



JNCC Report

No. 409

**Broadscale seabed habitat survey
of a sandbank to the
east of the Isle of Man**

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The GIS project “manx1.mxd” should be available for use in conjunction with this report.

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Summary

- Three research cruises were conducted on the area of sandbanks to the east of the Isle of Man.
- Benthic grab samples were collected for infaunal analysis.
- Acoustic data was generated using AGDS and Side Scan Sonar.
- Video Ground truthing was undertaken with video sledge and ROV.
- The interrelationships between grain size, faunal community and acoustic facies have been investigated.
- A habitat map & GIS project containing all analyses has been produced.

Contents

1. Introduction	1
2. Methodology	3
2.1 Research cruises	3
2.2 Acoustic data collection	3
2.2.1 RoxAnn acoustic ground discrimination system data collection	3
2.2.3 RoxAnn data analysis	4
2.2.4 Sidescan sonar data processing	5
2.3 Grab sampling	5
2.3.1 Sediment processing and analysis	6
2.3.2 Infauna analysis and data interpretation	6
2.4 Video and stills image acquisition	6
2.4.1 Video data analysis	7
2.5 Biotope/habitat classification	7
2.6 Data integration and habitat map production	8
3. Results	9
3.1 Sediment description	9
3.2 Acoustic class	13
3.3 Sidescan sonar mosaic	13
3.4 Infauna analysis	19
3.5 Multi-variate infauna analysis	21
3.5.1 TWINSpan analysis	25
3.6 Infaunal Trophic Index	26
3.7 Habitat assessment from video and stills imagery	26
3.8 Biotope classification	29
4. Survey site assessment	32
5. Discussion and conclusion	36
6. Acknowledgements	37
7. References	38
Appendix 1. GIS layer outputs	39

1. Introduction

An area of shallow sandbank in UK offshore waters to the east of the Isle of Man (Figure 1.1) was identified by the Joint Nature Conservation Committee (JNCC) to be considered as a potential offshore SAC (Special Area of Conservation) in 2004. Following initial discussions the Department of Agriculture and Rural Development (DARD, now the Agri-Food and Biosciences Institute - AFBI) offered the use of the research vessel RV *Lough Foyle* to conduct an initial Acoustic Ground Discrimination System (AGDS) and infauna survey. Following this, two additional surveys were undertaken by AFBI using the RV *Corystes* which were co-funded by JNCC. This work was undertaken in support of the AFBI project 0431; “Sensitivity of Benthic Habitats in the NW Irish Sea and Malin Shelf”.

This report supports an accompanying Geographical Information System (GIS) project (manx1.mxd) that holds the datasets gathered during this survey work. The report identifies a number of biotopes and sediment types in the survey area and justifies the selection of these biotope classifications with illustrative data.

JNCC’s aims to improve the understanding of the benthic habitats present in this area. Knowledge of benthic habitats and the biological communities therein is essential for supporting the sustainable use of seas around the United Kingdom. Furthermore, this project will provide information on habitats listed in the EC Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) as requiring special protection. This information would support the process of designating Special Areas of Conservation for habitats in UK offshore waters, thus contributing to the formation of the Natura 2000 site network. Outputs from this work have been entered on the MESH (Mapping European Sea Bed Habitats) database.

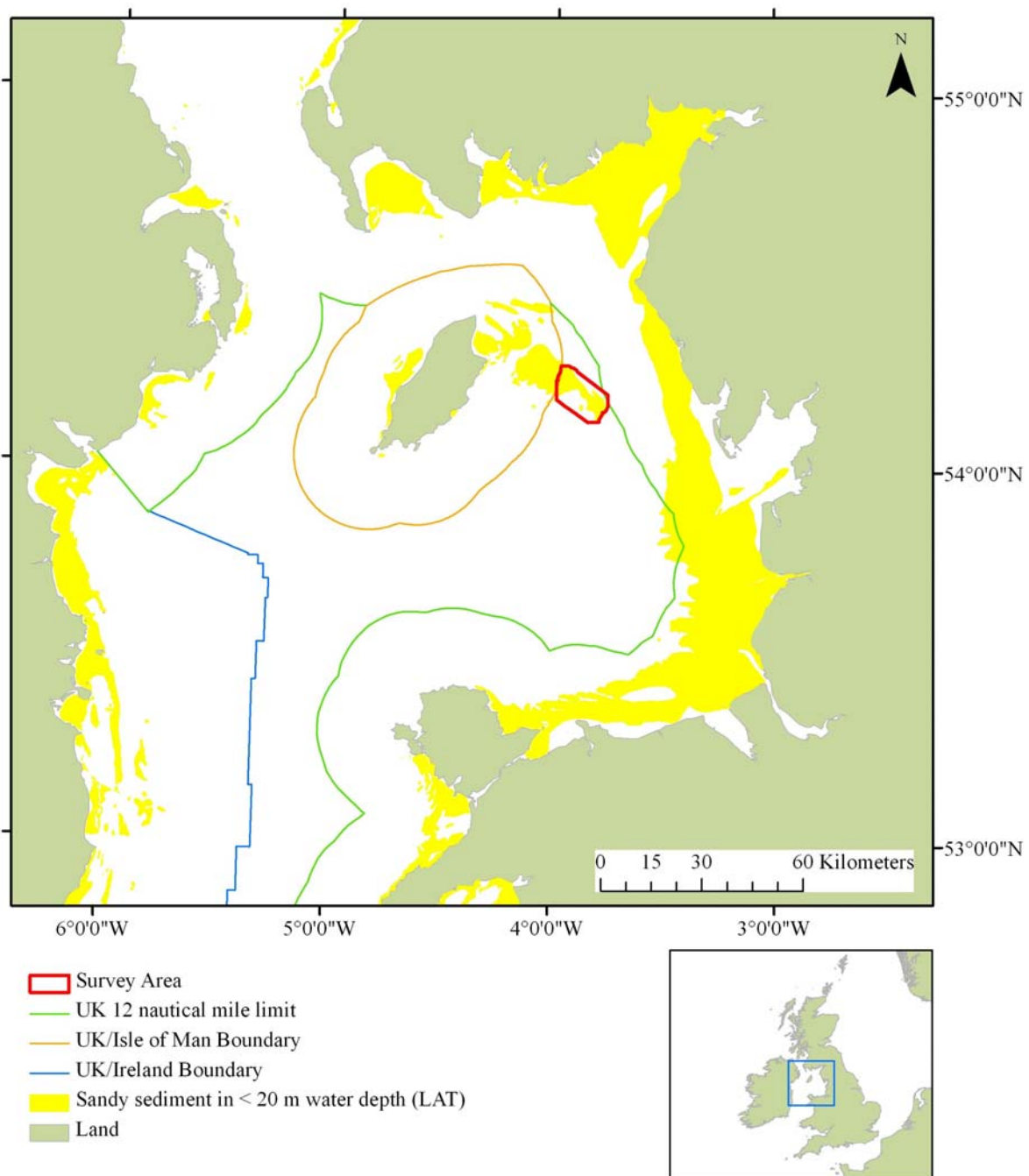


Figure 1.1 Overview of study area (highlighted in red) in context with the Irish Sea and territorial waters boundaries. World Vector Shoreline © US Defense Mapping Agency. Seabed habitat derived from BGS 1:250,000 seabed sediment maps by permission of the British Geological Survey © NERC (Licence No. 2002/85) and in part from bathymetric data © British Crown and SeaZone Solutions Limited. All rights reserved. Products Licence No. PGA042006.003.

2. Methodology

2.1 Research cruises

Data was gathered during three separate AFBI research cruises with funding for sample analysis and report writing provided by JNCC. Grab sampling and an attempt at RoxAnn AGDS data collection were made over 16-18 November 2004 aboard RV *Lough Foyle*. Due to poor weather conditions the RoxAnn system was unable to collect adequate quality data and therefore effort focussed upon grab sample collection. Additional acoustic data and video data were gathered over the site opportunistically as part of a longer research cruise on 4 May 2005 aboard the RV *Corystes*. Both RoxAnn, video and sidescan sonar data were successfully gathered over the sandbanks, however due to time restrictions and the size of the survey area the RoxAnn track coverage was not completed. The final RoxAnn and sidescan sonar data collection for the sandbanks area was made on the 10-11 February 2006 aboard RV *Corystes* while undertaking a habitat mapping research cruise. In addition a remotely operated vehicle (ROV) was deployed at a small number of sites over the sandbanks to complement the video data previously gathered.

2.2 Acoustic data collection

2.2.1 RoxAnn acoustic ground discrimination system data collection

RoxAnn datasets (Appendix 1.6) were obtained using a 50kHz transducer (deployed through the aft instrument tube), a Simrad ES60 echosounder and a GroundMaster RoxAnn signal processor. These signals were combined with RoxMap software saving at a 5 second interval. A differential Geographical Positioning Systems (dGPS) provided positional information and was integrated via the RoxMap computer. Track spacing varied between 250 and 500m.

2.2.2 Sidescan sonar data collection

Sidescan sonar data collection (see GIS project) was undertaken on 6 May 2005 and 10 and 11 February 2006 from aboard the RV *Corystes*. In the 2005 survey, two 15km legs were taken separated by approximately 0.5km. The lines were on a NW to SE orientation, extending throughout the middle of the survey area. During the 2006 survey, a total of 39km were covered in the same orientation, to the north of the existing sidescan coverage from 2005. Due to the immense size of the survey area the sidescan tracks could not cover the entire site. The following equipment was used:

Tow Fish:	Edgetech Model 272 with Analog Control Interface (ACI)
Interface and trigger unit:	Coda Octopus (Marine Systems Ltd) 160
Record and display unit:	Coda Octopus (Marine Systems Ltd) 460 PCU unit
DGPS:	CSE DGPS unit
USBL:	Ore Offshore Division Accosonic Technologies Inc. Integrated Positioning System Multibeacon Model 4330B.
Data storage:	2GB Jazz Drives

The Model 272 towfish operates on 100 or 500kHz and will collect sonar data from 25 to 300m to each side of the vessel. The surface unit digitizes the sonar signal and allows for

starboard and port gain adjustments. Data was recorded at the 100kHz setting. Range values varied. All raw data was saved in *.xtf format.

Key Specifications

EdgeTech 272-TD Tow Fish	
Frequency	100kHz - $105 \pm 10\text{kHz}$, 500kHz* - $390 \pm 20\text{kHz}$
Horizontal Beam Width	100kHz - 1.2° (3dB points), 500kHz* - 0.5° (3dB points)
Operating Depth (maximum)	1000m
Operating Range (maximum)	100kHz - 500m swath, 500kHz* - 200m swath
Tow Cable Type	7 conductor
Tow Fish Diameter	11.4cm
Tow Fish Length	140cm
Towing Speed (operational)	3 – 5 knots
Weight (in air)	25kg
Weight (in saltwater)	12kg

*Note: Actual operating frequency is $390\text{kHz} \pm 20\text{kHz}$. Specifications subject to change without notice.

2.2.3 RoxAnn data analysis

The datasets were exported from RoxMap and imported into MS Excel where a macro highlights consecutive depth changes of greater than 1.5m to flag potentially erroneous data points ('depth spiking'). Such depth spikes occur more commonly in rougher weather due to bubbles underneath the transducer. The highlighted data points were reviewed and where it was judged that such data points were erroneous, were removed from the dataset. The resulting dataset was then imported into MS Access, which was viewed in a GIS using a non-earth plot (depth as Y axis, data point ID (sequential) as X axis) as a final check to examine and remove any remaining erroneous depth values. In addition, the datasets were clipped such that only data over the survey site as covered by the grab sampling and specified by JNCC were retained. The dataset was additionally examined in GIS using a standard Earth plot (Longitude as X coordinate and Latitude as Y coordinate) to check for jumps in the navigational data, which revealed no such errors.

E1 and E2 ('roughness' and 'hardness') values were standardised as the two RoxAnn surveys of the site were carried out at different times. This was achieved by dividing each value by the 95th percentile of the range of values. Additionally a variability index, 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. Only depth, the E1 and E2 values (standardised) and the variability index were taken further for analysis. Positional data was converted from WGS 84 datum geographic coordinate system to a projected coordinate system, Universal Transverse Mercator (UTM) Zone 30N, such that subsequent data grids could be created in square metres. The entire dataset for the main survey area was amalgamated in Surfer. Upon examination of the merged datasets some obvious differences were observed, possibly due to the different survey conditions (waves, tide etc.) but also possibly due to shifts within the sandbank. Part of the 2006 dataset was clipped as this showed significant differences to the

adjacent 2005 dataset, and also because it covered an area that had not been ground-truthed by either the grab samples or video tows. The final merged and clipped dataset was used for subsequent analysis.

Variograms were created in Surfer (version 7; Golden Software Inc.) using E1 and E2 values. The variance within these variables appears to level off at a distance of 1000m 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 500m. Grid pixel size was selected at 20m. The interpolated data grids (in GSASCII format) were then imported into Idrisi (version 32 release 2; Clark Labs) image processing software. Each grid was stretched between 1 and 255 so that all the datasets were using the same scale. 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 also created. These were used for the ISOCLUSTER unsupervised classification routine within Idrisi. A histogram of clusters that expresses the frequency with which they occur in the composite image is produced; this is examined and where significant breaks are seen in the curve this is used to select the number of clusters desired for the map output. These represent major changes in the generality of the clusters. A major curve break was seen at seven clusters (six within survey area, one of 'unsurveyed' area in image rectangle), and composite B produced the most reliable results (depths had not been tidally corrected (no nearby reliable tidal gauge data) and therefore showed artificial 'steps' and patterns that were unlikely to be real).

The resulting cluster map, and the E1 (roughness) and E2 (hardness) interpolated grids were exported using the ARCASTER routine, to produce ASCII data grids. These were then imported into ESRI ArcInfo GIS and converted into an Erdas Imagine grid file (Appendices 1.7 and 1.8). The RoxAnn raw track data, video and grab sample positions were entered into MS Access, and loaded into the GIS such that they could overlay the cluster map and the roughness and hardness grids.

2.2.4 Sidescan sonar data processing

Coda Octopus 461 software was used for mosaicing of tracks and the production of geo-rectified tiff images, which have been imported into the GIS project. No USBL-based positional correction has been undertaken due to an incompatibility between the USBL interrogation rate and software-based correction routine. From layback calculations based on Pythagoras, it is estimated that the positional inaccuracy is $\pm 50\text{m}$. The mosaic images presented are based on the position of the ship only with out correction for layback. The resulting sidescan sonar tiff images have been overlaid on the RoxAnn cluster map and other datasets (see above).

2.3 Grab sampling

A 0.1m² Day-grab was used to collect sediment for both infaunal analysis and particle size analysis (PSA). All 63 grab samples were collected and processed between the 16 and 18 November 2004 and were sieved using a 1mm sieve immediately after collection before being preserved in 4% seawater buffered formaldehyde. A subsample of each grab was taken for the PSA and placed in a standard sample tube and frozen. Grab sites are illustrated in figure 4.2.

2.3.1 Sediment processing and analysis

Particle size analysis (PSA) was undertaken on a sub sample of the sediment taken from each infaunal grab. Data were supplied to JNCC by Andrews Survey as a sub-contractor to Marine Ecological Surveys in a “% passing sieve” format at 10.0mm, 8.0mm, 6.3mm, 4.0mm, 2.0mm, 1.0mm, 0.5mm, 0.25mm, 0.125mm and 0.063mm fractions. The output of the PSA analysis was converted to “% retained” at each sieve class and was then processed using the GRADISTAT grain size analysis macro for Excel (Blott, 2000) to produce a concise summary of sediment characteristics (Table 2.1). The summary statistics of Folk (1974), Graphic Mean (Mz), Inclusive Graphic Standard Deviation (sorting), skewness and kurtosis are used to summarise the data. These methods are used as they use up to 90% of the particle size distribution and thus include the “tails” of the curve. This makes them more a sensitive measure of a skewed or bimodal sediment distribution.

2.3.2 Infauna analysis and data interpretation

Infauna analysis was carried out by a contractor to the JNCC; data was supplied for the purpose of the analysis for this report in Marine Recorder output format. Infauna data were filtered and standardised by the exclusion of colonial and epifaunal species such as hydroids and barnacles and juvenile fauna unassigned to a species. Transformations of the data were made using a square root transformation before analysis.

Univariate and multivariate analysis were performed using PRIMER (PRIMER-E Ltd), Community Analysis Package (Pisces Conservation Ltd) and MS Excel for windows. Infauna data was clustered (Figure 3.6) using a multi dimensional scaling (MDS) routine to allow the influence of associated parameters (such as sediment characteristics) to be identified. Dendrograms (Figure 3.5) were made to identify “cluster” boundaries to group samples with similar infauna communities together. TWINSpan analysis (Section 3.5.1) was used to identify species characteristic of these groups (and also key to determining the difference between groups). These similar groups were characterised by both sediment and fauna before being compared to recognised biotope descriptions for classification and habitat map production.

