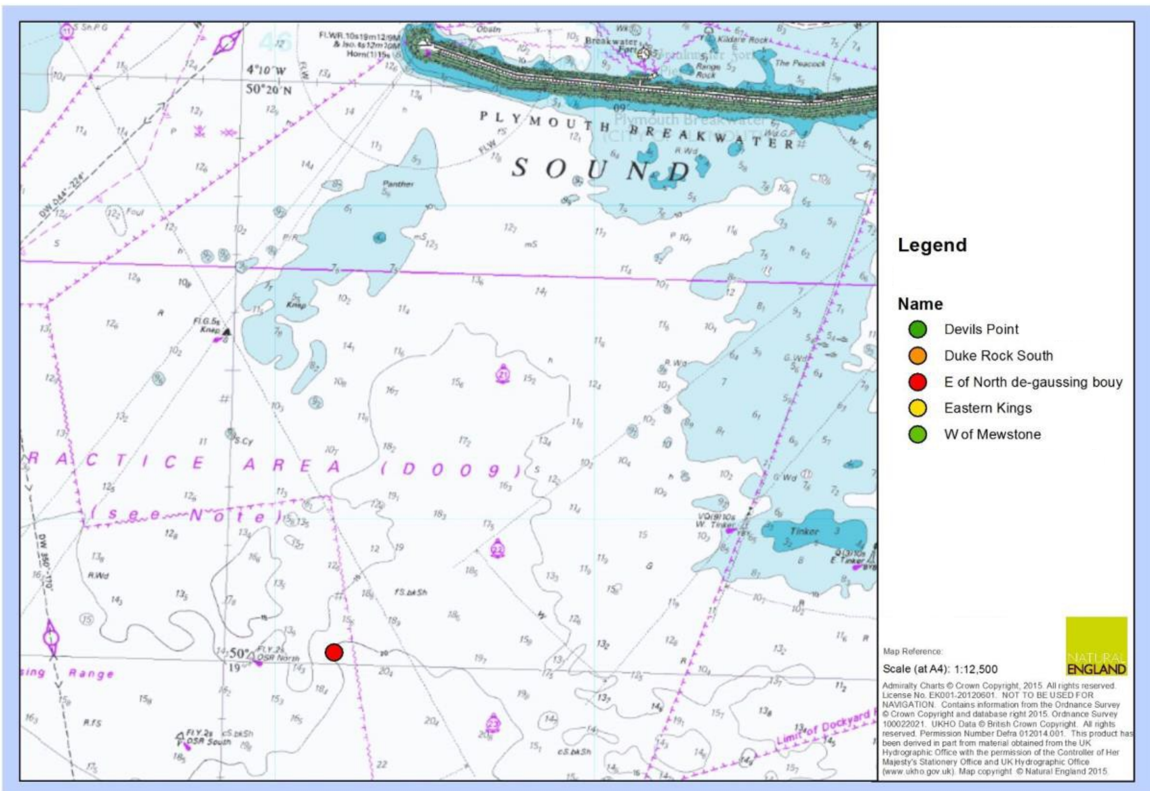


Figure 3: Map of East of Northern degaussing buoy monitoring site

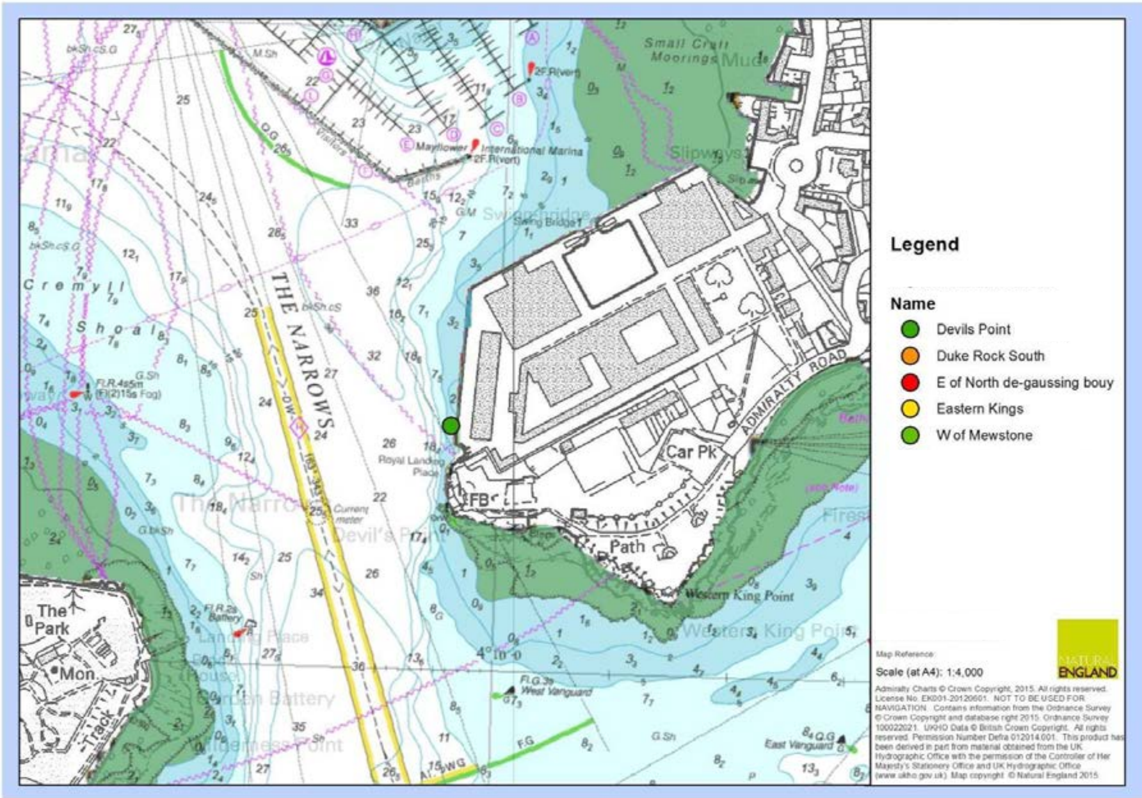


Figure 4: Map of Devil's Point monitoring site

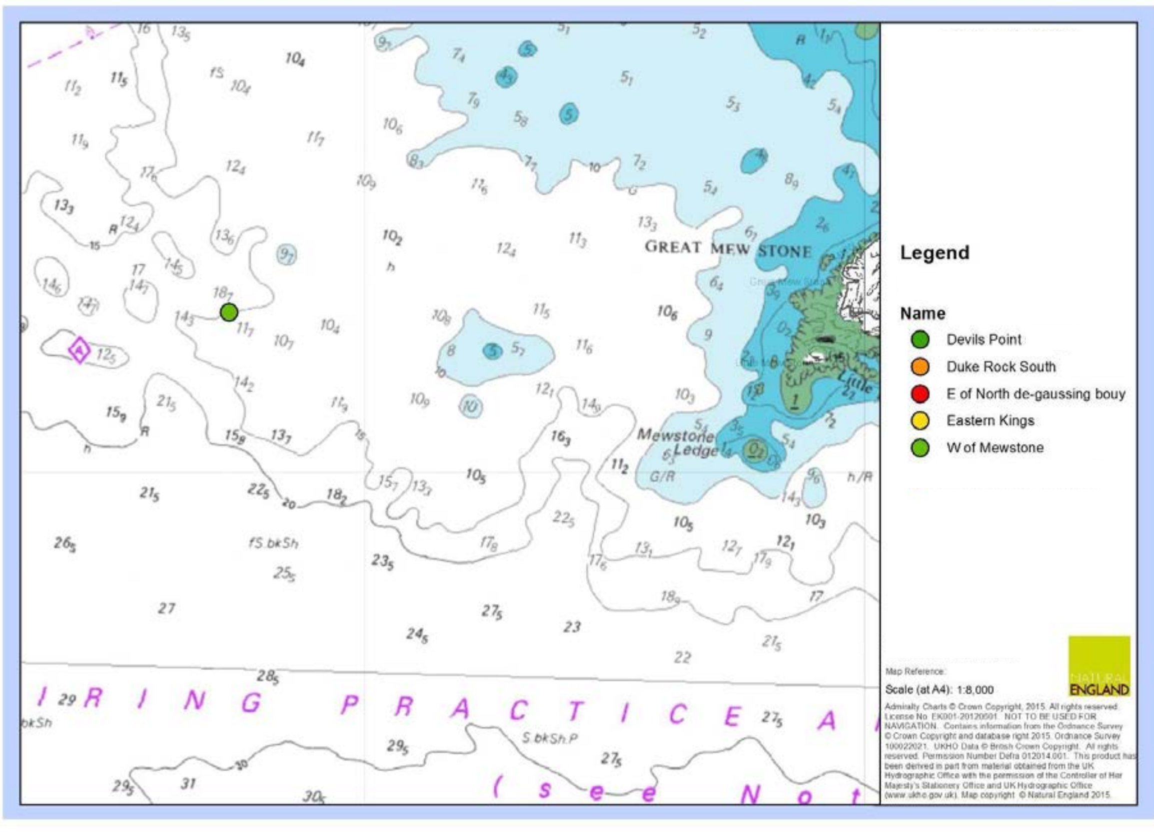


Figure 5: Map of West of Mew Stone monitoring site

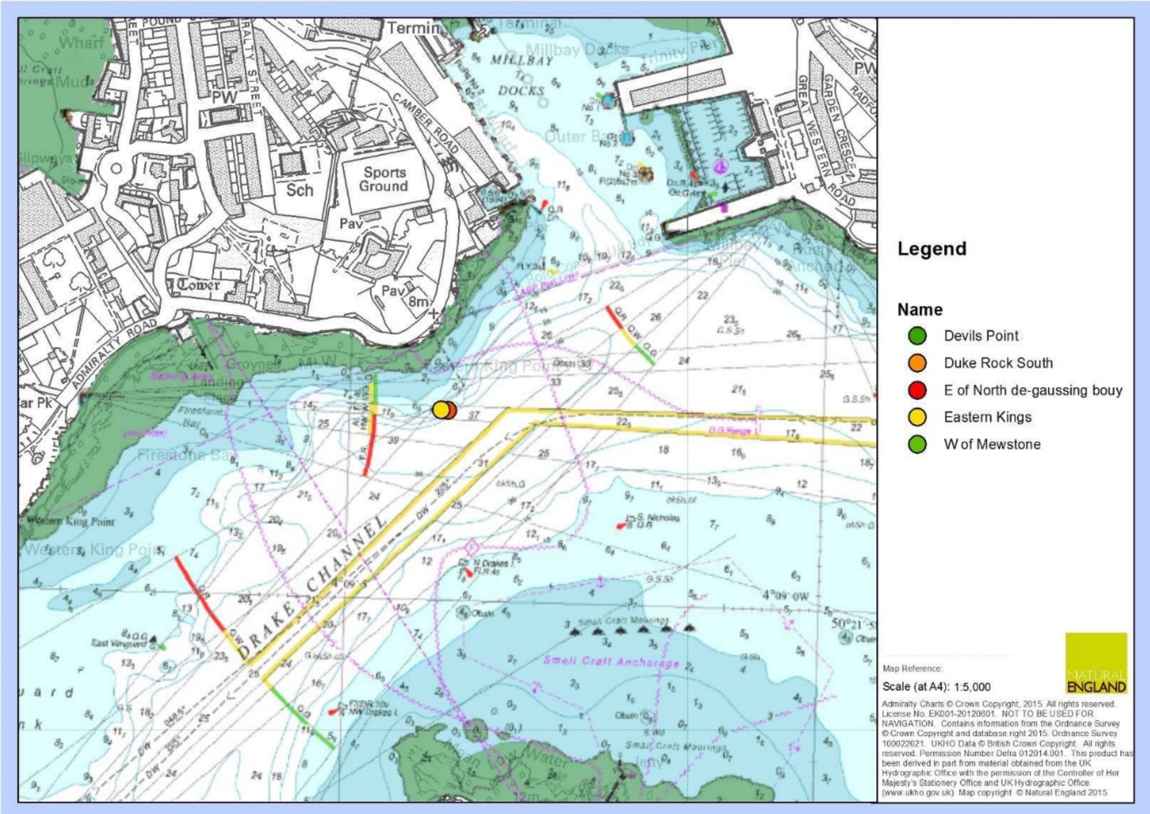


Figure 6: Map of Eastern King Point monitoring site

2.1.2 Diving operations

The diving work comprised a team of eight divers who surveyed all five sites over a five-day fieldwork period. This number of divers allowed for one dedicated non-diving supervisor and a surface stand-by diver on the vessel. All diving was planned to take place at slack-water times in a neap-tide period. A Plymouth-based chartered hard boat *Venture*, a category 2 MCA registered vessel, acted as the diving platform. The vessel operated from Sutton Harbour in 2017 but picked divers up at Mount Batten Centre in 2018 which saved the field survey team travel time to sites.

The survey was designed to record benthic species data *in situ*, supplemented by videography and/or photography, to provide a general overview of each site. One pair of divers was deployed to set up the site and undertake general site recording and videography/photography; the other two pairs of divers recorded benthic species along two transect lines simultaneously.

2.1.3 Diving procedure

All diving practice followed the Health and Safety Executive (HSE) Approved Codes of Practice for Scientific and Archaeological Diving and the Rules and Guidance for Scientific Diving in the Statutory Nature Conservation Bodies (Holt 2015). These comply with the Diving at Work Regulations, 1997. In accordance with these regulations all divers were qualified to HSE Pt IV or equivalent CMAS 3* qualification.

Natural England produced and supplied a Diving Project Plan detailing diving operations, site specific information, risk assessment and emergency procedures. The plan detailed the sites to be dived on each day of field work and the times of slack water when diving operations could take place.

The scientific diving team used SCUBA diving equipment and Nitrox gas, but using air no-stop times. Diver pairs were equipped with through-water surface-to-diver voice communications with a diver-to-surface beep return (one per buddy pair as a minimum). This communication system provided the primary communication and recall facility.

2.2 Data collection: benthic species data

Each of the selected dive sites was located by the skipper using previously known GPS positions. Once on site, a buoyed shot line was deployed from the dive vessel which acted as a guideline for the descent of the divers to the seabed. As mentioned, the methodology required one set of divers to locate a previously known area of seabed and lay transect lines across the reef community to be surveyed; subsequently two pairs of divers recorded the epibiota along the transects using 0.25m2 quadrats.

2.2.1 Survey tasks

At each site the first pair of divers were deployed to locate the representative subtidal reef community, with the aid of an underwater site description sheet. This provided details of the target community description, with notes on the physical aspect of the habitat, angle of slope and specific details of both physical characteristics and community characteristics to locate the target community (see Appendix 2). A 6 m-long transect line was then reeled out within the representative biotope (habitat and community) maintaining a consistent depth contour as much as possible, recording the depth and compass bearing of the line.

Once the transect line was laid within the area of habitat selected for sampling the first pair of divers recorded qualitative survey notes to produce a detailed description of the physical habitat, substratum type, and key features which could identify the site for sampling in the future, and also the wider community detail (MNCR phase II / Seasearch surveyor style recording). The semi-quantative SACFOR scale was used to record species abundance. Photography / videography was used to record the general features, layout and species on site.

A delayed surface marker buoy was deployed to allow the vessel to record the precise GPS position of the sampling site. This also signalled diver pairs two and three to enter the water to commence quadrat recording along the transect line.

It should be noted the second pair of divers recording from quadrats had to reel out their transect line tape to 6m in the opposite direction to pair one along the same depth contour and within the biotope set out by pair one (see Figure 7).

Each diver used a 0.25m^2 quadrat to record the percentage cover of characterising species within the quadrat area, following recording rules (Appendix 3). Pro-forma recording sheets specific to each site were used to record species. Divers were advised to place quadrats at 5m, 4m and 3m along the transect line, to ensure some spatial separation between diver pairs but this could be adjusted if necessary. The quadrats were maintained along a depth contour and homogenous topography as much as possible. The distance along the transect tape and depth of each quadrat was recorded on the survey forms. In order to stay within estimated bottom times, a maximum sampling time of 10 minutes per quadrat was allowed. Divers aimed to survey two to three quadrats per dive, depending on available no-stop dive times.

Photographs / samples were taken of common / characterising species that could not be identified *in situ*. Identification was undertaken in the field laboratory in the evenings.

The sampling layout for each dive site is represented in Figure 7 below.

