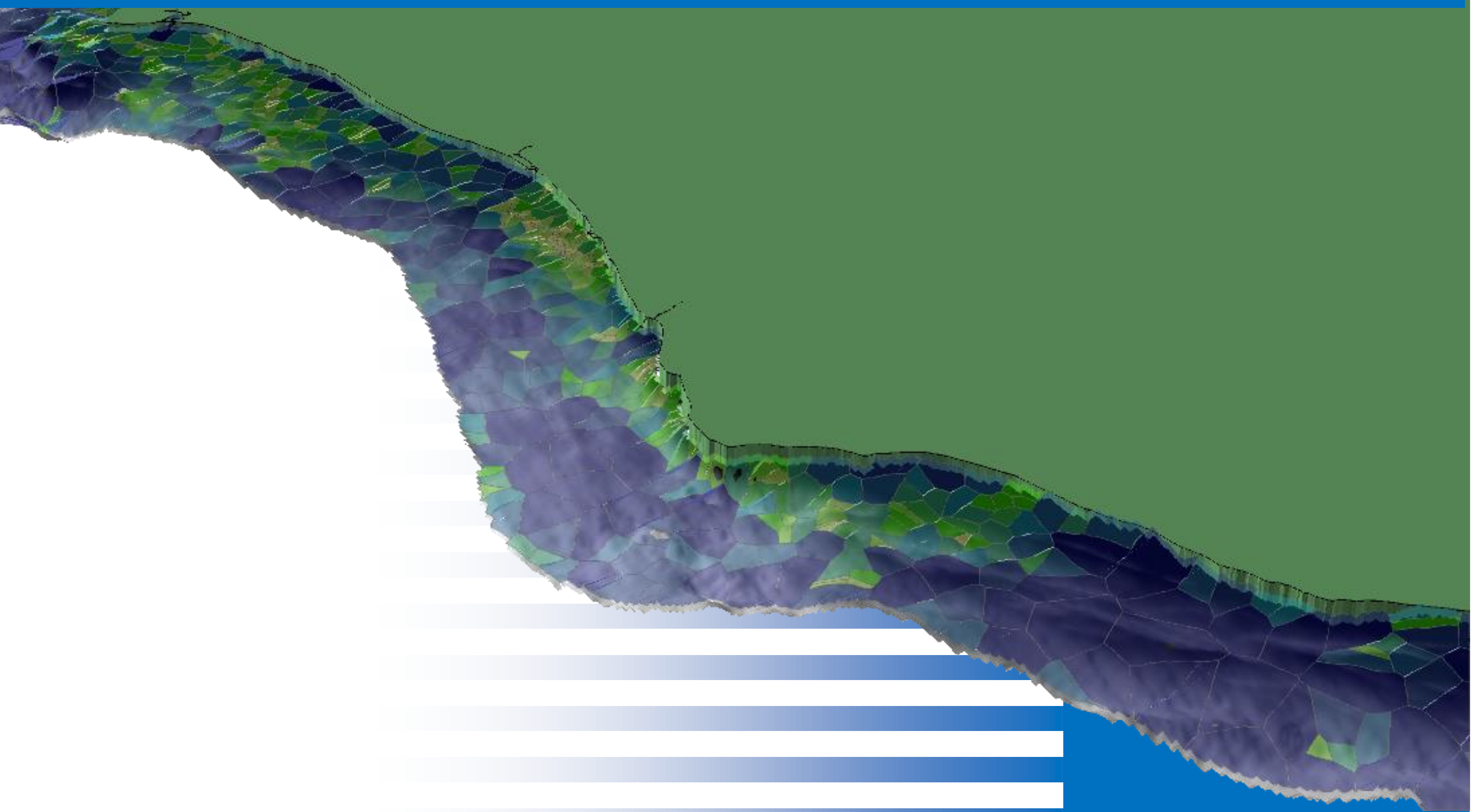
University of Brighton

Sussex Coastal Habitats Inshore Pilot II:

Marine Habitat and Bathymetry Modelling Project Report



Sussex IFCA

Inshore Fisheries and Conservation Authority

Executive Summary

This project aims to provide habitat and bathymetry models for the Sussex IFCA district. Various third party habitat and bathymetry data sets have been collated. Broad scale and fine scale habitat data were identified. Four remotely sensed broad scale habitat models, and three fine scale habitat data sets were identified. The EUNIS habitat classification system was used. Polygon data were used for broad scale mapping, point data were used for fine scale. Habitat metadata were collated for each data set, and an assessment was made of the data quality. EUNIS level 2 and EUNIS level 3 habitat maps were produced for each EUNIS class present. For the broad scale data, comparison techniques were developed to compare and cross validate the predicted habitat distributions, identifying areas of agreement between the broad scale data. Spatial confidence was indicated throughout each broad scale habitat map. Fine scale point data were analysed using appropriate geostatistical techniques to identify areas of good and bad survey coverage, and areas with poor survey coverage. Good survey coverage was used to infer good spatial confidence, and vice versa. Additionally, a voronoi polygon approach was used so as to extrapolate the fine scale categorical points over the entire district. Voronoi polygon size was used as a proxy for spatial confidence. Kriging was used to model broad scale bathymetric data.

Three main habitat types were identified: Infralittoral rock and other hard substrata (A3), circalittoral rock and other hard substrata (A4), and sublittoral sediment (A5). Among the broad scale habitat data, large differences were found between each of the four habitat models over most of the Sussex IFCA district. This made predicting broad scale habitat distribution with any confidence difficult at both EUNIS level 2 and 3. Two small isolated areas were identified where three or more data sets agreed on the EUNIS habitat type, these were predominantly EUNIS A5.2 habitats. These areas covered only 19% of the district at EUNIS level 2, and 14% at EUNIS level 3. The remaining area was predicted with low confidence to be either A3, A4, or A5; depending on the model used. Based on the metadata, two models were identified as being more robust, which suggested A3 habitat to be dominant, followed by A5 and to a lesser extent A4. The fine scale data had good coverage throughout most of the Sussex IFCA district. The fine scale data were mainly expert interpreted ground truth points and Seasearch observations. These were mapped to EUNIS level 2 as points, and EUNIS level 2 to level 6 as voronoi polygons where data were available. Contrary to the broad scale data, the fine scale data predicted A5 habitat throughout that Sussex IFCA district, with small areas of A3 and A4. It was noted that this did correlate well with the two broad scale habitat models suggested to be less robust by their metadata. Given the uncertainty, the EUNIS system itself was critically reviewed using scientific literature and relevant project reports. It was found that mixed sediment and rock habitats are poorly represented by the current EUNIS classifications, which were found in some cases to perhaps cause ambiguous habitat descriptions. A broad scale bathymetric model was interpolated from existing Sussex IFCA data, with 230m resolution. Fine scale data were provided for isolated areas at between 1 and 2m resolution.

The study indicates that local habitat mapping with the available third party broad scale remotely sensed data is difficult to do with high confidence, due to large conflicting habitat predictions. However, fine scale data based on observations from Seasearch divers and expert interpreted ground truth videos are perhaps a good indication of what can be seen on the immediate sea floor surface. A methodology for extrapolating categorical point data over unknown areas has been provided. Broad scale and fine scale bathymetry models have been provided.

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Prepared for:

Sussex Inshore Fisheries Conservation Authority

Authors:

Mr Nicholas J Tomline

Dr Niall G Burnside

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List of abbreviations

AGDS Acoustic Ground Discrimination Systems

ALSF Aggregates Levy Sustainability Fund

BGS British Geological Survey

CEFAS Centre for Environment, Fisheries, and Aquaculture Science

EUNIS European Nature Information System

IFCA Inshore Fisheries Conservation Authority

JNCC Joint Nature Conservation Committee

KDE Kernel Density Estimation

MALSF Marine Aggregates Levy Sustainability Fund

MBES Multi Beam echo-Sounder

MCZ Marine Conservation Zone

MESH Mapping European Seabed Habitats

OHA Optimised Hotspot Analysis

SAC Special Area of Conservation

SCHIP Sussex Coastal Habitats Inshore Pilot

1 Introduction

1.1 Background

The Sussex Coastal Habitats Inshore Pilot (SCHIP) 2 project follows on from the preceding SCHIP 1 project, which was led by the Sussex Inshore Fisheries and Conservation Authority (IFCA), working in partnership with Sussex Wildlife Trust, and funded by the Environment Agency. SCHIP 1 sought to work with decision-makers, local experts and key stakeholders to develop a better and shared understanding of the habitats, species and pressures on the Sussex coastal water body which stretches from Selsey in the west to Beachy Head in the east; out to one nautical mile offshore. A key output of the SCHIP1 project was the creation of a habitat map for the Sussex coastal water body, far more accurate and detailed than anything else that existed previously. Sussex IFCA commissioned the Channel Coast Observatory to interpret the available bathymetry, backscatter, and ground truthing data for Dungeness to Selsey out to 1km.

The SCHIP 2 project aims to build on the outputs from SCHIP 1 with the development of a habitat map for the whole Sussex Inshore Fisheries and Conservation Authority (IFCA) district. The district is approximately 1,700 km^2 and covers the area from the Hampshire-West Sussex border in Chichester Harbour in the west to the East Sussex-Kent border between Rye and Dungeness in the east and from the mean high water mark to 6 nautical miles offshore. Where previous projects have looked at either large areas in low resolution or small areas in high resolution, this project aims to bring together all available data and produce a detailed habitat map of the whole district.

Knowledge of the distribution of marine habitats is vital for Sussex IFCA to assess those potentially impacted by identified pressures and for directing management to where it is most needed. Habitat mapping assists in informing a range of planning policy and marine conservation objectives, such as the delineation of features of importance within Marine Patrol Areas (MPAs) within the Sussex coastal water body, helping to focus future monitoring and management work.

1.2 Outline of aims and objectives of project

1.2.1 Project aim:

The project aims to explore and analyse existing sea floor habitat and bathymetric data sets available for the Sussex IFCA district. These data will be used to construct a broad scale habitat model classified to European Nature Information System (EUNIS) level 3; detailed fine scale habitat model classified up to EUNIS level 6, and provide a bathymetric model of the entire district. It is anticipated that these data will be suitable to inform the management of fisheries and the marine environment and for the ecological assessment of Sussex Coastal Waterbody under Water Framework Directive (out to one nautical mile offshore).

1.2.2 Project objectives:

1.2.2.1 Habitat mapping objectives

- Collate existing available habitat and bathymetry data sets
- Identify areas of data conflict, data agreement, and areas with no available data
- Evaluate the usefulness of the MESH confidence assessment and use to examine the data quality for each data set
- Produce maps showing high, medium, and low confidence levels; based on the quality of data and cross comparisons between independent data sets
- In areas of data conflict between different habitat data sets, select areas with highest confidence to put forward into a final habitat model

- Produce spatially broad scale habitat model of the Sussex IFCA district to EUNIS level 3, following or adapting existing approaches by Robinson *et al*. (2009) used in the Habmap sea floor habitat mapping project in order to produce standardised output maps
- Produce spatially fine scale map of specific areas where there are sufficient data to do so, to EUNIS level 3, suitable for use as evidence for management
- Develop confidence map for the Broad scale and fine scale EUNIS coded habitat maps
- Where there are sufficient data, develop a method for mapping to EUNIS level 4 or greater
- Produce habitat map to the highest possible EUNIS level, suitable for informing management decisions and directing future survey work.

1.2.2.2 Bathymetric mapping objectives

- Collate existing bathymetric data from relevant marine and statutory organisations
- Produce a continuous, interpolated broad scale bathymetric raster model of the Sussex IFCA district, scaled with appropriate colours, suitable for education and public engagement.

1.3 Study site

1.3.1 Location

The SCHIP 2 study area is located on the southeast coast of the United Kingdom, bordering the county of Sussex. Specifically, the study area extends from just east of Rye Harbour, to Chichester Harbour in the west, and extends from the intertidal zone six nautical miles offshore. The general location is seen in Figure 1.

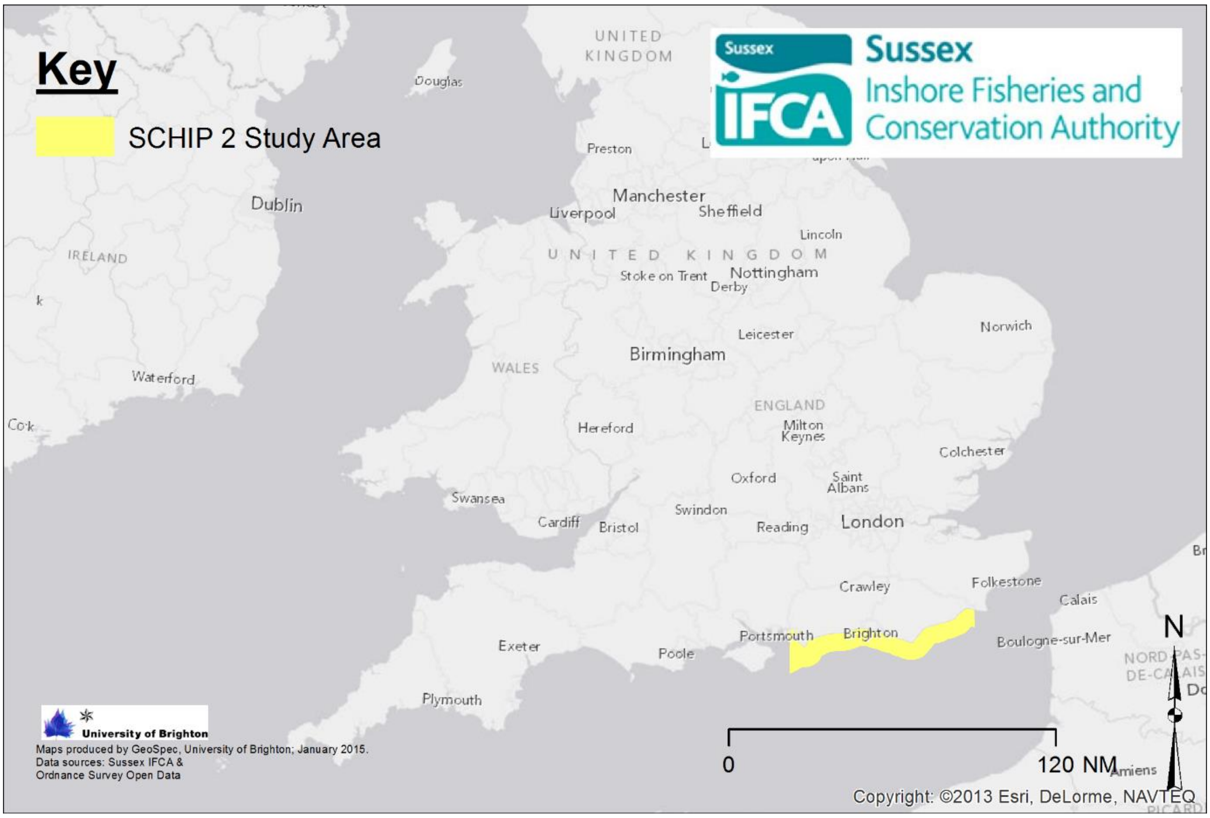

Figure 1 Location of the Sussex Inshore Fisheries and Conservation Authority district/Sussex Coastal Habitats Inshore Pilot 2 study area

1.3.2 Site description

Figure 2 shows the SCHIP 2 study area, highlighted in yellow. The area contains various sites recognised locally for their topography and physical characteristics. A brief description of these notable marine locations is provided here.

Beginning at the western end of the Sussex IFCA district, the first notable feature are the Owers to the south of Selsey, characterised by large undulating submerged rocks. Between the Malt Owers and Outer Owers is a feature known locally as the Looe Channel, a narrow navigable passage between the rocks, which exaggerate tidal currents. The surrounding and underlying rocks create tidal upwellings. Moving east, the next notable feature is Kingmere Rocks which extend south-eastwards, located approximately three to five nautical miles offshore. These adjoin the adjacent inshore area known as Kingston rocks. Further east the next notable feature is the chalk headland known as Beachy Head. This area is composed of rocky shallow reefs inshore and comparatively strong tidal currents. The seafloor drops away relatively steeply offshore. Offshore of Eastbourne is a comparatively shallow, rocky area known as the Royal Sovereign Shoals, which begin approximately four nautical miles southeast of Sovereign Harbour, and extend a further two nautical miles out to sea. Smaller rocky shoals extend back towards the shore. The area is renowned locally for abundant fishing, and comparatively strong tidal currents and upwellings. Finally in the far eastern end of the SCHIP 2 study area is the Four Fathoms Sand Ridge. This forms part of a series of charted sand ridges and outcrops which extend offshore.

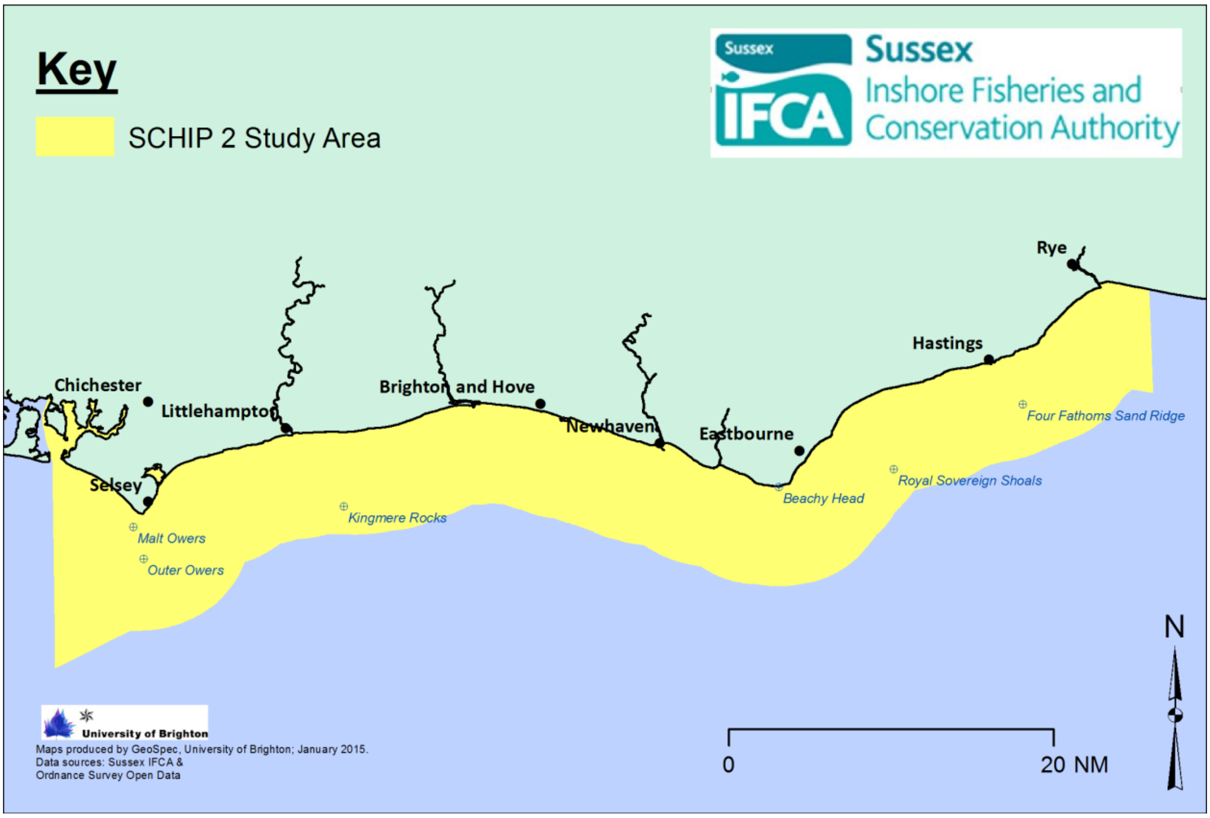

Figure 2 Sussex Inshore Fisheries and Conservation Authority district/Sussex Coastal Habitats Inshore Pilot 2 study area, including notable marine locations

1.3.3 Geology

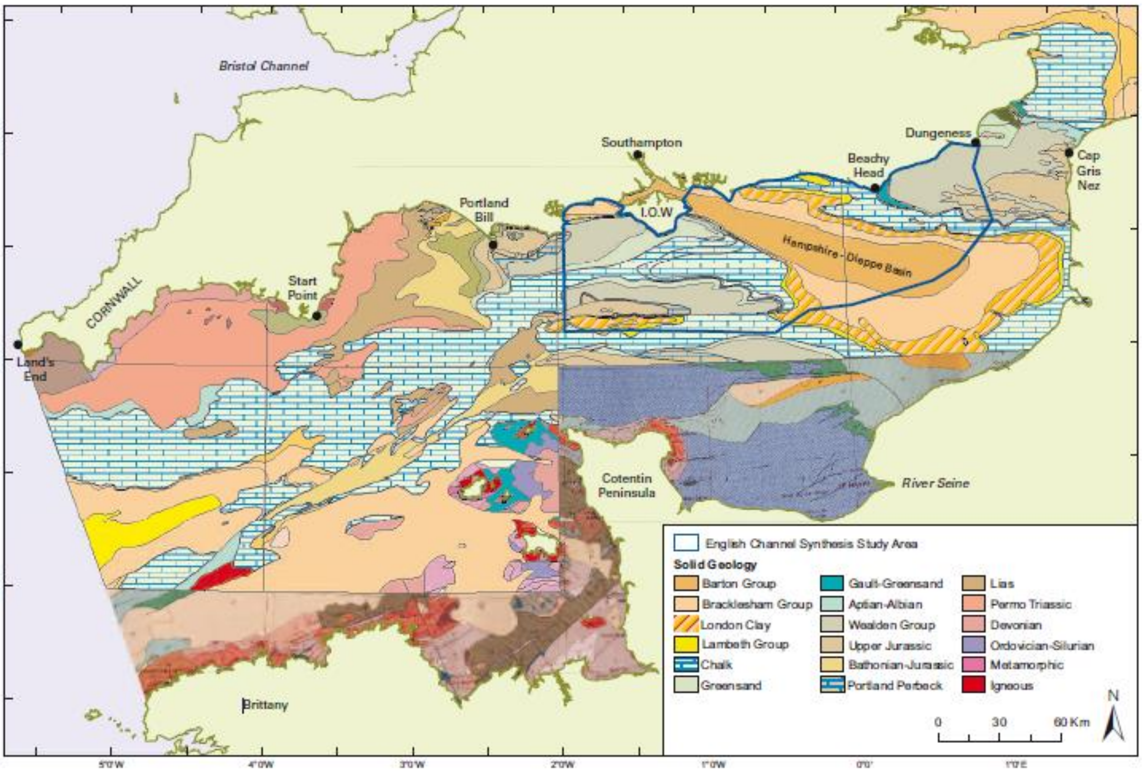

Figure 3 English Channel offshore geology. Taken from James et al. *(2011)*

Using the offshore solid geology map in Figure 3, it is observed that the English Channel is dominated by sedimentary rock formations. Indeed, the SCHIP 2 area consists entirely of sedimentary bedrock. More specifically, the following geological groups are found within the SCHIP 2 area, from west to east: In the vicinity of Selsey, the Lambeth group consisting gravels, sands, and clays; the Bracklesham group consisting clays and marls with sand; and the London Clay. Moving towards the vicinity of Littlehampton and towards Beachy Head, there is predominantly chalk inshore with Lambeth group gravels, sands, and clays. Offshore are the Lambeth group gravels, sand, and clay as well as London clay. Eastwards of Beachy Head the SCHIP 2 study area is characterised by a small Gault-Greensand outcrop of sand, clay, and silt; and the Wealden group (interbedded sandstones, silt stones, shales, and limestones) which dominate the study area between Eastbourne and Dungeness. It is noted that overlying loose or unconsolidated sediment, known in geological terms as drift deposits, are not included in this map.

1.3.4 Sea conditions

Statistics obtained from the Channel Coast Observatory (2015) wave buoys for the period 2010-2014, reveal general trends in the wave conditions at three locations spread across the SCHP 2 study area. The maximum wave height in the area recorded was 13.0m by the Rushington wave buoy, offshore from Littlehampton. The Pevensey Bay and Hailing Island buoys recorded maximum wave heights of 4.4m and 4.6m respectively. The average wave height ranges between 0.6m and 0.7m for all three locations. Sea surface temperatures range between 3 and 23 degrees Celsius.

1.4 EUNIS habitat classification

The EUNIS habitat classification system was used to describe marine habitats within the SCHIP 2 study area. The EUNIS habitat classification system was developed for the European Environment Agency (EEA) and the European Environmental Information Observation Network (EIONET) by the European Topic Centre for Nature Protection and Biodiversity (ETC/NPB) (Davies *et al*., 2004).

The EUNIS system is a hierarchical habitat classification system (Davies *et al.* 2004), with progressive levels providing more detailed habitat descriptions, culminating at level 6. It should be noted that not all classes reach EUNIS level 6, in some cases EUNIS level 3, 4, or 5 are the highest given hierarchical classification. It aims to provide a universal habitat identification system (Davies *et al*., 2004). Davies *et al*. (2004) define EUNIS habitats as follows:

'Habitat' is defined as "a place where plants or animals normally live, characterised primarily by its physical features (topography, plant or animal physiognomy, soil characteristics, climate, water quality etc.) and secondarily by the species of plants and animals that live there". While it is emphasised that the EUNIS habitat classification system is intended for 'habitats', as defined above, it is acknowledged that some areas may be devoid of living organisms other than microbes. Davies *et al*. (2004) state that although these aren't true habitats as defined above, they are included for completeness.

The marine section of the EUNIS system was originally based on the BioMar classification system (Davies *et al* 2004; Monteiro *et al*. 2014) and was developed in collaboration with marine experts from across Europe, managed by the European Topic Centre for Nature Protection and Biodiversity for the European Environment Agency (Monteiro *et al*., 2014).

The EUNIS system classifies habitats based on thresholds set for few environmental variables which are said to structure biological communities. Accurate measurement and interpretation of these variables are of great importance in the implementation of EUNIS coding (Monteiro *et al*., 2014).

Dauvin *et al.* (2008) point out a need for a standardised ecological classification system, the absence of which can result in confusion of habitat definitions. A standard classification allows for direct comparisons to be drawn between different data for a given area. EUNIS level 3 is the standard used by the Joint Nature Conservation Committee (JNCC) (JNCC, 2014a). Standardised habitat mapping in this sense is the principle purpose of the Marine Habitat Mapping Framework (MESH) project (Cefas, 2014), which aims provide seabed habitat mapping across northwest Europe in the standardised EUNIS system (JNCC, 2014b). The virtues and limitations of the EUNIS system, together with the importance of a unified classification shall be discussed further in the following chapters.

2 Methodology

2.1 Habitat classification system – EUNIS

The EUNIS habitat classification system was used to describe marine habitats within the SCHIP 2 study area in a standardised format. EUNIS has become the accepted marine classification in Europe (James *et al.* (2011). As such, its use within SCHIP 2 makes the project compatible with wider studies such as the UK and EU Sea Map projects.

A standardised colour coding system has been developed specifically for use on the SCHIP 2 project, reflecting the three main EUNIS habitat types found in the Sussex IFCA District. The EUNIS classes have been colour coded according to Table 1. This colouring system differs from the standard EUNIS colouring scheme recommended by the MESH guidelines. This is in order to represent and differentiate the EUNIS classes which are present in the SCHIP 2 data, optimising the output maps for visual interpretation. It should be noted that EUNIS Sussex 2010 data set, in connection with the report by James *et al.* (2011) adds nonstandard EUNIS codes, highlighted in grey Table 1. It will be shown in latter sections of this study that some data sets exhibit classifications beyond EUNIS level 3, up to EUNIS level 6. Where this is the case, the graduated colour scheme applied in Table 1 is applied in the same way to differentiate EUNIS classes.

Table 1 SCHIP 2 standardised colour coding based on the habitat types present within the study area. Classifications highlighted in grey are none standard EUNIS codes used by the EUNIS Sussex 2010 Survey.

EUNIS Level 2	Colour	EUNIS Level 3	Colour
A3 Infralittoral rock and other hard substrata		A3.1 : Atlantic and Mediterranean high energy infralittoral rock	
		A3.2 : Atlantic and Mediterranean moderate energy infralittoral rock	
		A3.3 : Atlantic and Mediterranean low energy infralittoral rock	
		A3.8 : High energy infralittoral rock and thin sediment	
		A3.9 : Moderate energy infralittoral rock and thin sediment	
		A3.A : Low energy infralittoral rock and thin sediment	
A4 Circalittoral rock and other hard substrata		A4.1 : Atlantic and Mediterranean high energy circalittoral rock	
		A4.2 : Atlantic and Mediterranean moderate energy circalittoral rock	
		A4.3 : Atlantic and Mediterranean low energy circalittoral rock	
		A4.8 : High energy circalittoral rock and thin sediment	
		A4.9 : Moderate energy circalittoral rock and thin sediment	
		A4.A : Low energy circalittoral rock and thin sediment	
A5 Sublittoral sediment		A5.1 : Sublittoral coarse sediments	
		A5.2 : Sublittoral sand	
		A5.3 : Sublittoral mud	
		A5.4 : Sublittoral mixed sediment	
		A5.5 : Sublittoral macrophyte-dominated sediment	
		A5.6 : Sublittoral biogenic reefs	

2.2 Software packages

Throughout this project, spatial data analysis and mapping have been undertaken in ArcGIS 10.2.2 (ESRI Inc, 2014). Where appropriate, spatial attribute data have statistically analysed in Microsoft Excel. Habitat data are processed using ESRI shape file format, and bathymetric data outputs are produced as GeoTiff images.

2.3 Projection/coordinate system

All data have been converted and projected in British National Grid.

2.4 Broad scale habitat maps

2.4.1 Data sources

A summary of the broad scale data sources can be found in Table 2.

Table 2 summary of broad scale habitat data sources

Data	Source	Habitat classification system
EUNIS 2010 Sussex	The MALSF Synthesis study: regional environmental characterisation in the central and eastern English Channel (James *et al*., 2011)	Modified EUNIS
EUNIS South East	Study by Coggan and Diesing (2011) reinterpreting and combining existing data sets for the eastern English Channel	EUNIS
JNCC UK Sea Map 2010	JNCC interactive map: http://jncc.defra.gov.uk/page-5534. Associated project report: http://jncc.defra.gov.uk/page-5955#download	EUNIS
"RoxAnn" AGDS	Envision, referred to in the report by Clark *et al.* (No Date a)	Converted from custom classification to EUNIS

2.4.2 Brief summary of broad scale data sets

2.4.2.1 EUNIS Sussex 2010 (MALSF Synthesis study)

The following information in this section is taken from the MALSF Synthesis Study: Regional Environmental Characterisation (REC) in the central and eastern English Channel (James *et al*., 2011), unless stated otherwise:

The EUNIS Sussex 2010 survey, also known as the MALSF synthesis study, was a broad scale survey effort carried out on behalf of the Marine Aggregate Levy Sustainability Fund (MALSF) commissioned by the Marine Environment Protection Fund. The survey was based on two previous regional environmental studies: Eastern English Channel Marine Habitat Map, and the South Coast Regional Environmental Characterisation. Principle objectives of the synthesis study included integrating the marine geology and biology to provide seabed habitat maps. The synthesis study reanalysed these two original studies and incorporated additional new data. Broad scale data were gathered using remote sensing technology: Multi beam echo sounder, side scan sonar, and boomer sub-bottom profiler. The survey lines were done at approximately 1 kilometre intervals. Ground truthing was carried out in order to validate the remote sensing techniques. Techniques used were: Hamon grab, clamshell grab, beam trawl, drop camera, and camera sledge (James *et al*., 2011).

The overall remote sensing survey effort and ground truth effort for the synthesis study (EUNIS Sussex 2010 data set) can be seen in Figure 4 and Figure 5. Within the SCHIP 2 study area, the overall survey coverage is varied and poor in many locations. The intention of MALSF Synthesis study was to produce a broad scale habitat map for the eastern and central English Channel, and therefore its use in localised studies is treated with caution.

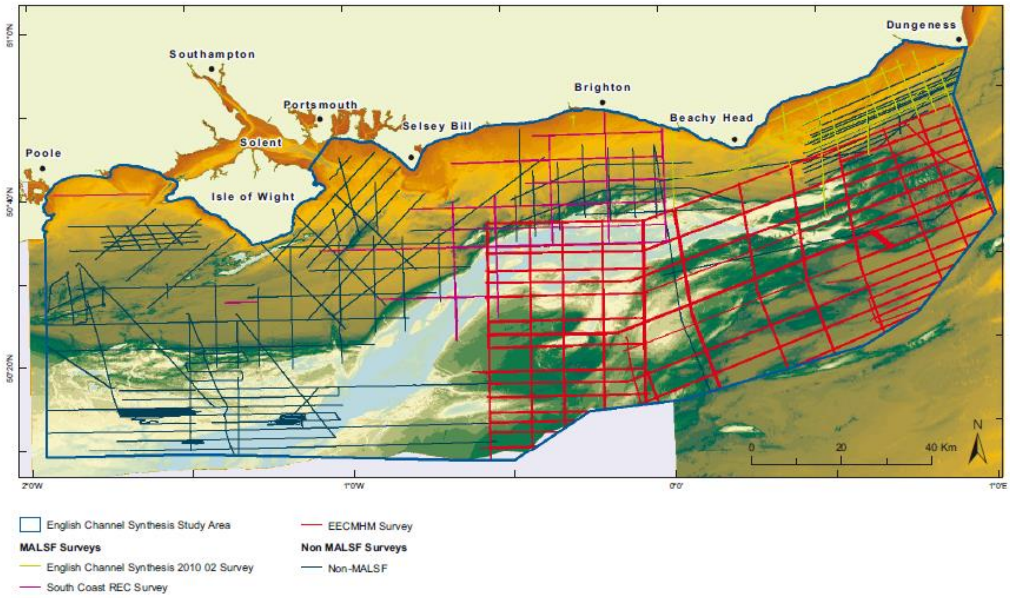

Figure 4 MALSF Synthesis study acoustic remote sensing survey lines (James et al.*, 2011)*

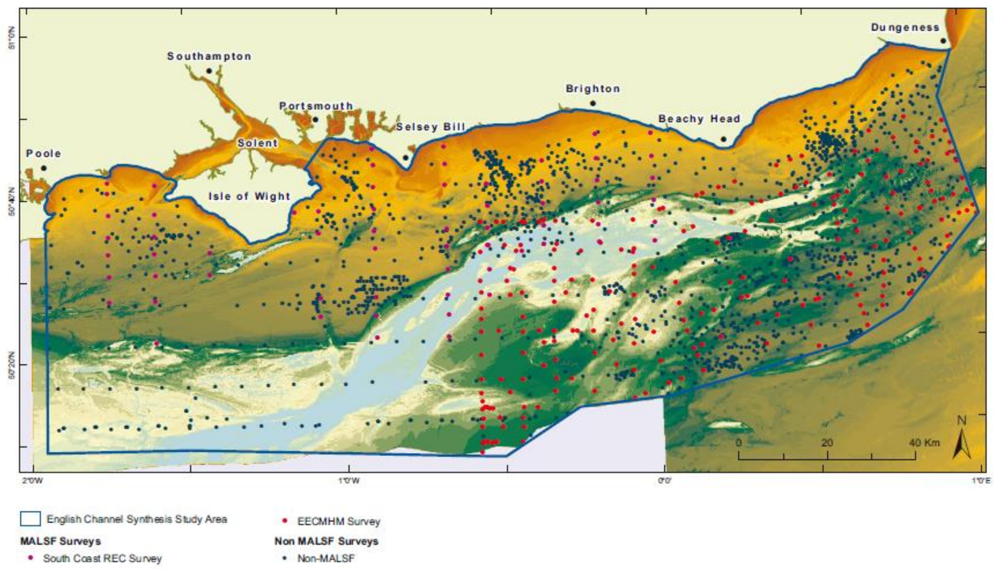

Figure 5 MALSF Synthesis study ground truth locations (James et al.*, 2011)*

2.4.2.2 EUNIS South East

The EUNIS South East data set was based on research by Coggan and Diesing (2011), which compared past models by Holme (1966) and Cabioch *et al.* (1976 and 1977) with a modern predictive model. Coggan *et al.* (2009) and Diesing *et al.* (2009) carried out sea floor habitat survey work for the central English Channel using acoustic and ground truthing techniques; this initial work aimed to facilitate the selection of Special Areas of Conservation (SAC). Coggan and Diesing (2011) extrapolated this work, and attempted to integrate the results with the MESH EUNIS model developed by Coltman *et al.* (2008), to produce a broad scale habitat map for the entire English Channel. The MESH EUNIS map by Coltman *et al*. (2008) can be seen in Figure 6. The integrated map derived from this by Coggan and Diesing (2011) can be seen in Figure 7. The study makes use of British Geological Survey (BGS) seabed sediment maps to help interpret patterns in seafloor habitat distribution, however where sufficient datdauvina were available, survey data were used as the primary source of habitat interpretation.

Coggan and Diesing (2011) go on to use this to validate old studies by Holme (1966) and found there to be 64% agreement between the 21st and 20th century studies.

