Characterisation of the benthos in the Big Russel, Guernsey

2011

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1. Introduction

The islands of Guernsey (termed the Balliwick) lie in the bay of St Malo in the English Channel approximately 30 miles off the northern French coast (Figure 1.1). Marine life in the area is rich due to its location on the convergence between the Boreal (cold temperate) and Lusitanian (warm temperate) regions, its strong tidal currents and its topography.

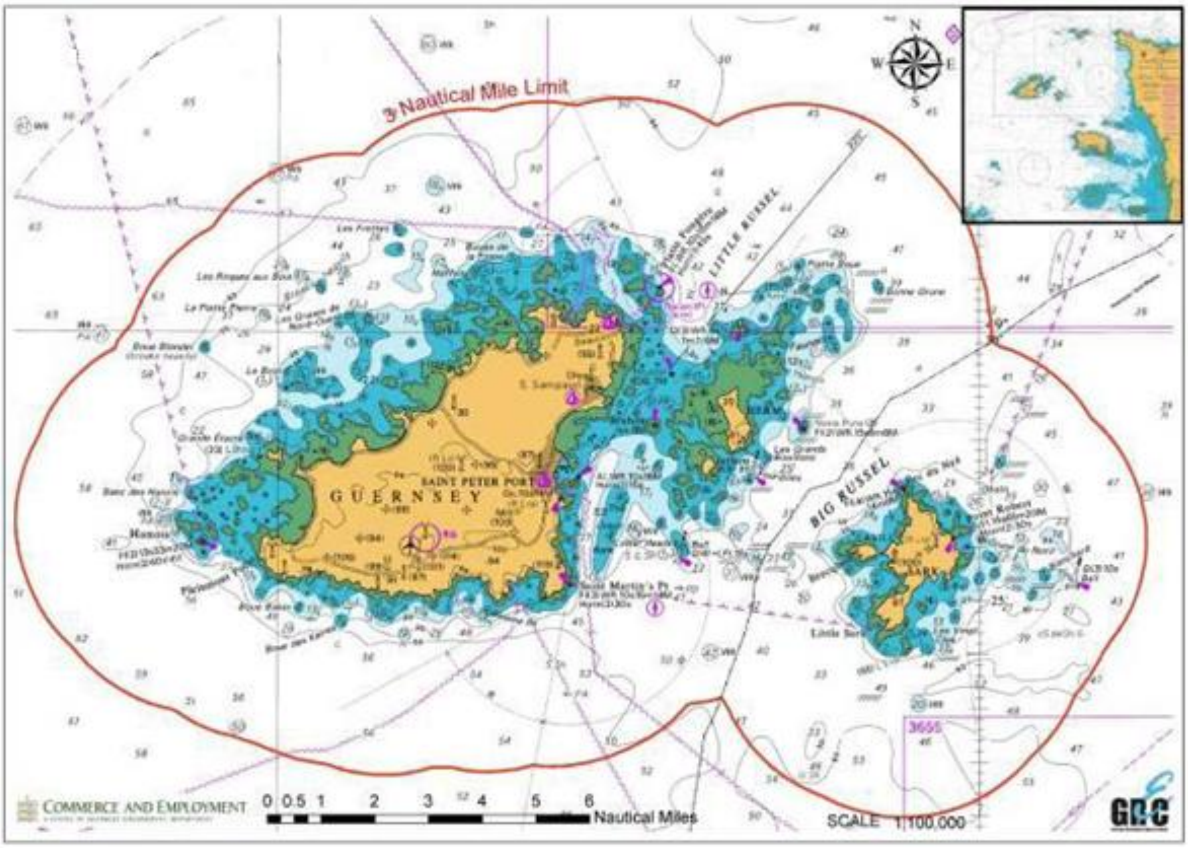

Figure 1.1: The Balliwick of Guernsey off the north coast of France. The Big Russel is the channel running between the islands of Guernsey and Sark (Source: RET)

The tidal currents around the Balliwick are some of the strongest in the world, and the exposure to wave action from the Atlantic Ocean make this area a good prospective location to harness marine renewable energy. The States of Guernsey's Energy Report, published in June 2008 identified this potential and led to the creation of the Renewable Energy Team (RET) whose purpose is to progress the creation of local renewable electricity generation on a large scale. Investigations were subsequently undertaken to determine the feasibility of marine renewable energy developments within the Territorial Waters of the Balliwick.

The waters of the Balliwick are very diverse. Habitats range from rocky reefs to seagrass beds and the species present include cold water corals, many different sponges, and a range of fishes and crabs. It is essential that the impact of any development occurring within the marine environment is minimal to protect these habitats. For this reason, a Regional Environmental Assessment (REA) was undertaken to determine the likely environmental impacts arising from the development of wave and tidal energy production in the area. The document was also designed to aid the development of marine environmental planning policy on the islands and to inform subsequent Environmental Impact Assessments carried out by independent energy developers. The benthic ecology section of the REA report focussed on pre-existing information from online marine biological databases, the Guernsey Biological Records Centre, Volunteer research programmes and UK Government sources. Information regarding the habitats and associated species in the Big Russel was lacking and so, to assess the potential future impact of marine renewable development in this area and to identify particularly sensitive and/or important habitats and species, a benthic survey was undertaken.

RET commissioned the Peninsula Research Institute for Marine Renewable Energy (PRIMaRE), Marine Institute, Plymouth University to quantify the tide swept benthic communities present in the Big Russel using a survey method newly developed at Wave Hub, a renewable energy site off the north coast of Cornwall. The method was developed specifically to survey benthic communities at renewable energy sites. It is therefore cost-effective, relatively non-destructive and suitable for use over a range of habitat types and sea conditions (Sheehan et al 2010).

The purpose of this study was to survey the Big Russel and document the various habitats and associated flora and fauna. These data could be used in future to create habitat maps, as a baseline account of the habitats and species present for future tidal development impact assessment.

2. Methods

Benthic surveys were conducted in the Big Russel from 13th – 22nd September, 2010, from the fishing trawler the ‘Nicola May’ (Figure 2.1a) skippered by Mr Shane Petit. The aim of the survey was to document the benthos to provide a baseline of species composition in an area where tidal development may occur, and to identify suitable control areas for future comparison.

The strength of the tides in Guernsey were such that the established methodologies had to be adapted, and the successful completion of the survey demonstrates the suitability of the methodology detailed below for tidal conditions of up to 2.4 knots.

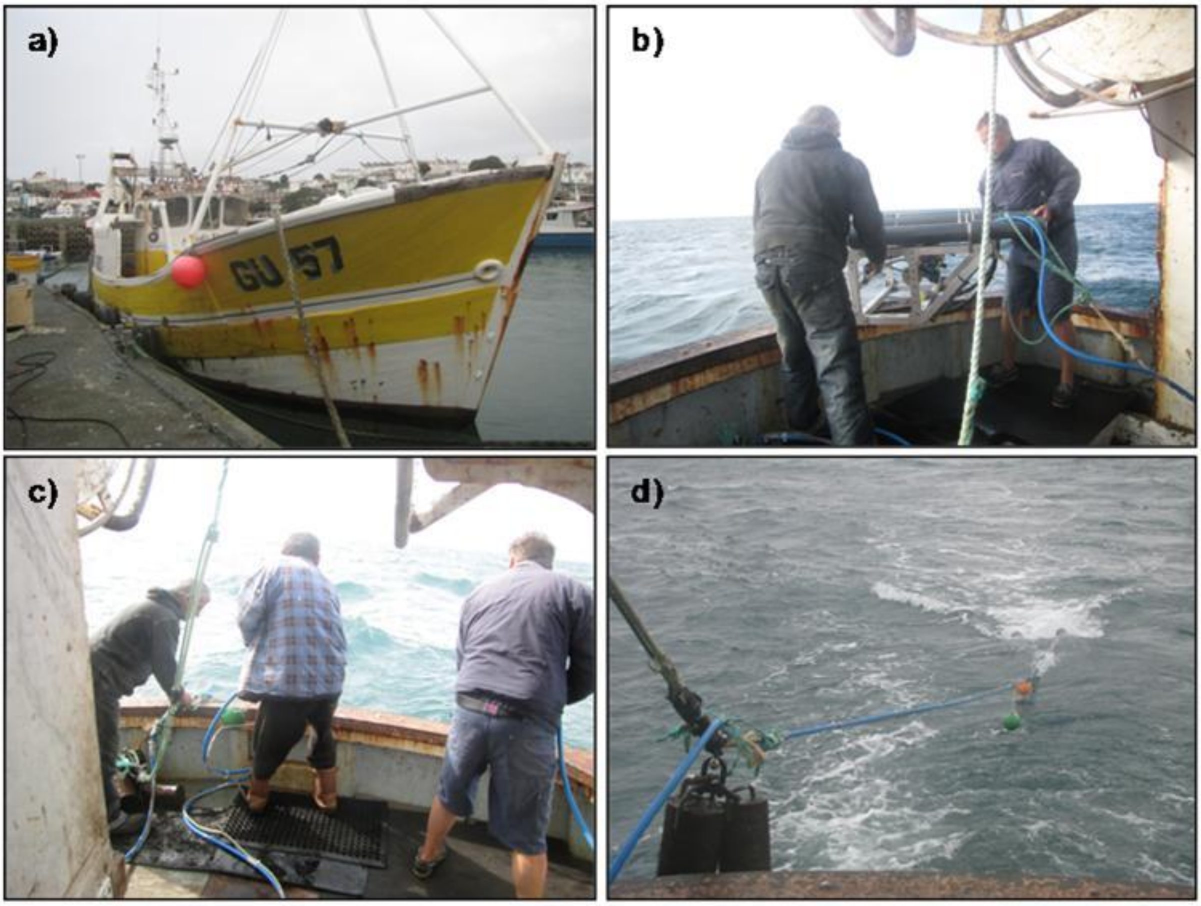

Figure 2.1: a) the vessel ‘Nicola May’ in port, b) & c) the flying array being deployed from the stern, d) the towed array emerging showing the umbilical (blue) and drop-weights for stability

