Assessment of offshore habitats in the Cardigan Bay SAC

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Introduction

The scallop fishery for *Pecten maximus* in the Irish Sea is open from 01 November for a period of six months. Towards the end of the last open season in 2009, complaints were made to the European Commission regarding the amount of scallop dredging activity that had occurred in the previous 18 months. The concerns of the complainants related to the possible effects of the increased levels of fishing activity on the seabed and cetacean features for which the Cardigan Bay SAC was designated (namely bottlenose dolphins, cobble reefs and sand banks). Given the lack of scientific information that would enable an appropriate assessment of the risk of damage to the features of the SAC, the Welsh Assembly Government extended the closed season until 01 March 2010 to allow sufficient time to gather and process additional scientific information in relation to the features of the SAC.

Approach

Given the large size of the SAC and the potentially fine-scale nature of the reef features, it was necessary to undertake a survey that was fine-scale enough to provide sufficient confidence that the risk to any features was assessed in a robust manner. Given the time constraints to undertake the survey, analyse the data and produce a report, it was accepted that only a proportion of the area could be surveyed within the time budget. As the evidence derived from the survey would be used to assess whether it was possible to re-open a proportion of the area to fishing, the survey was to be focused on a prioritized subset of those areas of the SAC that were subject to scallop dredging activities. These areas were prioritized in consultation with the fishing industry on the basis of their economic importance. Accordingly, a meeting was convened by WAG with the Welsh Scallop industry in Aberystwyth. Fishermen who attended the meeting were asked to identify the areas of the SAC that were the most important in terms of their economic yield to the fishery. The fishermen were also asked to identify on a map those areas that were considered to be the primary and secondary fishing grounds of importance to the industry. This exercise yield six maps that were integrated in ArcGIS software to provide a consensus view of the most important scallop ground within the SAC and hence a means of prioritising areas to survey for the purposes of this report.

The present study has been undertaken in a short time scale, hence the data presented herein do not represent an analysis of all the information collected as this was not possible given the deadline of the 15th January 2010 to deliver scientific evidence that could be used within the timescale dictated by the legislative processes.

Background

The king or great scallop *Pecten maximus* is a high value commercial species prosecuted by fishing vessels that used toothed dredges. Experimental and large-scale comparative studies that have quantified the effects of towed bottom-fishing gears have clearly identified that scallop dredges cause direct mortality to benthic biota leading to a reduction in diversity, abundance, biomass and production (Collie et al. 1997; Kaiser et al. 2006; Hiddink et al. 2006). The magnitude of these effects will vary among different types of habitat according to the species assemblage associated with that habitat. Thus reefs composed of long-lived reef-building organisms will be affected most severely by scallop dredging due to the degradation of the habitat, the slow growth rates and infrequent recruitment of the reef-building fauna. The recovery time for such habitats and associated species will be measured in periods of between 5 – 20 years or may not occur at all. At the other extreme, habitats that are subjected to frequent, seasonal and periods of intense natural disturbance are associated with species that are tolerant of these environmental conditions. Examples of large-scale disturbances would include wave erosion at the seabed from winter storms (greater exposure is associated with a higher magnitude of disturbance) that would lead to the resuspension of seabed sediment and its associated fauna, resuspension of sediment by tidal currents leading to the scouring of the seabed fauna, movement of sediments by currents leading to periodic smothering and death of fauna. The species that live in these habitats tend to be opportunistic species that have high growth rates, high reproductive output and recruit frequently following disturbance events. These habitats typically have low species diversity and are dominated by small-bodied fauna and ephemeral epifauna that tend to be high mobile and are scavengers (e.g. crabs, whelks, starfish). Thus while scallop dredging will have a negative impact on such species, the recovery rate of these habitats and their fauna is measured in periods of less than one year (Kaiser 1998; Kaiser et al. 2002; Kaiser et al. 2006).

Definition of 'stony reef'

The Joint Nature Conservation Committee (JNCC) held a workshop in 2008 to defined 'stony reefs' from a conservation and management point of view (Irving 2009). While various views existed about what constituted to a stony reef a consensuses was reached. A 'stony reef' was defined as an area of sea bed containing more than 10% of stones above 64 mm (cobbles) with an elevation greater than 64 mm. The extent of the reef has to be above 25 m^2 and it should be dominated by epifaunal species as opposed to infaunal species (Table 1). The extent of resemblance to a stony reef was further graded into low, medium and high (see Table 1). It was concluded that if a low score in reef resemblance was apparent in any of the four characteristics (composition, elevation, extend and biota) a strong justification would be needed for the area to be considered as an Annex I 'stony reef' and thus to contribute to the Marine Natura site network (Irving 2009).

Table 1. Summary of the main characterising features of a stony reef as outlined by the JNCC report (Irving 2009).

Characteristic	Not a 'stony reef'	'Resemblance' to being a 'stony reef'		
		Low[2]	Medium	High
Composition:	**<10%**	10-40% Matrix supported	**40-95%**	**>95% Clast supported**
Notes:	*Diameter of cobbles / boulders being greater than 64mm.* *Percentage cover relates to a minimum area of 25m²*. *This 'composition' characteristic also includes 'patchiness'.*			
Elevation:	**Flat seabed**	<64mm	**64mm-5m**	**>5m**
Notes:	*Minimum height (64mm) relates to minimum size of constituent cobbles.* *This characteristic could also include 'distinctness' from the surrounding seabed.* *Note that two units (mm and m) are used here.*			
Extent:	**$<25m^2$**	←	**$>25m^2$**	→
Biota:	**Dominated by infaunal species**			**>80% of species present composed of epifaunal species**

Methods

Survey design

The planned survey consisted of two main survey areas: priority area 1 and priority area 2 (see Fig. 1). The location of these areas and their size were chosen following a consultation process with scallop fishermen to delineate the most important fishing grounds within the Cardigan Bay SAC (Fig 2) and on the basis of resource availability for the scientific survey. All the initially planned 48 stations of priority area 1 were sampled during the survey (10^{th} -17^{th} of December), while within priority area 2 only 22 stations were sampled due to time limits (see Fig 1). Neighbouring sampling stations were separated by approximately 2 km. The final survey area encompassed the most important fishing grounds as indicated by the industry and covered an area of 225 km^2, 23% of the total area of the SAC (960 m^2).

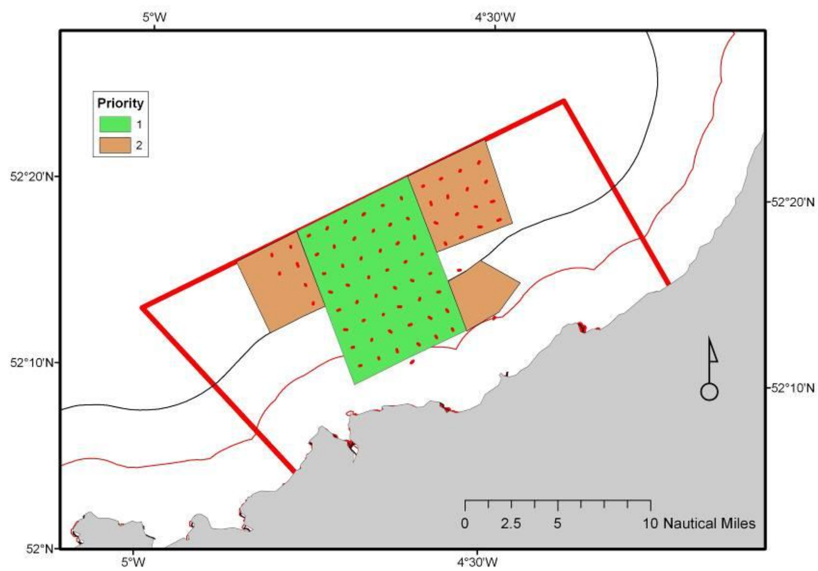

Fig. 1. Sampling priority areas and positions of camera tows conducted during the December 2009 cruise.

Three additional sites at which the presence of rocky reefs was recorded in previous scientific surveys were resurveyed using the towed camera system (Station 100-102, see Fig. 5). Within priority area 1 both grab samples and camera tows were conducted while in priority area 2 only camera tows were carried out.

Additional to the grab and video survey a side scan sonar survey was carried out covering the extent of priority area 1. While grab samples and video tows give a spatially more restricted impression of sediment types and ground topography the side scan sonar delivers larger scale information.

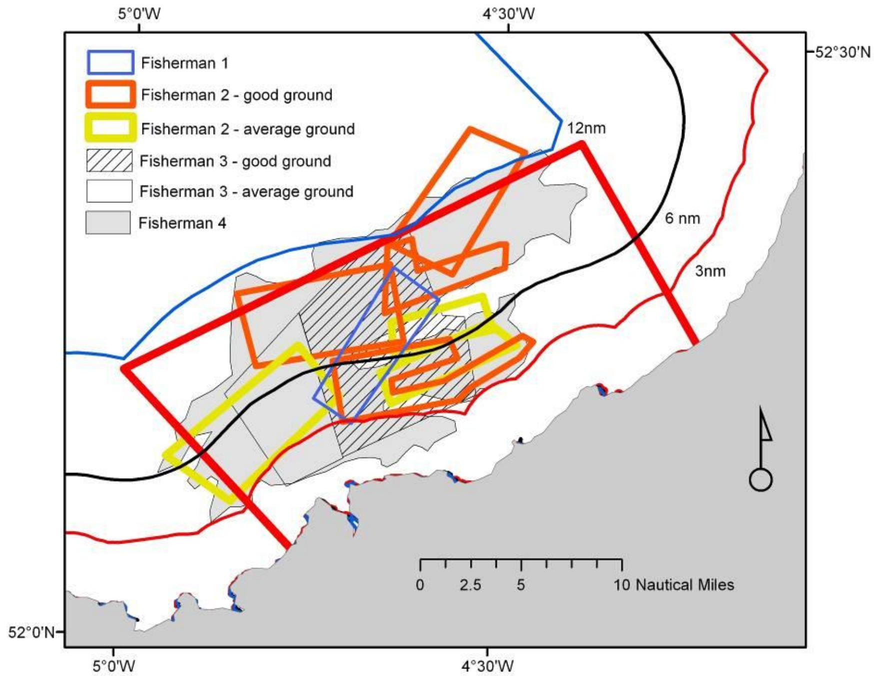

Fig. 2. Important fishing grounds as marked by fishermen during the consultation process.

