

Scottish Natural Heritage

Commissioned Report 351

*Biotope Mapping and Survey of Sullom Voe Special Area
Conservation*





COMMISSIONED REPORT

Commissioned Report No. 351

Biotope Mapping and Survey of Sullom Voe Special Area of Conservation

For further information on this report please contact:

Laura Clark
Scottish Natural Heritage
Great Glen House
INVERNESS
IV3 8NW
Telephone: 01463 725237
E-mail: laura.clark@snh.gov.uk

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COMMISSIONED REPORT

Summary

Biotope Mapping and Survey of the Sullom Voe Candidate Special Area of Conservation (cSAC)

Commissioned Report No. 351
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Background

Sullom Voe in Shetland has been identified as a Special Area of Conservation (SAC) under the EC Habitats Directive (92/43/EEC). It is representative of the most northerly of the geographical range and ecological variation of 'large shallow inlets and bays' within the UK. Sullom Voe encompasses a variety of reef habitats and boreal-arctic species that are characteristic of Shetland voes and found nowhere else in the UK. Other interest features include 'reefs', in particular the biogenic reefs formed by the horse mussel *Modiolus modiolus*. The site also includes 'lagoons', which are a nationally rare habitat and priority habitat type under the EC Habitats Directive.

The aim of this report is to describe the results from intertidal and sublittoral surveys of the SAC to provide comprehensive broadscale biotope distribution maps. A team from Envision Mapping Ltd, Newcastle University, undertook the sublittoral mapping in August 2004 using Acoustic Ground Discrimination Systems (AGDS), swath bathymetry and video groundtruthing. A team from Heriot-Watt University, Edinburgh carried out the intertidal biotope mapping work in September 2004 following standard JNCC techniques.

Main findings

- A total of 43 biotopes and sub-biotopes were identified during the intertidal survey, from approximately 60 km of coastline. Overall, the shores were characterised by fucoid communities on bedrock or mixed substrates, in particular *Fucus vesiculosus*. There were, however, extensive exposed areas in the north with predominant barnacle cover.
- On the less exposed mid and inner Voe rocky shores, communities were dominated by *Fucus spiralis*, *F. vesiculosus*, *F. serratus* and, *Ascophyllum nodosum*. Soft sediment areas were generally confined to the heads of the Voes and in houbts/lagoons and in some of the shallower sloping shores, *Macoma balthica* and *Arenicola marina* were to be found. Barren shingle/coarse sand shores were common.

- There is a wealth of marine biological data for Sullom Voe from the 1970s onwards, mainly from monitoring programmes associated with the Oil Terminal. The results from the present intertidal mapping survey correspond with what is known from previous work.
- Sublittorally, a total of 26 biotopes with 9 Biotope Complexes within the Sullom Voe SAC were recorded from a total of 106 video samples.
- There was a gradation of sediment types with depth. Sand and sandy muds were found close to the shoreline and in sheltered areas. Bedrock and boulders were found close to the shoreline, with mixed sediments in areas where tidal influence is present. The deeper areas of the Voe consist of softer muds and silts.
- Most of the subtidal survey area comprised sedimentary habitats. The three most frequently recorded biotopes were kelp (mainly *Laminaria saccharina*) and red algal communities, circalittoral mixed sediments with scallops (*Aequipecten opercularis*) and deep finer sediments with seapens (*Virgularia mirabilis*). Other commonly recorded biotopes were kelp on bedrock and boulders immediately adjacent to the shore and in the more exposed areas. Brittlestar beds were circalittoral and were found only in the entrance to Orka Voe on bedrock and boulders.

For further information on this project contact:

Laura Clark, SNH, Great Glen House, Leachkin Road, Inverness, IV3 8NW Tel: 01463 725237

*For further information on the SNH Research & Technical Support Programme contact:
DSU (Policy & Advice Directorate), Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or pads@snh.gov.uk*

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1 INTRODUCTION

1.1 Sullom Voe SAC – Site background

Sullom Voe has been identified as a Special Area of Conservation (SAC) under the European Habitats Directive (92/43/EEC). It is the most northerly site in the UK to be selected as a representative of 'large shallow inlets and bays', and within the site series it is the only Scottish example of a ria (known locally as a 'voe'). 'Reefs' and 'lagoons' are also interest features of the SAC. The boreal-arctic (northern) species-rich communities of Sullom Voe are restricted to Shetland voes and are not represented elsewhere in the SAC series. Howson (1999), in her summary of Marine Nature Conservation Review (MNCR) and other information on Shetland sector areas, noted that the intertidal sediments of Sullom Voe, generally confined to lagoons near the mouth of the voe, are colonised by a diverse faunal community including bivalves, polychaetes and the sea cucumber *Leptosynapta inhaerens*. In addition to rocky reefs, the horse mussel *Modiolus modiolus* is widespread throughout the site and forms an extensive biogenic reef to the south of Little Roe island. Poorly-mixed, muddy sediments which characterise the sublittoral are colonised by horse mussels, sea-pens (*Virgularia mirabilis*) and diverse burrowing communities. A range of bivalves, polychaetes and amphipods can be found in the organically enriched shell-sand, gravel and muddy-sand sediments. Lagoons are a nationally rare habitat and a priority habitat type under the EC Habitats Directive. The Houb of Haggrister is a percolation lagoon and the Houb of Fugla Ness is a silled lagoon (Thorpe, 1998). A map of Sullom Voe indicating the boundary of the SAC is shown in Figure 1.1.

1.2 Aims of the study

This report details the studies undertaken by Heriot-Watt University (main contractor) and Envision Mapping Ltd. (sub-contractor) for Scottish Natural Heritage (SNH) to undertake broad scale intertidal and subtidal biotope mapping of Sullom Voe Special Area of Conservation.

The project consisted of a descriptive intertidal mapping survey of the SAC using MNCR Phase I methodologies (Hiscock, 1996; Wyn *et al.*, 2000) and subtidal mapping utilising Acoustic Ground Discrimination Systems (AGDS) with groundtruthing (Foster-Smith *et al.*, 2000).

The specific objectives of the work were to:

- review existing information relating to the intertidal and subtidal regions of Sullom Voe;
- undertake broadscale intertidal and subtidal habitat/biotope mapping surveys of the area;
- compile a report of the survey work with maps showing the distribution of biotopes;
- compile the data and outputs into a Geographic Information System (GIS) project that is compatible with the SNH ArcView GIS.

Additional objectives were for research relating to the Site Condition Monitoring (SCM) undertaken during the same survey period (but reported separately in Mairet *al* 2010).

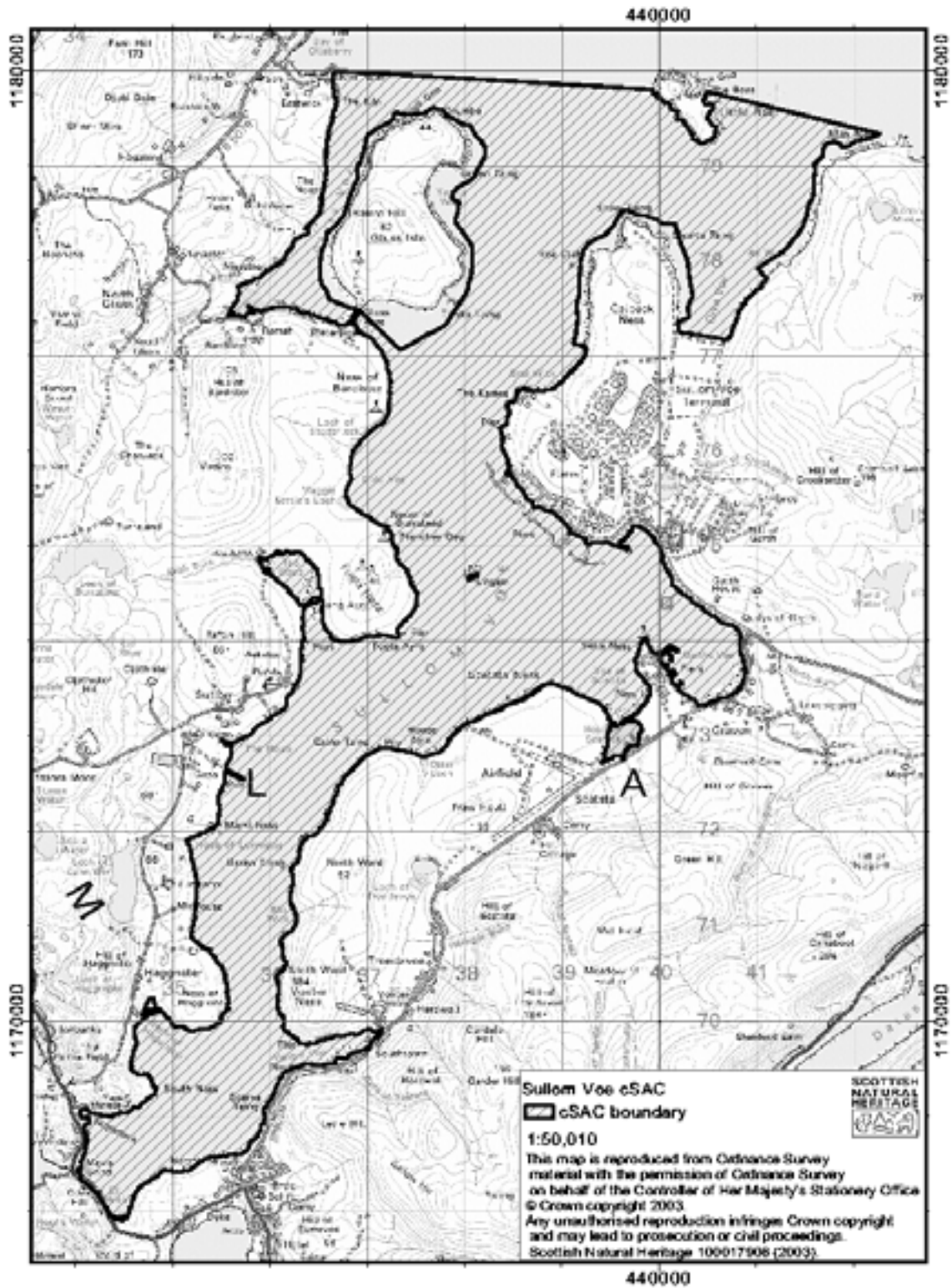


Figure 1.1 *Sullom Voe SAC showing site boundary and area of the biotope mapping survey (August - September 2004)*

2 PREVIOUS INFORMATION ON SULLOM VOE

There is a wealth of information that exists on many aspects of the terrestrial and marine environment of Sullom Voe, primarily due to monitoring programmes established at the time of the development of the Shetland Oil Terminal in the mid-1970s and subsequently by numerous marine site descriptions as part of the MNCR. SOTEAG (Shetland Oil Terminal Environmental Advisory Group) established many baseline surveys and long-term monitoring programmes (Dunnet, 1995) that included ornithological and atmospheric (lichens) monitoring as well as chemical and biological sampling of the marine environment. The Terminal Operator (BP) was, and still is, also required to carry out statutory monitoring of discharges such as atmospheric and effluent emissions and, specifically on the marine environment, to measure impacts from its treated ballast-water discharge site to the north of Calback Ness (within the boundary of the SAC). This monitoring programme for effluent discharges covers both chemical contamination levels in sediments and biota and biological impacts on the benthos (Davies & Matheson, 1995). The statutory programme surveys were initially carried out every six months from 1978 until 1985 and then subsequently continued on an annual basis. Scottish Office (now Scottish Government) departments and agencies have carried out many other studies in the area including assessments of hydrography, fisheries effects, macrobenthos production, ballast water discharges and hydrocarbon levels. Numerous other groups such as SMRU, SNH, RSPB, and WWF have similarly surveyed mammal and bird populations.

Much scientific information and descriptions of the above studies have been published in two special Proceedings of the Royal Society of Edinburgh, the first in 1981 ('The marine environment of Sullom Voe and the implications of oil developments' – Pearson & Stanley, eds. 1981) and the second, entitled 'Monitoring at an oil terminal: the Shetland experience', in 1995 (Dunnet & McIntyre, 1995). A further comprehensive review, particularly of the marine conservation status of the SAC area, was published in 1999 (Howson, 1999 – Marine Nature Conservation Review Sector 1. Shetland: area summaries.).

Sullom Voe SAC encompasses not only the whole of the main Voe (Sullom) but also Gluss Voe in the north-west and Orka Voe in the north-east. These three Voes are situated on the southern part of Yell Sound in Mainland, Shetland. There are frequent North Atlantic storms passing over the Shetland Islands although the SAC is sheltered from the prevailing south-westerly winds. Sullom Voe is one of the longest and deepest voes in Shetland reaching a depth of 51m at the mouth and 49m towards the head although the main channel is typically 21-32m deep. Conditions towards the head of Sullom Voe and Gluss Voe (and in the several lagoons) tend to be extremely sheltered, while the entrances to Gluss, Sullom and Orka Voe are moderately exposed to wave action. At its south-easterly end, Gluss Voe is separated from Sullom Voe by a shingle spit, which is often breached in severe weather and extreme tides.

The tidal streams are normally negligible except at the entrances to the Voes where they can be moderately strong. The tidal range is small (about 0.9m mean neaps to 1.9m mean springs) and the area is predominately marine.

Most of the SAC has bedrock, boulders and cobble shores with a few soft sediment shores situated towards the head of the Voes and smaller patches of soft sediments in isolated coves in the outer region and on Little Roe island. Detailed descriptions of various rocky shore sites within the area of the SAC have been given in Hiscock (1981) and Moore *et al.* (1995). Studies on particular intertidal species, e.g. impacts of TBT on dogwhelks, etc. have been reported to SOTEAG and in Bailey & Davies (1988) and Bailey *et al.* (1995). Soft sediment shore descriptions were given by Jones & Jones (1981) and Jones (1995), whilst salt marsh environments were described by Dalby (1981) and saline lagoons in Thorpe (1998).

Sublittorally, numerous comprehensive studies have been carried out and submitted in unpublished reports to the Terminal Operators, SOTEAG, Scottish Government departments, and to SNH and MNCR/JNCC. These reports include descriptions of benthic surveys as part of the statutory

monitoring programme around the Calback Ness effluent diffuser discharge site in the north of the SAC (Davies & Matheson, 1995) and also surveys undertaken throughout the whole length of Sullom Voe (under SOTEAG's remit). Published descriptions and summaries of available information are given in Pearson & Eleftheriou (1981), May & Pearson (1995), and Howson (1999) on macrobenthos of the soft sediments. Infralittoral algae at several sites have been studied on a decadal basis since 1973 by Tittley *et al.* (1977) and Tittley & Farnham (2001).

3 METHODS

Survey work comprised of three elements: aerial photography; broadscale intertidal biotope mapping; and broadscale sublittoral biotope mapping using Acoustic Ground Discrimination Systems (AGDS), multibeam swath bathymetry and video groundtruthing. The approach and methods used are detailed in the following sections.

3.1 Aerial photography

Aerial photography of Sullom Voe was contracted out by SNH to the Unit of Landscape Modelling, University of Cambridge. To coincide with the time of low water spring tides in the area (1605 GMT), the survey flight took place on 3 July 2004, between 1500 and 1520 GMT. The flight pattern during photography comprised of five runs aligned 030°/210° up the Voe at an altitude of 5,000 feet above sea level (an approximation of the flight pattern is shown in Figure 3.1). A Zeiss LMK15 camera fitted with a 152mm lens was used to take 60 photographs to cover the area of Sullom Voe SAC. With the lens type used and altitude flown, the ground area covered in each frame was 2000m by 2000m. The filmstock was Agfa N400 colour print film. The aerial imagery was supplied in the form of colour prints (scale approximately 1:10,000). The prints were then scanned and merged together to create a single mosaic image of the SAC. The mosaic image was then geo-rectified for display within a GIS environment.

3.2 Intertidal

3.2.1 Fieldwork

The survey methods applied during the intertidal biotope mapping generally followed those described by Wyn *et al.* (2000). Fieldwork took place during the 10-day period 7th-17th September 2004. Dr Hamish Mair, Dr Colin Moore, Dr Martin Wilkinson, Dr Alistair Lyndon, Dr Ian Tittley, Jade Berman, Sarah Holt and Paul Wood were involved with the intertidal survey. The weather was mostly fine, especially in the initial period, although two days weather downtime was incurred in the latter stages due to strong winds preventing safe work.

Ordnance Survey (OS) Landline data for Sullom Voe were provided by SNH, and were combined with the aerial photography to provide a series of laminated and grid referenced colour photographs for use in the field at a scale of 1:5000. In addition, forms for recording biotope details, waypoints, target notes and photography were printed onto waterproof paper. As many areas of the Voe (especially the outer areas of Orka Voe and the Little Roe island) were inaccessible by road, the chartered fishing vessel "*Charisma*" operating out of Sella Ness harbour in Sullom Voe was used as a mothership, in addition to which a 4m inflatable boat was used for ferrying teams ashore. The majority of the shoreline was observed from the inflatable with frequent trips onto shore to map biotope boundaries. In some areas it was impossible to land ashore, such as around the steep cliff faces around outer Gluss Voe, and other areas in which it was forbidden from going ashore or using an outboard engine on the inflatable, for example around the Sullom Voe Oil Terminal loading jetties. To cover this particular area, permission was obtained from the terminal operators to map the shores from the "*Charisma*" which was able to enter between the loading jetties and approach the shore closely.

The observed biotope distribution was drawn directly onto the paper copies of the grid-referenced aerial photographs/maps as a series of adjoining polygons. The aerial photographic data eased the mapping process considerably, since distinct biotope boundaries visible on the shore were often evident in the photographs. The photographs also aided navigation and position fixing, through relating GPS data to the maps. This was facilitated by having a 50m by 50m grid labelled with eastings and northings superimposed on all the maps. Handheld GPS was used to record the position of biotope boundaries, target notes and photographs in the form of stored waypoints. As far as possible each area (or polygon) mapped corresponded to a single biotope. Biotopes too small to be mapped (polygons smaller than approximately 5m by 5m) were recorded as a target note at a point location. To provide a record of these areas, forty-five profiles were also sketched and photographed to show the general zonation along the shore. Photography was integral to the recording process, and digital photographs were taken to illustrate the site in general and the biotopes present. Close-up shots were taken of many of the marine organisms present.

Whilst the field team generally operated as one unit, in some areas smaller teams were left to survey more complicated shores or carry out descriptive transects of the shore. The teams only split off after working practices were harmonised during the first day and the identity of the more widespread shore biotopes was agreed upon (based on Connor *et al.*, 1997a). Upon completion of each day's fieldwork, field notes were typed up and the information on the field maps detailing polygon boundaries and target notes was transferred onto a neat map. Biotope codes were also assigned to the data or finalised at this stage. As the survey progressed, a master list of numbered biotopes was maintained, and used to harmonise the labelling of polygons on the neat maps by the teams. Digital photographs were downloaded onto a laptop computer at the end of each day, together with GPS waypoints, tracks, photographs and target notes.

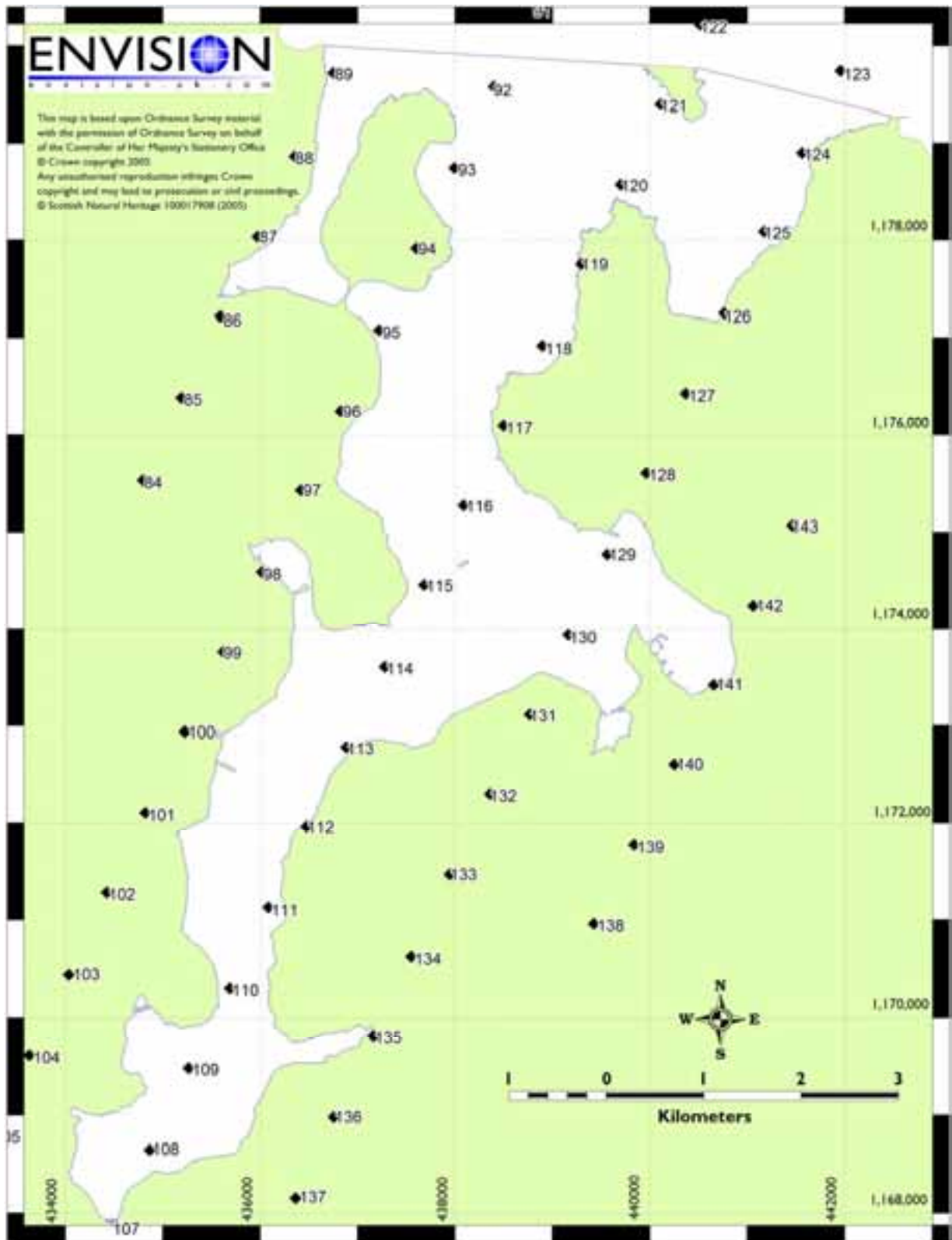
Surveying of the shore biotopes was carried out on most days over a period of approximately two hours either side of low water. During other states of the tides, and at high tide slack water, the subtidal surveys of the *Modiolus* beds were carried out in the first week and the lagoon surveys in the second week. With transit time to and from the sites, the fieldwork each day typically amounted to approximately 10 hours. Overall, the 10 days budgeted for was sufficient for the intertidal mapping.

3.2.2 Data analysis

The neat maps were again checked with reference to field notes, photographs and plotted waypoints, and minor adjustments made to polygon boundaries if necessary. The information on the field and neat maps was imported into a GIS and the hand-drawn polygons then digitised and double-checked with waypoint positions. The final data record consisted of a site sheet including the following information:

Date:	The date on which each survey record was made
Time:	The time at which each survey record was made
Aerial photograph grid map number:	The aerial photograph section upon which each record or polygon was located
Waypoint number:	The identifier for each waypoint logged
Position:	Geographic position
Photo number:	The identifier for each photograph taken in or of a polygon
Bearing:	Bearing at which photograph taken
Target number:	A record of any target note associated with a given polygon
Higher code:	Habitat code from the biotope manual
Biotope code:	Biotope code applicable to each polygon
Description of the biotope:	The main species dominating or characterising the main biotope in the polygon
Target Notes:	Other supporting information on the biotope, polygon or species present or its location or profile taken

For the final map representation, biotopes were coloured according to the MNCR scheme in Connor *et al.* (1997a, b).



3.3

Figure 3.1 *Flight pattern and photograph positions of aerial photographic survey of Sullom Voe, 3 July 2004*

3.3 Sublittoral

The primary acoustic technique for broad scale mapping was a RoxAnn acoustic ground discrimination system (AGDS) operating at 200 kHz. This system is based on a single beam echo sounder and its use in broadscale mapping has been described by Foster-Smith et al. (2001) and Foster-Smith & Sotheran (2003). It returns point values of hardness (termed E2) and roughness (termed E1) of the sea floor for areas ensonified by the sounder as the boat traverses the survey area. A complete coverage of an area is interpolated from these track point data. Resolution is primarily determined by track spacing and this varied from 60m to 90m depending on depth. Although AGDS are low resolution systems, they can be used to discriminate sediment types and the digital data are readily handled by computer image processing software.

Although the data were displayed in real time to enable an assessment of the seafloor types to be made during the progress of the survey, Envision analysed the data using image processing and GIS (Sotheran et al. 1997) after carrying out detailed data quality assurance procedures. Further processing was required to correlate AGDS values to swathe/side scan features to assist with their interpretation.

GeoAcoustics' GeoSwath meets IHO SP44 Special Order specifications. It is an interferometric system operating at 250kHz that uses the phase content of the signal to measure the angle of the wave front of the returning echo. The depth of the seabed reflecting surface is calculated from this angle and elapsed time. The system also measures signal amplitude and sidescan images are derived from this information. The system offers a good resolution from which accurate and detailed bathymetric models can be produced.

Ground truth data on the nature of the seabed to interpret the AGDS data were obtained using a drop down/towed video system. The digital camera was controlled from the surface and the footage recorded digitally within the camera in its housing. Additionally, the video picture was relayed to a surface unit and the full drop was recorded in digital (MiniDV) format. The surface unit also had the facility to record GPS position onto the digital tape.

The charter boat MV Hegrie provided a stable survey platform with adequate cover for electronic equipment and deck space. All equipment was installed in a transportable trailer fixed to the vessel deck. AC power was provided by a generator on board the vessel.

3.3.1 *Fieldwork*

The survey ran from 23rd August 2004 to 1st September. Weather was moderate for the survey with some days being cut short due to sea state making survey areas inaccessible. Days when the weather was good were maximised and longer days worked to make up for any lost time. The boat was based at Sullom Voe Harbour and travel time to and from the site was minimal.

The emphasis of the survey was on tracking, although a small number of video drops were carried out to build up knowledge of the sea floor. The track data were plotted to show variation in acoustic values as the survey progressed and the results used to help select locations for ground truth sampling. The main survey tracks were run in an east to west orientation, across the Voe (Figure 3.2). Tracks were also run around the edge of the Voe as close to shore as possible to define the inner limit of the survey. Other tracks were collected as the vessel travelled between the selected ground truth locations. Overall, track spacing over the survey area varied from less than 100 m to a maximum of 250 m at the deeper outer limits of the survey area (Figure 3.2). A total of 106 video drops and short tows were taken of between 1 and 3 minute duration. Long tows traversing different ground types were avoided wherever possible to simplify the classification of the records. Notes were made on survey of the conspicuous habitat features seen on the surface monitor. The locations of the ground truth data are shown in Figure 3.3.

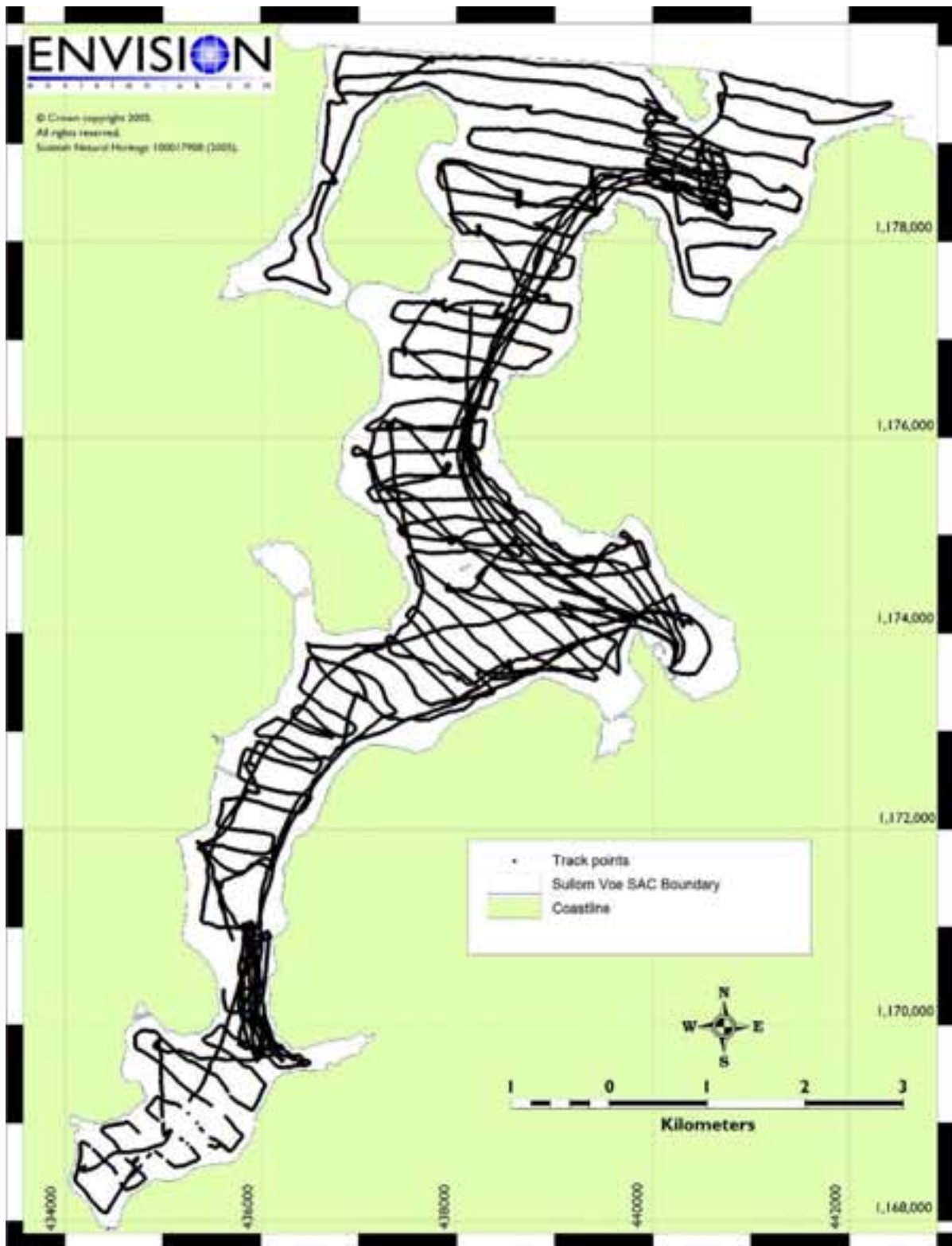


Figure 3.2 AGDS track data collected in Sullom Voe, August 2004

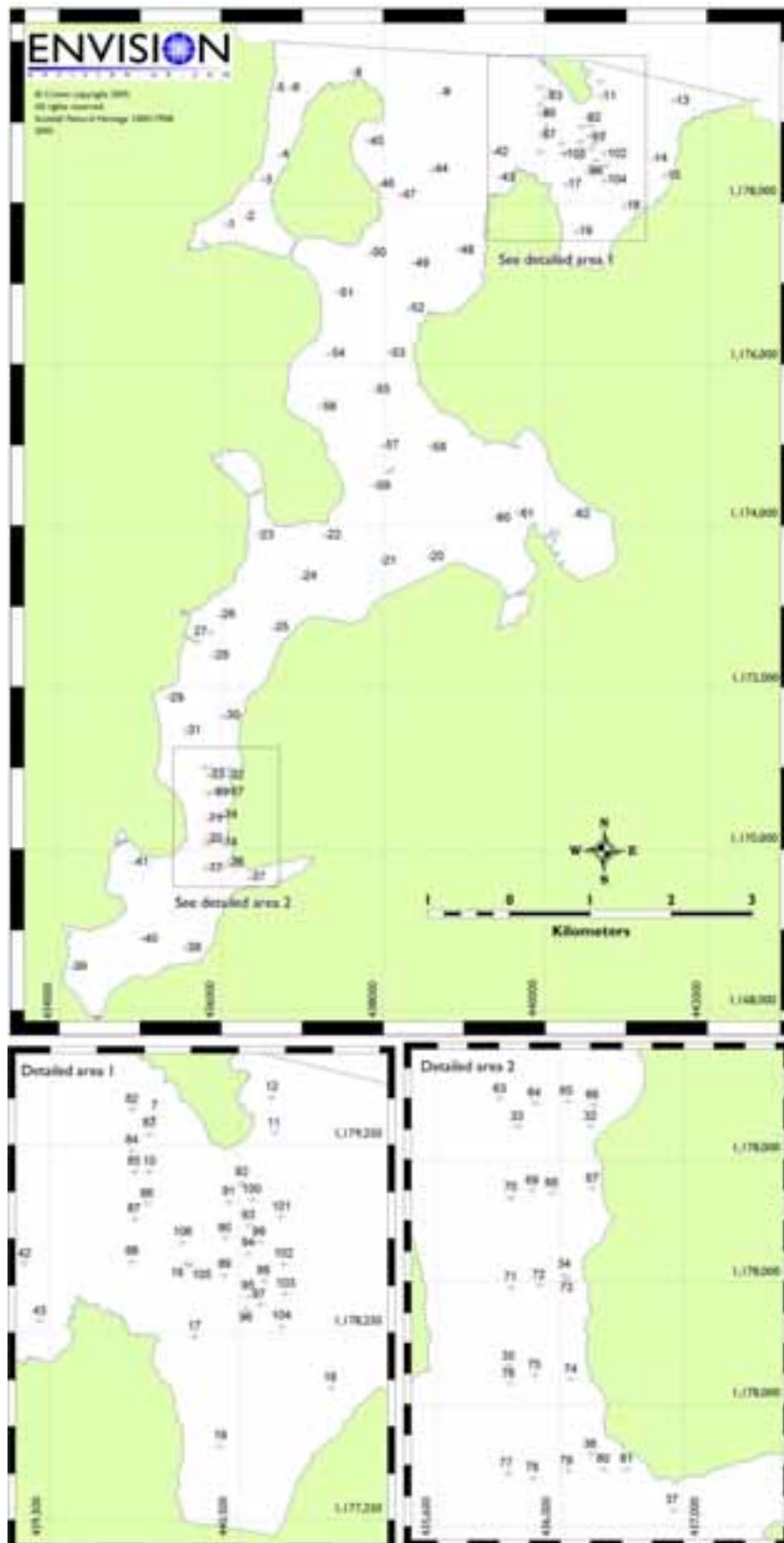


Figure 3.3 *Drop-down video locations in Sullom Voe, August 2004*

3.3.2 Data analysis

The AGDS data were edited on a day-to-day basis. The data were cleaned (removal of depth spikes, records when the vessel was stationary and where there were zero values for depth). Tidal corrections were made to the depth records through the use of predicted tides of the nearest port (TotalTide™) and allowing for the depth of the transducer below water level (1m). The data were imported into MapInfo and displayed showing incremental values in E1 (roughness) and E2 (hardness) and records removed where there was any doubt about values (as compared to surrounding tracks). The data were acquired using lat/longs and WGS84. The data were converted to OSGB36 positions.

The daily data sets were compared using scatter grams and there appeared to be no obvious shifts in the pattern of values between days. This being the case, it was deemed to be safe to leave the E1 and E2 values as recorded rather than attempt to standardise on a daily basis. Spurious depth data were removed using plots of depth against time to re-run the depth profile of the data. A very small proportion of the data were removed and these were largely accounted for as caused by equipment being turned off or when depths greater than 50m were encountered (both returning zero depths). There were very few depth spikes. There were no positional errors. After completion of the quality assurance procedures on each day's track data, copies of the daily data sets were amalgamated in MapInfo to create a single data set. The amalgamated track data, displaying depth, E1 and E2 are shown in Figure 3.4, Figure 3.5 and Figure 3.6.

The point values for E1, E2 and depth were interpolated to create continuous surfaces for each variable using Surfer™. These surfaces were exported into Idrisi™ for classification as described in the following section.

3.3.2.1 Interpolation

Interpolation transforms point data to a continuous surface by calculating new values for a grid of positions covering a rectangular area that encompasses the track point data. The reasons for interpolation are, firstly, to produce a coverage that is easier to view as a map than point data and, secondly, to enable raster-based image processing techniques to be applied to the data.

The edited track data were interpolated in *Surfer™* using the following parameters:

- a grid spacing of 25 m;
- inverse distance algorithm with a weighting toward the grid centroid of 1;
- a search and display radius of 750 m (to ensure there were no gaps in the coverage);
- a six-sector search with a maximum of 62 values per sector;
- a smoothing coefficient of 2.

These parameters resulted in quite a high smoothing of the raw data and this was felt necessary because of the high point-to-point variability of the original track data.

The reports generated by *Surfer™* during the interpolation are available on the data CD accompanying this report.

3.3.2.2 Supervised classification

The raster grid images were imported into *Idrisi™* for classification. Supervised classification using the maximum likelihood classifier is generally regarded as the most satisfactory means of interpreting multispectral data, and the different acoustic variables have been considered as analogous to electromagnetic data from satellite or airborne sensors. The maximum likelihood classification process also allows Bayesian prior probabilities to be included based on rules and this feature has been used to improve the classification as detailed below.

The grid images used for classification were E1, E2 and depth.

The video data were categorised to biotope or, if this fine level of detail was not possible, to higher habitat complex level. A buffer zone of 50 m was created around each video sample and these zones then used as 'training' sites to create the acoustic signatures from the three variables used (as above). The signatures were then applied using the maximum likelihood classifier.

Supervised classification does not work particularly well when there is just a single ground truth record for a particular biotope, because there are then insufficient data from which to derive a statistically satisfactory acoustic signature. In these circumstances it is usual to amalgamate the record into a broader biotope category. This may result in an apparent mismatch between the number of biotopes identified from ground truth data and the number classified from the acoustic data.

The process was repeated for the habitat classes without the need to constrain or enhance any individual class. The agreement between classification and the video ground truth data can be visually assessed from the resultant maps presented in Section 4. A measure of the agreement can be calculated by overlaying the ground truth and classified images and matching predicted to actual on a pixel-by-pixel basis (the 'error matrix'). The percentage agreement for the biotope and life form classifications were 70% and 72% respectively, with a Kappa agreement (probability of agreement above chance) of 0.62 and 0.64 respectively. This level of agreement is typical of remote surveys where perfect agreement is never expected due to a combination of positional error and variability in the acoustic reflectance data. Overall, the classification can be considered successful, particularly in demonstrating broad spatial patterns in habitat and biotope distribution.

3.3.2.3 Analysis of the video data

Video data were recorded in a spreadsheet. The video tapes were replayed and at least one frame grab was captured for each sample. The frame grabs were stored in a sub-table linked to the master table. Notes were taken in a systematic way recording main habitat features, conspicuous species or, where this detail was not possible, general growth forms and higher taxonomic categories. The biota were also scored from 1 to 5 to show their relative abundance. The species were recorded in a sub-table linked to the master table so that site/species tables could easily be extracted. The notes were first made on paper and then the tapes were replayed and the notes entered into a database, but with entries for biotope codes and habitat categories left blank. The final stage consisted of reviewing the database, frame grabs and if necessary the tapes, in order to tag the records with biotope codes and habitat classes. This staged process to biotope recording and the use of look-up tables for codes and terminology was designed to promote consistency in classification of the records.