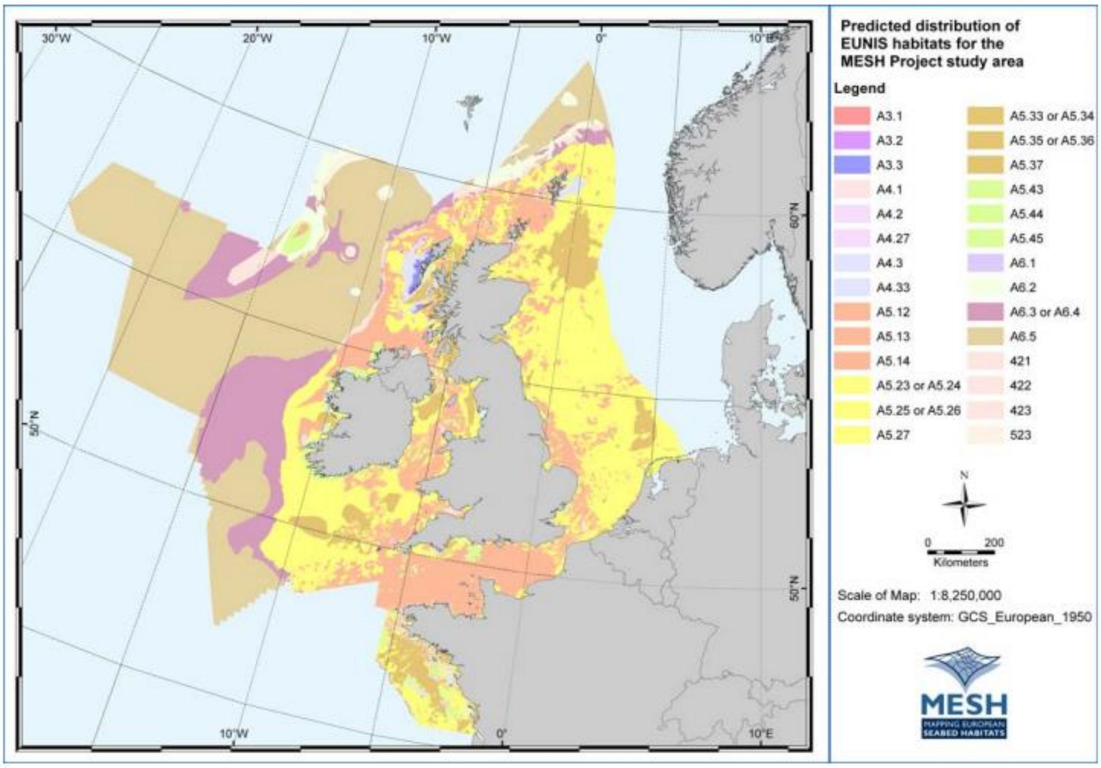

Figure 6 MESH EUNIS sea floor habitat map by Coltman et al. *(2008)*

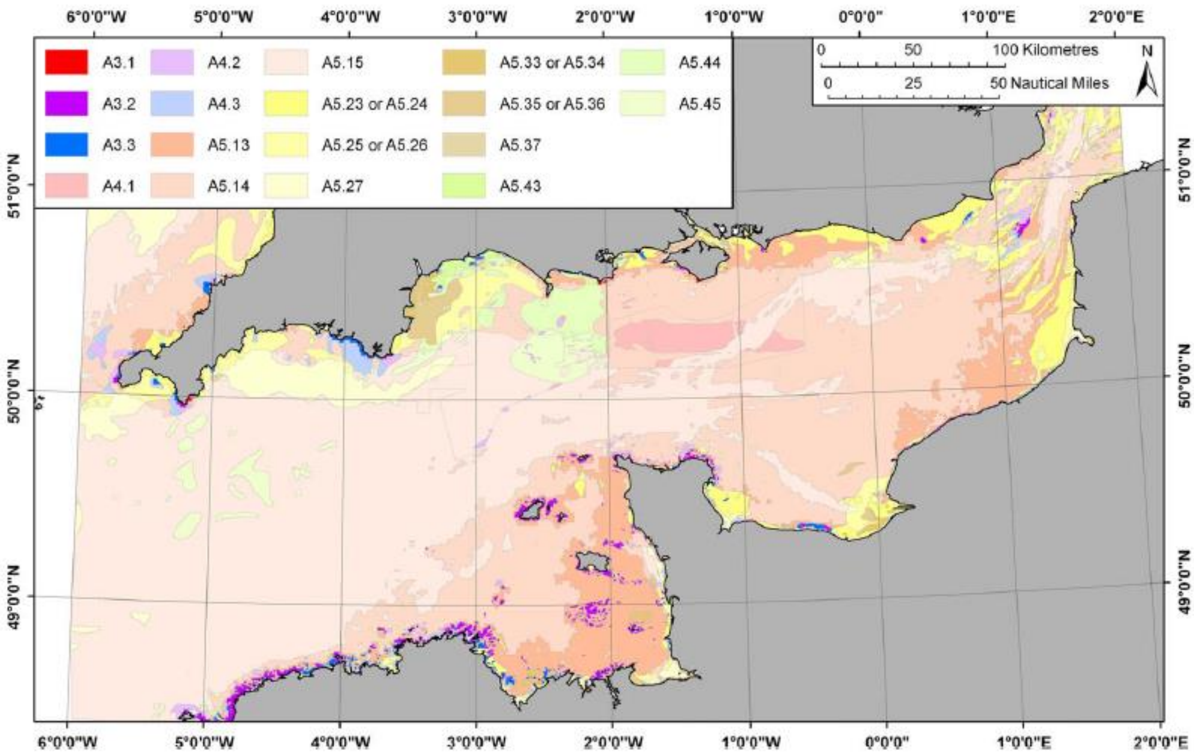

Figure 7 English Channel EUNIS habitat map by Coggan and Diesing (2011)

2.4.2.3 RoxAnn AGDS

The RoxAnn AGDS data used in this report were collected by Seamap Research Group, now known as Envision. During the preparation of this report, the original project report associated with the collection of RoxAnn AGDS data was not available. In its absence, a report by Clark *et al*. (no date a) has been sourced which reviews acoustic marine data collection methods for use in habitat modelling. Specifically, an updated review of the RoxAnn AGDS survey within Annex 4 of the Clark *et al.* (no date a) report. The RoxAnn AGDS data were collected between 1995 and 1997, as shown in Figure 8. AGDS systems are designed to use acoustic properties of the seabed to identify the physical and biological nature of the sea floor. The survey data has been interpreted to produce a map of the predicted ground type distribution, using 11 bespoke classes. The RoxAnn Survey uses a nonstandard classification system, which has been converted to EUNIS. This process is described later in this chapter. Ground truth video drops were used to validate class delineation. The RoxAnn data were subsequently correlated with fishing activity sitings by Clark *et al*. (no date a), who note that these correlate well with the RoxAnn data.

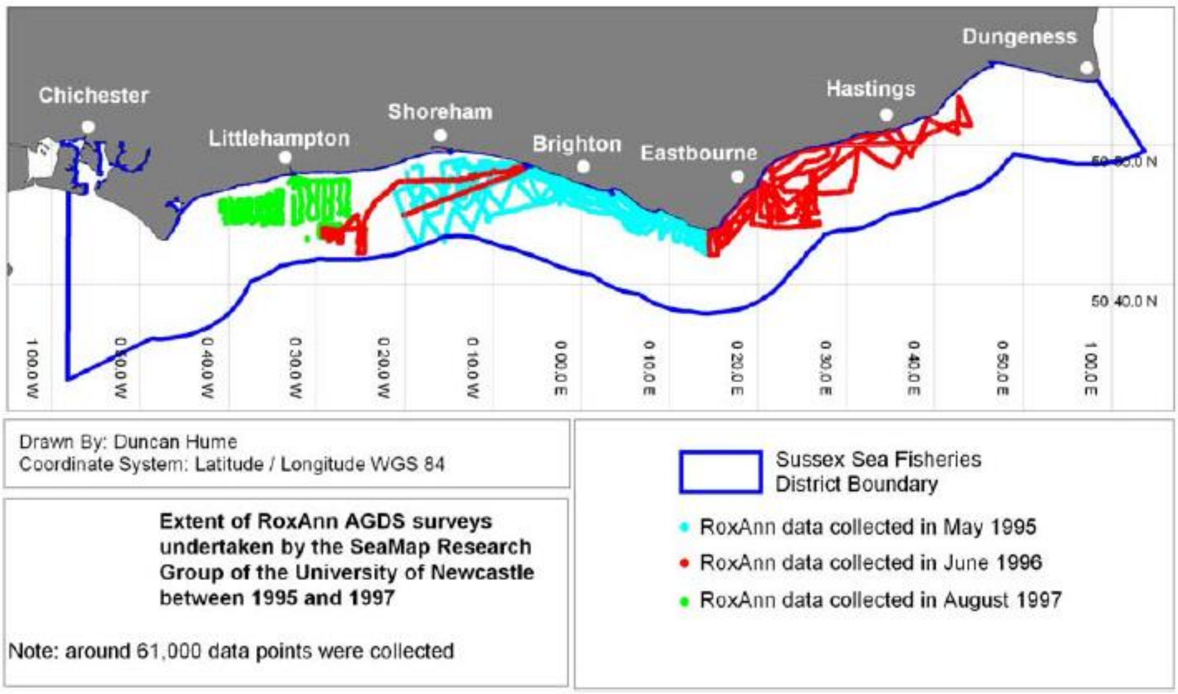

Figure 8 RoxAnn AGDS data extent. (Clark et al.*, no date a)*

2.4.2.4 JNCC UK Sea Map 2010

The UK Sea Map 2010 is bespoke project led by the Joint Nature Conservation Committee (JNCC) with the aim of producing an ecologically relevant, full coverage map of the seabed habitats across the entire UK marine area (McBreen *et al.*, 2011). The associated project report by McBreen *et al.* (2011) has been used to obtain background information regarding this study.

The study is the largest in terms of area of any of those used within the SCHIP 2 project. The project is mapped at approximately 300m spatial resolution, limited by generally available data resolution for much of the UK Sea Map 2010 study area. The UK Sea Map 2010 used a variety of input layers in order to produce a EUNIS habitat map. These include: Biological zone data such as light, wave energy, and depth data; geological seabed substrate which reflect changes in sediment type associates with changes in biological communities; energy conditions at the seabed including both wave and tidal energy; and biogeography using depths as boundaries to divide the project area into Atlantic and

Arctic zones (McBreen *et al.*, 2011). The UK Sea Map 2010 uses secondary data from a variety of sources, although the specific details of data sources are not explicitly stated within the project report. The project also builds on previous predictive habitat models, especially the UK Sea Map 2006. The UK Sea Map 2010 uses confidence mapping to select the most likely habitat to occur at a particular location, based on the variables given above.

2.4.3 Broad scale data extents

Figure 9 shows the unclipped original data extents of the broad scale polygon data sets described above. Where the extent of the original data exceeded the SCHIP2 study area, the data have been clipped to fit. The extent of the resulting habitat data sets can be seen in Figure 10. EUNIS Sussex 2010, EUNIS South East, and JNCC UK Sea Map all cover the entirety of the study area, while RoxAnn covers a smaller inshore central region.

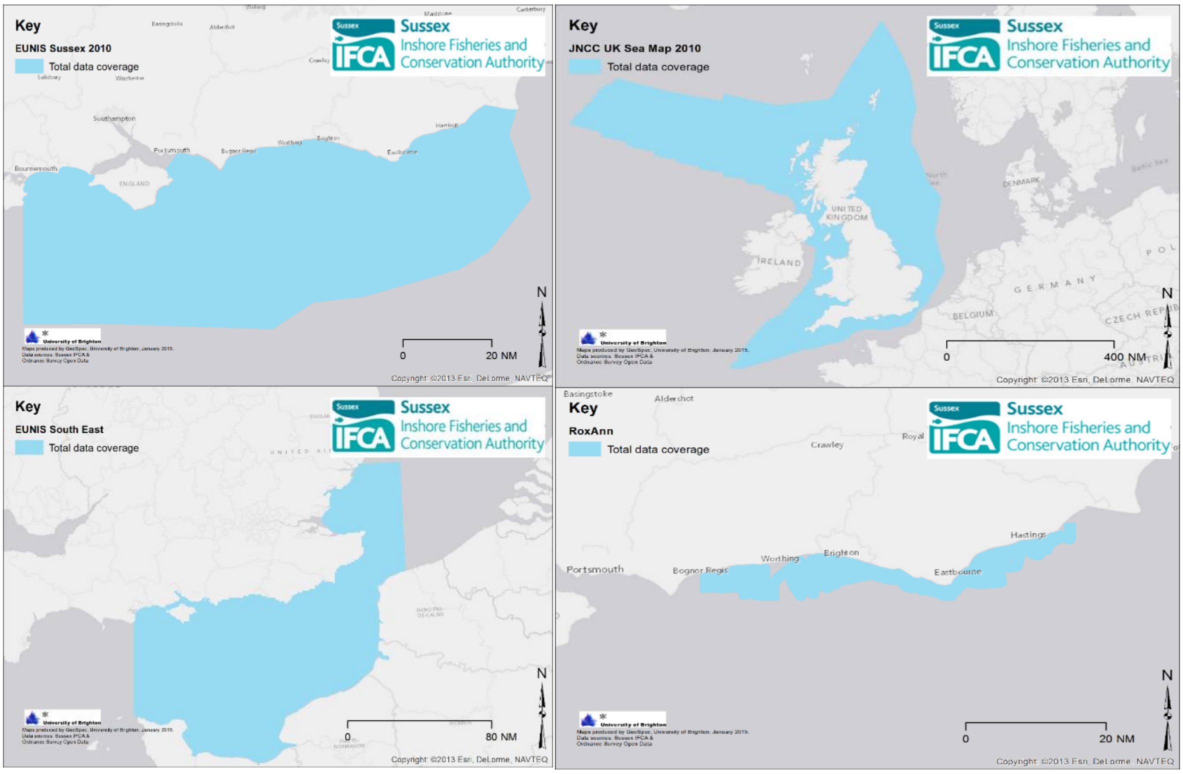

Figure 9 Habitat models: EUNIS Sussex 2010, EUNIS South East, JNCC UK Sea Map 2010 and RoxAnn total data coverage

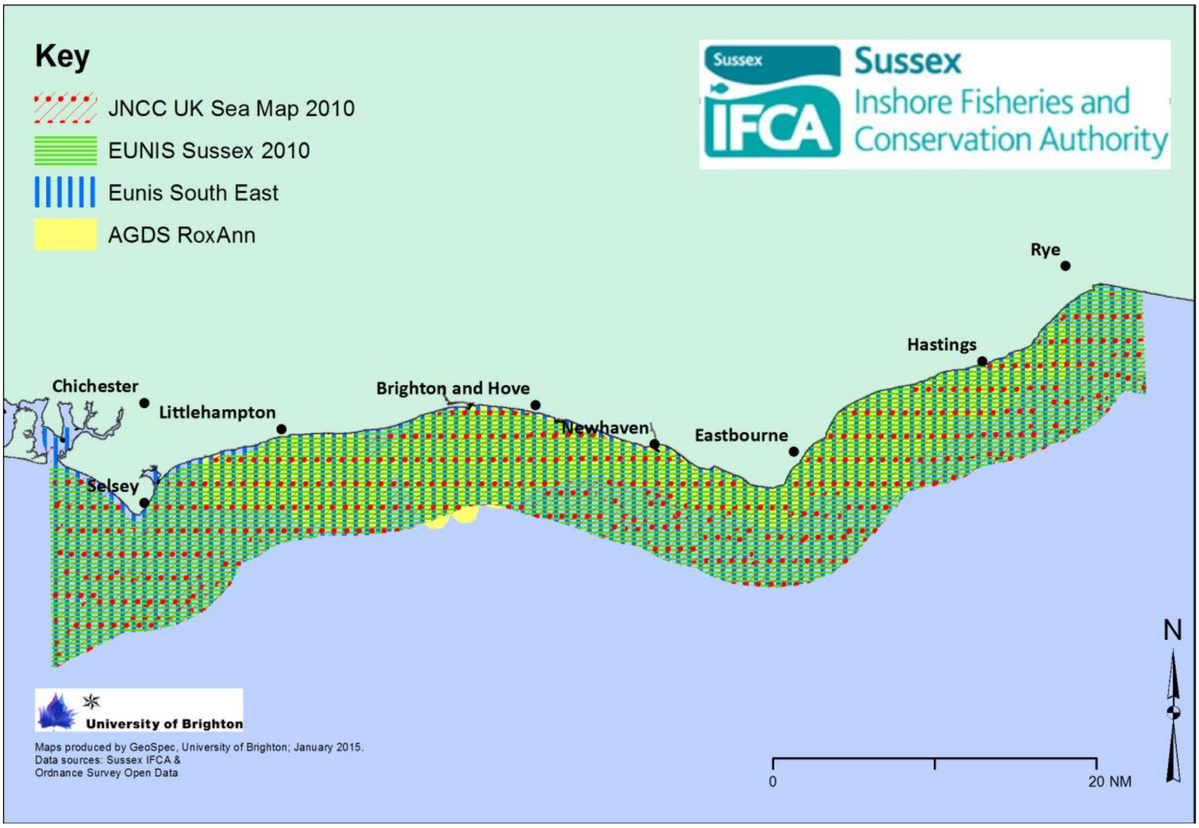

Figure 10 Summary of habitat polygon data extents clipped to the Sussex IFCA district

2.4.4 Conversion of non EUNIS data sets to EUNIS habitat classification

2.4.4.1 EUNIS Sussex 2010 Data set conversion to standard EUNIS classes

The following conversion has been made in order to make the EUNIS Sussex 2010 data associated with the James *et al.* (2011) report compatible with the other standard EUNIS classified data sets used in this study. As such, the EUNIS Sussex 2010 data set is the only data set directly affected by the following conversion process.

2.4.4.1.1 System used by EUNIS 2010 survey

All four habitat layers identified here use EUNIS coding to classify habitats. However, in the case of EUNIS 2010, a modified version of EUNIS is used. This adds additional classes to the standard EUNIS system, identified in Table 1 as the grey highlighted classes. The reasoning for this is clarified in the corresponding project report associated with this data set, by James *et al.* (2011), page 69. To summarise, James *et al*. (2011) suggest that the EUNIS coding system, while very useful, can be problematic, and does not allow for the identification of certain unique habitats. Instead, these are forced into other groupings which, James *et al*. (2011) argue, do not represent their proper characteristics. To this end, James *et al*. (2011) have added six additional classes to the EUNIS system at EUNIS level 3 which are relevant to this study.

2.4.4.1.2 Justifying the conversion to standard EUNIS classification

Although it is argued that this does indeed provide a better representation of the sea floor habitat distribution, this makes the data incompatible when attempting to draw comparisons with other data sets which utilise the standard EUNIS coding. Indeed, such comparisons will have differing results, simply because the classifications use different terminology.

If we were to compare the predicted habitats at a given point X, JNCC data may indicate A3.2, EUNIS 2010 may call this A3.9 (one of their additional classes) and EUNIS SE may identify it as A5.3. In this case, all three disagree. If predicted habitat confidence intervals are then represented as a fraction, each habitat has a 1/3 confidence score. If however, the EUNIS 2010 codes are converted into the same language as the other data sets, standard EUNIS, then the comparison is perhaps more valid and meaningful. For example if after conversion A3.9 is found to be most similar to and therefore reclassified as A3.2, then in the example above A3.2 gains a confidence score of 2/3, while A5.3 remains at 1/3. This is described in greater detail in Appendix 1.

2.4.5 Broad scale habitat map output

2.4.5.1 Data preparation

The four data sets (EUNIS Sussex 2010, JNCC UK Sea Map 2010, EUNIS South East, and RoxAnn) were converted into one master shape file containing the features and attributes of all four individual shape files. This has been carried out using the Intersect and Union tools in ArcMap, illustrated in Figure 11. The Intersect tool creates a geometrical intersection of the overlapping source features and attributes, producing a single output feature class (ESRI, 2013a). The Union tool creates a geometric merger of polygon features (ESRI, 2013b).

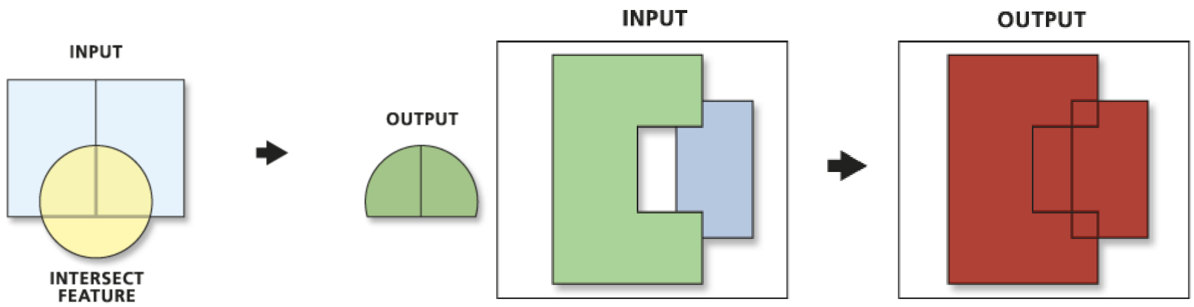

Figure 11 Illustration of the Intersect tool (left) and Union tool (right) in ArcMap. Taken from ESRI (2013a and 2013b)

The JNCC UK Sea Map 2010 and RoxAnn data have slightly different spatial extents, for example the JNCC UK Sea Map 2010 does not quite reach the shore line. The Union tool has been used to combine these data with the other two data so as not to lose the latter's slightly larger spatial extents.

The resulting combined attribute table has been exported to Excel for data processing, so that EUNIS data for each of the four original data sets can be displayed at EUNIS level 2 and 3. The intersection and unification of the data also allows for easier data comparison and cross validation, which is to be explained in latter sections of this chapter.

2.4.5.2 Presentation of habitat map outputs

The importance of effective presentation of the habitat output maps was of the utmost importance, to ensure that the maximum amount of detail could be represented in the habitat maps. The methods set out in the Habmap Irish sea marine mapping project (Robinson *et al.*, 2009a; Robinson *et al.*, 2009b; Robinson *et al*. 2011) were adapted to stylise the SCHIP 2 project output maps. The Habmap study uses individual maps for each biotope or habitat class. The advantage of this is that it emphasises each classification equally, regardless of the habitat extent and allows colour coding to be reserved for assigning spatial confidence, where appropriate.

2.5 Confidence mapping

2.5.1 Cross validation:

EUNIS habitat values from all four polygon data sets were compared using a four way comparison of column values, and returning the number of matching values. This was carried out to compare all four data sets, and subsequently the two data sets which had the highest agreement. Each data set was placed in an individual column, each row representing value for one polygon. An ID column was used to join, export, and import data from ArcMap, ensuring the rows remain in the correct order and therefore correlate with the same polygon.

Where data sets have common values or predict the same habitat type, this was treated as agreement between those data. The number of data sets in agreement was displayed as the agreement value for both EUNIS level 2 and 3. It is noted that the data do not have identical extents, most notably the RoxAnn data set. In areas where there is no overlap between the layers being compared, these are treated as areas of disagreement between the data.

2.5.2 MESH confidence assessment

The MESH confidence assessment tool was used as a means of assessing the quality of datasets used in the SCHIP 2 project. This tool has been used in a variety of previous studies including the UK Sea Map 2010 (McBreen *et al*., 2011), and the Habmap Irish sea habitat mapping project (Robinson *et al*., 2009b). The method has been devised as a standardised protocol for assessing the quality of remotely sensed spatial habitat data sets. The method evaluates various aspects of data collection, requiring detailed metadata concerning survey techniques. The data quality is split into three main aspects: Remote sensing, ground truthing, and interpretation. Within these categories, various qualities of the data set are evaluated and scored out of three: Three being good, one being poor. A weighting system is available in order to emphasise certain qualities over others. As with McBreen *et al*., (2011), the default weighting values have been used. The final confidence score ranges between 33 (lowest) and 100 (highest). The tool uses specific guidelines for each section, in order to make the process as standardised and none subjective as possible (MESH 2010).

The MESH Confidence Assessment tool was used to assess two EUNIS habitat datasets on the basis of their metadata and survey techniques.

2.6 Fine scale habitat maps

2.6.1 Fine scale data sources

The data sets used for fine scale habitat mapping were supplied as point data shape files. No 'pre' or 'post' processing was required beyond habitat classification, and no extrapolation over broad areas was undertaken with the original datasets. The raw fine scale data define the habitat at specific points within the SCHIP 2 study area.

The following surveys were extracted from a variety of data files provided by Sussex IFCA: Seasearch 1992-2005, ALSF 2007, and Seafish 2008. The data points were identified and organised according to their associated survey. It is noted that Seasearch 1992-2005 is a compilation of all Seasearch surveys from 1992 to 2005. For the purposes of this study, these are treated as one overall survey. A summary of the data sources is provided in Table 3.

Table 3 Fine scale habitat data sources

Data	Source	Habitat Classification system
Seasearch 1992-2005	Seasearch surveys	Converted from UK Biomar classification to EUNIS
ALSF 2007	Sussex IFCA	EUNIS
Seafish 2008	Sussex IFCA	EUNIS

2.6.1.1 Seasearch 1992-2005

Seasearch was originally implemented by the JNCC in the 1990's, after it was acknowledged that a growing number of none professional divers offered a great deal of knowledge and enthusiasm relevant to the collection of sea floor habitat data (Seasearch, no date a). Specific training courses were developed and specific survey forms were used to record a variety of geographical, physical, and biological aspects at a given location. These data were then later used to classify each point according to the BioMar marine classification scheme. Davies *et al*. (2004) explained that the marine section of the EUNIS habitat classification system was derived from the BioMar system, and therefore the BioMar codes can be converted directly to EUNIS via the conversion table available from the JNCC website (JNCC, 2014b). This was undertaken so that the Seasearch 1992-2005 data were compatible with the SCHIP 2 project. These data provide the most detailed EUNIS codes, classified to EUNIS level 6 in some cases.

2.6.1.2 ALSF 2007

The data referred to here as ALSF 2007 were collected as ground truth data as part of a larger acoustic surveying project. The Aggregate Levy Sustainability Fund (ALSF) were jointly involved in a project with Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and the Sussex Sea Fisheries District Committee, now known as Sussex IFCA. The ALSF 2007 data are described in the report by Clark *et al.* (no date b). At each point, a video sledge was used to visually record the seafloor, over a six week period during August and September 2007. Video interpretation was carried out by an expert marine biologist in order to classify each location.

2.6.1.3 Seafish 2008

Localised trial survey carried out off of Eastbourne and Bexhill.

2.6.1.4 Distribution of points

Figure 12 shows the distribution of survey points throughout the SCHIP 2 study area. More detailed investigation into the distribution of points and predicted habitat models shall be explored in detail in latter sections of this report.

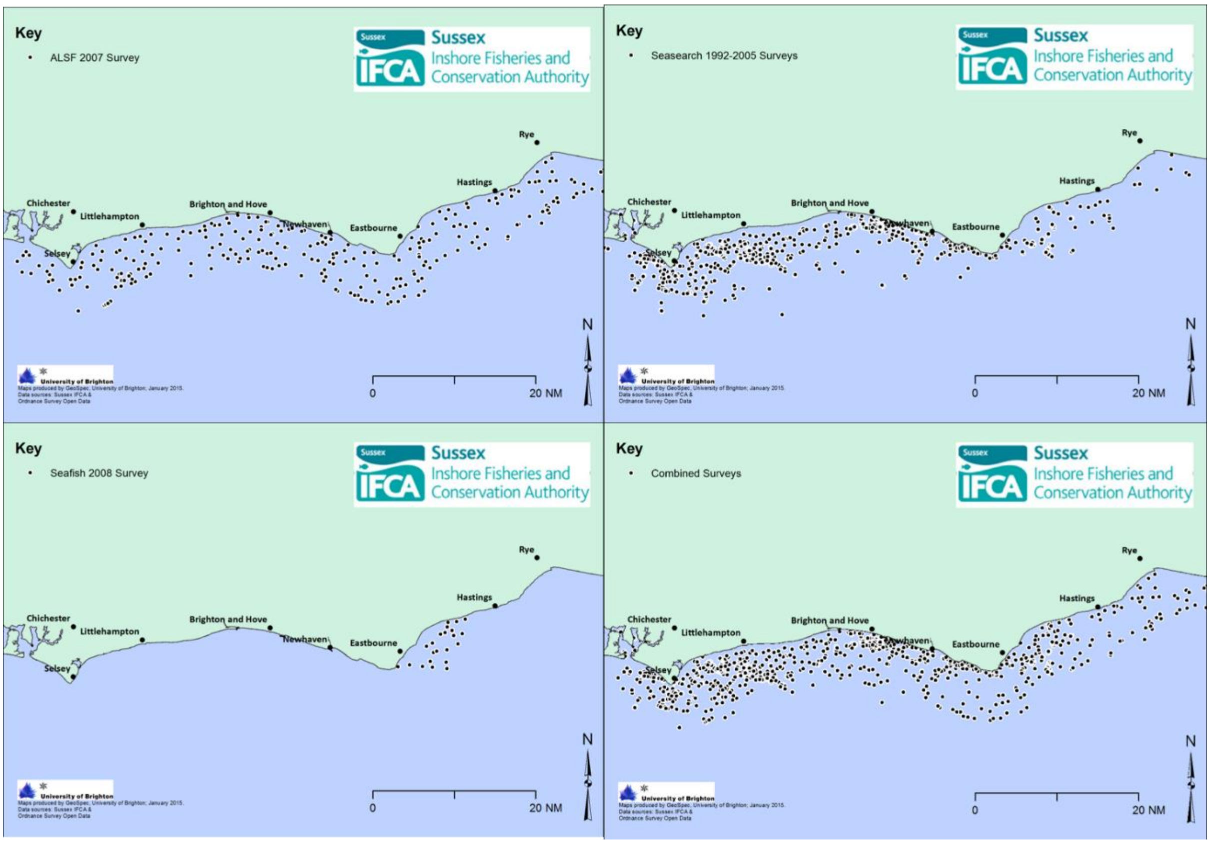

Figure 12 Seasearch 1992-2005, ALSF 2007 and Seafish 2008 surveys individual distributions and all three combined

2.6.2 Displaying points

The three fine scale point data sets (Seasearch 1992-2005, ALSF 2007, and Seafish 2008) were intersected using the intersect tool in ArcMap, in order to produce a single homogeneous data set, allowing the feature attributes to be exported to spread sheet software for data processing. The combined point layer has been classified to EUNIS level 2, and colour coded according to Table 1. For better visual interpretation, a method for converting the point data to representative polygons has been developed. This classifies areas according to the nearest known point. The methodology for this is described later in this section. It should be noted that because habitat classification is categorical by nature, providing discontinuous data, it is not suitable for interpolation methods such as Inverse Distance Weighting or Kriging, as these require continuous data fields such as temperature or elevation.

2.6.3 Comparison

There were no coinciding points between the three fine scale data sets, so comparative methods such as those used in the broad scale were not used with the fine scale data. However, it was been possible to intersect the point data with the broad scale habitat data for means of validation, using ArcMap's intersect tool.

2.6.4 Voronoi polygons

In order to create a continuous EUNIS habitat layer a Voronoi polygon method was developed and used. Voronoi polygons were created to convert point data into a polygon coverage and to divide up the seabed into EUNIS habitat codes. Each location within a polygon is closer to the sample point in that polygon than any other sample point (ESRI, 2007), and was used to determine possible EUNIS habitat type for broader areas.

Due to the categorical nature of EUNIS codes it was not valid to use the mean, minimum or maximum methods for coincidental points. Therefore, coinciding points were removed prior to the generation of the Voronoi polygon layer. In addition, the data were found contain NULL habitat values, where no EUNIS data were available at any level for that data point. These were also removed.

Following the calculation of the voronoi polygon layer, the EUNIS habitat data were joined to create one polygon layer containing all EUNIS attributes from the combined point surveys (Seasearch 1992-2005, ALSF 2007, and Seafish 2008 and clipped to the SCHIP 2 study area. The resulting polygon layer can be seen in Figure 13 Combined surveys voronoi polygon output.

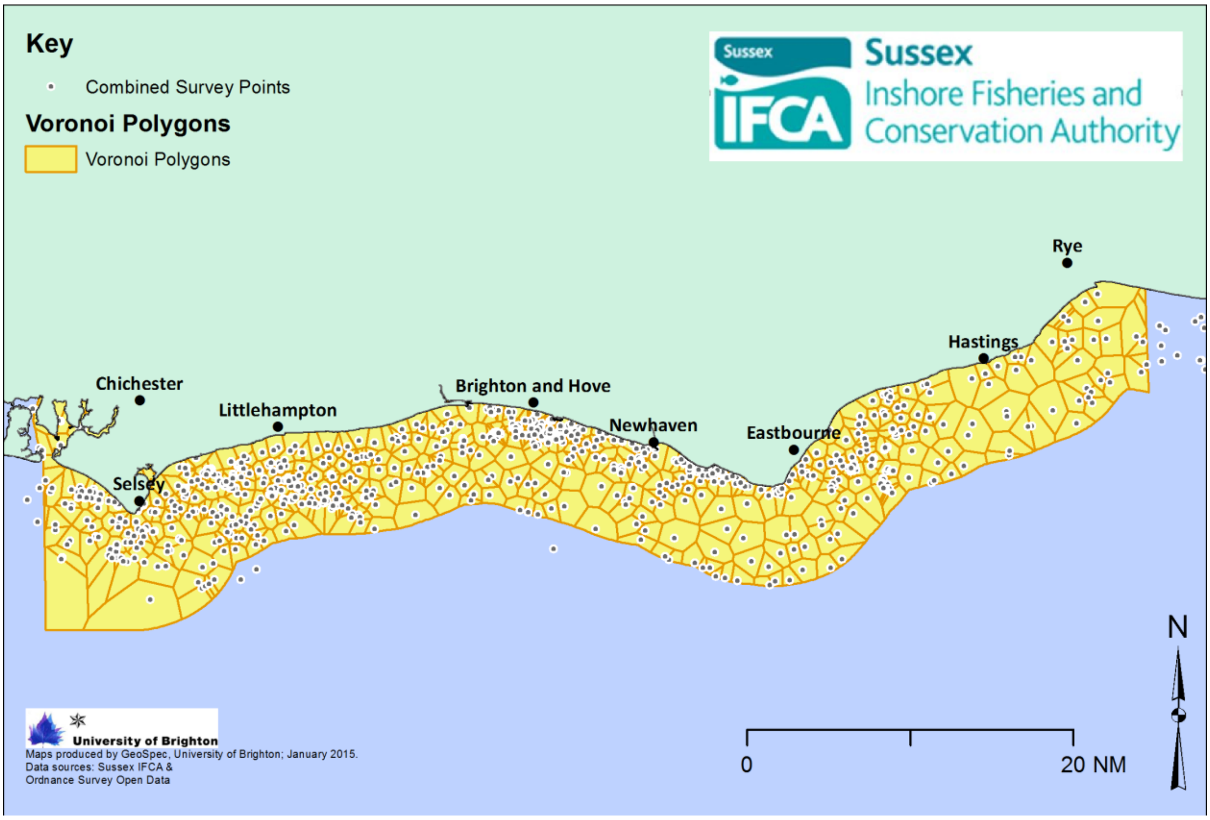

Figure 13 Combined surveys voronoi polygon output (Seasearch 1992-2005, ALSF 2007, and Seafish 2008)

2.6.5 Confidence surface derivation

2.6.5.1 Kernel Density Estimation

Point Kernel Density Estimation (KDE) mapping was used to assess the spatial distribution of the data points used in the fine scale mapping. KDE mapping enables the mapping and assessment of sampling density where multiple points share the same geographical location.

KDE treats each individual point as a discrete object, and generates a continuous surface based on the number of data points within a given search radius for each individual point (Longley *et. al.*, 2007). The resulting output can be thought of conceptually as a continuous surface laid over the point data. The surface is highest at the location of a given individual point, and reaches zero, or is lowest, when the search radius distance from the point is reached. This known as the kernel surface. Where multiple points exist within close proximity to one another, these kernel surfaces overlap. Thus, the output raster cells are calculated by summing the values of all kernel surfaces where they overlay the centre of the raster cell (Longley *et al.,* 2007; ESRI, 2014). For the purposes of this study a KDE search distance of 1475.5m was used, the selection and application of this method is described in full in Appendix 2.

2.6.5.2 Optimised Hot Spot Analysis

Optimised Hotspot Analysis (OHA) was also used on the point data to offer an additional perspective on the data. OHA can be used on categorical data, as it does not use attribute data. Rather, it creates a map of statistically significant hot spots and cold spots, based on the Getis-Ord Gi* statistic (ESRI, 2014). The Getis-Ord Gi* statistic identifies areas of clustering which are greater than what would be expected through random chance, these are referred to as hot spots (ESRI Developer Network, No Date). It also identifies areas where points are less densely clustered than would be expected through random chance, these are known as cold spots. This method has been used to generate an additional confidence surface. Areas identified as hot and cold spots with 90% confidence or greater have been generalised and exported to create new layers containing data hot spots and cold spots respectively.

2.6.5.3 Voronoi Polygon Area

Areas where data points are more densely clustered in the original point layer produce smaller voronoi polygons, which can be considered to have a higher spatial resolution. These areas are therefore likely to be a spatially more accurate representation of the underlying data. This can be seen as a proxy for Kernel Density, indeed it could be inferred that the level of confidence is inversely proportional to the size of the polygon.

