Marine benthic monitoring of the proposed Corrib Gas Pipeline

Pre construction survey

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INTRODUCTION

Background

A gas pipeline will be laid from the Corrib Gas Field, situated approximately 65 km to the west of the Mullet Peninsula, to a landfall in Broadhaven Bay. Enterprise Energy Ireland Ltd (EEI), the operator of the pipeline has been requested by the Department of Communications, Marine and Natural Resources (DOCMNR), to carry out monitoring works, pre, during and post installation of the pipeline in the vicinity of the landfall.

The DOCMNR is concerned that the installation of the pipeline will create elevated levels of suspended solids that will be redistributed and in turn will cause impacts to the resident fauna of the area. The DOCMNR has requested that a series of surveys be undertaken by an independent contractor to establish the baseline conditions in the Bay, and provide comparable sets of data post construction.

Ecological Consultancy Services Limited (EcoServe) were commissioned by EEI to provide the initial baseline study of the marine fauna present in Broadhaven Bay which are likely to be impacted upon prior to the construction of the pipeline though the site. The survey will be followed with additional survey work one month, six months and twelve months after the pipeline has been constructed.

Study area

Broadhaven Bay is a large bay situated between the north-east side of the Mullet Peninsula and the north-west Mayo coast. It is exposed to prevailing winds and wave action diminishes from the mouth toward the head of the bay. The bay supports a range of marine habitats from extremely exposed bedrock at the entrance, to sheltered sediments in the inner bay. However the majority of the seabed is sedimentary ranging from coarse sand in exposed areas to finer sand in more sheltered areas in the inner bay (Picton and Costello, 1999).

METHODOLOGY

The DOCMNR has requested that samples be taken from six locations on six transects which cross the pipeline route totalling 36 stations. The locations of these sites are shown in Appendix1, Figure 1, and are located at 10, 50 and 500m from the pipeline route on both sides.

Stations were located using a differential GPS and the survey boat was anchored over the station to minimise drift during sampling. At each station two sampling techniques were employed. Firstly a Remotely Operated Vehicle (ROV) was used to take video footage of the seabed and to identify the suitability of the site for grab sampling. Secondly grab samples were taken for infauna and sediment analysis.

Remotely Operated Vehicle (ROV)

A VideoRay ROV was used to visually survey each of the sample stations prior to grab samples being taken. The unit consisted of a full colour video camera, with twin variable illumination halogen lights, a depth gauge and a compass. Twin horizontal thrusters and a vertical thruster manoeuvred the ROV underwater. The unit was controlled from the surface via a video monitor, with footage recorded directly to video cassette. The high

manoeuvrability and portability of the ROV enabled a comprehensive survey of the marine flora and fauna within the area of each station.

The video samples were returned to the laboratory for examination to identify and describe the marine habitats and species present.

Infaunal grab samples

Three replicate samples were taken at each station using a $0.1m^2$ stainless steel van Veen grab fitted with 17 kg weights. Each replicate sample was then sieved separately through a 0.1cm stainless steel sieve and the material retained was preserved in 70% Industrial Methylated Spirits (IMS) and returned to the laboratory for identification.

Infaunal analysis

In the laboratory specimens were identified to the lowest possible taxonomic level, using:

Crothers and Crothers (1988)	crabs
Fauchald 1997	polychaete worms
Graham (1988), Tebble (1976) and Picton and Morrow (1994)	molluscs,
Hayward and Ryland (1995)	other taxa
Lincoln (1979)	amphipods
Makings (1977)	mysid crustaceans
Picton (1993)	echinoderms
Smaldon (1993)	shrimps and prawns
Wheeler (1978)	fish

A voucher collection of representative specimens was made. Species nomenclature follows Howson & Picton (1997).

Sediment grab samples

A sub sample of sediment was taken from the first successful grab sample at each station. This sample was labelled and retained in an unpreserved state for further analysis in the laboratory.

Granulometric analysis

Each sediment sample was dried, weighed and passed through a series of sieves of known mesh size. The amount of material retained on each sieve was weighed and the percentage of the total mass of the sample calculated.

The results were then compared with standard sediment scales (Wentworth, 1922 and Folk, 1954).

Loss on ignition

A sub sample of each dry sediment sample was taken and weighed. It was then placed in an oven at 815°C to burn off any organic matter. The sample was then reweighed and the mass of organic matter calculated as a percentage of the total sub sample.

RESULTS

Remotely Operated Vehicle (ROV)

Video samples were collected from all the stations and the results are supplied on the enclosed video cassette. During their examination the main substratum, habitats and species were noted (Appendix 2, Table 2). Still images of representative habitats and species made from the video at most of the sites (Appendix 4).

Infaunal grab samples

Grab samples were taken from each station identified from the video to be sedimentary (Appendix 2, Table 1).

Infaunal analysis

Currently 78 species or higher taxa have been identified (Appendix 2, Table 3). This number is likely to increase with further analysis of some groups, particularly the polychaete worm. The dominant taxa are polychaete worms (23 species or higher taxa), crustaceans (mostly amphipods) (21 species or higher taxa), molluscs (particularly bivalves) (20 species or higher taxa) and echinoderms (starfish, brittlestars and sea urchins) (11 species or higher taxa). The number of taxa appears to increase towards the entrance to the bay (Appendix 3, Figure 1) reaching a peak at Transects D and E.

The polychaetes were also the most numerically abundant taxa (837 individuals recorded), followed by the molluscs (485 individuals) and crustaceans (456 individuals). Echinoderms followed with 262 individuals and, although only one Anthozoa taxa was recorded 112 individuals were present. The number of individuals per station also appears to increase towards the entrance to the bay (Appendix 3, Figure 2) reaching a peak at Transect D despite only four stations being sampled on Transect B and only five stations on Transect C and F.

Sediment grab samples

Granulometric analysis

Analysis of the sediment grain size showed that the seabed of Broadhaven Bay is in general uniformly sand, when using the scale developed by Folk (Folk 1954, Appendix 6) although when using the more divided Wentworth scale (Wentworth (1992, Appendix 6) the seabed varies from very coarse sand to medium sand (Appendix 2, Table 4). The majority of the sites towards the inner bay (Transects A – D) are medium sand apart from site A1 which is very coarse sand. Towards the outer bay (Transects E and F) the sediment is predominantly coarse sand although medium sand occurs to the east of each transect.

The results of the granulometric analysis are given in full in Appendix 5. No sediment samples were analysed from stations B1, B6, D6, F6 and Ref 2, as the substratum was bedrock and boulders.