3.3.2.4 Swath bathymetry

The raw data were collected in GeoSwath32 and the volume of raw data collected amounted to about 10 gigabytes. Tidal corrections and sound velocity profiles were applied to the data and the data filtered to remove all data across the swath except those points associated with the depth profile. The bin size selected for the priority areas was 5m; the grids were de-spiked to remove spurious gridded depth values. In total, the volume of processed data files and gridded images is very large, especially for those areas gridded to a high resolution. The raw data have been saved in GeoSwath grid format which can be exported into other software packages.

The data from raw files were selected for mosaicing and gridding prior to display and export to other software. During the gridding process, data are amalgamated into 'bins' whose size is selected by the operator and determine the dimensions (in terms of rows and columns) of the output grid. Larger bin sizes (e.g. 20m) gives a relatively coarse resolution image of small file size whilst a small bin size (e.g. 1m) gives a high resolution image but a large file size.

The gridded data were exported to *Surfer™* for display and 3-D rendition. The features are best seen using graduated colours for depth and sun illumination for both flat maps and 3-D renditions. Both modes of display are useful and have been provided in most cases.

The bathymetric data collected during the survey contained a relatively large amount of noise and it is suspected that this was due to the hull shape of the vessel (flat) causing aeration around the transducer head. Data were cleaned to remove these noisy data in the bathymetry. The backscatter data were affected more than the bathymetric data and due to this only some sections were processed.

The Geoswath system also produces backscatter data and these data were slant range corrected and mosaiced for selected areas. These areas concentrated on the site condition monitoring areas.

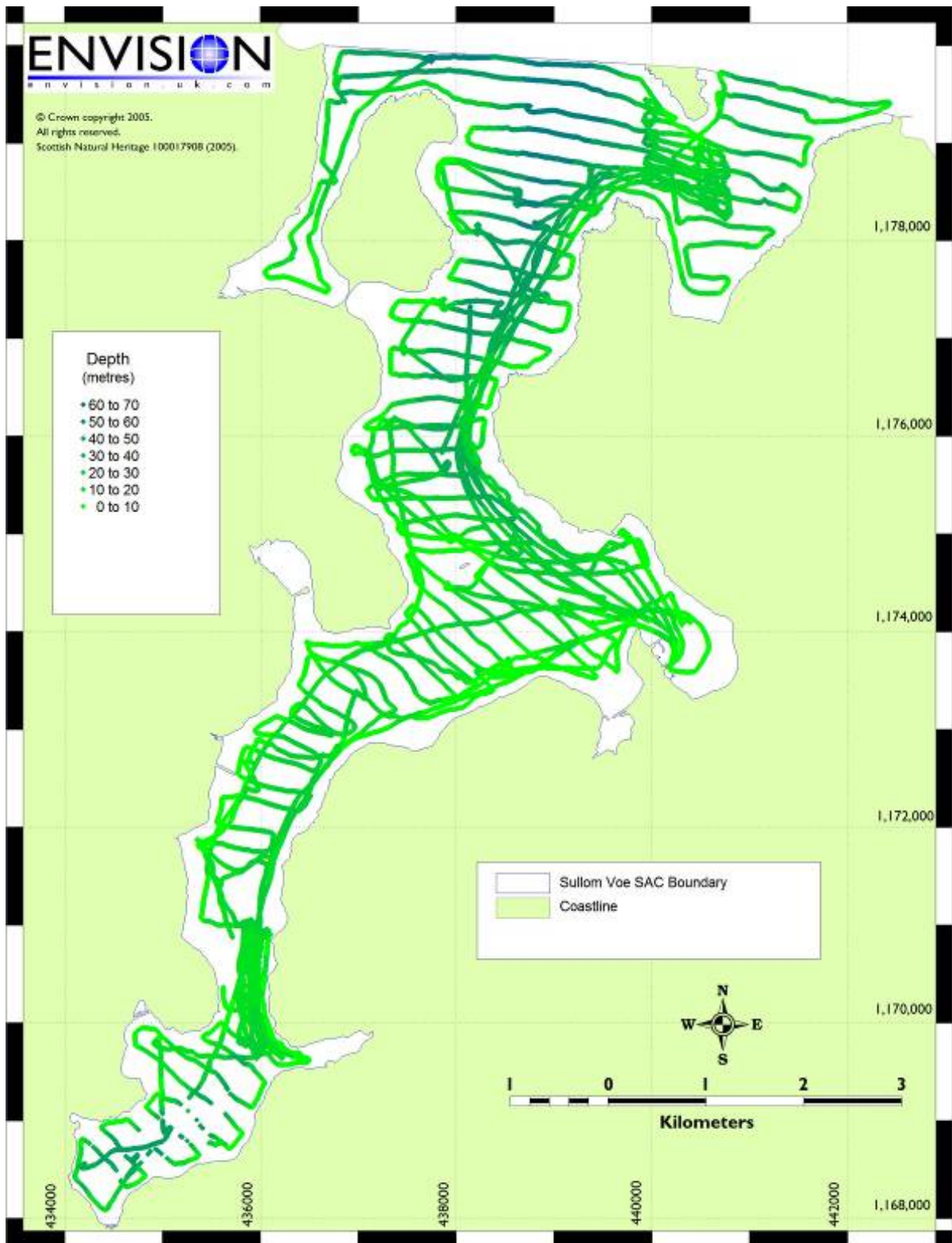


Figure 3.4 AGDS tracks coloured by depth

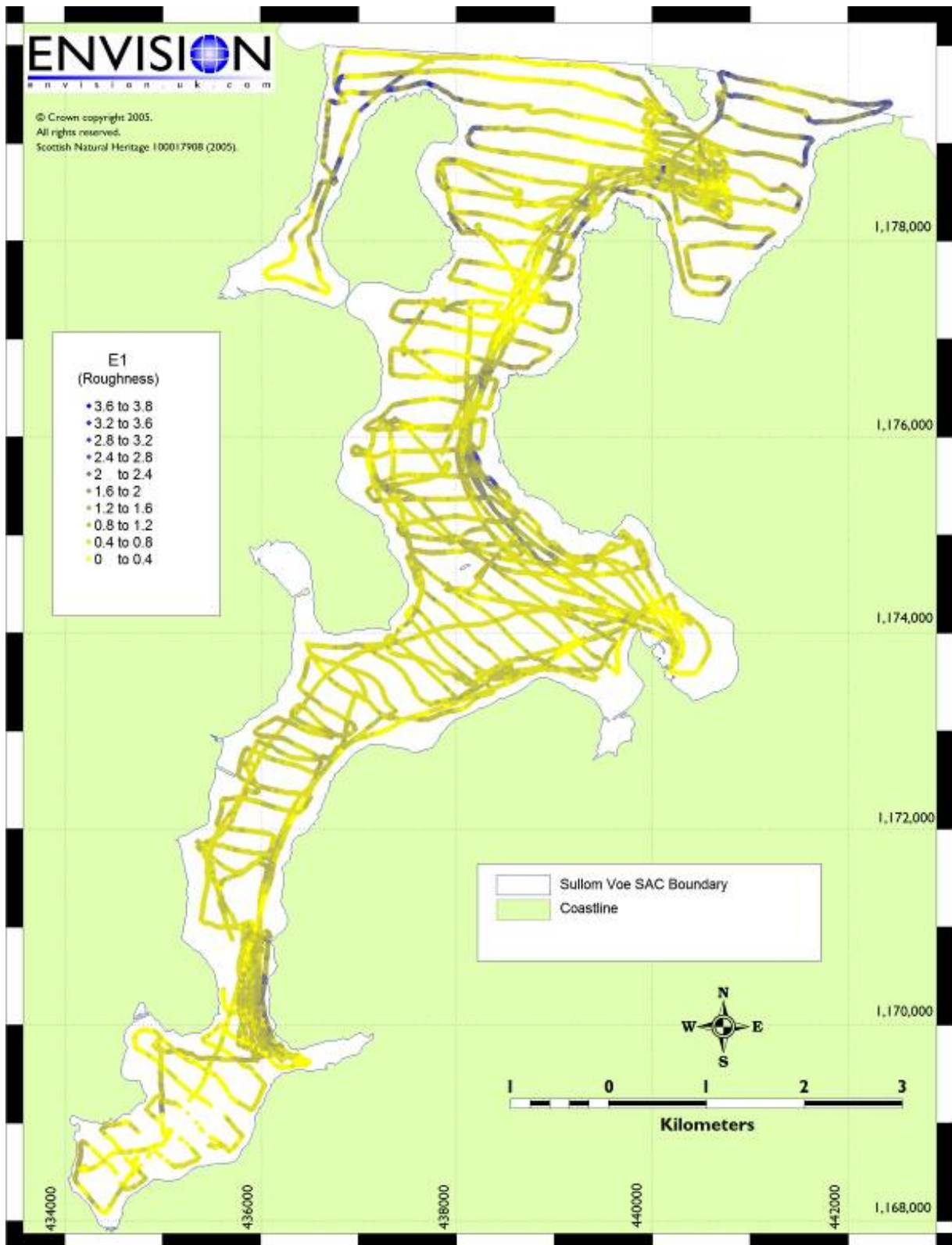


Figure 3.5 AGDS tracks coloured by E1 (Roughness)

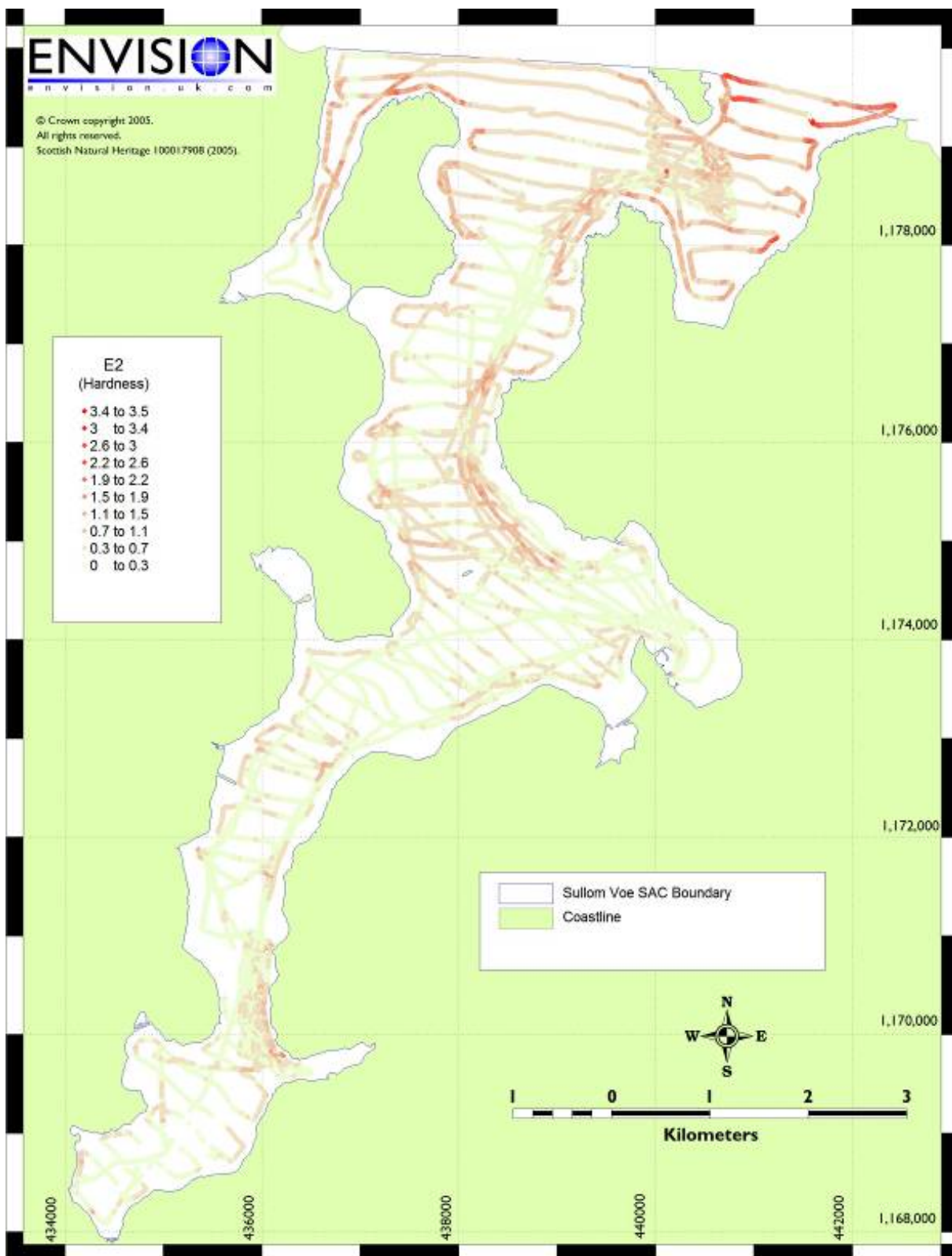


Figure 3.6 AGDS tracks coloured by E2 (Hardness)

4 RESULTS

Field log notes completed during the survey, together with electronic data files, video tape and photographs, have been supplied separately to SNH (as an Annex to this report). In addition, the maps and data presented below have been supplied electronically as image and document files, as well as in Access database and ArcView GIS formats. A summary of the data from the intertidal photographic, waypoint, target note and biotope logs that have been supplied electronically is given in Appendix A. Similarly a summary of the sublittoral data supplied electronically is given in Appendix B. In the following section, the text precedes the figures to avoid breaking up the descriptive text.

4.1 Intertidal

With a relatively small tidal range (maximum just over 2m) much of the steeper sloping coastline has extremely narrow intertidal zones. The shores of Sullom Voe SAC, especially in the more exposed outer regions, are predominantly of bedrock and with varying slope. Inner, more sheltered, rocky shores generally vary from gently sloping bedrock to boulder and mixed cobble/sediment but there are also regions of steep cliff and boulder covered shores especially around Mavis Grind and Voxter Ness at the head of Sullom Voe. Significant areas of intertidal sediments only occur at the heads of Gluss, Garths, Scatsta and Voxter Voes, and around the spit and inside the Houbes of Fugla Ness and Scatsta. Smaller patches of intertidal sediments (coarse sands/gravel) occur sporadically around the region, some at the heads of small coves or at high water mark on Little Roe island. The shores on the outer regions of the SAC which are open to Yell Sound (from Ness of Bardister to the Kames northwards) are generally moderately exposed apart from the inner region of Gluss Voe which is sheltered by the narrow entrance between Gluss Isle and Mainland. The middle region of Sullom Voe (approximately from Ness of Bardister and Kames south to Lunnister and Grona Taing) is more sheltered and is a more varied coastline, indented in places by small voes and houbes/lagoons. At the head of Sullom Voe lies, again varied, but relatively more protected shorelines, especially in the sheltered inlet of Voxter Voe.

4.1.1 *Intertidal biotope data*

A total of 43 biotopes and sub-biotopes was identified during the intertidal survey work from approximately 60 km of coastline. These are listed and described in Table 4.1. The distribution and larger polygon areas are illustrated in subsections of the SAC in Figures 4.1 - 4.10 based on the MNCR colour scheme. Figure 4.11 (on page 29 which folds out) provides a key to the intertidal biotopes illustrated and identifies the areas of the SAC shown in greater detail in the separate Figures (4.1 – 4.10). All detailed distributional information is held in the GIS. The figures mainly show the middle shore biotope polygons. Due to the small tidal range, and often steep shores, many narrow zones of lichens and biotopes on the upper and lower fringes of the intertidal were not wide enough to be represented as map polygons. During the field mapping exercise therefore, 45 rapid assessment shore profiles (identifying and estimating width of all the biotope zones on the intertidal) were surveyed and these profile figures are given in Appendix A. Similarly, at 5 sites more detailed shore surveys were carried out and species lists from these are also given in Appendix A. The locations of these transect/shore profiles are illustrated in Figure 4.12.

Of the biotopes found in the mid-shore regions, the most common on the most exposed areas (northern coasts of Gluss Isle, Little Roe Island, and Mio Ness – Figures 4.3, 4.4 and 4.5) were of barnacles and small mussels: MytB and BPat.Sem. These biotopes were also found predominantly on the artificial habitats of piers and the buildings holding oil-spill booms. In these areas the main upper zone biotopes were YG, Ver.B and Ver.Por, (lichens and algae) and in the lower zones Fser, Him, Ala.Ldig and Ldig (fucoids and kelp). Rock pools (Higher code LR.Rkp) were not particularly common but, where present, tended to be small and contain the biotopes of G, Cor, and FK (algal turf and fucoid/kelp). Otherwise in most of the rocky mid eulittoral shores in many less exposed parts of the Voes (e.g. areas illustrated in Figures 4.6, 4.7 and 4.8) the fucoid biotopes Fves, FvesB, FvesX were the most predominant and, where there was shelter, Asc.Asc. and AscX. The predominant upper shore biotopes associated with these main areas were the lichens YG, Ver.Ver.,

and the fucoids Pel, PelB, Fspi. On the lower shore and sublittoral fringe, the fucoid, *F. serratus*, was ubiquitous as Fser, FserX and Fser.Fser and the laminarian kelps Ldig, Lhyp, Lsac.Ldig, and LsacX were common biotopes. In the occasional area subjected to freshwater flow over the shore, *Fucus ceranoides* (Fcer) was observed.

On non-rocky parts of the intertidal, there were numerous areas throughout the SAC of barren shingle (BarSh). Around some of the piers and jetties for the deployment of oil spill boom protection, barren coarse sand areas have accumulated. In sheltered coves, especially on Little Roe island, some small beaches of clean sand were observed with burrowing amphipods and polychaetes (AP and AP.P). In sheltered, low slope shores (e.g. on the sea side of the spit separating off the Houb of Fugla Ness, and particularly at the south-west corner of inner Gluss Voe – Figure 4.2) extensive intertidal areas containing *Macoma balthica* and *Arenicola marina* were observed (MacAre, MuSa.MacAre). Many upper shores had a strandline of decomposing seaweeds with the charactersitic talitrid amphipod biotope (Tal). On the lower fringes and infralittoral of such sedimentary shores was the LsacX biotope (*Laminaria saccharina*, *Chorda filum* and filamentous red seaweeds). Saltmarsh (*Puccinellia maritima*) was present in localised sites at the heads of Gluss Voe, Garths Voe, Voxter Voe, Houbs of Scatsta, Fugla Ness, Sullom and Houb of Haggrister.

A summary of the distribution of the main biotopes found in each of the areas illustrated in Figures 4.1 - 4.10 follows:

Gluss Voe (Sites 1 & 1a, Figures 4.1 & 4.2): At the exposed East Ness, on angular bedrock, the main mid to lower zones were FvesB, Him, and Ala.Ldig. These biotopes were present on the coastline running south until, mid Voe, bedrock gave way to boulders with Fves and Fser.Fser and then, Asc.Asc. Most of the inner Voe had FvesX apart from the sedimentary shore at the Head around Bardister. The easterly shore of Gluss Voe followed a similar pattern to the western shore but at the exposed head of Gluss Isle BPat.Sem predominated.

Little Roe island (Site 2, Figure 4.3): The exposed northern side of the island had mostly bedrock with MytB apart from numerous coves with beaches of clean sand (AP and AP.P). Bedrock dominated the southern part of the island with FvesB and beaches of BarSh.

Mouth of Sullom Voe (Site 3, Figure 4.4): At the northern exposed headlands MytB predominated whilst moving into the Voe, there were mainly areas of FvesB with some smaller areas of BPat.Sem and beaches of BarSh. In the inner part of this area FvesX was the main intertidal biotope.

Orka Voe (Site 4, Figure 4.5): The biotopes on most of the coastline were exposure dependent and mainly varied between MytB or FvesB.

Northern mid-Sullom Voe (Site 5, Figure 4.6): On the western shore FvesX was common, and there were numerous beaches of BarSh. The eastern shore, especially around the Terminal Jetties, had many areas covered by BPat.Sem.

Garths Voe and Voe of Scatsta (Site 6, Figure 4.7): The mid shore in this region had biotopes mainly of FvesX, AscX or BPat.Sem depending on exposure and the presence of artificial structures such as the piers at Sella Ness.

Southern mid-Sullom Voe (Site 7, Figure 4.8): On the western shore FvesX was predominant in most places with patch areas of BPat.Sem and, on the lower seawards shore of the Houb of Fugla Ness, there was a large area of MacAre.

Head of Sullom Voe and Voxter Voe (Site 8 & 8a, Figures 4.9 & 4.10): On the western coastline the mid-shore biotopes varied from AscX, Asc.Asc to FvesX depending on exposure and on some small steep cliff areas BPat.Sem was found. On the eastern shore, the northern part of the coastline (mainly steeply sloping bedrock) had FvesB and MytB as the most common biotopes and, in the

more southern and sheltered part, the main biotopes varied between FvesX and AscX, with an area of FcerX in the inner part of Voxter Voe.

Table 4. 1 Intertidal biotope listing with summary habitat and species information, Sullom Voe mapping survey, September 2004

Life Form	Higher Code	Biotope	Description
Lichens and Algae	LR.L	YG	Yellow and Grey lichens on supralittoral rock.
Lichens and Algae	LR.L	Ver.B	<i>Verrucaria maura</i> and sparse barnacles on exposed littoral fringe rock.
Lichens and Algae	LR.L	Ver.Por	<i>Verrucaria maura</i> and <i>Porphyra umbilicalis</i> on very exposed littoral fringe rock.
Lichens and Algae	LR.L	Ver.Ver	<i>Verrucaria maura</i> on moderately exposed to very sheltered upper littoral fringe rock.
Mussels and Barnacles	ELR.MB	MytB	<i>Mytilus edulis</i> and barnacles on very exposed eulittoral rock.
Mussels and Barnacles	ELR.MB	BPat.Lic	Barnacles and <i>Lichina pygmaea</i> on steep exposed upper eulittoral rock.
Mussels and Barnacles	ELR.MB	BPat.Sem	<i>Semibalanus balanoides</i> on exposed or moderately exposed or vertical sheltered, eulittoral rock.
Kelp	ELR.FR	Him	<i>Himanthalia elongata</i> and red seaweeds on exposed lower eulittoral rock.
Fucoids	MLR.BF	PeIB	<i>Pelvetia canaliculata</i> and barnacles on moderately exposed littoral fringe rock.
Fucoids	MLR.BF	FvesB	<i>Fucus vesiculosus</i> and barnacle mosaics on moderately exposed mid eulittoral rock.
Fucoids	MLR.BF	Fser	<i>Fucus serratus</i> on moderately exposed lower eulittoral rock
Fucoids	MLR.BF	Fser.Fser	Dense <i>Fucus serratus</i> on moderately exposed to very sheltered lower eulittoral rock.
Algal turf	MLR.R	Osm	<i>Osmundea (Laurencia) pinnatifida</i> and <i>Gelidium pusillum</i> on moderately exposed mid eulittoral rock.
Lichens and Algae	MLR.Eph	Ent	<i>Enteromorpha</i> spp. on freshwater influences or unstable upper eulittoral rock.
Lichens and Algae	MLR.Eph	EntPor	<i>Porphyra purpurea</i> or <i>Enteromorpha</i> spp. on sand scoured mid or lower eulittoral rock.
Fucoids	SLR.F	Pel	<i>Pelvetia canaliculata</i> on sheltered littoral fringe rock.
Fucoids	SLR.F	Fspi	<i>Fucus spiralis</i> on moderately exposed to very sheltered upper eulittoral rock
Fucoids	SLR.F	Fves	<i>Fucus vesiculosus</i> on sheltered mid eulittoral rock.
Fucoids	SLR.F	Asc.Asc	<i>Ascophyllum nodosum</i> on full salinity mid eulittoral rock.
Fucoids	SLR.F	Fcer	<i>Fucus ceranoides</i> on reduced salinity eulittoral rock.

Table 4.1 (continued)

Life Form	Higher Code	Biotope	Description
Mussels and Barnacles	SLR.FX	BLit	Barnacles and <i>Littorina littorea</i> on unstable eulittoral mixed substrata.
Fucoids	SLR.FX	FvesX	<i>Fucus vesiculosus</i> on mid eulittoral mixed substrata.
Fucoids	SLR.FX	AscX	<i>Ascophyllum nodosum</i> on mid eulittoral mixed substrata.
Fucoids	SLR.FX	FserX	<i>Fucus serratus</i> on lower eulittoral mixed substrata.
Lichens and Algae	SLR.FX	EphX	Ephemeral green and red seaweeds on variable salinity or disturbed eulittoral mixed substrata.
Fucoids	SLR.FX	FcerX	<i>Fucus ceranoides</i> on reduced salinity eulittoral mixed substrata.
Mussels and Barnacles	SLR.MX	MytX	<i>Mytilus edulis</i> beds on eulittoral mixed substrata.
Algal turf	LR.Rkp	G	Green seaweeds (<i>Enteromorpha</i> spp. and <i>Cladophora</i> spp.) in upper shore rock pools.
Algal turf	LR.Rkp	Cor	<i>Coralina officinalis</i> and other coralline crusts in shallow eulittoral rockpools.
Kelp	LR.Rkp	FK	Fucoids and Kelps in deep eulittoral rockpools.
Shingle	LGS.Sh	BarSh	Barren shingle on Gravel shores
Sand	LGS.S	Tal	Talidrid amphipods on decomposing seaweed on the strandline.
Sand	LGS.S	BarSnd	Barren coarse sand shores
Sand	LGS.S	AP	Burrowing amphipods and polychaetes in clean sand shores.
Sand	LGS.S	AP.P	Burrowing amphipods and polychaetes (often with <i>Arenicola marina</i>) in clean sand shores.
Sand	LGS.S	Lan	Dense <i>Lanice conchilega</i> in tide-swept lower shore sand.
Sand	LMS.MS	MacAre	<i>Macoma balthica</i> and <i>Arenicola marina</i> in muddy sand shores.
Sand	LMS.MS	MacAre. Mare	<i>Arenicola marina</i> , <i>Macoma balthica</i> and <i>Mya arenaria</i> in muddy sand shores.
Kelp	EIR.KFaR	Ala.Ldig	<i>Alaria esculenta</i> and <i>Laminaria digitata</i> on exposed sublittoral fringe bedrock.
Kelp	MIR.KR	Ldig	<i>Laminaria digitata</i> on moderately exposed or tideswept sublittoral fringe rock.
Kelp	MIR.KR	Lhyp	<i>Laminaria hyperborea</i> and foliose red seaweeds on moderately exposed upper eulittoral rock.
Kelp	SIR.K	Lsac.Ldig	<i>Laminaria saccharina</i> and <i>Laminaria digitata</i> on sheltered sublittoral fringe rock.
Kelp	IMX.KSw	LsacX	<i>Laminaria saccharina</i> , <i>Chorda filum</i> , and filamentous red seaweeds on sheltered infralittoral sediment.

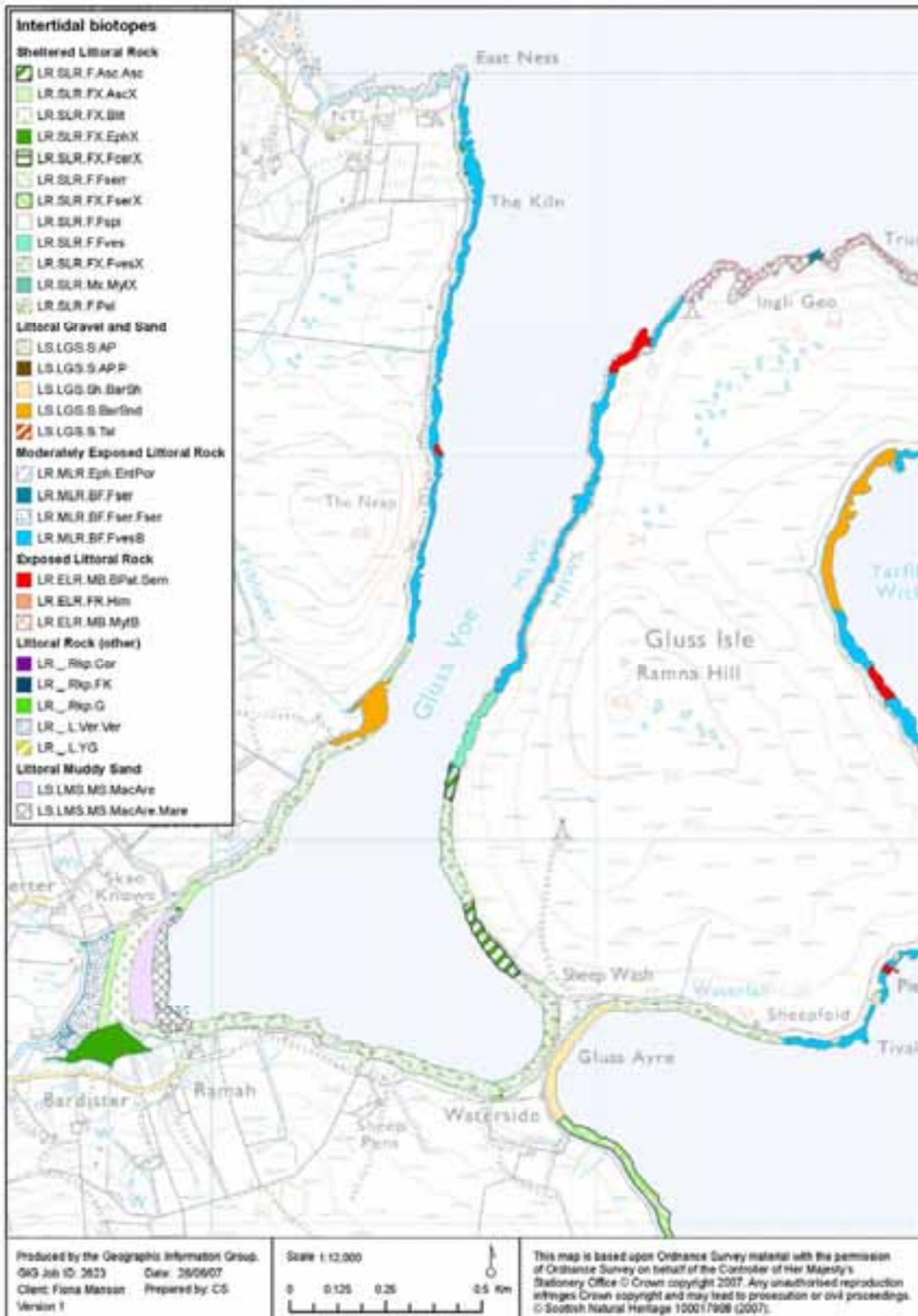


Figure 4.1 *Intertidal biotope distribution (MNCR colour scheme, Connor et al. 1997a) within Site 1 (Gluss Voe) of Sullom Voe SAC, September 2004*

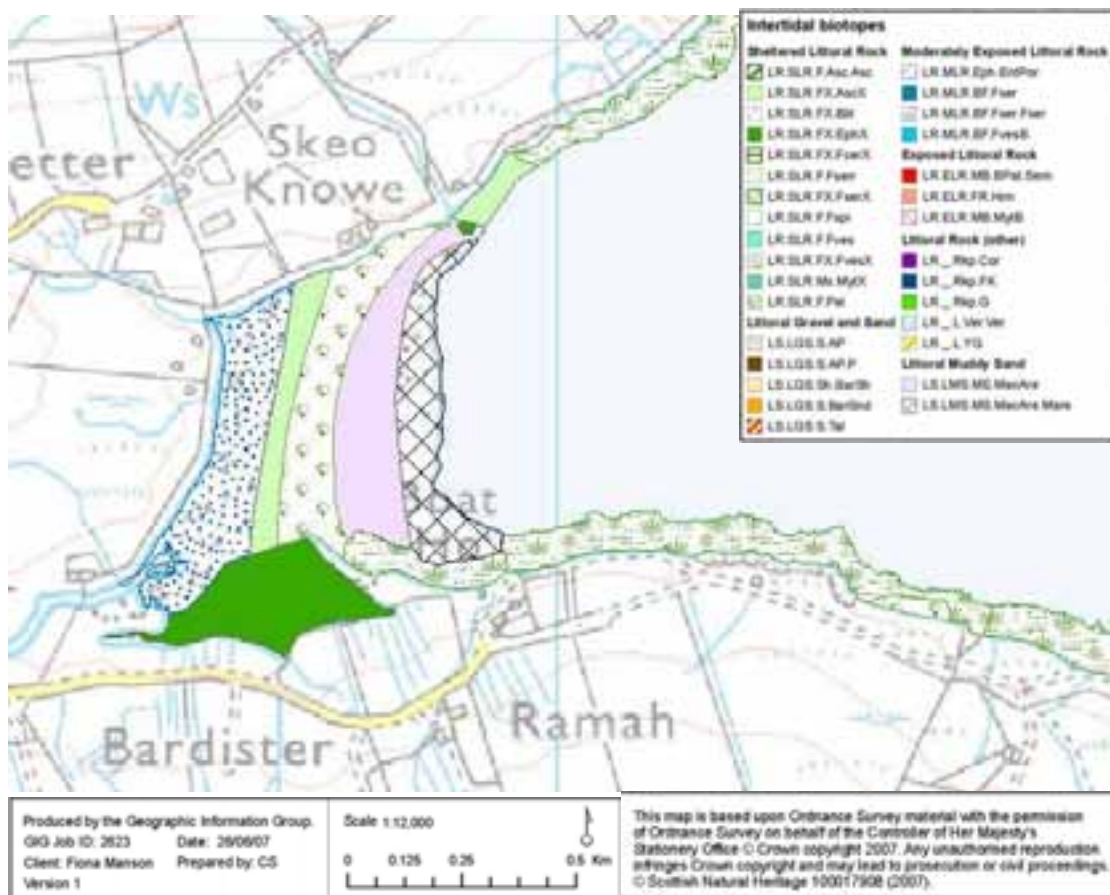


Figure 4.2 *Intertidal biotope distribution (MNCR colour scheme, Connor et al. 1997a) Head of Gluss Voe (Site 1a), Sullom Voe SAC, September 2004*



Figure 4.4 *Intertidal biotope distribution (MNCR colour scheme, Connor et al. 1997a) within Site 3 (mouth of Sullom Voe) of Sullom Voe SAC, September 2004*

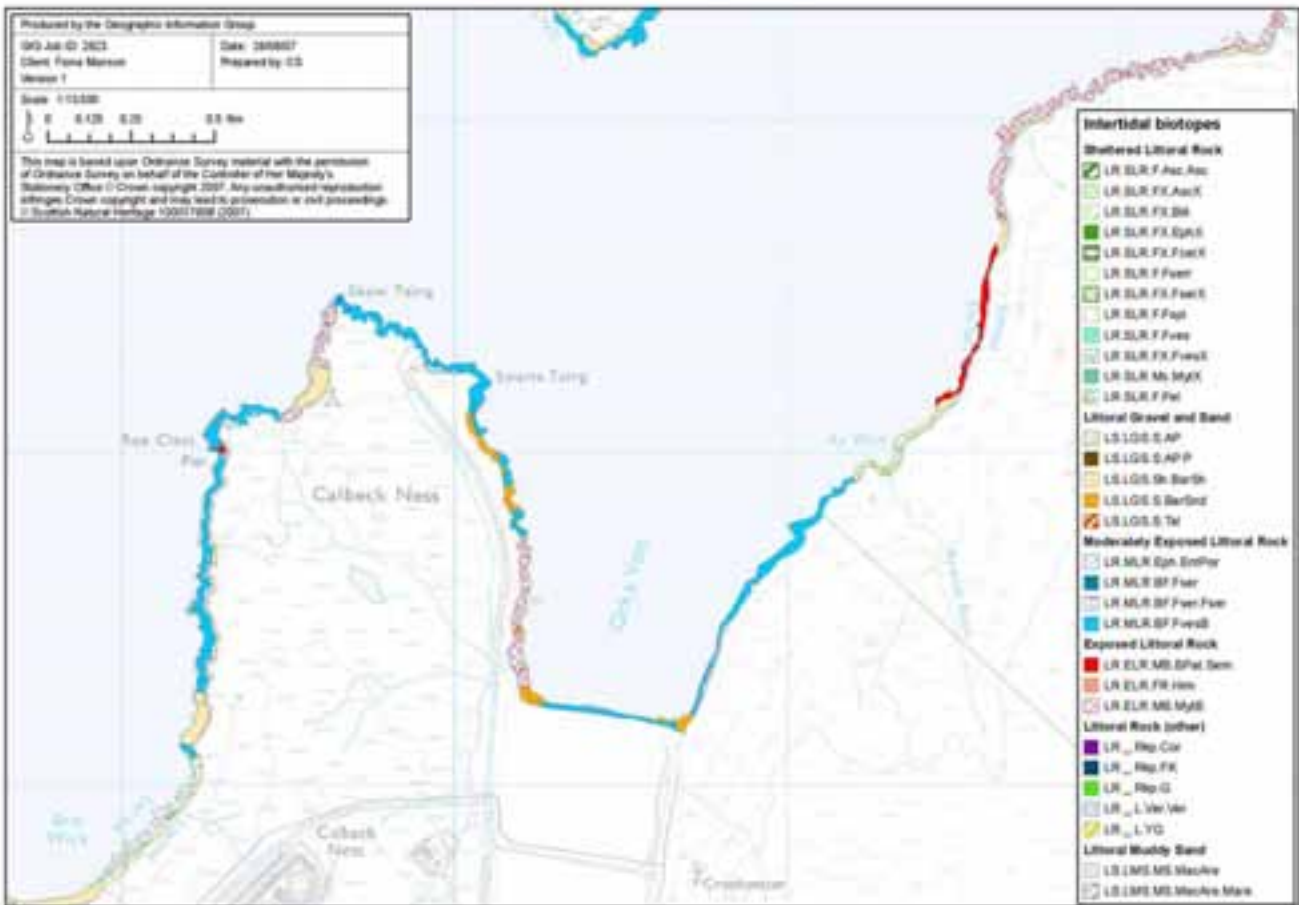


Figure 4.5 Intertidal biotope distribution (MNCR colour scheme, Connor et al. 1997a) within Site 4 (Orka Voe area) of Sullom Voe SAC, September 2004