2.7 Bathymetric mapping

2.7.1 Broad scale data

The broad scale bathymetric data used in the preparation of this work contains approximately 200,000 data points. These data were collected by Sussex IFCA's vessel *Watchful* using acoustic techniques. Bathymetric data is a form of continuous elevation data, and so interpolation models were used to estimate continuous surfaces from known points. Interpolation facilitated the estimation of depth at a given location by using the values of nearby known points (Longley *et al.,* 2007).

2.7.1.1 Interpolation techniques

Generally speaking, there are two main approaches to spatial data interpolation: Inverse Distance Weighting (IDW) and Kriging. Kriging was used in this project. Kriging uses a statistical model to predict the value of unknown locations by developing a statistical model of the relationship between known point values. A surface model is generated based the value of known points and the distances between measured values. The model can be developed further to include the spatial arrangement of the known values (ESRI, 2011a). Conceptually it is similar to fitting a line of best fit to model trends on a graph. A more detailed explanation of the two approaches and techniques used is provided in Appendix 3.

2.7.2 Fine scale bathymetric models

Third party bathymetric data sets were sourced to produce high resolution bathymetric maps for the SCHIP 2 study area where data are available.

Bathymetry data were sourced from the Bathymetry Geodesy and Imagery Centre at United Kingdom Hydrographic Office (UKHO) and also from the Centre for Environment, Fisheries & Aquaculture Science (CEFAS). The data was sourced under Open Government Licence (OGL; https://www.nationalarchives.gov.uk/doc/open-government-licence/version/2/) and the data contains public sector information, licensed under the Open Government Licence v2.0, from the Maritime and Coastguard Agency.

High resolution data have resolution values between 1 and 2 metres (Table 4). All bathymetry data are provided as georeferenced image file (GeoTiffs) and are projected in British National Grid.

Table 4 Fine scale bathymetric model metadata, resolution, licence and survey dates are shown. All data are licensed under the Open Government Licence v2.0, from the Maritime and Coastguard Agency. (National Archives, no date) or CEFAS.

	HI1279Eastern Approaches to the Nab Channel	**HI1437 Selsey Bill to Lee-on-Solent**	**HI1312 Newhaven to Dungeness Blk 1-3**	**HI4961 Beachy Head East**
Survey start date	10/05/2008	15/05/2013	20/06/2013	2012
Survey Standard	IHO S44 Edition 4	IHO S44 Edition 5	IHO S44 Edition 5	IHO S44 Edition Unknown
Resolution	2m	1m	2m	1m
Sensor type	Echosounder – multibeam	Echosounder – multibeam	Echosounder – multibeam	Echosounder – multibeam
Datum	WGS84	WGS84	WGS84	WGS84
IPR Holder	Maritime and Coastguard Agency	New Forest District Council	New Forest District Council	CEFAS
Licence	Open Government Licence	Open Government Licence	Open Government Licence	Open Government Licence
Point of contact	Bathy.dac@ukho.gov.uk	Bathy.dac@ukho.gov.uk	Bathy.dac@ukho.gov.uk	helpline@defra.gsi.gov.uk

3 Results

3.1 Introduction

The EUNIS habitat classification system was used to describe marine habitats within the SCHIP 2 study area. The four principal data layers included: EUNIS Sussex 2010, EUNIS South East, and JNCC UK Sea Map and RoxAnn. The three former layers all covered the entirety of the study area, while RoxAnn was a more restricted survey and covered a smaller inshore central region. Fine scale data are presented as both point and polygon maps. Fine scale data are mapped to EUNIS level 6. Bathymetry data are presented, both as broad scale for the entire Sussex IFCA District, and for localised areas where fine scale data are available.

3.2 Broad scale habitat models

3.2.1 EUNIS Sussex 2010

The EUNIS Sussex 2010 data, taken from the MALSF 2010 Synthesis study by James *et al*. (2011) is given in Figure 14 and Figure 15. These show variation across the Sussex IFCA District. A3 (Infralittoral rock and other hard substrata) and A5 (Sublittoral sediment) habitat types are predicted to be dominant throughout the district. A4 (Circalittoral rock and other hard substrata) is present offshore from Eastbourne and Beachy Head, and offshore from Selsey. Inspection of the EUNIS level 3 codes shows that among the A3 habitats, a thin strip of A3.3 hugs the coastline inshore, while A3.2 is dominant offshore. Among the A5 predicted habitat zones, A5.1 is dominant in the eastern end of the Sussex IFCA district, while A5.4 becomes more dominant in the west. A4.2 is the dominant A4 predicted habitat, found offshore from Beachy Head.

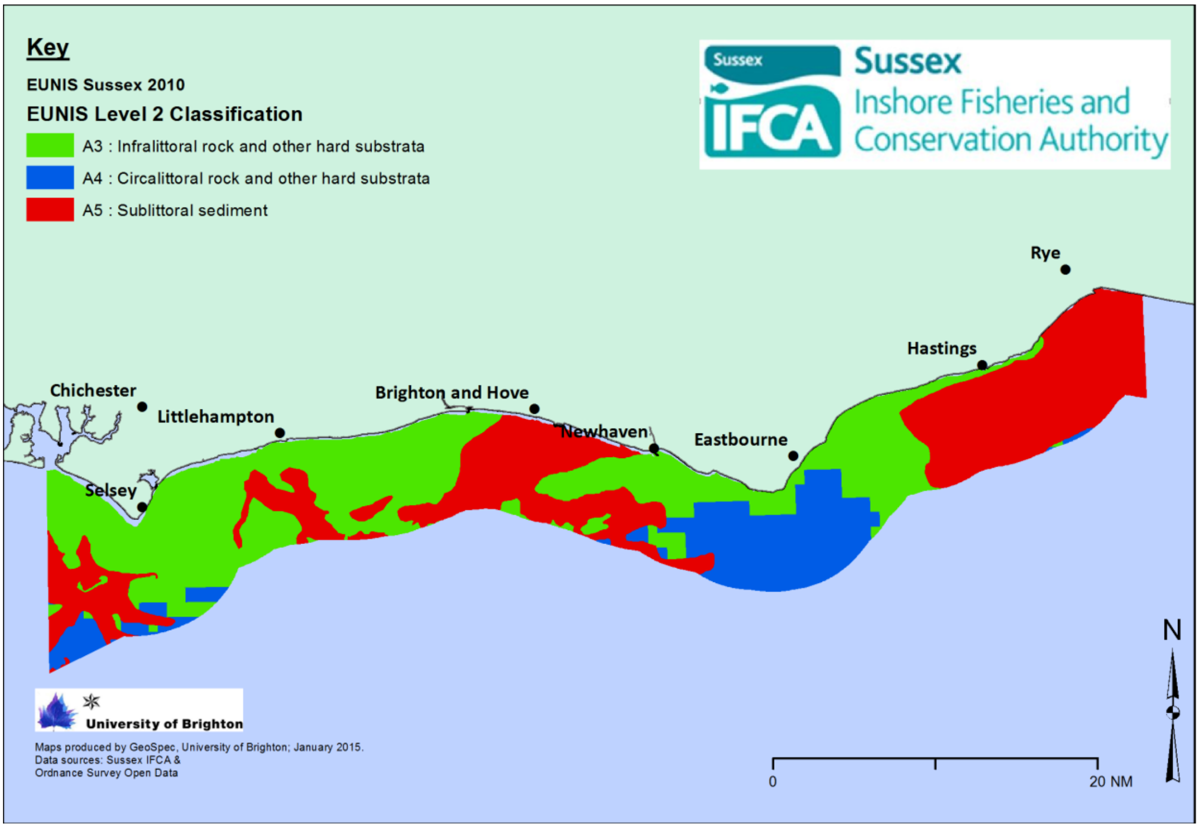

Figure 14 EUNIS level 2 Habitat prediction by James et al. *(2011) 2010 Synthesis study for the Sussex IFCA district*

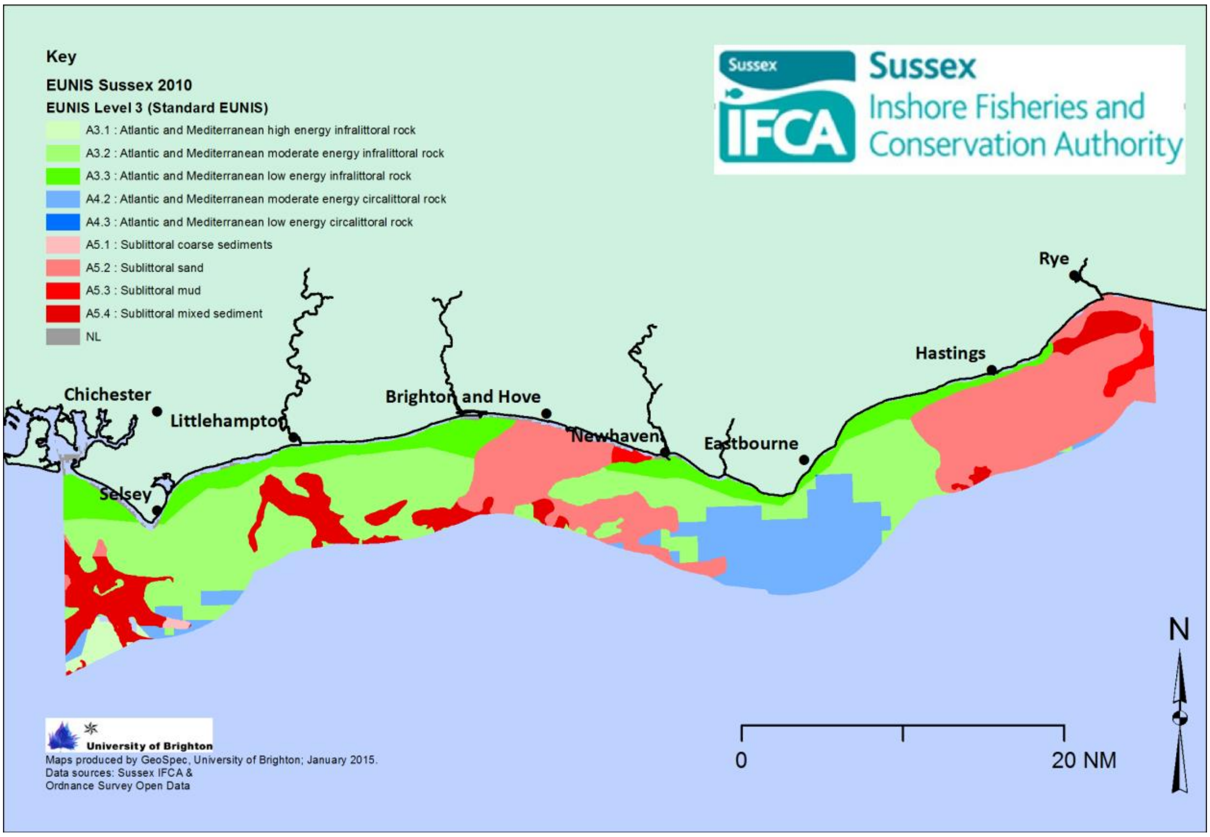

Figure 15 EUNIS level 3 Habitat prediction by James et al. (2011) 2010 Synthesis study for the Sussex IFCA district.

3.2.2 JNCC UK Sea Map 2010

The JNCC UK Sea Map 2010 data can be seen in Figure 16 and Figure 17. The JNCC UK Sea Map 2010 predicts a similar habitat distribution to the EUNIS Sussex 2010 data. A3 and A5 are the dominant habitat types. A5 is predicted in smaller extents than in the EUNIS Sussex 2010 model, most notably the large A5 area off of Rye and Hastings is suggested to be broken by A3 and A4 habitat types. A4 is once again predicted offshore from Beachy Head and Selsey Bill.

At EUNIS level 3, A3.1 is by far the most broadly predicted habitat type, suggested to occur broadly throughout the district. A5.2 is the most common among the A5 habitat areas, and A4 areas are predominantly A4.2, especially offshore from Beachy Head.

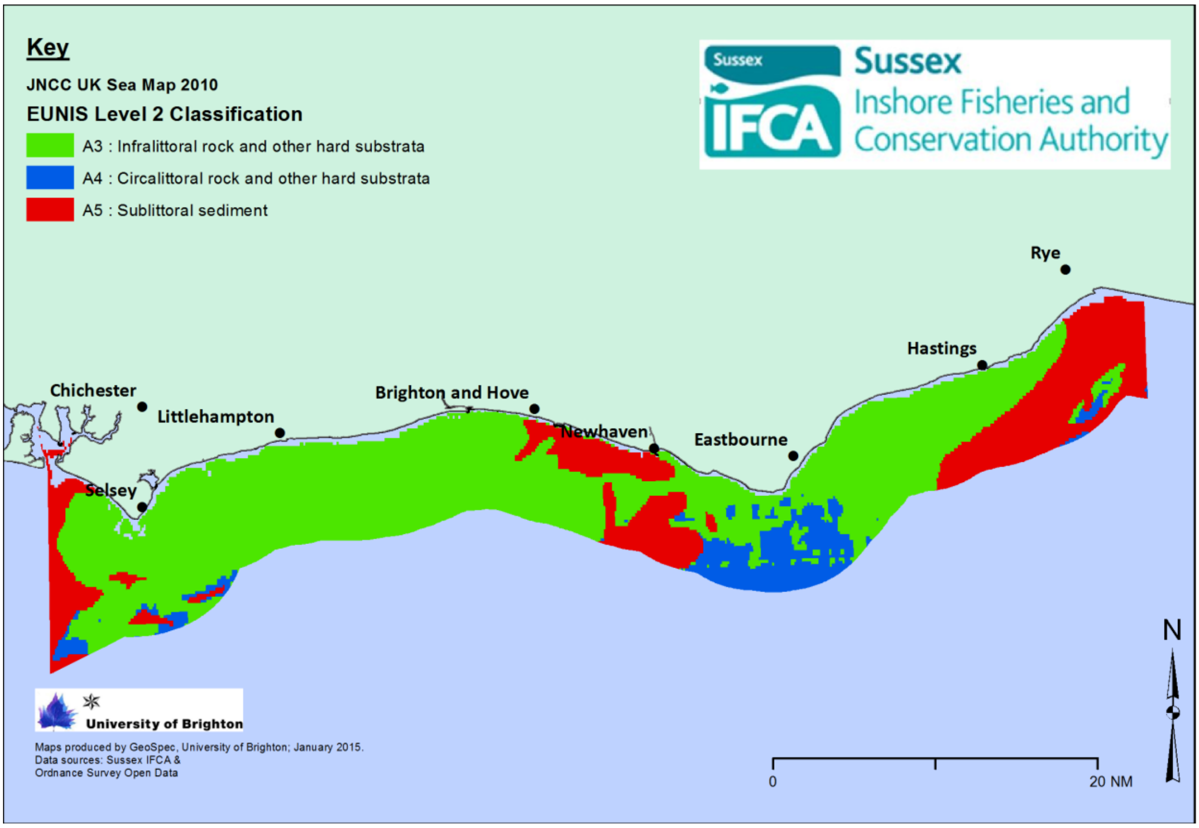

Figure 16 UK Sea Map 2010 from the JNCC, predicted EUNIS level 2 habitat distribution for the Sussex IFCA District

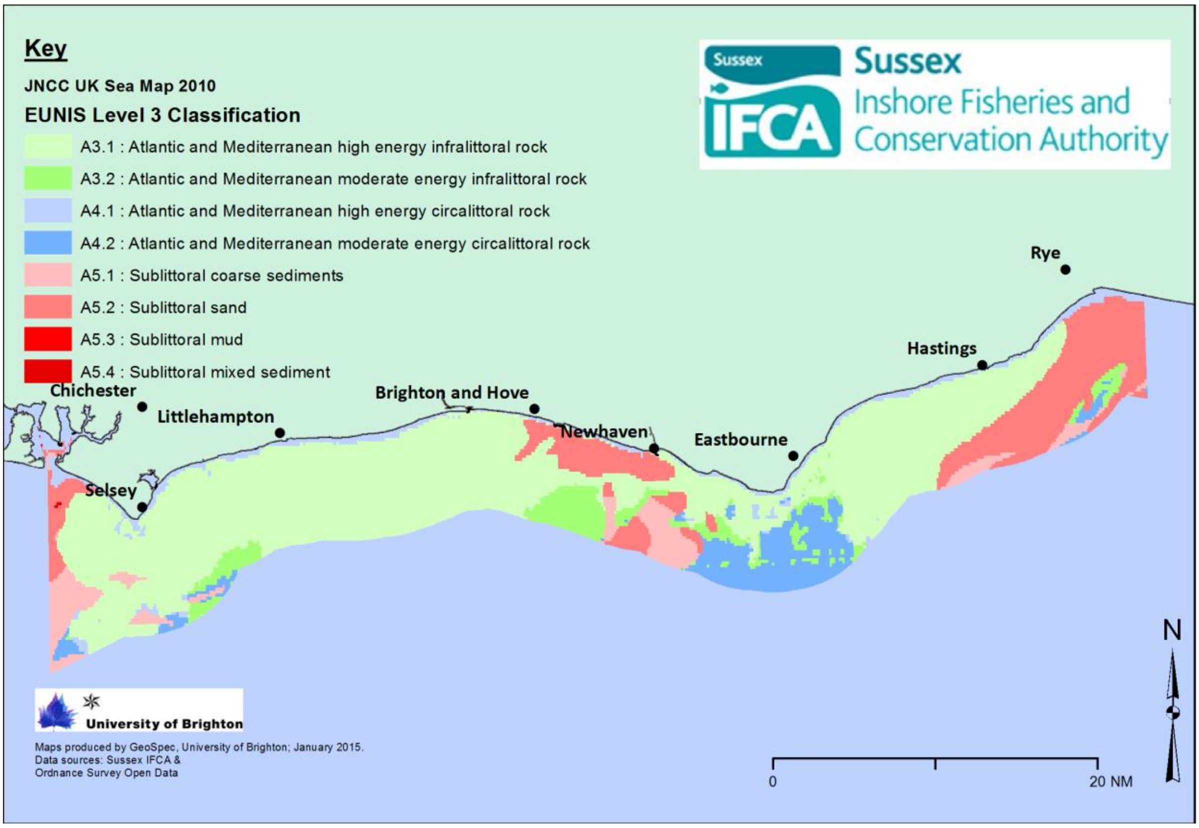

Figure 17 UK Sea Map 2010 from the JNCC, predicted EUNIS level 3 habitat distribution for the Sussex IFCA District

3.2.3 EUNIS South East

The EUNIS South East habitat model in Figure 18 and Figure 19 suggests a broadly different habitat distribution to the EUNIS Sussex 2010 and the JNCC UK Sea Map 2010 maps. It is notably characterised by the dominance of EUNIS A5 habitat classes. A3 and A4 habitats are predicted, but in very small comparatively remote locations. Initial expert analysis of these A4 and A3 areas suggests that they coincide with notably rocky areas such as the Owers rocks at Selsey and the Royal Sovereign Shoals to the south east of Eastbourne. Within the A5 habitat area, A5.1 is suggested to be dominant, especially offshore. However, large areas of A5.2 are predicted in large inshore areas, especially between Littlehampton and Newhaven, as well as off of Hastings and Rye.

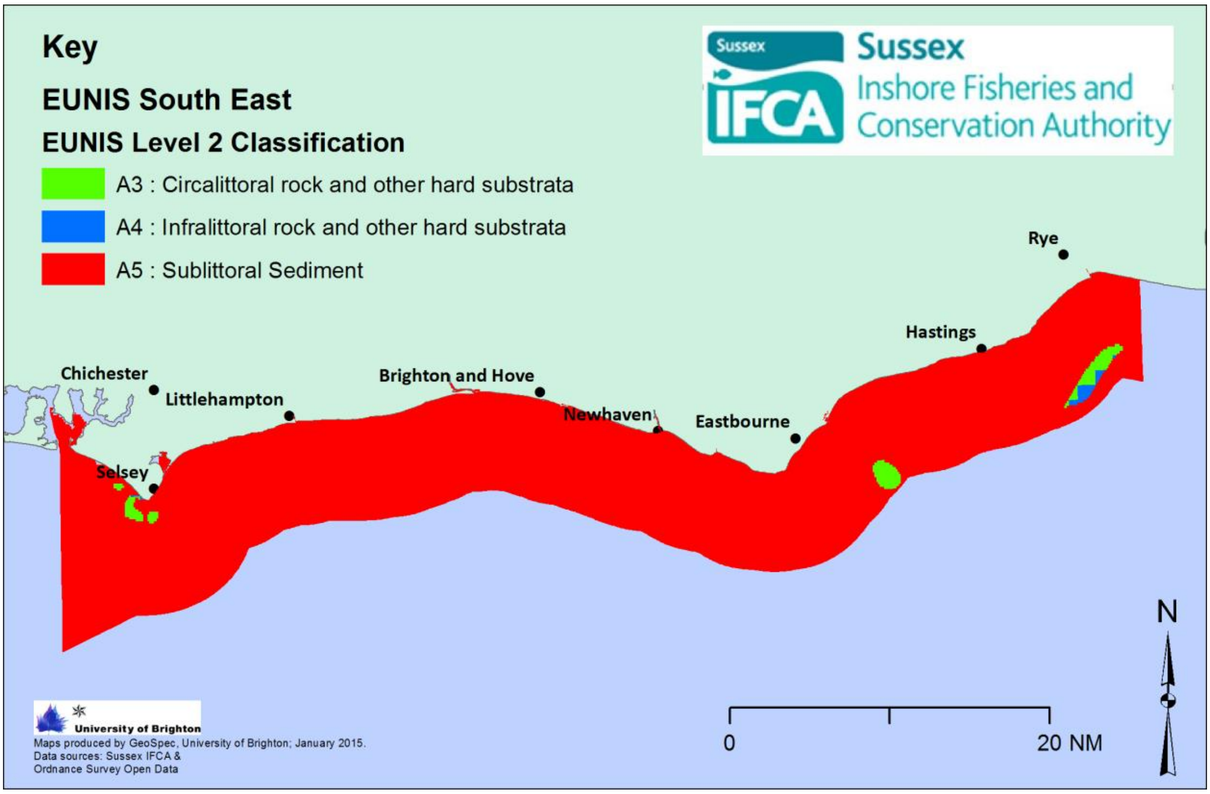

Figure 18 EUNIS South East EUNIS level 2 predicted habitat distribution for the Sussex IFCA District

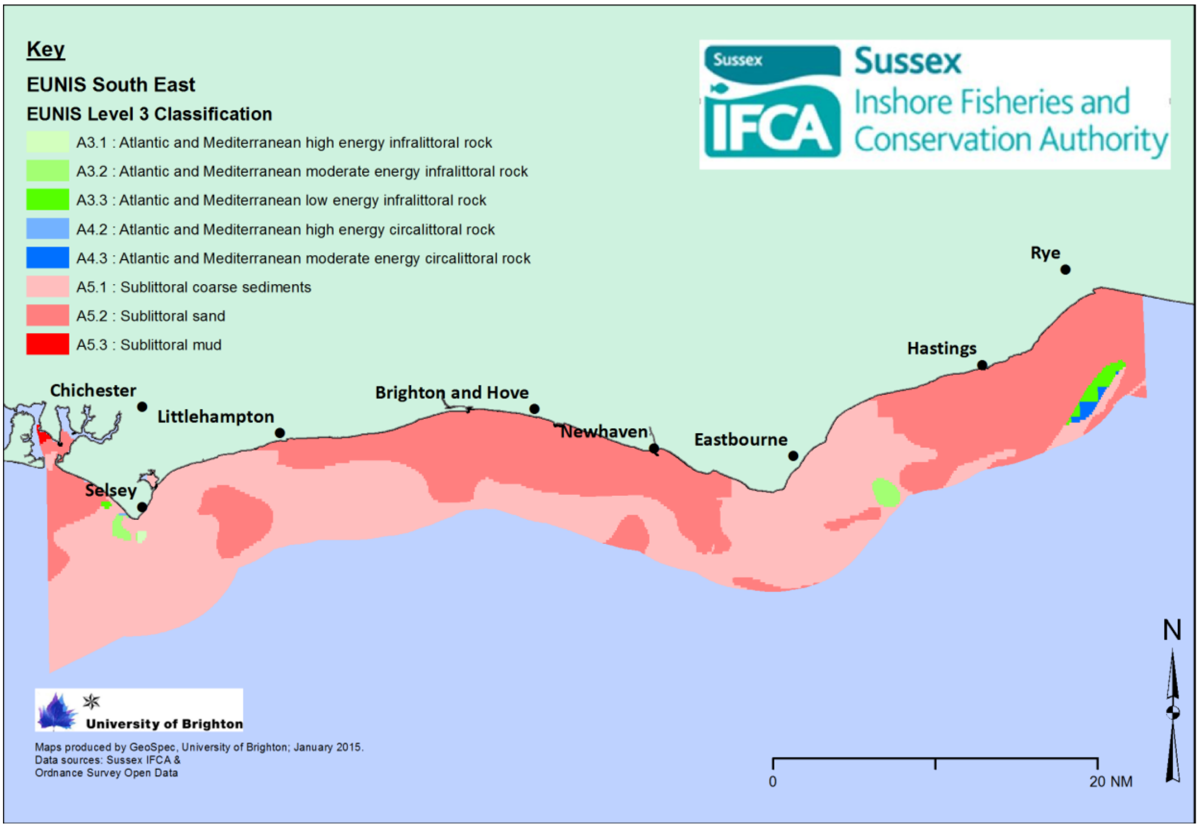

Figure 19 EUNIS South East EUNIS level 3 predicted habitat distribution for the Sussex IFCA District

3.2.4 RoxAnn

The RoxAnn AGDS data shown in Figure 20 and Figure 21 show a similar distribution of habitat to the EUNIS South East data, in that it is predominantly predicting A5 habitat. However, smaller areas of A3 and A4 are also predicted. A3 habitat is generally distributed nearer the coast, although areas offshore from Eastbourne and Hastings have more offshore areas of A3 habitat. A4 habitat is predicted to the southeast of Eastbourne, and around Beachy Head inshore. Smaller areas of A4 habitat are indicated offshore from Littlehampton and Brighton. Figure 21 suggests that A5.1 and A5.2 are the most common EUNIS level 3 habitats.

3.2.4.1 EUNIS Level 2

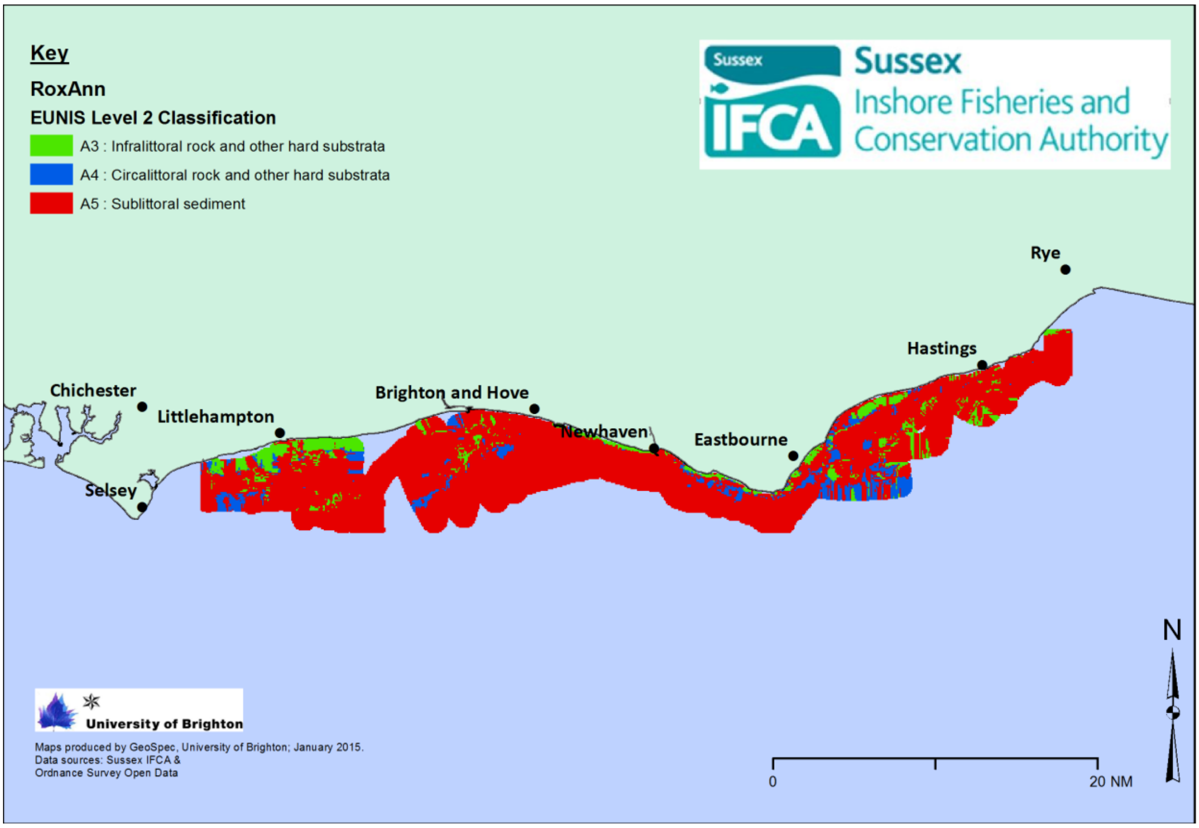

Figure 20 RoxAnn AGDS survey classified to EUNIS level 2

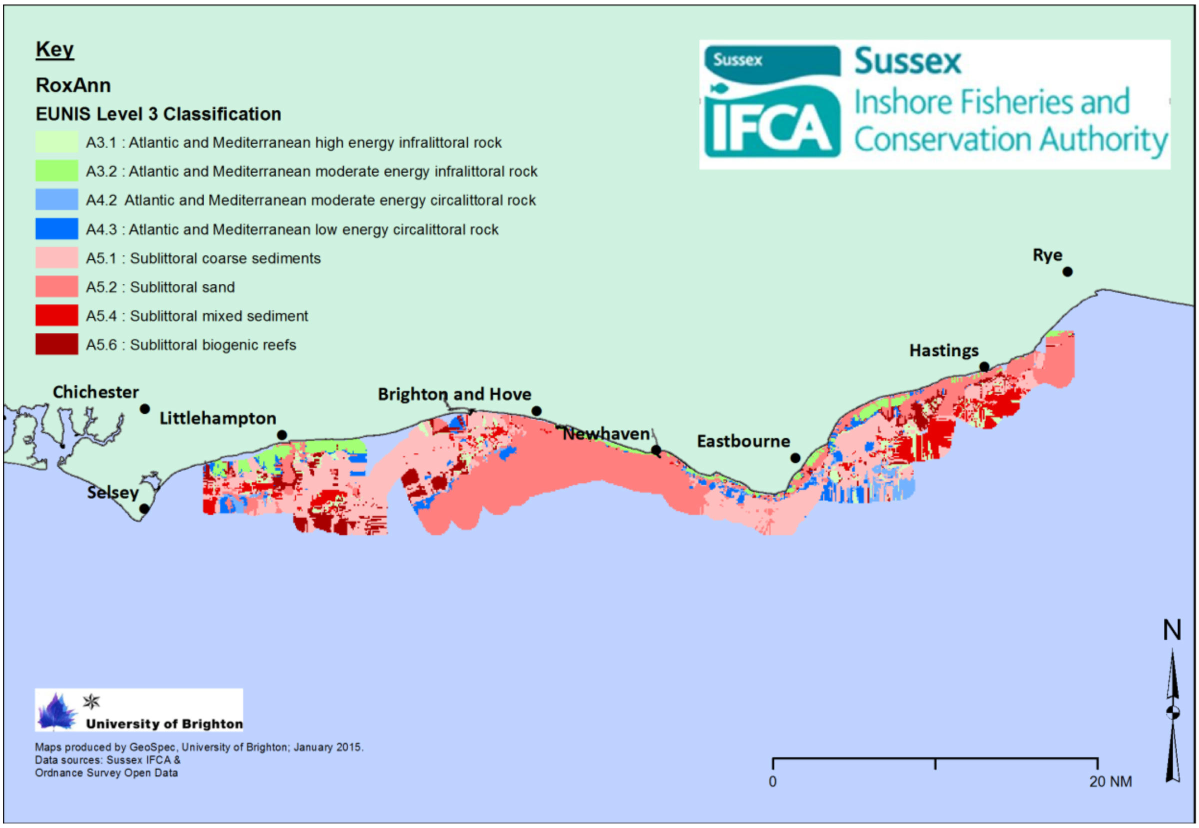

Figure 21 RoxAnn AGDS survey classified to EUNIS level 3

3.2.5 Summary of predicted habitat coverage by area

3.2.5.1 EUNIS data summary

Table 5 EUNIS level 2 habitat distribution by area for each broad scale data set

Habitat	Area	JNCC	Sussex 2010	South East	RoxAnn
A3	Km^2	1156.7	768.9	24.0	66.2
	%	67.0	44.5	1.4	3.8
A4	Km^2	139.7	248.3	4.9	55.7
	%	8.1	14.4	0.3	3.2
A5	Km^2	389.0	699.5	1687.8	635.1
	%	22.5	40.5	97.7	36.8
No Data	Km^2	41.4	10.2	10.2	969.9
	%	2.4	0.6	0.6	56.2
Total	Km^2	1726.8	1726.8	1726.8	1726.8
	%	100	100	100	100

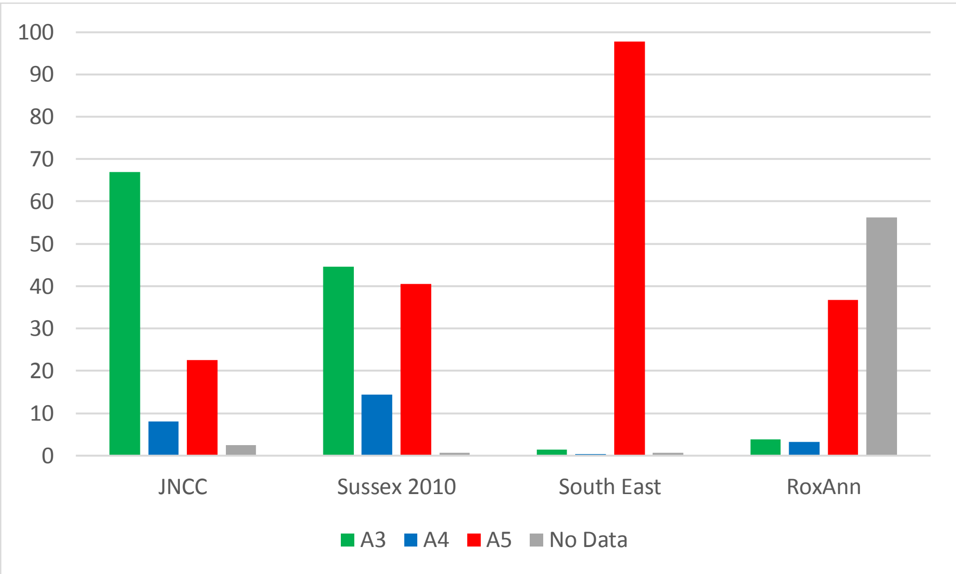

Figure 22 EUNIS level 2 habitat distribution by area for each broad scale data set as a percentage of the total Sussex IFCA District

Table 5 and Figure 22 show the proportional differences between the extents of each EUNIS level 2 habitats as described by each broad scale model. The RoxAnn and EUNIS South East data sets predict A5 as the foremost habitat class, whilst the JNCC UK Sea Map 2010 and EUNIS Sussex 2010 show a more even habitat distribution. These latter two surveys show larger proportions of A3 habitat predicted throughout the district. These similarities and differences are discussed further in the next chapter.

3.2.6 Broad scale confidence mapping

The habitat maps given in Figure 14 to Figure 21 have undergone cross validation and pairwise comparison to determine where there is agreement and disagreement between surveys. The four surveys were intersected and compared on a polygon by polygon basis. For each polygon, the number of the above data sets in agreement on the predicted EUNIS classification are used as an agreement proxy. Polygons have then been grouped to display individual predicted EUNIS classes as per the Habmap approach outlined in the previous chapter with confidence values attached.

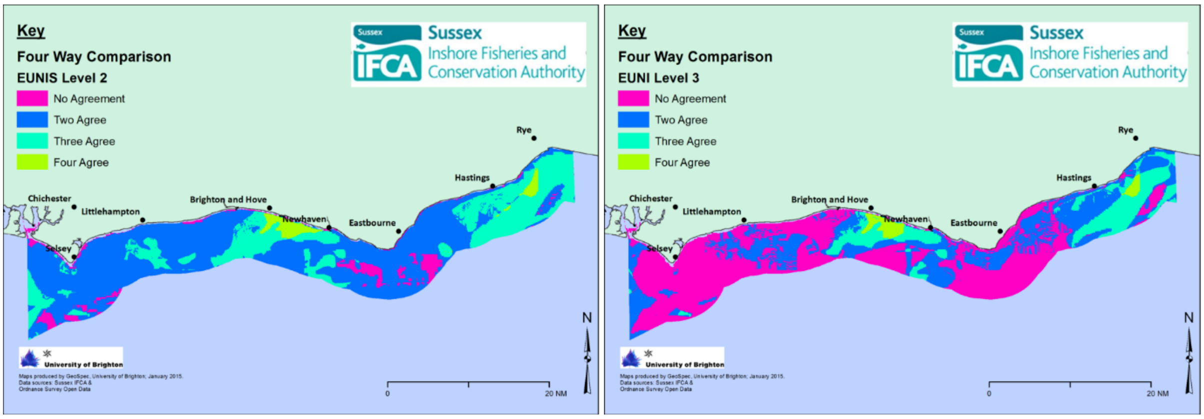

Figure 23 Comparison of the predicted habitat distribution at EUNIS level 2 (left) and level 3 (right) by the EUNIS Sussex 2010, JNCC UK Sea Map 2010, EUNIS South East, and RoxAnn data sets within the Sussex IFCA district

The predicted habitat comparison maps in Figure 23 show the extent of agreement between the broad scale habitat models at EUNIS level 2 and then EUNIS level 3. In both cases, there are similar overall patterns in the areas of higher and lower agreement. In this context, areas where separate habitat data sets predict the same EUNIS value are termed areas of agreement. The areas covered by each agreement level are summarised in Table 6.

