Theoretical Framework 1

On a year to year basis, the dredging activity may have a measurable impact on the number of species, abundance, biomass or derived community statistics in the Active Dredge Zone (ADZ), PIZ and SIZ.

To determine the validity of the baseline data for the measurement of year to year changes in community structure, the primary variables of species number and abundance were assessed to determine if the sites in the PIZs, SIZs and reference areas were significantly different from each other or were drawn from the same statistical population. Before this was completed an initial multivariate analysis was conducted using group average sorting of site similarity data within the PRIMER package. This was employed to identify if any outlier sites or groups of sites existed.

The data employed in this analysis is the data which do not include the colonial epibenthic species. The initial output from this study (see **Appendix 21**) demonstrated that 6 sites were isolated due to very low species numbers. In addition to this one group of sites separated from the remainder of the sites at a similarity of approximately 20%. The sites comprising this group were exclusively found in reference area 3 to the north east of the survey area, which had been previously seen to comprise low diversity and low abundance sites. On this basis reference area 3 was not considered in the following analysis. ANOVA was conducted between individual reference areas and each licence block, with the PIZ and SIZ area in each block considered separately. An initial ANOVA of the SIZ and PIZ in each licence block was also conducted. The ANOVA used both the species number and abundance values, although future analysis will include a wider range of community structure variables and biomass.

The results of the analysis are presented in **Table 1** with output values expressed as probability that the average value from the sites in the PIZ, SIZ and Reference zone is the same. A value of <0.05 indicates that the mean values may be considered to be significantly different. Should groups of sites be present with the same or statistically similar numbers of species and abundances, they may be considered as appropriate for inclusion in analysis of impacts, post dredging activity. Although a change from significantly different at the baseline stage to no significant difference post dredging may also be considered, the current assessment is to determine similarity and to subsequently seek differences due to dredging. Considering each block in turn:

477 North showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that areas 4 and 6 are appropriate for future assessment of change with respect to species number, while reference area 2 is the only area suitable for comparison of abundances.

477 South showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that areas 4 and 6 are appropriate for future assessment of change with respect to species number, while reference areas 2, 4, 5 and 6 are suitable for comparison of abundances.

478 showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that areas 4, 5 and 6 are appropriate for future assessment of change with respect to species number, while reference areas 4, 5 and 6 are suitable for comparison of abundances.

475 showed no significant difference between the PIZ and SIZ for species number or abundance, although the latter was only just over the probability value of 0.05. Comparison with the reference zones indicates that areas 4, 5 and 6 are appropriate for future assessment of change with respect to both species number and abundance.

461 showed no significant difference between the PIZ and SIZ for species number or abundance.

Comparison with the reference zones indicates that areas 4, 5 and 6 are appropriate for future assessment of change with respect to both species number and abundances.

Areas 464 and 458 have been combined due to their potentially close proximity once dredging commences, with the licence blocks joining along their shared border. The combined area showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that areas 4, 5 and 6 are appropriate for future assessment of change with respect to species number, while reference areas 4, 5 and 6 are also suitable for comparison of abundances.

473 West showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that areas 4, 5 and 6 are appropriate for future assessment of change with respect to both species number and abundances.

473 East showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that areas 5 and 6 are appropriate for future assessment of change with respect to species number, while reference areas 4, 5 and 6 are suitable for comparison of abundances.

474 Central showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that all reference areas are suitable for future assessment of change with respect to species number, although reference area 2 was the least appropriate. Reference areas 2, 4, 5 and 6 are suitable for comparison of abundances.

474 West showed no significant difference between the PIZ and SIZ for species number or abundance. Comparison with the reference zones indicates that areas 4, 5 and 6 are appropriate for future assessment of change with respect to species number, while reference areas 2, 4, 5 and 6 are suitable for comparison of abundances.

474 East showed no significant difference between the PIZ and SIZ for species number or abundance, although species numbers were marginal with a P value of 0.057.

Comparison with the reference zones indicates that areas 4, and 6 are the most appropriate for future assessment of change with respect to species number, although again current differences are bordering on significant. In contrast the abundance values in reference areas 2, 4, 5 and 6 are suitable for future comparison.

The most appropriate reference sites are, therefore areas 4 and 6 with area 5 and to a lesser extent 2, also suitable. Reference area 1 along with reference area 3 appears to be generally inappropriate. However, the PRIMER analysis has indicated that despite differences in species number and abundance, the sites in reference area 1 comprise sites that have similar faunal composition to several in the wider array.

Theoretical Framework 2

On a year to year basis, the clustering of the benthic community sites derived from the Hamon Grab samples will correspond to the different impact and reference areas.

The objective of this initial analysis is to identify a precondition such that future analysis may be undertaken, as follows:

Are the communities found in the impacted zones (PIZ and SIZ) adequately represented in the reference areas?