Loss on ignition

The organic component in the sediment varies between 0.02% at site D6 up to 21.41% at site E1 (Appendix 2, Table 5). Transect D across the centre of the bay has the lowest values of any transect whilst the south side of the bay (stations A1, C1 etc) are generally high than the north side of the bay (stations A6, D6 etc).

No sediment samples were analysed from stations B1, B6, D6, F6 and Ref 2 as the substratum was bedrock and boulders.

DISCUSSION

Remotely Operated Vehicle (ROV)

The video samples clearly indicate the extent of the sandy habitat within Broadhaven Bay. For many of the stations it was not possible to identify any infaunal species. However they did give an overview of the epifauna communities present including fish, crabs and starfish which would be unlikely to be recorded in the grab samples.

The video samples gave a good overview of the rock habitats encountered at stations A1, B1, B5, B6, C6 and Ref 2 which would otherwise not be sampled using grab techniques. The rock habitats varied from sand influenced infralittoral bedrock and boulders at the shallowers stations (A1, B1, B5, B6 and C6) to deep circalittoral bedrock at Ref 2. The shallower station supported kelp plants with a sparse understorey of red algae. The high water and sediment movement in this habitat possibly restricts the growth of foliose red algae on stable boulders and bedrock. Attached fauna, tunicates *Aplidium punctum*, dead mans fingers *Alcyonium digitatum* and the sponges *Cliona celata* and *Polymastia* sp. were restricted to areas of bedrock subject to less scouring. Mobile fauna such as the sea urchin *Echinus esculentus*, the sea cucumber *Holothuria forskali* and starfish *Asterias rubens* and *Marthasterias glacialis* were found on all areas of the rock but probably avoid areas of high scour when conditions prevail. At site B6 and C6 the water was deeper and the rock was most likely subject to less scour except during stormy conditions. At these sites the bedrock supported a kelp park with a more established understorey of brown and red algae. At station Ref 2 the water was in excess of 70m deep. At this depth it is unlikely that algae will occur due to the reduced light penetration through the water column. Therefore animals dominated the organisms that occurred there. Although it was not possible to examine the seabed closely due to limitations in the ROV it was possible to identify a number of echinoderm, species the sea urchin *Echinus esculentus*, the sea cucumber *Holothuria forskali* and starfish *Luidia ciliaris* and the sponge *Cliona celata*.

None of the species identified from the video samples are of specific nature conservation importance and are widespread in Ireland (Picton and Costello, 1999).

Infaunal grab samples

Broadhaven Bay is uniformly sandy and this is reflected in the faunal taxa recorded in the grab samples. None of the species identified are of specific nature conservation importance and are widespread in Ireland (Picton and Costello, 1999).

Infaunal analysis

The number of taxa recorded from each station appears to increase from Transect A at the head of the bay to Transects D and E towards the entrance to the bay. There is a slight decrease at Transect F. The number of taxa at station Ref 1 is comparable to stations along transects D and E. The granulometric analysis shows that there is a very slight gradient from medium sand to coarse sand towards the head of the bay. The exception being station A1, which was very coarse sand. At this station the number of taxa recorded was also low.

The number of individuals recorded from each station also shows a general increase from Transect A to Transect D before decreasing towards Transects E and F. Although these very general trends occur it is not possible to fully correlate the number of taxa and individuals to sediment type, depth or amount of organic matter (LOI). Further analysis will be carried out following the remaining sampling trips.

The dominant taxa occurring at every site were the polychaete worms with 23 species or higher taxa recorded. The polychaetes were more numerically abundant at Transects C, D and E towards the centre of the bay. Crustaceans (mostly amphipods) were also well represented with 21 species or higher taxa recorded. Unlike the polychaetes the crustaceans were more numerically abundant towards the head of the bay at transects A and B. The molluscan fauna which was dominated by bivalves particularly *Chamelea gallina* were also numerically dominant toward the middle of the bay (Transects C, D and E). Twenty species or higher taxa were recorded. The echinoderms (starfish, brittlestars and sea urchins) also followed this pattern. The number of taxa appears to increase towards the entrance to the bay (Appendix 3, Figure 1) reaching a peak at Transects D and E.

The species recorded from this survey are similar to those recorded during the benthic sampling for the Offshore Environmental Impact Statement (Enterprise Energy Ireland Ltd 2000).

Sediment grab samples

Granulometric analysis

The granulometric analysis shows that there is a very slight gradient from medium sand to coarse sand towards the head of the bay. The exception was station A1, which was 'very coarse sand'. This site is shallow (11.2 m BSL) and adjacent to bedrock outcrops on the south side of the bay. It is likely that the close proximity of the hard substratum locally intensifies the water movement from wind and waves causing an increase in mobility of the sediments. An increase in sediment movement may result in the loss of the finer sediment particles resulting in generally coarser sediment than the rest of the bay.

Sediments in the middle of the bay are 'medium sand' with very low or no 'silt' or 'mud' present. Towards the entrance of the bay along Transects E and F the sediment is 'coarse sand' also with little or no 'mud' or 'silt' present.

Loss on ignition

It is not easy to explain the patterns in the organic carbon content of the sediments. Organic content would arise from organisms and their by-products, from material washed into the bay from the open ocean and material transported down the river system for example wood and peat. However it is unclear as to the source of the low LOI value at Transect D or high LOI value at station D1.