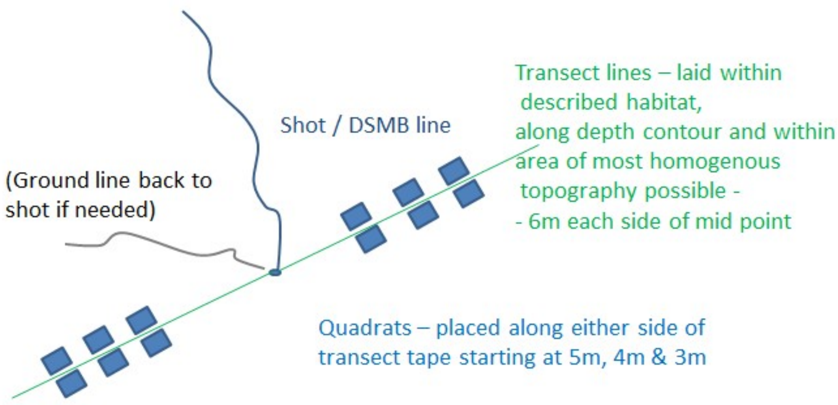


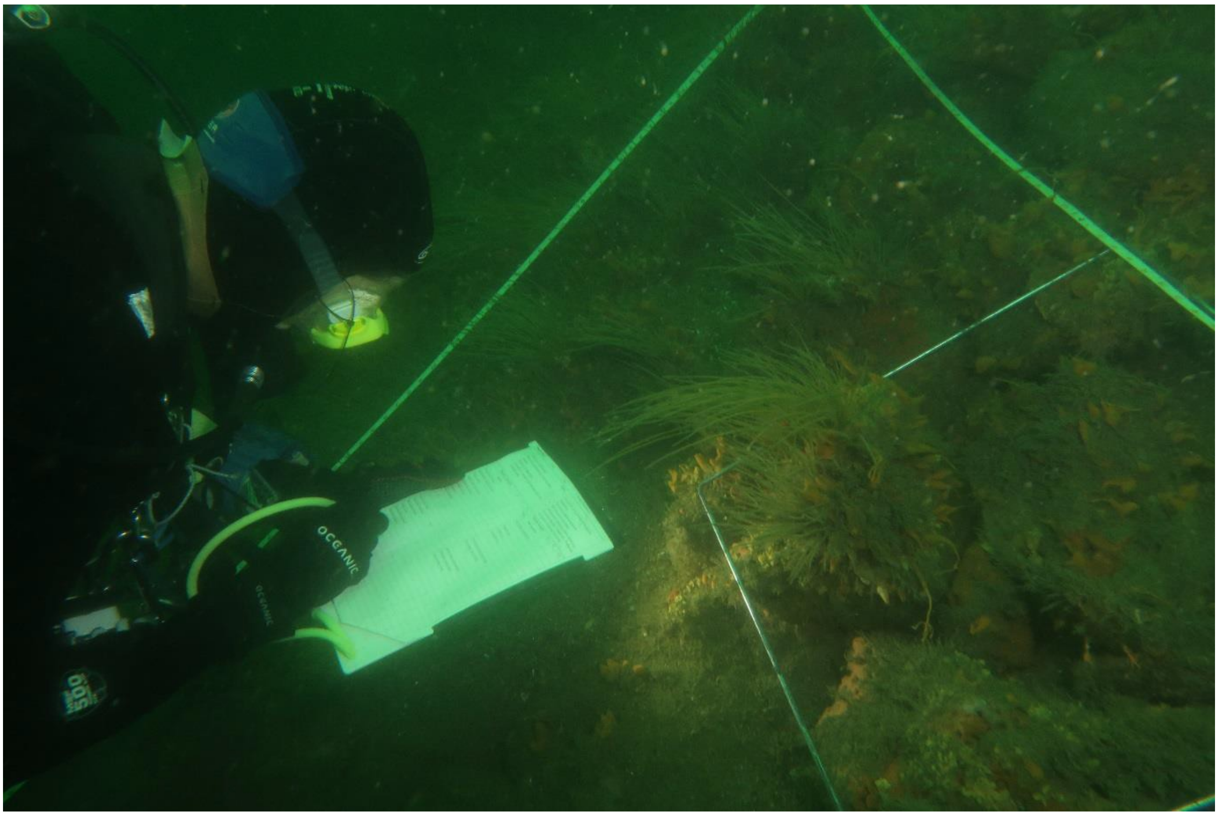
Figure 7: Diagrammatic representation of transect lines and quadrat placement

2.3 Quality assurance

Scientific divers from Natural England personnel were joined by two experienced contract marine biological surveyors providing an experienced diving team with excellent marine biological expertise to identify species *in situ* from quadrats and work up specimens in the evenings that required further identification. The team of divers was kept to the same personnel as much as possible over the 2017 and 2018 field seasons to minimise the effect of diver variability in recording (see Appendix 4 for list of divers). The same diving vessel and skipper were chartered for 2017 and 2018 with knowledge of the dive sites. At the commencement of the fieldwork the survey specific 'recording rules' were discussed to ensure surveyors applied the rules consistently. In addition to this there was a briefing each evening to discuss site-specific details (target community to be surveyed, pro-forma recording sheets, any notable species likely to be encountered) in preparation for each site.

Videography and phase II recording by the first pair of divers supplemented the information available as a record of each site visited.

Algal specimens of note were collected and pressed in the evenings to build up a collection of algal species to feed back into the quality assurance process.



Quadrat recording in progress at Devils Point

2.4 Data analysis methods

The main purpose of the analyses presented here was to determine whether the data show that similar communities were surveyed each year and that the methods used are robust and repeatable enough to provide meaningful data pertaining to the biological communities at each site. Data were analysed to determine the level of similarity of the data collected on a site-by-site basis between 2017 and 2018.

The data from the surveys in each year were entered into Excel spreadsheets. All taxon names / classifications were checked using the World Register of Marine Species (WoRMS) Taxon Match facility online and corrections were made where required. Duplicate row entries were identified and merged. Ambiguous entries that could be confused with one another were identified and appropriate actions taken e.g. '*Dendrodoa* sp.', '*Dendrodoa/Distomus*' and '*Dendrodoa grossularia*' were merged to '*Dendroa / Distomus* spp.' to avoid artificially increasing the dissimilarity between samples during multivariate analysis. Full records of this data processing are detailed in the Excel worksheets for each survey for future reference. Following the changes outlined above, a final taxon match was completed using the WoRMS portal and the taxonomic hierarchies for each data row were added to the data sets.

Data for 2017 and 2018 were then merged using PRIMER v7™ (Plymouth Routines in Multivariate Ecological Research). The resulting data sheet was re-exported to Excel for a final check for duplicate entries and to create a Master Datasheet for the project. The master data were then re-imported to PRIMER v7 for analysis. PRIMER is designed to analyse multivariate datasets. Its advantage over univariate techniques is that it is able to assess the community as a whole rather than using many univariate comparisons which can compound errors. The analysis uses similarity matrices that calculate the similarity between each pair of samples using biological guidelines (i.e. joint absence of a species at any two sites implies nothing, joint presence implies similarity and presence opposite absence implies dissimilarity). Prior to analysis the data were transformed using a square root transformation (see Appendix 5).

Descriptions of the statistical tests used are provided in Appendix 5. For each site non-metric multidimensional scaling (nMDS) plots were produced and ANOSIM tests for differences between the years were completed. Where there were shown to be statistically significant differences between years, a SIMPER analysis was carried out to determine the taxa responsible for causing the greatest dissimilarities between years. Full outputs from the SIMPER analyses are given in Appendix 6.

3 Results

3.1 Diving

Fieldwork was undertaken by eight scientific divers in five-day periods over two survey seasons; 3rd to 7th July in 2017 and 2nd to 6th July in 2018. Data were collected from all five sites in both years.

The data collected allowed for a baseline to be established in 2017 for this survey, with additional data added in 2018 beginning the time-series for monitoring. This will add to the data collated for the reef feature from previous surveys in 1999, 2003 and 2013 (as listed in Appendix 1).

Table 2: Survey effort at monitoring sites (no. of quadrats and transects recorded).

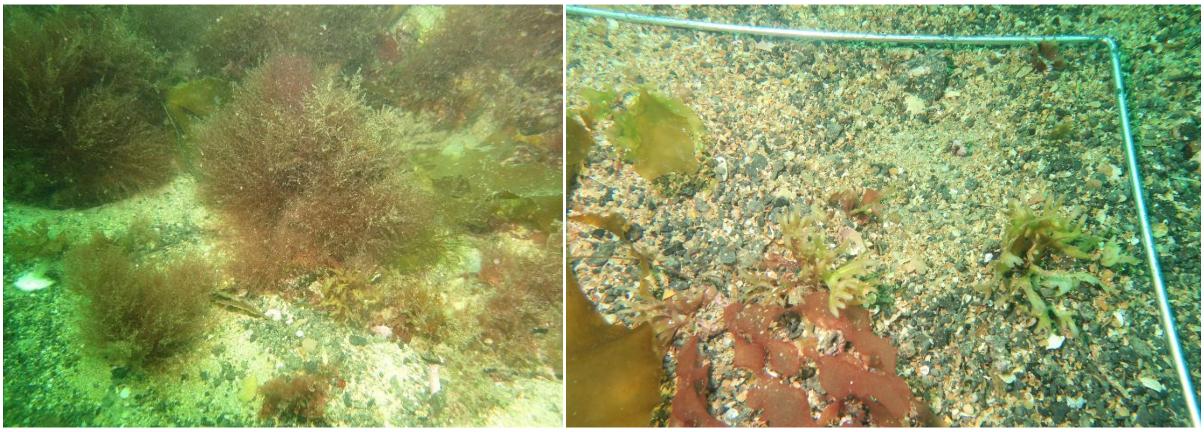
Site	**2017 no. quadrats**	**2017 no. transects**	**2018 no. quadrats**	**2018 no. transects**
East of Northern degaussing buoy	20 complete	4	16 complete	4
West of Mew Stone	23 complete	4	23 complete	4
Duke Rock South	23 complete	4	24 complete	4
Eastern King Point – shallow	0 complete	0	12 complete	2
Eastern King Point - deep	24 complete	4	12 complete	2
Devil's Point	12 complete	2	12 complete	2

Please note this table has been updated to reflect the true number of transects after the numbering protocols were updated following the first draft of this report. These changes do not affect the subsequent analysis but the numbering in the analysis follows the raw data so in some cases does not match what is recorded here.

3.2 Description of the habitats/biotopes monitored

3.2.1 Infralittoral rock communities

3.2.1.1 Duke Rock South



Typical communities encountered at Duke Rock South

Biotope code: IR.MIR.EphR (97.06 classification)

SS.SMp.KSwSS.LsacR.CbPb Red seaweeds and kelps on tide-swept mobile infralittoral cobbles and pebbles (15.03 classification code)

Duke Rock South is an area of tide-swept infralittoral mixed substrata located north of the Eastern Channel entrance to Plymouth Sound. It is a shallow site, approximately 6-7 m BCD, subject to weak to moderate tidal streams. The site is characterised by robust perennial algae that are able to tolerate sand-scour and the seasonal mobility of the mixed substrata (cobbles, pebbles, shell fragments, sand) on which they occur. Red algae such as *Stenogramma interruptum*, *Halarachnion ligulatum*, *Dudresnaya verticillata*, *Naccaria wiggii* and the delicate brown alga *Arthrocladia villosa* typified this community though they all occurred in relatively low abundance. The area of mixed substrata is flanked by bedrock outcrops but the patchily distributed community proved difficult to locate. It required experienced knowledge of the site and the target algal community in order to identify the correct area for transect placement and recording. Much of the sediment between bedrock outcrops is highly mobile sands, from which the target community is absent, as the community requires more stable areas, likely to be seasonally disturbed, where algae are sparsely found attached to pebbles and shell fragments. This highlights the seasonal variability in the location of the community and the skills required to identify the correct community. Limited underwater visibility further hampered the search for the target community in both 2017 and 2018.

3.2.2 Circalittoral rock communities

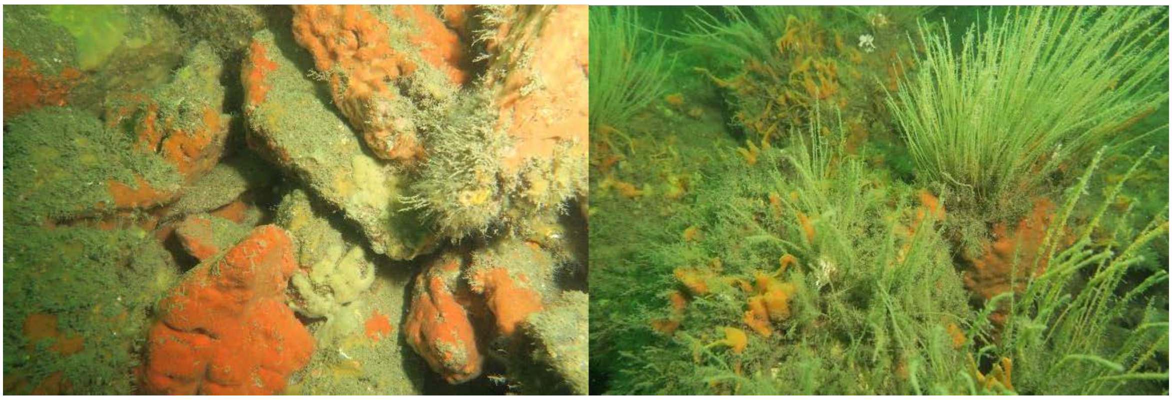
3.2.2.1 East of Northern degaussing buoy

Typical view of target community on sides of bedrock gullies

Biotope: CR.MCR.XFa.ErSEun (97.06 classification)
CR.HCR.XFa.ByErSp.Eun *Eunicella verrucosa* and *Pentapora foliacea* on wave-exposed circalittoral rock (15.03 classification code)

This site is located 1.9 km south of the western end of the breakwater. One of the deeper monitoring sites, it is found on the 20 m depth contour (BCD), a series of limestone bedrock ridges, slightly tide-swept, moderately exposed rock. The target community at this site is the faunal turf on the sides of sloping bedrock ridges rather than the upper faces which are more dominated by algal turf species. Small gullies (0.5 to 2m wide) run between the bedrock ridges with mobile coarse sediment. In 2017 and 2018 the low-lying bedrock reefs were characterised by a hydroid-bryozoan faunal turf, most prominent of which was the delicate crissid turf. Most abundant red algae included *Heterosiphonia plumosa*, *Drachiella heterocarpa* and *Calliblepharis ciliata*. Other red algae included *Acrosorium venulosum*, *Pterosiphonia parasitica* (2017) and *Pterosiphonia complanata*. It was noted in the general description for the site that there were abundant sea cucumbers *Holothuria forskali*, which are common in this area, and the starfish *Martasterias glacialis*. Of note, pink seafans *Eunicella verrucosa* were only present in 2018 as very small specimens and similarly there were small colonies of the bryozoan *Pentapora foliacea*.

3.2.2.2 Devil's Point



Typical communities observed at Devil's Point

Biotope: CR.SCR.SubSoAs (97.06 classification)
CR.MCR.CFaVS.CuSpH.VS Cushion sponges and hydroids on turbid tide-swept variable salinity sheltered circalittoral rock (15.03 classification code)

Devil's Point is located north of Drake Channel at the entrance to the River Tamar. The bedrock slopes steeply from the shore to 20m BCD. The site is sheltered from wave action but exposed to strong tidal streams which limited the diving period to a relatively short period of high water slack. Descending through the dense kelp forest of the upper infralittoral the target community of faunal turf species is located along a depth contour of 9.7m BCD. It comprises a steep slope of limestone bedrock and tumbled boulders. There was a diverse faunal turf with a high proportion of encrusting and cushion sponges (*Amphilectus fucorum*, *Cliona celata*, *Halichondria* spp., *Hymeniacidon perleve* and *Raspaillia ramosa*), hydroids (*Nemertesia* spp. and *Plumularia setacea*) and bryozoans (*Scrupocellaria* spp., *Bugula* spp. and Crissidae indet.). There was noted variability in the abundance of certain species from one end of the transect to the other in both years, despite both running along the same depth contour and being recorded simultaneously. In 2017 it was noted that some quadrats contained a very sparse community of encrusting sponges, however, further NW along the transect there were more luxuriant growths of *Amphilectus fucorum*, large clusters of *Nemertesia* spp. boring *Hiatella* siphons visible and also phoronids.

3.2.2.3 West of Mew Stone

Typical view of target communities at West of Mewstone

Biotope: CR.MCR.XFa.ErSEun (97.06 classification)
CR.HCR.XFa.ByErSp.Eun *Eunicella verrucosa* and *Pentapora foliacea* on wave-exposed circalittoral rock (15.03 classification code)

The monitoring site is located approximately 1.3 km west of the Mew Stone. It is an open coast site exposed to moderate wave action and tidal streams. The target community lies on the 14 m BCD contour, as a series of bedrock and boulder reefs. The large boulders are up to 1 m high and the bedrock indented with many fissures and crevices. A silted cobble and pebble slope descends to the low-lying reef, which in 2018 was surrounded by waves of sandy shell gravel. The tops of the bedrock exposures run at about 20 degree slopes and are characterised by dense foliose algae. The upper infralittoral kelp forest lies approximately 3 m above the target community in which the survey transect lines are laid. In 2017 and 2018 the general site description records red algae *Calliblepharis ciliata* and *Heterosiphonia plumosa* dominated the algal turf along with the brown alga *Dictyopteris polypodiodes* and encrusting pink algae. The quadrat data were recorded from the sloping sides of the bedrock, where there were fewer turf forming algae and more faunal species. A diverse range of fauna were recorded from this site; the colonial ascidian *Diplosoma listerianum* was common on the vertical rock as were aggregation of the solitary ascidian *Stolonica socialis* and the colourful jewel anemone *Corynactis viridis*. Other characteristic species included the cup coral *Caryophyllia smithii*, the sea cucumber *Holothuria forskali*, tufts of the hydroid *Nemertesia* spp., and a range of bryozoans with dense patches of turf-forming species such as *Bugula* spp. and crissids and occasional *Pentapora foliacea*. Although the pink seafan *Eunicella verrucosa* is known to be found in the area none were recorded from the site in 2017 or 2018, they would more likely be on the upward facing rock surfaces, maximising the current flow. The surveyors noted there was considerable patchiness in the faunal cover of the quadrats due to the rugosity of the rock; some quadrats contained patches of dense algal turf whilst others were more depauperate and had little faunal turf.

3.2.2.4 Eastern King Point

Typical communities at Eastern King Point

Biotope: CR.SCR.SubSoAs (97.06 classification)
CR.MCR.CFaVS.CuSpH.As Cushion sponges, hydroids and ascidians on turbid tide-swept sheltered circa-littoral rock. (15.03 classification code).

Eastern King Point is a prominent outcrop of limestone bedrock at the north-western reaches of Plymouth Sound. It is sheltered from wave action but exposed to strong tidal streams, so dived at high water slack.

The survey aimed to repeat sampling at two depth bands previously sampled in 1999

(Moore *et al.*, 1999) which also cover the depth range covered in 2013 survey (PML, 2014). The two depth bands for the target communities are at 5.8 to 6 m BCD and 14 m BCD.

