ENVISION MAPPING

Shell Flat and Lune Deep Sensitive Special Area of Conservation & Fylde Marine Conservation Zone Interpretation and Mapping 2015

PREPARED FOR Natural England

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1 Summary

1.1 The Shell Flat and Lune Deep candidate Special Area of Conservation is a Site of Community Importance, and current evidence identifies the qualifying Annex 1 habitat and feature: Sandbanks which are slightly covered by water all the time. The Shell Flat subtidal sandbank is an example of a Banner Bank, and has a typical sandy substrate biological community. Shell Flat is the only sandbank feature identified within the outer Shell Flat site and is known to provide important habitats for commercial fish species and bird populations. The unique enclosed deep hole (kettle hole) known as Lune Deep provides a contrasting habitat to the surrounding muddy communities of the Eastern Irish Mudbelt. Lune Deep and the area immediately to the north support mixed faunal turf communities over a cobble/rock substrate. The reef habitat present in the area represents a good example of boulder and bedrock reef.

1.2 Fylde MCZ lies immediately adjacent to the South of Shell Flat and was designated in 2013 for its subtidal sand Broad Scale Habitat feature, although subtidal mud also occurs across approximately 50% of the site. These sediment features are considered to be good representatives of the seabed habitats and communities found on the eastern side of Liverpool Bay. The sediment habitats are known to support rich bivalve mollusc populations, and include important nursery and spawning grounds for several commercially important fish.

1.3 The focus of this contract was to undertake analysis of the available data in these areas (Figure 1) and to produce topography and habitat maps to the highest practicable resolution, and where possible, to look at changes in biota, habitats and topography over time across the sites, drawing conclusions as to the condition of the features, comparing habitats between sites and the data returned by both Day and Hammon grab methods. These maps are to provide a basis for long term monitoring of feature condition.

1.4 Combined topographic maps have been produced for the Shell Flat & Lune Deep SAC and Fylde MCZ. Maps of the predictive distribution of sediment types show the Shell Flat to be dominated by slightly gravelly sand, (g)S, on the top of the bank with slightly gravelly muddy sands, (g)mS, in the deeper areas. Lune Deep shows a distinct rock/hard area on the northern flat of the deep channel with the southern flank comprising of gravelly sand and some gravelly mud. The predominant difference between the sediments of Shell Flat and the adjacent Fylde MCZ is the quantity of silt or mud found within the sediments. Within the northern area of the Fylde MCZ the proportion of silt increases, making for more muddy substrates. Only in the southern area of the MCZ does the silt fraction lower and the sediment become more sand influenced again.

1.5 In total 11 biotopes were assigned over the Shell Flat and Lune Deep SAC and Fylde MCZ, although only 10 were mapped, as one biotope occurred infrequently and conflicted with other data. The habitat distribution maps support the sediment maps in that the Shell Flat area is occupied by the *Fabulina fabula* and *Magelona mirabilis* biotope (SS.SSa.IMuSa.FabMag) in the fine shallower sediments of the bank with *Abra alba* and *Nucula nitidosa* biotope (SS.SSa.CMuSa.AalbNuc) occurring in the deeper and slightly muddier sediments found on the slopes and in deeper areas of the bank. The northern section of the Fylde MCZ is composed of a sandy mud biotope extending east-west, interrupted by a finger of the sandier *Abra alba* and *Nucula nitidosa* biotope (SS.SSa.CMuSa.AalbNuc). The remaining areas are mostly sand and muddy sand based habitats (SS.SSa and SS.SSa.CMuSa) The Lune Deep area shows the only hard substrate in the SAC with the northern slope of the areas having moderate and exposed circalittoral rock habitats and the southern slopes having mixed substrate biotopes with occasional sand influenced habitats.

1.6 The whole of the Shell Flat area of the SAC area has been identified as being Annex 1 Sandbank, with the edges of the sandbank extending further than the current SAC boundary. This may be explained by the use of the 0.1° slope cut-off from the method in Elwood 2014, along with sample data showing suitable habitat being present in these areas. Using the same criteria and slope parameters a smaller sandbank feature has been identified within the Fylde MCZ which is a smaller and less distinctive feature than the Shell Flat sandbank and is identified from the UKHO data and PSA data.

1.7 Previous seabed habitat maps from existing survey data (EUNIS maps) identify similar substrates, but show the Shell Flat area of the SAC to be muddier than part of the Fylde MCZ, which is contradicted by the PSA from the current sample data. The dissimilar distribution of habitats is likely to be due to dissimilar spatial scales and resolution of the data used to produce the previous maps. Although Lune Deep has very little mapping data associated with it, that which does exist at a similar scale agrees with the current maps which have been produced.

1.8 An examination of change over time in biota and habitats was performed, but was only possible in the Shell Flat area where data sets were comparable in terms of type of data collected and areas sampled. Multivariate analysis using PRIMER showed clustering of the samples into the different year groups, which may suggest some changes in community structure over time. However, the clusters appear to be distinguished by different proportions of a common pool of frequently recorded species, with only slight differences in the exact order and composition of the same dominant species. The appearance of relatively high numbers of a crustacean in the 2012 data, not recorded previously, might have also separated this year's data from previous years, however this species does not appear to play a large role in influencing biotope allocation. The minor changes between years could also be the result of the sampling and processing techniques used which may have varied between surveys and years, and because the datasets were not collected as part of a long term monitoring plan with robust replication between samples/sites.

1.9 Comparison of topography in the Shell Flat area over time also showed little change in the topographic profile between the 2002 and 2007 data, with only small differences in bathymetry evident. The UKHO data showed the southern slope of the Shell Flat bank to be steeper than the other two data sets, but any differences with this data are likely to be due to the predictive/modelled nature of the UKHO dataset, or the resolution.

1.10 The condition of the features within the Shell Flat area and the Fylde MCZ were considered over time, including the Shell Flat sandbank feature, and the subtidal sands and subtidal muds Broadscale Habitats found in Fylde MCZ, which are all to be maintained in favourable condition. The Shell Flat sandbank shows no decrease in area, and, as discussed previously, shows no appreciable changes in community structure over time, and therefore does not suggest any change in feature condition. The majority of the Fylde MCZ data contained only PSA information so changes in biota were impossible to examine. As the entire area of the MCZ is comprised of either subtidal sands or subtidal muds, these features cannot be considered to have decreased in extent and therefore indicate no decline in condition.

1.11 Further comparison of the data from different sampling methods (e.g. Hammon and Day grabs) was undertaken. Multivariate analysis of the infaunal data showed no difference in sites based on their species composition despite the differences in sampling method, and similar plots of sediment type indicated that particle size analysis of the samples is not thought to be influenced by the sampling gear used.

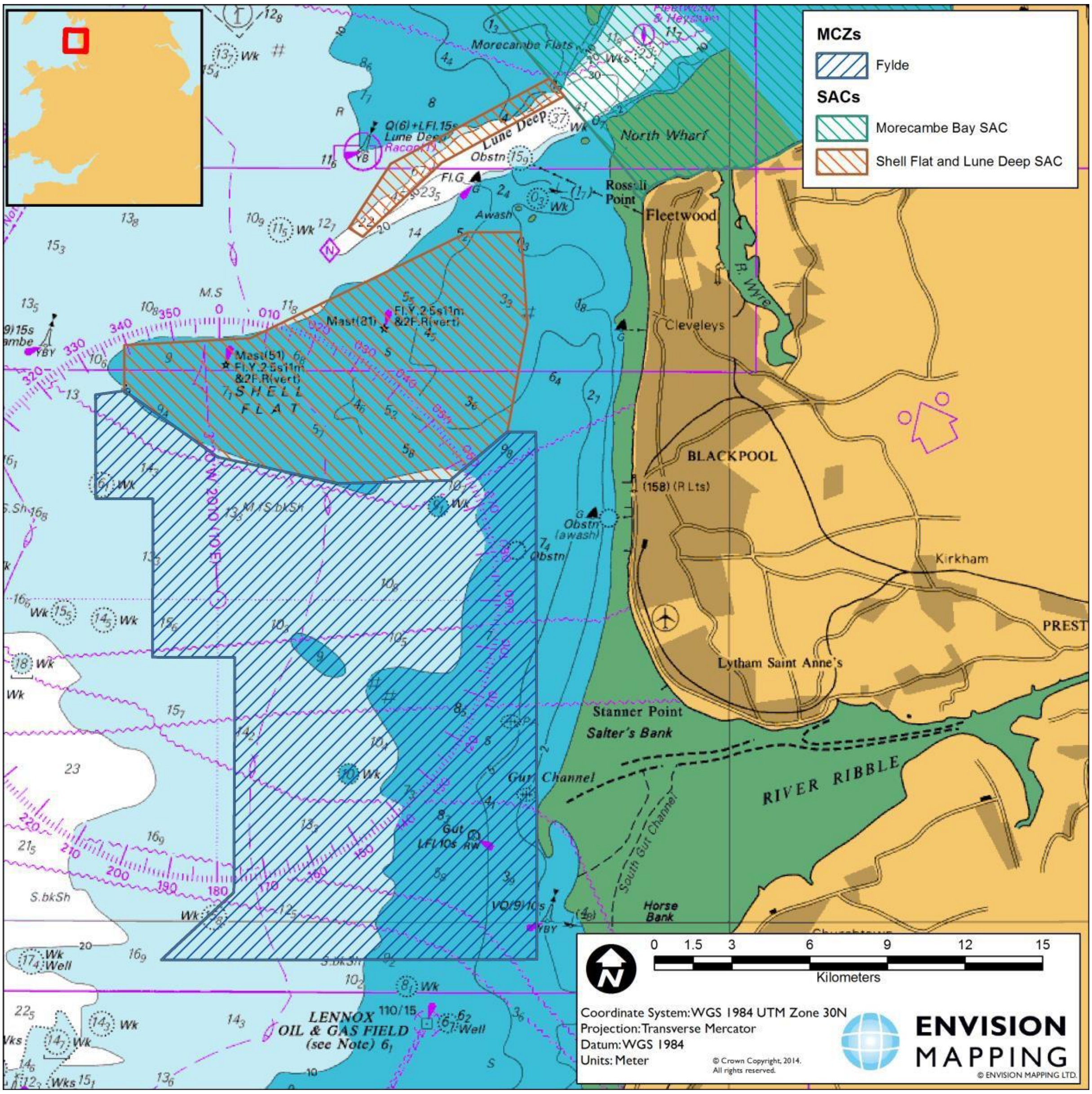

Figure 1 Extent of Shell Flat & Lune Deep SAC with Fylde MCZ

2 Introduction

2.1 The Shell Flat component of the Shell Flat and Lune Deep SAC is a crescent shaped sandbank comprising a range of mud and sand sediments. Shell Flat is the only sandbank feature identified within the outer Shell Flat site, and has a typical sandy substrate biological community, known to provide important habitat for commercial fish species and bird populations. The bank is an example of a Banner Bank, which are generally only a few kilometres in length with an elongated pear/sickle-shaped form, located in water depths less than 20m below chart datum. They take the form of single long banks of sand protruding to seaward from headlands with one end almost touching the shore (hence banner). They are thought to form by differences in tidal ebb and flood flows. The existing data has identified slight sediment changes across the sandbank with the top of the bank being softer and smoother and sediment becoming rougher and harder on the northern and southern slopes (Royal Haskoning, 2008). Previous studies also found that the central crest is bound to the north and south by a more muddy (or clayey) sand sediment dominated by *Ophiuroids* (Titan Environmental Surveys, 2002). The current evidence base shows the following Annex I habitat and features to be present in the area: Sandbanks which are slightly covered by seawater all the time.

2.2 Lune Deep and the area immediately to the north have been seen to support mixed faunal turf communities over a cobble/rock substrate. These areas are thought to provide habitat for erect hydroids and bryozoans with some areas having erect sponges which form the biotope *Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed substrata. The reef habitat present in the area represents a good example of boulder and bedrock reef, with the largest proportions of rock found along the unique kettle hole feature known as Lune Deep. The northern edges of Lune Deep have been characterised as heavily silted cobble and boulder slopes, subject to strong tidal currents with a dense hydroid and bryozoan turf. This unique enclosed deep hole provides a contrasting habitat to the surrounding muddy communities of the Eastern Irish Mudbelt. Data from a 2004 survey show that the northern flanks of Lune Deep are composed of exposed bedrock with a rugged seabed physiography. In contrast, the southern flank consists of a smooth seabed which is a sink for muddy sands.

2.3 Fylde MCZ lies immediately adjacent to the South of Shell Flat and was designated in 2013 for its subtidal sand Broad Scale Habitat feature, although subtidal mud also occurs across approximately 50% of the site. These sediment features are considered to be good representatives of the seabed habitats and communities found on the eastern side of Liverpool Bay. The sediment habitats are known to support rich bivalve mollusc populations. The site includes important nursery and spawning grounds for several commercially important fish species including sole (*Solea solea*), plaice (*Pleuronectes platessa*) and whiting (*Merlangius merlangus*).

2.4 Both sites overlap with the Liverpool Bay Special Protection Area which provides protection for particular bird features including common scoter (*Melanitta nigra*) and red-throated diver (*Gavia stellata*) and their supporting habitats.

2.5 The specific objectives of this contract are to produce topography and habitat maps of subtidal sandbank features within the Shell Flat & Lune Deep SAC along with habitat maps for Fylde MCZ, to the highest practicable resolution. The approach will focus on key attributes, namely the gross morphology (depth distribution and profile), the variety and distribution of sediment types, the extent and distribution of individual subtidal sandbank communities and the community composition of the subtidal sandbank feature within the sites. Delineation of sandbanks will consider their original definition from the SAC designation, as well as the more recent approach to delineating sandbank features approved in 2012 (Ellwood, 2014).

2.6 The report will also include a comparison of previous data sets and habitat maps where available, with comment on changes in biota, habitats and topography over time across the sites, and any changes in condition of the features being mapped. Additionally comparison of the biota from Shell Flat to the Fylde MCZ, and of the biota returned by different grab methods (Day and Hammon grabs) will be considered.

3 Methodology

3.1 Existing geophysical acoustic data were available from previous surveys (Figure 2), including multibeam and backscatter from ABP (2012): Mapping the extent of the Shell Flat candidate Special Area of Conservation (SAC), AGDS multibeam and sidescan from Envision (2008): Mapping the Marine Habitats of Morecambe Bay. Ground truth data were provided from 3 main sources, Cirrus Shell Flat Array benthic data (2002), Kaiser et al COWRIE benthic data (2003) and Environment Agency (EA) benthic monitoring data (2012). Data held within Marine Recorder JNCC (2012) were also used.

3.2 Data holdings varied across the Shell Flat & Lune Deep SAC and Fylde MCZ with a regularly spaced, partial coverage high resolution bathymetric data set available for Shell Flat and partial coverage data for Lune Deep. Side scan data for Shell Flat provided good coverage at regular intervals and again partial coverage for Lune Deep with no sidescan available for Fylde MCZ. (Figure 2).

3.3 In addition to the bathymetric and sidescan data for the Shell Flat & Lune Deep SAC, a national bathymetric dataset at a resolution of one arc second (UKHO Data) was employed to assist with the mapping of the Fylde MCZ and areas of the SAC with no multibeam coverage. The data for the SAC area were extracted from the national dataset and plotted at a 25m resolution (Figure 4).

3.4 AGDS Data were available for parts of the site and these data have been previously interpreted to identify Annex 1 features and other habitats, and have been used to compare/verify any resulting feature maps which have been generated.

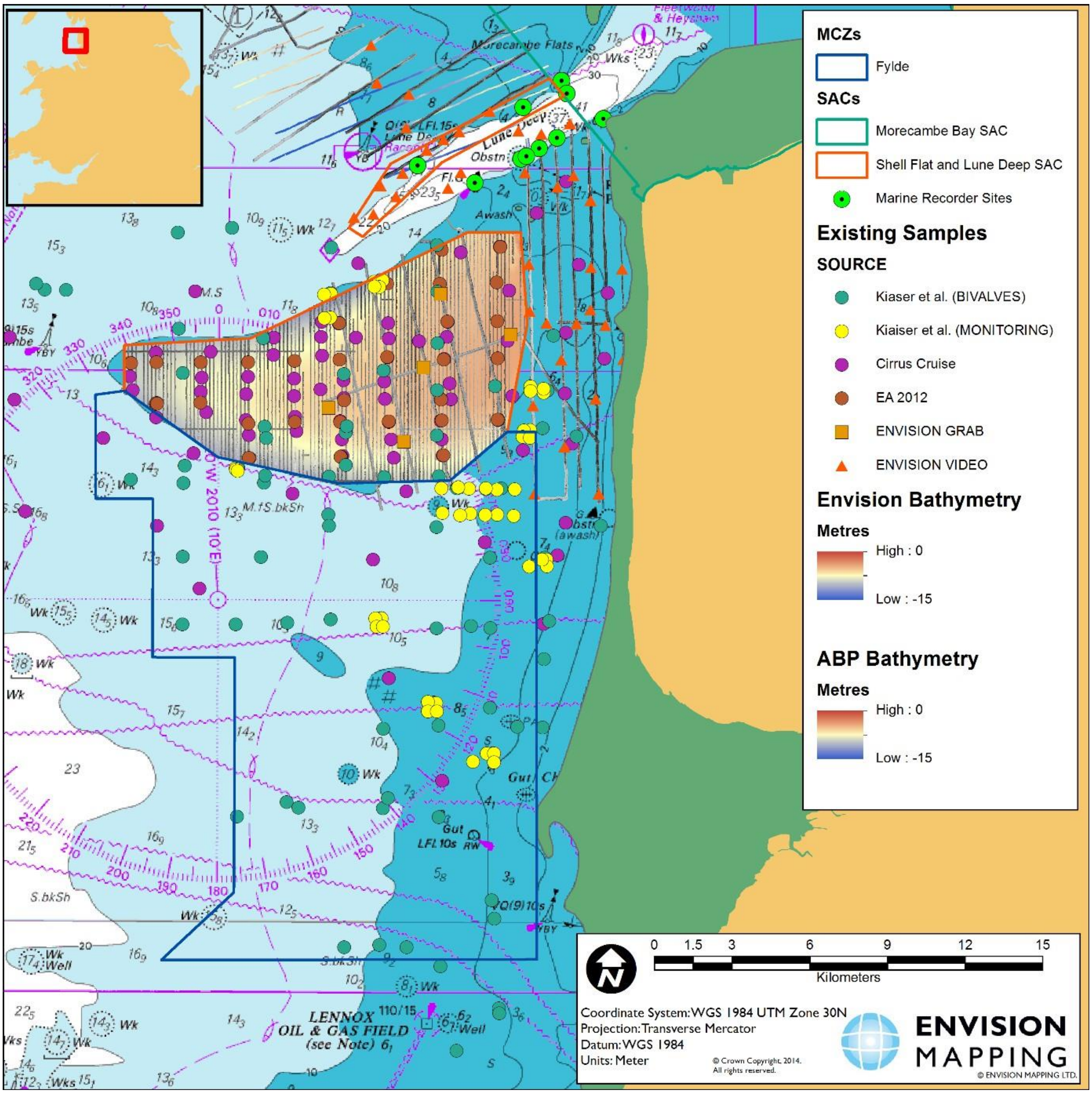

Figure 2 Bathymetric, Sidescan and sample point data for Shell Flat & Lune Deep SAC and Fylde MCZ and the wider area.