2.4 Video and stills image acquisition

Five transects were made using a towed video sledge (with stills camera) that was deployed from the stern of the RV *Corystes* on 4 May 2005. The amount of cable deployed and depth of water were noted enabling the sledge layback to be calculated and the position corrected. The video & lighting system comprised of a Kongsberg-Simrad Osprey underwater video camera operated by a Simrad video control deck unit recording directly to a Sony DVD recorder. Positional information was imprinted on the video records using a dGPS linked to TrakView overlay system. A stills camera system (Photosea 1000A 35mm camera and Photosea 1500S strobe) was also fitted to the sledge and operated through the Simrad video control unit. Slide film (Kodak or Fuji 200 ASA) was used, with the resulting stills scanned onto computer using a Nikon CoolScan IV slide scanner. These images were enhanced using Adobe Photoshop (brightness, contrast and colour adjusted), and catalogued with positional information, which was determined as far as possible using the associated video footage and field log notes. A further six surveys were made using a SeaEye Tiger remotely operated vehicle from the RV *Corystes* on 10 February 2006. The ROV is equipped with a Kongsberg OE14-124 3CCD video camera and a Kongsberg OE14-208 digital stills camera with the

OE11-242 flash unit. A Triton imaging scale unit camera is also mounted on the ROV allowing distance and size measurements of objects to be made. Positional information was provided by a Trak Link 1510 USBL acoustic tracking system.

The video footage from Isle of Man sites 1, 2, 3, 4 and 5 was of fair quality however the suspended sediment & plankton component sometimes reduced image quality. Currents at the site meant sledge speed was on occasions too fast (or camera position too high relative to the substrate) to get the best image quality, but in general coverage was good. The stills images were of excellent quality and their high resolution facilitated the identification of many epifaunal species that are too blurred on the video footage (due in part to the movement of the video camera). 51 stills images were taken for ground-truthing from the sledge deployments: this compliments the video footage analysis. Underwater visibility at all sites was typically fair. The video footage from the six ROV drops was of fair quality impeded only by suspended solids and backscatter affecting the primary camera (consequently the Triton scaling camera was used with reduced lighting to reduce the backscatter effect). The sediment at these sites (positions supplied in the GIS project) contained a high proportion of fine material so disturbance from the vehicles thrusters and a subsequent loss of visibility was not uncommon. Field of view is adequate to permit the identification of fauna and sediment, but epifaunal encounters were infrequent meaning that biotope identification from video footage alone was not possible.

2.4.1 Video data analysis

Videos were analysed in the laboratory in combination with the field notes and high-resolution stills in order to assist with species identification and sediment categorisation. Video quality was not always good enough to make species identification reliable, but the process of identification was performed by two scientists working semi-independently to maintain objectivity. All video footage were reviewed, fauna was identified (where possible to species level), and SACFOR abundances (Hiscock, 1996) estimated for significant species. These biological notes are made alongside qualitative notes on sediment and topographic characteristics. Geo-referenced stills were reviewed at the same time to aid in the identification of species encountered in the video transects, and to provide more detailed images on the sediment type.

2.5 Biotope/habitat classification

Biotope selection was performed by identifying characteristic infauna and sediment from the aggregated sample stations within each of the four groups identified by the multivariate analysis. The multivariate analysis clustered closely related samples (when considering infauna) and provided closely related groups or pseudo-samples with sample replication.

Each individual member (a member is one sediment sample and its associated infauna) of a cluster identified by the multivariate analysis had its most abundant ten species selected and pooled. This aggregated data for each cluster was then ranked to provide a reduced ranked species list of the most commonly occurring species within the cluster. This list (for each of the four clusters) was used in combination with the epifauna from the video and stills camera and the sediment analysis to match up to the characteristic biotope in the JNCC Marine Habitat Classification for Britain and Ireland (v04.05) (Connor *et al*, 2004).

The biotope selection process was performed by cross-matching species lists from each biotope description to the clusters reduced ranked species list from the infauna in a data matrix. This matrix provides a score, which indicates the strongest matches between the infauna and the species lists in the Habitat Classification scheme. This matrix matching procedure was repeated for each of the four clusters identified by the multivariate analysis. The potential biotopes were then reviewed for each example whilst considering the environmental, video/stills and sediment data, allowing a more comprehensive and holistic interpretation of the data. Exclusion of remaining biotope descriptions and the selection of the most likely biotope from the classification scheme was then performed. This process was performed by two scientists working semi-independently to maintain objectivity, and the results are presented in section 3.8.

2.6 Data integration and habitat map production

All acoustic and ground-truthing data is presented and accessed through the GIS. This incorporates database tables (grab sample data, RoxAnn data, video track and stills positional data), roughness (E1) and hardness (E2) grids, sidescan sonar mosaics (tiff images) and RoxAnn cluster map. The associated legends for the presentation of these data are saved as layer files only where necessary. Where possible, GIS file metadata is completed and can be accessed readily through ArcCatalog.

The final habitat maps (shapefiles) are generated by combining the interpretation of each of these different datasets, through the assumption that where a habitat or biotope identified from ground-truthing occurs consistently upon similar topological regions (e.g. RoxAnn roughness and hardness, and sidescan sonar reflectance), and upon a similar substrate (as interpreted from RoxAnn and sidescan data, and the grab particle size data), an area surrounding the ground-truthing site with similar properties can be considered to be the same habitat or biotope. It was found that fairly consistent patterns existed between the grab sample biotopes and the RoxAnn cluster map, with additional agreement with the sledge video track data. Habitat areas are drawn by hand within the GIS environment to create a series of non-overlapping polygons, each of which is given the relevant biotope/habitat code. The resulting shapefile was converted into a raster grid and gridded at 20m pixel size. This was done to ensure that interpretation to a finer level would be discouraged due to the inherent limitations of the input datasets. The raster grid was then converted back to a shapefile and formatted to meet the MESH (Mapping European Seabed Habitats) Data Exchange Format.

3. Results

Note that all results and outputs from this work programme are presented in the associated GIS project, with selected output maps presented in the appendix of this report. This report summarises the habitat classifications summarised from the data and the accompanying GIS project includes the stills images, the video transects, the epifaunal (video) observer logs, the acoustic interpretations, analytical tools such as the infaunal trophic index (ITI) and other data as individual layers.

3.1 Sediment description

Visual assessment from the video and stills images (see GIS project and/or section 3.2 of this report) indicated sediments ranged from fine well-sorted muddy sands (seen during the ROV deployments), fine sands through to coarse sands with gravels and pebbles. Sediments frequently had more than one mode with a stratified structure of coarse material overlying finer sands. Shell debris and fine gravels made up a significant part of the overlying larger sized material with belts of alternating pebble and sands being common.

The PSA analysis and GRADISTAT processing of the data reflected what was noted from direct observation at site. Interpretation of sedimentary data is not a simple process and only summary statistics as described by Blott (2001) are presented here. The parameters used to describe a grain size distribution fall into four principal groups: those measuring (a) the average size, (b) the spread (sorting) of the sizes around the average, (c) the symmetry or preferential spread (skewness) to one side of the average, and (d) the degree of concentration of the grains relative to the average (kurtosis).

Sediments with a high “mud” (< 63 micron) content classed as “Very Fine Sands” were observed at a number of sites (e.g. Sample 43). Bimodal and polymodal “Coarse Sands” were evident with gravel contents ranging as high as 33 % (Sample 23). These coarser sediments often retained a significant proportion of mud, which again was evident on the video and stills imagery (e.g. samples 37 and 46). Summary statistics on the PSA analysis and GRADISTAT processing can be seen in table 3.1.

Broadscale seabed habitat survey of a sandbank to the east of the Isle of Man

Sample	MEAN	SORTING	SKEWNESS	KURTOSIS	MEAN	SORTING	SKEWNESS	KURTOSIS	MEAN:	SORTING:	SKEWNESS:	KURTOSIS:	% GRAVEL:	% SAND:	% MUD:
1	241.3	1.752	-0.072	1.370	2.051	0.809	0.072	1.370	Fine Sand	Moderately Sorted	Symmetrical	Leptokurtic	4.5%	94.5%	1.0%
2	180.9	1.408	0.568	1.735	2.467	0.494	-0.568	1.735	Fine Sand	Well Sorted	Very Coarse Skewed	Very Leptokurtic	0.7%	98.0%	1.3%
3	228.4	1.437	-0.457	0.593	2.130	0.523	0.457	0.593	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Very Platykurtic	0.3%	97.0%	2.8%
4	252.5	1.473	-0.330	2.370	1.986	0.559	0.330	2.370	Medium Sand	Moderately Well Sorted	Very Fine Skewed	Very Leptokurtic	0.1%	98.4%	1.4%
5	238.7	1.428	-0.516	0.629	2.067	0.514	0.516	0.629	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Very Platykurtic	0.0%	98.1%	1.9%
6	237.7	1.525	-0.282	0.864	2.073	0.608	0.282	0.864	Fine Sand	Moderately Well Sorted	Fine Skewed	Platykurtic	0.1%	98.7%	1.2%
7	348.9	1.520	0.284	2.465	1.519	0.604	-0.284	2.465	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic	0.4%	98.9%	0.7%
8	152.7	1.243	0.287	1.732	2.711	0.314	-0.287	1.732	Fine Sand	Very Well Sorted	Coarse Skewed	Very Leptokurtic	0.2%	98.4%	1.4%
9	174.3	1.710	0.082	3.776	2.520	0.774	-0.082	3.776	Fine Sand	Moderately Sorted	Symmetrical	Extremely Leptokurtic	0.1%	93.2%	6.7%
10	649.4	4.326	0.616	1.226	0.623	2.113	-0.616	1.226	Coarse Sand	Very Poorly Sorted	Very Coarse Skewed	Leptokurtic	23.1%	75.7%	1.2%
11	240.1	1.421	-0.539	0.651	2.058	0.507	0.539	0.651	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Very Platykurtic	0.0%	98.0%	2.0%
12	240.8	1.414	-0.549	0.662	2.054	0.500	0.549	0.662	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Very Platykurtic	0.0%	98.2%	1.8%
13	173.2	1.358	0.542	1.679	2.530	0.441	-0.542	1.679	Fine Sand	Well Sorted	Very Coarse Skewed	Very Leptokurtic	0.2%	97.5%	2.3%
14	175.8	1.375	0.540	1.627	2.508	0.460	-0.540	1.627	Fine Sand	Well Sorted	Very Coarse Skewed	Very Leptokurtic	0.0%	97.2%	2.8%
15	172.3	1.875	0.013	4.474	2.537	0.907	-0.013	4.474	Fine Sand	Moderately Sorted	Symmetrical	Extremely Leptokurtic	0.2%	90.6%	9.3%
16	292.7	1.223	-0.297	1.814	1.773	0.291	0.297	1.814	Medium Sand	Very Well Sorted	Fine Skewed	Very Leptokurtic	0.0%	98.9%	1.1%
17	393.5	1.552	0.500	0.813	1.346	0.634	-0.500	0.813	Medium Sand	Moderately Well Sorted	Very Coarse Skewed	Platykurtic	1.2%	97.6%	1.2%
18	244.8	1.407	-0.574	1.734	2.031	0.493	0.574	1.734	Fine Sand	Well Sorted	Very Fine Skewed	Very Leptokurtic	0.0%	97.9%	2.1%
19	464.0	1.436	-0.498	0.599	1.108	0.522	0.498	0.599	Medium Sand	Moderately Well Sorted	Very Fine Skewed	Very Platykurtic	0.4%	97.4%	2.2%
20	152.6	1.323	0.043	2.448	2.712	0.403	-0.043	2.448	Fine Sand	Well Sorted	Symmetrical	Very Leptokurtic	0.0%	96.9%	3.1%
21	123.4	1.787	-0.710	4.334	3.019	0.837	0.710	4.334	Very Fine Sand	Moderately Sorted	Very Fine Skewed	Extremely Leptokurtic	0.0%	89.3%	10.7%
22	181.4	2.242	0.310	5.742	2.463	1.165	-0.310	5.742	Fine Sand	Poorly Sorted	Very Coarse Skewed	Extremely Leptokurtic	3.1%	89.3%	7.6%
23	844.5	4.527	0.249	0.685	0.244	2.179	-0.249	0.685	Coarse Sand	Very Poorly Sorted	Coarse Skewed	Platykurtic	33.9%	63.1%	3.0%

Table 3.1. Sediment characteristics of samples from the sandbank to the East of the Isle of Man – output of GRADISTAT interpretation.

Broadscale seabed habitat survey of a sandbank to the east of the Isle of Man

Sample	MEAN	SORTING	SKEWNESS	KURTOSIS	MEAN	SORTING	SKEWNESS	KURTOSIS	MEAN:	SORTING:	SKEWNESS:	KURTOSIS:	% GRAVEL:	% SAND:	% MUD:
24	292.6	1.325	-0.053	2.543	1.773	0.406	0.053	2.543	Medium Sand	Well Sorted	Symmetrical	Very Leptokurtic	0.3%	98.7%	1.0%
25	382.9	1.536	0.236	0.827	1.385	0.619	-0.236	0.827	Medium Sand	Moderately Well Sorted	Coarse Skewed	Platykurtic	0.5%	97.2%	2.3%
26	345.0	1.518	0.282	2.579	1.536	0.603	-0.282	2.579	Medium Sand	Moderately Well Sorted	Coarse Skewed	Very Leptokurtic	0.4%	98.3%	1.3%
27	292.6	1.340	-0.055	2.608	1.773	0.422	0.055	2.608	Medium Sand	Well Sorted	Symmetrical	Very Leptokurtic	0.0%	97.9%	2.1%
28	253.3	1.541	-0.258	2.290	1.981	0.624	0.258	2.290	Medium Sand	Moderately Well Sorted	Fine Skewed	Very Leptokurtic	0.0%	99.3%	0.7%
29	127.7	1.755	-0.552	4.363	2.970	0.811	0.552	4.363	Fine Sand	Moderately Sorted	Very Fine Skewed	Extremely Leptokurtic	0.0%	91.6%	8.4%
30	240.1	1.539	-0.633	1.004	2.058	0.622	0.633	1.004	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Mesokurtic	0.0%	96.5%	3.5%
31	169.1	3.762	0.109	3.026	2.564	1.912	-0.109	3.026	Fine Sand	Poorly Sorted	Coarse Skewed	Extremely Leptokurtic	8.9%	80.8%	10.3%
32	186.1	1.645	0.118	1.088	2.426	0.718	-0.118	1.088	Fine Sand	Moderately Sorted	Coarse Skewed	Mesokurtic	0.0%	94.7%	5.3%
33	362.4	1.562	0.242	0.958	1.464	0.643	-0.242	0.958	Medium Sand	Moderately Well Sorted	Coarse Skewed	Mesokurtic	0.1%	98.7%	1.2%
34	149.3	1.732	-0.249	5.061	2.743	0.792	0.249	5.061	Fine Sand	Moderately Sorted	Fine Skewed	Extremely Leptokurtic	0.3%	89.4%	10.3%
35	194.4	1.431	0.413	0.587	2.363	0.517	-0.413	0.587	Fine Sand	Moderately Well Sorted	Very Coarse Skewed	Very Platykurtic	0.1%	97.6%	2.3%
36	254.9	1.369	-0.579	1.873	1.972	0.454	0.579	1.873	Medium Sand	Well Sorted	Very Fine Skewed	Very Leptokurtic	0.0%	97.2%	2.8%
37	562.1	4.574	-0.084	1.392	0.831	2.193	0.084	1.392	Coarse Sand	Very Poorly Sorted	Symmetrical	Leptokurtic	20.7%	71.3%	8.0%
38	193.2	1.430	0.421	0.588	2.372	0.516	-0.421	0.588	Fine Sand	Moderately Well Sorted	Very Coarse Skewed	Very Platykurtic	0.2%	97.6%	2.3%
39	101.0	2.451	-0.668	2.317	3.307	1.293	0.668	2.317	Very Fine Sand	Poorly Sorted	Very Fine Skewed	Very Leptokurtic	0.0%	81.3%	18.7%
40	186.9	1.506	0.293	0.838	2.419	0.591	-0.293	0.838	Fine Sand	Moderately Well Sorted	Coarse Skewed	Platykurtic	0.2%	97.5%	2.3%
41	125.2	1.880	-0.538	4.538	2.998	0.911	0.538	4.538	Fine Sand	Moderately Sorted	Very Fine Skewed	Extremely Leptokurtic	0.0%	90.5%	9.5%
42	78.45	2.266	-0.291	1.646	3.672	1.180	0.291	1.646	Very Fine Sand	Poorly Sorted	Fine Skewed	Very Leptokurtic	0.0%	80.5%	19.5%
43	85.50	2.196	-0.322	1.569	3.548	1.135	0.322	1.569	Very Fine Sand	Poorly Sorted	Very Fine Skewed	Very Leptokurtic	0.0%	81.6%	18.4%
44	185.1	1.973	0.492	2.023	2.434	0.980	-0.492	2.023	Fine Sand	Moderately Sorted	Very Coarse Skewed	Very Leptokurtic	4.8%	90.5%	4.6%
45	465.5	1.780	-0.453	1.294	1.103	0.832	0.453	1.294	Medium Sand	Moderately Sorted	Very Fine Skewed	Leptokurtic	1.6%	95.2%	3.2%

Table 3.1.(continued) Sediment characteristics – output of GRADISTAT interpretation.