The analysis of the faunal data derived from the grab survey has resulted in 8 relatively distinct clusters of sites based on faunal similarity. Several very distinct groups exist, with others tending to be from an apparent continuum of communities. These have been illustrated in **Figures 23** and **24**. As a means to summarise the data derived from the clusters, the occurrence of each of the clusters with respect to presence in the reference areas, PIZ and SIZ in each licence block has been used to produce a table (**Table 2**). Where clusters are identified which also exist both within a PIZ, an SIZ and one or more reference areas they may be considered as appropriate for analysis of change in future monitoring.

It is evident from **Table 2** that all PIZ and SIZ have sufficient representatives of one or more clusters with which to make an assessment of change. However some clusters are either poorly represented or absent from impact or reference zones. These include the absence of cluster 9 from any of the impact zones, only occurring in reference area 3. This has previously been identified and the need to discontinue sampling in this area has been proposed. Similarly cluster 8 is only present at a limited number of impact sites, although the cluster is well represented in reference area 2. The only other cluster which is under-represented is Cluster 5, which was important in Areas 475 and 461 but absent from all of the reference areas. However, it should be noted that the spatial stability of the community, which is characterized by *Ophiothrix fragilis*, is not known, although it is anticipated to be highly variable. In addition a replacement reference area close to licence Area 478 has been proposed which is designed to account for this community type.

A further test of data suitability was undertaken using ANOSIM on the data with a priori separation using the PIZ zones from each of the blocks and each of the reference zones. The analysis the SIZ sites has currently been excluded due to practical constraints with overlapping arrays. The results of the global analysis indicated an R value of 0.469 which indicated a significant difference within the data set. To identify the source of this difference the pair-wise data have been presented in **Table 3**. The results indicate that all primary impact zones have some similarity to one or more of the reference areas, with the exception of Area 478, although reference area 4 appears to have the best degree of similarity. The data also confirm that reference area 3, as previously concluded, is clearly dissimilar from all other reference areas and all of the PIZ areas.

The R values calculated between each of the PIZ and reference areas may offer a quantifiable measure of change for future monitoring. Variation in natural change will be available through comparison of the R values for the reference areas in future years and this may be cross compared with changes between the PIZ, SIZ and reference areas year on year. This will be a focus of attention for determination of appropriate thresholds in future.

Theoretical Framework 3

On a year to year basis, measures of dredging activity will be assessed with respect to their influence as the environmental/physical variables responsible for clustering of the sites based on the Hamon Grab data.

This framework cannot currently be addressed as dredging has not yet been instigated. However, the basic sediment conditions have been integrated with the ecological data in the PRIMER analysis to enable baseline conditions to be described. The sediment particle size data have also been described and illustrated in **Figures 47** to **53**.

An initial comparison of particle size parameters with faunal data has been made using scatter plots to identify trends. **Appendix 22** illustrates the relationship between the number of species with both sediment median diameter and percentage gravel. In both cases a trend with respect to species number is evident, the coarser sediments supporting a greater number of species. These data are subject to a considerable degree of variation however, with the numbers of species in the coarsest sediments ranging from 30 to 100 species. It is also apparent that the changes in species number only begin to occur in sediments with less than 20% gravel.

The BIOENV analysis, with PCA indicated some relatively clear trends in relation to the principal sediment components. For example the percentage sand (<4mm diameter) and gravel (>4mm diameter) were identified as the most important in the structuring of the clusters and corresponded well with the abundance of some of the species most important in structuring the communities identified. A further environmental value of importance was the sorting coefficient, which indicates the uniformity of the sediment and by implication the stability of the current speeds, with several of the faunal clusters clearly correlated to this measure of environmental conditions.

As a test of the potential to make future comparison between sediments in the PIZ areas and the reference areas an ANOSIM analysis has been completed on the full range of sediment fractions. The results are presented in **Table 4**. It is evident that all impact zones have equivalent reference areas for the purposes of measuring change to sediment particle size. As concluded for the faunal component, reference area 3 is substantially dissimilar from all other areas. On this occasion reference area 1 also shows a high degree of dissimilarity although Area 477 North is relatively similar.

Additional epibenthic habitat data have been collected through the use of drop down static cameras and video systems. The data from these surveys have been subjected to PRIMER analysis and a range of characteristic clusters defined. All clusters defined are present in one or more PIZ, SIZ or reference areas such that future measurements of change may be made. One exception occurs which relates to the *Ophithrix* based community, which was only found in PIZ and SIZ areas, but has no appropriate reference areas. As suggested for the infaunal data the inclusion of a new reference area may assist with the determination of year to year changes.

With respect to the video data it is considered that the employment of the individual species data may be of greater relevance to measurement of future impacts due to the low definition of some of the taxonomic groups, which weakens the value of the PRIMER analysis. In terms of physical factors the data with respect to the influence of the cobble, pebble, gravel and shell components has been found to be particularly relevant. Changes in these components will be included in the recording of future static image data and related to both individual species and communities.

