MAPPING THE MARINE HABITATS OF MORECAMBE BAY

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NOTES:

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1 Introduction

The primary aim of the report is to provide data from a commissioned survey to be used for the characterisation the Annex I Habitat features within the selected Areas of Search, with particular emphasis on those features for which the area is likely to be designated as cSAC (reefs and sandbanks). This information will form a contribution to the knowledge of habitats within Morecambe Bay. The survey work consisted of acoustic remote sensing along tracks that crossed potential sandbank and reef areas (identified from the Desktop Survey) combined with grab and video ground truthing (Map 1, produced from the survey specifications provided by Royal Haskoning).

The survey was designed to fill gaps in knowledge from the desktop study by Royal Haskoning. The required survey work differed between the Areas of Search depending upon information requirements.

Envision sampled specific locations chosen by Royal Haskoning, video sampling was specificed for certain areas and grabs samples for others. If ground proved unsuitable for grab sampling then video samples were used as an alternative method.

The acoustic tracks were run along lines prescribed by Royal Haskoning. These were widely-spaced single lines designed as transects across areas considered likely to have reef habitats. Thus, mosaicing of overlapping tracks to produce a composite image was not possible with the data collected in this survey. Instead, the lines were characterised using information from visual inspection of the swath and sidescan data, interpreted from information provided by the video and AGDS. Images from the swath and sidescan, however, have been used to illustrate the nature of the seafloor.

A complete characterisation of the reefs and sandbanks in the areas as a whole requires information from both survey and desk-top studies. It is stressed that there is no attempt in this report to make a full characterisation of the reefs and sandbanks that uses information from the desk-top study undertaken by Royal Haskoning and the characterisation is based purely on the survey data.

2 Methodology and analysis

2.1 Interferometric Bathymetric Sidescan Sonar survey

2.1.1 Equipment and deployment

Envision used a GeoAcoustics GeoSwath Plus Interferometric system. This system provides simultaneous true sidescan sonar and bathymetric data which are geographically coincident and corrected for tide, vessel movement and position. The data are also corrected for distortion caused by variations in the speed of sound through water: sound velocity profiles are taken at intervals through the survey using an Odum SVP transducer lowered to the seafloor. The system gives sidescan sonar images across a swath 10-12 times water depth as well as swath bathymetry. This combination of sidescan and swath bathymetry provides complementary information on the physical nature of the seafloor. For example, the swath data can reveal topographic features (often quite large) which may be undetected by sidescan sonar and, conversely, sidescan can show seabed textures resulting from fine-scale sediment features (boulders, sand ripples) that cannot be resolved by the swath bathymetry.

The system was deployed at a tracking speed of ~10km.hr^{-1}. It was calibrated when first set up on the vessel and cross tracks were collected during the survey for quality control measures to ensure data consistency.

2.1.2 Processing

The sidescan from the swath system has a resolution of about 10cm across the swath. This resolution can be best seen in the 'waterfall[1]' display seen in real-time or in replay mode after post processing. The waterfall display was observed during the survey, but the survey program permitted some processing in the evenings. Sidescan sonar data were also corrected for vessel movement and the sonar lines were 'mosaiced' to produce sidescan sonar swaths for each acoustic line. This process forms part of the mosaicing operation, except that in this case there were no overlapping tracks to merge. However, 'mosaiced' images are at a lower resolution than the raw data as seen in the waterfall displays and have limited value for showing fine-scale texture.

The swath bathymetric data also were processed between survey days and this permitted the inspection of the bathymetric model (sun-illuminated to reveal small topographic detail). The data were then gridded to produce bathymetric grids at 5m resolution. The grids were then used to create a three dimensional terrain model which was sun-illuminated to highlight the topographic features on the tracks. These images were then exported as geotiffs into the survey GIS workspace.

2.2 RoxAnn single beam Acoustic Ground Discrimination System (AGDS)

2.2.1 Equipment and deployment

An AGDS was run in conjunction with the swath system: it provides useful complementary data on sediment hardness and roughness and this can aid the interpretation of the sidescan images. It does not interfere with the swath system and is inexpensive to run. Thus, it is a cost-effective add-on to any swath survey.

AGDS has the advantage over swath systems in that it is a single-beam system with a vertically directed signal. This means that no complicated correction has to be made for reflectance or slant range. It also can measure scatter away from the vertical, which is problematic for swath systems. Thus, it can measure reflective strength (hardness) and scatter (roughness) quite robustly.

A RoxAnn Groundmaster system was used operating at a frequency of 50kHz. Point values for hardness, roughness and depth were taken at 2 second intervals as the vessel tracked over the sea. The data were recorded onto a laptop together with position and time.

2.2.2 Analysis

The AGDS data were cleaned (removal of depth spikes, records when the vessel was stationary and where there were zero values for depth). The daily data sets were compared using scatter grams and there appeared to be no obvious shifts in the patterns or overall 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. Copies of the daily data sets have been amalgamated in MapInfo™ to create a single data set. The data did not undergo further analysis and the hardness and roughness values were simply displayed over the swath images to aid interpretation.

2.3 Drop-down Video

2.3.1 Equipment and deployment

Envision used a forward directed digital video system mounted in a small frame and controlled from the surface. The system records digitally on a high quality tape in the housing and a back-up tape in the surface unit. The system was used as a drop-down/short tow system for takes of 2 minutes duration. There are a number of reasons for this deployment strategy; firstly, with drift the tidal currents can quickly carry the sledge so fast that the tape becomes of very limited use for extracting

[1] Waterfall display - A top-down image presentation method where the image pixels for each sonar return appear at the top of the image and fall downward as they are replaced by each new sonar return at the top

information during analysis and replay. With a short deployment there is always a period of slack before the current picks up the system. Secondly, towing requires a long layback and the position of the sledge becomes very uncertain (without the aid of sonar positioning systems).

Royal Haskoning specified the number of survey locations in the Survey Requirements: sample locations were specified by Royal Haskoning prior to survey commencement or on site by the Royal Haskoning representative.

2.3.2 Analysis

Paper notes for the tapes and sediment were recorded during the survey as part of the survey log.

Data were extracted from video tapes by visual inspection during replay and the data entered into a spreadsheet. In addition, several frames were captured for each sample. These were selected from periods when the sledge was near stationary, which improved the quality of the captured images. The main habitat features, conspicuous species or, where this detail was not possible, general growth forms and higher taxonomic categories were identified and used to assign a biotope category to each video sample. Species and life forms were assessed on the semi-quantitative SACFOR system. Visual estimates for percentages of silt, sand, gravel, pebbles, cobbles, boulders and the features of any bedrock were made for each video sample. Written descriptions have been included as a summary of the habitat.

The data were matched to description in the Marine Habitat Description for Britain and Northern Ireland (MHD) (http://www.jncc.gov.uk/marine/biotopes/) and the records tagged with the most appropriate biotope and code. Any discrete, clear signs of anthropogenic habitat damage seen were to be recorded (i.e., not widespread and general impression of habitat degradation); but no such signs were observed.

3 Data Interpretation

All the above data were incorporated into a GIS system which allowed the datasets to be compared with each other. This allowed the analyst to view all data along each survey line and categorise the swath line to a habitat type which was suggested by the topography shown from (1) the sun-illuminated bathymetry, (2) the sonar reflection of the sea bed shown in the sidescan imagery and (3) the AGDS data indicated the roughness and hardness along the track.

The method allowed the seabed characteristics to be mapped for the acoustic survey lines in the Area of Search . Since the tracks were designed as transects, it was felt that the characteristics were best summarised as a segmented line coded according to a typology devised to describe the features observed from the acoustic images. Video coverage was very limited as compared to the acoustic coverage and it should be pointed out that the majority of the tracks have not been ground truthed directly. Thus, the distribution of habitat features is indicative and cannot be regarded with a high level of certainty.

The route for the analysis between the datasets and the supporting maps and analysis and overall assessment has been outline in Figure 1.

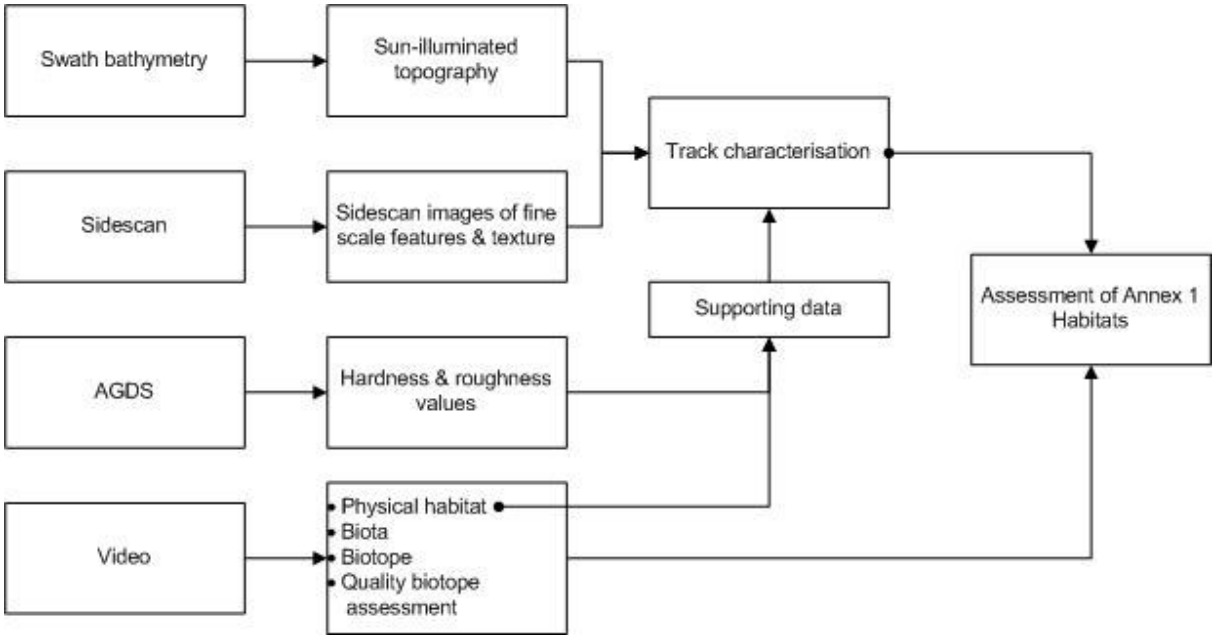


Figure 1 Scheme for the analysis and interpretation of the data to derive the assessment and distribution of Annex 1 Habitats

4 Results of survey

The results are presented as an interpretation of the data in terms of habitat feature characterisation and biotope distribution. Details of the survey, the equipment used and methods for analysis have been presented in the field report and are not repeated here in the interests of clarity and succinctness. A brief summary of the survey is given since this sets out the limitations of the characterisation possible from the survey data. These limitations are the result of the survey specifications adhered to by Envision. Thus, there is no attempt in this report to make a characterisation that uses information from the desk-top study undertaken by Royal Haskoning.

Three Areas of Survey were selected by Royal Haskoning in the Morecambe Bay area and the survey requirements varied between the three areas of survey. These differences are reflected in the summaries for each of the three areas of survey (Table 1).

A fourth area was used for reporting purposes as it formed a distinct area, the area was between areas M01 & M03 and was given the label MO4

Table 1 Summary of survey work undertaken for the Area of Search

Area of Survey	Name	Acoustic survey	Video on tracks	Video samples not supported by acoustic data	Grab Sample on Tracks	Grab samples not supported by acoustic data
MO1	Inshore Fleetwood	Yes	22	None	None	None
MO2	Offshore Fleetwood	Yes	None	None	5	None
MO3	Offshore Walney	Yes	7	1	1	1
MO4	Between M01-03	Yes	9	7	None	None

The position of the planned survey lines and sample locations are shown in Map 1 and resulting lines and samples are shown in Map 2 (the maps are presented in a folio that follows the written sections of the report).

4.1 Summary of result outputs

The raw data within each of the four areas where acoustic survey (MO1, MO2, MO3 & MO4) was undertaken have been gridded and these datasets are provided as sun-illuminated images taken from the digital terrain models in the accompanying GIS project.

Sidescan images were mosaiced, but the reduction in resolution and dynamic range in the grey scale of the resulting images made them of limited use for the interpretation of seafloor features. However, the waterfall displays contained useful information and short sections were extracted and matched to the corresponding section of the terrain model and have been used to illustrate examples of the reef features. These are presented together with the sun-illuminated images in Appendix 3.

The AGDS data are presented showing roughness and hardness values (Map 13 & Map 14).The values of the AGDS data do correspond well with changes in habitat type, with the rougher and harder areas showing as possible reef features. The AGDS data also suggest a change in sediment type over the sandbank feature in area MO2, with top of the sandbank feature having softer values than the deeper sloping areas.

The video have been transferred to a DVD that accompanies the report. A number of frame captures were taken for each of the video takes and these are to be found on the accompanying CD. The data extracted from the video have been entered into a single spreadsheet which includes details of sediment types, rock features and species records for each take. This spreadsheet is to be found on the CD and a summary table of the main data is in Appendix 1. Biotopes and sediment information for each sample is presented in the Folio Map 5 to Map 12 for each of the survey areas.

4.2 Distribution of Seabed Features

The habitats have been characterised by their acoustic features as revealed by (1) sidescan images, (2) digital terrain models (derived from swath bathymetry) and (3) acoustic hardness and roughness. The acoustic data have been interpreted with reference to the physical seabed habitat features as seen on video. However, the ground truth sampling stations are few in number and often targeted at features considered likely to be reef from an inspection of the acoustic data. The majority of the acoustic track data have been interpreted directly from the swath images. Thus, the characterisation of the acoustic data must be regarded as predictive rather than being certain.

The seabed habitat features that have been used for characterising the acoustic data are presented Table 2. The features in Table 2 are ordered from boulder/rock habitats through to cobble and cobble/gravel/sand mixtures.

Each of the features are illustrated by examples from the acoustic images which are presented in Appendix 3.

Table 2 Description of the sea bed habitat features and typology used for maps and summary descriptions of the Area of Searchs

Habitat Feature	Habitat	Notes
Rock & Boulder Annex 1Reef Features	**BOULDERS/ROCK**	Outcroppings of bedrock or very large boulders and areas of larger stable boulders
	BOULDERS/ROCK & SAND	Rock or boulders predominate with sediment in between
Cobble Reef Features (Possible Annex 1 Reef Features)	**COBBLES**	Field of cobbles identified from the side scan sonar imagery and the video footage. Cobbles tend to be stable and embedded in sediment
	COBBLES & BOULDERS	Again a field of cobbles but interspersed with larger rocks/boulders
	COBBLES & BOULDERS WITH SAND	Cobbles and boulders with patches of sand between
	COBBLES & SAND	Cobble field with sand patches
Sand Bank Feature Annex 1 Sandbank Feature	**SAND**	Appears as featureless sediment
	SAND & BOULDERS	Sediment plain with patched of boulders and harder substrates
	SAND WAVE	Sand appears in a large wave
	RIPPLED SAND	Obvious rippled features visible on sediment surface
Anthropogenic Features	RIDGE	This appears to be a pipeline which runs through Area MO3 and can been seen in the north of the area

Bold habitat features represent Annex 1 Habitats.

Areas MO1, MO3 and MO4 contain boulder reef features often mixed with sediment habitats, area MO2 does not contain any obvious reef feature and is wholly occupied by a large sand bank feature.

4.2.1 Distribution of habitat features

Bathymetric images and sidescan sonar mosaics are available for each area but due to the broad-scale of the Area of Search the images do not display well and are therefore not presented. They are however available in GIS and as geotiffs on digital media accompanying this report.

AGDS and sidescan data supplement these sea bed descriptions, and the information from all the acoustic data have been used to categorise the tracks using the sea bed typology presented in Table 2. Map 4 summarises the tracks and Map 5, Map 6, Map 7 and Map 8 show the Area of Search at a finer scale. They also show the data on the composition of the substratum as pie charts for each of the video records.

Estimates of the proportion of the surveyed area occupied by the various reef types and other sediment classes are shown in Figure 2 to Figure 5. These are indicative only, but give a summary of the likely reef composition for each of the areas of search where acoustic and video data were collected. A similar statistic has been calculated from the video data for the various grades of sediment (Figure 6). The video records have also been used to calculate the proportion of the area assessed.

Areas MO1, MO3 and MO4 contain reef features with Area MO2 containing only sediment habitats which is a Sandbank feature. The reef features are predominantly boulder and cobble features with the occasional area having outcropping bedrock.

Area MO1 has large proportions of possible reef habitat features in the form of cobble dominated habitat with only 10% of habitats presented having little or no obvious sand features.

Area MO3 has extensive boulder and cobble reef areas identified from the acoustic tracks but these are interspersed with sediment patches and areas of mixed habitat type.

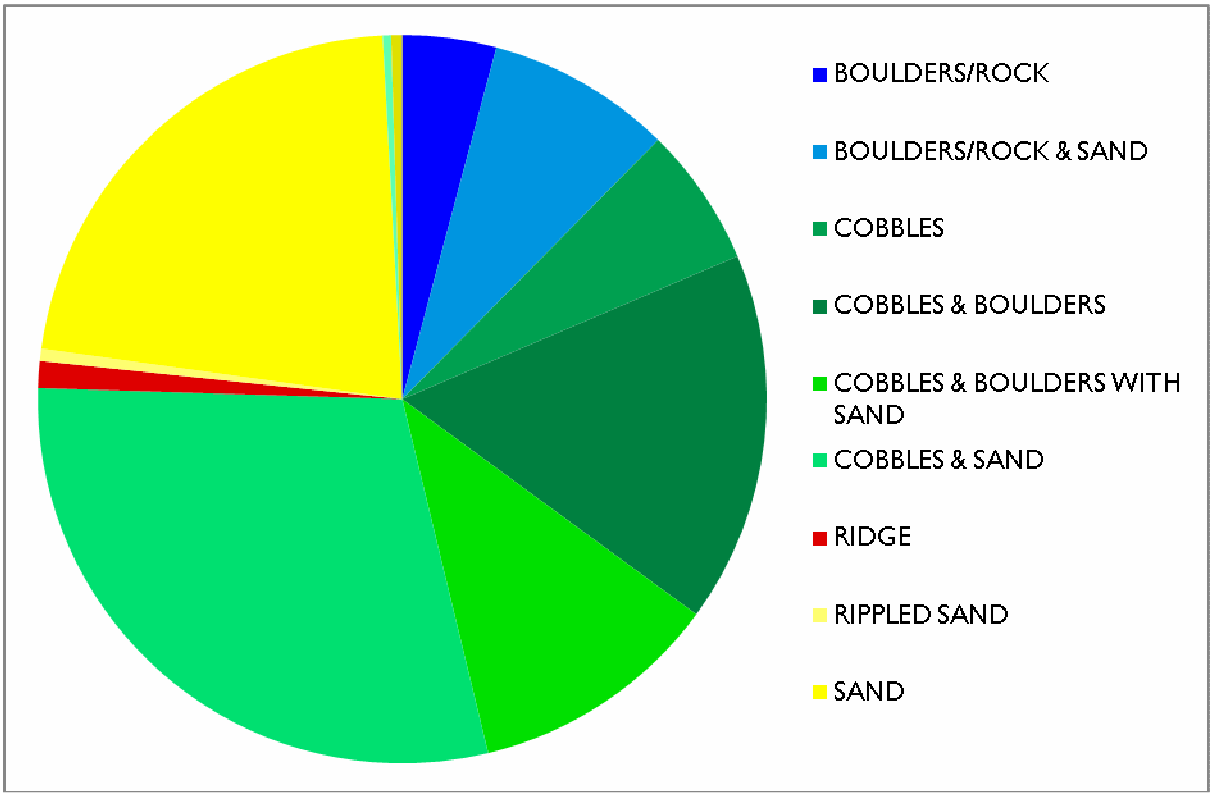


Figure 2 Proportion of habitat feature along the acoustic lines surveyed for area MO1