Broadscale seabed habitat survey of a sandbank to the east of the Isle of Man

Sample	MEAN	SORTING	SKEWNESS	KURTOSIS	MEAN	SORTING	SKEWNESS	KURTOSIS	MEAN:	SORTING:	SKEWNESS:	KURTOSIS:	% GRAVEL:	% SAND:	% MUD:
46	512.7	4.015	-0.377	2.492	0.964	2.005	0.377	2.492	Coarse Sand	Very Poorly Sorted	Very Fine Skewed	Very Leptokurtic	13.7%	77.6%	8.8%
47	360.8	1.500	0.341	2.301	1.471	0.585	-0.341	2.301	Medium Sand	Moderately Well Sorted	Very Coarse Skewed	Very Leptokurtic	0.3%	97.7%	2.1%
48	775.0	1.607	0.085	0.920	0.368	0.684	-0.085	0.920	Coarse Sand	Moderately Well Sorted	Symmetrical	Mesokurtic	3.2%	95.5%	1.3%
49	179.6	1.611	0.175	1.152	2.477	0.688	-0.175	1.152	Fine Sand	Moderately Well Sorted	Coarse Skewed	Leptokurtic	0.1%	94.6%	5.2%
50	158.0	1.968	-0.166	1.622	2.662	0.977	0.166	1.622	Fine Sand	Moderately Sorted	Fine Skewed	Very Leptokurtic	0.0%	92.7%	7.3%
51	247.5	1.521	-0.310	2.439	2.014	0.605	0.310	2.439	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Very Leptokurtic	1.1%	96.3%	2.6%
52	195.3	1.442	0.399	0.589	2.356	0.528	-0.399	0.589	Fine Sand	Moderately Well Sorted	Very Coarse Skewed	Very Platykurtic	0.1%	96.7%	3.2%
53	587.5	1.343	-0.061	2.715	0.767	0.425	0.061	2.715	Coarse Sand	Well Sorted	Symmetrical	Very Leptokurtic	1.0%	98.7%	0.3%
54	235.3	1.438	-0.497	0.614	2.087	0.524	0.497	0.614	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Very Platykurtic	0.2%	97.3%	2.5%
55	128.9	1.656	-0.678	4.033	2.955	0.727	0.678	4.033	Fine Sand	Moderately Sorted	Very Fine Skewed	Extremely Leptokurtic	0.1%	91.1%	8.7%
56	146.8	1.564	-0.257	4.294	2.769	0.645	0.257	4.294	Fine Sand	Moderately Well Sorted	Fine Skewed	Extremely Leptokurtic	0.0%	92.2%	7.8%
57	713.6	2.581	0.365	1.117	0.487	1.368	-0.365	1.117	Coarse Sand	Poorly Sorted	Very Coarse Skewed	Leptokurtic	16.7%	81.9%	1.4%
58	236.8	1.537	-0.618	0.930	2.078	0.621	0.618	0.930	Fine Sand	Moderately Well Sorted	Very Fine Skewed	Mesokurtic	0.0%	96.3%	3.7%
59	542.9	2.125	0.152	1.229	0.881	1.087	-0.152	1.229	Coarse Sand	Poorly Sorted	Coarse Skewed	Leptokurtic	6.9%	92.2%	0.9%
60	294.0	1.958	0.126	1.170	1.766	0.969	-0.126	1.170	Medium Sand	Moderately Sorted	Coarse Skewed	Leptokurtic	2.2%	95.1%	2.7%
61	290.4	1.246	-0.295	1.795	1.784	0.318	0.295	1.795	Medium Sand	Very Well Sorted	Fine Skewed	Very Leptokurtic	0.0%	98.4%	1.6%
62	184.1	1.410	0.524	0.650	2.441	0.496	-0.524	0.650	Fine Sand	Well Sorted	Very Coarse Skewed	Very Platykurtic	0.0%	98.0%	2.0%
63	177.8	1.476	0.321	2.262	2.492	0.562	-0.321	2.262	Fine Sand	Moderately Well Sorted	Very Coarse Skewed	Very Leptokurtic	0.2%	96.3%	3.5%

Table 3.1. (continued) Sediment characteristics – output of GRADISTAT interpretation.

3.2 Acoustic class

The acoustic class of each grab sample site was taken from the RoxAnn cluster map. The results are presented as a layer in the GIS project.

The acoustic class corresponding to each grab sample was identified and grouped. The mean grain size (expressed as mean phi) was calculated from the output of the PSA for each class. When all sediment classes are included the regression between the acoustic class and grain size a relationship with an R^2 value of 0.5583 is identified (Figure 3.1 (A)). If the 6th acoustic class was excluded from the regression, a stronger relationship ($R^2 = 0.9196$) between the acoustic class and the mean grain size of the sediments is described (Figure 3.1 (B)). This “6th” acoustic class corresponds to a “Fine Sand” sediment and may be affected by other modes being present in its composition – for example overlying shell debris may affect its acoustic signature, but may not be adequately represented by the sediment analysis. An effect of depth on the acoustic classification of the fine sands was also noted.

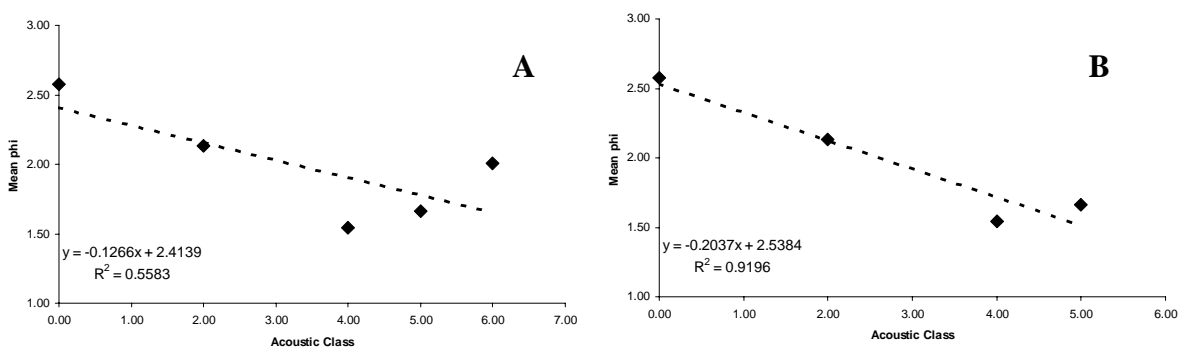


Figure 3.1. Acoustic class plotted against mean sediment size (A), and Acoustic class plotted against mean sediment size (excluding acoustic class 6) (B).

The interpreted RoxAnn signal is distinguishing between sediments of differing grain size very reliably when the grain sizes are coarser, but this relationship is not as strong when the finer sediments are included. This breakdown in the relationship between acoustic class and mean grain size could be influenced by the polymodality of many of the sediments and could be investigated further. The presence of gravels and shell material overlying fine sands could further complicate the relationship between mean grain size and acoustic signal as the acoustic reflectance of the surface material will not represent the mean grain size collected for particle size analysis. Table 3.3 supports this theory and illustrates how two sediments with no statistical difference in their mean phi (sediment groups 1 and 4) actually have quite different sediment structures and modes.

3.3 Sidescan sonar mosaic

The seabed area surveyed with sidescan sonar was approximately 15km by 5km, and on a NW – SE orientation. Due to the size of the site, the survey was split between May 2005 and February 2006. Transects with the sidescan sonar were either 100m or 150m wide, with an approximate gaps of 500m – 1000m between transects.

Starting in the SSE corner (54° 10' 37.99 N, 3° 49' 21.65 W), the sidescan images indicate a featureless and soft seabed (Figure 3.2). Large sand wave features and small surface ripples

are apparent at $54^{\circ} 12' 16.96 \text{ N}$, $3^{\circ} 53' 29.05 \text{ W}$ (Figure 3.3). This type of seabed reappears between $54^{\circ} 13' 7.19 \text{ N}$, $3^{\circ} 55' 45.05 \text{ W}$ and $54^{\circ} 13' 25.01 \text{ N}$, $3^{\circ} 56' 26.39 \text{ W}$ (Figure 3.4). Further NW along the transect there is an extensive area with small, superficial sand rippling ($54^{\circ} 13' 42.83 \text{ N}$, $3^{\circ} 57' 10.06 \text{ W}$); after this point the seabed becomes fairly featureless again.

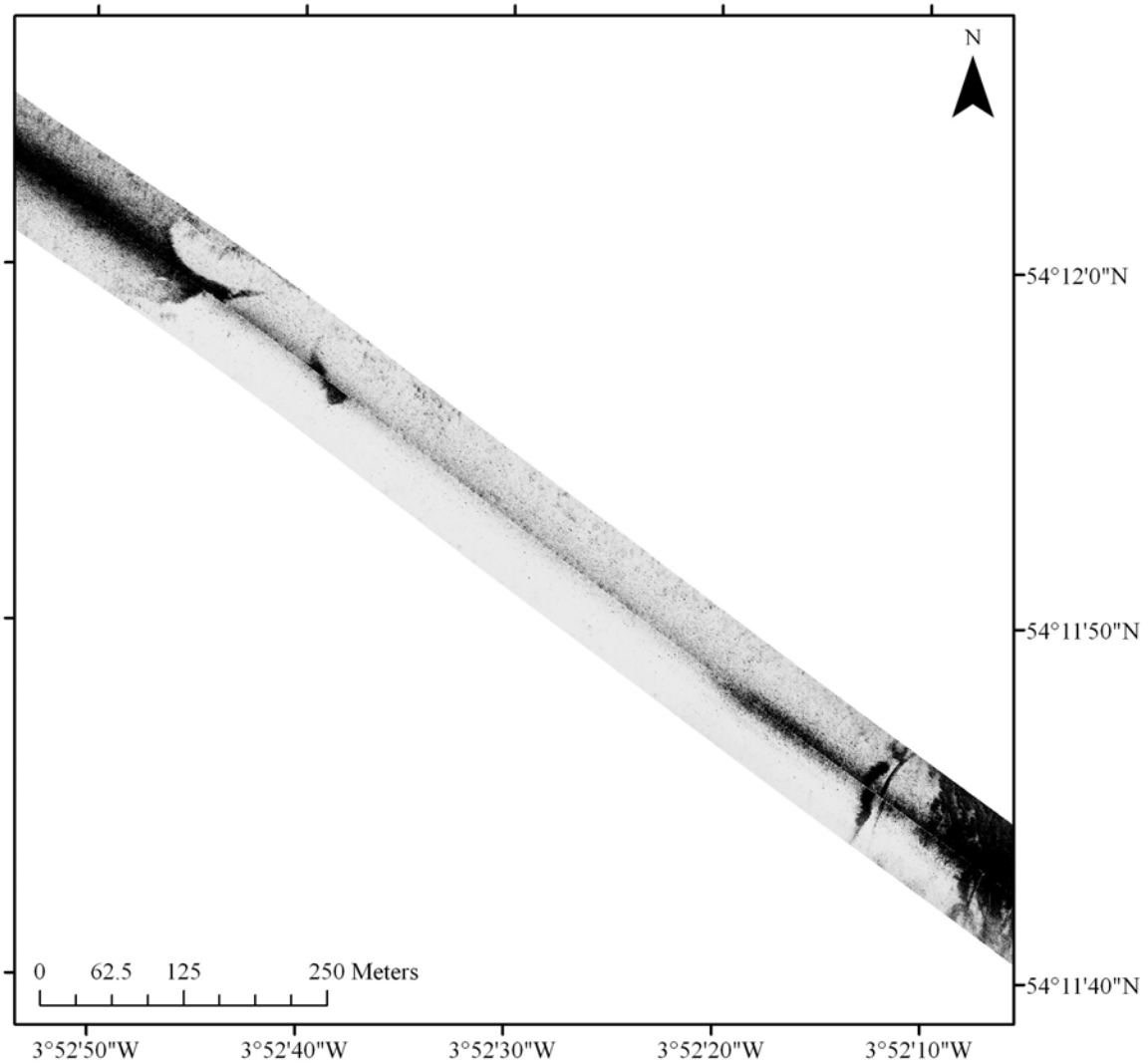


Figure 3.2 Example sidescan sonar trace of a flat and soft seabed ($54^{\circ} 10' 37.99 \text{ N}$, $3^{\circ} 49' 21.65 \text{ W}$). Large sand bank features are discernable at either end of the transect.

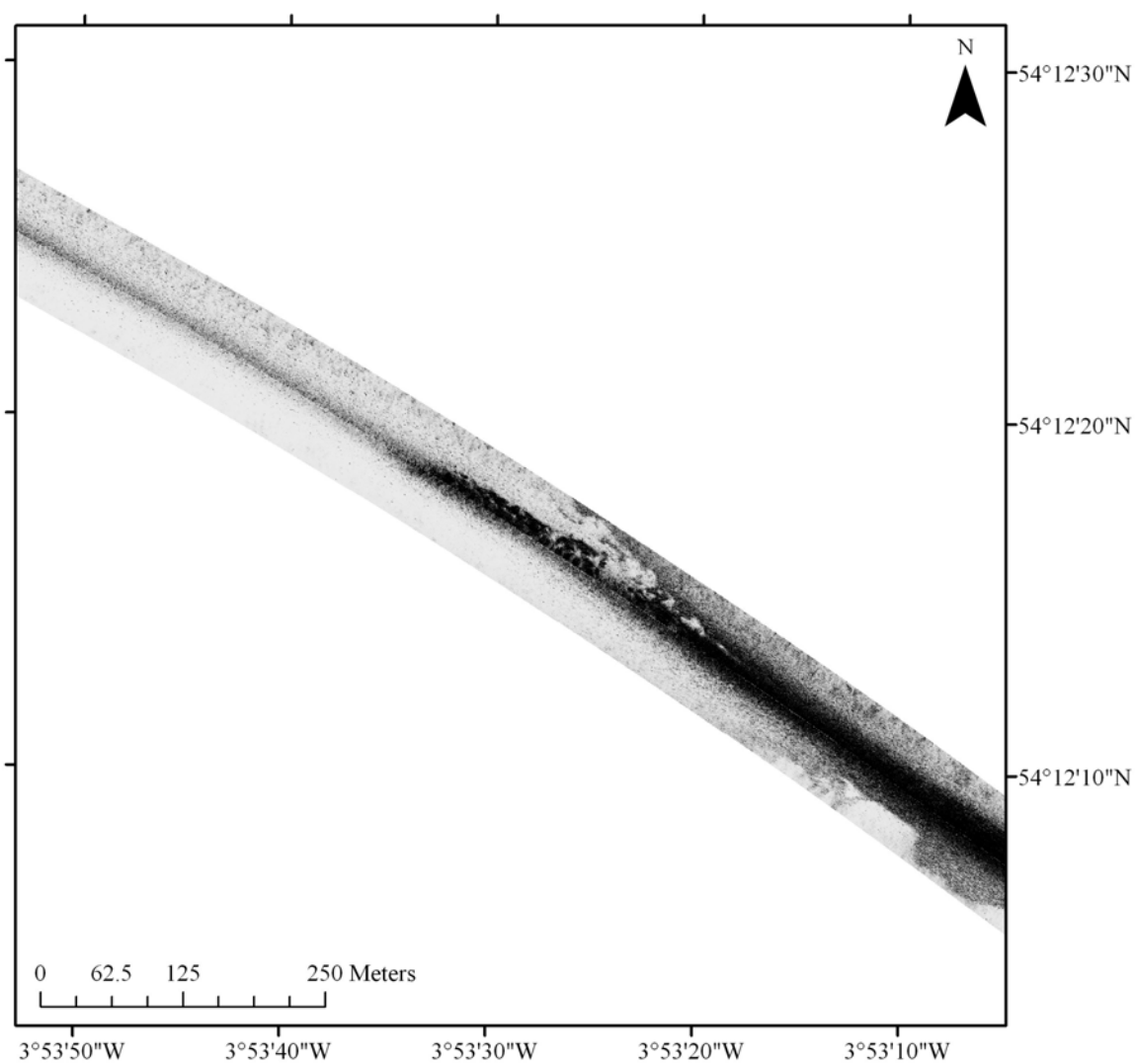


Figure 3.3 Large sand wave features and small surface ripples at 54° 12' 16.96" N 3° 53' 29.05" W