Hamon grab samples

Two 0.2m^2 hamond grab samples were taken at stations 1 – 48 (Fig 5). Sediment samples were partly processed on board. After carefully running off any excess sea water each sample was photographed and subsequently weighed. A sub-sample of approximate 500 g of the finer sediment was taken from the total sample and weighed. The remaining sample was sieved onboard over 5 and 64 mm sieves. Each fraction was subsequently weighed. For a preliminary analysis the mean percentage weight of cobbles (sediment over a grain size of 64 mm) was calculated per station from the two replicate grab samples. The sub-sample will be used to determine the grain size distribution of the finer sediment fraction and its water content.

Video and stills camera tows

A sledge mounted video and stills camera system was deployed at each station and towed at a speed of approx. 0.5 knots for a period of 10 minutes. Start and end positions of each tow were recorded from the point the sledge had visibly reached the sea floor to the point when the sledge lifted off the ground during hauling. While the video system delivered continuous live picture which was recorded on DVD the digital stills camera took a high resolution image every 10 seconds. The field of view of the video camera covered an area of approximately 0.12m^2 (width 0.41m x depth 0.30m). Each still image covered an area of 0.13m^2 (0.44m x 0.30m).

Habitat description

Benthic habitats type of each tow were assessed as the amount of time a certain habitat type was visible in the video footage. Additionally habitat types were determined using the stills images. From this information the percentage of a particular habitat type per tow was calculated. Currently only the stills image data has been processed and quality checked.

From video and stills images four main habitats were distinguishable: a) mud, b) sand c) gravel and d) cobble and boulder habitat. To allocate images to either habitat category more than 50% of the image's surface area had to be covered by the respective sediment type. To aid differentiation between gravel and cobble habitats a grid of 64mm was overlaid over each image during analysis using the software package ImageJ.

Benthic fauna

Abundance of benthic organisms as well as species numbers were determined from video recordings and stills images. While from the video footage only larger benthic fauna could be identified and counted the still images allow a more detailed description of benthic fauna. Organisms in stills images were identified to the lowest taxonomic possible while organisms in the video, due to its poorer image quality, could only be identified to family or group level. Again due to time limits only the results of obtained from the stills images were used for the current report as these provide the highest quality data.

Side scan sonar survey

The side scan survey was conducted over a 3 day period from 12th to 14th December using the fishing vessel Mercurius working alongside the RV Prince Madog. The side scan sonar system was a Cmax CM800 system using a 300m fibre optic tow cable from a 24v battery powered winch. Initially a sonar range of 100m (total swath width 200m and sonar frequency 325kHz) was employed with the tow-fish altitude above the seabed kept between 5 to 10m. Halfway through the survey, however, the signal was lost using the fibre optic cable and the system was then configured to use a 50m coaxial cable. This resulted in a tow-fish altitude of 20m above the seabed, because of the shorter cable, and so a sonar range of 200m (total swath width 400m, sonar frequency 100kHz) was selected and used for the remainder of the survey.

Initially the survey lines were chosen to run parallel to the coast, i.e. in the direction of the tidal currents in order to ensure that the tow-fish followed the track of the vessel. These tracks (lines 1-8) were selected to go through the 48 primary benthic sampling stations. These stations were 2km apart, so the sonar survey would only give 10% coverage of the area. It was intended to carry out further infill survey lines parallel to the existing lines but during the survey it was noted that the bedform features (sand waves) showed up much more clearly on the turns between the survey lines when the vessel was heading perpendicular to both the shore line and the tidal currents. For this reason 6 survey lines (lines A to F – labelled 1 – 6 on Fig. 3) were run through the benthic sample stations but perpendicular to the original survey tracks. The actual survey tracks are shown in Fig. 3. Apart from the top of survey line B all of the shore perpendicular survey lines were carried out with a sonar range of 200m which would have resulted in a sonar coverage of about 20%. This was deemed sufficient to give an overall picture of the types of seabed present in the area and would provide data to correlate with the video and sediment sampling survey carried out from the RV Prince Madog.

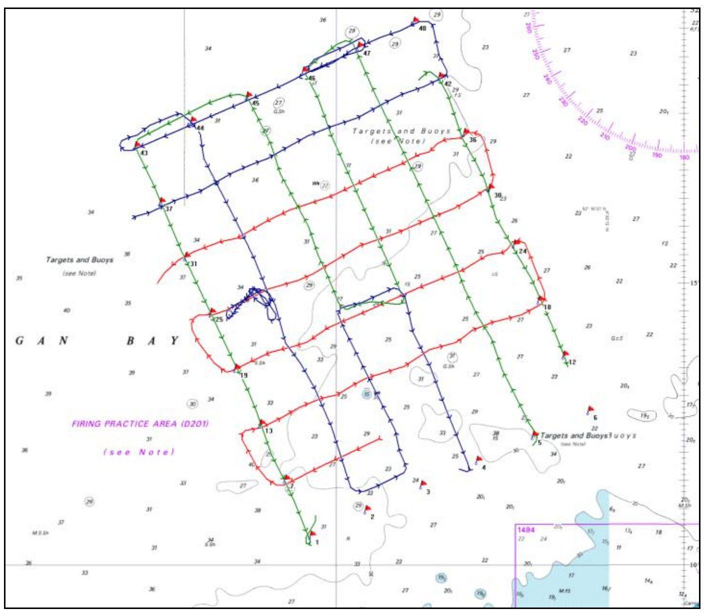

Fig. 3. Side scan sonar survey tracks colour coded by days of survey undertaken in December 2009: 12th red, 13th blue 14th green. The flags at the base of the diagram are labelled 1 – 6 and indicated the lines that ran in a southeast/northwest direction through the sites sampled using the camera system and Hamon grab.

For the initial analysis of this report only the side scan lines A-F have been processed and used to compile this report. Features within these tows were clearer due to more distinct acoustic shadows (see above).

Analysis of benthic community data from stills images

Species number, total abundance of benthic fauna, as well as indicator species of reef structures were visualized within a GIS. Generally sessile attached benthic fauna such as hydroids, soft corals, anemones, bryozoans and tunicates were classified as species associated with rocky reefs. To allow the reader to scale abundance data of the species collected in Cardigan Bay against other known rocky reef areas additional video tows from previous surveys conducted by the School of Ocean Sciences were analysed. The mean of three stills camera tows with abundances standardized to 10 m^2 from two other areas, Lyme Bay (south west England) and the Point of Ayre (Isle of Man), were calculated and presented together with data from Cardigan Bay SAC. Abundances of the King scallop *Pecten maximus* were also presented within the GIS. The data from Lyme Bay was chosen because this area was sampled after a similar closure to scallop dredging. Hence both Lyme Bay and Cardigan Bay are areas that had a similar period of recovery after the cessation of scallop dredging. The Point of Ayre remains open to scallop and other forms of fishing disturbance.

Benthic community composition as identified from the still photographic images was analysed using multivariate statistics PRIMER v6 (Clarke & Gorley 2006). Prior to analysis the data was standardised due to differences in the tow length and hence number of stills images per tow. The abundance of species recorded was standardised to numbers/m^2 to make the abundance data comparable. This standardisation is not applicable to the number of species recorded, hence the number of species represents the total number observed per tow. Due to the low abundance of the observed fauna, a fourth root transformation was applied to the data to down-weight the influence of extreme abundance records that occurred in a relatively small number of stations. A similarity matrix of the standardised community data was calculated using the Bray-Curtis index of similarity for each pair-wise combination of sampled sites. A cluster analysis was then performed to generate a dendrogram to indicate potentially significantly different groups of sites based on their community composition. Significantly different clusters were ascertained using the SIMPROF randomisation permutation procedure. A multidimensional scaling ordination plot was then generated to visualise the relationship among sites and groups identified by the SIMPROF procedure. An initial analysis revealed that site 5, 30, 61, 62 and 73 had such a low abundance and number of species that they could not be included in the MDS ordination plot such that interpretation of the relationships among the other sites could be determined. These sites were omitted such that it was possible to visualise the relationship among the remaining 64 sites. A SIMPER analysis was undertaken to identify those species that accounted most for the similarity among sites (indicator species) within the three differentiated groups of sites and the species that accounted for the dissimilarity among groups.