The 2013 survey recorded the *Antedon* biotope (CR.LCR.BrAs.AntAsH) was most representative of the site, however, it should be noted that it does not capture *Alcyonium digitatum* which is characteristic of the site, as were anemones, in particular *Urticina felina*. In 2017 the site was described as sloping bedrock, pitted with occasional crevices and fissures, dominated by featherstars *Antedon bifida* and daisy anemones *Cereus pedunculatus* with a range of other anemone (*Urticina felina*, *Sagartia elegans*, *Actinothoe sphyrodeta*), hydroids, dead man's fingers *Alcyonium digitatum*, dense clusters of *Nemertesia* spp., and hydroid-bryozoan turf.

3.3 Data analysis results

3.3.1 All data

Prior to analysing the data for individual sites, an overall MDS plot demonstrated that the community data formed distinct clusters for each site with the exception of 'EN DG Buoy' and 'West of Mew Stone' which showed a greater degree of similarity to one another. This is not unexpected as both sites represent the open coast *Eunicella* biotope CR.HCR.XFa.ByErSp.Eun. The data were not analysed further in this 'overall' format but this figure is included to illustrate that the survey method can differentiate clearly between different community types.

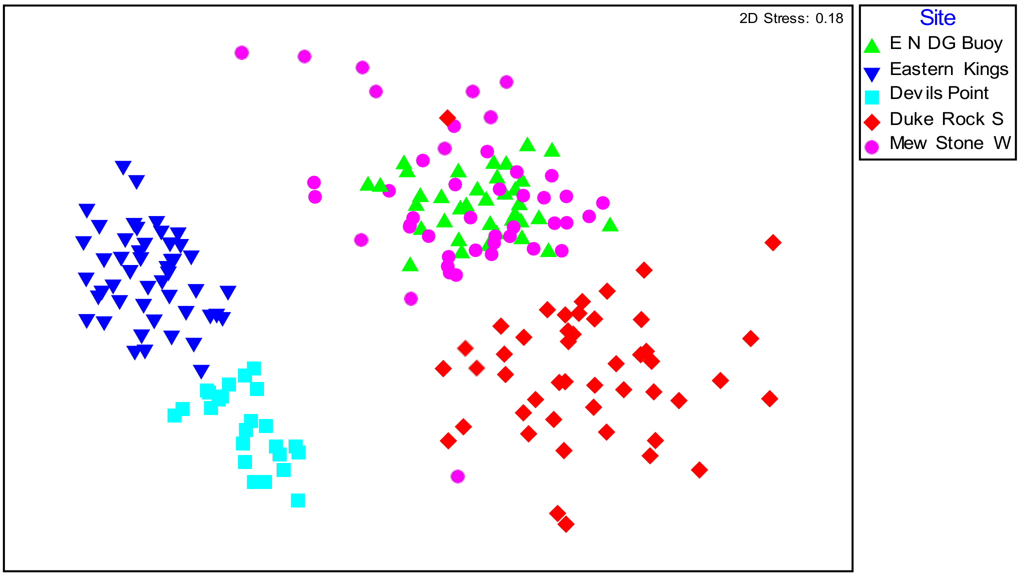


Figure 8: MDS plot of all the community data from 2017 and 2018.

Table 3 below shows the minimum and maximum number of taxa per quadrat and total overall taxa per site in both 2017 and 2018. A number of quadrats for Devil's Point and Duke Rock South had notably low numbers of taxa recorded in either 2017 or 2018. The reasons for this were unclear and therefore the samples remained included in the analysis as there were no justifiable reasons to exclude them.

Table 3: Minimum and maximum number of taxa per quadrat and total overall taxa per site in 2017 and 2018.

	Site									
	EN DG Buoy		Eastern King Point		Devil's Point		Duke Rock South		West of Mew Stone	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Min taxa per quadrat	11	13	11	14	6	13	5	4	7	15
Max taxa per quadrat	22	22	24	25	24	22	22	23	32	27
Total taxa recorded at site	68	55	66	73	43	42	66	79	94	76

The following sections provide the MDS plots and results of the ANOSIM and SIMPER analyses for each survey site from the surveys undertaken in 2017 and 2018. Where the stress values (see definition in Appendix 5) exceeded 0.2 for 2-dimensional plots, 3-dimensional plots were displayed instead as they often gave a better representation of the data.

3.3.2 EN DG Buoy

The MDS plot for EN DG Buoy showed separate clustering of the samples from 2017 and 2018 (Figure 9). The ANOSIM test (R = 0.529, p = 0.001, n = 36) confirmed the differences between years were statistically significant.

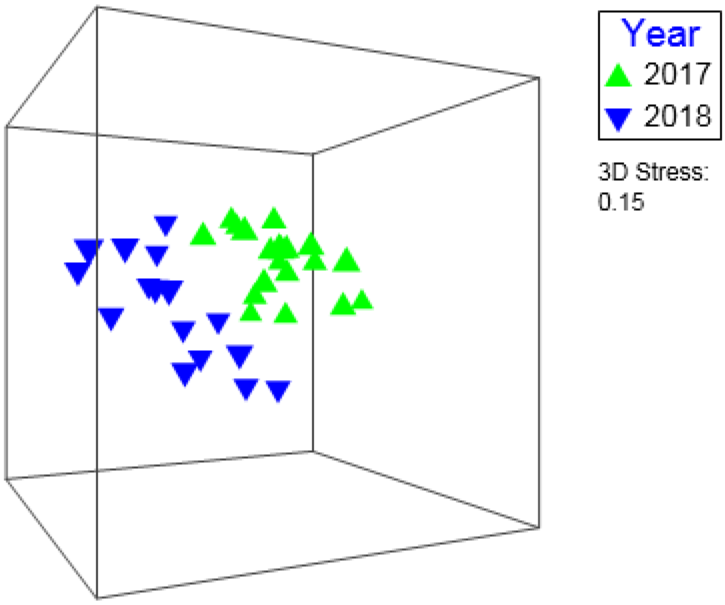


Figure 9: 3-dimensional MDS plot of the community data for the 'EN DG Buoy' site from 2017 and 2018.

SIMPER analysis of the data for both years showed the taxa responsible for the similarities between quadrats within year groups and for the dissimilarities between years groups were largely the same (Appendix 6). It was the differences in relative abundances of most of these taxa causing the differences between year groups rather than the presence or absence of different taxa recorded between years. Many of these characterising taxa were red and brown algae e.g. *Heterosiphonia plumosa*, *Calliblepharis ciliata*, *Dicyota dichotoma* and *Dictyopteris polypodiodes*, as well as hydroid and bryozoan turf e.g. crisiids and *Nemertesia antennina*.

Of the taxa contributing toward 90% of the dissimilarities between year groups, very few were absent (unrecorded) in any one year. Taxa which were unrecorded in one of the two years were *Perophora listeri* (2017), *Electra pilosa* (2018), *Pterosiphonia parasitica* (2017), *Spirobranchus / Spirorbis* sp. (2018), *Eunicella verrucosa* (2017), *Plumularia setacea* (2017) and *Cellaria* sp. (2018).

3.3.3 Devil's Point

The MDS plot for Devil's Point showed separate clustering of the samples from 2017 and 2018 (Figure 10). The ANOSIM test ($R = 0.280$, $p = 0.006$, $n = 24$) confirmed the differences between years were statistically significant.

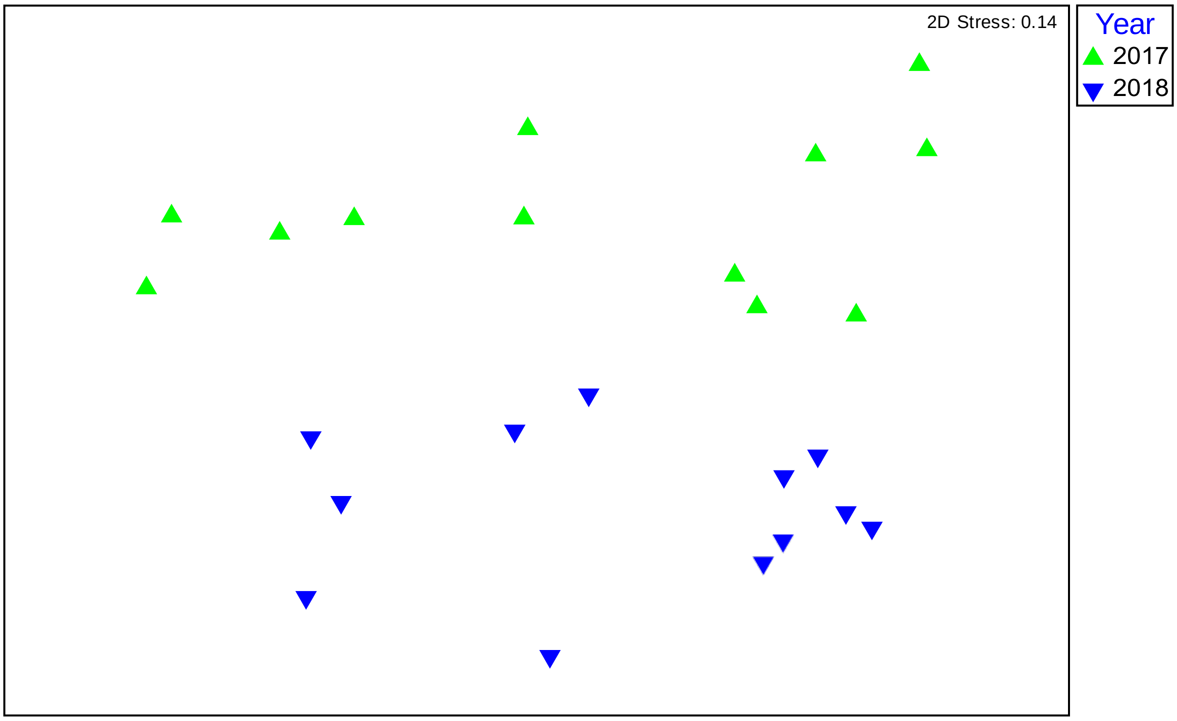


Figure 10: 2-dimensional MDS plot of the community data for the 'Devil's Point' site from 2017 and 2018.

SIMPER analysis of the data for both years showed the taxa responsible for the similarities between quadrats within year groups and for the dissimilarities between years groups were largely the same (Appendix 6). It was the differences in relative abundances of most of these taxa causing the differences between year groups rather than the presence or absence of different taxa recorded between years. Many of these characterising taxa were hydroids e.g. *Nemertesia antennina*, *Plumularia setacea* and 'hydroid turf', bryozoans e.g. *Bugula* sp., *Scrupocellaria* sp., 'bryozoan turf', and sponges e.g. *Amphilectus fucorum*, *Cliona celata* and *Hymeniacidon perlevis*.

Of the taxa contributing toward 90% of the dissimilarities between year groups, very few were absent (unrecorded) in any one year. Taxa which were unrecorded in one of the two years were *Halichondria* spp. (encrusting) (2017), Porifera indet. (2017) and *Nemertesia ramosa* (2017).

It was noted in 2018 that although both transect lines ran along the same depth contour and were surveyed simultaneously by two pairs of surveyors, that when discussed in the evening the community composition of the two transects appeared to be markedly different. General site description adds that *Nemertesia antennina* were more prominent at the SW end of the transect (KN/RB)

3.3.4 Duke Rock South

The MDS plot for Duke Rock showed considerable overlap between the samples from 2017 and 2018 (Figure 11). The ANOSIM test ($R = 0.106$, $p = 0.007$, $n = 36$) confirmed the differences between years were statistically significant however.

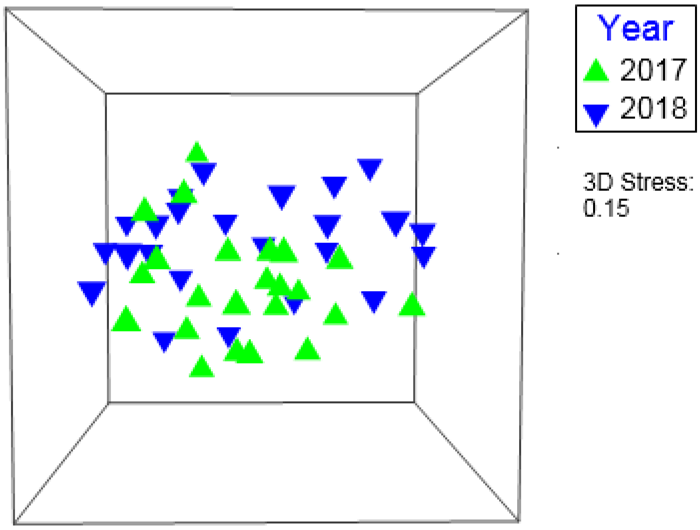


Figure 11: 3-dimensional MDS plot of the community data for the 'Duke Rock South' site from 2017 and 2018.

SIMPER analysis of the data for both years showed the taxa responsible for the similarities between quadrats within year groups and for the dissimilarities between years groups were largely the same, particularly for the most abundant taxa (Appendix 6). Many of these characterising taxa were red and brown algae e.g. *Stenogramme interruptum, Vertebrata byssoides, Acrosorium ciliolatum, Calliblepharis ciliata, Heterosiphonia plumosa* and *Dictyota dichotoma* as well as encrusting sponges and bryozoans and hydroid turf.

The list of taxa contributing to the dissimilarities contained many taxa with small overall contributions. Of those taxa making smaller contributions toward 90% of the dissimilarities between year groups, several were absent (unrecorded) in any one year and included: Crissidae (2017), *Membranipora membranacea* (2017), *Amphilectus fucorum* (2018), *Dudresnaya verticillata* (2017), *Obelia* sp. (2017), *Scinaia* interrupta (2018), bryozoan turf (2017), *Chondrus crispus* (2017) and *Polysiphonia elongata* (2017).

Eight of the quadrats surveyed at Duke Rock in 2018 were reported as originating from the kelp forest on one of the rocky outcrops adjacent to the target mixed substrata community. Removal of these quadrats from the analysis made little difference to the ANOSIM comparison between years (R = 0.253, p = 0.001, n = 28).

3.3.5 West of Mew Stone

The MDS plot for West of Mew Stone showed separation of most of the samples from 2017 and 2018 with four outliers from transects two and three in 2017 toward the right hand side of the plot (Figure 12). The ANOSIM test (R = 0.438, p = 0.001, n = 45) confirmed the differences between years were statistically significant.

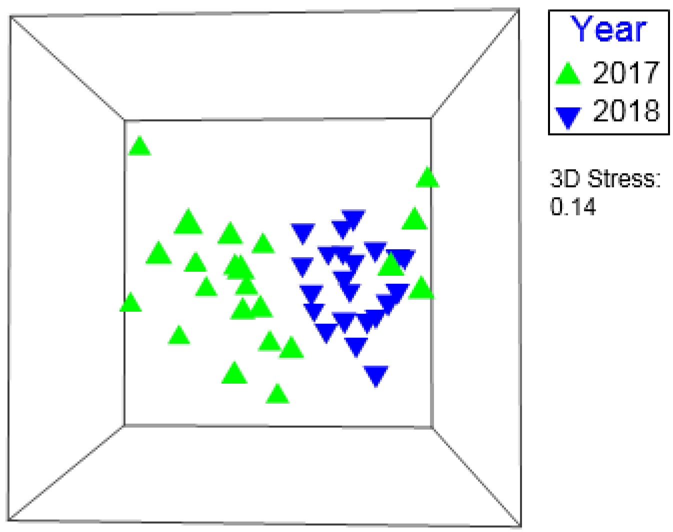


Figure 12: 3-dimensional MDS plot of the community data for the 'West of Mew Stone' site from 2017 and 2018.

SIMPER analysis of the data for both years showed the taxa responsible for the similarities between quadrats within year groups and for the dissimilarities between years groups were very similar, particularly for the most abundant taxa (Appendix 6). Many of the characterising taxa were red and brown algae e.g. *Dictyopteris polypodiodes*, encrusting pink algae and *Heterosiphonia plumosa* as well as various tunicates e.g. *Diplosoma listerianum, Stolonica socialis* and *Morchellium argus*, and bryozoans including turf and encrusting species.

The list of taxa contributing to the dissimilarities again contained many taxa making small overall contributions. Of those taxa making smaller contributions toward 90% of the dissimilarities between year groups, several were absent (unrecorded) in any one year and included: *Isozooanthus sulcatus* (2018), *Plocamium* spp. (2018), *Corynactis viridis* (2018), *Rhodophyllis irvineorum* (2017), *Pachymatisma johnstonia* (2018), *Clavelina lepadiformis* (2018), *Halurus flosculosus* (2017), *Halecium* sp. (2018) and *Cryptopleura ramosa* (2017).

3.3.6 Eastern King Point

Transects at Eastern King Point were completed in both 'shallow' and 'deep' habitats and requested to be analysed separately, however the sample raw data were not labelled as such. When processing the data in preparation for analysis, it was unclear whether several of the transects should be classified as either shallow or deep in each year, perhaps with the exception of transect 3 which was notably shallow in 2018.

Therefore all the data for Eastern King Point were analysed together. Data from transect 3 showed some separation from the other data for 2018 only (Figure 13 and Figure 14) (note the high stress value) whilst data from no single other transects stood out from the others, perhaps as an indication of the site's depth and / or habitat type.

This was investigated post-analysis and the depth of all quadrats in 2017 were within 4m of each other, thus these can be considered to be within the same 'deep' habitat. In 2018 half of the quadrats (Transect 3) were in the target shallow band.

A 3-dimensional MDS plot of the Eastern King Point data shows the same separation of the two years' sampling data with three outliers from transect four in 2017 (Figure 15).

