UKSeaMap 2010 Technical Report 6

Comparison of UKSeaMap 2010 predictive habitat map with other predictive habitat maps and maps derived from surveys

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1 Introduction

Several seabed habitat datasets now exist for parts of the UK; these fall into two categories:

1. Habitats mapped using survey data – data are collected, stored and standardised at JNCC according to guidance from the MESH project (www.searchMESH.net); and

2. Habitats predicted using hydrographical, oceanographic and geological data – for example, UKSeaMap.

The first category includes studies ranging from maps covering national or regional seas such as those maps of seabed sediments produced by national geological agencies, to more detailed local studies such as maps of the habitats present in marine protected areas. Many of these existing studies mapped the seabed habitats present using a classification system appropriate to the study. The MESH project translated these maps into the EUNIS classification. The online mapping portal is updated by the JNCC with new survey maps as they become available and can be freely viewed and downloaded by the public (see www.searchMESH.net/webGIS).

The MESH project also developed a method of assessing the reliability of habitat maps for their purpose. Only MESH survey maps which had overall confidence scores higher than 58% are discussed in this analysis as we can be certain that maps with these scores were derived using both remote sensing and ground-truthing data; the extent of these maps is shown in Figure 1.

Another product of MESH was a predictive EUNIS habitat map (henceforth the MESH predictive map)covering the exclusive economic zones of the UK, Ireland, France, Belgium and the Netherlands (Figure 2; Coltman *et al*, 2008), an example of the second category of habitat maps described above. A predictive habitat map created using a slightly different approach to that of MESH and UKSeaMap is HABMAP, which covers the Irish Sea (Figure 3; Robinson *et al*, 2009).

Because of the existence of various habitat datasets for UK waters, it must be decided which map to use in different circumstances in order to make these maps useful for management and policy decisions. Therefore a general comparison with the habitat maps from survey data and the MESH and HABMAP modelled outputs is presented in this report.

The modelling methods of the MESH, HABMAP and UKSeaMap 2010 projects are summarised in Table 1, as well as the methods used in the original UKSeaMap project (Connor *et al*, 2006). UKSeaMap 2006 mapped broadscale habitats that did not follow the EUNIS classification, hence it is not appropriate to directly compare UKSeaMap 2006 with UKSeaMap 2010; and it is not discussed further in this report.

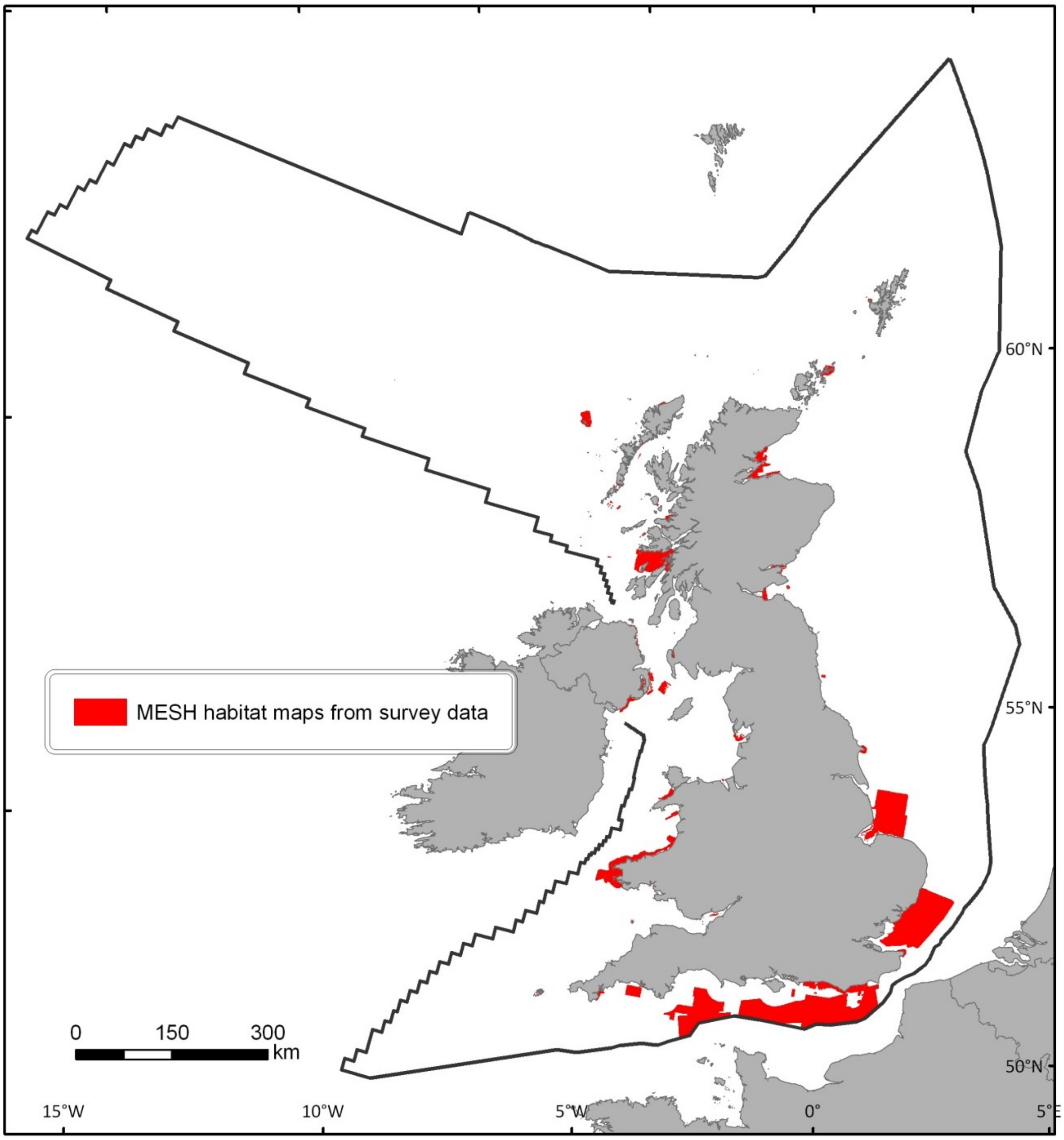

Figure 1: Coverage of MESH habitats maps produced from survey data with a MESH confidence score of 58% or higher – equivalent to high or very high confidence.

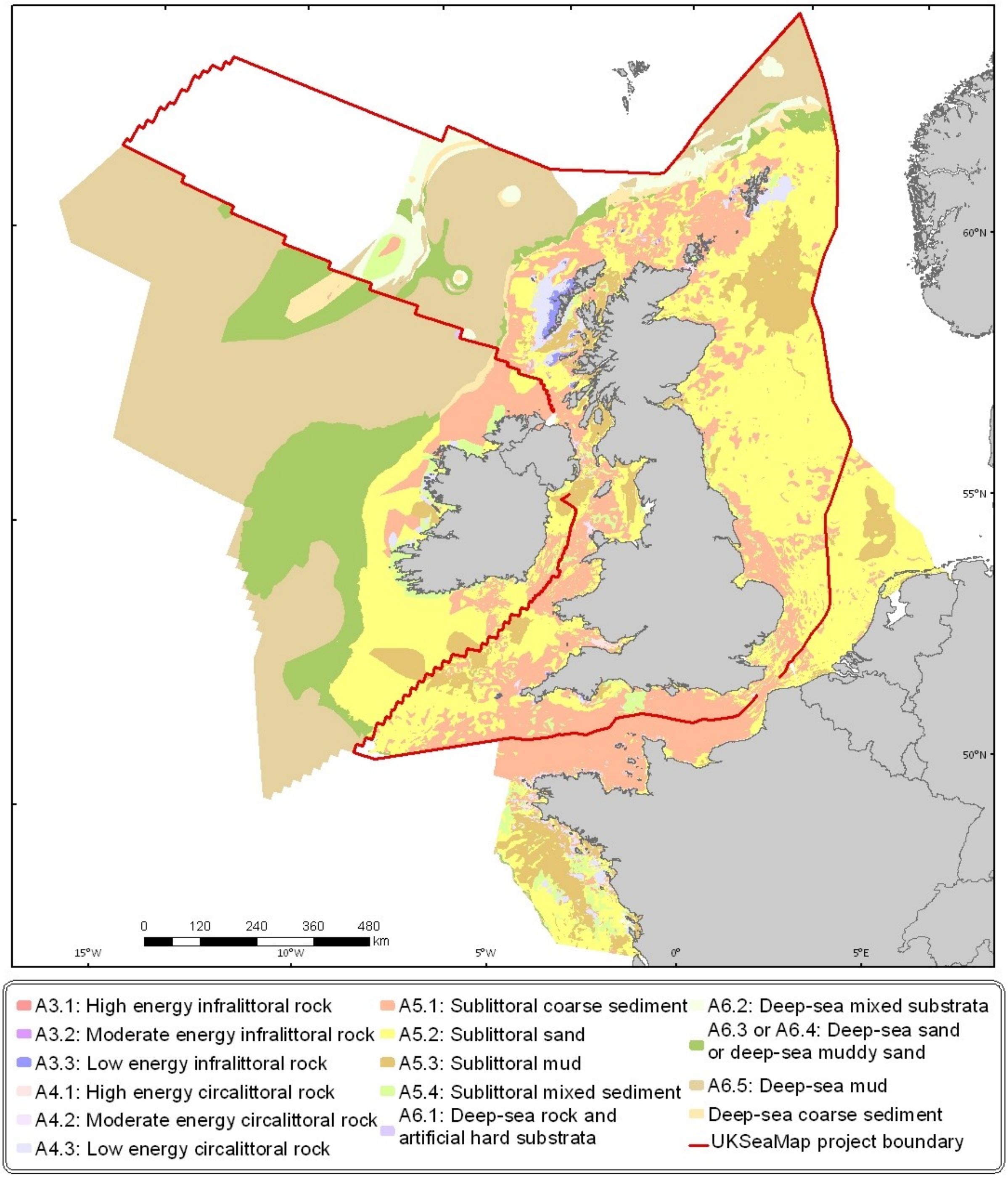

Figure 2: MESH EUNIS level 3 predictive habitat map (Coltman *et al*, 2008).