3.5 The multibeam and sidescan data were compiled and processed at the highest resolution possible (25m) in order to delineate the requested features. The infaunal and PSA data required a high level of sorting and reorganisation, and also checking of sediment descriptions in order to ensure grouping into legitimate and useful substrate and biota categories / biotopes.

3.6 Sample data supplies ranged from 1991 for data held within marine recorder to 2012 for EA benthic monitoring data. Each data set had positional information, some had qualitative descriptive data only, and some had quantitative data either as PSA or as infaunal species compositions: some were attributed with all these data. Table 1 shows the files available and the data contained within, and Table 2 provides a summary of each annual data set.

Table 1 Summary of data supplied

Filename	Description
Shell Flat Interpolated All - 2m Grid.xyz	2m bathymetry for shell Flat
Shell Flat All - 4m Interpolated Grid with Backscatter.tif	Mosaic of MBES backscatter for Shell flat (not 100% coverage)
2m sss envision.tif	2m sidescan lines mosaic for some of shell flat and lune deep and surrounding area
2m envision.asc	2m bathymetry grid for some of Shell Flat and Lune Deep and surrounding area
MORECAMBE AGDS.TXT	Envision AGDS data from 2007 for shell flat and lune deep and surrounding area
envision_grabs.shp	2007 grab sample data
Morecambe Video Species2.xls	1993-2010 Sample site info, and infauna
Morecambe Bay Grabs Data 2007.xls	2007 grab infauna data and PSA data
331JEN_ShellFlat_alldata.xls	Cirrus cruise data, infauna & PSA for grabs along with trawl data
Shell Flat Sample Summary.xls	EA 2012 sample summary
Shell Flats SAC 2012 modified.xls.xlsx	EA 2013 Macrofauna data
Shell Flat PSA results.xls	EA 2012 PSA Data
Bivalves(1).xlsx	Kaiser et al data PSA & Macrofauna (bivalves only)
One Arc Second Grid © UKHO.lyr	UKHO bathy (1sec resolution for whole area)
Infauna_total_biomass.xls	Kaiser et al data infauna biomass

Table 2 Summary type of of data available per dataset

Data & Year	PSA	Infauna	Qualitative
Cirrus Shell Flat Array benthic data (2002)	Yes	Yes	Yes
Kaiser et al COWRIE benthic data (2003)	Yes	Yes (restricted)	Yes
EA monitoring benthic data (2012)	Yes	Yes	Yes
Envision Video (2008)	No	No	Yes
Envision Grabs (2008)	Yes	Yes	Yes
Marine Recorder MNCR data 1991	No	Epifauna	Yes

Processing and Analysis of the Geophysical Acoustic Data

3.7 The geophysical acoustic data available originated from a variety of sources and an initial task was to compile these data in to a common dataset. Bathymetry data consisted of gridded multibeam data and single beam soundings.

3.8 In addition to the bathymetric and sidescan data, a national bathymetric dataset at a resolution of one arc second (UKHO Data) was employed to assist with the mapping of the wider area and Fylde MCZ. Figure 3 shows the individual coverage overlaid but not combined. The data for an area encompassing the SAC and MCZ area were extracted from the national dataset and plotted at a 25m resolution. It is noted that the UKHO data set is derived from a variety of sources to produce a comprehensive coverage but this has some data processing artefacts which can be seen as linear features or striping in the data set (Figure 3) especially in the Fylde MCZ area.

3.9 The combined dataset used a common resolution (25m) to enable a composite dataset to be produced and utilised within the mapping process. The composite bathymetric data is presented as the bathymetric grid for the Shell Flat & Lune Deep SAC and Fylde MCZ areas (Figure 4).

3.10 The sidescan sonar and backscatter data for Shell Flat & Lune Deep SAC showed generic sediment features and variations along the tracks with some small scale features visible and some continuous linear features were obvious extending between adjacent tracks which are possibly trawl or dredge marks. Final processing of the sidescan data produced a mosaic for the Shell Flat & Lune Deep SAC (Figure 5) with inset showing linear features.

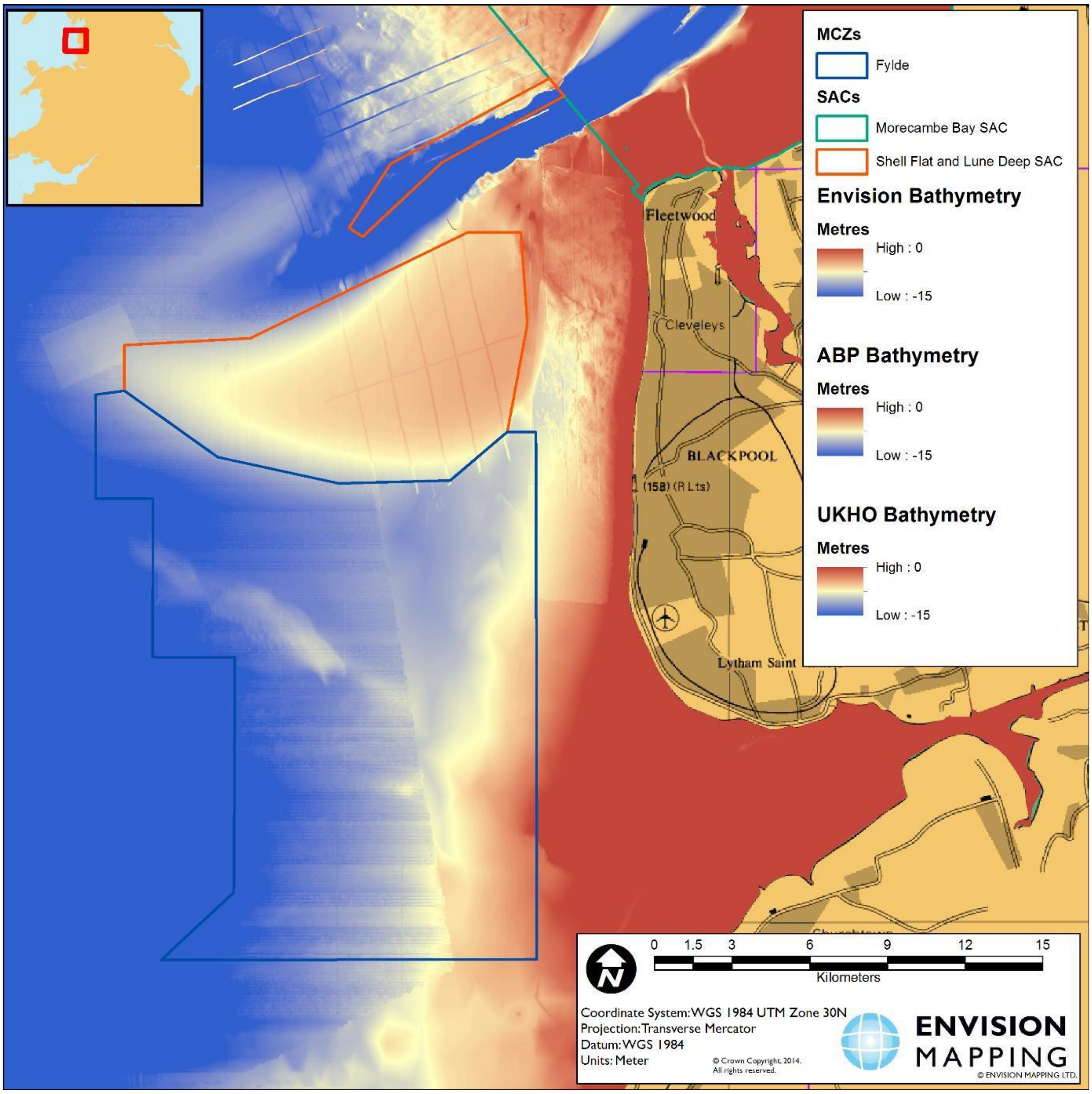

Figure 3 Bathymetric data for the Shell Flat & Lune Deep SAC and Fylde MCZ

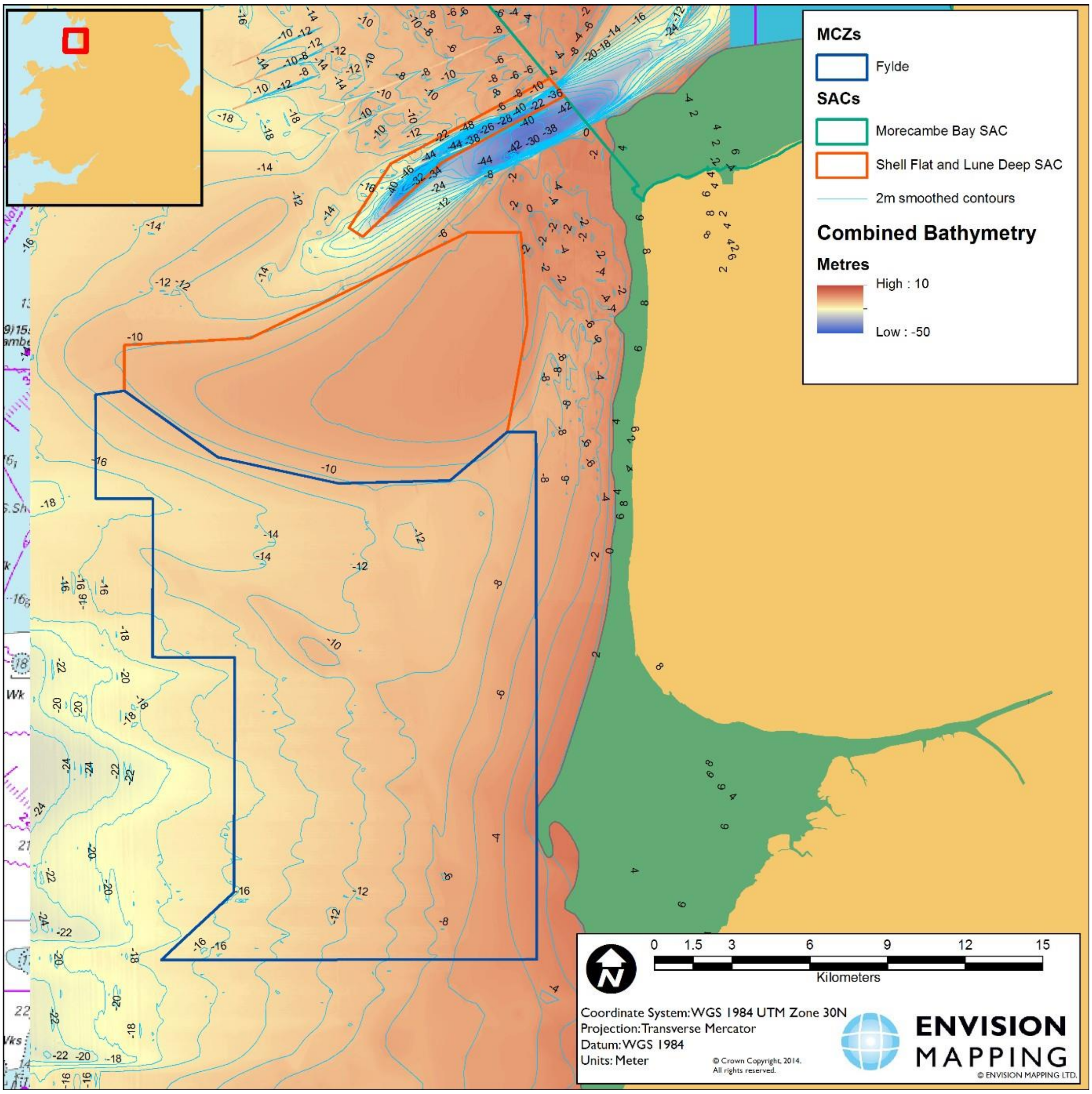

Figure 4 Combined data for the Shell Flat & Lune Deep SAC and Fylde MCZ

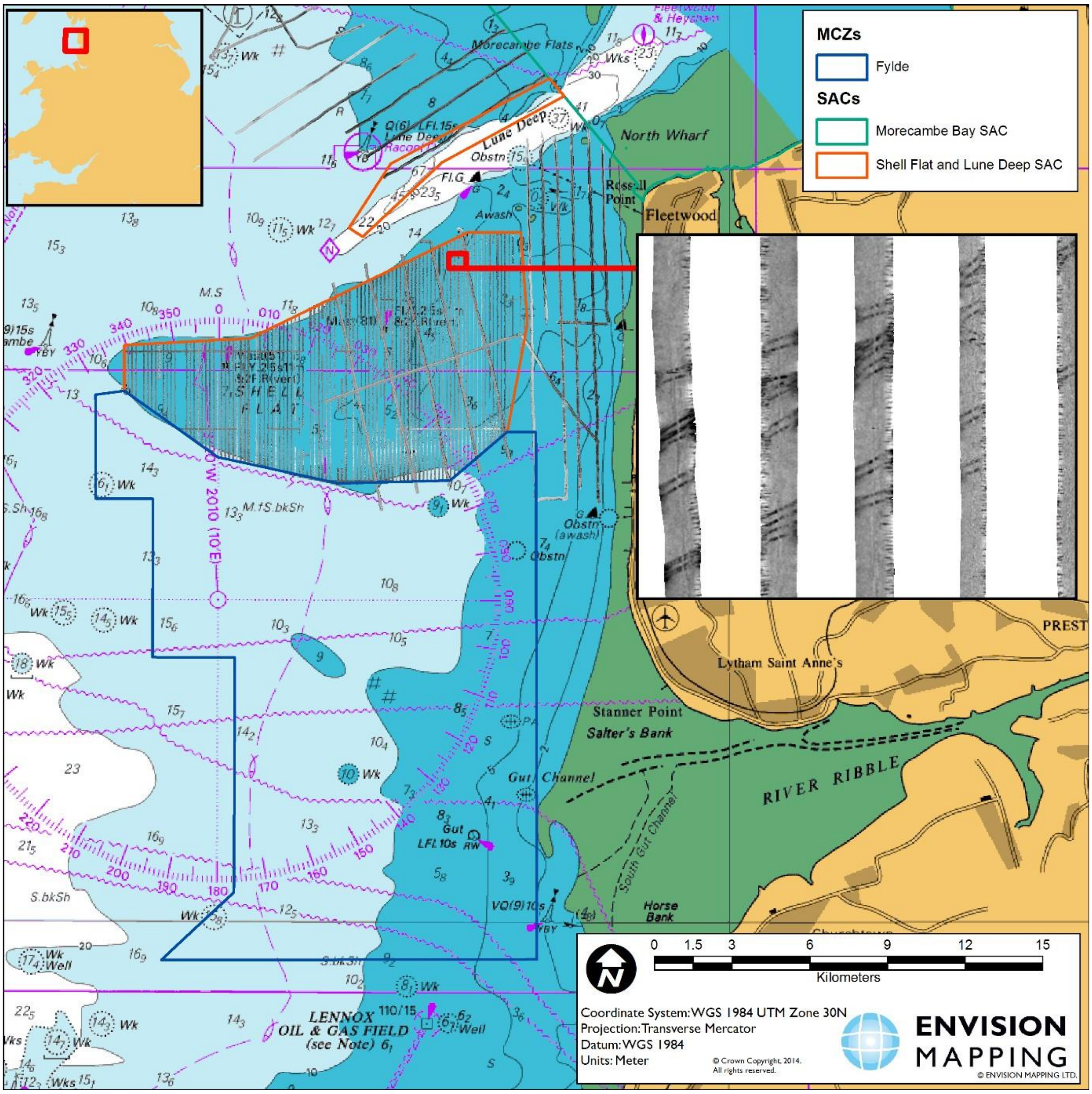

Figure 5 Sidescan sonar mosaic for the Shell Flat & Lune Deep SAC and Fylde MCZ

3.11 In addition to the bathymetry and sidescan data sets, derivatives of the bathymetric data were also used within the mapping process. The aspect and slope of the seabed were calculated along with an index of seabed rugosity - terrain ruggedness index TRI (Riley *et. al.,* 1999), calculated from the bathymetry data for the SAC and the MCZ. These datasets assist in understanding of the topographic complexity of the seabed which can determine the nature of sediments and/or biota present.

