7.1 Review of Works Undertaken During Regional Baseline Monitoring, Resulting Data

The works undertaken during baseline survey operations have provided data as follows:

Regional Sediment Characteristics

- *Regional bathymetry and sidescan sonar data*
- *Drop-camera static image sediment descriptions*
- *Hamon grab sieve particle size analysis data*

Area 473 East Seabed Sediments

- *Collated data from licence specific pre-dredge reports including swath bathymetry and sidescan sonar*
- *Drop-camera images*
- *SPI images*
- *Video sled transects*
- *Clamshell grab images*
- *Hand core logs and sieve/laser particle size analysis data*

Regional Biological Communities

- *Regional bathymetry and sidescan sonar data*
- *Drop-camera static image biotope and significant epibenthic species data*
- *Hamon grab infaunal and epifaunal data*
- *2m beam trawl data*
- *4m beam trawl fish, shellfish and epibenthos data*
- *Scallop dredge shellfish data*

The data has been analysed and integrated as far as possible to provide a description of the seabed sediments, habitats and biological communities that exist across the region and also within the physical process monitoring 'type site', Area 473 East.

The volume and variety of data available is considerable and full interpretation will only be possible once the epibenthic component of Hamon grab samples has been fully analysed. That said, the available data clearly describe the types of habitats and communities that exist across the area.

The data are of a quality and type that will enable comparison with future surveys in order to detect dredging related impacts. How the data are used and applied in decision making processes must now be carefully considered in order to obtain the best value from them.

Determining the cause of detected changes, and ultimately the significance of the changes on a regional scale, will be key to making robust decisions regarding the management of aggregate extraction activities.

Recommendations for future surveys are presented later in this section. There is also a consideration of determining suitable indicators of change that monitoring data can be used to investigate. At present it is not practical to ascribe threshold values when considering these indicators of change. As understanding of the nature of impacts develops over the first 1-3 years of monitoring, determination of thresholds values and adjustment of dredging management will be possible.

7.2 Regional Seabed Sediment Characteristics

The drop camera and Hamon grab survey undertaken as part of the regional biological monitoring survey provides an extensive data set capable of describing the broad-scale physical characteristics of the seabed within the ECR. The quality of the data is good and the data analysis techniques that were employed can be replicated during the life of the monitoring programme.

The seabed across the region is almost exclusively composed of a sand and gravel mix. The proportion of each varies across the region. To the far north and east of the region the seabed sediment is more sandy. A distinct area of coarse sediment has been identified through the centre of the region. To the west sediment is generally sandy gravel with less extensive coarse patches. No where across the region have significant proportions of fine (<0.063mm) sediment been identified.

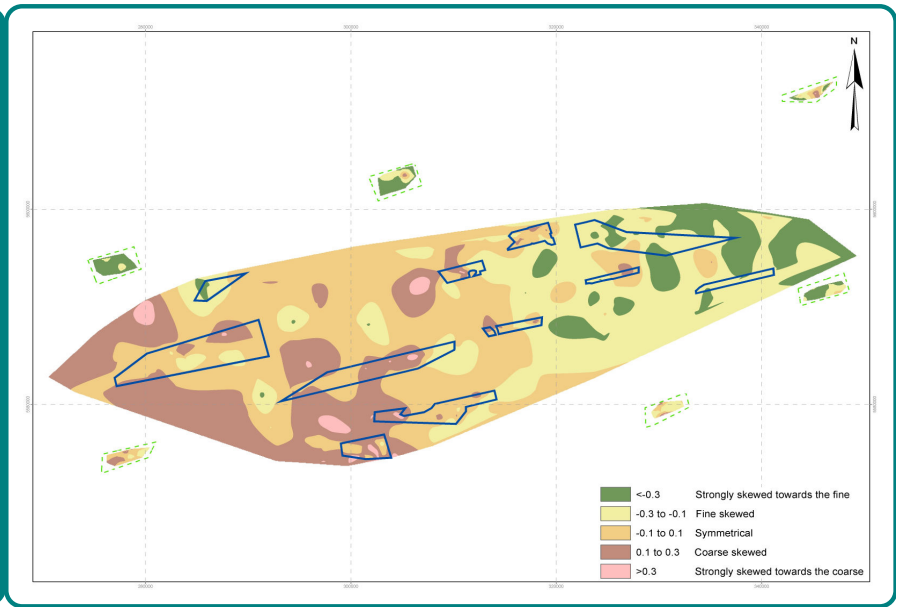
The d50 values calculated from Hamon grab sediment samples compare with those described in the REA (Posford Haskoning, 2003). To the south west d50 is locally >8mm and more extensively >4mm. To the east of the coarser seabed, d50 is largely <2mm with isolated coarser areas where d50 is 2-4mm.

Except at sites to the extreme North East of the ECR, camera operations have not identified any significant areas of seabed that are influenced by mobile sediment. To date, licence specific and regional sidescan monitoring have not identified any bedforms that would indicate the presence of significant natural mobile sediment within areas of extraction operations.

The nature of the data acquired during the regional survey will be adequate for determining changes to seabed character either as a direct result of aggregate extraction or due to secondary impacts from deposition of fine sediment. Natural changes in the physical nature of the seabed in the region will also be possible through use of data acquired from regional reference areas.