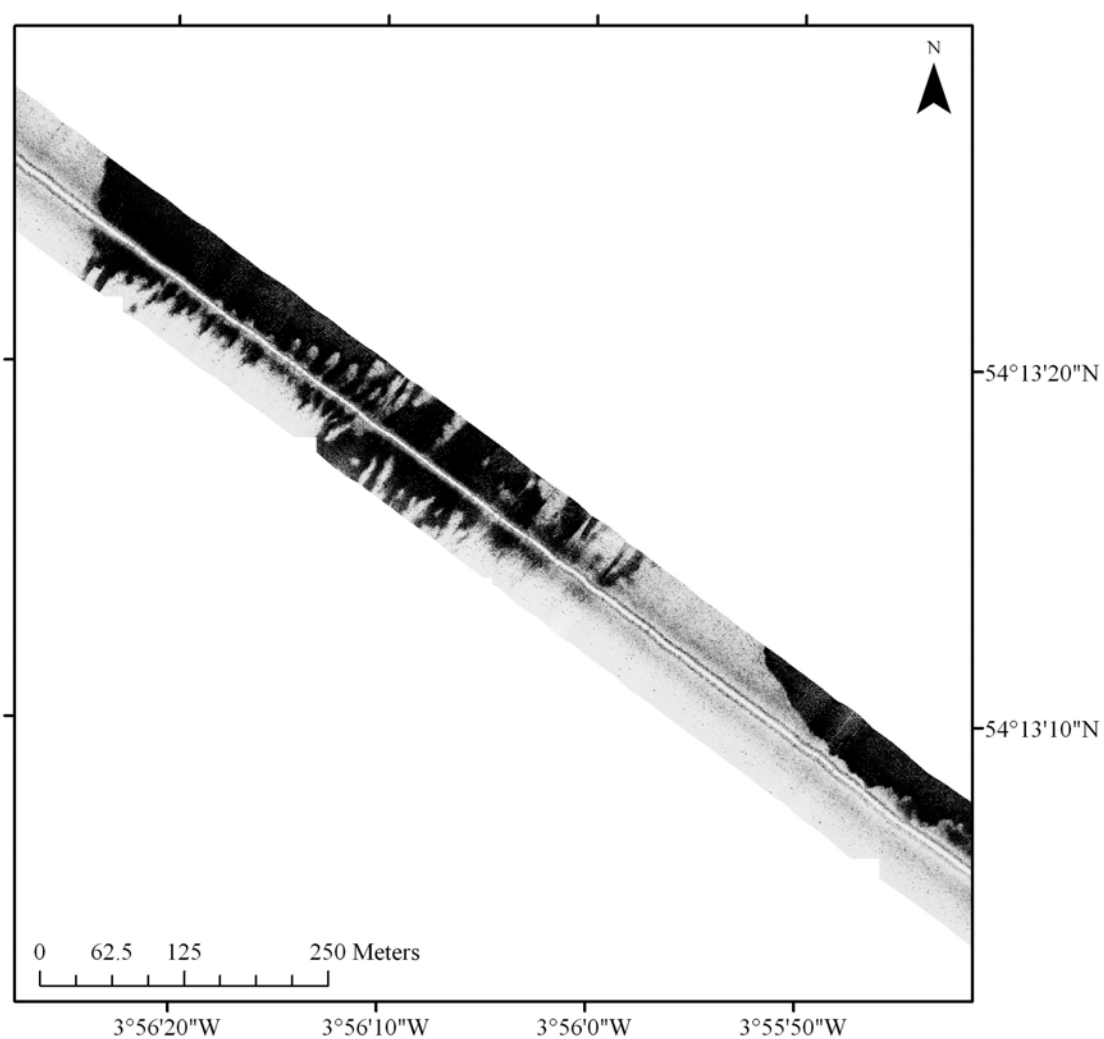


Figure 3.4 Large sand wave features and small surface ripples between 54°13' 7.19" N 3°55' 45.05" W and 54°13' 25.01" N 3°56' 26.39" W

The transect starting from 54° 11' 1.98 N, 3° 48' 44.98 W appears flat with some areas of small and occasional superficial rippling for the majority of that transect (Figure 3.5). Towards the NNW corner of the sidescan box, an area of large sand ripples with superficial ripples is evident (54° 13' 8.72 N, 3° 54' 3.48 W) (Figure 3.6). The rest of the area surveyed with sidescan sonar appears to be characterised by featureless sand with either slight superficial rippling or irregular sand banks.

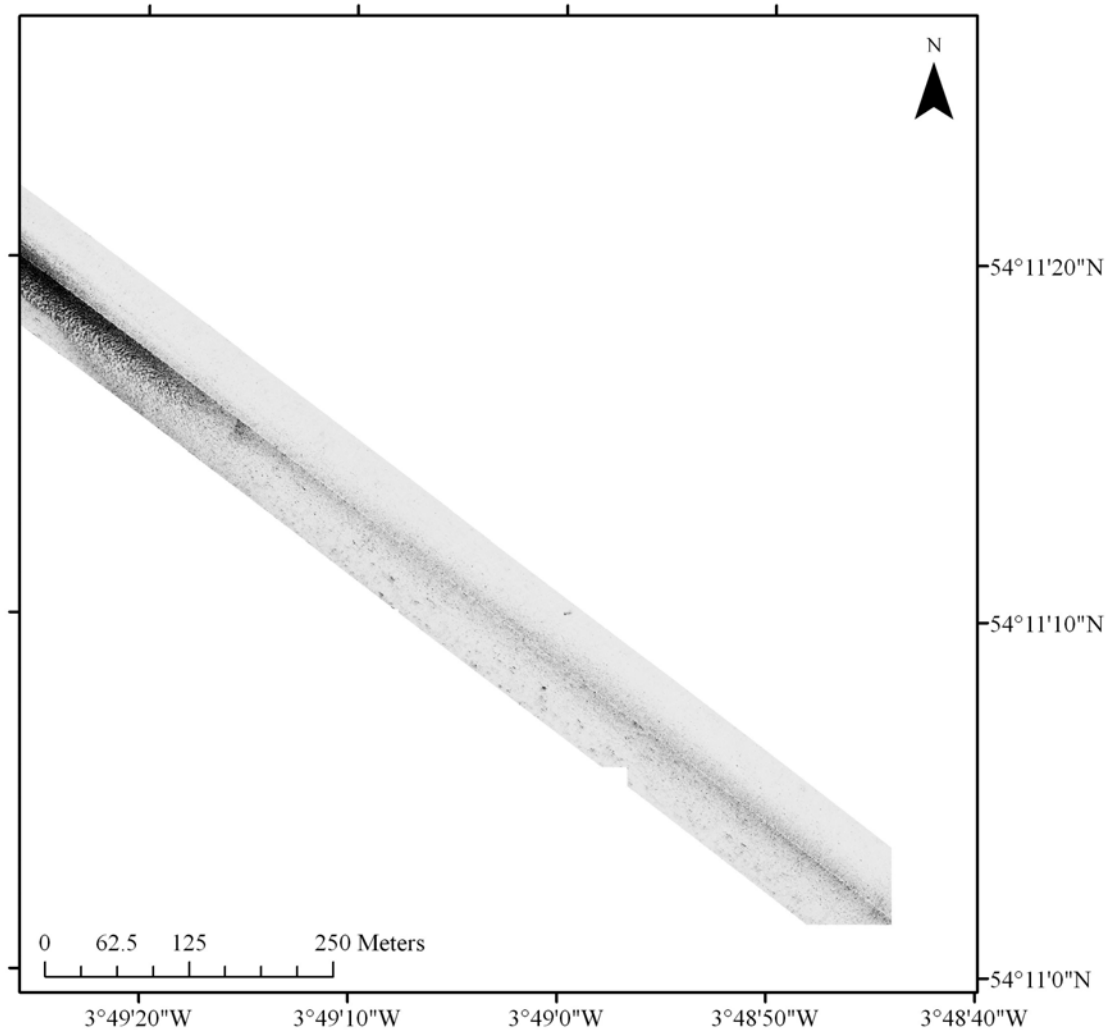


Figure 3.5 Flat sand with some areas of small and occasional superficial rippling.

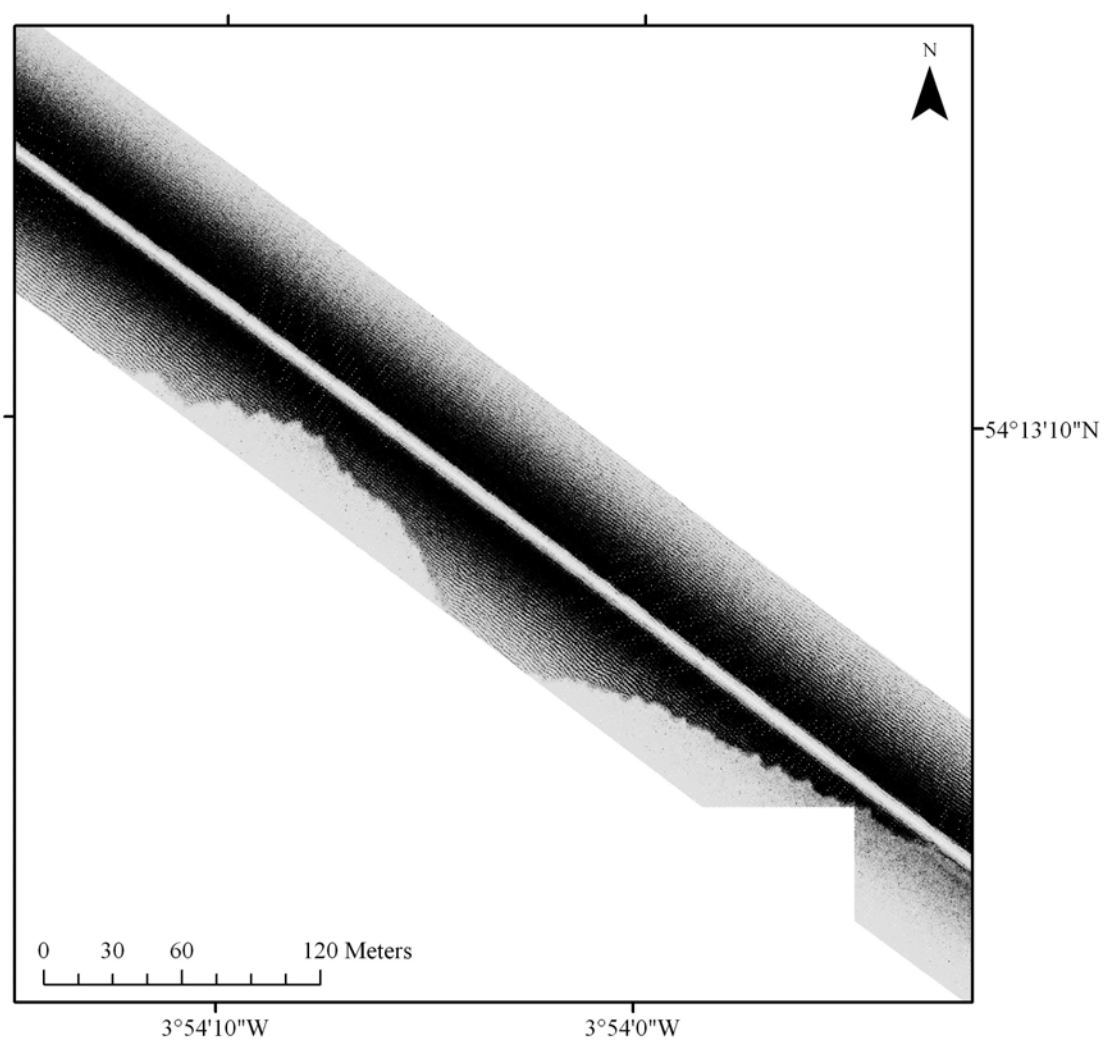


Figure 3.6 Large sand ripples and superficial sand rippling at 54° 13' 8.72" N, 3° 54' 3.48" W.

3.4 Infauna analysis

The summary statistics for the sites sampled from the sandbank to the east of the Isle of Man area are summarised below (Table 3.2). Samples ranged from those with a very low number of individuals (3) and species (3) to those with a relatively high diversity. Diversity was highest ($H = 3.34$) in sample 46 where the sediment showed the greatest spread of components across the gravels and muds, and was lowest in sample 12 ($H = 1.10$), which was classed as a “well-sorted” sand.

Site	No.Species (S)	No. Individuals (N)	Species Richness	Pielou's evenness (J)	Shannon Wiener diversity (H) (<i>natural log</i>)
1	9	12	3.219	0.9534	2.095
2	6	13	1.949	0.9329	1.672
3	6	24	1.573	0.688	1.233
4	12	19	3.736	0.95	2.361
5	12	37	3.046	0.6235	1.549
6	18	79	3.891	0.6985	2.019
7	6	8	2.404	0.9306	1.667
8	17	58	3.94	0.8161	2.312
9	13	32	3.462	0.9191	2.358
10	26	68	5.925	0.9172	2.988
11	12	37	3.046	0.6418	1.595
12	3	3	1.82	1	1.099
13	17	28	4.802	0.9142	2.59
14	5	7	2.056	0.963	1.55
15	22	134	4.288	0.6919	2.139
16	8	9	3.186	0.9826	2.043
17	11	39	2.73	0.8121	1.947
18	10	18	3.114	0.9147	2.106
19	19	46	4.701	0.9253	2.724
20	24	83	5.205	0.8554	2.718
21	27	251	4.705	0.6394	2.108
22	23	134	4.492	0.7928	2.486
23	41	132	8.192	0.8398	3.119
24	5	7	2.056	0.9165	1.475
25	10	19	3.057	0.938	2.16
26	11	19	3.396	0.9122	2.187
27	15	19	4.755	0.9795	2.653
28	7	12	2.415	0.9353	1.82
29	24	140	4.654	0.7241	2.301

Table 3.2. Univariate summary statistics on infauna from the Sandbanks to the east of the Isle of Man.

Site	No.Species (S)	No. Individuals (N)	Species Richness	Pielou's evenness (J)	Shannon Wiener diversity (H) (<i>natural log</i>)
30	18	59	4.169	0.8404	2.429
31	32	190	5.908	0.6886	2.387
32	21	126	4.135	0.7906	2.407
33	16	25	4.66	0.9459	2.622
34	22	67	4.994	0.8127	2.512
35	8	12	2.817	0.9172	1.907
36	15	35	3.938	0.887	2.402
37	33	110	6.808	0.8454	2.956
38	8	14	2.652	0.9178	1.909
39	20	153	3.777	0.6762	2.026
40	22	71	4.926	0.8657	2.676
41	26	212	4.667	0.676	2.202
42	25	86	5.388	0.8686	2.796
43	26	92	5.529	0.8384	2.732
44	29	196	5.305	0.6718	2.262
45	32	99	6.746	0.8738	3.029
46	50	164	9.608	0.8539	3.341
47	12	23	3.508	0.9099	2.261
48	33	174	6.203	0.7138	2.496
49	23	135	4.485	0.7482	2.346
50	30	201	5.468	0.7343	2.497
51	23	34	6.239	0.9588	3.006
52	12	41	2.962	0.9052	2.249
53	22	58	5.172	0.8623	2.665
54	9	35	2.25	0.5356	1.177
55	25	149	4.796	0.7017	2.259
56	24	143	4.634	0.7572	2.407
57	30	91	6.429	0.8956	3.046
58	17	24	5.035	0.9586	2.716
59	28	57	6.678	0.9435	3.144
60	13	17	4.235	0.9654	2.476
61	8	12	2.817	0.9518	1.979
62	15	64	3.366	0.711	1.926
63	11	18	3.46	0.8921	2.139
Mean	18.37	71.02	4.28	0.84	2.29
Median	17.00	46.00	4.24	0.87	2.31
Max	50.00	251.00	9.61	1.00	3.34
Min	3.00	3.00	1.57	0.54	1.10
SD	9.63	62.94	1.57	0.11	0.49

Table 3.2 (continued). Univariate summary statistics on infauna from the Sandbanks to the east of the Isle of Man.

3.5 Multi-variate infauna analysis

Multi dimensional scaling of the square root transformed and filtered (exclusion of colonial and epifaunal species such as hydroids and barnacles and juvenile fauna unassigned to a species) infauna data shows discrete groups of samples clustering together, and a pattern of orientation that is strongly influenced by the mean grain size (expressed as mean phi). The dendrogram (Figure 3.7) graphically illustrates the clusters of samples that have been identified and where they diverge. The mean sediment size (as allocated by GRADISTAT using the Folk & Ward method) has been used to label the samples in this dendrogram, and a pattern between the groups of samples (oriented by their infauna) and the sediment grain size becomes apparent (Figure 3.7). The initial division of samples suggests a strong difference in the communities found in the coarse sands and gravels as one group, and the medium and fine sands as the other. The samples with fine and medium sands divided into two further clusters – generally associated with the very fine sands and the medium/fine sands. The medium/fine sands then appeared to have a further subdivision with samples that appeared to group by the medium sands and medium/fine sands. Analysis that has progressed from the identification of sample clusters has identified the samples by number from a suitably labelled dendrogram; key sediment and infauna data can then be extracted from sources such as the tables 3.1 and 3.2 for further analysis.

A multi dimensional scaling plot (Figure 3.8) illustrates the trend between the mean grain size and the sediments biological community. This plot does not highlight clustering as clearly as the dendrogram in figure 3.7 - clustering has not been superimposed onto this plot as it is more clearly illustrated by the dendrogram. Labels displaying each individual samples phi value help to illustrate the influence that grain size has on the community. The pattern of the infauna (biology) changes as the phi value increases clockwise from the top left hand corner of the plot, suggesting a strong link between the mean sediment phi (grain size) and the biological community. One sample (Sample 45) of medium sand has grouped into the coarse sands & gravels group – this could possibly result from the fauna associated with multiple modes within the sediment; a sediment which has fauna associated with a second or third mode of the sediment may influence how it relates biologically to another sediment without being well represented in statistics such as the mean phi. The different modes present within any one sample serve to blur the separation of different communities, but the mean phi of the primary mode has in general acted as a good indicator of the main sediment type (and hence the associated biological community).

