UKSeaMap 2010 Technical Report 5

Analysing the relationship between substrate and energy data

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1 Introduction

In the EUNIS classification rock habitats are classed into high, moderate and low energy at Level 3. The classification system treats sediment type alone as a good indicator of the hydrodynamic conditions, and therefore does not use energy conditions to structure the sediment part of the classification. Seabed sediments can be re-suspended, moved and re-deposited by the combined effect of wave action and currents. Wave action may be the dominant factor in determining sediment type in shallow waters; however, beyond around 100m, the effect of waves is dissipated and currents are usually dominant. Re-suspension of sediment particles is governed by the threshold velocity and roughness of the sediment. The threshold velocity is the minimum velocity at which a particle of a certain size can be picked up by a moving fluid. The sediment roughness determines how easy it is for particles to be picked up by movement of the overlying water, with rough particles being easier to pick up than smooth particles (Gray & Elliott, 2009).

This analysis explored whether using seabed sediment types as a proxy for seabed energy in broadscale modelling is sufficient, or whether there is merit in also dividing seabed sediments into energy categories. Sediment and energy data were compared to investigate whether the energy classes used to define rocky habitats could also be used to describe sedimentary habitats.

2 Methodology

The analysis was split into two parts:

1. Comparing sediment types with continuous (unclassified) spatial data layers for current and wave kinetic energy. The following data layers were used:

    a. sediment type, classified as mud and sandy mud, sand and muddy sand, coarse sediment and mixed sediment
    b. kinetic energy at the seabed due to waves (in Newtons per square metre (Nm^{-2}))
    c. kinetic energy at the seabed due to currents (Nm^{-2})

2. Comparing sediment types with combined wave and current seabed kinetic energy data classified into three energy classes, as applied to rock habitats in the EUNIS classification and UKSeaMap 2010. The following data layers were used:

    a. sediment type, classified as mud and sandy mud, sand and muddy sand, coarse sediment and mixed sediment
    b. combined energy class, classified as low, moderate and high

In the first part of the analysis, for each sediment class, the proportion of the UKSeaMap area corresponding to each energy value was plotted. The majority of the study area contained low energy values, with very few high energy values. To better display this information, the logarithm of the area mapped for each energy value was calculated and plotted as a proportion of the sum of the logged area values. This quantity is shown in the following formula, where *i* is the index of each energy value:

$$\frac{(\log_{10} area)_i}{\sum_i (\log_{10} area)_i}$$

In the second part of the analysis, each sediment type was plotted as a proportion of the total area of each energy class. Likewise, each energy class was plotted as a proportion of the total area of each sediment type.

3 Results

3.1 Comparing sediment with continuous seabed kinetic energy data

The mean energy values for mud and sandy mud, sand and muddy sand and coarse sediment show a predictable pattern (see Figure 1). It can also be seen that the mean wave energy is higher than the mean current energy for these three classes. The values for mixed sediment are similar to those of mud and sandy mud.

