7. Appendix II: *RV* Lough Foyle cruise *(Irish) Sea Mounds* (NW Irish Sea) Habitat Mapping

Introduction and methods

All surveys were undertaken aboard the RV Lough Foyle (DARD) during June 2003.

Acoustic surveys

A RoxAnn™ acoustic ground discrimination survey (AGDS) was undertaken of the main survey area between 1st and 3rd June 2003, by A. Mitchell. Two additional RoxAnn™ datasets were collected by M. Service on 23rd June 2003 during the multibeam sonar survey. All RoxAnn™ datasets were obtained using a hull-mounted 38kHz transducer, a GroundMaster RoxAnn™ signal processor combined with RoxMap software, saving at a rate of between 1 and 5s intervals. An Atlas differential Geographical Positioning Systems (dGPS), providing positional information, was integrated via the RoxMap laptop. Track spacing varied between 500m for the large area and 100m for the multibeam survey areas.

Multibeam sonar datasets were collected for two of the *(Irish) Sea Mounds* on 23rd June 2003, using an EM2000 Multibeam Echosounder (MBES, Kongsberg Simrad Ltd; operators: J. Hancock and C. Harper.). The sonar has a frequency of 200kHz and a ping rate of 10Hz. It operates with 111 roll-stabilised beams per ping with a 1.5 degree beam width along-track and 2.5 degree beam width across-track. The system has an angular coverage of 120 degrees. In addition to bathymetric coverage, the system has an integrated seabed imaging capability through a combination of phase and amplitude detection (referred to here as ‘backscatter’).

The EM2000 was deployed with the following ancillary parts:

- Seapath 200 – this provides real-time heading, attitude, position and velocity solutions with a 1pps timing clock for update of the sonar together with full differential corrections supplied by the IALA GPS network. The GPS derived heading is measured with a 2.5m beam, 0.075 degree RMS (root mean square).
- Motion Reference Unit - MRU5 - Roll and pitch accuracies of 0.03 degree RMS.
- Sound velocity meter - Applied Microsystems singaround velocimeter to measure sound velocity at the sonar head.

The data derived from the Seapath 200 and MRU5 were integrated within the Merlin acquisition software suit for full geo-reference solutions at each sounding (depth) location.

A number of software suites were used during the acquisition and subsequent data reduction. During the survey Merlin acquisition software was used on a Solaris UNIX workstation (Simrad Survey Systems) for acquisition and quality assurance/quality control. This recorded all the acquisition data and also applied sound velocity at the sonar head and through the water column. Roll, pitch, timing, and heading calibrations were undertaken with this software.

Tidal corrections were applied to the multibeam data from 10 minute tidal curves modelled using information from the Admiralty Tide Tables and the UK Hydrographic Office. The tidal models were entered directly into the navigation computer and to the multibeam acquisition software during acquisition so that real-time corrections could be made.

Post-processing of bathymetric data was carried by J. Hancock of Kongsberg Simrad. This involved using the software Neptune (Simrad Survey Systems) Version 4.11 for Windows to produce cleaned XYZ data (eastings, northings, depth). Subsequent to removing poor data points the bathymetric and amplitude (backscatter) data were processed using the Poseidon suite of programmes for production of the sonar mosaics. Further quality assurance/quality control was performed on the data using the software packages Cfloor (Roxar) and Fledermaus (IVS).

Ground-truthing surveys

Ground-truthing information was gathered on 4th June 2003 by M. Service and A. Mellor (QUB). 11 quantitative samples, over five locations were collected, using a ??? Day grab., with 11 Day grab samples completed over five locations, and four video tows were undertaken over four locations. Ground-truthing was limited by poor weather conditions and therefore the ground-truthing was restricted in its spatial coverage. The video tows were undertaken from a drop-frame that was deployed from the side of the ship such that layback was minimised. The video system comprised of a Kongsberg Simrad Osprey underwater video camera operated using a Simrad video control deck unit and recorded on VHS tapes via a Panasonic video recorder. Positional information was imprinted on the film using a dGPS linked to TrakView overlay system. Videotapes were later copied to DVD using a Phillips DVD Recorder. A stills camera system (Photosea 1000A 35mm camera and Photosea 1500S strobe) was also fitted to the drop-frame and operated through the Simrad video control unit. Slide film was used, with the resulting stills scanned onto computer using a Nikon CoolScan IV slide scanner. These images were enhanced using Adobe Photoshop, and catalogued with positional information, which was determined as far as possible using the associated video footage.

Due to very strong tidal currents in the survey area the video footage was of poor quality, as it proved problematic keeping the drop frame still or moving at a slow enough speed for the video camera to focus. In addition the water was of high turbidity which further degraded video images. Eight stills images were of adequate quality to enable further analysis, and these complemented the video footage.

RoxAnn™ data analysis

The datasets were exported from RoxMap and split into a number of spreadsheets due to the large size of the datasets so that they could be edited and examined within MS Excel, and by using non-earth plots in a GIS to examine erroneous depth values. The data was cleaned with respect to depth spikes and ‘sticking’ of E1, E2 (‘roughness’ and ‘hardness’) and depth values that occurred when the ship was turning. No positional jumps were present in the data. The data for the main survey area was then averaged for every 5 records so that the two spreadsheets containing the dataset could be amalgamated, and the relationships between E1 and E2 and these variables with depth could be examined graphically. There was no significant relationship between either variable and depth which deems the data acceptable for further analysis. The same checks were made on the multibeam area RoxAnn™ datasets and passed adequately.

For the main survey area, a variability index was calculated for raw E1 and E2 values, which shows how variable particular seabed areas are, was calculated by measuring the variability between sequential E1 and E2 data points. This was generated by square-rooting the absolute value of the next data point minus the current data point for each of E1 and E2, then adding these together. This provides a measure of along-track data variability for E1 and E2, which was used in later analysis. The entire dataset for the main survey area was amalgamated in Surfer. The two (Irish) Sea Mounds datasets collected during the multibeam survey were treated in a similar manner, although prior to calculation of variability indices E1 and E2 were standardised by dividing each value by the 95th percentile of the range, such that the two surveys could be compared if necessary in the future. Positions for all RoxAnn™ data were converted into Irish National Grid and to Universal Transverse Mercator projection (zone 30N) using Geocalc software.

Variograms were created in Surfer using E1 and E2 values. The variance within these variables appears to level off at a distance of 400-500m between points for the main survey area, which indicates the maximum interpolation distance possible if interpolation is to give more information than simply the local mean. The variables depth, E1, E2, and variability index were interpolated throughout the survey area using linear kriging interpolator within Surfer, with a search radius of 400m and pixel size of 30m2. For each of the multibeam datasets, the variograms levelled off at between 200 and 300m. Grids were interpolated in these areas using linear kriging, with a search radius of 200m and pixel size of 30m2. These interpolated grids were then imported into Idrisi where raster images of each grid were created, with values stretched between 0-255. Composite images of two combinations of the variables were then produced (A: E1, E2, depth; B: E1, E2, variability index). A collection of all four variables was created and this was used in the unsupervised classification of the data. The ISOCLUST routine in Idrisi was used to produce unsupervised cluster maps for the survey areas.

Unsupervised classification was used for the analysis of RoxAnn™ interpolated data due to the limited spatial coverage of the ground-truthing sites. The number of clusters created was determined using a histogram of the grid datasets in Idrisi, as an integral part of the ISOCLUST routine. For the main survey area some eight clusters were chosen, relating to eight different ground-types. For each of the multibeam survey areas, six clusters were created.

The resulting cluster maps were converted into vector files, and then exported from Idrisi as shapefiles. The shapefiles were imported into ArcMap, part of the ArcGIS 8.3 geographical information system (ESRI). The RoxAnn™ track data, video and grab sample positions were entered into MS Access, and loaded into the GIS such that they could overlay the cluster maps.

Multibeam data analysis

Multibeam data for two sites (Peak 1 and Peak 4) was provided as XYZ files and as backscatter mosaics (in .tif format). The XYZ files contained positions given in Universal Transverse Mercator (Zone 30N) projection, based on 5x5m grid spacing. The XYZ files were imported into MS Access, where the depth values were converted into negative numbers such that they were comparable with the RoxAnn™ data format and would enable production of elevation models. The data was loaded into ArcMap 8.3, and TIN (triangulated irregular networks) files created from the data using the 3D Analyst extension, which use depth as the elevation field. The TIN files were then converted into Raster grids. These elevation / bathymetric data layers were then presented in ArcScene 8.3, where they are viewed in 3D. The accompanying datasets (cluster maps, RoxAnn™ tracks, ground-truthing data) were overlaid on these bathymetric layers to improve habitat interpretation. The multibeam backscatter images were georeferenced in ArcMap and also added into ArcScene in 3D.

Ground-truthing data analysis

The video data was played back and where the footage was of adequate quality, notes were made of substrate type and characterising species. The positions of the video at such points were noted from the video overlay. The stills images showed considerably more detail than the video footage and added to the habitat descriptions by facilitating species identification. The positions of each clear area were entered in MS Access, with the associated species and substrate information. Once all footage had been examined, habitats were assigned to each area based upon the species and substrate descriptions. This data is provided in Annex I. The habitat categories identified from the video data are provided in Table 7.1 below.

For each of the grab samples, particle size analysis (PSA) data and species lists are provided. This data is summarised by the use of Shannon-Weiner diversity index and this, along with PSA data and species data, is provided in Annex II, along with a map showing the codes for each grab sample.

Results and Discussion

Main survey area

Figure 7.1 shows a bathymetric plot for the main survey area, and also shows the areas Peak 1 and Peak 4 that were surveyed using multibeam sonar. The bathymetry for the main survey area was produced from RoxAnn™ data. The region shows four distinctly raised areas, or peaks, with an additional peak/ridge towards the south of the region in the centre. The four peaks identified on figure 7.1 range between 3.5km and 1.5km in diameter, with the largest distinct peak being Peak 1 and smallest being Peak 3. The 'ridge' discussed above is approximately 10km in length with a maximum width of 3.5km. The features (peaks and troughs) appear to run generally in a NNW to SSE orientation, with the deeper areas towards the north of the region, shallowing to the south. The maximum depth is approximately 170m, with the shallowest depth found at 40m on Peak 1.

Figures 7.2 and 7.3 show the RoxAnn™ raw data for the region. As with the bathymetry, roughness and hardness data shows NNW-SSE running features. Each peak shows a notable increase in E1 and E2 (roughness and hardness), although in general Peak 1 and Peak 2 show the highest level of hardness (E2). This could in part be due to the shallower depth here, which may favour the second return echo. However no depth dependency was shown in any of the RoxAnn™ datasets and therefore it is possible that the substrate at these two peaks is harder or denser than that found in any other area of the survey region. It is also notable that the area known as Peak 4 shows a lower hardness range than any of the other peaks. The areas of lowest roughness and hardness occur in general from about 54°31' southwards, particularly dominating the west of the survey area. These areas interestingly do not only correspond to the deepest areas between the peaks, but also occur between Peak 2, Peak 3 and the peak/ridge towards the south in the centre of the survey area, as discussed above. The 'trough' in the centre of the survey area, measuring some 11km in length and 1.5km in width, and running NNW-SSE between 54°33' and 54°28', is characterised by very low roughness and hardness. The trough to the northwest edge of the survey area, of which only part of the feature was covered by the RoxAnn™ survey, shows generally higher roughness and hardness values than the more southerly trough, indicating that the substrate may be different. There are also a number of smaller raised areas east of the main trough that show moderate-high levels of roughness and moderate to low levels of hardness.