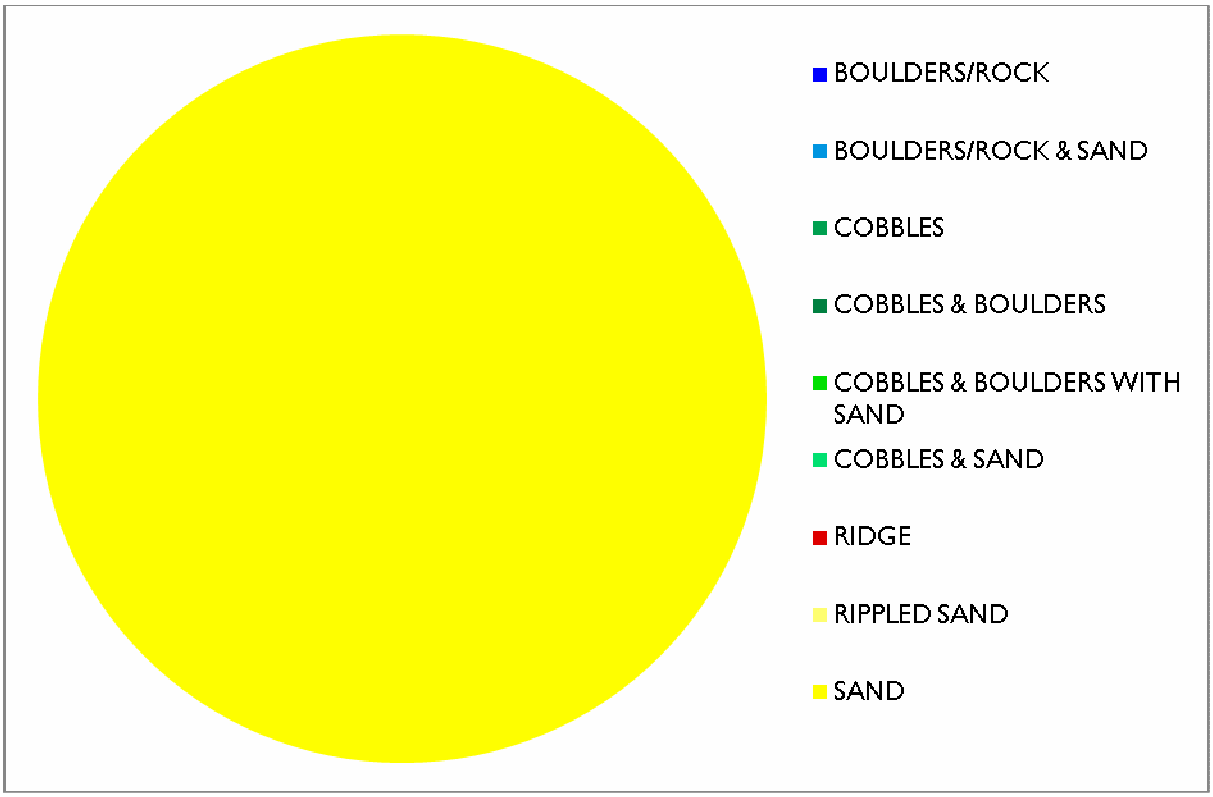


Figure 3 Proportion of habitat feature along the acoustic lines surveyed for area MO2

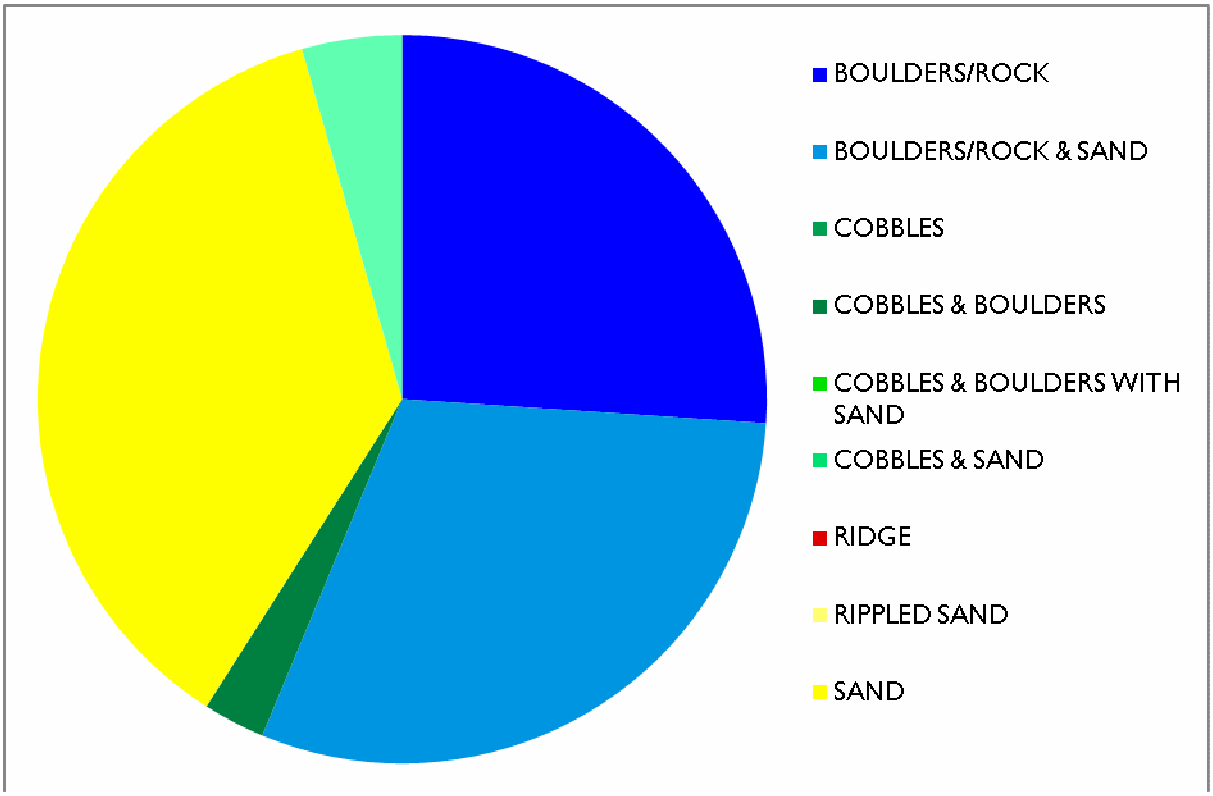


Figure 4 Proportion of habitat feature along the acoustic lines surveyed for area MO3

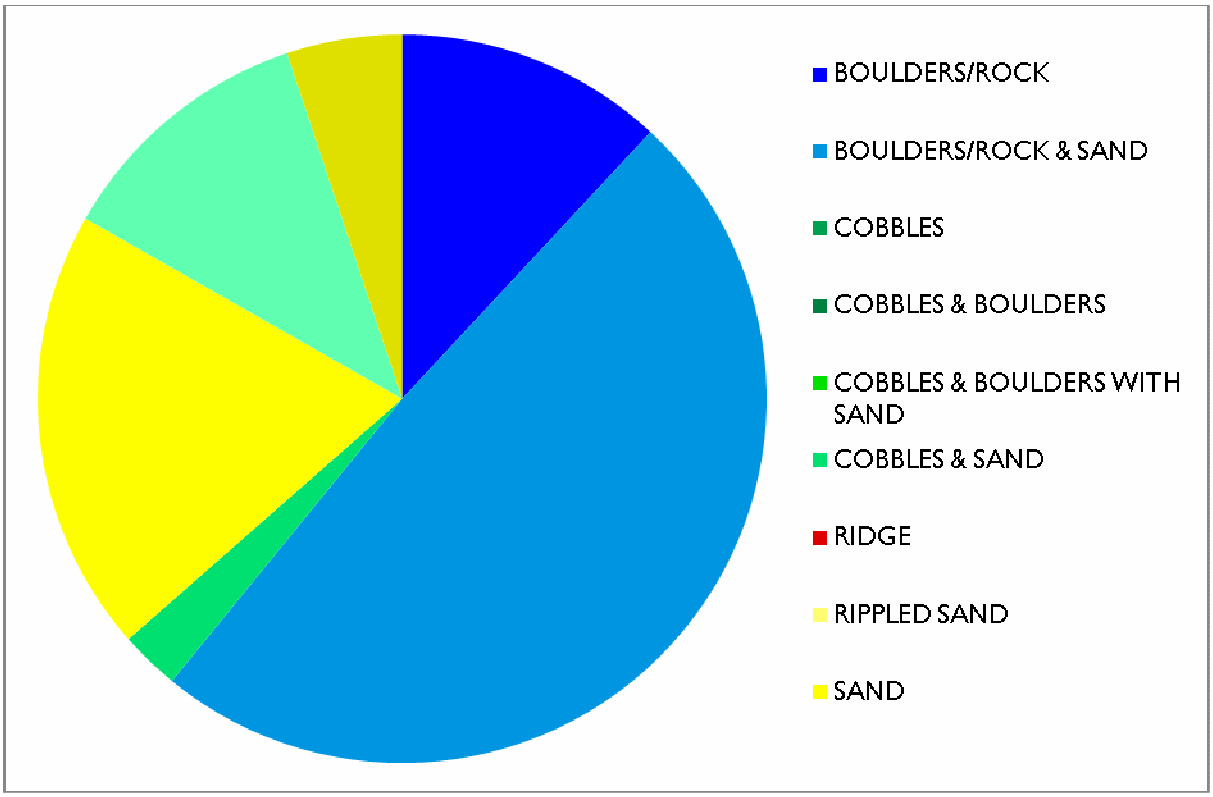


Figure 5 Proportion of habitat feature along the acoustic lines surveyed for area MO4

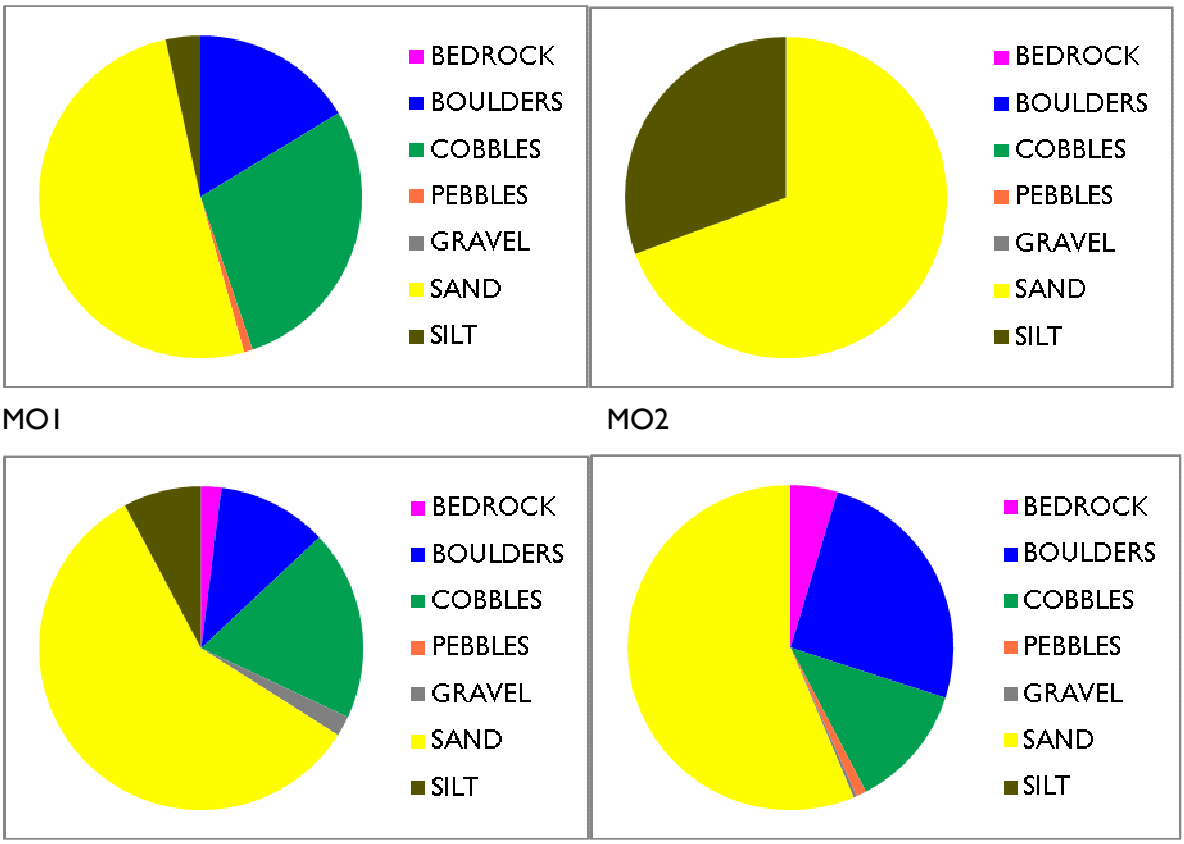


Figure 6 Proportion of sediment composition determined from the video records within each area of Morecambe Bay

The composition of area MO1 from the video samples shows that the hard substrate reef features of boulder and cobble are missed with a high proportion of sand (51%). This varies from the proportions of seabed habitats estimated from the acoustic data in that the acoustic data suggests a lesser proportion of sand overall (23%). This variation is likely to be due to an issue of scale, in that the hard substrates dominate the acoustic data and the line will be categorised as a reef habitat, but when this habitat is examined closely using video footage is can be seen that the harder substrate is either on a sediment base of has patched of sediment between the rocky habitats.

The area offshore from this MO2 has no hard substrate present identified from the acoustic data and the particle size analysis from the grab samples shows a silty (31%) sand (69%) substrate.

Offshore of Walney in area MO3 there is a mix of seabed types with video and grab data indicating harder substrate (bedrock, boulders cobbles, pebbles) making 32% of the sea bed composition with the sediments (sand and silt) composing 68%. As with area MO1 this is inconsistent with habitat proportions indicated from the acoustic data. Again this is due to the rocky habitats being influenced buy sediments but also this area does have a large sand plain to the west of the rocky areas and there are distinct sediment patches interspersed between rocky habitats which increase the proportions of sediment found overall.

Area MO4 has the largest proportion of boulders/rock of any of the areas (25%) but as with the other areas these are sediment influenced, as with areas MO1 and MO3.

Examining the proportions of sediment identified from the video and grab samples alongside the habitat features identified from the acoustic track data the areas which have a high proportion of reef habitat identified from the acoustic data, when in examined in detail with video or grab samples contain and are influenced by sand and other sediments.

4.3 Description of biota and biotope classes

An overview of biotope distribution is shown in Map 3. The distribution for each of the Areas of Search is shown in Map 5 to Map 8. These point data have been overlaid on the track characteristic where available.

The biology and biotopes with the Morecambe Bay Area of Search are limited with 3 being sediment biotopes indentified from infaunal species composition and the majority of the remaining biotopes only assigned to level 3 within the biotope hierarchy. At this level biotopes are identified from the physical nature of the biotope rather than the species found within. This is due to many of the samples used to identify biotopes being of low diversity and richness, which gave a limited number of species available for biotope matching.

There were no algal biotopes indentified throughout the Area of Search and this is likely to be due to the high turbidity of the water column restricting light penetration and therefore algal growth.

The area is heavily sediment dominated and where rock substrate exists it is heavily influenced by sediment with biotopes identified being impoverished versions of those in the Marine Habitat Description of Britain and Northern Ireland.

The biology of the rocky substrate was dominated by erect hydroids and bryozoans especially *Flustra foliacea, Nemertesia antennina* and *Alcyonidium diaphanum.* Occasionally there were populations of encrusting and erect sponges (*Haliclona oculata)* which altered the biotope complex. Certain sites have burrowing anemones in the sediment between rocks and *Sabella pavonina* growing on the hard substrata.

The sediment habitats were muddy sand and infaunal populations were bivalve and polychaete or brittlestar (*Ophiura spp*) dominated.

Assigning biotope codes to samples proved to be difficult since many of the samples did not match well to any of the biotope descriptions as provided in the Marine Habitat Description of Britain and Northern Ireland (JNCC) or there were insufficient obvious epifauna to identify the sediment biotopes from the video records. The closest class was chosen to tag the records. However, the

description accompanying the codes in the Table 3 below should be referred to when interpreting the biotope composition of the area and their distribution within the Area of Search and a full, illustrated description of the biotopes is found in Appendix 3.

The distribution of the biotopes at each sample location are shown in Map 3.

Table 3 Biotopes assigned to video records from the survey. The Biotope Description is from the Marine Habitat Description for Britain and Northern Ireland (MHD) (http://www.jncc.gov.uk/marine/biotopes/). Additional comments expand on the descriptions as applied to the Morecambe Bay Survey

Biotope Code	Biotope Description from MHD (JNCC)	Additional Description & comments
SS.SSa	Sublittoral sands and muddy sands	Clean sand with no obvious epifauna to enable higher code assignment
SS.SSa.IMuSa	Infralittoral muddy sand	Muddy sand, often with *Asterias rubens* and *Pagarus bernhardus*
SS.SSa.CMuSa	Circalittoral muddy sand	Muddy sand, often with *Ophiura spp,* little evidence of infauna, sparse burrows. No *Ophiura* biotope in MHD therefore level 3 biotope, could SS.SSa.CMuSa.Ophi
SS.SSa.CMuSa.AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	Identified from infaunal sample, but without *Abra alba* component but with a *Magelona spp* component. Possible mix with SS.SSa.IMuSa.FfabMag.
SS.SMu.CSaMu.AfilMysAnit	*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud	Identified from infaunal sample
SS.SMx.IMx	Infralittoral mixed sediment	A mixed substrate biotope identified from infaunal sample.
CR.MCR	Moderate energy circalittoral rock	Very similar substrate to CR.HCR.XFa but lacks *Flustra foliacea* in the turf and has dense *Sabella pavonina* on stable boulders & cobbles
CR.HCR.XFa	Mixed faunal turf communities	Stable boulders, cobbles & rock with *Flustra foliacea, Nemertesia antennina, Hydralmania falcata & Alcyonidium diaphanum.* These species along with other erect hydroids and bryozoans for a turf community but no obvious colonial ascidians & sponges mean it the biotope could be impoverished CR.HCR.XFa.FluCoAs.
CR.HCR.XFa.FluHocu	*Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed	Biotope is similar to CR.HCR.XFa above but obvious sponges are

	substrata	interspersed withing the faunal turf.

4.4 Summary descriptions of the Area of Search

4.4.1 Area MO1

Refer to Map 9

This area is characterised by a cobble boulder reef area running north south through the centre of the area. Harder stable substrate changes to more sand and sediment dominated seabed to the southwest and the west of the area. In the north, the inshore region has a greater proportion of cobbles and smaller rocks in the substratum while inshore regions to the south are sand dominated. At the northern edge of the area there is evidence of a large sand wave/slope as the seabed deepens.

The biology of the stable cobble and boulder habitat is dominated by a faunal turf with erect hydroids and bryozoans. The sediment habitats have very little epifauna present and no infauna samples were requested on sediment areas.

The area contains 4 biotopes, CR.HCR.Xfa; CR.MCR; SS.SSa.IMuSa; and SS.SSa.CMuSa. The rocky biotopes form a reef habitat but the biotopes are impoverished and of low diversity when compared the national description but locally are representative.

4.4.2 Area MO2

Refer to Map 10

The sidescan sonar, surface topography for this area reveal very few features, and the grab samples all have similar infauna dominated by *Nucula nitidosa* and *Magelona johnstoni* with some *Fabulina fabula* forming the SS.SSa.CMuSa.AalbNuc biotope.