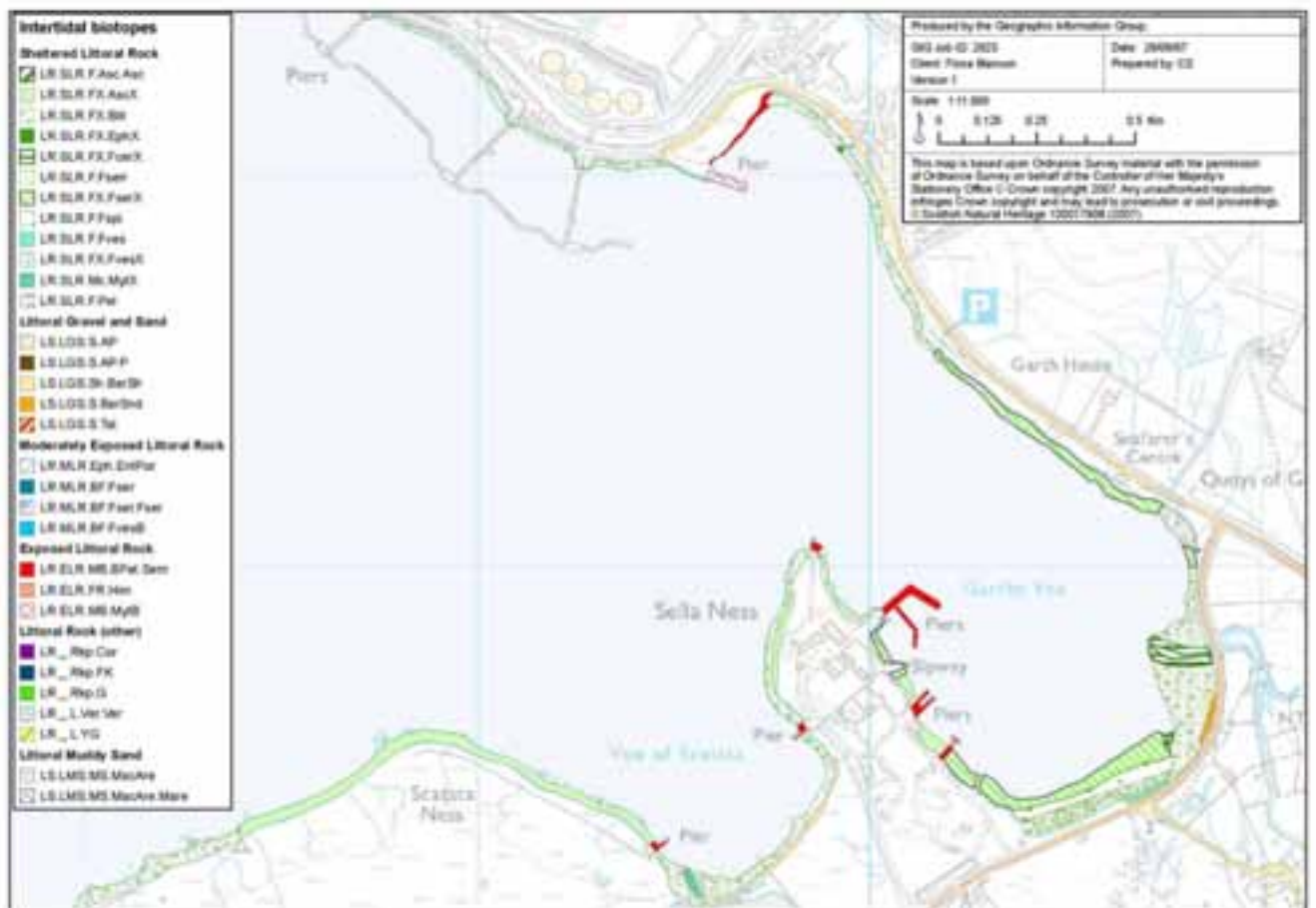


Figure 4.7 Intertidal biotope distribution (MNCR colour scheme, Connor et al. 1997a) within Site 6 (including Garths Voe and Voe of Scatsta) of Sullom Voe SAC, September 2004



Figure 4.9 Intertidal biotope distribution (MNCR colour scheme, Connor et al. 1997a) within Site 8 (head of Sullom Voe) of Sullom Voe SAC, September 2004



Figure 4.10 Intertidal biotope distribution (MNCR colour scheme, Connor et al. 1997a) within Site 8a (Voxter Voe) of Sullom Voe SAC, September 2004

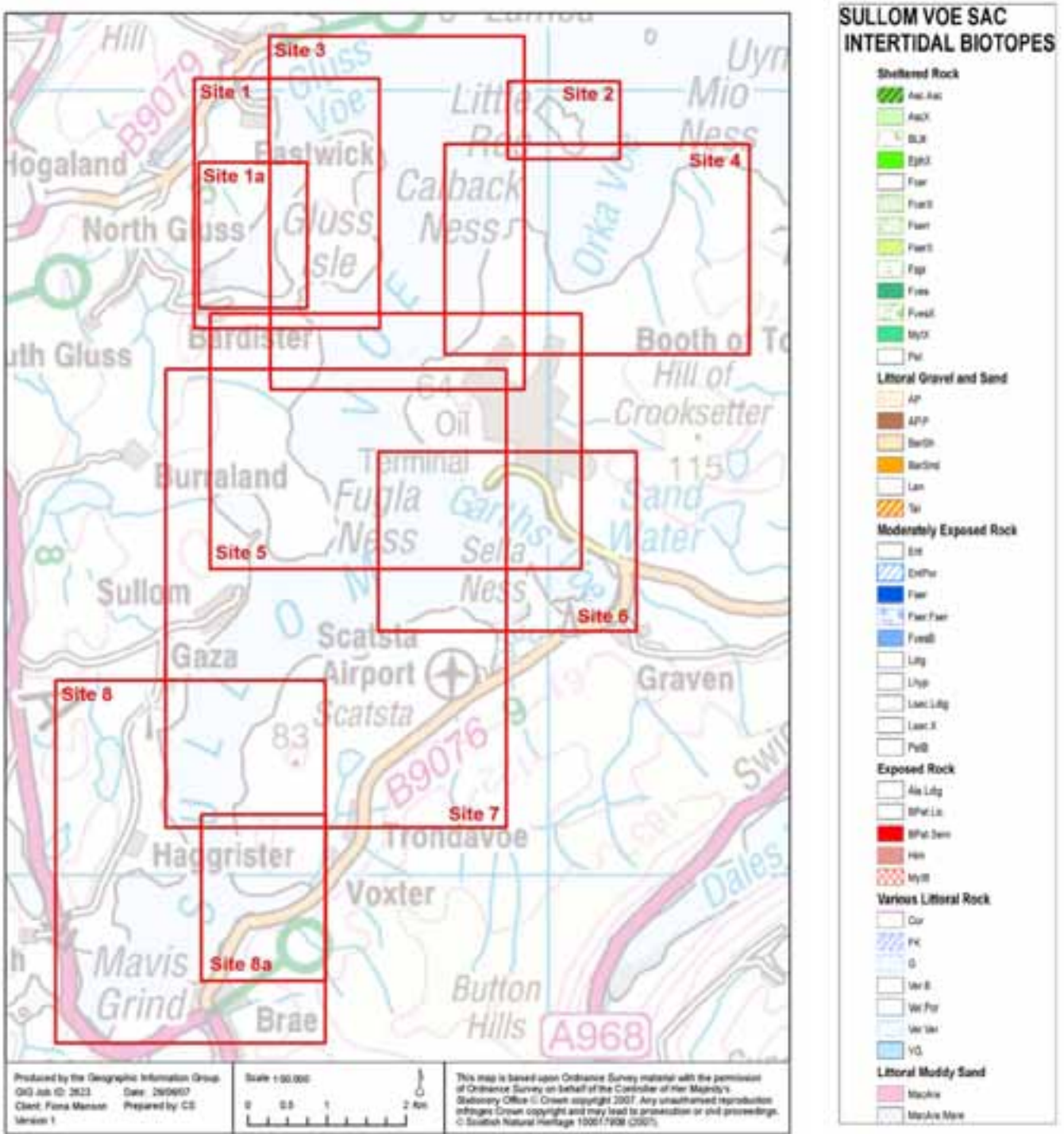


Figure 4.11 Map location aid and key to biotopes for Figures 4.1 – 4.10, Sullom Voe SAC intertidal biotope mapping survey, September 2004



Figure 4.12 Locations of the 45 rapid assessment shore transects (indicated by open circle symbols marked 1 to 45), five more detailed transects (indicated by red circles labelled A to E), and the SOTEAG programme shore stations (black circle symbols marked with original SOTEAG station numbering system)

4.2 Sublittoral

The bathymetry of the survey area derived from the AGDS data is illustrated in Figure 4.13. The swath bathymetric system produces a more detailed bathymetric data set and this is shown in Figures 4.14a-c. The seabed falls away rapidly within a relatively short distance of the shoreline, forming a deep trough in the central region of the Voe, the periphery of the Voe has shallow inlets and bays. As the Voe widens towards the north, a deep (over 50m) basin is found. Close to the terminal is a steep-sided channel which is used as a deep water shipping channel.

4.2.1 *Sublittoral biotope data*

Eight subtidal habitat types were identified from the video and the map produced from these data is shown in Figure 4.15. The entrance to the Voe is characterised by a deep trough with mud in the deepest areas, changing to sandy mud as the depth decreases. Around the fringes at the Voe entrance more mixed substrata are encountered with the hard bedrock and boulder substrates found around the headlands and outcrops. Further into the Voe the habitats change to a more mixed habitat with sandy bays around the edges and, towards the head of the Voe, the area deepens and becomes characterised by sand dominated habitats and sandy mud in the deeper areas around the Bight of Haggrister.

The predicted distribution of Life Form categories in the subtidal is illustrated in Figure 4.16. Using the lifeform categories assists with the interpretation of the maps and identification of trends in the distribution of biological complexes and the distribution of kelp and mixed habitat lifeforms such as scallops and mussel areas, whereas the biotope map is heavily related to the physical habitats found in the areas rather than the biology found.

A total of 26 biotopes were recognised from the ground truth video record obtained during the survey. These were grouped into 9 biotope mapping complexes, and these are listed and described in Table 4.2. The predicted distribution of these biotopes, based on both the video and the acoustic data, is mapped for the survey area in Figure 4.17 (based on the MNCR colour scheme).

It should be noted that certain biotopes were identified from a single video observation. As noted in Section 3, supervised classification does not work particularly well in such instances, because there are insufficient data from which to derive a statistically satisfactory acoustic signature. In these circumstances it is usual to amalgamate the record into a broader biotope category and this has resulted in an apparent mismatch between the number of biotopes identified from ground truth data and the number classified from the acoustic data.

For ease of description the Voe can be separated into 4 areas or zones:

1. The area to the south and east of Little Roe, Orka Voe:

This area is characterised by kelp biotope fringing the edges (0-20m below chart datum) of the area and extending between Calback Ness and Little Roe. The deeper areas (>25m B.C.D) of Orka Voe are dominated by sandy muds.

2. The area to the west of Gluss Isle, Gluss Voe:

The area is a shallow inlet, between 0-10 m B.C.D of mixed sediments with sheltered kelp communities. There is a deeper area at the entrance to Gluss Voe which is similar to the entrance to Sullom Voe and extends to depths of 45m and is occupied by circalittoral fine muds.

3. The entrance to Sullom Voe to the Terminal area:

A deep trough (60m B.C.D) with circalittoral mud biotopes in the central areas changes to more sandy biotopes as the seabed shallows around 35m and a fringing edge of more exposed kelp dominated communities from 25-20m B.C.D

4. The area from Fugla Ness to the head of the Voe:

The central region of this area, with depths greater than 20m, is dominated by mixed sediment communities with areas of scallop beds and mussel shells. The Voe has several larger bays in this area and these are occupied by kelp biotopes on sediment habitats. Towards the head of the Voe the mixed substratum lessens and the deeper central areas (~45m B.C.D) become muddier with fringing kelp biotopes from 20 m.

The three most frequently recorded biotopes were kelp and seaweed communities on sublittoral sediment (SS.SMP.KSwSS; 33 records), circalittoral mixed sediments with *Aequipecten opercularis* (SS.SMX.SMx; 23 records) and circalittoral muds with seapens (SS.SMU.CSaMu & SS.SMU.CFiMu; 16 records).

Sediment communities with the seapen *Virgularia mirabilis* in abundance occupy the deeper outer areas of the Voe. The central region of the Voe is occupied by scallop (*Aequipecten opercularis*) communities on shells, the shells appear to be *Modiolus* but there were no mussel beds detected here during the survey.

The kelp biotopes (SS.SMP.KSwSS, IR.MIR.KR) as expected mostly occupy the shallower (<20m) mixed sediment substrates in Sullom Voe. The kelp was often sparse within these biotopes and with evidence of algal debris where plants had died or been detached due to rough weather.

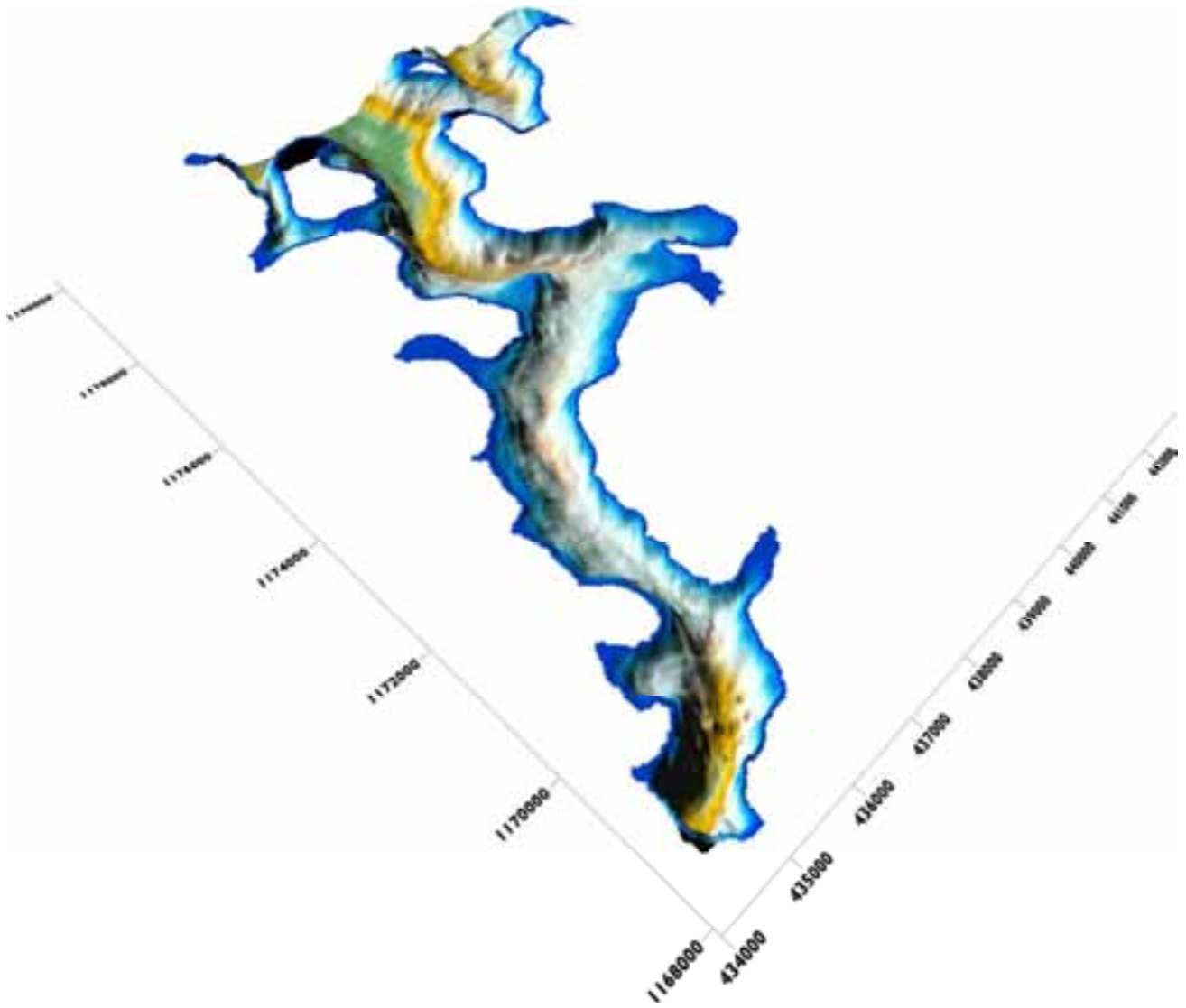


Figure 4.13 *Bathymetry within the survey area, Sullom Voe SAC*

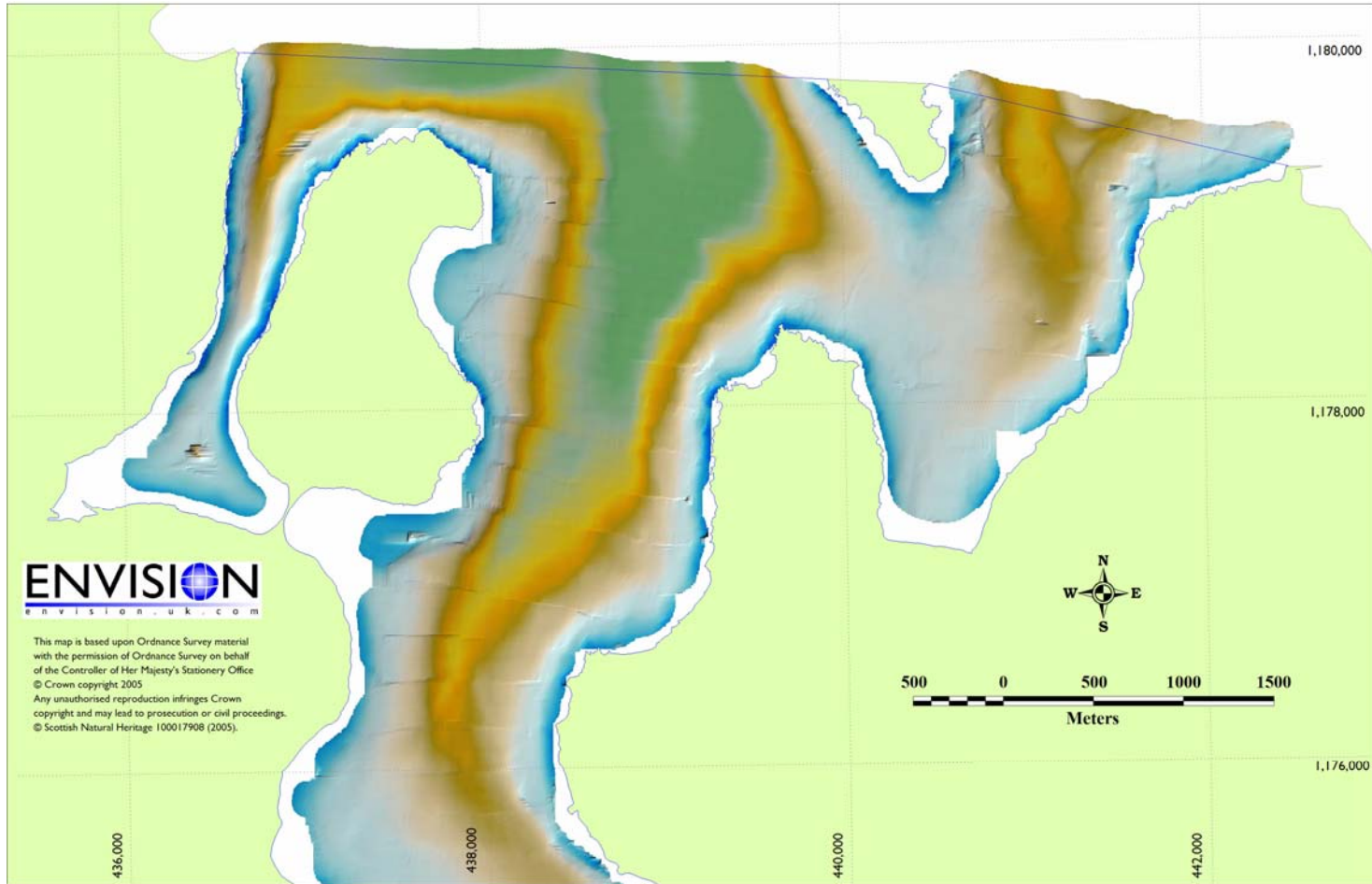


Figure 4.14a A sun-illuminated image of the bathymetry of the northern part of Sullom Voe SAC (Source Interferometric Swath)

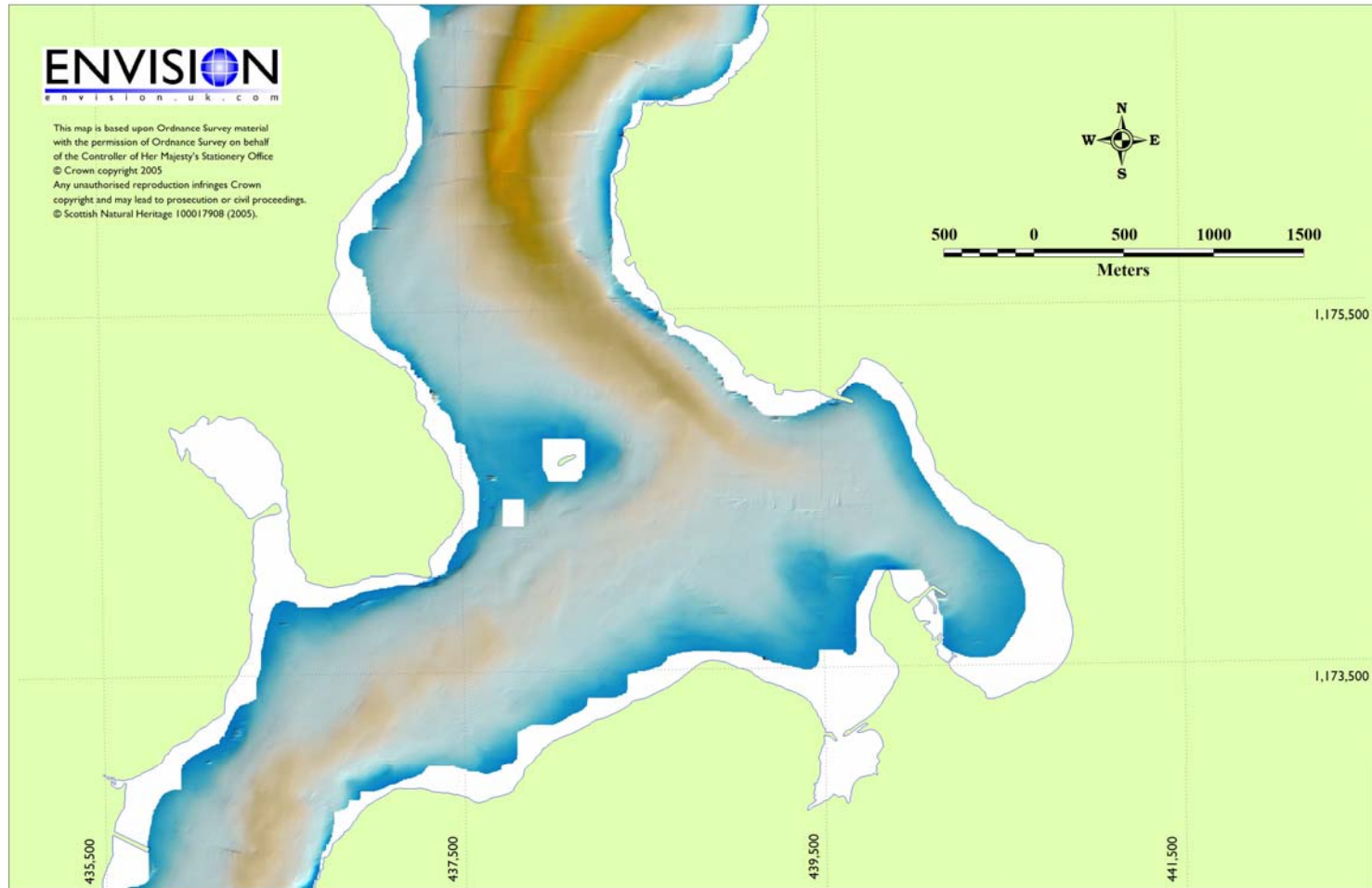


Figure 4.14b A sun-illuminated image of the bathymetry of the central part of Sullom Voe SAC (Source Interferometric Swath)

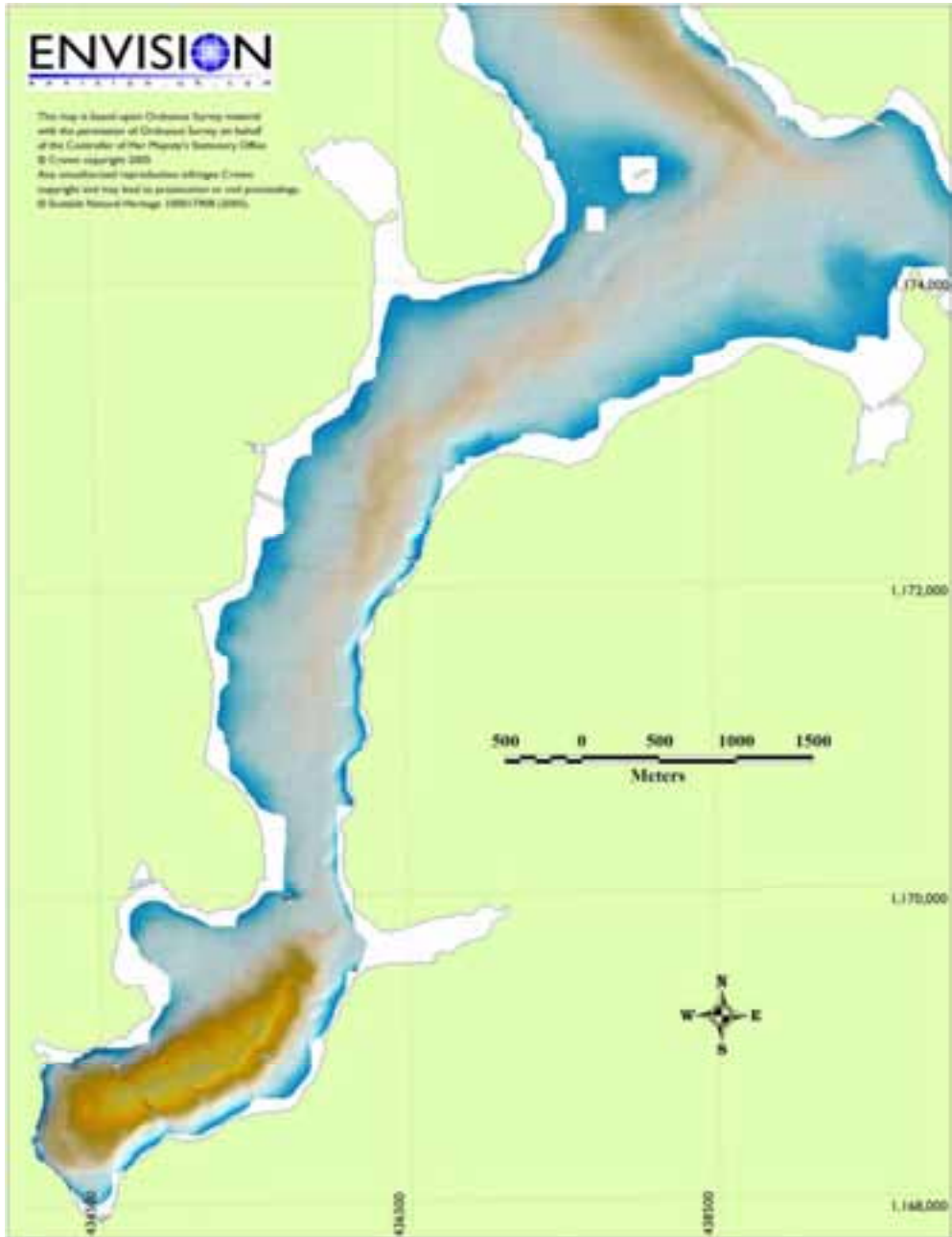


Figure 4.14c A sun-illuminated image of the bathymetry of the southern part of Sullom Voe SAC (Source Interferometric Swath)

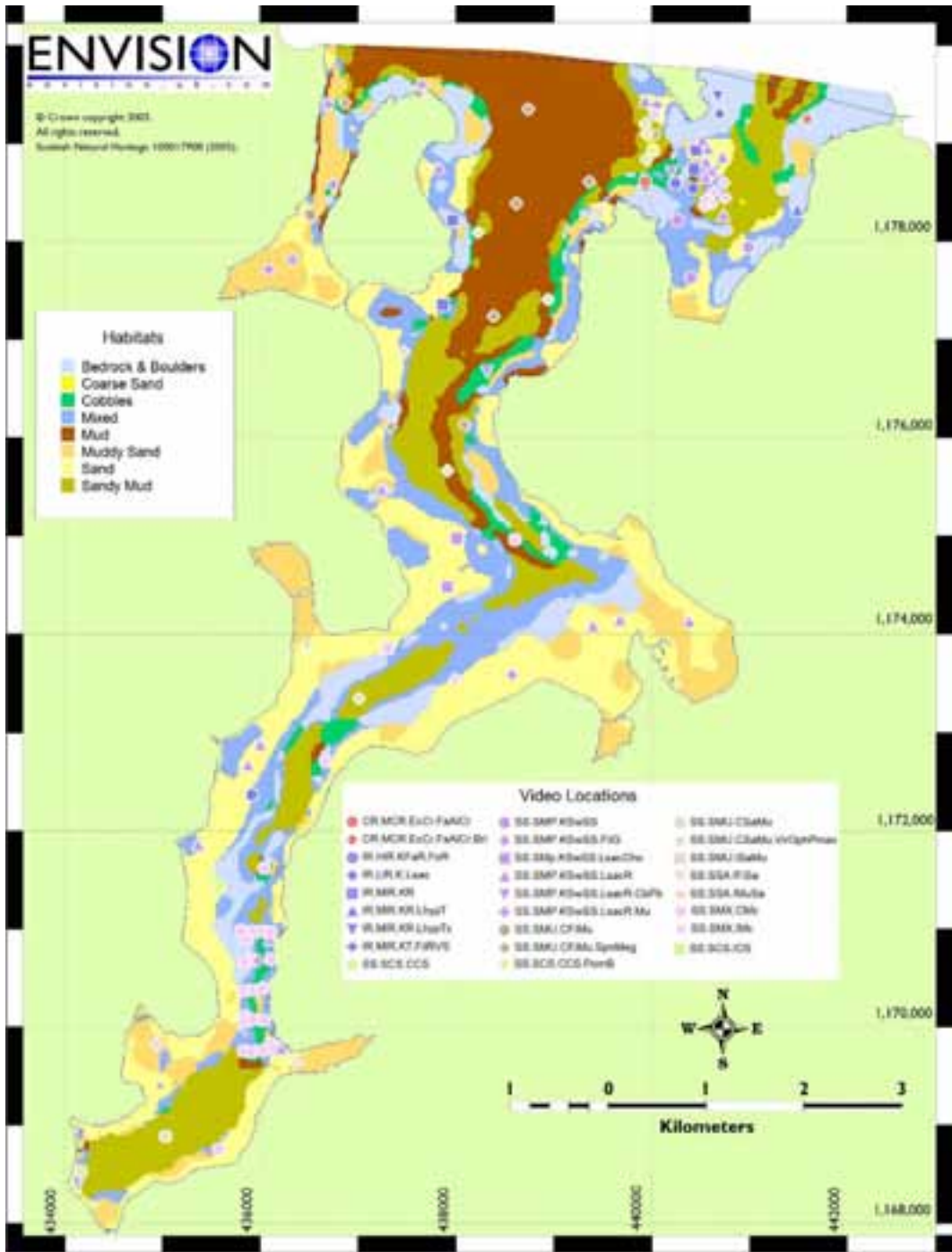


Figure 4.15 Seabed habitats within Sullom Voe SAC

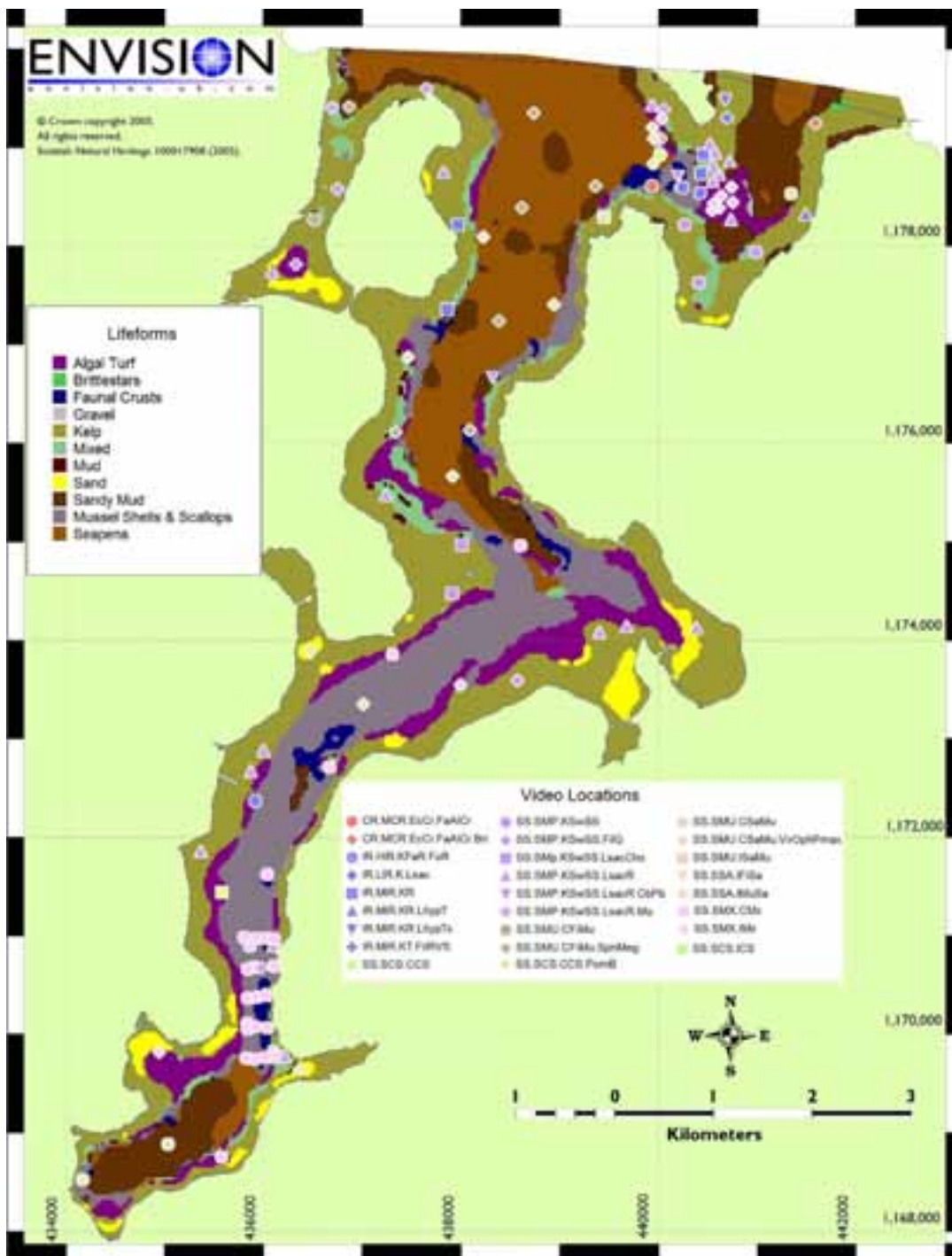


Figure 4.16 Seabed Life Form distribution (Life Form colours; Foster-Smith et al. 2000) within Sullom Voe SAC, mapping survey, August 2004

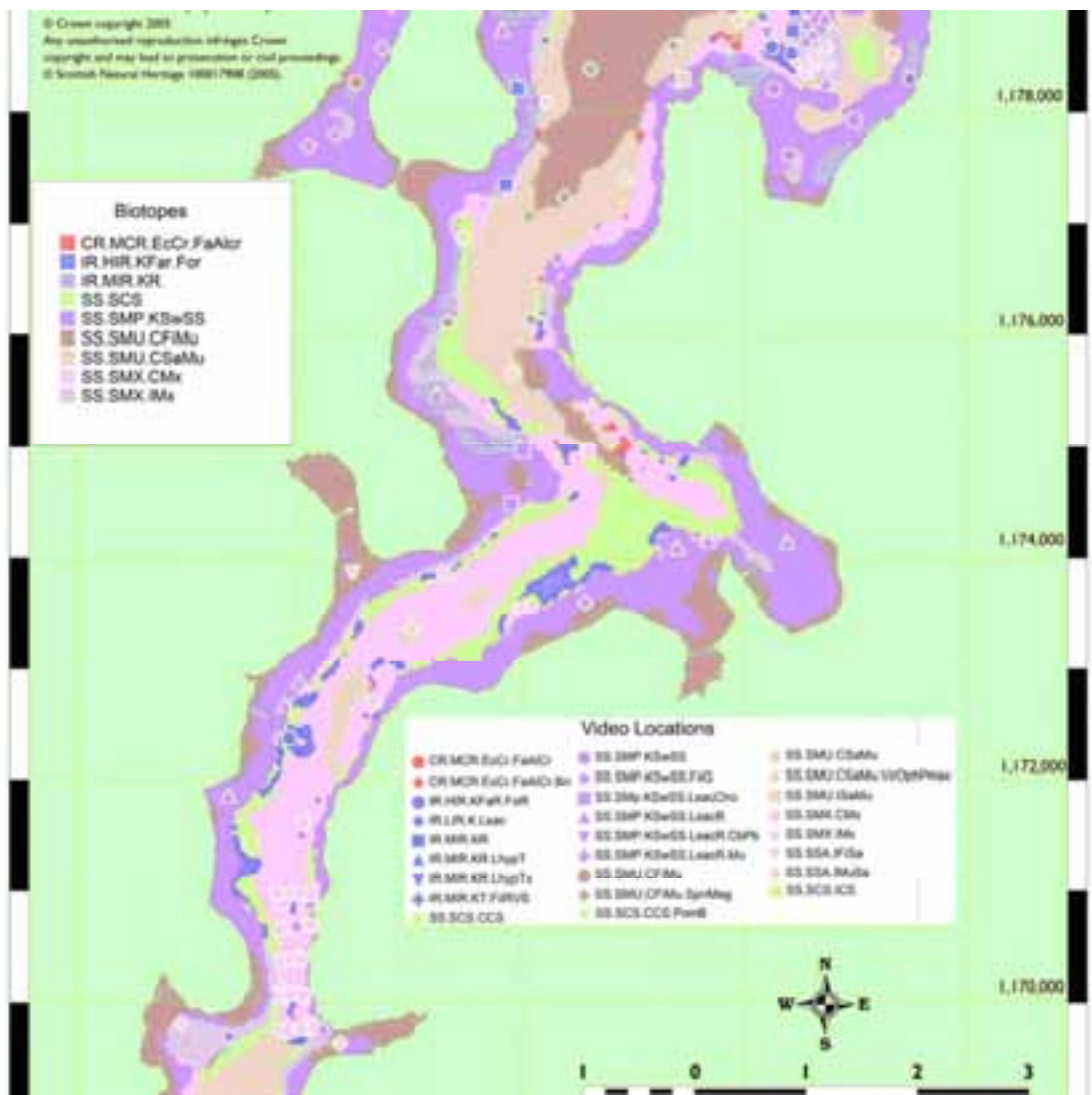


Figure 4.17 Seabed biotope distribution (Life Form colours; Foster-Smith et al. 2000) within Sullom Voe SAC, August 2004

Table 4.2 Sublittoral biotope listing with summary habitat and species information, Sullom Voe mapping survey, August 2004.

Biotope Code	Biotope Mapping Complex	Life Forms	No.	Depth range (m)	Habitat	Characteristic species
CR.MCR.EcCr.FaAlCr	Echinoderms and crustose communities	Brittlestars Faunal crust	1 1	~25	Circolittoral bedrock & boulders.	<i>Ophoithix fragilis</i> , <i>Echinus esculentus</i> . <i>Corallina officinalis</i> , encrusting coralline algae and <i>Pomatoceros</i> sp.
IR.HIR.KFaR.FoR	Kelp with cushion fauna and red seaweeds	Algal Turf	4	16 to 22	Infralittoral bedrock & boulders	Grazed kelp forest or kelp park with <i>Laminaria hyperborea</i> , ephemeral algal turf, <i>Echinus esculentus</i>
IR.MIR.KR	Kelp and red seaweeds	Kelp	7	6 to 12	Infralittoral bedrock & boulders	<i>Laminaria hyperborea</i> and red algae understorey
SS.SCS	Sublittoral coarse sediments	Algal Turf	1	~15	Mixed substrate of sand cobbles and gravel	Red algal turf with encrusting coralline algae on exposed substrate.
		Gravel/Coarse Sediment	1	~30		
		Faunal Crusts	1	~10		
SS.SMP.KSwSS	Kelp and seaweed communities on sublittoral sediment	Kelp	33	5 to 24	Varied sediment ranging from muddy sand to sand with cobbles.	<i>Laminaria saccharina</i> present but not abundant with abundant red algae turf
		Algal Turf	1	~27		
SS.SMU.CFiMu	Circolittoral fine mud	Seapens Mud	8 1	18 to 51 ~15	Circolittoral Mud	<i>Virgularia mirabilis</i> with occasional burrow
SS.SMU.CSaMu	Sandy mud	Seapens Sandy Mud	8 4	17 to 34 15 to 34	Circolittoral sandy mud	<i>Virgularia mirabilis</i> with sparse foliose red algae, some hydroids on stable substrate.
SS.SMU.ISaMu	Sandy mud	Sand	2	~2	Infralittoral Sandy mud	Clean sandy mud
SS.SMX.SMx	Circolittoral mixed sediment	Shells & Scallops	23	14 to 25	Mixed sediment, with sandy mud with covering of shells with occasional pebble	Shells and scallops <i>Aequipecten opercularis</i> frequent, hydroids and faunal turf present
		Mixed	2	10 to 13		
SS.SMX.IMx	Infralittoral mixed sediment	Algal Turf	8	9 to 23	Mixed substrata of sand with small pebbles.	Red algal turf on stable sediment
		Mixed	1	~20		

5 DISCUSSION

These 2004 broadscale biotope mapping surveys of the intertidal and sublittoral environment of Sullom Voe SAC have completed the broader picture of the area which has, over the last 30 years, seen numerous detailed marine biological surveys of particular regions of the SAC. Many previous studies are part of monitoring programmes which, by their nature, repeatedly sample fixed stations. With such studies, and broadscale maps, a comprehensive understanding of the varied communities and biotopes of the SAC is now available.