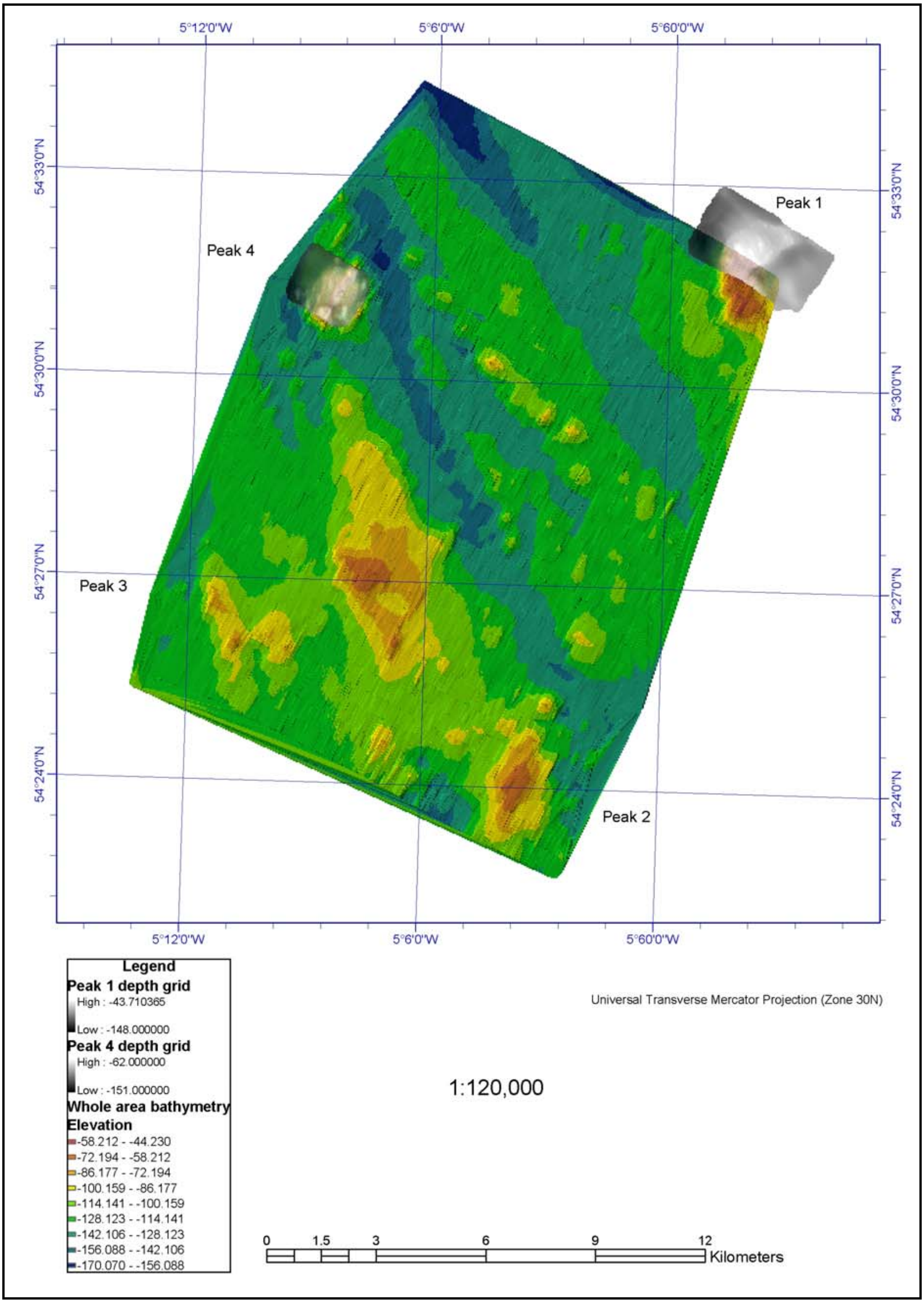

Figure 7.1: Bathymetry of North Channel Peaks region, created from RoxAnn™ data, with multibeam survey areas displayed (Peaks 1 and 4).

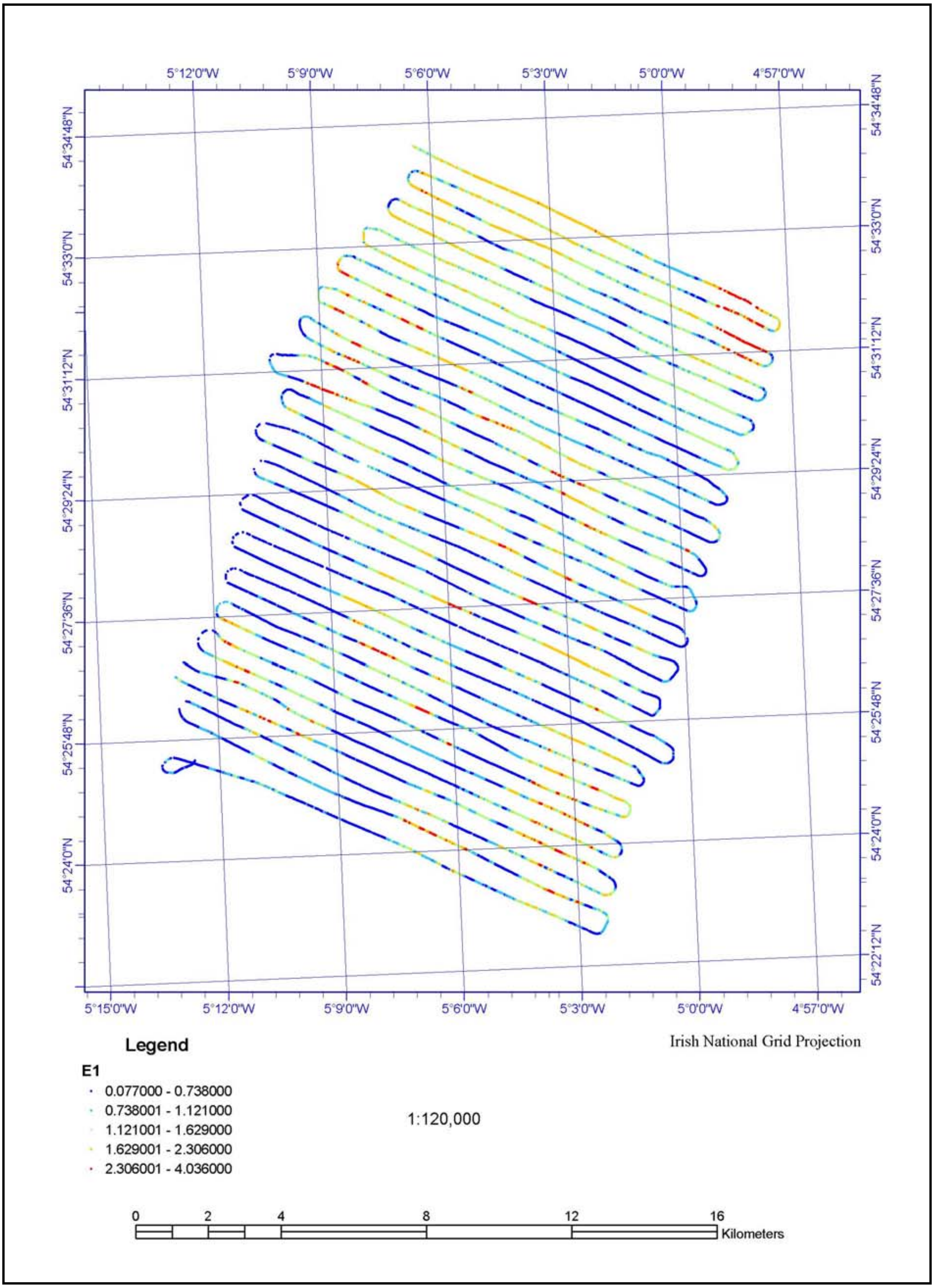

Figure 7.2: RoxAnn™ dataset for North Channel Peaks region, displayed according to E1 (roughness) values.

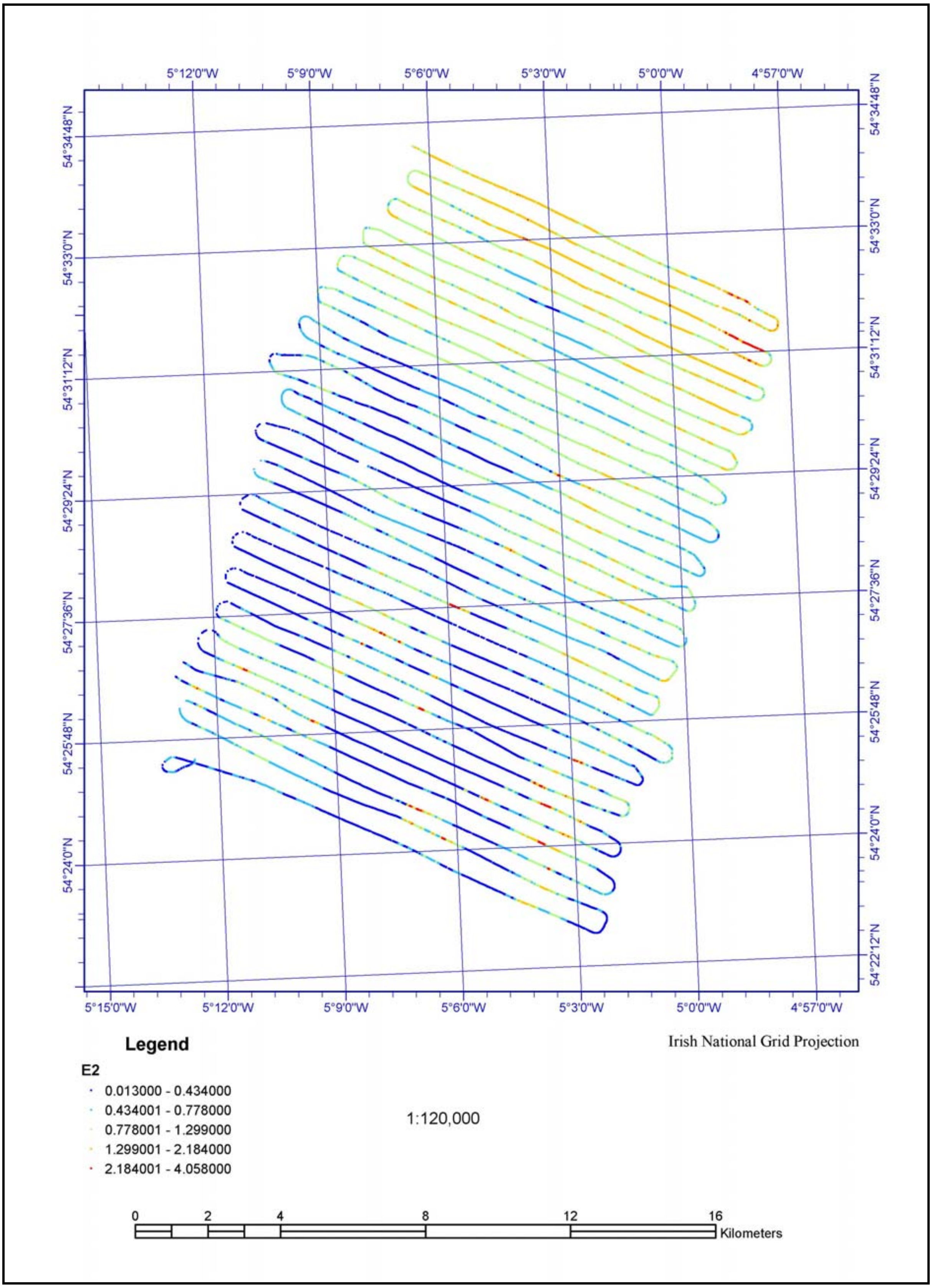

Figure 7.3: RoxAnn™ dataset for North Channel Peaks region, displayed according to E2 (hardness) values.