The area surveyed within MO2 is all sand bank formed of muddy sand. The AGDS data do suggest the sediment changes slightly over the sand bank with the sediment becoming rougher and harder on the northern and southern slopes with the top of the bank being softer and smoother. PSA data shows some slight variation in the sediment types/proportions with grabs 3 & 5 having higher proportions of very fine sand in the substrate.

The infaunal data from the 5 sites over the sand bank feature show similar species composition with little variation and all being assigned to the *Abra alba* and *Nucula nitidosa* biotope but all samples lack a large *Abra alba* species component.

The area contains only one biotope, SS.SSa.CMuSa.AalbNuc identified from Infauna species composition and this and the habitat do form an Annex I sand band by definition, although the biotope is not representative nationally and the sand bank should be compared to background local information to assess its significance in a local context.

4.4.3 Area MO3

Refer to Map 11

This area has rock and boulder features throughout but they are predominant in the north while sediment patches are found more frequently to the south. Where the survey lines extend offshore (8-11km from the shore) the harder substrates are not present and sand dominates. The seabed along these survey lines shows very little in terms of surface features.

Again the biology of the stable cobble and boulder habitat is dominated by a faunal turf with erect hydroids and bryozoans. Two grab samples were taken in M03. There is mixed sediment, heavily influenced by the presence of epifaunal sponge in one sample whilst the second sample shows muddy sand with brittle stars and bivalves.

The visual estimates of the habitat proportions from the acoustic track (Figure 2 and Figure 5) show that the rock, boulder and cobble habitats in this area have a greater proportion of sediment in them

when compared to similar habitats in area M01. Despite this the sediment proportions estimated from the video samples suggests that these reef habitats have a larger proportion of sediment influencing them than the habitats in area MO1.

The reef biotopes in the area include similar biotopes found elsewhere in the Morecambe Bay Area of Search,but the biotope CR.HCR.XFa.FluHocu is also found in the area which is a more diverse and species rich biotope compared to CR.HCR.Xfa.

4.4.4 Area MO4

Refer to Map 12

This area falls between areas M01 and M03. The area has a central section of rock and boulders with occasional sand patches. The biology is a faunal turf with erect hydroids and bryozoans with some areas having erect sponges which may form the biotope '*Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed substrata' (CR.HCR.XFa.FluHocu).

To the south of the rock area, grab samples show muddy sand sediments with a population of *Ophiura* spp on the surface. There is also an area of sediment to the north of the rock which has some rock and boulder mixed with the sediment.

The area on the periphery of the Lune deep and is likely to be subject to stronger currents than surrounding areas and the sediment proportions estimated from the rocky video samples suggest that more boulder and rock are more visible in this region.

5 Annex I Habitats

5.1 Summary Description

Reefs are rocky or biogenic concretions that arise from the seafloor and are topographically distinct. Two main types of reef are regarded as qualifying as Annex I Habitats: those where animal and plant communities develop on rock or stable boulders and cobbles (generally >64 mm in diameter), and those where structure is created by the animals themselves (biogenic reefs). Reefs are very diverse and include a variety of topographic features and the greatest diversity of communities is found where the range of topographic features, rock type, water conditions (wave exposure and tidal streams) and depths are varied.

The reefs found with the Morecambe Bay Area of Search belong to type 2 reefs, stony reefs (cobble and boulder reefs) as they are characterised by stable boulders and cobbles raised from the surrounding sediment habitat.

Figure 7 *Flustra Foliacea* and *Nemertesia antennina* on small boulder and cobble reef

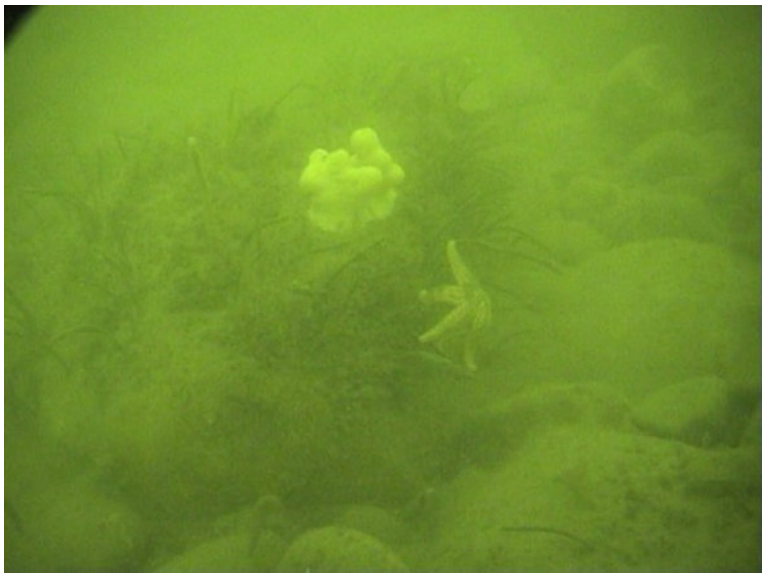


Figure 8 Boulder with *Alcyonium digitatum* and *Asterias rubens* on silted cobbles

The majority of the reefs were colonised by an erect hydroids and bryozoans turf, *Flustra foliacea* was dominant throughout the area with *Nemertesia antennina* also being very frequent. In several areas branching sponges such as *Haliclona occulata* were more obvious and these areas also had an increase diversity. Suspended matter and high siltation levels restricted the identification of smaller and cryptic species. Figure 7, Figure 8 and Figure 9 show examples of the habitat and biology present.

Figure 9 Erect hydroids and sponges (*Haliclona occulata*) along with small *Asteria rubens* on boulders

Annex I Sandbanks which are slightly covered by sea water all the time are elevated seabed features consisting of sandy sediments permanently covered by sea water. Water depth above sandbanks is seldom more than 20m below chart datum, but some sandbanks may extend into deeper waters. Sandbanks can be classified topographically (for example, those associated with headlands, the open shelf or estuary mouths) or by sediment type (for example, gravelly and clean sands, or muddy sands).

The survey of Morecambe Bay found only one possible sand bank feature within search area MO2, this feature has an impoverished biological community which is typical of sandbank features. The sediments comprising the sand bank are muddy sands with the top of the sand bank feature containing more very fine sands then the slope and edges of the feature.

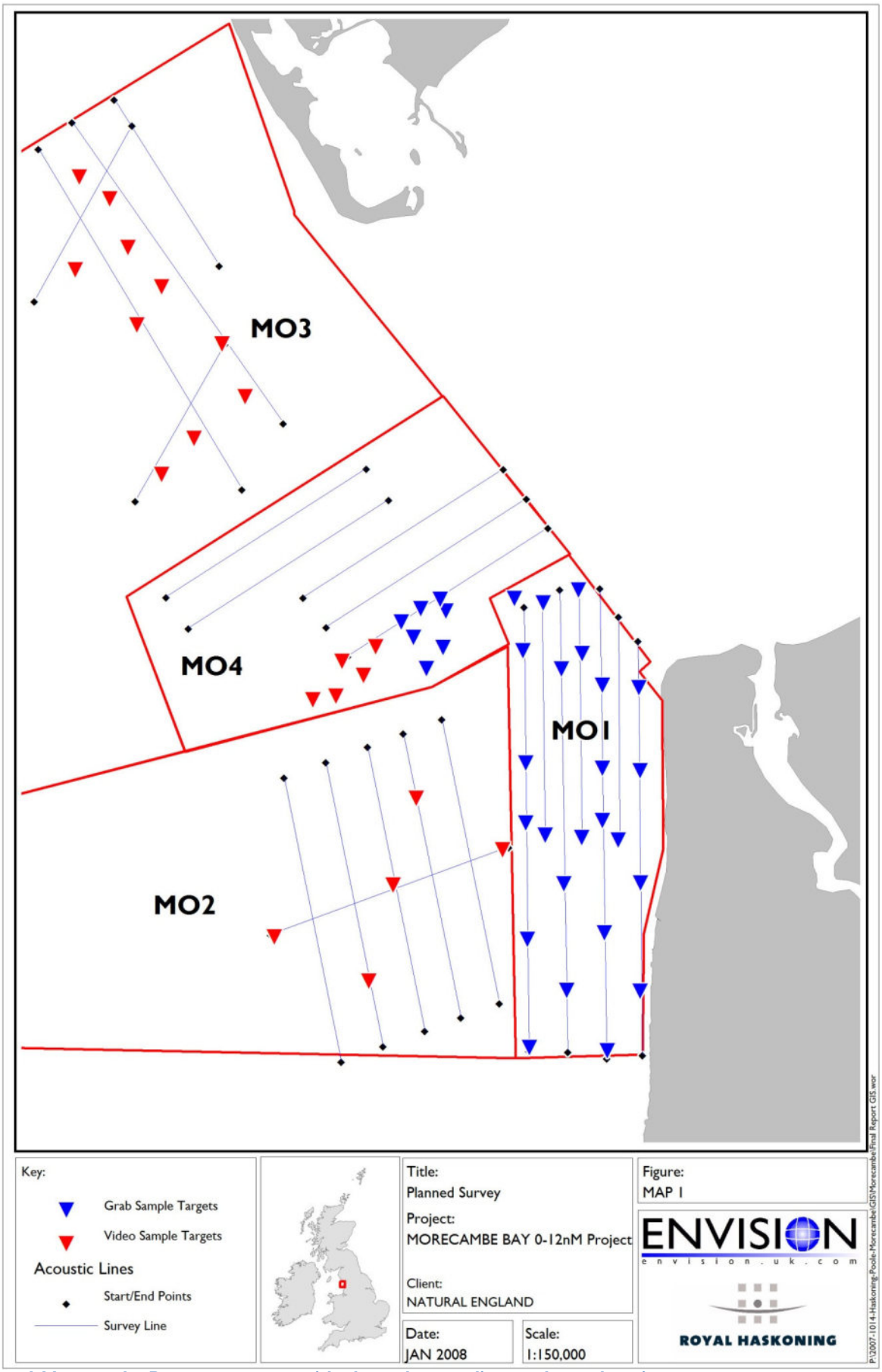
5.2 Delineating areas of Annex I Reef & Sandbank

Annex I habitats have been delineated using sedimentary and topographical features rather than the biological communities existing on them.

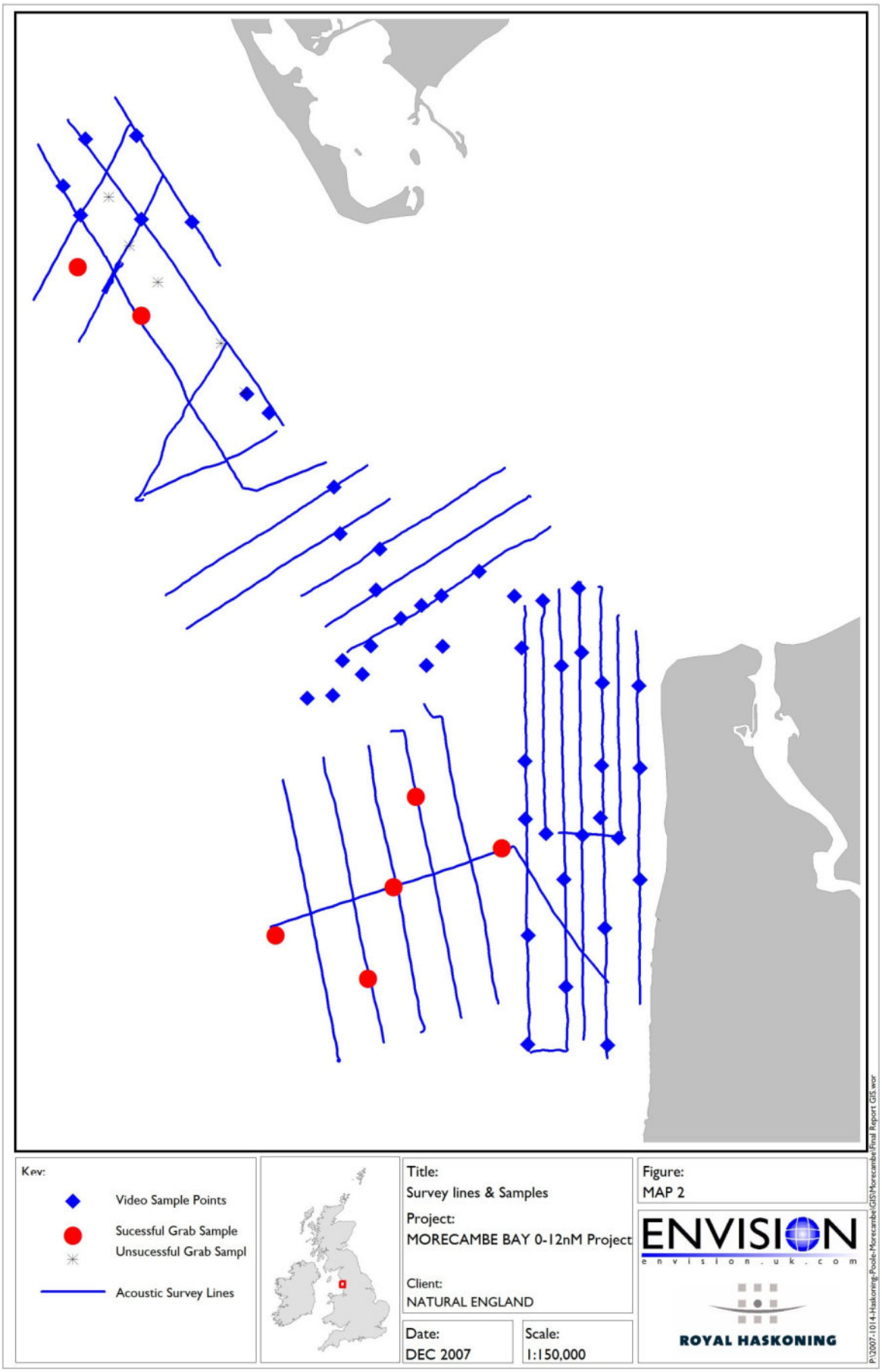
Annex I Reef Habitats have been delineated, therefore, on the basis of their sediment characteristics as observed on the video and from evidence from the acoustic data (particularly the sun-illuminated swath images). A 500m grid has been placed over the track lines surveyed and where the grid cells contained a habitat feature which is possible Annex I Reef or Sandbank the grid cell was marked as such. This approach assists in creating an 'area' feature of habitat rather than a line feature and if an area is of interest and is to be taken for further development in management terms then assumptions can easily be made regarding the un-surveyed area between the lines.

Map 15 shows the possible distribution of Annex I habitat within the Morecambe Bay Area of Search.

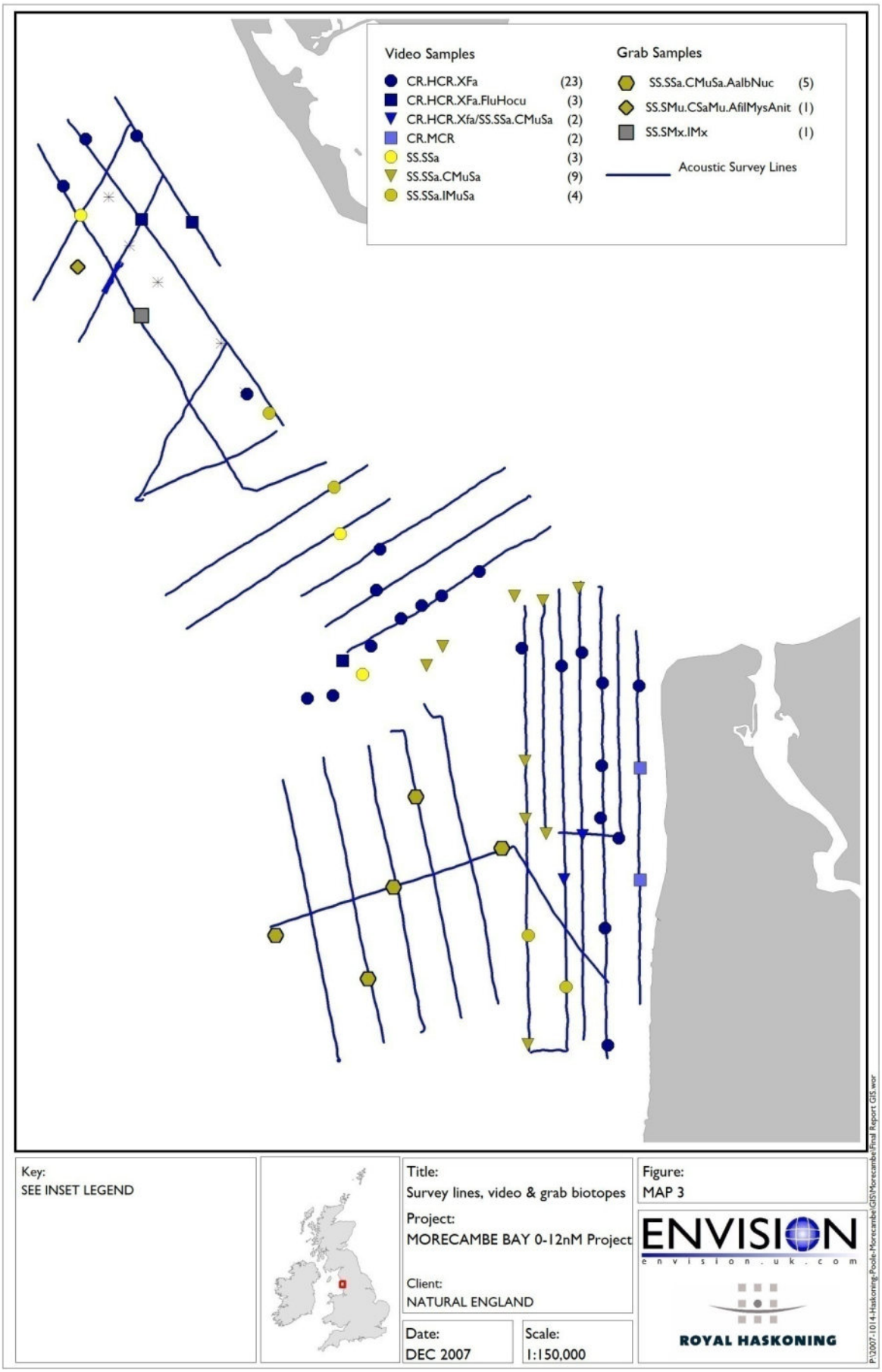
6 Map Folio



Map 1 Morecambe Bay survey areas with planned survey lines and sample points

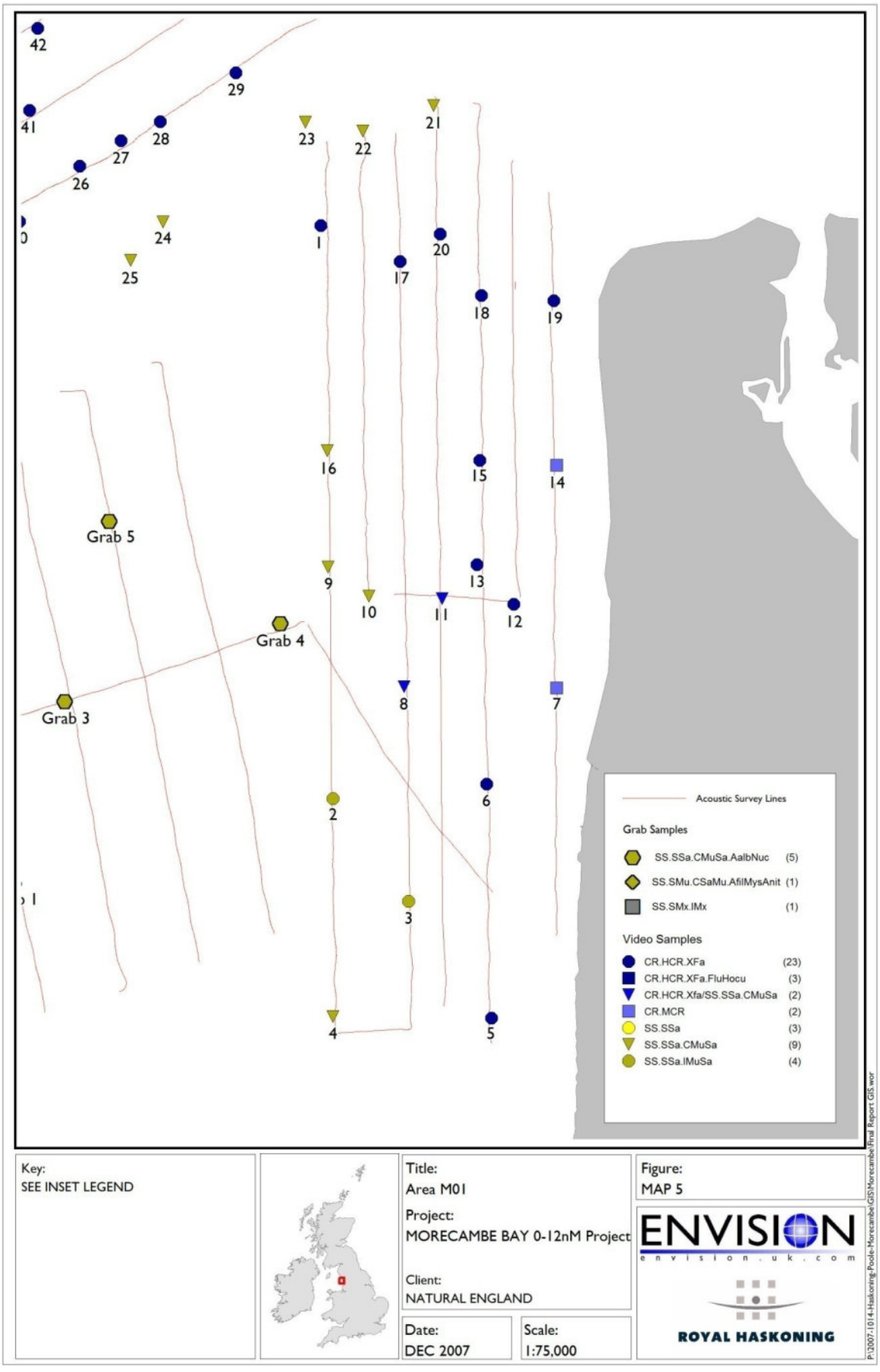


Map 2 Resulting survey lines and sample locations for the Morecambe Bay Area of Search