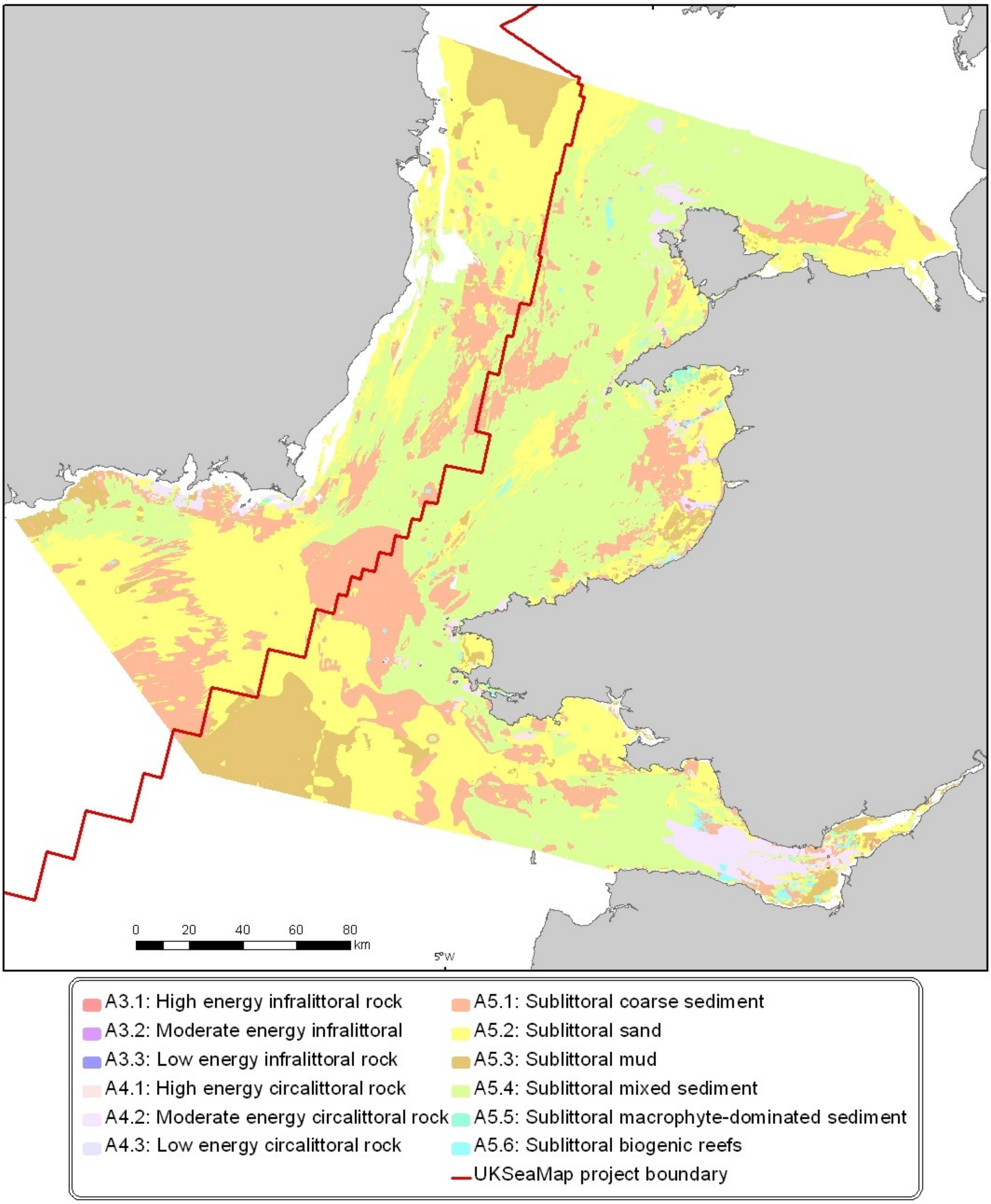

Figure 3: HABMAP EUNIS level 3 predictive habitat map (Robinson *et al*, 2009).

Table 1: Comparison of different habitat modelling methods used in the UK.

	UKSeaMap (2004 – 2006)	MESH (2004 – 2008)	HABMAP (2004 – 2010)	UKSeaMap (2009 – 2010)
Classification system	Broadscale habitats (not EUNIS)	EUNIS	Marine Habitat Classification of Britain & Ireland	EUNIS
GIS approach	Vector net (standard polygon size & shape)	Raster	Vector (unrestricted polygons)	Raster
Equivalent EUNIS level	3 or 4	3 or 4	4 or 5	3 or 4
Resolution	Fine – 0.02° Coarse – 0.5°	0.0025°	Variable polygon sizes	0.0025°
Seabed substrata	5 classes	5 classes	43 classes	5 classes
Salinity	Not used	Not used	6 classes	2 classes
Biological zones	Aphotic Photic Shallow Shelf	Infralittoral Circalittoral Deep circalittoral Deep sea	Infralittoral Circalittoral Offshore[1]	Infralittoral Circalittoral Deep circalittoral Slope Upper bathyal Mid bathyal Lower bathyal Abyssal
Energy	**Shear stress** Currents	**Shear stress** Currents	**Shear stress** Waves Currents	**Kinetic energy** Waves Currents
Biogeography	Warm deep-water Cold deep-water	Not used	Not used	Arctic Atlantic
Citation	Connor *et al* (2006)	Coltman *et al* (2008)	Robinson *et al* (2009)	McBreen *et al* (2011)

[1] Offshore is the term used in the Marine Habitat Classification of Britain & Ireland, and is exactly equivalent to the deep circalittoral zone, which is the term used in the EUNIS classification system.

The MESH EUNIS model was based on a similar technique to UKSeaMap 2010. However, data resolution and/or number of sources have increased in UKSeaMap 2010 for all of the physical input layers. The main differences in modelling technique, as seen in Table 1 are:

- UKSeaMap 2010 uses kinetic energy from waves and currents to classify high, moderate and low energy environments while the MESH EUNIS model used shear stress due to currents.

- UKSeaMap 2010 uses an additional five biological zones to classify deep sea areas, as well as identifying estuarine areas. Note: for comparison purposes, the additional deep sea biological zones were aggregated to one “deep sea” class, which is the zone used in the MESH model.

- The UKSeaMap 2010 analysis considers two biogeographic zones, which were not part of the MESH model, and were therefore not included in the comparison.

The approaches to UKSeaMap 2010 and HABMAP differ in that while UKSeaMap uses a ‘top-down’ approach, i.e. determining broadscale habitats using oceanographic and geophysical data, the technique used by HABMAP is more ‘bottom-up’, which uses oceanographic and geophysical data to extrapolate and interpolate between biological point data. The process is less rigid than that of UKSeaMap and as a result, biological information for an area may override the physical data when defining biotopes beyond EUNIS levels 3 and 4.

The HABMAP modelling technique involved predicting several possible biotopes for an area and assigning confidence scores to each predicted biotope in each polygon. Some polygons have up to 40 possible biotopes. When referring to the biotopes predicted by HABMAP, unless otherwise stated, the author is referring to the map composed of the biotopes with the highest confidence scores.

1.1 Aims

This report aims to assess the similarities and differences between the predictive habitat maps produced by UKSeaMap 2010 and those of HABMAP and MESH, as well as the habitat maps produced as a result of localised surveys. Where differences occur, explanations are sought and conclusions are made about the most suitable maps to use for different purposes.

2 Methodology

The UKSeaMap 2010 predictive habitat map was compared with the survey maps and HABMAP and MESH predictive habitat maps separately using a combination of the ArcGIS 9.2 GIS package, Microsoft Access 2007 and Microsoft Excel 2007. The steps for the comparisons are summarised below:

2.1 ArcGIS 9.2

The layer for comparison and the UKSeaMap layer were first clipped to the area where they overlapped. A Union operation was then performed, which created one layer with attributes from both layers in it; at this point each polygon had one habitat code for the comparison layer and one for the UKSeaMap layer. The area of each polygon was calculated and the value added to the attribute table.

2.2 Microsoft Access 2007

The attribute table was imported and two queries were performed on the data – one to compare EUNIS codes (i.e. the habitat assigned to a polygon) and one to compare different components of that habitat assignment (biological zone, substrate and energy). The queries created additional Boolean fields that indicated whether or not in a certain row, the codes match.

For the survey habitat maps and HABMAP an extra step was involved – the habitat components described above (biological zone, substrate and energy) had to be assigned based on the biotope code (see Table 2). This is because habitat components were not involved in the HABMAP modelling process in the same way as they were in UKSeaMap 2010 and MESH and they are not used in creating habitat maps from surveys. This extra step was incorporated into the query for comparing components.

Crosstab queries were then run to produce pivot tables for each habitat component and for EUNIS level 3, to show the area for which the codes match.

2.3 Microsoft Excel 2007

Areas were converted to proportions of the total area predicted for each UKSeaMap habitat type and plotted as bar charts.

Table 2: Translation from EUNIS 2007-11 (corresponding to Marine Habitat Classification 04.05 used in HABMAP), to habitat components used in UKSeaMap 2010. '*' refers to the given biotopes as well as all higher level EUNIS biotopes associated with it. 'x' means the habitat component cannot be derived from the EUNIS description.

EUNIS code	Biological zone	Substrate	Energy
A1*	x	x	x
A2*	x	x	x
A3	*infralittoral*	*rock*	x
A3.1	*infralittoral*	*rock*	*high*
A3.11	*infralittoral*	*rock*	*high*
A3.12	*infralittoral*	*rock*	*high*
A3.2	*infralittoral*	*rock*	*moderate*
A3.21	*infralittoral*	*rock*	*moderate*
A3.22	*infralittoral*	*rock*	*moderate*
A3.225	*infralittoral*	*rock*	*moderate*
A3.3	*infralittoral*	*rock*	*low*
A3.31	*infralittoral*	*rock*	*low*
A3.32	*infralittoral*	*rock*	*low*
A3.36	*infralittoral*	*rock*	*low*
A3.71	x	x	x
A4	*circalittoral or deep circalittoral*	*rock*	x
A4.1	*circalittoral*	*rock*	*high*
A4.11	*circalittoral*	*rock*	*high*
A4.12	*deep circalittoral*	*rock*	*high*
A4.13	*circalittoral*	*rock*	*high*
A4.2	*circalittoral*	*rock*	*moderate*
A4.21	*circalittoral*	*rock*	*moderate*
A4.22	*circalittoral*	*rock*	*moderate*
A4.23	x	x	x
A4.24	*circalittoral*	*rock*	*moderate*
A4.25	*circalittoral*	*rock*	*moderate*
A4.27	*deep circalittoral*	*rock*	*moderate*
A4.3	*circalittoral*	*rock*	*low*
A4.31	x	x	x
A4.33	*deep circalittoral*	*rock*	*low*
A4.72	x	x	x

EUNIS code	Biological zone	Substrate	Energy
A5	x	x	x
A5.1	x	x	x
A5.11	x	x	x
A5.12	*estuarine*	*coarse sediment*	x
A5.13	*infralittoral*	*coarse sediment*	x
A5.14	*circalittoral*	*coarse sediment*	x
A5.15	*deep circalittoral*	*coarse sediment*	x
A5.2	x	x	x
A5.22	*infralittoral*	x	x
A5.23	*infralittoral*	x	x
A5.24	*infralittoral*	x	x
A5.25	*circalittoral*	*sand & muddy sand*	x
A5.26	*circalittoral*	*sand & muddy sand*	x
A5.27	*deep circalittoral*	*sand & muddy sand*	x
A5.3	x	x	x
A5.32	*infralittoral*	*mud & sandy mud*	x
A5.33	*infralittoral*	*mud & sandy mud*	x
A5.34	*infralittoral*	*mud & sandy mud*	x
A5.35	*circalittoral*	*mud & sandy mud*	x
A5.36	*circalittoral*	*mud & sandy mud*	x
A5.37	*deep circalittoral*	*mud & sandy mud*	x
A5.4	x	x	x
A5.42	*infralittoral*	*mixed sediment*	x
A5.43	*infralittoral*	*mixed sediment*	x
A5.44	*circalittoral*	*mixed sediment*	x
A5.45	*deep circalittoral*	*mixed sediment*	x
A5.5*	x	x	x
A5.6*	x	x	x
B*	x	x	x

3 Results and Discussion

3.1 UKSeaMap 2010 compared to the MESH EUNIS model

3.1.1 Comparing habitat components

The effect of the improvement in data and changes to the modelling method is that the proportions of each biological zone, substrate type and energy class and therefore the predictive EUNIS maps are changed to some extent (Figure 4). Table 3 gives a summary indication of the extent to which the habitat components used in UKSeaMap 2010 and MESH are similar.

Table 3: Extent to which data from UKSeaMap 2010 and MESH predictive maps match at three habitat components.

Habitat component	Total area (km^2)	Area of matching codes (km^2)	Area of matching codes (% of total area)
Biological zone	701,912	600,563	**86**
Substrate type	701,912	600,681	**86**
Energy class	701,912	307,900	**44**
Energy class (infralittoral or circalittoral rock only)	43,064	12,554	**29**

Energy enters the EUNIS classification at level 3, but is only used for classifying infralittoral and circalittoral rocky habitats; therefore the matching area for energy was also calculated for only areas mapped as rock and infralittoral or circalittoral in UKSeaMap. Energy accounts for the largest difference between habitat components used in the two models; represented by a shift from the large amount of low energy areas in the MESH model to more moderate energy areas in UKSeaMap (Figure 4 and Figure 5).

The large difference is due to a combination of the following:

1. Only current data were considered in MESH, while both waves and currents are considered in UKSeaMap. The addition of wave data in UKSeaMap 2010 is likely to be responsible for a large part of the difference, this can be clearly observed in the pattern of energy classes (Figure 5 (A to C)).

2. Kinetic energy of water at seabed was used in UKSeaMap, whereas seabed shear stress was used in MESH. As a result, the numeric energy values of cells and hence the thresholds between energy levels are not equivalent in the two projects. The difference between how current energy in UKSeaMap and MESH is classified can be seen by comparing Figure 5 (B and D), respectively.