IOM Infauna dendrogram - labelled with Folk & Ward sediment descriptor

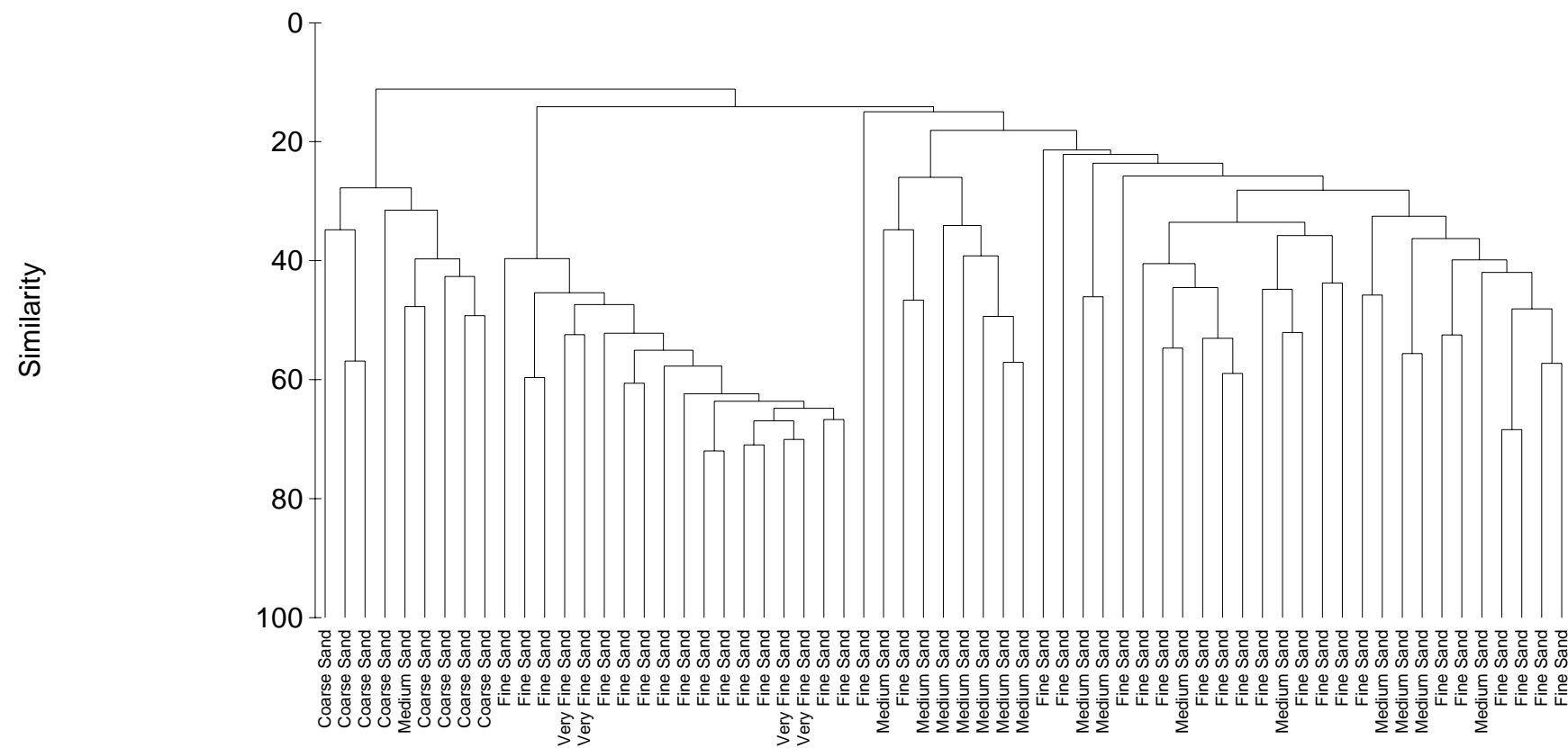
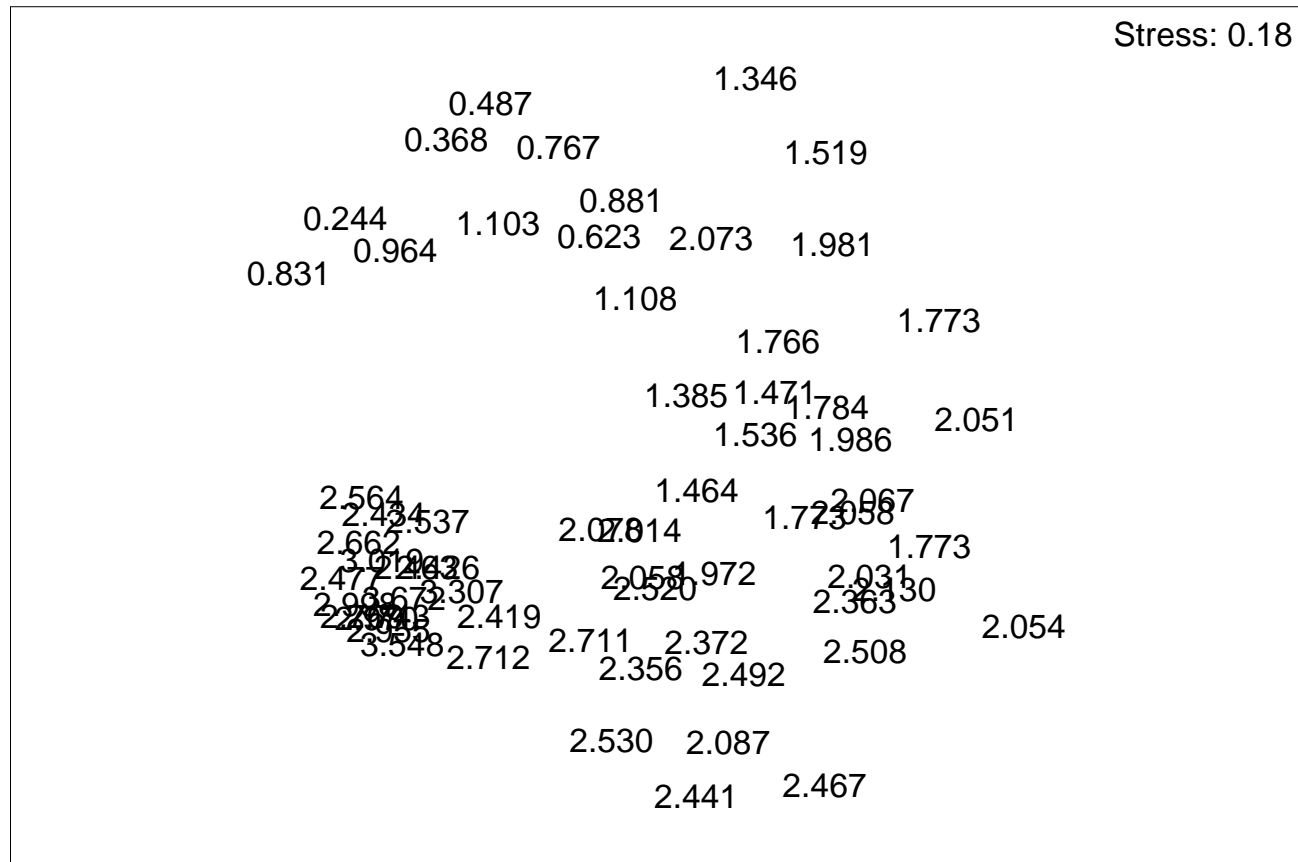


Figure 3.7 Dendrogram illustrating the similarity of infauna from the Sandbanks to the east of the Isle of Man, labelled with mean sediment class.



The separation of biological clusters of samples is apparent in the averaged mean phi values of samples from within each biologically distinct cluster. These clusters were matched with the descriptive output of the sediment analysis (Figure 3.8) to identify four clear textural groups. Figure 3.10 illustrates how the very fine sands (cluster 1 on the bar chart), the medium sands (cluster 2) and the coarse sands (cluster 3) are distinct in terms of their averaged mean phi values (One-way ANOVA $P < 0.05$). Despite the biologically induced separation, there was no significant difference in the mean sediment grain size of the very fine sands and the medium/fine sands (Groups 1 and 4).

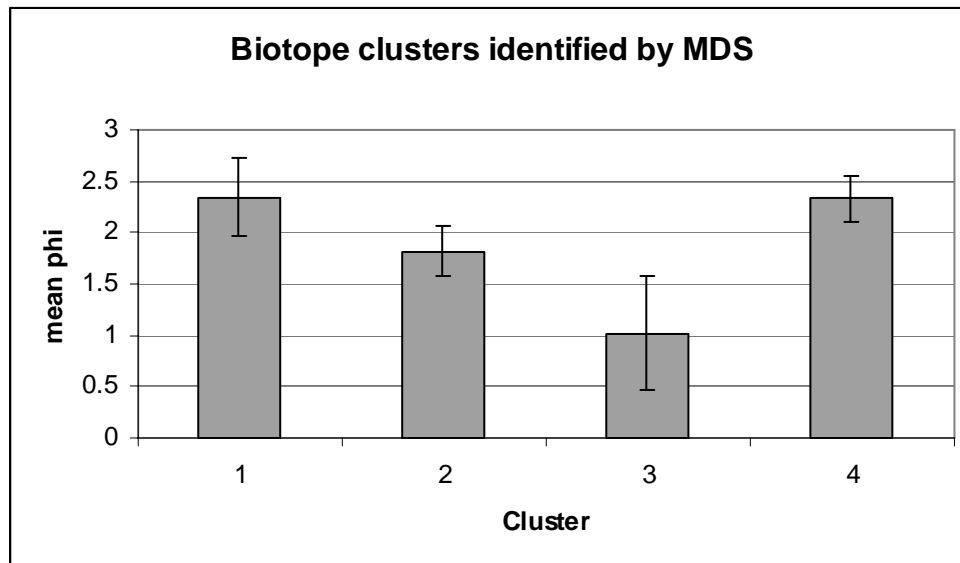


Figure 3.9 Mean sediment phi of four clusters identified from a multivariate analysis of the infauna from the Sandbanks to the east of the Isle of Man.

From the dendrogram and MDS plot (Figures 3.8 & 3.9) produced by PRIMER we can suggest that we may have four biologically distinct groups of samples occurring in the 63 samples recovered from the Isle of Man site. Whilst sediment grain size has strongly influenced the clustering and is significantly different across three of these four groups (One-way ANOVA $P < 0.05$), groups 1 and 4 have been described as biologically distinct despite having similar mean grain sizes (see section 3.5.1; TWINSpan identified the presence of *Mysella bidentata* as the key indicator of difference between the two groups).

Whilst mean grain size in clusters 1 and 4 is very similar, table 3.3 demonstrates that the components making up these often polymodal sediments are quite different: the sediments from samples included in cluster 4 include a much larger percentage of the larger “gravel” sized material – this may help to explain the difference in biological community.

Cluster	% GRAVEL	% SAND	% MUD (<63 micron)
1	1.093%	89.381%	9.526%
2	0.21%	96.93%	2.86%
3	0.58%	97.65%	1.77%
4	8.77%	88.79%	2.44%

Table 3.3. Summary sediment characteristics of the four biotopes identified from multivariate infauna analysis.

3.5.1 TWINSpan analysis

A two-way indicator species analysis (TWINSpan) was run using the Community Analysis Package (CAP) on the filtered and square root transformed infauna data. This analysis showed a first divergence of biological community groups, which related to the difference between the fine and coarser sands (One-way ANOVA, $P < 0.05$). After the second iteration of TWINSpan there were four clusters of communities whose mean sediment grain size (expressed as mean phi) covered a range from coarse sands/fine gravels to fine sands, and whose clustering agreed with the MDS visualisation generated by PRIMER. Two of the groups did not differ significantly in their sediment characteristics (expressed as mean phi).

A very similar pattern of clustering and divergence was seen in the multi dimensional scaling analysis in PRIMER, though the coarser sediment cluster in this analysis encompassed a slightly larger number of samples. The species significant in ordering these four groups are listed below along with the sediment grain size (expressed as mean phi).

- **Fine sediments (mean phi = 2.34):**
Turbellaria, *Nemertea*, *Aphroditidae*, *Sigalion mathildae*, *Paranaitis kosteriensis*, *Kefersteinia cirrata*, *Ehlersia cornuta*, *Typosyllis armillaris*, *Scoloplos armiger*, *Laonice bahusiensis*, *Mediomastus fragilis*, *Ophelina acuminata*, *Pista cristata*, *Enchytraeidae*, *Perioculodes longimanus*, *Pontocrates arenarius*, *Hippomedon denticulatus*, *Guernea coalita*, *Ampelisca tenuicornis*, *Bathyporeia tenuipes*, *Megaluropus agilis*, *Melitidae*, *Lembos*, *Leptocheirus hirsutimanus*, *Pagurus cuanensis*, *Lepidochitona cinerea*, *Philine aperta*, *Pelecypoda*, *Nucula nitidosa*, *Kellia suborbicularis*, *Mysella bidentata*, *Laevicardium crassum*, *Phaxas pellucidus*, *Moerella donacina*.
- **Medium/fine sediments (mean phi = 2.33):**
Ophiodromus flexuosus, *Nicomanche*, *Polygordius lacteus*, *Terebellides stroemi*, *Scaphander lignarius*.
- **Medium sediments (mean phi = 1.81):**
Harmothoe andreapolis, *Sigalion mathildae*, *Exogone naidina*, *Nereis longissima*, *Scolecopsis cantabra*, *Polycirrus medusa*, *Pontocrates arenarius*, *Pariambus typicus*, *Corbula gibba*.

- **Coarse sediments (mean phi = 1.02):**

Notoplana atomata, *Sipuncula*, *Phascolion strombus*, *Harmothoe*, *Pholoe inornata*, *Mysta picta*, *Anaitides groenlandica*, *Anaitides rosea*, *Eumida*, *Paranaitis kosteriensis*, *Glycera alba*, *Goniada maculata*, *Exogone verugera*, *Procerastea*, *Nephtys cirrosa*, *Nephtys hombergii*, *Lumbrineris fragilis*, *Aonides oxycephala*, *Aonides paucibranchiata*, *Polydora caeca*, *Prionospio*, *Spio filicornis*, *Spio martinensis*, *Diplocirrus glaucus*, *Mediomastus fragilis*, *Notomastus latericeus*, *Nicomache*, *Ophelina acuminata*, *Scalibregma inflatum*, *Polygordius lacteus*, *Owenia fusiformis*, *Ampharete lindstroemi*, *Pista cristata*, *Sabellidae*, *Enchytraeidae*, *Ophelia borealis*, *Urothoe marina*, *Guernea coalita*, *Upogebia deltaura*, *Polinices pulchellus*, *Cylichna cylindracea*, *Pelecypoda*, *Nucula hanleyi*, *Thyasira*, *Kellia suborbicularis*, *Ensis ensis*, *Phaxas pellucidus*, *Fabulina fabula*, *Moerella pygmaea*, *Chamelea gallina*, *Tapes rhomboides*.

3.6 Infaunal Trophic Index

The Infaunal Trophic Index (ITI) was applied to the species data as an additional exercise to classify the biological communities. Whilst this index is not designed for this descriptive purpose of biotope classification (it is designed to describe the feeding behaviour of soft bottom benthic communities) it was employed here as an investigative tool to identify possible differences in samples from within the four clusters identified by MDS.

The results of the ITI analysis are presented as a geographical pattern in a layer in the GIS project. The communities in the samples (when described by their ITI index) were classed into two trophic categories (ITI category 2; surface detritus feeders, and ITI category 3; surface deposit feeders). Variation of ITI values within the clusters identified by multivariate analysis was small; no other correlations have been made at this stage.

3.7 Habitat assessment from video and stills imagery

The habitat encountered on this survey was typically characterised by soft or mobile sediments with sparse epifauna. Due to the low camera encounter rates with epifauna it was not deemed suitable to identify habitats or biotopes using camera assessments alone. The information from the camera was however integrated to provide information useful to biotope selection that the infaunal technique would miss, such as the presence of *Ensis*, and physical conditions such as the presence of shell debris that would be removed during analysis.

The habitats seen were found to range from fine well-sorted muddy sands through to coarse sands with gravels and pebbles overlying. Sediments frequently had more than one mode with a stratified structure of coarse material overlying finer material. The presence of comminuted shell material was seen in most of the sediments with the exception the very muddy sands. Sediment relief was generally flat with areas of ripples ranging from very fine structures (on the muddy sands) to large, potentially mega-rippled structures on the coarser sediments. Listed below are some visual descriptions of habitats encountered across the video and camera surveys with accompanying stills images where suitable.

1. Muddy sands were observed by the ROV deployments with *Asterias rubens*, *Alcyonium digitatum*, *Ophiura ophiura* observed on them. No suitable stills images are currently available, but video footage from the ROV deployments is available.

2. Fine sands (containing shell material and a little mud) with little or no bioturbation, were often rippled and typically included fauna such as *Pagurus bernhardus*, *Asterias rubens*, *Metridium senile* & *Liocarcinus* spp. & *Corystes* spp.



