BEACH MATERIAL PROPERTIES

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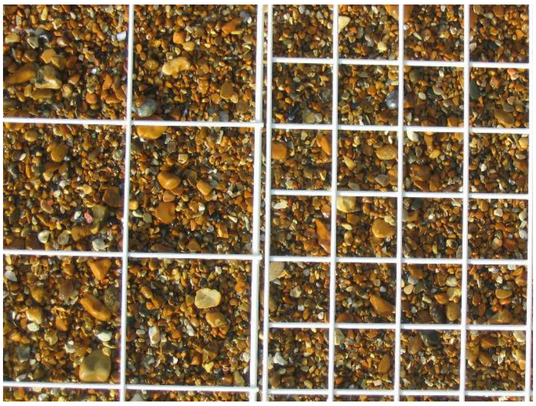

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1 Aims

Sediment characteristics of individual beaches are an important component in the prediction of beach behaviour and in assessing the evolution of individual beaches in the context of sediment cells and possible sediment sources. This report outlines work with the following aims, namely to:

- Measure sediment variation with depth in order to develop a methodology for characterising bulk beach material properties from small samples
- Measure relative proportions of different size fractions of beach material for type sites to assess intra-site and regional variations.

2 Summary

Sampling of beach material at depth in the beach has shown that in most cases there is a surface layer of up to several decimetres exists with a narrow grain size range (gravel with no sand) and which is unrepresentative of the material that makes up the bulk of the beach. A method has been developed to sample mixed sand and shingle beaches avoiding this top layer. Sediment sampling and grain size and colour analysis has been carried out, involving 108 samples on 39 transects on 12 type beaches. The results show that significant differences exist both within type beaches and between them in relation to D_{50} and sand content. Shingle pebble colour is quite different on natural beaches close to chalk cliffs and those that have been recharged with offshore-dredged material. On natural beaches the proportion of grey flint pebbles decreases with downdrift distance from chalk cliffs. It has also been found that pebble size correlates with colour and that a decrease in size coincides with an increase in non-grey flints.

3 Introduction

Shingle beach facies are, broadly, the beach core that is relatively stable in its composition (stability increases with distance from the active layer) and the surface layer that is the product of short term sorting processes which select different grains sizes from the core or sort the material in the active layer. This surface layer is highly variable laterally (changes within a few metres are common) and temporarily (changes are likely to occur even during one tidal event).

In more detail, the core consists of layers that show significantly different grain size composition (see section 4). The surface layer often contains no sand and is therefore not representative of the beach as a whole, particularly with regard to its hydraulic properties which are linked to the sand component. Therefore it seems desirable to sample material from the core rather than the surface to obtain results that are a) representative of the bulk properties of the beach, b) show comparatively small lateral variation and c) show relatively little temporal variation.

Having decided on the part of the beach to be sampled, there are difficulties in defining a representative sample with regard to sample size and the location(s) from which to take the sample(s). The appropriate sample size has been investigated and controversially discussed by a number of researchers (e.g. Church et al., 1987; Dunkerley, 1994; Gale and Hoare, 1992; 1994). Sample size has to be a function of the size of the largest particles in a sample and recommended values for the largest particle or size class as a percentage of the total sample size range from 1% to 5%. On shingle beaches this would result in samples of several tens of kilos. In this study, individual samples of this size were considered impractical. In addition, the spatial and temporal variability in beaches means that more than individual samples should collected to obtain a representative sample. If several smaller samples that are easier to handle are collected, then the combined results are probably more representative than those from a single large sample and the total volume of material analysed corresponds more closely to the desired size.

BAR therefore had to develop a method that would take sediment variability into account whilst at the same time keeping the amount of sediment to be sampled to a manageable volume. Based on the measurements of the temporal and spatial variation on a number of beaches over more than one year and investigations of the variations with depth down to 4m below beach surface at a few locations on Pevensey Beach (see section 4.1) it was decided that sampling of the surface material (e.g. Bray, 1996) would not provide a representative measure of the bulk material properties of the beach. This report summarises the results of sampling of beach material at different depths carried out on Pevensey beach and describes the results from the beach material characterisation carried out in Summer 2004.

4 Sediment change with depth

To achieve a better understanding of how representative the sediment found on a beach surface is for the composition of the whole beach several pits were dug by mechanical diggers made available by Pevensey Coastal Defence in Pevensey Bay. Sampling was carried out on three occasions. During the first, 11 pits were dug but samples were only taken from a few layers of each pit to get an overview of the type of sediment encountered. During the second dig samples were taken only from two pits due to time constraints but an attempt was made to sample each layer within each pit to arrive at a representative grain size distribution for each site. The sites were selected to allow comparison between beaches with and without recharge history. The third dig involved 6 pits which were sampled at 20cm intervals resulting in the most complete data set (85 samples).

Sediments were sampled by collecting 3 to 5 kilograms of material from a discrete location in the pit wall using a trowel to release the sediment and a plastic bowel to collect it. During dig one and two samples were taken from representative layers whereas during the third dig samples were taken every 20 cm or, where necessary, at closer distances to sample thinner layers.

The three sections below summarise the main findings reported in more detail in the reports *Sampling of Pevensey Pits 15-10-2003.doc*, *2004-04-01-beach sampling at depth at beachlands.doc* and *2004-10-22-beach sampling at depth at Sand Castle.doc.*

4.1 First reconnaissance dig (15th October 2003)

28 samples were collected from 11 pits (**Figure 1**).

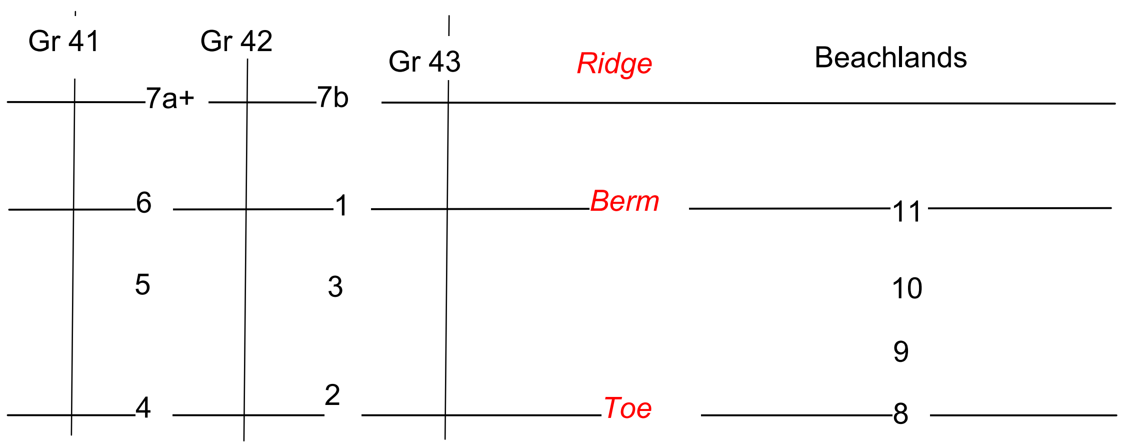

Figure 1: Sketch of pit locations in relation to groynes and morphological features. Groynes 41 to 43 are located near the Sand Castle and are shown in more detail in **Figure 6** between sites 1 and 2.

The samples can be divided into 4 groups. The first group are all surface or near surface samples and contain very little sand (samples 1b, 1d, 3a, 6a, 6b, 7a, 7c in **Figure 2**).The second group have bimodal grain size distributions (samples 2a, 4a, 6c) and are from sites either near the beach toe or very deep in the beach. The third group contain more than 70% sand (samples 11b, 9a, 10b and 7b). They are all found in the upper part of the beach at various depths and are often quite massive layers of almost pure sand (**Figure 3**). With the exception of sample 7b, which is from a beach ridge at the Sand Castle, they are all from the recharge site at Beachlands. It has been suggested that these sandy layers develop as an apron around recharge heaps shortly after they are deposited on a beach. The apron is subsequently buried by the re-profiling activity and is therefore an artefact of the recharge process (Ian Thomas, *pers. comm.*). The fourth group contains the majority of samples and is characterised by a sand content of 10 - 35%. Samples of this type are found in all the pits.

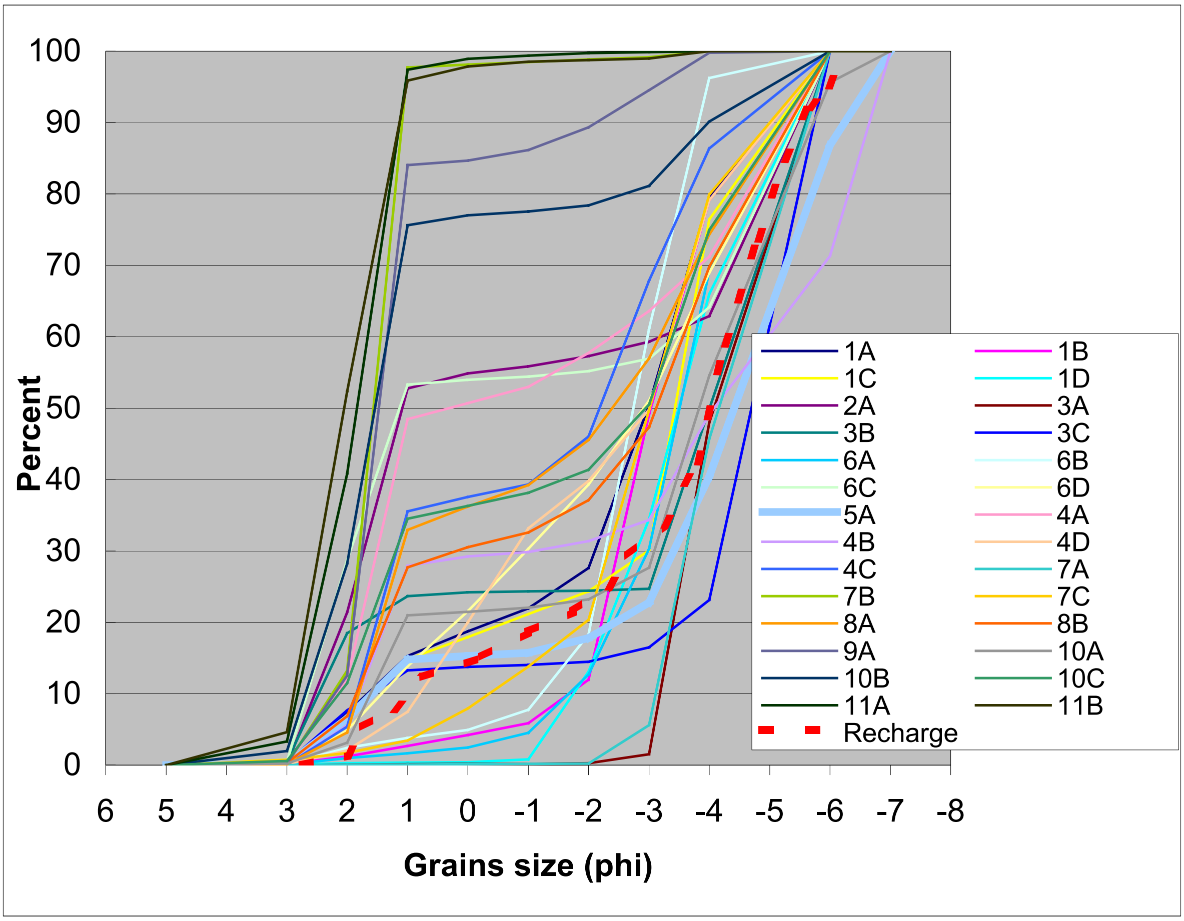

Figure 2: Plot of all cumulative frequency curves of 24 samples and, for comparison, grain size distribution of the recharge material used at Pevensey in 2003.