Wider regional surveys have been undertaken as part of an ALSF funded project. Results suggest that sub-seabed geology may have an influence on the seabed surface characteristics. The findings of licence specific assessments of resource morphology and wider regional habitat studies will be incorporated into the interpretation of ECR physical conditions.

The influence of sediment characteristics on the nature of seabed communities has been fully investigated during the baseline monitoring. The principle components analysis of faunal clusters has integrated the species and physical variable data, such as the skewness of particle size distributions.



7.3 473 East Seabed Characteristics

Area 473 East is situated in the north central part of the ECR. The area is the site at which regional studies will be undertaken to test the predictions made in the REA model for dispersion, transport and deposition of fine sediment mobilised by the dredging process.

Bathymetry

The area is located on the eastern edge of a relatively flat, uniform 'plain' approximately 40-45m bcd (**Figure 2b**). To the east of this water depths increase gently to a maximum of >50m. The western end of the licence area appears to have two channel features that join just beyond the western boundary of the licence area.

Sidescan Sonar

The sidescan sonar data for Area 473 East shows that the seabed is largely uniform in character with no evidence of significant natural mobile sediment on the seabed (**Figure 2a**). This is also true of the seabed within the overall survey limit.

The seabed is interpreted as being composed of sand and gravel. Isolated areas of coarser sediment and small sand streaks are evident but do not constitute a significant area of the seabed. Some targets indicate the presence of boulders and some of these have subtle finer sediment 'tails' associated with them.

Extensive areas of the seabed show evidence of demersal fishing gear highlighted in pre-dredge reports of the area (Emu, 2006). In places this is the result of beam trawling but there is also evidence of scallop dredge gear.

Seabed Photography

The results of drop camera photography, in combination with the sidescan sonar data, clearly define the nature of the seabed within the study area. The photography has been reviewed to detect any general characteristic differences in the proportion of sand, gravel, cobbles and shell at the surface of the seabed (**Figure 12**).

The photography shows that the seabed surface in the survey area is largely composed of gravely sand. Sediment was noticeably sandier to the east of the study area. Some variation is noticeable across the site based on increased proportions of shell and gravel.

Comparison with the bathymetry data indicates that the variability is not clearly due to physical setting although there does appear to be an indication that sediment in the vicinity of the subtle channel features is sandier than the shallower seabed to the east.

Seabed Profile Image Photography (SPI)

The SPI results show that the seabed surface at the sites targeted is formed of gravely sand with some larger, potentially cobble, particles. As predicted by the review of sidescan data, there was no evidence of fine, mobile sediment bedforms at the seabed surface. As also noted during drop camera survey works, there was very little suspended sediment evident on SPI images.

Clamshell Grab Core and Particle Size Analysis

The majority of sediment in cores from the clamshell grabs was described by Andrews Survey (2006) as gravely sand, with sites distinguishable by a sand fraction that constituted >80% sand (gS – 1 site), 60-76% sand (vgS – 23 sites) and 40-60% sand (GS – 37 sites). The remaining 4 sites were characterised by a sand proportion of <40%.

Sieve analysis shows that silt/clay content of the samples was never more than 4.1% by weight. Shell content varied from 4-10% of the total sample the majority of which was >2mm in size. Shell fragments <2mm constituted 2-4% of the total sample.

Core logs note that larger particles in cores tended to be flint cobbles (>64mm) and whilst flint gravels predominate in general other gravel constituents were evident, notably sandstone and quartz.

The laser particles size analysis showed that the majority of sand samples were poorly or moderately sorted, medium or coarse sand. The sand fraction of the sediment samples was, with the exception of 4 sites, unimodal in character. The 2-4% shell component of the sample was identified through laser particle size analysis as a reason for the 'tails' on the particle size curves.

7.4 Area 473 East Physical Baseline Description

The regional geological setting for Area 473 East is best described in the REA (Posford Haskoning, 2003). The licence area is located in a region of sandy gravel/gravely sand seabed that is draped over underlying lower Tertiary bedrock and palaeo-channel infill deposits of mid-Quaternary age.

Peak tidal currents across this area on ebb and flood tides are noted in the REA as being 0.75-1.1m/s respectively. Net sediment transport in the region is accepted as being to the north east to a bedload convergence zone in the Dover Strait. According to the REA only the highest peak flood currents will be capable of mobilising sand particles >1mm at the seabed. It is not likely that waves will have any significant mobilisation effect on seabed sediment due to the water depths across the site.

Regional variation in sediment characteristics are evident in the predominance of seabed with d50 grain sizes of <2mm to the east. There is also a significant area of seabed through the central southern and western parts of the region with d50 values >4mm.

The seabed across the region has been shown to be starved of natural mobile sediment. The seabed is composed primarily of gravely sand, with sand fractions tending to be predominantly medium-very coarse (0.25-2mm) in size.

Area 473 East is located on the upper part of a bathymetric rise to the east of a NW-SE orientated surface channel, approximately 50-55m deep, that lies between it and Area 473 West. To the east of the licence area the seabed forms a more uniform 'plain' of approximately 40-45m depth. Seabed slopes across the area of the survey are gentle and in no place exceed 1:20 slope gradient.