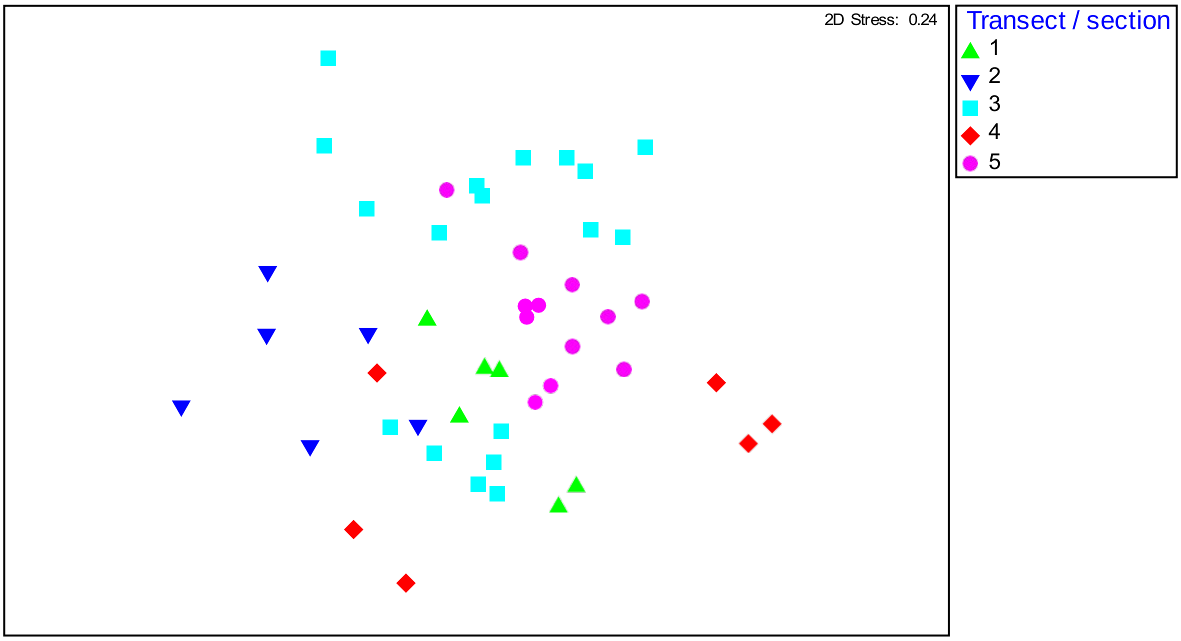


Figure 13: 3-dimensional MDS plot of the community data for the 'Eastern King Point' site from 2017 and 2018, coded by transect number.

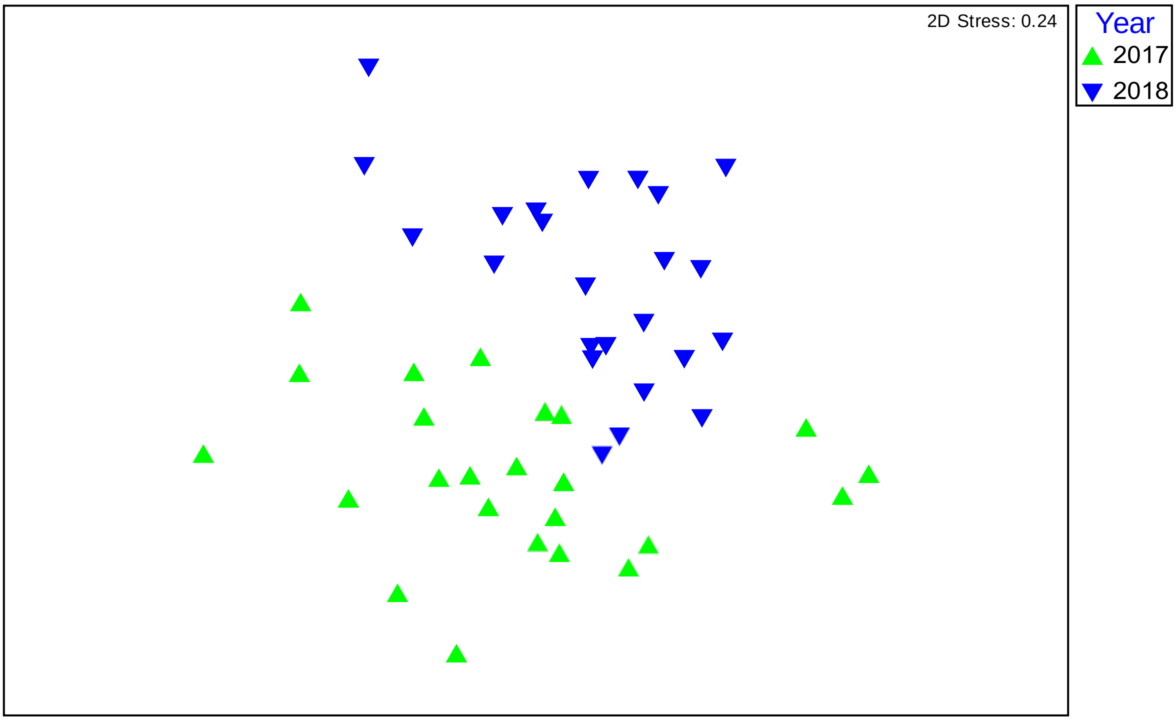


Figure 14: 3-dimensional MDS plot of the community data for the 'Eastern King Point' site from 2017 and 2018, coded by survey year.

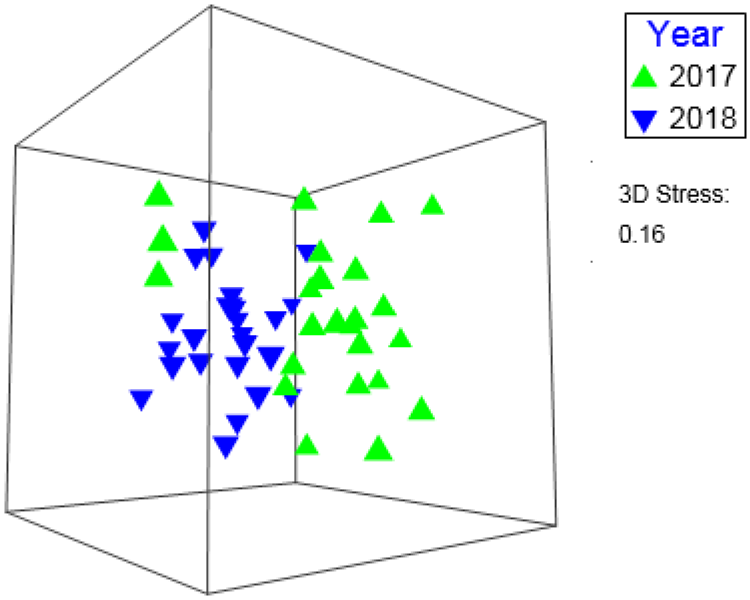


Figure 15: 3-dimensional MDS plot of the community data for the 'Eastern King Point' site from 2017 and 2018, coded by survey year.

The ANOSIM test (R = 0.348, p = 0.001, n = 48) of all the data confirmed the differences between years were statistically significant. Removal of transect three (assuming it to be the only 'shallow' transect) gave an ANOSIM result of the remaining 'deep' data of R = 0.169, p = 0.010, n = 30.

Analysis of data from transect three only, gave an ANOSIM result of the 'shallow' data of R = 0.772, p = 0.010, n = 18.

SIMPER analysis of the complete Eastern King Point data set for both years showed the taxa responsible for the similarities between quadrats within year groups and for the dissimilarities between years groups were highly similar, particularly for the most abundant taxa (Appendix 6). The characterising taxa contributing to similarity between samples within each year included the bryozoans *Cellepora pumicosa, Cellaria* sp. and Crissidae, the hydroid *Halecium* sp. and sponges including *Raspailia ramosa* and encrusting species.

The list of taxa contributing to the dissimilarities between year groups was relatively short compared with other sites surveyed with just sixteen taxa contributing to 90% of the observed dissimilarities between years. Of these, three were absent (unrecorded) in 2017 compared with 2018 and were *Scrupocellaria* sp., *Erythroglossum laciniatum* and *Cryptopleura ramosa*. The other dissimilarities were due to differences in abundances rather than presence or absence of taxa in any given year.

4 Discussion

4.1 Data analysis

The ANOSIM results for all the interannual comparisons across the sites showed statistically significant differences existed between the 2017 and 2018 data. The R-values associated with these differences were generally low to mid-range, with few exceeding 0.5.

Sites with low R-values were Devil's Point (R = 0.280), Duke Rock (R = 0.106 / R = 0.253) and Eastern

King Point 'deep' (R = 0.169). These results point toward no major ecologically significant differences existing between the data obtained in the two survey years; a conclusion supported by the SIMPER analyses (Appendix 6) which showed the taxa recorded at each site to be largely similar each year with only the relative abundances of the taxa recorded differing to varying extents.

Sites for which the ANOSIM tests generated mid-range R-values were EN DG Buoy (R = 0.529), West of Mew Stone (R = 0.438) and Eastern King Point 'all data' (0.348). These results suggest that the differences recorded in the data were greater than at the other sites listed above. However, examination of the SIMPER analyses again showed the differences to be largely the result of fluctuations in the abundances of the same taxa recorded between years rather than the complete appearance / disappearance of taxa from the habitats surveyed.

The Eastern King Point 'shallow' data had the highest ANOSIM R-value of 0.772. However the uncertainty surrounding the depth records for the transect and the lower number of quadrats available for analysis suggest caution should be taken before drawing any conclusions with respect to this result. Further data would help clarify both the level of variation along the transect and whether or not it should be analysed in isolation from the other transects at Eastern King Point.

Overall, the data suggest little significant ecological change across any of the sites and there were no changes in the recognised communities present in 2018 over 2017. The site with the highest R-value from the ANOSIM tests comparing 2017 to 2018 data was EN DG Buoy. The example shade plot (Figure A1 in Appendix 5) for data transformation options at this site provides a visual representation of the community data with few obvious differences in the community patterns between years.

The SIMPER analyses carried out on the data from each site identified a small number of taxa each year that were absent in one of the two years and contributed to the top 90% of dissimilarities between sites. Some of these can be considered relatively cryptic species, perhaps overlooked by some surveyors whilst others might exhibit a more patchy distribution and therefore be missed in some years where quadrats are positioned differently. Other notable taxa such as the pink seafans recorded at EN DG Buoy in 2018 were noted to be new recruits, not present in the previous year.

In situ quadrat-based recording of marine communities can often yield variable statistical results between years for a number of reasons, including in situations where quadrats are fixed, unlike in the present study where they were not fixed. Sources of variation can include:

- Surveyor experience
- Surveyor specialisms (making some recorders more likely to record certain taxa)
- Survey team variation
- Decision-making during quadrat placement
- Patchy distribution of species
- Population and community dynamics giving rise to natural cycles in abundance

These sources of variation may all be expected during a monitoring programme and must be considered carefully during interpretation of data analysis. Often several years' worth of data collection may be required to understand any inherent methodological variation in a study in order to then accurately identify when real ecological changes are occurring. Data interpretation therefore should ideally be carried out in conjunction with survey team members and should consult any images and video footage of the habitats surveyed.

In preparing the data for analysis a number of areas for improvement were identified that would likely improve data analysis and interpretation for subsequent monitoring surveys. A number of quadrats had very few taxa recorded (see Table 1) but there were no notes explaining why, nor were the ‘confidence’ or ‘time’ fields always completed on the data forms. Therefore it was not possible to determine if the number of taxa was low due to the presence of bare rock, lack of time, underwater conditions or if they truly represented the communities present; it would have been unreasonable at the time of data analysis to expect a surveyor to recall confidence for specific quadrats. Consequently there was no definitive reason to remove the samples from the analyses; it is possible that they made considerable contributions to some of the dissimilarities observed.

Furthermore, the transect numbers recorded at the sites often varied between years which creates uncertainty as to whether the same transects (and therefore communities) were being monitored each year e.g. at Devil’s Point in 2017 the transect numbers are given as 1 and 2, whereas in 2018 the transect number is given as 7. Clarity in this respect would aid confidence in the data analysis.

For each habitat being monitored, it might be helpful to produce / confirm a list of definitive characterising taxa. In future years these can be analysed in isolation from the main community data which may help reduce any ‘noise’ in the analysis. It should be noted however that analysis of the full community data is still highly valuable so as not to overlook potential differences in less abundant taxa over time.

Site notes available for each monitoring location suggest that historical monitoring has taken place. It may be feasible to analyse historical data alongside the 2017-18 data if it exists and gain a better understanding of both community dynamics at the sites and of any inherent methodological variation.

4.2 Consistency in surveyor recording

Consistent recording of species and taxa between surveyors is fundamental to producing sound data evidence. Therefore measures must be taken to reduce any variability in recording. The surveyors must adhere strictly to the protocol of recording the percentage cover, not individual counts, unless agreed for certain species. Recording a species as ‘Present’ should also be avoided since numerical values are required to process the data analysis.

In 2018 it became apparent that surveyors had not recorded some taxa consistently and deviated from the recording rules. This was evident in the recording of sponge crusts and bryozoan turf indet. Two surveyors had only recorded sponge crust as the ‘remaining percentage cover of species not already identified to genus or species’, rather than the entire percentage sponge crusts occupying the quadrat area. The same occurred in recording bryozoan turf. In order to identify any ‘gross’ changes in data over the years surveyors must be disciplined in recording data, complying with the recording rules:

- Record ALL sponge crust as % cover (not just the ones that cannot be identified to species)
- Record ALL bryozoan turf (<3 cm) % cover
- Record ALL hydroid turf (<3 cm) % cover

Surveyors must also be clear which species need to be recorded at the higher level of genus. For example, *Plocamium* spp., due to the taxonomic split in the species to three separate species; the bryozoan turf species within crisidae, *Bugula*/*Bugulina* and *Scrupocelleria* were also decided to group into these three entities to facilitate recording and reduce statistical variability. It was found in 2018 that the surveyors working through their raw data sheets collectively for each site, every evening, to discuss species conundrums, and species assignment etc assisted greatly in reducing recording discrepancies.

Since fixed sites are not used in this survey, in so much as there are no relocation devices on the seabed to indicate the placement of transect lines, care must be taken to ensure recording is being undertaken consistently from the same community every year. The methodology provides site information sheets identifying target communities in which to lay the transects and record for each site. It is imperative to ensure the correct community is identified. For example, at Duke Rock South the target infralittoral community must be recorded from the mixed substrata not the adjacent bedrock platforms.

5 Conclusions

The low to low-mid-range R-values from the ANOSIM tests are encouraging at this early monitoring stage and show some consistency in the data obtained. It is unlikely that the statistically significant ANOSIM results represent significant ecological changes at the sites being monitored.

Certain areas have been identified for improvement during field monitoring that include:

- Revision of site maps and descriptions with detailed instructions / diagrams as to the depths (below chart datum) and habitats within which the transects and quadrats should be placed. All surveyors to be briefed on this immediately prior to diving.
- Principal field scientist to ensure all survey form boxes are complete after each dive and that detailed site notes are made as and when required.
- Record transect depths in BSL (below sea level) and BCD (below chart datum) at all sites but particularly to aid in determination of depth categories at the Eastern King Point sites.
- Provide consistency and clarity in the numbering system for site transects.
- Record the percentage of bare rock / substrate.
- Follow-up on identification of any samples / images noted in the data.
- Task dive pair 1 with setting up quadrats and photographing each quadrat to build in photographic images as part of QA process and record of quadrats for potential post survey species ID issues.

Making such changes will help to reduce some of the possible sources of variation identified in the discussion and thereby increase the chances of detecting any real ecological changes, should they occur.

Fixed sampling stations were not used in the survey design, so it is essential that the first pair of divers are ideally familiar with the site and/or follow strict instructions on the site specific target community description to ensure the transect is laid in the same representative community year on year. The shot is not always in the exact location and travel lines may be necessary to relocate the correct site. Fixed re-location devices, such as acoustic transponders, could be fixed securely on the seabed to limit variability in transect selection. However, it should be considered this would incur additional costs in establishing the markers on site and additional diver pairs and/or dive time to maintain the equipment with changes in batteries required yearly or biannually. If a fixed transect is established and surveyors record from the exact same position every field season the site may become impacted by surveyors over time, introducing anthropogenic effects on the data collected.

The 2017/2018 data indicate the same communities have been recorded from the same sites over the two year monitoring period. The methods of site location and placement of transect lines within the target communities can therefore be concluded to be successful.

6 Recommendations for future monitoring

- If acoustic relocation devices were fixed at the monitoring sites then additional salinity and temperature loggers could also be fixed on the seabed to provide further data to use in future interpretation of marine biological community data.
- Produce Standard Operating Procedures to ensure thoroughly consistently recording techniques are applied – i.e. all percentage counts, how to record different taxa etc.
- Ensure robust quality assurance procedures are followed – all surveyors are briefed on species recording rules and check they are being applied consistently by conferring in evenings to discuss any identification, assigning percentages etc.
- Update site forms to reflect changes in nomenclature and taking into account characterising species and those most frequently recorded from 2017/18.
- Create a new master spreadsheet with updated species nomenclature into which future raw data is entered.
- It would be advantageous to factor in additional accommodation on the last day of survey to enable work up of specimens and ensure all data sheets are checked with surveyors for queries prior to data entry. This was not the case in 2017 and 2018 when the survey team disbanded after the diving was completed.

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PML 2013 – Vance, T. (2014) Plymouth Sound and Estuaries SAC: Sub-tidal and Mixed Gravel Sub-feature and Sub-tidal Rocky Reefs Sub-feature Condition Assessment Version 1.2.