Figure 3: Photo of ~5 m long trench at Beachlands. Two sand layers, one at ~2.1 m below the surface (11A and detailed photograph) and one 0.9 m below the surface (11B) could be traced along both walls of the trench.

4.2 Second dig (1st April 2004)

Due to time restraints only two holes were dug at the eastern end of Beachlands (**Figure 4**). Both were located close to ABMS lines to allow a comparison with topographic changes. The western site is located in the recharge area while the eastern site does not receive any direct recharge but due to the longshore transport will receive recharge material, at least in transit. Eleven samples were taken from the western site and six from the eastern site (**Figure 5**).

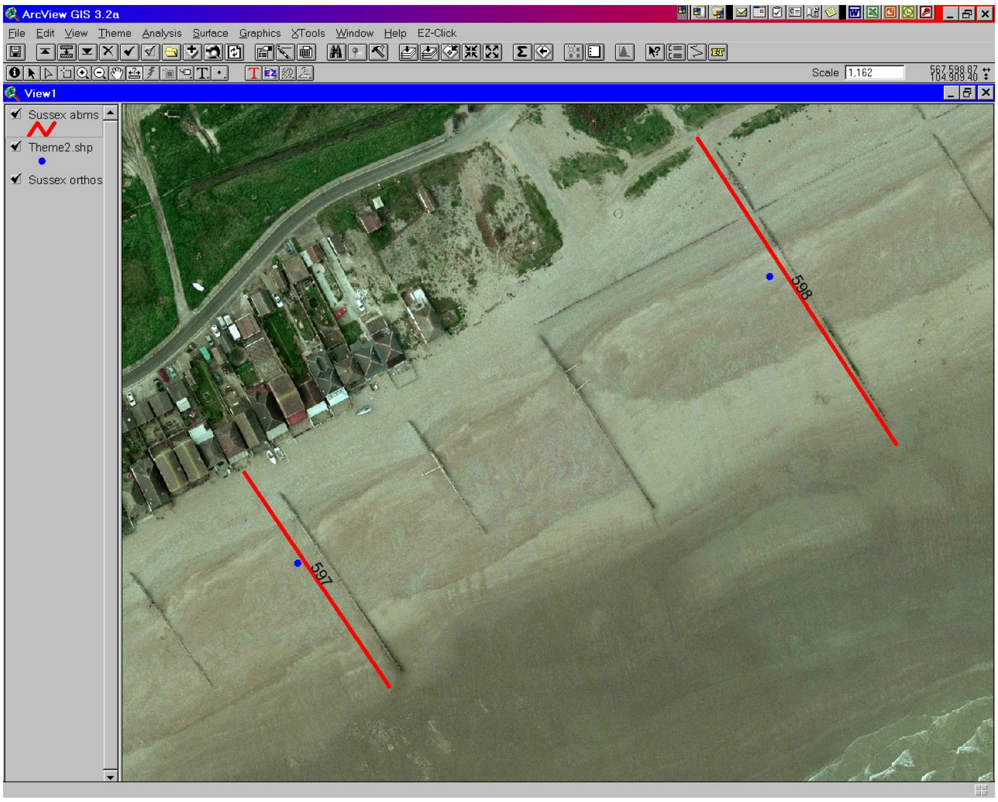

Figure 4: Location of sample pits and ABMS survey lines at the eastern end of Beachlands (back-drop ortho-photo May 2001).

The smaller sample interval reveals considerable grain size variations with depth. As in the first dig, a sandy layer was encountered at the recharge site at a depth of half a metre into the beach. The average difference in grain size between the two sites was 5mm. However, because of the smaller number of samples at the eastern site a direct comparison between the two cannot be made. The results confirm the findings from the first dig that the top layer contains little or no fine material, sand layers are found only in the recharge area and all sub-surface layers within the beaches contain fines in the interstices.

Western site	Height (OD)	D_{50} (mm)	Comment	Eastern site	Height (OD)	D_{50} (mm)	Comment
1	1.95 – 1.9	11.5	Surface layer without sand	11	1.9 – 1.6	28.7	
2	1.9 – 1.5	9.9		12	1.6 – 1.3	12.6	
3	1.5 – 1.3	0.3	Sandy layer	13	1.3 – 1.0	31.7	
4	1.3 – 0.8	16.3		14	1.0 – 0.8	4.1	
5	0.5 – 0.3	8.5		15	0.8 – 0.5	9.1	
6	0.3 – 0	14.1		16	0.4 - - 0.1	9.5	
7	0 – -0.6	7.5		21	~-1.6	Clay	
8	-0.6 - -0.9	4.8					
9	-1.1 - -1.3	16.6					
10	-1.3 - -1.5	14.6					
average		**11.6**				**16.6**	

Figure 5: Table showing changes of the D_{50} with depth at both sites together with the average. Average D_{50} takes thickness of each layer into account but excludes the sandy layer in the western site.

4.3 Third dig (22nd October 2004)

The third dig was the most comprehensive involving 6 sites all in close proximity within the unmanaged section of beach (**Figure 6**), from which 85 samples were collected at ~20 cm intervals. The only drawbacks were that the depth to which the holes could be dug was restricted by the ebbing tide to a maximum of 2.9 m below the surface and that the height control for the samples was poorer than could have been achieved by recording the surface elevation next to the scales shown in the figures.

Figure 6: Location of sampling sites (red dots) at the Sandcastle and location of ABMS profiles (green lines). The two groyne bays between site 1 and 2 have been sampled in 2003 and were therefore excluded.

Figure 7 shows the results for site 2. The sample pit was located at x=565409.7 y=103409.1 z=2.9, and was dug to 0.1 m OD covering 2.6m of beach. 16 samples were taken representing the layers shown in **Figure 8**.

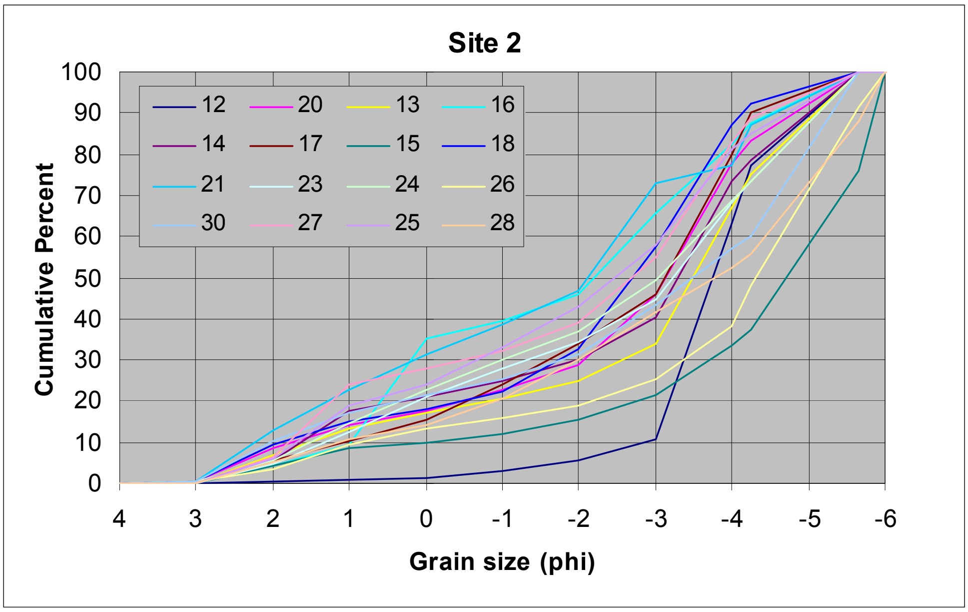

Figure 7: Grains size curves for samples collected at site

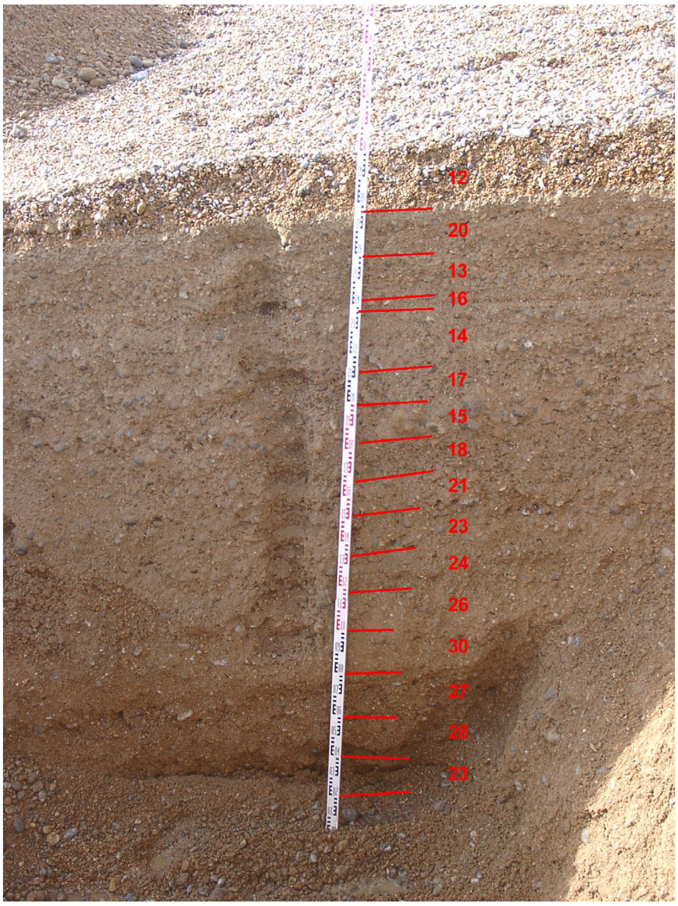

Figure 8: The western side of pit wall (site 2) showing location of samples.