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APPENDIX 1. MAP

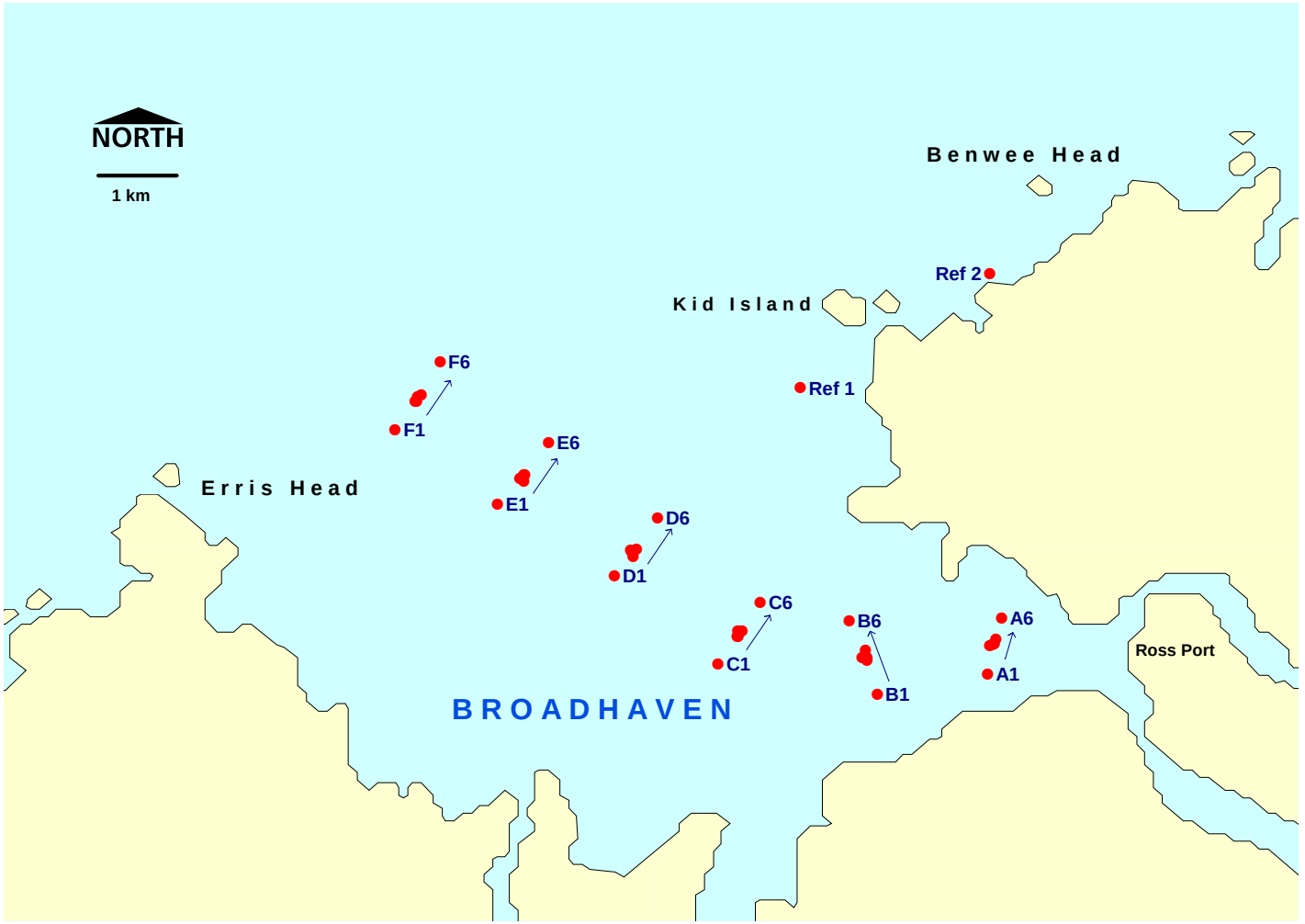


Figure 1. Map showing locations of the ROV and grab sample sites in Broadhaven Bay.

APPENDIX 2. TABLES

Table 1. Details of sublittoral grab and sediment sampling stations.

Station	Latitude and longitude	Depth (m)	Time	Grab	Sediment	Video	Date
A1	54.2821N 9.84133W	11.2	-	✓	✓	✓	01/06/02
A2	54.2848N 9.84053W	12.5	-	✓	✓	✓	01/06/02
A3	54.2851N 9.84043W	12.2	12:30	✓	✓	✓	01/06/02
A4	54.2853N 9.84037W	11.4	13:43	✓	✓	✓	01/06/02
A5	54.2857N 9.84027W	11.7	14:00	✓	✓	✓	01/06/02
A6	54.2883N 9.83947W	9.9	14:25	✓	✓	✓	01/06/02
B1	54.2797N 9.86354W	19.5	15:35	×	×	✓	01/06/02
B2	54.2835N 9.86579W	22.9	16:05	✓	✓	✓	01/06/02
B3	54.2838N 9.86599W	23	16:55	✓	✓	✓	01/06/02
B4	54.284N 9.86608W	23.5	17:20	✓	✓	✓	01/06/02
B5	54.2843N 9.86628W	24.2	17:45	✓	✓	✓	01/06/02
B6	54.2882N 9.86854W	23.4	18:10	×	×	✓	01/06/02
C1	54.283N 9.89506W	29.5	9:24	✓	✓	✓	02/06/02
C2	54.2863N 9.89099W	30	9:59	✓	✓	✓	02/06/02
C3	54.2866N 9.89063W	30	10:23	✓	✓	✓	02/06/02
C4	54.2867N 9.89045W	30.7	10:40	✓	✓	✓	02/06/02
C5	54.287N 9.89009W	29.9	11:08	✓	✓	✓	02/06/02
C6	54.2903N 9.88602W	22.4	11:21	×	×	✓	02/06/02
D1	54.292N 9.91643W	38	13:00	✓	✓	✓	02/06/02
D2	54.2953N 9.91238W	40.3	13:30	✓	✓	✓	02/06/02
D3	54.2955N 9.91202W	39.9	13:52	✓	✓	✓	02/06/02
D4	54.2957N 9.91184W	39.9	14:08	✓	✓	✓	02/06/02
D5	54.296N 9.91148W	39.8	14:24	✓	✓	✓	02/06/02
D6	54.2993N 9.90743W	42	14:42	✓	✓	✓	02/06/02
E1	54.3009N 9.93783W	45.7	16:00	✓	✓	✓	02/06/02
E2	54.3042N 9.93378W	45.6	16:16	✓	✓	✓	02/06/02
E3	54.3045N 9.93342W	45.5	16:28	✓	✓	✓	02/06/02
E4	54.3047N 9.93324W	45.6	16:48	✓	✓	✓	02/06/02
E5	54.305N 9.93288W	47.6	17:05	✓	✓	✓	02/06/02
E6	54.3082N 9.92882W	47.9	17:25	✓	✓	✓	02/06/02
F1	54.3099N 9.95918W	44	19:48	✓	✓	✓	02/06/02
F2	54.3132N 9.95517W	45.4	18:23	✓	✓	✓	02/06/02
F3	54.3135N 9.95481W	45.6	18:45	✓	✓	✓	02/06/02
F4	54.3136N 9.95463W	45.7	19:10	✓	✓	✓	02/06/02
F5	54.3139N 9.95427W	46	18:23	✓	✓	✓	02/06/02
F6	54.3172N 9.95025W	48.9	17:58	×	×	✓	02/06/02
Ref 1	54.3078N 9.86144W	47.3	12:30	✓	✓	✓	02/06/02
Ref 2	54.3281N 9.84086W	70		×	×	✓	11/07/02

Table 2. Details of ROV surveys.

