Appendix 9B

The following presents the results and interpretations of a series of multivariate analyses undertaken to test the hypothesis that habitats and communities within the influence of dredging are different from reference areas outside the footprint of aggregate extraction.

Figure 9B.1 below is a MDS ordination of all enumerated grab data from all stations across the region overlaid by the different dredging treatments. No clear separation between samples was discernible. This may be a consequence of the spatially variable nature of the south coast region which may give rise to different communities responding in different ways to different levels of dredging intensity. As such, distinct “impact groups” may not exist at the level of the south coast region and the hypothesis is rejected at this scale.

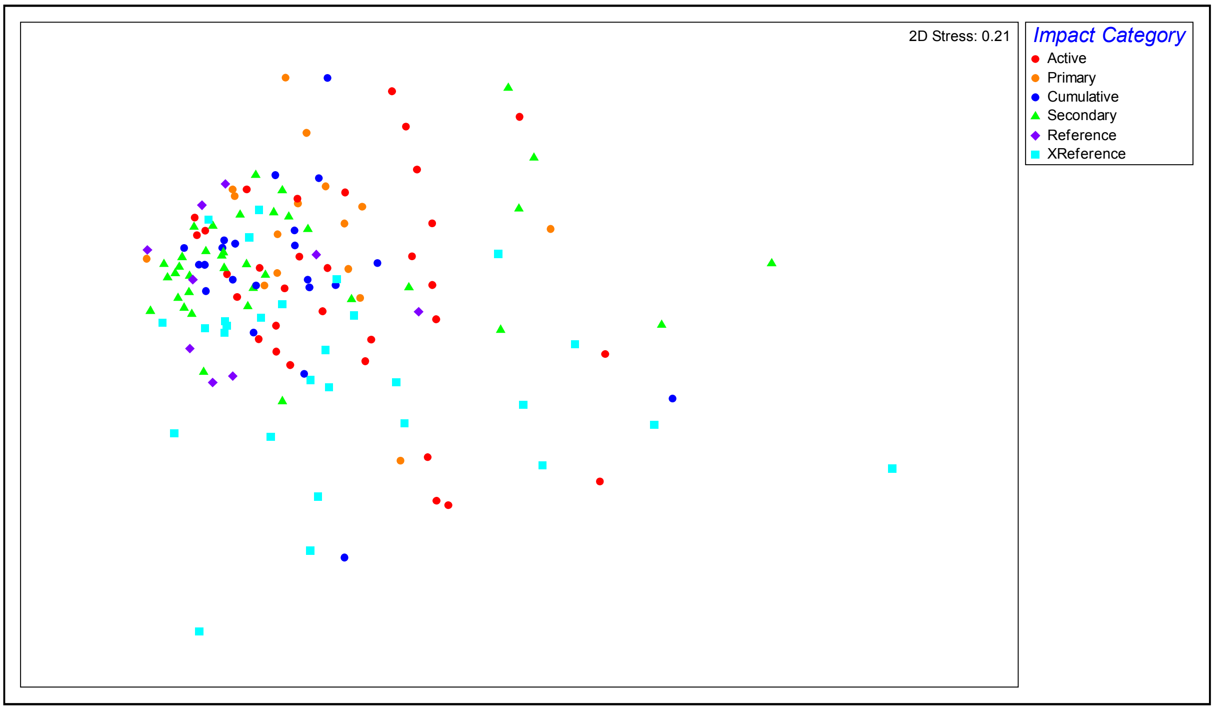


Figure 9B.1: MDS ordination based on Bray Curtis similarity measure. South Coast REA enumerated grab faunal data 4th root transformed.

In an attempt to overcome the potential spatial variability at regional level, the multivariate analyses were repeated at sub-regional level i.e. West Isle of Wight, East Isle of Wight and Owers areas (see Figures 9B.2, 9B.3 and 9B.4).

Figure 9B.2: MDS Ordination of enumerated grab faunal data from the East Isle of Wight sub-region.