5.1 Intertidal

The shores of the coastline within Sullom Voe SAC are varied but predominantly of bedrock or boulder. Shores are also generally narrow, steep and backed by cliffs, although more extensive intertidal rocky plateaux occasionally occur on the more exposed coasts. This narrowness and steepness, combined with the low tidal range in the area mean that the area and zonation of the intertidal is often compact. With several biotopes occurring within this range from upper to lower fringe of the shore, generally only the width of the mid-eulittoral biotope could be assigned to polygons on any reasonably scaled map. Only in the more sheltered heads of several of the smaller Voes or houbes are there reasonably extensive areas of flat or low-sloping intertidal area. To illustrate zonation better 45 shore profiles were recorded (see Appendix A figures A1-A45) and 5 MNCR Phase II surveys were recorded for future reference.

Although 43 intertidal biotopes were recorded, not unexpected given the length of coastline, the predominant biotopes are the fucoids in the mid shore area or, in the exposed outer regions, the barnacle and small mussel biotopes. There are significant stretches of coastline consisting of barren shingle and, as indicated above, a small number of flat sedimentary areas. Intertidal fauna and flora recorded in this broadscale mapping survey correspond to those previously described in the literature (Hiscock, 1981; Moore et al., 1995; Jones & Jones, 1981; Jones, 1995).

5.2 Sublittoral

A total of 26 biotopes with 9 biotope complexes were recorded from a total of 106 video samples.

A graduation of sediment type with depth can be observed, within Sullom Voe. Sand and sandy muds are found close to the shoreline and in sheltered areas. In some areas bedrock and boulders are also found close to the shoreline, with mixed sediments found in areas where tidal influence is present. The deeper areas of the Voe consist of softer muds and silts.

Most of the subtidal survey area comprised sedimentary habitats. The three most frequently recorded biotopes, and those predicted by classification as covering the largest part of the subtidal in the survey area, were kelp (mainly *Laminaria saccharina*) and red algal communities, circalittoral mixed sediments with scallops (*Aequipecten opercularis*) and deep finer sediments with seapens (*Virgularia mirabilis*). Other commonly recorded biotopes were kelp on bedrock and boulders immediately adjacent to the shore and in the more exposed areas. Brittlestar beds were circalittoral and were found only in the entrance to Orka Voe on a substratum of bedrock, and boulders.

The video analysis was expected to show the presence of *Modiolus modiolus* in beds but only solitary or small clumps of mussels were found. This does not mean there are no *Modiolus* beds in the areas, only that the video sampling failed to detect any. There is a possibility that

diver recordings from a survey carried out immediately after this survey will provide more detail on the distribution of the mussel beds (Mair et al 2010).

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APPENDIX A Intertidal biotope mapping survey

Table A1 - GIS project overview, Sullom Voe intertidal biotope mapping survey

Table A2 - Photograph log from Sullom Voe intertidal biotope mapping survey

Table A3 - Target note log from Sullom Voe intertidal biotope mapping survey

Figures A1-A45 – Shore profile diagrams drawn from field notes and observations

Table A1 - Photograph log from Sullom Voe intertidal biotope mapping survey

Type of Photo	ID No.	Subject matter
Profiles	1	Profile 1
Biotopes	2	Him
Biotopes	3	Him
Biotopes	4	FvesB
Biotopes	5	Ver.Ver and YG
Profiles	6	Profile 1
Profiles	8	Profile 2
Profiles	9	Profile 2
Biotopes	10	Fser
Biotopes	11	Fves
Biotopes	12	Pel, Fspi and Ver.Ver
Biotopes	13	Asc.Asc
Profiles	14	Profile 4
Non Profile Locations	15	General Overview of 14T
Non Profile Locations	16	View along shore 15T
Profiles	17	Profile 5
Profiles	18	Profile 6
Profiles	19	Profile 6
Biotopes	20	BarSh
Biotopes	21	BarSh
Biotopes	22	FK
Biotopes	23	FK
Biotopes	24	BarSnd in cove
Biotopes	25	BarSnd in cove
Workers	26	Boat
Profiles	28	Profile 7
Biotopes	29	MytB
Non Profile Locations	31	Large Cave 35T
Non Profile Locations	32	Side of Cave 35T
Non Profile Locations	33	Side of Cave 35T
Biotopes	34	Osm
Biotopes	35	Osm
Biotopes	39	BarSh 42T
Biotopes	40	Tal 42T
Biotopes	41	EntPor 42T
Biotopes	42	Cobbles on BarSh 42T
Biotopes	43	Ent and freshwater input
Biotopes	44	EntPor
Profiles	45	Profile 8
Profiles	46	Profile 8
Non Profile Locations	47	Blow Hole 46T
Non Profile Locations	48	Blow Hole 46T
Profiles	49	Profile 9
Non Profile Locations	50	Along beach 50T
Non Profile Locations	51	Rubbish on beach 50T
Type of Photo	ID No.	Subject matter
Non Profile Locations	52	Rubbish on beach 50T

Non Profile Locations	53	Rubbish and river on beach 50T
Non Profile Locations	54	Gabions and rubbish on beach 50T
Non Profile Locations	55	Gabions and rubbish on beach 50T
Profiles	58	Profile 10
Non Profile Locations	59	Profile of Beach 56T
Profiles	60	Profile 11
Profiles	61	Profile 11
Biotopes	62	Pier BPat.Sem
Non Profile Locations	63	Beach 66T
Workers	63	Beach 66T
Profiles	66	Profile 12
Profiles	67	Profile 12 inc. Oil terminal
Biotopes	68	FvesX 72T
Profiles	69	Profile 13
Biotopes	72	Pier MytB
Biotopes	73	MytB
Biotopes	74	MytB
Profiles	79	Profile 14
Profiles	80	Profile 15
Profiles	81	Profile 15
Non Profile Locations	82	Little Rock Island 95T
Non Profile Locations	83	Little Rock Island 95T
Profiles	84	Profile 16
Profiles	85	Profile 16
Biotopes	86	FvesX
Biotopes	87	FvesX Pukka
Profiles	88	Profile 18
Profiles	89	Profile 20
Profiles	90	Profile 20
Profiles	91	Profile 21
Profiles	92	Profile 22
Profiles	93	Profile 22
Biotopes	94	BLlit
Profiles	95	Profile 23
Profiles	96	Profile 24
Profiles	97	Profile 25
Profiles	98	Profile 26
Profiles	99	Profile 26
Biotope YG	100	Yellow lichen
Biotope YG	101	Brown lichen
Biotope YG	102	Yellow lichen
Biotope YG	103	White lichen
Biotopes	104	Pukka FcerX close up
Biotopes	105	Pukka FcerX
Biotopes	106	Asc.Asc on metal pipe
Profiles	107	Profile 27 Voxter Voe
Voxter Voe	107	Profile across Voxter Voe
Type of Photo	ID No.	Subject matter
Workers	108	Workers
Biotopes	109	FspiX close up

Biotopes	110	FspiX close up
Biotopes	111	Fspix close up
Biotope YG	112	Yellow lichen
Biotope YG	113	Orange lichen
Biotope YG	114	White lichen
Biotope YG	115	White lichen
Profiles	116	Profile 28
Profiles	117	Profile 29
Profiles	118	Profile 30
Profiles	119	Profile 30
Profiles	120	Profile 31
Profiles	121	Profile 32
Workers	122	122 Colin Working
Profiles	123	Profile 33
Profiles	124	Profile 33
Biotopes	129	Kelp zone at low tide
Profiles	130	Profile 33
Profiles	131	Profile 33
Gluss Voe	133	Spit at Gluss Voe.JPG
Profiles	135	Profile 34
Non Profile Locations	136	Gabions at profile 34
Non Profile Locations	137	Gabions profile 34
Profiles	140	Profile 35
Profiles	142	Profile 36
Profiles	143	Profile 37
Profiles	144	Profile 38
Biotopes	145	MytX & BLlit
Biotopes	146	MytX on Gravelly sand
Profiles	147	Profile 39
Biotopes	148	Nucella on BPat.Sem boulder
Profiles	149	Profile 40
Biotopes	151	Pucinella
Biotopes	152	Pucinella
Biotopes	153	Pucinella at top of shore
Biotopes	155	MacAre
Profiles	157	Profile 41
Profiles	158	Profile 42
Profiles	159	Profile 43
Profiles	160	Profile 44
Profiles	161	Profile 45
Profiles	162	Profile 45
Non Profile Locations	163	Scarva Tang
Gluss Voe	134A	Panoramic of Gluss Voe.JPG
Gluss Voe	134B	Panoramic of Gluss Voe.JPG
Gluss Voe	134C	Panoramic of gluss Voe.JPG
Type of Photo	ID No.	Subject matter
Houb of Haggrister	A	A The Houb Haggrister transect line
Houb of Haggrister	B	B Houb of Haggrister Details
Houb of Haggrister	C	C Houb Haggrister relocation shot

Houb of Haggrister	D	D Houb Haggrister relocation shot
Houb of Haggrister	E	E Houb of Haggrister relocation shot
Houb of Haggrister	F	F Houb of Haggrister shingle bank
Fugla Ness Transect 1	F-1-1	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-10	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-11	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-12	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-13	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-14	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-15	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-16	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-17	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-18	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-19	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-2	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-20	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-21	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-22	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-24	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-25	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-26	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-27	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-3	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-4	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-5	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-6	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-7	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-8	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 1	F-1-9	Transect 1 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-1	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-10	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-11	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-12	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-13	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-14	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-15	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-16	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-17	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-18	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-19	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-2	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-20	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-21	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-22	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-23	Transect 2 Fugla Ness photo quadrat
Type of Photo	ID No.	Subject matter
Fugla Ness Transect 2	F-2-24	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-25	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-26	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-27	Transect 2 Fugla Ness photo quadrat

Fugla Ness Transect 2	F-2-28	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-29	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-3	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-30	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-4	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-5	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-6	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-7	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-8	Transect 2 Fugla Ness photo quadrat
Fugla Ness Transect 2	F-2-9	Transect 2 Fugla Ness photo quadrat
Houb of Haggrister	G	G Houb of Haggrister in/outflow channel
Houb of Haggrister	H	H Houb of Haggrister in/outflow channel
Houb of Haggrister	I	Houb of Haggrister Inflow/outflow channel
Houb of Haggrister	J	J Transect line 1
Fugla Ness Transect 1	K	Details of Transect 1 Fugla Ness
Fugla Ness Transect 1	K	Relocation of Transect 1 Fougla Ness
Fugla Ness Transect 1	L	Relocation of Transect line Fugla Ness
Fugla Ness Transect 1	M	Relocation of Transect line Fugla Ness
Fugla Ness Transect 1	N	Transect line 1 Fugla Ness
Fugla Ness Transect 1	O	Fugla Ness shingle bank
Fugla Ness Transect 2	P	Transect 2 Fugla Ness relocation
Workers		Examining Sandy Biotoptes
Workers		Snorkler at work Fugla Ness
Workers		Recording on shingle beach
Biotope YG		Lecanora lichen
Biotope YG		Xanthoria Lichen
Biotope Ver.Ver		Verrucaria lichen
Biotope YG		Fruiting Ramalina Lichen
Biotope YG		Ramalina Lichen
Fugla Ness Transect 2		Transect 2 Fugla Ness relocation_1
Fugla Ness Transect 2		Transect 2 Fugla Ness relocation
Voxter Voe		Voxter Voe High tide 1020 13/09/04
Voxter Voe		Voxter Voe Low Tide
Voxter Voe		Voxter Voe High Tide
Voxter Voe		Voxter Voe Low Tide_1

Table A2 - Target note log from Sullom Voe intertidal biotope mapping survey.

(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
1T	1	31	9/7/04	8:35	60°30.019'N 1°20.076'W (No SD)	1			EphX Cove No Ver.Ver at top shore
2PR	1	31	9/7/04	8:40	60°30.035'N 1°20.078'W (No SD)	2		1	Profile 1
3T	1	31	9/7/04						Entromorpha at top shore in small isolated patches. In areas boulders & small pinnacles (not a smooth profile). Rock pools - Cor (Coralina, Littorina littorea, Patella, Actinia) - G (Ent). Patches of BPat.Sem on verticle rock faces.
(1)PH	1	31	9/7/04	9:02	60°30.036'N 1°20.076'W (No SD)	3	0°		General profile 1
(2)PH	1	31	9/7/04	as above	As above	as above			Himanthalia
(3)PH	1	31	9/7/04	as above	As above	as above			Himanthalia
(4)PH	1	31	9/7/04	as above	As above	as above			FvesB
(5)PH	1	31	9/7/04	as above	As above	as above	270°		Top shore lichens
(6)PH	1	31	9/7/04	as above	As 1T	1	190°		Profile 1T
(7)PH	1	31	9/7/04	9:12	As 1T	1	190°		Profile 1T
4T	1	31	9/7/04	9:17	60°29.905'N 1°20.049'W (No SD)	4			Pinnacle BPat.Sem
5T	1	31	9/7/04	9:30	OS 3656 7930	WPT A			Transition from Bedrock to predominantly Boulders
6T	1	29	9/7/04	9:33	60°29.322'N 1°20.235'W (No SD)	5			Transition from Him to Fser.ser, also change to Fves
7T	1	29	9/7/04	9:41	60°29.288'N 1°20.289'W (No SD)	6			Boundary between Fves and Asc.Asc
8PR	1	29	9/7/04	9:45	60°29.291'N 1°20.290'W (No SD)	7		2	Profile 2
(8)PH	1	29	9/7/04	9:45	60°29.291'N 1°20.290'W (No SD)	7	020°		Profile 2
(9)PH	1	29	9/7/04	9:47	60°29.291'N 1°20.290'W (No SD)	7	020°		Profile 2
(10)PH	1	29	9/7/04	9:50	60°29.291'N 1°20.290'W (No SD)	7			Fser
(11)PH	1	29	9/7/04	9:50	60°29.291'N 1°20.290'W (No SD)	7			Fves
(12)PH	1	29	9/7/04	9:51	60°29.291'N 1°20.290'W (No SD)	7	300°		Pel Fspi and Lichens
9PR	1	29	9/7/04	9:55	60°29.285'N 1°20.288'W (No SD)	8		3	Profile 3
(13)PH	1	29	9/7/04	9:56	As above	8	230°		Ascophyllum
10T	1	29	9/7/04	9:59	60°29.262'N 1°20.326'W (No SD)	9			Transition to sand
11T	1	27	9/7/04	10:16	60°28.775'N 1°20.845'W (SD)	10			House (start) FvesX [FserX lower shore]
12PR	1	27	9/7/04	10:18	60°28.775'N 1°20.835'W (No SD)	11		4	Profile 4
(14)PH	1	27	9/7/04	10:25	60°28.774'N 1°20.832'W (No SD)	12	080°		Profile 4
13T	1	27	9/7/04	10:25					Small patches AscX. Small patches BLlit confined to tombola area.
14T	1	26	9/7/04	10:37	60°28.752'N 1°20.426'W (No SD)	13			BLlit Top shore Tal. Lower shore LsacX. Pebbles, occassional Cobbles on coarse sand gravel.
(15)PH	1	26	9/7/04	10:39	60°28.752'N 1°20.426'W (No SD)	13	280°		General overview of above (14T).

15T	1	26	9/7/04	10:49	60°28.854'N 1°19.935'W (No SD)	14			Transition to predominantly Asc.Asc. With AscX amongst. FserX at lower shore. Fspi, Pel, Ver.ver and YG on top shore.
(Photo No.)	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
(16)PH	1	26	9/7/04	10:54	As above	14	300°		View along shore above (15T).
16T	1	26	9/7/04	10:54					Small patches of BPat.Sem on vertical rocks
17T	1	26	9/7/04	11:05	60°29.415'N 1°20.066'W (No SD)	15			Transition of AscX to FvesX. Lower shore LsacX. Upper shore Tal.
18T	1	29	9/7/04	11:13	Obvious from Map				BLlit. Upper shore Tal. Lower shore FserX
19T	1	29	9/7/04	11:20	Obvious from Map				Transition to Asc.Asc & patches of AscX. Upper shore Fspi and Pel. Lower shore FserX for 8m. Patches of BPat.Sem on vertical rock faces. Fves on promontaries.
20T	1	29	9/7/04	11:28	60°29.152'N 1°20.128'W (No SD)	16			Beginning of Mosaic. L.sacX on lower shore (As for most of the bay). Mosaic - Fves (and FvesB, on promontaries and Asc.Asc in bays
21T	1	29	9/7/04	11:36	60°29.230'N 1°19.924'W (No SD)	17			End of mosaic. Transition to FvesB (on not flat or vertical rocks), Fves (on flat rocks) with patches of BPat.Sem. (on vertical rock).
22T	1	30	9/7/04	11:52	60°29.812'N 1°19.468'W (No SD)	18			Mast and end of Site 1
23T	1	31	9/7/04	12:04	60°29.735'N 1°19.564'W (No SD)	19		5	Profile 5
(17)PH	1	31	9/7/04	12:10	As above	19	390°		General of above (23T)
24T	1	31	9/7/04	12:16	60°29.701'N 1°19.669'W (SD)	20			Transition from Fves to BPat.Sem
25PR	2	37	9/8/04	9:43	60°29.983'N 1°16.509'W (No SD)	21		6	Profile 6
26T	2	37	9/8/04	9:58					BarSh in patches (Coves). FvesB in sheltered and horizontal areas (Mosaic with BPat.Sem. Rock pinnacles and small arches all along shore. Ceranium shuttleworthonian and Rhodothamnella purpurea collected from BPat.Sem zone. Porphyra umbilicalis and Enteromorpha intestinalis collected from Him zone.
(18)PH	2	37	9/8/04	10:10	Obvious from Map	21	120°		Photo of profile 25PR
(19)PH	2	37	9/8/04	10:11	Obvious from Map	21	120°		Photo of profile 25PR
(20)PH	2	37	9/8/04	10:12	Obvious from Map		330°		Photo of BarSh
27T	2	37	9/8/04	10:13	Obvious from Map				Patches of bedrock with Ent/Porphyra biotope on BarSh. Fser lower shore.
(21)PH	2	37	9/8/04	10:15	Obvious from Map		060°		BarSh
28T	2	37	9/8/04	10:19	60°29.814'N 1°16.288'W (No SD)	22			Transition to boulders but still FvesB
29T	2	37	9/8/04	10:27	Obvious from Map				F.K. rock pools. Patches of BarS on BarSh. Tal on top shore of BarS
(22)PH	2	37	9/8/04	10:30	Obvious from Map		330°		F.K. rock pool.
(23)PH	2	37	9/8/04	10:32	Obvious from Map		040°		F.K. rock pool.
30T	2	37	9/8/04	11:00	60°29.947'N 1°15.765'W (No SD)	23			Transition to AlaLdig. At lower shore. MytB in F.K. rock pools (also containing Alaria) Upper shore mostly Ver.Ver patches of Ver.Por. And VerB. Then YG.
31T	2	37	9/8/04	11:08	Obvious from Map				Description of BarS - Thin veneer of medium sand overlying shingle. Well drained. Rhodothamnella purpurea and floridula collected from this area.
(24)PH	2	37	9/8/04	11:09	Obvious from Map		050°		BarS in cove
(25)PH	2	37	9/8/04	11:09	Obvious from Map		140°		BarS in cove
(26)PH	2	37	9/8/04	11:10	Obvious from Map				Boat
(27)PH	2	37	9/8/04	11:11	60°29.947'N 1°15.765'W (No SD)		120°		Boat
32T	2	37	9/8/04						Patches of FvesB in sheltered Coves. Areas of BPat.Sem and MytB in exposed areas. Tal at upper shore of BarSh
(Photo No.)	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject

33T	2	30	9/8/04	11:43	60°29.812'N 1°19.468'W (No SD)	18			Start from end of site 1 on Gluss Island. BPat.Sem with FvesB
34PR	2	30	9/8/04	11:48	60°29.831'N 1°19.232'W (No SD)	24		7	Profile 7
(28)PH	2	30	9/8/04	11:51	As above	24	110°		Profile 7
(29)PH	2	30	9/8/04	11:52	As above	24	140°		MytB
(30)PH	2	30	9/8/04	11:54	As above	24	140°		MytB
35T	2	30	9/8/04	12:03	60°29.853'N 1°19.032'W (No SD)	25			Large Cave. Actinia, Callyostomer, Cladophora, Rhodothaminella. Lower shore Fser. Mainly BPat.Sem
(31)PH	2	30	9/8/04	12:05	As above	25	090°		Large Cave. 35T
(32)PH	2	30	9/8/04	12:05	As above	25	030°		Side of cave 35T
(33)PH	2	30	9/8/04	12:06	As above	25	250°		Side of cave 35T
36T	2	30	9/8/04	12:07	60°29.726'N 1°18.599'W (No SD)	26			Transition to FvesB. No change to lower shore
37T	2	30	9/8/04	12:30					BarS lower shore. BarSh and boulders on upper shore. Patches of rock with FvesB. on beach.
38T	2	30	9/8/04	12:34	60°29.383'N 1°18.997'W (No SD)	27			End of beach. Beginning of FvesB
39T	2	28	9/8/04	12:56	60°29.282'N 1°18.924'W (No SD)	28			BPat.Sem above Osm on bedrock. Him on lower shore
(34)PH	2	28	9/8/04	12:46	As above	28	110°		Dense patches of Osm (39T)
(35)PH	2	28	9/8/04	12:46	As above	28	110°		Dense patches of Osm (39T)
(36)PH	2	28	9/8/04	12:46	As above	28	110°		Dense patches of Osm (39T)
(37)PH	2	28	9/8/04	12:46	As above	28	110°		Dense patches of Osm (39T)
(38)PH	2	28	9/8/04	12:46	As above	28	110°		Dense patches of Osm (39T)
40T	2	28	9/8/04	13:04	60°29.171'N 1°18.774'W (No SD)	29			Transition to AlaLdig. Him. MytB. Ver.Por. Ver.Ver and YG. going up the shore.
41T	2	28	9/8/04	13:08	60°29.109'N 1°18.631'W (No SD)	30			Transition to FvesB. with patches of BarSh and BPat.Sem.
42T	2	28	9/8/04	13:18	60°29.052'N 1°18.690'W (No SD)	31			Description of BarSh - Bed of rounded pebbles, cobbles and occasional boulders on a bed of gravely coarse sand. Well drained. Ent.Por on large boulders and Porphyra linearis and Littorina littorea and Semibalanus and Patella. Gamarids under boulders. Tal on upper shore (with Ligia).
(39)PH	2	28	9/8/04	13:27	As above	31	0°		Photo of BarSh (42T)
(40)PH	2	28	9/8/04	13:28	As above	31	290°		Tal (42T)
(41)PH	2	28	9/8/04	13:31	As above	31	060°		Ent.Por biotope (42T)
(42)PH	2	28	9/8/04	13:35	As above	31			Cobbles on BarSh (42T)
43T	2	36	9/9/04	11:36	60°29.728'N 1°13.725'W (No SD)	32			Start of East side of site 2. MytB (with Rock pools - Cor. Lower shore AlaLdig.
44T	2	36	9/9/04	11:48	Obvious from Map				Beaches. AlaLdig, then Ent.por, then BarSh containing barren boulders and cobbles, then Tal. Upper shore.
(43)PH	2	36	9/9/04	11:48	Obvious from Map		260°		Ent and freshwater input
(44)PH	2	36	9/9/04	11:51	Obvious from Map		260°		Ent.Por
45PR	2	36	9/9/04	12:01	60°29.658'N 1°14.032'W (No SD)	33		8	Profile 8
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
(45)PH	2	36	9/9/04	12:03	As above	33	080°		Photo of profile 8 (45PR)
(46)PH	2	36	9-Sep	12:05	As above	33	080°		Photo of profile 8 (45PR)
46T	2	35	9/9/04	12:08	60°29.631'N 1°14.109'W (No SD)	34			Blow Hole

(47)PH	2	35	9/9/04	12:10	As above	34	210°		Blow Hole
(48)PH	2	35	9/9/04	12:13	As above	34	150°		Blow Hole
47T	2	35	9/9/04	12:28	As above	34			Him. In sheltered areas
48T	2	34	9/9/04	12:33	60°29.034'N 1°14.995'W (No SD)	35			Transition to BPat.Sem (possibly MytB with FvesB in flatter more sheltered areas). Going up the shore - AlaLdig, Fser.ser (6m), FvesB (10m), Fspi (1m), Pel (1m), Ver.Ver (4m) and YG. (4m).
49PR	2	33	9/9/04	12:52	60°28.754'N 1°15.558'W (No SD)	36		9	Profile 9
(49)PH	2	33	9/9/04	12:50	As above	36	190°		Photo of profile 9 (49PR)
50T	2	33	9/9/04	12:51	Obvious from Map				Rubbish on upper shore. BarSh with Tal on upper shore. (Rabbit warrens in sand amongst Tal.)
(50)PH	2	33	9/9/04	13:05	Obvious from Map		260°		Along beach (50T) profile and beyond
(51)PH	2	33	9/9/04	13:06	Obvious from Map		260°		Rubbish on beach (50T)
(52)PH	2	33	9/9/04	13:07	Obvious from Map		260°		Rubbish on beach (50T)
(53)PH	2	33	9/9/04	13:09	Obvious from Map		260°		Rubbish and river on beach (50T)
(54)PH	2	33	9/9/04	13:10	Obvious from Map		260°		Gabions and rubbish on beach (50T)
(55)PH	2	33	9/9/04	13:11	Along artificial infill		170°		Gabions and rubbish on beach (50T)
(56)PH	2	33	9/9/04	13:14	Along artificial infill		170°		Gabions and rubbish on beach (50T)
(57)PH	2	33	9/9/04	13:15	Along artificial infill		170°		Gabions and rubbish on beach (50T)
51T	2	33	9/9/04	13:15	Along artificial infill				FvesB on boulder and shingle at infill. EntPor on lower shore.
52T	2	33	9/9/04	13:16	End of artificial infill				FvesB and BPat.Sem on vertical faces. Patches of BarSh.
53PR	2	33	9/9/04	13:22	60°28.886'N 1°16.217'W (No SD)	37		10	Profile 10
(58)PH	2	33	9/9/04	13:25	As above	37	270°		Profile 10 (53T)
54T	2	33	9/9/04	13:26	As above	37			Transition to MytB
55T	2	33	9/9/04	13:29	Obvious from Map				Transition to FvesB. with patches of BarS
56T	2	33	9/9/04	13:38	60°29.024'N 1°16.337'W (No SD)	38			Sandy beach. (removed sediment sample for confirmation of biotope)
(59)PH	2	33	9/9/04	13:41	As above	38	280°		Profile of Beach (56T)
57T	2	33	9/9/04	13:42	As above	38			BarS. - Thin veneer of medium sand over shingle. Well drained.
58PR	2	32	9/9/04	13:55	60°29.191'N 1°16.875'W (No SD)	39		11	Profile 11
59T	2	32	9/9/04	13:56	Obvious from Map				Transition to MytB at point.
(60)PH	2	32	9/9/04	13:59	Obvious from Map	39	130°		Profile 11 (58PR)
(61)PH	2	32	9/9/04	14:00	Obvious from Map	39	130°		Profile 11 (58PR)
60T	2	32	9/9/04	14:03	Obvious from Map				FvesB on boulders on shingle.
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
61T	2	32	9/9/04	14:05	Obvious from Map				BarSh with EntPor on lower shore.
62T	2	32	9/9/04	14:07	End of Bar.Sh after (61T)				MytB with patches of FvesB (Fspi and Pel on upper shore).
63T	2	32	9/9/04	14:10	60°29.031'N 1°17.237'W (No SD)	40			Pier. BPat.Sem
(62)PH	2	32	9/9/04	14:13	As above	40	020°		Pier. BPat.Sem
64T	2	25	9/9/04	14:25	60°28.639'N 1°17.298'W (No SD)	41			Transition from bedrock to boulders & BarSh - promontaries of MytB and FvesB.

65T	2	25	9/9/04	14:43	Obvious from Map				Transition to FvesX
(63)PH	2	25	9/9/04	14:46	Obvious from Map		120°		Beach (66T)
66T	2	25	9/9/04	14:51	Obvious from Map				Beach
67T	2	25	9/9/04	15:07	60°28.293'N 1°17.901'W (No SD)	42			End of Site 2.
68T	3	20	9/10/04	12:38	60°26.885'N 1°15.666'W (SD)	43			Start of site 3. In harbour area. AscX
69PR	3	20	9/10/04	12:52	60°27.010'N 1°15.930'W (SD)	44		12	Profile 12
(64)PH	3	20	9/10/04	12:55	As above	44	170°		Profile 12 (69PR)
(65)PH	3	20	9/10/04	12:57	As above	44	075°		Profile 12 (69PR)
(66)PH	3	20	9/10/04	12:58	As above	44	075°		Profile 12 (69PR)
(67)PH	3	20	9/10/04	12:59	As above	44	310°		Profile 12 (69PR) including oil terminal in the background
70T	3	21	9/10/04	13:03	60°27.140'N 1°16.281'W (SD)	45			Artificial substrate boulders & wall starts. Transition to lower shore FserX. Boulders and concrete BPat.Sem. Boulders inbetween slope - Tal, then 5m BarSh, 2m sparse Fspi, then FvesX, then FserX. Twin blocks of concrete (still LsacX)
71T	3	21	9/10/04	13:19	60°27.439'N 1°16.575'W (No SD)	46			Ent at outfall pipe
72PR	3	21	9/10/04	13:20	60°27.461'N 1°16.590'W (No SD)	47		13	Profile 13
(68)PH	3	21	9/10/04	13:24	As above	47			FvesX (72T)
(69)PH	3	21	9/10/04	13:25	As above	47	310°		Profile 13
73T	3	21	9/10/04	13:27	Obvious from Map				Artificial substrate with BPat.Sem
(70)PH	3	21	9/10/04	13:30	Obvious from Map				Pier MytB
(71)PH	3	21	9/10/04	13:31	Obvious from Map				Pier MytB
(72)PH	3	21	9/10/04	13:32	Obvious from Map				Pier MytB
74T	3	21	9/10/04		Obvious from Map				Pier MytB
75T	3	X	9/10/04	13:37	Obvious from Map				Rock armour BPat.Sem
76T	3	X	9/10/04	13:39	Obvious from Map				As profile 13 (72PR) and Pel on outcropping bedrock
77T	3	X	9/10/04	13:40	Obvious from Map				General description under Piers of Oil Terminal. BPat.Sem on rock armour. On dolphins 0.5m BPat.Sem, then below MytB (small patches of natural beach in between predominately artificial rock armour). At North of Jetty 3 80m of shingle substrate - borderline between FvesX and BarSh. Between Jetty 3 and 4 more natural looking coast. North of Jetty 4 natural shore FvesX predominantly boulders on shingle. Fves south of boom pier. Boom pier is BPat.Sem.
78T	3	23	9/10/04	14:26	Obvious from Map				BarSh with Tal on upper shore
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
79T	3	25	9/10/04	14:36	Obvious from Map				A.P. - Beach seen on Map
80PR	3	25	9/10/04	14:40	60°28.304'N 1°18.039'W (No SD)	48/49		14	Profile 14 (MytB on rock outcrops)
(73)PH	3	25	9/10/04	14:42	As above	48/50			MytB
(74)PH	3	25	9/10/04	14:43	As above	48/51			MytB
(75)PH	3	25	9/10/04	14:44	As above	48/52			MytB
(76)PH	3	25	9/10/04	14:46	As above	48/53			MytB
(77)PH	3	25	9/10/04	14:47	As above	48/54			MytB

(78)PH	3	25	9/10/04	14:47	As above	48/55			MytB
(79)PH	3	25	9/10/04	14:48	As above	48/56	330°		Profile 14
81T	3	25	9/10/04	14:49	60°28.201'N 1°18.178'W (No SD)	50			Transition of Fves to MytB
82T	3	28	9/10/04	14:50	60°26.846'N 1°18.863'W (SD)	51			Start site 3. East side (boom pier). Continuation FvesB. Patches of BarSh. (with BPat.Sem. On large boulders and bedrock).
83T	3	28	9/10/04	15:07	60°28.749'N 1°18.957'W (SD)	52			Transition to FvesB on boulders. Lower shore FserX.
84PR	3	28	9/10/04	15:14	60°28.751'N 1°19.272'W (SD)	53		15	Profile 15
(80)PH	3	28	9/10/04	15:27	As above	53	210°		Profile 15
(81)PH	3	28	9/10/04	15:28	As above	53	270°		Profile 15
85T	3	28	9/10/04	15:33	60°28.750'N 1°19.225'W (SD)	54			Transition from FvesB to FvesX
86T	3	26	9/10/04	15:38	Obvious from Map				BarSh with Tal upper shore. LsacX lower shore
87T	3	26	9/10/04	15:40	Obvious from Map				Transition to FvesX and Tal on upper shore. Still LsacX lower shore. As (84PR)
88T	3	24	9/10/04	15:45	60°28.235'N 1°19.470'W (No SD)	55			Transition to bedrock and FvesB
89T	3	24	9/10/04	15:49	60°28.131'N 1°19.516'W (No SD)	56			Back to FvesX
90T	3	24	9/10/04	15:51	Obvious from Map				Transition Tal upper shore above BarSh, then FvesX
91T	3	22	9/10/04	15:53	Obvious from Map				EphX
92T	3	22	9/10/04	15:58	Obvious from Map				BarSh
93T	3	22	9/10/04	16:03	60°27.558'N 1°19.593'W (No SD)	57			Transition to bedrock & BarSh. Coves/.patches of FvesX & FvesB on rock outcrops
94T	3	19	9/10/04	16:10	60°27.335'N 1°19.365'W (No SD)	58			Transition to Tal, then BarSh, then FvesX., then FserX {NB FAO Hamish - Broad spectrum of FvesX}
95T	3		9/10/04	16:20	60°27.256'N 1°18.629'W (No SD)	59			Little rock island - Sheltered east side. FserX, FvesX, BarSh, then Tal going up the shore. North side FvesX to AscX. North west tip AscX, then back to FvesX. EntPor on south side. Seal haulout.
(82)PH	3		9/10/04	16:21	As above	59	240°		Little rock island
(83)PH	3		9/10/04	16:23	As above	59	290°		Little rock island
96T	3	19	9/10/04	16:39	60°26.949'N 1°19.404'W (No SD)	60			End of site 3 - East side.
97T	4	15	9/11/04	13:14	60°26.525'N 1°18.262'W (No SD)	61			Upper shore, BarSh. Midshore, very scattered FvesX. Lower shore, impoverished FvesX and LsacX (paste in same to Scatsta Ness Point)
98PR	4	15	9/11/04	13:16	60°26.525'N 1°18.262'W (No SD)	61		16	Profile 16
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
(84)PH	4	15	9/11/04	13:20	60°26.525'N 1°18.262'W (No SD)	61	150°		Profile 16
(85)PH	4	15	9/11/04	13:22	60°26.525'N 1°18.262'W (No SD)	61	060°		Profile 16
99T	4	15	9/11/04	13:32	Obvious from Map				Transition from FvesX - A.P (Aronicola present). Upper shore Tal.
(86)PH	4	15	9/11/04	13:33	Obvious from Map				FvesX
(87)PH	4	15	9/11/04	13:34	Obvious from Map				FvesX
100T	4	15	9/11/04	13:39	Obvious from Map				Transition back to FvesX (after 98T) and BPat.Sem on large boulders.
101T	4	15	9/11/04	13:41	Obvious from Map				BPat.Sem on artificial boom pier.
102T	4	12	9/11/04	13:45	60°26.145'N 1°20.041'W (No SD)	62			Transition to FvesB on promentries and Asc.Asc in sheltered bays.
103PR	4	12	9/11/04	13:47	60°26.033'N 1°20.120'W (No SD)	63		17	Profile 17.