Site	Substratum	Description
A1	A plain of coarse rippled sand adjacent to bedrock and boulders	Boulders and bedrock supported large kelp plants *Laminaria hyperborea* with red algae (*Dilsea carnosa*) forming a sparse understorey. Scour on more exposed rock likely due to the movement of the sand.
A2	Plain of rippled fine sand	Fine sand with drift algae and other organic debris. No obvious infauna or epifauna.
A3	Plain of rippled fine sand	Fine sand with drift algae and other organic debris. No obvious infauna or epifauna.
A4	Plain of rippled fine sand	Fine sand with drift algae and other organic debris. No obvious infauna or epifauna.
A5	Plain of rippled fine sand	Fine sand with drift algae and other organic debris. No obvious infauna or epifauna.
A6	Plain of rippled fine sand	Fine sand with dense drift algae and other organic debris. No obvious infauna or epifauna.
B1	Bedrock and boulders with patches of coarse sand and gravel	Bedrock supported sparse kelp with coralline crusts on the rock surface. Few red algae on or beneath the kelp, although some *Delesseria sanguinea*, probably due to the high scour caused by mobile cobbles and gravel. Shoal of saithe (*Pollachius virens*).
B2	Plain of rippled and ridged fine sand	Fine sand with sparse drift algae and other organic debris. No obvious infauna or epifauna.
B3	Plain of rippled and ridged fine sand	Fine sand with sparse drift algae and other organic debris. No obvious infauna or epifauna.
B4	Plain of rippled and ridged fine sand	Fine sand with sparse drift algae and other organic debris. No obvious infauna or epifauna.
B5	Plain of fine rippled sand adjacent to a large area of bedrock	Scoured bedrock with very sparse fauna including *Alcyonium digitatum*, *Calliostoma zizyphinum*, *Holothuria forskali* and the sponge *Polymastia* sp. The colonial tunicate *Aplidium punctatum* was quite common on the rock with small *Asterias rubens*. No obvious algal growth apart from coralline crusts on the rock surface. The more scoured parts of the rock had the keel worm *Pomatoceros* sp. Sediment supported no obvious infauna or epifauna although some filamentous green algae present which appeared to accumulate at the sediment rock interface.
B6	Bedrock and boulders	Scoured bedrock with sparse fauna including the sea urchin *Echinus esculentus*, dead man's fingers *Alcyonium digitatum*, the starfish *Marthasterias glacialis*, bryozoan crusts, and the sponge *Cliona celata*. The surface of the rock had dense coralline crusts with few other erect algae.
C1	Plain of mobile sand formed into large ripples	Fine sand with no obvious infauna or epifauna apart from one *Marthasterias glacialis*. Little drift material.
C2	Plain of mobile sand formed into large ripples	Fine sand with no obvious infauna or epifauna. Little drift material
C3	Plain of mobile sand formed into large ripples	Fine sand with no obvious infauna or epifauna. Little drift material.
C4	Plain of mobile sand formed into large ripples	Fine sand with no obvious infauna or epifauna. Little drift material.
C5	Plain of mobile sand formed into large ripples	Fine sand with no obvious infauna or epifauna. One small flatfish recorded. Little drift material.

Site	Substratum	Description
C6	Bedrock with small boulders and cobbles.	Bedrock supporting *Laminaria hyperborea* kelp park with a sparse understorey of red and brown algae including *Delesseria sanguinea* and *Cryptopleura ramosa.* The kelp fronds were covered with hydroids, possibly *Dynamena pumila*, and encrusting bryozoans with the occasional gastropod *Calliostoma zizyphinum.* The rock supported dense coralline and bryozoan crusts with *Echinus esculentus, Alcyonium digitatum and* the sponge *Cliona celata*,
D1	Rippled sand	No obvious infauna or epifauna. Very little drift material (no image).
D2	Rippled sand	No obvious infauna or epifauna. Very little drift material.
D3	Rippled sand	No obvious infauna or epifauna. Very little drift material. One starfish *Astropecten irregularis* (no image)
D4	Rippled sand	No obvious infauna or epifauna. Very little drift material. One starfish *Luidia ciliaris* and a small crab *Liocarcinus* sp.
D5	Rippled sand	No obvious infauna or epifauna. Very little drift material. One hermit crab possibly a *Pagurus bernhardus*.
D6	Rippled sand	No obvious infauna or epifauna. Very little drift material. One flatfish possibly a plaice *Pleuronectes platessa*.
E1	Rippled sand	No obvious infauna or epifauna. Very little drift material.
E2	Rippled sand	No obvious infauna or epifauna. Very little drift material.
E3	Rippled sand	No obvious infauna or epifauna. Very little drift material. One hermit crab possibly a *Pagurus bernhardus*.
E4	Rippled sand	No obvious infauna or epifauna. Very little drift material. One fish possibly a grey gurnard *Eutrigla gurnardus* part buried in the sand.
E5	Rippled sand	No obvious infauna or epifauna. Very little drift material. One edible crab *Cancer pagurus* part buried in the sand.
E6	Rippled sand	No obvious infauna or epifauna. Very little drift material. One edible crab *Cancer pagurus* and several hermit crabs probably *Pagurus bernhardus*.
F1	Rippled sand	No obvious infauna or epifauna. Very little drift material.
F2	Rippled sand	No obvious infauna or epifauna. Very little drift material.
F3	Rippled sand	No obvious infauna or epifauna. Very little drift material.
F4	Rippled sand	No obvious infauna or epifauna. Very little drift material. One starfish *Astropecten irregularis*.
F5	Rippled sand	No obvious infauna or epifauna. Very little drift material.
F6	Rippled sand	No obvious infauna or epifauna. Very little drift material.
Ref 1	Rippled sand	No obvious infauna or epifauna. Very little drift material.
Ref 2	Bedrock and boulders	Kelp free bedrock with the sea urchin *Echinus esculentus*, sea cucumber *Holothuria forskali*, the sponge *Cliona celata* and the starfish *Luidia ciliaris*

Table 3. Infaunal species and their abundance recorded from sublittoral grab samples. Numbers are the sum of three replicate 0.1m^2 van Veen samples.