2.1 Sampling methods

A High Definition video system was used to survey the seabed. This comprised of a camera (Surveyor-HD-J12 colour zoom titanium camera, 6000 m depth rated, 720p) positioned at a 45° angle to the seabed, LED lights (Bowtech Products limited, LED-1600-13, 1600 Lumen underwater LED) mounted either side and below the camera, and two laser pointers (Figure 2.2). The two laser pointers were mounted to the frame either side of the camera at a fixed distance apart which allowed calibration of the field of view during data analysis (Figure 2.2). An umbilical connected the camera to the surface control unit (Figure 2.1d). The camera system was mounted on an aluminium frame, which was a positively buoyant ‘flying array’ (Figure 2.2) and was grounded by a short length of chain to provide stability and allow it to fly at a fixed height above the seabed (Sheehan *et al.*, 2010). A drop-weight was also attached to the tow rope to provide extra stability and minimize the effect of the pitch and roll of the boat on the flying array (Figure 2.1d).

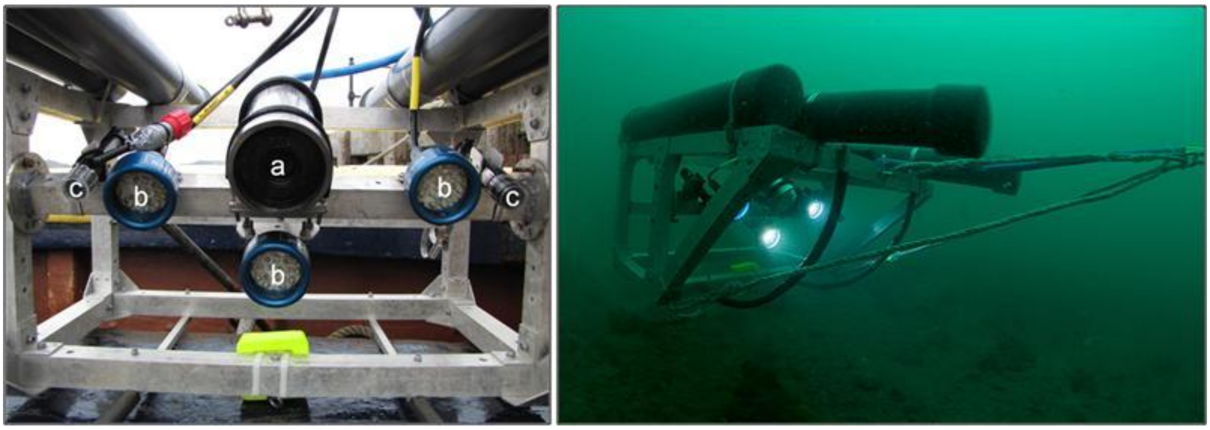

Figure 2.2: Flying array used for the video survey. a = high definition video camera, b = LED lights, c = lasers

To fly the camera over the seabed to film the benthic organisms, the flying array was deployed over the stern of the boat and towed slowly (0.4 knots) for approximately 200 m (Figure 2.1a-d).

This method was selected as it is cost-effective, allowing large areas to be surveyed rapidly (e.g. Stevens & Connolly, 2005). It is also has minimal impact on the seabed, which is essential for studies where there is interest in documenting change over time as it avoids confounding the results with impacts resulting from the survey method. The use of high definition video provides data of a high quality, and also a data archive for future use.

2.2 Site selection

Sites were selected across the Big Russel to include the areas, which had been identified as potential locations for the development of tidal energy and to document the remaining areas to ensure that those selected were most suitable (Figure 2.3). Surveys were also conducted to the south of St Martins Point to provide a control area that will be un-impacted by future development, allowing the degree of change caused by energy devices in the impacted sites to be measured.

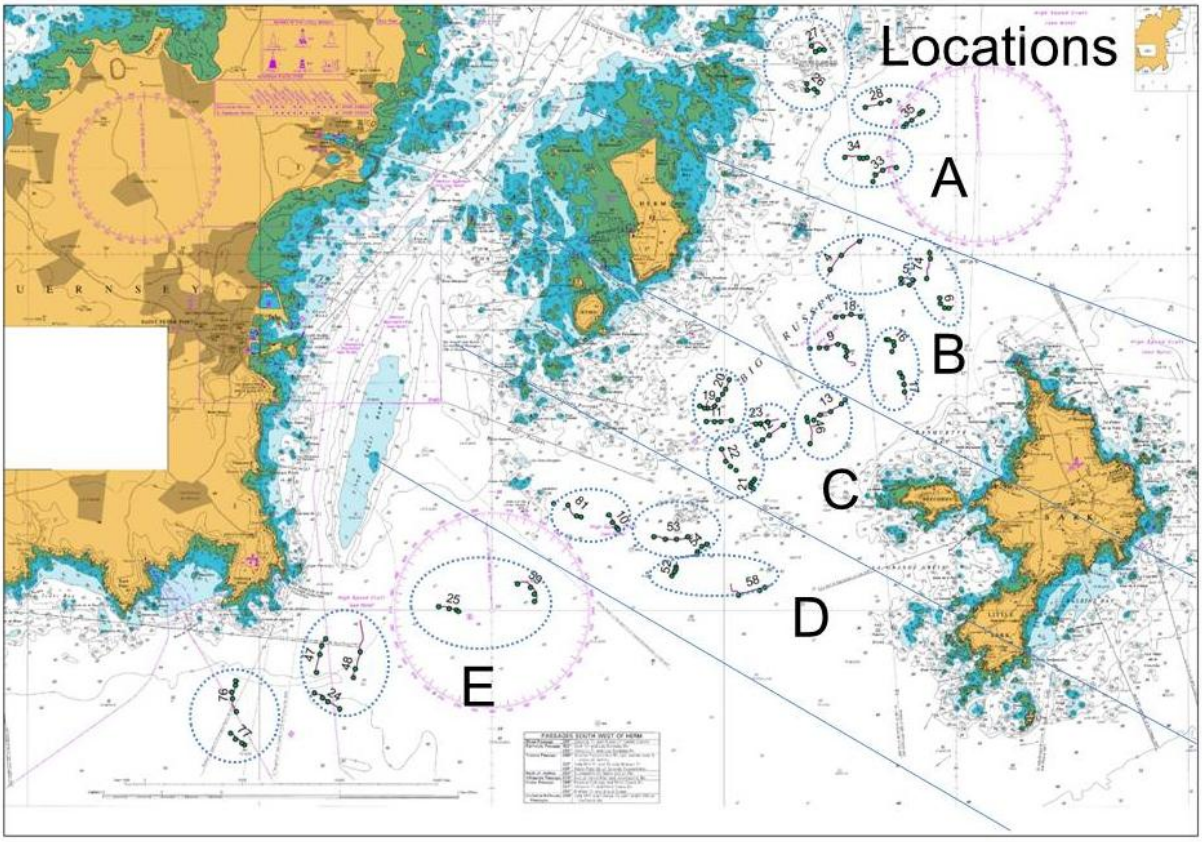

Figure 2.3: Towed video transects (sites) used for analysis in the Big Russel and south of St Martins Point, Guernsey, September 2010. To understand the variability of species assemblages in the Big Russel, the channel has been divided into Locations (A,B,C,D,E) and Areas (dotted lines), which comprise of 2 or 3 sites (black filled in circles)

The Big Russel was divided into 5 different Locations, and within these, 3 or 4 areas were sampled by collecting video transects over 200 m tows (sites), (Figure 2.3). Approximately 8 sites were surveyed by the team per day depending on the magnitude of the tide, and of these, a total of 36 were selected for analysis based on the clarity of the footage and the location of the transect.

2.3 Video analysis

Video was analysed in two stages, firstly species counts were made from the entire video transect to document all infrequent organisms and conspicuous sessile and mobile fauna. Counts were made by playing the video and recording all identifiable taxa that passed within the ‘gate’ made by the two laser pointers (see Table 2.1 for these taxa). This did not include counts of the smaller or encrusting organisms.