Results

Habitat classification from camera tows and grab samples

The average tow length of the 70 camera tows conducted was 191m (S.D. $\pm$54m). Thus on average an area of 78m^2 per tow were surveyed with the video camera and 7.2m^2 with the stills camera (average number of images 56 S.D. $\pm$9). Due to malfunctioning of the stills camera images from three stations were not available for the analysis (Stations: 19, 45, 46,). Thus far only the habitat classification from the stills images has been completed and the analysis of the grab samples is in a preliminary stage.

Still images showed that cobble and boulder habitats were rare within the survey area and that most stations were dominated by either sand or gravel habitats. At 16 stations cobble habitats were recorded (Fig. 4) of which 6 stations showed a percentage cover of cobbles and boulders above 10% (Stations 4, 15, 27, 76 and 101, Fig 4 and 5).

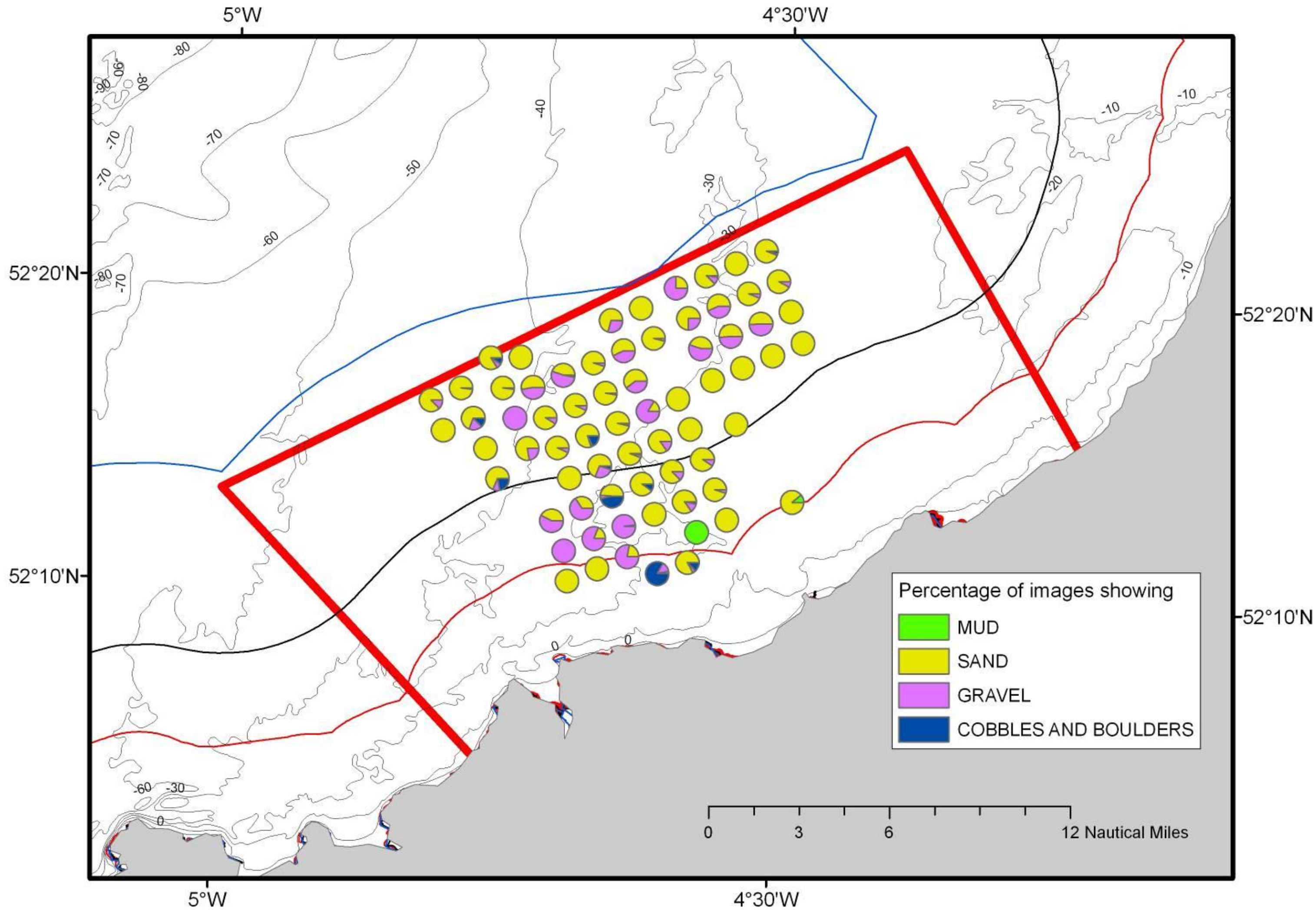

Fig. 4 Percentage of images showing the different habitat types within individual still camera tows.

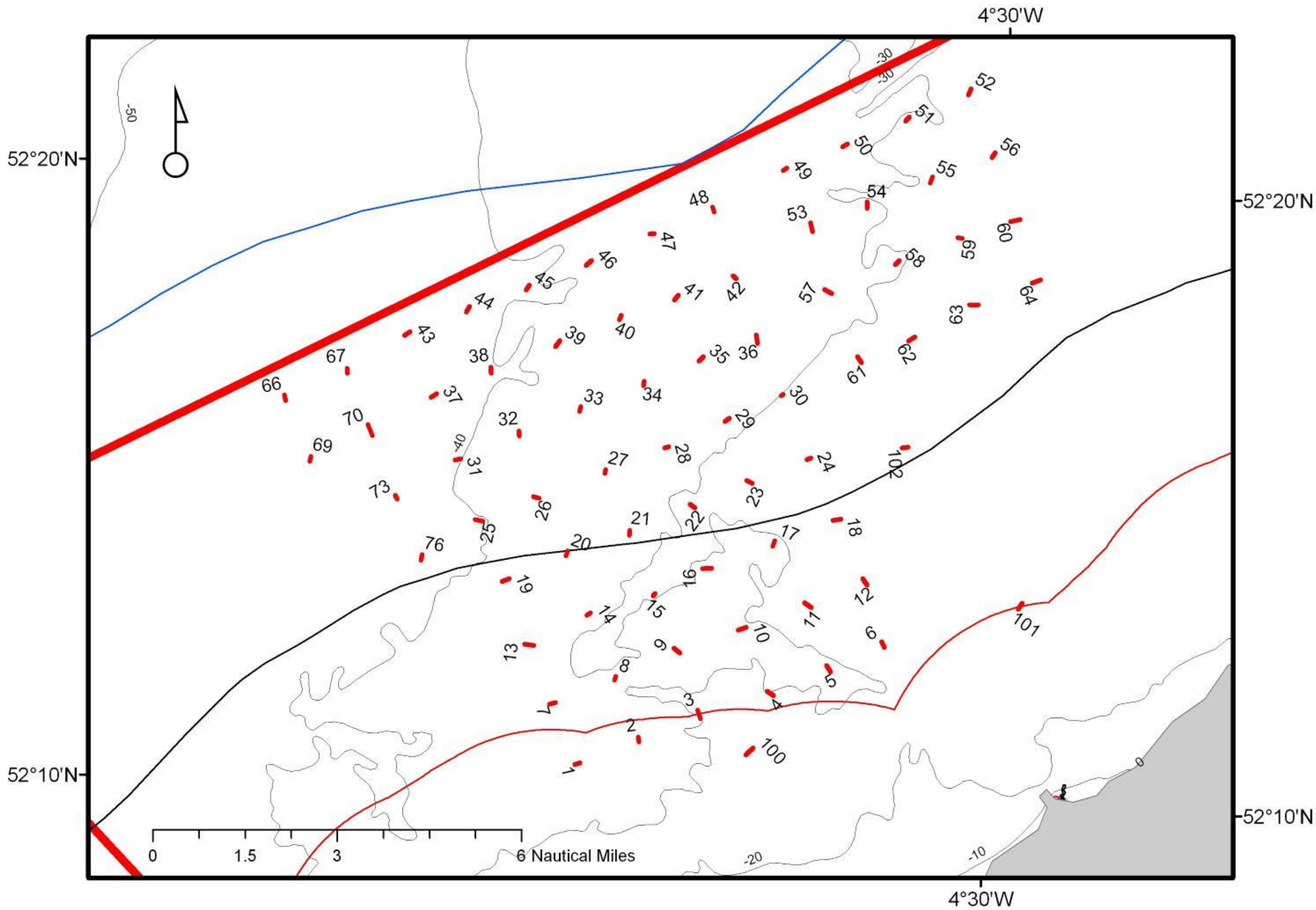

Fig. 5 Positions of all camera tow stations.