Species	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B2**	**B3**	**B4**	**B5**	**C1**	**C2**	**C3**	**C4**	**C5**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**Ref1**
ANTHOZOA (sea anemones)																																	
Edwardsiidae indet.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	25	4	20	15	10	2	6	3	3	7	9	1	1	1	1	1	-	2
PLATYHELMINTHES (flat worms)																																	
Turbellaria indet.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NEMERTEA (bootlace worms)																																	
Lineus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
SIPUNCULA (peanut worms)																																	
Sipuncula indet.	-	-	-	-	-	-	-	-	1	-	1	-	10	-	-	3	-	3	4	-	4	6	1	6	-	4	7	-	2	2	-	-	4
ANNELIDA (round worms)																																	
Aphroditoidea indet.	-	-	-	-	-	-	1	2	-	-	-	3	5	1	5	7	1	5	2	1	1	1	1	1	2	3	2	1	-	-	-	-	9
Phyllodocidae indet.	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	1	-	-	2	-	-	1	-	-	-	-	-	-	-
Pirakia punctifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Glyceridae indet.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	1	-	1	-	-	3	-	1	-	2	1	1	-	-
Glycera alba	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereidae indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Neanthes fucata	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nephtys sp.	-	9	8	9	12	5	12	15	5	8	-	1	5	1	4	1	2	3	3	3	2	4	8	7	-	5	1	7	6	5	6	4	3
Nephtys caeca	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-
Eunicidae indet.	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	1	1	-	2	1	-	2	2	1	3	-	2	2	-	-	-	2	1
Arabella iricolor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Orbiniidae indet.	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	2	-	1	-	2	-	1	1	2	-	-	-	-	-	-
Spionidae indet.	-	-	10	-	-	-	1	4	-	-	1	-	-	1	2	-	-	1	3	1	3	2	3	-	1	1	-	4	6	7	2	4	2
Malacoceros fuliginosus	-	-	1	-	-	-	2	5	1	-	2	1	2	2	4	1	1	1	4	4	-	1	9	1	1	9	4	1	-	-	-	3	3
Magelona mirabilis	-	-	1	1	-	-	9	12	3	-	4	16	22	30	15	10	4	10	26	14	10	11	16	15	5	7	11	7	-	-	-	1	4
Cirratulidae indet.	-	-	-	-	1	-	1	2	1	-	5	8	3	8	9	12	12	15	5	8	4	1	1	2	2	1	7	8	1	1	2	1	8
Cirratulus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species	A1	A2	A3	A4	A5	A6	B2	B3	B4	B5	C1	C2	C3	C4	C5	D1	D2	D3	D4	D5	D6	E1	E2	E3	E4	E5	E6	F1	F2	F3	F4	F5	Ref1
Cirriformia tentaculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Opheliidae indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	5	-	1	1	-	-	1	1	-	-	-	-
Ophelina acuminata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Owenia fusiformis	-	-	-	-	-	2	5	2	2	-	2	1	-	-	1	-	2	-	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-
Terebellidae indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Pomatoceros sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
CRUSTACEA (crabs, shrimps and barnacles)																																	
Gastrosaccus sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphipoda indet.	1	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oedicerotidae indet.	-	-	1	2	2	1	2	1	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Hippomedon denticulatus	-	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	2	3	-	-	-	1	-	-	-	2	-	-	1	1	1	5	-
Lysianassidae indet.	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-
Atylus vedlomensis	-	-	1	1	-	-	8	18	13	2	1	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Bathyporeia elegans	-	7	24	6	12	5	30	30	22	10	5	3	3	1	5	-	-	-	-	-	-	1	-	2	-	2	2	5	4	1	-	2	-
Corophium sp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopoda indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
Eurydice sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Eurydice pulchra	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	2	-	-	-	-	1	-	-
Eurydice spinigera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	2	2	3	4	-	2	-	4	8	13	-	10	-
Cumacea indet.	-	-	-	-	-	-	8	1	3	-	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bodotriidae indet.	-	-	5	4	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iphinoe sp.	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iphinoe trispinosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diastylis rugosa	-	-	1	1	-	1	17	13	10	12	-	1	2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Euphausiacea indet.	-	4	1	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Inachus leptochirus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Macropodia tenuirostris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Corystes cassivelaunus	-	-	-	-	-	-	1	-	-	-	2	-	2	1	-	-	-	-	-	-	1	-	1	-	-	1	-	-	2	1	-	-	1
MOLLUSCA (snails, bivalves and sea slugs)																																	
Gastropoda indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbula umbilicalis	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B2**	**B3**	**B4**	**B5**	**C1**	**C2**	**C3**	**C4**	**C5**	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**Ref1**
Polinices catena	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-
Acteon tornatilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Cylichna cylindrica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Retusa truncatula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1
Mactra stultorum	-	-	-	-	-	-	-	-	-	-	1	1	17	-	3	1	2	3	2	2	2	7	1	2	4	2	2	1	-	-	-	1	-
Spisula subtruncata	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellinacea indet.	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fabulina fabula	-	-	-	-	-	-	-	2	1	-	1	1	7	1	1	1	2	-	1	-	-	2	-	3	2	2	1	1	-	3	-	1	-
Moerella donacina	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Donax vittatus	-	-	1	-	-	2	2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gari fervensis	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Abra sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Dosinia sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	3	1	-	2	-	1	5	2	7	-	2	-	-	-	-	-	1
Dosinia lupinus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Dosinia exoleta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	2	2	1	-	-	1	-	-	-	-	-	1	-	-	4
Chamelea gallina	-	-	-	-	-	-	-	-	1	-	6	3	4	-	4	32	17	24	22	47	37	14	9	12	11	6	5	-	-	-	-	-	22
Thracia sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	1	2	-	-	-	1	-	-	-	-	-	-	-	1	-
Cochlodesma praetenue	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	-	3	2	2	2	-	3	6	2	-
ECHINODERMATA (sea urchins and starfish)																																	
Astropecten irregularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Henricia oculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Amphiura brachiata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2	4	4	3	1	1	1	1	-	-	-	-	-	-	-	-	8
Amphiura chiajei	-	-	-	-	-	1	-	3	1	1	2	4	5	3	5	11	6	9	12	23	13	3	2	2	3	4	4	-	1	1	-	2	30
Amphiura filiformis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Amphipholis squamata	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Echinocyamus pusillus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	12	8	6	4	12	2	2	2	3	8	4	-
Spatangus purpureus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Echinocardium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Echinocardium cordatum	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
No. of taxa	**6**	**4**	**13**	**7**	**8**	**9**	**18**	**18**	**18**	**6**	**21**	**15**	**18**	**15**	**16**	**23**	**18**	**22**	**23**	**21**	**17**	**25**	**23**	**23**	**20**	**25**	**21**	**18**	**14**	**16**	**11**	**18**	**21**
No. of individuals	**6**	**21**	**56**	**24**	**36**	**20**	**104**	**118**	**72**	**34**	**44**	**51**	**92**	**58**	**63**	**117**	**68**	**112**	**116**	**130**	**87**	**91**	**87**	**77**	**63**	**82**	**61**	**51**	**38**	**45**	**30**	**47**	**111**