Appendix 1: Pre 2017 surveys

Previous Survey (Survey Date)	East of Northern degaussing buoy	West of Mew Stone	Duke Rock South	Eastern King Point	Devil's Point
PML (2013)	No	No	Yes	Yes	Yes
ASML (2003)	Yes	Yes	Yes	Yes	No
Moore (1999 & 1998)	No	No	Yes	Yes	No

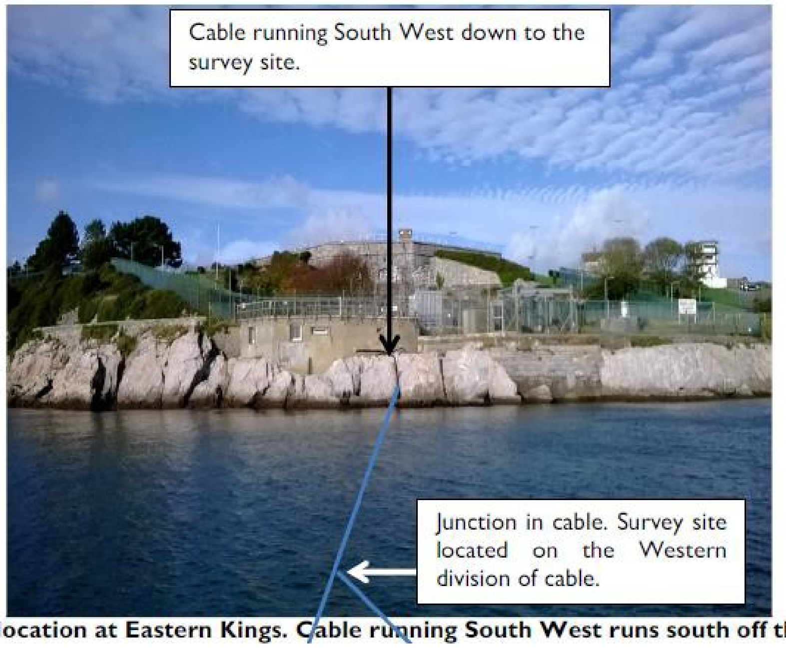
ASML 2003 – Howson, C., Bunker, F. & Mercer, T. (2005). Plymouth Sound European Marine Site Sublittoral Monitoring 2003.

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

Moore 1998 – Moore, J., James, B. & Gilliland, P. (1999). Development of a monitoring programme and methods in Plymouth Sound cSAC: application of diver and ROV techniques.

PML 2013 – Vance, T. (2014) Plymouth Sound and Estuaries SAC: Sub-tidal and Mixed Gravel Sub-feature and Sub-tidal Rocky Reefs Sub-feature Condition Assessment Version 1.2.

Appendix 2: Plymouth Sound and Estuaries SAC Survey – Site Descriptions

Site Name:	**Eastern King Point**
Location (WGS84)	50.36045, - 4.15662 50' 21.627'(N) -4' 09.397' (W)
Location Description	Eastern King Point, the first headland west of Millbay Docks. 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 of this cable. For 2017 the survey aims to repeat sampling at two depth bands previously sampled in 1999 which will also cover the depth range covered in 2013. See below diagram Depth bands at 5.8-6m BCD and 14m BCD will be the target sampling depths High water during survey dates ranges from 4.46m to 4.77m therefore the survey sites will be expected to be between 10.5 – 11m BSL and 18.5 & 19m BSL. This site is highly tidal and should be dived from an hour before high water to 30 – 40m after high water (slack water will always vary and should be assessed daily).  **Site location at Eastern Kings. Cable running South West runs south off the beach**

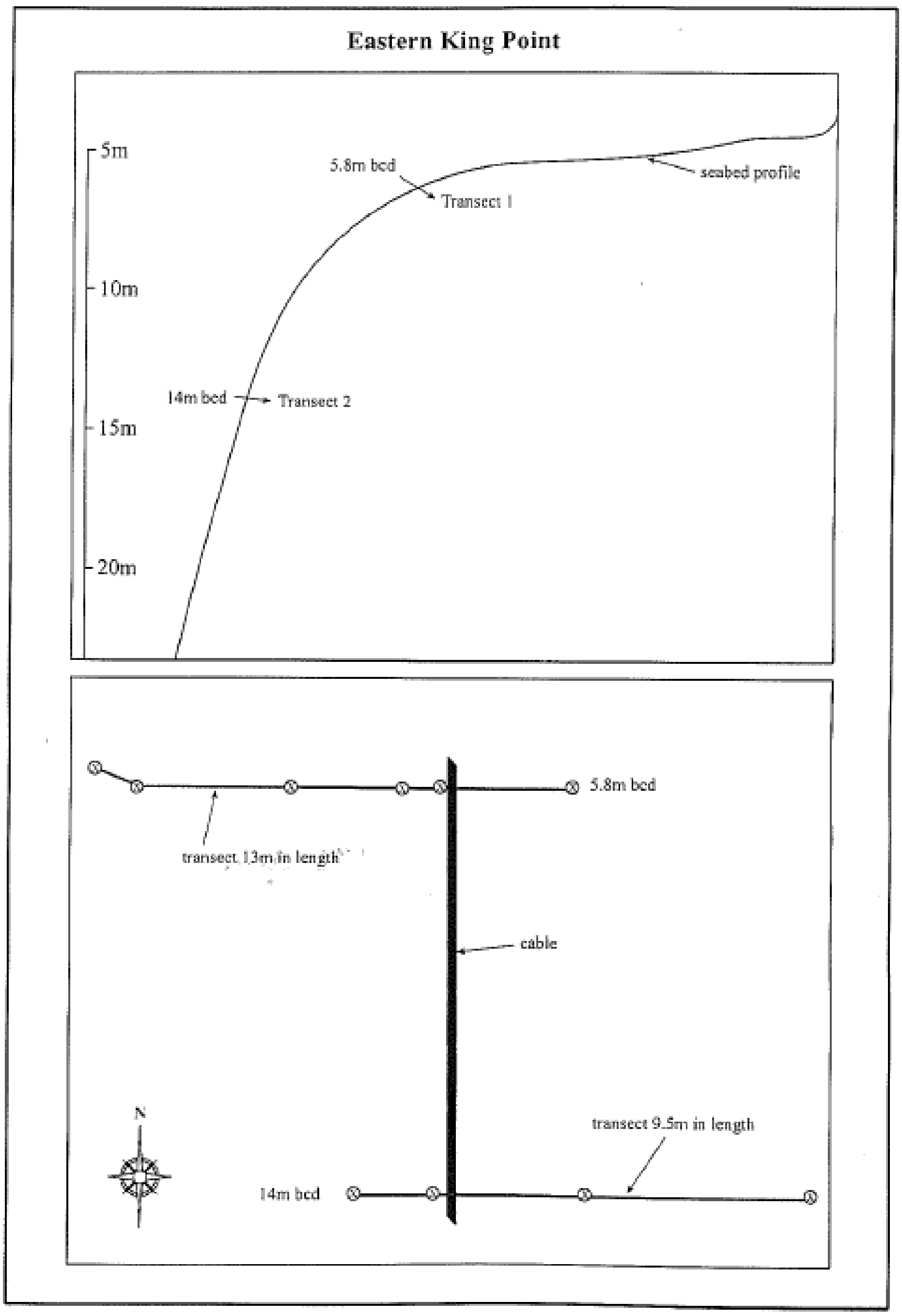
<table>
<tr><td></td><td>

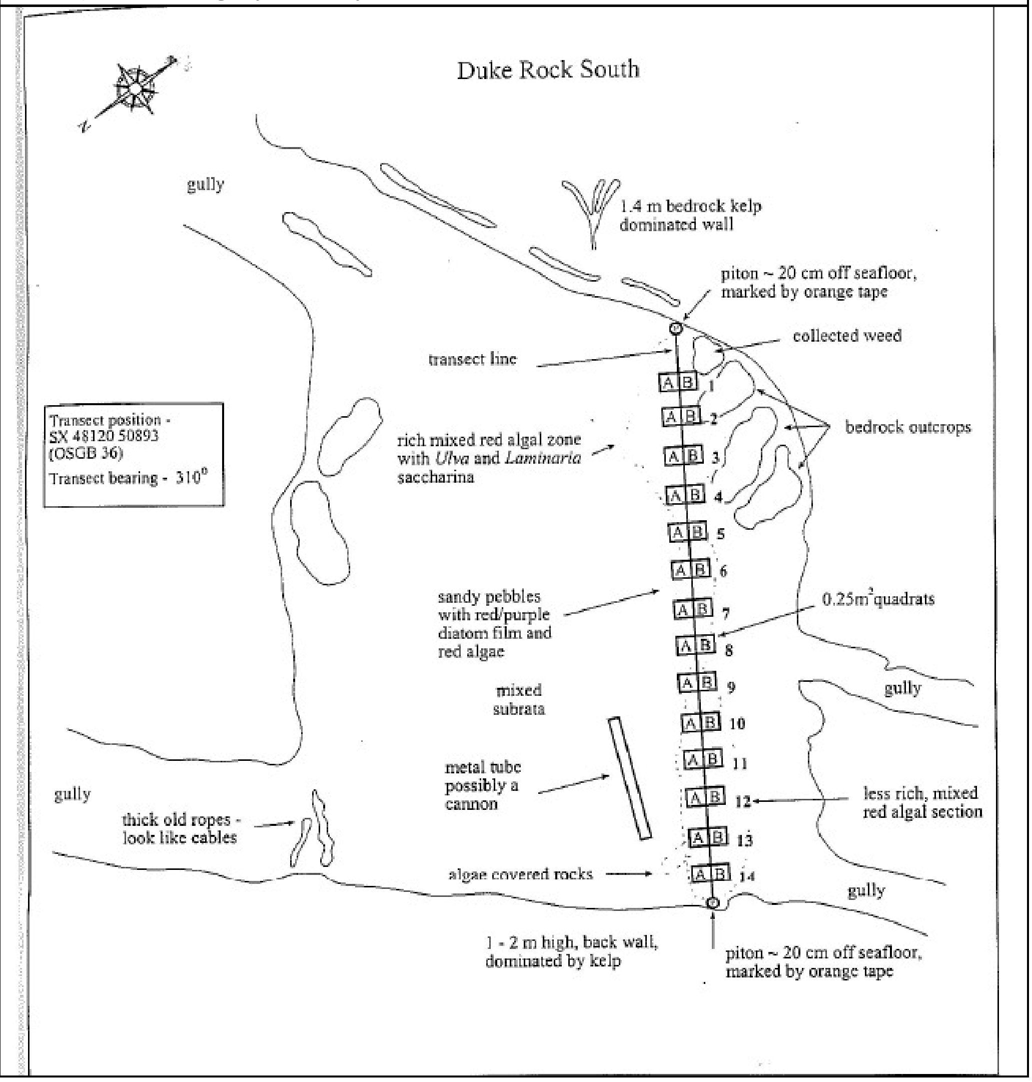
Fig. 2 The locations of the transects at Eastern King Point.</td></tr>
<tr><td>Target Community description</td><td>Target biotope(s) - Antedon spp., solitary ascidians and fine hydroids on sheltered circa-littoral rock / Suberites sp. and other sponges with solitary ascidians on very sheltered circa-littoral rock

Codes: CR.LCR.BrAs.AntAsH / SCR.SubSoAs

2013 surveys notes that the Antedon biotope was most representative of the site however note that it doesn't capture Alcyonium digitatum which is characteristic of the site, as were anemones, in particular Urticina felina.
The site consists of a steep slope (est. 45 degree) of limestone bedrock in tide-</td></tr>
</table>

	swept, wave-sheltered conditions. It is essential that sampling takes place in areas as uniform as possible, maintaining a consistent depth contour and surface orientation and complexity and rugosity. Fauna consist of 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.

Site Name:	**E. of Northern degaussing buoy**
Location (WGS84)	50.31701, -4.16188 50' 19.0206' (N) -4' 9.7128' (W)
Location Description	Roughly 250m East of the charted position of the Northern Yellow OSR buoy roughly 1.9km south of the Western end of the breakwater. Site should be situated on the 20m contour (chart datum) looking for a slope / series of gullies from 15 – 20m (Chart datum)
Target Community description	Nominally targeting biotope: Erect sponges, *Eunicella verrucosa* and *Pentapora foliacea* on slightly tide-swept moderately exposed circalittoral rock. MCR.ErSEun Erect sponges, *Eunicella verrucosa* and *Pentapora foliacea* on slightly tide-swept moderately exposed circalittoral rock. However – likely to be on the edge of infralittoral and circalittoral at the depths at this site therefore expect a reasonable cover of brown and red algae especially on upward facing surfaces. The brown alga *Dictyota dichotoma* has previously been recorded as covered much of the rock surface; Suggest that the sides of sloping faces of gulley walls / bedrock ridges should be the focus of this site rather than flat / upward facing surfaces. Looking for a depth contour of roughly 18m BCD – (need to correct for BSL) – expected BSL – 18 - 21m Best understanding of the site is that only weak – moderate tides are experienced throughout the tidal cycle. Fauna to look for to identify suitable sampling site – A diverse range of animal turf species - sponges, hydroid and bryozoan species should be present. *Eunicella verrucosa & Pentapora foliacea* may be present as may *Alcyonium digitatum*, *Holothuria forskali*, & *Caryophyllia smithii*

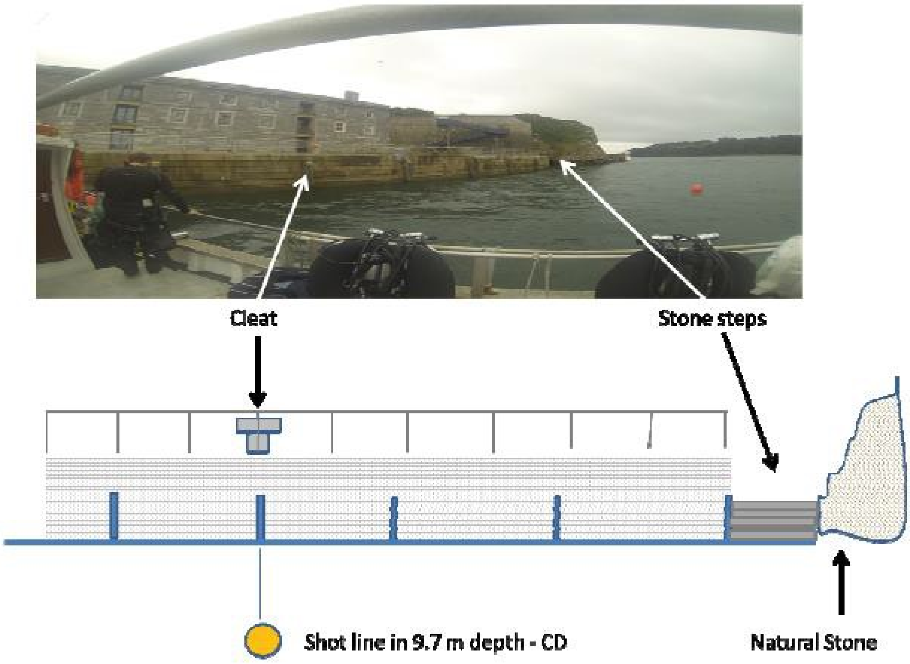
Site Name:	Duke Rock South
Location (WGS84)	50.3383, -4.134983 50' 20.298' (N) -4' 8.0988' (W)
Location Description	Located near the entrance to the Eastern entrance to Plymouth Sound. Approximately 150m south east of the charted position of the Duke Rock West Cardinal buoy on a rough transit with the end of Bovisand Harbour. Exact depth of the transect site is not clear. 2003 survey worked between 7 and 8m BCD, 2013 survey located the sample site with a shot at 5.6m BCD. The 2017 survey will examine the area around the GPS marks and following examination of the chart and site diagram agree a target depth expected to be between 6 – 7m BCD. Best Understanding of this site is that weak or moderate tidal flow is experience across some times of the tidal cycle but this should not dramatically limit working times. In order to try to re-locate the sample site see site diagram below – the position given here for this transect: SX 48120 50893 – Slightly different to positions given above by more recent reports. 50.338329 -4.1356391 (50 20.29974' N 4 8.138346' W). Position given above should be attempted initially and establish if site resembles site diagram below. Pitons were fixed into the rock gulley walls slightly above the sea bed (approx. 20cm) but are highly unlikely to remain/ be found after this time.
	

Target Community description	The Duke rock south site is across a level area of tide-swept infralittoral mixed substrata between two extensive bedrock outcrops. Target communities / biotopes - Ephemeral and scour-tolerant seaweeds on cobbles and sand Original code: MIR.EphR Ephemeral red seaweeds and kelps on tide-swept mobile infra-littoral cobbles. Suggested alternate code: SS.SMp.KSwSS.LsacR.CbPb Red seaweeds and kelps on tide-swept mobile infra-littoral cobbles and pebbles. The area is characterised by broad gullies between kelp-covered bedrock ridges. The seabed consisted of a clean mixed substratum of pebbles, gravel, sand and scattered cobbles, interspersed by outcrops of bedrock. In light of the site diagram above the sampling site must remain within the mixed substratum areas and not combine areas of mixed cobbles and pebbles and bedrock. The cobbles and pebbles supported a diverse assemblage of scour-tolerant redalgae, with *Stenogramme interrupta* dominant but with other species present in relatively low abundances. Conspicuous algae included *Callophyllis laciniata, Cryptopleura ramosa, Dilsea carnosa*, and *Delesseria sanguinea*. Brown algae were common including *Dictyota dichotoma*, *Laminaria ochroleuca*, *Saccharina latissima*, *Saccorhiza polyschides* and with *Laminaria* sporelings and *Cystoseira* sp. attached to stones.