At EUNIS level 2, throughout 62% of the district, two habitat models can be found to agree on the predicted EUNIS classification. Large areas where three data sets agree can be found off of Rye and Hastings, as well as off of Brighton and Newhaven. Other small, isolated areas where three broad scale models agree can be found throughout the district. Combined, these make up 29% of the district by area. Two small areas where all four data sets agree can be seen to the southeast of Hastings, and between Brighton and Newhaven, making up nearly 3% of the total district area.

At EUNIS level 3, there is far less agreement between the broad scale habitat models. 42% of the district is made up of areas where no data sets agree on the EUNIS classification. Where two habitat models agree, this covers 41% of the district by area, and are distributed spatially throughout the area, becoming perhaps more numerous in the east. Where three habitat data sets agree, this covers 14% of the total area. These areas are mostly found between Brighton and Newhaven, and between Hastings and Rye. Within these, limited areas where all four data sets agree are identified. These make up 2% of the total district area.

Table 6 Summary of the predicted EUNIS habitat distribution by the EUNIS Sussex 2010, JNCC UK Sea Map 2010, EUNIS South East, and RoxAnn data sets within the Sussex IFCA district

Area	None Agree	Two Agree	Three Agree	Four Agree
EUNIS Level 3 km^2	728.50	711.79	246.66	39.89
EUNIS Level 3 Percentage	42.19	41.22	14.28	2.31
EUNIS Level 2 km^2	101.92	1078.30	498.03	48.58
EUNIS Level 2 Percentage	5.90	62.44	28.84	2.81

3.2.7 Broad scale EUNIS coded confidence maps

The confidence mapping approach used above has been adapted to incorporate methods outlined by Robinson *et al*. (2009a; 2009b) in their Habmap study, to produce confidence maps for each predicted EUNIS class individually, using the number of habitat models predicting it in any given location as a proxy for categorical confidence levels. These are given firstly as EUNIS level 2 classes, and then as EUNIS level 3.

3.2.7.1 *EUNIS level 2 predicted habitat distribution*

The prediction of the distribution of EUNIS level 2 habitat Figure 24 indicates that A5 habitat is likely to be the most dominant across the district, with evidence to suggest sedimentary environments predicted at almost all locations with varying degrees of confidence. Visual analysis would suggest that this habitat type is predicted with the most confidence, especially in specific locations. A3 habitat is also widely predicted, with large areas of high confidence, especially in the eastern part of the district. A4 is the least predicted habitat type, although a large area is predicted with medium confidence south of Beachy Head, near Eastbourne.

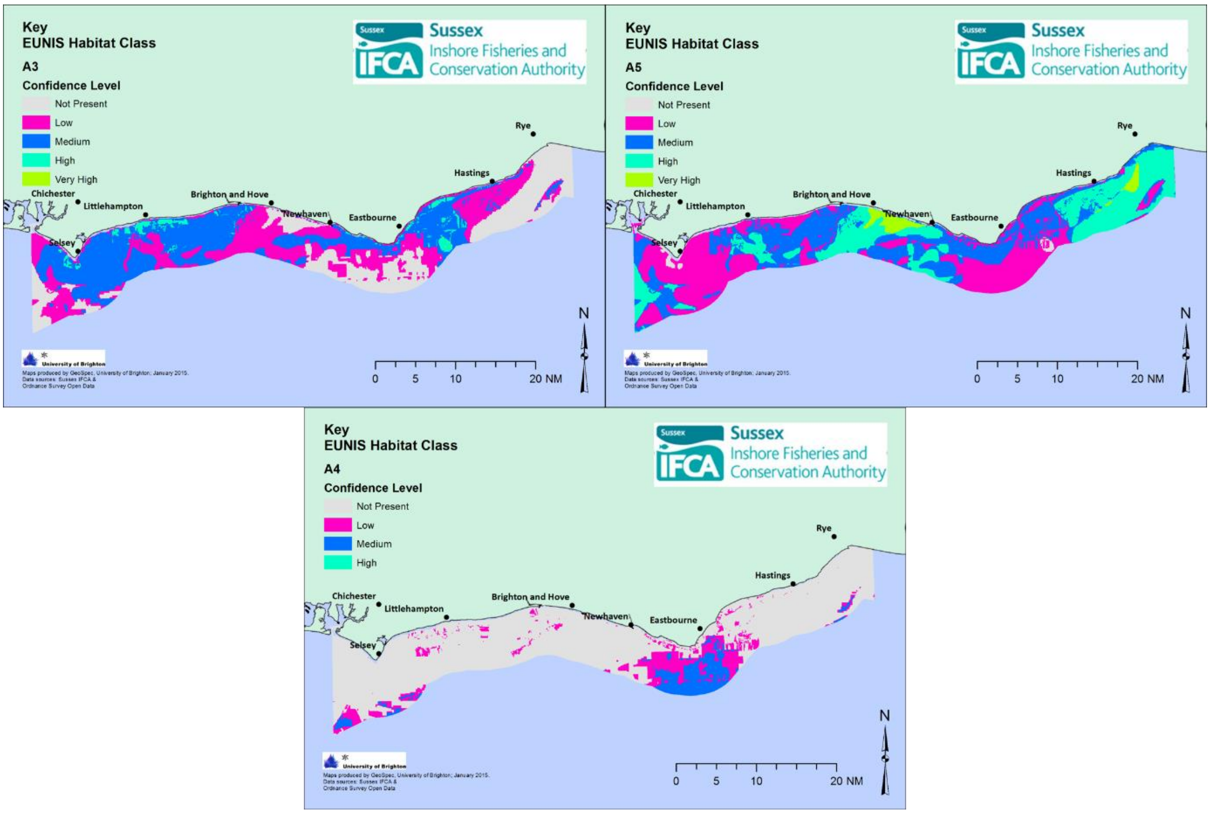

Figure 24 Predicted distribution of A5 (Sublittoral sediment), A4 (Circalittoral rock and other hard substrata), and A3 (Infralittoral rock and other hard substrata) within the Sussex IFCA district. Confidence levels are derived from the number of habitat models predicting this habitat type at a given location.

3.2.7.2 *EUNIS level 3 predicted habitat distribution*

Figure 25 shows EUNIS level 3 predicted habitat distributions, based on predictions made by all four available broad scale habitat models. It is observed that as with the EUNIS level 2 classifications, A5 habitats give the highest confidence, specifically A5.2 and to a lesser extent A5.1. Elsewhere, A3.1 and A3.2 are predicted with low to medium confidence, and are the next most numerous predicted habitat type. A large area of A4.2 is predicted with medium confidence offshore from Eastbourne and Beachy Head, and in some small isolated locations such as off of Selsey. All other habitat types are predicted with medium to low confidence, often in small areas.

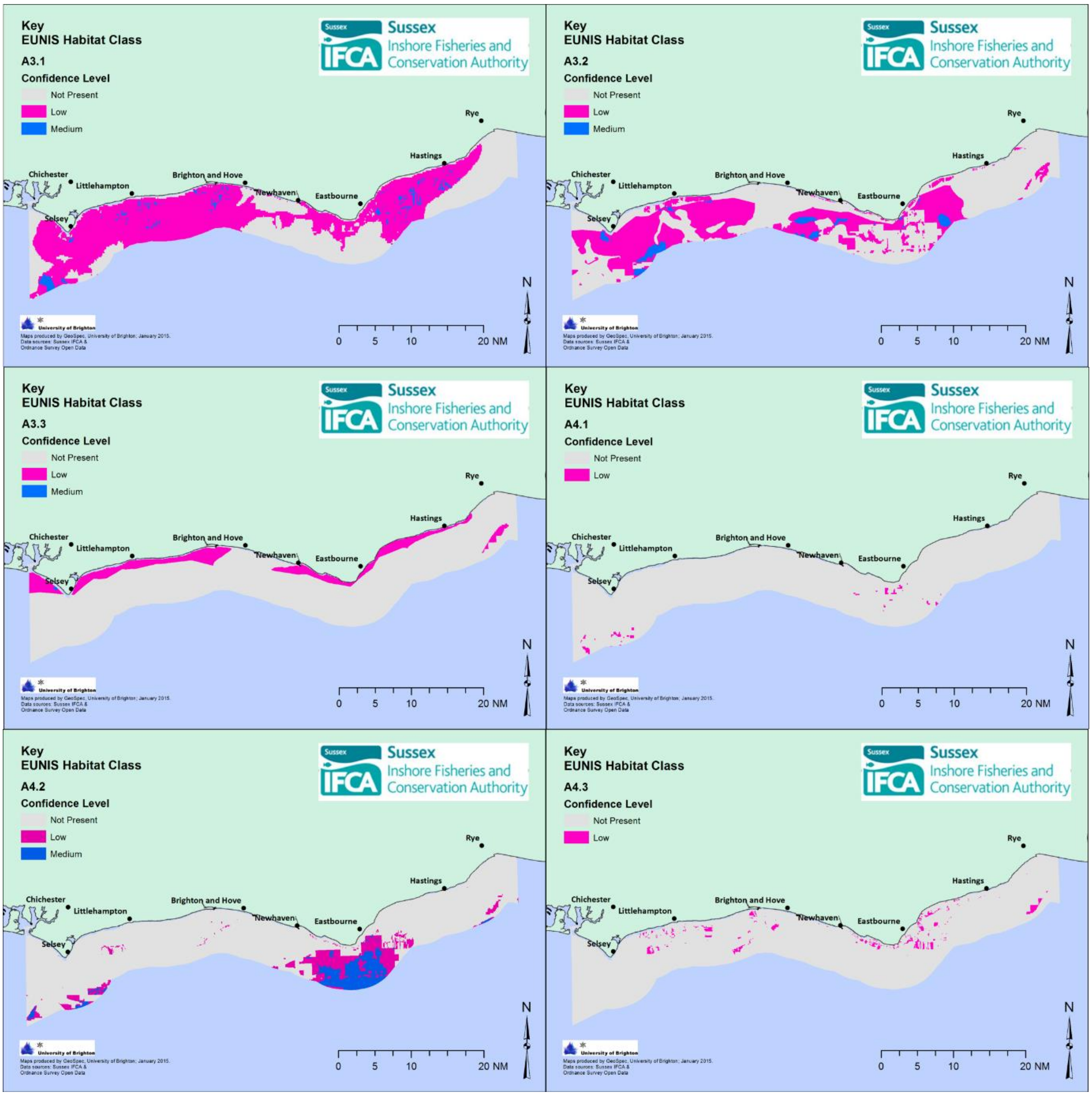

Figure 25 Predicted distribution of: A3.1 (Atlantic and Mediterranean high energy infralittoral rock); A3.2 (Atlantic and Mediterranean moderate energy infralittoral rock); A3.3 (Atlantic and Mediterranean low energy infralittoral rock); A4.1 (Atlantic and Mediterranean high energy circalittoral rock); A4.2 (Atlantic and Mediterranean moderate energy circalittoral rock); A4.3 (Atlantic and Mediterranean low energy circalittoral rock), within the Sussex IFCA district. Confidence levels are derived from the number of habitat models predicting this habitat type at a given location.

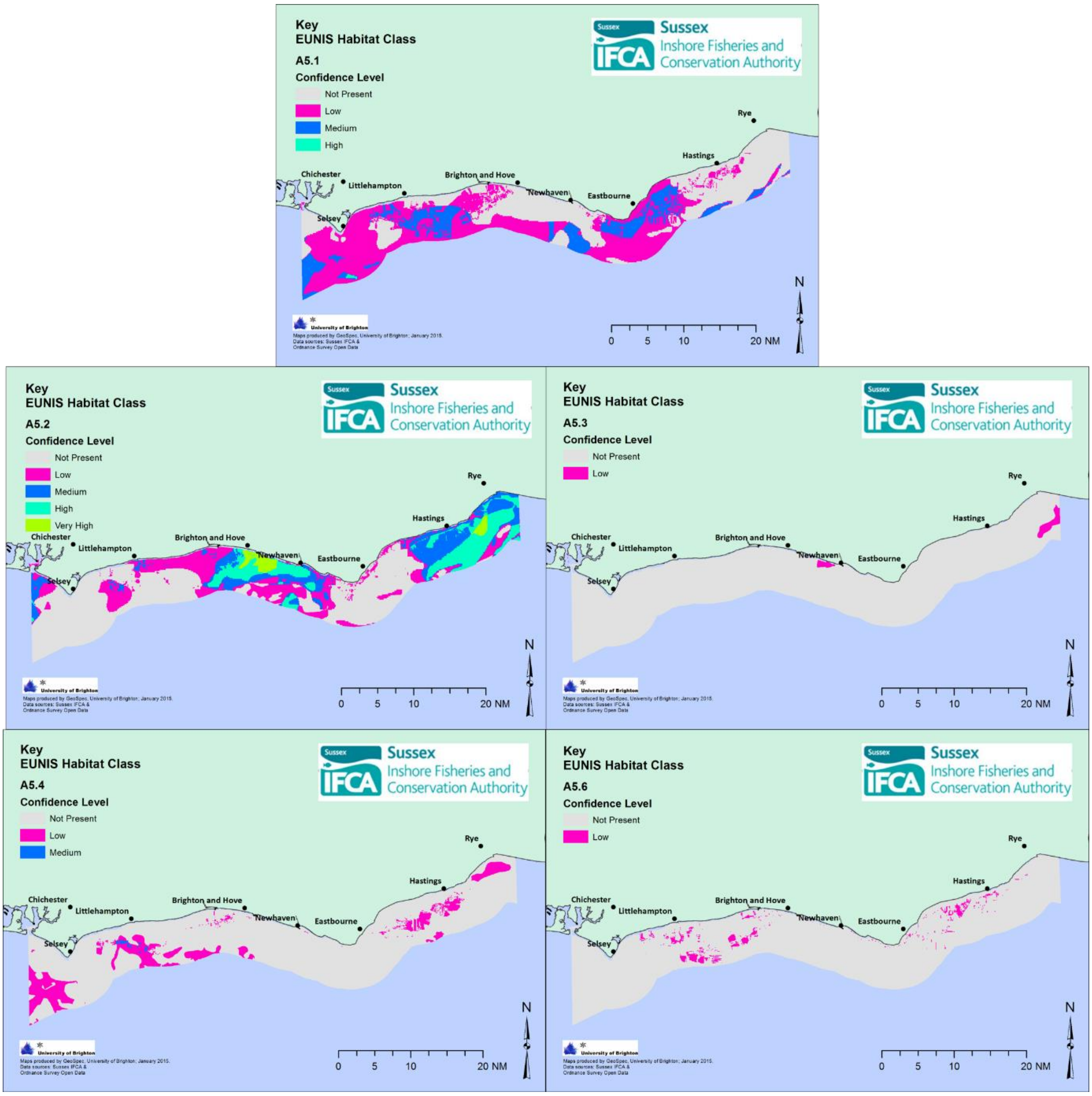

Figure 26 Predicted distribution of A5.1 (Sublittoral coarse sediment); A5.2 (Sublittoral sand); A5.3 (Sublittoral mud); A5.4 (Sublittoral mixed sediments; A5.6 (Sublittoral biogenic reefs), within the Sussex IFCA district. Confidence levels are derive from the number of habitat models predicting this habitat type at a given location.

3.2.8 MESH confidence scores

Data quality is an important consideration in the development of predictive maps (Burnside & Waite, 2011). The MESH confidence assessment was used as a method to assess data quality for individual data sets. However, while investigating and undertaking this process, it was found that this could not be undertaken for the JNCC UK Sea Map 2010 and the EUNIS South East data sets, as these are composite data sets made up of many surveys. The MESH Confidence Assessment is principally designed to work with individual surveys. As a result, only the EUNIS Sussex 2010 data using the report by James *et al.* (2010), and the RoxAnn data using the report by Clark *et al*. (no date a) were assessed using the MESH methodology.

After careful analysis of the associated reports the RoxAnn data set was scored at 53, and the EUNIS Sussex 2010 data scored 81. The assessment scale ranges from 33 (poor) to 100 (excellent) (see Table 7).

Although the EUNIS South East data and the JNCC UK Sea Map 2010 data could not be scored, careful inspection of the relevant project reports and data sources indicated that the JNCC UK Sea Map 2010 would appear to be more robust. The JNCC UK Sea Map 2010 is based on various bespoke surveys, which were individually assessed using the MESH Confidence Assessment, and those with the best score were carried forward into the final model (McBreen *et al*., 2011).

EUNIS South East appears to be less reliable when examined at a fine scale. This is because it is based on the integration of existing habitat data sets, which in some areas of have been extrapolated based on correlations with British Geological Survey sediment maps (Coggan and Diesing, 2011). It is not explicitly clear that ground truthing has been undertaken in these extrapolated areas, and therefore the dataset may not be robust at fine scales.

Table 7 MESH Confidence Assessment for the RoxAnn AGDS data (top) and EUNIS Sussex 2010 data (bottom)

Assessment	Feature	Included?	Quality (1,2,3)	Weighting	Ind. Score	Group Score	Rating
How good is remote sensing?	Remote Techniques	Y	2	50	13	60/100	
	Remote Coverage	Y	1	50	7		
	Remote Positioning	Y	2	50	13	50	
	Remote Standards	Y	3	50	20		
	Remote Vintage	Y	1	50	7		
How good is the Ground-Truthing (GT)?	Biological GT Technique	Y	1	100	10	43/100	
	Physical GT Technique	Y	1	34	3		
	Position	Y	2	50	10	50	**53**
	Sample Density	Y	1	50	5		
	Standards Applied	Y	2	50	10		
	Vintage	Y	1	50	5		
How good is the interpretation? Overall map?	GT interpretation	Y	1	50	8	58/100	
	Remote interpretation	Y	3	50	25		
	Detail level	Y	2	50	17	50	
	Map accuracy	Y	1	50	8		
How good is remote sensing?	Remote Techniques	Y	3	50	20	66/100	
	Remote Coverage	Y	1	50	7		
	Remote Positioning	Y	2	50	13	50	
	Remote Standards	Y	2	50	13		
	Remote Vintage	Y	2	50	13		
How good is the Ground-Truthing (GT)?	Biological GT Technique	Y	3	100	30	85/100	
	Physical GT Technique	Y	3	34	10	50	
	Position	Y	2	50	10		**81**
	Sample Density	Y	3	50	15		
	Standards Applied	Y	2	50	10		
	Vintage	Y	2	50	10		
How good is the interpretation? Overall map?	GT interpretation	Y	3	50	25	92/100	
	Remote interpretation	Y	3	50	25		
	Detail level	Y	2	50	17	50	
	Map accuracy	Y	3	50	25		

3.2.9 Predicted habitat distribution based on the JNCC UK Sea Map 2010 and EUNIS Sussex 2010 data

The results of the combined broad scale habitat assessment suggest that the more robust data are the EUNIS Sussex 2010 data and the JNCC UK Sea Map 2010. The analysis on the datasets using four way comparisons and a modified MESH assessment suggests that the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 data sets have more similarity between layers and are of a higher quality than both RoxAnn and EUNIS South East. These assertions are based on the MESH confidence assessment and metadata which documents the data collection methods. Figure 27 represents the resultant EUNIS level 2 and 3 predictive habitat maps. These suggest A3 to be the dominant EUNIS habitat, especially in the western end of the district. Towards the east, A4 and A5 become more common. At EUNIS level 3, Figure 27 interestingly shows that there is little agreement within areas of classified as A3 whereas A4 and A5 habitats still show similar, comparatively large areas of agreement.

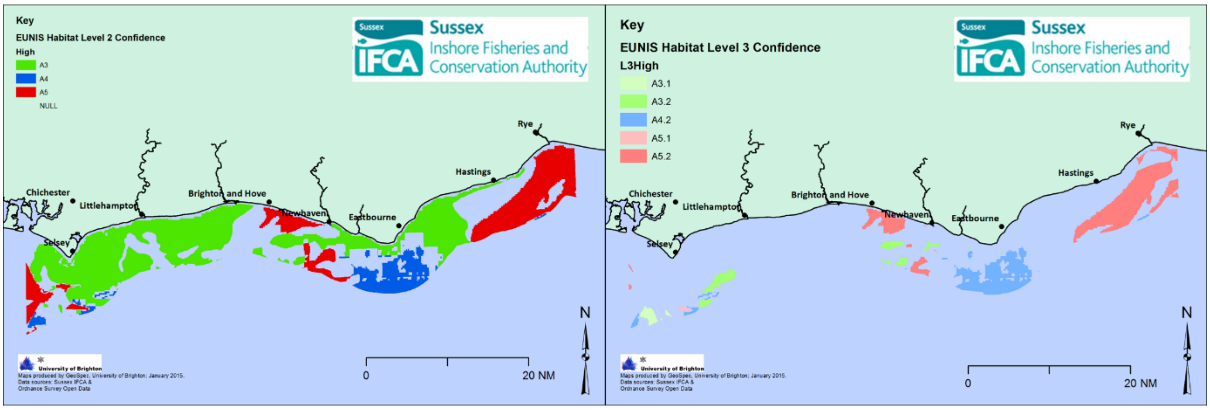

Figure 27 EUNIS level 2 (left) and level 3 (right) predicted habitat map based on areas where both the EUNIS Sussex 2010 data and JNCC UK Sea Map 2010 data predict the same classification

3.3 Fine scale habitat models

3.3.1 Raw point data

In an attempt to provide habitat classification to a higher EUNIS level (levels 4, 5 and 6) survey point data were utilised. The three individual fine scale habitat models (Seasearch 1992-2005, ALSF 2007, and Seafish 2008) were mapped as raw points at EUNIS level 2. Figure 28 suggests that EUNIS class A5 is found throughout the Sussex IFCA district, interwoven with occasional A4 and to a lesser extent A3 habitat. The A3 habitat is predicted mostly along the coastline from Selsey to Brighton. The bottom left map in Figure 28 shows a very localise survey covering an area off of Eastbourne, which is predicted to contain a mixture of A5 and A4 habitat, and very little A3. All three of the individual surveys have been combined to produce a single output map, shown in the bottom right of Figure 28.

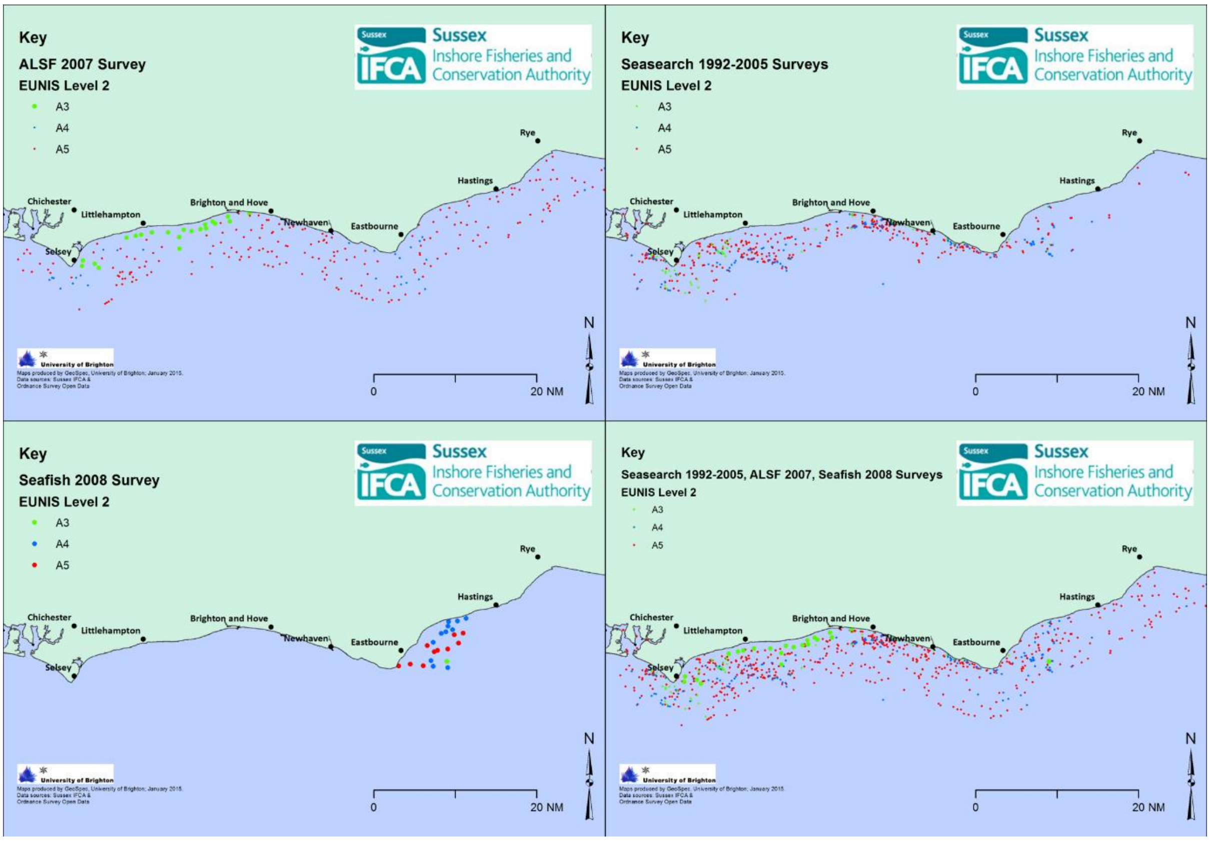

Figure 28 Predicted EUNIS level 2 habitat distribution according to the Seasearch 1992-2005, ALSF 2007, and Seafish 2008 surveys

3.3.2 Creation of voronoi polygons from the raw point data

As described in the methods section, the project has sought to develop a robust method that will facilitate the creation of a continuous surface model of EUNIS habitat types across the entire IFCA region. Following the creation of a combined point layer containing all surveys (Seasearch 1992-2005, ALSF 2007, and Seafish 2008), a voronoi polygon output layer was calculated to give a better visual representation of the fine scale point data.

The Voronoi polygon output has been clipped to the study area, and can be seen in Figure 29. Where point density is higher, smaller and more accurate polygons are constructed. Areas where voronoi polygons are smaller are likely to represent seabed habitats more closely due to higher survey/point density. This increased confidence can be seen when comparing Figure 29 with Figure 30. Figure 30 is an Optimised Hot Spot Analysis, a spatial clustering statistical test within ArcMap based on the Getis-Ord-Gi statistic. This looks at the overall spread of the data points, and finds areas where points are more densely or less densely spread than the expected distribution. A visual inspection shows that areas represented by larger voronoi polygons in Figure 29 correlate with cold spots in Figure 30, and *vice versa*.

Poor point coverage can be found offshore from Selsey, where large voronoi polygons represent very few data points/survey effort. Spatial confidence is discussed further in subsequent sections of this chapter.

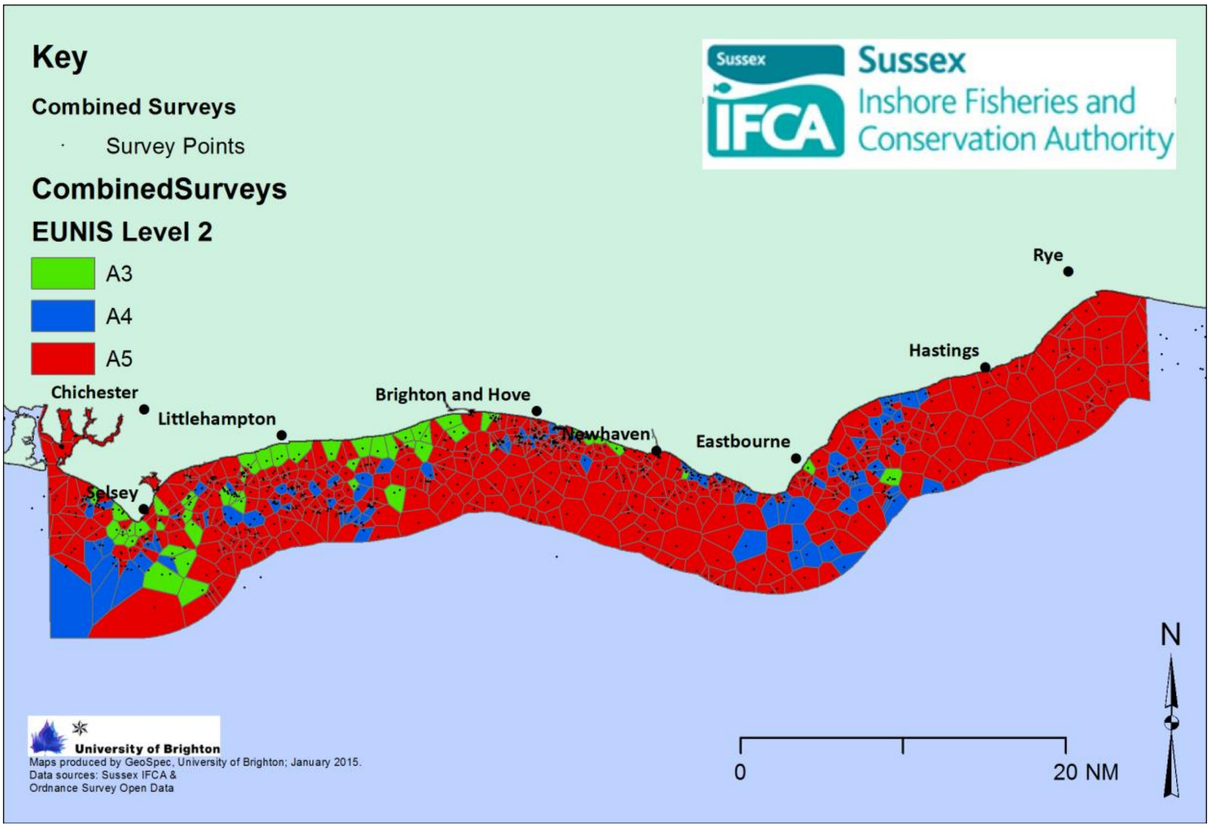

Figure 29 Combined survey point layer, containing Seasearch 1992-2005, ALSF 2007, and Seafish 2008 points data; overlaying voronoi polygons calculated for the combined point data. Data have been classified to EUNIS Level 2.

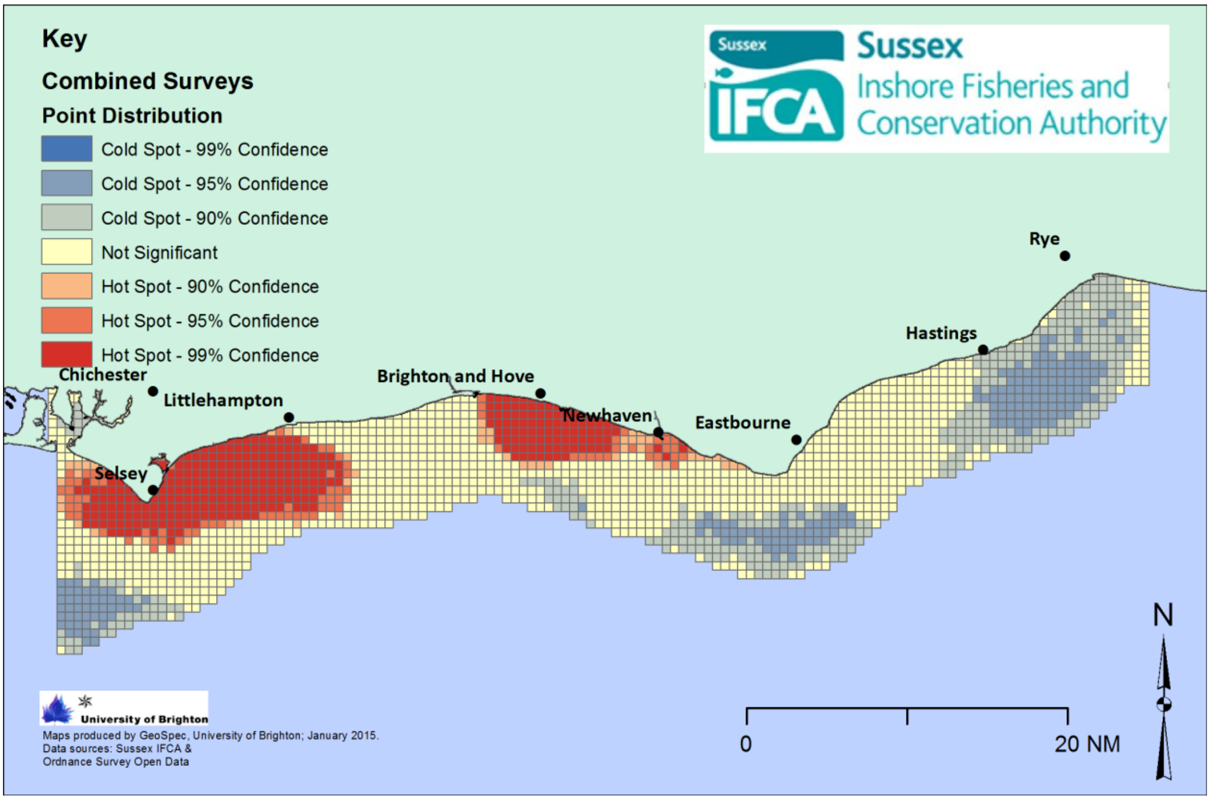

Figure 30 Optimised Hot Spot Analysis for the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data points. Areas identified as hot spots contained points which are clustered, cold spots are areas where points are dispersed, compared with the average distribution of points.

3.3.3 Predicted habitat distributions

The voronoi polygons have been used to represent EUNIS habitat distributions from EUNIS level 2 to EUNIS level 6, where sufficient data are available. The predicted habitat distributions are given in Figure 31 to Figure 42. Areas indicated as "not classified" are those where no EUNIS classification is available for that location at that EUNIS level. For EUNIS level 6, the area not classified has not been shaded, due to the comparatively small size of the EUNIS level 6 voronoi polygons. The voronoi predictive habitat maps suggest that A5 habitats are dominant throughout the district. A3 and A4 habitats are predicted in small areas. The EUNIS level 3 map is perhaps adequate as an indication of the overall habitat trends, however the EUNIS level 4, 5, and 6 maps allow for a more detailed biological interpretation at specific locations where data are available. For example, studying the EUNIS level 4 maps shows that fine sediment habitat types are more common in the eastern parts of the district, becoming predominantly coarser in the west. The A3 coded areas which are common inshore from Brighton to Selsey, when studied at higher EUNIS levels represent Kelp sea weed communities in rock dominated environments. A4 environments fall mostly under the EUNIS level 4 category A4.23, which describes communities on soft circalittoral rock. When this part of the EUNIS hierarchy is looked at in greater detail, the A4.23x EUNIS level 5 classes describe chalk and lime stone environments. This is not surprising given the adjacent chalk and limestone cliffs extending from Beachy Head to Brighton.