Figure 7.4 shows the unsupervised classification map of the RoxAnn™ dataset for the main survey area. Eight distinct groundtypes were identified, with clusters 8 and 2 exhibiting the highest values of roughness and hardness, and clusters 1, 6 and 3 the lowest values of roughness and hardness. Cluster 5 was characterised by moderate to high values of roughness but low hardness, while cluster 4 showed low levels of roughness but moderate levels of hardness. Cluster 7 showed moderate levels of both roughness and hardness. The peaks and ridges are characterised by cluster 8, and bordered by cluster 2. The main trough was dominated by cluster 1 and cluster 5, while clusters 3 and 6 dominate the extensive soft areas to the south of the survey area. As expected the clusters show a distribution following features running NNW to SSE.

The distribution of the ground-truthing surveys are also shown on Figure 7.4, and it can be seen that these fall on clusters 8 and 2. It is therefore not possible to ascertain what habitat each cluster relates to throughout the survey area due to the limited spatial coverage of the ground-truthing data. The habitats identified from the video footage and stills images show a degree of heterogeneity that is not reflected by the distribution of clusters, which is due to the scale of this heterogeneity being smaller than the spacing of the RoxAnn™ survey tracks. However, it is likely that both clusters 8 and 2 relate to bedrock outcrops (reef habitat), interspersed by crevices and areas filled with softer sediments (muddy sand) and loose boulders. Much of the bedrock is covered by a sediment veneer consisting of either muddy sand of shell gravel, which may explain the lower hardness values compared to the high roughness values given by RoxAnn™. The areas that correspond to troughs are most probably soft sediments such as bioturbated mud or muddy sand, bordered by sand and gravel areas (coarse sediments), possibly with a significant proportion of comminuted and whole dead shell. Additional spatially targeted survey effort is required to verify such ground-types, by means of grabs and towed underwater video.

On the basis of the identified distribution of peaks, a number of areas were chosen for the multibeam survey campaign to target reef habitat. Due to ship time constraints only two of these areas were completed by the multibeam survey: Peak 1 and Peak 4.

Full towed video and stills log sheets are presented in table 7.2 (Annex I). Figure 7.13 shows the location and codes of Day grab sampling stations. Full particle size analysis of each grab sample is shown in table 7.4 (Annex II). The results of the biological qunatittaive sampling are presented in table 7.5 (Annex II).

Table 7.1: Habitat Descriptions for the North Channel Peaks region.

Habitat code	Substrate description	Characterising fauna/flora	Energy environment	Comments
CR.HCR.FaT 	>70% bedrock outcrops and boulders.	Visually dominated by dense numbers of Alyconium digitatum or Metridium senile and Urticina eques. Turbularia spp. abundant (T. indivisa and T. larynx?). Some dense areas of Ophiothrix fragilis. Sagartia elegans and Balanus spp. common. Frequent occurrence of Echinus esculentus.	High energy/ very exposed to tidal currents	As per National Marine Habitat Classification version 03.02 (JNCC).
CR.HCR.ShM 	>70% bedrock or boulders with overlying shell and muddy gravel, which forms a veneer of varying thickness.	Some Alcyonium digitatum, Metridium senile, Ophiothrix fragilis, Ophiocomina nigra and occasional Balanus spp.	High energy/ very exposed to tidal currents	

Habitat code	Substrate description	Characterising fauna/flora	Energy environment	Comments
CR.HCR.MuS 	>70% bedrock or boulders with thin to thick muddy sand veneer on horizontal and gently sloping surfaces. Little or no shell.	Ophiothrix fragilis and Ophiocomina nigra abundant. Munida rugosa common. Patches of hydrozoan turf. On vertical bedrock slopes, dense patches of Alcyonium digitatum, Urticina eques and Metridium senile are common, and Echinus esculentus is frequent.	High energy/ very exposed to tidal currents	
CMS/HCR 	Small-medium boulders on muddy sand and gravel.	Thick hydrozoan turf on boulders. Munida rugosa and Sagartia elegans common. Tunicates frequent.	Moderate-high energy, with varying exposure to strong tidal currents	Occurs between bedrock outrcrops or in wide crevices
CMS.Sh (no still image available)	>70% muddy sand with a significant proportion of comminuted shell.	Tunicates frequent. Poor visibility restricted analysis of this habitat.	Moderate energy (often deeper and therefore less exposed to strong tidal currents).	

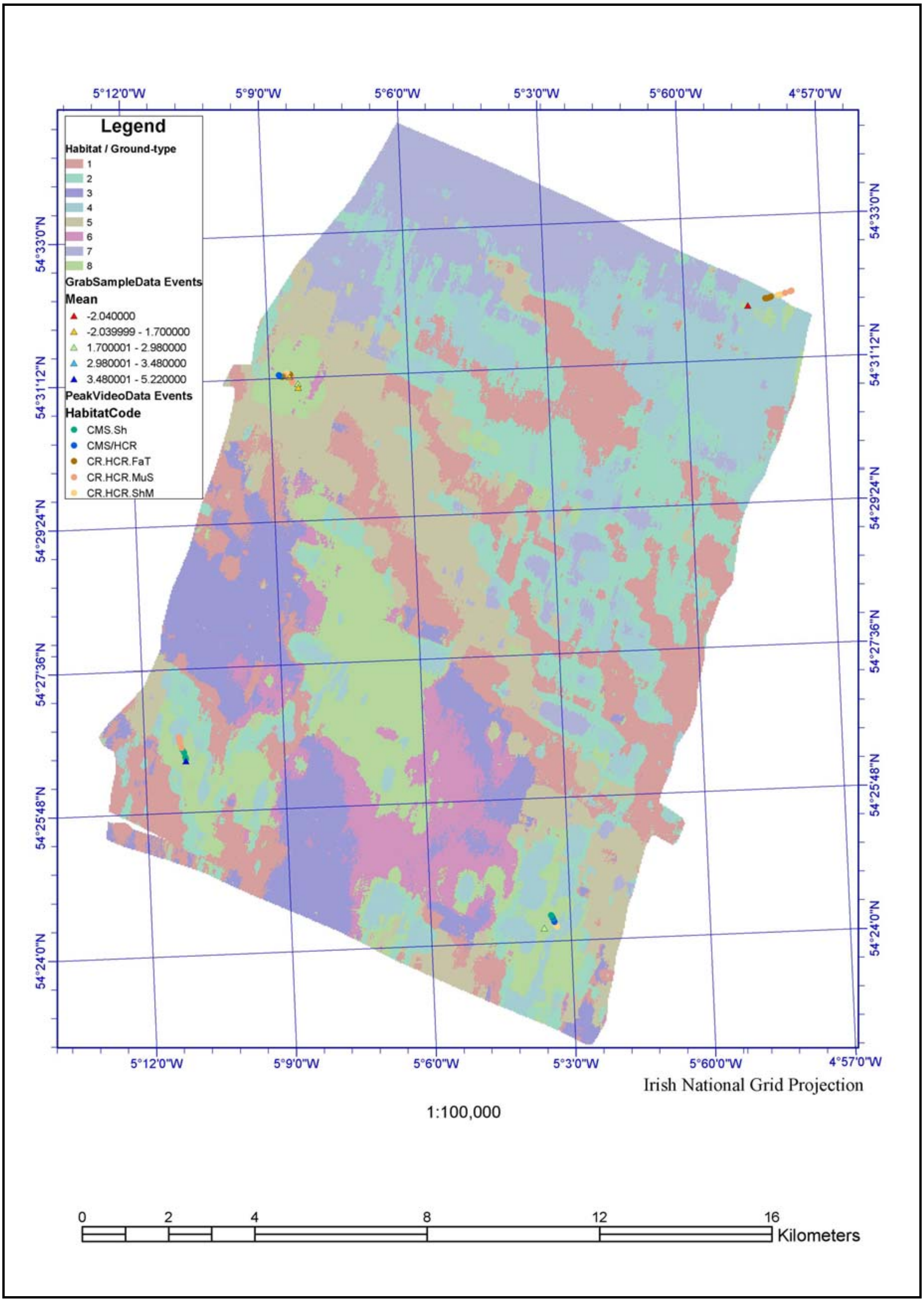

Figure 7.4: Unsupervised classification of RoxAnn™ data for the North Channel Peaks region, with video tow positions and grab sample positions displayed.

Peak 1 Survey Area

Figure 7.5 shows RoxAnn™ and multibeam survey tracks over Peak 1, along with the habitats identified by the video footage and the grab sample site. Underlying these data is an unsupervised cluster map based on the RoxAnn™ data for the area. It appears that the habitat CR.HCR.MuS occurs on cluster 2, while CR.HCR.ShM occurs on cluster 6 and CR.HCR.FaT occurs on cluster 4. All three clusters occur on very rough and hard ground, although cluster 6 also incorporates lower levels of roughness and hardness. From the available ground-truthing it would appear that clusters 2, 4 and 6 are representative of reef habitat, which in this survey area corresponds to a region of 3.75 km^2.