104T	4	12	9/11/04	13:54	Obvious from Map				FvesX in sheltered bays.
105T	4	12	9/11/04	13:56	Obvious from Map				BarSh.
106T	4	12	9/11/04	13:59	60°25.598'N 1°20.674'W (No SD)	64			Transition to Asc.Asc with patches of FvesB (Unstable bits more FvesX)
107T	4	12	9/11/04	14:05	60°25.501'N 1°20.628'W (No SD)	65		18	Profile 18.
(88)PH	4	12	9/11/04	14:07	As above	65			Profile 18.
108T	4	10	9/11/04	14:11	60°25.409'N 1°20.679'W (No SD)	66			Transition to FvesB (A steeper shore)
109T	4	10	9/11/04	14:14	Obvious from Map				Impoverished FvesX
110T	4	8	9/11/04	14:15	Obvious from Map				FvesX
111T	4	8	9/11/04	14:16	60°25.253'N 1°20.664'W (No SD)	67			Transition to predominantly FvesB patches with BPat.Sem on vertical faces.
112T	4	8	9/11/04	14:19	60°25.192'N 1°20.793'W (No SD)	68			Transition to Asc.X with BPat.Sem on Vertical faces. Lower shore still LsacX
113T	4	8	9/11/04	14:26	60°25.027'N 1°20.801'W (No SD)	69			Transition to BPat.Sem
114PR	4	8	9/11/04	14:28	60°24.991'N 1°20.814'W (No SD)	70		19	Profile 19. (Algae sample taken)
115T	4	8	9/11/04	14:40	60°24.964'N 1°20.832'W (No SD)	71			Transition to FvesB
116T	4	8	9/11/04	14:41	Obvious from Map				Upper shore Tal, Midshore FvesX and Lower shore LsacX
117T	4	8	9/11/04	14:45	Obvious from Map				BarSh
118T	4	5	9/11/04	14:47	60°24.717'N 1°20.761'W (No SD)	72			Transition to MytB and Pel.
119T	4	5	9/11/04	14:50	60°24.661'N 1°20.730'W (No SD)	73			Transition to FvesB
120T	4	5	9/11/04	14:52	60°24.625'N 1°20.620'W (No SD)	74			Transition to FvesX
121T	4	5	9/11/04	14:55	60°24.589'N 1°20.491'W (No SD)	75			Transition to AscX
122PR	4	5	9/11/04	15:01	60°24.607'N 1°20.383'W (No SD)	76		20	Profile 20.
(89)PH	4	5	9/11/04	15:04	60°24.607'N 1°20.383'W (No SD)	76	240°		Profile 20.
(90)PH	4	5	9/11/04	15:05	60°24.607'N 1°20.383'W (No SD)	76	070°		Profile 20.
123T	4	5	9/11/04	15:11	60°24.571'N 1°20.011'W (No SD)	77			Transition to FvesX
124PR	4	5	9/11/04	15:15	60°24.546'N 1°20.213'W (No SD)	78		21	Profile 21.
(91)PH	4	5	9/11/04	15:21	As above	78	110°		Profile 21.
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
125T	4	5	9/11/04	15:28	60°24.509'N 1°20.275'W (No SD)	79			Transition to AscX
126T	4	5	9/11/04	15:30	60°24.498'N 1°20.541'W (No SD)	80			Mainly AscX with FvesB on promentries starting & BPat.Sem on vertical faces.
127T	4	5	9/11/04	15:38	60°24.357'N 1°20.868'W (No SD)	81			End of Map 5 at white boulder.
128T	4	7	9/12/04	13:23	60°25.347'N 1°21.636'W (No SD)	86			Start location at fence.
129PR	4	7	9/12/04	13:27	60°25.370'N 1°21.696'W (No SD)	87		22	Profile 22.
(92)PH	4	7	9/12/04	13:29	As above		080°		Profile 22.
(93)PH	4	7	9/12/04	13:31	As above		020°		Profile 22.
130T	4	7	9/12/04	13:38	Obvious from Map				Where there is more shingle FvesX and less AscX.
131T	4	7	9/12/04	13:41	60°24.943'N 1°21.321'W (No SD)	88			Transition to BLlit.
132PR	4	7	9/12/04	13:44	60°24.860'N 1°21.344'W (No SD)	89		23	Profile 23.
(94)PH	4	7	9/12/04	13:47	As above				BLlit

(95)PH	4	7	9/12/04	13:48	As above				Profile 23.
133T	4	7	9/12/04	13:57	Obvious from Map				Transition to AscX
134PR	4	7	9/12/04	14:14	60°24.711'N 1°21.860'W (No SD)	90		24	Profile 24.
(96)PH	4	7	9/12/04	14:16	As above		150°		Profile 24.
135PR	4	7	9/12/04	14:26	60°24.781'N 1°22.179'W (No SD)	91		25	Profile 25.
(97)PH	4	7	9/12/04	14:31	As above		160°		Profile 25.
136T	4	7	9/12/04	14:46	Obvious from Map				Transition to FvesX for 50m then back to AscX
137T	4	7	9/12/04	14:50	60°24.348'N 1°22.095'W (No SD)	92			End at South Ness.
138PR	4	7	9/12/04	15:48	60°24.609'N 1°19.782'W (No SD)	93		26	Profile 26.
(98)PH	4	7	9/12/04	15:49	As above		030°		Profile 26.
(99)PH	4	7	9/12/04	15:49	As above		150°		Profile 26.
139PR	4	7	9/12/04	15:59	60°24.629'N 1°19.747'W (No SD)	94		27	Start of profile 27, at end of Voxter Voe.
	4	7	9/12/04	16:06	60°24.630'N 1°19.755'W (No SD)	95			FcerX
	4	7	9/12/04	16:12	60°24.064'N 1°19.905'W (No SD)	96			Metal pipe with Asc.Asc. (End of FcerX zone.)
	4	7	9/12/04	14:22	60°24.679'N 1°19.815'W (No SD)	97			Boundry between FspiX and AscX
	4	7	9/12/04	14:26	60°24.684'N 1°19.816'W (No SD)	98			End of Profile 27.
(100)PH	4	7	9/12/04	16:03	As at WPT 94				Lichens (close up)
(101)PH	4	7	9/12/04	16:04	As at WPT 94				Lichens (close up)
(102)PH	4	7	9/12/04	16:05	As at WPT 94				Lichens (close up)
(103)PH	4	7	9/12/04	16:06	As at WPT 94				Lichens (close up)
(104)PH	4	7	9/12/04	16:09	As at WPT 95				FcerX (Close up)
(105)PH	4	7	9/12/04	16:10	As at WPT 95		070°		FcerX
(106)PH	4	7	9/12/04	16:12	As at WPT 96		230°		Ascophyllum on metal pipe.
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
(107)PH	4	7	9/12/04	16:25	As at WPT 98		130°		Profile from other end.
(108)PH	4	7	9/12/04						Workers
(109)PH	4	7	9/12/04	16:21	As at WPT 97				FspiX (close up)
(110)PH	4	7	9/12/04	16:21	As at WPT 97				FspiX (close up)
(111)PH	4	7	9/12/04	16:22	As at WPT 97				Fsp.X (close up)
140PT	4	7	9/12/04	16:34	60°24.654'N 1°20.038'W (No SD)	99			Degenerated concrete dyke on upper shore.
141PR	4	7	9/12/04	16:39	60°24.652'N 1°20.071'W (No SD)	100		28	Profile 28.
(112)PH	4	7	9/12/04	16:38	As above				Lichen (close up)
(113)PH	4	7	9/12/04	16:38	As above				Lichen (close up)
(114)PH	4	7	9/12/04	16:38	As above				Lichen (close up)
(115)PH	4	7	9/12/04	16:38	As above				Lichen (close up)
(116)PH	4	7	9/12/04	16:42	As at WPT 100		080°		Of profile 28
142PR	4	19	9/14/04	15:12	60°27.199'N 1°20.270'W (No SD)	108			Start or survey and Profile 29

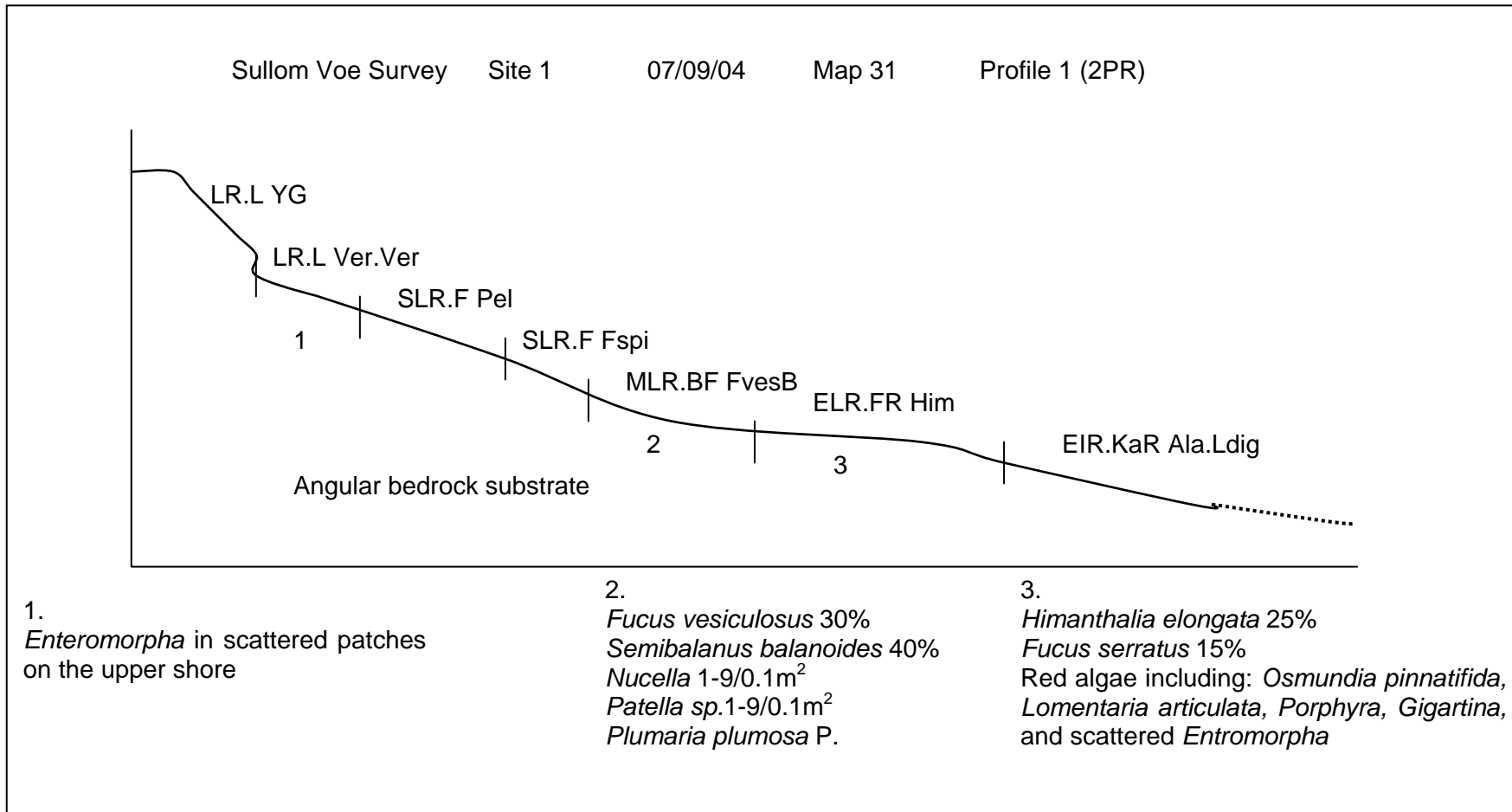
(117)PH	4	19	9/14/04	15:15	As above		190°	29	Of profile 29
143T	4	19	9/14/04	15:21	Obvious from Map				Transition to FvesX
144PR	4	19	9/14/04	15:28	60°26.902'N 1°19.705'W (No SD)	109		30	Profile 30
(118)PH	4	19	9/14/04	15:31	As above		170°		Of profile 30
(119)PH	4	19	9/14/04	15:32	As above		090°		Of profile 30
145T	4	17	9/14/04	15:46	60°26.958'N 1°20.438'W (No SD)	110			Abundant Arenicola on fine sand at a depth of 60cm. Patchy Chorda
146T	4	17	9/14/04	15:49	60°27.024'N 1°20.416'W (No SD)	111			Abundant Arenicola on fine sand at a depth of 50cm. Patchy Chorda
147T	4	13	9/14/04	16:03	60°26.285'N 1°21.195'W (No SD)	112			Impoverished FvesX with patches of FcerX
148T	4	11	9/14/04	16:20	60°25.821'N 1°21.540'W (No SD)	113			Mosaic of AscX, Asc.Asc, and FvesX
149T	4	11	9/14/04	16:31	60°25.561'N 1°21.639'W (No SD)	114			Outcrops with BPat.Sem and end of Northern survey.
150PR	4	1	9/14/04	16:51	60°23.660'N 1°22.553'W (No SD)	115		31	Profile 31 and beginning of Southern survey
(120)PH	4	1	9/14/04	16:55	As above		030°		Of profile 31
151T	4	1	9/14/04	16:58	60°23.733'N 1°22.491'W (No SD)	116			Predominantly Asc.Asc but also AscX.
152T	1	29	9/15/04	15:57	60°29.252'N 1°20.314'W (No SD)	117			EphX on Cobbles & Pebbles on Gravely sand. Profile 32.
153T	1	29	9/15/04	16:04	60°29.240'N 1°20.380'W (No SD)	118			End of 152T zone.
(121)PH	1	29	9/15/04	16:08	As above		200°	32	Of profile 32
(122)PH	1	29	9/15/04	16:10	As above		200°		Surveyor working
154T	1	27	9/15/04	16:19	60°29.179'N 1°20.430'W (No SD)	119			Transition to FvesX and FserX
155PR	1	27	9/15/04	16:27	60°29.152'N 1°20.519'W (No SD)	120			Profile 33
(123)PH	1	27	9/15/04	16:31	As above		130°	33	Of profile 33
(124)PH	1	27	9/15/04	16:32	As above		130°		Of profile 33
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
(125)PH	1	27	9/15/04	16:33	As above		130°		Kelp zone and boat
(126)PH	1	27	9/15/04	16:34	As above		130°		Kelp zone and boat
156T	1	27	9/15/04	16:40	60°29.095'N 1°20.597'W (No SD)	121			Transition to a mosaic of Fves & Asc.Asc on boulders and bedrock, FvesX & AscX on boulders and cobbles on sediment (all upper shore). On lower shore good Fser On bedrock and FserX on boulders & cobbles on sediment
157T	1	27	9/15/04	16:50	60°29.049'N 1°20.694'W (No SD)	122			Ian's transect
(127)PH	1	27	9/15/04	16:59	As above				Kelp zone at low tide
(128)PH	1	27	9/15/04	16:59	As above				Kelp zone at low tide
(129)PH	1	27	9/15/04	17:00	As above				Kelp zone at low tide
158T	1	27	9/15/04	17:02	60°29.006'N 1°20.842'W (No SD)	123			Transition to FvesX
159T	1	27	9/15/04	17:04	60°28.978'N 1°20.899'W (No SD)	124			Dyke - BPat.Sem
160T	1	27	9/15/04	17:08	60°28.867'N 1°20.980'W (No SD)	125			Start of profile, at Low water. Substrate = slightly muddy gravely medium sand with surface scatter gravel, anoxic layer at 4cm. Lit.lit - super abundant, Mytilus - occasional, Semibalanus on pebbles, polychetes - abundant, Arenicola 1-9/0.1m ² , Ensis - occasional, Cerastoderma - occasional, Lanice occasional and Mya.
161T	1	27	9/15/04	17:22	60°28.857'N 1°21.043'W (No SD)	126			Lit.littorea - abundant, Cerastoderma - 1-9 m ² (quite large), Arenicola 1-9 0.1m ²
162T	1	27	9/15/04	17:24	60°28.852'N 1°21.092'W (No SD)	127			Arenicola upper shore limit

163T	1	27	9/15/04	17:31	60°28.852'N 1°21.113'W (No SD)	128			BLlit 1-9 3x3m ² , Cerastoderma 1-9m ² , Mytilus present.
164T	1	27	9/15/04	17:34	60°28.858'N 1°21.152'W (No SD)	129			Asc.Asc on bedrock and boulders, AscX on boulders & cobbles on sand, 1.5m of Fspi - boulders, cobbles on pebbly sand, 2m Pel - cobbles boulders on pebbly, gravely sand, 1m Ver.Ver on boulders & cobbles on pebbly gravely sand, 1m of YG on boulders and bedrock with Tal on cobbles on pebbly gravely sand.
(130)PH	1	27	9/15/04		As above				Of profile
(131)PH	1	27	9/15/04		As above				Of profile
(132)PH	1	27	9/15/04		As above				kelp and oil refinery
165T	1	27	9/15/04		60°28.768'N 1°21.109'W (No SD)	130			Gravely fine sand with: Cerastoderma1-9 0.1m ² , Arenicola 1-9 0.1m ² . Surface water present with a film of Enteromorpha.
166T	1	27	9/15/04	17:56	Obvious from Map				Sparse FvesX, 3m Fspi and 11m BarSh on gravely coarse sand.
(133)PH	1	27	9/15/04	18:11					Of spit
(134)PH	1	27	9/15/04	18:12					Panoramic view of Gluss Voe
167T	3	20	9/16/04	15:46	60°26.822'N 1°15.579'W (No SD)	131		34	Profile 34
(135)PH	3	20	9/16/04	15:48	As above		000°		Of profile 34
(136)PH	3	20	9/16/04	15:48	As above				Gabions
(137)PH	3	20	9/16/04	15:49	As above				Gabions
(138)PH	3	20	9/16/04	15:49	As above				Gabions
168T	3	20	9/16/04	15:55	60°26.775'N 1°15.586'W (No SD)	132			A.P. Angula tenuous present. Arenicola 1-9/0.1m ² , Cerastoderma edule = 1.
169T	3	20	9/16/04	16:00	60°26.735'N 1°15.595'W (No SD)	133			FcerX
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
(139)PH	3	20	9/16/04	16:04	As above		080°		Of freshwater influence.
170T	3	20	9/16/04	16:09	Obvious from Map				Transition from BarSh on medium sand to Fspi and Pel
171T	3	20	9/16/04	16:14	Obvious from Map				Vertical rock and pipe with BPat.Sem and start of a 15m FserX band.
172T	3	20	9/16/04	16:19	Obvious from Map				YG and Ver.Ver - 3m and AscX on boulders & cobbles on gravely, pebbly sand.
173T	3	20	9/16/04	16:25	60°26.566'N 1°16.197'W (No SD)	134			Concrete slipway with Fves.
174PR	3	20	9/16/04	16:29	60°26.581'N 1°16.238'W (No SD)	135		35	Profile 35
(140)PH	3	20	9/16/04	16:31	As above		220°		Of profile 35
175PR	3	20	9/16/04	16:37	60°26.695'N 1°16.373'W (No SD)	136		36	Profile 36
(141)PH	3	20	9/16/04	16:40	As above				Mixed fucoids at profile 36
(142)PH	3	20	9/16/04	16:40	As above				Mixed fucoids at profile 36
176T	3	20	9/16/04	16:43	60°26.716'N 1°16.412'W (No SD)	137			Transition to AscX & Fves
177T	3	20	9/16/04	16:57	Obvious from Map				15m FserX, 9m FvesX, 3m Fspi and sparce YG on Boulders
178PR	3	20	9/16/04	17:06	60°26.635'N 1°16.644'W (No SD)	138		37	Profile 37
(143)PH	3	20	9/16/04	17:10	As above		075°		Profile 37
179T	3	20	9/16/04	17:12	60°26.592'N 1°16.601'W (No SD)	139			Transition to profile below
180PR	3	20	9/16/04	17:19	60°26.566'N 1°16.598'W (No SD)	140		38	Profile 38
(144)PH	3	20	9/16/04	17:20	As above		160°		Profile 38
181T	3	20	9/16/04	17:21	60°26.546'N 1°16.528'W (No SD)	141			Transition to FvesX

182TT	3	20	9/16/04	17:27	Obvious from Map				BLlit verging on MytX Mussels - 0-9/0.1m ² and <i>Littorina littorea</i> & <i>Semibalanus</i> - abundant. All on pebbles on gravelly sand.
(145)PH	3	20	9/16/04	17:28					MytX & BLlit.
183T	3	20	9/16/04	17:30	Obvious from Map				MytX 20/0.1m ² (at Freshwater influence). Pebbly, gravelly sand on medium sand with patches of mussels. 10% Fves.
(146)PH	3	20	9/16/04	17:33					MytX Pebbly, gravelly sand on medium sand with patches of mussels at 1-9/10x10cm. 10% Fves.
184T	3	20	9/16/04	17:36	60°26.429'N 1°16.996'W (No SD)	142			Edge of MytX bed.
185PR	3	20	9/16/04	17:39	60°26.463'N 1°17.083'W (No SD)	143		39	Profile 39
(147)PH	3	20	9/16/04	17:41	As above		030°		Profile 39.
186PR	3	20	9/16/04	17:47	60°26.520'N 1°17.142'W (No SD)	144		40	Profile 40
(148)PH	3	20	9/16/04	17:49	As above				<i>Nucella lapillus</i>
(149)PH	3	20	9/16/04	17:49	As above		010°		Profile 40
(150)PH	3	20	9/16/04	18:02			160°		Houb profile=Top shore -2m Tal on pebbles & cobbles, 1m pucenilla & <i>Fucus muscoides</i> on pebbles & cobbles on gravelly sand, sparse Pel on cobbles on pebbly/gravelly sand.
187PR	3	20	9/16/04	18:07	60°26.373'N 1°17.052'W (No SD)	145			2m of Fspi on cobbles & pebble on gravelly sand, 18m of AscX on boulders on muddy sand with patches of pebbles and gravel
				18:17	60°26.351'N 1°16.966'W (No SD)				WPT for end of MacAre & <i>Arenicola</i> abundant
(Photo) No.	Site	Map	Date	Time	Position	WPT	(Bearing)	Profile No.	Notes/Subject
				18:20	60°26.344'N 1°16.933'W (No SD)				Patch of BLlit
				18:21	60°26.340'N 1°16.920'W (No SD)				MacAre with <i>Arenicola</i> 1-9/0.1m ² and a filamentous green algal mat (probably <i>Rhizoclonium</i>) on muddy sand.
				18:27	60°26.287'N 1°16.792'W (No SD)				End of MacAre zone. Then: 7m AscX (30%) with Fspi (10%) on silty sand with scattered pebbles, 2.5m Fspi, 1.5m Pel, 1.5m Ver.Ver, all on a substrate of cobbles, boulders & pebbles on silty sand. 2m Pucinella with Ver.Ver on boulders and a 50cm Tal band.
(151)PH	3	20	9/16/04	18:09					Pucinella
(152)PH	3	20	9/16/04	18:09					Pucinella
(153)PH	3	20	9/16/04	18:10					Pucinella
(154)PH	3	20	9/16/04	18:10					Pucinella
(155)PH	3	20	9/16/04	18:29					<i>Arenicola</i>
(156)PH	3	20	9/16/04	18:31					Of Houb profile
188T	4	3	9/17/04	16:43	60°24.317'N 1°22.142'W (No SD)	150			Start of shore survey
(157) PH	4	3	9/17/04	16:52	60°24.363'N 1°22.176'W (No SD)	151		41	Profile 41
T190	4	3	9/17/04		Obvious from Map				FvesX on shingle
T191	4	3	9/17/04	17:05	60°24.213'N 1°22.540'W (No SD)	152			Substrate changes from shingle to bedrock and AscX
PH158	4	3	9/17/04		60°24.217'N 1°22.600'W (No SD)			42	Profile 42
T193	4	3	9/17/04		Obvious from Map				Transition to AscX in bays
T194	4	3	9/17/04	17:19	60°24.209'N 1°22.882'W (No SD)	154			Transition to Asc. Asc.
T195	4	3	9/17/04		Obvious from Map				A few <i>Mytilus</i> on shingle, mainly FvesX and in sheltered areas AscX

PH 159	4	3	9/17/04	17:26	60°24.208'N 1°22.961'W (No SD)	155		43	Profile 43
T197	4	3	9/17/04		Obvious from Map				Shingle Beach F ves X & L.sac X
T198	4	3	9/17/04			Blue81			Transition Asc.Asc to BPat.Sem.
T199	4	3	9/17/04						Embayments Asc.Asc, BPat.Sem on Boulders
PH160	4	3	9/17/04					44	Profile 44
T201	4	3	9/17/04			Blue82			Transition to Asc. Asc
T202	4	3	9/17/04			Blue83			Transition to AscX
T203	4	3	9/17/04			Blue84			Transition to Outcrops of BPat.Sem and Asc.Asc In sheltered embayments.
T204	4	2	9/17/04			Blue85			Transition to AscX
PR205	4	2	9/17/04			Blue86		45	Profile 45
PH161	4	2	9/17/04						Profile 45
T206	4	4	9/17/04			Blue87			Transition to predom. Impoverished FvesX and patches of AscX and Asc.Asc. LHyp and Halydris sub littoral. Patches of BPat.Sem and large Mussels and FvesB
PH162	4	4	9/17/04						Scarva Tang

Figures A1-A45 – Shore profile diagrams drawn from field notes and observations



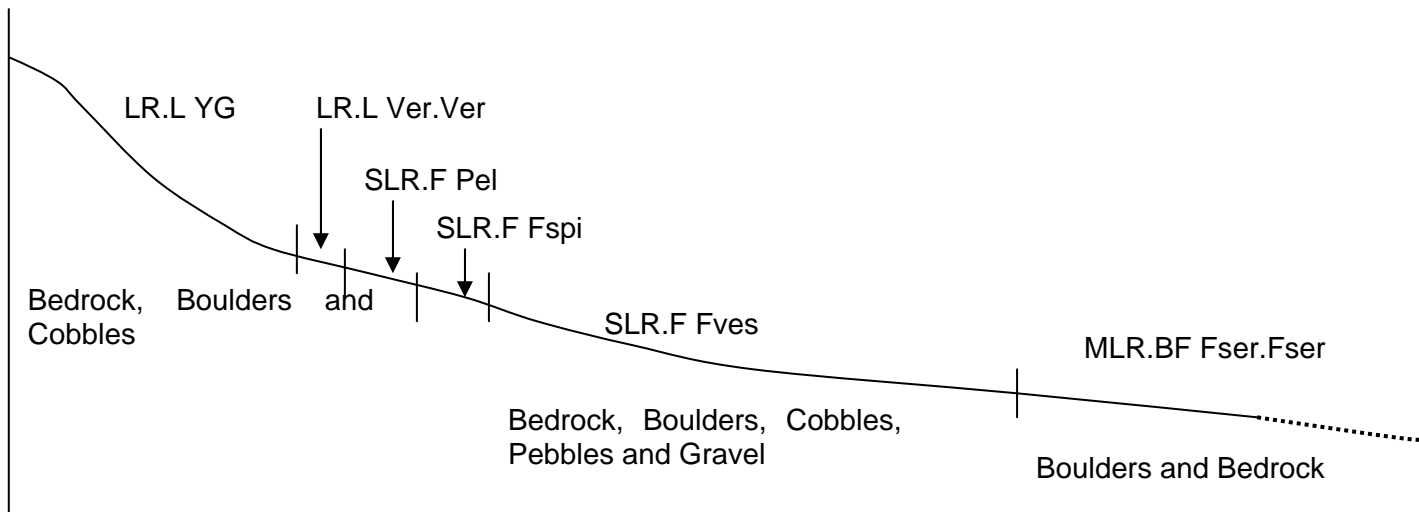
Sullom Voe Survey

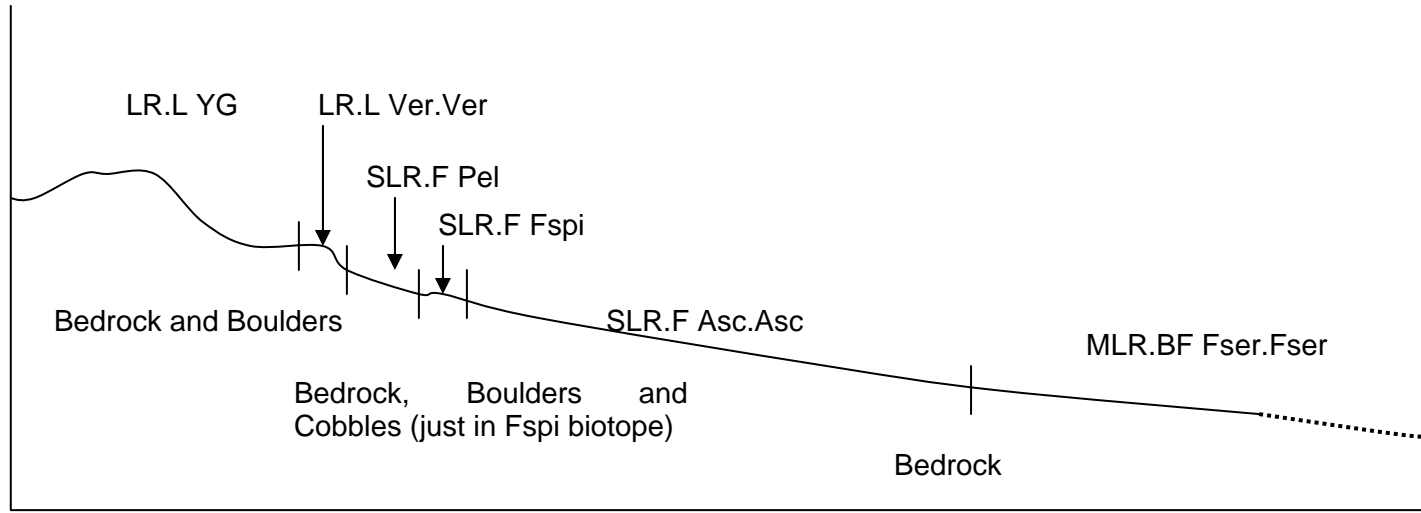
Site 1

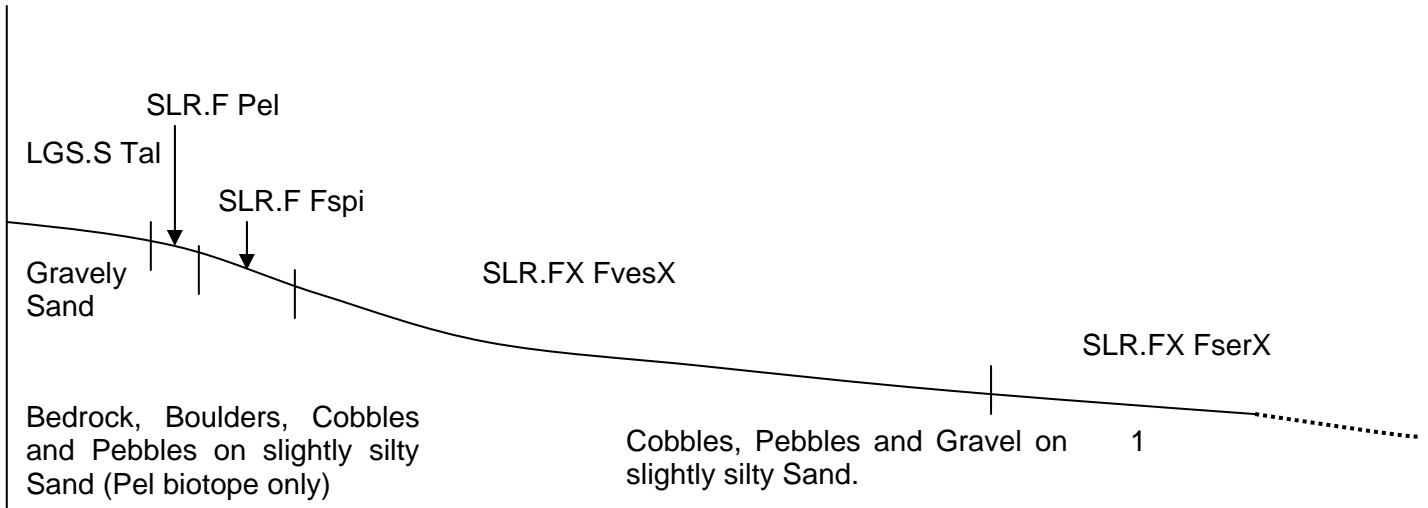
07/09/04

Map 31

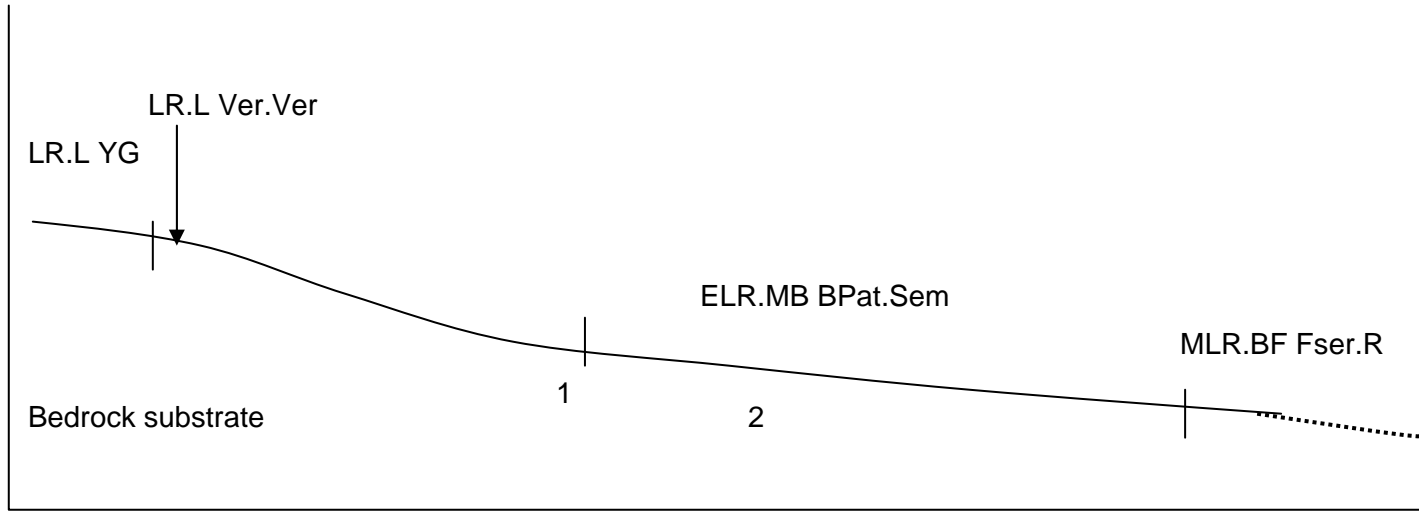
Profile 2 (8PR)





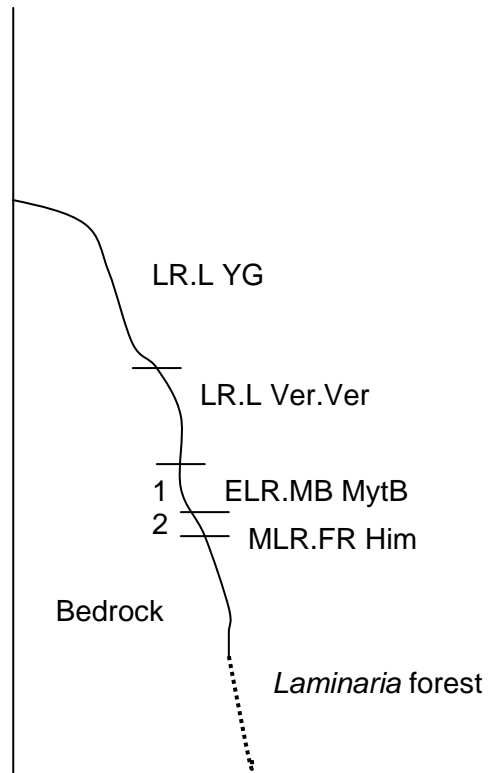


1. *Arenicola* Present



1. Rockpools LR.Rkp Cor

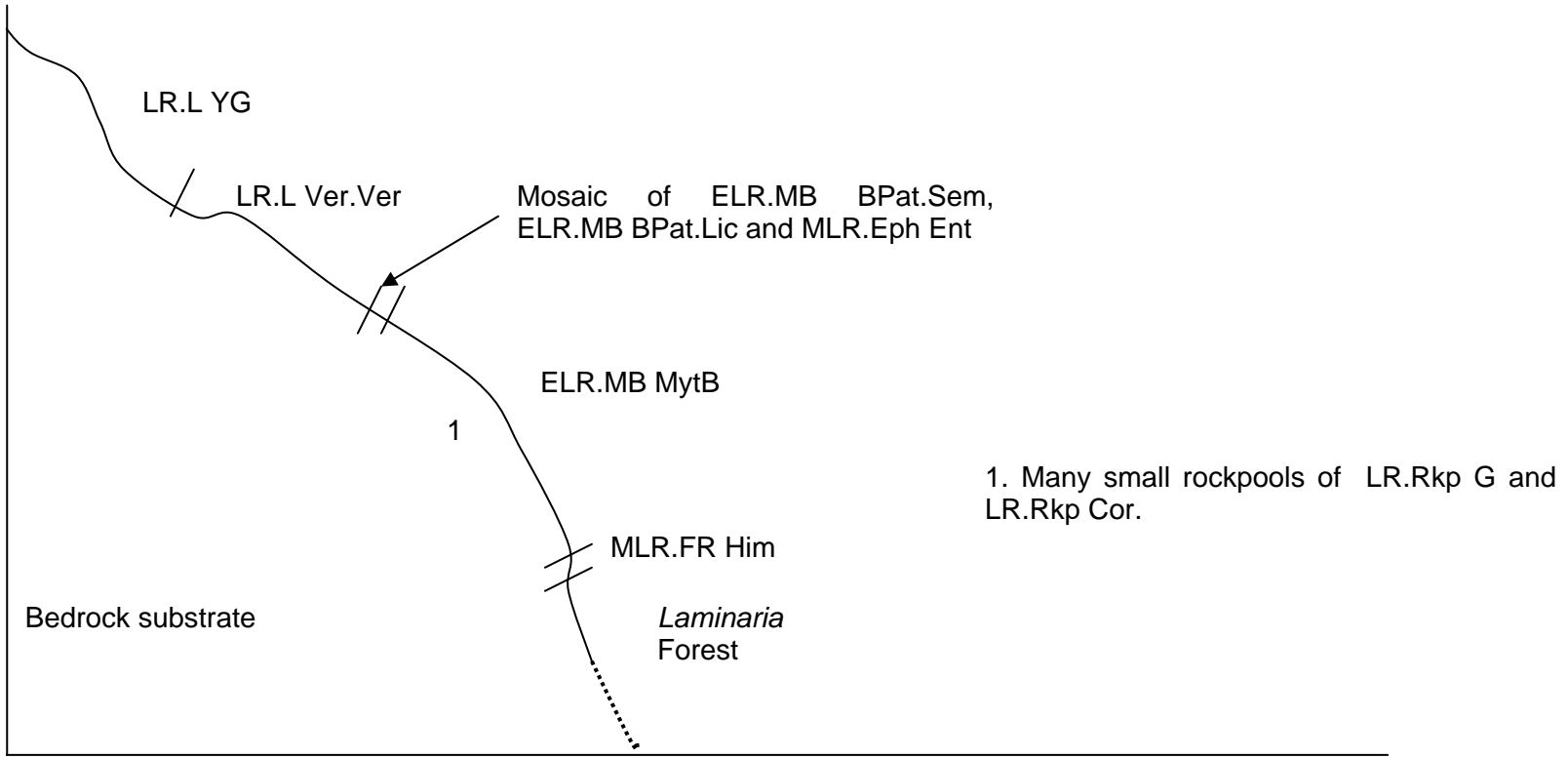
2. Patches of MLR.BF FvesB present.



1. *Semibalanus balanoides* 80 % cover
 Also present
 Very dense tiny *Mytilus* in cracks 5%
Ceramium shuttleworthonian 3%
Mastocarpus stellatus <1%
Nucella occasional.

2. *Himantalia* 70% cover
 Also present:
Semibalanus balanoides,
Gibbula,
Patella,
Fucus serratus
Porphyra umbilicalis,
Mastocarpus stellatus,
Ulva latuca,
 Corraline crusts.