3.3.3.1 EUNIS level 2

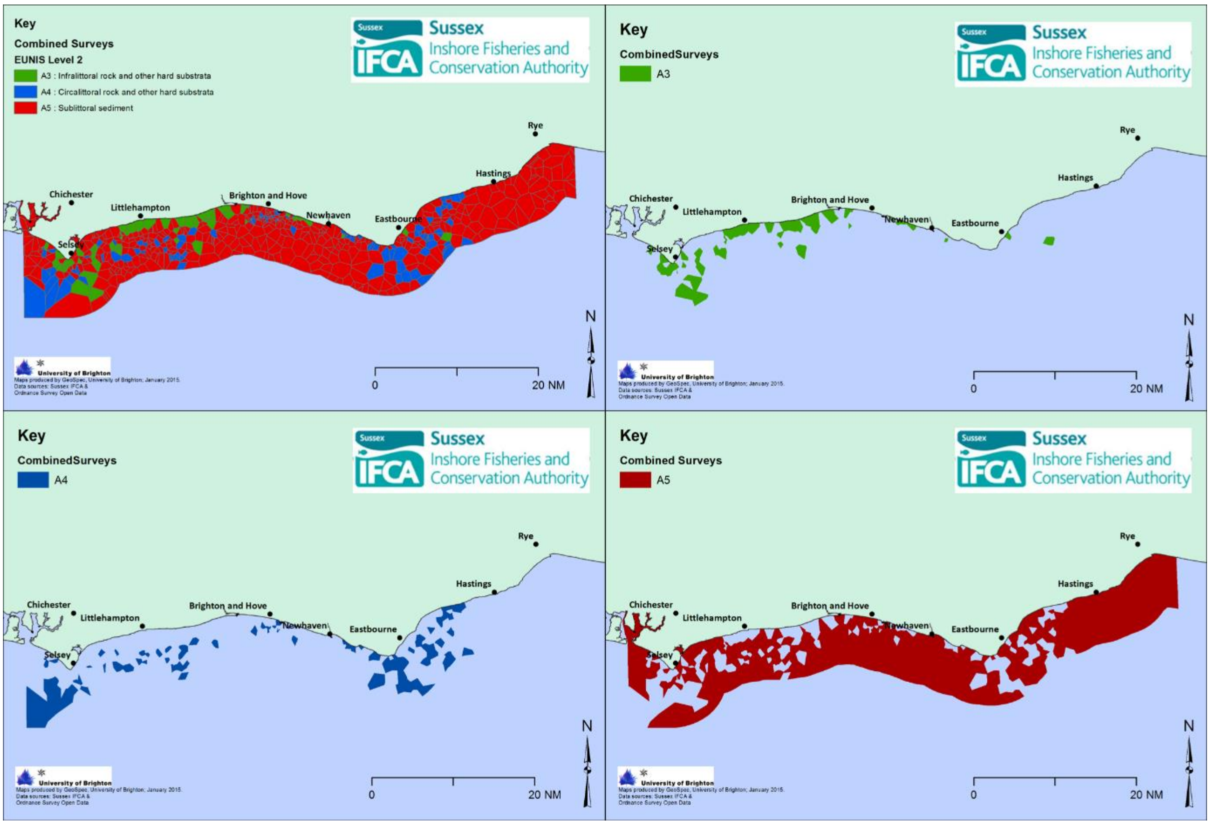

Figure 31 EUNIS level 2 voronoi predictive habitat models based on the combined Seasearch1992-2005, ALSF 2007, and Seafish 2008 surveys for the Sussex IFCA district

3.3.3.2 EUNIS level 3

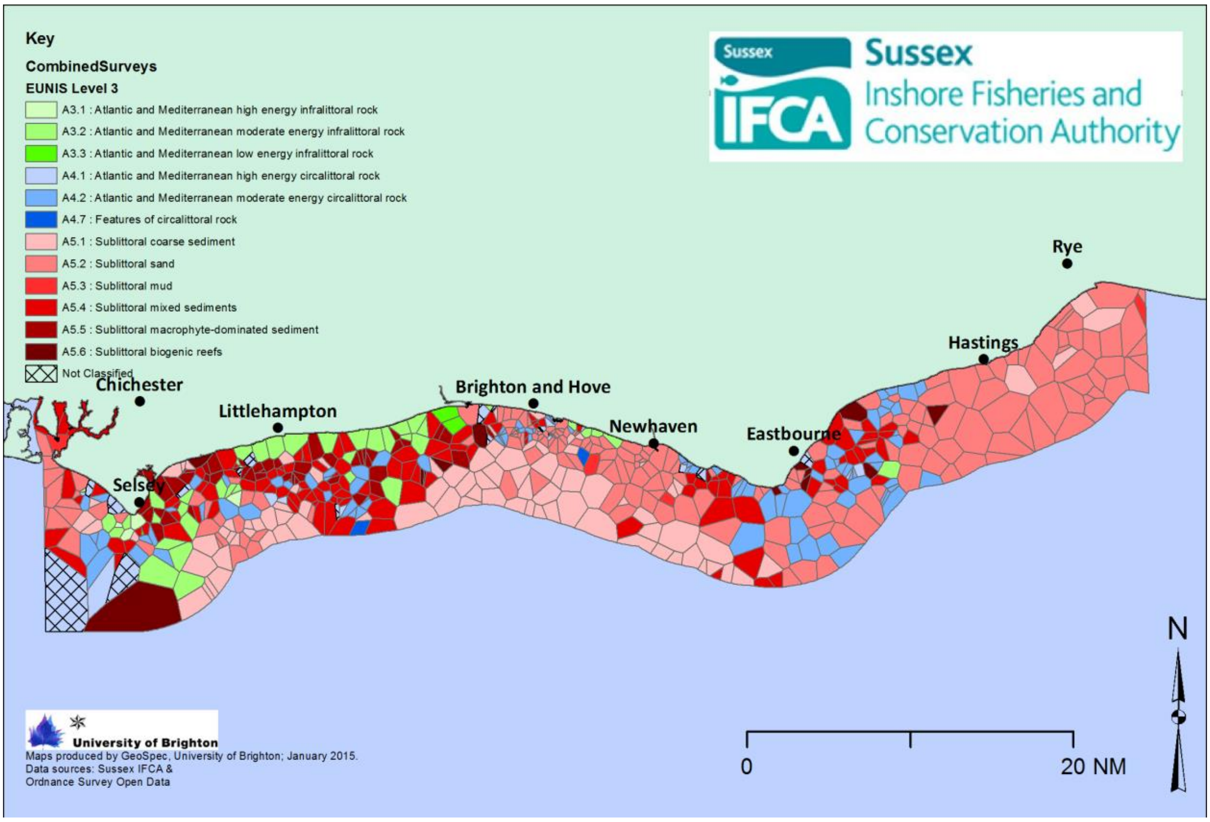

Figure 32 EUNIS level 3 overall voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data, for the Sussex IFCA district.

Figure 33 EUNIS level 3 voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district, showing the predicted distributions of EUNIS A3 and A4 habitats.

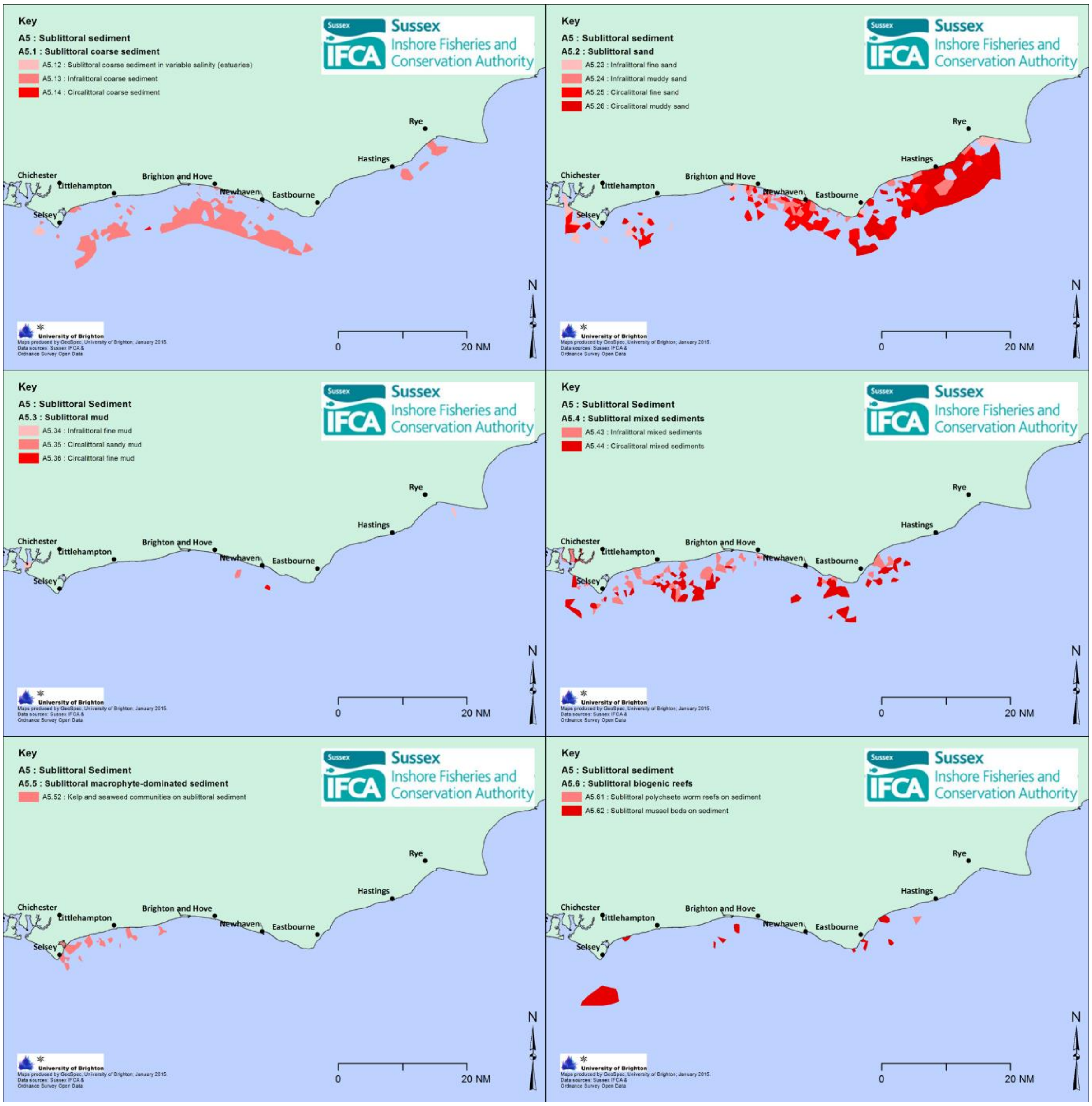

Figure 34 EUNIS level 3 voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district, showing the predicted distributions of EUNIS A5 habitats.

3.3.3.3 EUNIS level 4

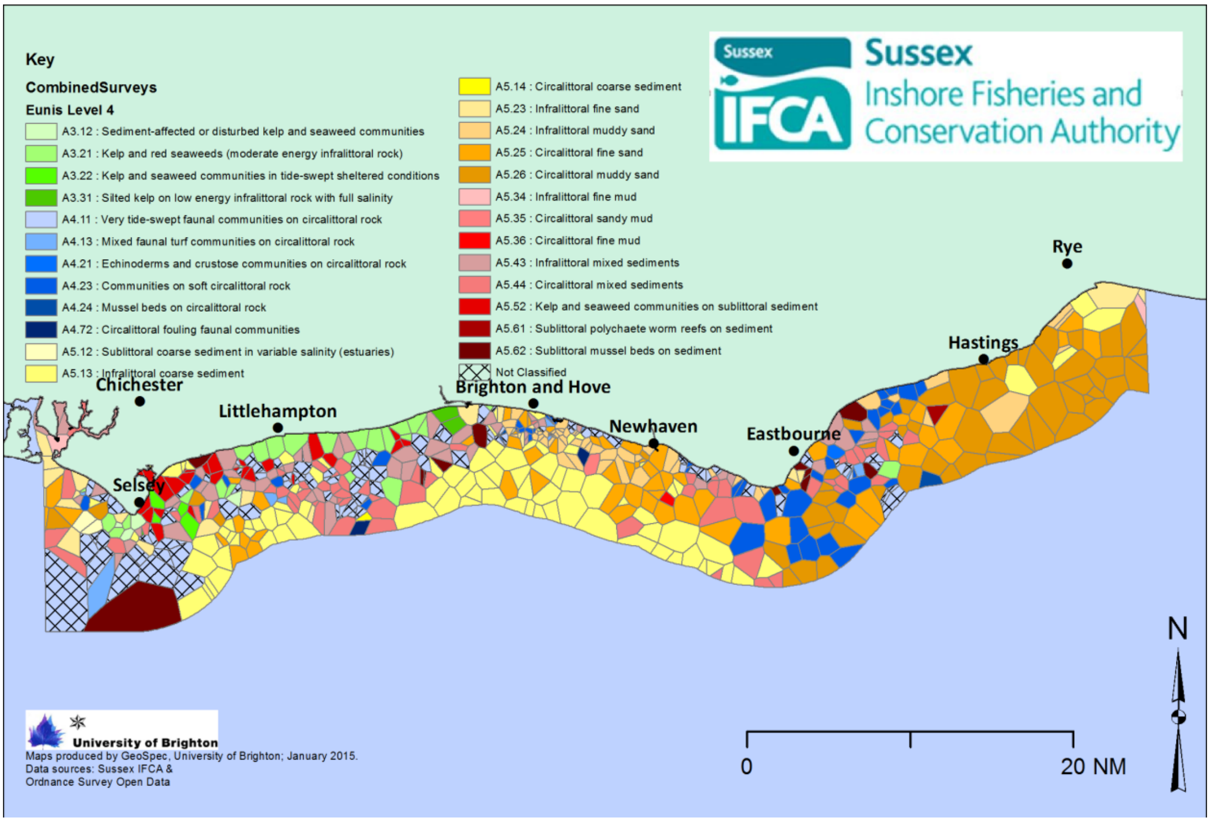

Figure 35 EUNIS level 4 overall voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district.

Figure 36 EUNIS level 4 voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district, showing the predicted distributions of EUNIS A3 and A4 habitats.

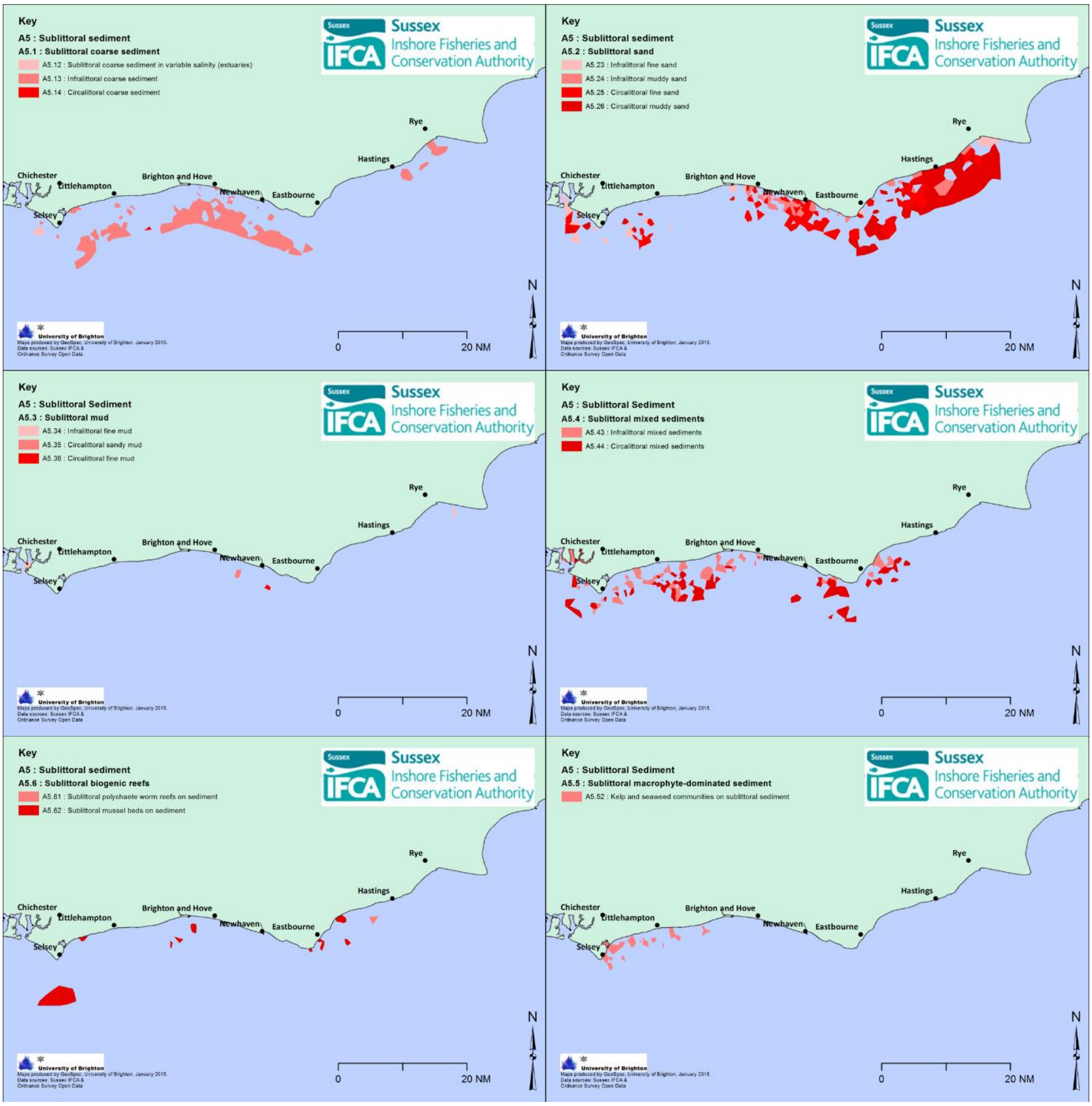

Figure 37 EUNIS level 4 voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district, showing the predicted distributions of EUNIS A5 habitats.

3.3.3.4 EUNIS level 5

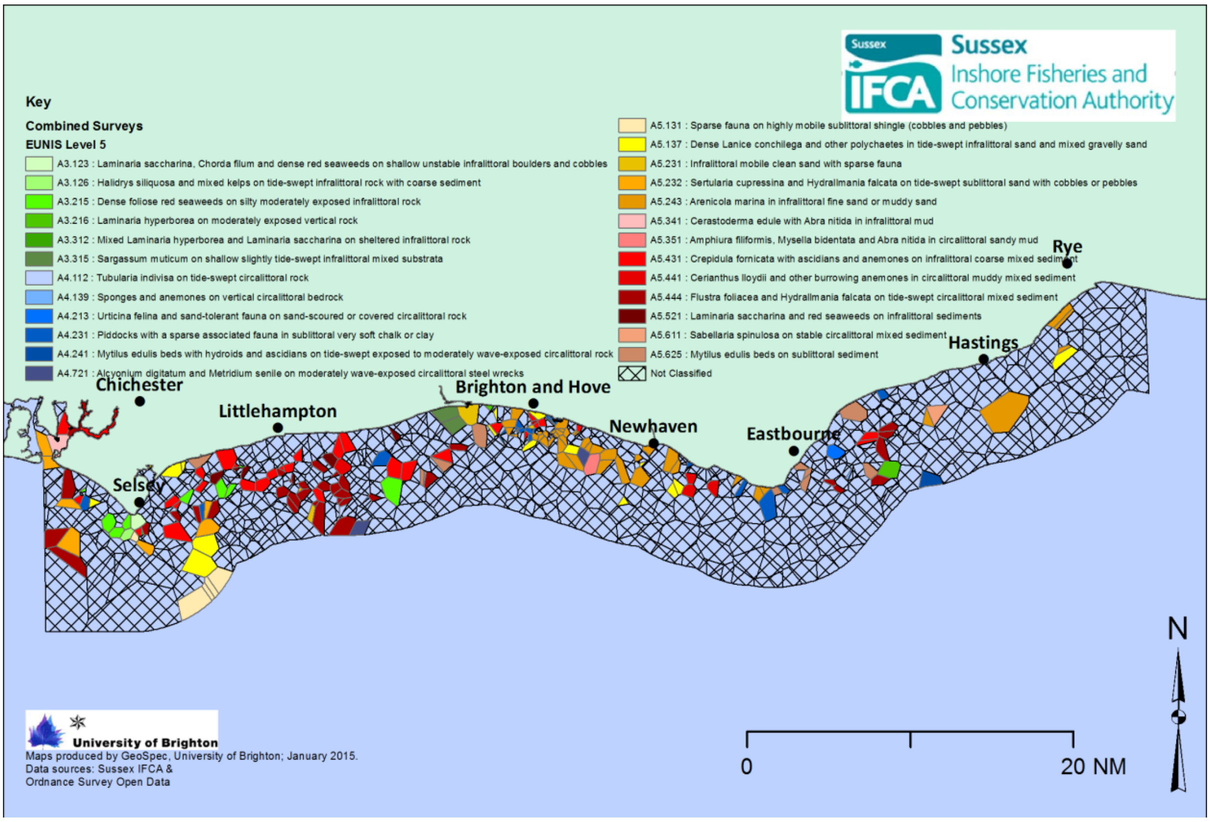

Figure 38 EUNIS level 5 overall voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district.

Figure 39 EUNIS level 5 voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district, showing the predicted distributions of EUNIS A3 and A4 habitats.

Figure 40 EUNIS level 5 voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district, showing the predicted distributions of EUNIS A5 habitats.

3.3.3.5 EUNIS level 6

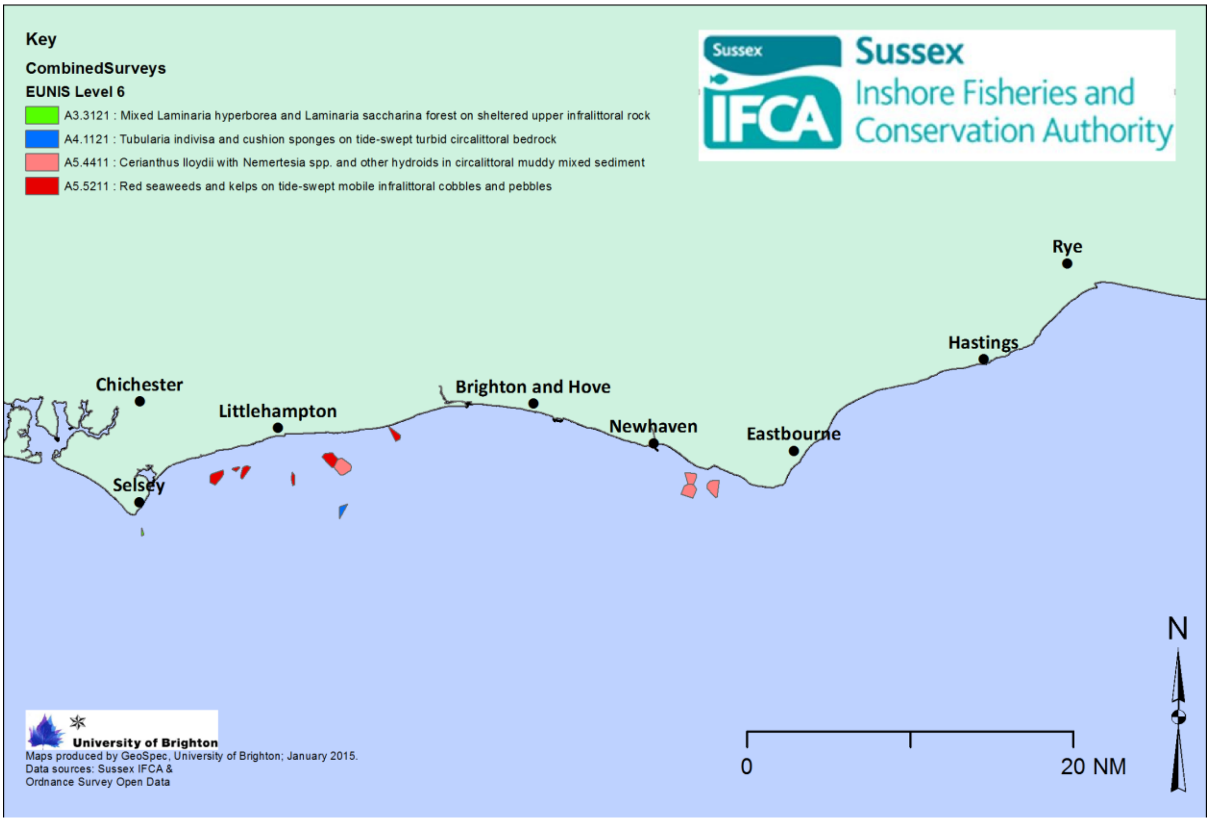

Figure 41 EUNIS level 6 overall voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district.

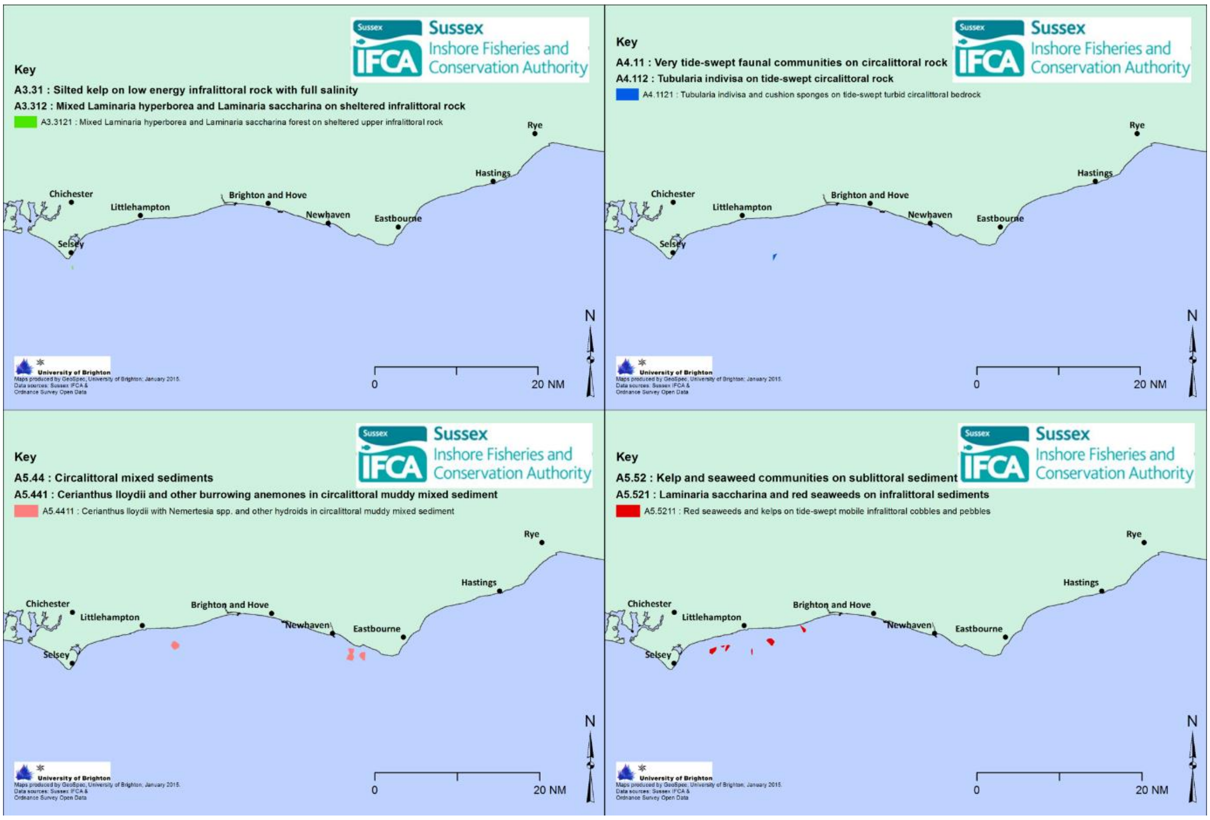

Figure 42 EUNIS level 6 voronoi predictive habitat model using the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data for the Sussex IFCA district, showing the predicted distributions of EUNIS A3, A4, and A5 habitats.

3.3.4 Confidence maps

The confidence mapping aims to analyse the spatial distribution of the survey effort for the combined fine scale data sets. The distribution of the survey points have been analysed using spatial statistics, so as to map the distribution of survey effort throughout the Sussex IFCA district. Areas which are identified as having a high density of survey points represent a higher level of survey effort, and so more is known about these areas. As a result, it is suggested that these areas offer more confidence in the accuracy of the associated fine scale habitat predictions. In addition, these maps can be used to determine where there is less survey effort, less confidence and therefore identify areas which might be prioritised for future survey work.

3.3.4.1 Voronoi polygon area

Areas where data points are more densely clustered in the original point layer produce smaller voronoi polygons, which can be considered to have a higher spatial resolution. These areas are therefore likely to be a spatially more accurate representation of the underlying data. This can be thought of as a proxy to kernel density analysis, suggesting that the confidence for each polygon is inversely proportional to its size.

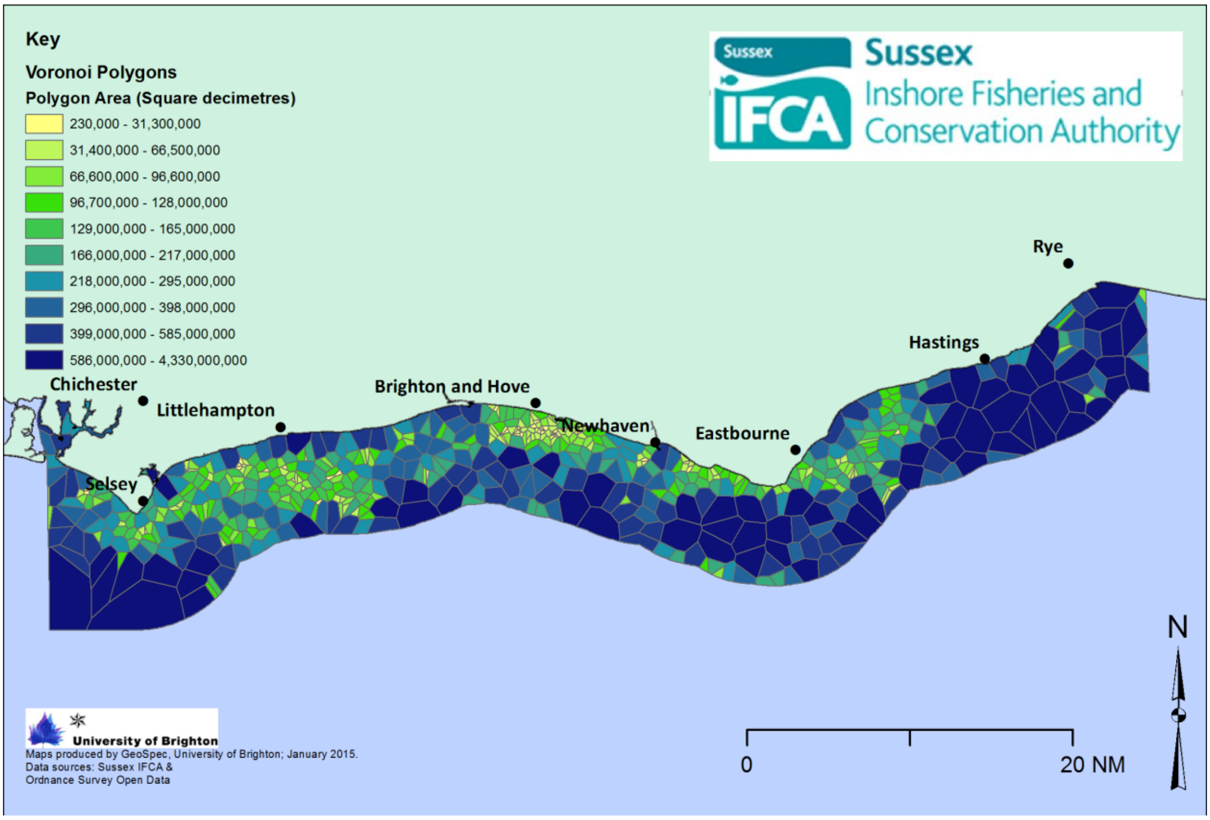

Figure 43 Voronoi polygons shaded by individual polygon area, given in decimetres squared

3.3.4.2 Kernel density estimation based confidence map

Kernel density estimation has been calculated using the average nearest neighbour statistic multiplied by a factor of 100 to give an appropriate search radius (a full description of KDE methods is provided in Appendix 3). Additionally the Average Nearest Neighbour statistic carried out on polygons and combined survey points revealed significant clustering patterns, with a p-value less than 0.05 in both cases.

The kernel density surface portrays the point density distribution of the combined survey (Seasearch 1992-2005, ALSF 2007, and Seafish 2008) layer. The kernel density data are heavily skewed, and therefore assumed not be normally distributed. Natural Breaks classification (Jenk's Rule) has been used to split the data into classes. This has been chosen for the way in which it categorises data based on natural groupings of data values (Longley *et al*. 2007), and suitability for non-parametric data.

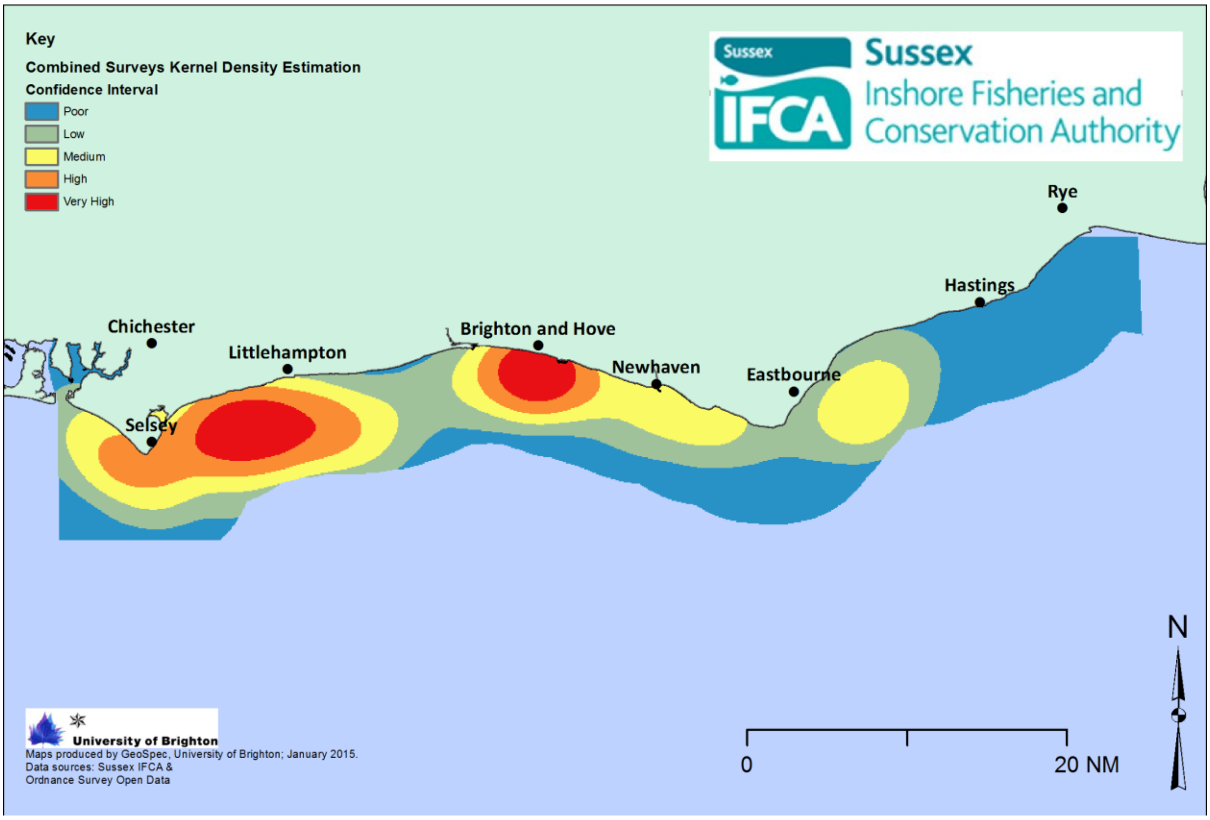

Figure 44 Kernel Density Estimation based on the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 combined survey data. The output surface has been arbitrarily delineated using Jenks natural break class divisions

The resulting kernel density surface can be seen in Figure 44. Here the values have been divided into five classes, classified using the Jenks natural breaks method. These are used as arbitrary confidence intervals, based on the density of points. Areas of high point density are displayed as areas of high confidence. This method is analogous to that used in the similar Habmap project, devised by Robinson *et al.* (2009a, 2009b, and 2011). These breaks have been converted into confidence contours in Figure 45.

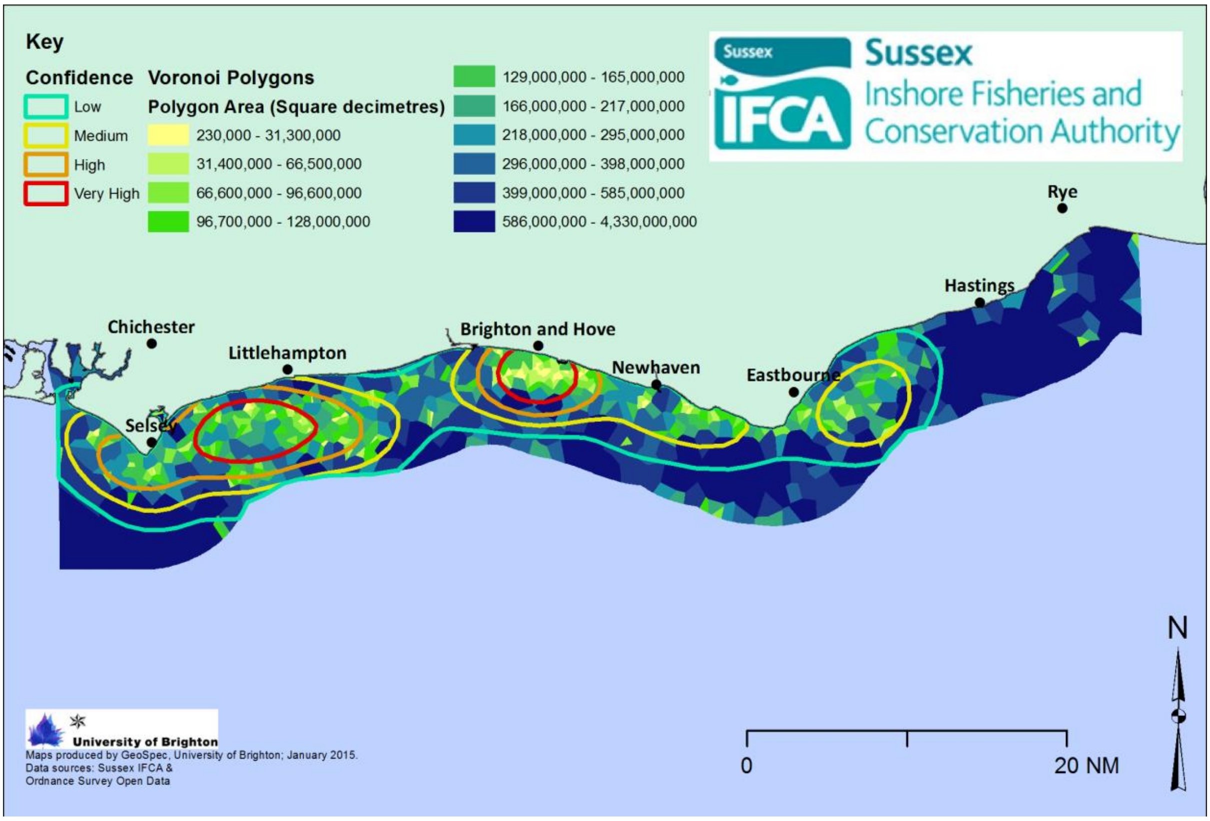

Figure 45 Kernel density estimation based confidence intervals. These are based on Jenks natural breaks class intervals. These overlie voronoi polygons classified by individual polygon area. Both layers are derived from the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 survey data points

In Figure 46 the kernel density surface has been layered on top of the voronoi polygon layer, albeit with a stretched classification in place of the classified version in Figure 44. Lighter areas are those of high point kernel density. These appear to correlate well with small polygons, which both suggest good spatial resolution and confidence. This is further visualised in Figure 45, where the break values used in Figure 44 have been converted into confidence contours, overlaying the voronoi polygon area layer.