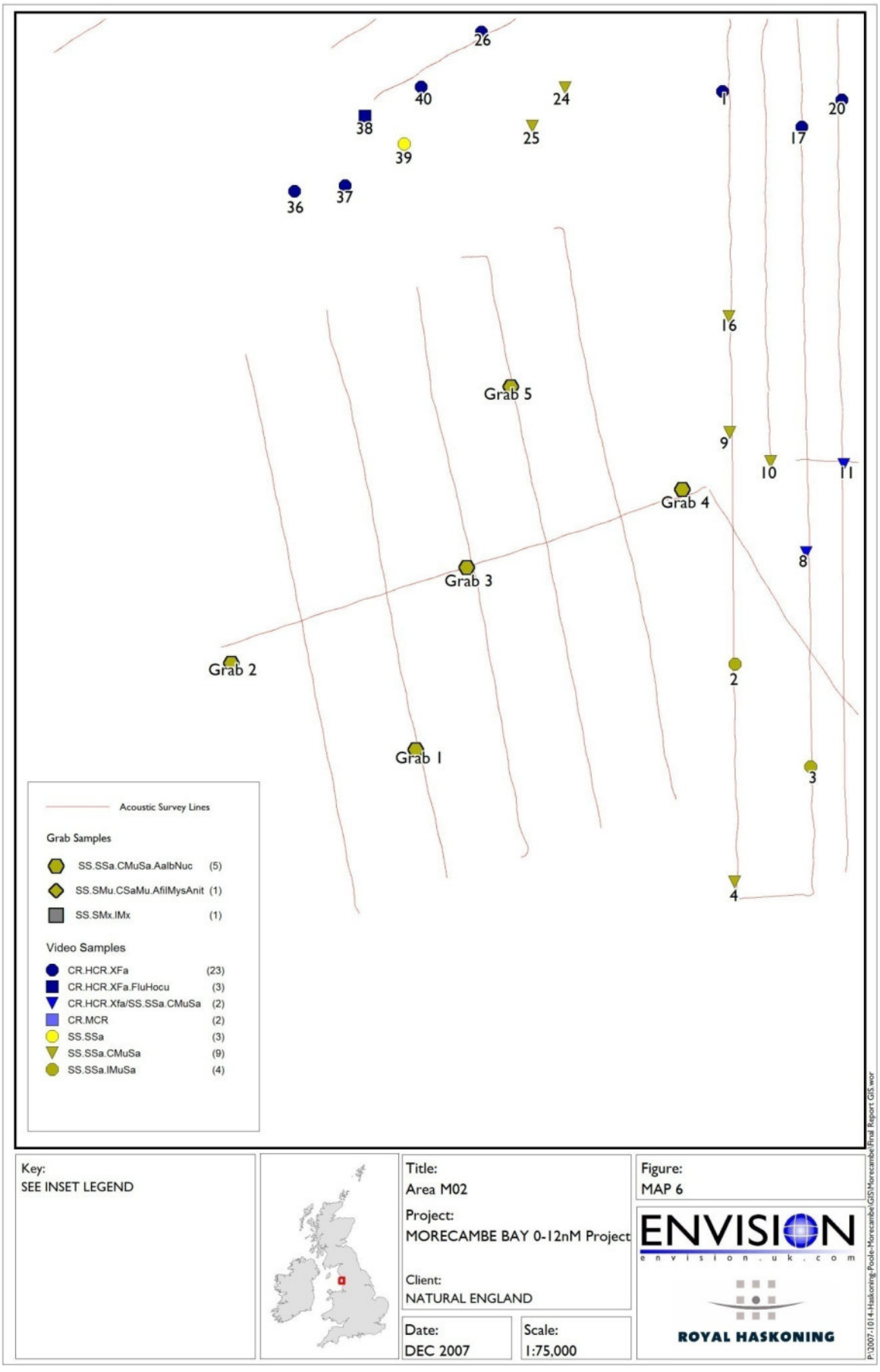


Map 3 Survey lines and location of samples showing the biotope at each location

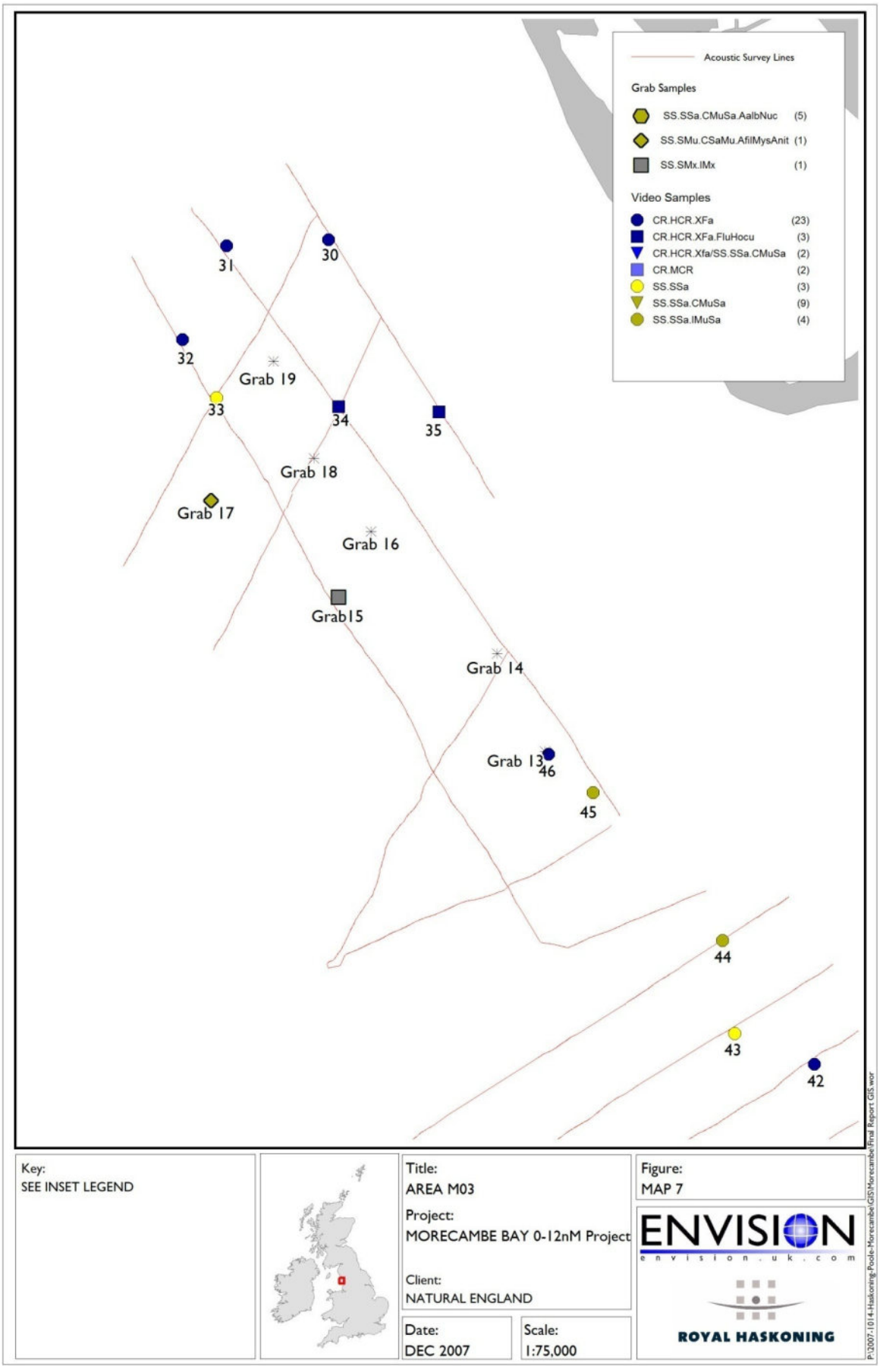
Map 4 Characterisation of the acoustic tracks for Morecambe Bay Area of Search



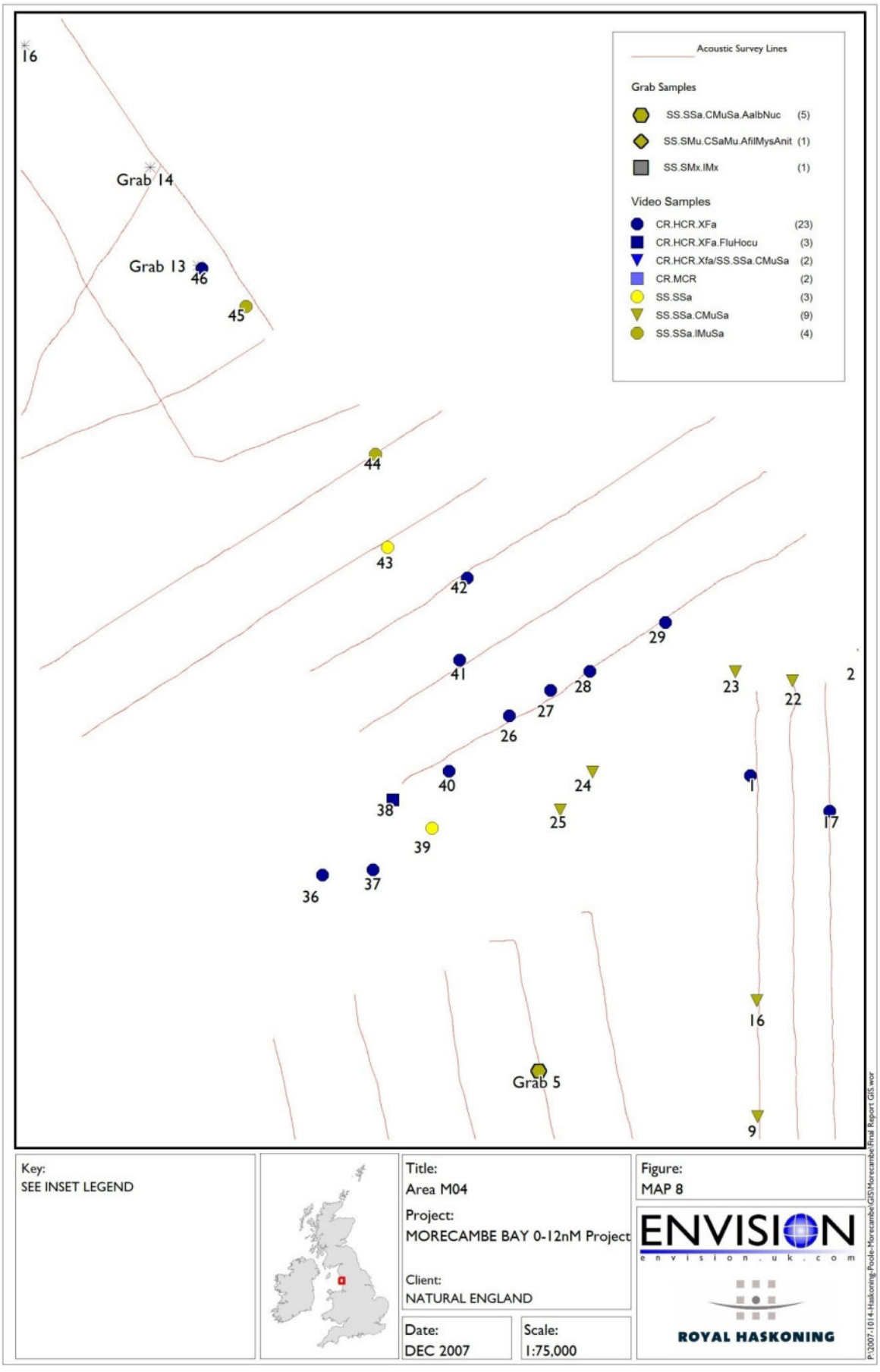
Map 5 Biotopes present at each sample location for Morecambe Bay Area of Search MO1



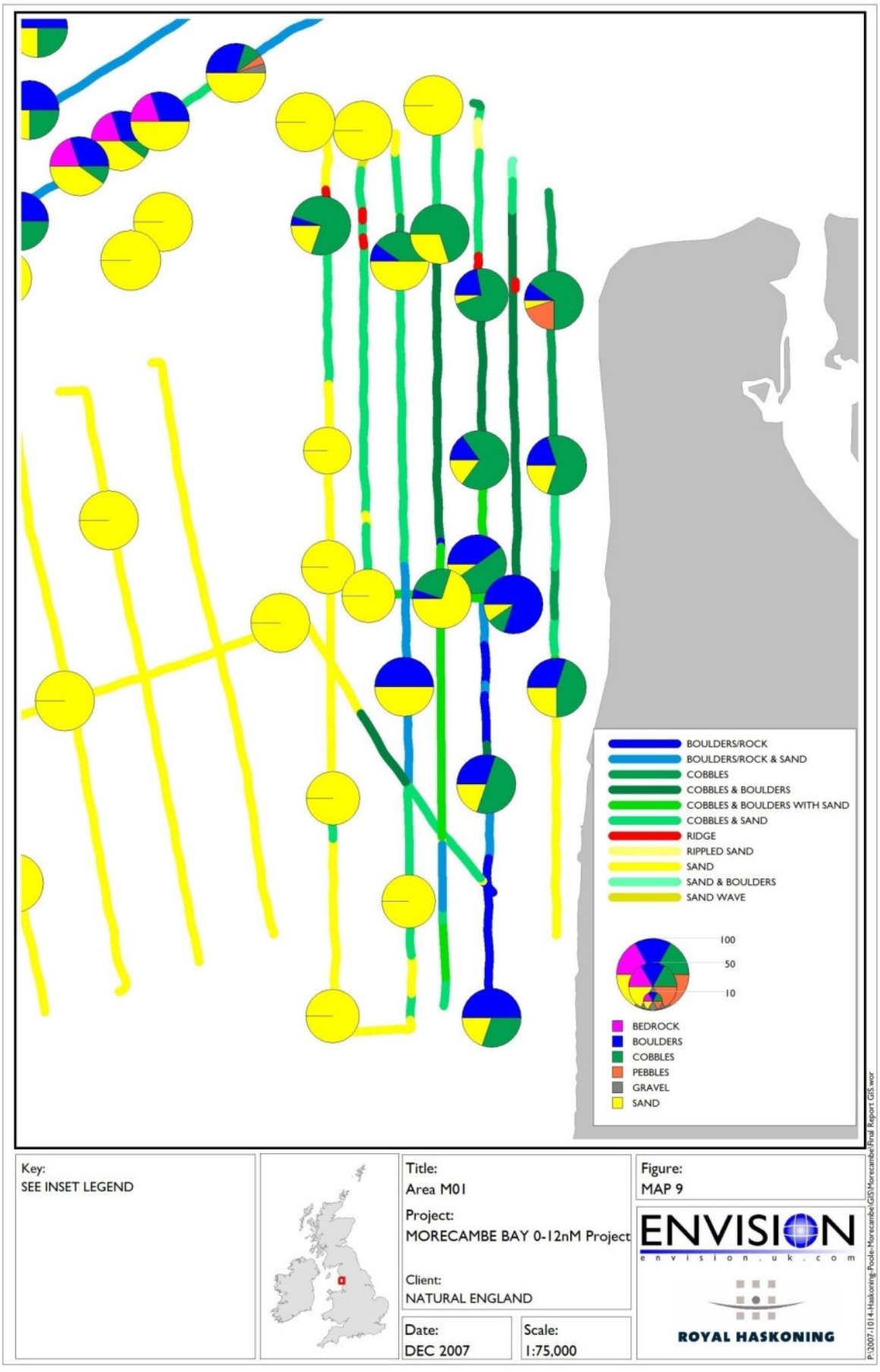
Map 6 Biotopes present at each sample location for Morecambe Bay Area of Search MO2