Processing and Analysis of Sediment and Qualitative Data and Infaunal Data

3.12 Where possible, if a sample site had particle size analysis (PSA) data, the proportions of mud/silt (<63µm), sand (2mm-63µm) and gravel (4-2mm) were calculated to enable the identification of seabed sediments according to the Folk classification (Folk, 1954) (Figure 6) at each location.

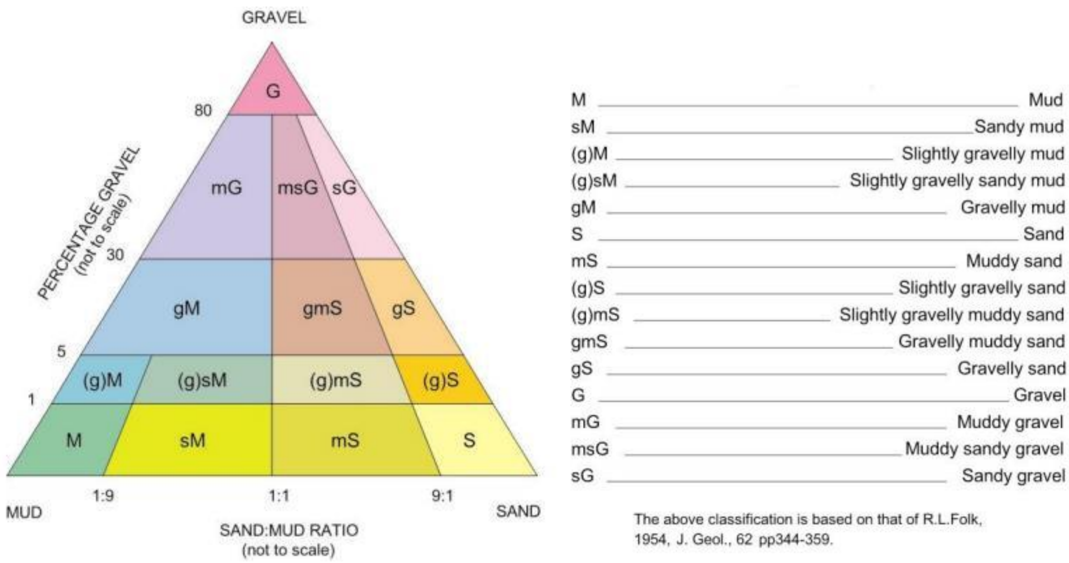

Figure 6 Folk classification of seabed sediments

3.13 Multivariate analysis was used as guidance in biotope assignment and the primary tool for the statistical analysis of the infaunal data was the PRIMER v6 software package.

3.14 Initially, all the available sample data (grab samples, video, depths and PSA) and their positions were collated into a master Excel spreadsheet for the purpose of the data analysis. However, this highlighted the variability of the different datasets, therefore, each survey was analysed separately. This also enabled any changes in biota and habitats due to differences in grab methods or temporal changes to be examined.

3.15 All analysis was based on a Bray-Curtis similarity index. Statistical tests used were Hierarchical Clustering, non-metric Multidimensional Scaling (MDS) Ordination and Species Contributions (SIMPER). The SIMPER routine lists species and their abundances that contribute most to the distinctiveness of the groups identified in the classification process.

3.16 Any correspondence between biota cluster groups and sediment PSA data was explored and then matched to biotopes from the Marine Habitats Classification (04.05) (Connor *et al.*, 2004) using the published biological comparative tables and the biotope descriptions. Where there was insufficient species data, the biotope allocation was derived solely from the geological PSA data available for that site and thus, the resulting biotopes selected were confined to EUNIS Level 3.

3.17 The remaining samples from surveys which had not been included in the separate PRIMER analysis were later reviewed for similarity to biotopes allocated elsewhere in the SAC or MCZ, and, according to their species composition and domination of certain species groups, fitted into suitable biotopes to be included in the mapping process.

3.18 In some cases, upon examination of the data it appeared that the original biotope code had been misattributed and steps were taken to match to current biotopes.

Interpretation Methodology

3.19 The overarching strategy for the interpretation was to combine information from the spatially continuous geophysical acoustic data with the point sample benthic data using image processing and statistical analysis. This process uses the benthic sample data to ‘ground truth’ the geophysical data, a strategy described in the MESH documentation (http://www.searchmesh.net/default.aspx?page=1661) from which Figure 7 is based. The geophysical and ground truth data required considerable processing prior to integration so that the data were in a suitable format for the mathematical analyses. The main outputs are descriptions of habitats and distribution maps.

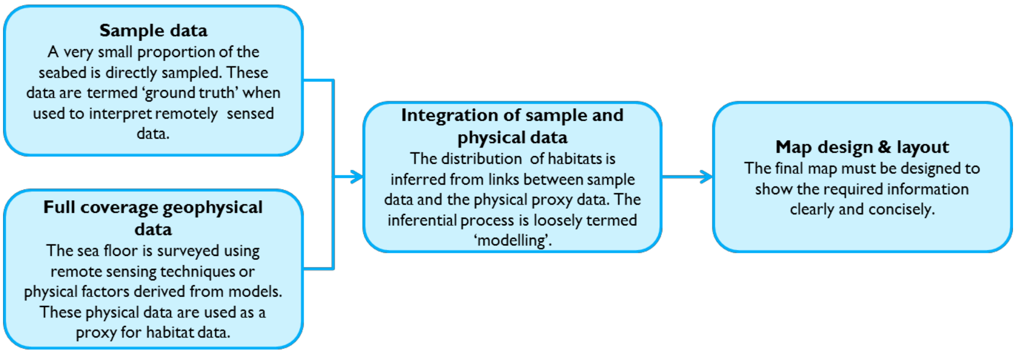

Figure 7 A flow chart of the main stages in making a habitat map by integrating sample data and full coverage physical data (after MESH)

3.20 The analysis used the geophysical acoustic survey data and derivatives of these such as slope and variability/rugosity along with the summarised data from the benthic sampling campaigns such as sediment type, biota and qualitative information.

Integration of Sample and Physical Data for Mapping

3.21 The point locations of the sample data were buffered to create a 100m training site around each point. These were used to extract data from the acoustic datasets from which statistical signatures for the classes were calculated.

3.22 These signatures were then applied to the geophysical acoustic images to classify the pixels. The maximum likelihood routine was employed for supervised classification. This calculated a posterior probability of every pixel in an image belonging to each of the classes. The class with the highest probability was then assigned to a pixel. The default option for this routine was to use equal prior probabilities for all classes (in other words, pixels were assigned only on the basis of the statistical match to the signatures without the benefit of any prior knowledge). However, there was the option to use prior probability images instead of the default equal probability values. This weighted the calculated posterior probabilities towards the likely distribution based on the prior knowledge of spatial distribution obtained from the spatial distribution of the point data.

3.23 The prior probability distribution images for each of the classes were obtained by interpolation from the point data. For each class, the point sample data were accorded the value of 1 if the point was a member of that class, or 0 if it was not. The point data were imported into Surfer™ for interpolation using a distance weighting algorithm. Thus, the calculated prior probabilities for a class were higher where there was a concentration of points of that particular class. The prior probabilities may "tip the balance" in favour of a particular class where the evidence from the signatures is ambiguous. However, if the evidence from the signatures was strong, the prior probabilities had little influence over the final assigned class.

3.24 A schematic diagram illustrating the main stages in the analytical process is shown in Figure 8.

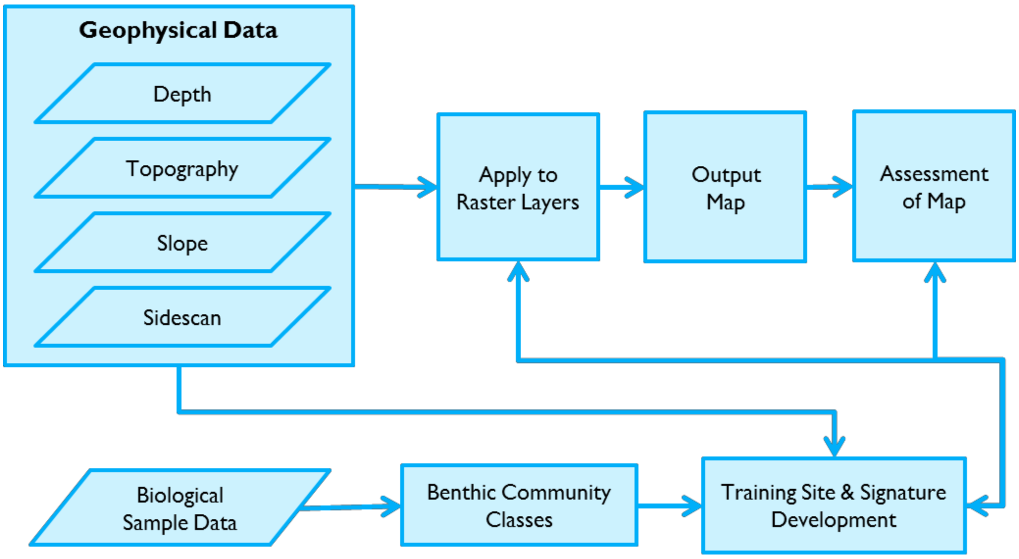

Figure 8 Schematic diagram outlining the main stages in the production of the distribution of habitats & sediments

3.25 The maps were then reviewed and contextual editing undertaken to remove data artefacts and to incorporate any additional background information which was known for each area. The data artefacts were mostly from edge effects where two data sets had been combined or at the periphery of the surveyed area where interpolation of data over extended the coverage outside the area surveyed. Sample data were used to contextually edit some polygons which were misclassified or where the physical environment prevented the biotope or habitat class occurring. An example would be an inshore habitat of coarse sediment being classified circalittoral or infralittoral depending upon the bathymetry of the area.

Identification of Annex 1 Sandbanks

3.26 Since the designation of the Shell Flat & Lune Deep SAC and the subtidal sandbank feature being delineated, a more consistent approach to delineating sandbank features has been proposed by the JNCC and approved in 2012 (Elwood, 2014). This proposed method focuses on the "sandbank slope analysis method" extending from Klein (2006). This approach was used and further detailed in JNCC Report no. 429 in investigations of Annex I habitat extent on Dogger Bank (Diesing et al. 2009).

3.27 This method was used to process the bathymetric data for the MCZ and the SAC and the slope and aspect derivatives to identify sandbank features within the SAC.

3.28 The seabed sediment data from the sample sites were reviewed and if the sediment class assigned was one of a “sandy sediment” which includes “Gravel, sand and silt”, “Gravelly, muddy sand”, “Gravelly sand”, “Muddy sand”, “Sand”, “Slightly gravelly, muddy sand” and “Slightly gravelly sand” indicated in Figure 9, the sample was identified as a possible sandbank habitat.

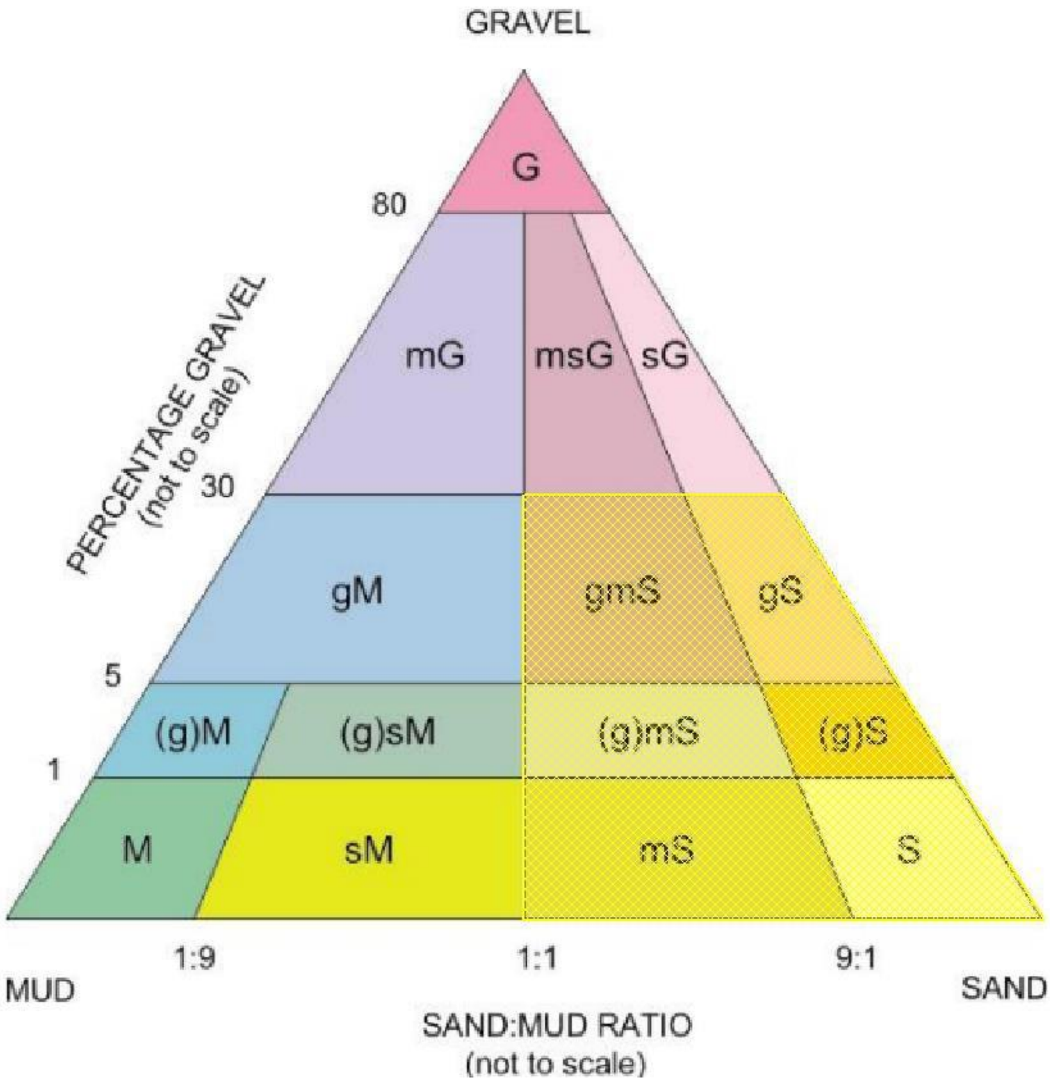

Figure 9 Folk triangle with ‘Sandy substrates’ highlighted (hatched)

3.29 The sample data were overlaid in GIS onto the bathymetry and slope data to identify the areas of sandy sediments which fell in possible bank features.

3.30 A slope threshold of 0.1° was used to identify the edges of any bank features with sandy sediments and the nearest 1m contour line was used to guide the precise location of the sandbank boundary.

3.31 The slope threshold of 0.1° was chosen as the data outside the SAC is of moderate resolution but is modelled data and contains various artefacts from this modelling process. Additionally, the Shell Flat bank is a distinct feature of raised seabed surrounded by a lower profile flat seabed, although the changes in depth are relatively small which result in small slope values. This is illustrated in Figure 10 which shows profile of the bank.

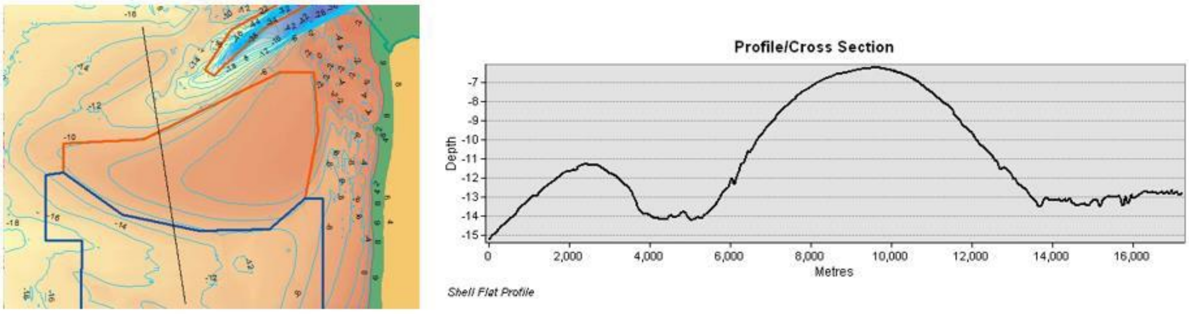

Figure 10 Profile line of Shell Flat from north to south showing raised seabed

4 Results & Discussion

Combined Topographic Maps of Shell Flat & Lune Deep SAC and Fylde MCZ

4.1 The composite bathymetry grid with associated 2m contour lines is shown for the Shell Flat & Lune Deep SAC with Fylde MCZ in Figure 4.

4.2 The sidescan sonar data provided as baseline data for the project is shown in Figure 5.

Map of Dominant Particle Sizes (Folk Classification)

4.3 The predictive distribution of the sediment types are shown in Figure 11 and Figure 12. The point sample data is also shown in these maps and coloured by the Folk classification.

4.4 The maps show the Shell Flat to be dominated by slightly gravelly sand, (g)S, on the top of the bank with slightly gravelly muddy sands, (g)mS, in the deeper areas. Lune Deep shows a distinct rock/hard area on the northern flat of the deep channel with the southern flank comprising of gravelly sand and some gravelly mud.

4.5 The Fylde MCZ is shown to have finer sediment with an increased proportion of silt in the sample data and the resulting maps showing expanses of sandy mud, sM, and muddy sands, mS. The eastern section of the MCZ does have some gravel present in the samples which give the sediments a slightly gravelly nature but with muddy sands and sandy muds. To the south east, samples show very little or no gravel fraction present and only a small amount of silt giving an area of sand substrate.

4.6 The predominant difference between the sediments of Shell Flat and the adjacent Fylde MCZ is the quantity of silt or mud found within the sediments. Figure 11 shows the silt fraction within each sample throughout the area. Within the northern area of the Fylde MCZ the proportion of silt increases and influences the sediments found in the MCZ area, making for more muddy substrates. Only in the southern area of the MCZ does the silt fraction lower and the sediment become more sand influenced again.