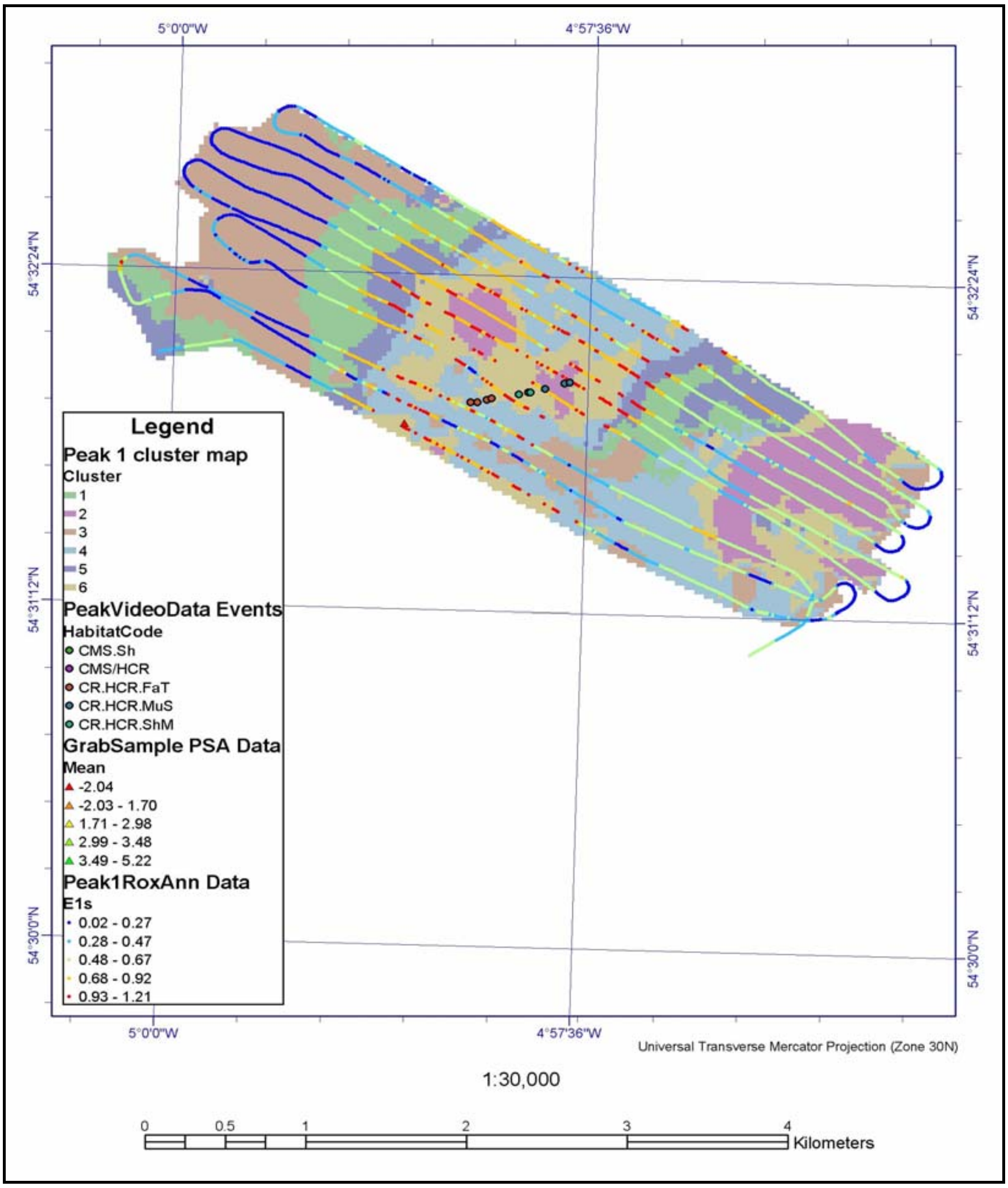

Figure 7.5: Unsupervised classification of RoxAnn™ data collected during multibeam survey of Peak 1, with RoxAnn™ tracks, video habitat category start positions and grab sample data displayed.

This also incorporates an area to the east (see Figure 7.5), which shows moderate levels of roughness and high levels of hardness and is classified as clusters 2 and 6. Cluster 6 may consist of rock with a dense faunal cover (including *Alcyonium digitatum*, *Metridium senile*, *Urticina eques* and *Tubularia* spp.) that could act to dissipate the acoustic energy from the transducer and therefore reduce the roughness and hardness values recorded by RoxAnn™.

Figure 7.6 below presents the multibeam bathymetric data for Peak 1. The distribution of reef outcrops is readily evident from this bathymetry, which, when overlaid by the cluster map (figure 7.7) indicates that clusters 2, 4 and 6 indeed correspond to such an area. The vertical/sloping areas bordering the peak, which should also be included as reef, consist predominantly of clusters 1 and 5. These regions correspond to an area of 2.204 km^2, giving a total of 5.96 km^2 reef habitat.

The multibeam backscatter data is overlaid upon the bathymetry in figure 7.8 below. Unfortunately there is little distinction between the different areas, although it can be seen that darker reflectance occurs on the raised areas (reef) and on an area to the east, which has also been identified as possible reef. Lower reflectance areas occur to the southeast and to the western border of the survey area, indicating possibly softer sediments. No obviously light areas are visible on the backscatter image, indicating that there are possibly no very soft or flat areas in this region, such as mud habitats.

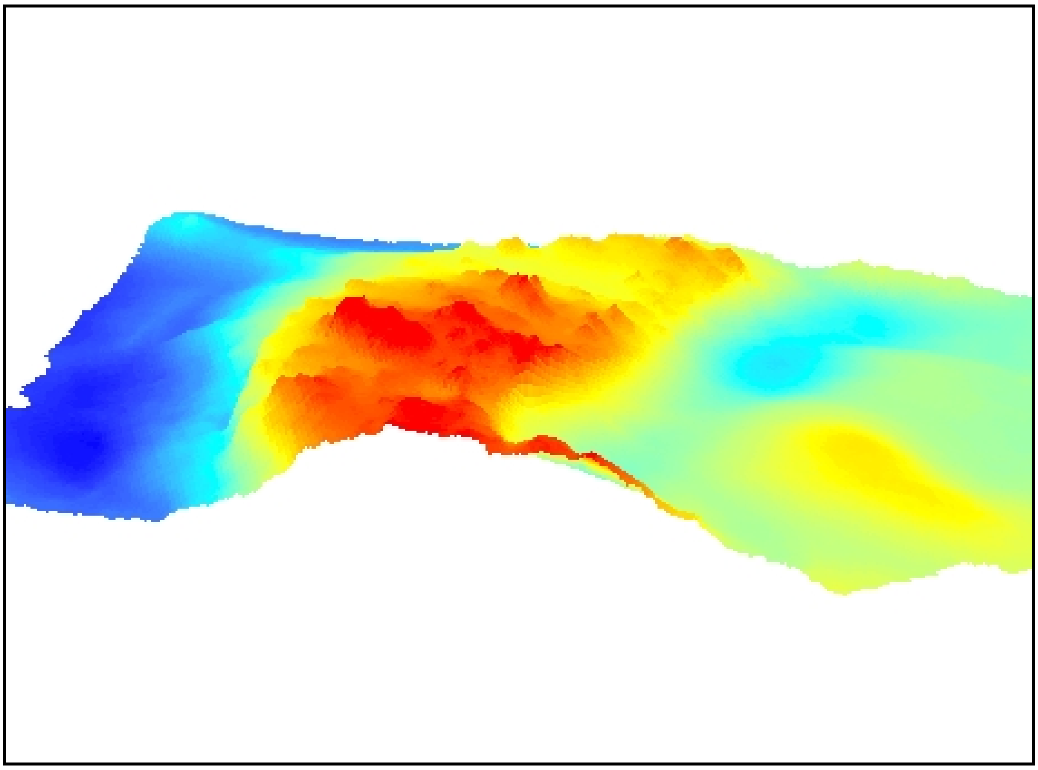

Figure 7.6: Multibeam bathymetry of Peak 1. Vertical exaggeration: x5.

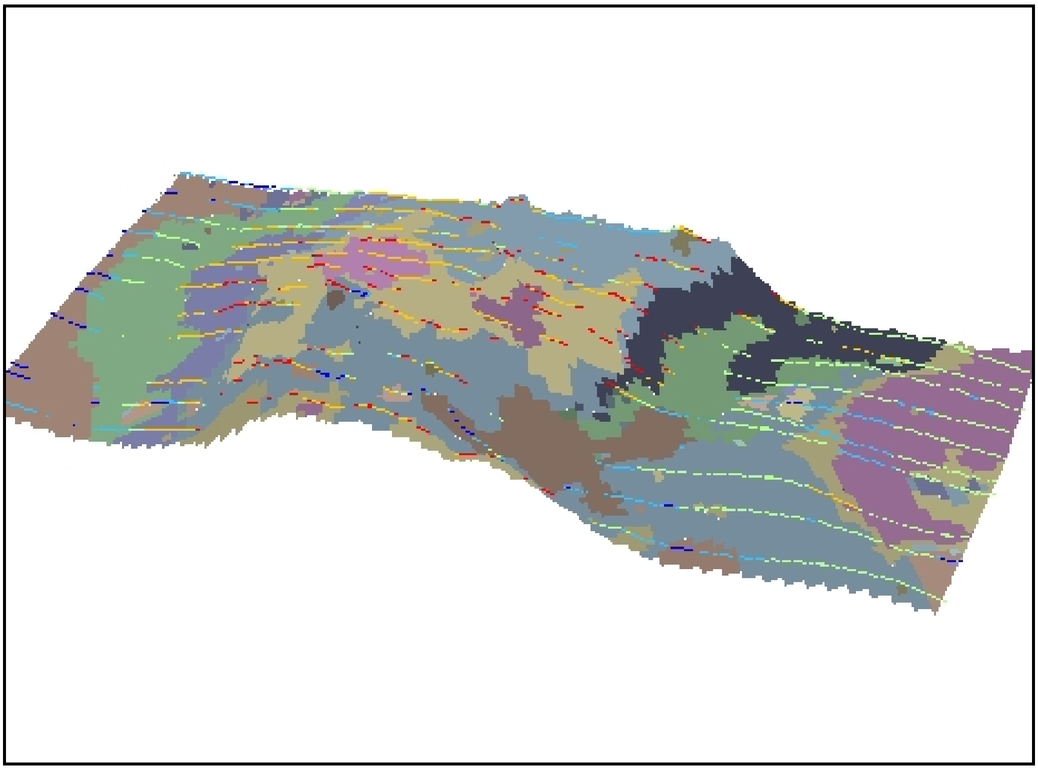

Figure 7.7: Cluster map overlaid upon multibeam bathymetry for Peak 1, with RoxAnn™ tracks displayed according to E1 (roughness). Vertical exaggeration: 5. Note dark blue area is in shade, and actually corresponds to purple area (see figure 7.5).

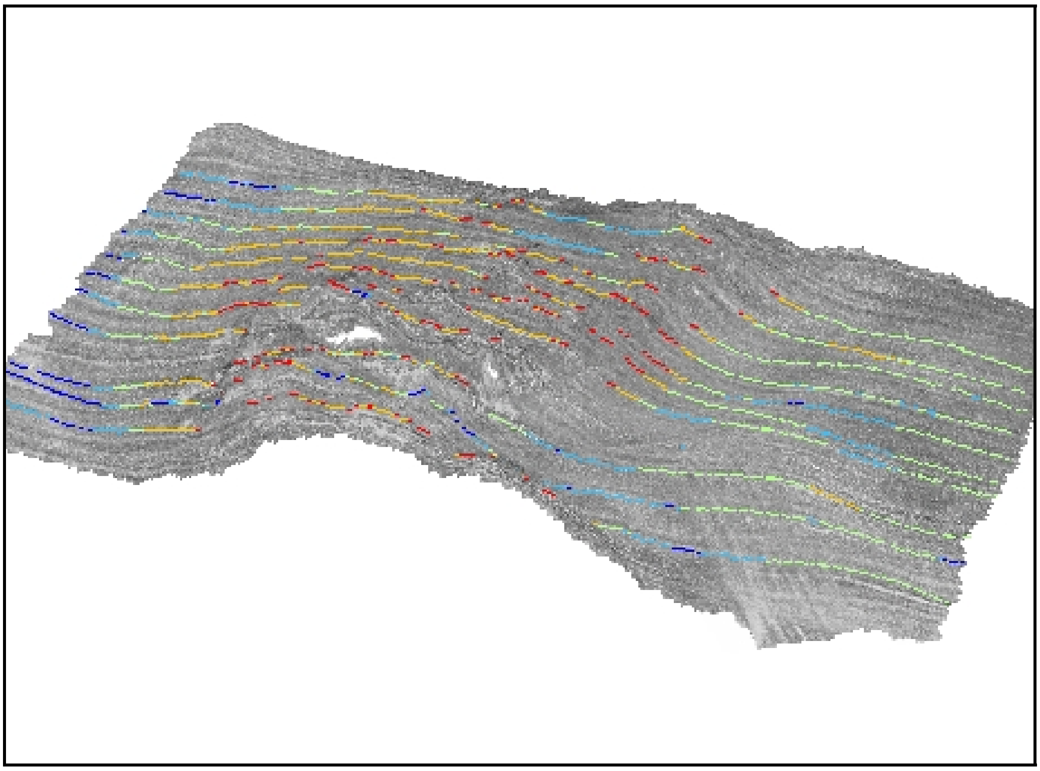

Figure 7.8: Multibeam backscatter data overlaid upon bathymetry for Peak 1, with RoxAnn™ tracks displayed according to E1 (roughness). Vertical exaggeration: 5.