The seabed within and immediately surrounding Area 473 East is exclusively composed of a gravel/sand mixture with spatial variation evident due to the proportion of each component. The proportion of shell material also distinguishes some sample sites. Isolated and spatially restricted areas may be distinguished from the surrounding areas by the presence of boulders and sand streaks.

Swath bathymetry image of Area 473 East.
Dotted lines show orientation of 'channel' depressions.

-41.33

Depth (m)

-50.06

N

W

E

S

Bathymetry data courtesy of HAML and CEMEX.

2km

Clamshell grab sites

Clamshell Grab Sites

%age gravel >2mm

10 - 20%
20 - 30%
30 - 40%
40 - 50%
>50 %

Sand/silt/clay proportion

Laser Analysis Results (%)
25%
0%
Very Coarse Sand
Coarse Sand
Medium Sand
Fine Sand
Very Fine Sand
Very Coarse Silt
Coarse Silt
Medium Silt
Fine Silt
Very Fine Silt
Clay

%age med, fine, v fine sand

Laser Analysis Interpolation
Medium, Fine & Very Fine Sand Fractions
20 - 30%
30 - 40%
40 - 50%
50 - 60%

The volume of data acquired at Area 473 East is considerable. The available acoustic data describe the bathymetry of the site and surrounding seabed and the textural character of the seabed. Seabed photography, acquired during the regional and site specific surveys, is available for approximately 100 sites. Quantitative seabed sediment data exist for approximately 110 sites (Hamon and clamshell grabs) including laser sizing of sand fractions for 65 sites. The seabed in Area 473 East and to the east of the area is largely uniform in depth. To the west depths increase. Sediment in the survey area is exclusively sandy gravel/gravely sand. No mobile sediment exists in or surrounding the area. The upper layers of the sediment are immobile. There is no evidence of sediment mixing of any significance anywhere in the study area. The majority of the surface seabed sediment within the survey area is composed of >40% gravel. The laser analysis of the sediment shows that the majority of the sand fraction is composed of coarse and medium sand.
(Figure above included on CD-ROM – Numbers 2b, 5, 14, 15 and 16)

7.5 Regional Biological Communities Description

The physical and faunal data sets from the benthic grabbing surveys, static image/video studies, 2m beam trawl and 4m beam trawl studies have been considered individually in the preceding sections. Several thematic observations can be made based on the combination of data.

In general a west to east gradient is evident across the area, ranging from the coarse sediment communities in the west to sand based habitats in the east and north east. A clear transition or boundary area is evident that runs from the south to the north east through the middle of the area. This was evident in all data sets.

The clearest pattern was found for the infauna (**Figure 22**), based on the Hamon grab samples, which is partly a consequence of the high level of sampling and precision of the sample analysis.

The analysis of the infaunal components indicated that the faunal communities were primarily related to the sedimentary conditions, particularly the relative contributions of the sand and gravel components; although data derived from the static image studies have also indicated the importance of some of the larger sediment components, including cobbles, in these groupings.

A secondary factor is likely to be hydrodynamic conditions. This is inferred through the importance of the value for sediment sorting, which was an important vector in the analysis of the community trends, particularly when considered in combination with the sand fraction.

Other conditions in which hydrodynamic conditions may affect communities have been determined from the regional video analysis, which was linked to the sidescan and swath bathymetry data.

One of the most important observations from this study is that areas of seabed where variable depth was observed, were also related to some of the largest populations of the brittlestar, *Ophiothrix fragilis.*

The conditions in which they were found would appear to be highly specific, with a coarse cobbled and gravel seabed in combination with areas where potentially high, near seabed current conditions are likely to occur due to variation in seabed depth, typically occurring on raised seabed areas adjacent deeper waters.

The distribution of the *Ophiothrix* dominated areas from the infaunal study is similar to that found in the video and static image studies and both the 2m and 4m beam trawl surveys. In the latter case the relationship is extended to the fish communities and species, specifically bib (pouting) and *Pomatoschistus* community, the former of which is known to occur around seabed features such as reef or wrecks.

The region to the north east of the area was also consistent across all surveys, supporting low diversity sand based communities, with numerous pagurids and infaunal echinoids. These areas also supported relatively distinct fish communities, typically including the smooth hound *Mustelus mustelus* and *Pleuronectes platessa*.

The remainder of the survey area comprised a mixture of sandy gravel and gravel shell habitat with a variety of community types present. To some extent the biotopes defined for these areas and the more distinct habitats described above were variable depending on the survey and data recording methodology.

Biotope interpretation

The interpretation of the data with respect to biotope definition is based on how the biotope in Conner*et al* (2004) was originally surveyed and eventually described, i.e. using observational data or infaunal grab data. This has been further complicated in the current data sets by the inclusion of very detailed colonial epifauna data, which would have been largely ignored from grab data historically and would not have been at a sufficiently high level of accuracy from observational studies. The employment of the trawling techniques has also introduced a new factor in that some species, which occur at abundances below that which grab sampling will detect successfully, were being collected in abundance using the trawling methods, a good example being the echinoderm *Psammechinus miliaris*.