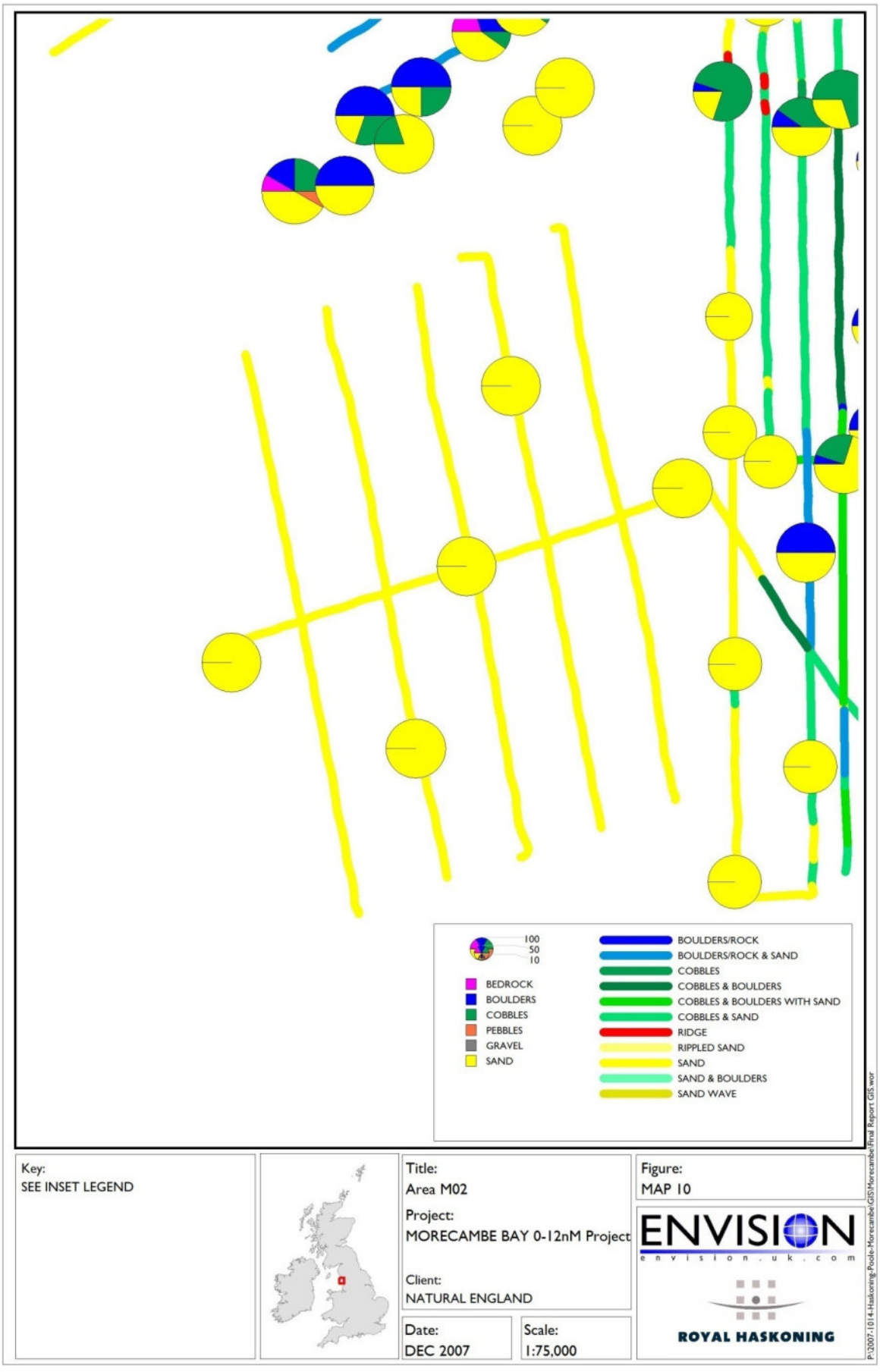
Map 7 Biotopes present at each sample location for Morecambe Bay Area of Search MO3



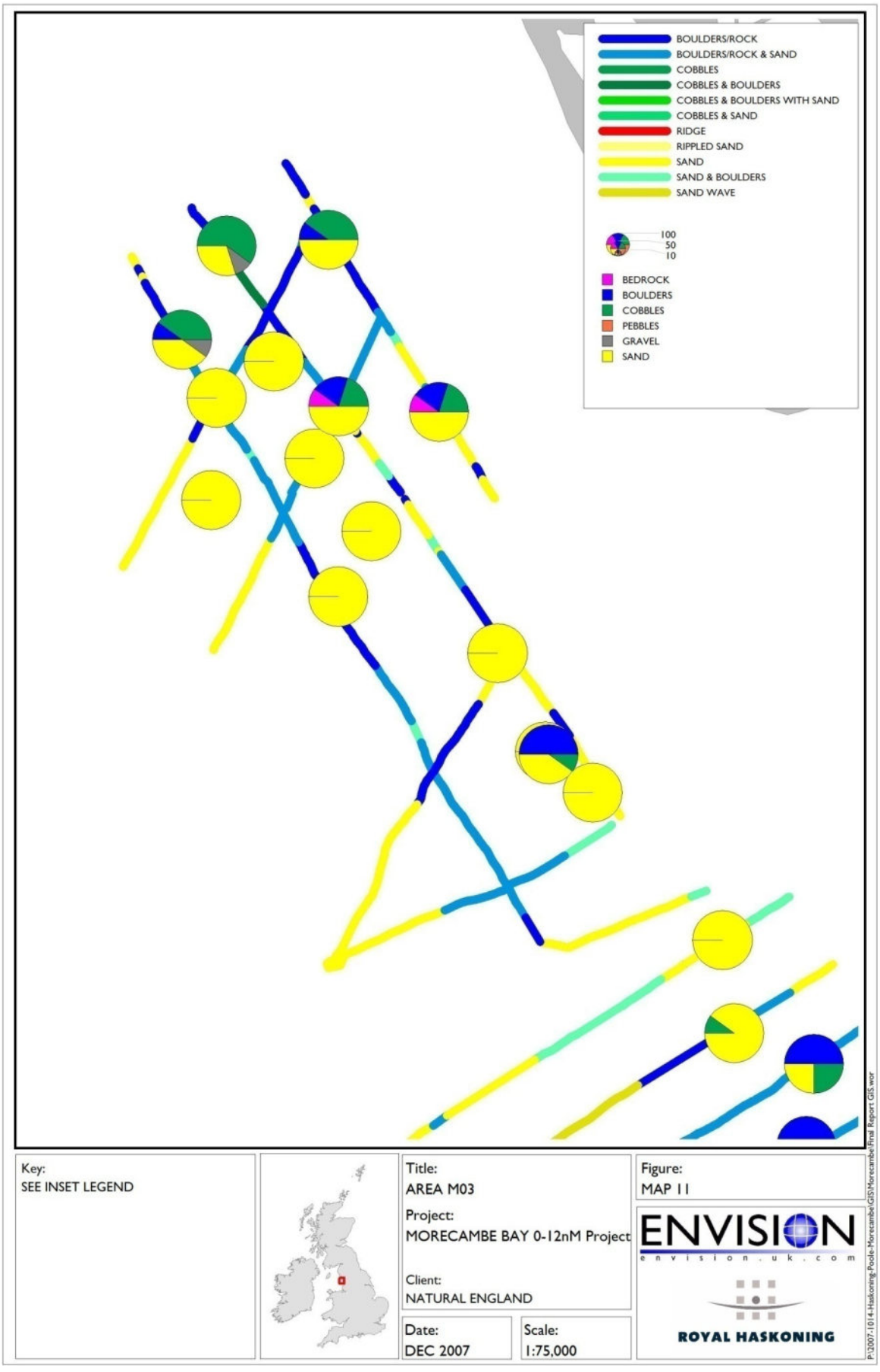
Map 8 Biotopes present at each sample location for Morecambe Bay Area of Search MO4



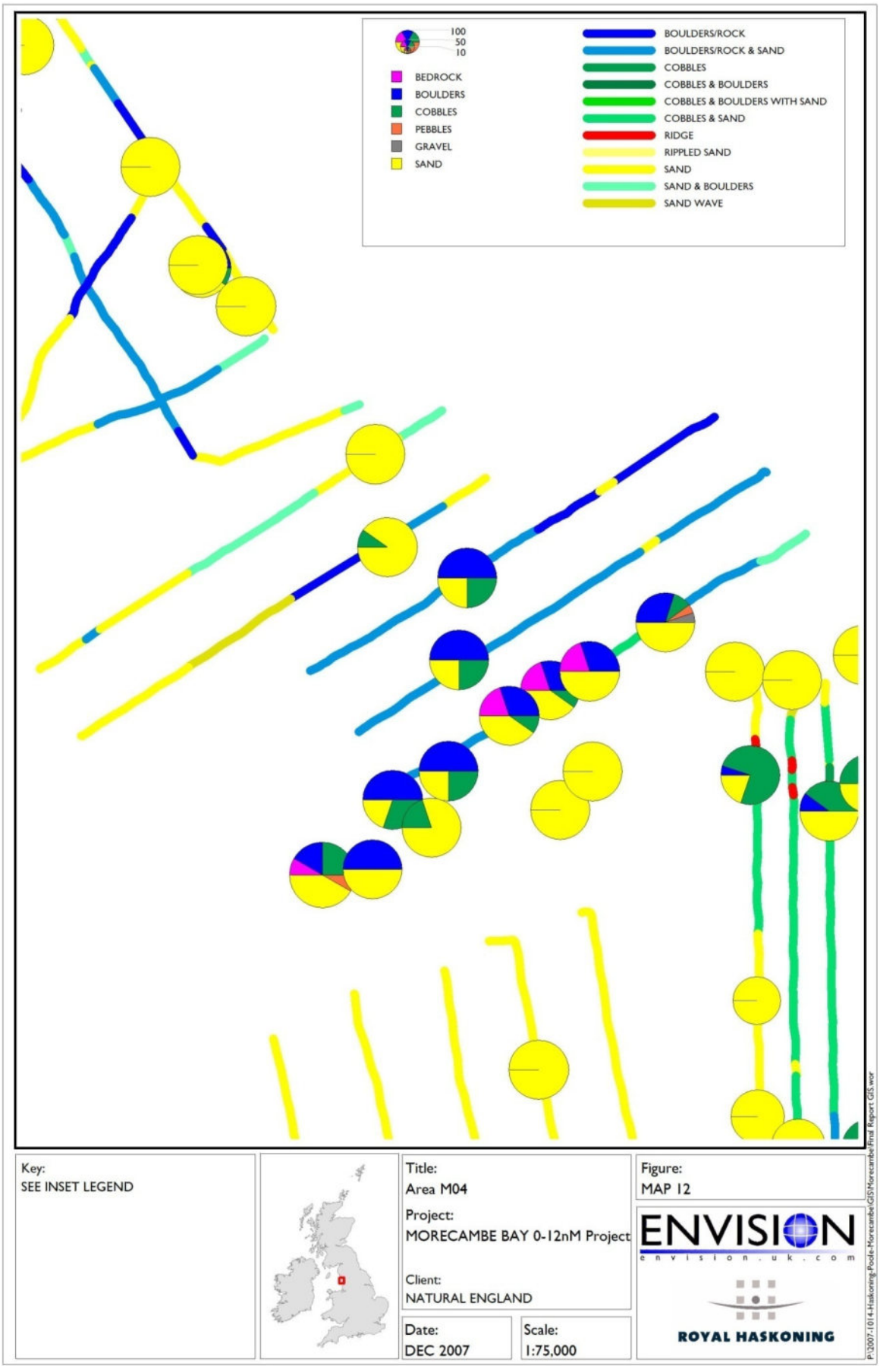
Map 9 Characterisation of the acoustic tracks for Morecambe Bay Area of Search MO1



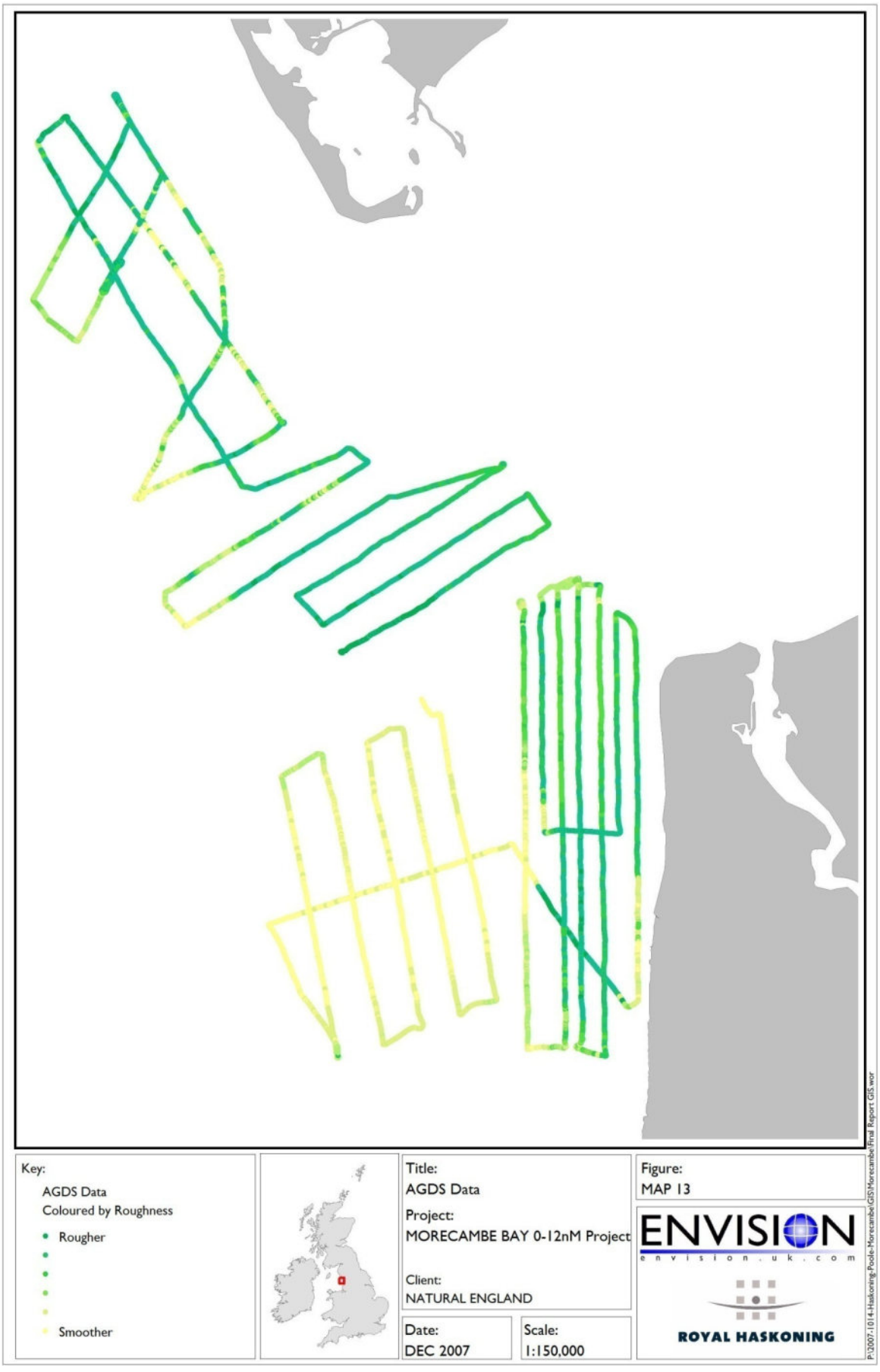
Map 10 Characterisation of the acoustic tracks for Morecambe Bay Area of Search MO2



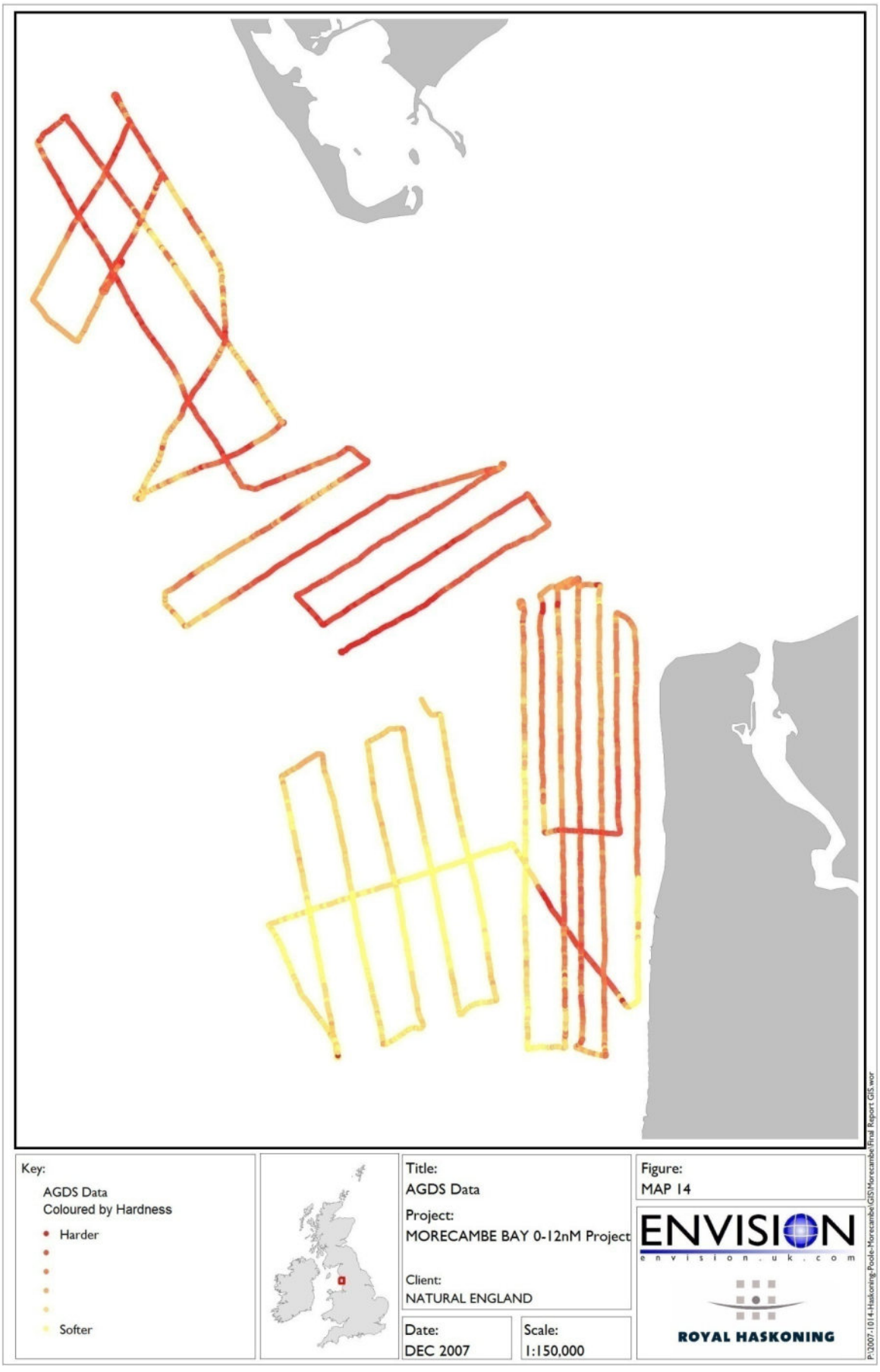
Map 11 Characterisation of the acoustic tracks for Morecambe Bay Area of Search MO3



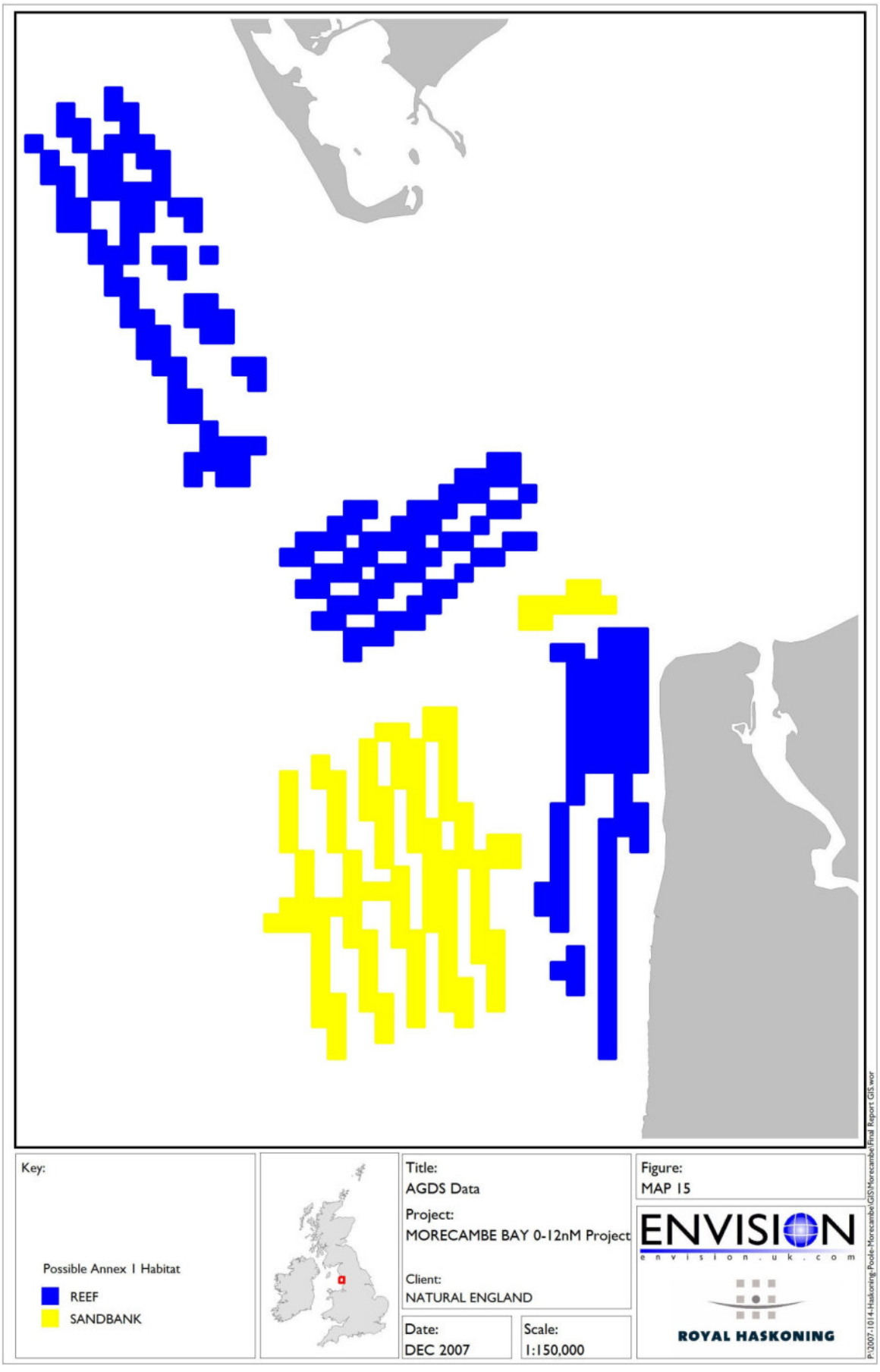
Map 12 Characterisation of the acoustic tracks for Morecambe Bay Area of Search MO4



Map 13 AGDS tracks coloured by E1 (roughness) for Morecambe Bay Area of Search



Map 14 AGDS tracks coloured by E2 (hardness) for Morecambe Bay Area of Search



Map 15 Location of Possible Annex I habitat with the Morecambe Bay Area of Search

7 Outputs

Accompanying this report are several outputs which are delivered on other media.