The average D_{50} was 9.2 mm.The surface sample 12 had a very low fine content compared to the other samples which is very obvious in the photograph. The pit walls showed some visible variation (e.g. the thin layer 16 and layer 15 with conspicuous larger pebbles) which is evident in the grains size curves, but most samples are relatively similar and occupy a relatively narrow band of possible variation. All sites showed a marked change between the surface sediment (thickness ~10-30 cm) that contains only traces of fine material and the body of the beach, illustrating that the surface sediment is not representative of the bulk beach material but consists of a sorted subset. This difference is clearly shown in **Figure 9**. For five sites the surface layer had less than 5% fine material. The situation at the sixth site was similar but the surface sample showed evidence of mixing with the layer below, resulting in a total fines content of 18%. Changes in the content of fine material with depth were significant within each site ranging from 10-15% to ~40%. Sand content variations appear to be related across sites, particularly between the neighbouring sites 2, 3 and 4, with high contents around 1.9, 1.2 and 0.3 m and lower contents at ~1.5 and 0.6 m, a pattern that in the lower part is shown also at site 6.

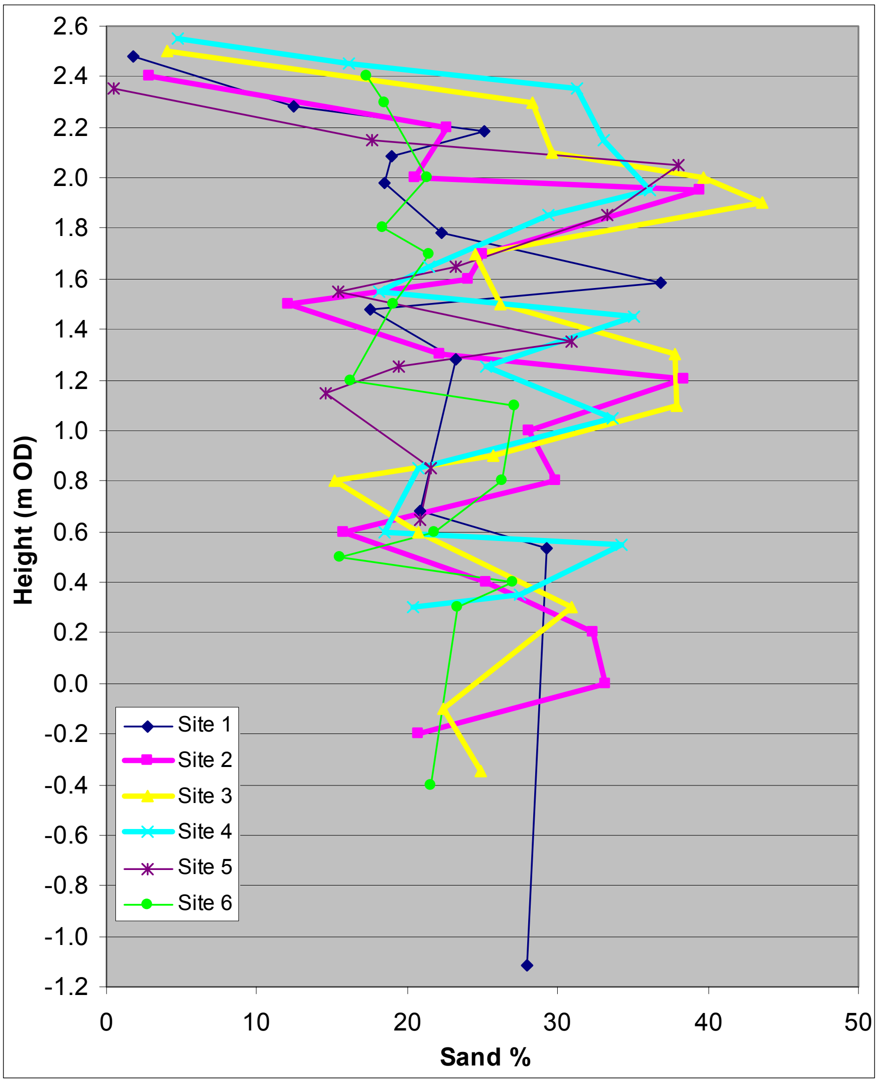

Figure 9: Variation of the sand content (gain size <2mm) with depth at all sites.

The average D_{50} for each site showed some variations with averages of 8 to 9.2 mm at sites 1 to 4 and 12.1 and 11.3 at sites 5 and 6 (**Figure 1**). The difference between the surface layer and the body of the beach shown in **Figure 9** is not reflected in the D_{50} as shown in **Figure 10**. However, variations with depth did show some correlation across sites that seemed to get stronger towards the bottom of the pits. D_{50} of ~-2.6phi was found in all sites at ~0.2 to 0.5 m with a significantly coarser layer (D_{50} of ~ -3.5 to –4.5phi) immediately above at ~0.6 m. Low values in the D_{50} were also found at ~2 m indicating that the pattern is similar to that for the sand content, again particularly visible in samples 2, 3 and 4. Between ~1.2 m and 1.9 m inter-site correlation seems to be poor which might relate to disturbance of the beach material during installation of groynes in the early 1950s.

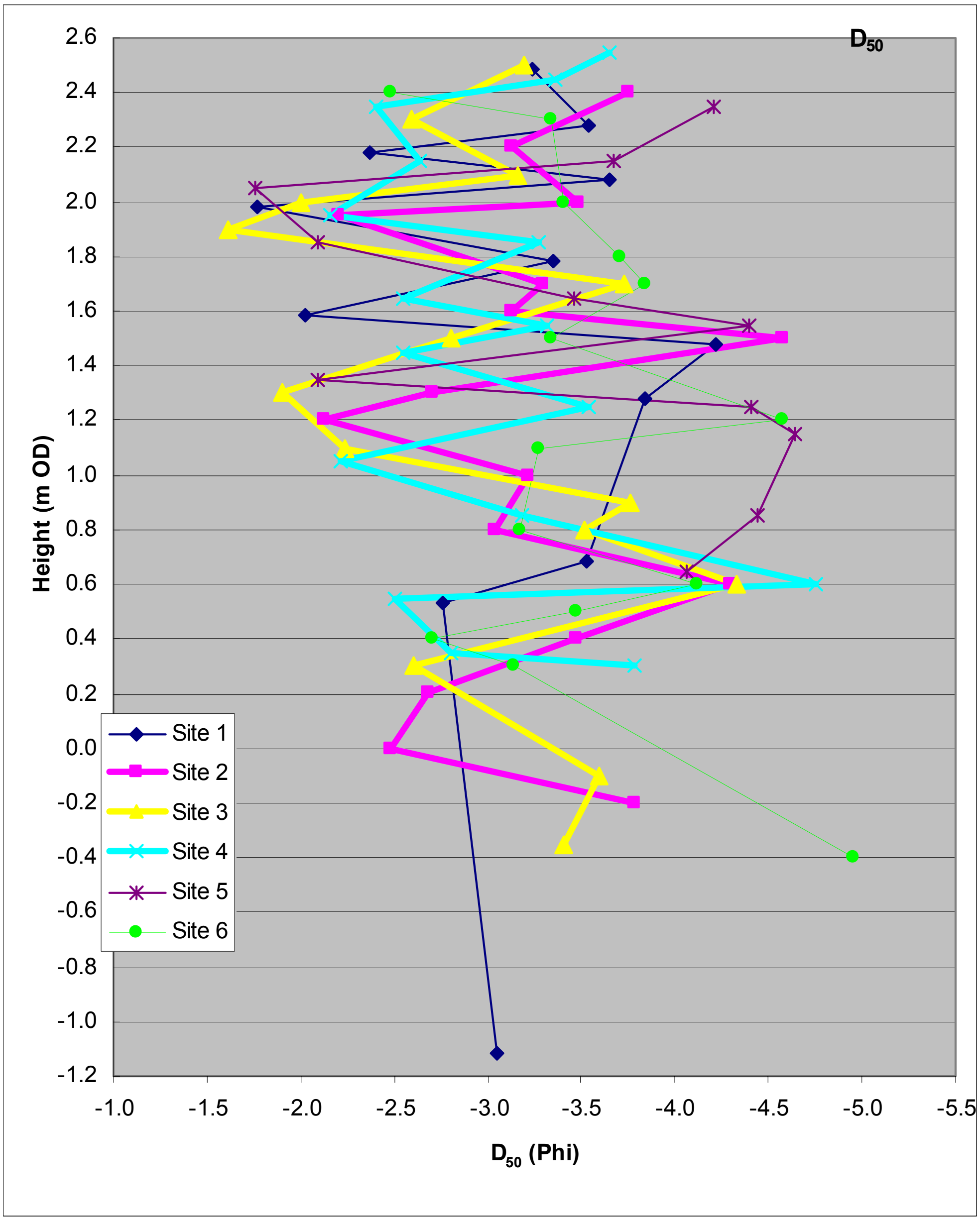

Figure 10: Variation of the D_{50} with depth at all sites.

The b-axis of the largest pebble in each sample was measured and is plotted against depth in **Figure 11**. Because the size of the largest particle is more influenced by sampling procedure and sample size than the other parameters, the general trends observed on the sand content and D_{50} are less visible. However, it would appear as if the length of the largest b-axis decreased towards the surface and the largest values occured at all sites below 1.6 m except for site 3. The average for each sample ranged from 42 to 47mm for samples 1 to 4 and 52 to 53mm for samples 5 and 6.