3. Better resolution data were used in UKSeaMap; this will alter the maps at a fine scale; however the majority of the differences in extent of the energy classes appear to be due to points 1 and 2, above.

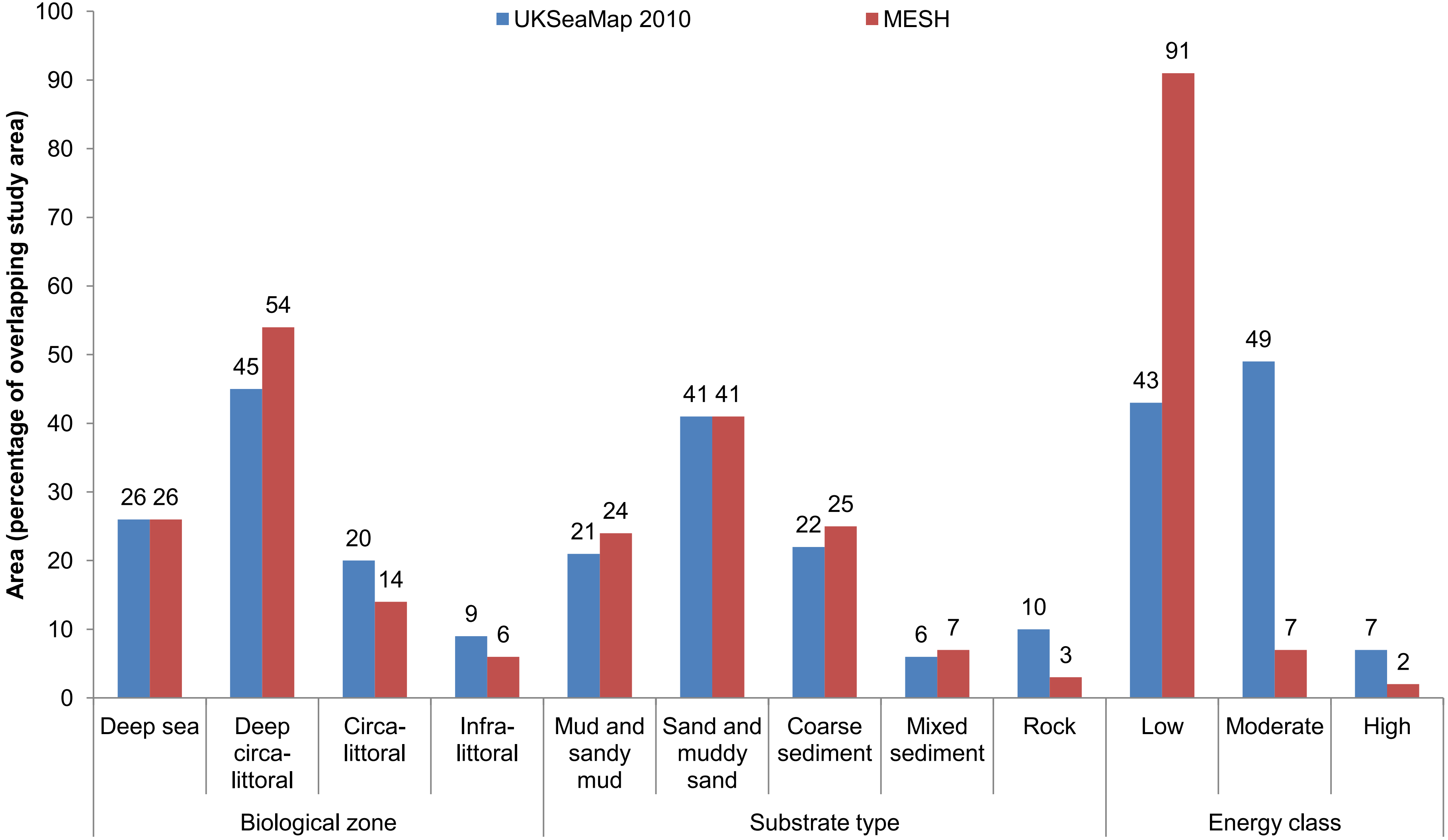

Figure 4: Extent of biological zones, substrate types and energy classes predicted by UKSeaMap 2010 and MESH.

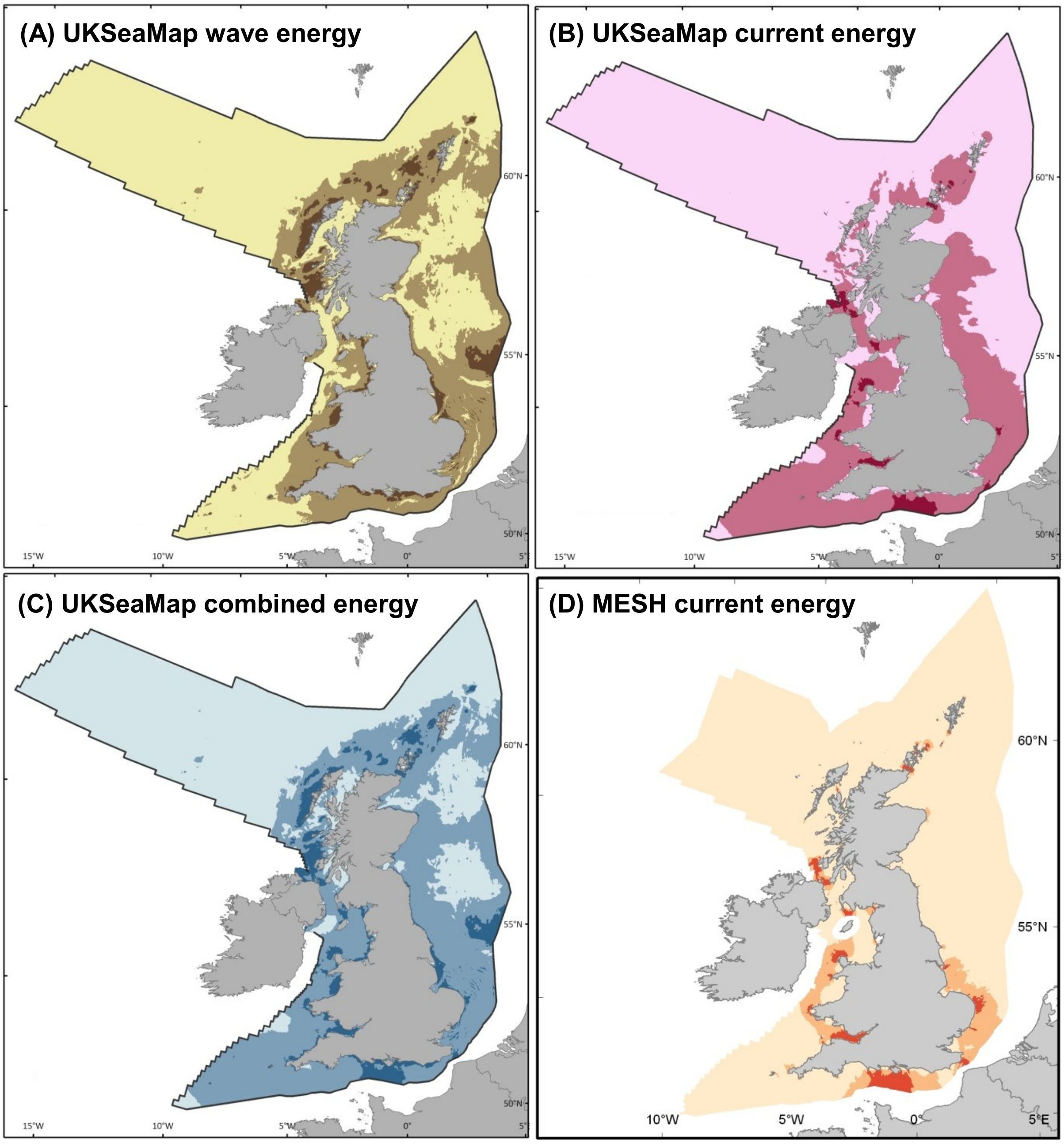

Figure 5: Energy classes used in UKSeaMap (A) to (C) and MESH (D). UKSeaMap used kinetic energy due to the combined effect of currents and waves (image C) and MESH used bed shear stress due to currents (image D) to determine energy classes. Darkest shades are high energy, medium shades are moderate energy and lightest shades are low energy areas.

It can also be seen in Figure 4 that the infralittoral zone in UKSeaMap covers a greater percentage of the overlapping area than in the MESH model (9% and 6% respectively). This is the effect of UKSeaMap using the 1% threshold for percentage of surface light reaching the seabed, as opposed to 2.36% (as in MESH),which shifts the infralittoral-circalittoral zone boundary to deeper water, with a resulting increase of 50% in the area of the infralittoral zone in UKSeaMap relative to MESH (see Figure 6 (A)). For the justification behind the change in light threshold, see Technical Report 2.

A decrease in extent of the deep circalittoral zone and increase in the extent of the circalittoral zone in UKSeaMap relative to MESH is visible in Figure 4 and Figure 6 (B). This is a result of the improved method for determining the extent of the region of wave disturbance at the seabed. In creating the layer used in MESH, the 12km ProWAM grid of wave periods was translated into wavelengths and subsequently interpolated to the 300m model grid. The steps for creating the layer used in UKSeaMap were reversed; the wave periods were interpolated to the 300m grid first, then the wavelengths were calculated.

This approach is an improvement “since wavelength is a function of the square of the wave period but is also strongly dependent upon water depth. The spatial variation in wave period is therefore considerably less than that of wavelength … [which] removes a potential source of errors” (Frost & Swift, 2010). Another improvement for UKSeaMap is that whereas MESH used the NOC (then POL) ProWAM model alone to calculate the wave base, UKSeaMap used a combination of ProWAM and Cefas field data to create a probability layer of wave disturbance. On comparison of the ProWAM and Cefas data, it was found that ProWAM tends to underestimate wave periods by a small amount (Frost & Swift, 2010).

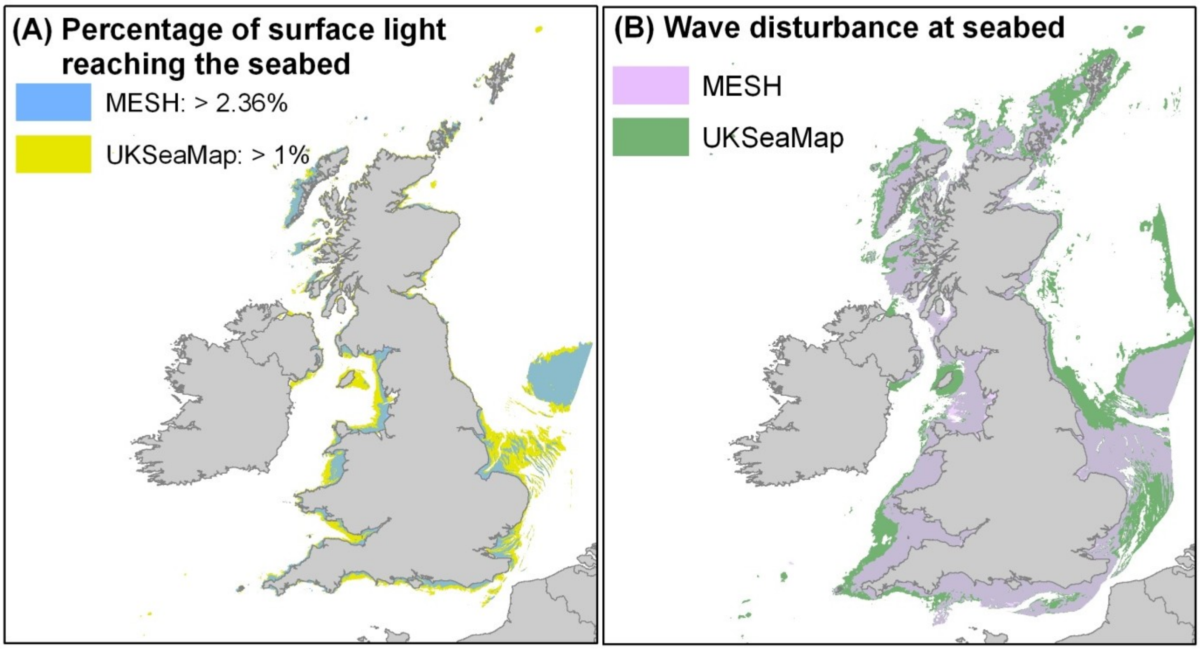

Figure 6: Comparisons between data used in UKSeaMap and MESH models. (A) Photic zone – used to define the infralittoral-circalittoral zone boundary. (B) Areas where the seabed is disturbed by waves – used to define the circalittoral-deep circalittoral zone boundary. Note: in each case, the spatial extent of the MESH data is less than that of the UKSeaMap data; therefore the former layer is placed on top of the latter in each case.