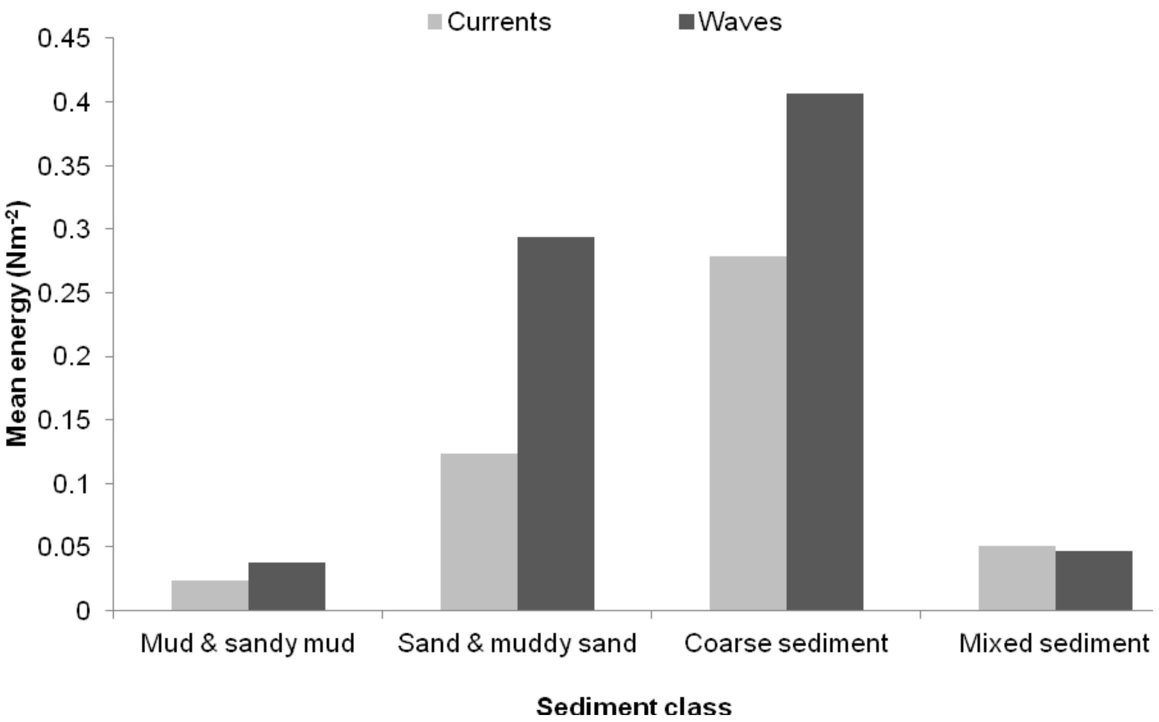

Figure 1: Mean values of energy due to currents and waves for each sediment class.

The distribution of energy values for each sediment class can be seen in Figure 2 and Figure 3, which show the proportional area covered by each sediment class for values of energy due to currents and waves, respectively. Note that the distribution of sediment at the seabed is affected by the combined effect of currents and waves and the energy regime with a higher energy in a particular location is assumed to have the largest effect. This must be considered especially when viewing low energy values in Figure 2 and Figure 3 – these figures are mostly useful for comparing the response between sediment types at different energies.

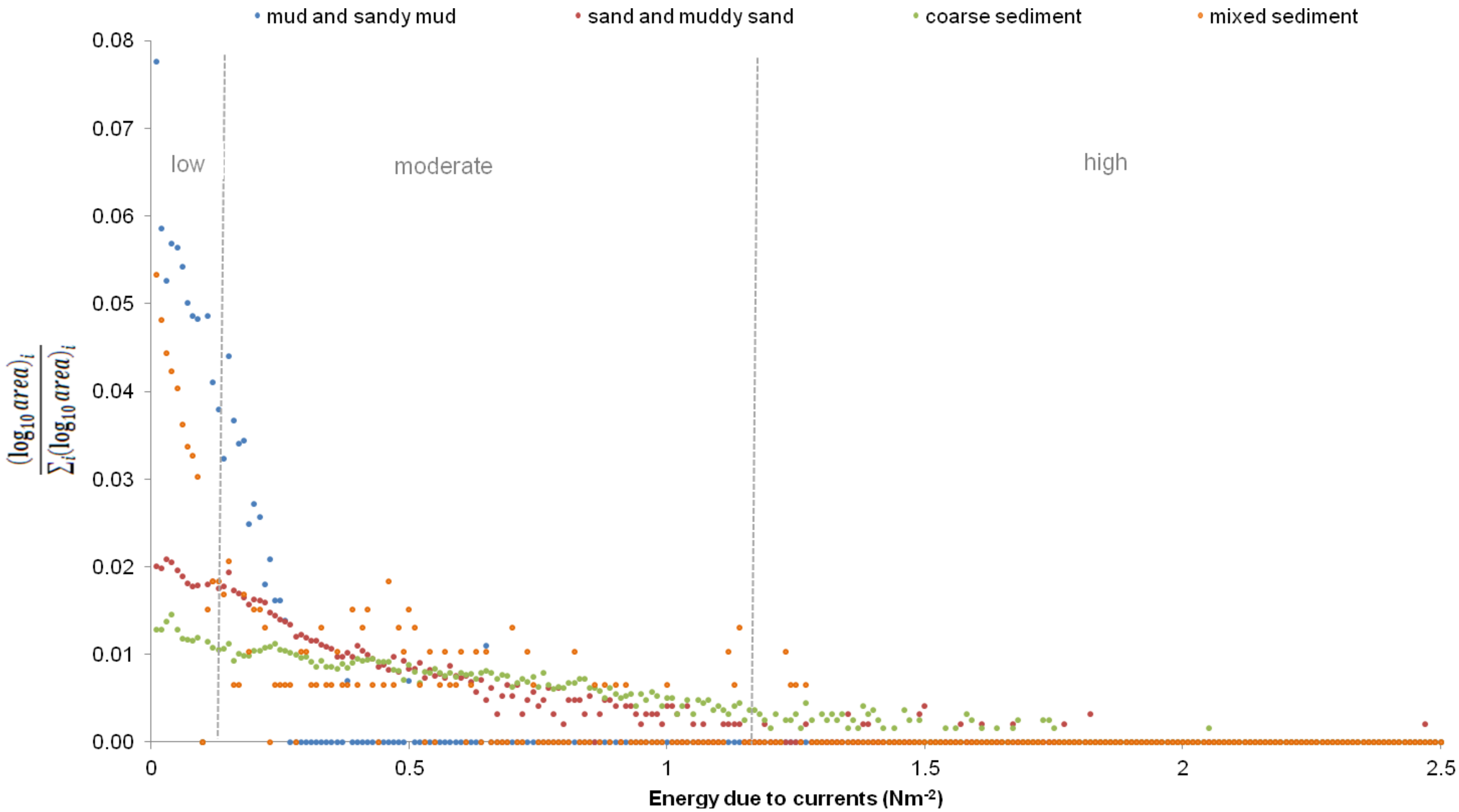

Figure 2: Proportion of sediment classes occurring in the same location as each value of energy due to currents. Zero energy values and zero area values have been removed. Dashed grey lines show boundaries between low, moderate and high energy classes, as defined in Table 7.

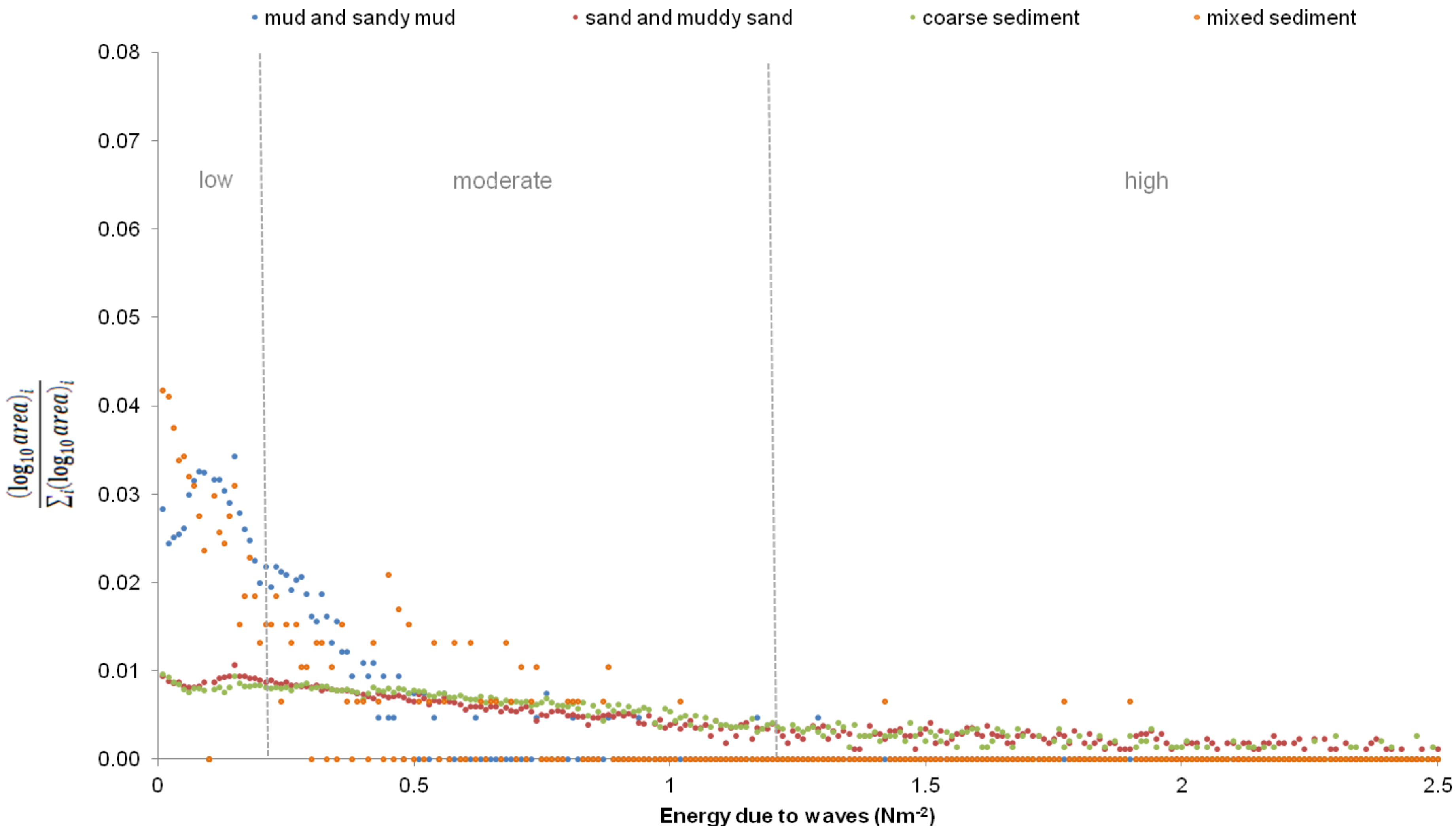

Figure 3: Proportion of sediment classes occurring in the same location as each value of energy due to waves. Zero energy values and zero area values have been removed. Dashed grey lines show boundaries between low, moderate and high energy classes, as defined in Table 6.

Mixed sediment follows a similar pattern to mud and sandy mud for current energies <0.25 Nm^{-2} and for wave energies <0.5 Nm^{-2} (Figure 2 and Figure 3). For higher energies, there are very few data points for mud and sandy mud. Coarse sediment and sand and muddy sand follow a similar pattern for both current and wave energy, but especially for the latter, where the difference between distributions of the two sediment types is indistinguishable for most energy values (Figure 2 and Figure 3). For higher values of current energy coarse sediment is present in larger quantities than sand and muddy sand, which is more in line with expectations.

3.2 Comparing sediment with combined energy classes

UKSeaMap 2010 combined wave and current energy by classifying each into high, moderate and low energy and subsequently choosing the higher energy class. This approach was used because of the difficultly involved in numerically combining different energy regimes that act in different directions and on different timescales (see Section 3.2.2 of main report and Technical Appendix 4). Therefore, comparing sediment type with the combined energy can only be done using energy classes. Figure 4 and Figure 5 shows this comparison in terms of sediment type and energy class, respectively.

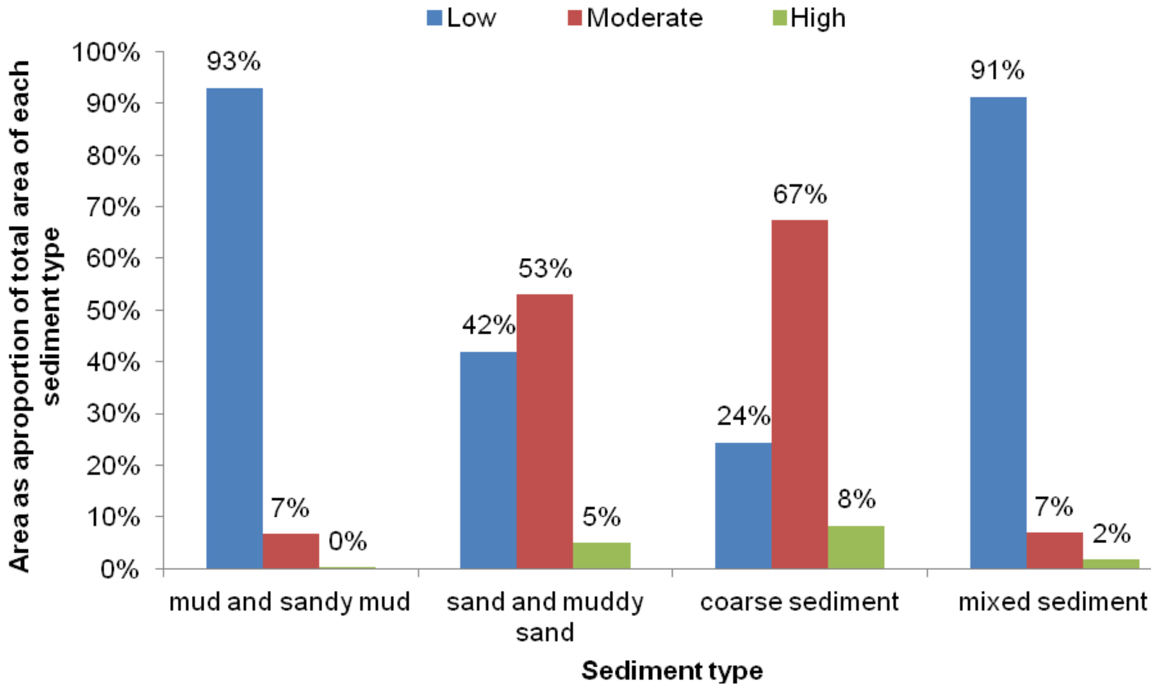

Figure 4: Breakdown of the energy classes for each sediment type.

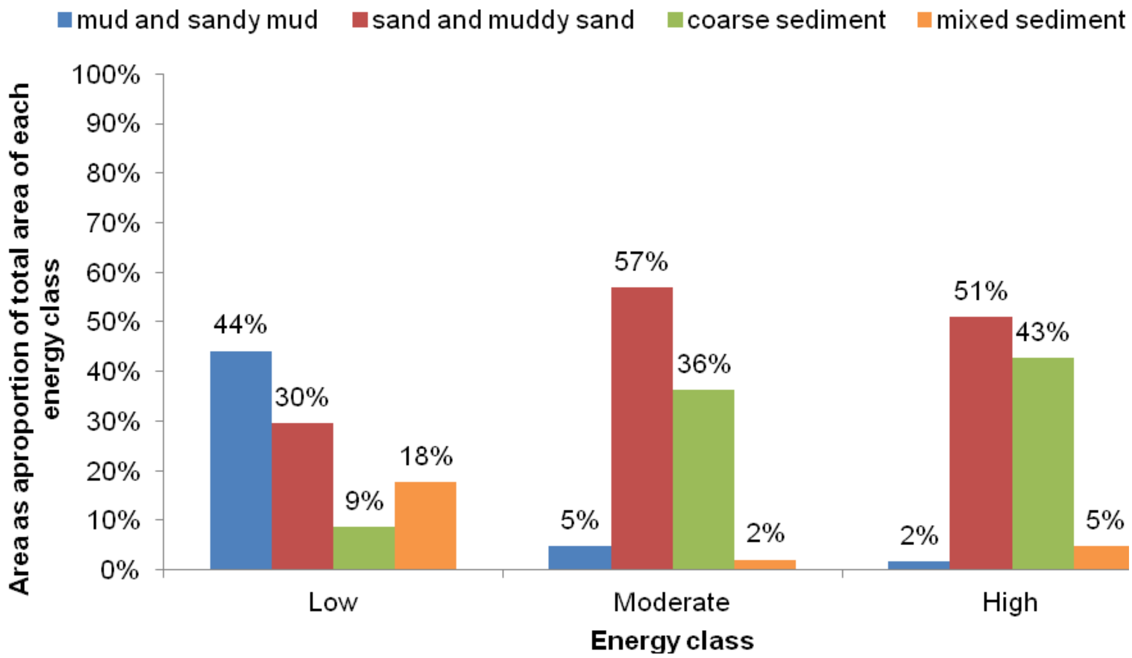

Figure 5: Breakdown of the sediment types for each energy class.

Figure 4 and Figure 5 show similar pattern to Figure 1 to Figure 3 – similarities between (a) mixed sediment and mud and sandy mud and (b) coarse sediment and sand and muddy sand. For low energy environments, the pattern of relative abundances of each sediment type is roughly what is expected – mostly mud and sandy mud (44%), followed by sand and muddy sand (30%) with coarse sediment having the lowest values (9%).

Moderate energy environments are dominated by sand and muddy sand (57%) but closely followed by coarse sediment (36%). It would be expected that coarse sediments would dominate high energy environments but this is not the case with high proportions of sand and muddy sand (51%) and coarse sediment (43%) being found in high energy environments.

4 Discussion

4.1 Mixed sediment and muddy and sandy mud

The occurrence of mixed sediment predominately in low energy environments is explained by the four Folk classes that the mixed sediment class is comprised of: muddy gravel, muddy sandy gravel, gravelly mud and gravelly muddy sand (see Section 3.1 of the main report), which all contain mud. Mud and sandy mud is virtually absent from higher energies; likewise, if the mud component of the four mixed sediment Folk classes were to be re-suspended at higher energies, gravel, sandy gravel and gravelly sand would remain – these are the Folk classes that make up coarse sediment.

4.2 Coarse sediment and sand and muddy sand

It has been suggested that gravelly sand – one of the Folk classes that make up the coarse sediment class in EUNIS – may be better placed in the sand and muddy sand EUNIS class. The similarities between the two sediment classes, described above, therefore lead to the question: would moving gravelly sand from coarse sediment to sand and muddy sand make the distributions more distinct? This could be investigated by removing gravelly sand from the coarse sediment data and examining the gravelly sand data separately in relation to the energy data. However, these data were not available; instead, gravelly sand data from the BGS product DigSBS250 version 1 was used, which is an earlier version of some of the data used to create the UKSeaMap substrate layer (see Figure 6).

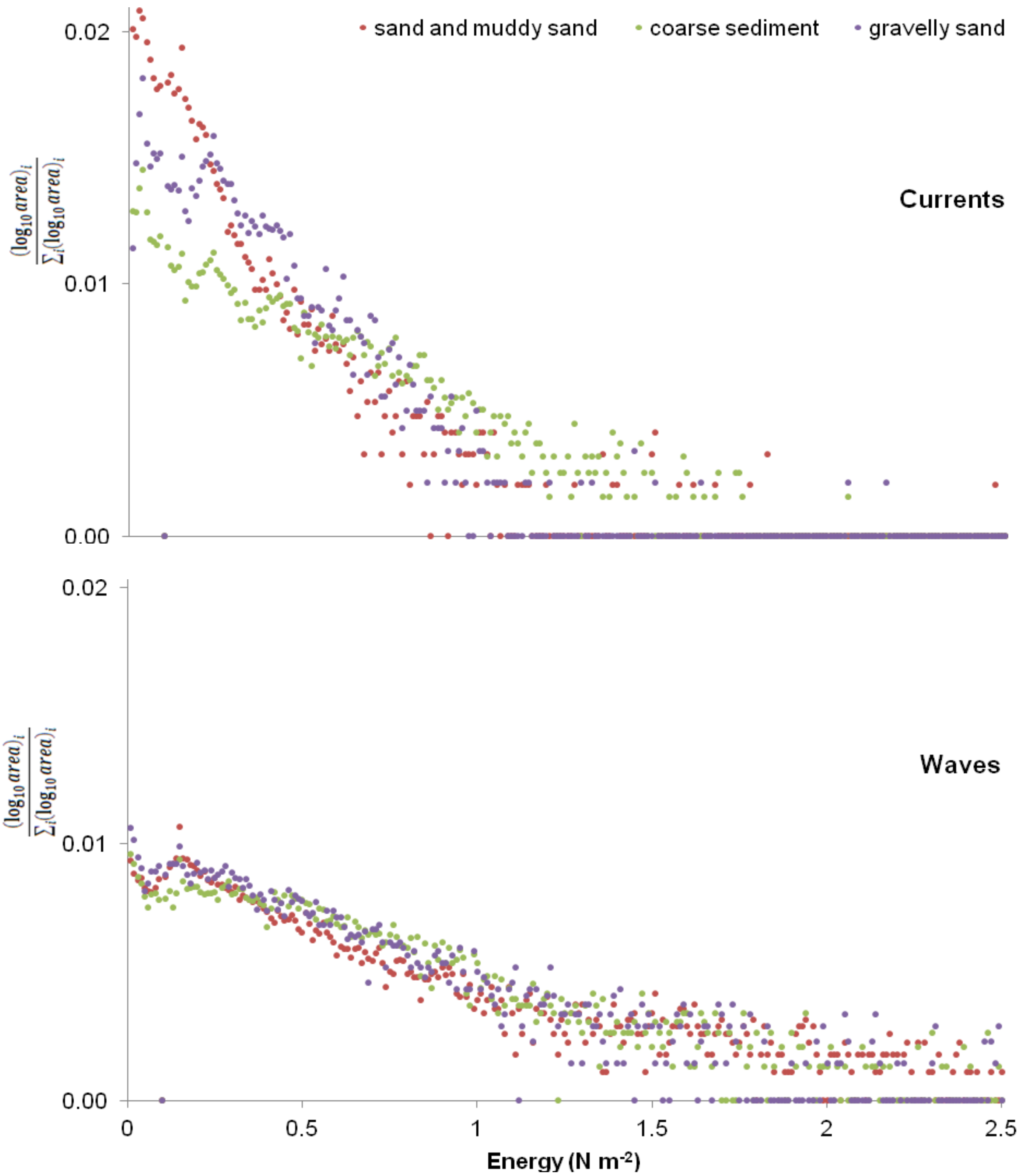

Figure 6: Proportion of sand and muddy sand, gravelly sand (a component of coarse sediment) and coarse sediment occurring in the same location as each value of energy due to currents (top) and waves (below). Zero energy values and zero area values have been removed.

Note that the gravelly sand data shown in Figure 6 are from an earlier version of the data used to create the coarse sediment layer; however, it is reasonable to assume that the gravelly sand data would show a similar pattern to that in Figure 6. For example, the local peak in proportion of coarse sediment when energy due to currents is around 0.23 Nm^{-2} can be assumed to be caused by the peak in proportion of gravelly sand at the same location. For energy due to waves, the proportion of gravelly sand follows a similar pattern to sand and muddy sand rather than coarse sediment, in that it is more likely to be present at lower energies and less likely than coarse sediment to be present at energies greater than around 0.8 Nm^{-2}. No clear patterns can be observed for energy due to waves, however.

5 Conclusions

Comparing sediment type with continuous current and wave energy, as in the first part of the analysis, has one main limitation: when viewing the distribution of sediment for one kinetic energy regime (e.g. currents), it is unclear which regime (e.g. waves) is more likely to control the sediment type, for each data point. Therefore it is difficult to make conclusions about the relationship between energy and sediment type. However, Figure 1, Figure 2 and Figure 3 show patterns that would be expected assuming the sediment types used in UKSeaMap can be used as a proxy for energy.

In order to compare sediment type with a combined energy dataset, part two of the analysis was performed. However, comparing sediment type with energy class involves accepting at least one of the following assumptions:

1. Sediment types, as used in the EUNIS classification, are appropriately defined;
2. Energy thresholds for wave and current energy are appropriate for sedimentary environments.

Accepting assumption 1, it may be concluded that the UKSeaMap 2010 low energy threshold for rocky environments could be applied to sedimentary environments but the relationship with moderate and high energy environments is not as clear – there may be other factors involved. Accepting assumption 2, it may be concluded that the Folk sediment classes used to define coarse sediment and sand and muddy sand need to be reinvestigated. It is not possible to come to firm conclusions about either energy thresholds or sediment classification due to the lack of more detailed Folk sediment types, and the difficultly in combining different energy regimes numerically.

Reference List

GRAY, J. S. & ELLIOT, M., 2009. Ecology of Marine Sediments: From Science to Management. *Oxford Biology*.