Despite the differences in survey approach and differing methods for defining biotopes, a degree of consistency was noted across the area surveyed. The clearest biotope identified was detected using all of the survey methods employed:

- ***SS.SMx.CMx.OphMx. Ophiothrix fragilis and/or Ophiocomina nigra brittlestar beds on sublittoral mixed sediments.***

This was most clearly delineated using the static image survey method or video system. The grab survey analysis, which included all epifauna resulted in the least well defined description of this biotope, emerging as a sedimentary version of the **CR.MCR.EcCr.** Echinoderms and crustose communities including **ECr.FaAlCr.Bri.** Brittlestars on faunal and algal encrusted, which, however, also included the *Ophiothrix* beds.

The sandiest sediments also supported two relatively distinct biotopes;:

- ***SS.SSa.CFiSa.EpusOborApri. Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand and;***
- ***SS.SCS.CCS. Branchiostoma lanceolatum in circalittoral coarse sand with shell.***

In both cases, however the biotopes are variants of those described in the Connor *et al* (2004). The video and trawling studies were not able to isolate these biotopes, as little if any of the infauna were included for analysis, the alternative biotopes falling within the generic habitat description for **SS.SCS.OCS.** Offshore Circalittoral Coarse Sediment.

The grabbing techniques produced poorly defined biotopes for a large number of the sandy gravel and pebbly gravel sites, with the generic description of **SS.SCS.CCS.** Circalittoral Coarse Sediments applied. The video and trawling methods were able to provide a greater degree of definition with some consistency across the techniques.

In particular large areas of the region were occupied by **SS.SCS.CCS.PomB.** *Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. A variant of this was also described which included those sites where *Aequipecten* was abundant.

This does not occur in the biotope codes described by Connor and has been attributed the code and title **SS.SCS.CCS.PomB.Aeq.** Pomatoceros triqueter with barnacles, bryozoan crusts and Aequipecten opercularis on circalittoral pebbles and gravel.

The only other biotopes identified were limited in distribution, primarily located in the regional video studies area and related to the occurrence of rock/boulder outcrop.

Infauna/Epifaunal Analysis

One of the main issues emerging from this current survey has been the requirement to pursue full analysis of the colonial epifauna so that numerical abundance equivalence values can be determined and a complete description of the benthic fauna provided. A data set was employed for analysis of the infauna, which included important elements of the epifauna that could be easily enumerated.

The outcome of the analysis provided a clear impression of distinct biotope, where present and also provided a description of the biological and physical continuum across the area. The analysis of the whole sample, including colonial epifauna, revealed a similar grouping of sites which did not clearly improve biotope definition.

The output, in terms of infaunal clusters have been overlaid on to the MDS of the epifaunal data (**Figure 122**). It is apparent from this plot that several of the clusters have remained discrete, particularly HI8, HI3, HI6 and to a lesser extent HI5 and HI4.

One of the primary concerns with the combined data is that a large proportion of the epifaunal species were extensively present, which tends to force the clusters together through high mutual similarity, despite apparent differences in the related infauna. For the purposes of the future monitoring the following recommendations are made:

Analysis of the colonial epifauna is essential at all sites, initially, to establish baseline conditions.

Sufficient data are available in the infaunal data sets (including non-colonial epifauna) upon which to make judgments with respect to the impacts of dredging.

It will be important to observe the impact of the effect of dredging on colonial epifaunal species, and as such repeat analysis of the epifauna at all sites, but this will be required at intervals of less than 5 years, preferably every 3 years.

During the intervening years analysis of epifauna should be undertaken on benthic samples only from a representative number of sites. These should ideally include one sample from each of the replicate sites in the array plus examples of other biotopes and habitats if they are not present in the replicate sites.

These data may be analysed in the same way that the 4m and 2m beam trawl data are, such that regional impacts may be detected, without resorting to unnecessarily detailed and costly analysis.

Reference areas

The current study has identified that the reference area to the north east (ref area 3) was not representative of the physical and biological environment, as defined by the Hamon Grab sampling, in the remainder of the area. Further detailed sampling of this area is therefore not considered necessary.

Efforts will be better placed to identify and sample a new reference area that represents some of the more complex habitats in the south west of the area, falling within the transition or boundary area between the south western coarse sediment based habitats and the north eastern, sandier sediments.