Table 4. Summary results of granulometric analysis for each station on each transect (- denotes no sediment sample taken) VCS = very coarse sand, CS = coarse sand, MS = medium sad, S = sand

	Station					
Transect	**1**	**2**	**3**	**4**	**5**	**6**
(a) Mean phi						
A	0.25	2.08	2.15	2.06	2.28	2.05
B	-	2.32	2.10	2.25	2.19	-
C	2.03	2.29	2.29	2.32	2.28	-
D	2.19	2.00	2.12	2.15	2.16	2.14
E	1.87	1.92	1.96	1.94	1.95	2.41
F	1.66	1.85	1.76	1.79	2.40	-
Ref 1	1.68					
Ref 2	-					
(b) Folk						
A	S	S	S	S	S	S
B	-	S	S	S	S	-
C	S	S	S	S	S	-
D	S	S	S	S	S	S
E	S	S	S	S	S	S
F	S	S	S	S	S	-
Ref 1	S					
Ref 2	-					
(c) Wentworth						
A	VCS	MS	MS	MS	MS	MS
B	-	MS	MS	MS	MS	-
C	MS	MS	MS	MS	MS	-
D	MS	MS	MS	MS	MS	MS
E	CS	CS	CS	CS	CS	MS
F	CS	CS	CS	CS	MS	-
Ref 1	CS					
Ref 2	-					

Table 5. Loss on ignition (% mass) sampling at 815ºC for each station on each transect (- denotes no sediment sample taken)

	Station					
Transect	**1**	**2**	**3**	**4**	**5**	**6**
A	12.98	12.02	2.72	12.25	5.67	10.04
B	-	11.2	18.36	11.23	7.84	-
C	8.92	8.89	11.65	10.44	10.74	-
D	5.12	8.7	5.93	5.79	6.84	0.02
E	21.41	19.08	17.76	16.59	13.15	8.97
F	11.43	8.33	11.98	12.21	7.79	-
Ref 1	11.32					
Ref 2	-					

APPENDIX 3. INFAUNA SUMMARIES

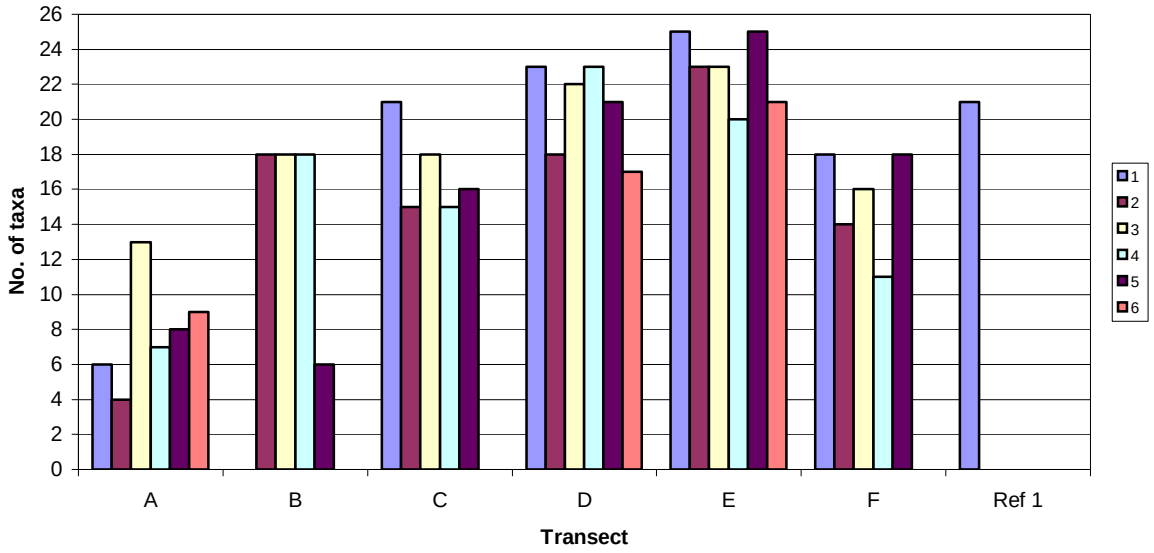


Figure 1. Total number of taxa per station by transect

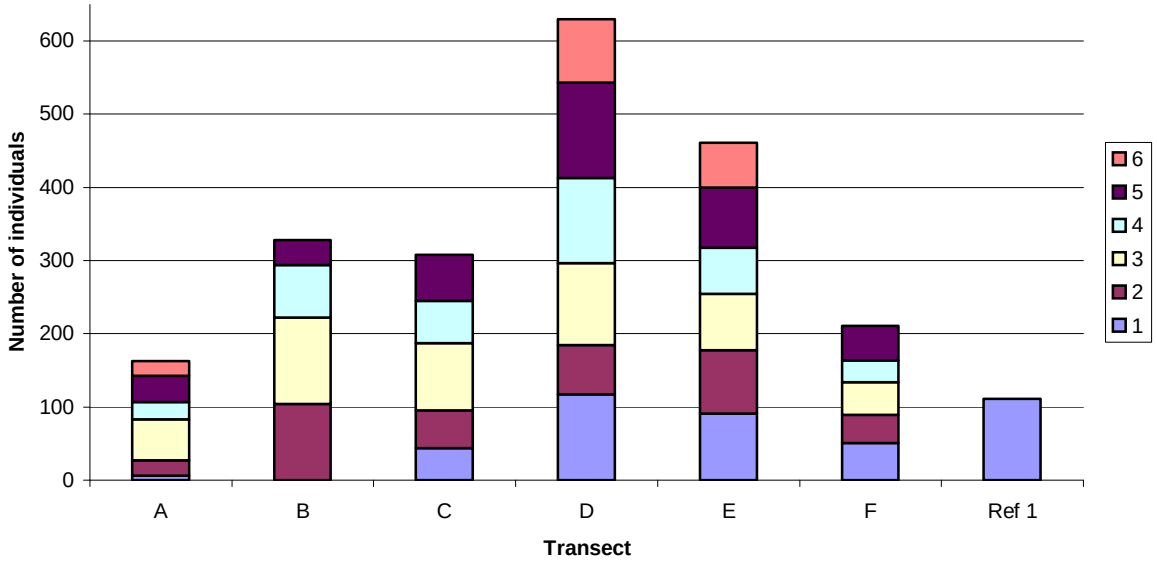
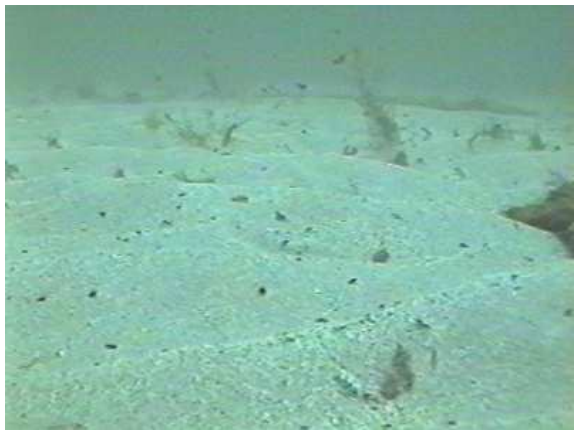