Site Name:	West of Mew Stone
Location (WGS84)	50.30635, - 4.12567 50’ 18.381’ (N) -4’ 7.5402’ (W)
Location Description	Roughly 1.3km West of the Mew Stone. Site should be situated on the 14m (chart datum) contour looking for a slope / series of gullies from 10 – 18m (chart datum).
Target Community description	Nominally targeting biotope: Erect sponges, *Eunicella verrucosa* and *Pentapora foliacea* on slightly tide-swept moderately exposed circalittoral rock. MCR.ErSEun Erect sponges, *Eunicella verrucosa* and *Pentapora foliacea* on slightly tide-swept moderately exposed circalittoral rock. However – likely to be on the edge of infralittoral and circalittoral at the depths at this site therefore expect a reasonable cover of brown and red algae especially on upward facing surfaces. The brown alga *Dictyota dichotoma* has previously been recorded as covered much of the rock surface; Suggest that the sides of sloping faces of gulley walls / bedrock ridges should be the focus of this site rather than flat / upward facing surfaces. Looking for a depth contour of roughly 16 – 18m BCD – (need to correct for BSL) – expected BSL – 18 - 20m Fauna to look for to identify suitable sampling site – A diverse range of animal turf species - sponges, hydroid and bryozoan species should be present. *Eunicella verrucosa* & *Pentapora foliacea* may be present as may A*lcyonium digitatum*, *Holothuria forsskali*, & *Caryophyllia smithii*

<table>
<tr><th>Site Name:</th><th>Devil's Point</th></tr>
<tr><td>Location (WGS84)</td><td>50' 21.634' (N) -4' 10.041' (W)</td></tr>
<tr><td>Location Description</td><td>The surveyed site from 2013 at Devils point is located adjacent to a 'large cleat' acting as a site locator on the outer victualling wall of Royal William Yard.

The site is located immediately adjacent to the first large metal cleat (looking right to left from the southern end of the victualling wall) (see below) at 9.7m BCD.



During the week proposed for the 2017 survey this site will be expected to be found between 14.5 and 15m BSL.

As per Eastern Kings this site is very tidally restricted. Work is only feasible at high water slack which is understood to be workable from 30 mins to 1hr before high to 15 – 30 mins after high.

The priority depth contour will be the surveyed depth contour 9.7m BCD – 14.5 – 15m BSL.</td></tr>
<tr><td>Target Community description</td><td>Previous code: SCR.SubSoAs Suberites sp. and other sponges with solitary ascidians on very sheltered circa-littoral rock.

Alternative code: CR.MCR.CFaVS.CuSpH.VS Cushion sponges and hydroids on turbid tide-swept variable salinity sheltered circa-littoral rock.

It is anticipated there will only be one high water slack in the week free to work on this site the priority depth contour will be the surveyed depth contour 9.7m BCD – 14.5 – 15m BSL.

It is essential that sampling takes place in areas as uniform as possible, maintaining a consistent depth contour and surface orientation and complexity and rugosity.</td></tr>
</table>

	The site consists of a steep slope of limestone bedrock and rubble in tide-swept, wave-sheltered conditions. There is diverse fauna with a wide range of sponges, hydroids and bryozoans present. Faunal turf dominated by the sponges *Esperiopsis fucorum*, *Halichondria bowerbanki* and the hydroids, *Nemertesia antennina, Nemertesia antennina*. The sponge *Suberites ficus* is common; The bryozoan *Alcyonidium diaphanium* was existing almost as a mono-culture in patches, particularly in the shallower areas.

Appendix 3: Plymouth Sound and Estuaries SAC – Site condition monitoring of subtidal reefs: Recording rules for surveyors to follow

Maximum 10 minutes per quadrat – (may be extended on significantly shallower sites

Only record sessile algae and animals, plus key characterising species which are relatively sedentary e.g. feather stars & urchins – and of course note separately any observed rare / scarce / non-native species e.g. spiny lobster (*Palinurus*), *Styela clava, Undaria (*Wakame kelp), Pacific Oyster (Magallana*)* Etc.

Start with the characterising and most abundant species then the conspicuous ones only then if there is time look at species present in small numbers.

Don't work your work way down the species list and do not assume everything will already be on the recording form.

Use % cover for all records, each record should be a whole number.

For *Pentapora* and *Eunicella* please also record number of colonies in addition to % cover.

Only record organisms which are attached to the rock surface inside the quadrat. For algae / stalked organisms – record % cover of the attachments on the rock surface rather than the canopy cover. (i.e. 1 kelp holdfast may represent 10% cover but the kelp frond could cover 90 – 100%).

If uncertain of the ID of a species use the blank rows at the bottom of the recording form and note the photo number/sample bag number - Remembering to focus on the characterising and most abundant species – not the cryptic / really scarce and obscure.

Record to the taxonomic group levels as listed on recording form - Key groupings which should be adhered to:

- Encrusting sponge (all encrusting sponges if not specifically listed i.e. *Halichondria*)
- *Halichondria* – encrusting & tasselled – (Stick to the two listed morphologies of *Halichondria* rather than trying to split to species)
- Encrusting Bryozoans (Do not try and split encrusting bryozoan species)
- Encrusting algae – Dark Red / Pink (/corallinaceae) (Do not split encrusting algae beyond these two groupings
- Barnacles / Cirripedia indet (Do not try and split barnacle species beyond those listed e.g. *Verruca stromeia*
- Hydroid (turf) indet. (all short hydroid turf species circa 1 – 3cm or less)
- Bryozoan (turf) indet. (All short bryozoan turf circa 1cm or less)
- *Halecium* spp. (do not split *Halecium* species)
- *Bugula* / *Bugulina* etc. – (All *Bugula* type species to be grouped together)
- Cellaria sp. And Crisia sp. (don't try and split to species)

Adapted from Moore: 1999 / 2000

Sponges – Record all as species except encrusting. Record all Encrusting sponges as 1 morphotype / group

Hydroids – Record larger species as individual species and all smaller as Hydroid (turf) indet. Anthozoa – Record all as species – disregard individuals <1cm

Polychaetes – Record large tubes / colonies that stand out above turf as species. Crustacea – Record amphipod tubes as group & other consipicuous individuals as species.

Bryozoa – Distinct colonies (e.g. Bugula / Bugulina / Crissidae / Cellaria) as individual species / groups. All smaller turf forms as Bryozoan (turf) indet.and all ecrusing species as Bryozoa (enc).

Exception – record number of colonies in addition to %age cover of Pentapora Echinoderms – record as species

Ascidians – record as species

Algae – record as far as possible as species, record any incrusting forms separately and analyse as species and reduced to Rhodophyta, Phaeophyta and Chlorophyta.

Appendix 4: Project personnel

(All Natural England staff unless otherwise stated)

Project led by Natural England personnel

Survey contract manager	John Bleach
Survey methodology	Ross Bullimore & Trudy Russell
Field survey leaders	John Bleach & Ross Bullimore
Survey team 2017	John Bleach Ian Saunders Angie Gall Ross Bullimore Gavin Black (1 day only) Trudy Russell Hazel Selley Kate Northen (Blue-C-Ecology) Nick Owen (Independent)
Skipper	Pete Fergus (Venture Charters)
Survey team 2018	John Bleach Ian Saunders Angie Gall Lucy May Ross Bullimore (Independent) Kate Northen (Blue-C-Ecology) Nick Owen (Independent) Charlie Sandercock (Independent)
Skipper	Pete Fergus (Venture Charters)
Data analysis	Matt Doggett (Seven Tenths Ecology Ltd)
Report writing	Kate Northen & Matt Doggett

Appendix 5: Data analysis

Data transformation

Data transformation is used to remove the weighting of common or rare species within a sample when undertaking statistical analysis. The type of transformation used depends on the biological (not statistical) questions being asked and whether a broad or specific approach is required. The stronger the transformation, the broader the answer as all species become more equal, thus giving a greater weighting to species with low abundances.

Clarke and Gorley (2015)[1] state: "*Transformation is usually applied to all the entries in an assemblage matrix of counts, biomass, % area cover etc, in order to downweight the contributions of quantitatively dominant species to the similarities calculated between samples…. The more severe the initial transformation, the more notice is taken of the less-abundant species in the matrix. If standardisation of samples by total is also required, for example to ameliorate the effects of differing sample volumes, it is logical to standardise first, then transform*."

Data may be standardised if required i.e. if the data are gathered in an uncontrolled way. In the present study, although the totals may exceed 100% (given the 3-dimensional structure of the communities being surveyed) the quadrats limited the area from which data were obtained and standardisation was not considered necessary.

Using a square root transformation on the assemblage data is a useful tool for community monitoring, as temporal or spatial changes in the less dominant taxa are given more weight in the subsequent analyses. This allows changes to be identified better if they occur mainly among less dominant taxa.

An example of the effect of data transformation is given using the data for the site EN DG Buoy. Shade plots provided a visual cue of the effect of each transformation option on the community data (Figure A1 in Appendix 5). The plots showed that a square root transformation avoided domination of the data by allowing the abundant species to play a greater role, but also taking into account contributions from a wide range of less-dominant species; this can be considered to give a better analysis of the overall community. Stronger transformations e.g. 4th root, make the data more akin to 'presence / absence' data meaning more random noise might affect the end result by placing less emphasis on the relative abundances of taxa within the communities.

In practice, the data were analysed as both raw data and square root transformations with the differences between the two being negligible in all cases. The results presented here are for the square root transformed data on the basis of the explanation above.

Similarity matrices and multi-dimensional scaling

A Bray-Curtis similarity matrix was produced from the square-root transformed data. This compared each and every quadrat sample to one another and ranked them based on their similarities. Multi-dimensional scaling (MDS) plots were produced to illustrate these differences and/or similarities between samples at each site. The MDS plots can provide useful, visual assistance with interpreting results from ANOSIM (Analysis of Similarity) tests depending on the degree of clustering between samples i.e. samples clustered closely together are more similar than those further apart.

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[1] Clarke, KR, and Gorley, RN, 2015. PRIMER v7: User Manual/Tutorial. PRIMER-E, Plymouth, 300pp.

The usefulness of MDS plots is indicated by a stress value. If stress values in a 2-D plot are too high, a 3-D plot can be generated which might provide a better representation as there is more dimensional space in which to plot the samples and their relative distances to each other. Stress values should be considered as follows:

- <0.05 – excellent representation of the relationships between the data;
- <0.1 – good plot with little prospect of a misleading interpretation;
- <0.2 – potentially useful although for values toward the upper end of this range too much emphasis should not be placed on the detail of the plot;
- 0.2 – 0.3 – treat these points with scepticism and consider plots at higher dimensions;
- >0.3 – the points are close to random – consider plots at higher dimensions.

Analysis of similarity (ANOSIM) tests

ANOSIM tests provide two results; R-values and p-values. Of these two values, R is often the most useful for data interpretation, being unaffected by the number of replicates but by actual dissimilarities between the groups of data i.e. R is "*an absolute measure of differences between two or more groups*."[2] 'p' is always influenced by the sample size and might mask confidence in the results obtained from smaller datasets.

R-values most often fall between zero and one. As values approach zero a greater degree of similarity is indicated, whereas those closer to one indicate a greater degree of dissimilarity. Where the p-value indicated a significant result, SIMPER (Similarity Percentages) analyses were examined to determine which taxa were contributing most to the differences between years.

SIMPER analysis

When differences have been detected between groups of samples, Similarity Percentage (SIMPER) tests can be used to determine the individual taxa or species that contribute to the differences between groups of samples and the similarities between samples within a group. The SIMPER test identifies species that typify a group and/or potentially an environmental condition or impact.

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[2] Clarke, KR, and Gorley, RN, 2015. PRIMER v7: User Manual/Tutorial. PRIMER-E, Plymouth, 300pp.

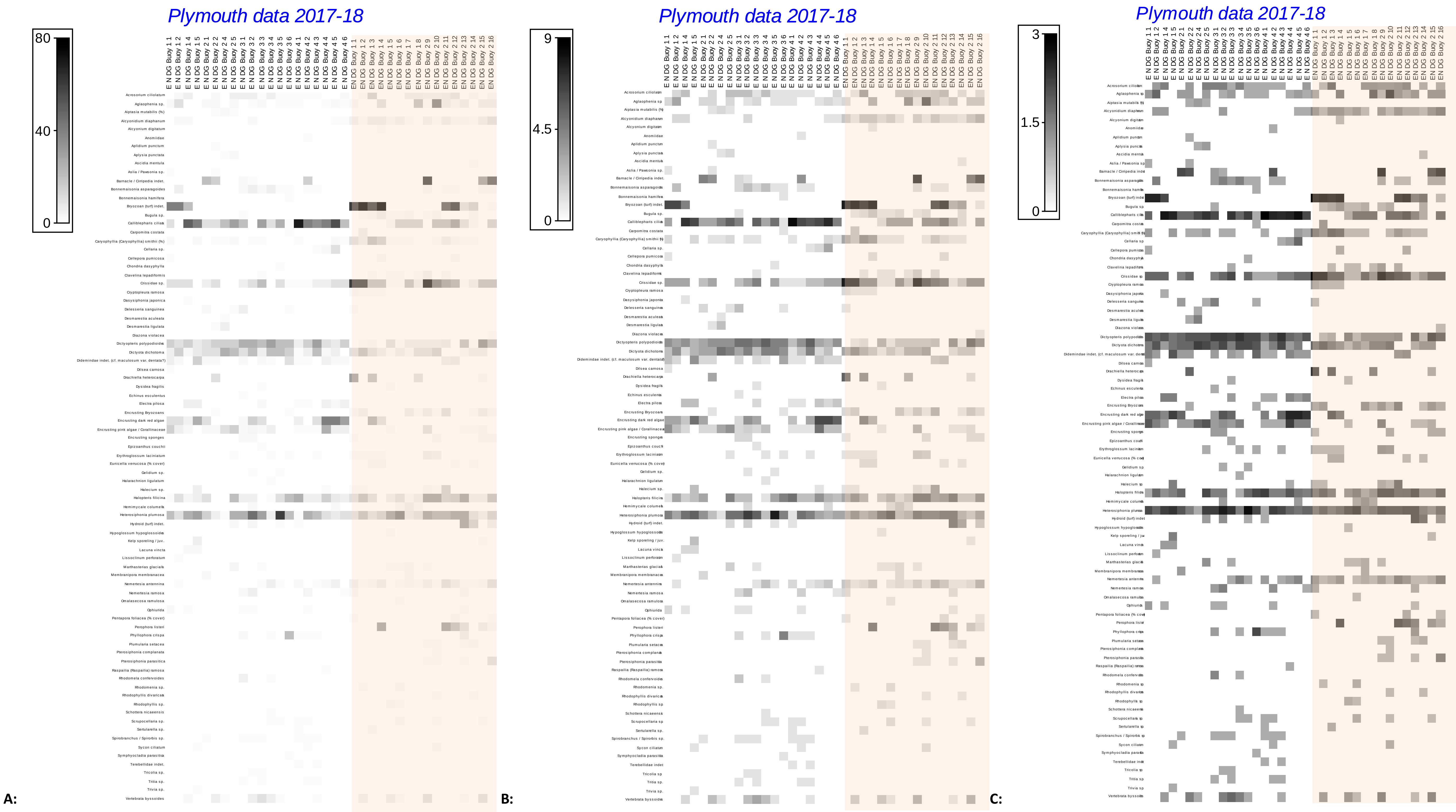

Figure A1: Shade plots giving an example of data transformation effects (A – no transformation; B – square root; C – 4th root) on samples from site 'EN DG Buoy' in 2017 (unshaded) and 2018 (orange shaded).

Appendix 6: SIMPER outputs

For each site non-metric multidimensional scaling (nMDS) plots were produced and ANOSIM tests for differences between the years were completed. Where there were shown to be statistically significant differences between years, a SIMPER analysis was carried out to determine the taxa responsible for causing the greatest dissimilarities between years.