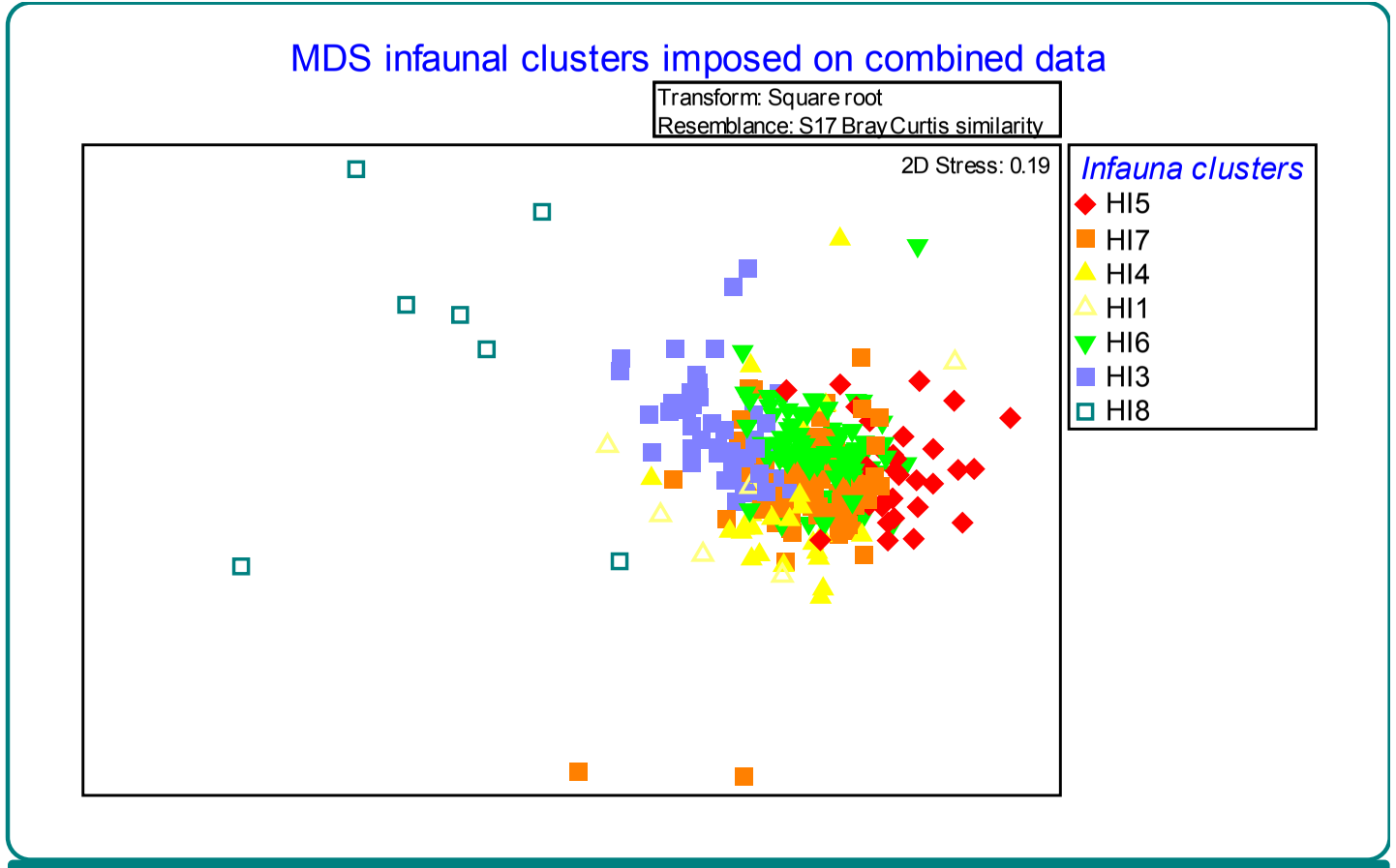


Figure 122 MDS of infaunal clusters imposed on epifaunal data from Hamon grab samples.