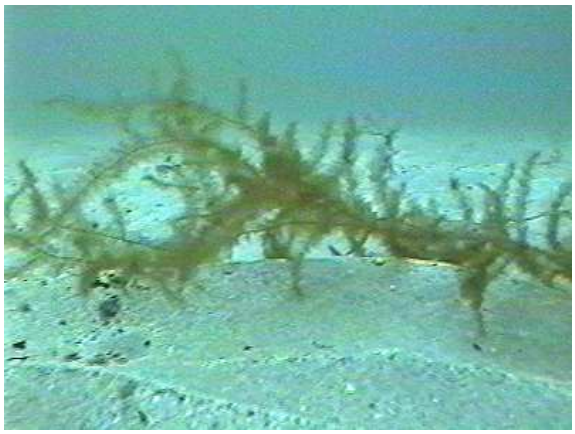
Figure 2. Total number of individuals per station by transects.

APPENDIX 4. PHOTOGRAPHS

Site A1. Coarse sand with kelp covered bedrock and boulders in the distance.



Site A2. Clean mobile sand with drift seaweed.



Site A3. Drift seaweed on clean, rippled sand.

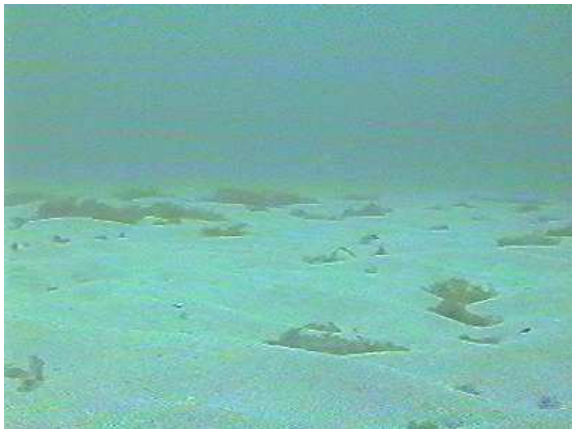
Site A4. Clean rippled sand with drift algae.

Site A5. Rippled sand and drift algae

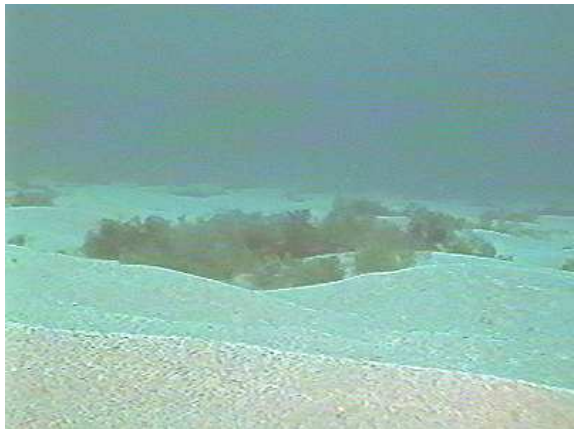
Site A6. Lots of drift algae on rippled clean sand.

Site B1. Bedrock and boulders with sparse kelp plants.

Site B2. Drift algae on slightly rippled sand.



Site B3. Rippled sand with clumps of drift algae.



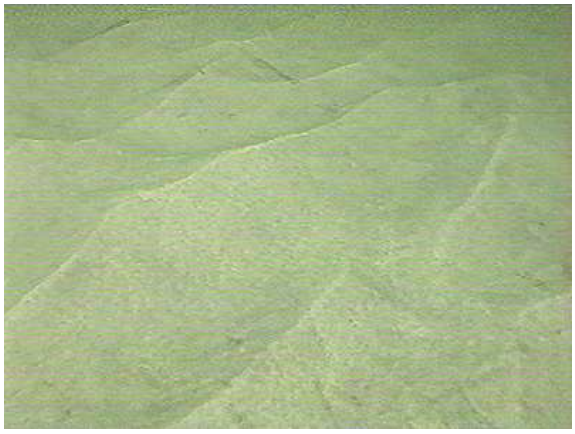
Site B4. Rippled sand with clumps of drift algae.

Site B5. ROV tender lying in front of an outcrop of scoured bedrock with clean sand in the foreground.

Site B6. Bedrock with the soft coral *Alcyonium digitatum* (back left), the sponge *Cliona celata* (middle right) and the sea urchin *Echinus esculentus* (front left).

Site C1. Rippled sand with no obvious infauna.

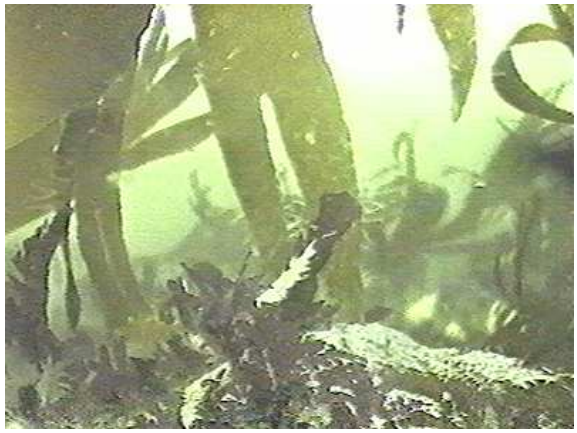
Site C2. Rippled sand with isolated pebble



Site C3. Very clean rippled sand.