Theoretical Framework 4

On a year to year basis, the clustering of epibenthic community sites, derived from the 2m beam trawling, will correspond to the different impact zones and reference areas.

To determine if the current array of sites in the 2m beam trawl analysis is suitable as a baseline for future monitoring, analyses was conducted to identify groupings within the data set which are sufficiently discrete, such that any effects of dredging activities may be identified in terms of changes in the groupings.

Although the current array does include one group which may not be appropriate for future monitoring (Cluster 2MA in reference area 3) the remaining sites appear to broadly cover sufficient sites to enable potential differences to be detected.

The two major clusters of 2MB and 2MD are found in PIZ, SIZ and reference areas.

To test this further ANOSIM was conducted on the whole data set, dividing the sites on the basis of PIZ, SIZ, Reference and peripheral sites.

The outcome of the global analysis indicates that there is a significant difference within the data set overall, with a global R of 0.115, at a significance of 0.8%.

However, examining the divisions based on the different splits (see below) it is evident that the three main groupings of PIZ, SIZ and Reference sites do not correspond with any separation of the data, only the context or peripheral sites illustrating significant differences from the PIZ, SIZ and Reference sites.

	Ref	SIZ	PIZ
Context	0.668	0.801	0.868
Ref		0.037	0.062
SIZ			-0.022

Theoretical Framework 5

On a year to year basis, measures of dredging activity will be assessed with respect to their influence as the environment/physical variables responsible for clustering of the site derived from the 2m beam trawl data.

Currently no site specific physical conditions are measured as part of the 2m beam trawl survey. The measures of physical environmental change will relate to levels of dredging activity determined through EMS data.

Theoretical Framework 6

Boundaries of designated habitats and or biotopes, will be determined and fluctuations in these boundaries will be assessed with respect to influencing factors, both natural & as a result of dredging activities.

With respect to the biotopes and habitats defined in the original Blueprint, three are present within the survey area:

- **Reef (stony, bedrock and biogenic reef)**
- ***Ophiothrix*/*Ophiocomina* sp. aggregations**
- **Sublittoral sands and gravels**

The latter of these is ubiquitous and boundaries in this respect are hard to define. The reef features in contrast may be mapped but on the basis of the present data set their occurrence is very limited.

In contrast the presence of the brittle star beds is frequent and has been noted to occur over large areas of seabed. The distribution and movement of this biotope may well be easily mapped hence potential impacts can be measured in future. Impacts on the smaller "reef" features will probably be better measured using the techniques identified in the following Theoretical Framework. **Figure 88** summarises the biotopes identified in the study area with corresponding habitat type.

Theoretical framework 7

On a year to year basis, the frequency of occurrence and abundance of the principal species which are determining the designated biotopes will not be expected to vary outside of those occurring naturally.

Of the species originally identified as useful for the measurement of change, the following have been selected as potentially relevant following completion of the analysis:

- ***Ophiothrix fragilis***
- ***Alcyonium digitatum***
- ***Pentapora foliacea***

Of these *Ophiothrix* and *Alcyonium* are widely distributed with the former in considerable abundance although infrequently present in the impact zone (**Figure 89**). The latter was present in lower abundance but was present extensively in both the impact and reference zone (**Figure 90**). *Pentapora foliacea* was very rarely present but is the best indicator for areas where significant bedrock/boulder exists (**Figure 91**). Additional species have been selected for use in the measurement of impacts on the basis of ease of observation on the video and their distribution in both the impact and reference area. These species comprise the sea urchin *Psammechinus miliaris* (**Figure 92**), the hydroid *Nemertesia antennina* (**Figure 93**) and the black brittle star *Ophiocomina nigra* (**Figure 94**) all of which occurred on several occasions in the impact and reference zones.

Report Part 1 – Section 6: Summary

→ Comparative analyses of species number and abundance data from reference areas and potential impact areas show that reference data is available that is relevant to all potential dredging permission areas.

→ Comparative analyses of clusters identified in reference and potential impact areas shows that reference area data is available that is relevant to impact sites for all potential dredging permission areas, however some clusters are poorly represented. Modification of the site of reference area 3, to target underrepresented seabed communities, was undertaken during repeat biological community monitoring in 2006.

→ Available cluster data are suitable for analysis of the effects of dredging activity when that data becomes available. Clustering of communities has been shown to be influenced most strongly by the relevant proportions of sand and gravel.

→ Although the 2m beam trawl array includes one group which may not be appropriate for future monitoring (Cluster 2MA in reference area 3) the remaining sites appear to broadly cover sufficient sites to enable potential differences due to dredging to be detected.

→ Influence of dredging on biotope boundaries will be possible. Reef features may be mapped using the current data set but present understanding suggests their occurrence is very limited. In contrast, the presence of the brittle star beds is frequent and has been noted to occur over large areas of seabed. The distribution and movement of this biotope may well be easily mapped hence potential impacts can be measured in future.