70



Sullom Voe Survey

Site 2

09/09/04

Map 36

Profile 8 (45PR)

LR.L YG

1. Many small rockpools of LR.Rkp G

2. Many small rockpools of LR.Rkp Cor.

1

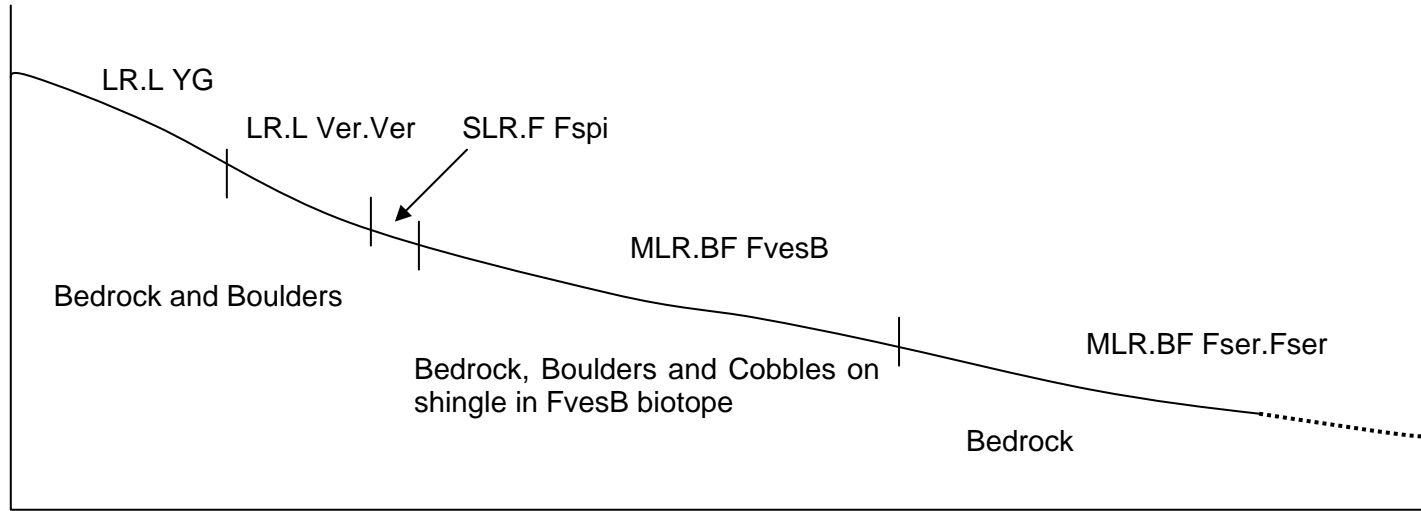
LR.L Ver.Ver

ELR.MB MytB

2

Bedrock substrate

EIR.KFaR Ala.Ldig



Sullom Voe Survey

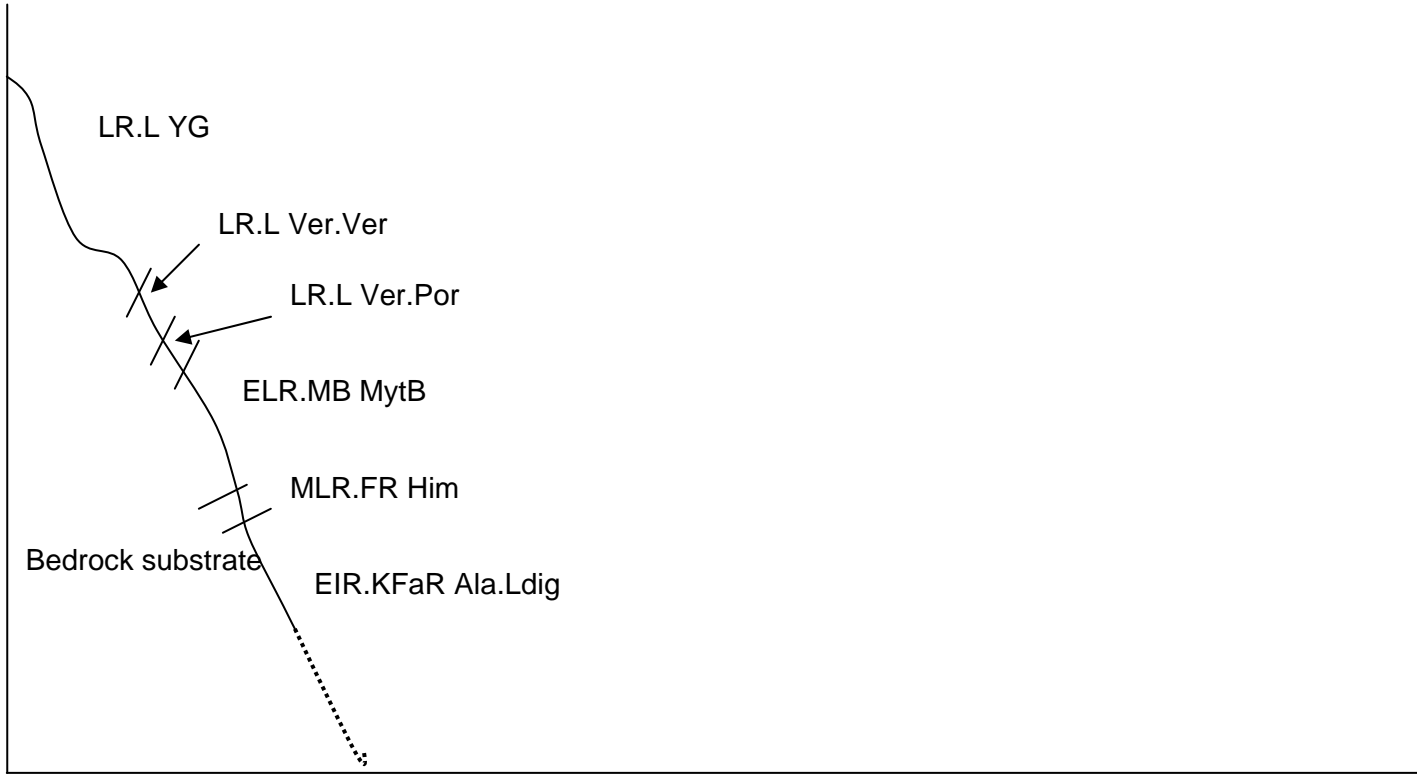
Site 2

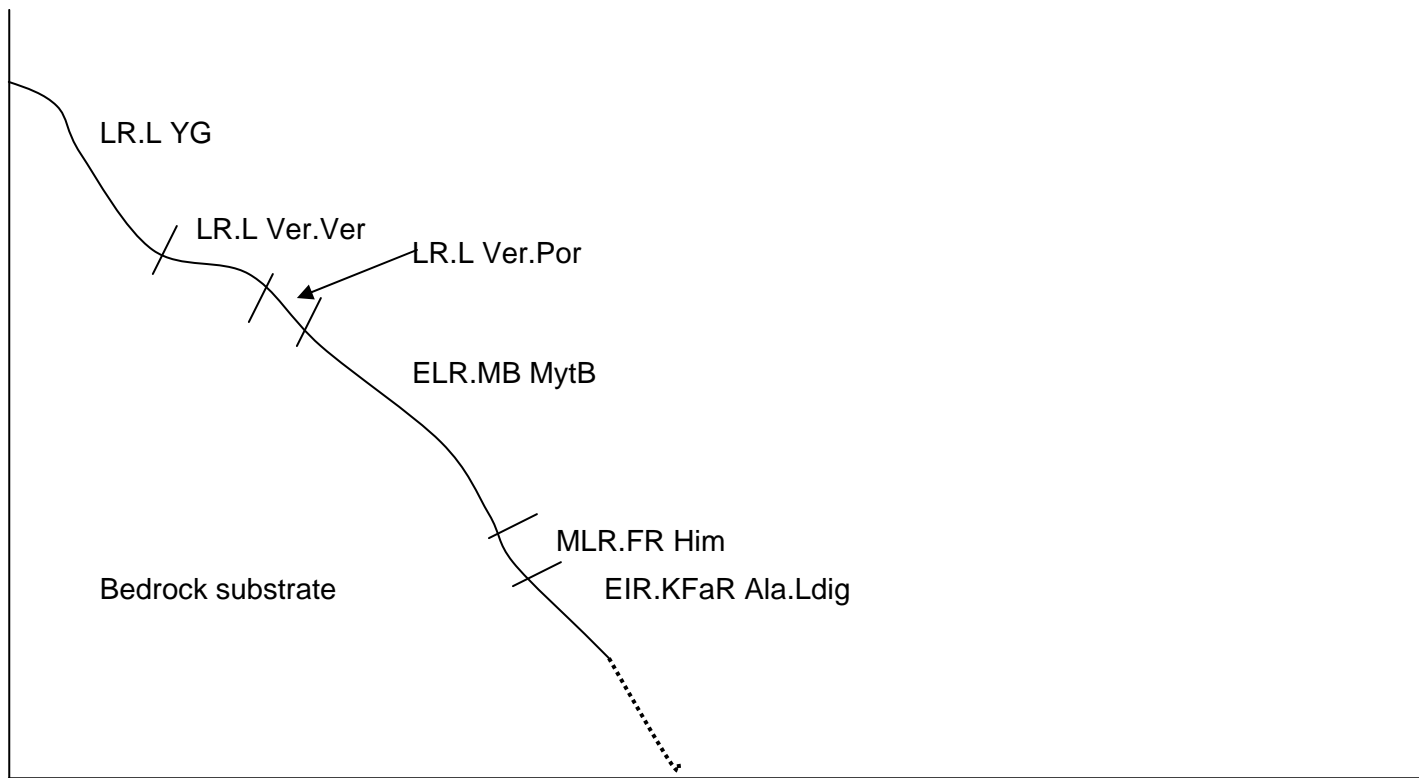
09/09/04

Map 33

Profile 10 (53PR)

73





Sullom Voe Survey

Site 3

10/09/04

Map 20

Profile 12 (69PR)

LGS.S Tal

Sparse SLR.F Fspi

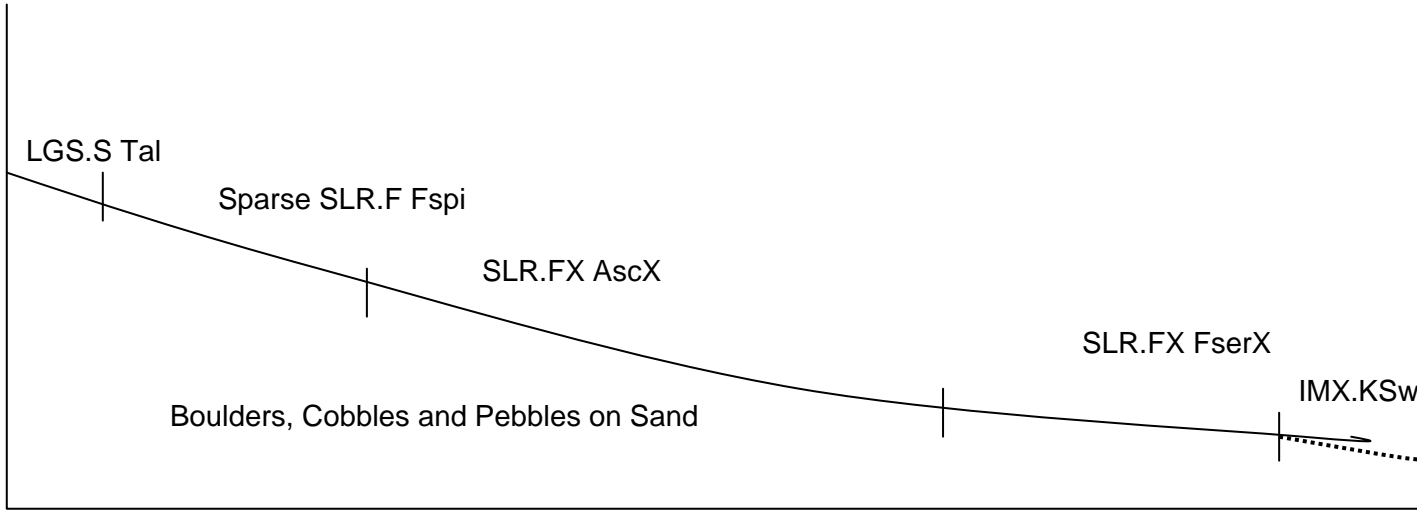
SLR.FX AscX

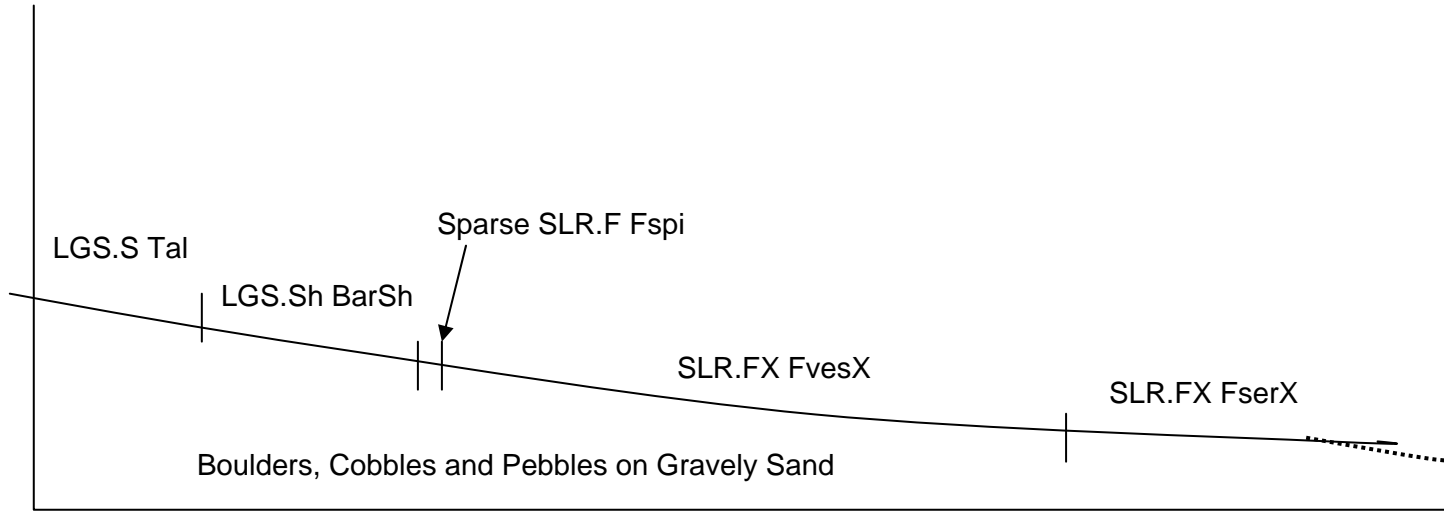
SLR.FX FserX

IMX.KSwMx LsacX

Boulders, Cobbles and Pebbles on Sand

75





1. Small rock pools LR.Rkp Cor

LR.L YG

LR.L Ver.Ver

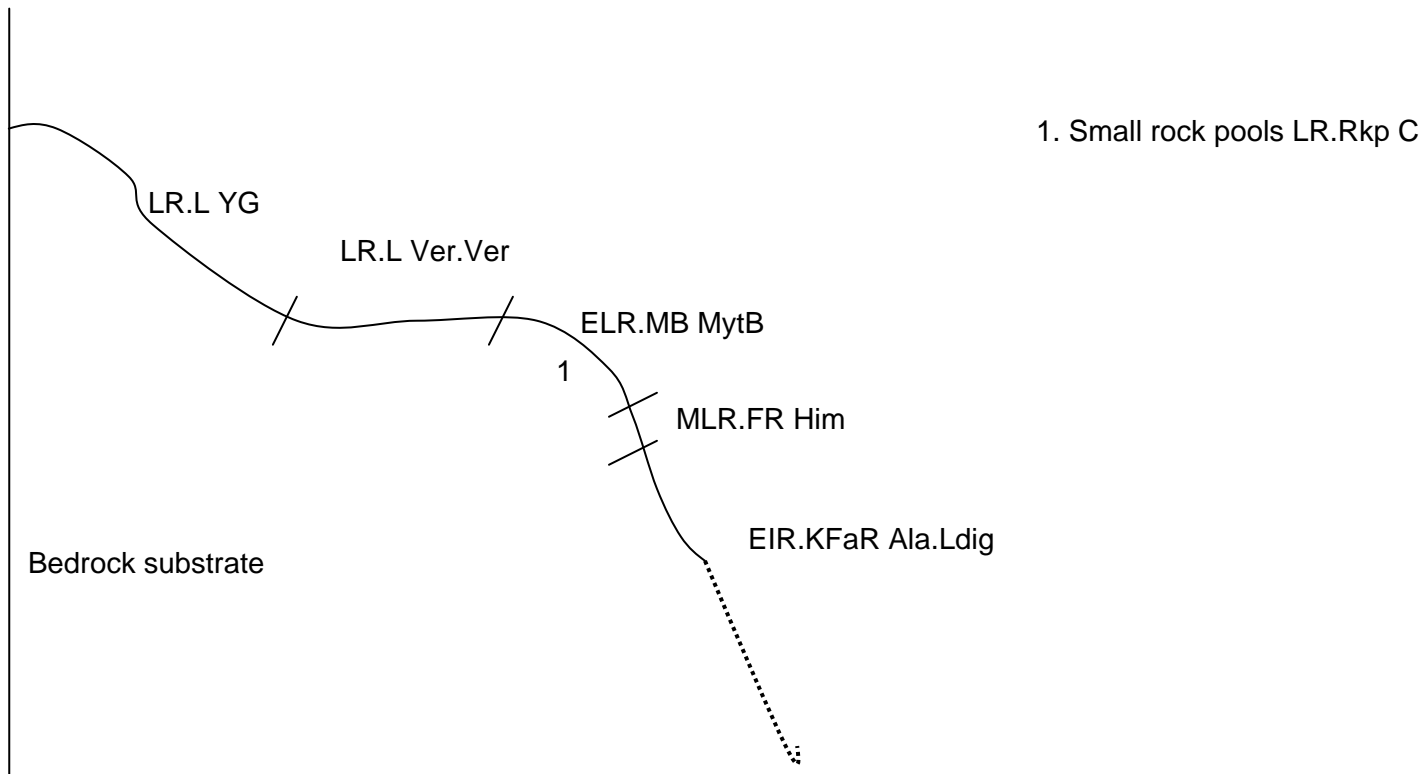
ELR.MB MytB

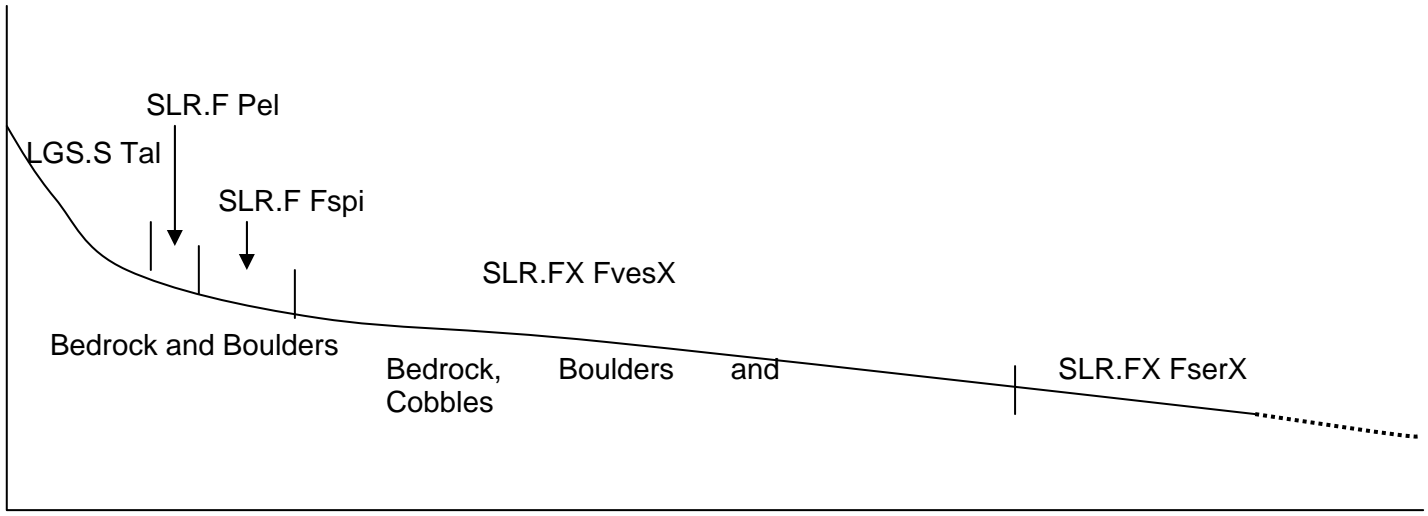
1

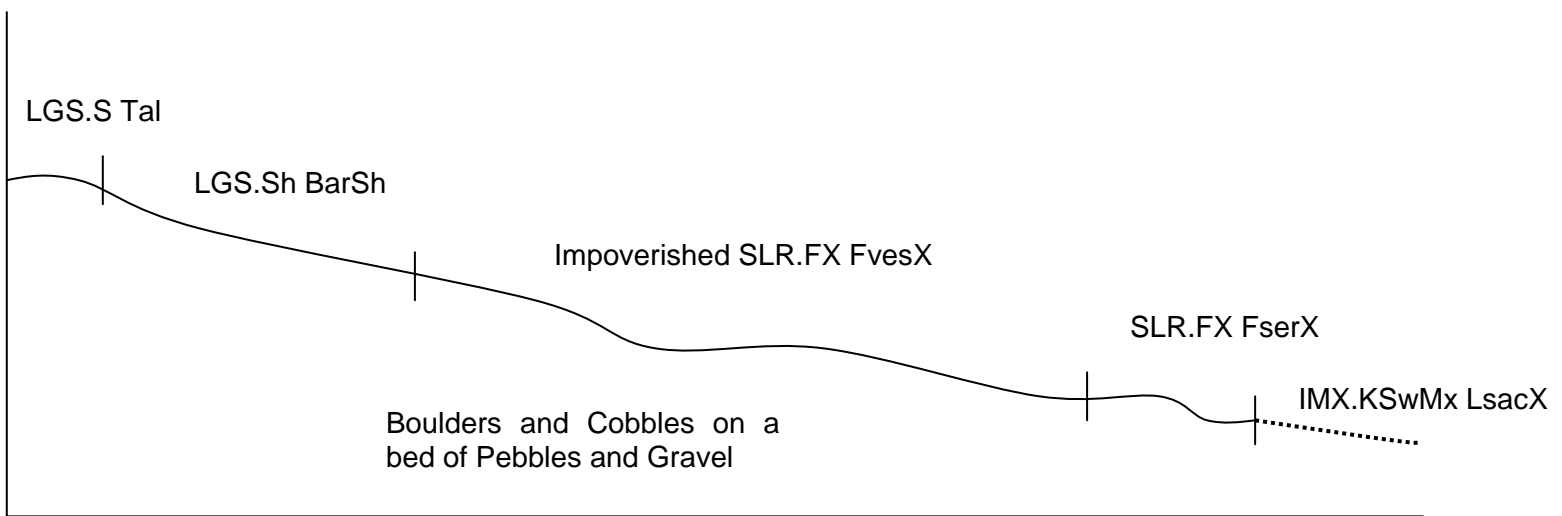
MLR.FR Him

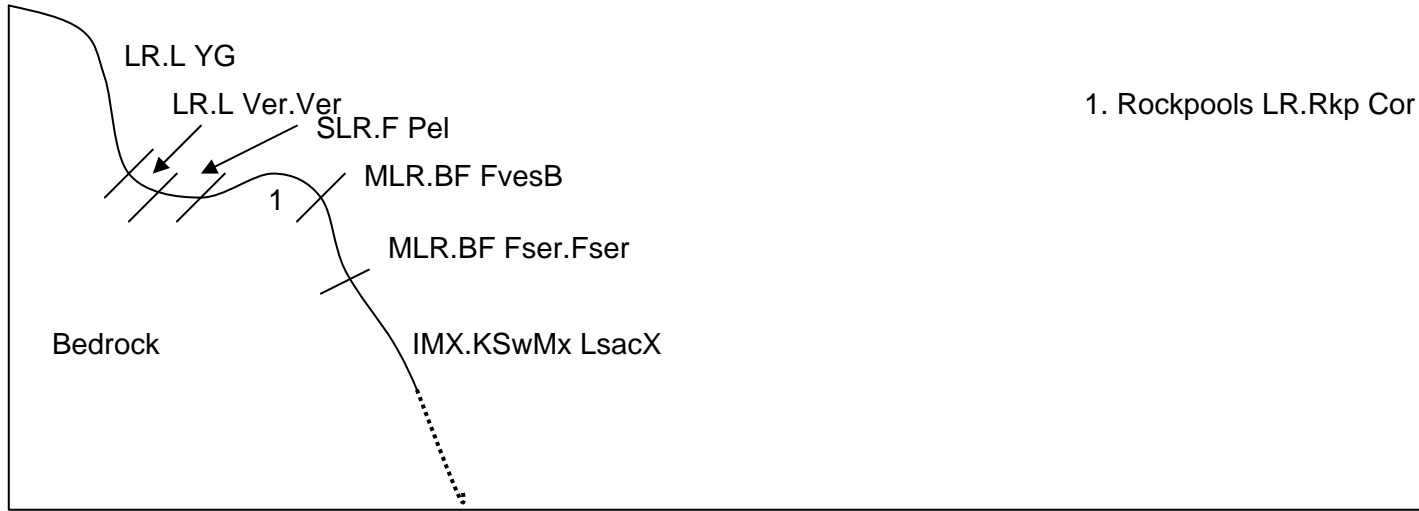
EIR.KFaR Ala.Ldig

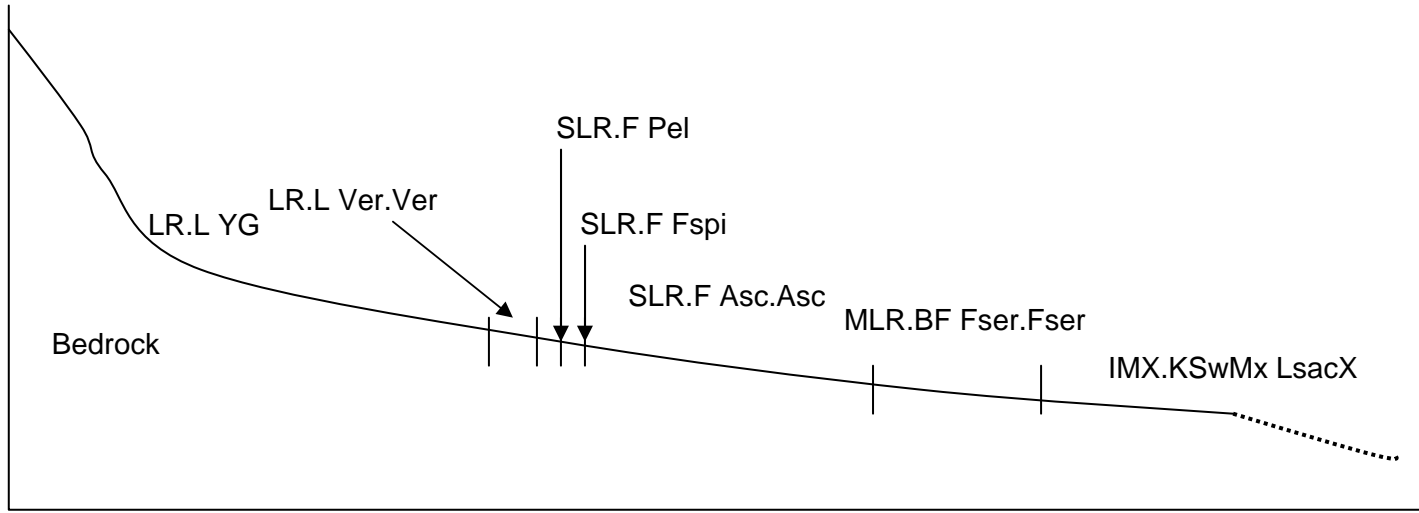
Bedrock substrate





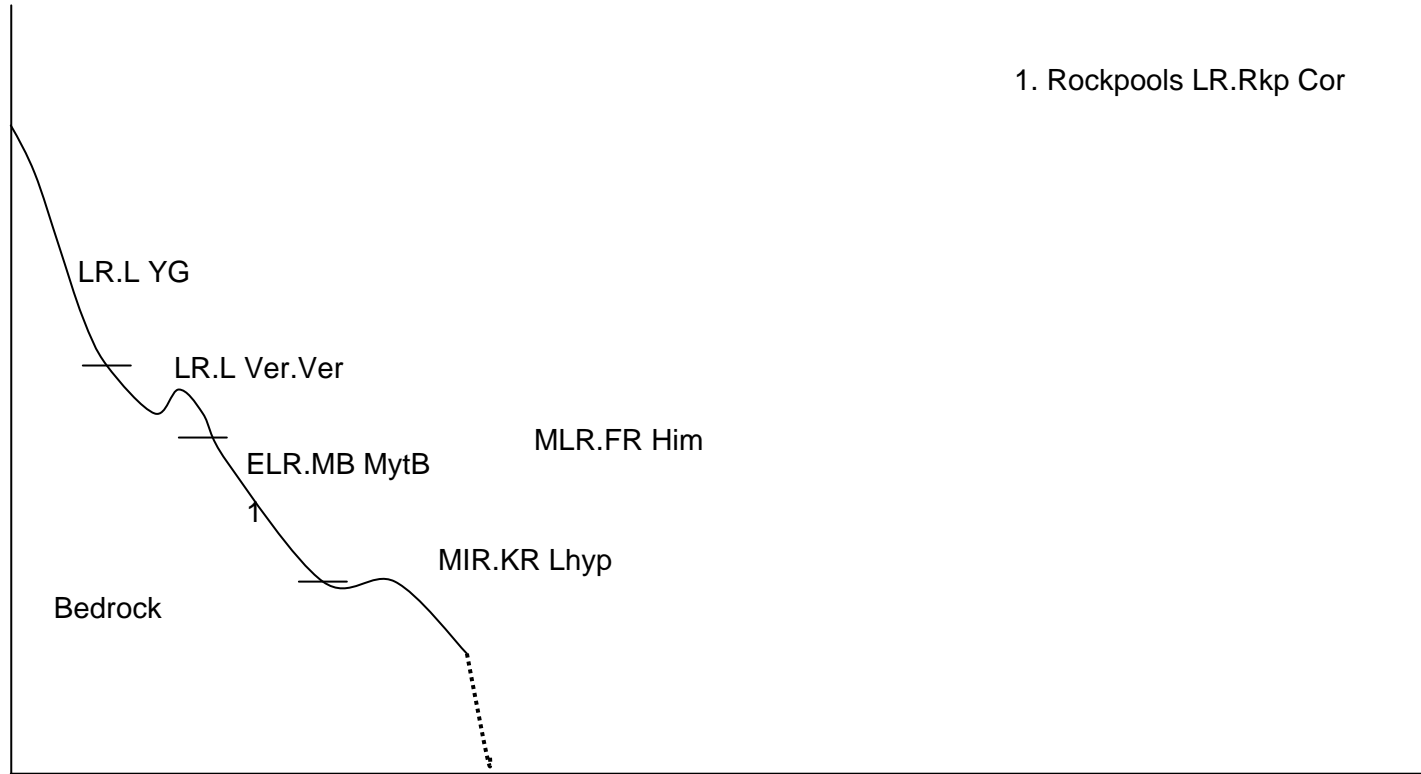


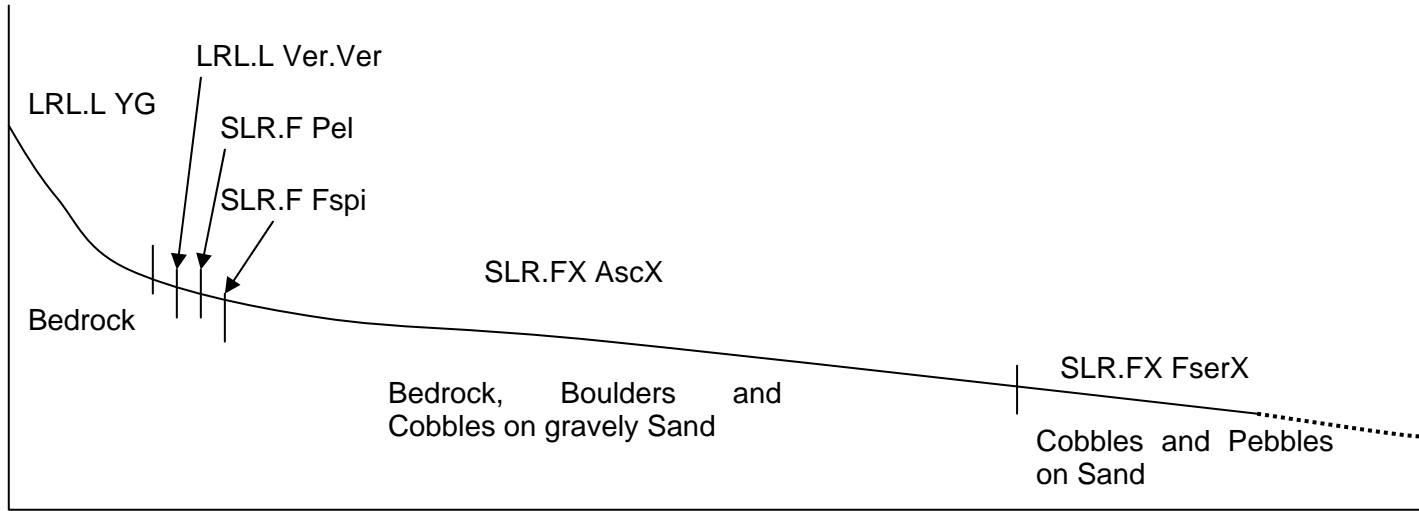


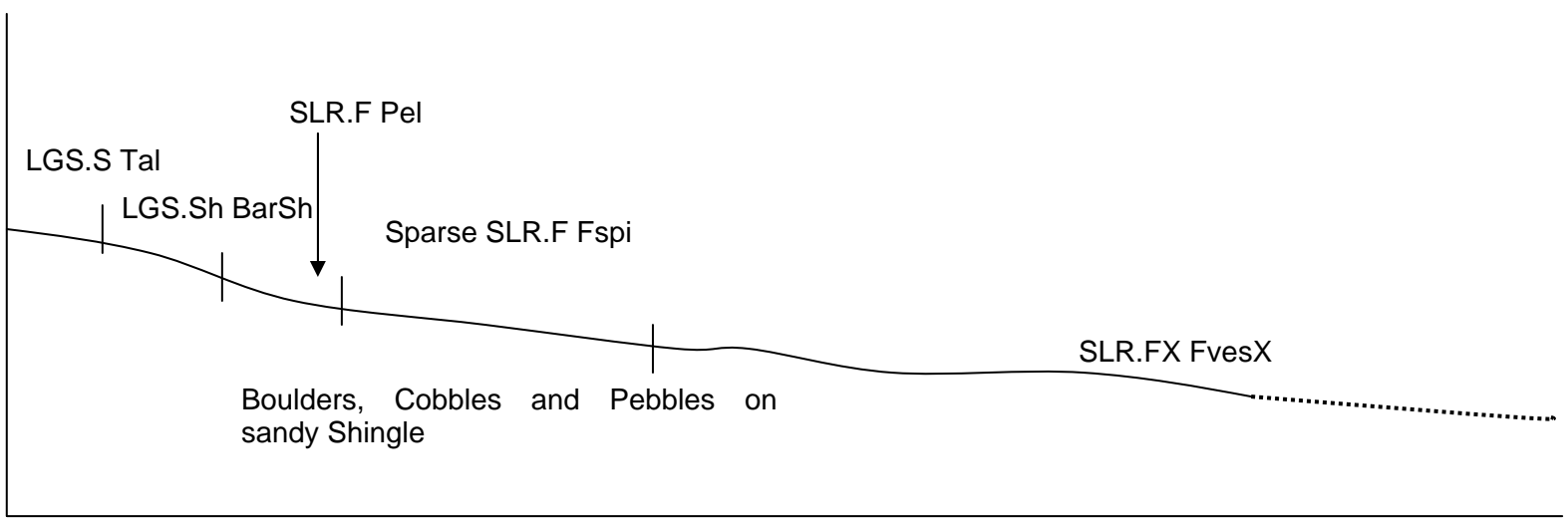


1. Rockpools LR.Rkp Cor

82







Sullom Voe Survey

Site 4

12/09/04

Map 7

Profile 22 (129PR)