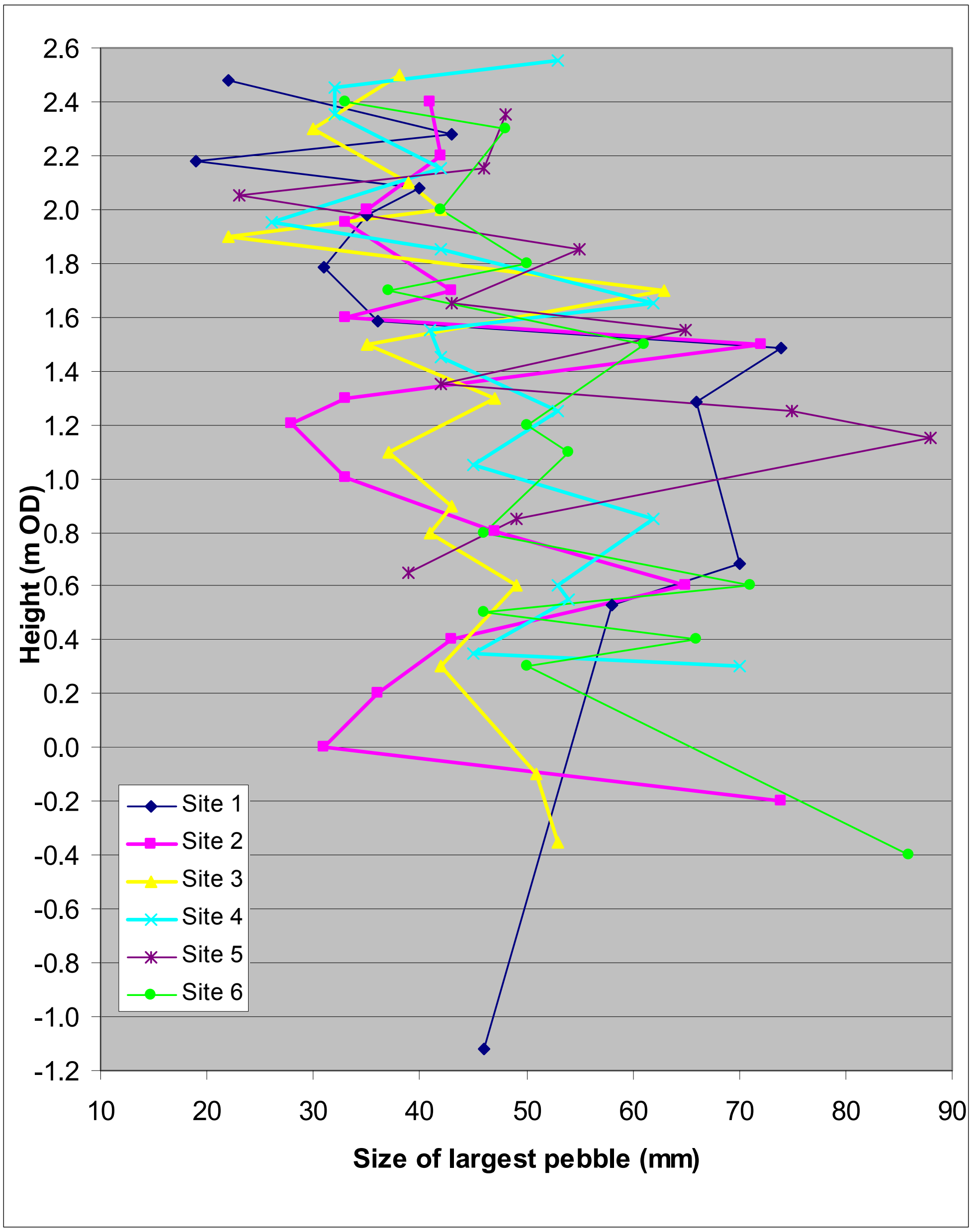

Figure 11: Variation of the b-axis length of the largest pebble in each sample with depth at all sites.

Comparison of the site averages for the D_{50}, fines content and the length of the b-axis (**Figure 12**) shows that sites 1 to 4 are somewhat finer than sites 5 and 6. Correlation between D_{50} and sand content/ length of b-axis exist for the site averages (**Figure 12**) but are even better developed if all samples excluding the surfaces layers are included (**Figure 13**, **Figure 14**). The correlation coefficient between D_{50} and the fines content is 0.79 and between the D_{50} and the b-axis length is -0.63.

	D_{50} (phi)	< 2mm (%)	b-axis (mm)
Site 1	-3.11	21.23	45.00
Site 2	-3.21	24.52	43.06
Site 3	-2.96	27.43	42.13
Site 4	-3.04	25.36	47.13
Site 5	-3.57	21.40	52.09
Site 6	-3.54	21.06	52.86
Correlation with D_{50}		.76	-.88

Figure 12: Table showing average values for D_{50}, fines content and b-axis length for each site.

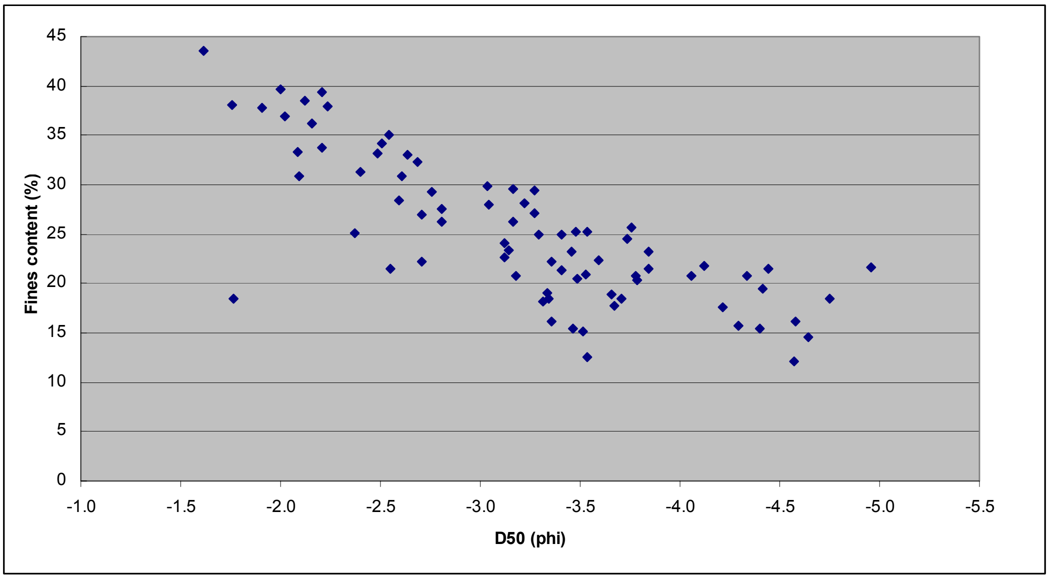

Figure 13: Scatter plot between D_{50} and fines content for all samples except surface samples.

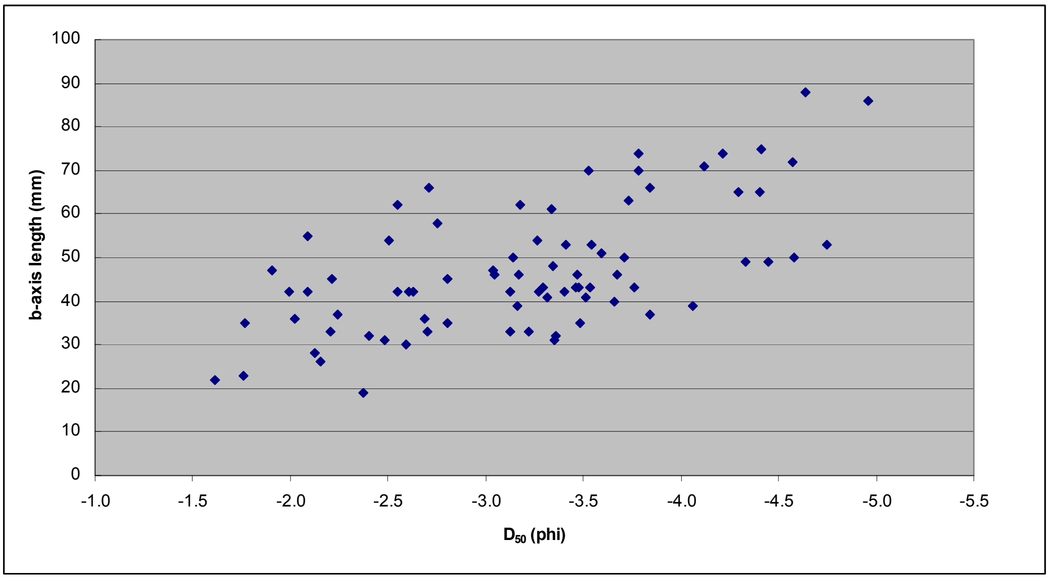

Figure 14: Scatter plot between D_{50} and b-axis length of the largest pebble for all samples

The large number of pits in close proximity, together with the high spatial resolution of the sampling, provides a detailed analysis of the beach composition.

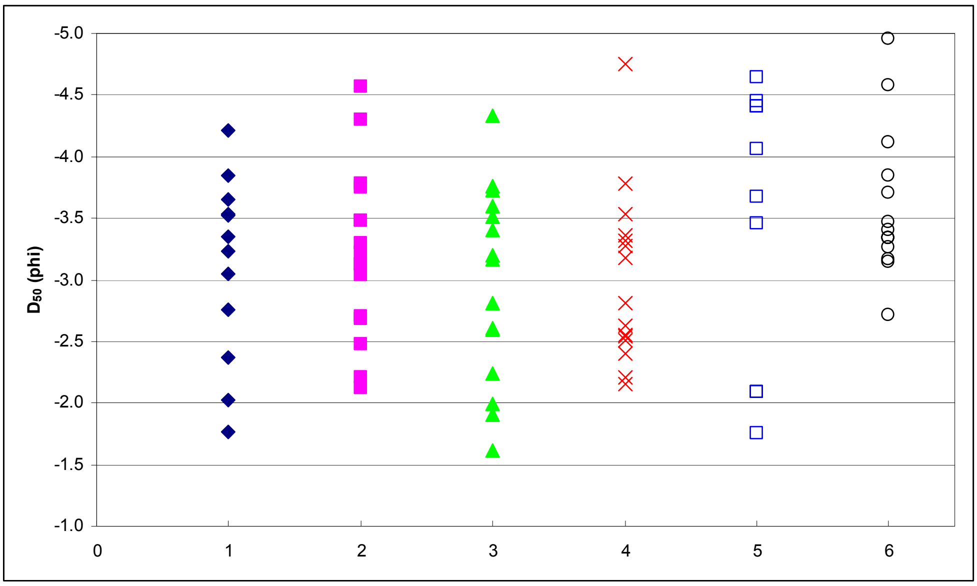

Figure 15: D_{50} of each sample in relation to site location.