Another notable difference in Figure 4 is the larger extent of rock in UKSeaMap and differences in extent of all substrate types except sand and muddy sand. Figure 7 shows the spatial extent of the mismatching areas; while disagreements in the rock data are widespread, differences in all other substrate types are especially concentrated in the deep sea area. These are caused by the following:

- **Rock**: Gafeira *et al* (2010) explain that much of DigSBS250 version 1, the substrate dataset used in the MESH model, was based exclusively on the contents of samples, with particle size analysis used to assign a sediment type. However, the procedure did not account for the poor recovery of rock samples and therefore DigSBS250 version 1 is known to consistently underestimate the total amount of rock at the seabed. Since MESH, multiple data sources have been re-analysed to improve the quality of the rock data (Gafeira *et al,* 2010). Because of the inclusion of larger amounts of acoustic data, the UKSeaMap substrate data shows rock at or within 0.5m of the seabed, rather than 0.1m, which was used in the original UKSeaMap and MESH projects (Connor *et al*, 2006, Coltman *et al* 2008).

- **Deep sea substrate**: since the conclusion of the MESH project, substrate data for the deep sea area has improved substantially – in terms of quality and quantity of data – as a result of the inclusion of deep sea survey data from the National Oceanographic Centre (NOC) (Jacobs and Porritt, 2009).

The inset in Figure 7 shows the largest patch of sediment disagreement outside of the deep sea area. The relatively straight edge along the northeast of the sand and muddy sand region suggests that this area may not have been mapped to a very high level of detail and may require more survey data to resolve this edge.

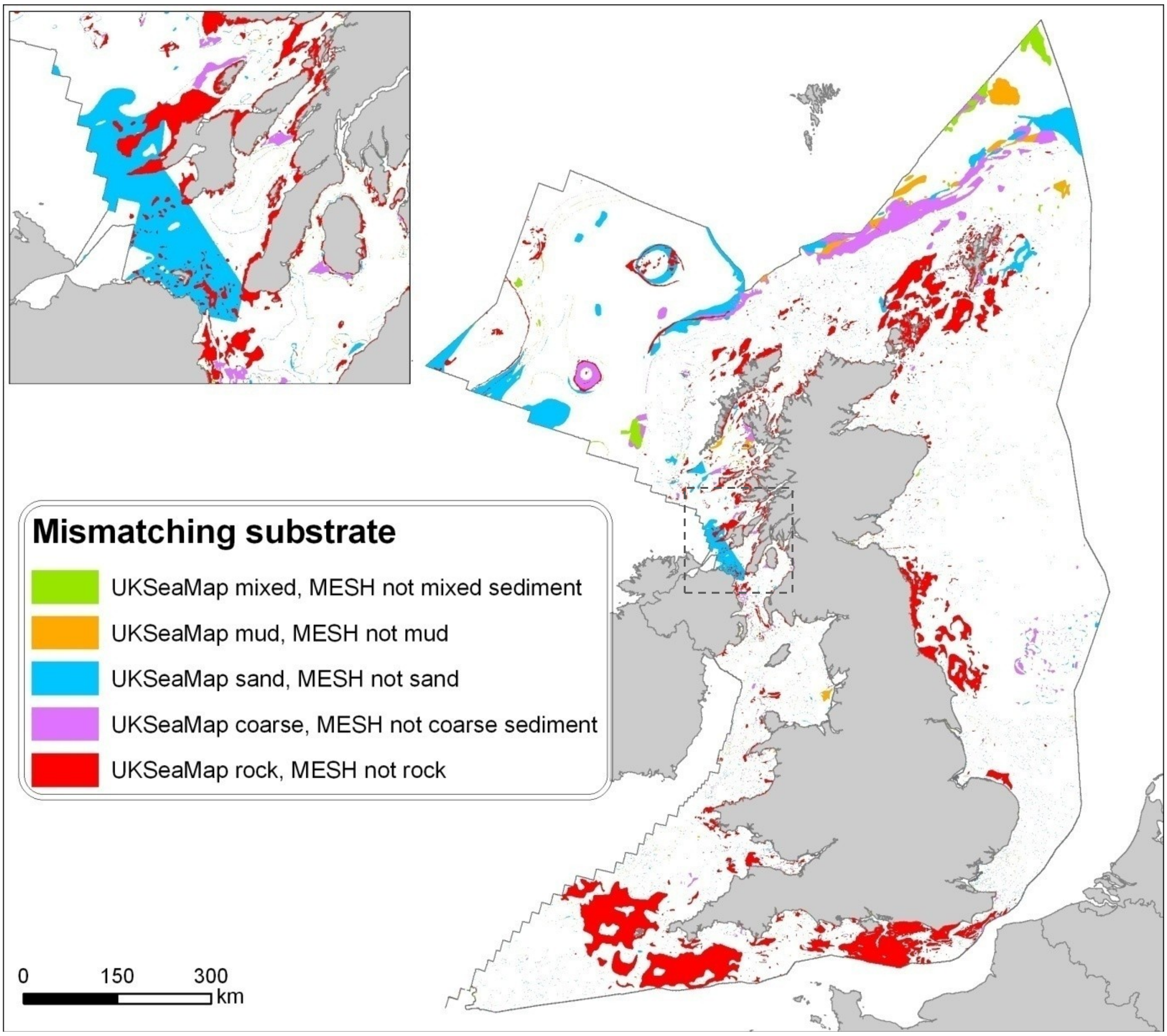

Figure 7: Regions where UKSeaMap substrate data do not agree with substrate data used in the MESH model. Inset: possibly dubious sand and muddy sand region in UKSeaMap substrate layer.

3.1.2 Comparing predicted EUNIS habitats

The effect of the differences discussed in Section 3.1.1 on the amount of agreement between predicted EUNIS habitats is summarised in Table 4. The total area differs for EUNIS level 4, and is less than the total of 701,912km^2 because only some areas in each model are classified as far as level 4. Figure 8 shows the proportion of individual EUNIS level 3 habitats predicted by UKSeaMap 2010 that match each EUNIS level 3 habitat predicted by the MESH EUNIS model.

Table 4: Extent to which UKSeaMap 2010 and MESH predictive maps match at three EUNIS levels.

EUNIS level	Total area (km^2)	Area of matching codes (km^2)	Area of matching codes (% of total area)
2	701,912	626,870	**89**
3	701,912	580,963	**83**
4	483,702	359,657	**74**

There is more than 50% agreement in seven of the 15 habitats predicted by UKSeaMap 2010. In areas covered by the five UKSeaMap habitats on the left of the graph, **A3** and **A4** (infralittoral and circalittoral rock of all energies), MESH predicts a lot of **A5.1** (sublittoral coarse sediment) and **A5.2** (sublittoral sand). This may be explained by the increase in extent of rock at the seabed in the substrate dataset used in UKSeaMap as discussed above (Gafeira *et al*, 2010).

This pattern continues in the deep sea, with UKSeaMap predicting rock where MESH predicts sediment. For example, MESH predicts a lot of **A6.5** (deep sea mud) and **A6.2** (deep sea mixed sediment) where UKSeaMap predicts **A6.1** (deep sea rock). This may be explained by the improvement in deep sea substrate data, as discussed above (Jacobs and Porritt, 2009).

Relatively large amount of **A3.3** (low energy infralittoral rock) are predicted by MESH where UKSeaMap predicts **A3.1** and **A3.2** (high and moderate energy infralittoral rock) and similarly for **A4** (circalittoral rock) habitats. This is a result of the low level of agreement between energy levels in the two models (Table 3 and Figure 5).

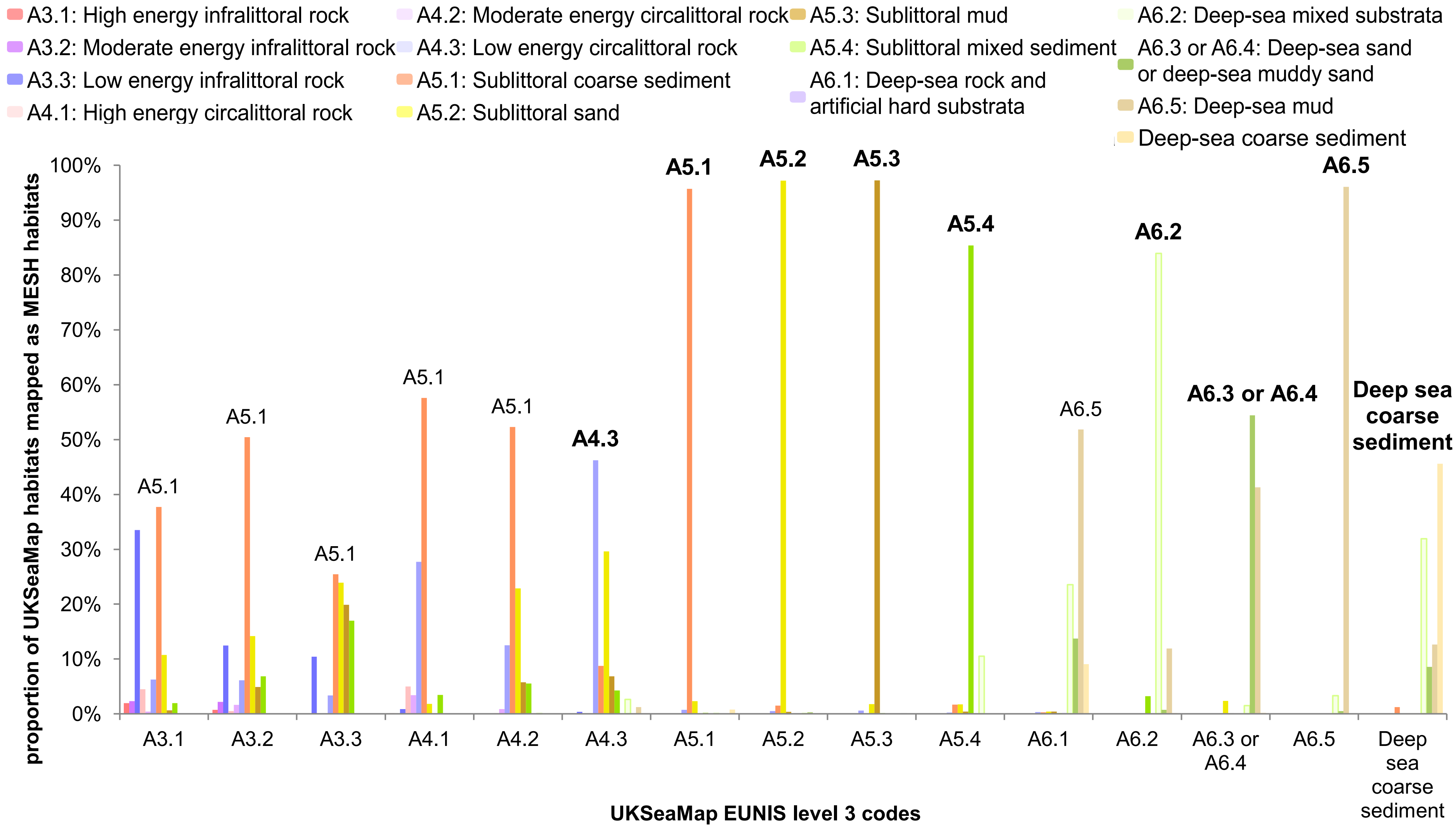

Figure 8: Proportion of matching EUNIS level 3 habitats in the overlap between UKSeaMap 2010 and MESH predictive maps. Bars show the proportion of habitats predicted by MESH that occur in the same area as each habitat predicted by UKSeaMap. Labels show the MESH habitats that occur most frequently within UKSeaMap habitats; where these agree, labels are bold.