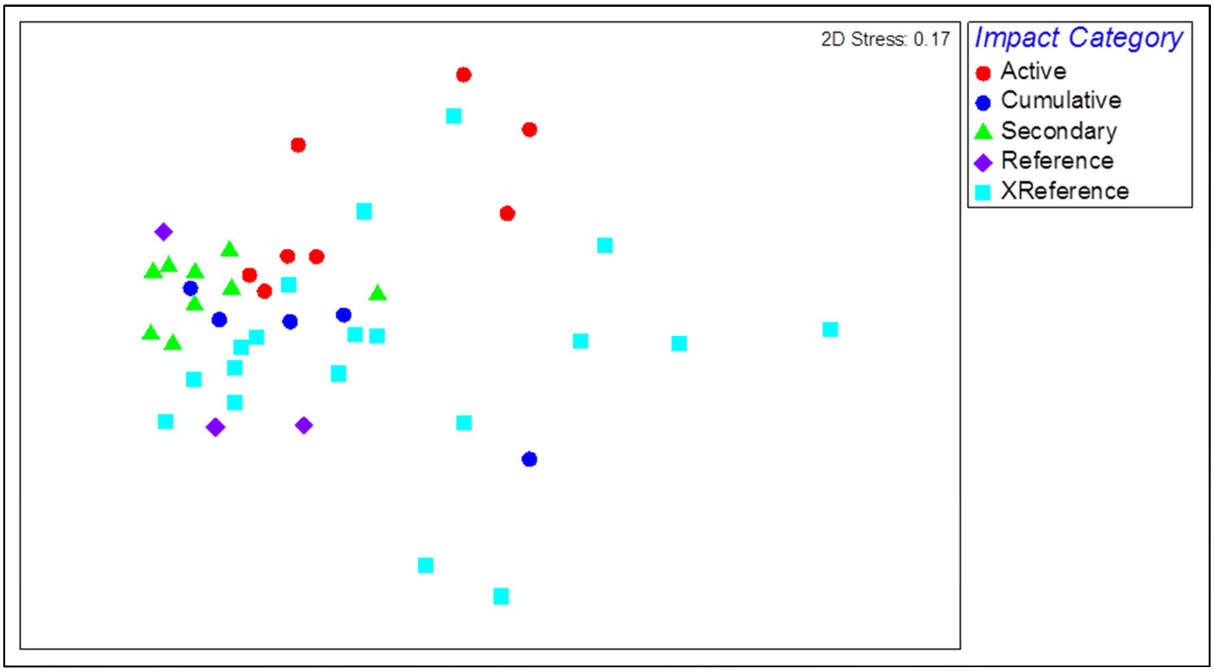


Figure 9B.3: MDS Ordination of enumerated grab faunal data from the West Isle of Wight sub-region

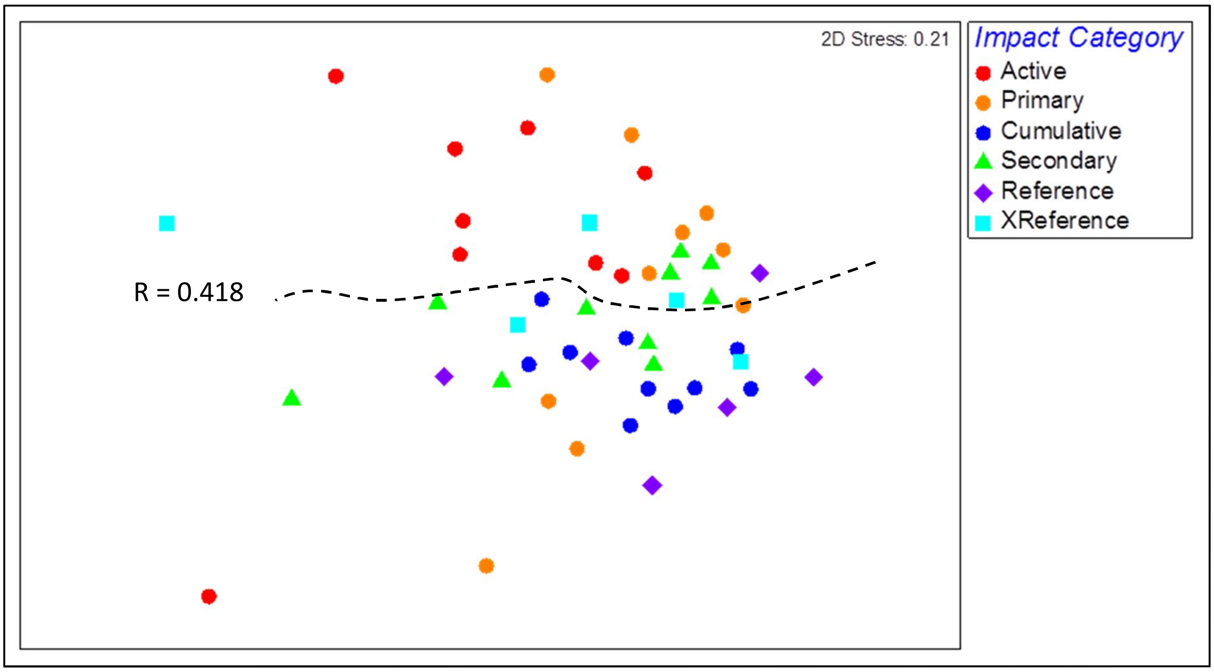


Figure 9B.4: MDS Ordination of enumerated grab faunal data from the Owers sub-region.