LGS.S Tal

Sparse SLR.F Pel

SLR.F Fspi

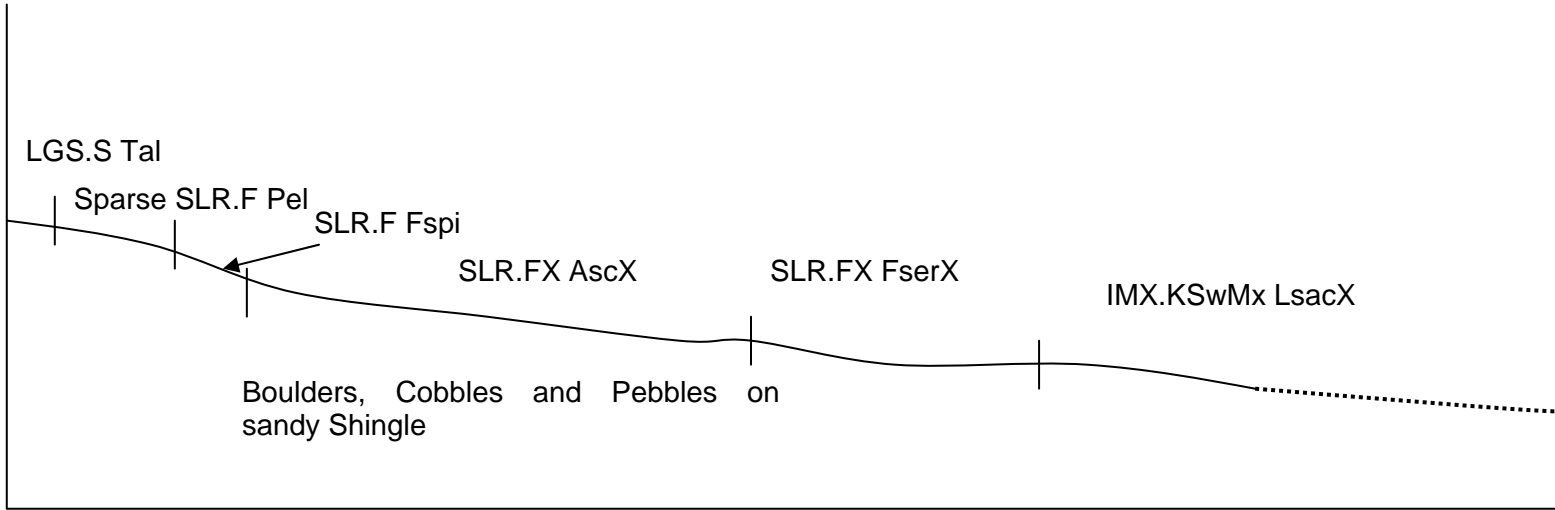
SLR.FX AscX

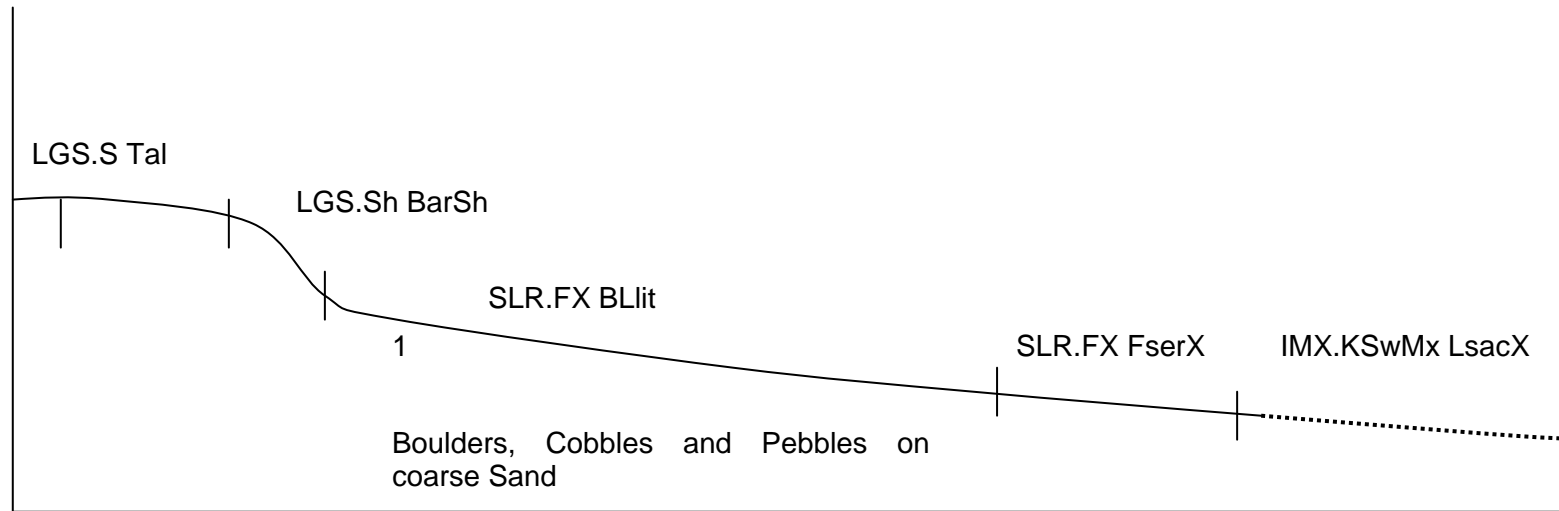
SLR.FX FserX

IMX.KSwMx LsacX

Boulders, Cobbles and Pebbles on
sandy Shingle

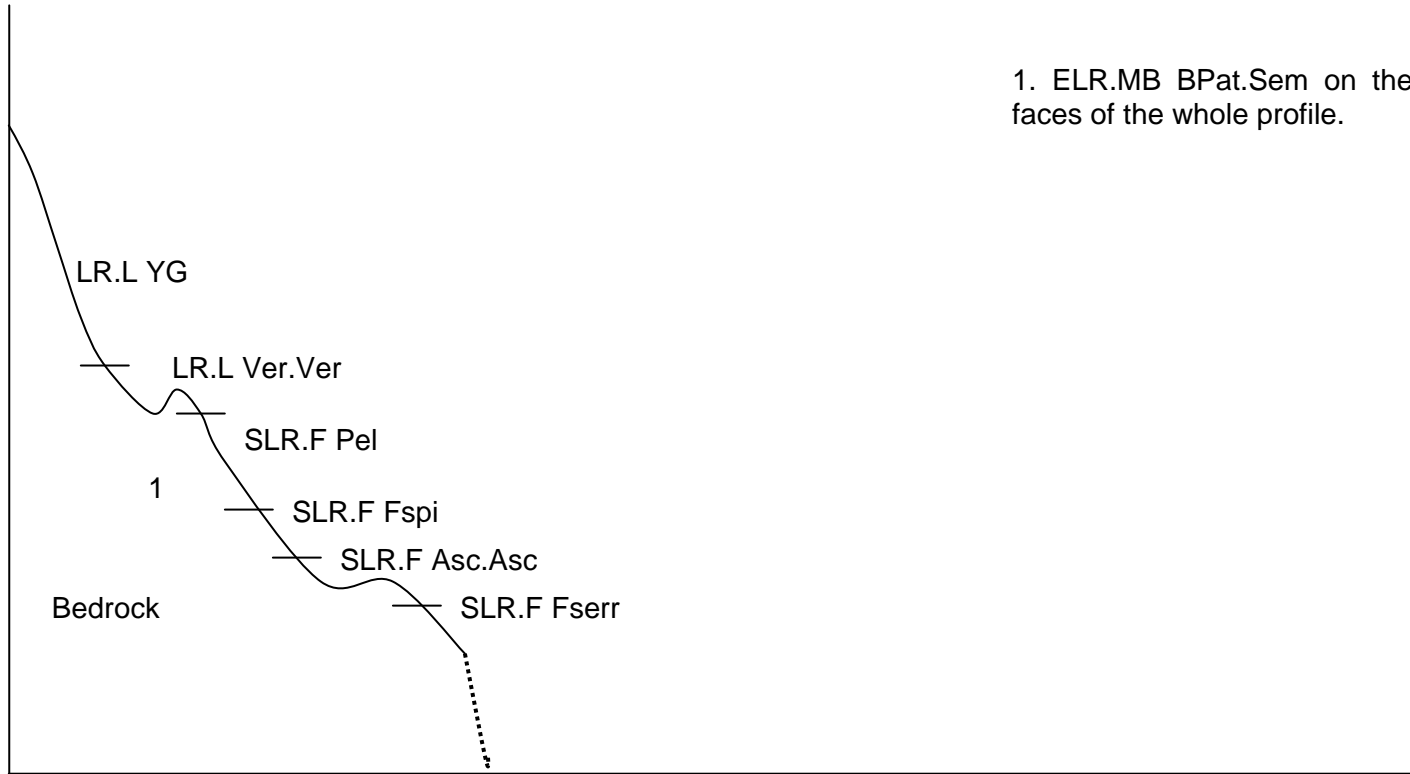
85

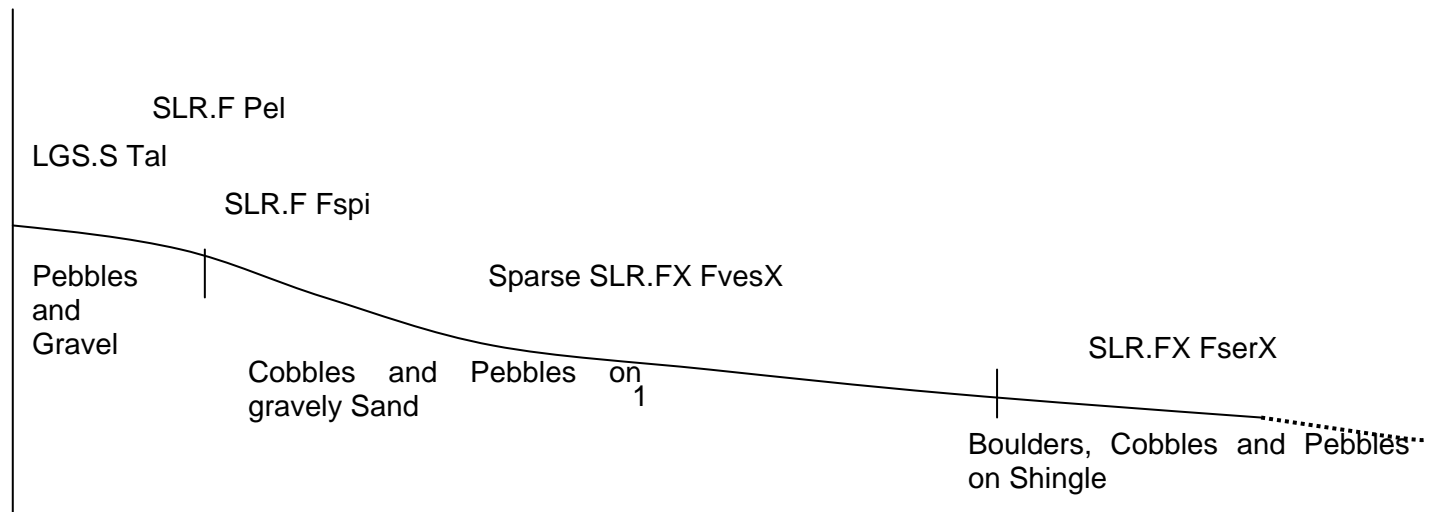




1. Scattered *Fucus vesiculosus* and *Porphyra linearis* on boulders. Under stones *Littorina saxatilis*, *Carcinus*, *Mytilus* and Gammarids are present.

1. ELR.MB BPat.Sem on the steeper faces of the whole profile.

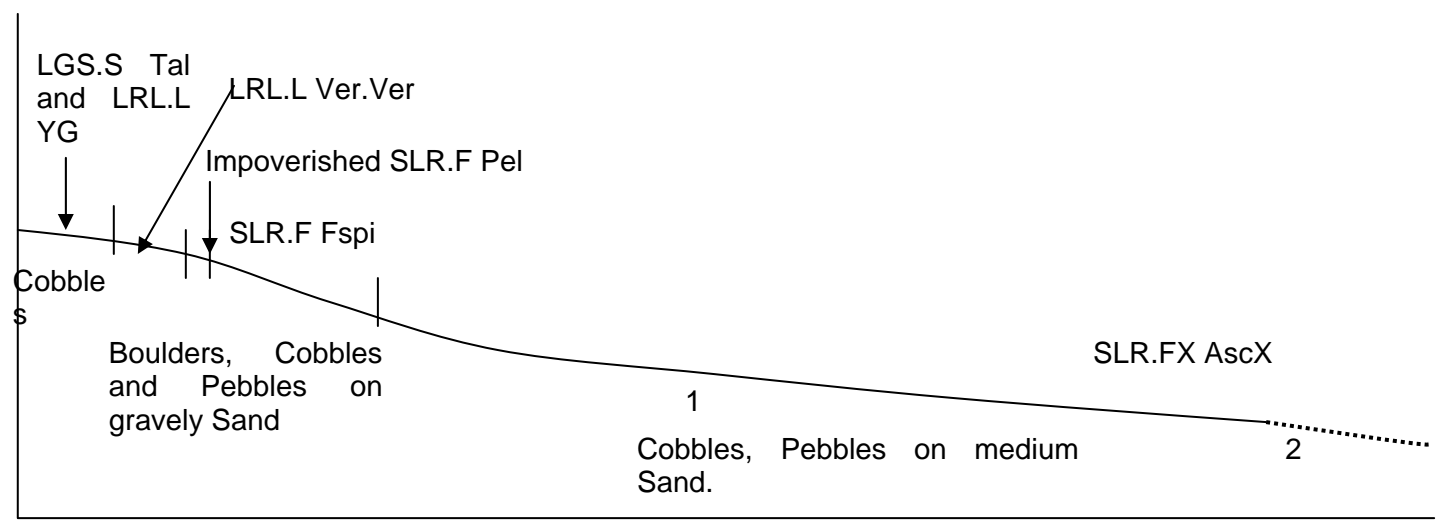




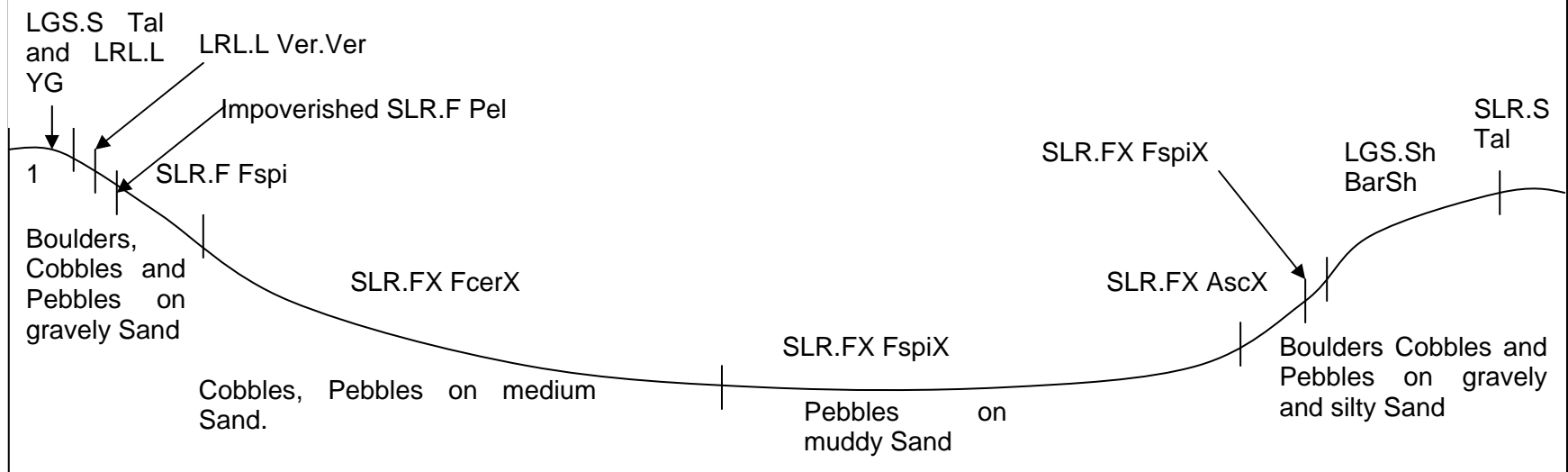
1. *Scololepis squamata* abundant.

Also present:

Small *Mytilus* and *Littorina saxatilis* under stones
and *Porphyra linearis* attached to pebbles.



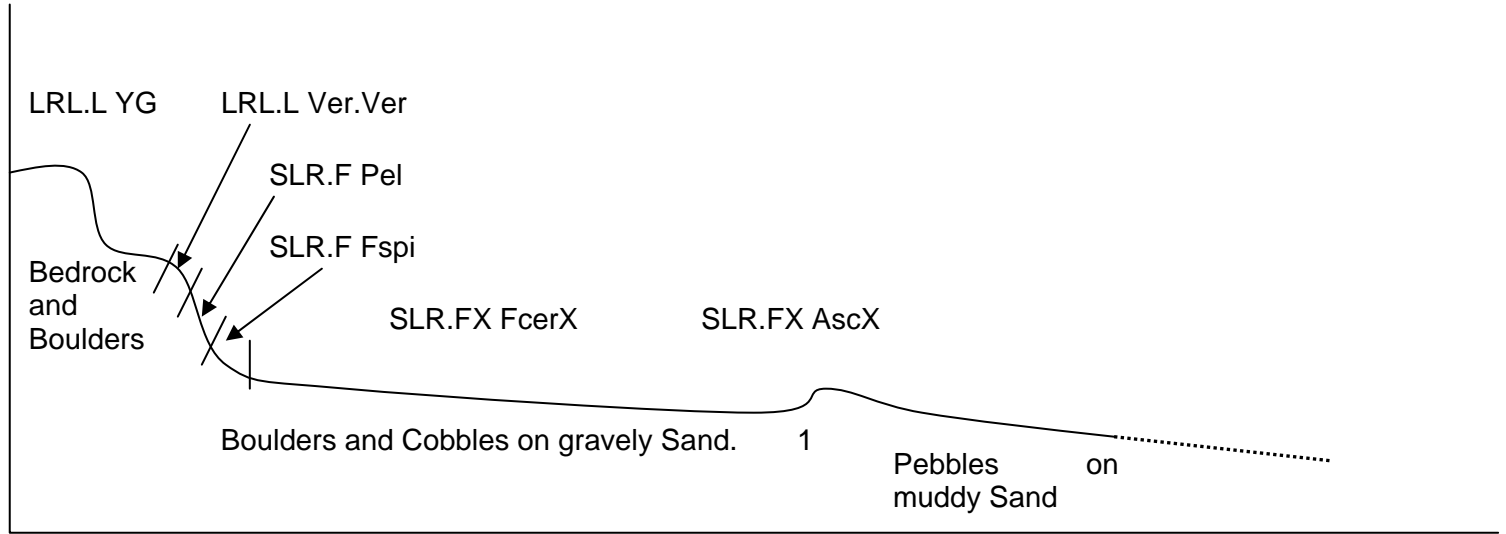
1. Patchy SLR.FX FcerX
2. SLR.FX AscX may spread across the whole bay



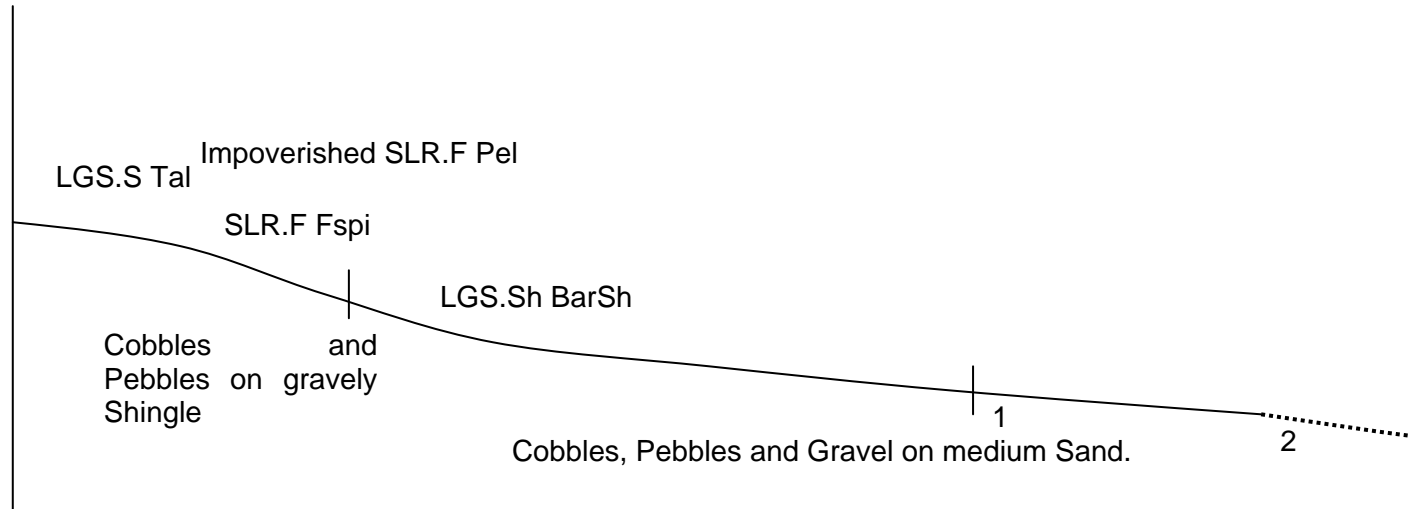
06

3. 139PR (start of Profile)

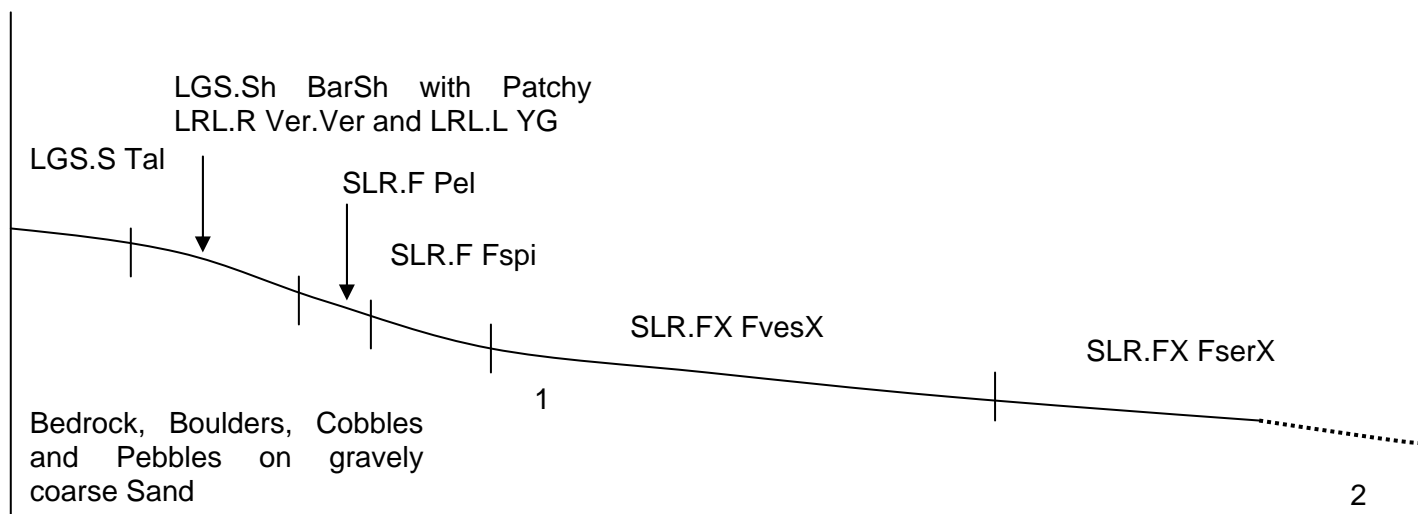
91



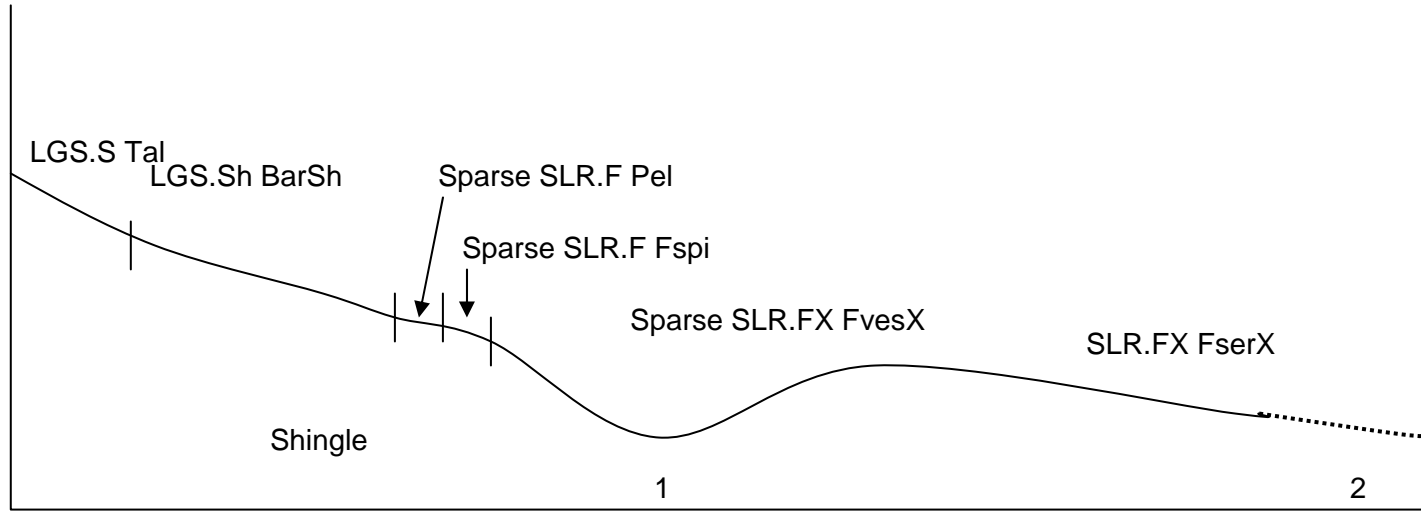
4. SLR.FX FvesX patches within the SLR.FX AscX



1. *Entromorpha* and *Porphyra* are abundant, *Littorina saxatilis* is occasional, *Fucus vesiculosus* is between 1-5% cover, *Semibalanus balanoides* is present on some of the cobbles and Nereidae are under a few of the cobbles.
2. *Dictyosiphon* is present in the sublitoral with filamentous brown epiphytes.



1. *Fucus vesiculosus* is abundant and *Ascophyllum nodosum* is common.
2. *Chorda*, *Halydris*, and *Laminaria hyperborea* and mixed in the sub-littoral.



- 3. Freshwater Influence
- 4. *Mastocarpus* present

LGS.S Tal and
LRL.L YG

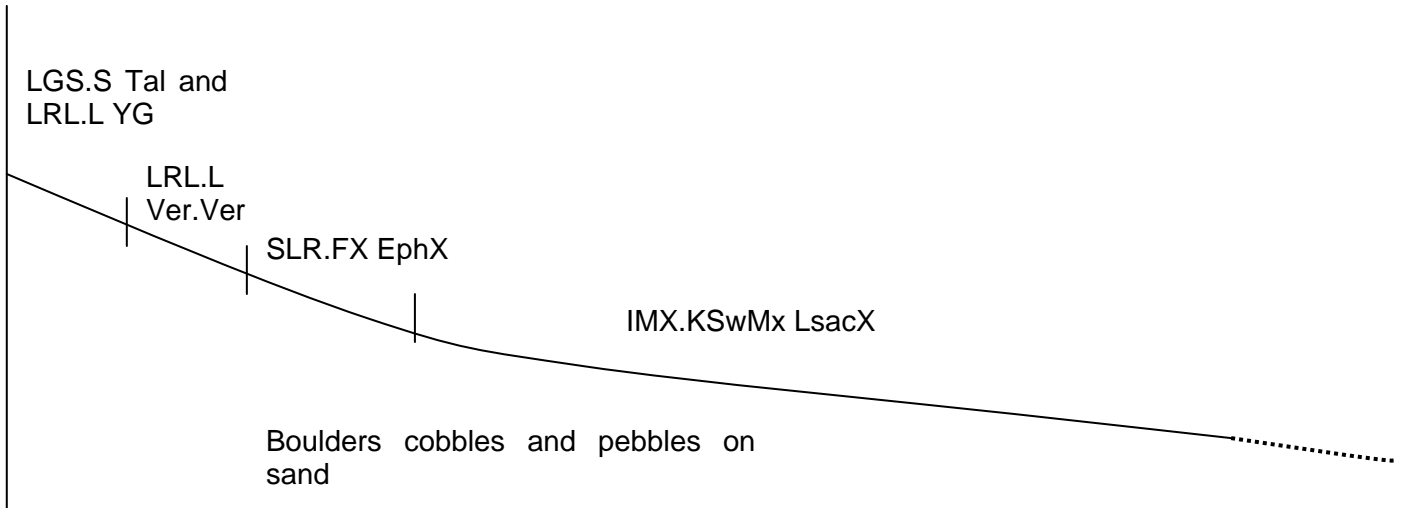
LRL.L
Ver.Ver

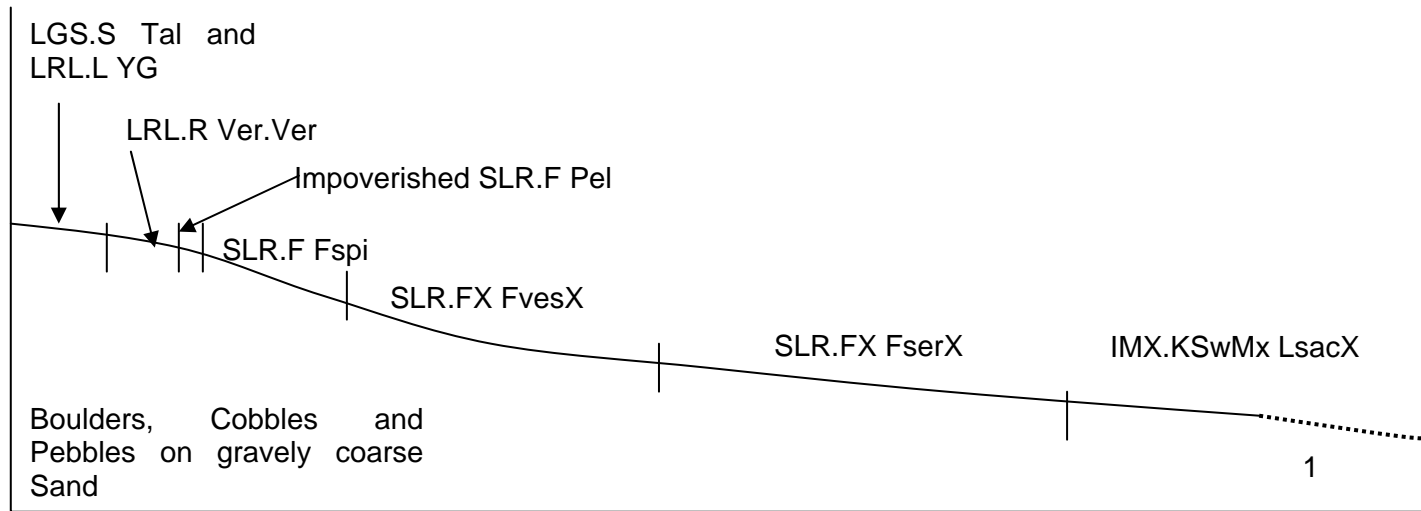
SLR.FX EphX

IMX.KSwMx LsacX

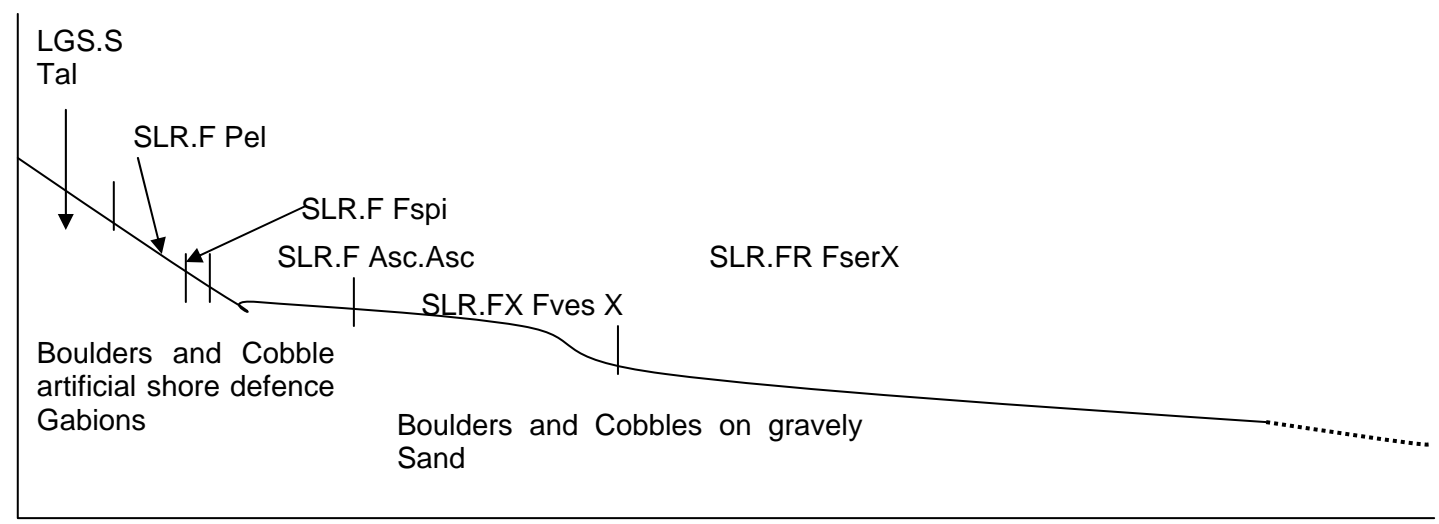
Boulders cobbles and pebbles on
sand

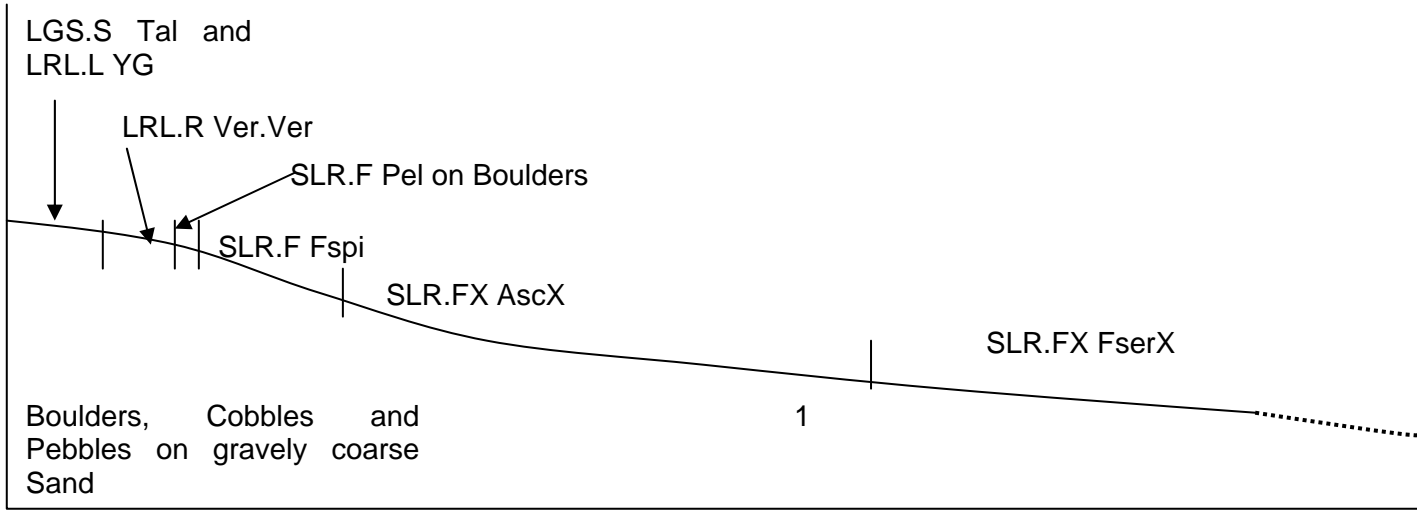
96



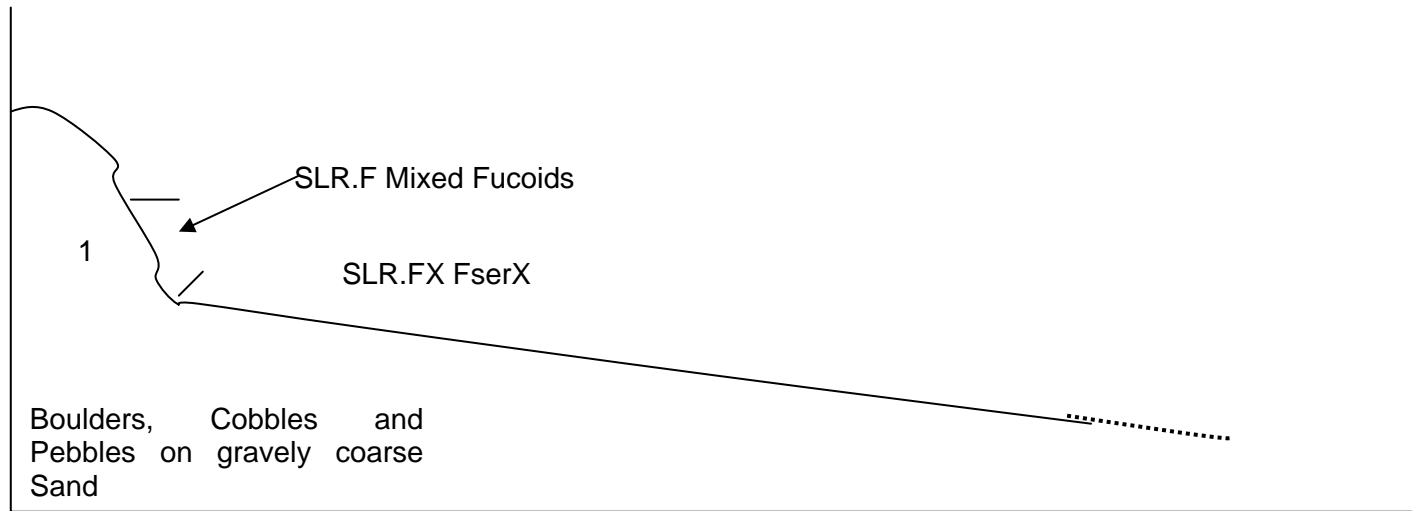


5. Also present *Laminaria hyperborea* and *Lamanaria digitata* both in cape forms attached to boulders and pebbles.





6. Large *Mytilus* Occasional



7. Mixture of *Ascophyllum*, *F. vesiculosus*, *F. spiralis*, and patches of ELR.MB BPat.Sem

Sullom Voe Survey

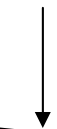
Site 3

16/09/04

Map 18

Profile 37 (178PR)

LGS.S Tal



LGS.Sh BarSh

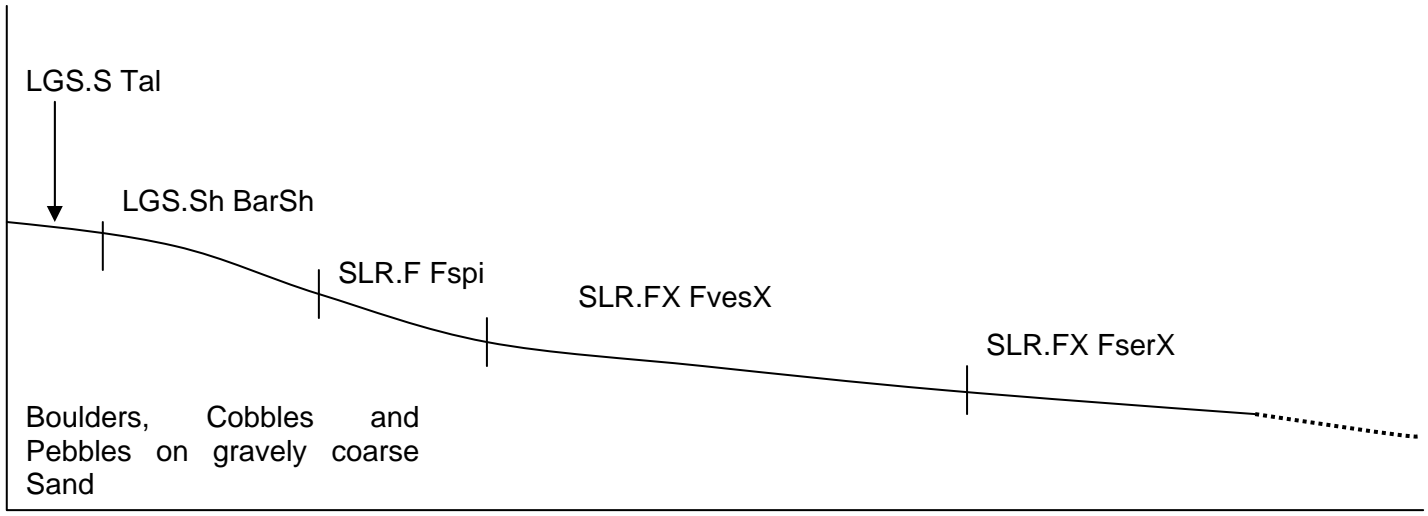
SLR.F Fspi

SLR.FX FvesX

SLR.FX FserX

Boulders, Cobbles and
Pebbles on gravely coarse
Sand

100



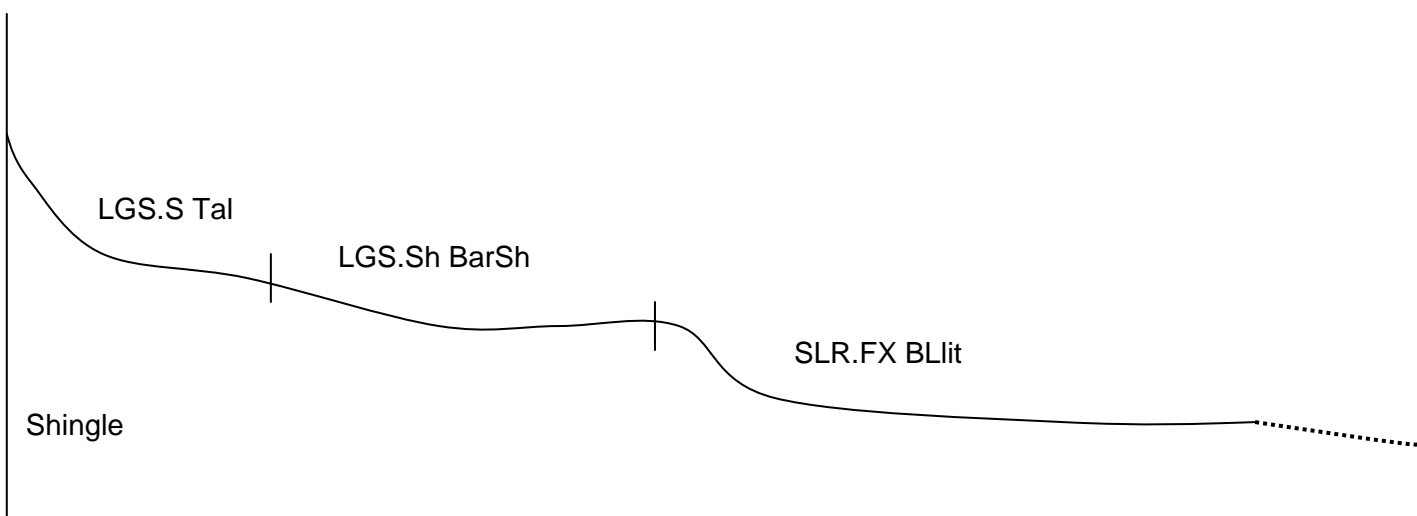
Sullom Voe Survey

Site 3

16/09/04

Map 18

Profile 38 (180PR)