Sampling at the three sites at which 'stony reefs' were previously recorded could only confirm the presence of boulder and cobble habitat for one site (Station 100) while the other two sites showed dominated by sand (Stations 101-102, Fig. 4-5)

The preliminary analysis of sediment samples showed that cobbles, sediment above 64mm, were recorded at 15 stations. The percentage weight of cobbles with respect to the total sample's wet weighed for all stations was found to be below 1% (Fig 6). As finer sediments will have contained a lot of interstitial water adding to the total weighed of the sample these values will have underestimate the true percentage of cobbles and boulders. This bias will be corrected once sediment sub-samples of the fine fraction will have been processed

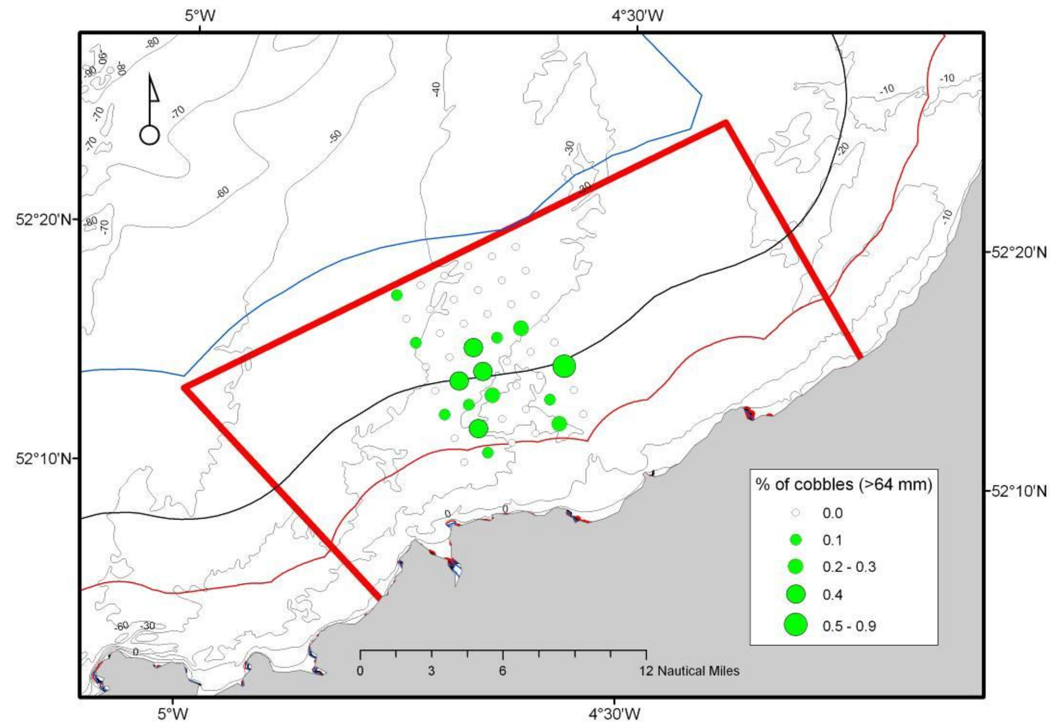

Fig 6. Percentage of cobbles and boulders (>64 mm) in grab samples. Data displayed underestimates the percentages of cobbles and boulders in sediment samples as they refer to the total wet weight of the sample as opposed to the dry weight. It is unlikely that the percentage composition of cobbles will increase much once the dry weight of sediments has been determined.

Interpretation of side scan sonar survey

The initial impression of the sonar data was that the area was very patchy. The general background area appears to be rough, possibly gravelly, with some areas having boulders which cast acoustic shadows. Characteristic for the whole area were fields of mobile sand which showed distinct bedforms (sand waves) (Fig 7-10). These sand waves were oriented perpendicular to the prevailing current and had a wavelength of about 1.3m and a height of about 0.25m (Fig.8).

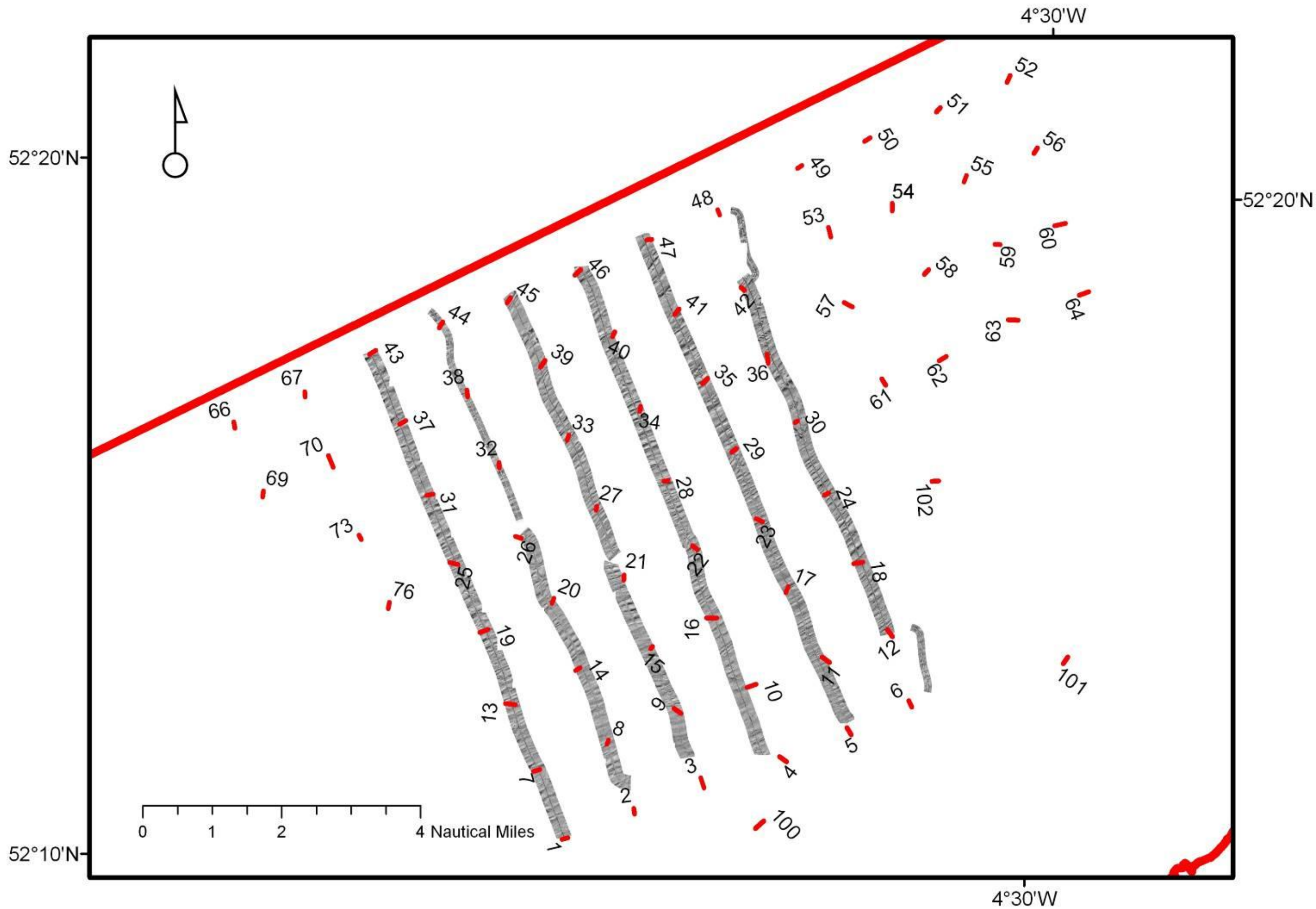

Fig. 7. Side scan sonar lines running N-S showing with camera survey tracks overlaid. Fields are clearly visible throughout the survey area as bands.

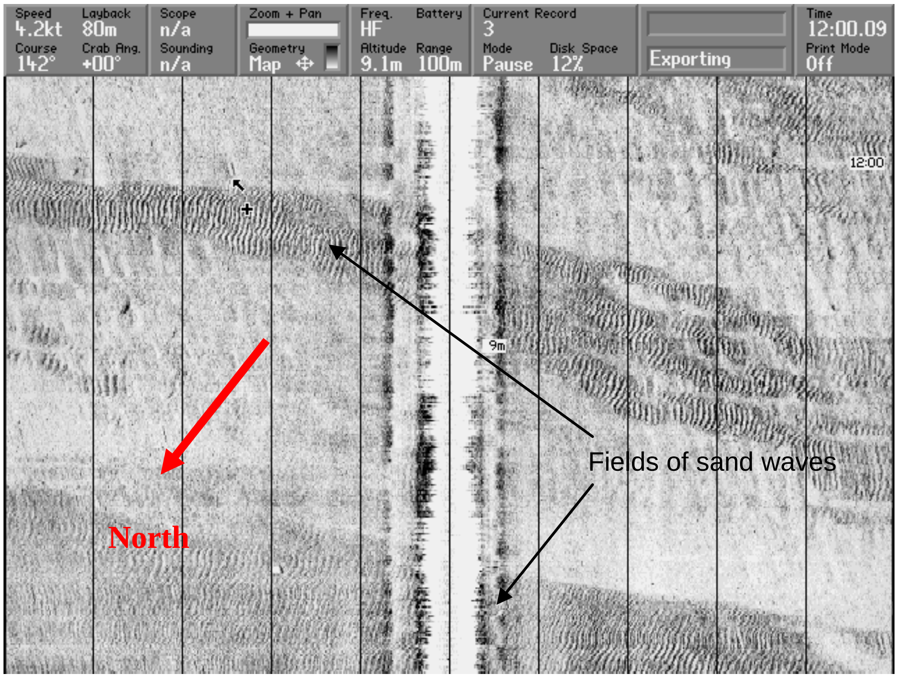

Fig. 8. Side scan screen dump from the top of line B with a sonar range of 100m showing fields of sand with distinct sand waves (wavelength 1.3m, height 0.25m). Note the longer wavelength (~5m) bedforms between the sand wave fields. (Image centred at 52° 17.869'N 4° 44.224'W).