Again, no clear separation between sample groupings was observed although a broad separation between samples collected in active dredge areas and cumulative effect areas within the Owers sub-region was apparent. A subsequent ANOSIM test however remained unconvincing (r = 0.418) (see Figure 9B.4). Further ANOSIM testing within each sub-region did not identify any significant differences between sample groupings.

Comparable multivariate comparisons of sediment particle size data (Euclidean distance) similarly showed no distinct treatment groupings at regional or sub-regional level. EMU has also tested the semi-quantitative video data within ANOSIM which although it suggested that the Owers sub-region could differ slightly from the east and west Isle of Wight sub-regions (more sandy), showed no separation between treatments. In conclusion, the hypothesis is unsupported and there do not appear to be any differences in communities or sediments from different treatment areas at regional or sub-regional level.

The impacts of aggregate extraction have been extensively researched and are well understood (see further below) with site specificity often emerging as an important factor determining community sensitivity characteristics. Given the high local variability in benthic habitats and associated communities within the south coast region it is likely that a range of different community trends and responses to the effects of dredging exists. As a result, grouping "like for like" samples within treatments at regional and sub-regional levels may not be possible. Furthermore, the variability in dredging intensities across the region introduces additional variability and further confounds sample clustering techniques and associated interpretations. Despite the difficulties in assessing spatial trends future regional monitoring will enable assessment of temporal trends related to dredging activities

To attempt to elucidate community differences between treatments within selected broad -scale strata a series of multivariate comparisons (MDS sample ordination and ANOSIM) between treatments (impact categories) within each EUNIS level 3 biotope classification as described in the South Coast REC were undertaken. The REC high level habitats were selected in preference to REA biotopes in this instance as the latter are largely based on data collected from areas potentially affected by dredging and which may caveat subsequent conclusions.

These additional assessments used combined REA/REC data (total 211 samples). Figure 9B.5 illustrates the distribution of REC and REA samples within the classified EUNIS level 3 habitats. Table 9B.1 summarises the numbers of samples representing each EUNIS habitat type.