SIMPER - EN DG Buoy

Data worksheet
Name: SQRT TRANSFORM ALL 2017-18 data
Data type: Abundance
Sample selection: 1-20,103-118
Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity cut off for low contributions: 90.00%

Factor Groups Sample			Year
EN DG Buoy	1	1	2017
EN DG Buoy	1	2	2017
EN DG Buoy	1	4	2017
EN DG Buoy	1	5	2017
EN DG Buoy	2	1	2017
EN DG Buoy	2	2	2017
EN DG Buoy	2	4	2017
EN DG Buoy	2	5	2017
EN DG Buoy	3	1	2017
EN DG Buoy	3	2	2017
EN DG Buoy	3	3	2017
EN DG Buoy	3	4	2017
EN DG Buoy	3	5	2017
EN DG Buoy	3	6	2017
EN DG Buoy	4	1	2017
EN DG Buoy	4	2	2017
EN DG Buoy	4	3	2017
EN DG Buoy	4	4	2017
EN DG Buoy	4	5	2017
EN DG Buoy	4	6	2017
EN DG Buoy	1	1	2018
EN DG Buoy	1	2	2018
EN DG Buoy	1	3	2018
EN DG Buoy	1	4	2018
EN DG Buoy	1	5	2018
EN DG Buoy	1	6	2018
EN DG Buoy	1	7	2018
EN DG Buoy	1	8	2018
EN DG Buoy	2	9	2018
EN DG Buoy	2	10	2018
EN DG Buoy	2	11	2018
EN DG Buoy	2	12	2018
EN DG Buoy	2	13	2018
EN DG Buoy	2	14	2018
EN DG Buoy	2	15	2018
EN DG Buoy	2	16	2018

Group 2017

Average similarity: 52.61

Species	Av.Abun	Av.Sim	Sim/SD	Contrib%	Cum.%
Dictyopteris polypodioides	3.92	8.86	4.43	16.84	16.84
Calliblepharis ciliata	4.54	8.41	1.55	15.99	32.83
Heterosiphonia plumosa	4.07	7.77	2.37	14.77	47.6
Dictyota dichotoma	3	5.72	1.71	10.88	58.48
Halopteris filicina	2.35	3.88	1.27	7.38	65.86
Crissidae sp.	2.09	3.3	1.08	6.27	72.13
Encrusting dark red algae	2.42	2.88	0.75	5.48	77.61
Encrusting pink algae / Corallinaceae	1.83	2.84	1.24	5.4	83.01
Didemindae indet. (cf. maculosum var.dentata?)	1.21	1.62	0.9	3.07	86.08
Acrosorium ciliolatum	1.07	1.49	0.88	2.83	88.91
Aglaophenia sp.	0.88	1.17	0.81	2.22	91.13

Group 2018

Average similarity: 46.89

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Heterosiphonia plumosa	4.25	8.1	3.33	17.27	17.27
Crissidae sp.	4.41	6.55	1.84	13.97	31.23
Halopteris filicina	3.33	5.42	2.12	11.56	42.79
Dictyota dichotoma	2.11	3.08	1.19	6.56	49.35
Bryozoan (turf) indet.	3.51	2.89	0.54	6.16	55.51
Alcyonidium diaphanum	1.65	2.72	2.02	5.8	61.32
Dictyopteris polypodioides	2.13	2.68	1.05	5.72	67.04
Calliblepharis ciliata	2.24	2.61	0.69	5.57	72.61
Nemertesia antennina	1.56	2.4	2.09	5.12	77.72
Caryophyllia (Caryophyllia) smithii (%)	1.46	1.59	0.95	3.4	81.12
Aglaophenia sp.	1.67	1.43	0.67	3.04	84.17
Acrosorium ciliolatum	1.33	1.38	0.71	2.95	87.12
Encrusting Bryozoans	1.11	1.13	0.71	2.4	89.52
Bugula sp.	0.74	0.82	0.63	1.75	91.26

Groups 2017 & 2018

Average dissimilarity = 59.21

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Bryozoan (turf) indet.	0.86	3.51	4.18	1.03	7.06	7.06
Calliblepharis ciliata	4.54	2.24	3.79	1.46	6.39	13.46
Crissidae sp.	2.09	4.41	3.46	1.5	5.84	19.3
Encrusting dark red algae	2.42	0.51	2.92	1.12	4.93	24.23
Dictyopteris polypodioides	3.92	2.13	2.73	1.66	4.61	28.84
Halopteris filicina	2.35	3.33	2.21	1.35	3.74	32.58

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Heterosiphonia plumosa	4.07	4.25	2.11	1.24	3.56	36.14
Dictyota dichotoma	3	2.11	2.09	1.33	3.52	39.66
Encrusting pink algae / Corallinaceae	1.83	0.47	2	1.27	3.38	43.04
Barnacle / Cirripedia indet.	0.73	1.27	2	0.68	3.38	46.42
Aglaophenia sp.	0.88	1.67	1.86	1.05	3.14	49.56
Alcyonidium diaphanum	0.31	1.65	1.69	1.79	2.85	52.41
Perophora listeri	0	1.39	1.57	0.69	2.66	55.06
Didemindae indet. (cf. maculosum var.dentata?)	1.21	0.31	1.51	1.19	2.56	57.62
Nemertesia antennina	0.55	1.56	1.45	1.51	2.45	60.07
Caryophyllia (Caryophyllia) smithii (%)	0.58	1.46	1.45	1.08	2.45	62.52
Acrosorium ciliolatum	1.07	1.33	1.43	1.29	2.41	64.93
Vertebrata byssoides	0.71	0.79	1.29	0.98	2.18	67.11
Encrusting Bryozoans	0.1	1.11	1.29	1.12	2.17	69.28
Drachiella heterocarpa	0.16	0.91	1.21	0.57	2.04	71.32
Hydroid (turf) indet.	0.26	0.72	1.09	0.57	1.84	73.16
Bugula sp.	0.05	0.74	0.93	1.04	1.56	74.73
Bonnemaisonia asparagoides	0.68	0.39	0.9	0.96	1.51	76.24
Electra pilosa	0.67	0	0.81	0.75	1.36	77.6
Phyllophora crispa	0.49	0.14	0.72	0.54	1.22	78.82
Halecium sp.	0.16	0.52	0.67	0.61	1.14	79.96
Erythroglossum laciniatum	0.2	0.51	0.65	0.83	1.09	81.05
Clavelina lepadiformis	0.05	0.46	0.58	0.77	0.98	82.03
Hemimycale columella	0.14	0.32	0.55	0.55	0.92	82.96
Nemertesia ramosa	0.32	0.18	0.51	0.61	0.85	83.81
Marthasterias glacialis	0.14	0.28	0.47	0.64	0.8	84.61
Encrusting sponges	0.14	0.33	0.46	0.65	0.78	85.39
Scrupocellaria sp.	0.2	0.21	0.43	0.66	0.72	86.11
Pterosiphonia parasitica	0	0.39	0.42	0.47	0.72	86.83
Spirobranchus / Spirorbis sp.	0.35	0	0.42	0.72	0.71	87.54
Delesseria sanguinea	0.28	0.06	0.39	0.52	0.65	88.19
Eunicella verrucosa (% cover)	0	0.3	0.36	0.57	0.61	88.8
Ophiurida	0.27	0.06	0.35	0.61	0.6	89.4
Plumularia setacea	0	0.28	0.33	0.54	0.56	89.96
Cellaria sp.	0.28	0	0.33	0.37	0.56	90.52

SIMPER - Devils Point

Data worksheet

Name: SQRT TRANSFORM ALL 2017-18 data

Data type: Abundance

Sample selection: 45-56,165-176 Variable selection: All

Parameters

Resemblance: S17 Bray-Curtis similarity cut off for low contributions: 90.00%

Factor Groups

Sample			Year
Devils Point	1	1	2017
Devils Point	1	2	2017
Devils Point	1	3	2017
Devils Point	1	4	2017
Devils Point	1	5	2017
Devils Point	1	6	2017
Devils Point	2	1	2017
Devils Point	2	2	2017
Devils Point	2	3	2017
Devils Point	2	4	2017
Devils Point	2	5	2017
Devils Point	2	6	2017
Devils Point	7	1	2018
Devils Point	7	2	2018
Devils Point	7	3	2018
Devils Point	7	4	2018
Devils Point	7	5	2018
Devils Point	7	6	2018
Devils Point	7	7	2018
Devils Point	7	8	2018
Devils Point	7	9	2018
Devils Point	7	10	2018
Devils Point	7	11	2018
Devils Point	7	12	2018

Group 2017

Average similarity: 49.04

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Encrusting sponges	5.75	12.22	2.89	24.92	24.92
Hydroid (turf) indet.	4.61	7.14	0.97	14.56	39.48
Amphilectus fucorum	3.11	4.35	1.12	8.87	48.36
Antho (Antho) inconstans	2.92	3.69	0.99	7.52	55.87
Cliona celata (boring form only)	2.23	3.35	1.48	6.83	62.7
Bugula sp.	1.41	2.81	3.23	5.74	68.44
Nemertesia antennina	2.49	2.53	0.66	5.16	73.61
Dendrodoa / Distomus sp.	2.33	2.15	0.63	4.38	77.99
Barnacle / Cirripedia indet.	2.04	1.75	0.49	3.56	81.55
Hymeniacidon perlevis	1.77	1.69	0.62	3.45	85
Spirobranchus / Spirorbis sp.	0.77	0.96	0.64	1.95	86.96
Bicellariella ciliata	0.74	0.95	0.85	1.94	88.89
Salmacina/Filograna	1.14	0.93	0.51	1.91	90.8

Group 2018

Average similarity: 56.11

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Encrusting sponges	6.97	11.36	5.55	20.25	20.25
Bryozoan (turf) indet.	6.35	9.2	4.5	16.4	36.65
Hydroid (turf) indet.	4.12	6.2	2.28	11.05	47.7
Bugula sp.	3.59	4.35	1.66	7.76	55.46
Nemertesia antennina	3.55	3.69	1.21	6.57	62.03
Plumularia setacea	2.69	3.2	1.55	5.71	67.74
Amphilectus fucorum	3.09	3.01	1	5.37	73.1
Halichondria spp. (encrusting)	2.34	2.56	0.97	4.57	77.67
Antho (Antho) inconstans	2.62	2.44	0.66	4.35	82.02
Scrupocellaria sp.	2.52	1.48	0.53	2.64	84.67
Alcyonidium diaphanum	1.44	1.16	0.77	2.06	86.73
Cliona celata (boring form only)	1.73	1.09	0.58	1.95	88.68
Barnacle / Cirripedia indet.	1.69	1.05	0.4	1.86	90.54

Groups 2017 & 2018
Average dissimilarity = 54.75

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Bryozoan (turf) indet.	1.09	6.35	5.58	2.25	10.2	10.2
Hydroid (turf) indet.	4.61	4.12	3.02	1.55	5.51	15.71
Nemertesia antennina	2.49	3.55	2.83	1.32	5.17	20.88
Antho (Antho) inconstans	2.92	2.62	2.76	1.27	5.04	25.92
Barnacle / Cirripedia indet.	2.04	1.69	2.67	1.12	4.87	30.79
Halichondria spp. (encrusting)	0	2.34	2.54	1.43	4.64	35.43
Bugula sp.	1.41	3.59	2.51	1.96	4.59	40.02
Amphilectus fucorum	3.11	3.09	2.48	1.26	4.54	44.55
Scrupocellaria sp.	0.08	2.52	2.38	0.97	4.34	48.89
Dendrodoa / Distomus sp.	2.33	1.57	2.37	1.22	4.33	53.23
Plumularia setacea	0.97	2.69	2.3	1.58	4.2	57.43
Cliona celata (boring form only)	2.23	1.73	2.04	1.41	3.72	61.15
Hymeniacidon perlevis	1.77	1.45	1.98	1.11	3.61	64.76
Encrusting sponges	5.75	6.97	1.95	1.42	3.56	68.32
Amathia spp.	1.04	1.26	1.67	1.04	3.05	71.37
Alcyonidium diaphanum	0.64	1.44	1.57	0.99	2.86	74.23
Raspailia (Raspailia) ramosa	1.32	1	1.54	1.05	2.81	77.04
Salmacina/Filograna	1.14	0.72	1.24	1.11	2.27	79.31
Spirobranchus / Spirorbis sp.	0.77	0.7	1	1.12	1.83	81.13
Crissidae sp.	0.25	0.9	0.94	0.86	1.72	82.86
Porifera indet. (pale purple, 'NO'sample)	0	0.81	0.92	0.64	1.68	84.54
Bicellariella ciliata	0.74	0.52	0.73	1.1	1.34	85.88
Phoronidae	0.4	0.47	0.71	0.84	1.3	87.17

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Hiatella sp.	0.62	0.08	0.7	0.85	1.28	88.46
Encrusting Bryozoans	0.08	0.59	0.7	0.81	1.28	89.73
Nemertesia ramosa	0	0.59	0.56	0.57	1.02	90.76

SIMPER - Duke Rock

Data worksheet

Name: SQRT TRANSFORM ALL 2017-18 data

Data type: Abundance

Sample selection: 57-79,119-142 Variable selection: All

Parameters

Resemblance: S17 Bray-Curtis similarity cut off for low contributions: 90.00%

Factor Groups Sample				Year
Duke Rock	S	1	1	2017
Duke Rock	S	1	2	2017
Duke Rock	S	1	3	2017
Duke Rock	S	1	4	2017
Duke Rock	S	1	5	2017
Duke Rock	S	1	6	2017
Duke Rock	S	2	1	2017
Duke Rock	S	2	2	2017
Duke Rock	S	2	3	2017
Duke Rock	S	2	4	2017
Duke Rock	S	2	5	2017
Duke Rock	S	3	1	2017
Duke Rock	S	3	2	2017
Duke Rock	S	3	3	2017
Duke Rock	S	3	4	2017
Duke Rock	S	3	5	2017
Duke Rock	S	3	6	2017
Duke Rock	S	4	1	2017
Duke Rock	S	4	2	2017
Duke Rock	S	4	3	2017
Duke Rock	S	4	4	2017
Duke Rock	S	4	5	2017
Duke Rock	S	4	6	2017
Duke Rock	S	1	1(2)	2018
Duke Rock	S	1	2(2)	2018
Duke Rock	S	1	3(2)	2018
Duke Rock	S	1	4(2)	2018
Duke Rock	S	1	5(2)	2018
Duke Rock	S	1	6(2)	2018
Duke Rock	S	1	7	2018
Duke Rock	S	1	8	2018
Duke Rock	S	1	9	2018
Duke Rock	S	1	10	2018
Duke Rock	S	1	11	2018
Duke Rock	S	1	12	2018
Duke Rock	S	2	13	2018
Duke Rock	S	2	14	2018
Duke Rock	S	2	15	2018
Duke Rock	S	2	16	2018
Duke Rock	S	2	17	2018
Duke Rock	S	2	18	2018
Duke Rock	S	2	19	2018
Duke Rock	S	2	20	2018
Duke Rock	S	2	21	2018
Duke Rock	S	2	22	2018
Duke Rock	S	2	23	2018
Duke Rock	S	2	24	2018

Group 2017

Average similarity: 35.86

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Stenogramme interruptum	2.74	6.28	1.49	17.5	17.5
Encrusting pink algae / Corallinaceae	2.51	5.77	1.3	16.1	33.6
Vertebrata byssoides	2.01	3.94	1	10.99	44.59
Acrosorium ciliolatum	2.13	3.41	0.93	9.5	54.09
Calliblepharis ciliata	1.81	1.78	0.5	4.95	59.04
Kallymenia reniformis	1.54	1.64	0.59	4.58	63.62
Dictyota dichotoma	1.74	1.64	0.58	4.57	68.19
Heterosiphonia plumosa	1.61	1.62	0.56	4.51	72.7
Electra pilosa	1.36	1.52	0.68	4.23	76.93
Cryptopleura ramosa	1.54	1.5	0.49	4.19	81.11
Erythroglossum laciniatum	0.97	1.19	0.7	3.31	84.42
Ulva sp.	1.01	0.88	0.41	2.46	86.88
Encrusting dark red algae	0.84	0.63	0.3	1.77	88.65
Hydroid (turf) indet.	0.57	0.46	0.34	1.3	89.95
Delesseria sanguinea	0.97	0.43	0.24	1.21	91.15

Group 2018
Average similarity: 26.02

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Vertebrata byssoides	2.06	4.31	1.21	16.56	16.56
Stenogramme interruptum	2	3.99	0.75	15.35	31.9
Encrusting pink algae / Corallinaceae	1.76	2.52	0.74	9.68	41.58
Dictyota dichotoma	1.6	2.02	0.74	7.77	49.35
Heterosiphonia plumosa	1.47	1.32	0.54	5.06	54.41
Cryptopleura ramosa	1.33	1.19	0.52	4.56	58.97
Halarachnion ligulatum	0.94	1.17	0.49	4.5	63.47
Kallymenia reniformis	0.98	0.9	0.46	3.45	66.92
Calliblepharis ciliata	1.21	0.85	0.31	3.27	70.19
Desmarestia ligulata	0.77	0.63	0.38	2.42	72.61
Punctaria sp.	0.46	0.45	0.31	1.75	74.36
Bonnemaisonia asparagoides	0.58	0.45	0.37	1.74	76.1
Acrosorium ciliolatum	0.79	0.45	0.32	1.73	77.83
Kelp sporeling / juv.	0.63	0.45	0.36	1.71	79.54
Metacallophyllis laciniata	0.78	0.44	0.31	1.69	81.24
Ulva sp.	0.53	0.43	0.29	1.65	82.89
Encrusting dark red algae	0.96	0.41	0.23	1.56	84.45
Delesseria sanguinea	0.75	0.38	0.27	1.44	85.9
Spirobranchus / Spirorbis sp.	0.46	0.35	0.33	1.36	87.26
Barnacle / Cirripedia indet.	1.08	0.33	0.19	1.26	88.52
Encrusting sponges	0.67	0.32	0.27	1.22	89.74
Hydroid (turf) indet.	0.48	0.28	0.28	1.08	90.83

Groups 2017 & 2018
Average dissimilarity = 71.72

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Calliblepharis ciliata	1.81	1.21	3.18	1.02	4.44	4.44
Acrosorium ciliolatum	2.13	0.79	2.99	1.28	4.17	8.61

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Dictyota dichotoma	1.74	1.6	2.93	1.16	4.09	12.7
Encrusting pink algae / Corallinaceae	2.51	1.76	2.93	1.2	4.08	16.78
Stenogramme interruptum	2.74	2	2.85	1.33	3.98	20.76
Heterosiphonia plumosa	1.61	1.47	2.77	1.13	3.86	24.61
Cryptopleura ramosa	1.54	1.33	2.73	1.13	3.81	28.43
Kallymenia reniformis	1.54	0.98	2.45	1.06	3.42	31.84
Vertebrata byssoides	2.01	2.06	2.32	1.16	3.24	35.08
Encrusting dark red algae	0.84	0.96	2.18	0.77	3.05	38.13
Electra pilosa	1.36	0	1.97	0.94	2.75	40.87
Delesseria sanguinea	0.97	0.75	1.96	0.78	2.73	43.6
Barnacle / Cirripedia indet.	0.57	1.08	1.9	0.63	2.65	46.26
Ulva sp.	1.01	0.53	1.88	0.82	2.62	48.88
Erythroglossum laciniatum	0.97	0.49	1.67	1.11	2.33	51.21
Halarachnion ligulatum	0.1	0.94	1.57	0.83	2.19	53.4
Desmarestia aculeata	0.79	0.38	1.56	0.67	2.18	55.58
Metacallophyllis laciniata	0.63	0.78	1.56	0.81	2.17	57.75
Bonnemaisonia asparagoides	0.7	0.58	1.48	0.8	2.07	59.82
Desmarestia ligulata	0.43	0.77	1.48	0.81	2.07	61.88
Kelp sporeling / juv.	0.41	0.63	1.26	0.84	1.75	63.64
Hydroid (turf) indet.	0.57	0.48	1.2	0.87	1.68	65.31
Dilsea carnosa	0.5	0.43	1.19	0.53	1.65	66.97
Encrusting sponges	0.25	0.67	1.1	0.72	1.53	68.5
Phyllophora pseudoceranoïdes	0.04	0.69	1.02	0.47	1.42	69.92
Stolonica socialis	0.06	0.69	1	0.5	1.39	71.31
Polysiphonia sp.	0.29	0.35	0.89	0.6	1.24	72.55
Spirobranchus / Spirorbis sp.	0.31	0.46	0.88	0.82	1.23	73.78
Punctaria sp.	0	0.46	0.84	0.6	1.18	74.96
Drachiella heterocarpa	0.37	0.29	0.82	0.55	1.14	76.1
Rhodomela confervoides	0.26	0.31	0.8	0.49	1.11	77.21
Crissidae sp.	0	0.55	0.77	0.53	1.07	78.28
Membranipora membranacea	0	0.51	0.73	0.35	1.02	79.3
Amphilectus fucorum	0.4	0	0.68	0.46	0.95	80.25
Dasysiphonia japonica	0.19	0.24	0.66	0.42	0.92	81.17
Phyllophora crispa	0.29	0.19	0.62	0.47	0.86	82.03
Palmaria palmata	0.19	0.29	0.6	0.44	0.83	82.86
Encrusting Bryozoans	0.1	0.37	0.59	0.46	0.82	83.68
Dudresnaya verticillata	0	0.38	0.58	0.4	0.8	84.49
Plocamium spp.	0.32	0.08	0.51	0.48	0.71	85.2
Obelia sp.	0	0.35	0.5	0.29	0.69	85.89