Following this, 10 frame grabs were haphazardly selected from the video throughout the length of the transect and all taxa within the frame identified (see Table 2.1 for these taxa). For the frame to be considered suitable it had to meet the following criteria:

i. Image must be well focussed

ii. Lasers must be within acceptable margins (positions -1, 0 or 1 (this was predetermined, see figure 2.4)

iii. Image must be clear of anything obstructing the view of the benthos (e.g. large fish)

This method identified every species present within the frame and therefore provided a means of quantifying the smaller and encrusting organisms that were not counted using the video method.

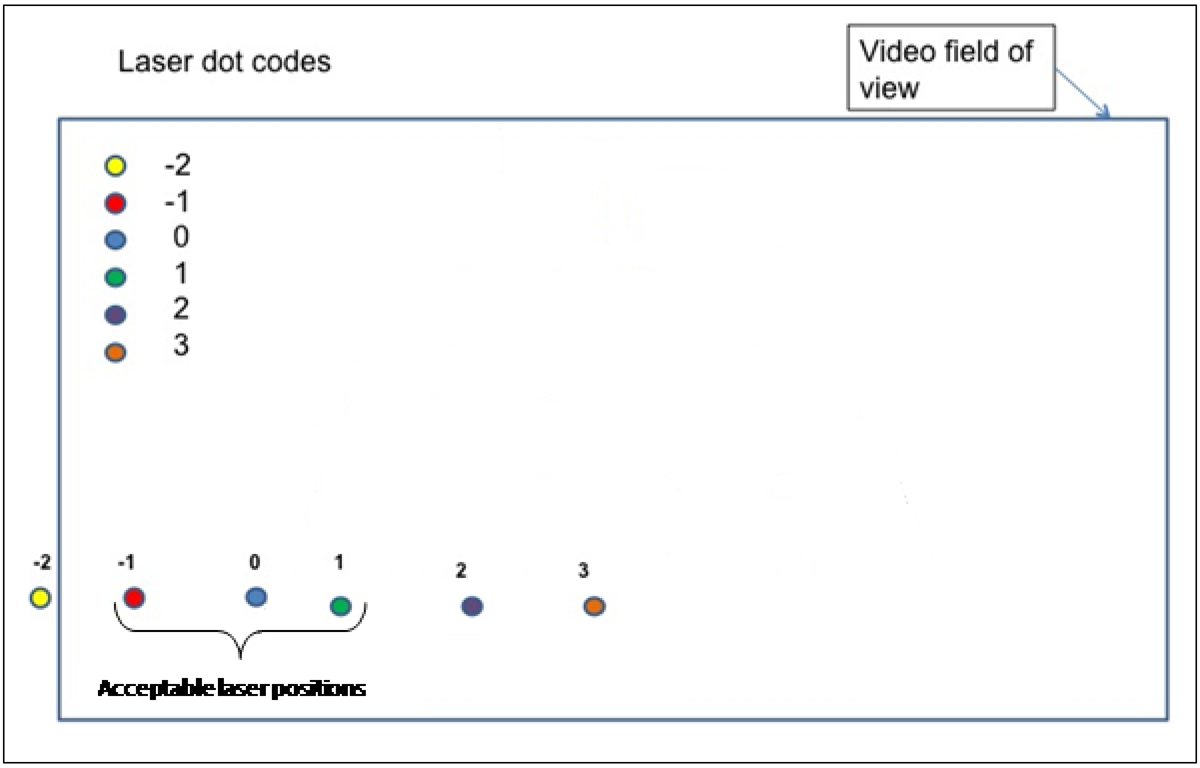

Figure 2.4: Diagrammatic representation of a frame grab with laser positions marked and numbered. Positions -1, 0 and 1 are acceptable for frame grab analysis

Taxa were identified to the lowest taxonomic level possible and recorded as density per transect for the video counts and presence/absence for the frames. Where it was not possible to identify taxa to species level some groupings were used as detailed below:

i. The spider crabs *Inachus* spp. and *Macropodia* spp. were identified to genus level as it was not possible to see the features necessary to identify these organisms to species level.

ii. The hydroid species *Halecium halecinum* (Herring-bone hydroid), *Hydrallmania falcata* and unidentified hydroids excepting *Nemertesia ramosa*, *Nemertesia antennina* (Sea beard), *Gymnangium montagui* (Yellow feathers) and *Tubularia indivisa* (Oaten pipes hydroid) were grouped due to the difficulties associated with identifying them from the video (e.g. they are often densely clumped together or coated in sediment).

iii. Goby species were grouped due to the difficulties in positively identifying them from the video.

iv. Positive species identification of most sponges can only be made under microscopic examination (Ackers *et al.*, 2007). Branching, massive and encrusting sponges that could not be identified with confidence were numbered and identification was therefore made based on colour and morphology with each number corresponding to what was thought to be a different taxa. Table 2.1 details these. Other sponges (*Cliona celata,* (Boring sponge) *Dercitus bucklandi*, *Hemimycale columella, Pachymatisma johnstonia* (Elephant's ear sponge)*, Polymastia boletiformis,* and *Suberites domuncula* (Sea-orange)) were identified to species level as they were considered to be taxonomically distinct enough for a positive identification to be made.

v. Turf comprises hydroid and bryozoans turf which projects < 1 cm above the seabed surface.

This report is accompanied by the dataset, so species codes are presented within the report so that the dataset can be understood and used by RET in future.

2.4 Data analysis

To aid the understanding of the variability of species assemblages in the Big Russel, the channel was spatially divided into different areas and the survey effort spread throughout (Figure 2.3). To determine whether assemblages of organisms were different between locations, the assemblage composition of the observed species were compared using PERMANOVA (Anderson 2001) in PRIMER V6 (Clarke & Warwick 2001). Multivariate results were visualised using nonmetric multi-dimensional scaling (nMDS). In the nMDS displaying the species quantified using the frame grabs, each point represented mean assemblage composition for one tow. In the nMDS, to display the infrequent and conspicuous species, each point represented the species observed over the entire 200 m tow.

Table 2.1: Descriptions of the sponges identified during the study and the number and suggested name assigned to each. Positive identification these species would require a physical sample to be examined under a microscope.

Species code	Taxa	Description

Braspo1	Branching sponge 1	Yellow, thick branches which often branch in the same plane. Smooth texture. Thought to be *Axinella dissimilis*
Braspo2	Branching sponge 2	Yellow, thinner branches than #1. Rough texture. Thought to be either *Stelligera stuposa* or *Raspailia hispida*
Braspo3	Branching sponge 3	Dark greyish brown, thick branches, smaller then either #1 or 2. Thought to be *Raspailia ramosa*
Braspo4	Branching sponge 4	Yellow. Thin wiry looking branches. Thought to be *Homaxinella subdola*.
Spoenc1	Encrusting sponge 1	Red encrusting sponge. Thought to be *Microciona atrasanguinea*
Spoenc2	Encrusting sponge 2	Yellow encrusting sponge. Thought to be *Pseudosuberites sulphurous*
Spoenc3	Encrusting sponge 3	Pinkish orange encrusting sponge, lighter round the edges. Slightly thicker crust.
Spoenc4	Encrusting sponge 4	Orange encrusting sponge. Thought to be *Amphilectus fucorum*
Spoenc5	Encrusting sponge 5	Pale yellow encrusting sponge with an uneven covering. Thought to be *Halichondria panicea*
Spoenc6	Encrusting sponge 6	Greyish encrusting sponge
Spomas1	Massive sponge 1	Greyish massive sponge, uneven surface with a blue-ish tinge
Spomas2	Massive sponge 2	Off white massive sponge. Thought to be *Thymosia guernei.*

For both video and frame data, the tow number, time stamp and habitat code were also recorded. Habitat codes used are presented in Table 2.2. A combination of the basic habitat types - rock, boulders, cobbles, pebbles, gravel and sand were used with definitions for these types based on the Wentworth Scale (Table 2.2). Where there was more than one habitat present, the dominant one was given at the beginning of the code e.g. RBC = rock followed by boulders and then cobbles.

Table 2.2: Habitat codes used for the video and frame analysis and their descriptions based on the Wentworth Scale. Sediment of < 2 mm is classified as sand as it was not possible to classify sediment smaller than this with accuracy

Habitat Code	Habitat Type	Description
R	Rock	Solid bedrock
B	Boulders	> 256 mm (approx)
C	Cobbles	64 – 256 mm (approx)
P	Pebbles	16-64 mm (approx)
G	Gravel	2-16 mm (approx)
S	Sand	< 2mm (approx)

3. Results & Discussion

The main habitat types are considered below, followed by the observed species. Formal comparisons are then made between the different species assemblages in the Big Russel and their associated habitat types.

3.1. Habitat types

The survey area had a large diversity of habitat types ranging from sandy plains in Location A in the far north east (site 28) to bedrock and rocky pinnacles in Locations C & D, (Figure 3.1). Analysis of frame data showed that rock was present in the majority of frames (36.34 %) (Figure 3.1), with 31.34 % composed entirely of bedrock. Cobbles and boulders were the next most common habitats, occurring in 27.05 % and 18.43 % of frames respectively (Figure 3.1), and 13.68 % of frames as combined habitat (BC).