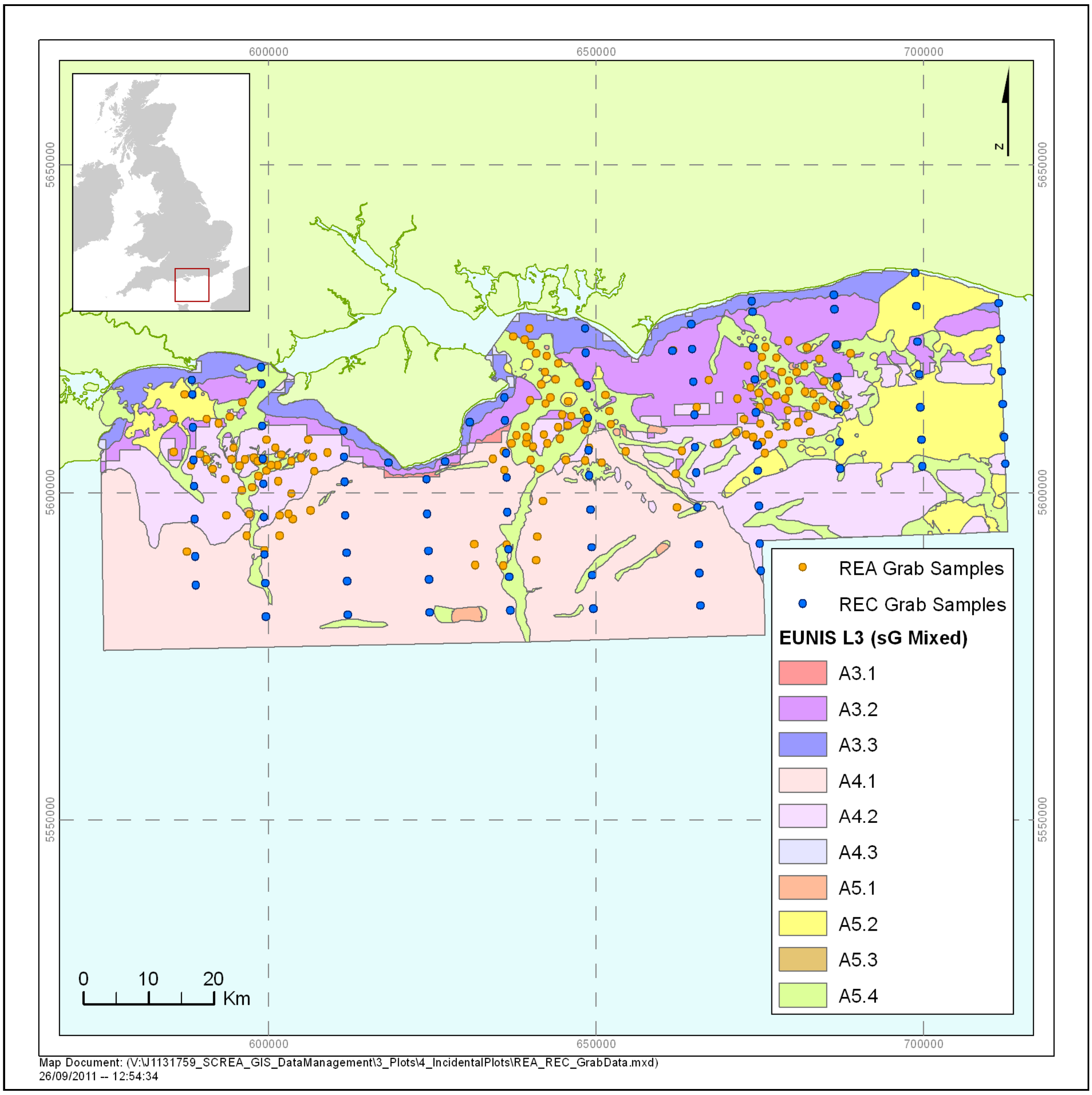


Figure 9B.5 Distribution of REA and REC grab samples within EUNIS level 3 habitats.

Table 9B.1 Numbers of grab samples representing each EUNIS habitat type

EUNIS code	EUNIS Name	No. samples
A3.2	Moderate energy infralittoral rock	23
A3.3	Low energy infralittoral rock	5
A4.1	High energy circalittoral rock	28
A4.2	Moderate energy circalittoral rock	41
A5.2	Sublittoral sand	22
A5.3	Sublittoral mud	1
A5.4	Sublittoral mixed sediment	90

MDS sample ordinations (data square root transformed) showing sample relationships within each EUNIS habitat type are presented below. Samples are classified according to predicted impact category as described in Technical Annex B. Summary results of an ANOSIM are presented alongside each of the MDS plots. Due to the low number of representative samples no assessment for EUNIS A3.3 and A5.3 strata is provided and as this type of strata is not present inside any licence blocks comparisons would not be applicable.

In general, results fail to show any pattern that might otherwise indicate potential dredging effects. The spread of samples from impacted sites fall largely within the spread of reference and Xreference stations suggesting any dredging effects were comparable to the effects of natural variation (Xreference stations being those stations which fall outside current predicted effects of dredging but may become affected due to the granting of new licences in the future). In addition, sample statistics and global R values were generally such that further investigation of the comparative tests was not warranted, the results of which are presented nevertheless.

There may be a number of factors overlying dredging effects and which may mask or interfere with the otherwise clear impact patterns including;

- differences in depths, salinity and bottom temperatures (thermal stability) at the regional level;
- sub-regional differences in community structures due to exposure to different extrinsic factors
- sub-regional differences in community responses to dredging; and
- variable commercial fishing (or other) pressures across the south coast aggregate licences.

The possible exception to this was the comparison between samples collected from active dredge sites (ADZ's) and reference sites in sublittoral sand deposits (EUNIS A5.2) (highlighted below). Both the MDS and ANOSIM suggested a degree of separation between these treatments.

SIMPER analysis revealed that the largest contributors to the apparent dissimilarity between treatments were an absence in the ADZ's of typical sand fauna such as *Spiophanes bombyx, Nepthys cirrosa, Nepthys* spp., *Echinocyamus pusillus, Magelona johnstoni, Bathyporeia* spp., *Lanice conchilega, Lagis koreni* and Opheliidae together with other fauna such as *Crepidula fornicata*, *Pomatoceros lamarcki* and *Balanus crenatus*, Spionidae and Ophiuriidae. Conversely, *Notomastus* spp. and *Spisula elliptica* were greater in abundance.

Impacts of dredging in sand deposits have been reported (e.g. Poiner and Kennedy, 1984; Sardá *et al*., 2000) and typically include reductions in species diversity, abundance and biomass compared to reference conditions. At first glance, the analyses using the REC category of sublittoral sands appears consistent with potential dredging effects. The data suggest that assessment and monitoring of effects of dredging in sublittoral sand (EUNIS A5.2) habitats may be undertaken at the regional level.

However, a large caveat must be placed on these results. The raw data underpinning the REC and REA reports, show that the sample sites chosen across the region that befitted the broad category of sublittoral sands in geological terms, revealed a high degree of natural heterogeneity at the macrofaunal community level. This was clear when comparing communities within the reference sites, which displayed a very similar surface physical appearance, but when grab sampled revealed a naturally different biological community.