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Ceramium sp.	0.09	0.26	0.49	0.5	0.69	86.58
Scinaia interrupta	0.3	0	0.49	0.43	0.68	87.26
Bryozoan (turf) indet.	0	0.32	0.45	0.36	0.63	87.89
Chondrus crispus	0	0.33	0.44	0.44	0.61	88.5
Schottera nicaeensis	0.04	0.27	0.43	0.41	0.6	89.09
Asterina gibbosa	0.17	0.18	0.42	0.62	0.58	89.67
Polysiphonia elongata	0	0.27	0.38	0.34	0.53	90.2

SIMPER - Mew Stone West

Data worksheet
Name: SQRT TRANSFORM ALL 2017-18 data
Data type: Abundance
Sample selection: 80-102,155-164,177-188 Variable selection: All

Parameters
Resemblance: S17 Bray-Curtis similarity cut off for low contributions: 90.00%
Factor Groups

Sample					Year
Mew Stone	W	1	1		2017
Mew Stone	W	1	2		2017
Mew Stone	W	1	3		2017
Mew Stone	W	1	4		2017
Mew Stone	W	1	5		2017
Mew Stone	W	1	6		2017
Mew Stone	W	2	1		2017
Mew Stone	W	2	2		2017
Mew Stone	W	2	3		2017
Mew Stone	W	2	4		2017
Mew Stone	W	2	5		2017
Mew Stone	W	2	6		2017
Mew Stone	W	3	1		2017
Mew Stone	W	3	2		2017
Mew Stone	W	3	3		2017
Mew Stone	W	3	4		2017
Mew Stone	W	3	5		2017
Mew Stone	W	3	6		2017
Mew Stone	W	4	1		2017
Mew Stone	W	4	2		2017
Mew Stone	W	4	3		2017
Mew	Stone W	4 4			2017
Mew	Stone W	4 5			2017
Mew	Stone W	6 1			2018
Mew	Stone W	6 2			2018
Mew	Stone W	6 4			2018
Mew	Stone W	6 5			2018
Mew	Stone W	6 7			2018
Mew	Stone W	6 8			2018
Mew	Stone W	6 9			2018
Mew	Stone W	6 10			2018
Mew	Stone W	6 11			2018
Mew	Stone W	6 12			2018
West	of Mew	Stone	8	1	2018
West	of Mew	Stone	8	2	2018
West	of Mew	Stone	8	3	2018
West	of Mew	Stone	8	4	2018
West	of Mew	Stone	8	5	2018
West	of Mew	Stone	8	6	2018
West	of Mew	Stone	8	7	2018
West	of Mew	Stone	8	8	2018
West	of Mew	Stone	8	9	2018
West	of Mew	Stone	8	10	2018
West	of Mew	Stone	8	11	2018
West	of Mew	Stone	8	12	2018

Group 2017

Average similarity: 30.97

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dictyopteris polypodioides	2.45	3.85	1.17	12.44	12.44

Encrusting pink algae / Corallinaceae	2.28	3.54	1.2	11.42	23.86
Encrusting Bryozoans	2.41	3.12	0.9	10.08	33.94
Alcyonium digitatum	2.01	2.37	0.85	7.66	41.59
Diplosoma listerianum	2.23	2.22	0.7	7.16	48.75
Stolonica socialis	2.1	1.68	0.45	5.42	54.17
Heterosiphonia plumosa	1.62	1.66	0.52	5.37	59.54
Morchellium argus	1.18	1.19	0.69	3.84	63.38
Bryozoan (turf) indet.	1.69	1.06	0.44	3.42	66.8
Nemertesia antennina	0.77	0.9	0.72	2.91	69.71
Crissidae sp.	1.28	0.89	0.48	2.87	72.57
Barnacle / Cirripedia indet.	1.24	0.82	0.48	2.65	75.22
Caryophyllia (Caryophyllia) smithii (%)	0.83	0.8	0.65	2.58	77.8
Erythroglossum laciniatum	0.93	0.64	0.42	2.07	79.87
Encrusting dark red algae	0.97	0.61	0.32	1.98	81.85
Bugula sp.	0.82	0.45	0.38	1.46	83.31
Encrusting sponges	0.86	0.44	0.24	1.43	84.75
Vertebrata byssoides	0.61	0.38	0.31	1.23	85.98
Marthasterias glacialis	0.43	0.29	0.34	0.93	86.9
Aslia / Pawsonia sp.	0.48	0.29	0.35	0.92	87.83
Bonnemaisonia asparagoides	0.52	0.27	0.33	0.87	88.7
Dictyota dichotoma	0.53	0.27	0.34	0.86	89.56
Plocamium spp.	0.59	0.25	0.25	0.82	90.38

Group 2018
Average similarity: 44.50

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Dictyopteris polypodioides	3.75	7.31	2.59	16.43	16.43
Heterosiphonia plumosa	3.1	4.6	1.19	10.34	26.78
Calliblepharis ciliata	2.68	3.74	1.14	8.4	35.17
Halopteris filicina	2.51	3.53	1.12	7.92	43.1
Diplosoma listerianum	2.27	3.18	1.25	7.16	50.25
Morchellium argus	1.45	2.4	1.73	5.39	55.65
Dictyota dichotoma	1.96	2.34	0.96	5.26	60.91
Vertebrata byssoides	1.73	1.96	0.8	4.4	65.31
Encrusting pink algae / Corallinaceae	1.9	1.88	0.7	4.21	69.52
Encrusting dark red algae	1.73	1.71	0.62	3.85	73.37
Desmarestia ligulata	1.28	1.43	0.81	3.22	76.59
Encrusting sponges	1.16	1.12	0.65	2.51	79.1
Kallymenia reniformis	0.83	0.93	0.68	2.09	81.19
Nemertesia antennina	0.97	0.88	0.57	1.99	83.18
Bryozoan (turf) indet.	1.32	0.87	0.42	1.96	85.14
Halarachnion ligulatum	0.89	0.72	0.44	1.61	86.76
Delesseria sanguinea	0.89	0.68	0.54	1.53	88.29
Acrosorium ciliolatum	0.9	0.66	0.45	1.48	89.77
Barnacle / Cirripedia indet.	0.96	0.64	0.43	1.44	91.22

Groups 2017 & 2018
Average dissimilarity = 71.73

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Calliblepharis ciliata	0.21	2.68	3.13	1.41	4.36	4.36
Heterosiphonia plumosa	1.62	3.1	2.9	1.37	4.05	8.4
Halopteris filicina	0.24	2.51	2.9	1.41	4.04	12.45
Encrusting Bryozoans	2.41	0.84	2.53	1.23	3.52	15.97
Stolonica socialis	2.1	0.3	2.51	0.85	3.5	19.47
Diplosoma listerianum	2.23	2.27	2.5	1.33	3.49	22.96
Bryozoan (turf) indet.	1.69	1.32	2.38	0.99	3.32	26.28
Alcyonium digitatum	2.01	0.05	2.32	1.14	3.23	29.51
Encrusting pink algae / Corallinaceae	2.28	1.9	2.3	1.35	3.21	32.72
Dictyopteris polypodioides	2.45	3.75	2.29	1.2	3.19	35.92
Encrusting dark red algae	0.97	1.73	2.18	1.14	3.03	38.95
Dictyota dichotoma	0.53	1.96	2.12	1.22	2.95	41.9
Vertebrata byssoides	0.61	1.73	1.89	1.19	2.63	44.53
Encrusting sponges	0.86	1.16	1.74	1.06	2.43	46.96
Barnacle / Cirripedia indet.	1.24	0.96	1.74	0.99	2.42	49.38
Crissidae sp.	1.28	0.71	1.6	1	2.23	51.61
Desmarestia ligulata	0.04	1.28	1.49	1.14	2.08	53.69
Morchellium argus	1.18	1.45	1.37	1.4	1.91	55.6
Bugula sp.	0.82	0.63	1.23	0.9	1.72	57.32
Nemertesia antennina	0.77	0.97	1.19	1.11	1.66	58.98
Acrosorium ciliolatum	0.36	0.9	1.19	0.92	1.66	60.64
Erythroglossum laciniatum	0.93	0.16	1.13	0.79	1.58	62.21
Halarachnion ligulatum	0.01	0.89	1.13	0.78	1.57	63.78
Kallymenia reniformis	0.2	0.83	1.09	1.05	1.53	65.31
Hypoglossum hypoglossoides	0.47	0.73	1.06	0.89	1.47	66.78
Delesseria sanguinea	0.06	0.89	1.04	0.85	1.45	68.23
Nemertesia ramosa	0.57	0.4	0.91	0.79	1.27	69.5
Caryophyllia (Caryophyllia) smithii (%)	0.83	0.43	0.9	1.19	1.25	70.75
Marthasterias glacialis	0.43	0.5	0.85	0.74	1.19	71.94
Isozoanthus sulcatus	0.58	0	0.79	0.36	1.1	73.04
Bonnemaisonia asparagoides	0.52	0.25	0.75	0.75	1.05	74.09
Encrusting brown algae	0.16	0.53	0.71	0.6	0.99	75.08
Plocamium spp.	0.59	0	0.69	0.56	0.97	76.04
Aslia / Pawsonia sp.	0.48	0.31	0.69	0.88	0.96	77.01
Corynactis viridis	0.56	0	0.61	0.36	0.85	77.86
Ophiurida	0.42	0.24	0.6	0.78	0.84	78.7
Rhodophyllis irvineorum	0	0.5	0.59	0.52	0.82	79.51
Pachymatisma johnstonia	0.53	0	0.59	0.48	0.82	80.33
Didemindae indet.	0.44	0.09	0.58	0.58	0.81	81.14
Spirobranchus / Spirorbis sp.	0.36	0.32	0.57	0.88	0.79	81.94
Hemimycale columella	0.41	0.14	0.56	0.56	0.78	82.72
Didemindae indet. (cf. maculosum var. dentata?)	0.47	0.06	0.55	0.64	0.76	83.48
Aglaophenia sp.	0.32	0.2	0.5	0.66	0.7	84.18
Cellepora pumicosa	0.4	0.06	0.46	0.66	0.65	84.83
Scrupocellaria sp.	0.33	0.08	0.46	0.34	0.64	85.47
Clavelina lepadiformis	0.38	0	0.43	0.64	0.6	86.07

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Meredithia microphylla	0.12	0.28	0.43	0.53	0.6	86.67
Schottera nicaeensis	0.23	0.13	0.41	0.43	0.57	87.24
Halurus flosculosus	0	0.3	0.37	0.34	0.52	87.76
Tethya citrina	0.18	0.1	0.31	0.41	0.44	88.19
Rhodymenia ardissonei	0.21	0.05	0.28	0.49	0.4	88.59
Halecium sp.	0.25	0	0.28	0.44	0.39	88.98
Alcyonidium diaphanum	0.1	0.17	0.28	0.42	0.39	89.36
Cryptopleura ramosa	0	0.23	0.27	0.38	0.38	89.75
Rhodophyllis divaricata	0.15	0.05	0.26	0.37	0.37	90.11

SIMPER Eastern Kings – all data

Data worksheet

Name: SQRT TRANSFORM ALL 2017-18 data

Data type: Abundance

Sample selection: 21-44,143-154,189-200

Variable selection: 1, 4-7, 14, 18, 19, 21, 22, 28, 31, 32, 35-37, 39-42, 48, 54, 60, 61, 63, 64, 66, 67, 69-71, 73, 74, 77, 79, 80, 83, 85-91, 93, 95, 96, 100, 103, 105, 109, 111, 116, 118, 122, 124, 126, 132, 133, 138, 139, 143, 144, 147, 153, 169, 170, 174-177, 179, 191, 193, 195, 200, 208, 209, 211, 213-215, 220

Parameters

Resemblance: S17 Bray-Curtis similarity cut off for low contributions: 70.00%

Factor Groups

Sample			Year
Eastern Kings	1	1	2017
Eastern Kings	1	2	2017
Eastern Kings	1	3	2017
Eastern Kings	1	4	2017
Eastern Kings	1	5	2017
Eastern Kings	1	6	2017
Eastern Kings	2	1	2017
Eastern Kings	2	2	2017
Eastern Kings	2	3	2017
Eastern Kings	2	4	2017
Eastern Kings	2	5	2017
Eastern Kings	2	6	2017
Eastern Kings	3	1	2017
Eastern Kings	3	2	2017
Eastern Kings	3	3	2017
Eastern Kings	3	4	2017
Eastern Kings	3	5	2017
Eastern Kings	3	6	2017
Eastern Kings	4	1	2017
Eastern Kings	4	2	2017
Eastern Kings	4	3	2017
Eastern Kings	4	4	2017
Eastern Kings	4	5	2017
Eastern Kings	4	6	2017
Eastern Kings	5	1	2018
Eastern Kings	5	2	2018
Eastern Kings	5	3	2018
Eastern Kings	5	4	2018
Eastern Kings	5	5	2018
Eastern Kings	5	6	2018
Eastern Kings	5	7	2018
Eastern Kings	5	8	2018
Eastern Kings	5	9	2018
Eastern Kings	5	10	2018
Eastern Kings	5	11	2018
Eastern Kings	5	12	2018
Eastern Kings	?	1	2018
Eastern Kings	?	2	2018
Eastern Kings	?	3	2018
Eastern Kings	?	4	2018
Eastern Kings	?	5	2018
Eastern Kings	?	6	2018
Eastern Kings	?	7	2018
Eastern Kings	?	8	2018
Eastern Kings	?	9	2018

Eastern Kings	?	10	2018
Eastern Kings	?	11	2018
Eastern Kings	?	12	2018

Group 2017
Average similarity: 31.14

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Cellepora pumicosa	1.18	5.96	1.08	19.15	19.15
Raspailia (Raspailia) ramosa	1.09	5.88	0.89	18.87	38.02
Cellaria sp.	1.43	4.93	0.74	15.84	53.86
Hydroid (turf) indet.	1.6	4.37	0.58	14.04	67.89
Crissidae sp.	1.03	3.03	0.48	9.72	77.62
Encrusting sponges	0.99	2.27	0.45	7.29	84.91
Halecium sp.	0.8	1.71	0.36	5.49	90.39

Group 2018
Average similarity: 38.92

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Cellaria sp.	2.16	7.16	1.13	18.41	18.41
Bryozoan (turf) indet.	3.04	6.89	0.74	17.7	36.11
Cellepora pumicosa	1.6	5.09	1.41	13.07	49.17
Encrusting sponges	2.32	4.54	0.76	11.66	60.84
Crissidae sp.	2.28	3.92	0.67	10.08	70.92
Halecium sp.	1.71	3.59	0.69	9.23	80.15
Bugula sp.	0.95	1.82	0.58	4.69	84.83
Scrupocellaria sp.	1	1.61	0.46	4.14	88.97
Raspailia (Raspailia) ramosa	0.68	1.04	0.43	2.68	91.66

Groups 2017 & 2018
Average dissimilarity = 72.10

Species	Group 2017 Av.Abund	Group 2018 Av.Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Bryozoan (turf) indet.	0.18	3.04	9.37	1.18	13	13
Crissidae sp.	1.03	2.28	6.8	1.17	9.43	22.43
Encrusting sponges	0.99	2.32	6.75	1.19	9.36	31.79
Cellaria sp.	1.43	2.16	6	1.29	8.32	40.11
Halecium sp.	0.8	1.71	5.46	1.09	7.57	47.68
Hydroid (turf) indet.	1.6	0.72	5.33	0.93	7.39	55.07
Encrusting Bryozoans	0.17	1.09	3.98	0.5	5.52	60.58
Cellepora pumicosa	1.18	1.6	3.55	1.23	4.92	65.5
Raspailia (Raspailia) ramosa	1.09	0.68	3.31	1.23	4.6	70.1
Scrupocellaria sp.	0	1	3.29	0.78	4.56	74.66
Bugula sp.	0.31	0.95	3.01	0.99	4.17	78.83
Nemertesia antennina	0.52	0.61	2.89	0.79	4	82.83
Erythroglossum laciniatum	0	0.55	1.71	0.56	2.37	85.2
Cryptopleura ramosa	0	0.38	1.45	0.44	2.02	87.22
Alcyonium digitatum	0.36	0.11	1.35	0.5	1.87	89.09
Tritia sp.	0.23	0.08	0.92	0.56	1.28	90.37