OUTPUT	MEDIA
• Edited DVD of video footage	2 DVDs
• Bathymetric grids in surfer format	DATA DVD
• Bathymetric girds as Geotiffs	DATA DVD
• GIS project as a ArcGIS™ workspace	GIS CD
• Digital frame captures from video footage.	DATA CD
• Data extracted from video footage	DATA CD
• Raw AGDS Data	DATA CD

8 Appendix 1

8.1 Grab Positions

ID	LONGITUDE	LATITUDE	SURVEY AREA	BIOTOPE
Grab 19	-3.3211	53.0521	MO3	Unsuccessful
Grab 18	-3.31097	53.0385	MO3	Unsuccessful
Grab 17	-3.33549	53.0323	MO3	SS.SMu.CSaMu.AfilMysAnit
Grab 16	-3.29698	53.0283	MO3	Unsuccessful
Grab15	-3.3046	53.0191	MO3	SS.SMx.IMx
Grab 14	-3.26626	53.0114	MO3	Unsuccessful
Grab 13	-3.25441	53.9977	MO3	Unsuccessful
Grab 1	-3.19099	53.8335	MO2	SS.SSa.CMuSa.AalbNuc
Grab 2	-3.2353	53.8452	MO2	SS.SSa.CMuSa.AalbNuc
Grab 3	-3.17957	53.8594	MO2	SS.SSa.CMuSa.AalbNuc
Grab 4	-3.12842	53.8709	MO2	SS.SSa.CMuSa.AalbNuc
Grab 5	-3.16972	53.8849	MO2	SS.SSa.CMuSa.AalbNuc

8.2 Grab PSA

Sample	Granule	V. coarse sand	Coarse sand	Medium sand	Fine sand	V. fine sand	Silt & clay
Site/Take	2-4 mm	1000-2000 µm	500-1000 µm	250-500 µm	125-250 µm	63-125 µm	<63 µm
1	0.00	0.00	1.00	0.50	27.00	34.00	37.50
2	0.00	0.00	2.00	6.00	28.00	37.00	27.00
3	0.00	0.00	2.00	0.50	9.00	62.00	26.50
4	0.00	0.00	3.00	1.00	27.00	40.00	29.00
5	0.00	0.00	1.00	0.50	5.00	60.00	33.50
15	0.00	0.00	3.00	3.00	11.00	48.00	35.00
17	0.00	0.00	7.00	15.00	25.00	10.00	43.00

8.3 Grab Infauna

GRAB ID		1	2	3	4	5	15	17
D662	*Actiniaria indet.*		1				1	
D766	*Edwardsia claparedii*			2				2
F	*Flatworm*						1	
G01	*Nemertea indet.*	1					5	2
G034	*Tubulanus polymorphus*							1
G039	*Cerebratulus sp.*							
G109	*Oerstedia dorsalis*						6	
N25	*Nephasoma minutum*						1	
P0050	*Harmothoe indet.*						9	
P0082	*Lepidonotus squamatus*						3	
P0092	*Pholoe inornata*	1			1			38
P0094	*Pholoe synophthalmica*						20	
P0104	*Sigalion mathildae*			1	1			
P0109	*Sthenelais limicola*	1	1			1		
P0118	*Eteone longa*			1				
P0146	*Phyllodoce rosea*		1					
P0167	*Eumida sanguinea*	1	1				5	
P0256	*Glycera alba*	1	4	3	6	5		
P0271	*Goniada maculata*							
P0305	*Kefersteinia cirrata*						1	
P0313	*Ophiodromus flexuosus*							1
P0319	*Podarkeopsis capensis*			1				3
P0421	*Exogone hebes*							1
P0422	*Exogone naidina*						5	1
P0453	*Proceraea picta*						7	
P0494	*Nephtys juv. indet.*	2		1	1	3		2
P0495	*Nephtys assimilis*	3	2		1			
P0499	*Nephtys hombergii*		1	1	1			2
P0579	*Lumbrineris gracilis*	2						4
P0661	*Orbinia juv. indet.*		1					
P0723	*Aonides paucibranchiata*						1	
P0748	*Polydora indet.*						1	
P0794	*Spiophanes bombyx*		2	3	1	1		1
P0803	*Magelona johnstoni*	4	22	13	24	12		
P0805	*Magelona filiformis*	1	1	3	2	6		
P1102	*Amphictene auricoma*							6
P1107	*Lagis koreni*					2		
P1117	*Sabellaria spinulosa*						10	1
P1340	*Pomatoceros lamarcki*						13	
Q15	*Achelia echinata*						5	1
Q5	*Nymphon brevirostre*						1	
S0131	*Perioculodes longimanus*				1			
S0158	*Amphilocus manudens*							2
S0186	*Cressa dubia*						33	
S0213	*Stenothoe marina*						14	
S0254	*Harpinia antennaria*							1
S0381	*Iphimedia nexa?*						16	
S0420	*Triteata gibbosa*						9	
S0427	*Ampelisca brevicornis*	1						
S0452	*Bathyporeia elegans*							1

GRAB ID		1	2	3	4	5	15	17
S0541	*Gammaropsis maculata*						6	
S0564	*Erichthonius punctatus*						2	
S0572	*Jassa pusilla*						9	
S0574	*Microjassa cumbrensis*						47	
S0615	*Corophium sextonae*						252	2
S0657	*Phtisica marina*						145	2
S0659	*Pseudoprotella phasma*						10	
S0892	*Janira maculosa*						2	
S0901	*Munna*						5	
S1197	*Bodotria scorpioides*						1	
S1248	*Diastylis bradyi*			1				
S1415	*Callianassa subterranea*							2
S1482	*Pisidia longicornis*						8	3
S1615	*Pilumnus hirtellus*						1	1
W0324	*Rissoidae indet.*						2	
W0491	*Polinices pulchellus*			1				
W1243	*Nudibranchia indet.*						4	
W1569	*Nucula nitidosa*	169	43	29	84	8		1
W1695	*Mytilus edulis*		2	1	1	4	33	
W1721	*Musculus*						6	
W1768	*Pectinidae juv. indet.*						4	
W1805	*Anomiidae*						12	
W1906	*Mysella bidentata*			1				17
W1975	*Spisula elliptica*	3	1		1	4		
W2004	*Pharus legumen*					2		
W2006	*Phaxas pellucidus*	2	1					
W2019	*Fabulina fabula*	1	19	6	10	7		
W2041	*Donax vittatus*				6	7		
W2059	*Abra alba*	3	2	2	3	2	2	
W2098	*Chamelea gallina*		1					
W2113	*Tapes rhomboides*						4	
W2128	*Dosinia lupinus*							2
W2157	*Corbula gibba*				1			1
ZA	*Phoronis sp.*							8
ZB124	*Ophiothrix fragilis*						54	
ZB154	*Amphiura filiformis*	1	1				4	104
ZB170	*Ophiura ophiura*			1	3	1		
ZB193	*Psammechinus miliaris*						4	
ZB223	*Echinocardium caudatum*	1		1				
	Sponge						P	
	Balanus sp,						P	
	Verucca stroemi						P	
	Hydroids						P	
	Bryozoa						P	
	Alcyonaria						P	

8.4 Video Positions & Biotopes

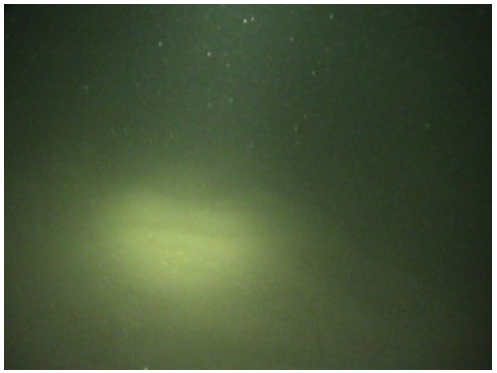
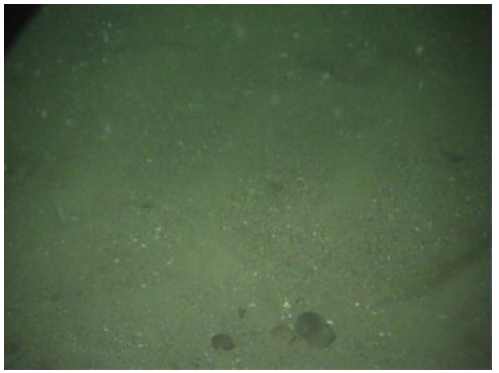
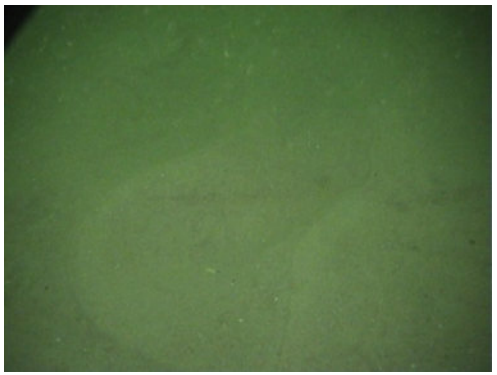
TAKE	SURVEY AREA	DEPTH (m)	LONGITUDE (WGS84)	LATITUDE (WGS84)	BIOTOPE (1°/2°)	HABITAT TYPE
1	MO1	6	-3.12032	53.927	CR.HCR.XFa	COBBLES & SAND
2	MO1	11	-3.11522	53.8462	SS.SSa.IMuSa	SAND
3	MO1	10	-3.09681	53.8319	SS.SSa.IMuSa	SAND
4	MO1	10	-3.11448	53.8154	SS.SSa.CMuSa	SAND
5	MO1	8	-3.07661	53.8156	CR.HCR.XFa	BOULDERS/ROCK & SAND
6	MO1	8	-3.07867	53.8485	CR.HCR.XFa	BOULDERS/ROCK & SAND
7	MO1	3	-3.06228	53.8623	CR.MCR	COBBLES & BOULDERS WITH SAND
8	MO1	11	-3.09865	53.8621	CR.HCR.Xfa/SS.SSa.CMuSa	BOULDERS/ROCK & SAND
9	MO1	8	-3.11729	53.8789	SS.SSa.CMuSa	SAND
10	MO1	10	-3.10746	53.8749	SS.SSa.CMuSa	SAND
11	MO1	10	-3.08997	53.8747	CR.HCR.Xfa/SS.SSa.CMuSa	COBBLES & BOULDERS WITH SAND
12	MO1	7	-3.07285	53.874	CR.HCR.XFa	BOULDERS/ROCK & SAND
13	MO1	7	-3.08173	53.8795	CR.HCR.XFa	COBBLES & BOULDERS WITH SAND
14	MO1	5	-3.06309	53.8937	CR.MCR	COBBLES
15	MO1	6	-3.08149	53.8943	CR.HCR.XFa	COBBLES & BOULDERS WITH SAND
16	MO1	7	-3.11791	53.8953	SS.SSa.CMuSa	SAND
17	MO1	5	-3.10127	53.9222	CR.HCR.XFa	COBBLES & SAND
18	MO1	5	-3.08165	53.9175	CR.HCR.XFa	COBBLES & BOULDERS
19	MO1	3	-3.06431	53.917	CR.HCR.XFa	COBBLES
20	MO1	4	-3.09179	53.9261	CR.HCR.XFa	COBBLES & SAND
21	MO1	35	-3.09382	53.9442	SS.SSa.CMuSa	SAND
22	MO1	44	-3.11065	53.9405	SS.SSa.CMuSa	SAND
23	MO1	45	-3.12433	53.9416	SS.SSa.CMuSa	SAND
24	MO4	36	-3.15801	53.9272	SS.SSa.CMuSa	SAND
25	MO4	28	-3.16561	53.9217	SS.SSa.CMuSa	SAND
26	MO4	17	-3.17818	53.9349	CR.HCR.XFa	BOULDERS/ROCK & SAND
27	MO4	16	-3.16844	53.9386	CR.HCR.XFa	BOULDERS/ROCK & SAND
28	MO4	15	-3.15912	53.9414	CR.HCR.XFa	BOULDERS/ROCK & SAND
29	MO4	10	-3.14119	53.9484	CR.HCR.XFa	BOULDERS/ROCK & SAND
30	MO3	14	-3.30852	54.0694	CR.HCR.Xfa	BOULDERS/ROCK
31	MO3	15	-3.33294	54.0683	CR.HCR.XFa	COBBLES & BOULDERS
32	MO3	17	-3.34314	54.0549	CR.HCR.XFa	COBBLES & BOULDERS
33	MO3	18	-3.33467	54.0468	SS.SSa	SAND
34	MO3	11	-3.30541	54.0459	CR.HCR.XFa.FluHocu	BOULDERS/ROCK & SAND
35	MO3	10	-3.28132	54.0454	CR.HCR.XFa.FluHocu	BOULDERS/ROCK & SAND
36	MO4	19	-3.22223	53.912	CR.HCR.XFa	BOULDERS/ROCK & SAND
37	MO4	23	-3.21018	53.9128	CR.HCR.XFa	BOULDERS/ROCK & SAND
38	MO4	20	-3.20568	53.9227	CR.HCR.XFa.FluHocu	BOULDERS/ROCK
39	MO4	48	-3.19622	53.9189	SS.SSa	COBBLES & SAND
40	MO4	22	-3.19238	53.9269	CR.HCR.XFa	BOULDERS/ROCK
41	MO4	12	-3.19034	53.9426	CR.HCR.XFa	BOULDERS/ROCK & SAND
42	MO4	12	-3.18877	53.9543	CR.HCR.XFa	BOULDERS/ROCK & SAND
43	MO4	14	-3.20797	53.9584	SS.SSa	SAND & BOULDERS
44	MO4	13	-3.21121	53.9715	SS.SSa.IMuSa	SAND

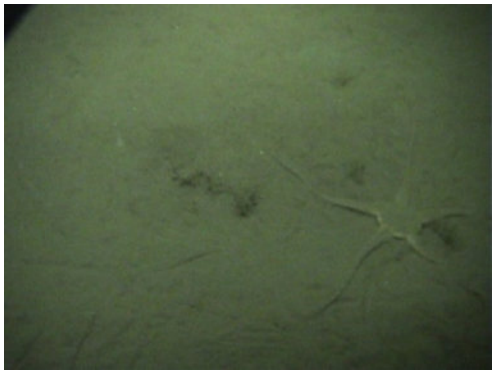
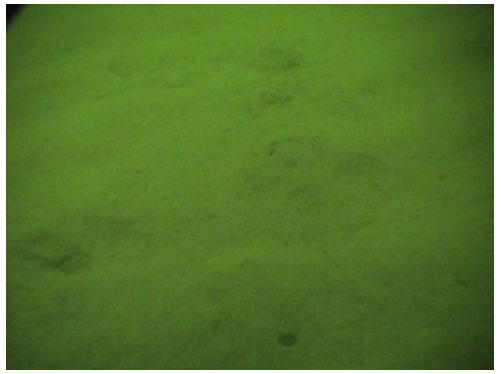
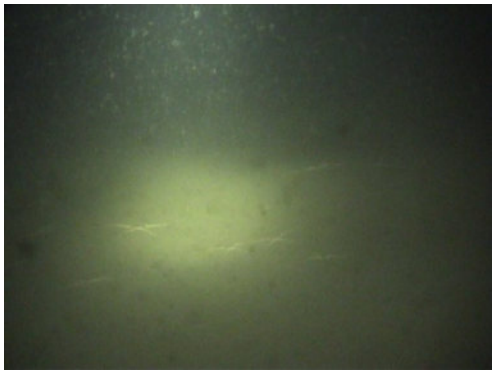
45	MO3	14	-3.24285	53.992	SS.SSa.IMuSa	SAND
46	MO3	13	-3.25358	53.9973	CR.HCR.XFa	COBBLES & BOULDERS WITH SAND

8.5 Video Sediment Visual Estimates

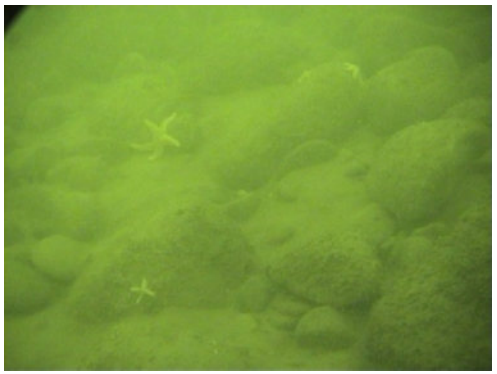
TAKE	BEDROCK	BOULDERS	COBBLES	PEBBLES	GRAVEL	SAND	COARSE SAND	MEDIUM SAND	FINE SAND	SILT
1		5	72						20	
2								70	20	10
3								70	20	10
4								70	20	10
5		50	30						20	
6		30	50						20	
7		30	45						25	
8		50							50	
9								70	20	10
10								70	20	10
11		5	25					70		
12		80	10					10		
13		40	50					10		
14		20	60			20				
15		15	70			15				
16					70				30	
17		10	40			50				
18		20	65			5				
19		10	65	20		5				
20			70			30				
21						100				
22						100				
23						100				
24						100				
25						100				
26	20	30	10						40	
27	20	30	10						40	
28	20	30								
29		30	10	5	5	50				
30		10	40			50				
31			60		10	30				
32		10	40		10	40				
33						100				
34	10	20	20			50				
35	10	20	20			50				
36	10	20	30	10		50				
37		50				50				
38		50	30			20				
39			20			80				
40		50	25			25				
41		50	25			25				
42		50	25			25				
43			10			90				
44						100				
45						100				
46		50	10			40				