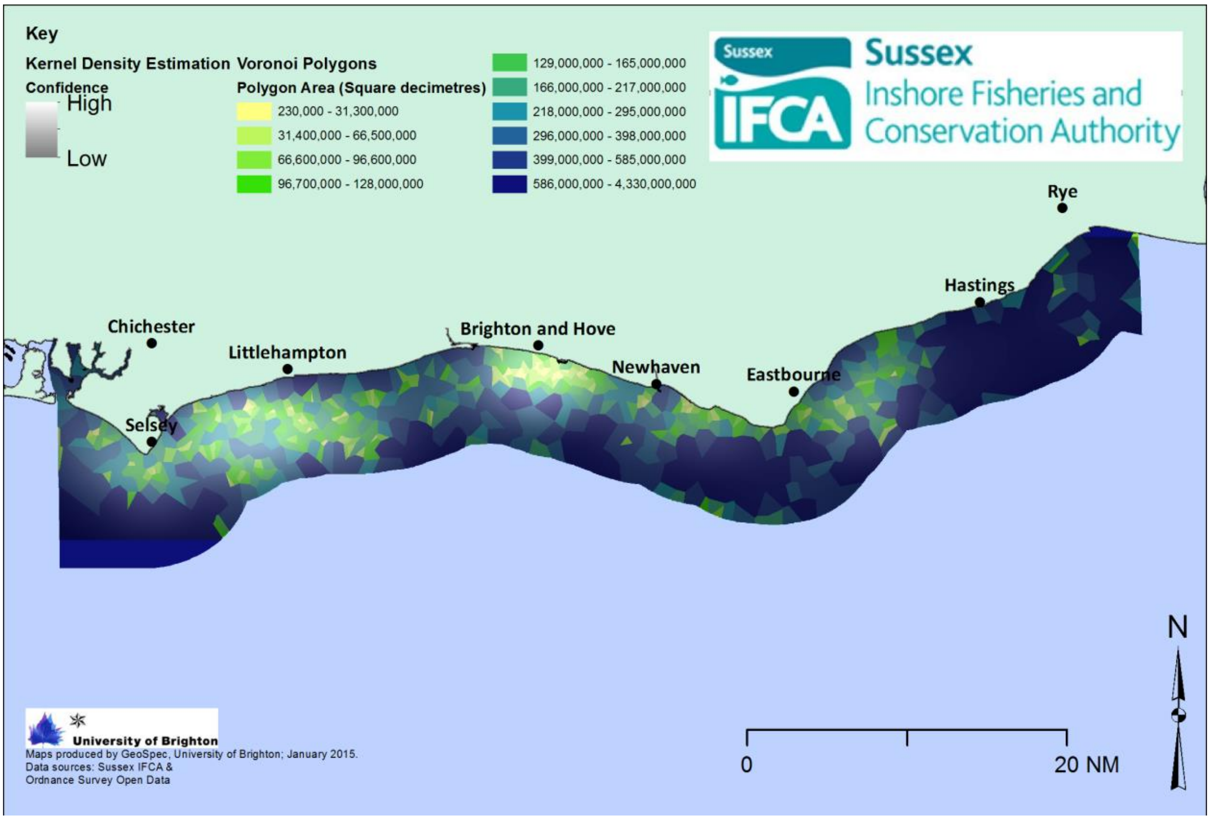

Figure 46 Kernel density estimation based on Seasearch 1992-2005, ALSF 2007, and Seafish 20008 combined points; overlaying voronoi polygons classified by polygon area, derived from the same data.

3.3.4.3 Optimised Hot Spot Analysis based confidence map

Arguably, an inadequacy of the Kernel density surfaces used in Figure 44 to Figure 46 is the omission of the specific identification of areas which are particularly lacking in confidence. Optimised hotspot analysis by no means replaces kernel density analysis, but rather offers an additional perspective on the data; the output for the combined fine scale surveys is given in Figure 47.

The resulting polygons have been added to the kernel density generated confidence intervals, illustrated in Figure 48. These Optimised Hot Spot Analysis derived confidence contours correlate well with areas of high confidence as identified by the kernel density derived confidence contours. Additionally, they pick out areas which are particularly lacking in data points, within the cold spot contours. These areas have lower point density, large voronoi polygons and points which are less densely clustered than would be expected by chance. These areas can be seen in Figure 48 offshore from Selsey, Beachy Head, and to the east of Eastbourne.

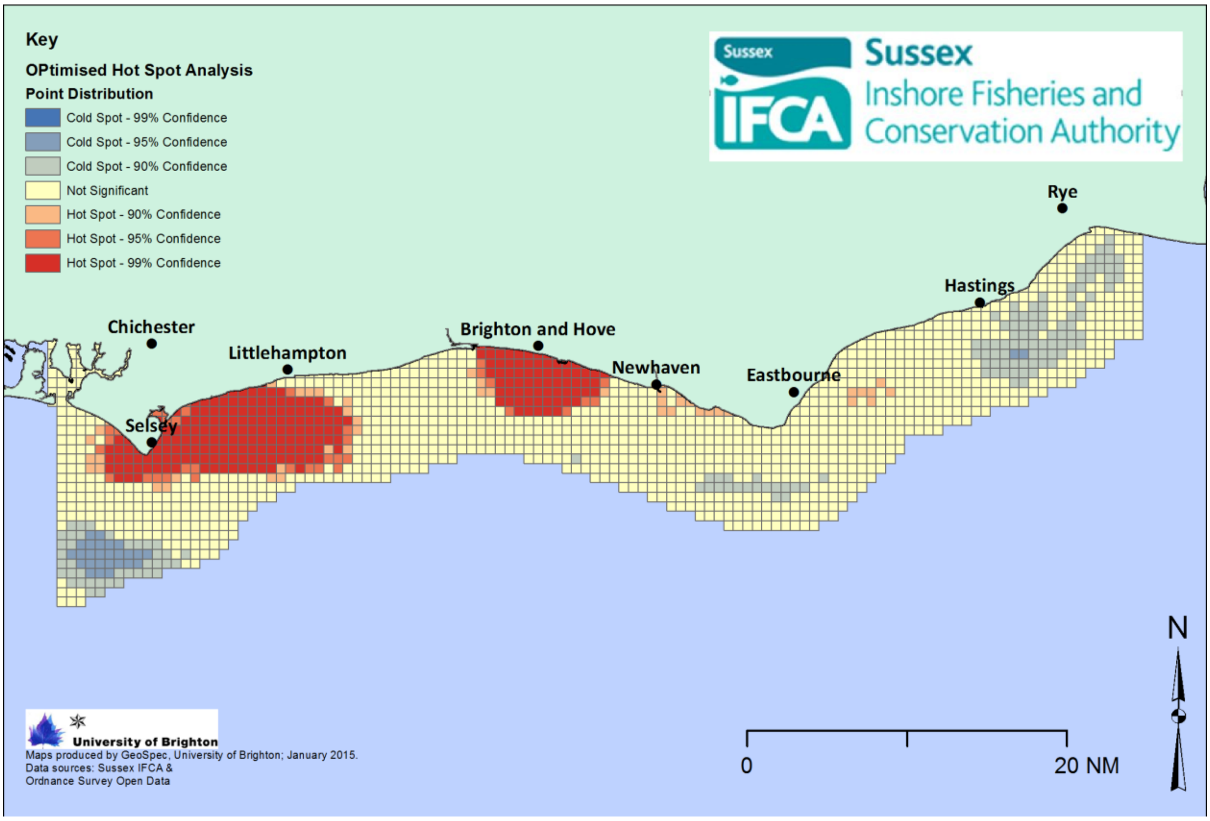

Figure 47 Optimised Hot Spot Analysis, identifying areas of higher than expected, and less than expected clustering; calculated for the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 combined data.

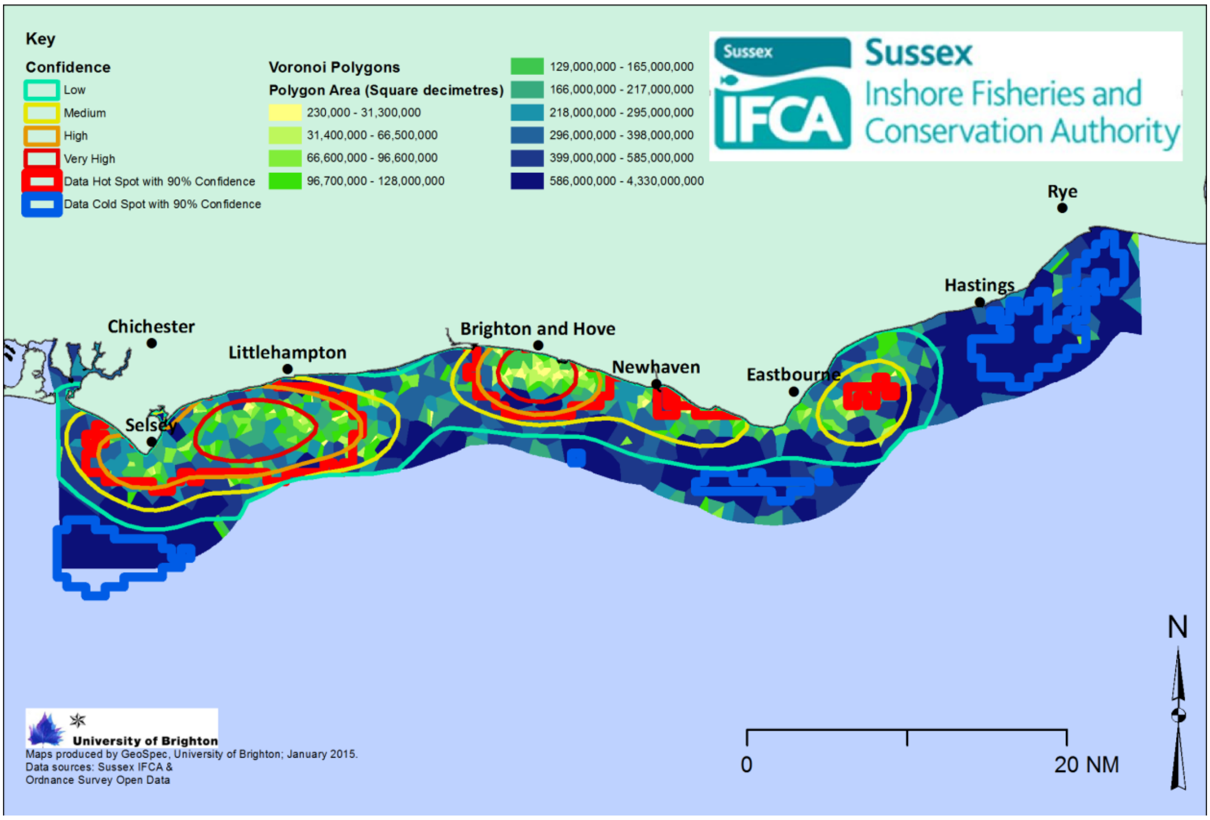

Figure 48 Kernel density and Optimised Hot Spot Analysis confidence intervals overlaying voronoi polygon data

3.3.4.4 Attribute resolution

In addition to the spatial accuracy and resolution, is the attribute resolution (Longley *et al*., 2007). This is related to the detail contained within the attribute data about the variable being measured. In this case, the level of the EUNIS code. This is illustrated for the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 surveys represented as voronoi polygons in Figure 49.

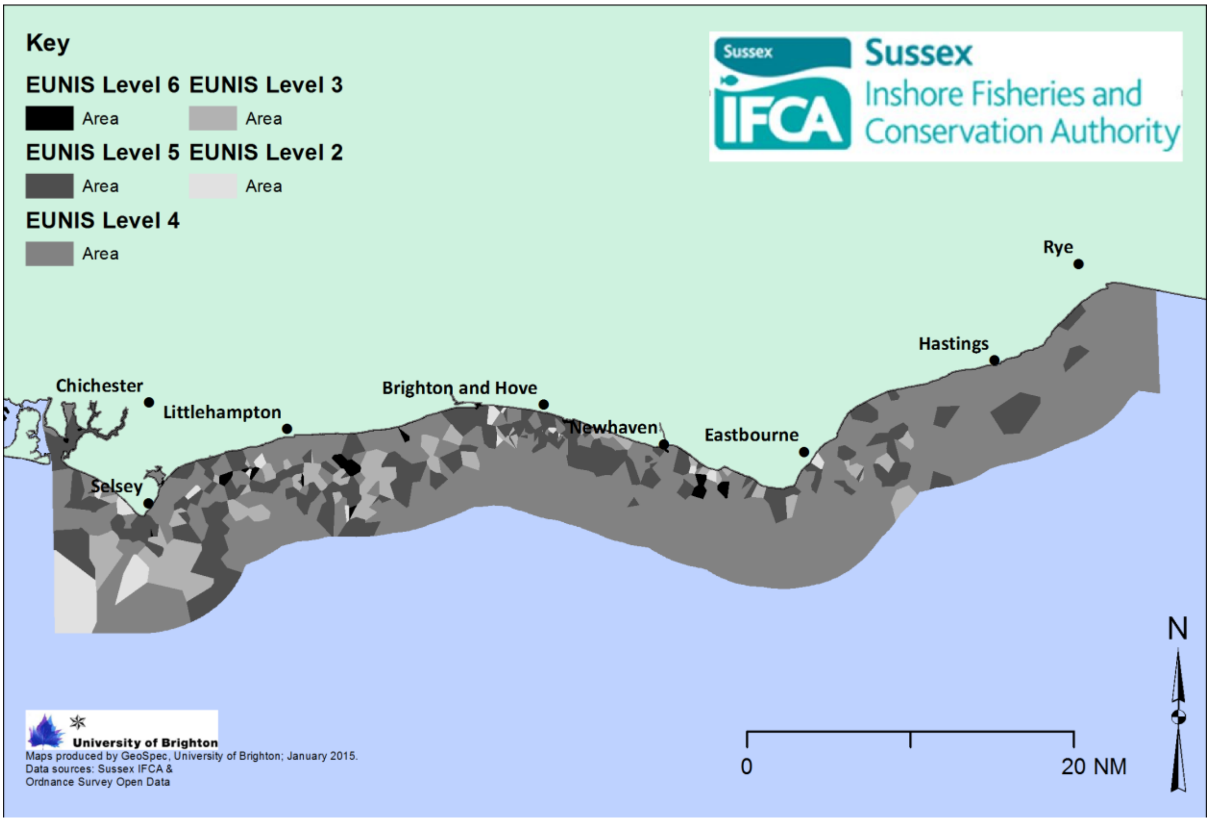

Figure 49 Voronoi polygons representing the highest EUNIS level classification available throughout the SCHIP 2 study area based on Seasearch 1992-2005, ALSF 2007 and Seafish 2008 survey data.

3.4 Bathymetric models

3.4.1 Broad Scale Bathymetry

The broad scale bathymetry model can be seen in Figure 50. Figure 51 represents the slope angles calculated from the broad scale bathymetric model. A notably steep drop off in depth can be found at Beachy Head, and the Outer Owers to the south of Selsey. The depth shallows within the bays from Selsey to Beachy Head and Beachy Head towards Rye. Shallow outcrops are present extending seawards at the Outer Owers, Kingmere Rocks, Royal Sovereign Shoals, and Four Fathoms Sand Ridge.

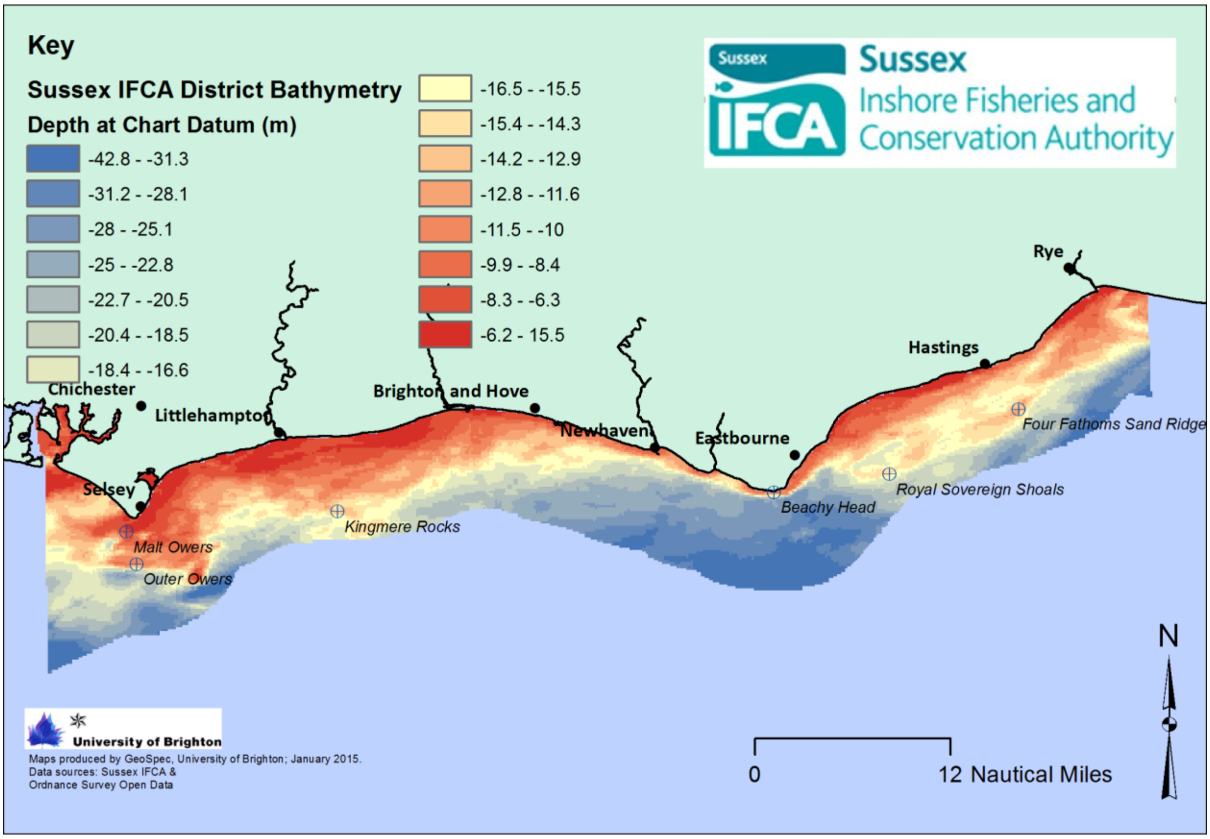

Figure 50 Broad scale bathymetry model for the Sussex IFCA district

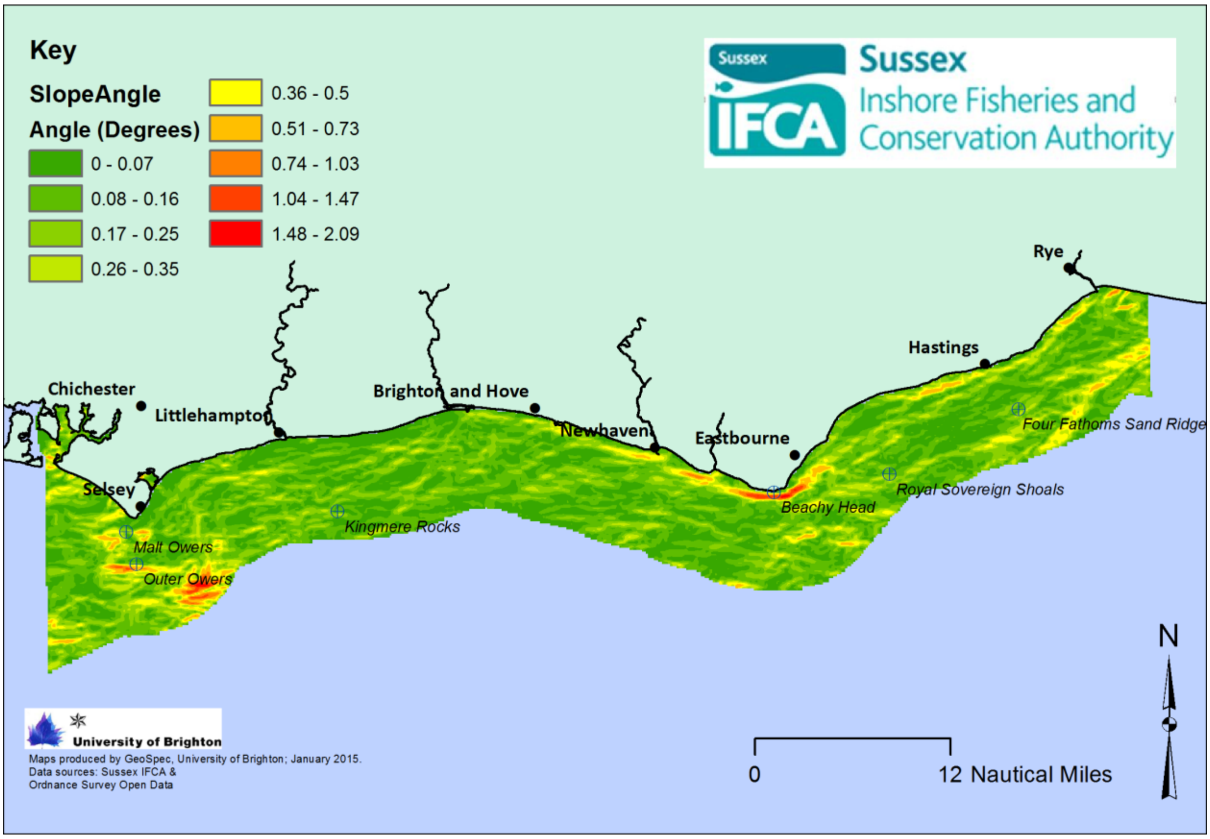

Figure 51 Broadscale slop angle distribution throughout the Sussex IFCA district

3.4.2 Fine Scale Bathymetry

High resolution bathymetric models which have been made available in localised areas can be seen in Figure 52. The Newhaven to Dungeness data provide the most detailed bathymetry, of 1m resolution, for up to 1km offshore. The Beachy Head East and East Nab data give bathymetry to a lower 2m resolution but over wider areas. These both represent areas of complex undulating sea floor.

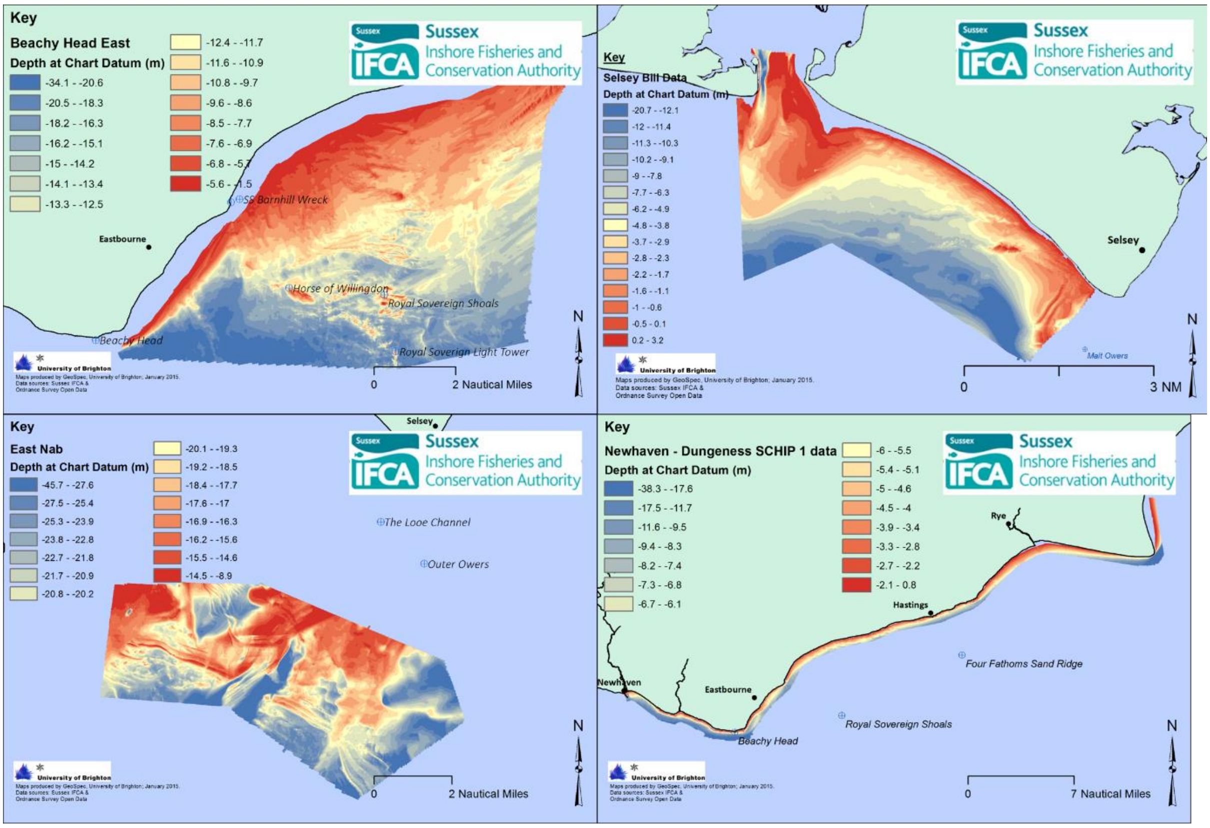

Figure 52 Fine scale bathymetry data. Contains public sector information, licensed under the Open Government Licence v2.0, from the Maritime and Coastguard Agency (National Archives, no date).

4 Discussion

4.1 Introduction

This section of the report discusses the interpretation of the results and key findings. These results and findings are then placed in the context of the initial objectives laid out at the beginning of this report. The main aim of this project was to explore and analyse existing sea floor habitat and bathymetric data sets available in the Sussex IFCA district for use in a constructing a detailed fine and broad scale habitat model classified to EUNIS level 3, and create a bathymetric model of the entire district. In the project aim it is stated that these should be suitable to inform the management of fisheries, and the marine environment and for the ecological assessment of Sussex Coastal Waterbody under Water Framework Directive (out to one nautical mile offshore).

4.2 Broad scale habitat data

4.2.1 Predicted habitat distributions

4.2.1.1 Initial observations

Four habitat models have been explored and mapped to EUNIS level 2 and 3. Each of these maps have been interpreted, and ultimately combined to provide a homogenous habitat model for the entire Sussex IFCA district. The differences between the four habitat models have been identified, quantified, and mapped. Broad scale data were found to cover the entire Sussex IFCA district.

The predictions of the individual habitat models show broadly differing habitat distributions across the district. Indeed, predicted sea floor habitat seems entirely dependent upon which model is selected. These differences reflect the apparent disparity between the currently available broad scale models for the Sussex IFCA district.

Despite these differences, the broad scale models can be loosely split into two groups: The RoxAnn and EUNIS South East data suggest large areas of EUNIS A5 habitat throughout the district, whilst the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 models predict A3 as the dominant habitat type and more habitat variation throughout. A summary of the differing habitat distributions, by total area, can be seen in Figure 53.

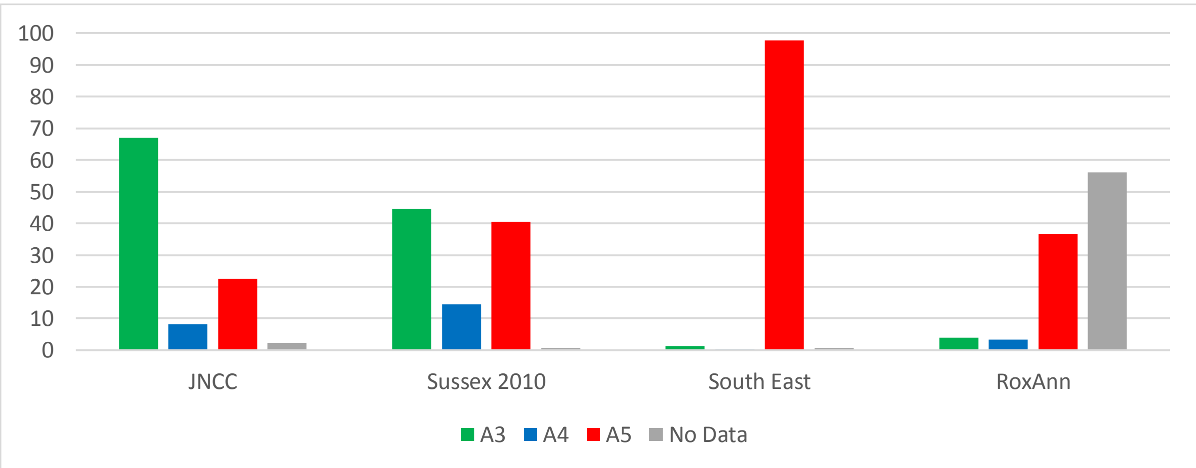

Figure 53 Summary of EUNIS level 3 habitat distribution for each broad scale EUNIS model for the Sussex IFCA area. Values given as a percentage of the total Sussex IFCA district area.

These large differences (emphasised in Figure 23 to Figure 26) in predicted habitat extent and disagreement make it difficult to predict with any confidence the overall habitat distribution for the entire the Sussex IFCA district. In order to attempt to overcome this issue as best possible, both the quality of the data sources and the level agreement between them were assessed.

4.2.1.2 Data quality assessment

In order to consider the data quality, it is necessary to consider data sources. Both the EUNIS Sussex 2010 and the JNCC UK Sea Map 2010 appear to be well documented, high quality data sets with good evidence of ground truthing techniques, with specific project reports available detailing the studies by James *et al*. (2011) and McBreen *et al*. (2011) respectively. The EUNIS Sussex 2010 data appear to have used a bespoke survey specifically for that project, while the JNCC UK Sea Map 2010 looks critically at a range of data sets using the MESH confidence assessment, and selects the best quality data available for a given location (McBreen *et al*., 2011). These studies, however, are not localised to the Sussex IFCA district, covering far greater extents. Therefore the spatial resolution and intended use of the data may not be appropriate for the SCHIP 2 objectives.

The RoxAnn data were a bespoke acoustic survey with the intent of providing the best possible habitat map with the technology available. However, the associated project report by Clark *et al*. (no date a) concluded that the accuracy of the survey is questionable due to limited ground truth sampling, which is key to the interpretation of acoustic techniques. However, the report notes that RoxAnn data match up well with fishing activity that would be expected for the predicted habitat types, although it is later suggested in the conclusion of the report that the RoxAnn data may be questionable (Clark *et al*., no date a).

The EUNIS South East data are perhaps the most difficult to gauge in terms of data quality. The broad scale polygon map used here was generated as an output of the study by Coggan and Diesing (2011). It took into account a range of available data sources such as the MESH EUNIS map by Coltman *et al*. (2008) and work by Coggan *et al.* (2009) in collaboration with CEFAS and further work by Diesing *et al.* (2009) looking at wide spread rocky reef occurrence in the English Channel, and sought to fill in the gaps where data were not readily available at that time, using BGS offshore geological maps and bathymetry maps as a basis for delineation in these unknown areas, based on correlations in known areas. There is however no mention of independent ground truthing within the Coggan and Diesing (2011) study relating directly to the EUNIS South East map.

Where it was possible to obtain MESH confidence assessment scores, EUNIS Sussex 2010 scored highly, whereas RoxAnn received a lower score.

With the above information in mind, it could be tentatively suggested that the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 are of better quality (or more fit for purpose) than RoxAnn and EUNIS South East data, based purely on the reliability of the data sources. Due to data uncertainty, confidence based habitat maps exclusively for EUNIS Sussex 2010 and JNCC UK Sea Map 2010 were generated, as well as confidence based habitat maps for all four surveys. The confidence based habitat maps in both cases reflect the large differences between the predicted habitat distributions and types across the four data sets.

In the latter parts of this chapter, the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 shall later be compared with fine scale data, so as to attempt to validate its predictions and attempt to gain some spatial confidence in the predicted habitat model.

4.2.2 Best broad scale models

4.2.2.1 Combining the EUNIS Sussex 2010 and JNCC UK Sea Map 2010

As suggested above, the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 appear to provide the most reliable source of information. These two data sources were combined and analysed to produce a seabed habitat map, which indicated habitat type where there was agreement between data layers. The output habitat map, (see Figure 27), indicated that much of the western end of the district was EUNIS A3 habitat. The A3 habitat becomes intermixed with A4 and A5 towards Newhaven and Eastbourne, and changes to A5 offshore of Hastings and Rye. This model was able to classify 63% of the Sussex IFCA District to EUNIS level 2.

While this model has good coverage, it is however inadequate to meet the project objectives, which are to produce a broad scale EUNIS level 3 for the Sussex IFCA district. At EUNIS level 3, the total area of agreement is greatly reduced, covering only 19% of the Sussex IFCA district (see Figure 27). The remaining 81% of the district was classified to EUNIS level 3 by both individual models, but there was no agreement between them.

Clearly, this approach is not adequate to fulfil the objectives of this study, and so a more homogenous approach was required.

4.2.2.2 Combining all individual broad scale data sets

As further analysis of broad scale habitat distribution, all four data sets were integrated to produce a map describing coverage of the entire district at EUNIS level 2 and EUNIS level 3. Unfortunately, the outputs from this analysis suggest that whilst habitat predictions can be made for the entire district, the majority of these predictions have a low level of confidence attached. The low confidence is principally due to the datasets being largely inconsistent. However, there are some areas of higher spatial confidence (see Figure 24 to Figure 26), these areas are almost exclusively EUNIS habitat A5 with a very small area of A4, and some localised areas of A3.

At EUNIS level 3 the areas of high or very high confidence are almost exclusively A5.2 with a very minor amount of A5.1. At EUNIS level 2, 31% of the district is covered by high or very high confidence habitat zones. At EUNIS level 3, this is area reduced to 17%. Interestingly, the Owers rocks off of Selsey, and the Royal Sovereign Shoals off of Eastbourne are among the small areas of A3 classified with high confidence. These are renowned locally and marked on nautical charts as rocky areas, which perhaps helps validate the confidence methods to some extent. Additionally, an area of A5.2 high to very high confidence offshore from Hastings and Rye is marked on nautical charts as the Four Fathoms Sand Ridge. Expert advice from a Sussex IFCA surveyor suggested that this location is known locally for a large sandy outcrop.

4.2.2.3 Comparison of broad scale models with ALSF 2007 ground truth data

Evidence from interpreted ALSF 2007 ground truth videos supports this, indicating A5.2 throughout the vicinity of the area of high and very high confidence off of Hastings and Rye. The ALSF ground truth data however cannot validate the A3 high confidence area in the vicinity of the Sovereign Shoals or the Malt Owers due to a lack of sample points in that area. Furthermore, the ALSF ground truth data suggest that EUNIS A5 habitat is dominant throughout the Sussex IFCA district, with only small areas of A3 and A4 in localised areas. In contrast to what were initially suggested to be the most reliable broad scale data sets (EUNIS Sussex 2010 and JNCC UK Sea Map 2010), the ground truth data appear to indicate that the EUNIS South East and RoxAnn data are in fact a better model of the seafloor habitat. Note: The ALSF ground truth data are examined in greater detail in the fine scale section of this chapter, and are referred to as ALSF 2007 data.

4.2.3 Broad scale habitat conclusions

Interpretation of the different predicted habitat distributions of each of the four broad scale data sets is far from straight forward. Although the EUNIS Sussex 2010 and JNCC UK Sea Map appeared to be the most robust in comparative terms, these surveys do not ground truth particularly strongly against independent data (*e.g.* ALSF data). Furthermore, these data begin to show strong differences at EUNIS level 3.