Peak 4 Survey Area

Figure 7.9 shows RoxAnn™ and multibeam survey tracks over Peak 4, along with the habitats identified by the video footage and the grab sample site. Underlying these data is an unsupervised cluster map based on the RoxAnn™ data for the area. It appears that the habitats incorporating a significant proportion of muddy sand occur on cluster 3 (CR.HCR.MuS, CMS/HCR, CMS.Sh) while CR.HCR.FaT and CR.HCR.ShM occurs on cluster 6. The grab samples also tentatively support this, with a higher mean sediment phi occurring on cluster 6 and lower mean phi occurring on cluster 3. Cluster 6 generally shows higher values of roughness and hardness while cluster 3 shows a moderate range of roughness and hardness. The underwater video tow went over a peak and through crevices, which occur at a scale not comparable with the RoxAnn™ track data. It is notable, however, that the RoxAnn™ data shows a high degree of heterogeneity over the peak in the central region of the survey area, and therefore interpolated data is likely to be erroneous or can only be considered at a broad scale.

Using the multibeam data, it is more evident which areas correspond to reef habitat. Figure 7.10 presents the bathymetry for the Peak 2 area, with the RoxAnn™ cluster map overlain in Figure 3.3. Here, it is immediately apparent that the cluster map fails to detect the very heterogeneous ground in the area of the peak, and both clusters 3 and 6 fall on the sides and tops of each rocky outcrop, which would be expected to harbour a number of different habitats, as identified from the video footage. The tops of the outcrops are very current-swept and consist largely of dense faunal turf, with a dominance of *Urticina eques*, *Tubularia* spp. and *Metridium senile*. In the deeper waters, which are less subject to tidal flow, a sediment veneer frequently covers the rock with only vertical surfaces harbouring dense faunal turfs. Peak 4 is deeply fissured, as is evident in Figure 3.2, with such crevices filled with softer substrates and shell debris, with frequent occurrence of *Munida rugosa*, *Ophiothrix fragilis* and *Ophiocomina nigra*. Despite the shortcomings of the RoxAnn™-based cluster map in terms of representing the true seabed heterogeneity as evident from the multibeam bathymetry, both clusters 3 and 6 only occur on the bedrock outcrops and therefore an estimate of the area of reef habitat can be made from the cluster map. This gives a result of 2 km2. Clusters 1 and 4 occur in areas at the edge of the rock outcrops, and possibly consist of mixed habitats with coarse material (boulders and cobbles, with some gravel) mixed with muddy sands, while clusters 2 and 5 occur in deeper water with low roughness and hardness values, indicating soft substrates, possibly muddy sand. Again such habitat suggestions require verification by additional ground-truthing.

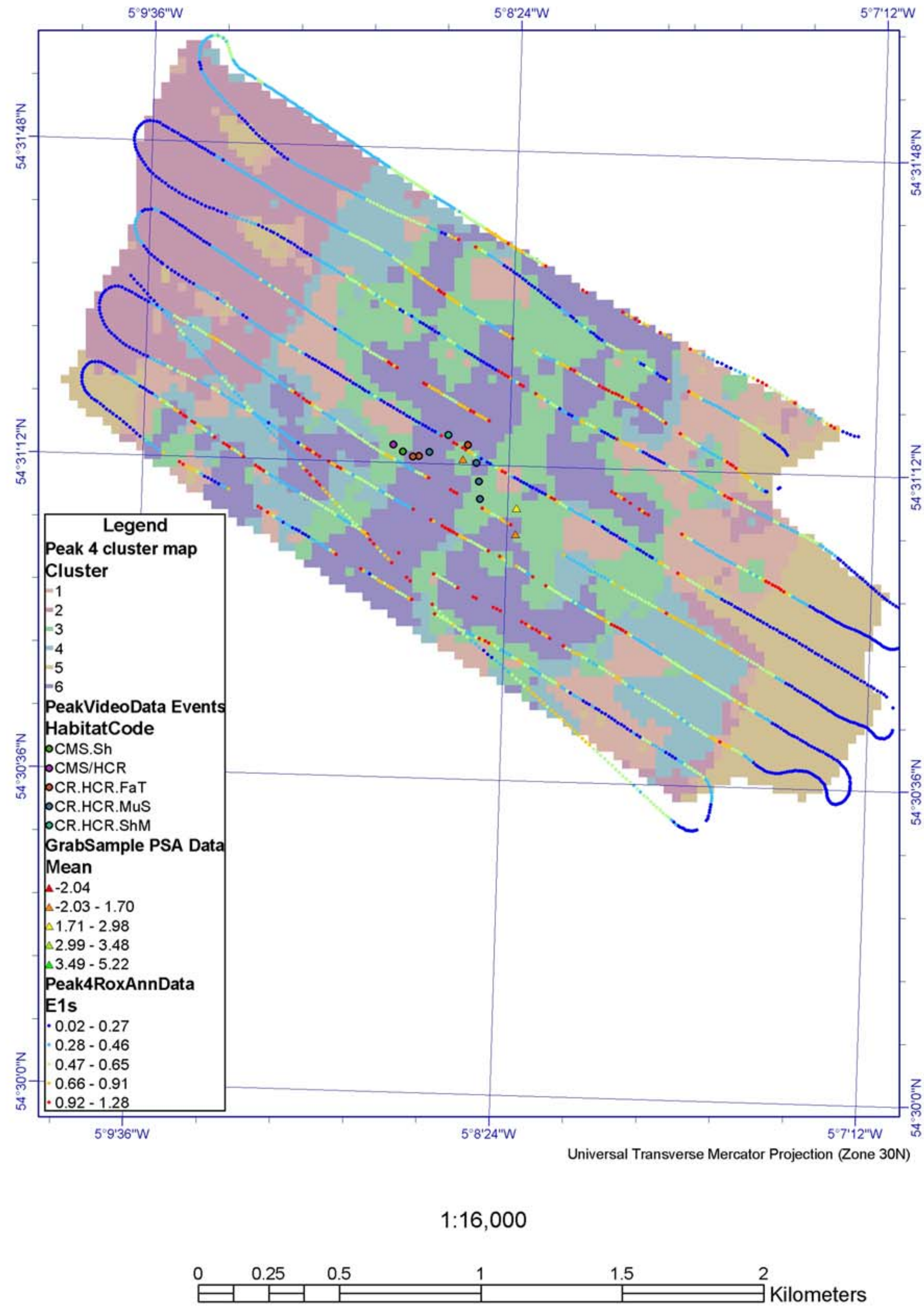

Figure 7.9: Unsupervised classification of RoxAnn™ data collected during multibeam survey of Peak 4, with RoxAnn™ tracks, video habitat category start positions and grab sample data displayed.

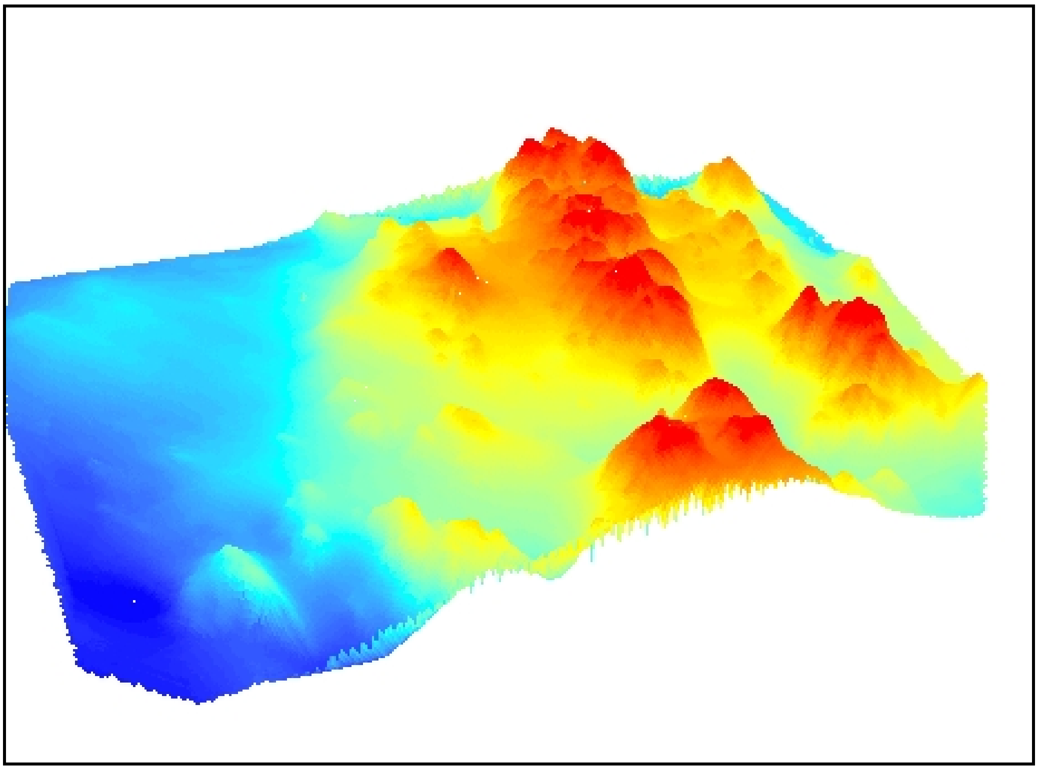

Figure 7.10: Multibeam bathymetry of Peak 4. Vertical exaggeration: x5.