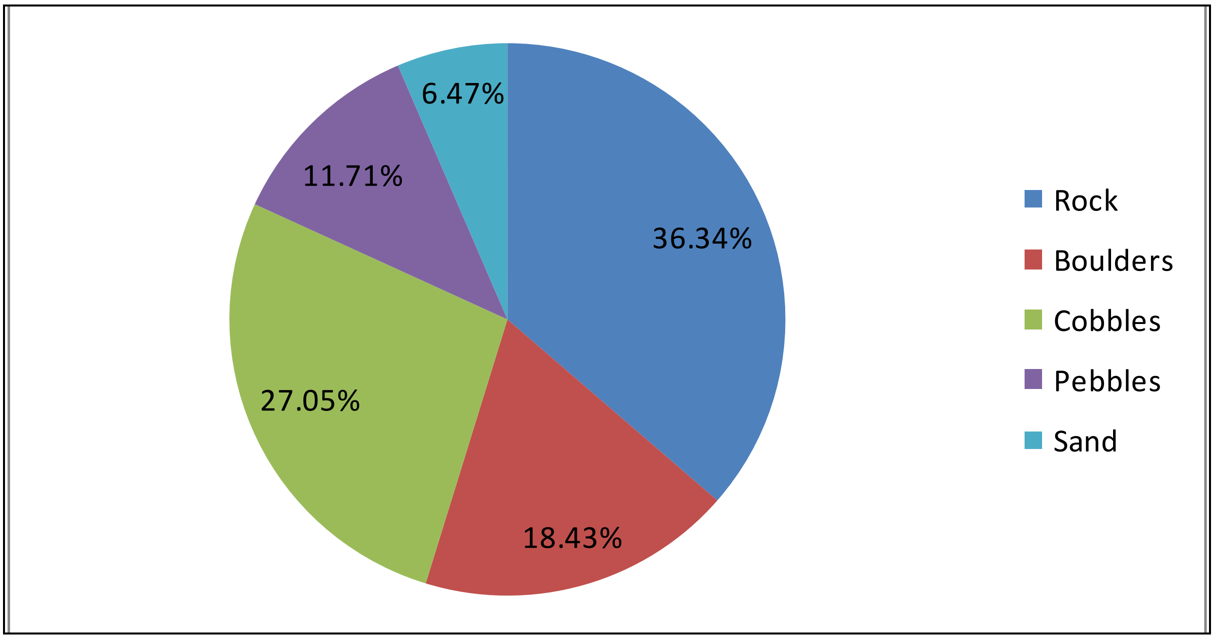

Figure 3.1: Percentage cover of each habitat type (rock, boulders, cobbles, pebbles, sand) from the frame data

3.2. Assemblage composition

A total of 74 taxa were identified during the survey, 39 from video transects and 59 from frame analysis. Table 3.1 gives a complete list of taxa identified in the Big Russel, and Figure 3.2 shows images of some of these (*Labrus bergylta* (Ballan wrasse, rockie), *Sepia officinalis* (Common cuttlefish, sieche), *Maja squinado* (Spiny spider crab), *Aspitrigla cuculus* (Red gurnard), *Henricia oculata* (Bloody henry starfish), *Cancer pagurus* (Edible crab, shanker), *Corynactis viridis* (Jewel anemones), *Echinus esculentus* (edible sea urchin), and in the north of the Big Russel where it is sandy, flatfishes such as *Scophthalmus rhombus* (Brill)).

Table 3.1: Species list detailing the taxa present, listed in alphabetical order of species code, with species/taxa name, common name and local name, and details of the survey method(s) that recorded them

Species code	Species/Taxa name	Common name	Local name	Video	Frames
Aeqope	*Aequipecten opercularis*	Queen scallop		Y	Y
Alcdia	*Alcyonidium diaphanum*	Sea chervil			Y
Alcdig	*Alcyonium digitatum*	Dead man's fingers		Y	Y
Ammtob	*Ammodytes tobianus*	Sand eel		Y	Y
Anspla	*Anseropoda placenta*	Goose foot starfish		Y	Y
Aspcuc	*Aspitrigla cuculus*	Red Gurnard		Y	Y
Botsch	*Botryllus schlosseri*	Star ascidian			Y
Braspo1	Branching sponge 1	A branching sponge		Y	Y
Braspo2	Branching sponge 2	A branching sponge		Y	Y
Braspo3	Branching sponge 3	A branching sponge		Y	Y
Braspo4	Branching sponge 4	A branching sponge		Y	Y
Callyr	*Callionymus lyra*	Common Dragonet		Y	
Calziz	*Calliostoma zizyphinum*	Painted topshell			Y
Canpag	*Cancer pagurus*	Edible crab	Shanker	Y	Y
Carsmi	*Caryophyllia smithii*	Devon cup coral			Y
Celfis	*Cellaria fistulosa*	A bryozoan			Y
Celpum	*Cellepora pumicosa*	A bryozoan			Y
Cioint	*Ciona intestinalis*	A sea squirt			Y
Clicel	*Cliona celata*	Boring sponge		Y	Y
Concon	*Conger conger*	Conger eel		Y	
Corvir	*Corynactis viridis*	Jewel anemone			Y
Cterup	*Ctenolabrus rupestris*	Goldsinny wrasse	Rockie	Y	Y
Dengro	*Dendrodoa grossularia*	Baked bean ascidian			Y
Derbuc	*Dercitus bucklandi*	An encrusting sponge			Y
Echesc	*Echinus esculentus*	Edible sea urchin		Y	Y
Eunver	*Eunicella verrucosa*	Pink sea fan		Y	
Flufol	*Flustra foliacea*	Hornwrack			Y
Galdis	*Galathea dispersa*	A squat lobster		Y	
Goby	Goby	Gobies (grouped)	Cabou	Y	Y
Gymmon	*Gymnangium montagui*	Yellow feathers			
Hemcol	*Hemimycale columella*	An encrusting sponge			Y
Henocu	*Henricia oculata*	Bloody henry		Y	Y
Holfor	*Holothuria forskali*	Cotton spinner		Y	
Hydspp	Grouped hydroids	Hydroids (grouped)			Y
Inaspp	*Inachus spp.*	Spider crabs		Y	Y
Labber	*Labrus bergylta*	Ballan wrasse	Rockie	Y	
Labmix	*Labrus mixtus*	Cuckoo wrasse	Rockie	Y	
Lippho	*Lipophrys pholis*	Shanny		Y	

Species code	Species/Taxa name	Common name	Local name	Video	Frames
Luicil	*Luidia cilaris*	A starfish		Y	
Macspp	*Macropodia spp.*	Spider crabs		Y	
Majsqu	*Maja squinado*	Spiny spider crab		Y	Y
Margla	*Marthasterias glacialis*	Spiny starfish		Y	Y

Necpub	*Necora puber*	Velvet swimming crab	Lady crab	Y	Y
Nemant	*Nemertesia antennina*	Sea beard			Y
Nemram	*Nemertesia ramosa*	A hydroid			Y
Ophoph	*Ophiura ophiura*	A brittlestar			Y
Pacjoh	*Pachymatisma johnstonia*	A sponge			Y
Pargat	*Parablennius gattorugine*	Tompot Blenny		Y	Y
Pecmax	*Pecten maximus*	Great scallop		Y	Y
Penfas	*Pentapora foliacea*	Ross coral		Y	Y
Phogun	*Pholis gunnellus*	Butterfish		Y	
Polbol	*Polymastia boletiformis*	A sponge		Y	Y
Pomtri	*Pomatoceros triqueter*	Keelworm			Y
Rajcla	*Raja clavata*	Thornback ray		Y	
Redalg	Red algae	Red algae (grouped)			Y
Sabpav	*Sabella pavonina*	Peacock worm			Y
Sagele	*Sagartia elegans*	A sea anemone			Y
Sepoff	*Sepia officinalis*	Common cuttlefish	Sieche	Y	Y
Server	*Serpula vermicularis*	A tubeworm			Y
Spoenc1	Encrusting sponge 1	An encrusting sponge			Y
Spoenc2	Encrusting sponge 2	An encrusting sponge			Y
Spoenc3	Encrusting sponge 3	An encrusting sponge			Y
Spoenc4	Encrusting sponge 4	An encrusting sponge			Y
Spoenc5	Encrusting sponge 5	An encrusting sponge			Y
Spoenc6	Encrusting sponge 6	An encrusting sponge			Y
Spomas1	Massive sponge 1	A massive sponge			Y
Spomas2	Massive sponge 2	A massive sponge			Y
Subdom	*Suberites domuncula*	Sea orange			Y
Trilus	*Trisopterus luscus*	Pouting		Y	
Trimin	*Trisopterus minutus*	Poor-cod		Y	
Tubind	*Tubularia indivisa*	A hydroid			Y
Turf	Turf	Turf			Y
Zeupun	*Zeugopterus punctatus*	Topknot		Y	Y

Frames that were composed entirely of bedrock were those with the greatest number of species, with 44 of the 59 species recorded occurring here. Cobbles and pebbles (CP) supported the second greatest abundance of species (32) followed by boulders and cobbles (BC) (27). Although there were some mobile fauna such as flatfish in the sandy habitat, no organisms appeared in the random frame grabs. The greatest abundance of fauna in sedimentary habitats occurs below the surface ‘infauna’, which the video does not sample. To quantify infauna would require dredges or a grab to take physical samples.