Therefore, the combination of EUNIS Sussex 2010 and JNCC UK Sea Map cannot be used for the entirety of the Sussex IFCA district. When all four data sets are combined, these produce more convincing habitat maps with confidence levels built in, which correlate to the number of data sets in agreement at a given point. These are able to predict small areas with high confidence, and the A5 areas match up well with ground truth data. This unfortunately still leaves large areas of data conflict and uncertainty throughout most of the district.

The regional discrepancy between rock and sedimentary habitat is initially puzzling, but may be a result of differing interpretations of the seabed. In effect, it could be that while these surveys are in effect seeing the same habitat, there may be inconsistencies in the way the observations are being recorded and transcribed into EUNIS categories. In chapter two, the need to translate the EUNIS Sussex 2010 data from a modified version of EUNIS to the standard classification brought about the idea of thin sediment veneers overlaying rock, which James *et al.* (2011) argue are unique environments which go overlooked by the standard EUNIS system, and it is these mixed habitats which seem predominant in the eastern English Channel. Indeed, the fuzzy cross over point between a "rock environment" and a "sediment environment" could be a limitation when deciding on the hard position of digital discontinuous boundary lines between habitat types, which seldom exist in the continually variable analogue world.

4.3 Fine Scale habitat data

4.3.1 Combined points

The fine scale habitat models were generated from point data sets, with coverage throughout the Sussex IFCA district. In total, there were three data sets: Seasearch 1992-2005, ALSF 2007, and Seafish 2008. As previously mentioned, the ALSF 2007 data are classified ground truth points, while the Seasearch 1992-2005 data are collected by trained amateur divers who observe the sea floor habitat first hand. The Seafish 2008 study was a pilot study carried out offshore from Eastbourne. These studies were used in the generation of fine scale habitat models for two reasons: (i) they provided EUNIS classification information up to level 6, and (ii) they represent data at exact habitat point locations. These studies are combined to give an overall output with the best possible coverage for the district.

A EUNIS level 2 output map has been provided in Figure 28 and Figure 31. These predict that the Sussex IFCA district is predominantly EUNIS A5 sedimentary habitat. A4 is found throughout the district but to a lesser extent, and A3 habitat is the least numerous, found mostly inshore from Selsey to Brighton. There are a total of 1230 points. Of these, 166 predict A3, 329 predict A4, and 735 predict A5. Clearly it should be noted that these numbers points do not correlate directly with area, for there may be many A4 points but many are clustered offshore from Selsey and Littlehampton, and so represent a small area. Area statistics cannot be directly calculated for point data. Although they cannot be compared directly, as there are no overlapping points between surveys, the individual data sets are consistent when visually compared on the same map. The Seasearch and ALSF data sets are very consistent over the entire district for all three predicted EUNIS habitat types. This is in great contrast with the differing broad scale polygon data sets. Additionally, these data correlate well with the RoxAnn data; and the EUNIS South East data where RoxAnn data is not available. A visualisation of this can be seen in Figure 54. In contrast, and perhaps more problematic for this study, the fine scale data correlated poorly with the suggested high confidence broad scale data from the JNCC UK

Sea Map 2010 and EUNIS Sussex 2010 in areas where these latter data sets are in agreement on the predicted habitat classification, shown in Figure 55.

Beyond this, visually interpreting detail from the points is difficult, as the size of the points can be misleading, and can obscure nearby points. Ideally, a continuous interpolated surface would be generated from the data points, in order to represent the overall trends. However, this is only possible with numerical continuous data such as temperature, salinity, or elevation. As a result, an alternative approach using voronoi polygons has been developed within this study.

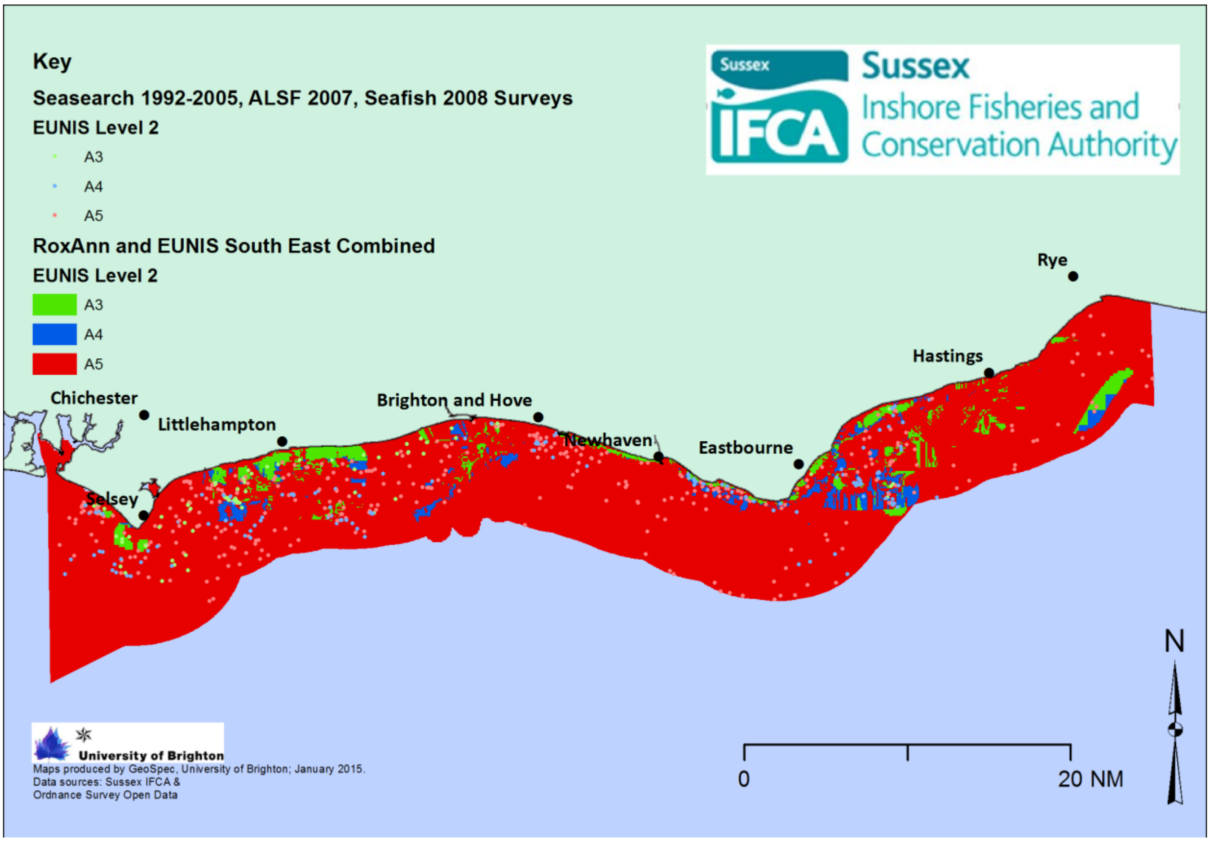

Figure 54 Combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data overlaying the combined RoxAnn and EUNIS South East data sets, coded to EUNIS level 2. The EUNIS South East data is used only to extend the RoxAnn data, where RoxAnn Data is available, this has is used instead of EUNIS South East data.

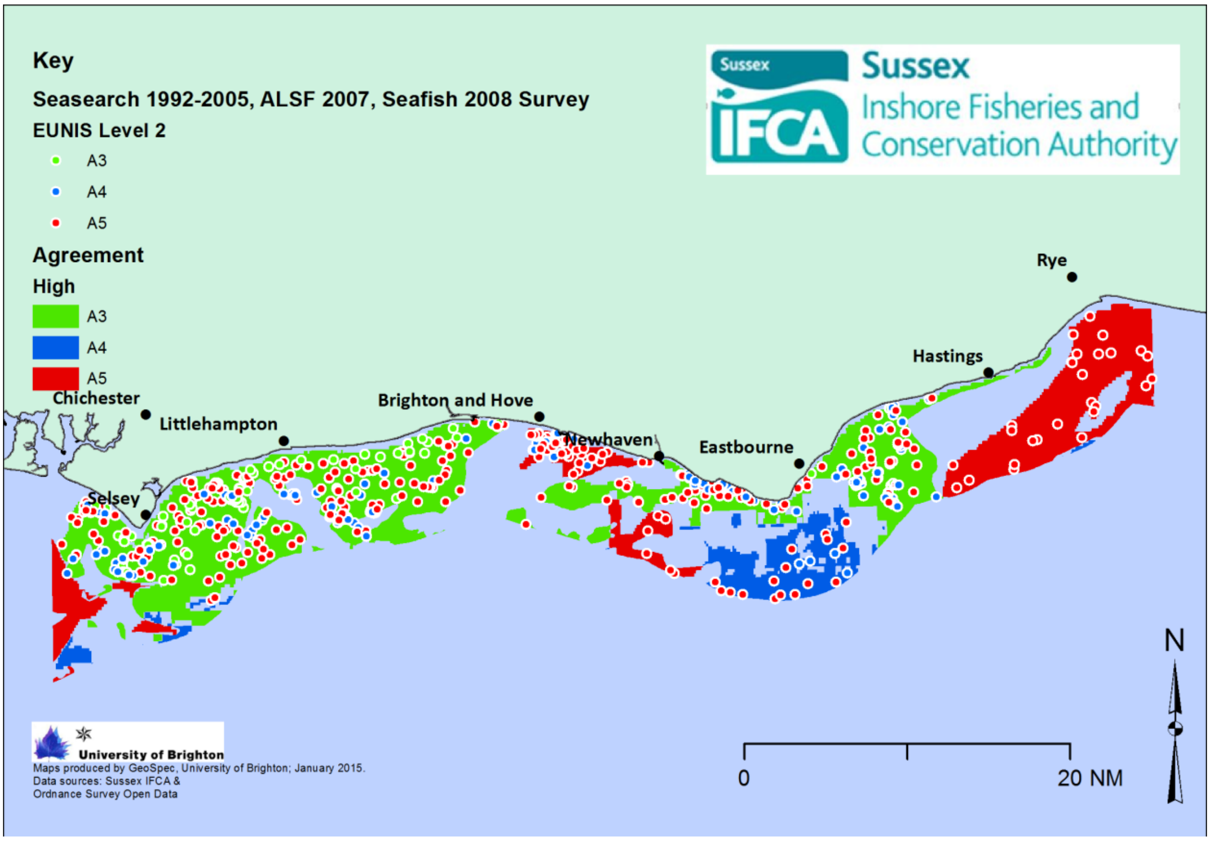

Figure 55 Combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 data overlaying the Broad scale high confidence predicted habitat map based on areas where the EUNIS Sussex 2010 and JNCC UK Sea Map data are in agreement on the EUNIS level 2 classification

4.3.2 Voronoi polygons predicted habitat distribution

The voronoi polygons help visualise trends and patterns in the discontinuous, categorical data. These allow the data to be effectively interpreted, and have been categorised to EUNIS level 6 where possible. EUNIS level 3, and to a certain extent EUNIS level 4 can be used to characterise the Sussex IFCA Study district. These suggest that the district is likely to be dominated by EUNIS A5 sedimentary habitat. This is similar to that predicted by EUNIS South East and RoxAnn data sets. Interestingly. The voronoi data also predict a localised area of A4 rock off of Beachy Head, to the southwest of Eastbourne, and inshore areas of A3 rock from Selsey to Brighton. The level 4 habitat map reveals more detailed information, especially regarding the A5 habitat types. Offshore from Littlehampton and towards Newhaven, coarse sediment are most common. Fine sands and fine muddy sands become more common inshore from Newhaven to Beachy Head, and become the dominant sediment type east of Eastbourne. Kelp and seaweeds on infralittoral rock are predicted inshore from Selsey to Brighton, with areas of kelp and seaweed communities overlying sublittoral sediment. A4.23 Communities on soft circalittoral rock is the most common A4 habitat type, and is found locally off of Beachy Head and inshore towards Eastbourne and Hastings. Given the nature of the nearby chalk cliffs at Beach Head and associated wave cut platform, this arguably fits with what might be expected. Further biological detail can be gained from studying the level 5 and six predicted EUNIS habitat maps.

4.3.3 Fine scale data spatial confidence

The voronoi polygons help indicate regional trends in discontinuous data, allowing it to be extrapolated across unknown areas. The extrapolation of data across unknown areas should, however, be treated with caution. The voronoi process assigns any given unknown location the category of the nearest known point. As such, it is appropriate to think of this in terms of the spatial autocorrelation of data. Any unknown location is assigned to the nearest known location, however locations further away from a known point should be treated with less confidence. The essence of this point was illustrated in Figure 43, which displays the voronoi polygons categorised by their respective area. Voronoi polygons with the smallest area are those with highest confidence, and large polygons contain areas with less known data points are those areas with less confidence. In summary, voronoi polygons represent an indication of what might be at any given location, based on the nearest known location.

Within the Sussex IFCA district, smaller voronoi polygons tend to be clustered between Selsey and Littlehampton, inshore from Brighton to Newhaven, and close inshore around Beachy Head to Eastbourne. These areas are predicted with a higher spatial confidence than surrounding locations. These assertions correlate well with kernel density estimation derived confidence contours, which suggest these to be areas of medium to very high spatial confidence (see Figure 45). In addition, Optimised Hotspot Analysis has been used to cross validate these confidence methods, areas of high spatial confidence coincide strongly with data hotspots. Data hotspots are areas where there is above average clustering of points, and so higher resolution and therefore more confidence can be assumed. In addition to highlighting areas of high spatial confidence, the Optimised Hotspot Analysis picks up on areas of below average clustering, areas which are using only very few points to predict comparatively large areas. These are identified offshore from Selsey, Offshore from Beachy Head, and covering a large area between Hastings and Rye, in the area known as the Four Fathoms Sand Ridge.

The latter area (Four Fathoms Sand Ridge) is an interesting location as it is a habitat area of very high spatial confidence within the broad scale data, and EUNIS level 3 habitat of A5.2. Additionally, we can use the broad scale data infer some additional confidence in the fine scale data in the Four Fathoms Sand Ridge area between Hastings and Rye, as the voronoi layer also predicts A5.2 for most of this location. It is noted that some areas have a very high spatial resolution, but can also have a low attribute resolution, or in this case a low EUNIS level.

4.4 Suitability of EUNIS classification system

4.4.1.1 A discontinuous approach to modelling a continuous world

Given the differences in predicted habitat distributions between data sets, especially among the broad scale data sets, further investigation may be required to determine the cause. The classification system is a common denominator between all data sets, variation may arise from the allocation of sections of the sea floor to a classification grade. The inference being that the EUNIS system is perhaps ambiguous in its descriptions even when expert interpretation is used, and allows for details or characteristics to become to an extent lost in translation.

Seafloor habitats are complex and varied, there is overlap between habitats, and the hard discontinuous, digital categories which we attempt to apply simply do not exist in reality. Furthermore, Longley *et al*. (2007) point out that the absence of objective geographic units mean that in practice, the categorical labels we assign are often vague guesses. For example, how much sand is needed to constitute a sand habitat? The discontinuous EUNIS categories require such equivocal decisions to be made. In doing so, Longley *et al.* (2007) suggest that two questions should be raised: Is the defining boundary crisp and well defined? And is the assignment of a given label to that zone robust and defensible?

Simplifying and categorising the real world is necessary, indeed by definition a model is a simplification of the real world (Longley *et al*., 2007) so as to further our understanding of the more complex processes. This is a prerequisite to achieving the objectives of this study. Brown *et al*. (2006) show the importance of spatial area visualisations for raising awareness and facilitating interpretation by non-specialist users such as members of the general public or decision makers. As such, a single homogenous system such as EUNIS is desirable, the question may be whether EUNIS in its current form is fit for purpose.

4.4.1.2 A need for homogeneity

Galparsoro *et al*. (2012) and Galparsoro *et al.* (2010) state that the importance of univocal habitat classification system is amplified by the fact that many European policies such as the Habitats Directive (92/43/EEC), Marine Strategy Framework Directive (MSFD; 2008/56/EC), Infrastructure for spatial information in the European Community (INSPIRE; 2007/2/EC), and the Maritime Spatial Planning roadmap (European Commission (2008) are increasingly using EUNIS habitat classifications with reports and legislation. EUNIS has been used for a variety of predictive habitat map projects for both research and management applications such as the Marine Habitat Mapping Framework (MESH) project (Cefas, 2014), and studies by Coggan and Diesing (2011), James *et al.* (2011), McBreen *et al*. (2011), Clark *et al.* (no date a, no date b), and the International Council for the Exploration who use it for their webGIS (ICES, 2011). These kinds of projects rely on having a homogenous habitat classification which is consistent throughout all areas (Galparasoro *et al.* 2012), The EUNIS classification system has been developed as a comprehensive system with the aim of harmonising data collection and habitat descriptions across Europe with standardised habitat identification criteria (Valentini *et al*., 2014). The net aim of the EUNIS system therefore, is to produce a standardised Europe wide habitat mapping procedure, making all studies directly comparable and compatible.

4.4.1.3 Limitations within the current EUNIS system

Galparsoro *et al*. (2012) recognise known existing inadequacies of the EUNIS system in identifying specific regional habitats such as in the Mediterranean and Black Sea areas. While updates to the EUNIS system have attempted to rectify this, it is suggested that the overall representation is still poor. With this in mind, it seems entirely justified to evaluate the system's suitability elsewhere.

Galparsoro *et al.* (2012) point out that EUNIS habitat classes are not always equivalent at a given level of the EUNIS system. While rock and sediment environments are differentiated at EUNIS level 2, other factors are less well dealt with. Biological zone characteristics are used to delineate more detailed classes, however these are introduced at different hierarchical levels. A map classified to EUNIS level 3 will discriminate biological zones in areas classified as rock (*e.g.* EUNIS classes A3 or A4), but not in sedimentary habitats (*e.g.* EUNIS class A5) (Galparsoro *et al*., 2012). Indeed, the only way to represent biological zones in all habitats is to classify rock habitats to EUNIS level 3 and sediment habitats to EUNIS level 4.

In a study by Dauvin (2014) looking at English Channel habitat classification, it is suggested that the EUNIS A4 and A5 classes particularly lack sufficient detail to identify the wealth of existing rock and sediment habitats. Dauvin (2014) suggests the addition of level 2 detail to classes accounting for information on the forms of the rocks and presence of ribbon and dune bedforms, including dune wavelength, and evidence of anthropogenic activity. It is also pointed out that North American EUNIS equivalent Coastal and Maritime Ecological Classification Standard (CMECS) already takes such morphology into account.

James *et al*. (2011) raised concerns regarding the lack of representation of thin sediment veneers. James *et al*. (2011) proposed classes extend EUNIS A3.x and A4.x at EUNIS level 3, allowing for rock with a thin layer of sediment <0.5m thickness to be identified. Further level 4 classes are also suggested. This therefore attempts to recognise that it is not always possible to define an area as entirely rock or entirely sediment, rather, it can be a mixture of both. A potential difficulty with this is the need to quantify the actual thickness of the overlying sediment layer, in order to properly justify the classification as a 'thin sediment layer' as opposed to simply 'sediment', especially where sediment layers approach the upper limit of the proposed thickness. Leading on from this, it is perhaps difficult to perceive how such an observation could be made reliably from methods such as ground truth videos, grab samples, and diver observations, as a so called 'thin sediment layer' approaching 0.5m thickness is likely to look very similar or identical to one of greater than 0.5m thickness. In the EUNIS habitat classification report, Davies *et al*. (2004) acknowledge that there are limitations to the system, and that revisions to the system are an ongoing research process.

Suggestions to add classes 'on the fly' have been made (*e.g.* James *et al*., 2011; Dauvin *et al*., 2008; Dauvin, 2014), however, this causes problems when it comes to the compatibility of the data with other existing or future surveys, as the custom classes mean that the data are no longer directly comparable. This is perhaps counterproductive, as it inhibits aforementioned advantages by Galparasoro *et al.* (2012) and Valentini *et al*. (2014) of the homogeneous, standardised EUNIS system.

Some of the issues raised above concerning mixtures of rock and sediment are in fact partially dealt with when data are classified to higher EUNIS classification levels. At EUNIS level 4, within EUNIS class A3, A3.1 (Infralittoral rock and other hard substrata, Atlantic and Mediterranean high energy infralittoral rock), which describe exclusively rock habitats at level 3 and 4, descriptions of sediment covered rock at EUNIS level 4 onwards are introduced. For example, class A3.12: Sediment-affected or disturbed kelp and seaweed communities. Within the A3.12 class, sediments are accounted for further at EUNIS level 5. Examples include, but are not limited to:

A3.124: Dense *Desmarestia* spp. with filamentous red seaweeds on exposed infralittoral cobbles, pebbles and bedrock;

A3.125: Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock;

A3.128: Pontic *Cystoseira barbata* on exposed cobbles, boulders and bedrock mixed with and scoured by sand.

Similarly, EUNIS class A4 also contains sediment descriptions at higher classification levels. Specifically within class A4.21: Echinoderms and crustose communities on circalittoral rock. At higher EUNIS levels, classifications describing sediment are added, for example:

A4.213: *Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock;

A4.2141: *Flustra foliacea* on slightly scoured silty circalittoral rock.

Indeed, it could be argued that James *et al.* (2011) may have overlooked the detail of the higher EUNIS classifications in describing rock environments covered in thin sediment. None the less, this detail is lost when habitat maps are produced to a lower EUNIS level using the current system, which is perhaps more representative of the point James *et al.* (2011) have made. Further examination and comparison of EUNIS codes with ground truthing can be found in Appendix 4.

4.5 Bathymetric modelling

4.5.1 Broad scale model

The broad scale bathymetry model was produced from acoustic survey data collected by Sussex IFCA's vessel *Watchful*. These were interpolated to produce a broad scale bathymetric model for the entire district at 230m resolution. A Kriging modelling approach was selected, as this provided the most robust model when compared to more deterministic methods (e.g. Inverse Distance weighting (IDW)). The calculated error estimates indicated that the Kriging model had a mean vertical accuracy of +/-1.7m. The Root-Mean Square Standardised value was close to 1, and the Root-Mean-Square and

Average Standard Error had similar values, suggesting a good model (ESRI 2012). The mean and mean standardised errors were close to zero, which indicated that the data and predicted errors were unbiased, and predicted known values well. Finally, the regression value was close to one, which suggested a strong correlation between the predicted and observed values. A summary of the predicted errors is found in Table 8 Kriging bathymetric model predicted error values.

Table 8 Kriging bathymetric model predicted error values

Error Prediction	Value
Samples	199014 of 199014
Mean	-0.00149
Root-Mean-Square	1.670
Mean Standardised	-0.000778
Root-Mean-Square Standardised	0.873
Average Standard Error	1.912
Regression function (R Squared)	0.969

The broad scale bathymetric model provided a complete bathymetric raster model of the Sussex IFCA district at approximately 230m resolution.

4.5.2 Fine scale

The fine scale bathymetry were sourced from third party sources, and prediction and error values cannot be calculated in such detail from secondary data. However, Table 3 provides the core metadata for each fine scale bathymetry model. The coverages are of small extents, and the resolution ranges between 1 metre and 2 metres. This is of such exceptional quality that bed forms such as sand bars, ridges, and shipwrecks can be identified. For example, it is possible to identify the SS Barnhill outside Sovereign Harbour in Eastbourne (Figure 56).

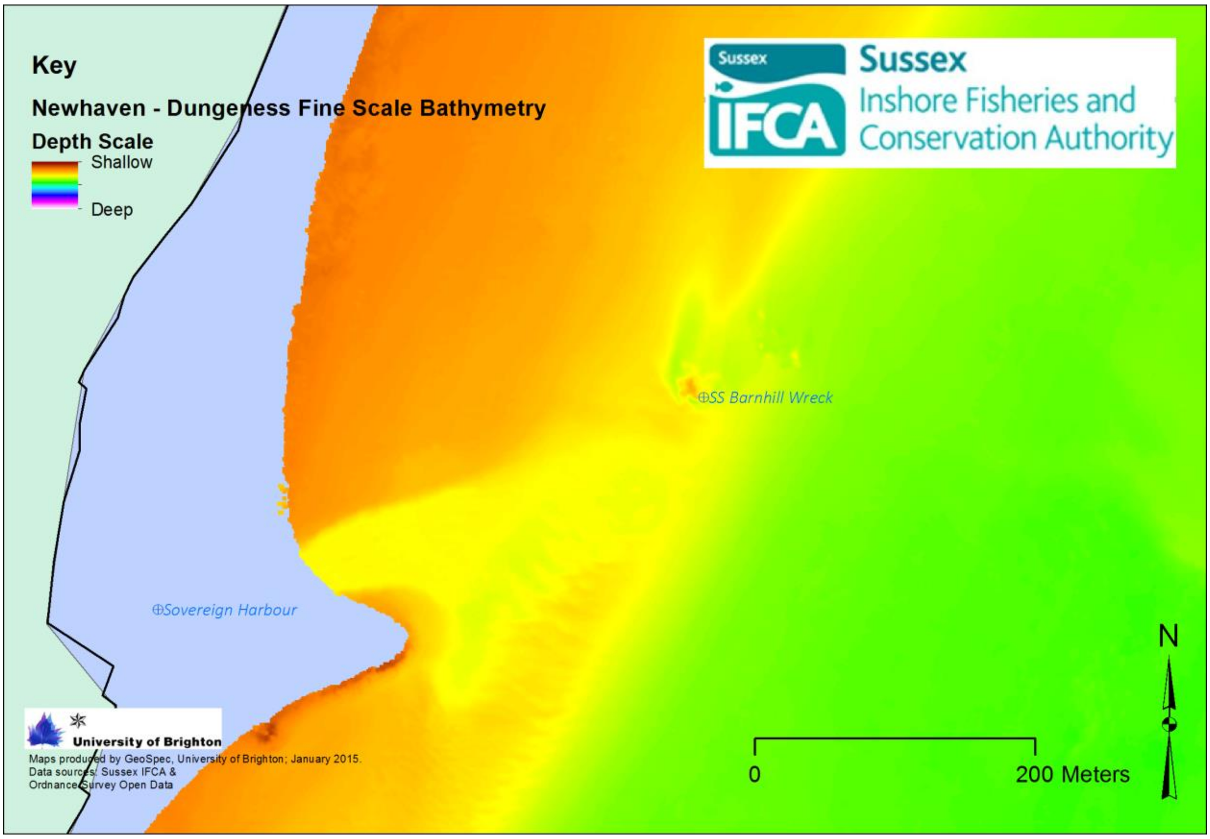

Figure 56 Fine scale bathymetry off of Sovereign Harbour, Eastbourne, showing the SS Barnhill wreck adjacent to the entrance channel. Contains public sector information, licensed under the Open Government Licence v2.0 (National Archives, no date), from CEFAS.

4.6 Summary

Four broad scale habitat maps have been generated, compared and discussed. These broad scale habitat maps were found to have different predicted habitat extents, especially at EUNIS level 3. The analysis shows that the JNCC UK Sea Map 2010 and EUNIS Sussex 2010 are broadly similar, and appear the most robust based on comparative analysis and available metadata. These habitat models predicted mostly A3 coded habitat, with A4 and A5 in lesser extents.

The fine scale maps were generated from available point data. These data were used to generate voronoi polygons to provide a continuous representation of habitat distribution within the Sussex IFCA district. The fine scale habitat models were classified mostly to EUNIS level 3 and 4, but in some cases to level 5 and 6.

Finally, when the fine scale data were compared with the broad scale mapping, it is a combination of the RoxAnn and EUNIS South East which appear to be the best broad scale representation. These suggest A5 to be dominant throughout the Sussex IFCA district, with A3 and A4 in small areas. Given the discrepancies, a review of the EUNIS system has been provided. A bathymetry data model has been generated for the entire Sussex IFCA district and cross-validation shows this to be a good model based on predicted errors. Fine scale bathymetry data has been sourced and provided where available.

5 Conclusions

5.1 SCHIP 2 Aim

The main aim of the SCHIP 2 project was to explore and analysis existing sea floor habitat and bathymetric data available for the Sussex IFCA district, with a view to creating a broad scale and fine scale predictive habitat map for the district, suitable for use in marine conservation management. In addition, a broad scale seafloor bathymetry map of the Sussex IFCA district was to be produced suitable for public engagement, as well as fine scale bathymetric data where available. In order to achieve this, a series of objectives were outlined, and the project split into two main themes: Habitat mapping; and bathymetry mapping. The objectives outlined at the beginning of this project report are discussed in turn.

5.2 Habitat findings

- *Collate existing available habitat data sets*

Existing habitat datasets were identified. These were divided into the following subcategories: (i) Broad scale habitat and (ii) fine scale habitat. In each case, the data sources were carefully studied and the best possible metadata was sourced in order to evaluate their relevance and quality. In total, four broad scale habitat data sets were identified: (i) EUNIS Sussex from the MALSF Synthesis study by James *et al*. (2011); (ii) UK Sea Map 2010 from the JNCC and associated report by McBreen *et al*. (2011); (iii) EUNIS South East from the study by Coggan and Diesing (2011); and (iv) RoxAnn AGDS study by Envision, reported by Clark *et al*. (no date a). All broad scale habitat data were vector polygon data.

Three data sets were identified as suitable for fine scale mapping. These included: (i) ALSF 2007 data reported by Clark *et al.* (no date b); (ii) Seasearch 1992-2005 surveys (Seasearch, no date a); and (iii) Seafish 2008 which comprised a localised survey off of Eastbourne. All fine scale habitat data were vector data and comprised discrete point data sets. All data were EUNIS coded, and in most cases to EUNIS levels 3 and 4 with some extending to EUNIS levels 5 or 6.

- *Identify areas of data conflict, data agreement, and areas with no available data*

Both broad scale and fine scale habitat data were analysed for areas of data conflict, data agreement and areas of no data.

Of the broad scale habitat data sets, only RoxAnn did not have full area coverage for the entire Sussex IFCA district. The remaining data sets were clipped to provide a full coverage of the Sussex IFCA district. Where these data sets overlapped, their predicted EUNIS habitat classifications at a given point were compared and agreement between data assessed. The comparative analysis showed that the predicted habitat distributions differed substantially between data sets.

The three fine scale data sets were combined to produce overall single EUNIS classified data set, and together provided coverage throughout the Sussex IFCA district. Point coverage was not evenly distributed, and analysis demonstrated that data points were significantly clustered. Some areas showed lower than average point clustering. Clustering was assessed using relevant geo-statistical techniques. The absence of coinciding points between data sets meant that independent validation of points was not possible beyond visual analysis of trends.

- *Evaluate the usefulness of the MESH confidence assessment and use it to examine the data quality for each data set*

The quality of the data sets were assessed through secondary analysis of the available survey reports associated with each data set. These were used as metadata. The MESH Confidence Assessment tool (MESH, 2010) was used to assess individual surveys. The MESH Confidence Assessment process provided a standardised method for assessing survey quality, although a degree of subjectivity remains. The EUNIS Sussex 2010 and RoxAnn data were tested, the UK Sea Map 2010 and EUNIS South East Survey were not able to be assessed via MESH methods. EUNIS Sussex 2010 was found to be of good quality, whilst RoxAnn was found to be poor.

- *Produce maps showing high, medium, low confidence levels, based on the quality of data and cross comparisons between independent data sets*

Confidence maps were produced for both the broad scale and fine scale data sets, however the processes and methods in each case were different. The differences in confidence mapping methods resulted from the broad scale data being supplied as polygon data, and the fine scale data being supplied as point data.

The polygon broad scale data restricted the extent of geostatistical analysis undertaken (e.g. data distribution). However, it did allow data intersection and cross-validation where the attributes from all four data sets were combined and compared in one polygon layer. From this spatial cross validation, comparison maps were generated and. Cross validation showed that, less than a third of the total area of Sussex IFCA district showed agreement between three or more data sets at EUNIS level 2. At EUNIS level 3, agreement was reduced to less than a fifth of the area. To summarise, there is very little overall agreement between the four broad scale habitat data sets.

Fine scale habitat confidence maps were created based on the spatial distribution of point data throughout the district. Kernel Density mapping and Optimised Hotspot Analysis have been used as proxies for spatial confidence. High and low confidence areas were identified. Direct cross validation between point data sets was not been possible as no coincidental points existed. However, similar patterns are inferred among point data sets.

- *In areas of data conflict between different habitat data sets, select areas with highest confidence to put forward into a final habitat model*

Areas of high spatial confidence were identified between the different habitat data sets. However, given the large level of data conflict, the areas of high confidence were small in extent. As a result, the district was mapped displaying the level of confidence for each predicted EUNIS class. Additionally, the EUNIS Sussex 2010 and JNCC UK Sea Map were suggested to have the highest level of agreement between data sets. Therefore areas where the JNCC UK Sea Map and EUNIS 2010 agree were mapped separately.

The fine scale data were displayed in a similar manner, and incorporated spatial confidence. Confidence contours were used to delineate levels of confidence, and all data points were used in the final outputs. Finally the method used to display the fine scale habitat data (Voronoi analysis) meant that both habitat type and spatial confidence can be inferred from the final habitat map.

- *Produce spatially broad scale habitat model of the Sussex IFCA district to EUNIS level 3, following or adapting existing approaches by Robinson et al. (2009) used in the Habmap sea floor habitat mapping project in order to produce standardised output maps*

Using the methods outlined in the Habmap Irish sea project by Robinson *et al*. (2009), habitat maps were created for each EUNIS habitat class individually. Each habitat map was colour coded according to the confidence level at a given location. In addition, a habitat map for the JNCC UK Sea Map 2010 and EUNIS Sussex 2010 data was produced.

- *Produce spatially fine scale map of specific areas where there is sufficient data to do so, to EUNIS level 3, suitable for use as evidence for management*

A EUNIS level 2 point map was produced from the fine scale data. To avoid data generalisation and data exaggeration (from overlapping symbols) the point data were extrapolated over larger areas using the Voronoi polygon approach. This method created a detailed full coverage EUNIS level 3 map showing the overall trends in the data. Smaller voronoi polygons represented a greater number (density) of survey points (and less extrapolation) whereas larger voronoi polygons represented a lesser number (density) of survey points (and greater extrapolation). In summary, voronoi polygon were used to represent EUNIS habitat type, and voronoi polygon size acted as a proxy for inferred spatial confidence. It is believed that this 'additional' attribute data might be useful at a management level for identifying areas of low point coverage (confidence) which could be targeted for future surveys.

- *Develop confidence map for the broad scale and fine scale EUNIS coded habitat maps*

An overall confidence map for both broad scale and fine scale habitat models is difficult to produce due to the high level of data conflict between the data sets. The fine scale data sets predict A5 sublittoral sediment to be dominant, with small inshore areas of A3 Infralittoral rock and other hard substrata localised more inshore, and small areas of localised A4 Circalittoral rock and other hard substrata. This differs greatly from that which was predicted by the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 maps, both of which suggest A3 to be the dominant habitat type, intermixed with smaller areas of A5 and localised patches of A4.

It is important to consider that the fine scale habitat data are derived from visual surveys of the sea bed by trained Seasearch divers, and ALSF interpreted ground truth videos specifically within the Sussex IFCA district. Conversely, the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 data are derived from remote sensing and broad scale acoustic surveys, covering far greater extents than the Sussex IFCA district. For this reason, it could be inferred that the fine scale data are a more reliable picture of the seafloor habitat.

With this in mind, and in support of this assertion, there is a very strong correlation between the fine scale data and the RoxAnn data, especially if the EUNIS South East data are used to extend this to cover the entire district. Interestingly, this similarity between these broad and fine scale surveys is contrary to the observation that MESH analysis suggests the data to be of a comparatively lower quality, especially the RoxAnn data. Moreover, further meta-analysis of the approaches used in the original RoxAnn surveys and classification suggests that the RoxAnn survey used Seasearch data as ground truth points. This may explain why there is such high agreement between these classification methods.

The broad scale comparison maps suggested the two areas of high confidence habitat can be found; The Four Fathoms Sand Ridge near Hastings, and a small inshore area off of Brighton. Both of these are A5 and A5.2 habitats. These areas concur with the fine scale data. The fact that the metadata for the EUNIS Sussex 2010 and JNCC UK Sea Map 2010 scale data infers that they are of high quality, it is difficult to draw any further conclusions with a degree of confidence without carrying further bespoke studies within the area. A possible contributing factor to this disagreement is, perhaps, the ambiguity of the EUNIS system itself. The EUNIS classification can have ambiguous and broad class descriptions at low EUNIS levels such as levels 2 and 3, especially when compared with higher levels. EUNIS is also restrictive and perhaps inadequate when trying to represent habitats which contain both rock and sediments, to varying degrees.

- *Where there is sufficient data, develop a method for mapping to EUNIS level 4 or greater*

Modelling to EUNIS level 4 and greater has been possible with fine scale data. These were mapped using the voronoi methodological approach developed for this research project. Most of the district can be mapped to EUNIS level 4, and smaller areas can be mapped to EUNIS levels 5 and 6.