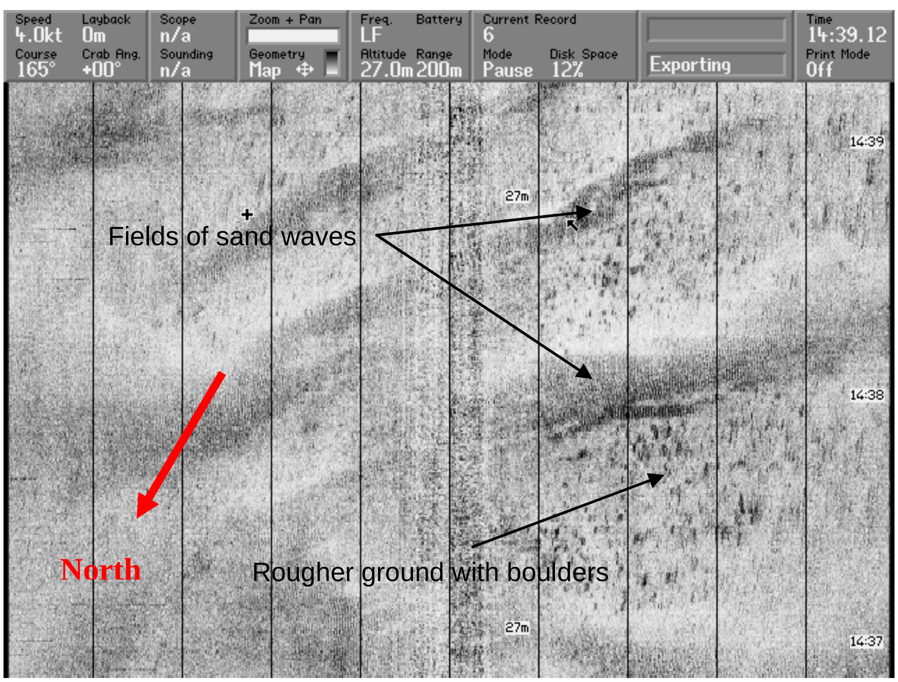

Fig. 9. An example screen dump of the 200m range, 100kHz record showing the sand fields (with bedforms) and showing the rougher areas in between (Image centred at 52° 14.088'N 4° 41.589W).

These features were consistent throughout the survey area (see Fig 7 and example side scan survey line Fig 10-12). Trawl marks from scallop dredging activity were not visible in side scan sonar images.

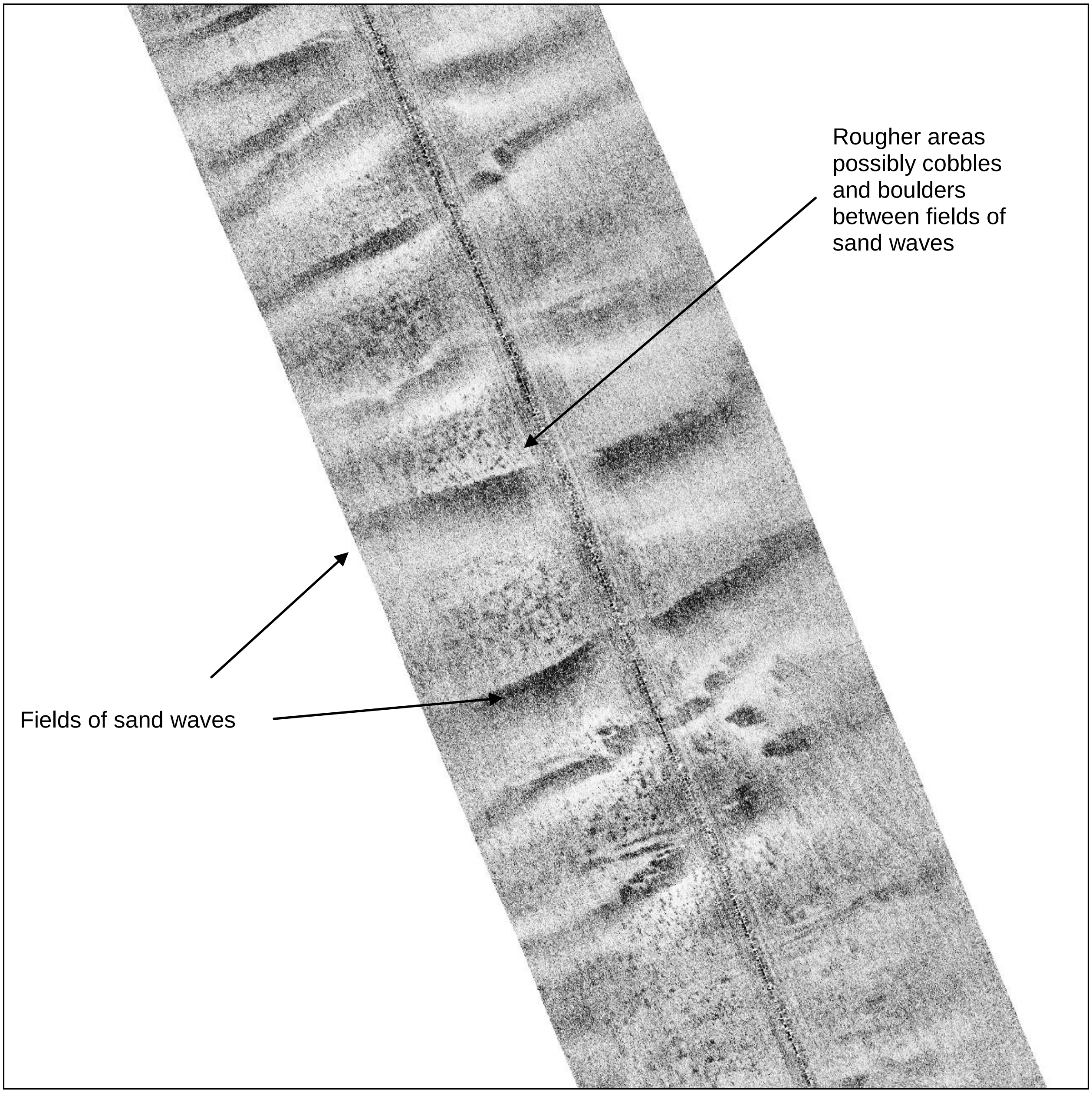

Fig. 10. Geo-referenced mosaic tile from line D, showing the patchy nature of the seabed texture. (1 km^2 and sonar range of 200m).

The stills image analysis can be used to ground truth side scan sonar images a preliminary analysis showed that recorded bedforms structures were indeed consisting of sand (see Fig. 11 and 12)

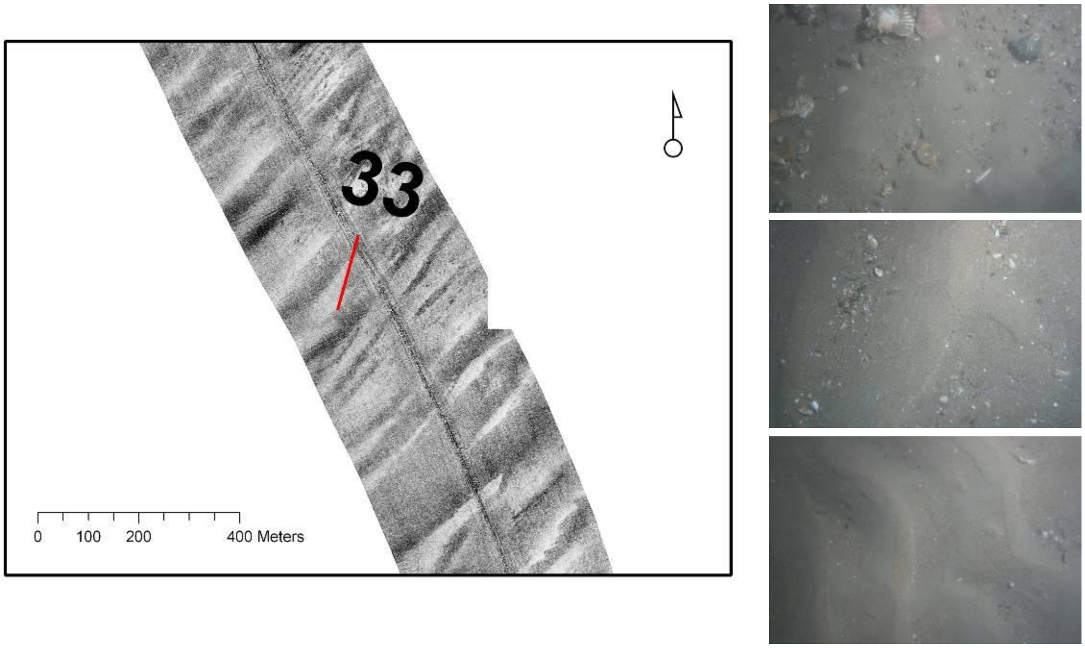

Fig. 11 showing tow line of station 33 and three representative pictures of that tow.