Figure 3.2: Examples of species present in the survey area. a) *Labrus bergylta* (Ballan wrasse, rockie), b) *Sepia officinalis* (common cuttlefish, sieche), c) *Maja squinado* (Spiny spider crab), d) *Aspitrigla cuculus* (Red gurnard), e) *Henricia oculata* (Bloody henry starfish), f) *Cancer pagurus* (Edible crab, shanker), g) *Corynactis viridis* (Jewel anemones), h) *Echinus esculentus* (edible sea urchin) and i) *Scophthalmus rhombus* (Brill)

Alcyonium digitatum (dead man's fingers) was the most abundant taxa identified from the video transects (mean abundance of 158.86 ± 27.44 ind. tow^{-1}), (Figure 3.3a) followed by *Pentapora fascialis* (ross coral), (mean abundance 86.91 ± 19.35 ind. tow^{-1}), (Figure 3.3b). The most common taxa in the frame grabs was 'grouped hydroids', which were present in 87.5 % of the frames (Figure 3.3c) followed by Turf which was present in 75.5 % (Figure 3.3d).

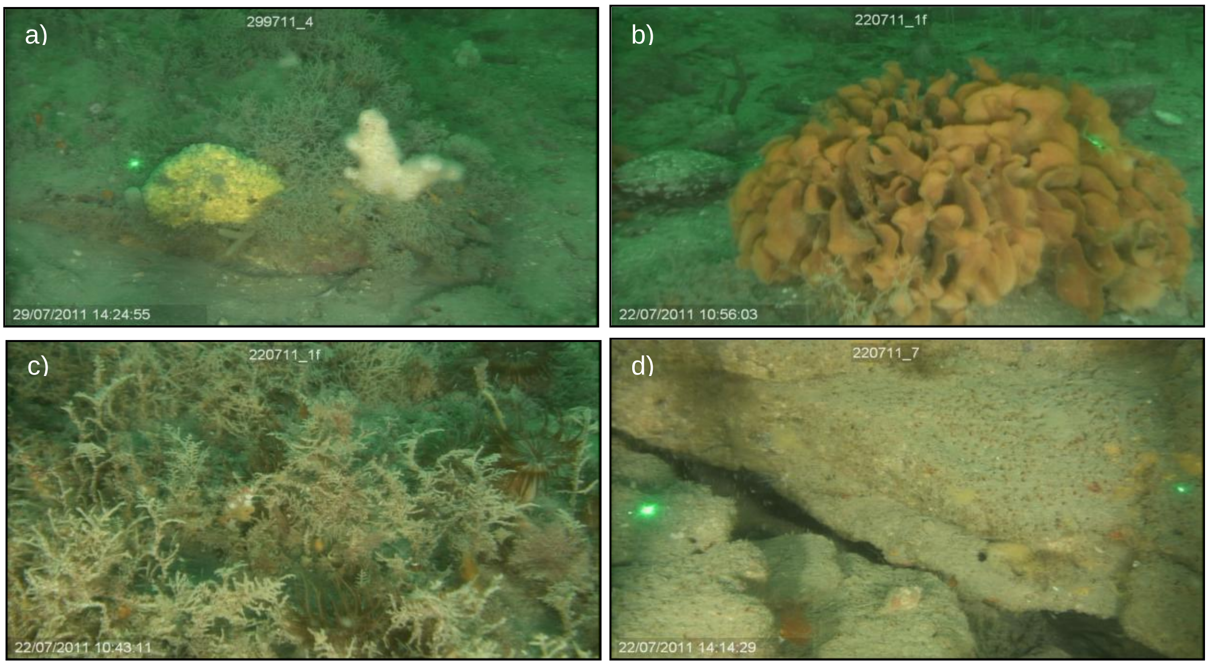

Figure 3.3: Examples of the most abundant taxa from video transects, a) *Alcyonium digitatum* (Dead man's fingers), b) *Pentapora fascialis* (Ross coral), c) Grouped hydroids, d) Turf

Table 3.2: Results of a) Permanova analysis for the relative distribution of the main assemblage species identified using frame data in response to the fixed factor Location (Lo) and random factors Area (Ar) and Site (Si) and their interactions, and b) pairwise testing for Location showing P values for the differences between Location pairings. Analyses were conducted using Bray Curtis similarities and data were dispersion weighted and square root transformed. P values in bold type are significant

a)

Source	***df***	**MS**	**Pseudo-F**	**P(perm)**
Lo	4	2246.6	1.9995	**0.0029**
Ar(Lo)	11	1125.4	1.2587	0.0825
Si(Ar(Lo))	16	894.08	No test	
Total	31			

b)

Location pairings	***P(perm)***
A & B	0.1719
A & C	0.1233
A & D	0.4978
A & E	0.4014
B & C	0.1127
B & D	**0.0270**
B & E	**0.0107**
C & D	**0.0218**
C & E	**0.0047**
D & E	**0.0470**

The assemblage composition of benthic fauna in the Big Russel was significantly different between locations (for both video transect and frame analysis), (both P < 0.05, Tables 3.2a & 3.4a). In the middle of the Big Russel, Location C had the greatest abundance of taxa, and Location D the greatest species richness (Figure 3.4). Location E, south of St Martin's Point had a considerably lower abundance and richness of taxa than in the locations in the main channel.

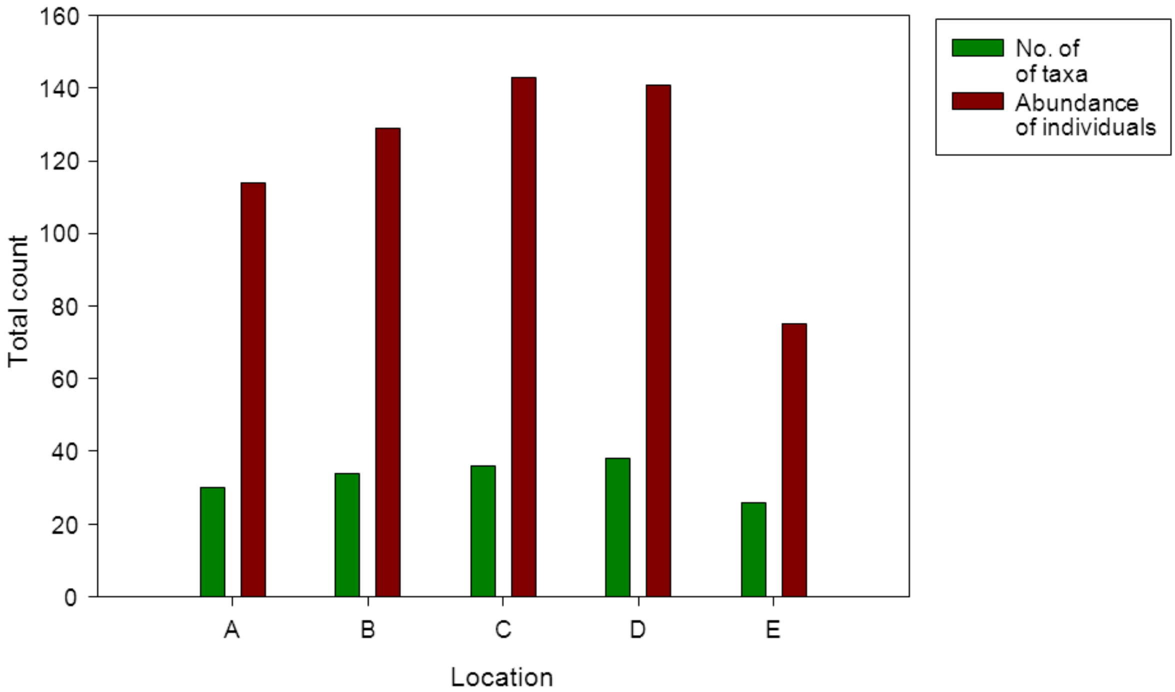

Figure 3.4: Species richness (no. of taxa) and abundance of individuals taken from the frame analysis for sites summed over area and averaged for Location (A,B,C,D,E)

Pairwise testing for species assemblage composition (Table 3.2b) showed that Location A was not significantly different to any other Location, but most other Locations were significantly different to each other (Table 3.2b). It must be considered however, that one of the sites in Location A (Site 28) was dominated by sand and no species were identified during the frame analysis for the entire length of the transect. When the similarities between sites were represented using an nMDS plot (Figures 3.5 & 3.7) the differences between this site and the remaining sites were such that it had to be removed in order to visualise the remaining sites. Most species assemblage compositions were significantly different to each other (Table 3.2, significance indicated by P < 0.05), but these differences were not clear to see in the nMDS, (Figure 3.5).