3.2 UKSeaMap 2010 compared to the HABMAP model

Because the HABMAP approach is not based on the more rigid 'top down' approach of UKSeaMap and MESH, it is not possible to analyse habitat components from classified input layers to explain the mismatch between predicted EUNIS habitats. However, as shown in Table 2, some, but not all, EUNIS codes can be translated into habitat components, which can indicate the extent of classes of biological zone, substrate and energy, as used in UKSeaMap. Although in Section 3.1, habitat components were used to describe the cause of differences in predicted EUNIS habitats, for comparison with HABMAP they only act to summarise the EUNIS habitats. Therefore they are discussed alongside, rather than prior to, discussion of EUNIS habitats. An overview of how well the two models agree is given in Table 5, which shows the extent to which EUNIS codes and habitat components match in the overlapping study area.

Table 5: Extent to which UKSeaMap 2010 and HABMAP predictive maps match at three EUNIS levels and for three habitat components.

		Total area (km^2)	Area of matching codes (km^2)	Area of matching codes (% of total area)
EUNIS level	2	29,603	27,003	**91**
	3	29,603	10,364	**35**
	4	27,885	5,683	**20**
Habitat component	Biological zone	29,327	16,004	**55**
	Substrate type	29,327	11,423	**39**
	Energy class	1,370	253	**18**
	Energy class (infralittoral or circalittoral rock only)	1,116	156	**14**

Because biological zone, substrate and energy are not specified in some EUNIS habitat names (see Table 2), the total areas are adjusted for the areas where those components can be determined from the EUNIS habitat in the HABMAP model. The total area differs for EUNIS level 4, and is less than the total of 29,603km^2 because only some areas in each model are classified as far as level 4. Similarly to the comparison with MESH, energy accounts for the largest difference between HABMAP and UKSeaMap outputs. Energy enters the EUNIS classification at level 3, but is only used for classifying infralittoral and circalittoral rocky habitats; therefore the matching area for energy levels was also calculated for only areas mapped as rock and infralittoral or circalittoral in UKSeaMap. As the energy classes only match in 14% of these habitats, this will contribute to the mismatch between models at EUNIS levels 2 and 3; however, infralittoral and circalittoral rocky areas cover less than 4% of the total overlapping area, therefore the effect on the overall match between EUNIS codes is limited. The match for substrate type is also low.

To indicate the impact of these differences on the level of agreement between individual habitats predicted by UKSeaMap 2010 and HABMAP, an overview of the extent of the individual habitat components is provided in Figure 9, and Figure 10 shows the proportion of each UKSeaMap 2010 habitat at EUNIS level 3 that agrees with the habitat predicted by HABMAP in the same place. There is more than 50% agreement in only three of the nine habitats predicted by UKSeaMap 2010 – all these are in the sublittoral sediment section of the classification (**A5**).

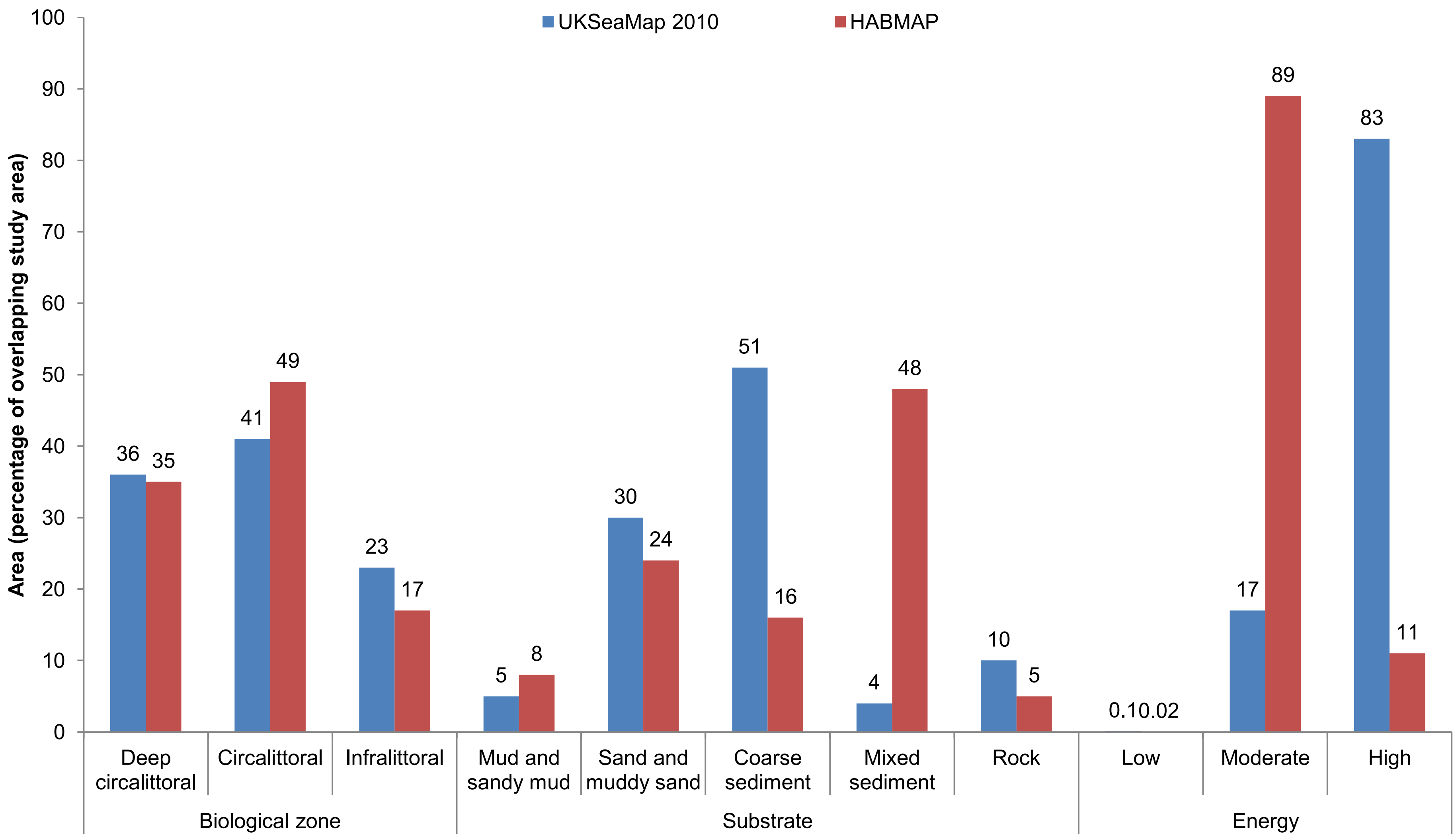

Figure 9: Extent of biological zones, substrate types and energy classes predicted by the UKSeaMap 2010 and HABMAP habitat models.

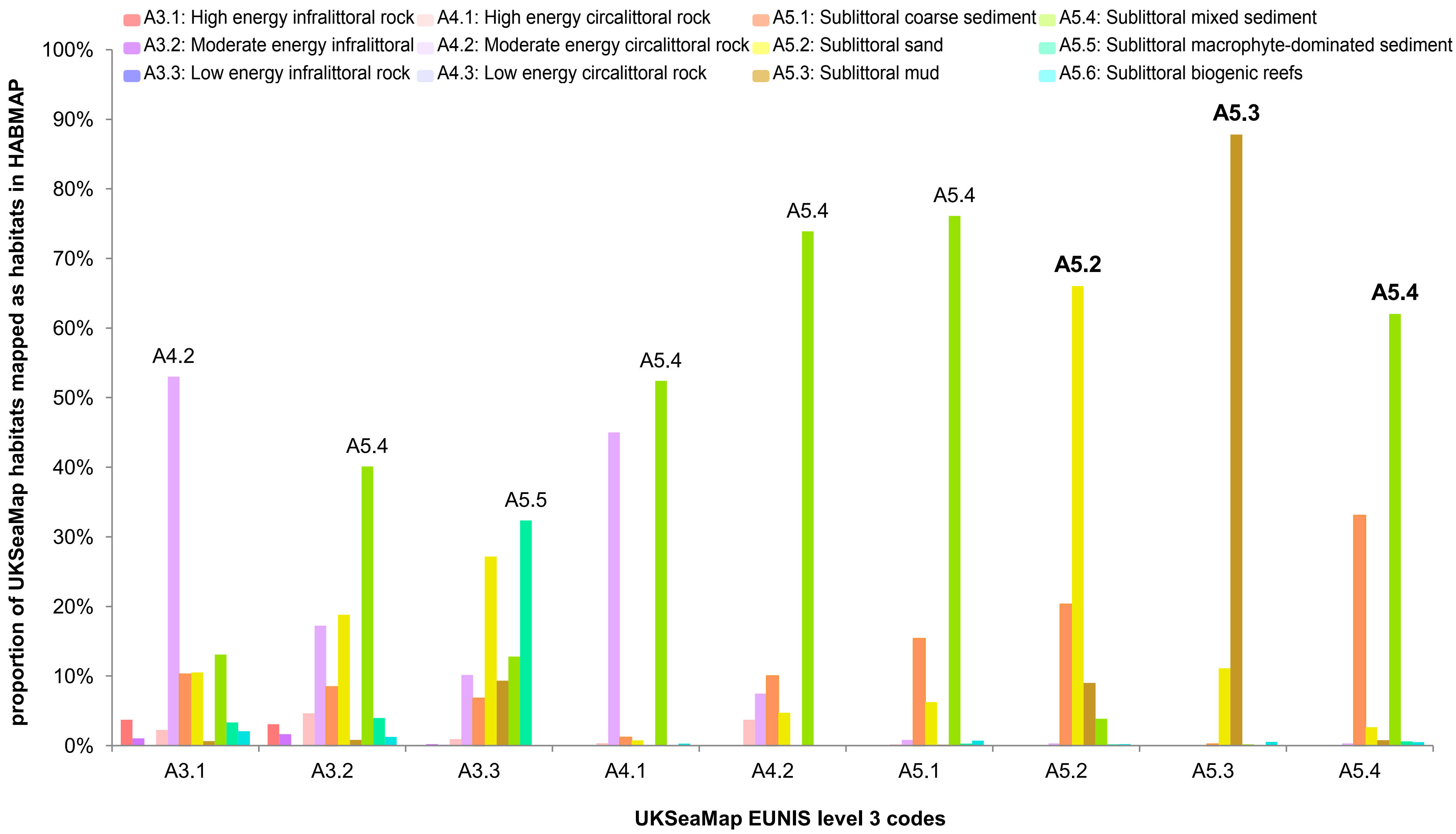

Figure 10: Proportion of matching EUNIS level 3 habitats in the overlap between UKSeaMap 2010 and HABMAP study areas. Bars show the proportion of habitats predicted by HABMAP that occur in the same area as each habitat predicted by UKSeaMap. Labels show the HABMAP habitats that occur most frequently within UKSeaMap habitats; where these agree, labels are bold.

For the area where energy classes could be determined from EUNIS codes in the HABMAP model, there is a large discrepancy between relative proportions of moderate and high energy in UKSeaMap and HABMAP (Figure 9). As a result, HABMAP has predicted a lot of **A4.2** (moderate energy circalittoral rock) biotopes where UKSeaMap has predicted **A4.1** (high energy circalittoral rock) (Figure 10). This is also reflected in the dominance of HABMAP **A4.2** habitats where UKSeaMap has predicted **A3.1** (high energy infralittoral rock); here the effect of different energy classifications is combined with the effect of the larger infralittoral zone predicted by UKSeaMap.