9 Appendix 2

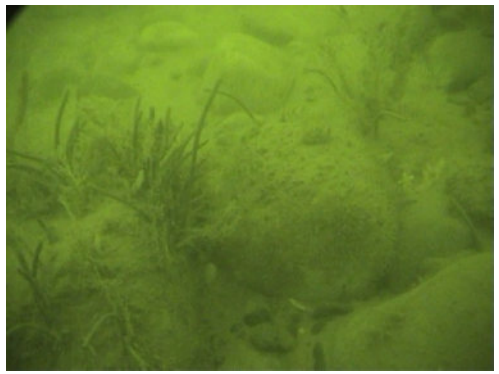
Biotope Code	Biotope Description from MHD (JNCC)	Biotope description from video records from the Morecambe Bay survey
SS.SSa	Sublittoral sands and muddy sands	Clean sand with no obvious epifauna to enable higher code assignment
		 33.1
		 43.4
SS.SSa.IMuSa	Infralittoral muddy sand	Muddy sand, often with *Asterias rubens* and *Pagarus bernhardus*
		 44.3
		 45.6 *Asterias rubens*

<table>
<tr><th>Biotope Code</th><th>Biotope Description from MHD (JNCC)</th><th colspan="2">Biotope description from video records from the Morecambe Bay survey</th></tr>
<tr><td rowspan="3">SS.SSa.CMuSa</td><td rowspan="3">Circalittoral muddy sand</td><td colspan="2">Muddy sand, often with Ophiura spp, little evidence of infauna, sparse burrows. No Ophiura biotope in MHD therefore level 3 biotope, could SS.SSa.CMuSa.Ophi</td></tr>
<tr><td> 
4.2 Ophiura spp</td><td> 
9.1</td></tr>
<tr><td> 
25.3 Ophiura spp</td><td></td></tr>
<tr><td>SS.SSa.CMuSa.AalbNuc</td><td>Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment</td><td colspan="2">No video footage, biotope identified from infaunal data.</td></tr>
</table>

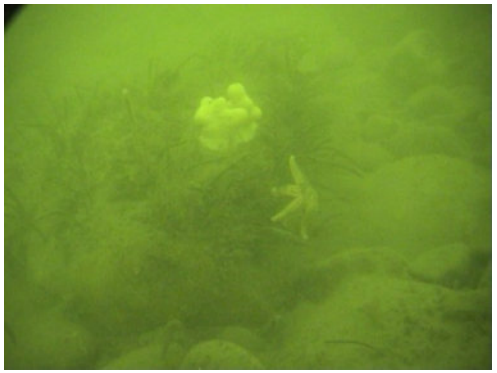
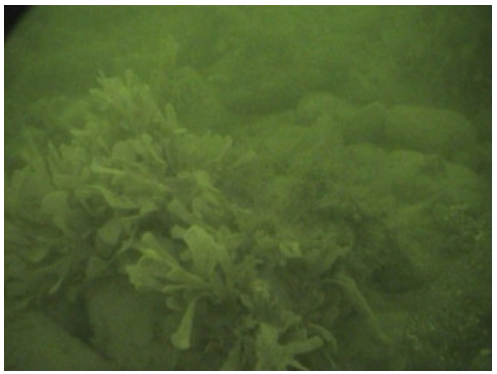
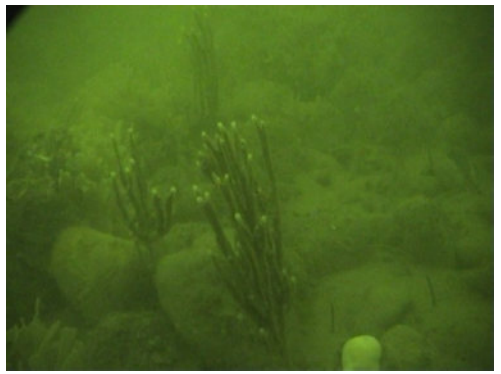
Biotope Code	Biotope Description from MHD (JNCC)	Biotope description from video records from the Morecambe Bay survey
SS.SMu.CSaMu.AfilMysAnit	*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud	No video footage, biotope identified from infaunal data.
SS.SMx.IMx	Infralittoral mixed sediment	No video footage, biotope identified from infaunal data.
CR.MCR	Moderate energy circalittoral rock	Very similar substrate to CR.HCR.XFa but lacks *Flustra foliacea* in the turf and has dense *Sabella pavonina* on stable boulders & cobbles

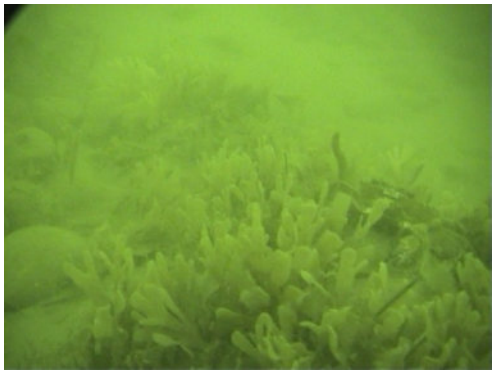
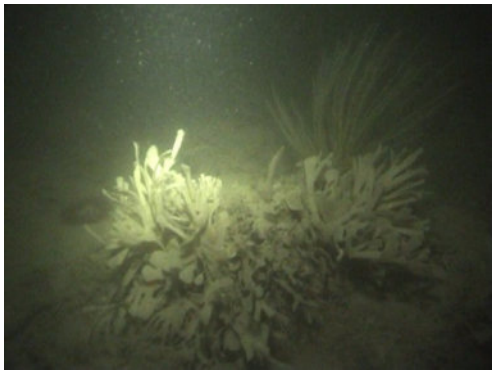
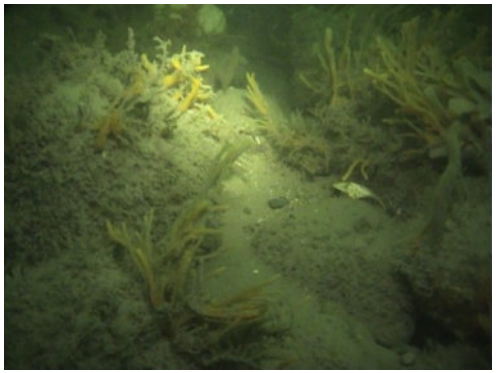


7.6



14.6 *Sabella pavonina*

Biotope Code	Biotope Description from MHD (JNCC)	Biotope description from video records from the Morecambe Bay survey	
		 14.10 Alcyonium & Asterias	
CR.HCR.XFa	Mixed faunal turf communities	Stable boulders, cobbles & rock with *Flustra foliacea, Nemertesia antennina, Hydralmania falcata, & Alcyonidium diaphanum.* These species along with other erect hydroids and bryozoans for a turf community but no obvious colonial ascidians & sponges mean it the biotope could be impoverished CR.HCR.XFa.FluCoAs.	
		 6.8 *Flustra foliacea,*	 12.12 *Alcyonidium diaphanum*

Biotope Code	Biotope Description from MHD (JNCC)	Biotope description from video records from the Morecambe Bay survey	
		 17.9 *Flustra foliacea,*	 27.3 *Flustra foliacea, Nemertesia antennina*
CR.HCR.XFa.FluHocu	*Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed substrata	Biotope is similar to CR.HCR.XFa above but obvious sponges are interspersed within the faunal turf.	
		 34.7 *Flustra foliacea & Haliclona oculata*	

10 Appendix 3

In the following illustrations two images from the same transect are shown; a sun-illuminated terrain model and a sidescan sonar image. The terrain model has been created from the swath bathymetric data to create a three dimensional surface model of the bathymetry of the seafloor. The model has been 'illuminated' as if the sun was at a position north east of the model. It is purely based on bathymetry and does not show any other acoustic properties of the seafloor.

The sidescan imagery has not been mosaiced or slant range corrected. This has preserved the resolution of the raw data and the depth profile of the seafloor directly under the vessel can be seen from the sediment/water interface either side of the centre line of the image. The imagery shows the reflectance properties of the sediment that depend upon fine-scale topography and strength of reflectance of different sediments.

As the mosaicing process georectifies sidescan images it follows that the un-mosaiced images presented cannot be accurately positioned and the images are used for illustrative purposes to show the characteristics of reef features.

Most of the ground surveyed was both hard and rough and this has resulted in the sidescan images appearing fairly uniform in texture (N.B., texture is due to fine-scale topography). Broader scale features are often not well picked up by sidescan, depending upon the direction the survey vessel takes in relation to the orientation of the features. Terrain models, on the other hand, are built up from depth data and the model of features is not so dependent on track direction. In general, therefore, the terrain models show reef features better than the sidescan images and this source of data has been used as the primary means for characterising reef features from the acoustic data.

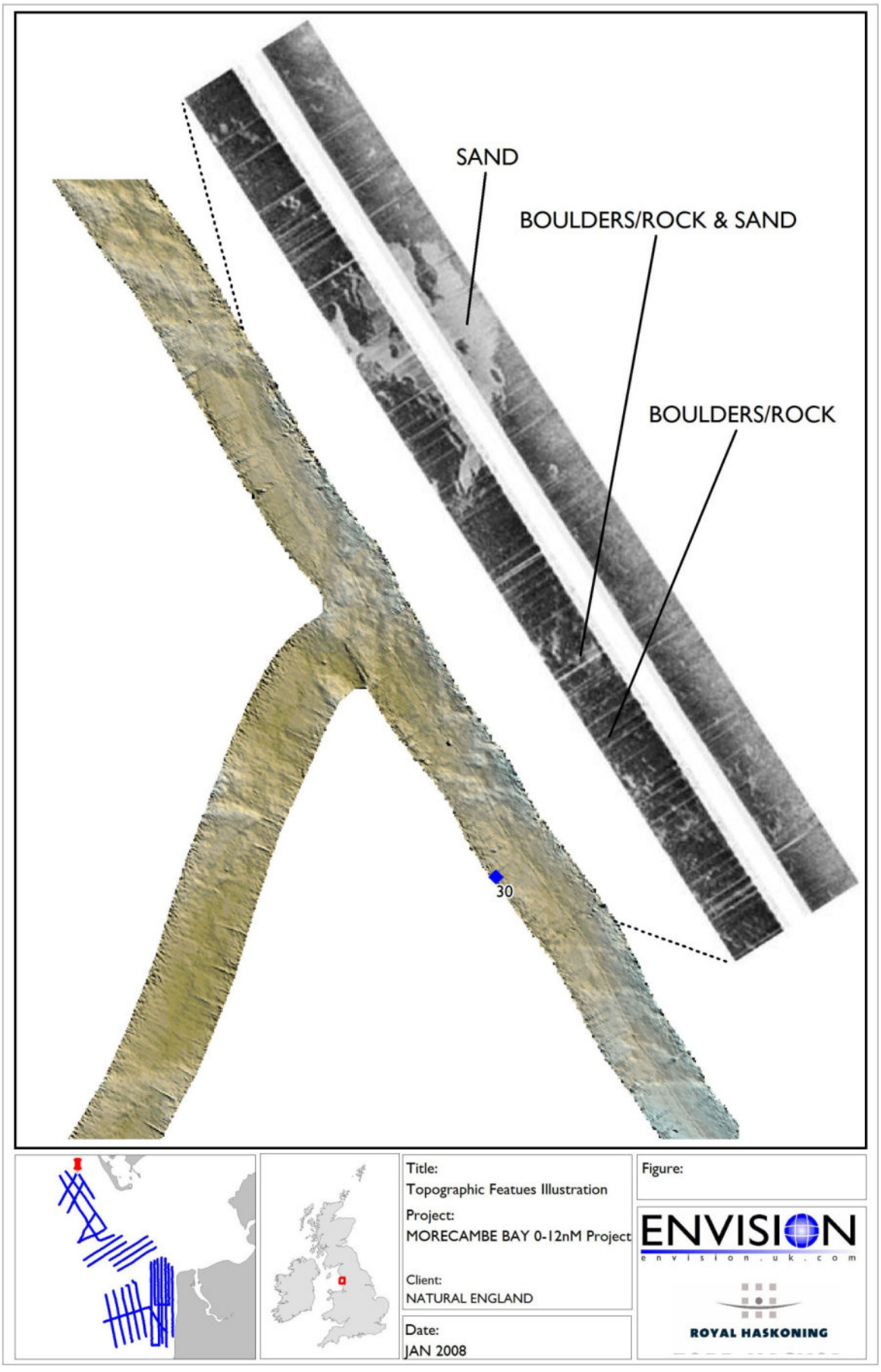


Illustration 1 Boulders/Rock; Boulders/Rock & Sand; Sand

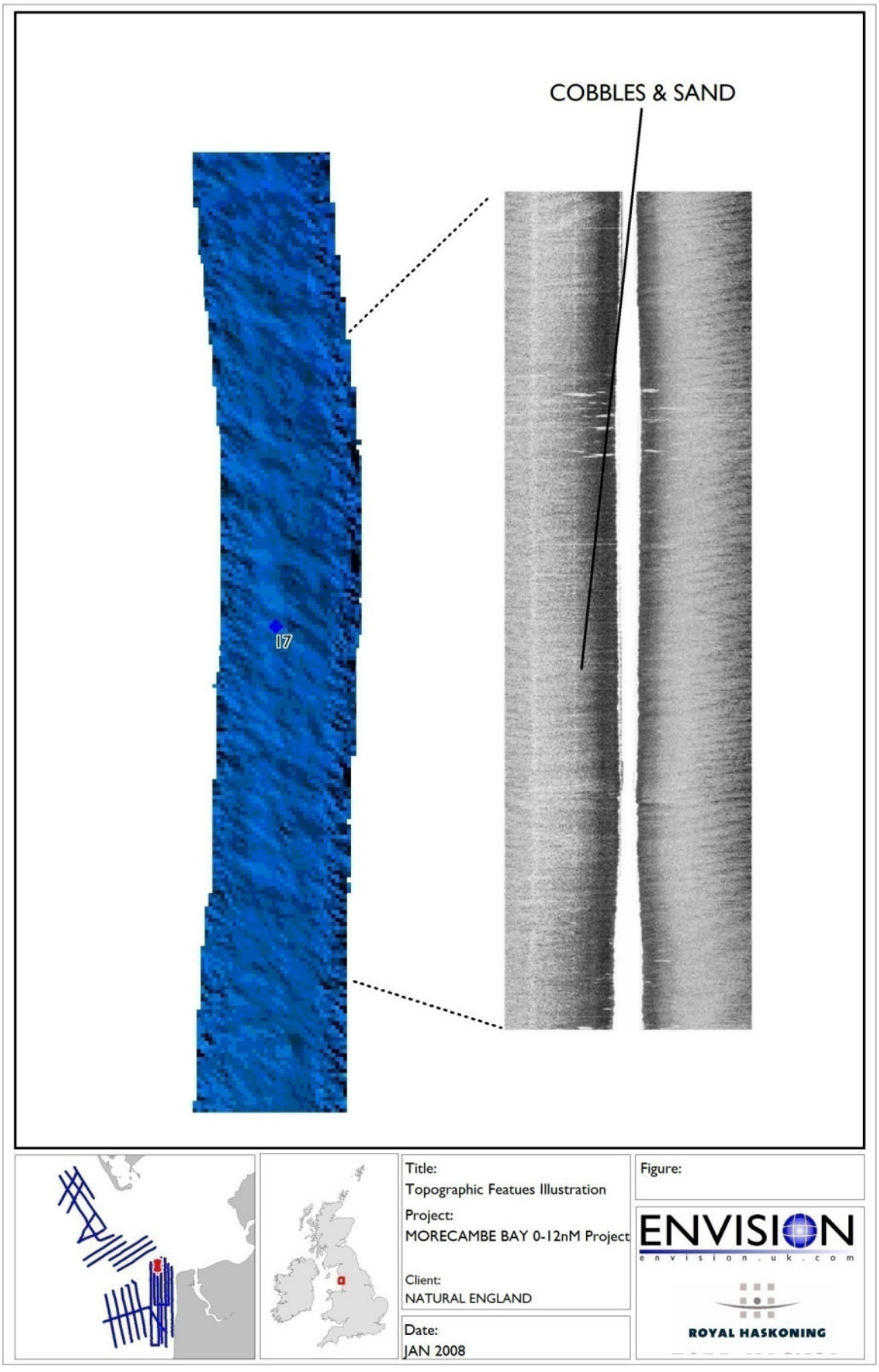


Illustration 2 Cobbles & Sand

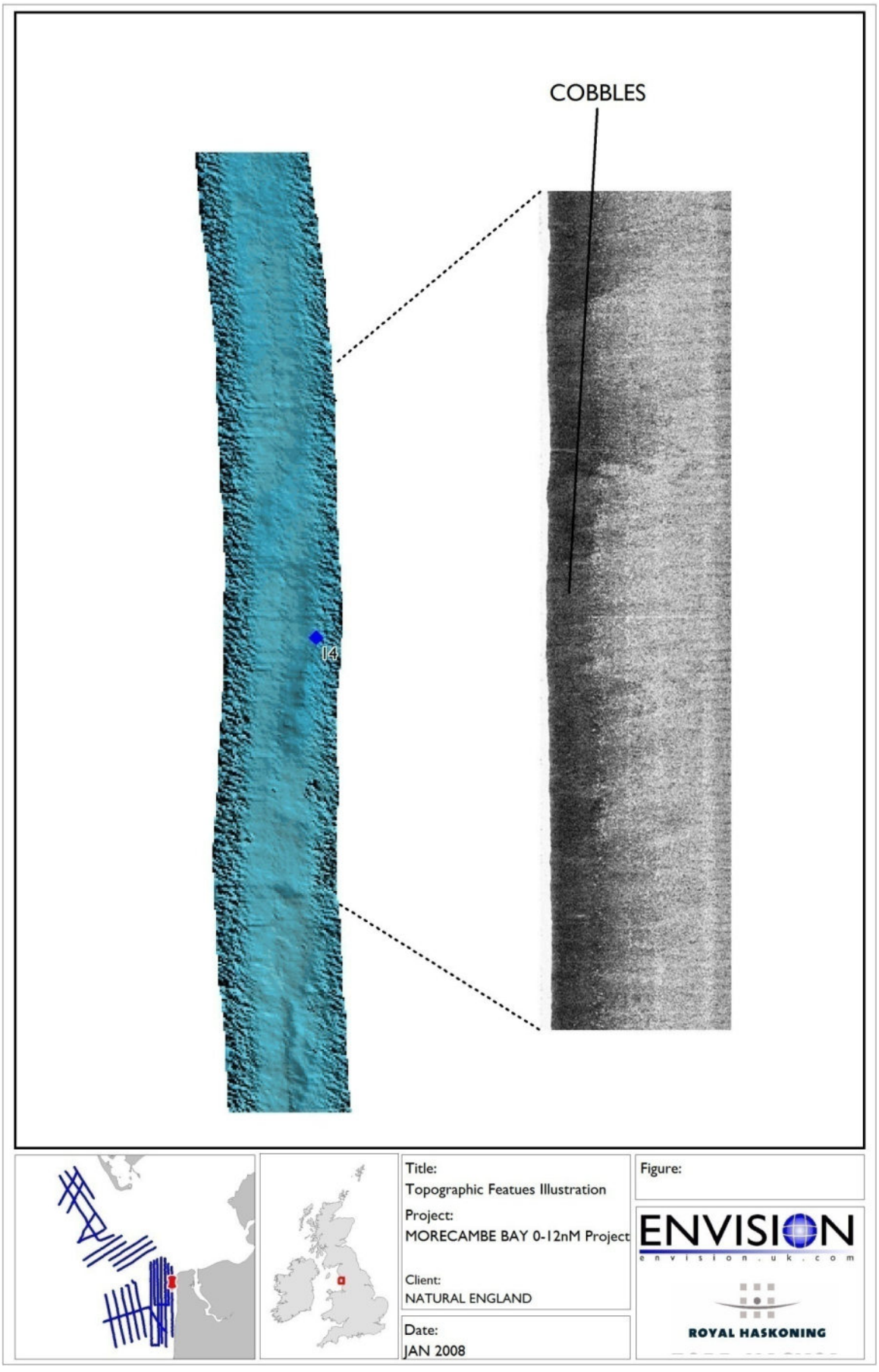


Illustration 3 Cobbles

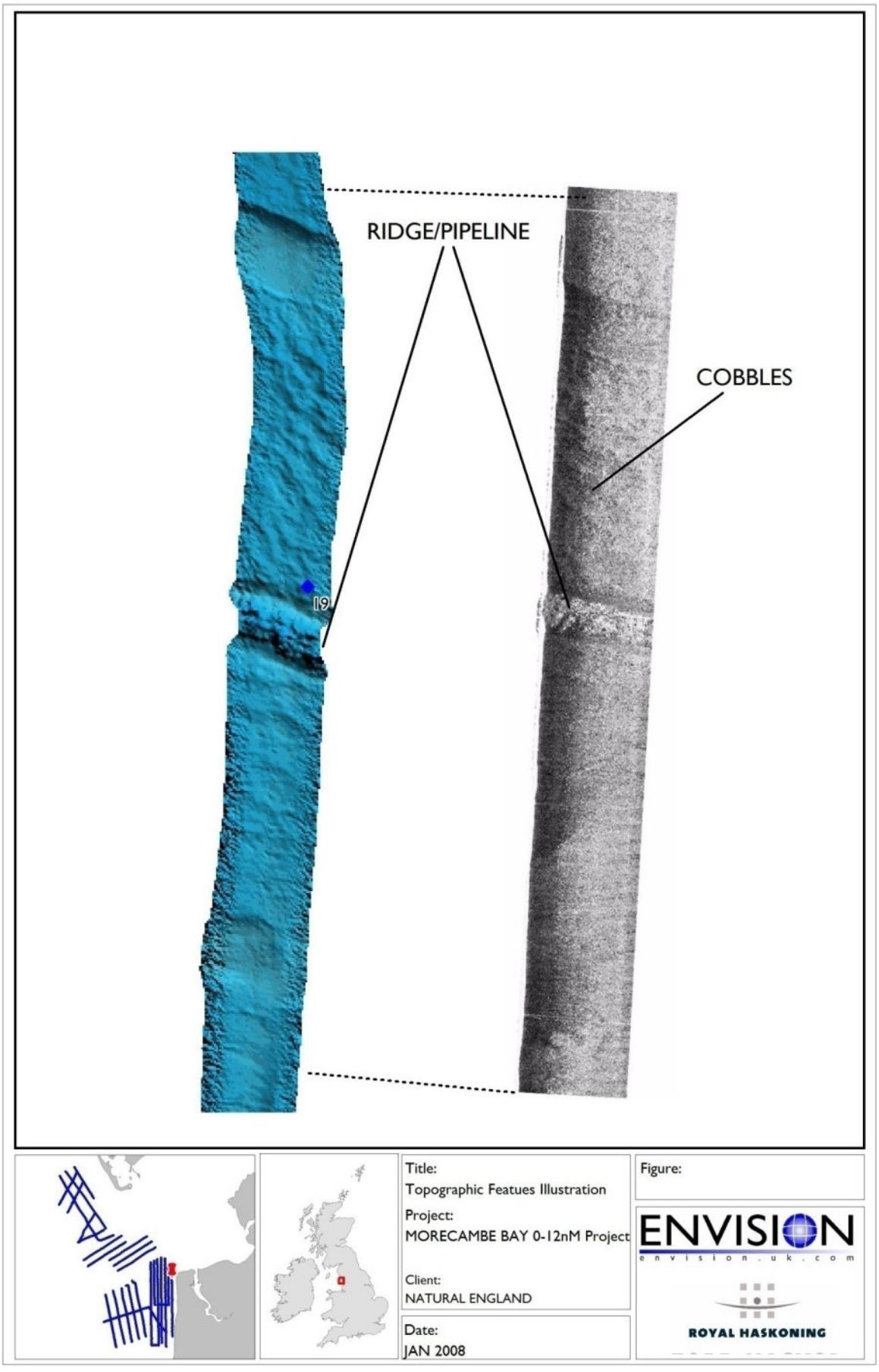


Illustration 4 Ridge/Pipeline/Outdall; Cobbles

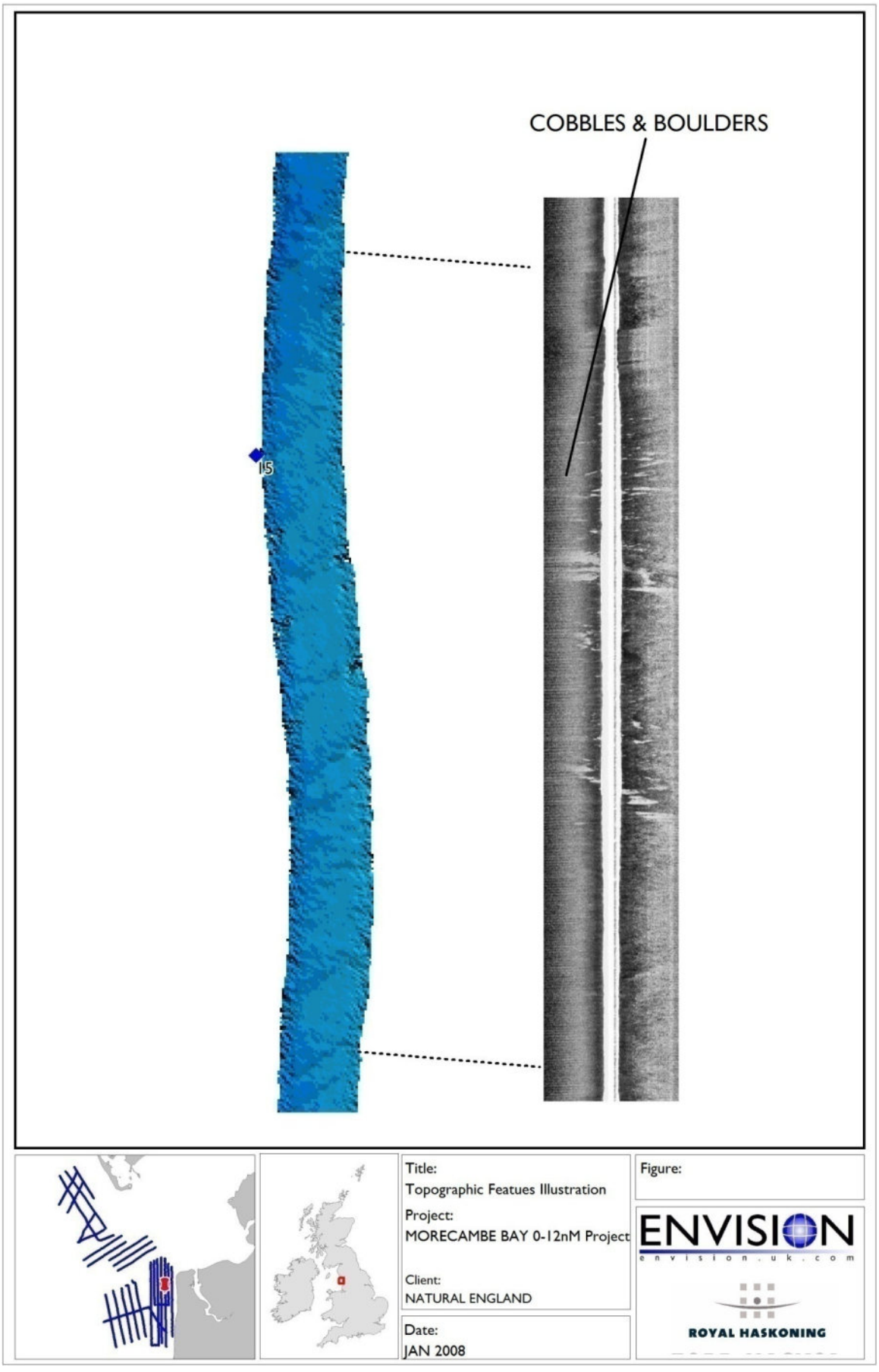


Illustration 5 Cobbles & Boulders with Sand

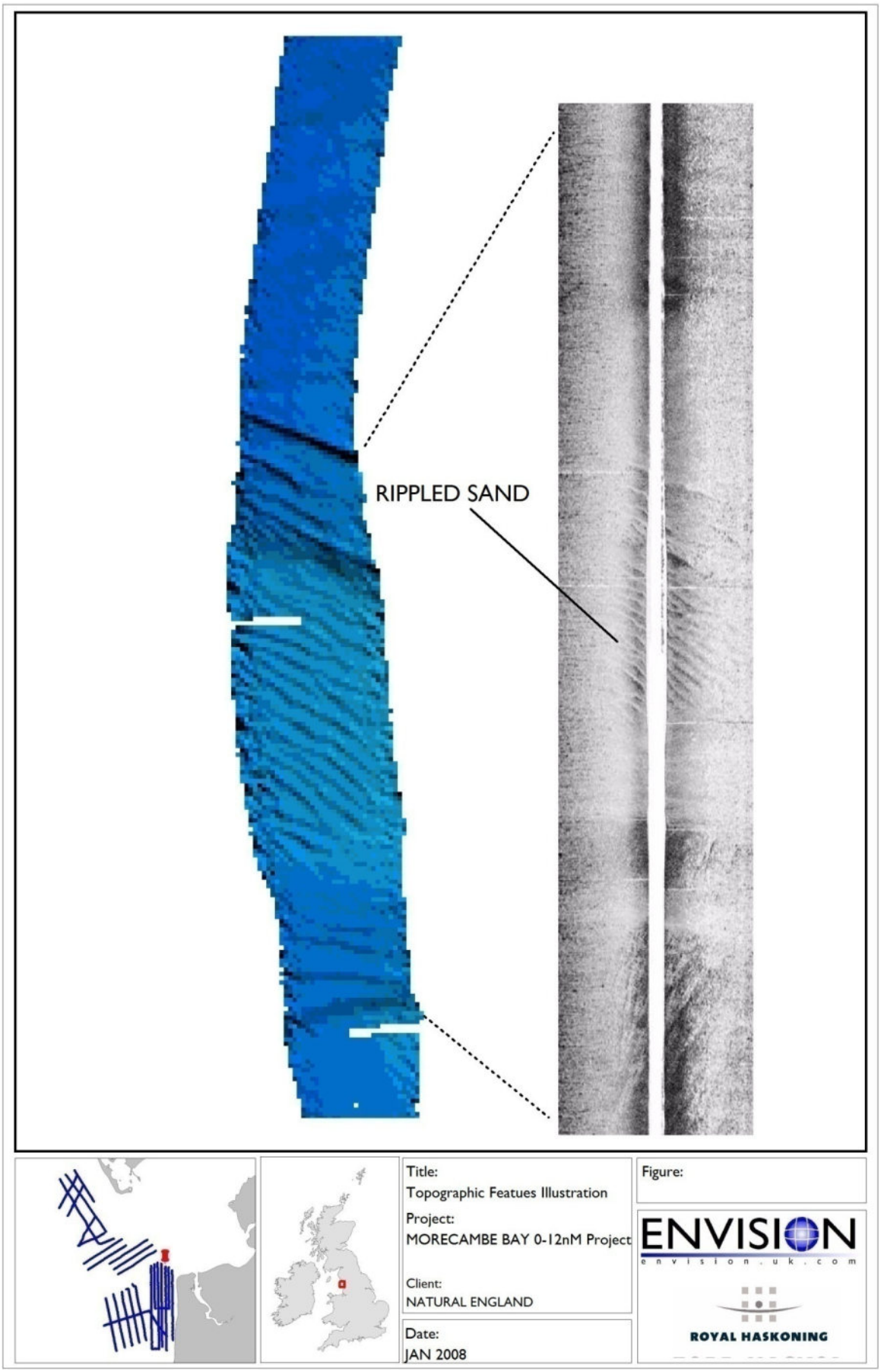


Illustration 6 Rippled Sand

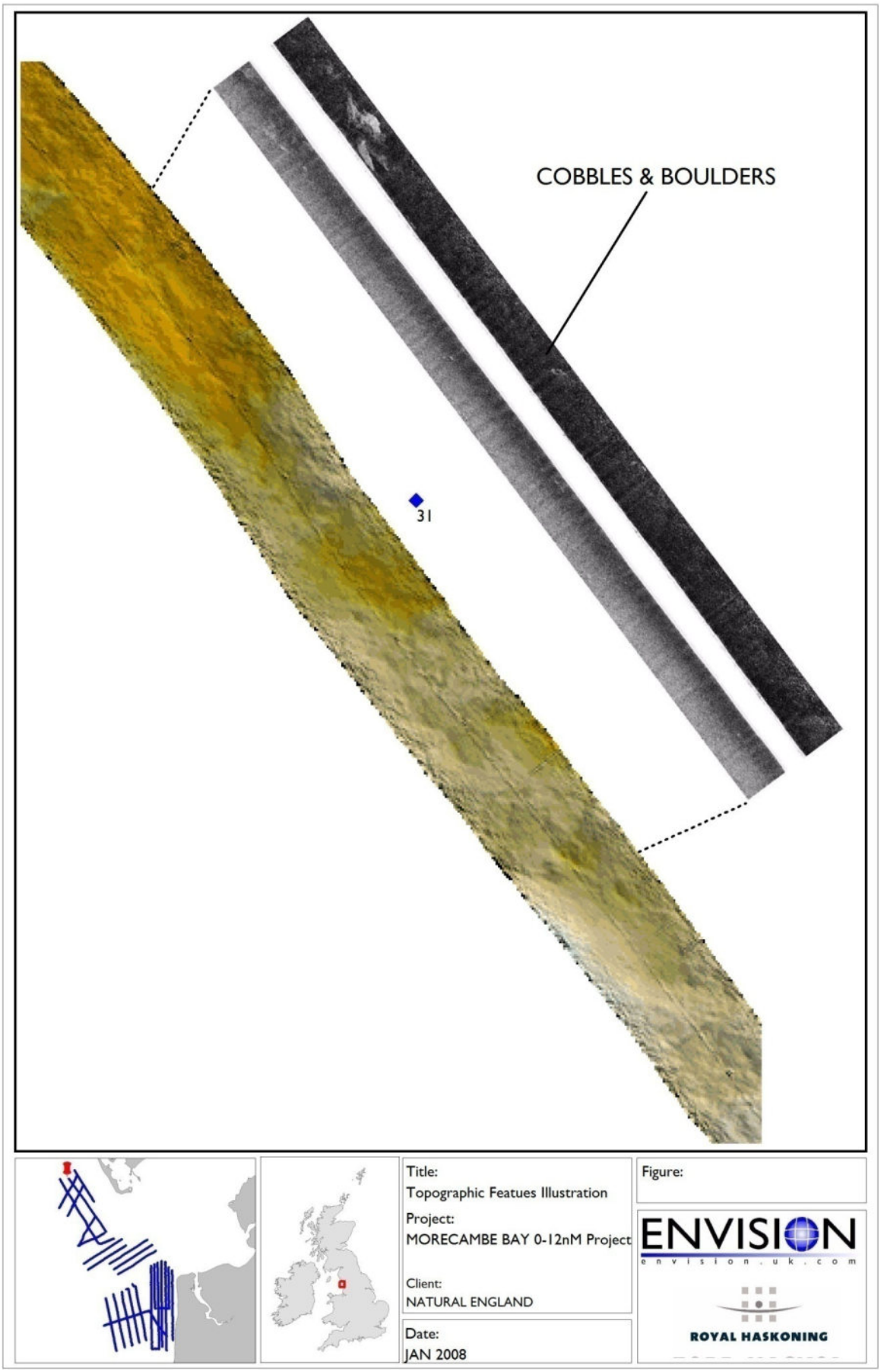


Illustration 7 Cobbles & Boulders

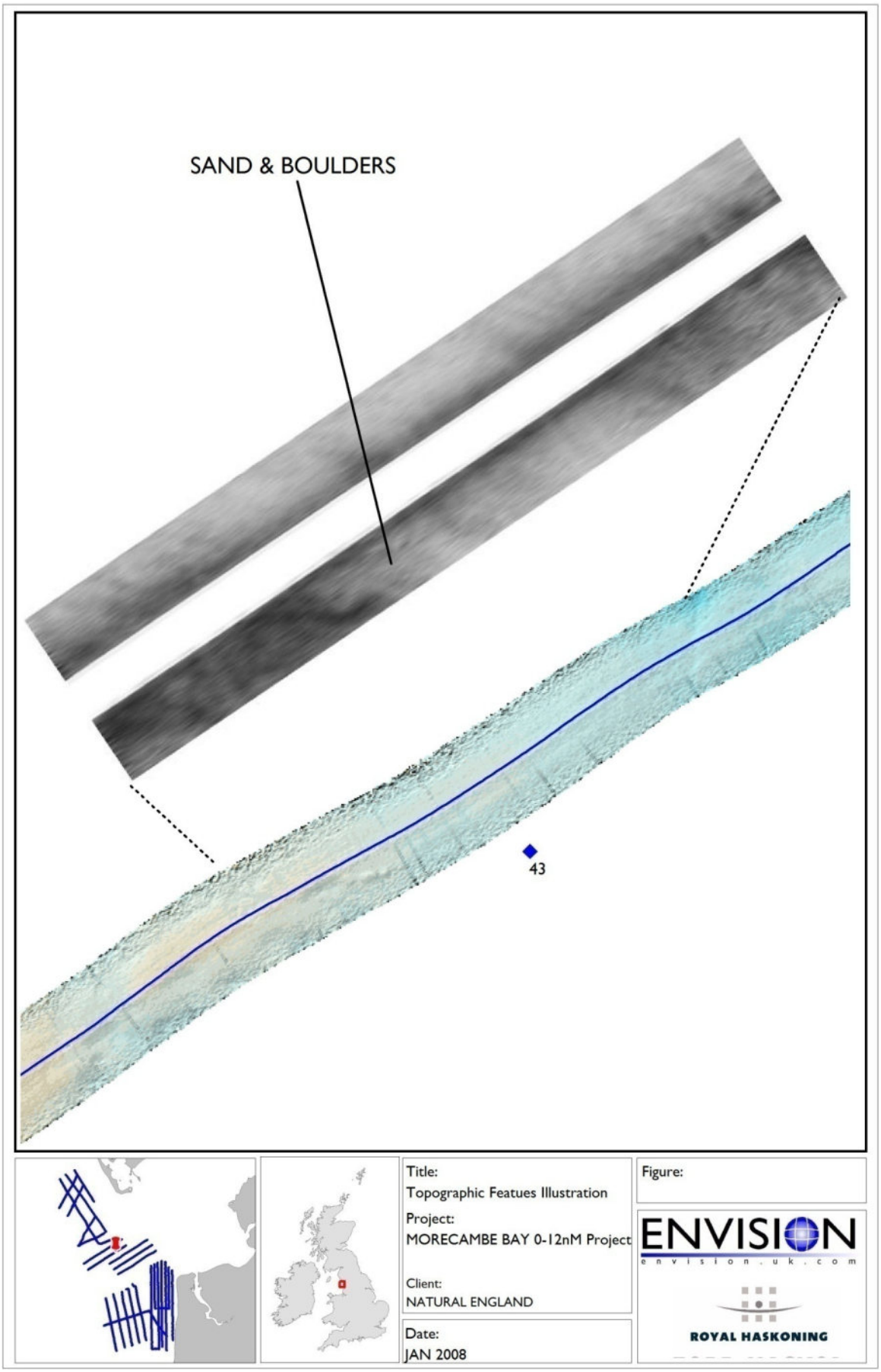


Illustration 8 Sand & Boulders