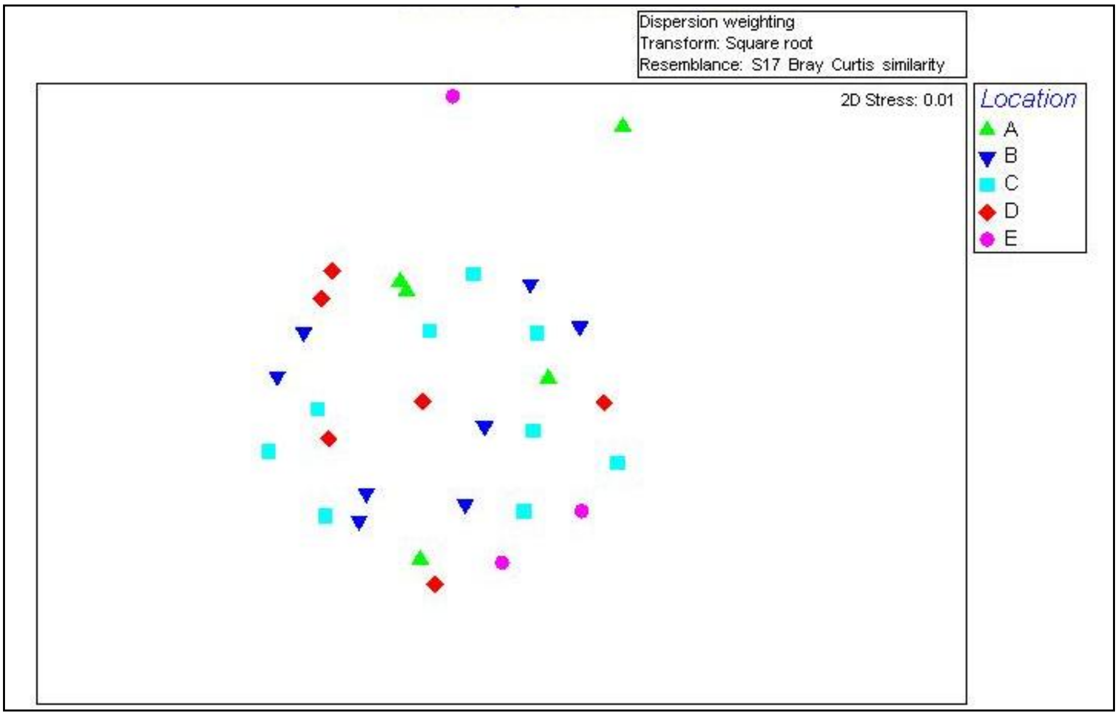

Figure 3.5: nonmetric Multi-Dimensional Scaling (nMDS) plot showing the similarities between main assemblage composition determined through frame analysis at sites in Locations A, B, C, D and E. Site 28 was removed as no species were identified through frame analysis

The assemblage composition of conspicuous sessile and mobile fauna between Locations was also significantly different ($P < 0.05$, Table 3.4a), which is clear to see in the nMDS (Figure 3.6).

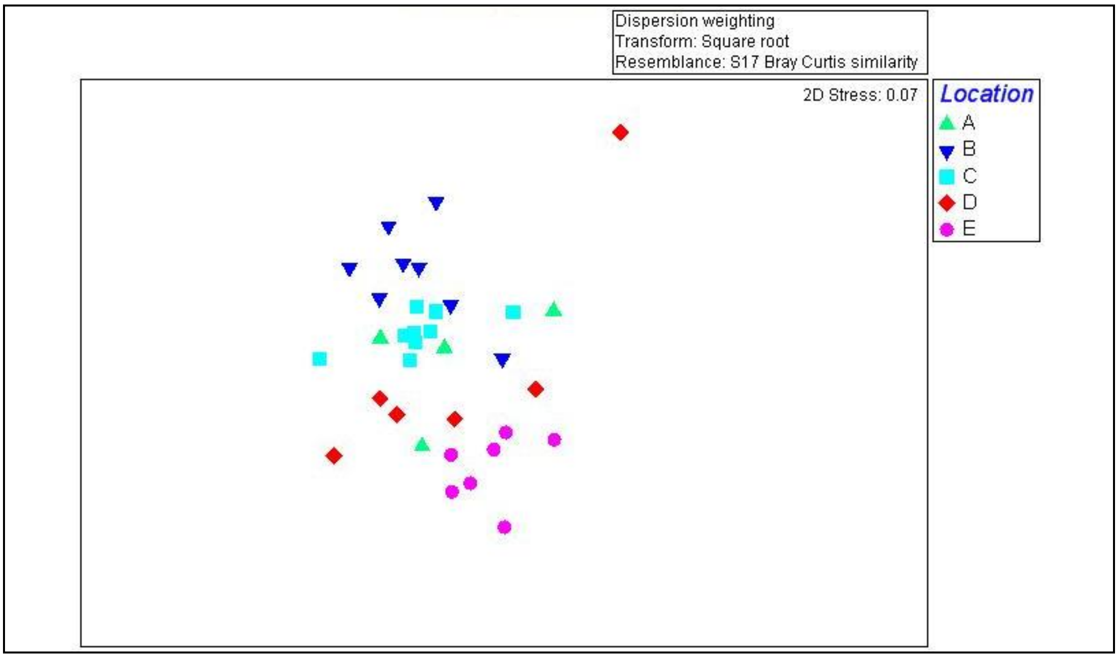

Figure 3.6: nonmetric Multi-Dimensional Scaling (nMDS) plot showing the similarities between composition of conspicuous sessile and mobile fauna determined through video transect analysis at sites in Locations A, B, C, D and E.

The areas in each Location aggregate, showing that they are more similar to each other than to areas in other Locations. Despite this, some areas within Locations were significantly different to each other (P < 0.05, Table 3.3). The infrequent and conspicuous fauna in Location C in the middle of the Big Russel were found to be significantly different to all other Locations indicated by a significant p value = P < 0.05), (Table 3.3b).

Table 3.3: Results of a) Permanova analysis for the relative distribution of the conspicuous sessile and mobile species identified using video transect data in response to the fixed factor Location (Lo) and random factors Area (Ar) and Site (Si) and their interactions, and b) pairwise testing for Location showing P values for the differences between Location pairings. Analyses were conducted using Bray Curtis similarities and data were dispersion weighted and square root transformed. P values in bold type are significant

a)

Source	*df*	MS	Pseudo-F	P(perm)
Lo	4	5036.5	2.8667	**0.0006**
Ar(Lo)	12	1725.4	2.1951	**0.0001**
Si(Ar(Lo))	19	786.02	No test	
Total	35			

b)

Location pairings	*P(perm)*
A & B	0.0565
A & C	**0.0146**
A & D	0.4946
A & E	0.2627
B & C	**0.0343**
B & D	**0.0298**
B & E	**0.0092**
C & D	**0.0145**
C & E	**0.0032**
D & E	0.0501

Nonmetric multi-dimensional scaling (Figure 3.6) showed that when considering these species, the differences between Locations were more pronounced, with Locations B and E being most different from each other and one site from Location D differing from all others.

Average similarity between sites within Locations was lowest for Location A (mean = 33.18 %), which is as would be expected due to the presence of two sandy tows. The similarities between sites in the other Locations were higher (mean = 61.83 %) with the greatest similarities found between sites within Location C (mean = 67.91 %).

SIMPER analysis determined the species within the assemblage that best explained the similarities seen between sites within the same Location (Table 3.4). Throughout the Big Russel the sessile species which were most abundant were grouped hydroids, the turf category, a few unidentified sponges, *Pomatoceros triqueter* (keelworm), the bryozoan *Celepora pumicosa* in Location E and *Flustra foliacea* in Location B. The infrequent and conspicuous taxa that were observed most often in the Big Russel were *Marthasterias glacialis* (spiny starfish), *Henricia oculata* (bloody henry starfish) *Alcyonium digitatum* (dead man's fingers) and the crabs *Maja squinado* (spiny spider crab *Necora puber* (velvet swimming crab) and *Cancer pagurus* (edible crab) (Table 3.4).

Table 3.4: Results of SIMPER analysis to determine the taxa whose abundance contributes most to the similarities seen between Locations for a) Frame and b) Video transect data. Average similarity (%) is given for sites within each Location along with average abundance (AvAbund) of the six species contributing most (Contrib%) to similarity of sites within each Location

a)

Frames	Av.Abund	Contrib%
Location A (Average similarity: 38.81)		
Hydspp	0.63	16.19
Turf	0.65	14.62
Spoenc4	0.5	11.54
Redalg	0.42	10.97
Spoenc1	0.52	9.78
Spoenc2	0.48	7.76
Location B (Average similarity: 65.67)		
Hydspp	0.93	20.14
Turf	0.68	13.2
Spoenc1	0.6	11.51
Redalg	0.61	11.02
Flufol	0.55	10.37
Spoenc2	0.48	9.18
Location C (Average similarity: 66.15)		
Hydspp	0.97	21.31
Turf	0.77	14.53
Redalg	0.48	9.26
Spoenc4	0.45	8.57
Spoenc1	0.46	7.5
Spoenc2	0.38	5.9
Location D (Average similarity: 61.34)		
Hydspp	0.92	20.81
Turf	0.82	17.61
Pomtri	0.7	12.96
Spoenc2	0.52	8.31
Spoenc1	0.5	6.78
Nemant	0.38	5.2
Location E (Average similarity: 56.38)		
Turf	0.8	16.76
Spoenc4	0.8	15.86
Hydspp	0.73	15.15
Celpum	0.73	13.6
Spoenc1	0.7	12.53

b)

Video transects	Av.Abund	Contrib%
Location A (Average similarity: 27.54)		
Margla	1.45	24.71
Alcdig	0.8	13.37
Henocu	0.81	9.7
Ammtob	0.34	8.8
Penfas	0.63	8.68
Canpag	0.52	6.22
Location B (Average similarity: 63.25)		
Margla	1.66	17.76
Henocu	1.55	13.8
Clicel	1.19	12.4
Canpag	1.32	11.1
Cterup	1.21	10.92
Necpub	1.05	8.37
Location C (Average similarity: 69.66)		
Margla	1.93	15.88
Henocu	1.72	15.04
Polbol	1.25	10
Alcdig	1.15	8.81
Canpag	0.97	8.23
Braspo1	1.05	8.05
Location D (Average similarity: 50.80)		
Margla	1.18	18.36
Penfas	1.39	14.06
Henocu	1.01	13.35
Braspo2	1.45	12.06
Polbol	1.1	8.88
Braspo4	0.95	6.67
Location E (Average similarity: 61.38)		
Braspo2	1.3	15.75
Margla	1.41	15.59
Henocu	0.99	11.54
Penfas	1.04	10.41
Alcdig	0.65	7.02

Penfas	0.67	11.85	Majsqu	0.78	5.85

3.3. Assemblage composition and habitat type

Dominant habitat types in the study area were rock (R) and boulders and cobbles (BC). Sand was also found to dominate some frame grabs and was therefore included as a dominant habitat type despite being relatively rare.

The habitat type with the greatest abundance of taxa was the rock habitat (50 taxa present), but the mean abundance of individuals was greatest in the boulders and cobbles habitat (74.33 ind. site^{-1}). Frames dominated by sand were by comparison species poor, with 12 species recorded and mean abundance of taxa 11 ind. site^{-1}. Table 3.5 presents the ten most abundant species and their abundances for these habitat types, showing that although some species were found to dominate consistently across habitat types, their abundance was much greater where rock and boulders & cobbles were the dominant habitat type in the frame.

Table 3.5: The ten species from frame analysis with the greatest abundance (Ab.) where rock, boulders & cobbles and sand were the dominant habitat type. Data are percentage of frames containing each species for each habitat type. Gravel and pebbles were excluded as they did not dominate the habitat in any frame. Please refer to Table 3.1 for full species names

Rock		Boulders & Cobbles		Sand	
Sp. code	**Ab.**	**Sp. code**	**Ab.**	**Sp. code**	**Ab.**
Turf	72.17	Hydspp	72.73	Hydspp	20.00
Hydspp	65.41	Turf	65.16	Redalg	20.00
Spoenc1	61.77	Pomtri	50.19	Spoenc4	15.00
Pomtri	51.77	Spoenc4	31.32	Turf	15.00
Spoenc2	50.10	Flufol	28.05	Alcdig	5.00
Spoenc4	33.54	Spoenc1	26.40	Ammtob	5.00
Spoenc3	33.33	Spoenc2	25.58	Calziz	5.00
Nemant	30.00	Nemant	24.63	Dengro	5.00
Alcdig	25.20	Penfas	20.15	Halhal	5.00
Redalg	23.74	Alcdig	19.71	Nemant	5.00

The species present in the sand habitats were mostly species that were associated with rocky substrata in the sandy habitat, with the exception of *Ammodytes tobianus* (Sand eel) as epifauna was only present in these habitats when the frame contained hard substrata.

Figure 3.7 shows that the species assemblage composition data (frame data), averaged over sites can be partially explained by habitat type. Sites where boulders and cobbles (BC) dominated the frames show some aggregation, which indicates that the species assemblage composition at those sites with the same habitats were similar. Sites where rock (R) dominated the frames also show similarities between species assemblage composition. The site dominated by rock and sand (RS) is site

26 (Location A), which is shown to be dissimilar to all other sites, indicated by the red diamond on the left side of the ordination.

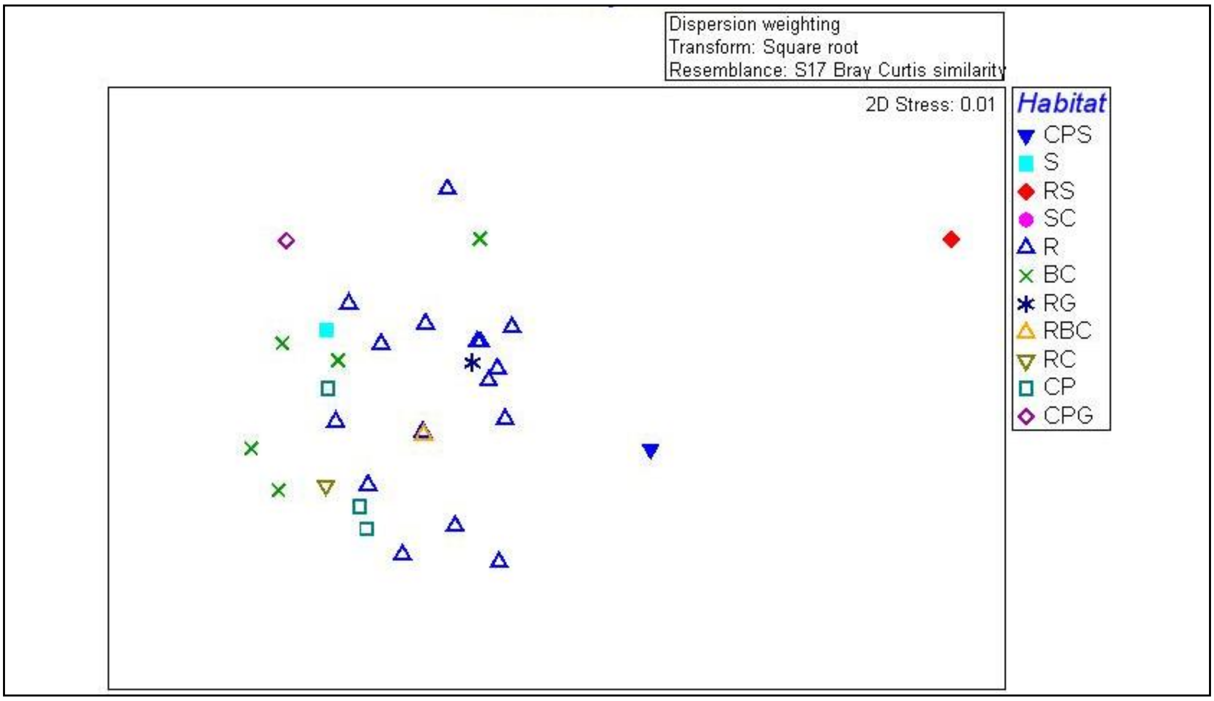

Figure 3.7: nonmetric Multi-Dimensional Scaling (nMDS) plot showing the similarities between species assemblages at different sites based on habitat type. Habitat type is the dominant type per tow calculated from the frame analysis (R (rock), B (boulders), C (cobbles), P (pebbles), G (gravel), and S (sand)), (see Table 2.2 for details)

Hard substrate

Below are some examples of frames where the dominant habitat type was rock, boulders, or cobbles (Figures 3.8 & 3.9). As discussed above, the habitats are very species rich, and due to the tide swept environment they tend to be characterised by species such as encrusting sponges, *Alcyonium digitatum*, *Pentapora fascialis* and *Flustra foliacea* which grow close to the substratum probably as a result of the strong tides found in the Big Russel.

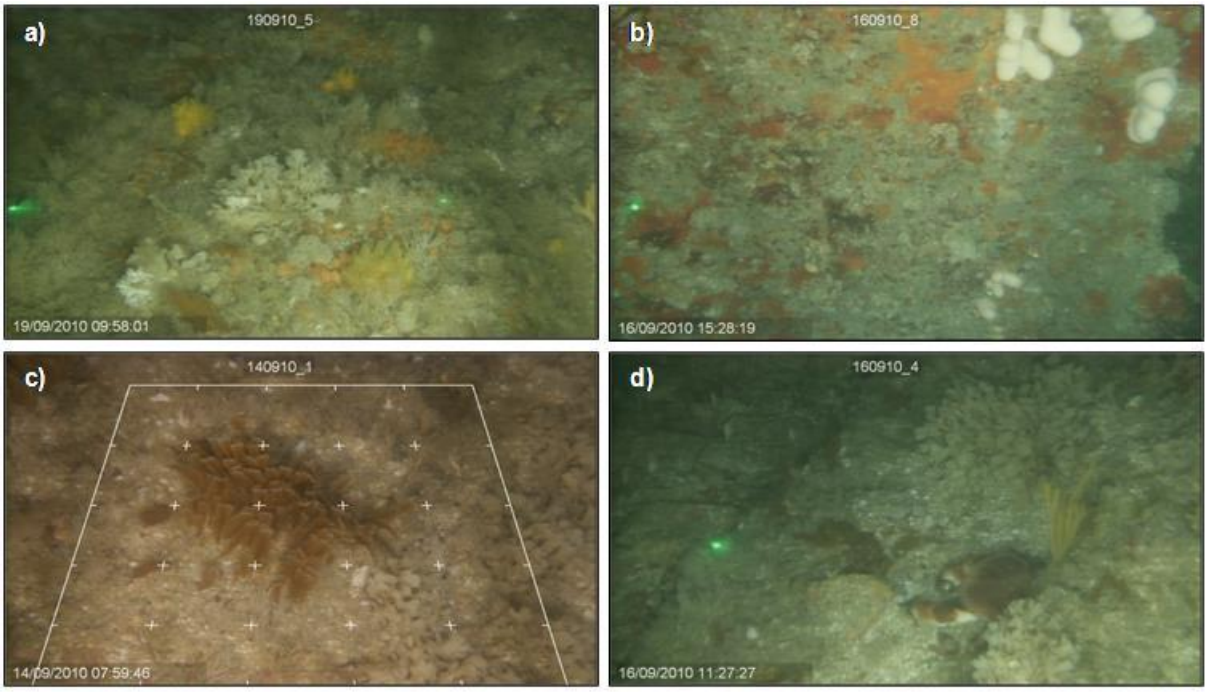

Figure 3.8: Examples of rock habitats with species including a) *Flustra foliacea* (Hornwrack), *Dendrodoa grossularia* (Baked bean ascidian), *Polymastia boletiformis* (A massive sponge), b) *Alcyonium digitatum* (Dead man's fingers), encrusting sponges, c) *Gymnangium montagui* (Yellow feathers) and d) *Cancer pagurus* (Edible crab, shanker) and branching sponges

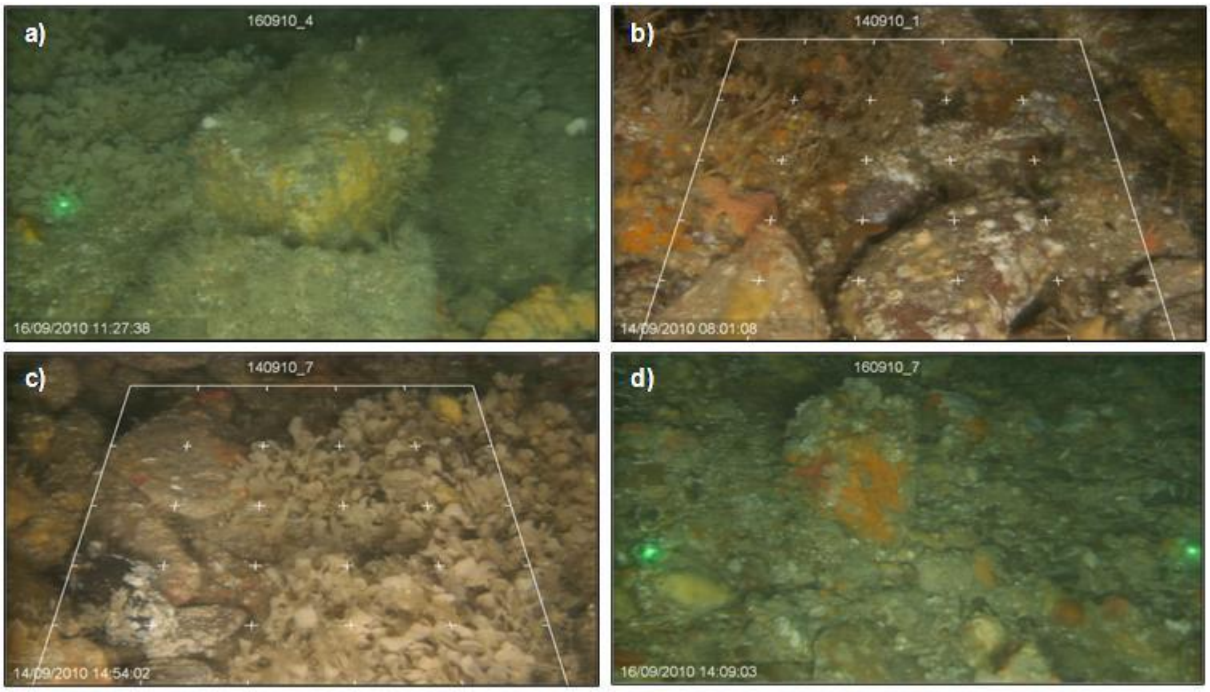

Figure 3.9: Examples of boulder, cobble and mixed boulder, cobble, pebble habitats with species including a) *Alcyonium digitatum* (Dead man's fingers) and encrusting sponges b) *Tubularia indivisa* (A hydroid), *Hemimycale columella* (An encrusting sponge), c) *Flustra foliacea* (Hornwrack), *Pomatoceros triqueter* (keelworms) and d) *Celepora pumicosa* (An encrusting bryozoans and encrusting sponges. Turf is present as a covering on most boulders, cobbles and pebbles in all 4 frames

Soft sediments

Below are examples of frames characterised by gravel and sand (Figure 3.10). As noted above, these are very species poor and for an adequate representation of the species present, sampling of infauna would also be necessary. However, as shown in Figure 3.10d, there are areas where epifauna can develop.

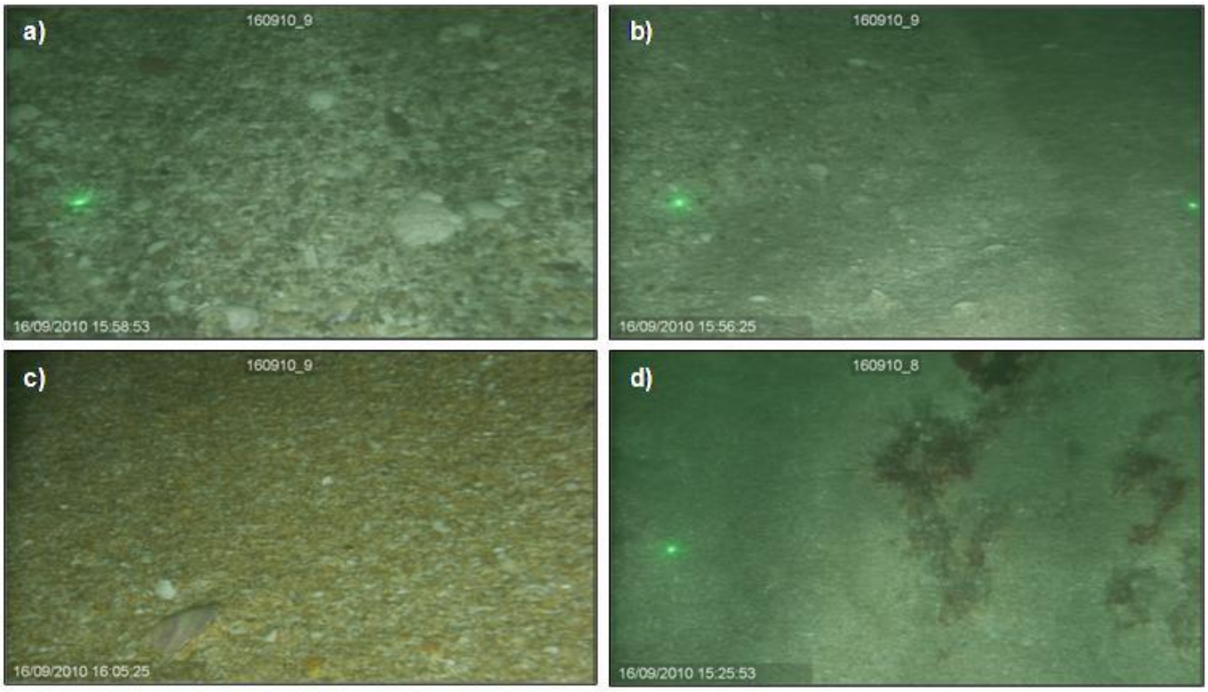

Figure 3.10: Examples of (a), gravel (b) gravel and sand and (c & d) sand habitats with species including d) grouped hydroids and red algae

4. Conclusion

The REA identified potential priority habitats, *Zostera marina* eelgrass beds, maerl beds, and tidal rapids, none of which have been identified during this study. Furthermore, no UK Biodiversity Action Plan (BAP) habitats or BAP species have been identified here. It is important to note however, that rocky reefs such as these do need to be considered in terms of the Habitats Directive Annex 1, and it is crucial that these results are not taken to mean that no BAP species are found in the area, only that this study has not identified them. Species such as the cup coral *Leptopsammia pruvoti* are commonly found in cracks and overhangs and are therefore not likely to be identified through a study using a towed camera which flies above the benthos.

Location E had been suggested by RET as a potential control area away from the likely points for tidal development. Location E however had the lowest number of taxa and abundance. The assemblage of organisms found there was also statistically different to the other Locations. Depending on the location of future developments, comparable un-impacted controls would need to be identified.

This study has provided a baseline assessment of the benthos of the Big Russel. The results can be used to inform the future development of tidal energy devices in the area, through the documentation of the species and habitats present, and once decisions are made regarding the location of devices, these results will allow suitable monitoring sites to be allocated, both those that may be impacted by the devices and appropriate controls.

Acknowledgements

We would like to acknowledge the help and support provided by all of the team at RET, particularly Peter Barnes for his GIS contribution. We would also like to thank Nicola May's crew Shane and Dave, and Mel Broadhurst for the information that she provided.

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