Comparing energy classes, a similar pattern is seen between UKSeaMap and MESH predictive maps (Figure 4), where UKSeaMap classifies larger areas as high and moderate energy. HABMAP uses a similar approach for classifying energy as the MESH EUNIS model: using shear stress as opposed to kinetic energy. It may be the case that further study is needed into the techniques and/or thresholds used for classifying energy in the context of defining seabed habitats since these techniques are relatively new.

Another observation from Figure 9 is that HABMAP has a larger area mapped as circalittoral biotopes than UKSeaMap (Figure 11).

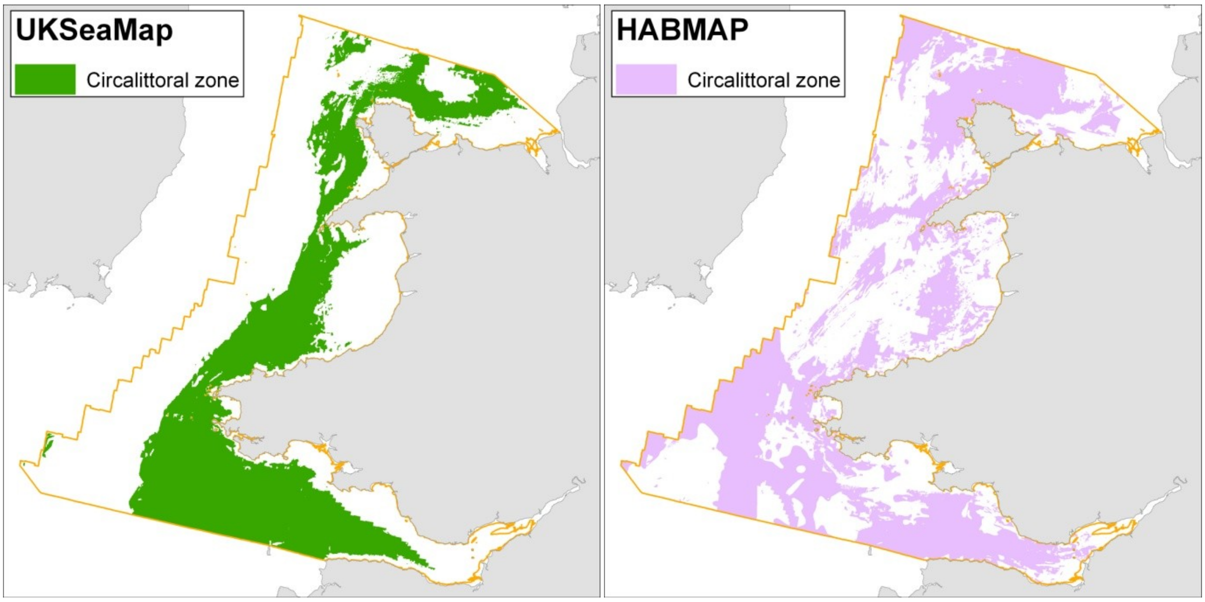

Figure 11: Extent of the circalittoral zone in UKSeaMap (left) and of circalittoral biotopes in HABMAP (right).

The distribution of HABMAP's circalittoral biotopes in Figure 11 suggest the discrepancy is less related to the resolution of light penetration data used by HABMAP (9 km) in comparison with UKSeaMap (4 km), and more likely to be caused by the impact of the modelling technique used by HABMAP. In this technique, biological sample data classified into biotopes are used to derive rules about the average conditions in which those communities are found. If a particular biotope falls in an area of e.g. sediment or depth that is not consistent with the definition of that biotope, the rules will be derived based on the conditions encountered at that location. Generally these discrepancies are unusual. However, the Marine Habitat Classification for Britain and Ireland is not well developed in its offshore (deep circalittoral) section. Hence, biologists interpreting sample data from offshore areas are likely to encounter communities which do not have an equivalent in the offshore part of the classification and may decide to classify the sample using a circalittoral code rather than an offshore code. The consequence of this on the HABMAP predictive map is that circalittoral biotope samples often fall on areas with physical conditions of the deep circalittoral, so that the rules to predict these circalittoral biotopes have a wider range of conditions than expected. Ultimately this leads to the increased circalittoral zone seen in Figure 11.

Returning to Figure 10, HABMAP has predicted a lot of **A5.4** (sublittoral mixed sediment) where UKSeaMap has predicted **A3** and **A4** (infralittoral and circalittoral rock – all energies). As discussed in the MESH comparison, in recent years (and since the release of HABMAP) multiple data sources have been re-analysed to improve the quality of the rock data (Gafeira *et al,* 2010). However, because of its regional coverage (rather than UK-wide) HABMAP was able to devote significant efforts to improving the substrate layer for the Irish Sea using additional particle size data. This points to the possibility that the substrate layer used by UKSeaMap 2010 overestimates the extent of rock at the surface by including rock that may be buried up to 50cm below the seabed (Gafeira *et al,* 2010).

There is discrepancy between relative proportions of coarse and mixed sediment in the predicted habitats (Figure 9) and Figure 10 indicates that HABMAP has predicted a lot of **A5.4** (sublittoral mixed sediment) where UKSeaMap has predicted **A5.1** (sublittoral coarse sediment). Figure 12 clearly shows that most of the area classed as coarse sediment in UKSeaMap is classed as mixed sediment biotopes in HABMAP.

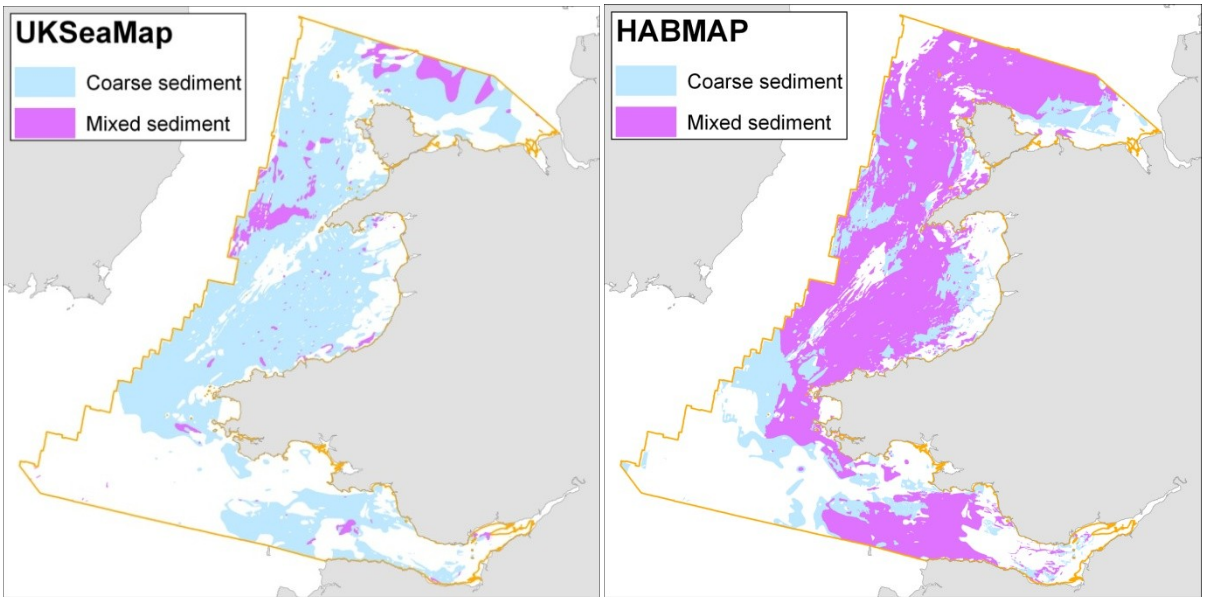

Figure 12: Distribution of coarse and mixed sediment in UKSeaMap (left) and HABMAP (right) predicted habitat maps.

In addition to the different extent of the circalittoral zone in HABMAP, this is an example of how in the HABMAP approach, biological data can take precedence over physical data in predicting biotope distributions. 62% of the area classed as coarse sediment by UKSeaMap and mixed sediment biotopes by HABMAP is identified by HABMAP to be **A5.451**: polychaete-rich deep *Venus* community in offshore mixed sediments. 97% of these areas have no biological sample points but are based on predictions made by associating a range of physical parameters with the biotope where sample data do exist. 179 sample points for

A5.451 were used in HABMAP; 100 of these occurred on coarse sediment while only 70 occurred on mixed sediment. This biotope was identified by Robinson *et al* (2009) as a biotope whose official description is based on a relatively small dataset, meaning the physical conditions as defined in the Marine Habitat Classification 04.05 (Connor *et al*, 2004) may not fully describe the whole range of preferred physical conditions and may indicate a problem for the classification system rather than either of the modelling methods.

HABMAP used point data to construct its predictive model for the southern Irish Sea (Robinson *et al*, 2009). Where samples were sparse, the predicted biotopes were awarded low confidence scores. It has previously been suggested that the HABMAP approach could be applied to the UK marine area. To scope the feasibility of this approach at a UK scale, UKSeaMap 2010 created sample density maps. This allows a visual comparison of the density of habitat samples in the HABMAP area (southern Irish Sea scale; Figure 13 (a)) and the density of samples at a UK scale (Figure 13 (b)).

Figure 13 (a) contains the locations of samples used in HABMAP (Robinson *et al*, 2009). Figure 13 (b) contains sample point data from the following sources:

- JNCC marine recorder database
- Environment Agency
- National Marine Monitoring Programme
- Irish Seabed Image Archive
- CEFAS ME3112 data points
- Data obtained from Emu Ltd. – English and Welsh coasts and offshore
- Data obtained from ABPMer – English coast
- Data obtained from MES – English and Welsh coasts and offshore

These sample density maps demonstrate why it is not currently appropriate to use the sample-based, ‘bottom-up’ approach for the UK marine area, because the sample density in offshore areas is too low to drive a reliable habitat model using the methods of the HABMAP project, particularly in the Northern North Sea and in the North-West Approaches.

(a)

(b)

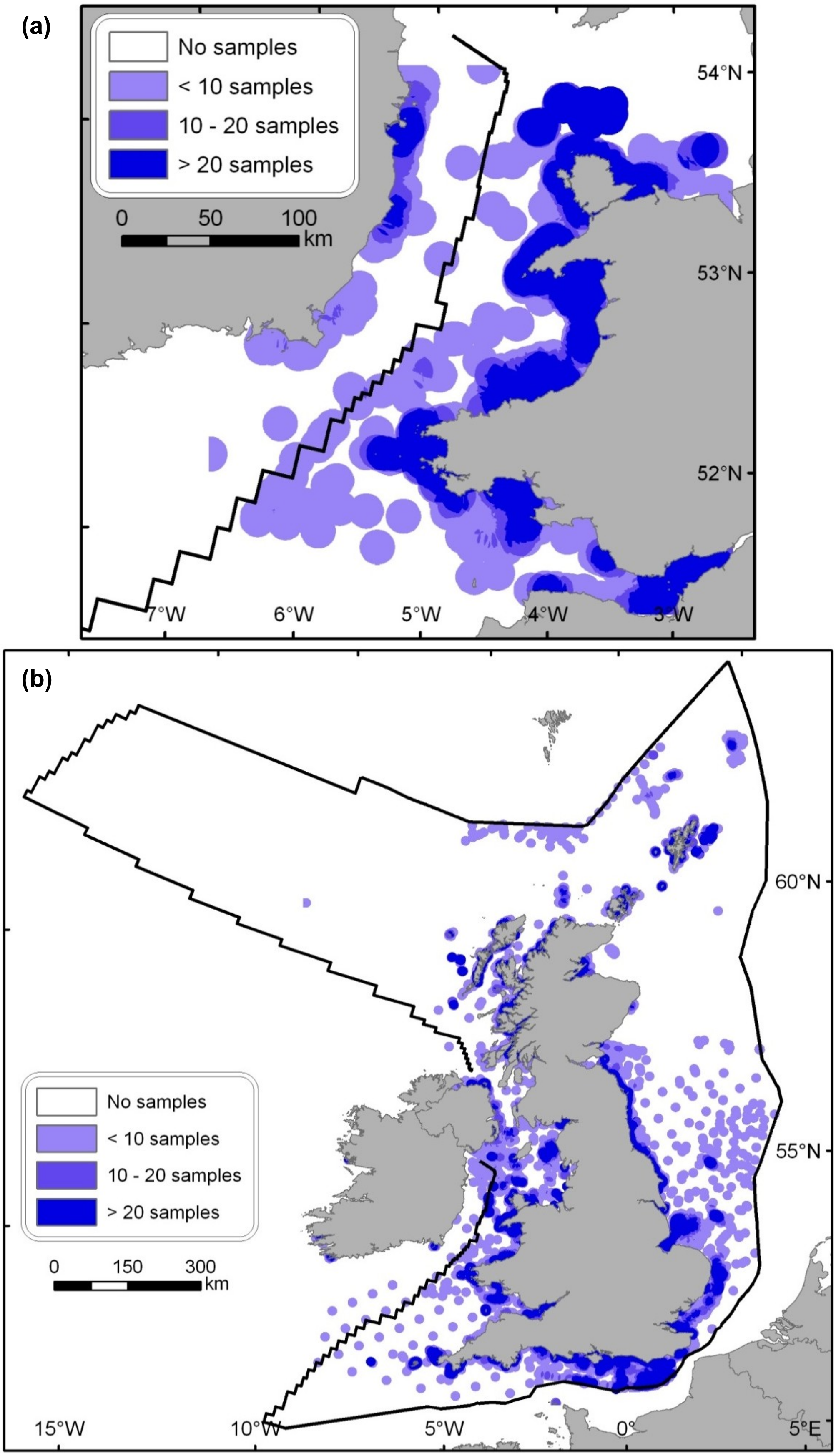

Figure 13: Sample density (as number of samples per 10km^2) for samples interpreted to habitats (a) used in the HABMAP project to build the predictive seabed habitat model in the Southern Irish Sea, and (b) available across the UK marine area.

3.3 Comparison with MESH survey maps

An overview of how well the UKSeaMap 2010 model agrees with habitat maps produced from smaller-scale surveys is given in Table 6, which shows the extent to which EUNIS codes and habitat components match in the overlapping study area.

Table 6: Extent to which data from UKSeaMap 2010 and MESH survey maps match at three EUNIS levels and with three habitat components.

		Total area (km^2)	Area of matching codes (km^2)	Area of matching codes (% of total)
EUNIS level	2	27,887	20,952	**75**
	3	27,887	10,071	**36**
	4	24,076	4,363	**18**
Habitat component	Biological zone	23,678	13,010	**55**
	Substrate class	23,687	9,782	**41**
	Energy class	3,305	2,031	**61**
	Energy class (infralittoral or circalittoral rock only)	2,089	1,302	**62**

The level of agreement between the energy classes in rocky areas (62%) is much higher than with the MESH (29%) or HABMAP predictive maps (14%), suggesting that perhaps seabed kinetic energy is a better measure of seabed energy in rocky areas than shear stress. Figure 14 shows also that the distribution pattern of the energy classes is much more similar between the UKSeaMap predictive map and survey maps than between UKSeaMap and the HABMAP or MESH predictive maps.

There is a similar amount of agreement between biological zones in UKSeaMap and survey maps as with UKSeaMap and HABMAP (55%), but less than the MESH predictive map, which matched UKSeaMap in 86% of the study area. The difference in extent of infralittoral and circalittoral zones (Figure 14) resembles that of the comparison with HABMAP (Figure 9) in that a larger proportion of habitats are mapped as circalittoral in HABMAP and survey maps.

The low level of matching could be resolved by a further look at the thresholds used to distinguish biological zones. High resolution light data (MERIS: 250m) is now available and could be used to refine the boundary of the infralittoral zone. There was insufficient time within this project to examine the boundary between the circalittoral and deep circalittoral zones and a detailed look at the thresholds used to distinguish this boundary may further improve the match between the biological zones.

There is also a similar amount of agreement between substrate types in UKSeaMap and survey maps (41%) as with UKSeaMap and HABMAP (39%), but much less than the MESH predictive map, which matches UKSeaMap in 86% of the study area. As the HABMAP predictive map, survey maps contain more mixed sediment habitats and less coarse sediment and rocky habitats (Figure 14). Figure 15 shows that rocky EUNIS habitats predicted by UKSeaMap (all **A3** and **A4** codes) do not match well with the survey maps.

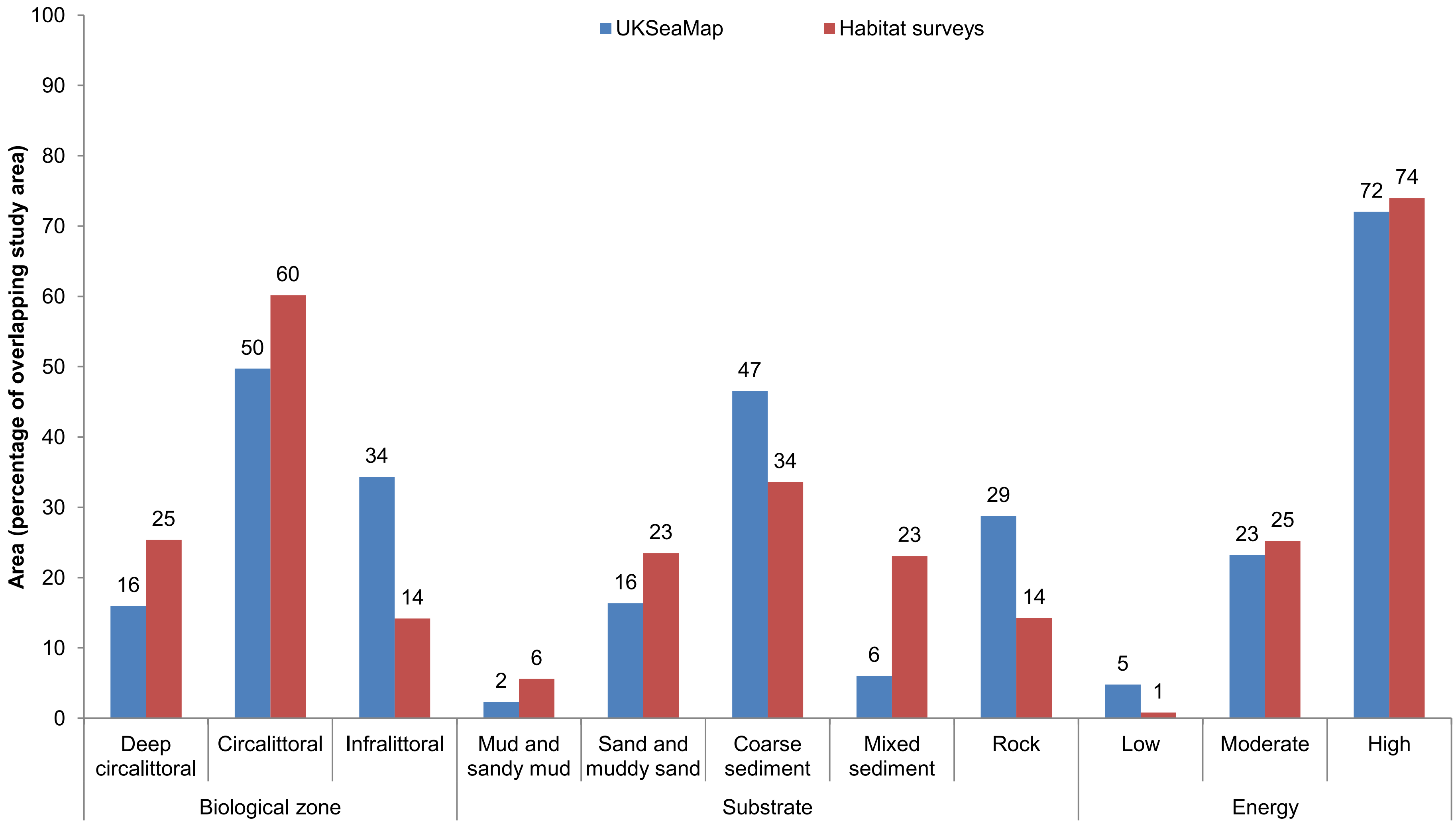

Figure 14: Extent of biological zones, substrate types and energy classes predicted by the UKSeaMap 2010 habitat model and derived from EUNIS habitats mapped from survey data.

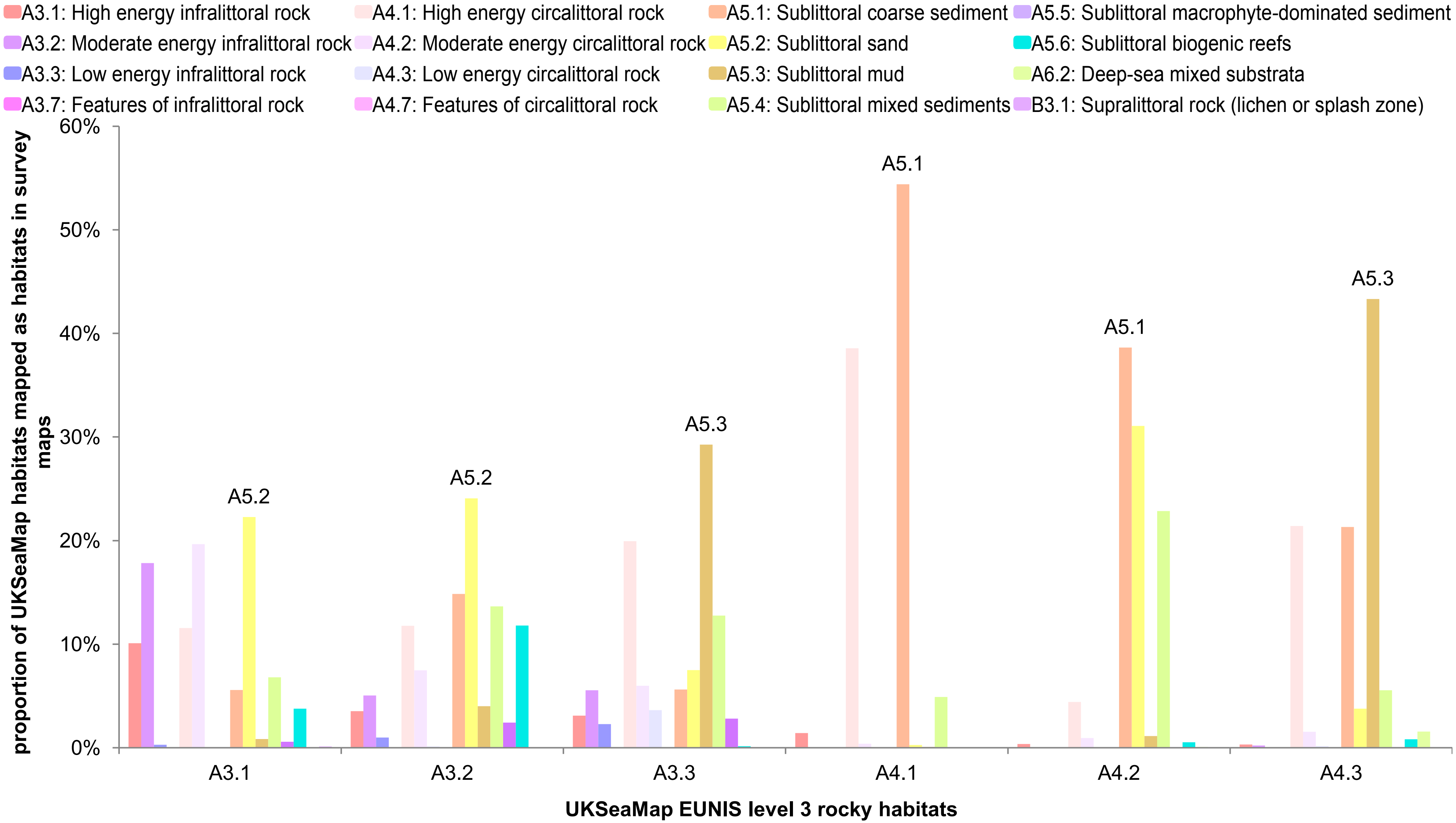

Figure 15: Proportion of matching EUNIS level 3 rocky habitats in the overlap between UKSeaMap 2010 and MESH study areas. Bars show the proportion of habitats mapped in surveys that occur in the same area as each habitat predicted by UKSeaMap. Labels show the MESH habitats that occur most frequently within UKSeaMap rocky habitats; in no cases do the habitat types agree for UKSeaMap EUNIS level 3 rocky habitats.