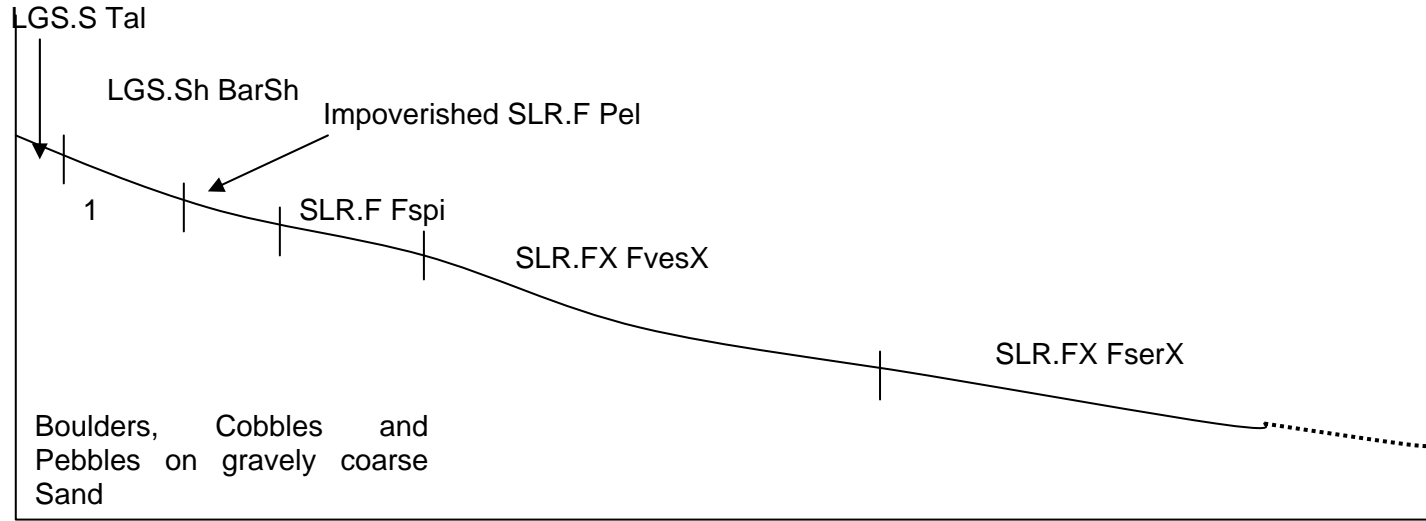
LGS.S Tal

LGS.Sh BarSh

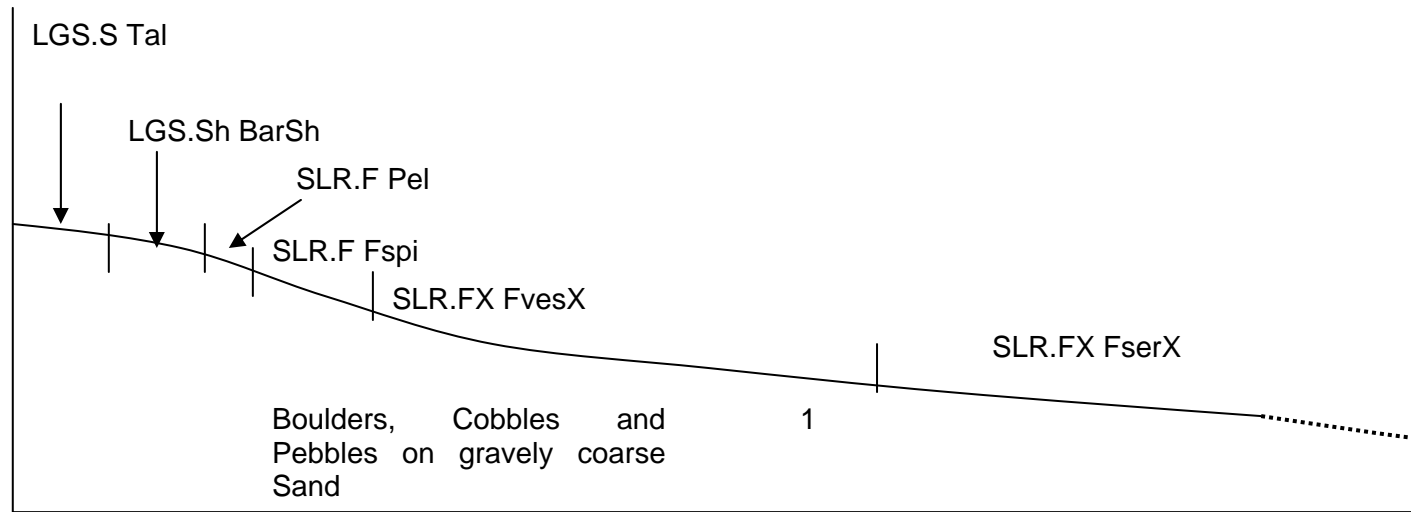
SLR.FX BLit

Shingle

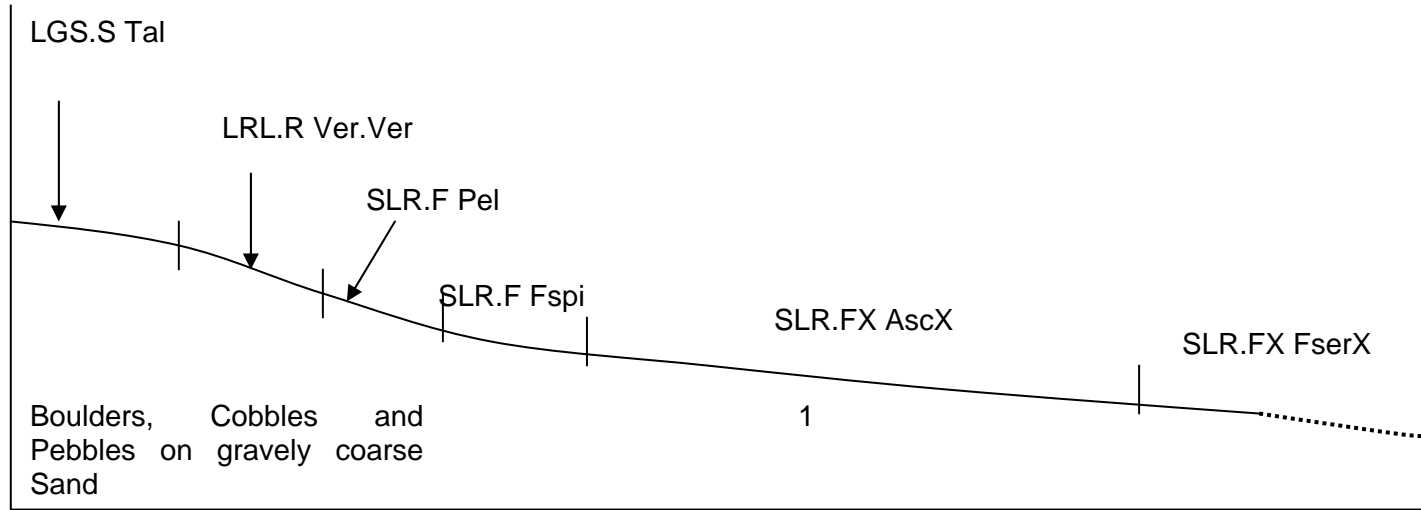
101



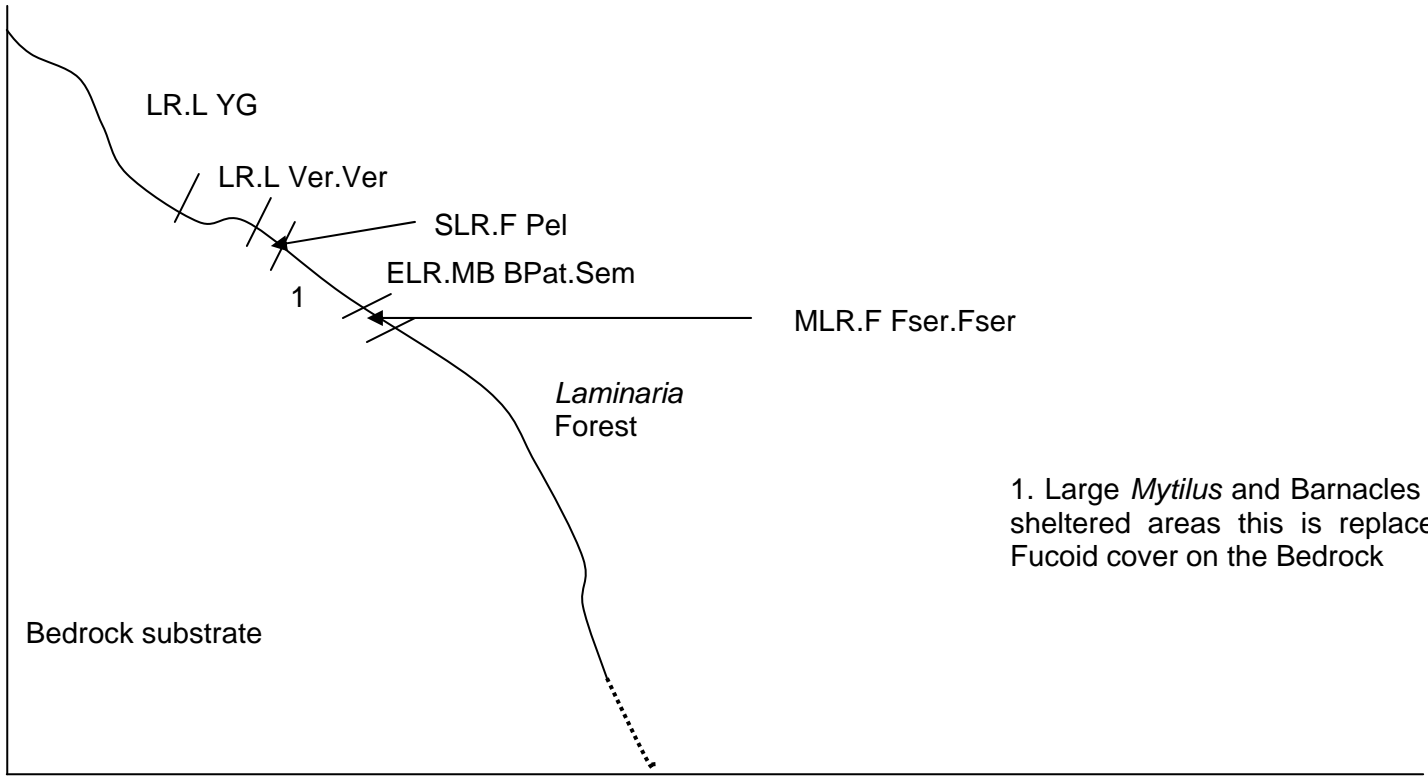
8. *Ligia oceanica* present



9. Also SLR.F F.ves present in small patches with some *Semibalanus balanoides*, *Patella*, and *Nucella* common.

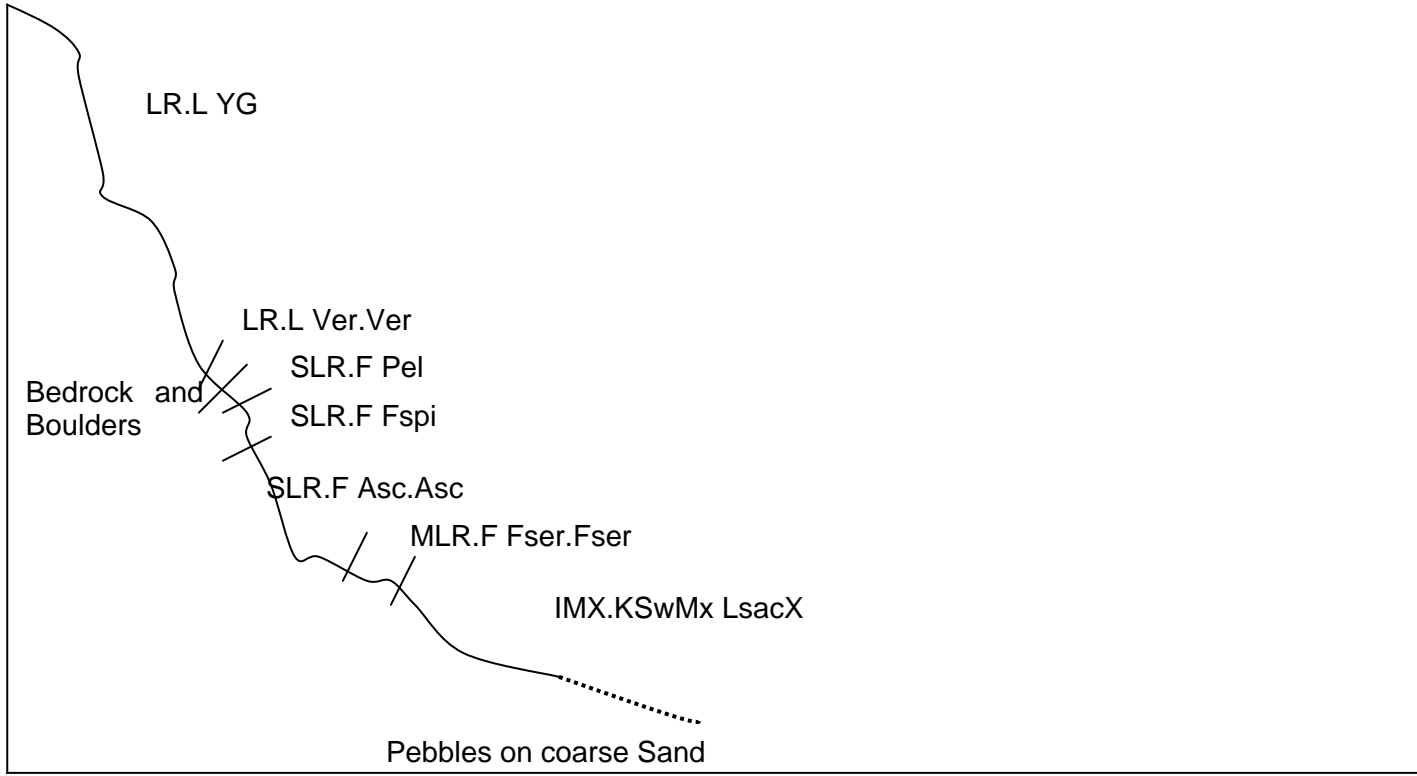


10. Also a mosaic of ELR.MB BPat.Sem and MLR.BF FvesB within the SLR.FX AscX biotope.

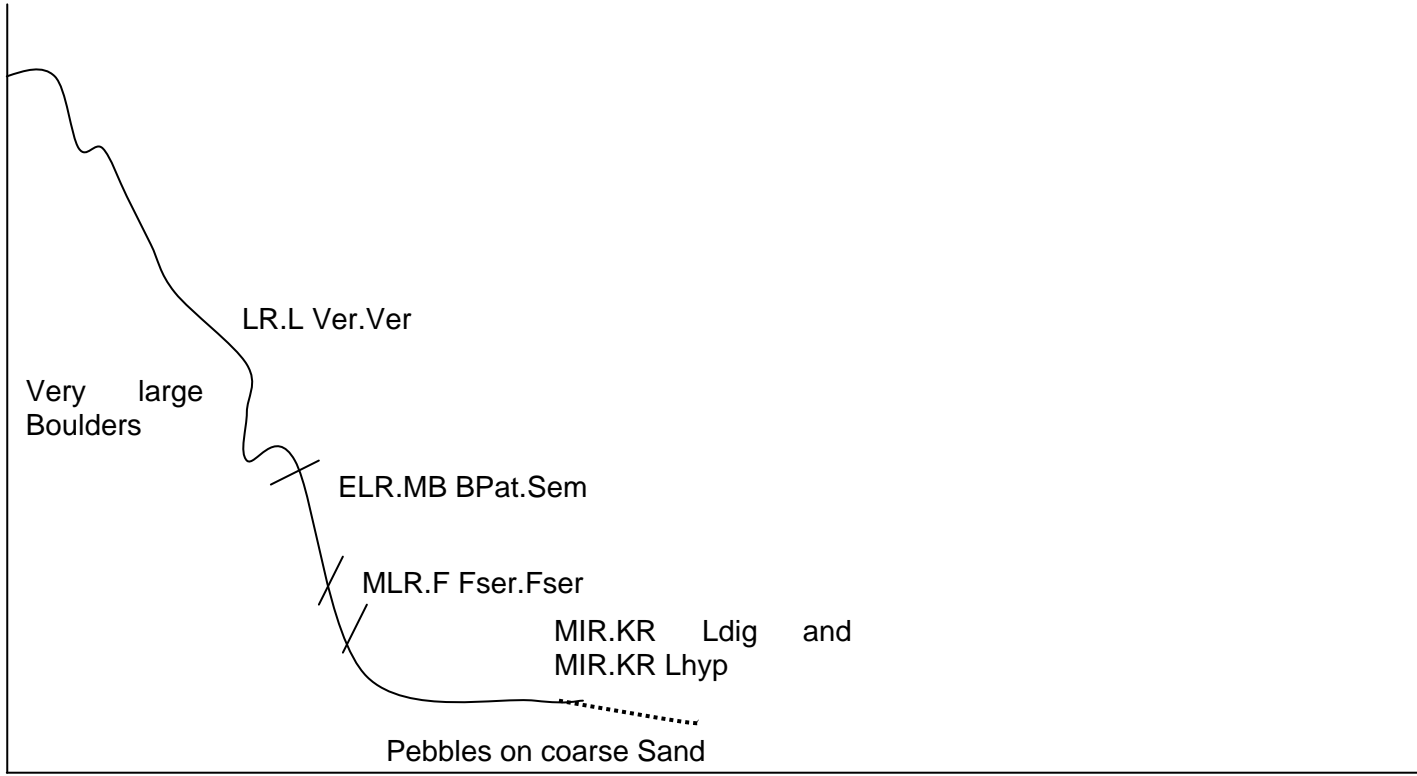


105

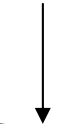
1. Large *Mytilus* and Barnacles common. In sheltered areas this is replaced by dense Furoid cover on the Bedrock



107



LGS.S Tal



LGS.S BarSnd

SLR.F Fspi mixed with
SLR.F Pel

Gravelly coarse
Sand

SLR.FX AscX

SLR.FX FserX

MIR.KR Lhyp

Boulders, Cobbles and
Pebbles on gravelly coarse
Sand

APPENDIX B Sublittoral biotope mapping survey

Section B1 – Calibration procedures

Section B2 – QC and calibration data, including navigational data

Table B1 - Video log from Sullom Voe sublittoral biotope mapping survey

B1 Calibration Procedure

Below are the standard calibration procedures carried out for GeoSwath Plus and RoxAnn.

B1.1 GeoSwath Calibration

The procedure for performing a calibration given below assumes that the vessel has moved into a position where the sea bed is relatively smooth, and where there is a slope (such as on a shallow bank). If the seabed terrain is unknown, then a few trial lines can be run and the data examined to determine whether the area is suitable for calibration.

The length of these survey lines again all depends on the seabed terrain, however GeoAcoustics recommends that they be less than 500m long. Using latency as an example, if the change in depth occurs very gradually then long lines will be required in order to accurately determine the calibration value. However, if the depth changes rapidly as for dredged channels then relatively short lines may be run. There are no hard and fast rules, but the time spent on ensuring that the relevant seabed terrain is found and length of lines longer rather than shorter will yield the best calibration parameters and ultimately the highest quality survey.

If the right patch of seabed can be found then all the calibration parameters may be determined from as little as four survey lines run as illustrated below.

General GS+ calibration (patch test) requirements are as follows:

Latency

A line run at normal survey speed ($\sim 2\text{ms}^{-1}$) runs over one of the following:

- a. A steep slope, perpendicular to contours.
- b. A dredged channel, perpendicular to channel.

The same line is to be run again in the same direction at a faster speed ($\sim 3\text{ms}^{-1}$).

If the vessel is crabbing due to currents and the amount of crabbing is different for the two lines then the line direction should be adjusted to reduce the effect. If this is not possible then a new latency calibration site should be chosen.

Roll

Three lines are to be run in opposite directions with 100% overlap in data, i.e. if ping length is 50m the line spacing should be a maximum of 50m. The lines are to be run at normal survey speed (2ms^{-1}) over a flat seabed. Line direction should be chosen to minimise vessel crabbing.

Pitch & Yaw

For most shallow water surveys using standard GeoAcoustics 'V' plate assembly the pitch offset may be assumed to be zero. Three lines are to be run in opposite directions with 100% overlap in data, i.e. if ping length is 50m the line spacing should be a maximum of 50m.

The lines are to be run at normal survey speed ($\sim 2\text{ms}^{-1}$) over one of the following:

- a. A steep slope, perpendicular to contours.
- b. A dredged channel, perpendicular to channel.

Line direction or location should be chosen to minimise vessel crabbing.

Transducer and GPS antenna offsets

These will be accurately measured and entered prior to processing of calibration data.

Sound Velocity Profiles

Before processing the calibration lines it is essential that adequate sound velocity profiles are taken.

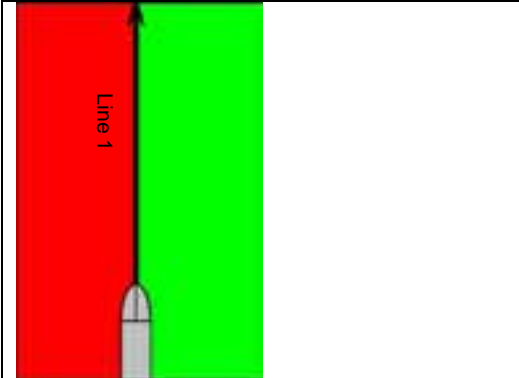
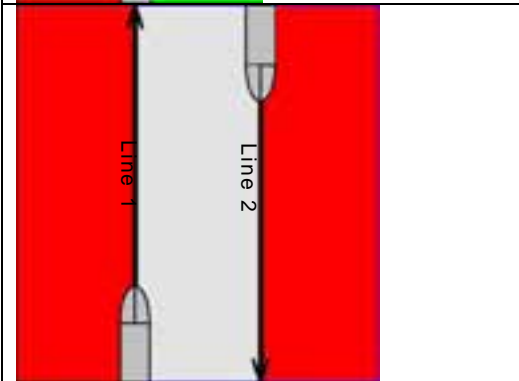
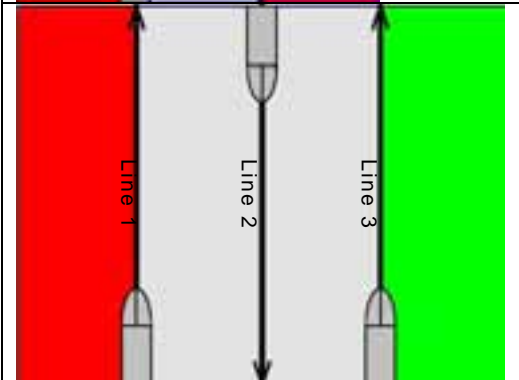
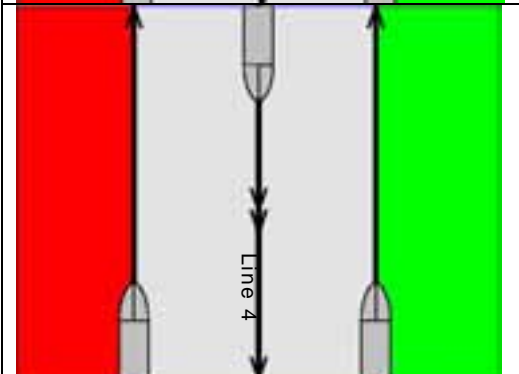
Tide Data

Use of accurate tide data is an essential requirement for processing of calibration data.

B1.2 RoxAnn Calibration

The system is calibrated when delivered from manufactures. This procedure involved positioning the vessel over substrates of know quality, Preferably soft mud in deeper water ($\sim 30\text{m}$), When positioned over these the calibration button is pressed and a value is given. This is then entered into the system and made permanent, if results are consistent and variable then there is no requirement to alter these settings. This procedure was carried out by Stenmar Sonarvison in July 2002.

Figure B1: Illustration of calibration lines carried out by the vessel during calibration

	<p>Line 1: In a straight line, At a constant Speed, Over a dredged channel (or flat area with a contour shift).</p>
	<p>Line 2: Straight line, opposite direction & parallel to the 1st line, At the same constant speed as the 1st line, Over the same dredged channel with 100% overlap.</p>
	<p>Line 3: Straight line, opposite direction & parallel to the 2nd line, At the same constant speed as the 1st & 2nd lines, Over the same dredged channel with 100% overlap.</p>
	<p>Line 4: Directly over line 2 and in same direction, At a faster speed (at least 2 knots faster) 100 % overlap.</p>

B2 QC and Calibration Data, Including Navigation Data

B2.1 Offsets

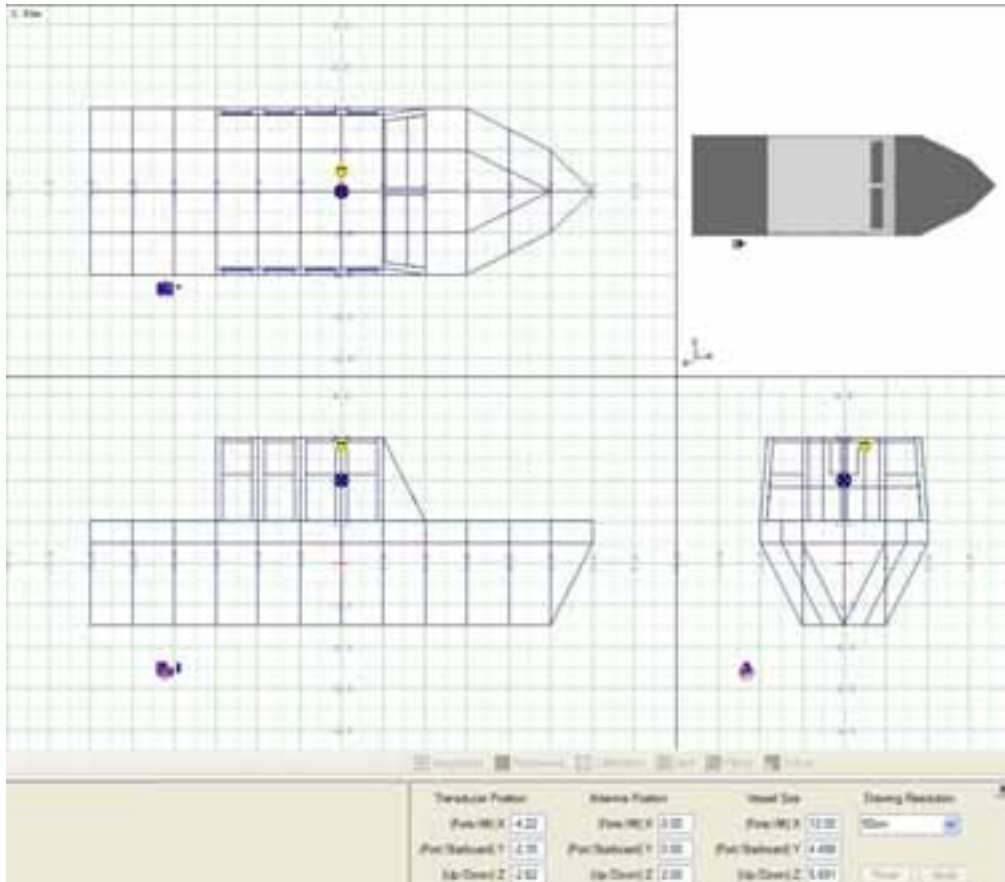


Figure B2 Offsets

B2.2 Calibration Image

After calibration the compensation values were:

Latency	-0.010 secs	0.010 secs	0.010 secs
Port	0.13°	0.00°	-2.40°
Starboard	0.54°	0.00°	-2.40°

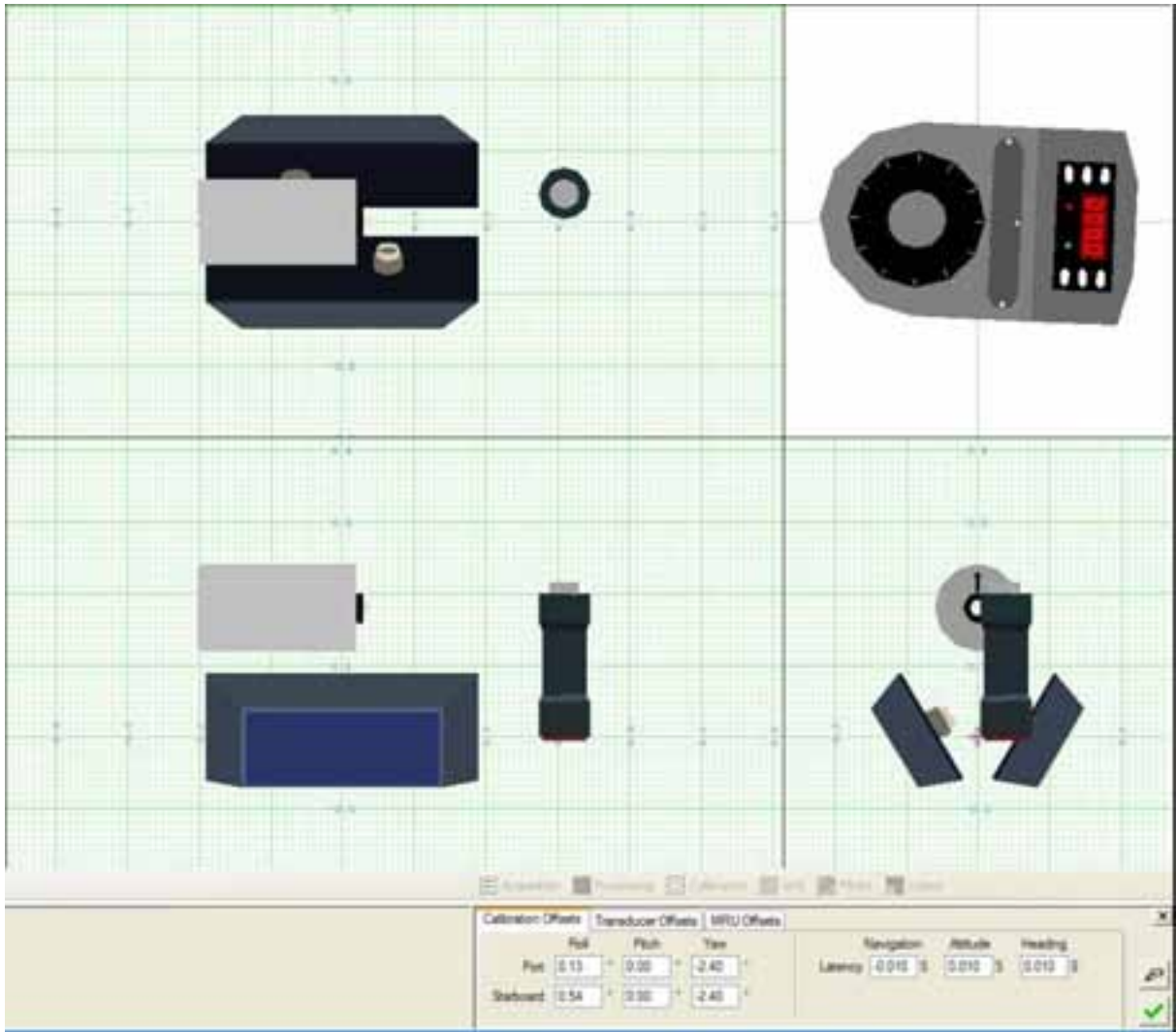


Figure B3 Image of calibration setting for GeoSwath


Table B1 - Video log from Sullom Voe sublittoral biotope mapping survey.

Depth	Habitat Description	Lifeform	Biotope	Biotope Complex	Additional Notes	Mussel Score
7.3	Muddy Sand	Kelp	SS.SMP.KSwSS.LsacR.Mu	SS.SMP.KSwSS		
14.1	Muddy Sand	Kelp	SS.SMP.KSwSS.LsacR.Mu	SS.SMP.KSwSS		
14.9	Mud	Mud	SS.SMU.CFiMu	SS.SMU.CFiMu		
15.3	Muddy Sand	Kelp	SS.SMP.KSwSS.LsacR.Mu	SS.SMP.KSwSS		
5.6	Muddy Sand	Kelp	SS.SMP.KSwSS.LsacR.Mu	SS.SMP.KSwSS		
39.1	Mud	SeaPens	SS.SMU.CFiMu.SpnMeg	SS.SMU.CFiMu		
11.7	Muddy Sand	Kelp	SS.SMP.KSwSS.LsacR.Mu	SS.SMP.KSwSS		
15.7	Muddy Sand	Kelp	SS.SMP.KSwSS.LsacR.Mu	SS.SMP.KSwSS		
50.7	Mud	SeaPens	SS.SMU.CFiMu.SpnMeg	SS.SMU.CFiMu		
26.8	Mud	SeaPens	SS.SMU.CFiMu.SpnMeg	SS.SMU.CFiMu		
12.7	Bedrock	Kelp	IR.LIR.K.Lsac	IR.MIR.KR		
6.3	Mixed	Kelp	IR.MIR.KR.LhypTx	IR.MIR.KR		
25	Bedrock	Brittlestars	CR.MCR.EcCr.FaAlCr.Bri	CR.MCR.EcCr.FaAlCr		
28.5	Sandy Mud	Sandy Mud	SS.SMU.CSaMu	SS.SMU.CSaMu		
8.6	Bedrock	Kelp	IR.MIR.KR.LhypT	IR.MIR.KR		
21.6	Bedrock	Algal Turf	IR.MIR.KT.FilRVS	IR.HIR.KFaR.FoR		
14.9	Mixed	Kelp	SS.SMP.KSwSS	SS.SMP.KSwSS		
15.9	Mixed	Kelp	SS.SMP.KSwSS	SS.SMP.KSwSS		
18.4	Mixed	Kelp	SS.SMP.KSwSS	SS.SMP.KSwSS		
6.5	Mixed	Kelp	SS.SMP.KSwSS.FilG	SS.SMP.KSwSS		
16.2	Sand	Algal Turf	SS.SMX.IMx	SS.SMX.IMx		
14.2	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
2.9	Sand	Sand	SS.SSA.IFiSa	SS.SMU.ISaMu		
27.1	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu		
16.1	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		

Depth	Habitat Description	Lifeform	Biotope	Biotope Complex	Additional Notes	Mussel Score
7.8	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
16.4	Bedrock	Algal Turf	IR.HIR.KFaR.FoR	IR.HIR.KFaR.FoR		
3.4	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
23.1	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
14.8	Sand	Algal Turf	SS.SCS.ICs	SS.SCS		
10.1	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
18.4	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
10	Cobbles	Faunal Crusts	SS.SCS.CCS.PomB	SS.SCS		
18.3	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
10	Mixed	Mixed	SS.SMX.CMx	SS.SMX.CMx		
3	Muddy Sand	Sand	SS.SSA.IMuSa	SS.SMU.CSaMu		
13	Mixed	Mixed	SS.SMX.CMx	SS.SMX.CMx		
33	Sandy Mud	Sandy Mud	SS.SMU.CSaMu	SS.SMU.CSaMu		
44	Sandy Mud	Sandy Mud	SS.SMU.CSaMu	SS.SMU.CSaMu		
9	Mixed	Algal Turf	SS.SMX.IMx	SS.SMX.IMx		
36	Mud	SeaPens	SS.SMU.CFiMu.SpnMeg	SS.SMU.CFiMu		
15	Sandy Mud	Sandy Mud	SS.SMU.ISaMu	SS.SMU.ISaMu		
50	Mud	SeaPens	SS.SMU.CFiMu.SpnMeg	SS.SMU.CFiMu		
9.7	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
10.3	Bedrock	Kelp	IR.MIR.KR	IR.MIR.KR		
33.5	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu		
29.6	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu		
43.2	Mud	SeaPens	SS.SMU.CFiMu.SpnMeg	SS.SMU.CFiMu		
15	Bedrock	Kelp	IR.MIR.KR	IR.MIR.KR		
17.3	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu		
27.4	Cobbles	Algal Turf	SS.SMP.KSwSS.LsacR.CbPb	SS.SMP.KSwSS		

Depth	Habitat Description	Lifeform	Biotope	Biotope Complex	Additional Notes	Mussel Score
18.5	Mud	SeaPens	SS.SMU.CFiMu.SpMg	SS.SMU.CFiMu		
31.5	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu		
13.6	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
8.7	Sand	Kelp	SS.SMp.KSwSS.LsacCho	SS.SMP.KSwSS		
25.1	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
4.3	Sand	Kelp	SS.SMp.KSwSS.LsacCho	SS.SMP.KSwSS		
5.3	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
5	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
5.5	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
22.6	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
22.3	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
22.8	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
17.5	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
35	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
129	Muddy Sand	Kelp	SS.SMP.KSwSS.LsacR.Mu	SS.SMP.KSwSS		
19.4	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
19.4	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
18.8	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
19.3	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
13.3	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
11.2	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
20	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
15	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
21	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
22.2	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
Depth	Habitat Description	Lifeform	Biotope	Biotope Complex	Additional Notes	Mussel Score

14.7	Mixed	Scallop	SS.SMX.CMx	SS.SMX.CMx		
6.6	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS		
22	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	MEDIUM SAND	0
20	Mixed	Mixed	SS.SMX.IMx	SS.SMX.IMx	SAND	0
30.6	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu	SAND & GRAVEL	0
25	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu	MEDIUM SAND	0
30	Gravel	Gravel	SS.SCS.CCS	SS.SCS	COARSE SAND	0
31	Sandy Mud	SeaPens	SS.SMU.CSaMu.VirOphPmax	SS.SMU.CSaMu	COARSE SAND	0
25	Bedrock	Faunal Crusts	CR.MCR.EcCr.FaAlCr	CR.MCR.EcCr.FaAlCr	COARSE SAND	2
20	Bedrock	Algal Turf	IR.HIR.KFaR.FoR	IR.HIR.KFaR.FoR	COARSE SAND	1
16	Bedrock	Kelp	IR.MIR.KR	IR.MIR.KR	COARSE SAND	0
11	Bedrock	Kelp	IR.MIR.KR	IR.MIR.KR	SAND?	0
10	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	SAND	0
22	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	COARSE SAND	1
21	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	COARSE SAND	0
22	Mixed	Algal Turf	SS.SMX.IMx	SS.SMX.IMx	COARSE SAND	1
22	Mixed	Algal Turf	SS.SMX.IMx	SS.SMX.IMx	COARSE SAND	1
22.2	Mixed	Algal Turf	SS.SMX.IMx	SS.SMX.IMx	COARSE SAND	2
21	Mixed	Algal Turf	SS.SMX.IMx	SS.SMX.IMx	SAND	1
20	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	COARSE SAND	0
16	Sand	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	MEDIUM SAND	0
22	Sand	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	SAND	1
23	Mixed	Algal Turf	SS.SMX.IMx	SS.SMX.IMx	MEDIUM SAND	2
23	Mixed	Algal Turf	SS.SMX.IMx	SS.SMX.IMx	MEDIUM SAND	1
24	Mixed	Kelp	SS.SMP.KSwSS.LsacR	SS.SMP.KSwSS	COARSE SAND	2
21	Bedrock	Algal Turf	IR.HIR.KFaR.FoR	IR.HIR.KFaR.FoR	SHELL SAND	1
22	Cobbles	Kelp	SS.SMP.KSwSS.LsacR.CbPb	SS.SMP.KSwSS	MUSSELS	3



Scottish Natural Heritage is a government body responsible to the Scottish Government.

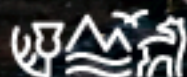
Statement of principles:

Scottish Natural Heritage – the government body that looks after all of Scotland's nature and landscapes, across all of Scotland, for everyone. Our 5 strategic priorities are:

- Caring for Scotland's nature and landscapes
- Helping to address climate change
- Delivering health and well being
- Supporting the Scottish economy
- Delivering a high quality public service

Find out more at www.snh.gov.uk

Policy and Advice Directorate,
Great Glen House,
Leachkin Road,
Inverness IV3 8NW
www.snh.gov.uk



Scottish Natural Heritage
All of nature for all of Scotland