3. Fine sands (containing shell material and mud) with bioturbation were typically less rippled, with *Asterias rubens*, *Alcyonium digitatum*, *Ophiura ophiura*, *Porania pulvillus*, *Corystes cassivelaunus*, and *Liocarcinus* spp. observed.



4. Sands with overlying shell debris and/or fine gravel typically supported a more diverse range of epifauna, with species such as *Cancer pagarus*, *Metridium senile*, *Alcyonium digitatum*, *Asterias Rubens*, Echinoderms & *Aequipecten opercularis* observed.



5. Sands (again with mud content) with overlying fine gravel were often bioturbated with *Cancer pagarus*, *Metridium senile*, *Alcyonium digitatum* observed. Relief was flat with no rippling or undulation.



6. Sands with overlying gravel and pebble appeared to be mobile with a mega-rippled structure; alternating peaks and troughs of pebble material and clean coarse sands could be seen. Very little epifauna was observed.



3.8 Biotope classification

Biotope selection was performed by identifying infaunal communities in order to cross-match clusters of similar sample sites with standard biotope descriptions. This was then reviewed with the environmental information, video/stills (epifauna and sediment) analysis and the sediment data. The biotope classifications adequately describe and classify what was found during the survey and each clusters corresponded well with at least one biotope description. The reduced species lists compiled for each cluster rarely agreed 100 % with the published species list for a specific biotope, but the presence of significant characterising species along with sedimentary and visual information helped with the allocation to a given class. Full methods are described in section 2.5.

Biotope 1: SS.SMx.CMx.MysThyMx

Mysella bidentata and *Thyasira* spp. in circalittoral muddy mixed sediment.

Habitat classification:

Salinity: Full (30-35ppt)

Wave exposure: Moderately exposed

Tidal streams: Moderate – up to 1.8kt

Substratum: Muddy sand and gravel

Zone: Circalittoral

Depth band: 20-30m

Biotope description:

These circalittoral muddy sands and gravels had a community including the bivalves *Thyasira* spp and *Mysella bidentata*. The infaunal polychaetes *Chaetozone setosa* and *Scoloplos armiger* are also common in this community whilst amphipods such as *Ampelisca* spp were common. The brittlestar *Amphiura filiformis* was abundant. The most common Folk and Ward description of the sediment in this group was “Fine Sands”. The mean Phi was 2.34, and the

mean sediment composition included about 10% of the sediment in the < 63 micron (silt/clay) class.

Biotope 2: SS.SSa.IMuSa.EcorEns overlaying **SS.SSa.IMuSa.FfabMag**

Echinocardium cordatum and *Ensis* spp. in lower shore and shallow sublittoral muddy fine sand overlaying *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand.

Habitat classification:

Salinity: Full (30-35ppt)

Wave exposure: Moderately exposed

Tidal streams: Moderate – up to 1.8 kt

Substratum: Medium to fine sand; slightly muddy sand

Zone: Circalittoral

Depth band: 20-30m

Biotope description:

The evidence for this shallow sublittoral sediment of sand (or muddy fine sand) in fully marine conditions has to be supported by the video observations. The urchin *Echinocardium cordatum* and the razor shell *Ensis siliqua* or *Ensis ensis* were observed whilst other notable taxa included *Lanice conchilega*, *Pagurus*, *Liocarcinus* spp. and *Asterias rubens*. Infaunal species included the polychaetes *Spiophanes bombyx*, *Magelona mirabilis*, *Nephtys cirrosa* and *Chaetozone setosa* and the amphipod *Bathyporeia elegans* was common. The most common Folk and Ward description of the sediment in this group was “Medium Sands”. The mean Phi was 1.82, and the sediment composition included approximately 2.8% of the sediment in the < 63 micron (silt/clay) class.

Note: *Ensis* may have been excluded by the sampling technique – shell was visible on video and stills but not recorded in infauna. Grabs of the type used are inefficient in collecting live *Ensis* due to their bite not being deep enough, and dead shell is excluded during the analysis.

Biotope 3: SS.SCS.ICS.MoeVen

Moerella spp. with venerid bivalves in infralittoral gravelly sand.

Habitat classification:

Salinity: Full (30-35ppt)

Wave exposure: Moderately exposed

Tidal streams: Moderate – up to 1.8kt

Substratum: Medium to coarse sand and gravelly sand

Zone: Circalittoral

Depth band: 20-30m

Biotope description:

A medium to coarse sand / gravelly sand subject to moderately strong water movement from tidal streams. *Moerella* spp. with the polychaete *Glycera lapidum* were abundant. Other infauna included nephtyd and spionid polychaetes and amphipod crustacea. The most common Folk and Ward description of the sediment in this group was “Coarse Sand”. The

mean Phi was 1.02, and the sediment composition included approximately 1.7 % of the sediment in the < 63 micron (silt/clay) class.

Biotope 4: SS.SSa.CFiSa.EpusOborApri

Echinocyamus pusillus, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand.

Habitat classification:

Salinity: Full (30-35ppt)

Wave exposure: Not known

Tidal streams: Not known

Substratum: Medium to fine sand.

Zone: Circalittoral

Biotope description:

This medium to fine sand was characterised by the polychaete *Ophelia borealis*. Other species included the polychaetes *Spiophanes bombyx*, *Pholoe* sp., *Exogone* spp., *Chaetozone setosa*, *Owenia fusiformis*, *Glycera lapidum*, *Lumbrineris* and the bivalve *Moerella pygmaea*.

The most common Folk and Ward description of the sediment in this group was “Medium/fine sand”. The mean Phi was 1.02, and the sediment composition included approximately 2.4% of the sediment in the < 63 micron (silt/clay) class, but the sedimentology differs from the other med/fine sand identified in this area in that approximately 8.7% of the sediment is classed as gravel (see table 3.3).

4. Survey site assessment

Figure 4.2 shows the final interpreted habitat map for the sandbank area. The RoxAnn unsupervised classification (cluster) map was used to guide the drawing of the final polygons, after interpretation of both the grab sample data and video data. The grab sample biotope distribution initially did not seem to correlate with the ground-types shown from the RoxAnn cluster map, which could be due to local heterogeneity in ground features, such as ripples and megaripples, which exist at a scale that would influence the RoxAnn signal but be undetected from the processed grab samples. The video provided a valuable ‘overview’ or ‘landscape’ view of the seabed, which supplemented the quantitative data from the grab samples. RoxAnn may penetrate seafloor sediment and therefore be affected by bioturbation, layering of sediments and rippled features. Due to the often large (>20m²) echosounder footprint, RoxAnn data points each represent an ‘average value’ from a fairly large area of seafloor, whereas grabs sample only a very small area. The video therefore provided a good link between these very different spatial scales.

It was found upon analysis of the various datasets that a few areas existed of harder sand with a significant proportion of shell debris (often whole shells) and some pebbles. These areas were readily detected by RoxAnn and the sidescan sonar mosaics agreed with the locations of such regions. It was found that such areas generally existed in large patches (which may actually be mosaics of dense shell areas with pebbles and softer sand areas), and extend throughout the middle and slightly to the south of the survey area. Based on the MNCR classification scheme (Connor *et al*, 2004), such areas have been categorised as SS.SCS.ICS. It is impossible to classify such areas to biotope level due to the high level of infaunal data needed to really support a link between the broadscale acoustic data and the finer scale capabilities of grab sampling. However, in such areas grab samples were commonly classified as SS.SCS.ICS.MoeVen, and, to a slightly lesser extent, SS.SSa.CFiSa.EpusOborApri.

Bordering the harder patches within the survey area were heterogeneous regions of both coarser and finer sands, with a fairly large proportion of shell debris. These sites generally incorporated the biotopes SS.SCS.ICS.MoeVen and the matrix of SS.SSa.IMuSa.EcorEns overlaying SS.SSa.IMuSa.FfabMag. For the purposes of broadscale mapping this area has been classified as SS.SCS.ICS & SS.SSa.IMuSa to reflect the heterogeneity of this sedimentary area.

To the north of the survey area, a large area of mixed sediment was detected, from which the grab samples detected almost unanimously the biotope SS.SMx.CMx.MysThyMx. This habitat unfortunately did not have a video tow run through it, and therefore interpretation has relied heavily on grab sample data and acoustic data. This appears to be the only ‘gravel’ region that was reliably detected (darker reflectance on sidescan sonar) but still contained a fairly high proportion of fine material (silt/clay). This region has been classified as SS.SMx.CMx.

To the south of the survey area a distinct region was identified comprising of much softer acoustic returns, indicating either fine sand or sandy mud. Unfortunately no grab samples were taken so the exact sediment type cannot be ascertained, however the ROV flights did cover some of this area and indicated bioturbated muddy sand (not plotted on GIS), and has therefore been classified as SS.SSa.IMuSa.

Finally, the regions in between the harder / high shell density regions and the gravel area to the north and muddy sand area to the south represent fine and muddy sands. These regions have been assigned to one category because distinguishing between muddy sand and fine sand using the acoustic data was not possible, and the biotope classifications from the grab samples could not further aid such interpretation. In fact the region is quite heterogeneous, including all the biotopes identified from the grab samples, although showing a predominance of SS.SSa.CFiSa.EpusOborApri. From the video

tows, it was seen that the region varied between rippled areas and bioturbated areas (although in some areas the sand was both bioturbated and rippled). Shell debris was found occasionally, but the sand always had relatively high silt/clay content. For the purposes of mapping this area, it has been classified as SS.SSa.CFiSa and SS.SSa.IMuSa.

To generalise, the area consists of bi- and poly modal sands, with most regions within the site showing a notable fine sand or silt/clay component. Shell debris is common throughout the area although is concentrated in certain patches, often associated with some pebble. Gravel is only found to the north-east border of the area, while the finest sands and possibly mud is found to the south. Features such as ripples and bioturbation (thought to be mainly from *Ensis* burrows) are very common. The region surveyed appears part of a larger sandbank feature (Figure 4.1), which would merit complete surveying. The distribution of sediments over the sandbank are likely to be transient, although the area is not affected by extreme currents so such changes may be gradual, except perhaps during storm season when due to the shallow nature of the bank, wave action could considerably rework the sediments.

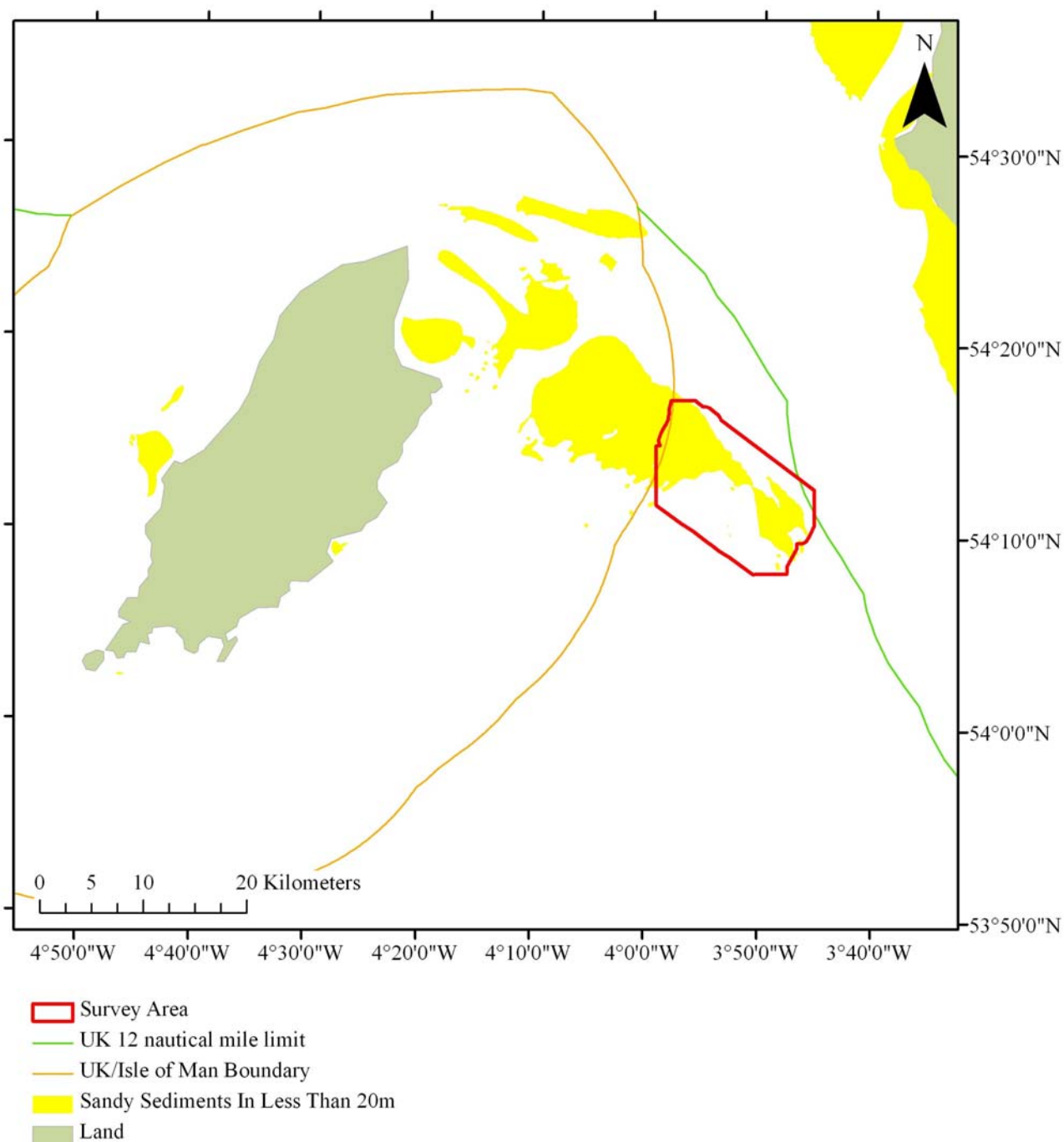


Figure 4.1 Sandy sediments to the east of the Isle of Man with survey area indicated in red. World Vector Shoreline © US Defense Mapping Agency. Seabed habitat derived from BGS 1:250,000 seabed sediment maps by permission of the British Geological Survey © NERC (Licence No. 2002/85) and in part from bathymetric data © British Crown and SeaZone Solutions Limited. All rights reserved. Products Licence No. PGA042006.003.

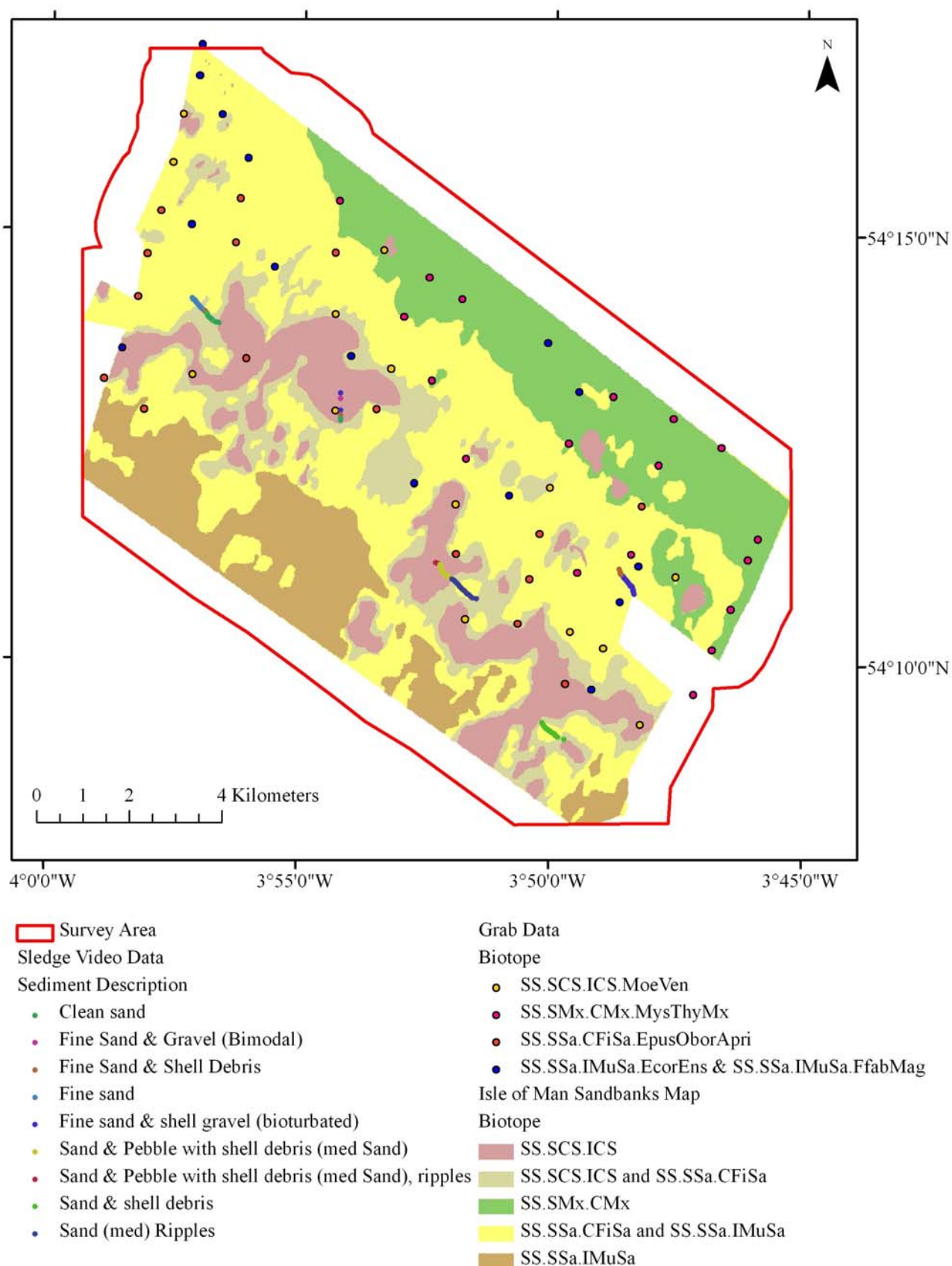


Figure 4.2. Final Habitat map from the Isle of Man Sandbanks survey including video sledge, infauna biotopes and habitat information

5. Discussion and conclusion

This study has provided the basis for an assessment of part of a sub-tidal sandbank lying to the east of the Isle of Man. Despite the fact that survey work was largely conducted opportunistically a large area with several key features has been mapped and the benthic communities described. The habitats and biological communities identified in this report are typical of mobile moderately exposed sands and muddy sands, and conformed well to established biotope and habitat descriptions.