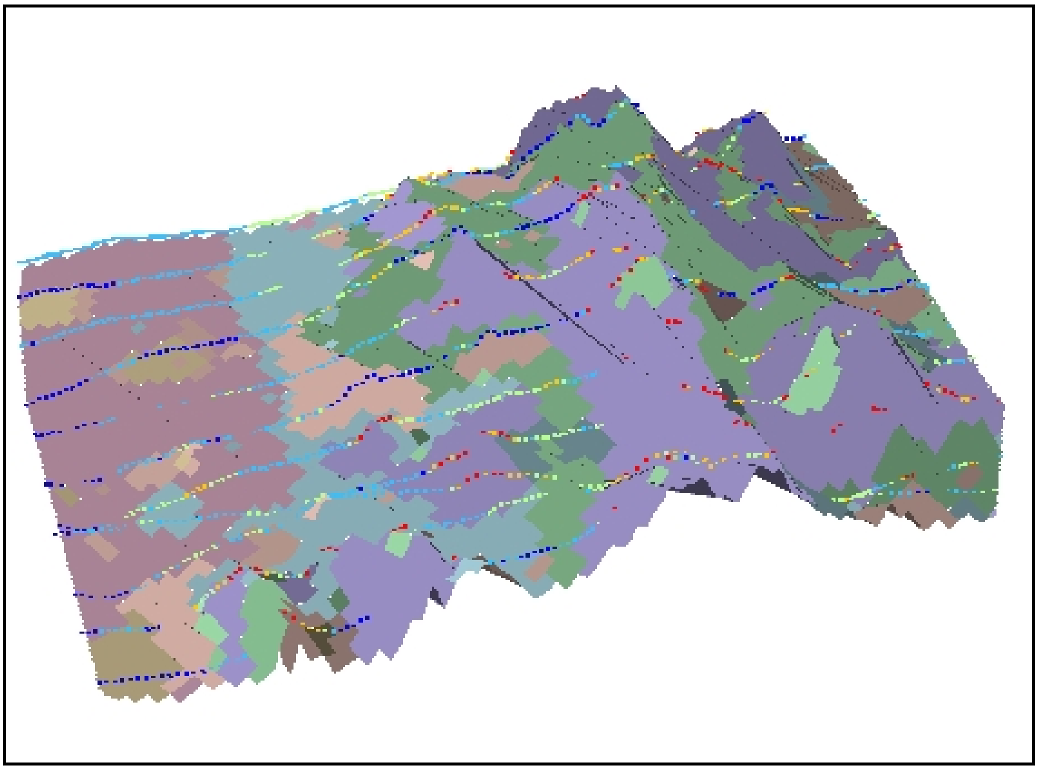

Figure 7.11: Cluster map overlaid upon multibeam bathymetry for Peak 4, with RoxAnn™ tracks displayed according to E1 (roughness). Vertical exaggeration: x5. Refer to figure 7.9 for cluster map legend.

The multibeam backscatter information is presented in 3D in figure 7.12. Dark reflecting areas indicating hard/rough substrates occur at the top of the outcrops as expected from the ground-truthing, and it would appear that many of the slopes of the outcrops show medium levels of backscatter, possibly coinciding with the video footage indicating thick sediment veneers over rock, which would be expected to reduce backscatter. This again agrees with the area classified as clusters 3 and 6 from the RoxAnn™ data. The lighter reflecting areas occur to the west of the survey region in the deeper water, in what was classified as cluster 2, where RoxAnn™ indicated low roughness and hardness. Such a region may consist of sand or muddy sands. A few small light reflecting areas occur immediately to the west of the outcrops, in what is an area classified as cluster 4, which may correspond to level, soft sediment areas. Ground-truthing would be necessary to confirm these suggestions.

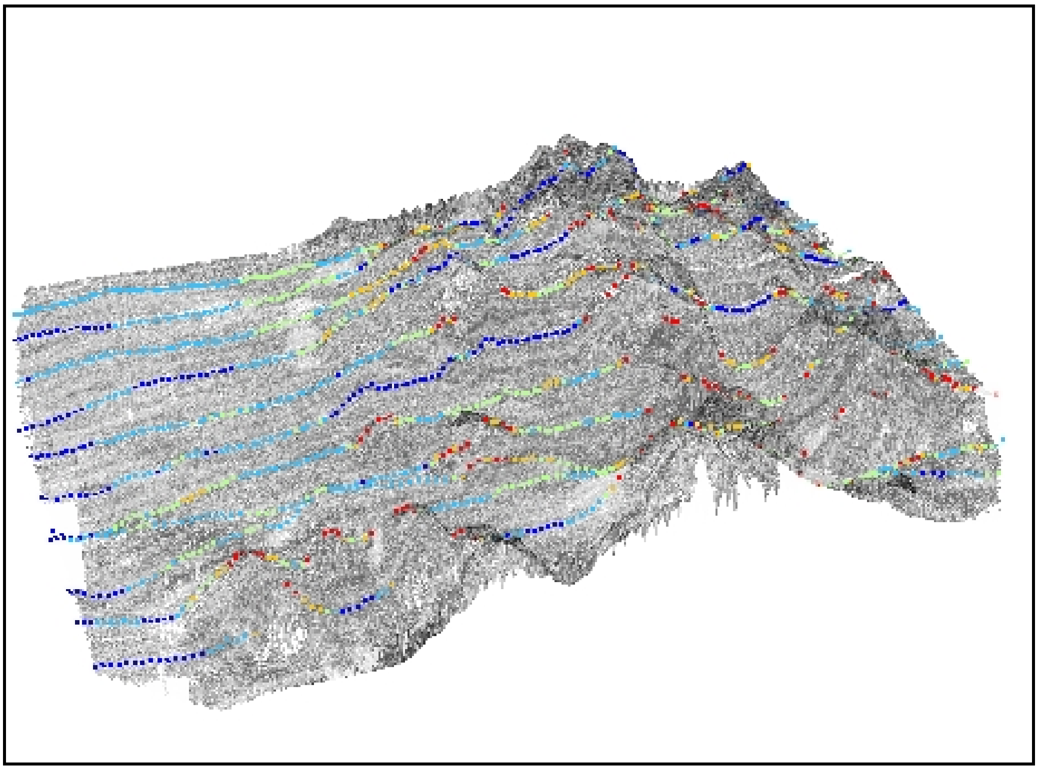

Figure 7.12: Multibeam backscatter data overlaid upon bathymetry for Peak 4, with RoxAnn™ tracks displayed according to E1 (roughness). Vertical exaggeration: x5.

In terms of biological diversity, Peak 4 showed the highest number of species determined from the grab samples (54 species in replicate NCP4A, taken at the edge of an outcrop), and showed a slightly higher Shannon-Weiner diversity index (average 3.16) than the other Peaks. Full results from the analysis of biological diversity can be found in Annex II; table 7.3.

Conclusions and Recommendations

The acoustic surveys, utilising both RoxAnn™ AGDS and multibeam sonar, identified a total of five significant areas of rocky outcrops within the survey area, corresponding to EC Habitats Directive Annex II Reef Habitat. Underwater video footage showed that such ‘peaks’ consisted of habitats typical of strongly current-swept areas, with dense faunal turfs characterised by thick carpets of anemones and soft corals. In deeper waters where some shelter is afforded from the tidal currents, a muddy sand or shell gravel veneer overlaid the bedrock, with its own characterising fauna. Peak 1 and Peak 4 of the reef areas were investigated in some detail, with bathymetric models built for these two regions based on multibeam data. The two areas, although predominantly sharing similar distributions of habitats, showed differing degrees of heterogeneity. Peak 1 showed a significant continuous area of high energy reef habitat (3.75km^2) and a smaller, deeper area of potential reef habitat to the east of the main peak (2.21km^2), while Peak 4 was revealed as a series of steep rocky outcrops and sediment-filled ‘crevices’, exhibiting a high level of heterogeneity over small distances. In this Peak 4 area the high energy reef habitat is believed to extend approximately 2 km^2.

It is recommended that further ground-truthing using towed sledge underwater video systems are used for investigation of the softer substrate areas as identified in paragraph 7.2.2.3, with associated grab sampling, and that further multibeam sonar and/or RoxAnn™ AGDS work be completed over the three remaining peak/ridge areas within the survey region, using tighter track spacing to facilitate recognition of the diversity and scale of habitats in such areas. In particular the ‘ridge’ running NNW-SSE warrants inspection, as it is the largest potentially continuous reef habitat within the survey region.

Annex I: Underwater video and stills log sheets

Table 7.2: Towed video and stills log sheets, showing habitat descriptions.

Peak ID	Video Section Start Latitude (dec)	Video Section Start Longitude (dec)	Latitude degree (N)	Latitude decimal minutes	Longitude degree (W)	Longitude decimal minutes	Still Image Code	Habitat Description	Habitat Code
1	54.53240	-4.97125	54	31.944	4	58.275	peak1a	Bedrock outcrops, dense *Alcyonium digitatum, Urticina eques* & *Metridium senile*, *Tubularia* spp. with *Echinus esculentus*	CR.HCR.FaT
1	54.53242	-4.97062	54	31.945	4	58.237		Bedrock outcrops, dense *A. digitatum*, *U. eques* & *M. senile*, *Tubularia* spp. with *E. esculentus*	CR.HCR.FaT
1	54.53257	-4.96970	54	31.954	4	58.182	peak1b22	Bedrock outcrops, dense *A. digitatum*, *U. eques* & *M.m senile*, *Tubularia* spp. with *E. esculentus*	CR.HCR.FaT
1	54.53267	-4.96925	54	31.96	4	58.155	peak1c23	Bedrock outcrops, dense *A. digitatum*, *U. eques* & *M. senile*, *Tubularia* spp. with *E. esculentus*	CR.HCR.FaT
1	54.53293	-4.96667	54	31.976	4	58		Shell and muddy gravel overlying bedrock. Some *A. digitatum* and *M. senile*, *Ophiothrix fragilis* and *Ophiocomina nigra*, *Balanus* spp.?	CR.HCR.ShM
1	54.53307	-4.96575	54	31.984	4	57.945	peak1d24	Shell and muddy gravel overlying bedrock. Some *A. digitatum* and *M. senile*, *Ophiothrix fragilis* and *Ophiocomina nigra*, *Balanus* spp.?	CR.HCR.ShM
1	54.53308	-4.96557	54	31.985	4	57.934		Shell and muddy gravel overlying bedrock. Some *A. digitatum* and *M. senile*, *Ophiothrix fragilis* and *Ophiocomina nigra*, *Balanus* spp.?	CR.HCR.ShM
1	54.53308	-4.96557	54	31.985	4	57.934		Shell and muddy gravel overlying bedrock. Some *A. digitatum*, *M. senile*, *O. fragilis*, *O. nigra*, & *Balanus* spp.?	CR.HCR.ShM
1	54.53332	-4.96413	54	31.999	4	57.848		*M. rugosa*, *O. nigra*, *O. fragilis* on rock with thin muddy sand veneer	CR.HCR.MuS
1	54.53365	-4.96228	54	32.019	4	57.737		*M. rugosa*, *O. nigra*, *O. fragilis* on rock with thin muddy sand veneer	CR.HCR.MuS