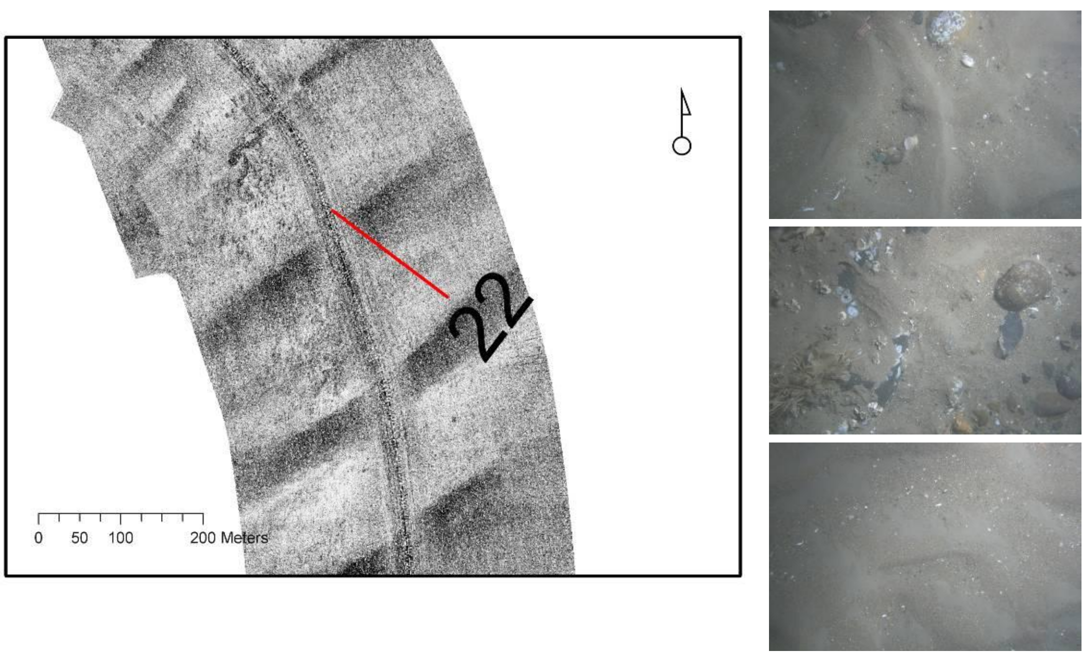

Fig. 12 showing tow line of station 22 and three representative pictures of that tow.

Analysis of benthic community data from stills images

Overall, at all sites, the number of species identified from the still photographic images was low with an average of 7 species (S.D. ±4) and a maximum of 15 species observed per tow (Fig. 13). In general species numbers were higher towards the western part of the survey area. Abundances were similarly low on average 45 organisms were observed per 10 m^2 (S.D. ±156) (Fig. 14). Abundances of attached fauna associated with hard substrates were equally low, on average 8 (S.D. ±11) individuals (individual colonies e.g. in case of hydroids or similar) were observed per 10 m^2 (Fig. 15). The maximum number of attached fauna per was 45 per 10 m^2. The soft coral *Alcyonium digitatum* a species typically found on established hard substrate was only observed at 12 stations located in the north west of the survey area (Fig. 16). The average abundance observed at these sites was 6 per 10 m^2 (S.D. ±8).

The king scallop *Pecten maximus* was found throughout the survey area and had an abundances of 3 individuals per 10 m^2 (S.D. ±5). Abundances were highest in the central area of the area surveyed which corresponded to the area indicated by the fishermen as a prime fishing ground (see Fig. 2 and 17). Maximum abundances were 25 individuals per 10 m^2.

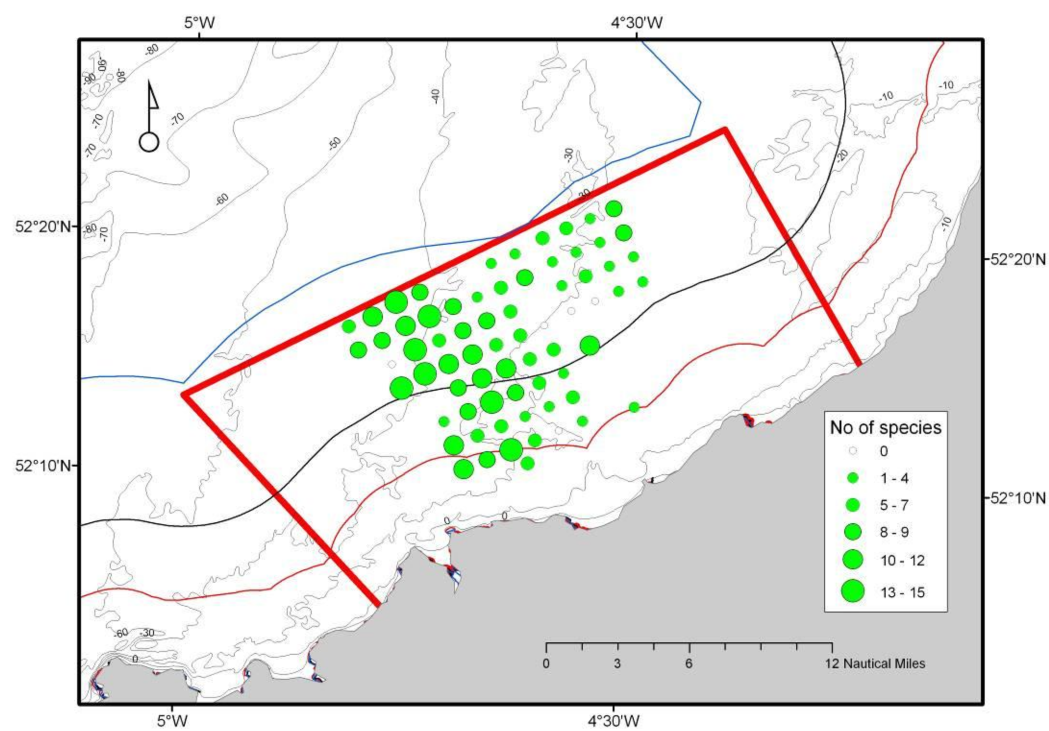

Fig. 13. No of species per tow observed in stills images.

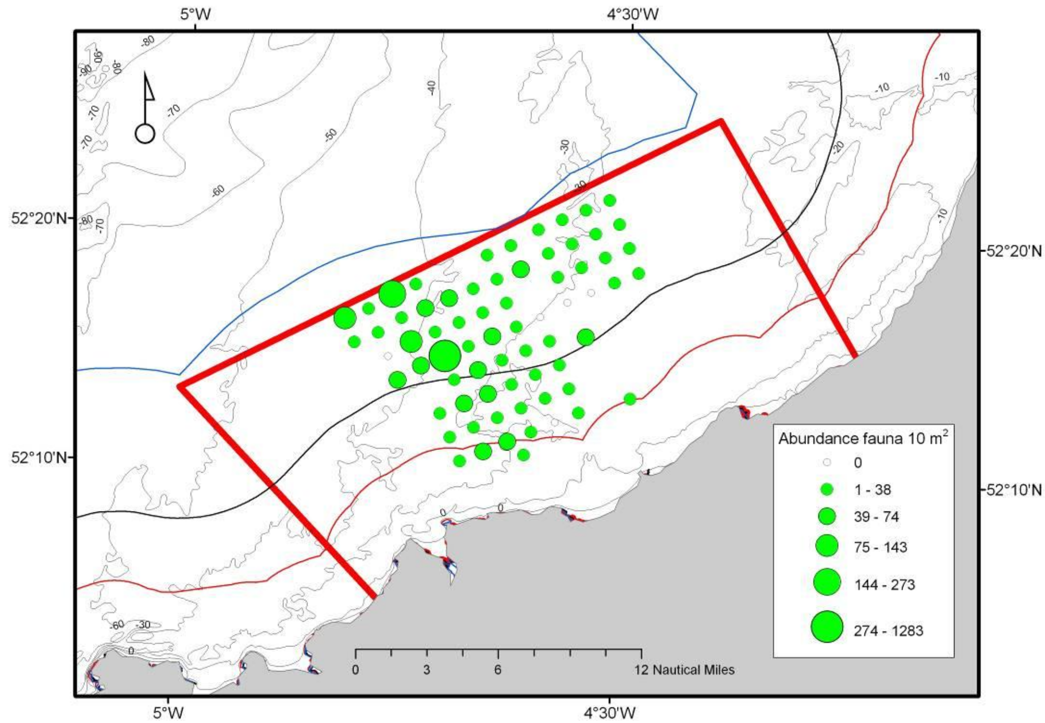

Fig. 14. Abundance of benthic organisms per 10m^2 as observed in stills images.

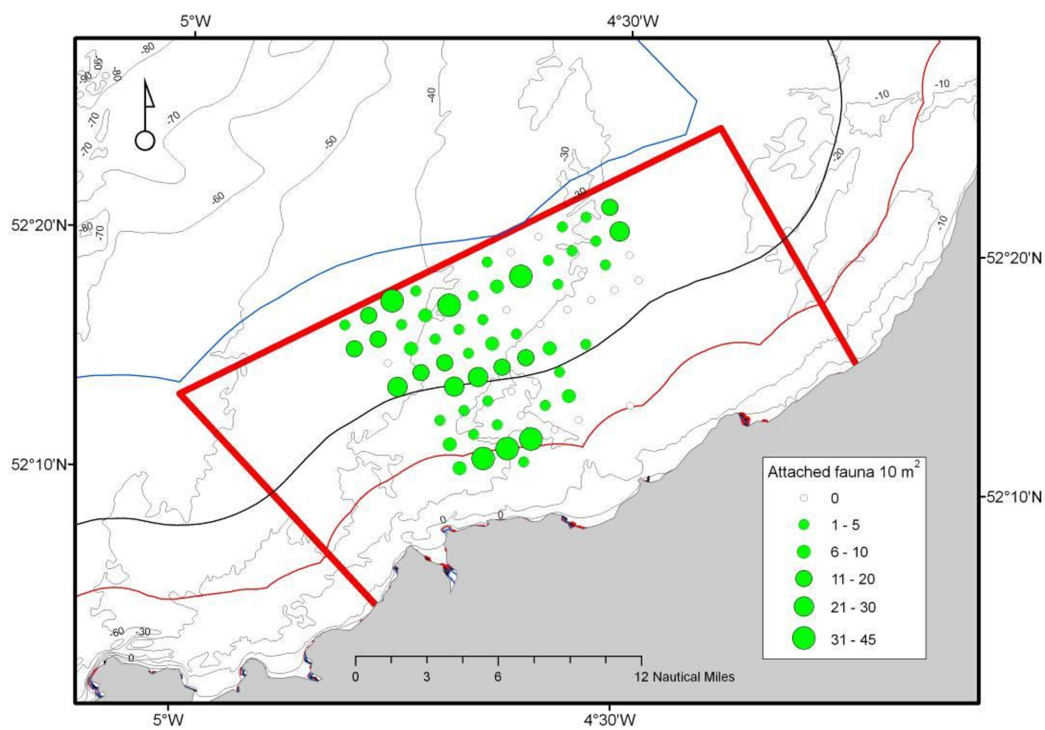

Fig. 15. Abundance of attached benthic fauna per 10m^2 as observed in stills images.

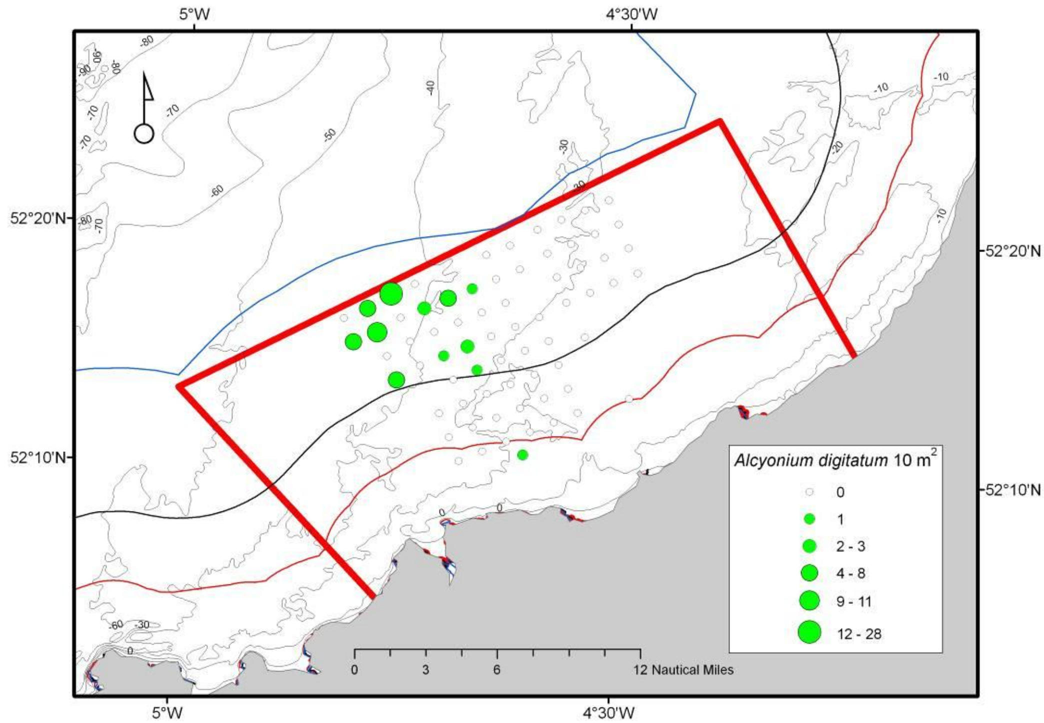

Fig. 16. Abundance of the soft coral *Alcyonium digitatum* per 10m^2 as observed in stills images.

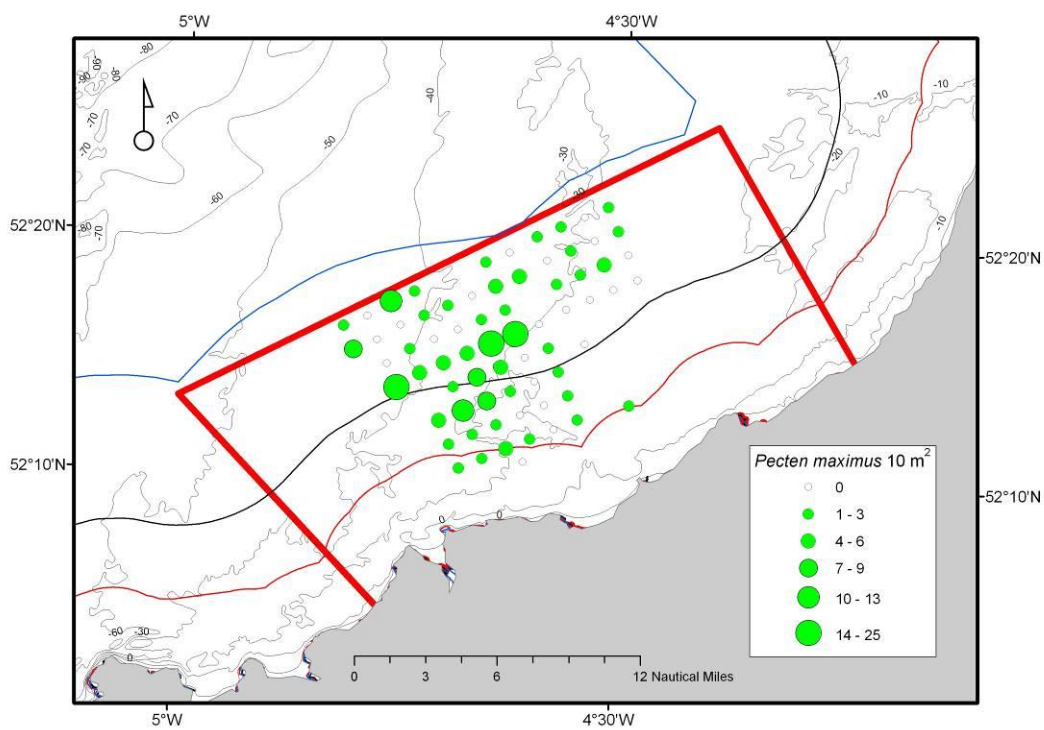

Fig. 17. Abundance of the king scallop *Pecten maximus* per 10m^2 as observed in stills images

Comparing abundances of species generally associated with hard substrates (ie. hydroids, soft corals, anemones, bryozoans and tunicates) recorded during the present survey with data from other areas containing rocky reefs (Lyme Bay and the Point of Ayre, Isle of Man) showed that abundances were considerably lower in Cardigan Bay (Table 2).

Table 2 Comparison of mean abundances of reef associated epibenthic species per 10m^2 from different areas. Three video tows were selected from each area for this analysis. For Cardigan Bay the 3 stations with the highest percentage of cobble and boulder habitat were chosen (station 15, 27 and 76). Note the pink sea fan *Eunicella verrucosa* does not occur within the research area and at the point of Ayre on the Isle of Man.

Location **Number of stations**	**Cardigan Bay** **(Station 15, 27 ,76)**	**Point of Ayre (Isle of Man)** **(3 stations)**	**Lyme Bay (South west England)** **(3 stations)**
Hydroid turf	2	136	213
Soft coral - *Alcyonium digitatum*	3	322	62
Gorgonian - *Eunicella verrucosa*	-	-	64
Anemones	0	78	26
Porifera (Sponges)	0	18	429
Emergent bryozoan	4	136	31
Ascidians	3	0	138
Total abundance per 10 m^2	**12**	**689**	**962**

Cluster analysis together with the SIMPROF procedure identified three significantly different clusters of sites (alpha = 0.05). Site 48 did not cluster with any of these groupings. The majority of the sites fell into one cluster (Group 3). However the mean similarity among these sites was extremely low (17% , Table 3). The taxa that contributed most to the similarity among the sites in Group 3 were scallops *Pecten maximus* and *Aequipecten opercularis*, the bryozoan *Cellaria*, hydroids turf, and ephemeral species such as hermit crabs, brittlestars, an opportunistic sea squirt species (*Ciona*) and swimming crab and small spider crab species. Group 2 had a slightly higher level of similarity (25%) and was characterised by *Cellaria*, the stone crab (*Ebalia*) and shrimps (*Crangon spp.*). Group 3 had the highest level of similarity (42%), but only the dragonet (*Callionymus spp.*) were identified as contributing to the similarity.

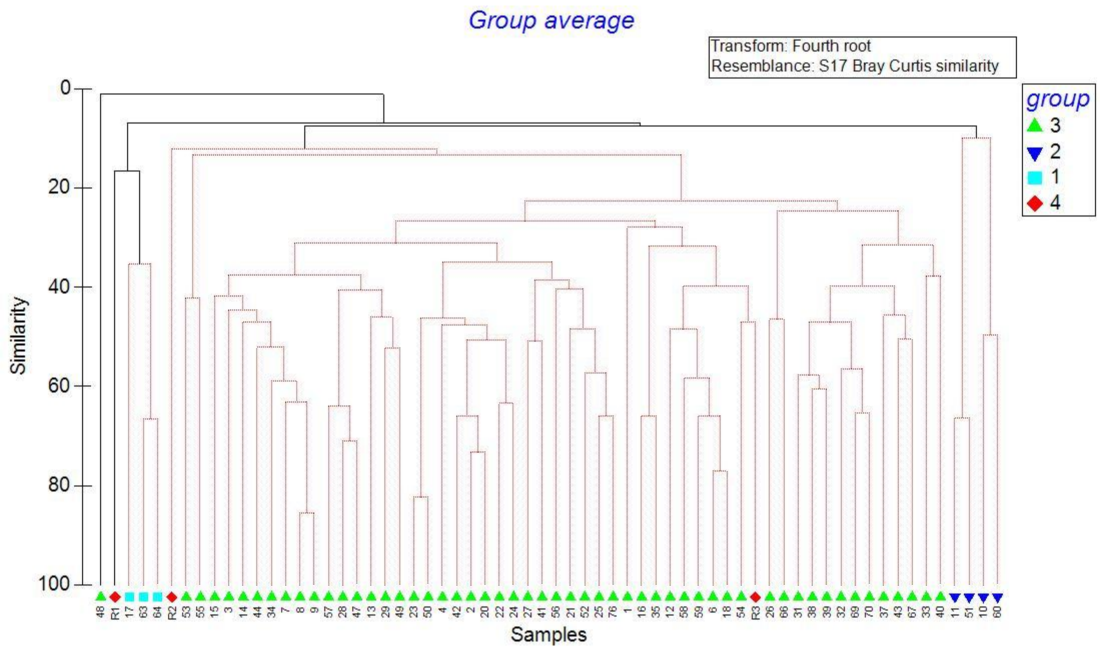

Fig. 18. Dendrogram of the trimmed dataset (with site 5, 30, 61, 62 and 73 removed from the analysis) using the group linkage method. The SIMPROF procedure highlighted three significantly different clusters, Group 1 (blue squares, stations 17, 63 and 64), Group 2 (dark blue triangles, stations 10, 11, 51 and 60), Group 3 (green triangles) is composed of the remaining stations, Stations denoted with red diamonds are the reference sites (previously sampled by CCW). Site 48 has a low level of similarity to any of the other sites.

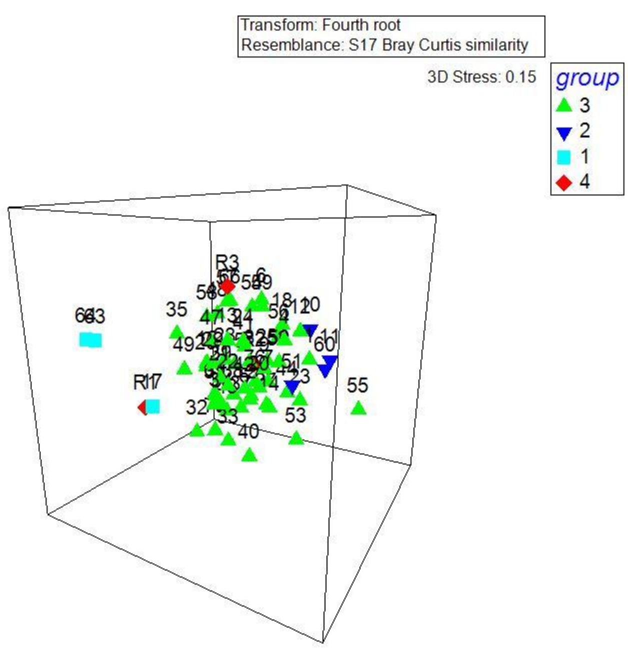

Fig. 19. Multidimensional scaling ordination plot that represents the relationship among sites visualised in Fig. 18 in three dimensions. Group 1 (blue squares, stations 17, 63 and 64), Group 2 (dark blue triangles, stations 10, 11, 51 and 60), Group 3 (green triangles) is composed of the remaining stations, Stations denoted with red diamonds are the reference sites (previously sampled by CCW). Site 48 is different from all other sites.

Table 3. Outcome of a SIMPER analysis that indicates those species that contribute most to the percentage similarity among the groups of sites identified by the SIMPROF analysis. Av. Abund. = Average abundance (numbers per m²). Av. Sim. = Average contribution to the group similarity. Sim/SD the ration of the average contribution to similarity divided by the standard deviation of the average contribution to group similarity. Contrib % = percentage contribution to group similarity. Cum. % = cumulative percentage contribution to group similarity.

Group 3					
Average similarity: 17.01					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Pecten maximus	0.39	5.57	0.78	32.71	32.71
Aequipecten opercularis	0.37	3.6	0.49	21.19	53.9
Cellaria	0.29	1.59	0.39	9.36	63.26
Hydroid turf	0.2	1.53	0.37	8.99	72.25
Ophiura albida	0.33	1.09	0.33	6.44	78.69
Liocarcinus spp.	0.07	0.78	0.28	4.6	83.29
Pagurus bernhardus	0.06	0.51	0.25	3.02	86.31
Ciona intestinalis	0.19	0.44	0.18	2.6	88.91
Inachus spp.	0.08	0.4	0.24	2.35	91.26
Group 2					
Average similarity: 25.39					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Cellaria	0.06	10.87	0.41	42.79	42.79
Ebalia spp.	0.07	7.99	0.41	31.48	74.27
Crangon spp.	0.06	6.53	0.41	25.73	100
Group 1					
Average similarity: 42.11					
Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Callionymus spp.	0.14	42.11	2.04	100	100

Discussion

The side scan and stills images indicated that some areas of seabed surveyed did show some patches of cobbles and boulders. Based on the camera observations 23% of the stations sampled showed cobble and boulder habitats and 8% showed a percentage cover of this habitat type above 10%. The predominant habitat type identified within the survey area was however sand and gravel.

The side scan sonar enabled us to sample over a wider spatial area and confirmed that the main habitat feature were fields of sand waves moving in east west direction in line with the main tidal currents. The fields of sand-waves are arranged on larger mega-ripples that indicated on-shore transport probably induced by wave action. Interspersed between fields of sand waves rougher ground with boulders casting distinct acoustic shadows were apparent. This observation leads to the conclusion that the area may be consisting of an underlying cobble and boulder habitat covered by highly mobile sand that has both an onshore and alongshore movement.

This supposition was further supported by the resurvey of three sites formerly known to constitute cobble and boulder habitats. Despite precise positioning only one site showed cobbles and boulders, while the other two were now covered by sand.

The evidence above leads to the conclusion that the area represents a highly dynamic environment, which was further supported by the low species numbers and abundance of opportunistic benthic biota. Benthic organisms typical of established reef communities such as hydroids, soft corals, anemones, bryozoans and tunicates were rare even within cobble and boulder habitats and in particular when compared with other established reefs (see above).

An alternative explanation for the impoverished fauna observed in our samples is that the scallop dredging activity in the previous scallop-fishing season had reduced the biomass and species diversity of the area. However, our samples were taken after a 7 month closure to scallop dredging. Furthermore, we compared the community data with other similar habitats that are either subject to scallop fishing or were similarly closed to scallop fishing with a similar period of recovery post closure (Lyme Bay). At both of these comparator sites the abundance and diversity of reef fauna was much higher (Table 2). These observations indicate that the Cardigan Bay SAC experiences high levels of natural disturbance and that the benthic community in the area sampled is impoverished through natural processes to a greater extent than fishing activities. The majority of species observed were either opportunistic (e.g. barnacles, Pomatocerid tube worms, sea squirts) or highly mobile (hermit crabs, ophiuroid brittlestars, swimming crabs, dragonets). The dominant fauna at the majority of sites were two commercially important species of scallop. All of the above, indicate a fauna typical of an area subject to high levels of natural disturbance similar to the mobile sand communities reported by Kaiser & Spencer (1996) on an area of seabed between Anglesey and the Great Orme in North Wales where they found that beam trawling had no detectable short-term effect on seabed communities compared to more stable sediment habitats in the adjacent areas. Furthermore, in this study, the highly mobile nature of the seabed meant that any visible trace of trawling activity was obliterated within a period of four days. Thus it is not surprising that 7 months after the cessation of scallop dredging in Cardigan Bay, no physical traces of scallop dredging were detected on the seabed. Kaiser et al. (1998) found similar results in a study of an experimental beam trawl disturbance study when they examined the biota in April then in October following the trawl disturbance. In this study overall community biomass had increased by the early winter in both control and fished areas, hence a six month period is sufficient for significant changes to be observed in community composition in this type of habitat.

In an extensive study of a range of habitat types in the North Sea, Hiddink et al. (2006) found that areas typified by high shear stress at the seabed (tidal currents) and that experienced high levels of wave erosion at the seabed, typically had low community biomass, production and diversity as found in our study. Cardigan Bay is exposed to prevailing south westerly and westerly gales that can develop a large uninterrupted swell. This wave action can remobilise the unconsolidated components of the seabed and was observed during our study. The period preceding our study was characterised by 5 weeks of strong winds and heavy sea state. At the beginning of the survey it was not possible to obtain images of the seabed due to the high sediment load suspended in the water column. Two days into the sampling programme the water had cleared following a period of calm weather. Only short-lived opportunistic species are capable of surviving in such a dynamic habitat. Biota that are intolerant of prolonged periods of smothering, such as sessile filter- and suspension feeders, will suffer high levels of mortality in such a mobile sedimentary environment.

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