The assessment and categorisation process employed, despite rigorous scientific and statistical processes can still (and quite possibly should) be influenced by a degree of subjectivity from the investigator. Expert opinion however could be further supported by tools such as the Habitat Matching Programme (not operational at the time of this investigation) which could offer a standardised routine of classification for assessments to be made upon and ensure greater comparability between studies and investigators. It would be an interesting exercise in future to revisit a number of studies using the Habitat Matching Programme and compare the outputs to the reported descriptions.

It should be noted that the entire sandbank feature (Figure 4.1) has not been mapped and any assessment of its significance or sensitivity will be limited due to the area not included in the survey. Sandbanks by their nature will tend to be dynamic environments with complex sediment transport pathways and seasonal movement of features such as sand-waves; the survey area is part of a larger system and may be closely coupled with the surrounding sediments on all sides, meaning that knowledge about the surrounding habitats and their stability would aid in the understanding of the conservation value of this area. It should also be noted that there is a requirement for statutory bodies to undertake certain work to agreed QA standards and protocols. In the case of this work the particle size analysis data was not supplied in an appropriate format. Whilst the use of research vessel “down time” has allowed this study to be conducted at minimal cost this approach may mean that seasonal differences in communities and habitat distributions may not have been identified.

This collaboration between AFBI and JNCC has allowed the objectives of both organisations to move forward and provide a broad assessment of a large area of sea-floor. The need (and scope) for improved coordination between research vessel programming and the project planning has been identified as a priority in order to maximise the value of future work, and should be more easily implemented following the experiences gained during this work package.

6. Acknowledgements

As always thanks to the master and crew of the AFBI research vessels for their professionalism and assistance, Andrew McDougal for ROV piloting and Dr Kerry Howell (JNCC) for developing this study.

7. References

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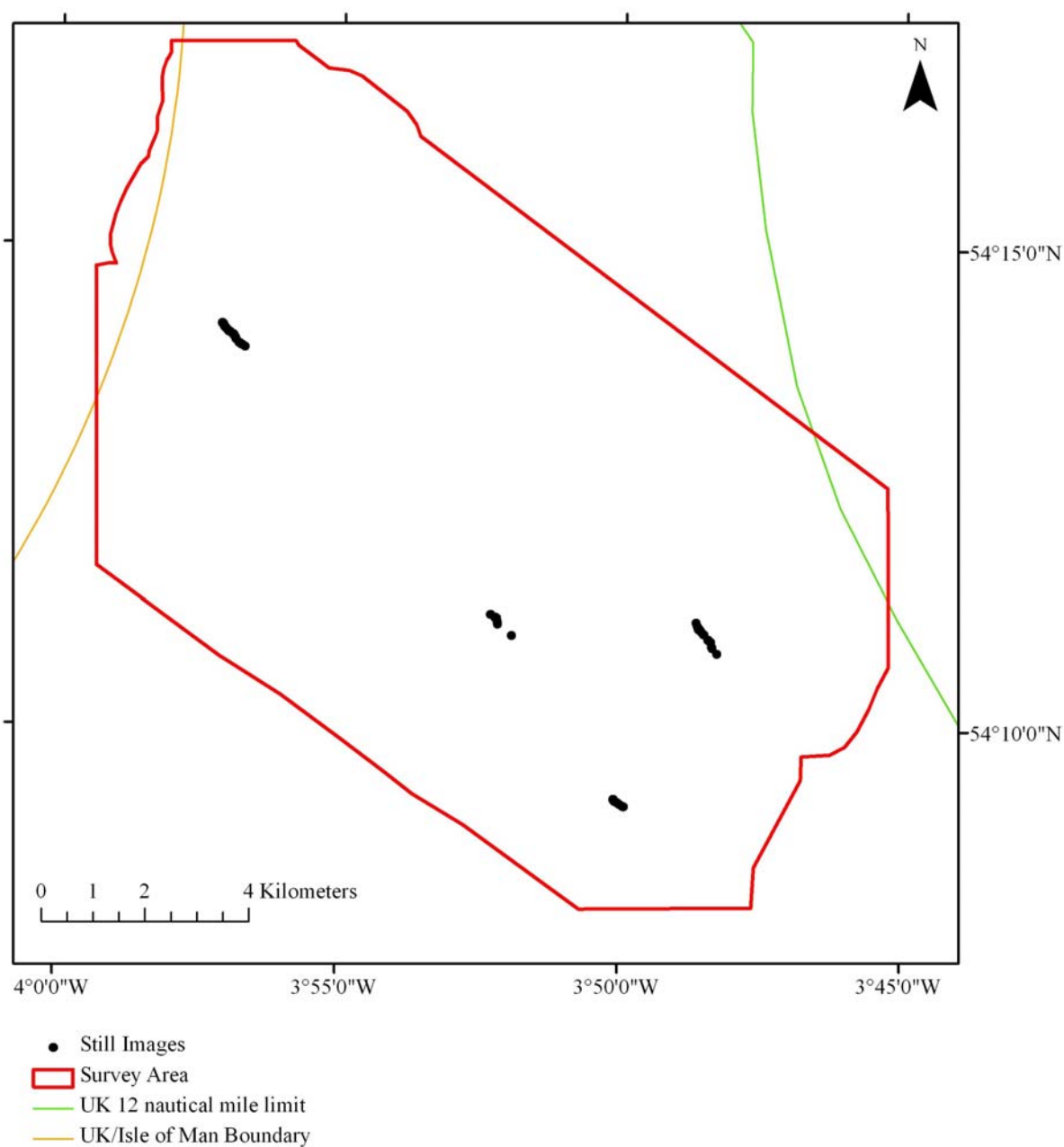
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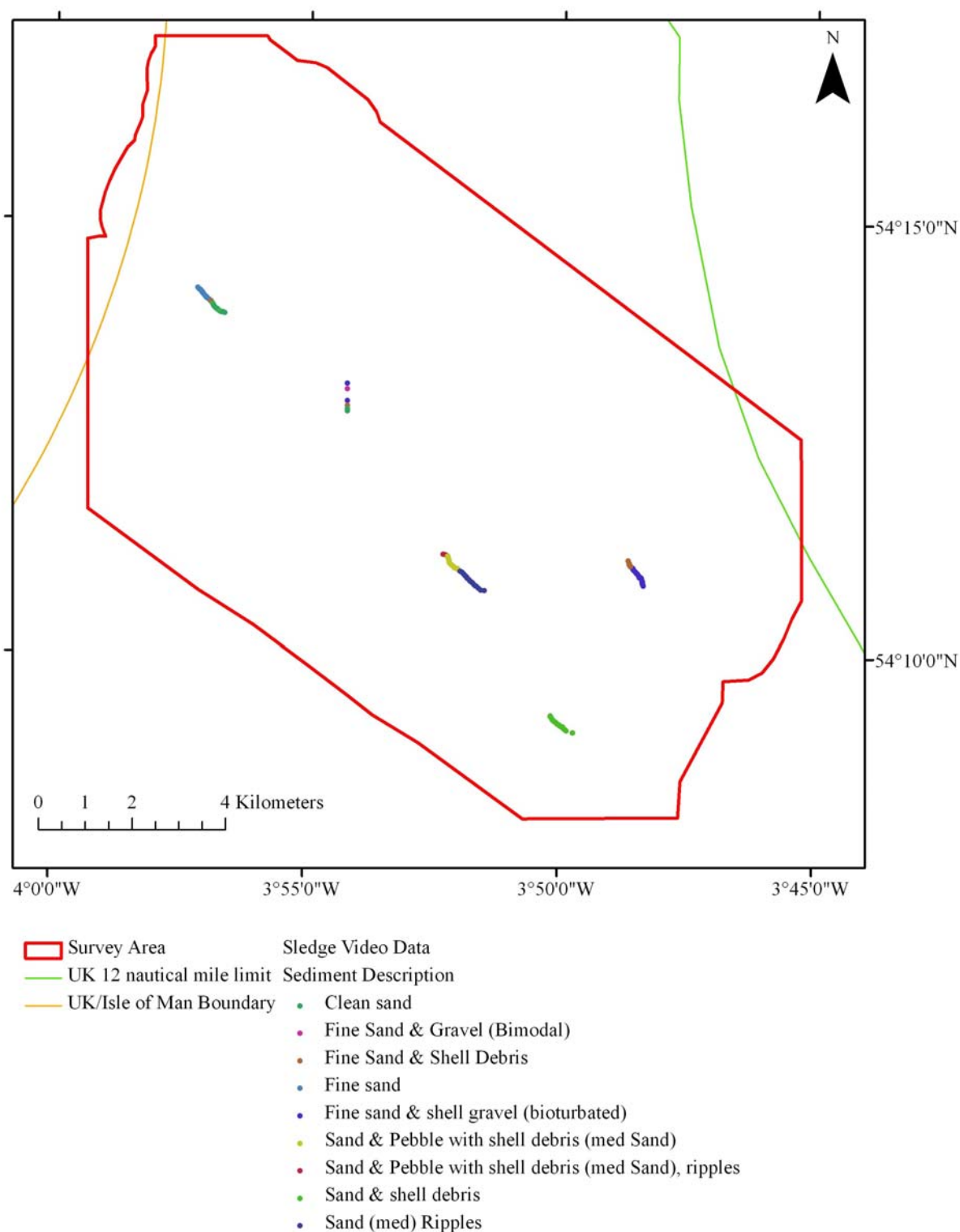
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Appendix 1. GIS layer outputs

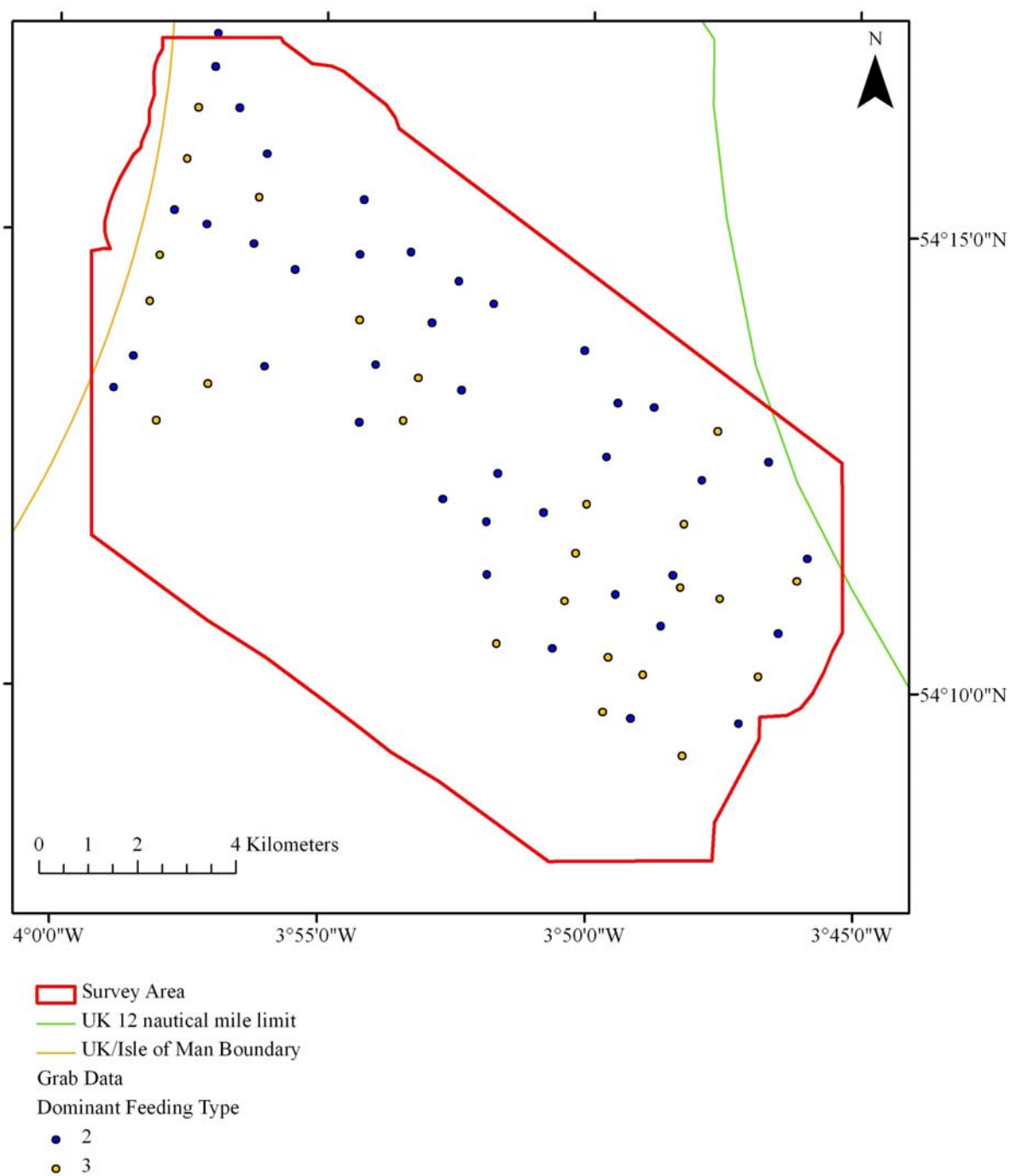
Appendix 1.1 – GIS project layer examples – 35mm stills image positions



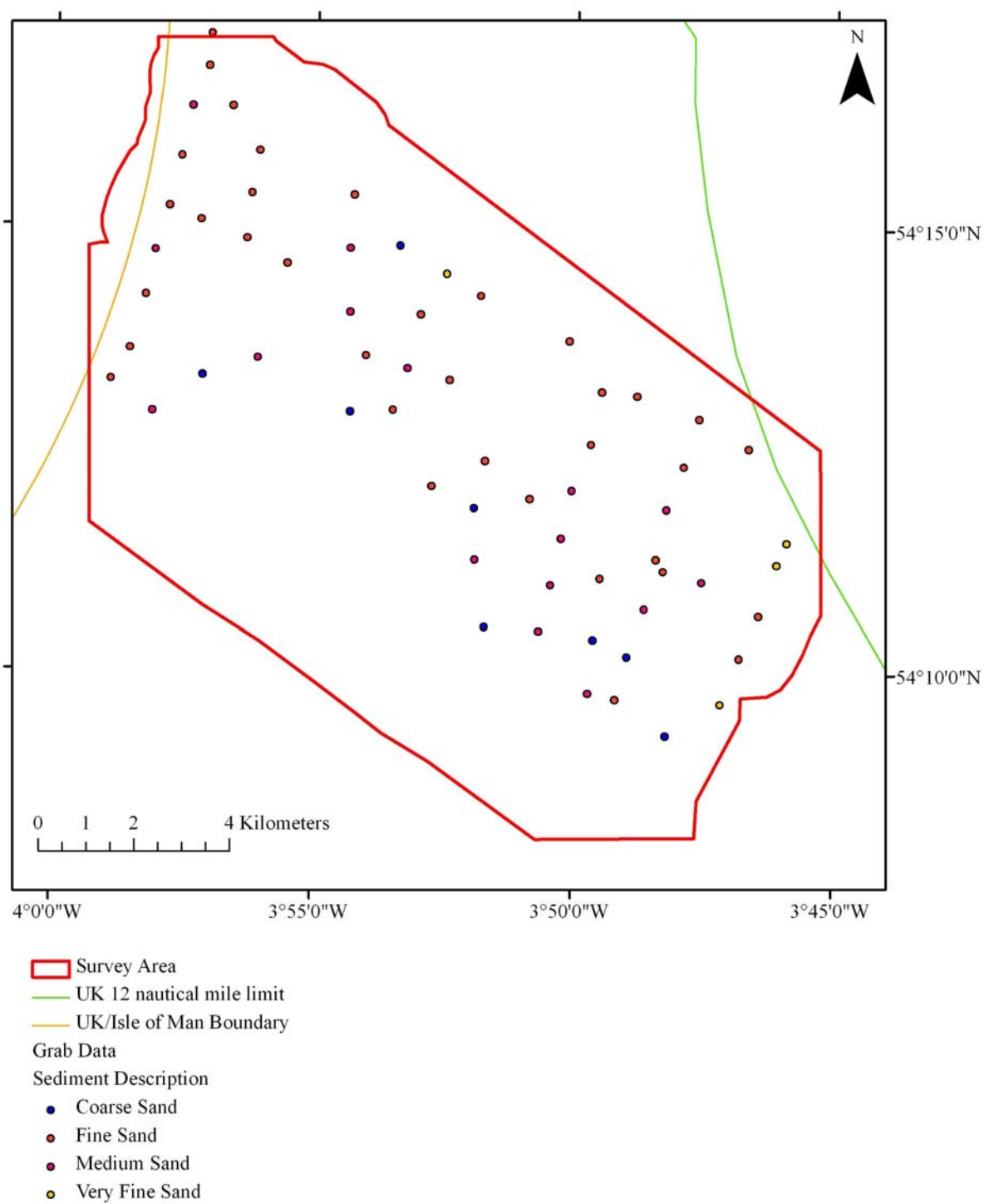
Appendix 1.2 – GIS project layer examples – Video sledge position summary