Peak ID	Video Section Start Latitude (dec)	Video Section Start Longitude (dec)	Latitude degree (N)	Latitude decimal minutes	Longitude degree (W)	Longitude decimal minutes	Still Image Code	Habitat Description	Habitat Code
1	54.53373	-4.96178	54	32.024	4	57.707		*Munida rugosa*, *Ophiocomina nigra*, *Ophiothrix fragilis* on rock with thin muddy sand veneer	CR.HCR.MuS
2	54.40338	-5.05508	54	24.203	5	3.305		Bedrock with muddy sand veneer and shell debris	CR.HCR.ShM
2	54.40367	-5.05543	54	24.22	5	3.326		Bedrock with muddy sand veneer and shell debris, crinoids?	CR.HCR.ShM
2	54.40435	-5.05593	54	24.261	5	3.356	peak2a25	Thick muddy sand in wide rock crevices, *Munida rugosa*, *Sagartia* spp.	CMS/HCR
2	54.40452	-5.05608	54	24.271	5	3.365		Some small boulders (loose) and pebbles on muddy sand. Tunicates.	CMS/HCR
2	54.40508	-5.05643	54	24.305	5	3.386		Muddy sand and comminuted shell	CMS.Sh
2	54.40535	-5.05663	54	24.321	5	3.398		Medium boulders and muddy sand	CMS/HCR
2	54.40563	-5.05688	54	24.338	5	3.413		Muddy sand and comminuted shell	CMS.Sh
2	54.40577	-5.05707	54	24.346	5	3.424		Muddy sand and comminuted shell	CMS.Sh
3	54.44140	-5.18493	54	26.484	5	11.096		Muddy sand and comminuted shell	CMS.Sh
3	54.44178	-5.18508	54	26.507	5	11.105		Muddy sand and comminuted shell	CMS.Sh
3	54.44278	-5.18553	54	26.567	5	11.132		Muddy sand and comminuted shell	CMS.Sh
3	54.44345	-5.18610	54	26.607	5	11.166		Muddy sand and comminuted shell, tunicates	CMS.Sh
3	54.44382	-5.18637	54	26.629	5	11.182		Muddy sand- thick veneer over rock? Some boulders and shell.	CR.HCR.MuS
3	54.44480	-5.18678	54	26.688	5	11.207		Muddy sand veneer on rock with patches of hydrozoan turf	CR.HCR.MuS
3	54.44553	-5.18693	54	26.732	5	11.216		Muddy sand veneer on rock with patches of hydrozoan turf	CR.HCR.MuS
3	54.44575	-5.18713	54	26.745	5	11.228		Muddy sand veneer on rock with patches of hydrozoan turf	CR.HCR.MuS
3	54.44602	-5.18725	54	26.761	5	11.235		Muddy sand veneer on rock with patches of hydrozoan turf	CR.HCR.MuS

Peak ID	Video Section Start Latitude (dec)	Video Section Start Longitude (dec)	Latitude degree (N)	Latitude decimal minutes	Longitude degree (W)	Longitude decimal minutes	Still Image Code	Habitat Description	Habitat Code
4	54.51892	-5.14150	54	31.135	5	8.49		Thick muddy sand overlying rock on horizontal surfaces; on rock slopes dense *Urticina eques* and *Metridium senile*	CR.HCR.MuS
4	54.51947	-5.14160	54	31.168	5	8.496		Thick muddy sand overlying rock on horizontal surfaces; on rock slopes dense *Urticina eques* and *Metridium senile*	CR.HCR.MuS
4	54.52005	-5.14177	54	31.203	5	8.506	peak4a26	Thick muddy sand veneer with hydroids (inc.*Tubularia* spp.) and anemones (*U. eques*, *Sagartia elegans, M. senile*) on rock	CR.HCR.MuS
4	54.52062	-5.14227	54	31.237	5	8.536	peak4a29	Rock with dense *U. eques*, *M. senile and some S.elegans*, *A. digitatum*, dense *Tubularia indivisa*, *Tubularia larynx* and nudibranch Dendronotus frondosus	CR.HCR.FaT
4	54.52092	-5.14333	54	31.255	5	8.6		Muddy gravel with shell (in between rock outcrops?), *Ophiocomina nigra*, *Ophiothrix fragilis* and *Echinus esculentus*	CR.HCR.ShM
4	54.52037	-5.14435	54	31.222	5	8.661	peak4d30	Sand veneer on bedrock with patches of *U. eques, A. digitatum* and *O. fragilis*	CR.HCR.MuS
4	54.52022	-5.14492	54	31.213	5	8.695		Dense *O. fragilis, M. senile, U. eques* and *Tubularia* spp. on bedrock	CR.HCR.FaT
4	54.52020	-5.14525	54	31.212	5	8.715		Dense *U. eques* and *Tubularia* spp. on bedrock	CR.HCR.FaT
4	54.52035	-5.14580	54	31.221	5	8.748		Muddy sand	CMS.Sh
4	54.52057	-5.14633	54	31.234	5	8.78		Muddy sand and gravel, with small boulders with hydrozoan turf	CMS/HCR

Annex II: PSA and biological diversity data from grab samples.

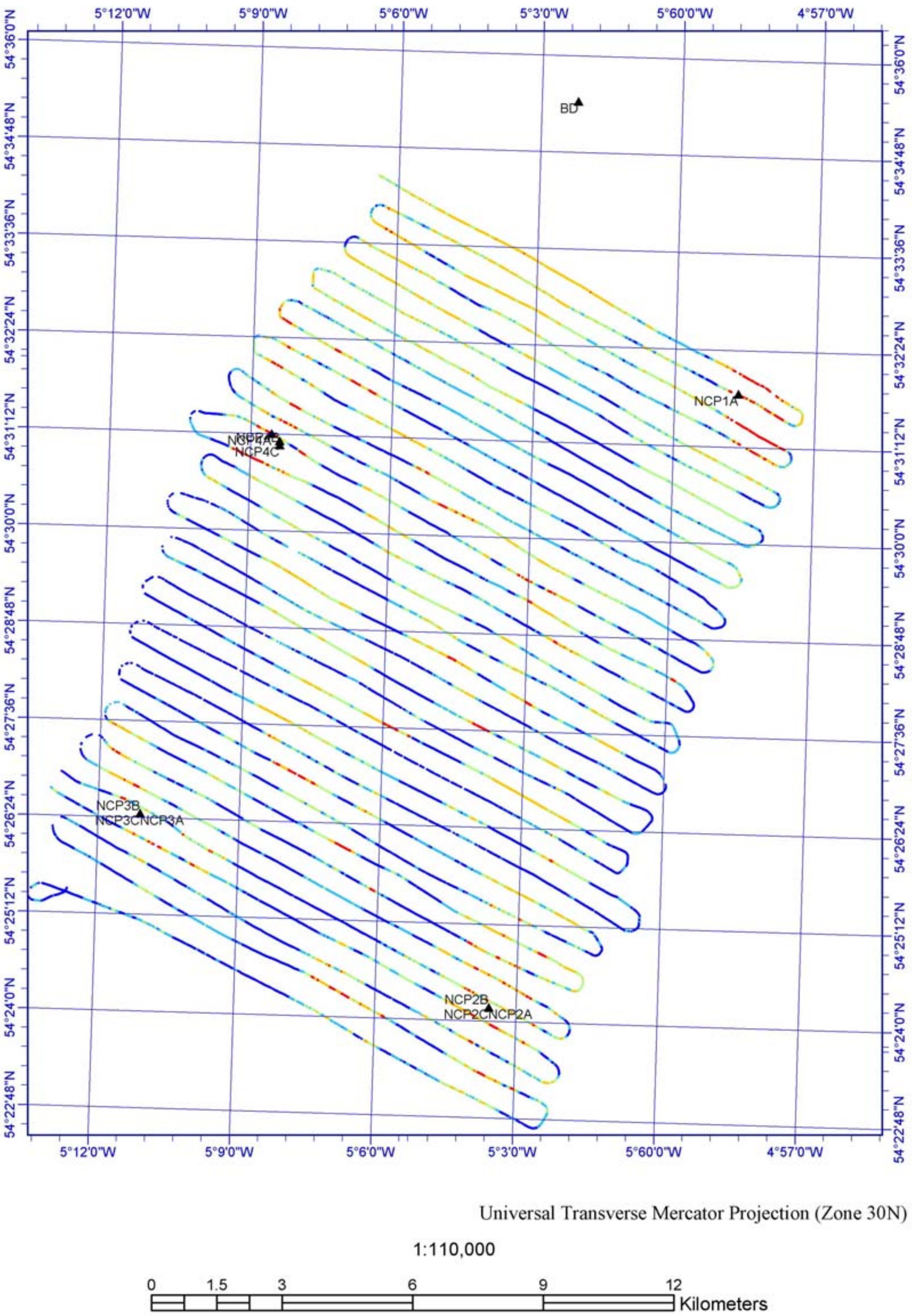

Figure 7.13: Map showing positions and ID codes of grab sampling stations.

Table 7.3: Shannon-Weiner diversity index from Day grab samples at each sample station.

GrabID	Latitude degrees (N)	Latitude decimal minutes	Longitude degrees (W)	Longitude decimal minutes	Latitude Decimal degrees	Longitude Decimal degrees	Shannon Weiner Diversity Index H	Variance H	Number of Species
BD	54	35.432	5	2.232	54.59053	-5.03720	2.6745	0.028253	25
NCP1A	54	31.864	4	58.654	54.53107	-4.97757	2.9718	0.012457	30
NCP2A	54	24.187	5	3.58	54.40312	-5.05967	2.9857	0.011424	28
NCP2B	54	24.187	5	3.58	54.40312	-5.05967	3.0137	0.010361	34
NCP2C	54	24.187	5	3.58	54.40312	-5.05967	n/a	n/a	4
NCP3A	54	26.46	5	11.094	54.44100	-5.18490	2.6096	0.009447	37
NCP3B	54	26.46	5	11.094	54.44100	-5.18490	2.5784	0.01663	41
NCP3C	54	26.46	5	11.094	54.44100	-5.18490	2.6265	0.009776	31
NCP4A	54	31.21	5	8.55	54.52017	-5.14250	3.5321	0.005426	54
NCP4B	54	31.12	5	8.37	54.51867	-5.13950	2.8026	0.008626	34
NCP4C	54	31.07	5	8.37	54.51783	-5.13950	3.1635	0.008349	48