Site C4. No picture available

Site C5. Rippled sand with no obvious infauna.



Site C6. Bedrock covered with kelp and an understorey of red and brown algae.

Site D1. No picture available

Site D2. Clean rippled sand

Site D3. No picture available

Site D4. The starfish *Luidia ciliaris* on rippled sand

Site D5. A hermit crab *Pagurus* spp. on clean rippled sand

Site D6. Clean rippled sand

Site E1. Coarse rippled sand with no obvious infaunal species

Site E2. Coarse rippled sand with no obvious infaunal species

Site E3. Coarse rippled sand with no obvious infaunal species

Site E4. Coarse rippled sand with no obvious infaunal species

Site E5. The edible crab *Cancer pagurus* on coarse rippled sand.

Site E6. A hermit crab *Pagurus* sp. on rippled sand.

Site F1. Coarse rippled sand with no obvious infaunal species

Site F2. Coarse rippled sand with no obvious infaunal species

Site F3. Coarse rippled sand with no obvious infaunal species

Site F4. Coarse rippled sand with no obvious infaunal species

Site F5. Coarse rippled sand with no obvious infaunal species

Site F6. Coarse rippled sand with no obvious infaunal species

Site Ref1. No picture available

Site Ref2. Bedrock at with the sea urchin *Echinus esculentus* (bottom centre) and sea cucumber *Holothuria forskali* (bottom right).

APPENDIX 5 GRANULOMETRIC DATA

Data from granulometric analysis showing the percentage of the total sample which passed through each sieve size.

			Station			
Sieve size µm	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**
2000	99.02	99.99	100	99.99	99.95	99.27
1180	91.61	99.64	99.83	99.79	99.89	98.94
850	72.41	99.2	99.49	99.28	99.76	98.38
600	28.51	98	98.61	98.02	99.48	97.04
425	8.29	96.06	97.31	95.76	98.97	94.17
300	2.87	87.73	91.84	88.38	98.42	87.41
212	1.46	67.57	72.85	65.87	77.13	67.73
150	0.74	20.75	21.89	16.51	35.04	21.19
62	0.47	0.01	0.43	0.04	0	0.14

Sieve size µm	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**
2000	-	99.94	99.77	99.98	100	-
1180	-	99.82	99.2	99.81	99.87	-
850	-	99.63	98.53	99.5	99.77	-
600	-	99.32	97.63	98.98	99.52	-
425	-	98.87	96.48	98.33	99.15	-
300	-	97.26	91.92	95.71	93.65	-
212	-	86.41	71.72	82.71	78.19	-
150	-	35.02	17.76	27.05	20.18	-
62	-	0	0	0	0.01	-

Sieve size µm	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
2000	99.91	99.95	100	99.96	99.97	-
1180	99.72	99.84	99.91	99.9	99.92	-
850	99.46	99.74	99.82	99.67	99.84	-
600	98.72	99.46	99.74	99.47	99.6	-
425	97.06	98.71	99.18	98.9	99.07	-
300	83.81	93.14	94.6	93.31	94.2	-
212	62.67	82.44	83.17	83.51	83.11	-
150	17.39	37.56	32.78	41.97	31.53	-
62	0.06	0.08	0.26	0.2	0.23	-

Sieve size µm	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
2000	99.91	99.84	99.72	99.94	99.93	99.83
1180	99.82	99.65	99.48	99.85	99.85	99.68
850	99.7	99.35	99.37	99.77	99.73	99.52
600	99.45	98.55	99.2	99.59	99.5	99.24
425	99.1	95.95	97.95	99.2	98.73	98.64
300	91.32	85.86	90.12	91.93	91.92	90.39
212	68.53	63.58	64.72	65.18	69.14	69.09
150	32.06	10.54	25.72	26.59	25.2	23.89
62	0.1	0.08	0	0	0	0

Sieve size µm	E1	E2	E3	E4	E5	E6
2000	99.97	99.87	99.9	99.92	99.96	99.43
1180	99.77	99.68	99.73	99.72	99.81	99.05
850	99.4	99.32	99.41	99.37	99.55	98.85
600	98.01	98.21	98.4	98.36	98.82	97.83
425	92.86	94.46	95.42	94.1	96.17	97.56
300	78.12	81.26	83.54	81.9	83.16	95.51
212	46.64	50.73	55.26	53.05	52.27	90.94
150	12.69	12.56	13.84	13.58	12.54	55.07
62	0	0	0	0	0.2	0.89

Sieve size µm	F1	F2	F3	F4	F5	F6
2000	99.91	99.88	99.89	99.92	99.89	-
1180	99.65	99.72	99.69	99.71	99.68	-
850	99.25	99.41	99.31	99.38	99.5	-
600	97.44	98.55	98.06	98.19	99.11	-
425	90.15	94.91	93.56	93.89	98.57	-
300	64.66	80.78	76.44	77.57	96.51	-
212	27.62	41.53	31.61	34.66	86.28	-
150	6.47	8.8	6.61	7.22	54.13	-
62	0	0	0	0	0	-

Sieve size µm	Ref 1	Ref 2
2000	99.96	-
1180	99.64	-
850	98.97	-
600	96.4	-
425	88.27	-
300	67.37	-
212	31.49	-
150	5.92	-
62	0	-

APPENDIX 6 GRANULOMETRIC SCALES

Granulometric scales used in classifying sediments after Wentworth (1922) and Folk (1954).

phi	mm	µm	Wentworth	Folk
-8	256	256000	Boulders	Gravel
-7	128	128000	Cobbles	Gravel
-6	64	64000	Cobbles	Gravel
-5	32	32000	Pebbles	Gravel
-4	16	16000	Pebbles	Gravel
-3	8	8000	Pebbles/granules	Gravel
-2	4	4000	Granules	Gravel
-1	2	2000	Granules	Gravel
0	1	1000	Very coarse sand	Sand
1	0.5	500	Coarse sand	Sand
2	0.25	250	Medium sand	Sand
3	0.125	125	Fine sand	Sand
4	0.0625	63	Very fine sand	Sand
5	0.0312	31	Silt	Mud
6	0.0156	16	Silt	Mud
7	0.0078	8	Silt	Mud
8	0.0039	4	Silt	Mud
>8	<0.0039	<4	Clay	Mud