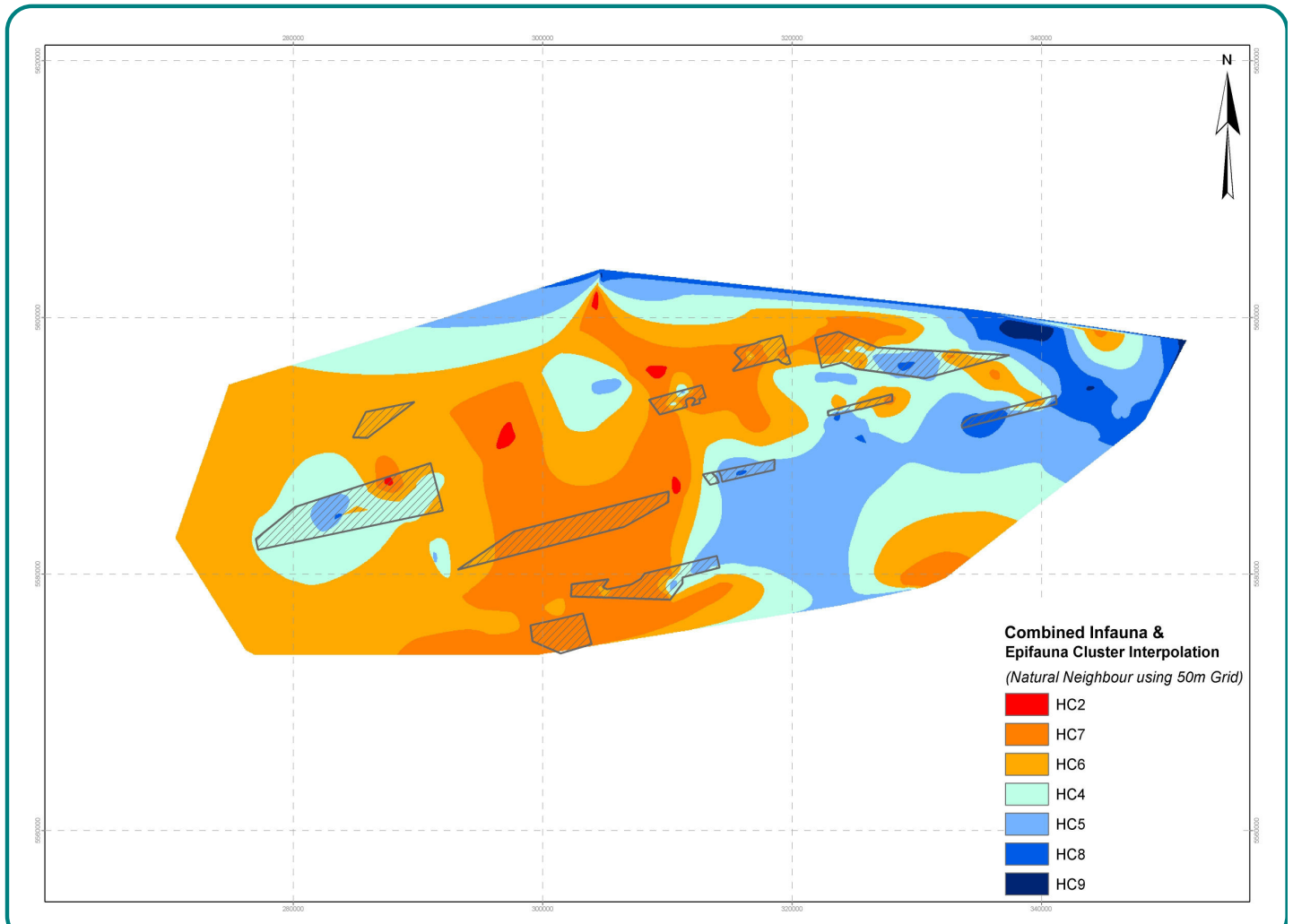


Figure 24 Interpolation of infauna and available epifauna data from Hamon grab samples.

Shellfish Communities

The spatial distribution of *A. opercularis* over the ECR survey array indicates certain areas where greater abundances were recorded compared to other sites. Of particular note is a group of sites in the central part of the array (comprising sites 18, 20, 21, 24, 25, 26 and 32) that all had high abundance values.

There also appears to be high abundances at Stations 35, 36, 37, 38 and 40 which are based around application Areas 474 Central, 464-2 and 458. The reference areas were notable for all generally having lower abundances per m^2 than other sites within actual licence areas.

The spatial distribution of *P. maximus* over the survey array does not indicate any noticeable trend in the distribution of this species. However, one observation of potential note is relatively higher abundances of *P. maximus* were evident at some sites, compared to surrounding sites. This corresponds to the higher abundances of *A. opercularis* relative to surrounding sites, at these same locations.

Also of note is that the two greatest abundances of this species, recorded using 4m beam trawl gear, occurred at Station 4 and Station 42 which are located within Areas 477 South and Area 474 East respectively.