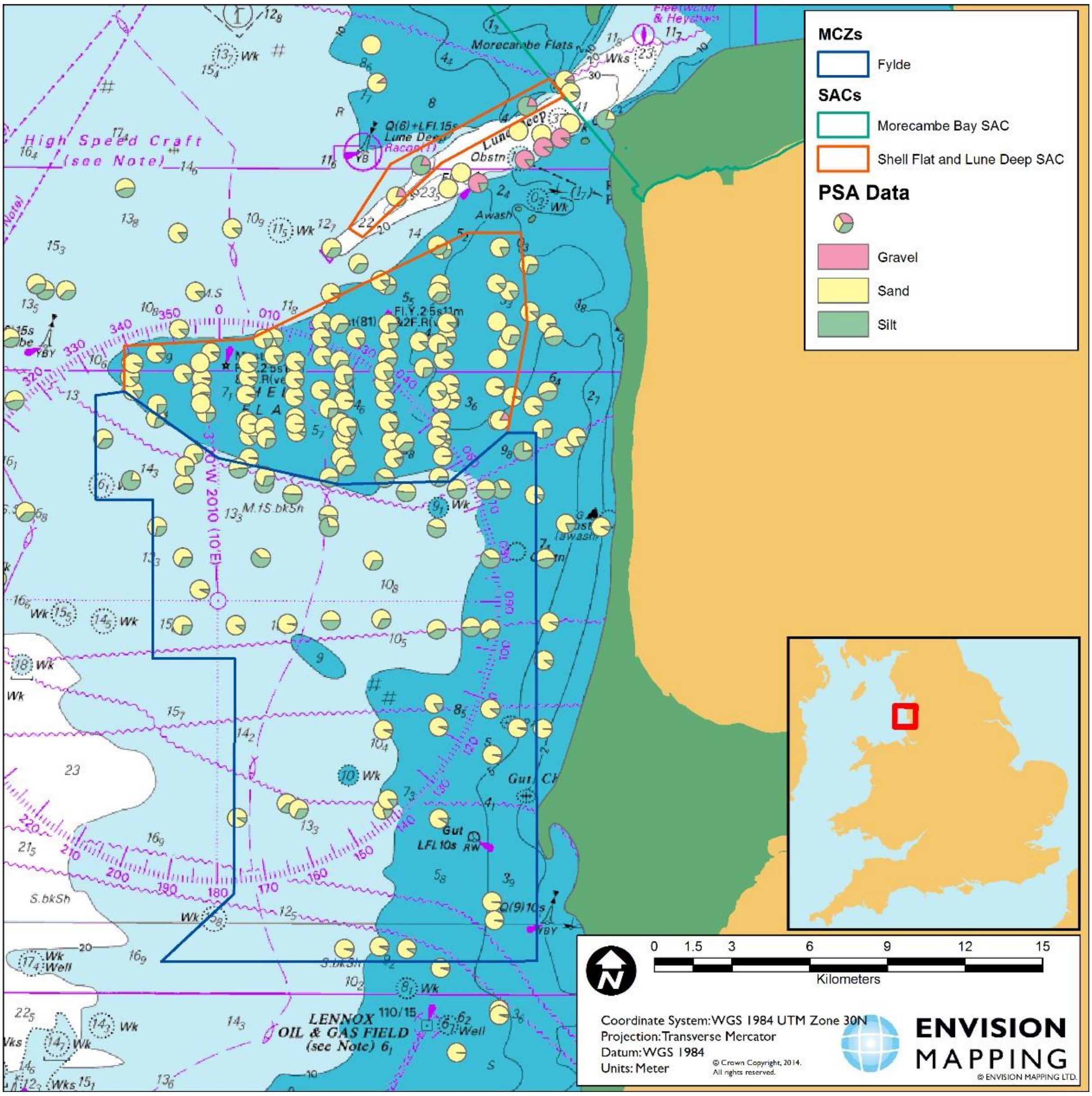

Figure 11 Proportions of sediment type in samples with PSA

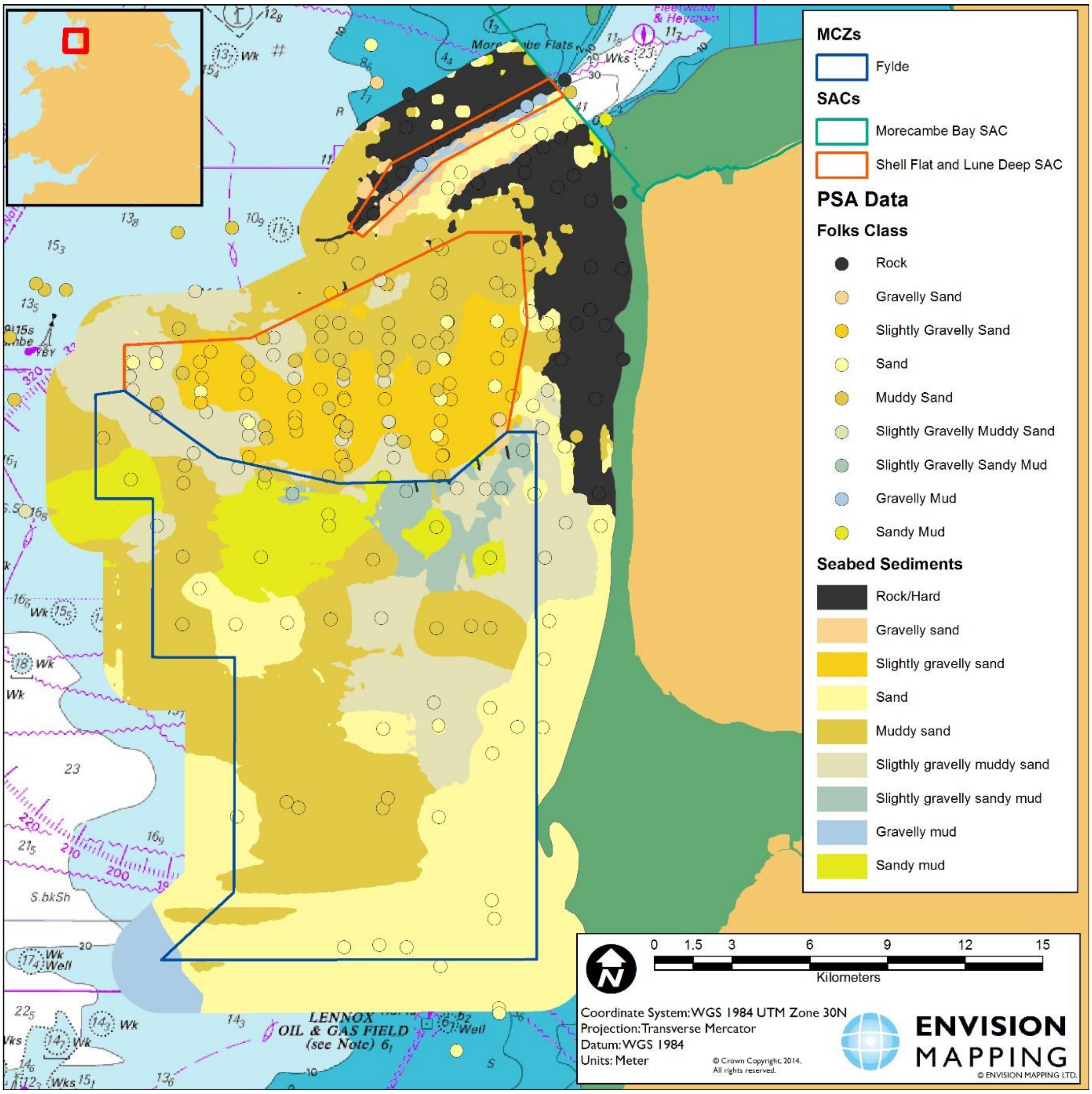

Figure 12 Shell Flat & Lune Deep SAC with Fylde MCZ Seabed sediments and samples classified using Folk 1954

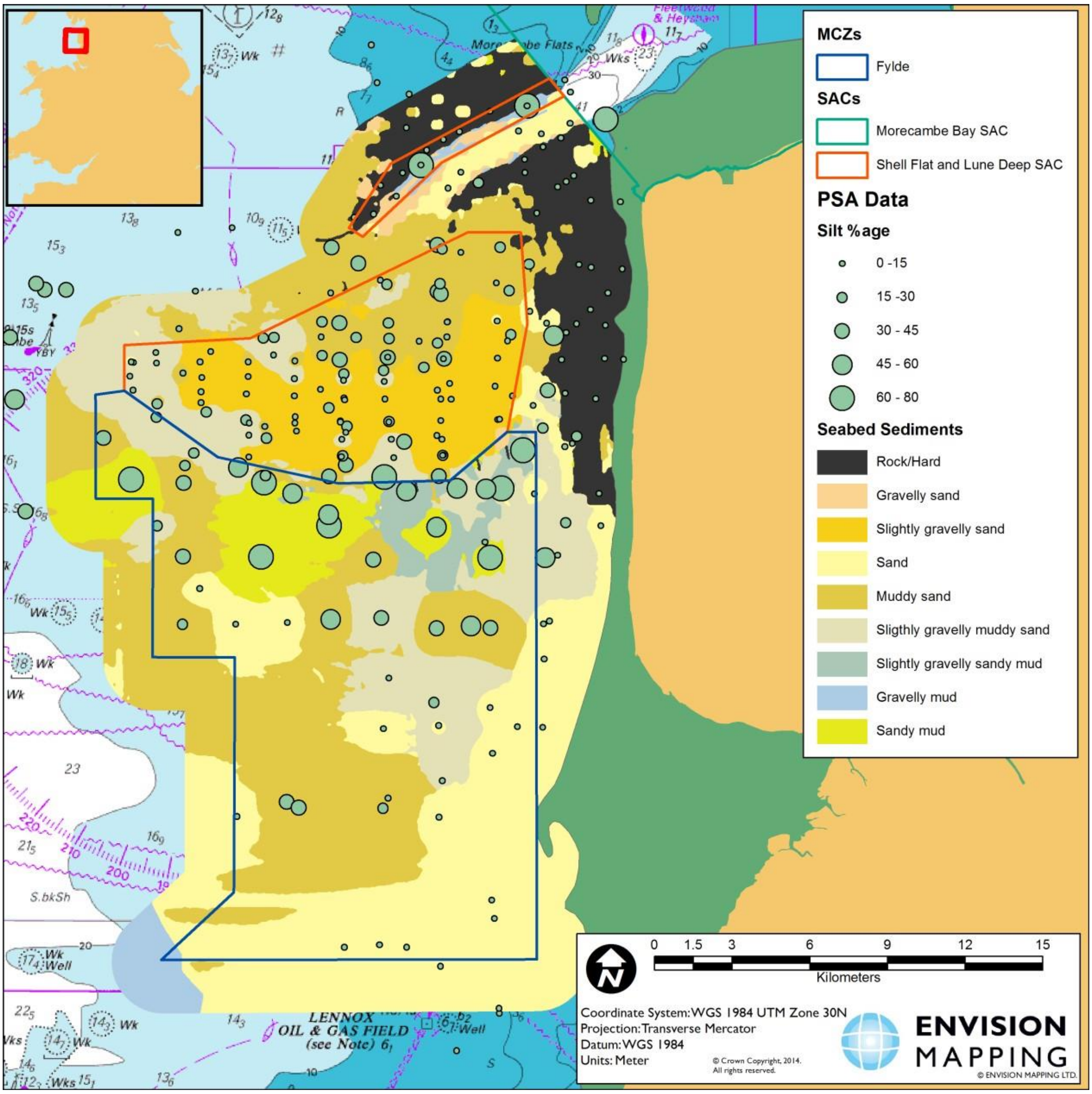

Figure 13 Proportion of silt/mud within each sample throughout the Shell Flat & Lune Deep SAC and Fylde MCZ

Infaunal Data Analysis and Biotope Allocation

4.7 Multivariate analysis was undertaken of the infaunal data to explore significant variation between the samples and to aid with the assignment of biotopes.

4.8 The classification dendrogram, the ordination plot and the average species composition of the resulting classes were used to justify and describe the characteristics of the groups. This process also drew upon the geographic plot of the groups, which showed where there were marked spatial clusters in the data. Data from the surveys carried out by Cirrus, the Environment Agency, Envision (grab data) and Kaiser et al (bivalve data) were seen to cover the Shell Flat SAC and Fylde MCZ sites. The Envision (video survey) and Marine Recorder datasets provided the main sampling data for the Lune Deep area. All infaunal sampling data provided was analysed, however, for the purpose of this report the results of the Cirrus (2002) survey analysis are used to illustrate the biological groupings found within all the datasets supplied. This was the most comprehensive dataset with coverage of both the Shell Flat and Lune Deep SAC and Fylde MCZ and with both infauna and PSA data.

4.9 Figure 14 displays the results of the cluster analysis on the Cirrus (2002) infaunal data. The dendrogram is based on group-averaged Bray-Curtis similarities computed on √ transformed abundances. At a similarity of around 40%, the dendrogram divides into 6 cluster groups of sample sites based on their species composition

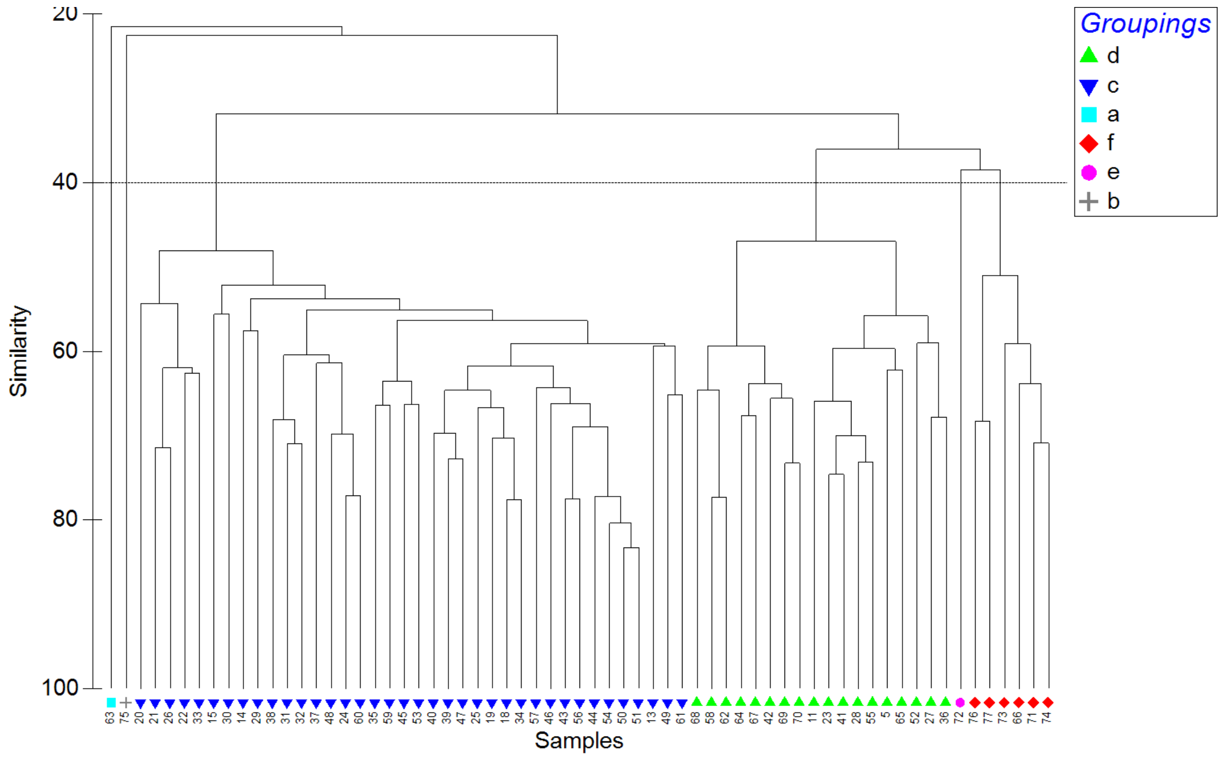

Figure 14 Cirrus (2002) infaunal data. Dendrogram using group average Bray-curtis similarity from square root transformed abundance data. The main groups defined at similarity level 40% are indicated

4.10 Figure 15 shows the 2-dimensional MDS plot of the same similarities. The groups determined from the cluster analysis (at a similarity level of 40%) are superimposed and indicate a good measure of agreement. The stress value of 0.14 gives confidence that the 2-dimensional plot is an accurate representation of the sample relationships.

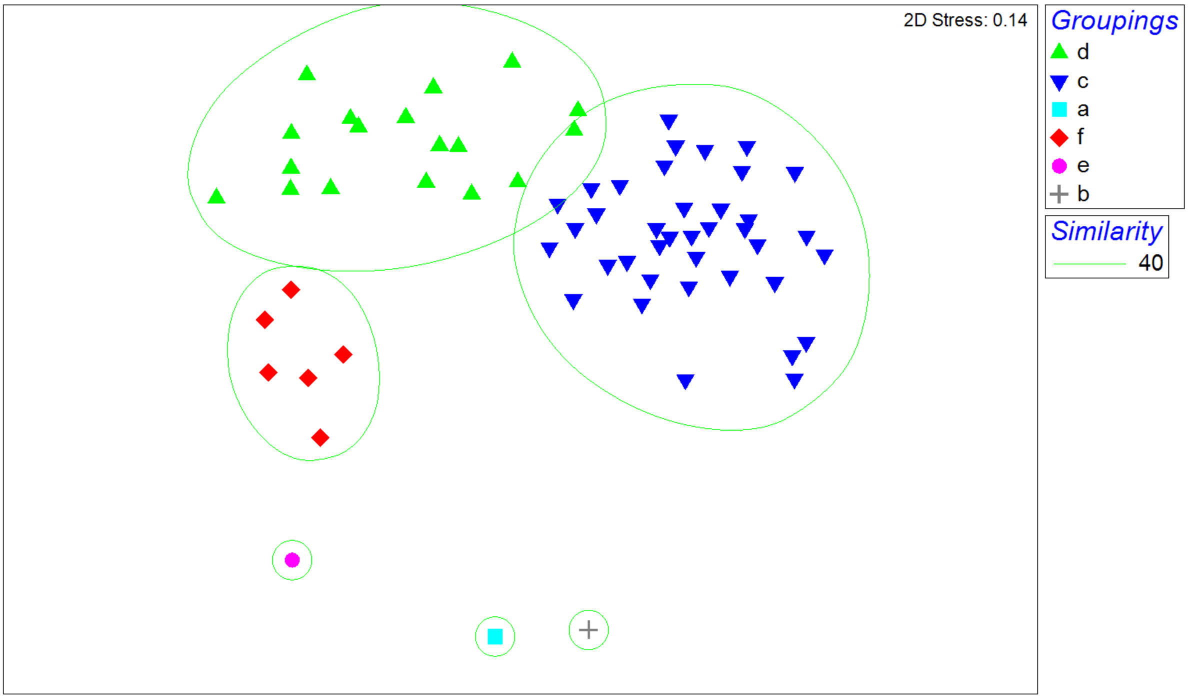

Figure 15 Cirrus (2002). 2-dimensional MDS of the species similarity matrix, as in Figure 14. The main groupings from the cluster analysis are indicated (stress = 0.14).

4.11 Overall the plot indicates sample points clustered around the 'centre' of the plot with a few outliers. Three major groups were designated from the infauna in the Shell Flat SAC and Fylde MCZ sites. The species that contributed to the three major groups (*c*, *d,* and *f*) are shown in Table 3, excluding cluster groups *a, b* and *e* as they had less than 2 samples in each group. It is apparent that the clusters were distinguished by different proportions of a common pool of frequently recorded species. Results of the SIMPER analysis showed that cluster groups *c* and *d* were distinguished by the bivalve mollusc, *Nucula nitidosa* and to a varying extent *Abra alba*. A greater occurrence of the polychaete, *Magelona mirabilis* and the bivalve mollusc, *Fabulina fabula* (now *Tellina fabula)* within group *c* contributed to this group's dissimilarity from group *d*.

Table 3 Species composition of the main groups to emerge from the SIMPER analysis of the infaunal samples from 2007 (Av Abund – Average Abundance; Cont% - Contribution Percentage)

Group	c			Group	d	
Species	**Av.Abund**	**Cont%**		**Species**	**Av.Abund**	**Cont%**
Nucula nitidosa	7.45	35.89		*Lagis koreni*	16.22	22.53
Magelona mirabilis	3.89	15.53		*Nucula nitidosa*	10.14	17.98
Fabulina fabula	2.10	8.10		*Abra alba*	8.30	15.21
Abra alba	2.37	7.23		*Lanice conchilega*	5.36	5.12
Glycera alba	1.57	7.14		*Kurtiella bidentata*	3.90	4.89
Nephtys hombergii	1.34	5.32		*Spiophanes bombyx*	2.48	4.36
Sthenelais limicola	0.94	3.14		*Nephtys hombergii*	1.82	3.11
Spiophanes bombyx	0.91	2.44		*Phaxus pellucidus*	2.07	2.89
Kurtiella bidentata	0.99	1.86		*Owenia fusiformis*	1.90	2.83
Nephtys assimilis	0.59	1.69		*Ophiura*	1.67	2.58
Ophiura	0.72	1.46		*Pharus legumen*	2.12	2.04
Phaxus pellucidus	0.71	1.33		*Magelona mirabilis*	1.86	1.93
				Nemertea spp. Indet.	1.31	1.89
Group	**f**			*Fabulina fabula*	1.29	1.31
Species	**Av.Abund**	**Cont%**		*Phoronis muelleri*	1.40	1.30
Kurtiella bidentata	6.92	14.34		*Glycera alba*	1.03	1.29
Amphiura filiformis	4.20	8.05				
Abra alba	5.02	7.11				
Nucula nitidosa	3.69	6.80				
Lagis koreni	3.83	6.59				
Phoronis muelleri	3.22	6.21				
Owenia fusiformis	3.06	5.05				
Phaxus pellucidus	2.73	5.04				
Nephtys hombergii	1.74	3.36				
Ophiura	1.56	2.88				
Mactra stultorum	1.33	2.32				
Thysanocardia procera	1.43	2.18				
Scalibregma inflatum	3.25	2.05				
Sthenelais limicola	1.14	1.95				
Hilbineris gracilis	1.44	1.95				
Pholoe inornata	0.97	1.95				
Spisula subtruncata	1.11	1.92				
Amphiura chiajei	2.24	1.88				
Spiophanes bombyx	1.26	1.66				
Ampelisca brevicornis	0.95	1.65				
Amphiura brachiata	1.07	1.63				
Echinocardium cordatum	1.29	1.60				
Diplocirrus glaucus	0.97	1.49				
Lanice conchilega	0.76	1.24				

4.12 Although the analyses for the various datasets provided were performed separately, the outputs of the infaunal analysis showed similar groups were identified for each survey, based on the PRIMER results of the faunal composition. The majority of samples across the range of datasets displayed some degree of similarity to each other. Typically, samples from the shallower and sandier regions of the sandbank were characterised by a greater abundance of *Fabulina fabula* (now *Tellina fabula)* and *Magelona mirabilis*. The bivalves *Nucula nitidosa* and *Abra alba* were found in large numbers at almost all sample stations, increasing in abundance in the slightly deeper and muddier sample sites to the south and west of the sandbank. One other group identified from both the Cirrus (2002) and Envision (2008) surveys was located in an area of deeper water to the west of the sandbank feature. This group was seen to be characterised by increased numbers of the bivalve *Kurtiella bidentata* and the echinoderm, *Amphiura filiformis*. Substratum and depth appeared to be the main determining factors in the variability of the biota, with an obvious community change linked to both increased depth and mud content of the sediment.

Biotope Assignment

4.13 The cluster groupings produced from the multivariate analysis have been matched to biotopes as defined by the Marine Habitats Classification (http://jncc.gov.uk/marine/biotopes/hierarchy.aspx). Possible candidate biotopes were selected on the basis of the biotope descriptions and using the PRIMER results to compare the infaunal abundance data of the grab samples to the species listed in the Comparative Biological Tables.

4.14 Where the infaunal data provided little or no information on the biota of the sample, the biotope assignment was based on the geological PSA data provided for that sample, and broad sediment classes (EUNIS Level 3) were generally considered most suitable. This methodology was applied to the Kaiser et al (2003) dataset due to the purpose of the original study, which focussed on bivalve data and gave only biomass/abundance of higher taxonomic groups of fauna rather than single species information.

4.15 In total 11 biotopes were assigned over the Shell Flat and Lune Deep SAC and Fylde MCZ, shown in Table 4, although only 10 were mapped, as circalittoral coarse sediment was identified only in one sample, which also had a replicate identifying the site as another biotope.

Table 4 Biotopes and habitat descriptions found in the Shell Flat & Lune Deep SAC & Fylde MCZ site samples.

Biotope	EUNIS Code	Habitat Description (MNCR)
CR.HCR.XFa	A4.13	Mixed faunal turf communities on circalittoral rock
CR.MCR	A4.2	Moderate energy circalittoral rock
SS.SCS.CCS*	A5.15	Circalittoral coarse sediment
SS.SMu.CSaMu	A5.35	Circalittoral sandy mud
SS.SMu.CSaMu.AfilMysAnit	A5.351	*Amphiura filiformis* , *Mysella bidentata* and *Abra nitida* in circalittoral sandy mud
SS.SSa	A5.2	Sublittoral sands and muddy sands
SS.SSa.CMuSa	A5.26	Circalittoral muddy sand
SS.SSa.CMuSa.AalbNuc	A5.261	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment
SS.SSa.IMuSa	A5.24	Infralittoral muddy sand
SS.SSa.IMuSa.FfabMag	A5.242	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand
SS.SMx	A5.4	Sublittoral mixed sediment

* biotope not mapped

4.16 No OSPAR threatened and/or declining habitats are present in the Shell Flat area or Fylde MCZ, and the only UK BAP (Biodiversity Action Plan) Priority Habitat present is ‘Subtidal Sands and Gravels’ which translates to the biotopes SS.SCS.CCS, SS.SSa, SS.SSa.CMuSa, SS.SSa.CMuSa.AalbNuc, SS.SSa.IMuSa and SS.SSa.IMuSa.FfabMag, indicated with the shaded rows in Table 4 (see Figure 16).

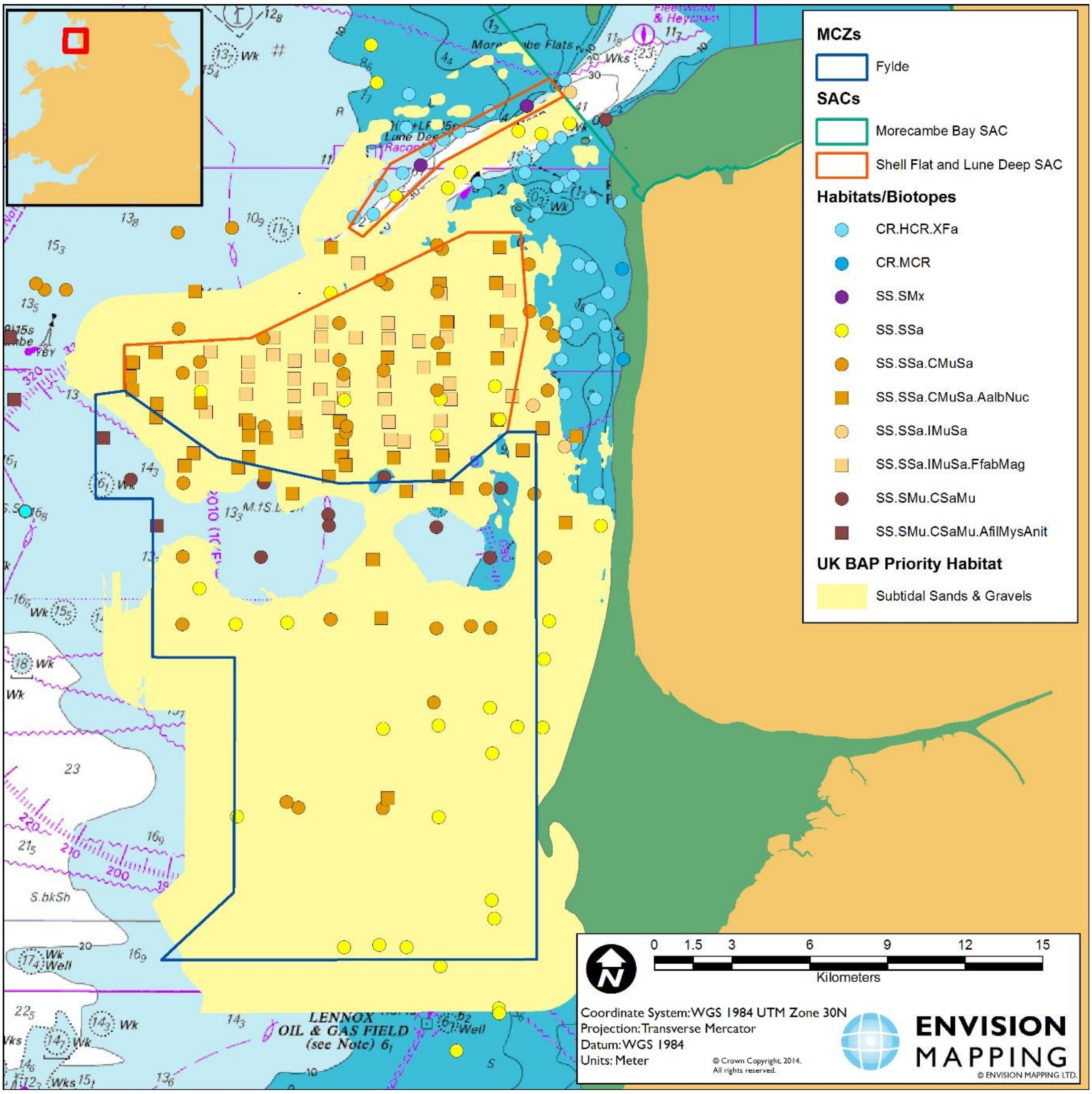

Figure 16 . The distribution of the UK BAP Priority Habitat – Subtidal Sands & Gravels.

Habitat Types and Biotope Distribution Maps

4.17 Figure 17 shows the predicted distribution of habitats (Level 2 of the biotope classification) for Shell Flat & Lune Deep SAC & Fylde MCZ.

4.18 Where possible, biotopes, with EUNIS habitat codes, have been mapped further to level 4 on the classification hierarchy and these predicted distributions are mapped in Figure 18 for Shell Flat & Lune Deep SAC & Fylde MCZ and adjacent areas.

4.19 The habitat distribution maps support the sediment maps in that the Shell Flat area is occupied by the *Fabulina fabula* and *Magelona mirabilis* biotope (SS.SSa.IMuSa.FabMag) in the fine shallower sediments of the bank with *Abra alba* and *Nucula nitidosa* biotope (SS.SSa.CMuSa.AalbNuc) occurring in the deeper and slightly muddier sediments found on the slopes and in deeper areas of the bank.

4.20 The Lune Deep area shows the only hard substrate in the SAC with the northern slope of the areas having moderate and exposed circalittoral rock habitats and the southern slopes having mixed substrate biotopes with occasional sand influenced habitats.

4.21 Fylde MCZ shares a boundary with the Shell Flat area of the SAC and the biotopes found along the southern edge of the SAC extend into the MCZ area and are predominantly *Abra alba* and *Nucula nitidosa* biotope (SS.SSa.CMuSa.AalbNuc) with very occasional circalittoral sandy mud (SS.SMu.CSaMu). This sandy mud biotope then occupies a stretch of seabed extending east-west through the northern section of the MCZ interrupted by a finger of the sandier *Abra alba* and *Nucula nitidosa* biotope (SS.SSa.CMuSa.AalbNuc). The remaining areas are mostly sand and muddy sand based habitats (SS.SSa and SS.SSa.CMuSa) for which little infauna data were available therefore these habitats have been determined by the physical properties alone rather than the biological component. At the western edge of the MCZ some samples and areas of seabed have been identified as the '*Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud' biotope (SS.SMu.CSaMu.AfilMysAnit) which occurs in a more muddy and deeper environment to the similar *Abra alba* and *Nucula nitidosa* biotope and these biotopes have been recognised as grading into one another.