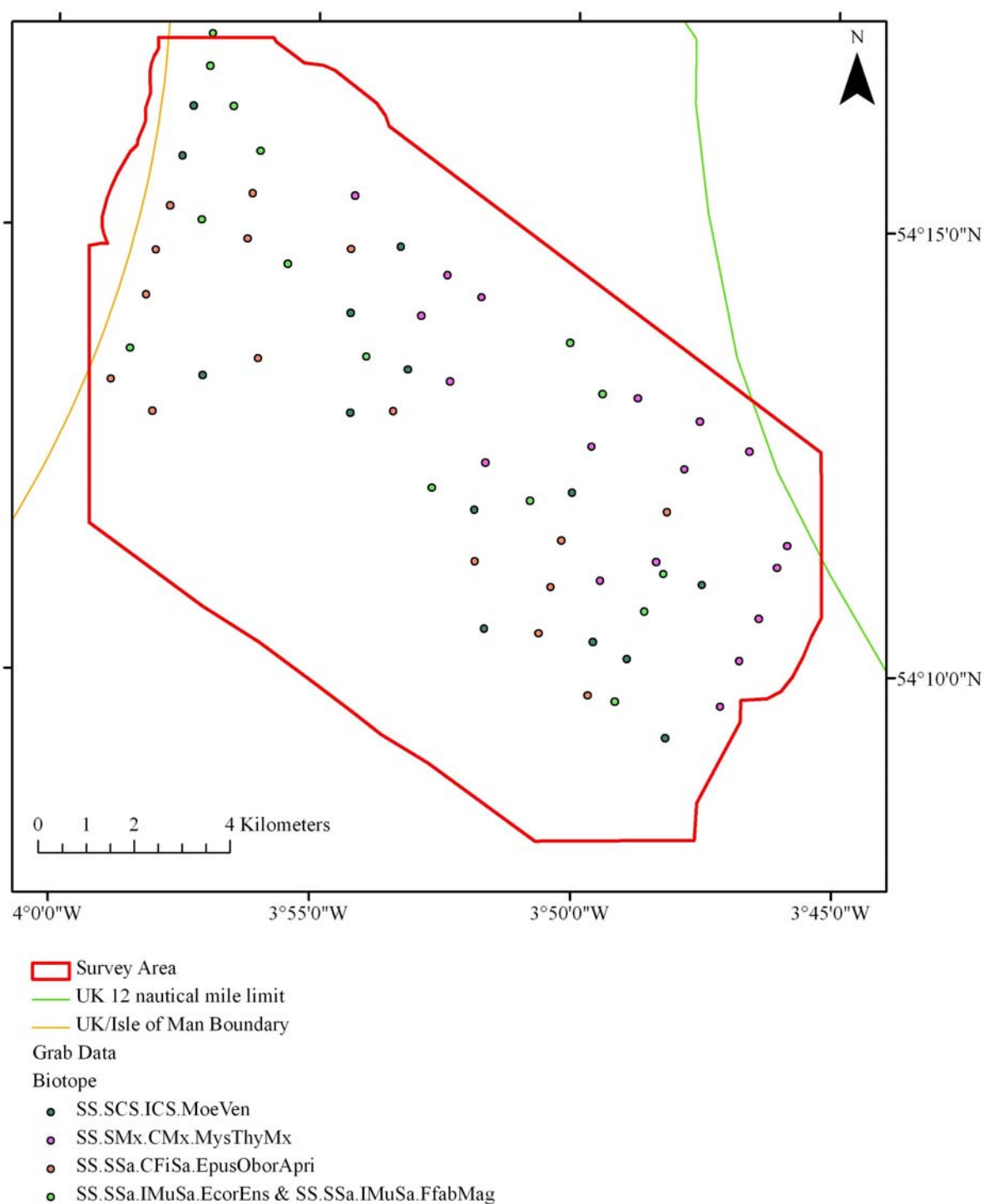
Appendix 1.3 – GIS project layer examples – Grab positions with ITI codes summary



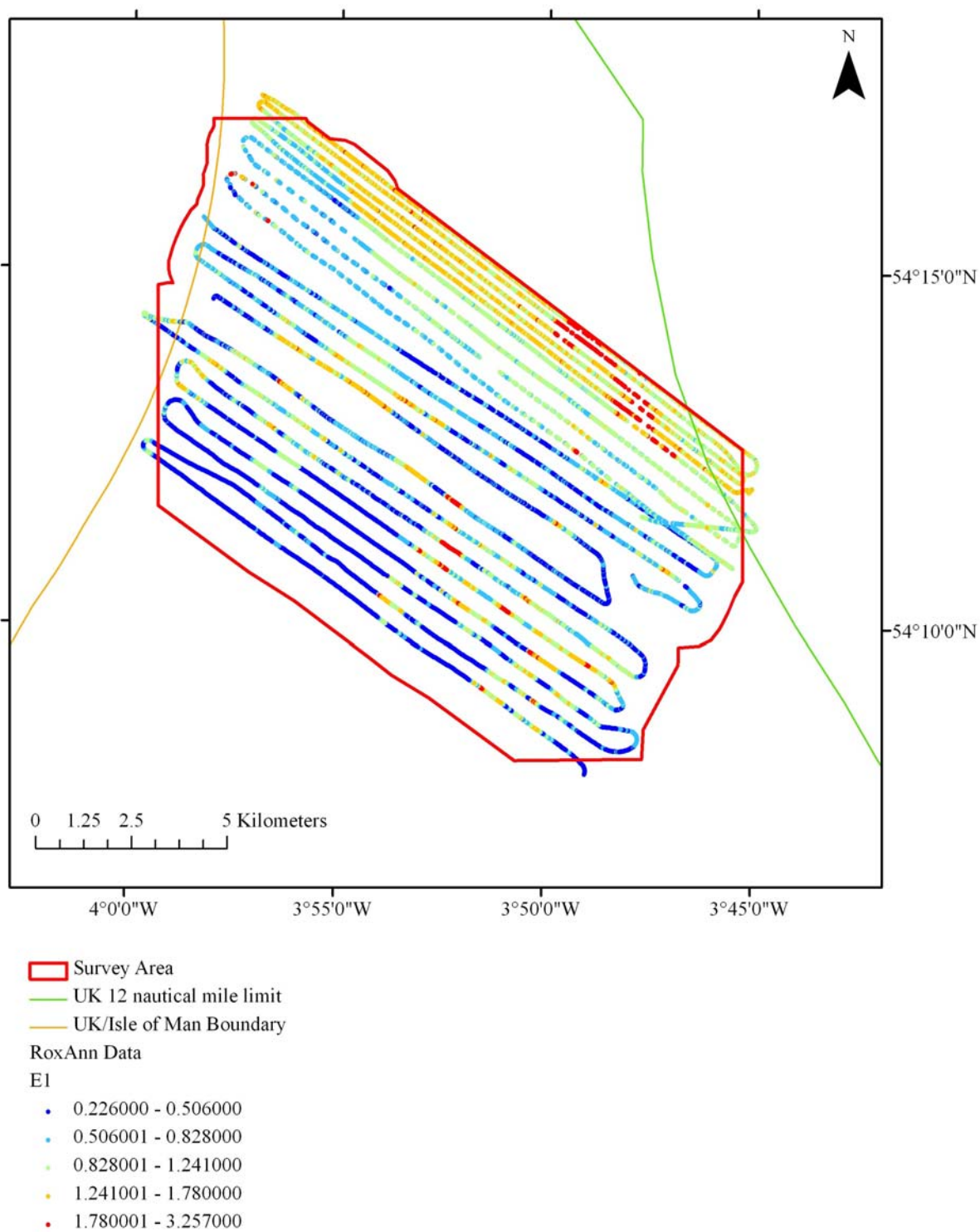
Appendix 1.4 – GIS project layer examples – Grab positions with sediment characterisation



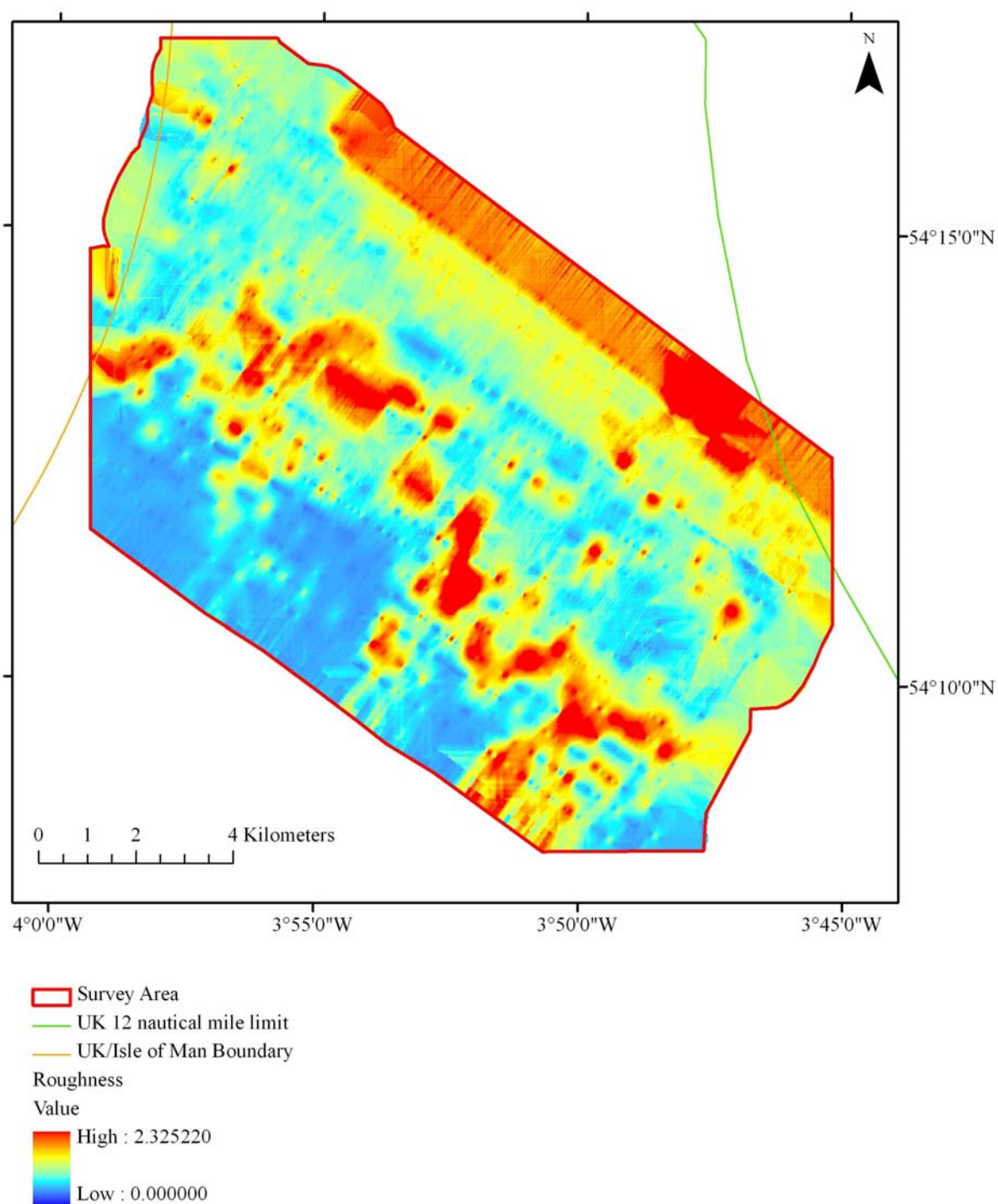
Appendix 1.5 – GIS project layer examples – Grab positions with biotope classifications



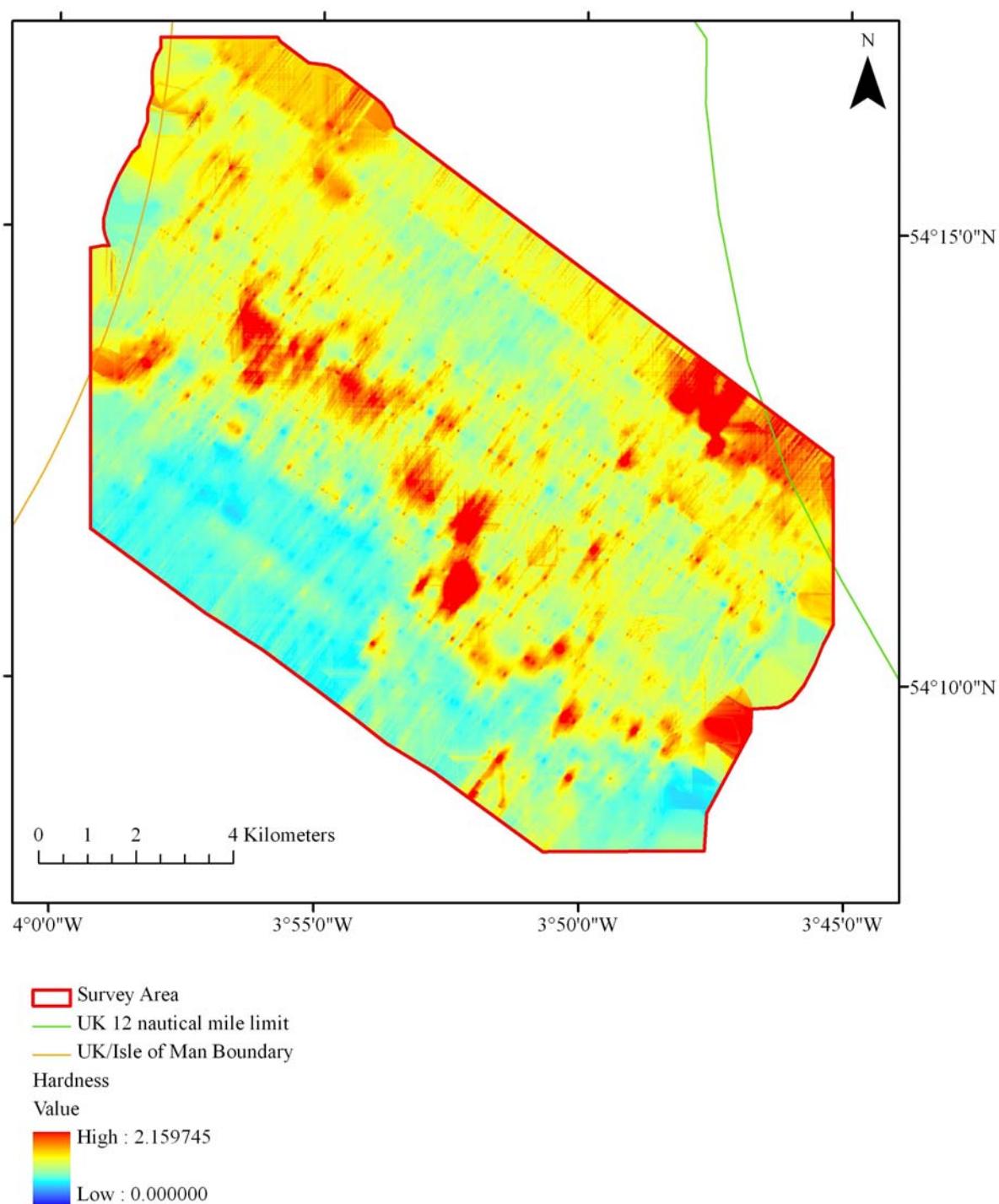
Appendix 1.6 – GIS project layer examples –Roxann tracks and merged E1 data



Appendix 1.7 – GIS project layer examples - Interpolated roughness map



Appendix 1.8 – GIS project layer examples – Interpolated hardness map



Appendix 1.9 – GIS project layer examples - Interpolated habitat map