For all of these rocky habitats predicted by UKSeaMap, the survey maps are dominated by sediment habitats. Several explanations are possible for this. Firstly, there is again the indication that the substrate data used by UKSeaMap 2010 may overestimate the amount of rock at the seabed by including rock that has up to 50cm of sediment above it. Secondly, the finer scale of mapping in the survey maps relative to UKSeaMap substrate layer, together with the patchiness of seabed substrate distribution, are likely to cause at least some mismatch.

Figure 17 shows that the sublittoral sediment habitats (all **A5** codes) match relatively well with the MESH survey maps. UKSeaMap 2010 deep sea habitats (all **A6** codes) do not match well with the MESH survey maps; however, it must be noted that the deep sea area covered by survey maps in the UKSeaMap study area is very small - only 9km^2. The high level of disagreement is expected to be due to the very low density of BGS substrate point data in deep sea areas (Figure 16).

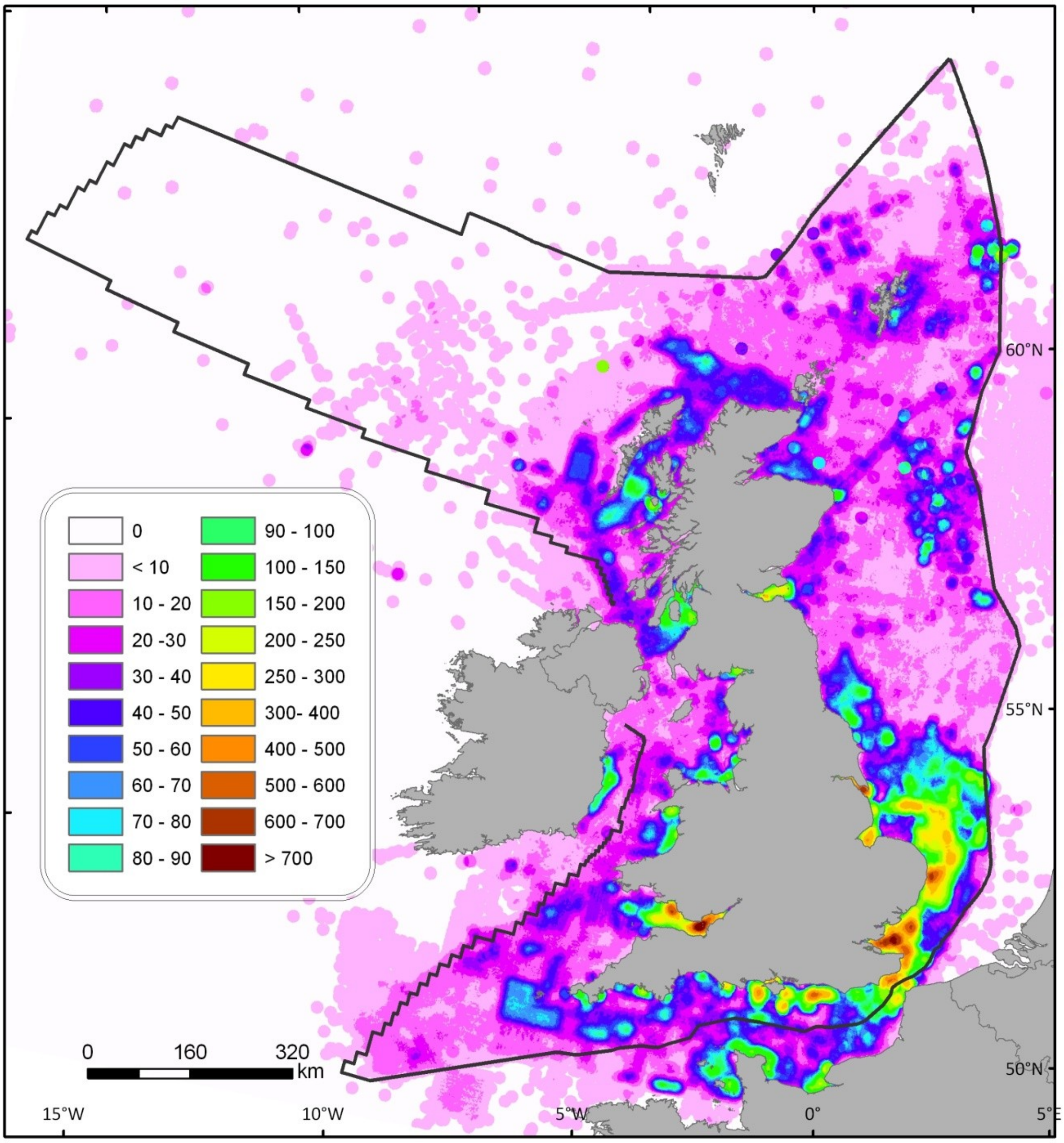

Figure 16: Sample density (as number per 10km^2) for BGS substrate samples.

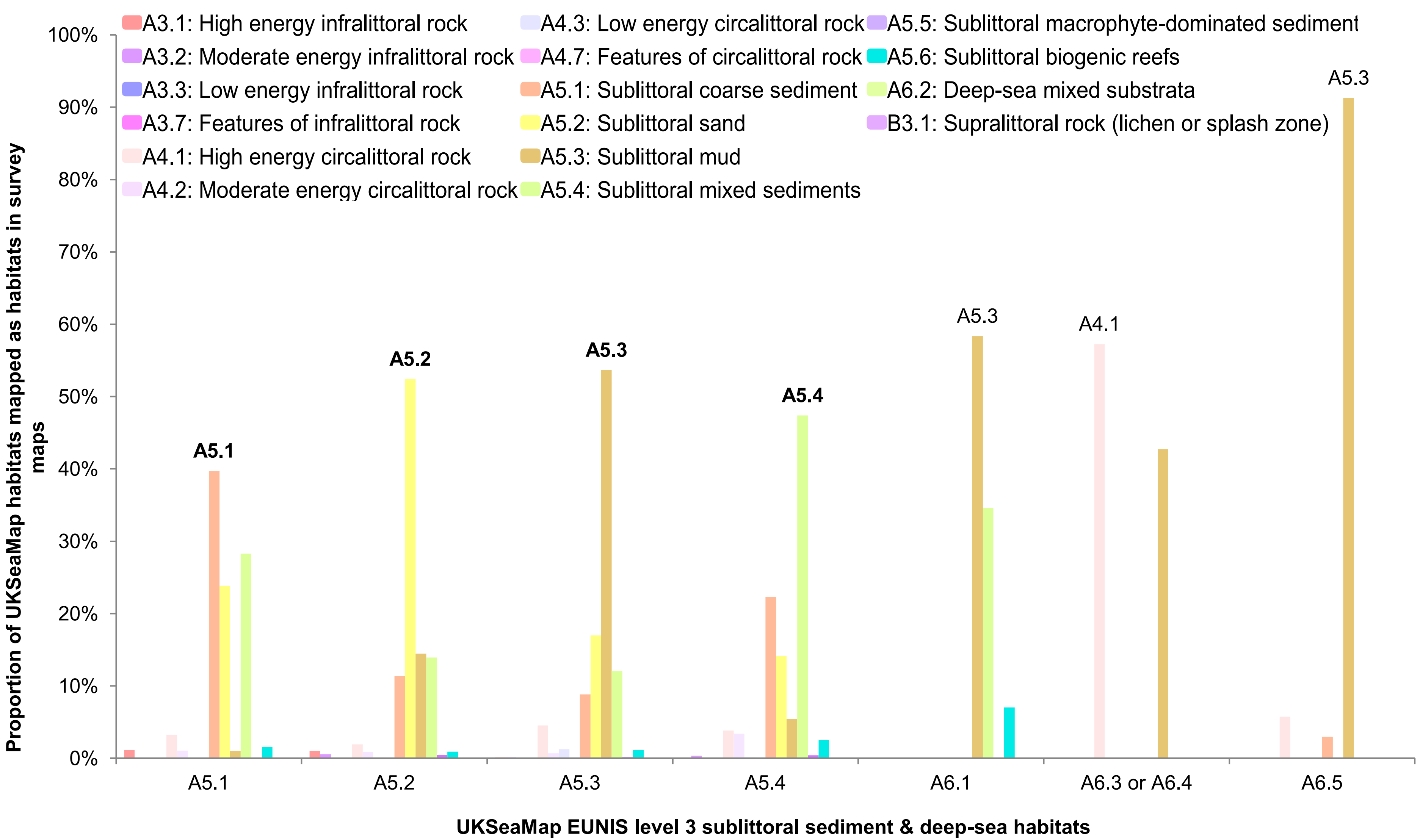

Figure 17: Proportion of matching EUNIS level 3 sediment and deep sea habitats in the overlap between UKSeaMap 2010 and MESH study areas. Bars show the proportion of habitats mapped in surveys that occur in the same area as each habitat predicted by UKSeaMap. Labels show the habitats that occur most frequently within UKSeaMap habitats; where these agree, labels are bold.

4 Conclusions

While these analyses examine the percentage of agreement between the maps, and possible reasons for mismatches postulated, it is important to note that the mismatches would need further investigation to be certain of the causes. UKSeaMap 2010 is an improvement on the MESH predictive habitat map for UK waters and it is therefore advised that the former be used as the most accurate broadscale EUNIS habitat map for UK seas.

HABMAP however should be viewed differently from UKSeaMap 2010; HABMAP predicts detailed biotopes beyond EUNIS level 3 and 4 based on biological and physical information; UKSeaMap predicts broadscale level 3 and 4 habitats based on physical information only, which is all that is needed to describe habitats at these levels. The fact that the models do not agree at level 3 for 65% of the overlapping study areas and at level 4 for 80% of the area is not cause for mistrust in either approach. The causes of a large proportion of the differences are biological data in HABMAP indicating that the best fitting detailed biotope is in the neighbouring biological zone, sediment type and/or energy class. This is an inherent consequence of a classification system, which, by its nature, pigeonholes transitional and variable environmental conditions into distinct groups.

However, accepting this, it is important to recognise that a detailed modelled biotope map based on biological data may be accurate at detailed levels of the classification system while being misleading if summarised to the non-biological levels of the classification. For example, if it turns out that polychaete-rich deep *Venus* communities are more likely to occur in coarse sediment than mixed sediments as the definition states for **A5.451**, then this causes a problem when generalising **A5.451** to EUNIS level 3. The level 3 habitat, **A5.4**, is simply 'sublittoral mixed sediment', which may be incorrect according to substrate data.

Conversely, accepting that the EUNIS/Marine Habitat Classification is imperfect, for some parts of the classification, it may not be wise to assume that a level 3 EUNIS habitat necessarily contains all the detailed biotopes below it in the hierarchy, as in reality the range of species associated with a particular biotope may occur primarily in a neighbouring biological zone, sediment type or energy class. Therefore, management decisions must involve careful consideration regarding biotopes with definitions based on a small amount of data and the possibility of biotopes occurring widely in a range of physical conditions.

Differences between UKSeaMap 2010 and MESH survey maps largely appear to be due to UKSeaMap predicting infralittoral and circalittoral rock where the MESH survey maps show sublittoral sediment, and disagreement in deep sea areas due both to the biological zones and the substrate types. Consideration should be given as to whether using rock data which show rock up to 0.5m below the surface of the seabed is the best method for mapping substrates to be used in these models. The results suggest seabed kinetic energy is a better match to the energy classes in EUNIS than seabed shear stress. An analysis of how MESH survey maps compare to the HABMAP and UKSeaMap 2010 predictive seabed habitat maps in the HABMAP area would provide a useful indication of which modelling technique is more successful, but a very small proportion of this area is covered by high and very high confidence habitat maps from survey; currently less than 1% of the overlapping HABMAP/UKSeaMap study area and thus the area being compared would be relatively small.

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