There is also an issue with the geographical spread of sample sites used in the sand category. The majority of the reference sites in the sublittoral sand category were located in the large natural sand deposits at the far east of the SCMAREA boundary, whilst the majority of the sites representing ADZ's were located to the west of the Isle of Wight. As these areas are not linked physically or biologically to the reference sites, the significant differences between them are likely to be a result of the large degree of geographical separation. The differences between communities in the three sub-regions of licence blocks, particularly the Owers region to the far east, were highlighted in the REA technical report. The flow dynamics around the Isle of Wight, mainland coastal processes and various other extrinsic influences has a large influence on the type of communities that reside.

A further factor that undermines the significance of the result for sublittoral sand is that the aggregate licence blocks in the SCMAREA region are generally associated with paleochannels which contain mainly coarse circalittoral sediments with some mixed sediments. Very few sites within the current ADZ's can be classed as sublittoral sand, and these few are highly influenced by the surrounding mixed sediment substrata as shown by the species data analyses.

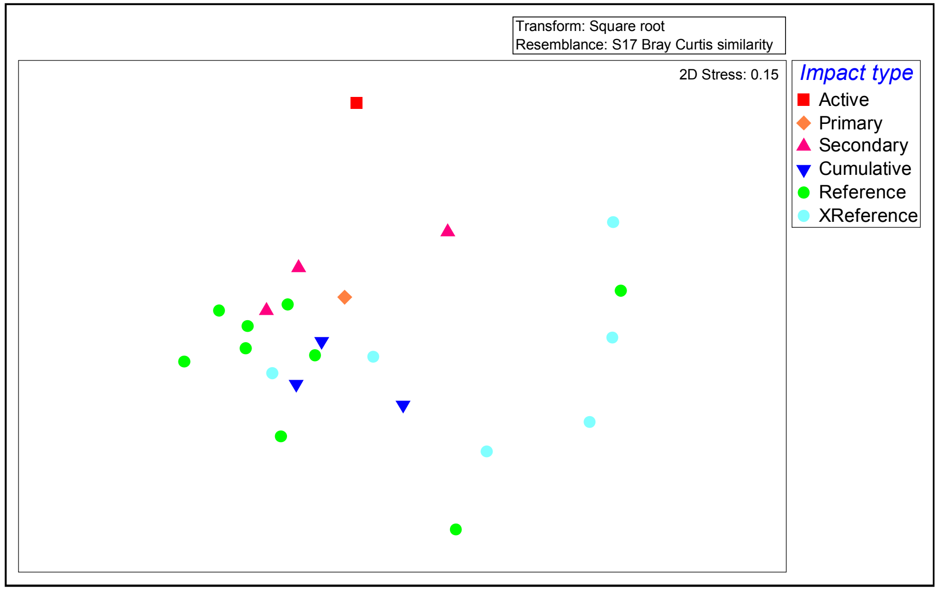
Therefore, although the PRIMER analyses found a significant difference between reference sites and ADZ's using the sublittoral sand category at the regional level, the allocation of these sample sites within the sublittoral sand category appears inappropriate because of the heterogeneous nature of the sediments in the region and the clear sub-regional differences.

Mid range values of R are observed in a number of the SIMPER comparisons below. These require caution during interpretation of potential differences as they can indicate that each group may contain samples that are both significantly and not significantly dissimilar (i.e. overlap). As a general guide to interpretation, values of R close to 0 indicate no differences between the groups whereas large R values suggest evidence of group separation (Clarke & Warwick (2001). Clarke & Gorley (2006) suggest that R-values >0.75 are considered as well separated; R>0.5 as overlapping, but clearly different and R<0.25 as barely separable at all. Mid range values, such as those calculated below therefore, can suggest differences between treatments but that some similarities may exist between some samples. For instance, the ANOSIM comparison between secondary and XReference samples collected within high energy circalittoral rock substrata returned an R value = 0.471 (p<0.001). Whilst significant in terms of p, the R value suggests some ambiguity/overlap. This ambiguity is reflected in the MDS plot which shows XReference samples were both spatially related to(similar) and spatially disparate (dissimilar) from secondary samples. A possible explanation for this sort of observation is the high degree of biological variation present within each category of broad-scale strata and which reflects the various factors as bullet pointed above.

Given the apparent lack of evidence of impacts within EUNIS 3 level habitats, attempts were made to identify differences between treatments at the biotope level. In this instance we have selected epifaunal (bryozoan and hydroid) dominated biotopes (including **XFa**, **FluHyd** and **ScupHyd** biotopes). These biotope types were selected because they were considered to be more sensitive to primary and secondary dredging effects than those dominated by sediment infauna and so any patterns relating to dredging impacts may be more easily detected. Again, both the REC and REA datasets were used, compatibility being achieved by classifying all samples within the combined dataset on the basis of the Marine Habitat Classification system (Connor *et al*., 2004). MDS and summary ANOSIM outputs for epifaunal biotopes are provided below.

Only 21 samples were confidently classified to the level of an epifaunal biotope but all impact categories were nevertheless represented. These biotope types were grouped together and subjected to a single MDS ordination and comparative testing via ANOSIM. The resulting MDS ordination (below) did not show any clustering or separation patterns that might otherwise identify any dredging effects - this is supported by the summary ANOSIM data which showed no significant differences between impact categories. The wide separation between samples within the ordination suggested a high degree of biological variability which could have masked dredging effects.

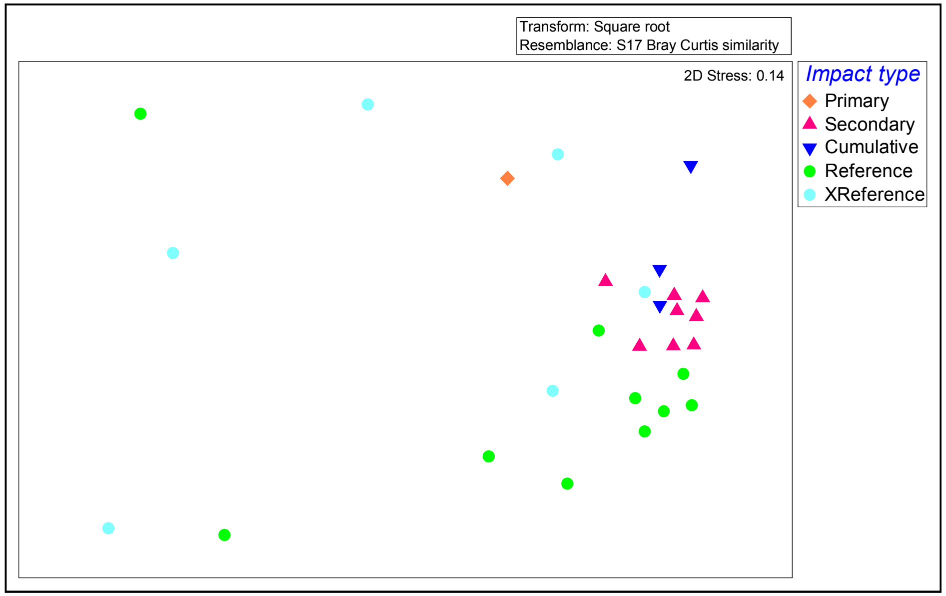
EUNIS A3.2 Moderate energy infralittoral rock



Sample statistic (Global R): 0.114
Significance level of sample statistic: 14.2%

Groups	R Statistic	Significance Level %
Primary, Secondary	-0.556	100
Primary, XReference	-0.133	71.4
Primary, Reference	-0.031	30
Primary, Cumulative	0.778	25
Secondary, XReference	0.105	23.8
Secondary, Reference	-0.029	51.8
Secondary, Active	0.111	50
Secondary, Cumulative	0.111	40
XReference, Active	0.711	14.3
XReference, Cumulative	0.068	33.3
Reference, Active	0.46	30
Reference, Cumulative	0.024	40.5
Active, Cumulative	1	25

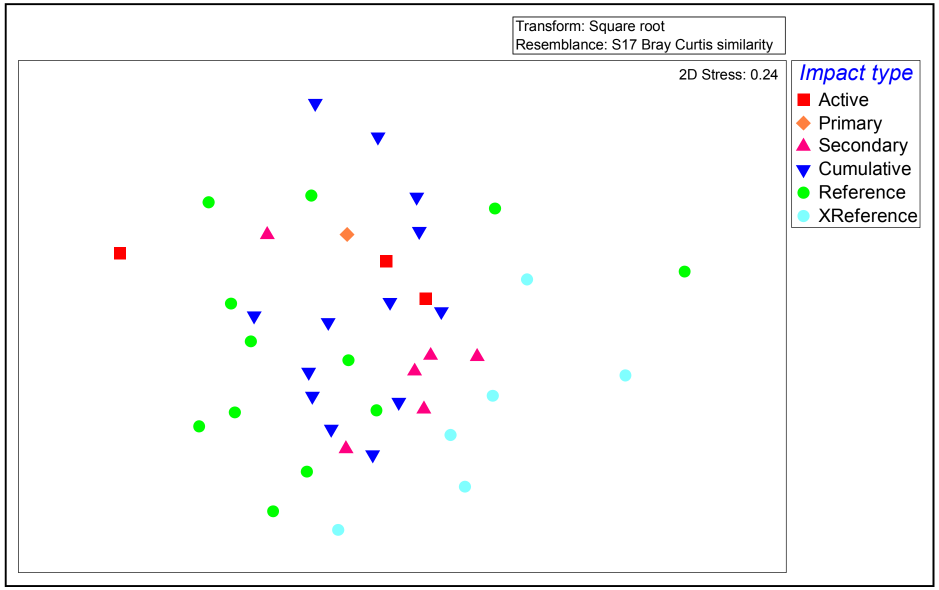
EUNIS A4.1. High energy circalittoral rock



Sample statistic (Global R): 0.265
Significance level of sample statistic: 0.3%

Groups	R Statistic	Significance Level %
Secondary, Primary	1	11.1
Secondary, XReference	0.471	0.1
Secondary, Cumulative	0.581	1.2
Secondary, Reference	0.255	0.4
Primary, XReference	-0.4	100
Primary, Cumulative	1	25
Primary, Reference	0.331	27.3
Cumulative, Reference	0.108	28.3

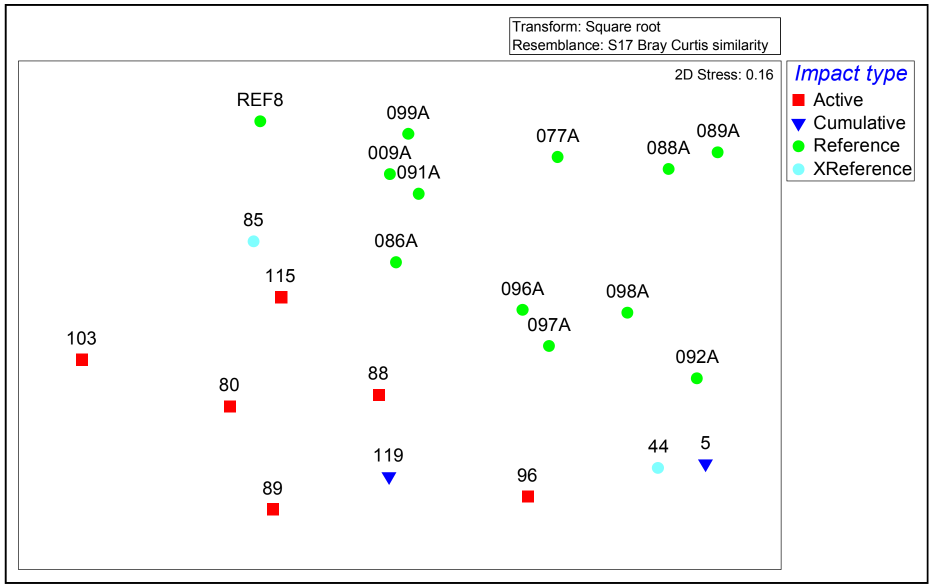
EUNIS A4.2 Moderate energy circalittoral rock



Sample statistic (Global R): 0.185
Significance level of sample statistic: 0.4%

Groups	R Statistic	Significance Level %
Cumulative, Active	0.115	28.8
Cumulative, Primary	0.02	42.9
Cumulative, Secondary	-0.034	59.7
Cumulative, Reference	0.107	3.2
Active, Primary	-0.556	100
Active, Secondary	0.512	3.6
Active, XReference	0.321	8.3
Active, Reference	0.279	10.1
Primary, Secondary	0.489	28.6
Primary, XReference	0.356	28.6
Primary, Reference	0.159	30.8
Secondary, XReference	0.4	0.4
Secondary, Reference	0.229	2.8

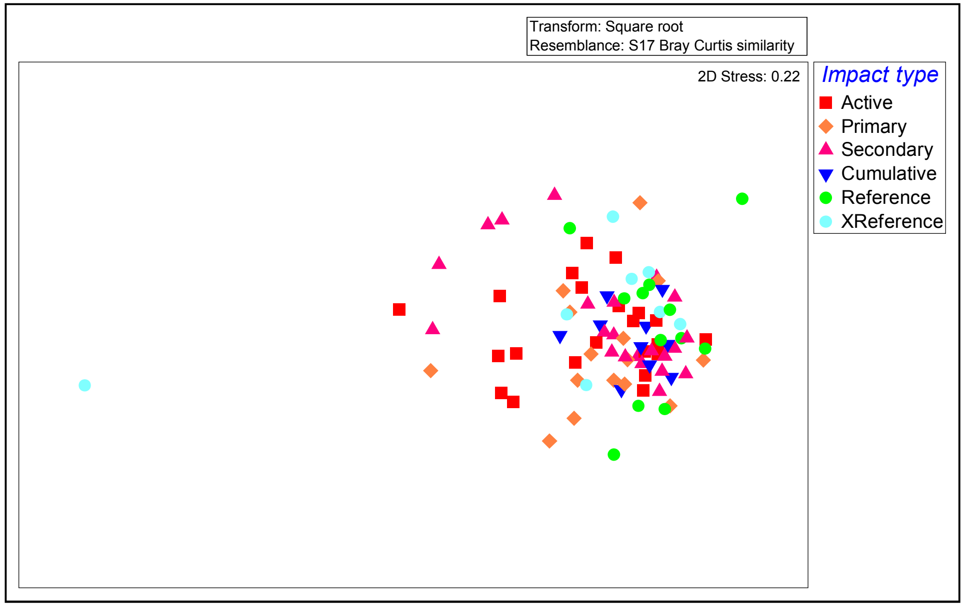
EUNIS A5.2. Sublittoral sand



Sample statistic (Global R): 0.358
Significance level of sample statistic: 0.1%

Groups	R Statistic	Significance Level %
Cumulative, XReference	-0.75	100
Cumulative, Active	0.182	21.4
Cumulative, Reference	0.468	2.2
XReference, Active	0.167	14.3
XReference, Reference	0.272	12.1
Active, Reference	**0.437**	**0.03**

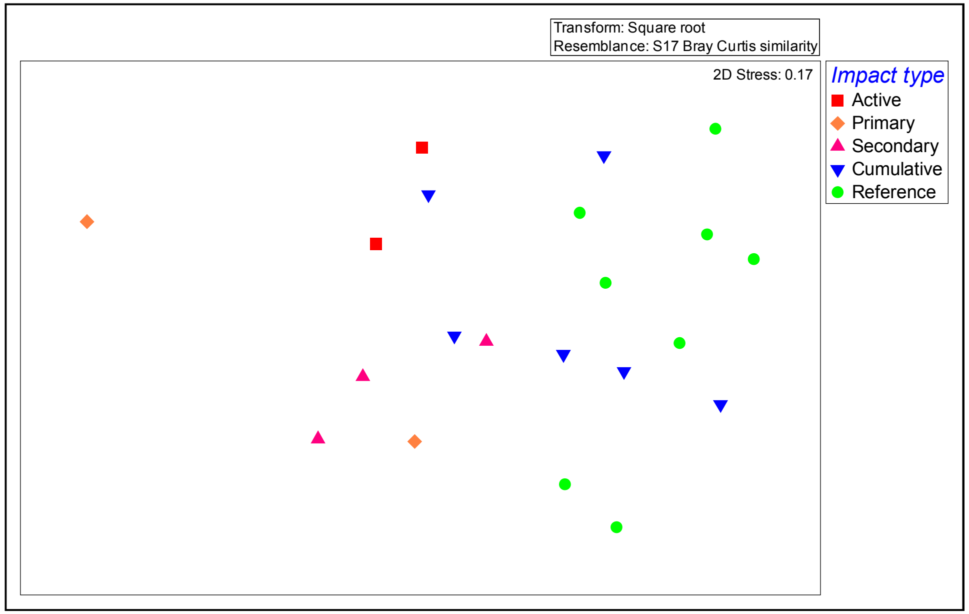
EUNIS A5.4. Sublittoral mixed sediments



Sample statistic (Global R): 0.031
Significance level of sample statistic: 16.5%

Groups	R Statistic	Significance Level %
Secondary, Active	0.02	17.2
Secondary, Primary	0.04	17.7
Secondary, Cumulative	-0.096	88.3
Secondary, Reference	0.096	11
Active, Primary	0.028	25
Active, XReference	0.026	35.1
Active, Cumulative	-0.119	93.7
Active, Reference	0.078	12.3
Primary, XReference	0.132	9.3
Primary, Cumulative	-0.048	73.5
Primary, Reference	-0.001	44.8
Cumulative, Reference	0.059	16.4

Epifaunal biotopes (XFa, FluHyd &ScupHyd)



Sample statistic (Global R): 0.341
Significance level of sample statistic: 0.2%

Groups	R Statistic	Significance Level %
Primary, Cumulative	0.5	10.7
Primary, Active	0	66.7
Primary, Secondary	-0.167	70
Primary, Reference	0.728	2.2
Cumulative, Active	0.167	21.4
Cumulative, Secondary	0.259	14.3
Cumulative, Reference	0.062	26.6
Active, Secondary	1	10
Active, Reference	0.586	2.2
Secondary, Reference	0.527	1.2

Conclusions

Because of these confounding issues, further analyses and statistical interpretation beyond what has already been attempted within the REA process using existing datasets were deemed either unnecessary or inappropriate to ascertain dredging impact on a regional scale.

Dredging impacts appear difficult to discern at the level of the south coast region and may require careful selection of representative reference sites which better replicate the range and local complexities of site level mixed and coarse habitat conditions and community composition than currently achieved. The introduction of standard tools or criteria to appraise acceptability of selected reference stations at site level, such as those adopted by the Comprehensive Studies Task Team during High Natural Dispersion Area (UWWTD) investigations for the water industry may have utility in this regard.