- *Produce habitat maps to the highest possible EUNIS level, suitable for informing management decisions and directing future survey work.*

EUNIS level 5 and 6 coded locations have been identified, however, the results of this study suggest that the level of EUNIS detail should not be the driver for future study. Rather, data conflict and areas of survey effort suggest that a bespoke district wide survey with detailed ground truthing is perhaps needed. The spatial confidence maps, especially the fine scale confidence maps, can be used to prioritise areas where there is currently low survey effort. Fine scale data have been used to produce the highest level EUNIS maps, and can be validated by the ALSF ground truth videos. This ground truthing provides a degree of spatial confidence for the fine scale data which is not possible for the broad scale data. The fine scale derived voronoi maps provide a detailed regional characterisation of the Sussex IFCA district suitable for informing decisions at a management level, and are perhaps the most reliable source of information due to the nature of the data being derived from first hand observations of the seafloor.

5.3 Bathymetric mapping

- *Collate bathymetric data*

Both broad scale and fine scale bathymetric data sets have been collated and produced. The broad scale bathymetric data cover the entire district at a cell size resolution of 230 metres, while the fine scale data are localised, ranging between 1 metre and 2 metre resolution.

- *Produce a continuous, interpolated broad scale bathymetric raster model of the Sussex IFCA district, scaled with appropriate colours, suitable for education and public engagement*

The fine scale data are supplied using third party data sets, which were supplied as interpolated continuous raster data. The broad scale data has been interpolated from point data collected by Sussex IFCA's vessel *Watchful*. 200,000 data points were interpolated using the Kriging statistical interpolator method. The resulting raster can be rendered in 3D, and is suitable for use in public engagement and education.

6 Recommendations

It is strongly recommended that a bespoke survey, or series of bespoke surveys, are undertaken throughout the entire Sussex IFCA District. These coordinated surveys should be undertaken to produce a reliable, high resolution habitat map of the entire Sussex IFCA district. This should include extensive ground truthing to provide an independent accuracy assessment, and could be designed with the MESH Confidence Assessment methodology in mind. If this approach were adopted it would provide a standardised method and assist in the future management and monitoring of this important marine environment.

Additional survey work is required in areas of high data conflict and in areas, identified in the fine scale habitat maps, with low confidence (re: Kernel Density Estimations and Hot Spot Analysis of the area around Beachy Head, which contains a low confidence area and a data cold spot could provide a pilot area in which to test new methods.)

The fine scale voronoi predictive habitat models were validated in sample areas against contemporary Multi Beam echo-Sounder (MBES) surveys and habitat maps (see Fernández Alonso & Burnside, 2013) to assess accuracy. Cross validation suggested a strong associated with these independent data. The study highlights the importance of citizen science data (e.g. Seasearch) in developing an increased understanding and knowledge of the habitats in this region and others throughout the UK. More developed seabed habitat maps are crucial for the success of current and fisheries management. Seasearch was originally implemented by the JNCC in the 1990's, after it was acknowledged that a growing number of non-professional divers offer a great deal of knowledge and enthusiasm relevant to the collection of sea floor habitat data (Seasearch, no date a). Specific training courses were developed and specific survey forms were used to record a variety of geographical, physical, and biological aspects at a given location. This ensures high quality data can be collected at a comparatively low cost, making use of readily available 'citizen science'.

The current Seasearch data has proven to be of great value to this study, offering unparalleled first hand observations. Within the Sussex IFCA district, these data are between 10 and 23 years old, therefore the active promotion of further Seasearch studies would be greatly beneficial, and would offer a low cost means of cross validating current data, and increasing the resolution of the voronoi model provided in this study. Furthermore, the fine scale data confidence maps developed in this study could be utilised to prioritise areas of low data coverage, which could be targeted for future Seasearch diving expeditions. Seasearch shares common values with Sussex IFCA, such as to raise public awareness of the diversity of marine life and habitats through the dissemination of information gathered and the identification of issues arising from it, and to make quality assured data available to partner organisations and the general public (Seasearch, 2009).

Very little research has been done into seasonal changes in habitats, and how this might affect EUNIS classifications taken at different times of year. This could be an additional factor which has affected the assessment and prediction of habitats within the marine environment. This is not something that could be assessed within the current research project, but should be considered in any future projects which seek to predict and map habitats within the Sussex IFCA district. Furthermore, the EUNIS classification is an evolving system and one that in its present form has been found to have limitations. Some habitats which are mixtures of sediments and rocks are not well represented within the EUNIS system and should be considered in future revisions (Galparsoro *et al.*, 2012; Coggan and Diesing, 2011; Galparsoro *et al.,* 2010).

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8 Appendices

8.1 Appendix 1: Converting none standard codes to EUNIS

The EUNIS Sussex 2010 data and RoxAnn data were supplied using none standard classifications. It is important to establish a standardised conversion or translation method, which is repeatable and non subjective. This section describes a standardised conversion method.

8.1.1 EUNIS Sussex 2010 data conversion to EUNIS

The EUNIS Sussex 2010 associated report by James *et al*. (2011) gives a conversion table for converting between a modified version of the Marine Nature Conservation Review (MNCR) classification system and the modified EUNIS Codes. The original MNCR classification system was used to derive the standard EUNIS coding system, and as such the Joint Nature Conservation Committee (JNCC) provide a conversion table between the two systems.

The MNCR system uses blocks of letters to describe the habitat type, each block separated by a full stop (“.”). For example: MNCR code “IR” represents “Infralittoral rock (and other hard substrate)”, which translates directly to EUNIS level 2 code “A3”. MNCR Code IR.HIR represents “high energy infralittoral rock”, and translates directly to EUNIS level 3 code A3.1. “IR.HIR.KFaR” refers to “Kelp with cushion fauna and/or foliose red seaweeds” and translated directly to EUNIS level 4 code “A3.11”, *etc*.

In addition, all MNCR codes beginning “IR” translate as EUNIS level code beginning “A3“, all MNCR codes beginning “IR.HIR” refer to “A3.1”. All MNCR Codes beginning IR.MIR equate to EUNIS A3.2. This consistency is important, and allows the modified MNCR codes to be converted into their standard EUNIS equivalents. The Modified MNCR codes used by James *et al.* (2011) differ from the standard equivalent with the addition of “thS” at the end of the second block of letters. This was added in to represent thin sediments as part of the habitat classification. This has been removed to convert to standard EUNIS codes, as shown in Table 9.

Table 9 Conversion between none standard EUNIS 2010 codes by James et al. *(2011) and standard EUNIS codes*

EUNIS 2010	MNCR 2010	Description	EUNIS	MNCR	Description
A3.8	IR.HIRthS	High energy infralittoral rock and thin sediment	A3.1	IR.HIR	High energy infralittoral rock
A3.9	IR.MIRths	Moderate energy infralittoral rock and thin sediment	A3.2	IR.MIR	Moderate energy infralittoral rock
A3.A	IR.LIRthS	Low energy infralittoral rock and thin sediment	A3.3	IR.LIR	Low energy infralittoral rock
A4.8	CR.HCRthS	High energy circalittoral rock and thin sediment	A4.1	CR.HCR	High energy circalittoral rock
A4.9	CR.MCRthS	Moderate energy circalittoral rock and thin sediment	A4.2	CR.MCR	Moderate energy circalittoral rock
A4.A	CR.LCRthS	Low energy circalittoral rock and thin sediment	A4.3	CR.LCR	Low energy circalittoral rock

It should be noted that there is a degree of subjectivity to any kind of habitat classification. In their study, James *et al*. (2011) argue that the standard EUNIS codes are not always suitable for representing the habitat types present within their study area, specifically when dealing with mixed sediment and rock environments (discussed in the main report), and use this as their justification for adding additional none standard classes. The classes account for the presence of thin sediment overlaying rock. Within standard EUNIS classification, in order to acknowledge the presence of sediment, areas must be classified as A5, which doesn't acknowledge the solid underlying rock. The problem being that standard EUNIS doesn't allow for the acknowledgment of the existence of both themes at EUNIS level 3. By converting these areas back, this detail is lost.

James *et al*. (2011) suggest that where sediments are present on the sea floor, these are classified as A5 only where they are greater than 0.5m in thickness. This suggests that the inference made was that the underlying rock type took priority in habitat classification over sediment in areas with sediment coverage of less than 0.5m thickness. By conserving the level 2 EUNIS classification during the conversion process, the spirit of the original classification is maintained as best possible.

However it is noted that this conversion creates a compromise and loss of information. This is unavoidable and necessary in order to achieve compatibility and comparability with the majority of other data sets.

8.1.2 RoxAnn AGDS data conversion from none standard classes to standard EUNIS classes

The RoxAnn data layer as described by Clark *et al*. (no date a) contains 11 discrete classes, as shown in Table 10. These classes and descriptions are taken from the report by Clark *et al*. (no date a).

The RoxAnn data originate from acoustic surveying done in the mid 1990's, preceding the implementation of EUNIS codes in 2001 (JNCC, 2014a).

Instead, a bespoke coding system was developed based on calibration of the original acoustic dataset through ground truthing. The original classification is given by Clark *et al*. (no date a) and shown in Table 10. Using expert knowledge and interpretation, these codes have been converted with to EUNIS level 3 codes. The conversion can be found in Table 10. This conversion has been added to the RoxAnn attribute table and used in the output maps. It is noted that the EUNIS descriptions are perhaps more generalised than the original RoxAnn classes.

Table 10 RoxAnn EUNIS Conversion

RoxAnn Class	Description	EUNIS Code (level 3)	Description
1	Kelp and/or algae on inshore reefs	A3.2	Atlantic and Mediterranean moderate energy infralittoral rock
2	Algal turf on offshore reefs	A3.1	Atlantic and Mediterranean high energy infralittoral rock
3	Silty faunal turf on bedrock and boulders	A4.3	Atlantic and Mediterranean low energy circalittoral rock
4	Mussel beds on bedrock	A4.2	Atlantic and Mediterranean moderate energy circalittoral rock
5	Rich algal turf on cobble	A5.1	Sublittoral coarse sediment
6	Sparse mixed algal/faunal turf on cobble	A5.1	Sublittoral coarse sediment
7	Silty faunal turf on deep boulder/cobble	A5.1	Sublittoral coarse sediment
8	Sparse faunal turf on cobbles	A5.1	Sublittoral coarse sediment
9	Mussel beds on sand	A5.6	Sublittoral biogenic reefs
10	Sand	A5.2	Sublittoral sand
11	Sand and cobble	A5.4	Sublittoral mixed sediment

8.2 Appendix 2: Kernel Density Estimation

This section looks at the use of Kernel Density Estimation and the methodology behind that used in the SCHIP 2 study. Kernel Density Estimation (KDE) mapping is used to assess the spatial distribution of the data points.

A critical part of kernel density models is defining the search radius or bandwidth, as this dictates the amount smoothing of the point pattern (Williamson *et al.*, 1999). A large search radius will produce a generalised output, where as a small search radius will generate localised, specific output. There are a variety of methods which have been defined for the calculation of the kernel density search radius (*e.g.* Raykar and Duraiswami, 2006; Kuter *et al.*, 2011), however despite its importance, no recognised standard has been agreed upon. Indeed, Willamson *et al*. (1999) criticise the default search radius generated by ArcMap for being too arbitrary, and not taking into account the characteristics of the spatial distribution of the data, ArcMap takes the shortest width of the output extent, and arbitrarily divides that by 30. Williamson *et al*. (1999) and Orava (2011) propose that it is meaningful to calculate the search radius based on the calculated average distance between the data points. This statistic can be calculated in ArcMap using the Average Nearest Neighbour tool in the ArcToolbox, which generates the expected and observed nearest neighbour distances. This method succeeds in accounting for the spatial distribution of points.

Because of the lack of a recognised standard approach, a selection of kernel density search radii were tested, and expert judgement has been used to choose the one which best fits the data in this report.

The search radius is given in the default map units. Because the data used are projected in British National Grid, the units are metres. A variety of search radii were tested, and the optimal models were chosen for the basis of further KDE analysis. As suggested by Orava (2011), Average Nearest Neighbour calculations have been used to derive the search radii from the observed and expected nearest neighbour statistics. Where a more generalise surface is desirable, these have been multiplied up by factors of 10, until a suitable surface is reached. Expert judgement has ultimately been used to discern the most suitable search radius. Using this method offers a standardised and repeatable approach. KDE outputs are expressed in arbitrary units, the units themselves are not comparable between different maps.

The resulting continuous KDE surfaces have been classified into categories, which can be used to produce confidence contours. The data are heavily skewed, and therefore assumed not be normally distributed. Natural Jenks classification system has been used to split the data into classes. This has been chosen for the way in which it categorises data based on natural groupings of data values (Longley *et al*. 2007), and suitability for none parametric data. This process is illustrated in Figure 57 and Figure 58.

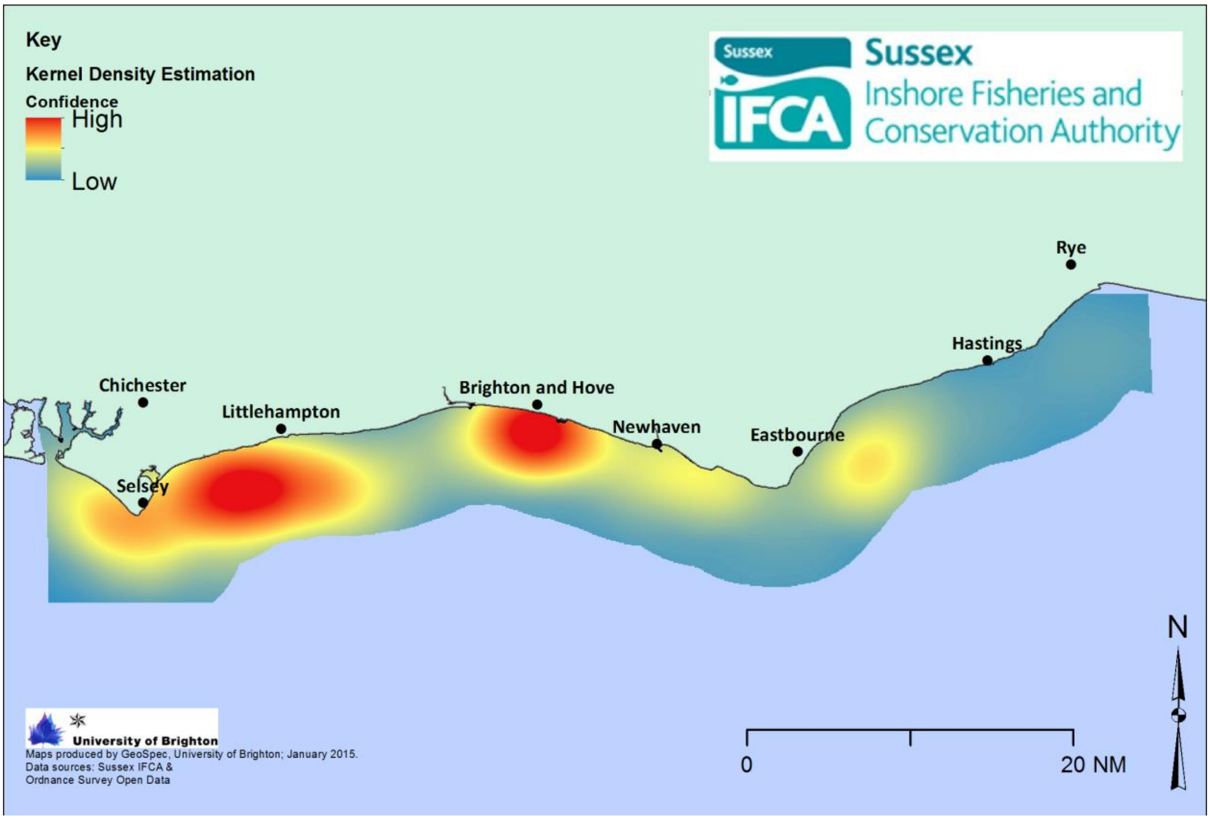


Figure 57 Kernel Density Estimation based on the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 combined survey points.

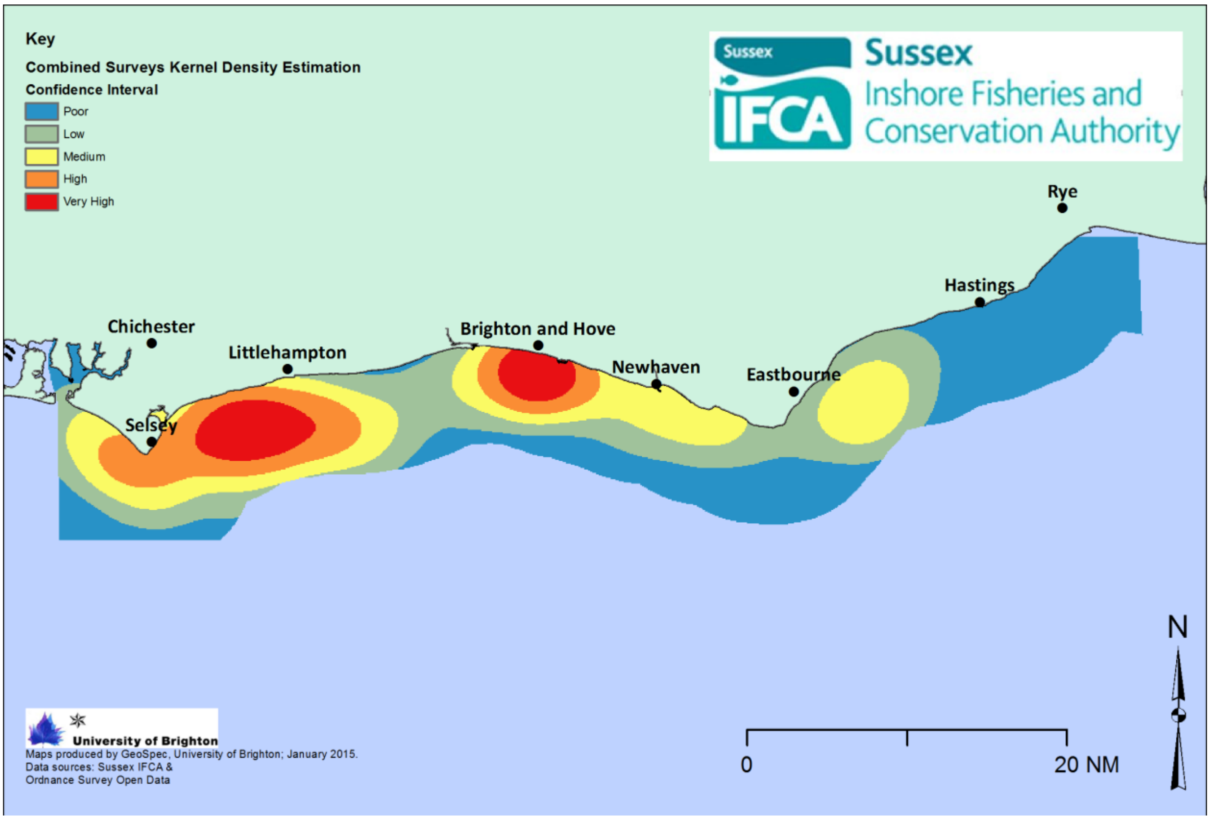


Figure 58 Kernel Density Estimation based on the combined Seasearch 1992-2005, ALSF 2007, and Seafish 2008 combined survey points. The output surface has been arbitrarily delineated using Jenks natural break class divisions

The resulting kernel density surface can be seen in Figure 58. Here the values have been divided into five classes, classified using the Jenks natural breaks method. These are used as arbitrary confidence intervals, based on the density of points. Areas of high point density are displayed as areas of high confidence.

8.3 Appendix 3 Explanation of bathymetric interpolation model

8.3.1 Choice of Interpolation method: Inverse Distance Weighting versus Kriging.

IDW is often chosen for its simplicity, requiring less statistical data analysis and computing time to produce an optimised model (Yasrebi *et al.*, 2009; Taniar *et al.*, 2010). IDW employs Tobler's first law of geography: "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970), a concept referred to as spatial autocorrelation. Any unknown point must be less than the largest known point but greater than the smallest known point, producing peaks and pits between known points (Longley *et al*., 2007). As a result of this, IDW's can produce a "bulls eye" effect around known points, especially where these differ greatly from other nearby known points (Taniar *et al.*, 2010). Kriging is conceptually similar to applying a regression line to a graph in order to predict variables between data points (ESRI, 2011a). This differs from IDW in that rather than construct the surface based directly on distance from measured values, Kriging uses statistical models to predict the surface, based not only on distance measured values but additionally taking into account the spatial arrangement of the known values (ESRI, 2011a). Kriging attempts to look at to what extent the data are spatially auto correlated, rather than assuming data are perfectly spatially auto correlated over infinite distances and all directions.

Although both methods were trialled, Kriging was found to produce the most accurate output surface, and was used to produce the broad scale bathymetry model for this study.

8.3.2 Statistical analysis of the distribution of known points

A Morans I test has carried out to test for statistically significant spatial autocorrelations. This has returned a p-value of <0.001 and z-score of 3301, which suggests that the data are spatially autocorrelated, with less than 1% chance that this is due to chance. The high Z-value indicates that the data are significantly clustered.

The spatial distribution for the bathymetric data were analysed using the Geostatistical Analyst toolbar, and Spatial Statistics Tools in ArcMap. Trend analysis shown in Figure 59 reveals a strong north-south longitudinal trend in the data. This is perhaps to be expected, as it infers that depth increases with distance from the shore. This would suggest a strong degree of anisotropy in the distribution of known points.

Further data trend analysis specific have been incorporated in the modelling process, and are described below under the relevant modelling process.

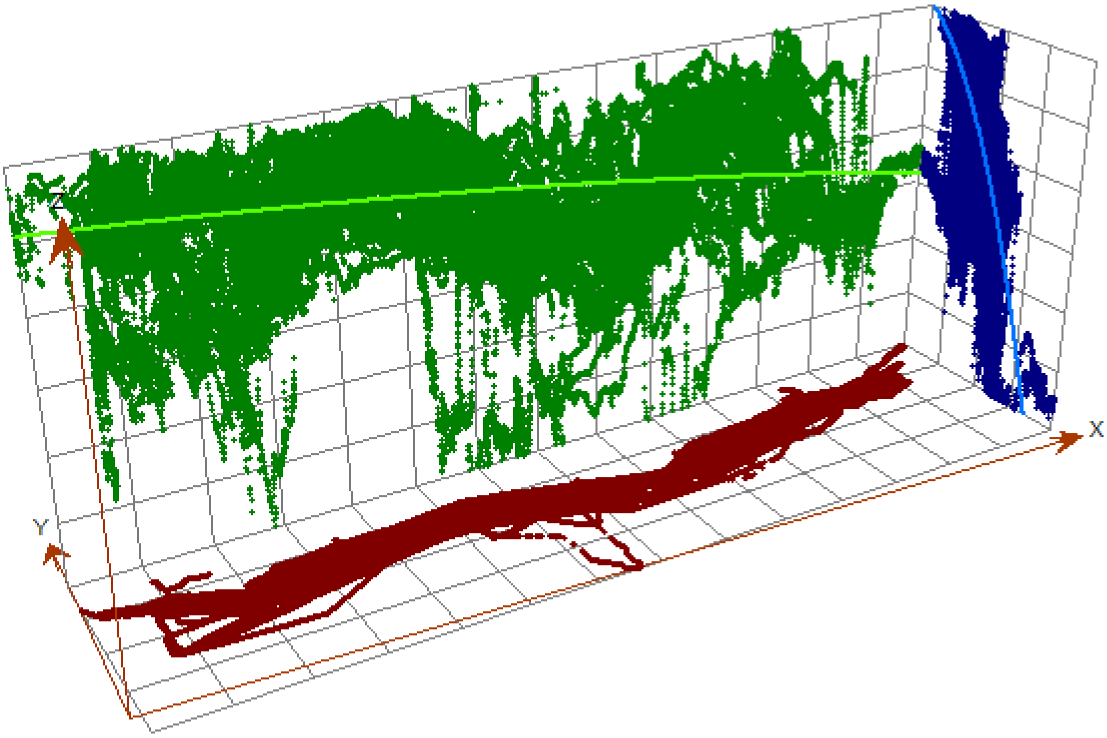


Figure 59 Three dimensional trend analysis for the broad scale bathymetric data, where the Y axis represents longitude, the X axis represents latitude, and the Z axis represents bathymetric depth

8.3.3 Kriging Model

Various models were trialled in order to find the one with the lowest predicted error. The model found to be most accurate is described here. The Kriging process goes through various aspects aimed at estimating patterns within the data, so that these can be taken into account when predicting values at unknown locations.

Ordinary Kriging has been used. A semi variogram is calculated within the Geostatistical Wizard during the Kriging process. This can be seen in Figure 60. This is designed analyse the assumption that things nearby tend to be more similar than things farther apart.

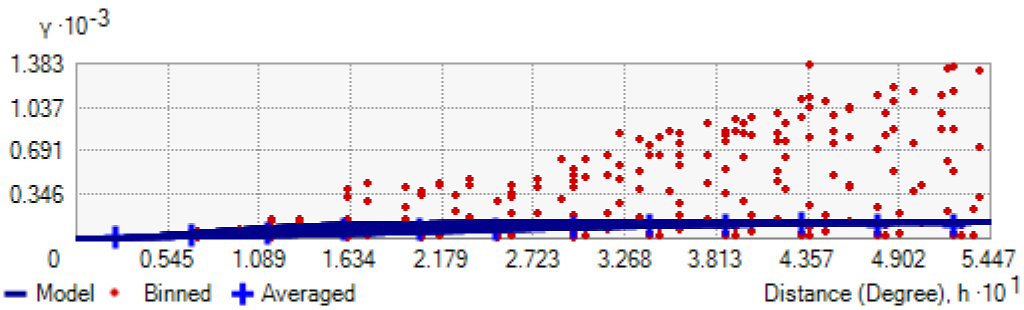


Figure 60 Semivariogram for ALLDATAMI depth points, generated within the Geostatistical Wizard in ArcMap during the Kriging process

The semivariogram plots the semivariance against the distance between points for each pair of data points. For data that are perfectly auto correlated, pairs of point close together spatially should have a small semivariance compared with pairs of points spatially further apart (Oliver, 1990; Longley et al., 2007; ESRIb, 2011). Therefore, in Figure 60, where the blue model line is steeper, a high level of spatial autocorrelation is predicted by the model, and the higher the influence these points have on the model. Where the blue model line is steep, there is evidence that points further away from any given point become less similar the farther away you look. Where the line levels out, this is no longer the case, and spatial autocorrelation no longer occurs. The blue fitted model is selected from a series of mathematical models, as the one which best fits the shape of the averaged semivariogram plots, and therefore best represents and predicts the degree of spatial autocorrelation within the data.

Because of the strong north-south trend revealed during the trend analysis, shown in Figure 59, the anisotropy setting has been set to “True”. This automatically adjusts and optimises the shape of the search radius, which is illustrated in Figure 61.

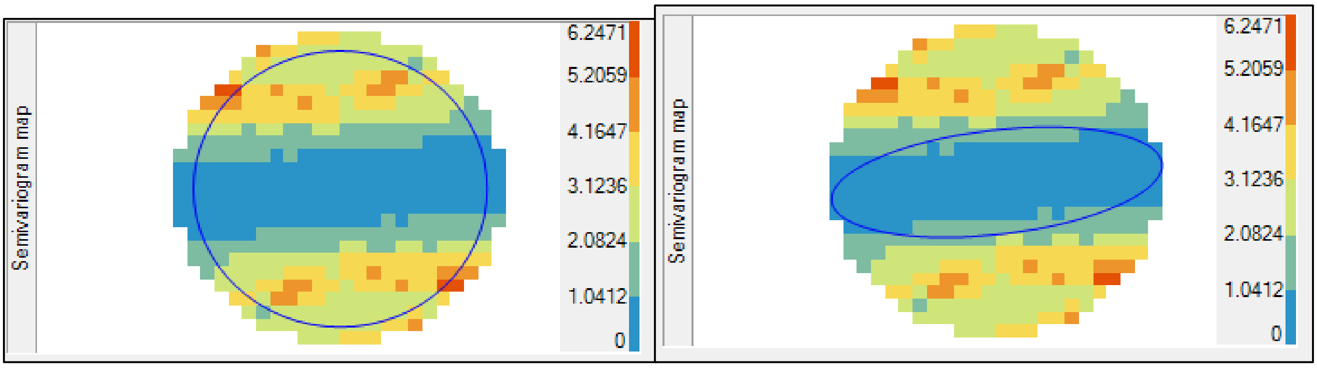


Figure 61 Semivariogram map, comparing isotropic (left) and anisotropic (right) selection methods used within Kriging in ArcMap’s Geostatistical Wizard

Additionally, the Geostatistical Wizard in ArcMap allowed for the computation of the Covariance plot during the Kriging process.

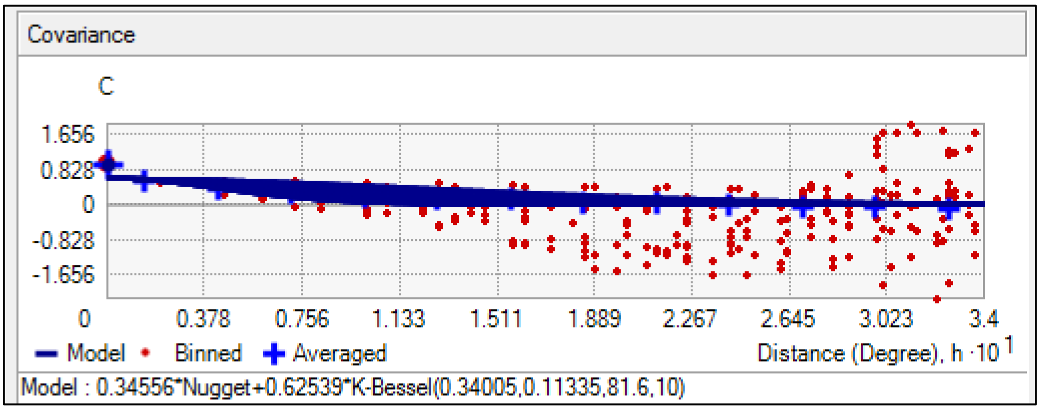


Figure 62 Covariance model, generated for the ALLDATAMI depth points, within ArcMaps Geostatistical Wizard during the Kriging process.

After visual inspection of Figure 60 and Figure 62, the Stable trend model has been chosen as the one which best reflects the spatial autocorrelation within the data.

The maximum and minimum neighbouring known points to be used within the search radius for the calculation of unknown points have been set to 10 and 30 respectively, reflecting the large number of points available, while keeping processing time down to a realistic level.

Default values calculated for the Angle, major semi axis, minor semi axis and the anisotropy factor have been taken from the variogram, and the neighbourhood type set to standard.

8.3.4 Predicted errors and final bathymetric model

Table 11 Kriging bathymetry model predicted errors

Error Prediction	Value
Samples	199014 of 199014
Mean	-0.001488241
Root-Mean-Square	1.669783
Mean Standardised	-0.0007780101
Root-Mean-Square Standardised	0.8730397
Average Standard Error	1.912397
Regression function (R Squared)	0.969435

8.4 Appendix 4 Ground truthing EUNIS classes

8.4.1 Defining EUNIS classes

Davies *et al.* (2004) (pages 4-5) provide definitions for each of the EUNIS level 2 habitat classes, including diagnostic features. Those relevant to the SCHIP 2 project are given here:

A3 Infralittoral rock and other hard substrata

Infralittoral rock includes habitats of bedrock, boulders and cobbles which occur in the shallow subtidal zone and typically support seaweed communities. The upper limit is marked by the top of the kelp zone whilst the lower limit is marked by the lower limit of kelp growth or the lower limit of dense seaweed growth. Infralittoral rock typically has an upper zone of dense kelp (forest) and a lower zone of sparse kelp (park), both with an understorey of erect seaweeds.

A4 Circalittoral rock and other hard substrata

Circalittoral rock is characterised by animal dominated communities (a departure from the algae dominated communities in the infralittoral zone). The circalittoral zone can itself be split into two sub-zones; upper circalittoral (foliose red algae present) and lower circalittoral (foliose red algae absent). The depth at which the circalittoral zone begins is directly dependent on the intensity of light reaching the seabed; in highly turbid conditions, the circalittoral zone may begin just below water level at mean low water springs (MLWS).

A5 Sublittoral sediment

Sediment habitats in the sublittoral near shore zone (i.e. covering the infralittoral and circalittoral zones), typically extending from the extreme lower shore down to the edge of the bathyal zone (200 m). Sediment ranges from boulders and cobbles, through pebbles and shingle, coarse sands, sands, fine sands, muds, and mixed sediments.

8.4.2 Comparing EUNIS defined classes to ground truthing

Although these descriptions sound initially clear cut, there sources for ambiguity and subjectivity, stemming from some of the diagnostic properties. For example, A3 clearly states that the presence of kelp growth is a key delineating factor, while this is absent from the A5 description, implying that these are mutually exclusive characteristics.

However, ground truth videos reveal that in the real world, distinguishing these habitat types is less simple. Figure 63 to Figure 66 are stills taken from ground truth videos from the Sussex coast line collected as part of the CFAS ALSF AGDS project 2007-2008. Videos G37 and G41 (Figure 65 and Figure 66) are identified as being A4, due to the presence of kelp and other fauna growing on the underlying sediment. The key aspect of this however is that the clear presence of sediment in the stills taken from the videos, which is not recognised in the A4 class description, a detail that is therefore lost, and source of error and therefore data conflict depending on which diagnostic feature (kelp or sediment) is chosen to describe that area.

In addition, it can be seen that habitats which appear to look fundamentally different are categorised under the same banner: Specifically videos GV71 and GT57 shown in Figure 63 and Figure 64. GV 71 appears to be characterised by large boulders covered in thin sediment, whereas GV 57 contains far more uniform muddy sediment. While these areas have different appearances, on a map they will be assigned identical classifications.

Habitat Classification GV71

Eunis code	A4.23
Eunis name	Communities on soft circalittoral rock

Figure 63 ALSF Ground truthing from within the Sussex IFCA district

Habitat Classification GT57

Eunis code	A4.23
Eunis name	Communities on soft circalittoral rock

Figure 64 ALSF Ground truthing from within the Sussex IFCA district

Habitat Classification GT41

Sussex Inshore Fisheries and Conservation Authority

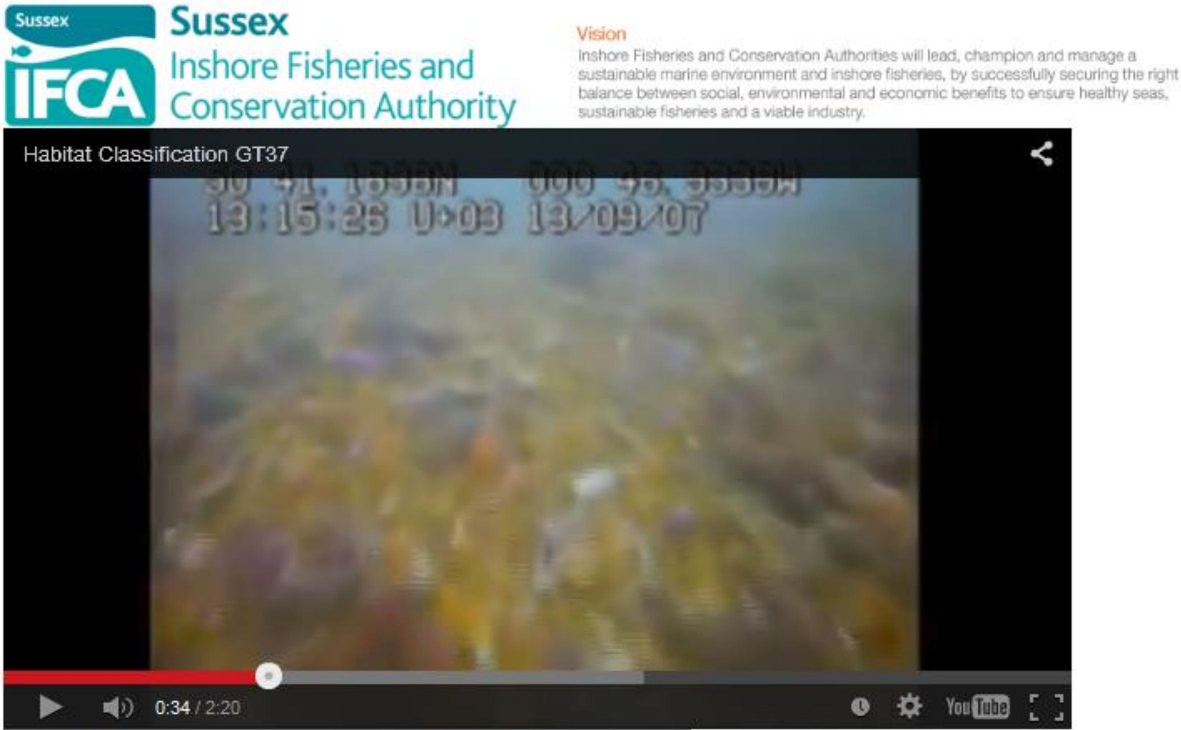
Vision

Inshore Fisheries and Conservation Authorities will lead, champion and manage a sustainable marine environment and inshore fisheries, by successfully securing the right balance between social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry.

Eunis code	A4.23
Eunis name	Communities on soft circalittoral rock

Figure 65 ALSF Ground truthing from within the Sussex IFCA district

Habitat Classification GT37



Eunis code	A4.2
Eunis name	Atlantic and Mediterranean moderate energy circalittoral rock

Figure 66 ALSF Ground truthing from within the Sussex IFCA district