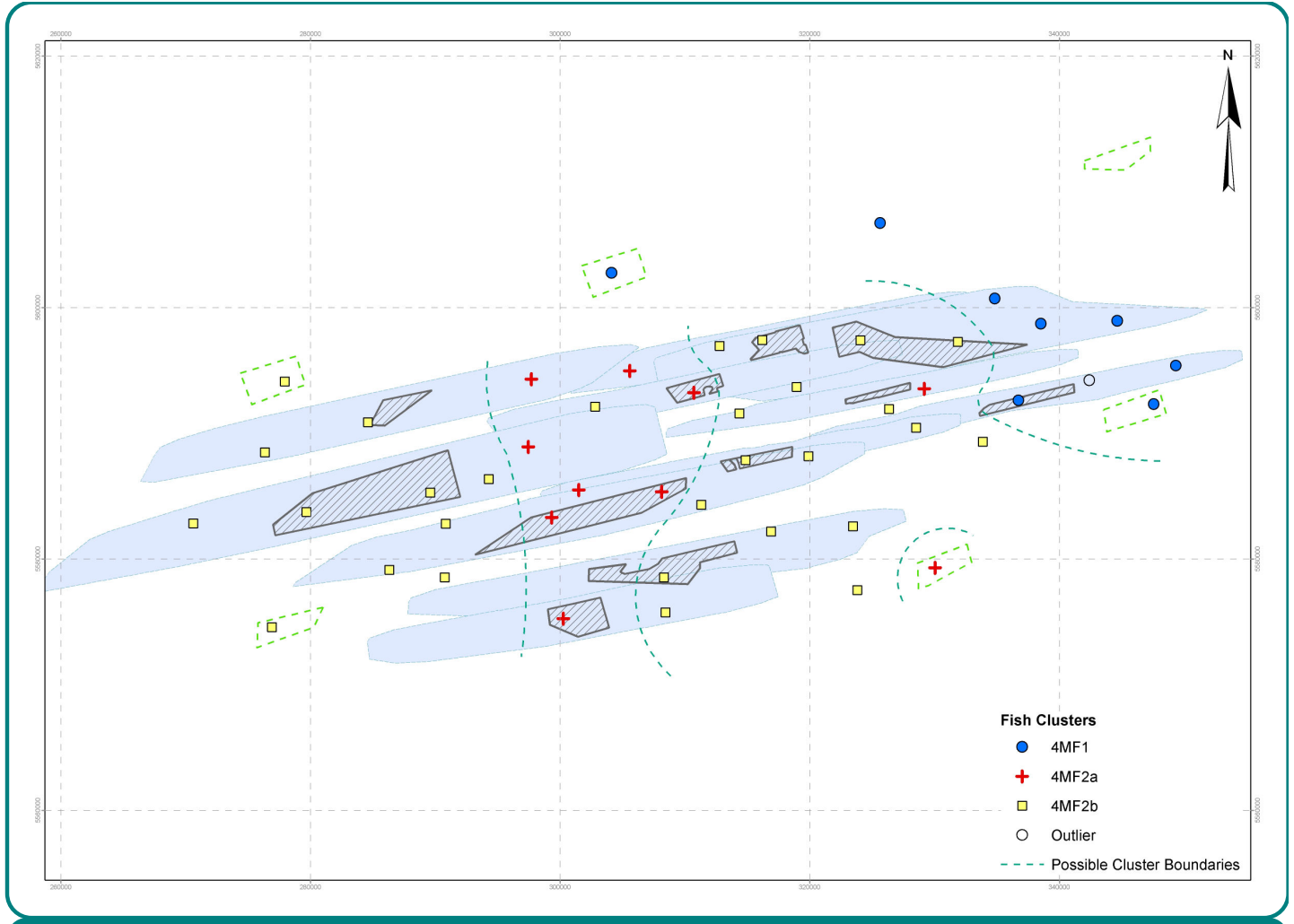
Fish and Invertebrate Communities

An east to west trend is evident in the distribution of clusters identified from analysis of 4m trawl data, but in this case the areas to the east also have a division separating Area 474 West and East from the licences to the north. The areas to the south of the division support very high abundance sites, with considerable *Aequipecten* and *Psammechinus*. This area is adjacent to the lower abundance *Aequipecten* sites to the north and east.

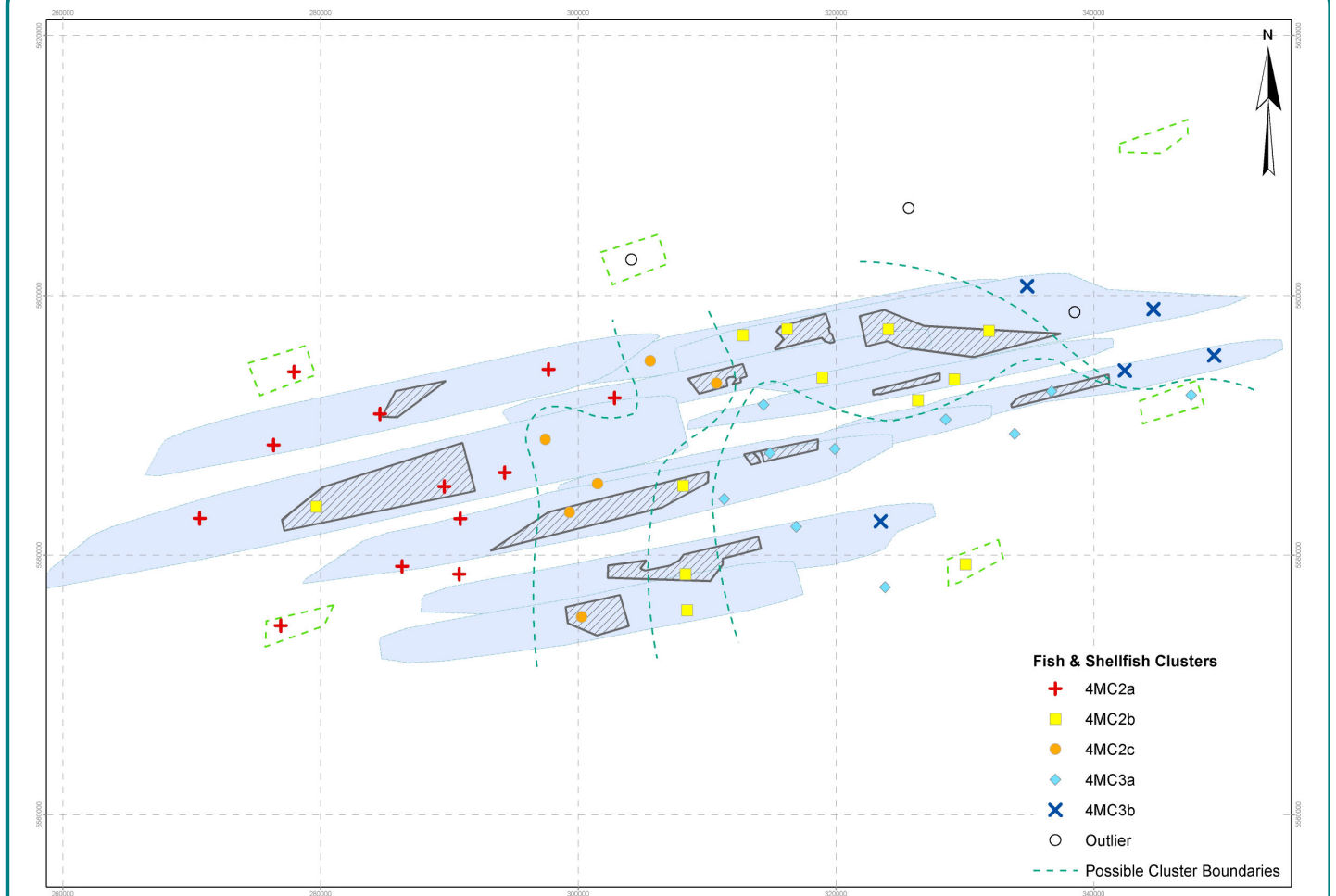
To the north east, the sites comprise the reduced *Aequipecten* population, but still with abundant *Psammechinus*. A north-south dividing line is also evident, which may reflect the presence of the coarse seabed occupied by *Ophiothrix* towards Areas 475 and 478. To the west of the area the low diversity and abundance sites were evident.