Table 7.4: Particle Size Analysis from Day grab samples at each sample station

GrabID	Latitude degrees (N)	Latitude Dec minutes	Longitude degrees (W)	Longitude dec minutes	Lat Dec	Long Dec	Shell/Mineral	Mean	Sorting	Sort Class	Skewness	Skew Class	Kurtosis	Kurt Class
BD	54	35.432	5	2.232	54.59053	-5.0372	>2mm 40/60 SHELL/ MINERAL	1.7	4.71	Extremely poorly sorted	0.15	Positively skewed	0.97	Mesokurtic
NCP1A	54	31.864	4	58.654	54.53107	-4.97757	>2mm 50/50 SHELL/ MINERAL	-2.04	2.22	Very poorly sorted	0.22	Positively skewed	2.79	Very leptokurtic
NCP2A	54	24.187	5	3.58	54.40312	-5.05967	>2mm 70/30 SHELL/ MINERAL	2.98	3.7	Very poorly sorted	0.58	Very positively skewed	0.7	Platykurtic
NCP2B	54	24.187	5	3.58	54.40312	-5.05967	>2mm 60/40 SHELL/ MINERAL	2.6	4.09	Extremely poorly sorted	0.46	Very Positively skewed	0.75	Platykurtic
NCP2C	54	24.187	5	3.58	54.40312	-5.05967	>2mm 60/40 SHELL/ MINERAL	2.89	4.31	Extremely poorly sorted	0.3	Very positively skewed	0.72	Platykurtic
NCP3A	54	26.46	5	11.094	54.441	-5.1849	>2mm 80/20 SHELL/ MINERAL	3.48	3.67	Very poorly sorted	0.51	Very positively skewed	0.66	Very platykurtic
NCP3B	54	26.46	5	11.094	54.441	-5.1849	>2mm 80/20 SHELL/ MINERAL	5.12	3.77	Very poorly sorted	-0.32	Very negatively skewed	0.71	Platykurtic
NCP3C	54	26.46	5	11.094	54.441	-5.1849	>2mm 60/40 SHELL/ MINERAL	5.22	3.86	Very poorly sorted	-0.31	Very negatively skewed	0.78	Platykurtic
NCP4A	54	31.21	5	8.55	54.52017	-5.1425	>2mm 30/70 SHELL/ MINERAL	1.48	4.79	Extremely poorly sorted	0.33	Very positively skewed	0.69	Platykurtic
NCP4B	54	31.12	5	8.37	54.51867	-5.1395	>2mm 100/0 SHELL/ MINERAL	2.84	4.94	Extremely poorly sorted	-0.15	Negatively skewed	0.56	Very platykurtic
NCP4C	54	31.07	5	8.37	54.51783	-5.1395	>2mm 20/80 SHELL/MINERAL	1.06	4.46	Extremely poorly sorted	0.71	Very positively ske	0.66	Very platykurtic

Table 7.4: contd

GrabID	Latitude degrees (N)	Latitude decimal minutes	Longitude degrees (W)	Longitude decimal minutes	Latitude Decimal degrees	Longitude Decimal degrees	Gravel	Cobbles	Pebbles	Sand	Silt	Clay
BD	54	35.432	5	2.232	54.59053	-5.03720	36.97	0	36.97	43.06	13.75	6.21
NCP1A	54	31.864	4	58.654	54.53107	-4.97757	82.96	0	82.96	10.24	5	1.81
NCP2A	54	24.187	5	3.58	54.40312	-5.05967	9.19	0	9.19	54.78	27.93	8.1
NCP2B	54	24.187	5	3.58	54.40312	-5.05967	17.24	0	17.24	49.73	24.62	8.42
NCP2C	54	24.187	5	3.58	54.40312	-5.05967	18.06	0	18.06	34.3	38.17	9.48
NCP3A	54	26.46	5	11.094	54.44100	-5.18490	6.35	0	6.35	46.4	37.67	9.58
NCP3B	54	26.46	5	11.094	54.44100	-5.18490	7.62	0	7.62	28.13	51.42	12.83
NCP3C	54	26.46	5	11.094	54.44100	-5.18490	8.45	0	8.45	24.05	53.19	14.31
NCP4A	54	31.21	5	8.55	54.52017	-5.14250	37.77	0	37.77	31.84	23.06	7.33
NCP4B	54	31.12	5	8.37	54.51867	-5.13950	40.95	0	40.95	10.63	38.42	10.01
NCP4C	54	31.07	5	8.37	54.51783	-5.13950	55.05	0	55.05	16.31	22.01	6.63

Table 7.4: Contd

GrabID	Latitude degrees (N)	Latitude decimal minutes	Longitude degrees (W)	Longitude decimal minutes	Latitude Decimal degrees	Longitude Decimal degrees	No Modes	Largest Mode (um)	Mode (phi)	Median (um)	Median (phi)	Folk Clay Silt Ratio	Folk Sand Mud Ratio	Shepard 1954
BD	54	35.432	5	2.232	54.59053	-5.03720	4	304.48	1.72	390.36	1.36	Silty sand	Muddy sandy gravel	Clayey sand
NCP1A	54	31.864	4	58.654	54.53107	-4.97757	6	2401.84	-1.26	3693.12	-1.88	Sand	Gravel	Silty sand
NCP2A	54	24.187	5	3.58	54.40312	-5.05967	4	543.93	0.88	423.29	1.24	Silty sand	Gravelly muddy sand	Silty sand
NCP2B	54	24.187	5	3.58	54.40312	-5.05967	5	544.47	0.88	473.21	1.08	Silty sand	Gravelly muddy sand	Silty sand
NCP2C	54	24.187	5	3.58	54.40312	-5.05967	6	582.68	0.78	289.8	1.79	Silty sand	Gravelly mud	Sand silt clay
NCP3A	54	26.46	5	11.094	54.44100	-5.18490	6	546.55	0.87	270.65	1.89	Silty sand	Gravelly mud	Sand silt clay
NCP3B	54	26.46	5	11.094	54.44100	-5.18490	3	570.37	0.81	15.42	6.02	Sandy silt	Gravelly mud	Sand silt clay
NCP3C	54	26.46	5	11.094	54.44100	-5.18490	4	579.68	0.79	14.96	6.06	Sandy silt	Gravelly mud	Sand silt clay
NCP4A	54	31.21	5	8.55	54.52017	-5.14250	5	628.76	0.67	766.3	0.38	Silty sand	Muddy sandy gravel	Sand silt clay
NCP4B	54	31.12	5	8.37	54.51867	-5.13950	2	8.12	6.94	78.74	3.67	Silty sand	Muddy gravel	Clayey silt
NCP4C	54	31.07	5	8.37	54.51783	-5.13950	2	4951.66	-2.31	2634.72	-1.4	Silty sand	Muddy gravel	Sand silt clay

Table 7.5: Biological composition of Day grab samples at each sample station: No's per ??

	NCP1(A)	NCP2(A)	NCP2(B)	NCP2(C)	NCP3(A)	NCP3(B)	NCP3(C)	NCP4(A)	NCP4(B)	NCP4(C)	Beaufort Dyke
HYDROZOA sp.						1	6	2	5	8	1
ANTHOZOA sp.		4	2		1						
Alcyonium digitatum	2										
Edwardsia sp.	3		6		7						7
TURBELLARIA sp.	1					1			1		
ANOPLA sp.		3	3		5	1	2	7	2	3	1
Sipunculidae sp.				1		1	1				
Harmothoe sp.	5	4			1	1	2	1	2	1	2
Pholoe inornata	1						1	4			
Eulalia bilineata	1										
Glycera alba		3	3		4	1	2	1	1	2	1
Glycera lapidum	4										
Glycera rouxi			4		3	1	3	1	5	3	1
Glycinde nordmanni						1				2	
Goniada maculata		2	2		10	1				2	
Sphaerodorum gracilis									1		1
Hesionidae sp.			1								
Ophiodromus flexuosus	2									1	
Ehlersia cornuta	1		5	1	1	4	2			2	
Sphaerosyllis bulbosa	4										
Autolytus sp.							1	1	1	2	
Nephtys sp.						1	1				
Pareurythoe borealis	1										

Lumbrineriopsis paradoxa					2				2	1	1
Lumbrineris sp.		1									
Lumbrineris gracilis	1	2	4		16	3	20	11	23	8	1
Protodorvillea kefersteini									1		
Aricidea sp.										1	
Aricidea simonae		2	1								
Spionidae sp.			1								
Aonides oxycephala								1			
Aonides paucibranchiata	5										
Laonice sp.									2		
Laonice cirrata					7	3	9	7		2	
Minuspio cirrifera	5	1	3								
Spio filicornis			1			1				1	1
Spiophanes kroyeri								15	39	21	
Magelona sp.								1			
Cirratulidae sp.											2
Caulleriella zetlandica								1	3	3	1
Cirratulus filiformis	1		1			1					
Cirriformia tentaculata								1	2	1	
Diplocirrus glaucus		1						1	1	1	
Capitella sp.	2							1	1		
Capitomastus minimus								5	14	25	
Notomastus latericeus		1								4	
Maldanidae sp.(A)			1					1		1	
Maldanidae sp.(B)								2			
Euclymene sp.(b)							1				

Euclymene sp.			1		6	6	7	8	1	3	
Myriochele heeri		1	14		7	5	3	2		4	2
Owenia fusiformis			1					1		1	4
Sabellariidae sp.				1							
Sabellaria spinulosa								25	4		
Melinna cristata		13	15		97	73	61	4		1	
Ampharete grubei		1	3		3	3	2	5			
Amphicteis gunneri		4			7	7	3	1		3	
Terebellides stroemi					1	1		5	6	11	
Polycirrus sp.								5	9	9	
Parathelepus collaris	1				1					2	
Streblosoma bairdi					1						
Thelepus sp.								4			
Sabellidae sp.									1		
Chone duneri								2			
Euchone southerni			2				2	3		3	
Laonome sp.									1		
Serpula sp.								1			
PYCNOGONIDA sp.								1		1	
Eusirus longipes	2										
Monoculodes packardi	1										
Amphilochus spencebatei			1								
Metopa alderi								5			
Stenothoe sp.	1					1		1	3	4	
Stenothoe marina					4						
Harpinia antennaria					1		1			2	

Acidostoma sp.									2	1	1
Ampelisca sp.			1								
Ampelisca spinipes		2	6		6	2	3	1			
Ampelisca tenuicornis										1	
Haploops tubicola						3	8				
Ceradocus semiserratus	2										
Cheirocratus intermedius		1									
Maera othonis						1		5	1		1
Maerella tenuimana											1
Photis longicaudata		3	1		9	3	5				
Ericthonius punctatus								2			
Autonoe longipes		1	1		5	2		1	4		
Microdeutopus anomalus						2		2			
Dyopedos monacanthus							1				
Caprellidae sp.					3			3			
Astacilla longicornis		1									
Tanaidae sp.										1	
Hemilamprops rosea					1						
Diastylis lucifera						2					
Diastyloides biplicata		9	18		3		5	8	2		
DECAPODA juv	2		1		3	1	1	6		1	
BRACHYURA								1			
Hyas araneus						1					
CAUDOFOVEATA sp.		1	2			1		1	3		
Leptochiton asellus	1								3		3
Dendronotus frondosus					1		4				

Nucula nucleus									22	33	1
Jupiteria minuta					1						
Musculus discors										1	
Chlamys varia var. *nivea*						1					
Anomia ephippium	1				1			1			
Lucinoma borealis									2		
Mysella bidentata											1
Astarte sulcata		1			1	1		2		3	
Parvicardium sp.					2	14	13	1			
Abra alba										1	
Abra nitida		1	1					4			
Abra prismatica								1			
Venerupis senegalensis					1	1					
Timoclea ovata		5									
Corbula gibba		5	2	1		3				1	
OPHIUROIDEA juv					6	1	2	7			
Ophiothrix fragilis	3				1	2					
Amphiura sp.	5										
Amphiura chiajei		3	3							2	
Amphiura filiformis					16	8	9		2	1	
Ophiuridae sp.	18										
Ophiura robusta											16
ECHINOIDEA juv											1
Echinus esculentus	1										
Echinocyamus pusillus											1
Brissopsis sp.											1

Brissopsis lyrifera		1						1		1	
HOLOTHURIOIDEA juv			1								
Holothuriidae sp.	1										
Thyone sp.								5		2	1
Ascidiella sp.										1	
Nematoda	9		1			3	1	2			