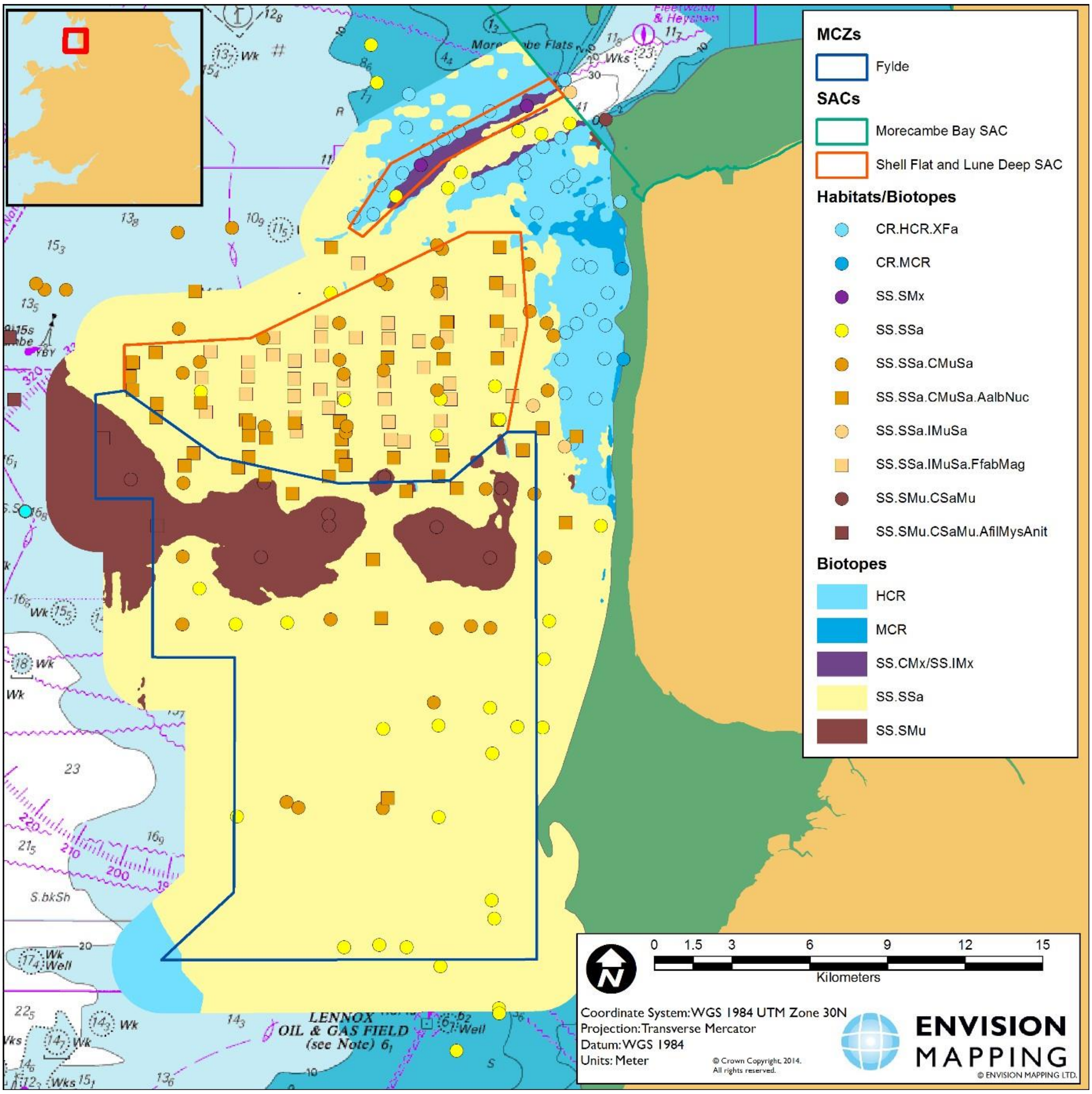

Figure 17 SAC Habitats (Level 2) with samples showing biotope present

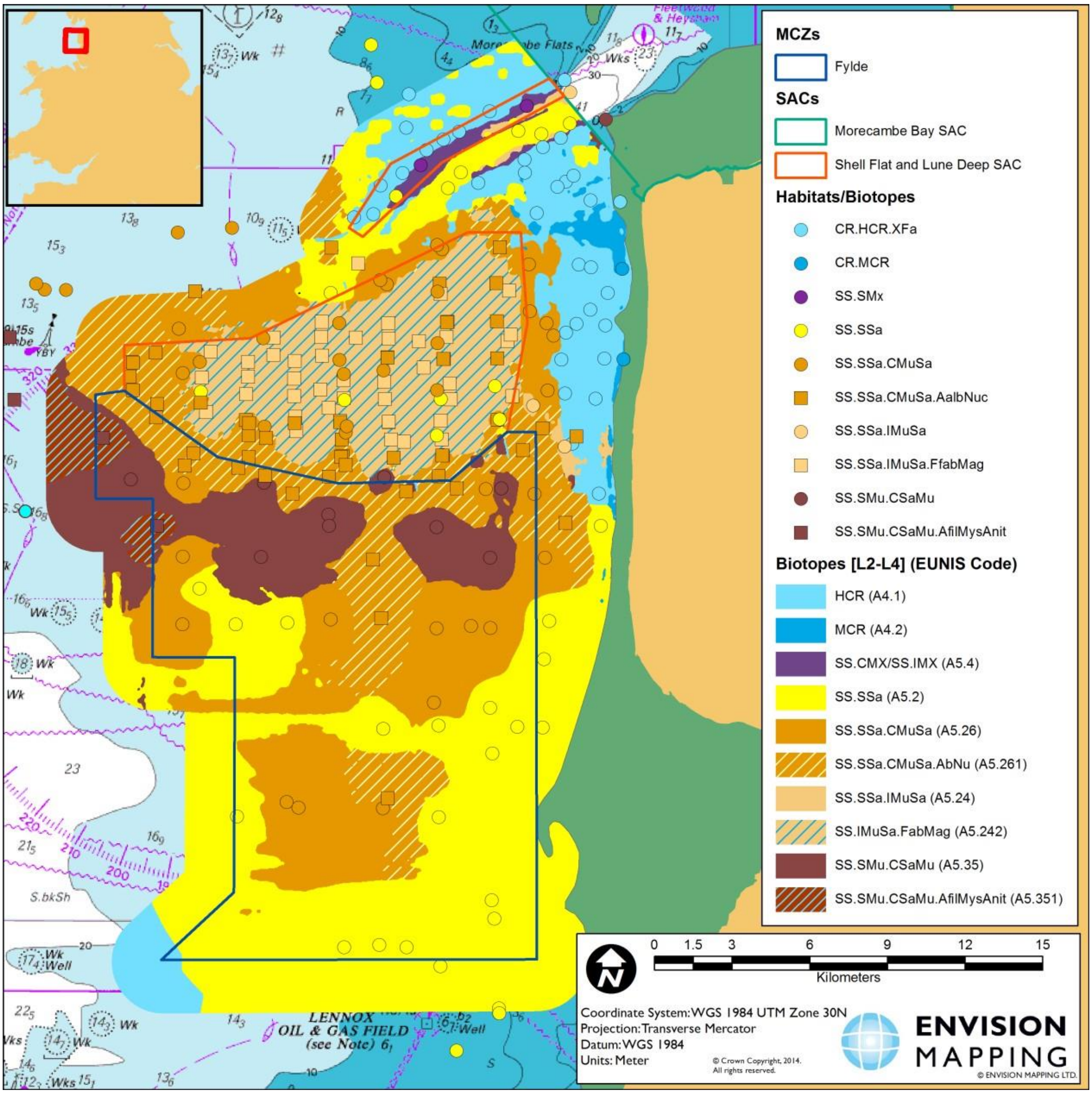

Figure 18 SAC Biotopes (Level 2-4) and EUNIS habitats with samples showing biotope present

Features of Conservation Interest: Maps of Annex 1 Sandbank Features

4.22 Figure 19 shows the Annex 1 Sandbank features identified using the method in Elwood 2014 for Shell Flat & Lune Deep SAC and Fylde MCZ. The underlying data used to determine the topography nature of each sandbank feature is slightly different in that the sandbank area identified within the Shell Flat area uses data from UKHO and the multibeam data collected over the sandbank feature, whereas the bank identified in the Fylde MCZ is delineated using only the UKHO bathymetric data.

4.23 The whole of the Shell Flat area of the SAC has been identified as being Annex 1 Sandbank with the edges of the sandbank extending outside the SAC boundary, which resulted from using the cut-off of 0.1°slope, and the sample data showing suitable habitat being present in these areas.

4.24 Using the same criteria and slope parameters a smaller sandbank feature has been identified within the Fylde MCZ which is a smaller and less distinctive feature than Shell Flat Sandbank and is identified from the UKHO data and PSA data.

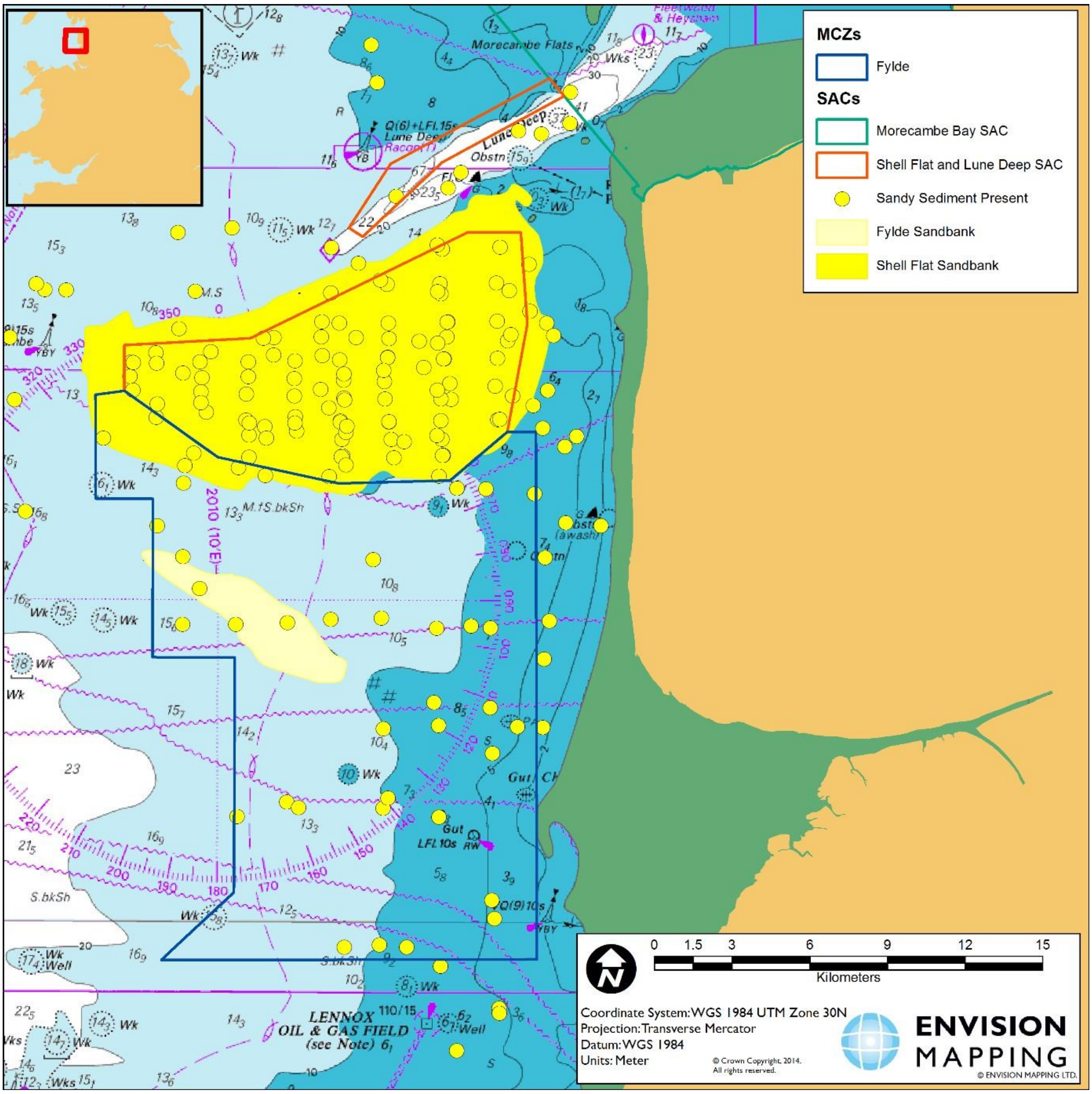

Figure 19 Annex 1 Sandbank feature identifed using JNCC methodology (Elwood, 2014)

4.25 The sidescan sonar and backscatter data for Shell Flat & Lune Deep SAC showed some continuous linear features extending between adjacent tracks which are possibly trawl or dredge marks (Figure 5).

Comparison with Previous Data Sets and Habitat Maps

4.26 The extent of Annex 1 Sandbank had previously been assessed and published (Figure 20), however the extents produced as part of the current project show some differences. The current data support a larger extent of sandbank feature extending outside of the SAC boundary which is supported by seabed slope and sample data. A 0.1° slope value has been used to delineate the feature and this may explain the expansion of the boundary. This slope value was chosen because a slope value of 0.5° failed to identify the sandbank. However, when compared with the surrounding seabed topography, it is clearly a raised feature, but due to relatively small changes in depth (15-9m) over large distances (9-10km), the slope values are small.

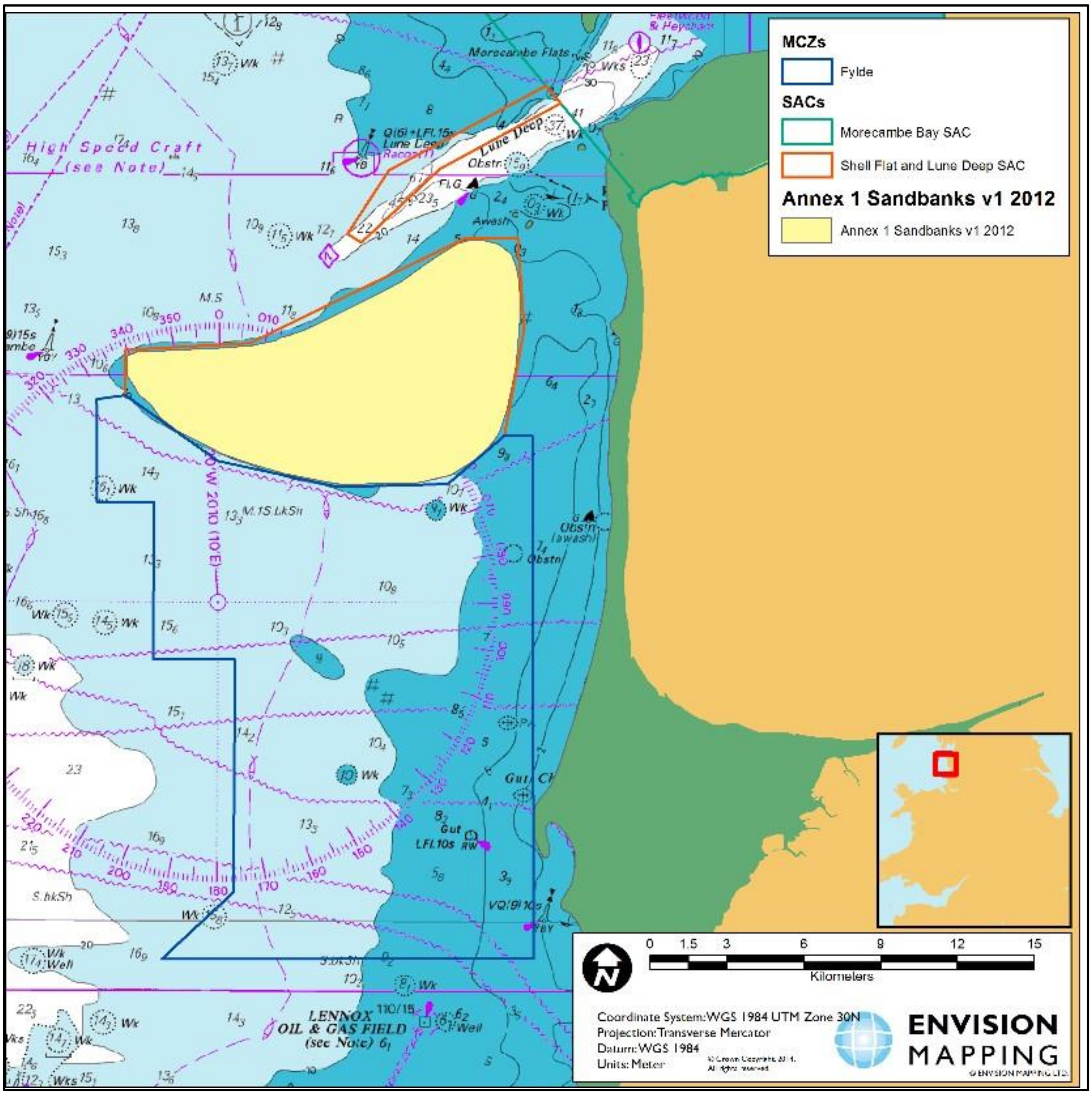

Figure 20 Current Annex 1 Sandbanks which have been identifed

4.27 As the same criteria are applied to the whole of the area to be mapped then a second sandbank feature was also identified to the south of Shell Flat within the Fylde MCZ. This is a smaller sandbank which has a longitudinal axis running south-east to north-west and is approximately 9km in length and 2km wide and sediment samples show this to have a characteristic sandy substrate (Figure 18).

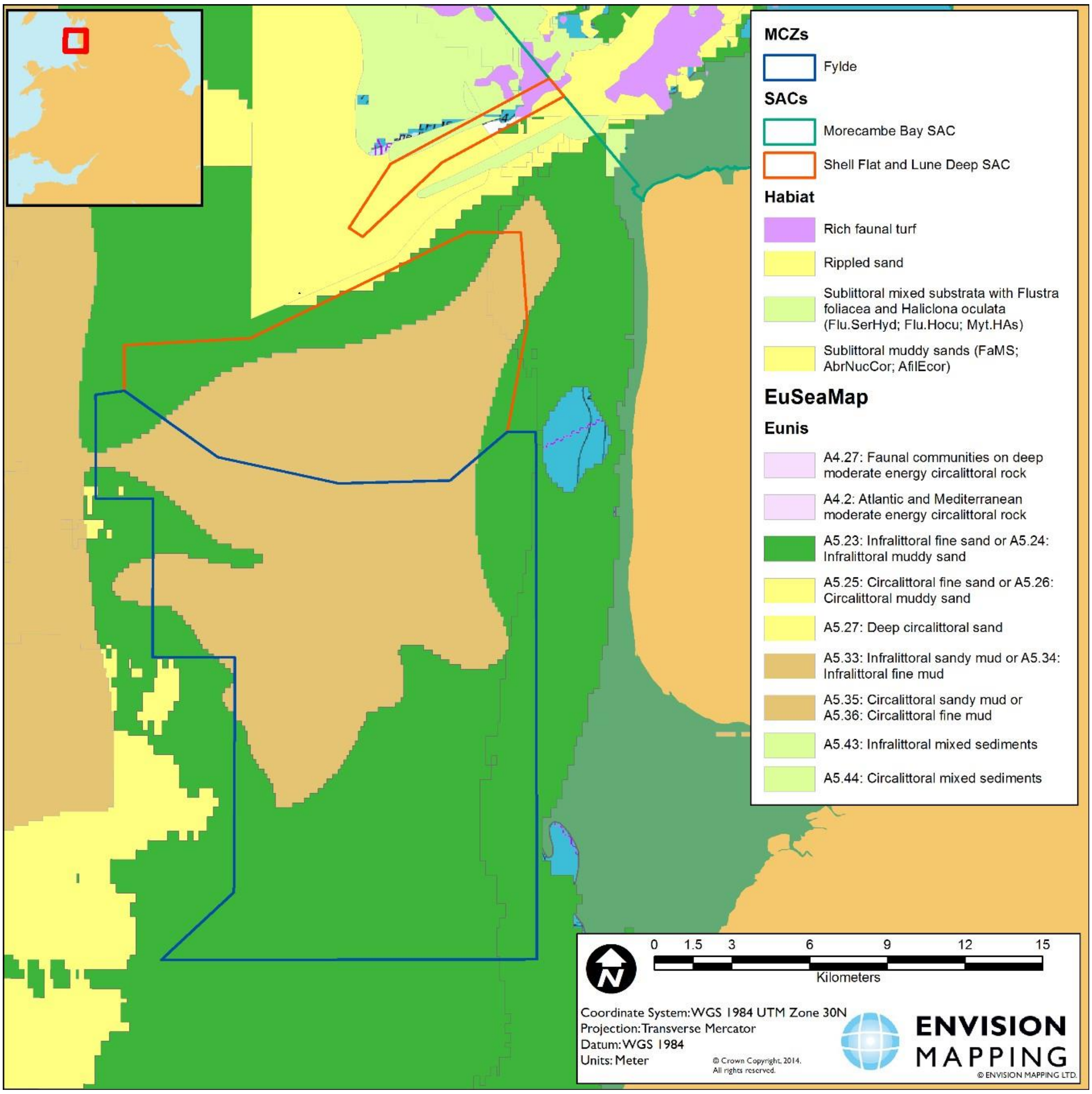

Figure 21 Current EUNIS habitat maps (EUNIS colour scheme) compiled from existing surveys

4.28 Available maps of seabed habitats from existing survey data for the area (Figure 21) are of a relatively low resolution and identify the habitats within the Shell Flat area of the SAC and Fylde MCZ as sandy muds and fine muds, and sands and muddy sands, and suggests the Shell Flat area to be muddier than part of the Fylde MCZ which is contradicted by the PSA from sample data. The maps do show the muddier and sandy habitats in the Fylde MCZ but with a dissimilar distribution which is likely to be due to the dissimilar spatial scales and resolution of the data used to produce the maps.

4.29 Lune Deep has very little mapping data associated with it and that which does exist at a similar scale suggests an area of rich faunal turf on the northernmost slope and a mixed substrate with a sponge and bryozoan community on adjacent edges of the area which agrees with the current maps which have been produced. A broadscale map suggests a muddy sand habitat encroaching into the Lune Deep from the west but this is likely to the broadscale nature of the existing map.

Comparison of Biota, Habitats and Topography and Condition of Features Over Time

Biota and Habitats Over Time

4.30 The survey data provided were analysed to compare changes in biota over time. The only data sets that were comparable (in terms of type of data and areas sampled) were the Cirrus 2002 data, the Envision grab samples from 2007 and the EA sample data from 2012, which could only be compared in the Shell Flat area. The Kaiser et al (2003) data was excluded from the temporal analysis due to restricted nature of the infaunal data.

4.31 Of the 78 grab sites taken for the Cirrus survey, only the sites which covered the Shell Flat SAC area, of which there were 59, were analysed. The sampling sites that fell within the Fylde MCZ were excluded due to lack of comparable data from other studies. Infaunal data from 5 grab sites were available from the Envision dataset and 51 sites from the Environment Agency survey.

4.32 Multivariate analysis was used to explore significant temporal variation between the biota samples from different years, using PRIMER and analysis based on a Bray-Curtis similarity index, as described previously in the methodology. The classification dendrogram, the ordination plot and the average species composition of the resulting clusters were used to examine any differences in the biota based on temporal changes.

4.33 Figure 22 displays the results of the cluster analysis on the combined infaunal data from the Cirrus (2002), Envision (2007) and Environment Agency (2012) surveys. The dendrogram is based on group-averaged Bray-Curtis similarities computed on $\sqrt{}$ transformed abundances. At a similarity of around 35%, the dendrogram divides into two cluster groups of sample sites based on their species composition. The 2-dimensional MDS plot, shown in Figure 23, relates this clustering of samples to the different survey years. The stress value of 0.14 gives confidence that the 2-dimensional plot is an accurate representation of the sample relationships.

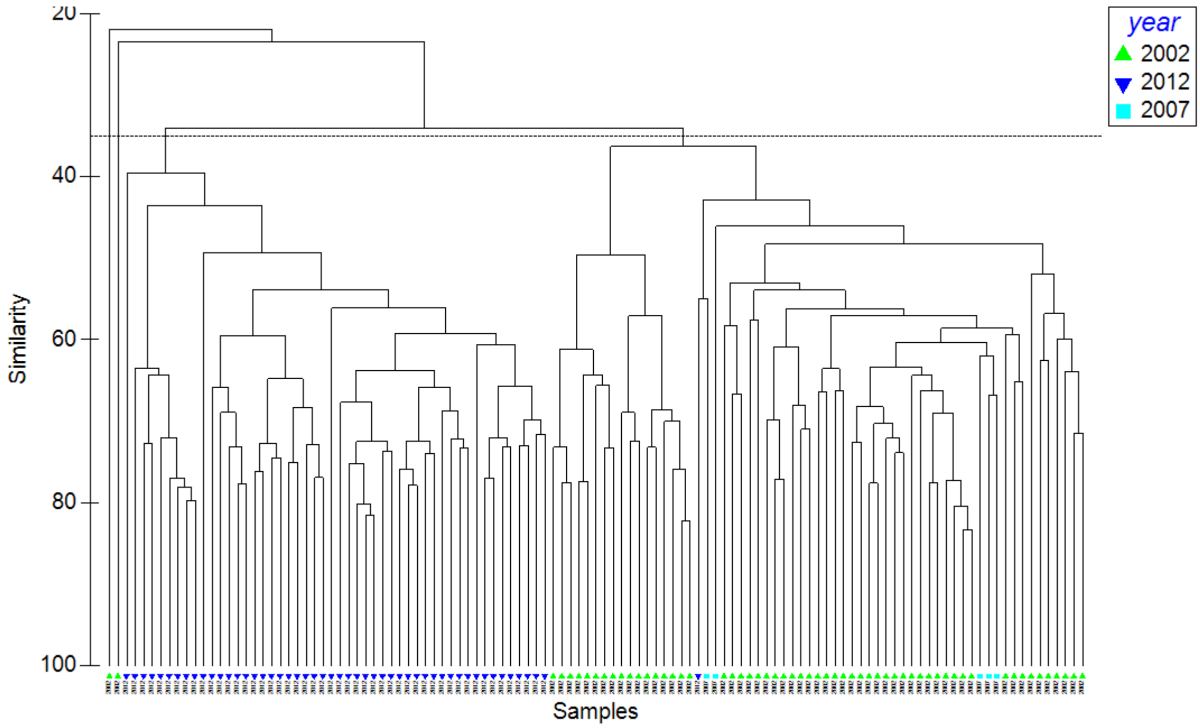

Figure 22 Combined infaunal data for Cirrus (2002), Envision (2007) and Environment Agency (2012) surveys. Dendrogram using group average Bray-curtis similarity from square root transformed abundance data.

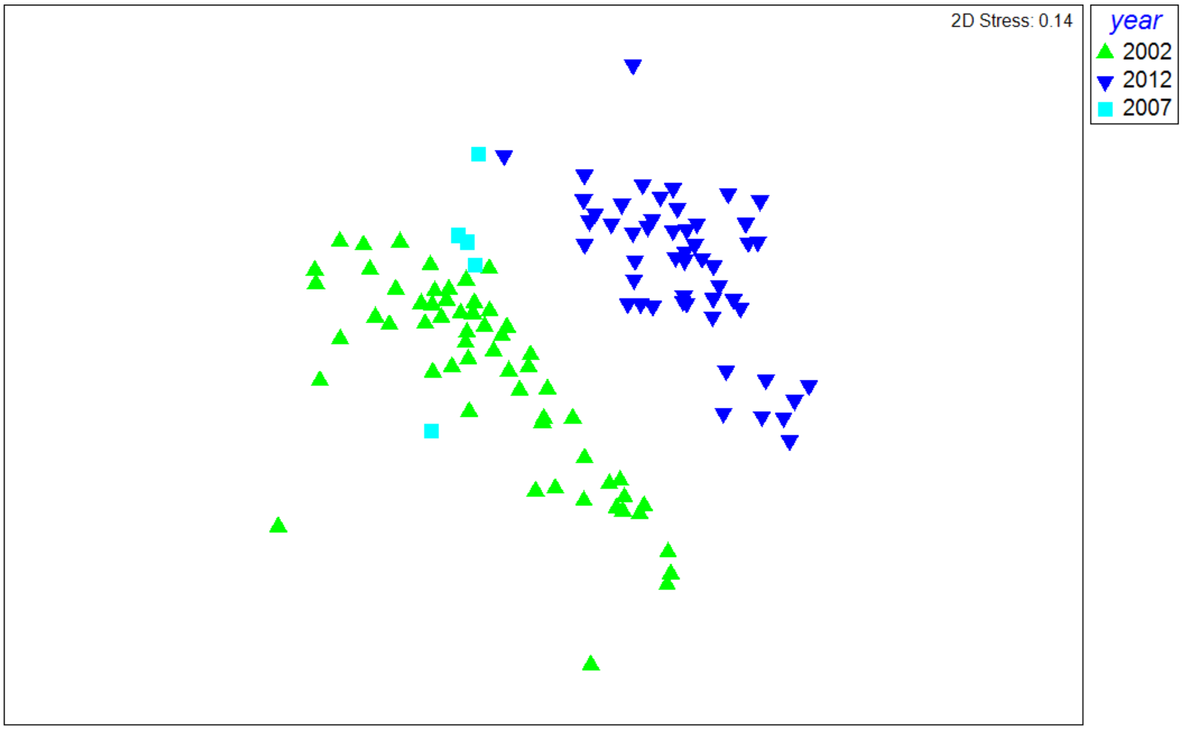

Figure 23 Two dimensional MDS of the species similarity matrix, as in Figure 22, showing survey year. (stress = 0.14).

4.34 The MDS plot showing survey years indicates that there is a separation between the 2002/2007 and 2012 infaunal datasets resulting in the observed clusters. However, the contribution of each species to the clusters was determined using SIMPER and it is apparent that the clusters were distinguished by different proportions of a common pool of frequently recorded species as shown in Table 5, and this supports the biotope allocations given previously in this report for the Shell Flat area.

Table 5 The results of the SIMPER analysis of the infaunal samples from surveys carried out in 2002, 2007 and 2012, showing species whose contribution is >5% (Av Abund – Average Abundance; Cont% - Contribution Percentage)

Year 2002				**Year 2007**		
Species	**Av.Abund**	**Cont%**		**Species**	**Av.Abund**	**Cont%**
Nucula nitidosa	8.87	34.80		*Nucula nitidosa*	7.39	26.12
Magelona mirabilis	3.30	11.76		*Magelona johnstoni*	3.73	16.19
Abra alba	3.94	9.13		*Fabulina fabula*	2.72	10.61
Fabulina fabula	1.96	7.02		*Glycera alba*	1.88	8.27
Glycera alba	1.41	5.72		*Abra alba*	1.54	7.71
Nephtys hombergii	1.47	5.44		*Magelona filiformis*	1.52	6.21
Year 2012						
Species	**Av.Abund**	**Cont%**				
Nucula nitidosa	7.94	16.65				
Abra alba	4.78	9.75				
Pseudocuma longicornis	4.56	8.66				
Fabulina fabula	3.72	7.79				
Magelona johnstoni	2.99	6.27				
Mytilus edulis	5.02	6.16				
Magelona filiformis	3.15	5.87				

4.35 As is evident from Table 5, the dominant species in the Shell Flat area do not vary appreciably between the different survey years – species such as *Nucula nitidosa*, *Magelona mirabilis/johnstoni*, *Abra alba* and *Fabulina fabula (*now *Tellina fabula)* (bivalves and polychaetes), despite small changes in the exact order and composition, consistently appear in the top five contributing species within the groupings. The difference detected between the Cirrus 2002 and Envision 2007 datasets, compared with the Environment Agency 2012 data could be attributed to the presence of the relatively high numbers of the crustacean *Pseudocuma longicornis* which was not recorded in previous years. However this species does not appear to play a large role in influencing biotope allocation and is not thought to constitute a notably different role in the functioning of the ecosystem.

4.36 The results of the statistical analysis for temporal change could suggest some changes at community composition level, however any changes are minor and are more likely to be the result of the sampling and processing techniques used which may have varied between surveys and years.

4.37 It should also be noted, the datasets and sampling regimes were not designed to be part of a long term monitoring strategy which would require robust replication between samples and sites.

Bathymetry and Topography Over Time

4.38 In order to investigate any temporal changes in bathymetry and topography an area which contained multiple bathymetric data sets which were collected over several years was used. The bathymetric data available were:

- Cirrus Data collected in 2002
- Envision Data collected in 2007
- UKHO Modelled data (composite data from various dates)

4.39 Cross sections or profiles of the bathymetric datasets were generated using consistent profile lines (Figure 24) and bathymetric data was extracted at 100m intervals along the length of these lines for each bathymetric data set and then plotted to show the bathymetric profiles (Figure 25).

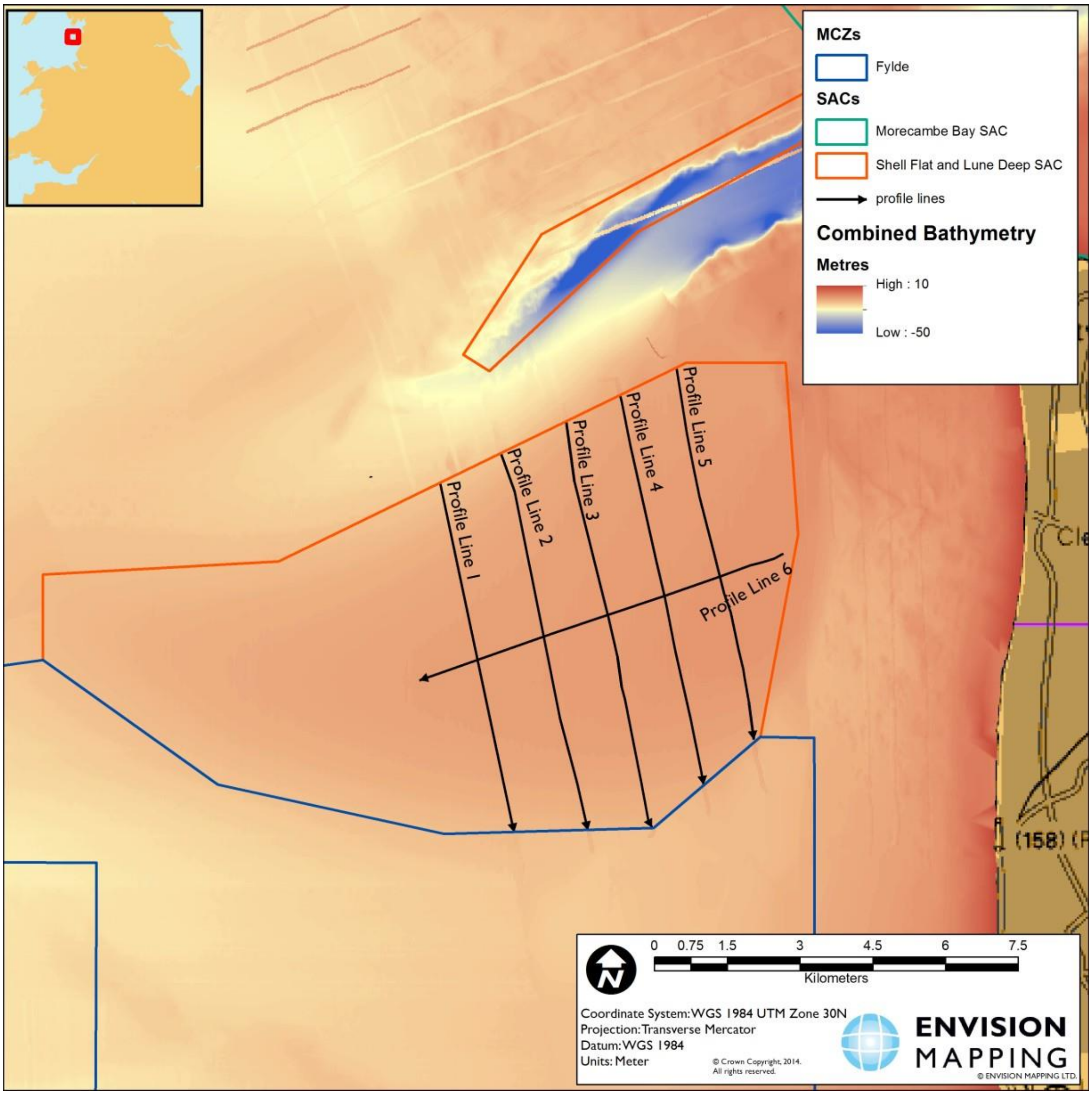

Figure 24 Map of Cross Sections across the Shell Flat Area of the Shell Flat and Lune Deep SAC

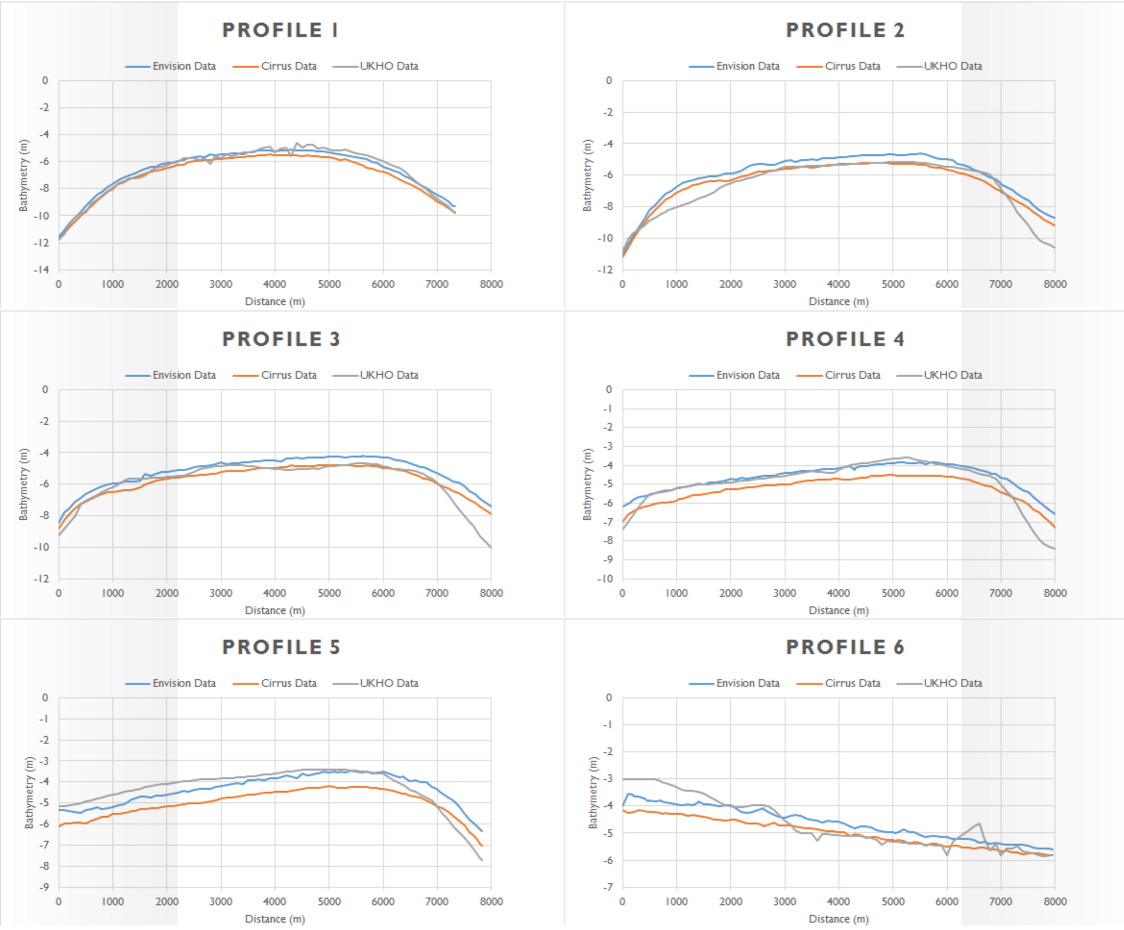

Figure 25 Bathymetric Profiles across the Shell Flat Area of the Shell Flat and Lune Deep SAC

4.40 The profile lines from the Envision and Cirrus data are consistent in the topographic profile they present with the profile showing some differences in the depth but these are in the range of 35-65cm, with an average difference of 49cm. Likewise the UKHO data set shows very little difference in the bathymetry but the topography of the southern slope of the Shell Flat bank is suggested as being steeper than the other two data sets which could be due to the resolution of the data or the predictive/modelled nature of the dataset.

4.41 Profile 6, which is taken from the top of the Shell Flat sandbank, does show some variation between the UKHO and the other two data sets with a 1m difference in depth in the shallower areas and some relatively rapid changes in bathymetry further offshore. Again these could be explained by the predictive or modelled nature of the data.

Feature Condition Over Time

4.42 The designated features of the Shell Flat and Lune Deep SAC (Annex I feature: Sandbanks which are slightly covered by seawater all the time) and Fylde MCZ (Broadscale Habitats: Subtidal Sand and Subtidal mud) features were considered at designation to be of favourable condition, with a target of maintaining this favourable condition.

4.43 Within the Shell Flat and Lune Deep SAC, the extent of the sandbank feature as detailed in the current maps, in comparison with previous habitat maps and the initial area designated, shows no decrease in area and therefore suggests no decline in condition.

4.44 The community structure of the sandbank feature in Shell Flat and Lune Deep SAC has not been seen to alter appreciably over time, as discussed in 4.35, and earlier in 4.12 and 4.19, and therefore do not infer any change in condition. The representative sandbank biotopes SS.SSa.CMuSa.AalbNuc and SS.SMu.CSaMu.AfilMysAnit were originally identified in the Favourable Condition Table for the feature, however the current analysis shows that the sandbank itself is largely comprised of the SS.SSa.IMuSa.FabMag biotope in the fine shallower sediments of the bank, with SS.SSa.CMuSa.AalbNuc occurring in the deeper and slightly muddier sediments found on the slopes and in deeper areas of the bank. The SS.SMu.CSaMu.AfilMysAnit biotope, which is less likely to occur in a sandbank area as it is fundamentally a mud habitat, has been found in the muddier sediments to the west of the Shell Flat sandbank area, and in the North West section of the Fylde MCZ.

4.45 The majority of the data from the Fylde MCZ contained only PSA information, with no detailed infauna data available, therefore it was not possible to consider changes in biota or condition of features over time in this respect. The current maps show the whole MCZ area (26,000 ha) to be comprised entirely of the Broad Scale Habitat features subtidal sands and subtidal muds which suggests these features have been maintained and indicates no decline in condition.

Comparison of Hammon and Day Grab Data

4.46 The Environment Agency survey data underwent further analysis to compare the biota returned by the different sampling methods e.g. Hammon and Day grabs. Multivariate analysis was undertaken of the infaunal data to explore any significant variation between the samples attributable to sampling method. Figure 21 displays the results of the cluster analysis on the Environment Agency (2012) infaunal data for both the Day Grab (DG) and Hammon Grab (HG) sampling methods. The dendrogram is based on group-averaged Bray-Curtis similarities computed on √ transformed abundances. At a similarity of around 40%, the dendrogram indicates that there is no difference in sites based on their species composition despite the differences in sampling method.

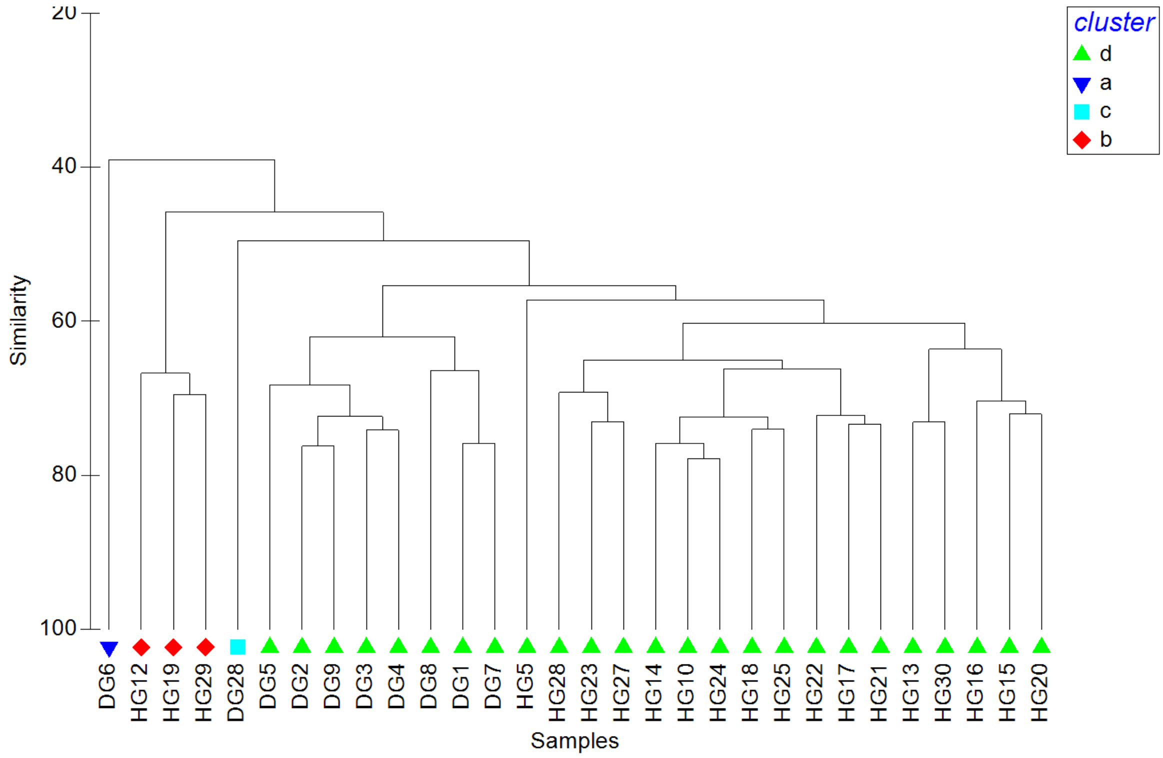

Figure 26 Environment Agency (2012) infaunal data. Dendrogram using group average Bray-curtis similarity from square root transformed abundance data, with sampling techniques for each site are denoted by DG (Day Grab) and HG (Hammon Grab)

4.47 Figures 22 shows the proportion of the major sediment types within the samples. The percentage of a particular sediment type is represented as a proportionally sized circle. The plots indicate that the percentage of sediment types found in both types of gear are of a similar order, and particle size analysis of the samples is not thought to be influenced by the sampling gear used.

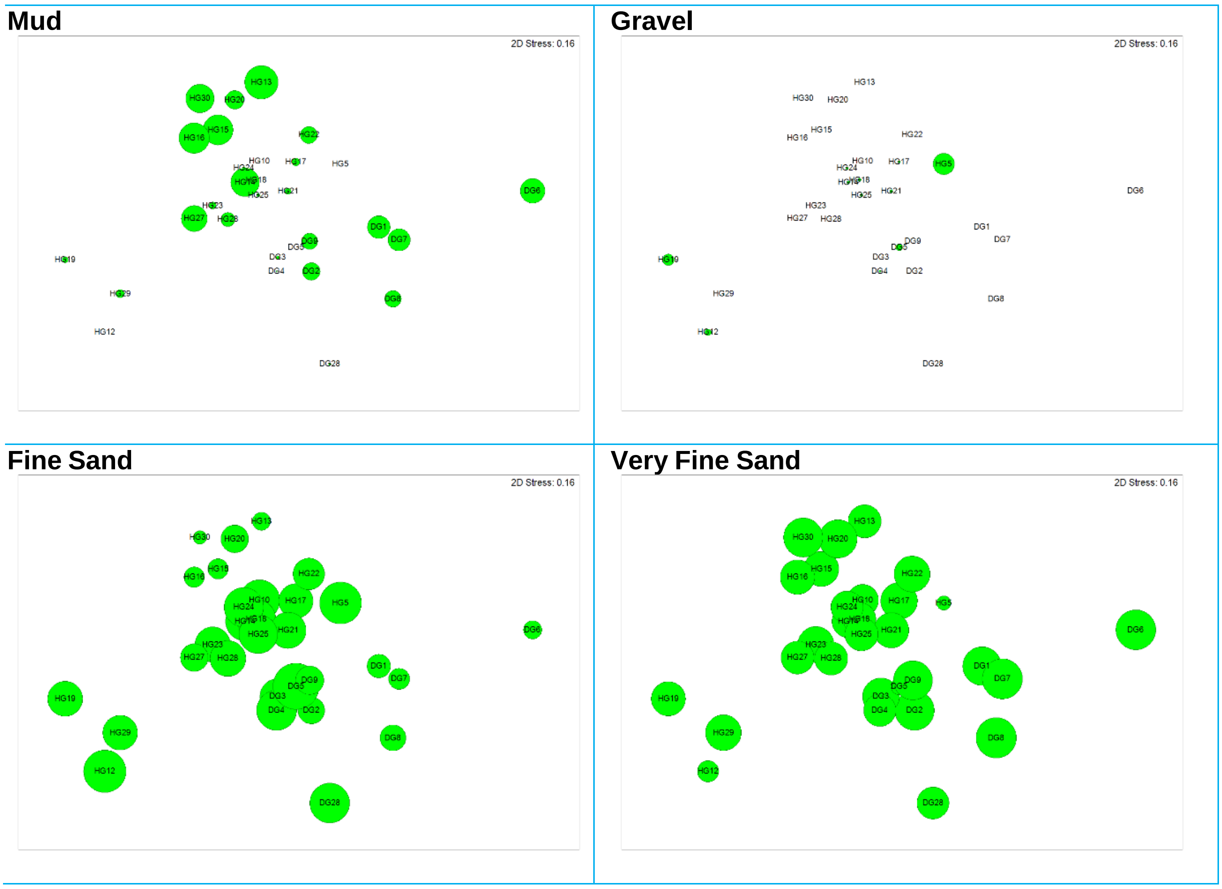

Figure 27 Environment Agency (2012) infaunal data. MDS plots for Day grab and Hammon Grab samples, with percentage of sediment type (mud, gravel, fine sand & very fine sand) represented as proportional circles

Recommendations

4.48 In order to add confidence and improve the certainty of the habitats mapped within the SAC and MCZ area several recommendations can be made. The maps presented as part of this study are based upon a composite of data sources. The level of data paucity varies over the Area mapped with the Shell Flat SAC having a relatively dense sampling array and also with relatively good bathymetric and sidescan coverages. The Fylde MCZ maps, however, are based upon predictive or modelled bathymetric data and the samples are relatively dispersed and low in number when compared to the other areas mapped.

4.49 Future survey effort should focus on the collection of further bathymetric data over the Fylde MCZ, and also a well-planned and structured sampling regime designed for habitat mapping and monitoring.

4.50 With the possible identification of a sandbank feature within the MCZ area, bathymetric and sediment data for this feature and the surrounding area would assist in supporting the nature and condition of this feature.

4.51 The collection of sample data could be used to update the current maps and also be used as ‘ground truthing’ or accuracy assessment data to provide a good measure and indication of the maps accuracy.

Issues & Assumptions

4.52 The bathymetric data used to produce the composite bathymetric dataset used within the mapping process was of variable coverage and quality. Multibeam data was of an excellent resolution but was acquired over a range of dates and was only partial but regular coverage which required some interpolation to produce gridded data formats. This interpolation does introduce some uncertainty into the underlying data used for mapping.

4.53 Artefacts within the composite bathymetry are present where there are steps or steep slopes introduced by differences between datasets, mostly due to the inherent nature of the modelling/post-processing techniques used to derive the original data. Attempts were made to reduce these however these artefacts will influence the mapping process and for this reason contextual editing was used to manually remove and correct any of these effects.

4.54 It should be noted that the geophysical acoustic datasets used within this contract do not provide 100% coverage of the SAC and MCZ and therefore where gaps existed, bathymetric data from the UKHO or interpolated data have been used to provide information to enable the delineation of any Annex 1 features along with the extents of sediments and biotopes. Where the distribution of sediment and biotopes is determined using the sample point data, the extents of these features are determined using topography variations only and should be considered with an appropriate level of confidence and not as definitive boundaries.

4.55 During the mapping process is it assumed that the full range of biotopes and sediment types likely to be found in the area have been sampled and they are fully representative of the area.

4.56 When collating the sample records from a variety of sources it was noted that datasets often had PSA data but, in some instances, restricted infaunal data (e.g. Kaiser *et al*, 2003). (Tables 1 & 2 summarises the data available). For samples of this type the dominant infauna were used to assign a biotope where possible.

4.57 Samples from impoverished or low diversity samples often could not be attributed to a biotope using the species data, in these cases biotopes were attributed based upon the physical nature of the sample (sediment/PSA data).

4.58 In some cases, upon examination of the data it appeared that the original biotope code had been misattributed and steps were taken to match to current biotopes.

Confidence

4.59 In order to assess the suitability of each map to its intended purpose, a confidence assessment using the MESH Confidence Assessment method (MESH, 2008) has been undertaken. This approach assesses the quality and suitability of the geophysical acoustic data, the point sample data, and the interpretative techniques using a scoring system (Table 6).

4.60 The Shell Flat & Lune Deep SAC & Fylde MCZ maps were all generated using geophysical acoustic data and ground truth data from a variety of different sources, however, the processing and interpretative techniques applied were kept consistent. The maps for the wider SAC rely purely upon bathymetric and topography data and the appropriateness of the data and the methods applied are very predictive and therefore the maps will have a lower confidence score.

4.61 A score of 2 has been used to score the ground truthing data for the Fylde MCZ area as the majority of these data contained only PSA information, with no detailed infauna available. The Shell Flat & Lune Deep SAC area scored 3 for this data set.

4.62 Clarification has been sought from JNCC regarding an updated confidence scoring system, and this will be incorporated in the final version of this report if it is available.

Table 6 MESH confidence assessment output for each map produced

	Remote Sensing (Geophysical data)					Ground Truthing (sampling)						Interpretation				Results			
	Remote Technique	Remote Coverage	Remote Positioning	Remote Stds Applied	Remote Vintage	BGT Technique	PGT Technique	GT Positioning	GT Density	GT Stds Applied	GT Vintage	GT Interpretation	Remote Interpretation	Detail Level	Map Accuracy	Remote score	GT score	Interpretation score	**Overall score**
Biotope & Substrate Maps Shell Flat & Lune Deep SAC	3	2	2	2	3	3	3	2	3	3	3	3	3	2	2	80	95	83.33	**86**
Biotope & Substrate Maps Fylde MCZ	1	2	2	2	1	2	2	2	2	2	2	3	3	2	2	53.33	66.67	83.33	**68**

4.63 The Shell Flat & Lune Deep SAC maps score high at 86 with good cover of both geophysical data and ground truth samples which enable good interpretive techniques to be applied.

4.64 The maps for the Fylde MCZ data score lower at 68 due to the predictive nature of the maps using the modelled bathymetric data.

5 GIS & Map Data

- An ArcGIS project for final interpretative maps is provided with associated MESH/Medin format metadata and MESH confidence assessments, and clean of any topology errors.
- Shape files for samples and polygon maps for biotopes, habitat and substrate for the Shell Flat & Lune Deep SAC and Fylde MCZ are provided in MESH DEF format with associated ArcGIS layer files.
- Habitat data supplied in Marine Recorder Exchange format (.mdb) (created using the Marine Merge tool)
- All report maps are provided as image files at 300 dpi or higher.
- Copies of original data spreadsheets / databases are also provided in appropriate Microsoft Office format or ArcGIS format, and on CD or DVD.

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7 Glossary

JNCC – Joint Nature Conservation Committee
UKHO –United Kingdom Hydrographic Office
EA –Environment Agency
NE –Natural England
SAC –Special Area of Conservation
MCZ –Marine Conservation Zone
ABP – Associated British Ports Ltd.
PSA – Particle Size Analysis

Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk** .

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