Although the variation of D_{50} between sites was relatively small, variations within each site are significant (**Figure 15**, standard deviation between 0.5 and 1 phi). For grain size characterization of beaches it is necessary to collect samples below the surface layer that contains no sand as this would make the result unrelated to the true beach properties. Sampling the subsurface layers has revealed that the resulting D_{50} obtained from any individual layer may differ by more than one phi size from the true beach composition. However, in the case of the 6 samples from the Third Dig, the D_{50} of the first subsurface layer differed only by a maximum of 0.4 phi units (~3 mm) from the site average. Therefore it would seem reasonable to attach an error bar of $\pm$5 mm to a D_{50} measured from the subsurface layer to allow it to be representative of the whole beach.

The range of D_{50} for each site (8 to 12 mm) and the fines content from this unmanaged part of Pevensey Bay illustrate that the material used for recharging other sections of Pevensey is of similar composition as it commonly has ~20% fines (<2 mm) and a D_{50} of 10 to 11 mm.

4.4 Discussion

Sampling beaches at depth has shown that significant variations occur, which show some lateral consistency, especially between neighbouring sites. The bulk sediment properties provide information on how regional characterisation of beaches can be obtained by using the immediate subsurface layer rather than the surface layer, and the possible range of error in this method. It also provides valuable data for the coastal manager in that it allows comparison of the properties of unmanaged sections with those that have recharge material. Recharge material at Pevensey matches closely the properties found on unmanaged stretches with regard to fines content and D_{50}. However, the beach structure in the recharge areas may be different due to the emplacement and burial of sand layers during the recharge operation. It is possible that these layers influence beach profile behaviour due to different porosity though no tests to support this assumption have been carried out. In addition, the post recharge material distribution has been changed at Pevensey to avoid the creation of sandy subsurface layers.

5 Beach sediment characterisation

5.1 Type sites

Based on observations of beach material, previous work and other work carried out under BAR the following type-site beaches were selected with those beaches assumed to be natural, without the influence of recharge, are highlighted in bold (

Figure 18)

- **Saltdean**: BERM (Beach Erosion in the Rives Manche) site and small beach with 'impenetrable' protection and recharge material (SSW facing), monthly surveys under BAR; one profile line in the middle between the eastern concrete groynes, one profile in the middle between the western boulder and concrete groyne
- **Telscombe**: BERM site and small natural beach, semi-protected (SSW facing), monthly surveys under BAR; one profile ~20-50m west of the terminal groyne, one sample from the middle of the centre of the beach and one from the middle close to the western end
- **Newhaven west beach**: Site for measuring historic beach evolution; one profile ~20m west of the harbour arm, one profile down the middle of the beach
- **Seaford**: large, ungroyned recharged beach with movement data from EA shingle redistribution (SW facing), suitable for comparison with Pevensey Bay; one profile close to the western end of the promenade road, one in the centre and one close to the terminal groyne
- **Cuckmere Haven** (BD): small semi natural beach with artificial reworking; input into Cuckmere Restoration project (S facing), monthly surveys under BAR; one profile in the middle of the middle groyne compartment on the western beach, one ~100m east of the mouth on the east beach and one were the cliff start at the eastern end
- **Birling Gap**: medium sized natural beach with natural 'catastrophic' beach movement (total loss has been reported in the winter); one profile ~50m east of the steps and one ~100m west of the steps
- **Pevensey Bay**: long beach with extensive management history; data gathering by Pevensey Coastal Protection (SSE facing)
- **Pett & Rye Harbour**: Site of the “Two Bays”-project and long beach with management; movement data from EA shingle redistribution (SSE facing), one profile at cliff end (where a ‘proper’ beach has formed), one at Winchelsea beach and one ~200m west of the Rother mouth
- **Dungeness**: Long shingle beach with a change in direction which is likely to show longshore grain size varation; one profile just east of Jury’s Gap, one in front of the eastern end of Power Station and one in the vicinity of the ‘harbour’ (were access to the beach is easiest but north of the EA extraction area (concrete road to the beach)
- **Folkestone**: Site for measuring historic beach evolution; one profile 250m and one 700 m west of the harbour arm
- **Samphire Hoe**: Site for measuring historic beach evolution (S facing) one profile ~20m west of Samphire Hoe and one half-way down the beach
- **St Margeret at Cliffe**: Semi-natural pocket beach along chalk cliffs; one profile through the centre of a groyne in front of car park, one of the second groyne compartment west of the terminal groyne
- **Sandwich Bay** (BD): Long semi-natural beach with significant size grading (E

facing); one at the northern end of Kingsdown, one just south of Deal Pier, one just north of Sandown Castle (a bit north of from where the protection work starts), one at Sandwich Bay Estate and one close to the ness itself

5.2 Method

At these sites samples were collected from the following points:

- At each location 3 samples were taken along a profile line from just below the high (last) tide berm, the middle of the shore face and somewhat landwards of the beach toe (amount of setting back from the beach toe depended on the beach).
- The location of the sample point below the high tide berm was recorded with a handheld GPS or by measuring the position from structures like groynes. The position of the remaining points were measured in relation to the top point.
- On longer beaches several profiles were sampled to establish any longshore variation. The profile sites were chosen in relation to accessibility and evenness of distribution.

To avoid sampling the upper layer the first 10cm of beach were removed. The material below was cored with a shingle beach corer to a depth >20cm depending on ease of penetration of the corer. In cases where coring proved impossible due to the grain size (i.e. material was composed predominantly of shingle > 20mm) material of a similar volume was removed with a shovel. If the beach was a pure shingle beach without fine material 100 clasts were collected from an area 50 x 50cm (this area was excavated to achieve the 100 clasts) and the b-axis was measured to fit into the size ranges given below.

A photo with a scale (50 x 50cm grid to fill the whole photo) was taken of the surface of each site where the sampling took place to record the surface composition on the sampling day. The samples were sieved through a sieve stack of diameter 30cm on the beach using wet sieving for the finer fractions. Sieves used were 0.5mm, 2mm, 4mm, 9.4mm, 19mm and 51mm. The b-axis of the largest pebble was measured.

For each size class >4mm, the proportion of grey, brown and pale flints was visually determined (based on the samples shown in Figure 16). Grey / black flints are defined as those that have recently come from cliffs and shore platforms and may retain some white patina from the chalk. Brown flints are all those with traces, or a full coating, of a brown patina which is indicative of reworked sediments dredged from offshore or from deposits presently cropping out at Selsey Bill. Pale flints are those that are significantly paler than grey / black flints and that again are found in outcrops at Selsey Bill and are therefore likely to come from secondary sources. Whilst the fact that some brown flints may have lost all their patina to look like grey / dark flints could not be excluded, this was considered to have a minimal impact on the general distribution of flint colour found in one sample. Material remaining on each sieve was weighed with a spring balance. All material passing through the 0.5mm sieve was collected in a bucket that was decanted after a short (1 minute) settling period. For each beach section that was sampled, the b-axis of the largest pebble found on the surface was also recorded.

Figure 16: Samples grey / black flints in the left hand column, brown flints in the centre column and pale flints in the right hand column. The sample includes 'transitory' pebbles such as the top one in the central column and the bottom one in the right hand column.

5.3 Results

Field sampling at the type sites took place in July/August 2004 during a period of relatively calm weather and consequently small variations in the wave environment. 105 samples were measured along 39 transetcs. The main areas that have been excluded from sampling are visible in

Figure 18, namely Eastbourne, Bexhill – Hastings and the east side of Dungeness. Eastbourne has recently been recharged and the results can be expected to be very similar to other recharge sites such as Saltean, Seaford or parts of Pevensey. From field observations it is apparent that the east side of Dungeness is dominated by sand and that along long stretches no beach exists above high water (e.g. Hythe).

5.3.1 Mean grain size of profiles

The D_{50} of all 105 samples is 12.2 mm (**Figure 17**). 11 samples have a D_{50} of less than 2mm that also corresponds to sand contents in excess of 60% and is only found in Sandwich Bay and on Thannet (

Figure 18). The D_{50} for the size fraction larger than sand is, for all samples, 16.3 mm. The average D_{50} for sizes above 2mm is coarsest in samples taken from the top of the beach (below the high tide berm) and decreases down the profile, while sand content increases down the profile. The overall sand content is 23.3% with beaches featuring a sandy platform (e.g. Pevensey, Rye and Sandwhich) showing significantly higher proportions of sand (**Figure 21**) together with the much sandier beaches of Thanet.

Comparing the results obtained with this method with those in section 4 the samples taken from close to the high tide berm at Pevensey have an average D_{50} of 8 – 9. mm (section 4.3) which is comparable to the top (6.1 mm) and middle (9.6 mm) samples taken in close proximity. The values for the top (11.2 mm) and middle (4.8 mm) samples at Beachlands also compare well with those of the average and individual layers shown in **Figure 5**.

	Profile			**Top**			**Middle**			**Bottom**		
	Min	Max	Aver	Min	Max	Aver	Min	Max	Aver	Min	Max	Aver
D_{50} all sizes	0.59	39.31	12.21	0.68	70.06	14.96	0.18	30.72	11.02	0.19	58.17	13.19
D_{50} >2mm only	5.71	39.63	16.30	4.86	70.7	17.83	2.92	37.41	14.86	5.65	65.94	7.36
Sand %	0.00	89.83	23.33	0	97.62	18.86	0	96.57	25.14	0	91.15	28.64

Figure 17: Summary table of the D_{50} and sand content for whole profiles and parts of profiles.

The geographic distribution of the average D_{50} of all samples from each profile is shown in **Figure 18**; the D_{50} for all samples from each profile but excluding the sand fraction (i.e. all material >2mm) is shown in

Figure 19. Larger D_{50} are found on beaches close to cliffs (e.g. Newhaven to Beachy Head and Folkestone to St Margarets Bay which are also the most natural beaches) whereas smaller D_{50} are found in the shingle barriers (e.g. Pevensey Bay, Rye to Dungeness and Deal which in some cases are also related to recharged beaches). The smallest D_{50} is found at the northern end of Sandwich Bay and on Thanet. Comparison between the D_{50} of the whole sample and the fraction >2mm shows the largest difference on the beaches of Pevensey and Rye which have high sand contents. However, even if only the gravel size is taken into account, these shingle barriers are finer than the beaches in closer proximity to cliffs which might indicate a size reduction in the shingle due to abrasion in relation to transport distance.

Some longshore patterns can be observed, for example the three samples taken on Seaford beach show an increase in grain size downdrift. A similar, though weaker pattern can be seen in the three profiles at Pevensey. The three samples at Rye show coarser material on either end of the beach and finer in the centre. This might be due to the beach material recycling carried out on the beach that takes material from the eastern end moves it to the western end. The beaches in Sandwich Bay show a fining only towards the Ness.

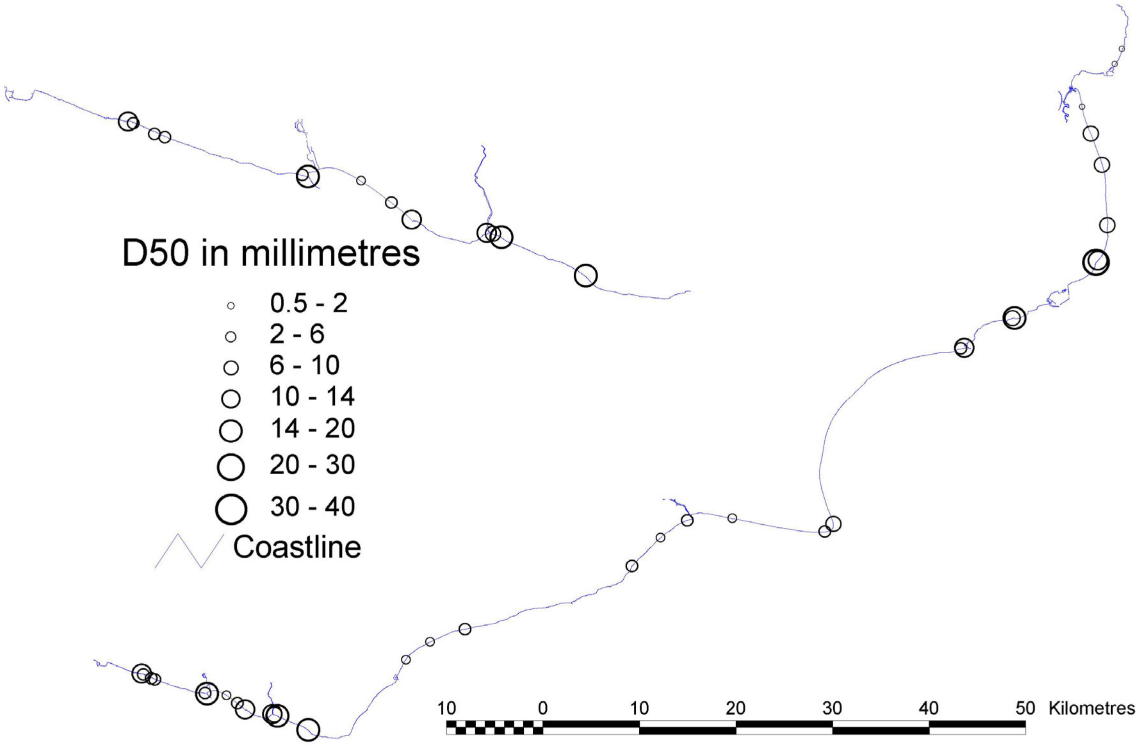

Figure 18: Map showing the D_{50} grain size averaged over each sample in a profile.

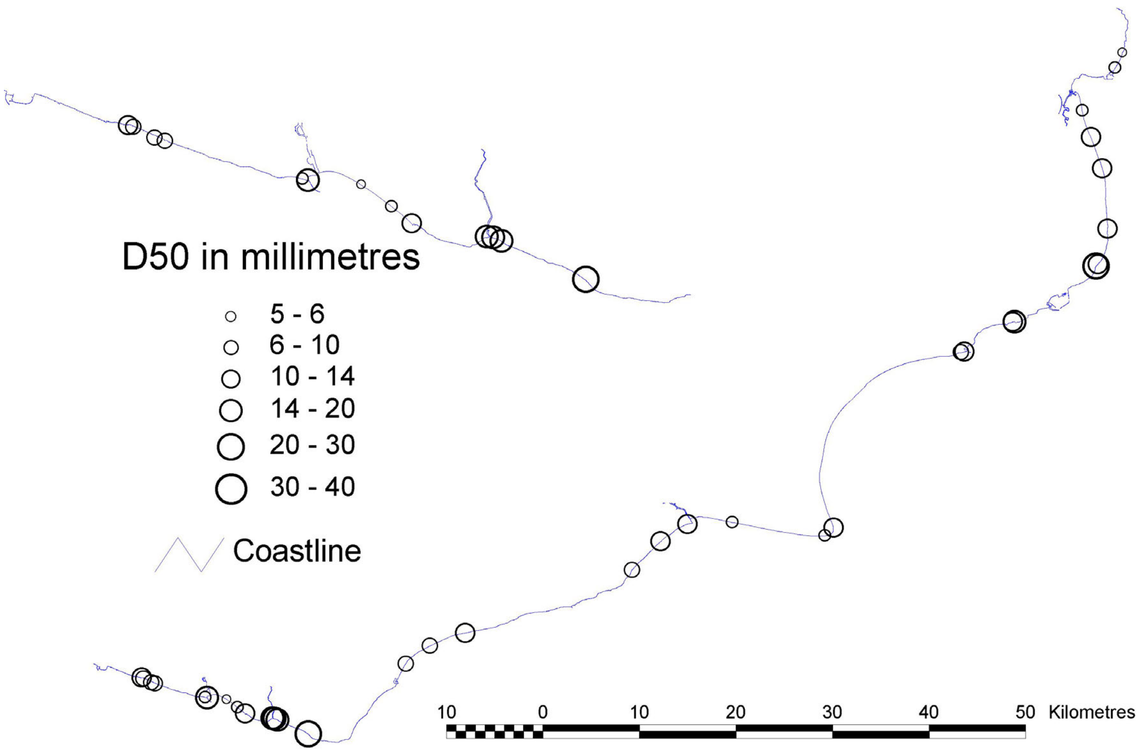

Figure 19: Map showing the D_{50} grain size averaged over each sample in a profile based on all material >2m.

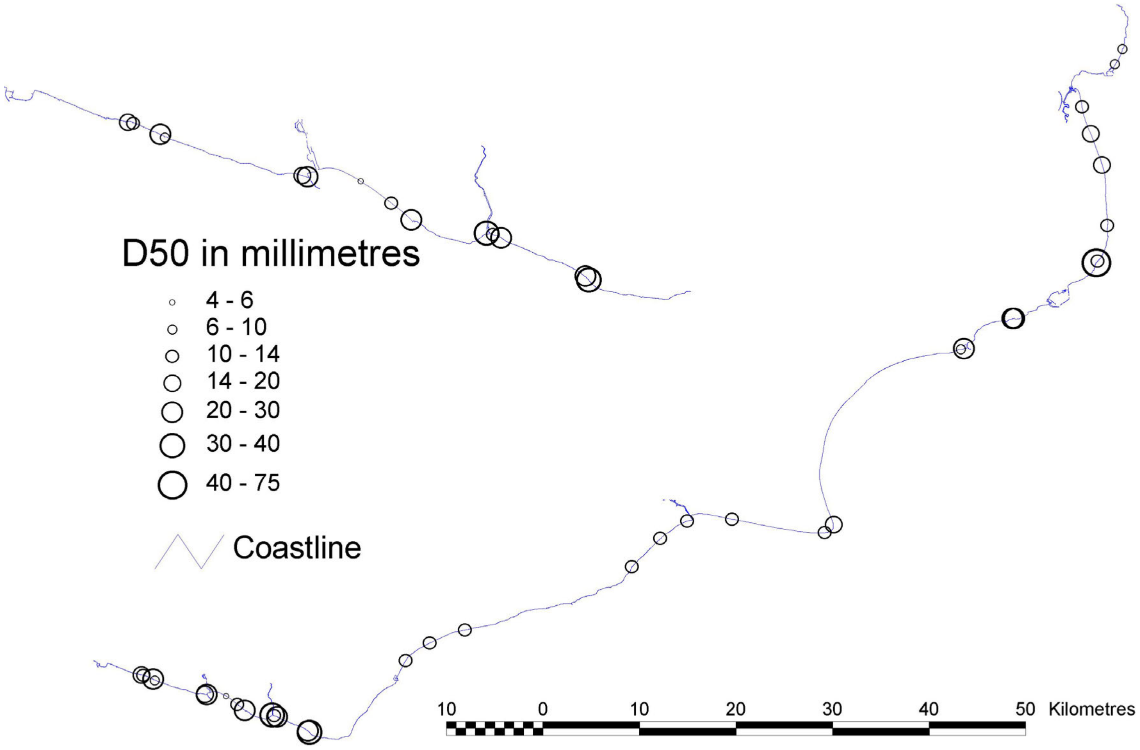

Figure 20: Map showing the D_{50} grain size for each sample taken from the top of the beach.

5.3.2 Mean profile sand content

The average sand content of all 105 samples is 23.3%; 17 samples contained no sand while 19 contained more than 50% sand (**Figure 21**). The latter encompassed samples from Thanet (**Figure 21**) and from the beach toe where most of the sample can be classified as belonging to the sandy foreshore rather than the mixed shingle beach. The geographical distribution (**Figure 21**) shows that the highest sand content is found where an extensive sandy platform exists. On Seaford Beach and in Pevensey Bay, the sand content decreases downdrift, while in Sandwich Bay it increases downdrift. For sand contents >40% the D_{50} for the material >2 mm does not exceed 14mm. However, there is no clear tendency for an increase in the D_{50} for material >2 mm with a sand content below 40%.

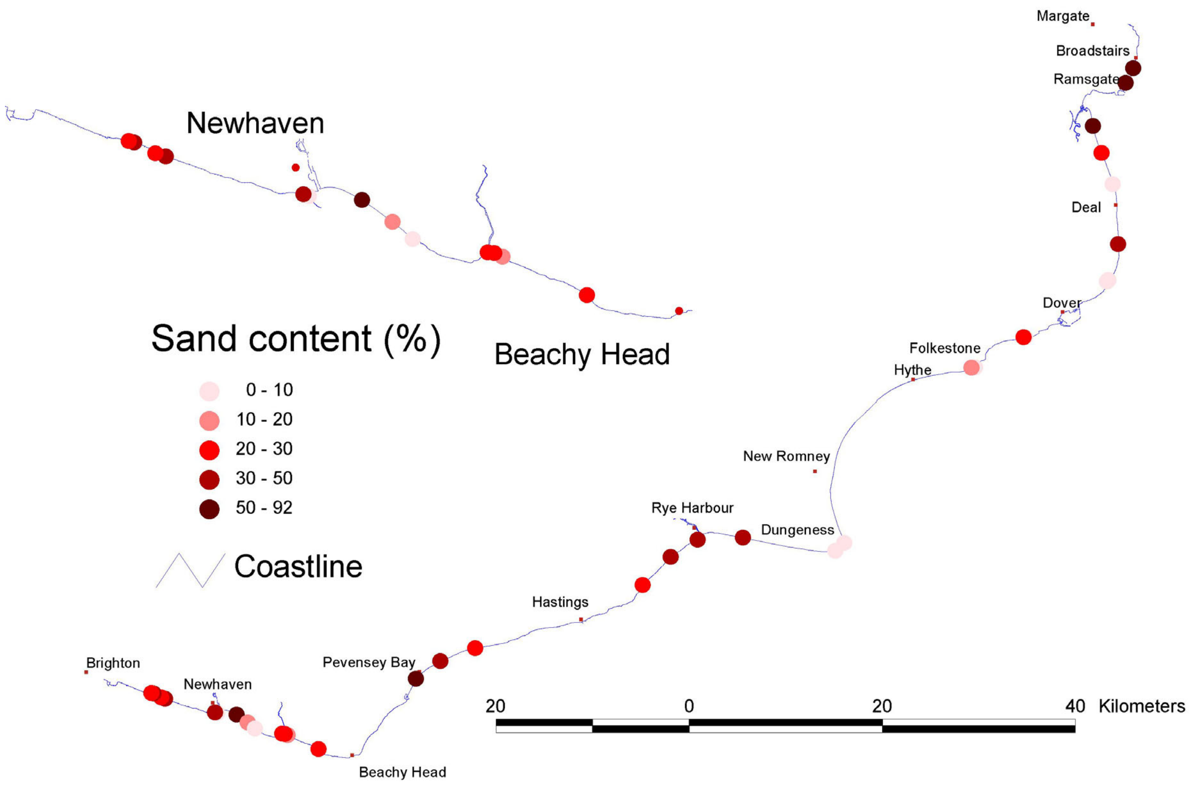

Figure 21: Map showing the average sand content of each profile.

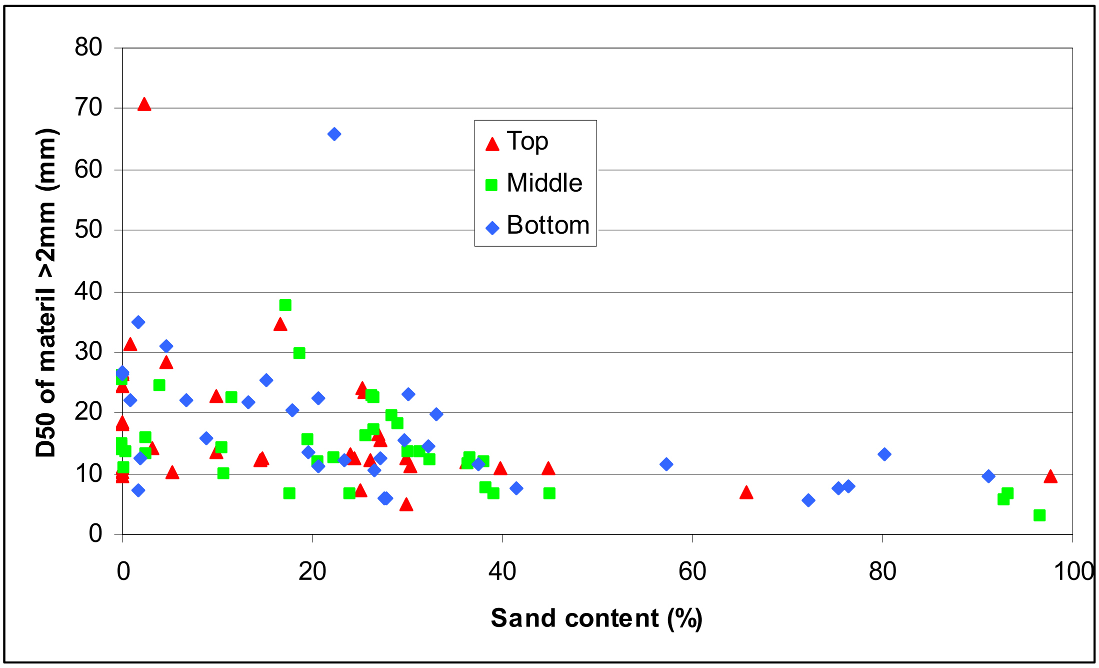

Figure 22: Scatter plot of D_{50} of material >2mm and sand content for all 105 samples.

5.3.3 Flint colour

Figure 23 summarises the colour distribution for all samples in relation to gravel size, while **Figure 24**, **Figure 25**, **Figure 26** and **Figure 27** show the proportion of grey and 'other' coloured flint as an average of all samples in one profile. Other coloured flints are usually over 90% brown with a minority being pale. However, pale flints were particularly difficult to distinguish from shell debris in the smaller size ranges so that only a division between grey and other colours is displayed. The proportion of grey to other coloured flints shows a significant relationship with size (**Figure 23**) with the proportion of grey flints increasing with size. The number of pebbles in each size class diminishes in each sample so that the size class 19-51 and especially the >51mm are often represented by no more than one pebble whose colour then determines that for the size class.

	grey	other
4-9mm	30	70
9-19mm	35	65
19-51mm	55	45
> 51mm	70	30

Figure 23: Comparison between grain size and flint colour averaged over all profiles.

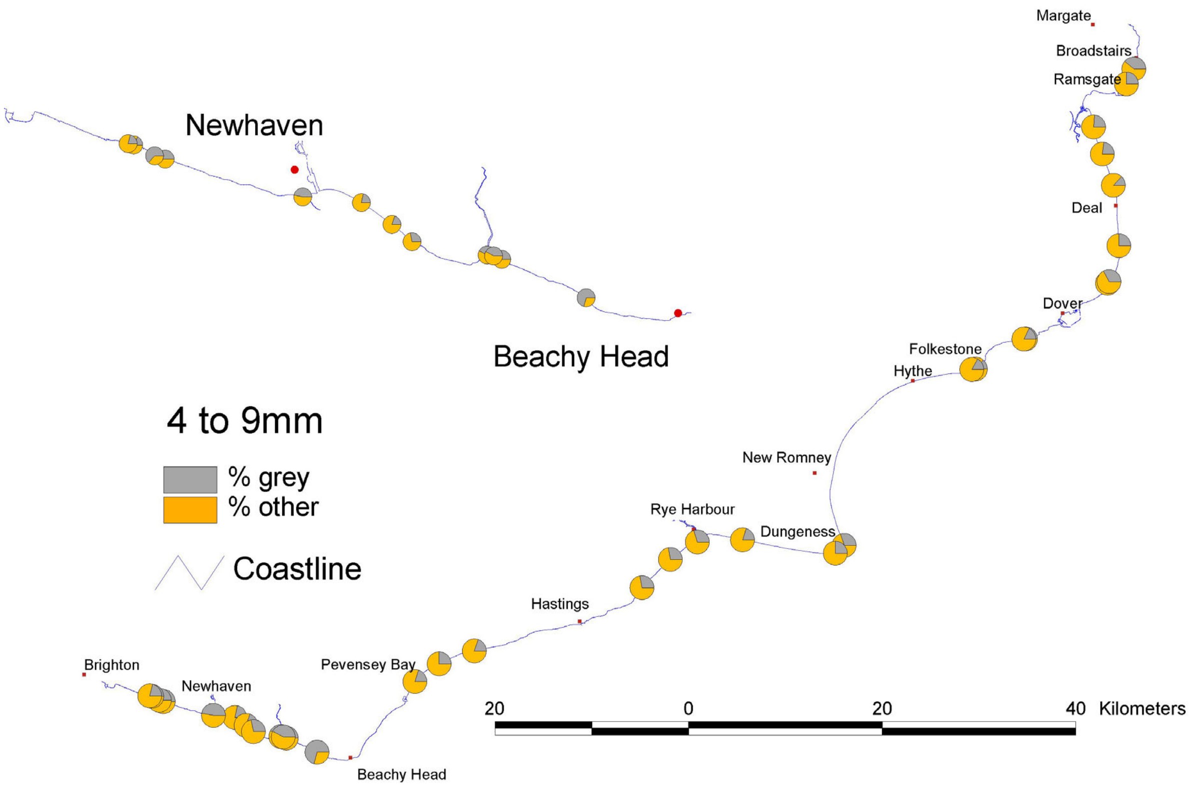

Figure 24: Average proportion of grey and 'other' coloured flint as an average of the samples for each profile for the size range 4-9mm

Apart from a size – colour relationship, colour is also influenced by location. In the size class 4-9mm (Figure 24), where on average grey flint is under-represented, grey dominates or comprises a far larger share on East Sussex beaches close to active cliffs such as at Newhaven, Cuckmere Haven and Birling Gap.

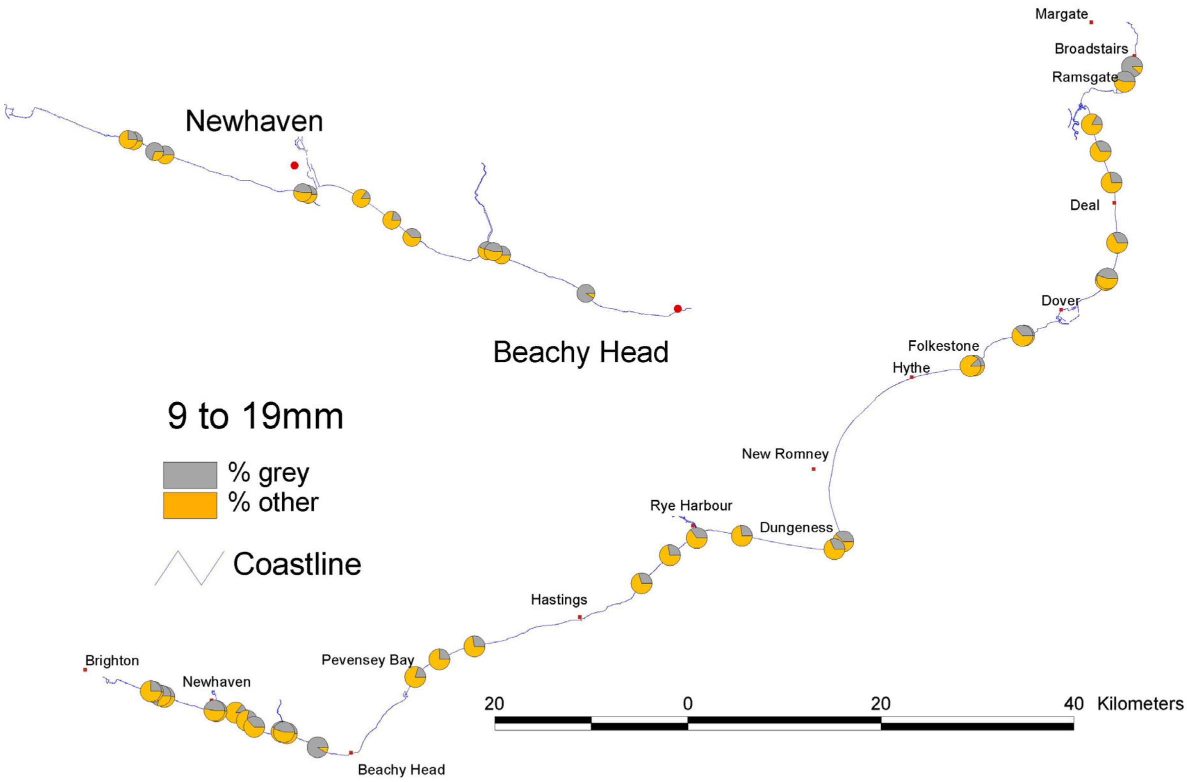

Figure 25: Average proportion of grey and other coloured flint as an average of the samples for each profile for the size range 9-19mm.

In the size range 9-19mm the proportion of grey flint increases and there are significantly higher proportions on Thanet and on the beaches between Brighton and Beach Head. The inset of Figure 8 shows the difference between recharge beaches (Saltdean and Seaford) and the more natural beaches at Telscombe, Newhaven, Cuckmere Haven and especially Birling Gap.

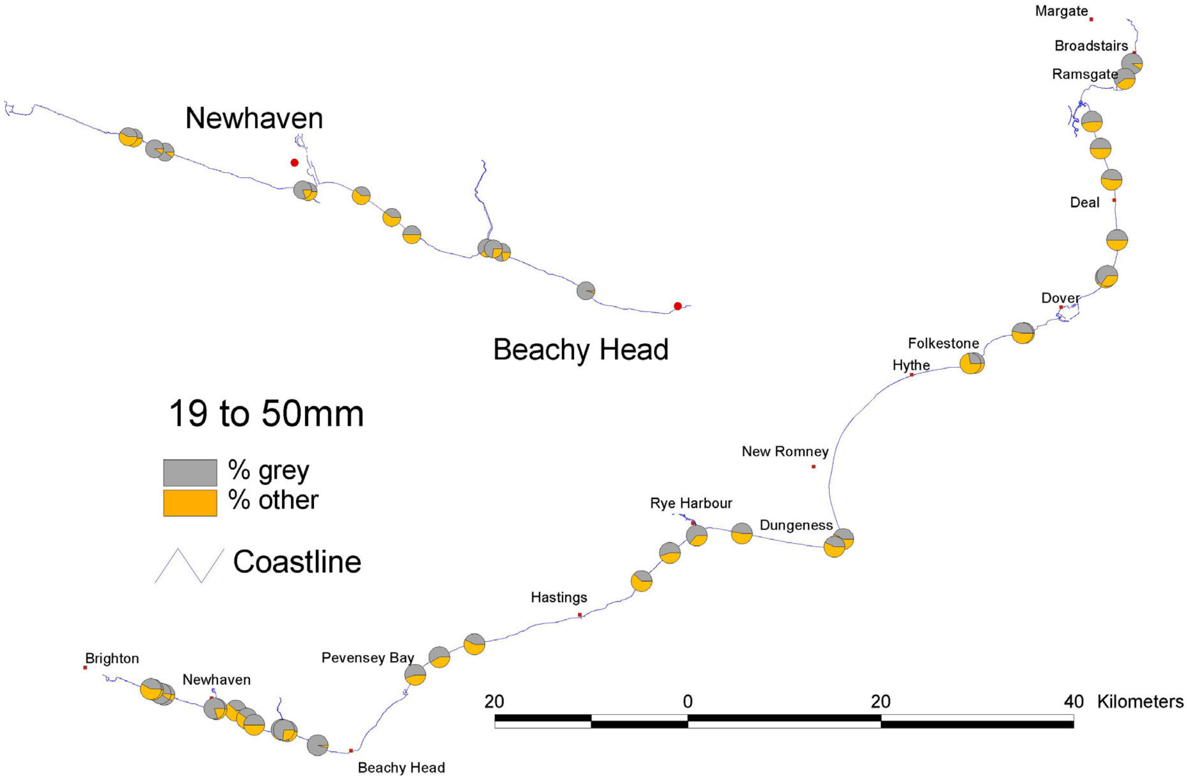

Figure 26: Average proportion of grey and other coloured flint as an average of the samples for each profile for the size range 19-50mm

In the size range 19-50mm grey flint is on average slightly the more abundant with notable exceptions at Folkestone where brown dominates and along the natural beaches of East Sussex, especially Birling Gap. Again, the difference between recharge beaches and natural beaches can be seen clearly in the inset.

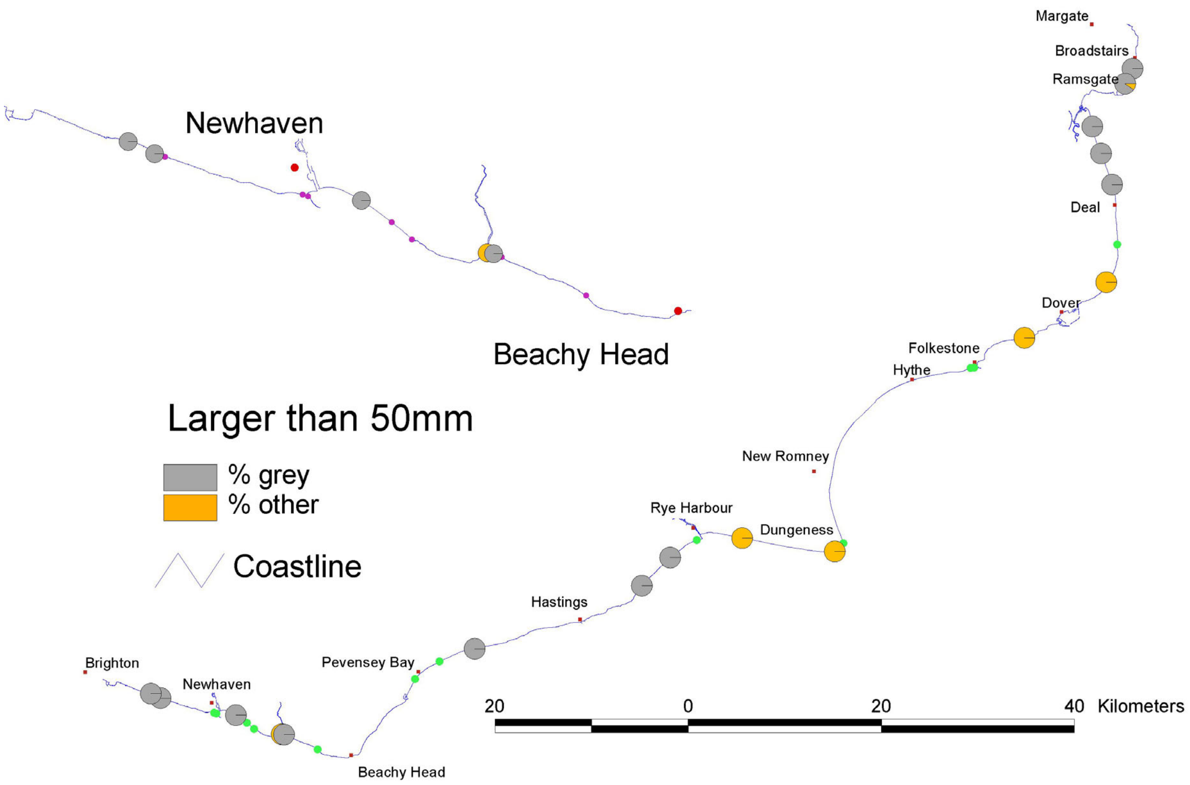

Figure 27: Average proportion of grey and other coloured flint as an average of the samples for each profile for the size range >50mm.

For the size range >50mm grey dominates except for the stretch from Rye to St Margarets, but this probably reflects the limited sample size rather than being a true representation of the pebbles on the beach.

6 Outlook for BAR phase 2

The work to date on the sediment characteristics of beaches in the BAR area has yielded interesting results. The sediment sampling method described in Section 5 provides D_{50} values in a range similar to that found with more detailed sampling in Section 4. The large scale survey described in section 5 needs to be repeated and needs to be applied to beaches in France to widen the regional comparison. Sampling of almost pure sand beaches (e.g. at Camber or the eastern side of Dungeness) if included, would need to employ additional mesh sizes to characterise the fine sand fraction. The smaller sample number and size would make laboratory grain size analysis more suitable.

7 References

This report is partly based on the following reviews, protocols and reports:

2004-02-19-Report_first cliff retreat rates for Kent.doc

2003-05-14-Report_Beach sediment sampling 01.doc

2003-06-12-Review_Sediment sampling Literature.doc

2004-07-12-Protocol_Beach material sampling.doc

2003-11-30-Report_Beach sediment sampling at Pevensey 01.doc

2004-02-01-Protocol_Material size classes for beach surveys.doc

2004-04-01-Report_Beach sediment sampling at Pevensey 02-Beachlands.doc

2004-10-22-Report_Beach sediment sampling at Pevensey 03-Sandcastle.doc

Bray, M.J., 1996. *Beach budget analysis and shingle transport dynamics in West Dorset.* PhD Thesis, London School of Economics, London.

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