Comparing the combined data with the fish data alone it is apparent that a similar trend is evident, with a central dividing line, occupied by the fish species *Trisopterus* and *Pomatoschistus*.

The areas to the east and west of this central group were dominated by the dogfish *Scyliorhinus canicula*. The area to the east and north east was characterised by the smooth-hound *Mustelus mustelus* and the plaice *Pleuronectes platessa* which may be responding to the sandier sediments occupied by numerous hermit crabs and *Psammechinus miliaris*.



The distribution of in fish communities (above) identified from 4m beam trawl surveys is modified slightly when invertebrate community data are included in the analysis (below).



7.6 Recommendations for Future Surveys

Area 473 East Seabed Sediment Survey

Whilst the baseline seabed sediment survey provided data that adequately describes the nature of seabed sediments within the monitoring area, subsequent sampling programmes should consider the use of alternative seabed sampling equipment. The REA model predicts that sand deposits will result from dredging and the sampling gear must be capable of retaining this sand deposit for retrieval to the surface.

Loss of this fraction through washout from uncovered grab jaws during sampling will cause significant problems when trying to determine the spatial impacts of fine sediment deposited by aggregate extraction operations.

Hamon Grab Survey

Positioning capability of vessels for future surveys will need to be improved in order to effectively resurvey the sites sampled during baseline operations. A review of the variability of seabed character at replicate sites may assist in determining the maximum allowable offset from the target position.

On a related issue use of vessels with twin screws, or variable pitch propellers, should ensure that time taken to get on station, and maintain position, is improved.

Dual deployment of camera and grab systems afforded an efficient and effective method of sampling. If camera operations are employed in future surveys then dual deployment with the Hamon grab should be repeated.

Tidal currents in the region are considerable and during deployment of equipment requiring umbilicals operators should ensure that they are suitably anchored to winch cables.

Further repeat grab surveys should sample all reference sites as sampled in 2005, context and PIZ/SIZ sites as sampled in 2006 and any sites that are located within the tidal excursion of active dredging permission areas.

This may be amended if the results of 2006 repeat monitoring suggest that scale of sampling can be reduced without compromising the validity of the data for the purpose of detection of dredging impact.

The data from reference area 3 was largely incompatible with the rest of the array, occurring in an apparently mobile sandy sediment. It is recommended that this area is no longer sampled and an alternative reference area has been established

The preferred location for the reference area has been chosen in order to suit Area 478, which was largely underrepresented in relation to faunally similar sites.

Static Image Analysis

Based on the current data, video and static image survey has a value with respect to assessing the presence of biotope characterising epifaunal species. Year to year comparisons will be possible on this basis in addition to measurement of the change in extent of the brittlestar beds.

The nature of future comparative studies should be determined in the next 6 months to better focus the analysis of static seabed image data, especially for sites within primary impact zones where changes are likely to be evident.

2m Beam Trawl Survey

The 2m beam trawl survey should be repeated at all sites sampled in 2006 plus additional sites that fall within the tidal excursion of active dredging permission areas.

Scallop Dredge Survey

Sampling as undertaken during the baseline scallop dredge survey should be repeated annually in the first five years of monitoring.

One target site in Reference Area 1 was not sampled using scallop dredge gear during the baseline survey. It is vital to sample this area during the first repeat survey to provide required data.

4m Beam Trawl Surveys

The 4m beam trawl surveys should be repeated annually during the first five years of monitoring, over the same array as the baseline survey.

The same methods employed during the baseline should be used during repeat surveys.

7.7 Determination of Suitable Indicators of Change

A requirement of licence specific monitoring is development of suitable indicators of change related to aggregate extraction. The data produced during the regional monitoring studies will be made available to licencees in order that such indicators can be developed.

During the first two years of extraction activity it is likely that useful indicators of change will be limited to:

- ***Measurement of changes in bathymetry within active dredge areas.***
- ***Measurement of changes in seabed character identified from sidescan sonar survey data.***
- ***Measurement of changes in the sediment composition within active dredge areas. identified through grab sampling.***
- ***Measurement of spatial extent of dredging activities within primary impact zones identified through grab sampling.***
- ***Identification of changes in seabed conditions beyond the boundaries of primary impact zones from sidescan and grab sample data.***
- ***Comparative studies using seabed images from impact sites.***

More involved indicators, based on changes in the faunal communities in primary and secondary impact zones will need to be developed over the first 3 years of activity.

The exact scope, value and validity of such indicators will need to be discussed by the members of the ECR TWG members prior to their adoption as required components of monitoring output.

The suitability, validity and practicality of using threshold values as a management tool will also be investigated during the first 1-3 years of monitoring activity. Thresholds are unlikely to provide a valid decision making tool until a useful time series of data are available for analysis as natural changes in biological communities may be more significant than those attributable to dredging.

Notes: