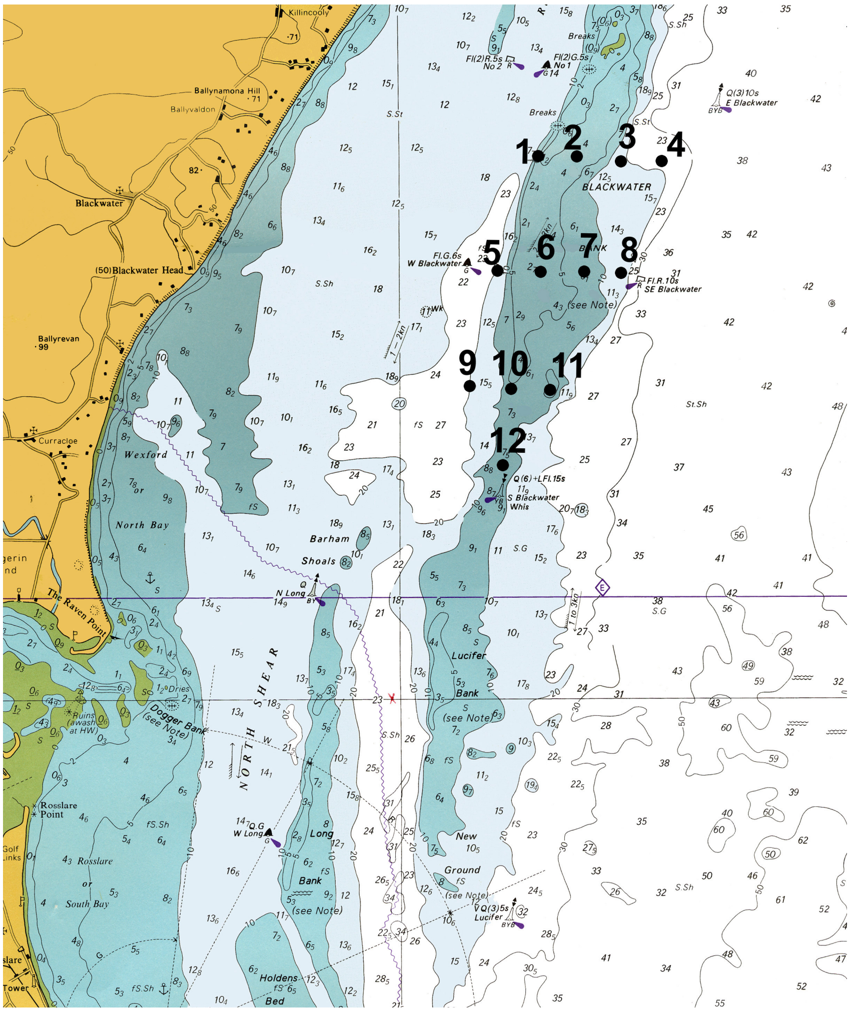
Benthic surveys of sandbanks in the Irish Sea



Irish Wildlife Manuals No. 29

AN ROINN COMHSHAOIL, OIDHREACHTA AGUS RIALTAIS ÁITIÚIL

DEPARTMENT OF THE ENVIRONMENT, HERITAGE AND LOCAL GOVERNMENT

Benthic surveys of sandbanks in the Irish Sea

Caroline Roche[1], David O. Lyons[2], José Fariñas Franco[1] & Brendan O'Connor[1]

[1] Aqua-Fact International Services Ltd., 12 Kilkerrin Park, Galway.

[2] National Parks & Wildlife Service, Unit 7, East Gate Avenue, Little Island, Co. Cork.

Citation:
Roche, C., Lyons, D.O., Fariñas Franco, J. & O'Connor, B. (2007) Benthic surveys of sandbanks in the Irish Sea. *Irish Wildlife Manuals*, No. 29. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Cover image: Sampling stations on the Blackwater Bank (reproduced under Copyright Licence Agreement Number 7391 from the UK Hydrographic Office)

Irish Wildlife Manuals Series Editors: F. Marnell & N. Kingston

ISSN 1393 – 6670

EXECUTIVE SUMMARY

Two grab surveys were undertaken on behalf of National Parks & Wildlife Service on the Blackwater and Kish Banks in the Irish Sea during May and June 2005. A series of 12 stations with five replicates per station was sampled at each location and analysed for sediment, faunal composition and organic carbon content.

The Kish Bank survey revealed a sandy substratum, ranging from medium to very-fine sand with relatively low organic carbon. A total of 101 species, ascribed to 12 phyla, were delineated into four distinct faunal assemblages by classification/cluster analysis. These comprised the marine habitat biotopes: *Glycera lapidum* in impoverished infralittoral mobile gravel and sand (SS.SCS.ICS.Glap); *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand (SS.SSA.CFiSa.ApriBatPo); *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand biotope (SS.SSA.IFiSa.NcirBat) and *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (SS.SSA.CMuSa.AalbNuc) although in some cases the species composition varied.

The Blackwater Bank survey revealed a sandy substratum, with all stations composed of fine sand with very low organic carbon. A total of 35 species, from 4 phyla, could be described as forming elements of four distinct faunal assemblages using multivariate analysis. There were two distinct biotopes: infralittoral mobile clean sand with sparse fauna (SS.SSa.IFiSa.ImoSa) and *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand biotope (SS.SSA.IFiSa.NcirBat).

Although the Kish Bank can be considered a richer habitat than the Blackwater Bank, it was apparent that there was considerable variance in species diversity amongst this habitat type. To analyse the "representivity" of the two survey sites they were compared with other banks surveyed along the Irish and Welsh coast. The sediment of both the Blackwater and Kish Bank is quite similar to those found in other sandbanks. The communities are considered to be regulated by physical rather than biological forcing as in muddy sand sediments. The calculated diversity, richness and evenness of the two survey banks are broadly similar to those designated as habitats of community importance within the UK jurisdiction.

CONTENTS

1. INTRODUCTION

Under National and European law, Ireland is committed to the protection and conservation of specific marine habitats and species. The conservation and monitoring of marine habitats necessitates an understanding of their physical and biological structure. The EU Habitats Directive (93/43/EEC) lists a series of habitat types in Annex I that require the designation of Special Areas of Conservation (SACs). One of these is *"Sandbanks which are slightly covered by sea water all the time"* (henceforth referred to as sandbank/s). They consist of sandy sediments that are permanently covered by shallow seawater, typically at depths of less than 20 m below chart datum (but sometimes including channels or other areas greater than 20 m deep). The habitat comprises distinct banks (i.e. elongated, rounded or irregular 'mound' shapes) that may arise from horizontal or sloping plains of sandy sediment. Where the areas of horizontal or sloping sandy habitat are closely associated with the banks, they may be included within the Annex I type (Johnston *et al.*, 2002). The diversity and types of community associated with this habitat are determined particularly by sediment type together with a variety of other physical, chemical and hydrographical factors. These include geographical location (influencing water temperature), the relative exposure of the coast (from wave-exposed open coasts to tide-swept coasts or sheltered inlets and estuaries), topographical structure of the habitat, and differences in the depth, turbidity and salinity of the surrounding water (Johnston *et al.*, 2002).

Sandbanks can be categorised into four main sub-types:

1. Gravelly and clean sands
2. Muddy sands
3. Eelgrass *Zostera marina* beds
4. Maerl beds (composed of free-living Corallinaceae)

The latter two sub-types are particularly distinctive and are of high conservation value because of the diversity of species they may support and their general scarcity in Irish and British waters (Johnston *et al.*, 2002).

Shallow sandy sediments are typically colonised by a burrowing fauna of worms, crustaceans, bivalve molluscs and echinoderms. Mobile epifauna at the surface of the sandbank may include mysid shrimps, gastropod molluscs, crabs and fish. Sand-eels *Ammodytes* spp., an important food for birds, live in sandy sediments. Where coarse stable material, such as shells, stones or maerl, is present on the sediment surface species of foliose seaweeds, hydroids, bryozoans and ascidians may form mixed communities (Johnston *et al.*, 2002). Shallow sandy sediments are often important nursery areas for fish, and feeding grounds for seabirds (especially puffins *Fratercula arctica*, guillemots *Uria aalge* and razorbills *Alca torda*) and sea-duck (e.g. common scoter *Melanitta nigra*) (Coveney Wildlife Consulting Ltd., 2004).

1.1. Physical/geographical information

The near-shore marine environment off the east coast of Ireland, is characterised by a series of coast-parallel, north-south trending linear sandbanks (Warren & Keary, 1989; Kearns-Mills, 1996; Molloy & Kennedy, 2001). These include from north to south: Dundalk Bank; Bray Bank; Kish Bank; Codling & Greater Codling Banks; Arklow Bank; Rusk Bank; Glasgorman Bank; Blackwater & Lucifer Bank and Long Bank/ Holden's Bank (a designated cSAC). Seismic profiling has interpreted the origin of near-shore sandbanks as moraines formed during de-glaciation (Hanna, 2002). Although there have been changes to the topography in the recent past, these are considered to have had a much smaller effect in shaping the sandbanks than glacial events. In particular, near-shore hydrodynamics were identified as a major control on sandbank morphology and coastal configuration. Soft glacial coastal sediments have little resistance to wave and hydrodynamic action and on the eastern seaboard of Ireland are slowly eroding (geological time scale) (Hanna, 2002). This erosion of coastal sediments is partially arrested by a supply of sediments from offshore banks and underlies the importance of the banks in sediment transport to shores along the east coast of Ireland. Soft sediment (sand & mud) is in turn fed to the south-eastern banks from deeper banks in the Celtic Sea. Therefore a dynamic relationship, which is largely tide-driven, has evolved to create a transport chain into, and along the coasts of, the western Irish Sea. Coastal protection structures can alter the natural erosion and deposition of sediments along the coast and has in some areas lead to increased erosion of coastal land.

A geological mapping exercise of the seabed in offshore banks in Dublin Bay included information relating to the Kish Bank (Wheeler *et al*., 2000). The side-scan survey of the Kish Bank showed it to be characterised by “stippled bank crest facies”. Side-scan sonar records produced evidence of seabed mobility on, and adjacent to, the banks in Dublin Bay. Furthermore, sand-waves increase in amplitude towards the edge of the banks suggesting currents are highest close to the banks. Therefore, the influence of banks on bottom current is one that tends to increase current experienced over banks beyond what is experienced in the adjacent areas. Granulometric analysis over Kish Bank found that it was dominated by sand, slightly-gravelly-sand and very occasional patches of muddy-sand and gravel (Wheeler *et al*., 2000). These sandy sediments are formed into sand-waves under the influence of tide and wind forces (Irish Hydrodata Ltd., 1996). Although there had been no similar study undertaken on the Blackwater Bank it was expected that the physical form and forces experienced were likely to be similar.

The area off the East Coast records a mean sea bottom temperature of 9.8° C (Dec-Feb) with a mixed and high salinity. The bottom depth in the entire area including sandbanks and surrounding waters lies entirely between 0 and 30 m below datum.

1.2. Biological Information

Biological information can be collected in three broad categories over, or adjacent to, sandbanks. These are:

a) Benthic sampling (cores/grabs and dive surveys)
b) Birds/mammals
c) Habitat characterisation

a) Benthic sampling

Of the benthic surveys undertaken in the Irish Sea, few have been completed directly over or immediately adjacent to sandbank habitat. Aqua-Fact International Services Ltd. (Aqua-Fact) (1989) were contracted by Bord Iascaigh Mhara (BIM) to analyse samples collected over Long Bank. Fehily & Timoney & Co. (2001) commissioned EcoServe Ltd to conduct a benthic survey for the proposed Arklow Bank wind-park over the bank and areas likely to be affected by its construction. The sediment of Arklow Bank was found to consist predominantly of sand, cobbles, shells and pebbles on the northern end tending towards fine sand at the southern end. The benthic surveys, conducted using a benthic dredge, showed that epibenthic species diversity and abundance were highest in the areas of "sandy shells" and "gravel with cobbles". The species richness was highest at the north-west of the bank where reef building polychaetes (*Sabellaria alvelota*) were recorded. Aqua-Fact (2005) was sub-contracted by Environmental Tracing Ltd. on behalf of Wexford County Council to carry out a benthic site investigation survey of a site located south/southeast of the Glasgorman Bank, off the east coast of County Wexford. Raw data from both of the Aqua-Fact surveys completed in 1989 and 2005 will be used in the analysis of the current study. A recent survey was also undertaken by Saorgus Energy Ltd. (2005) on the Kish/Bray Bank for the purpose of seeking a license to construct a windfarm. This survey showed moderate diversity from benthic dredges but did not include granulometric information.

b) Birds / mammals

A recent EIS over the Arklow Bank has shown that there is a far greater avian diversity (25-30 species) over shallow waters than surrounding waters (5-10 species) and shallow waters have been shown to be important for feeding and resting (Fehily & Timoney & Co., 2001). Therefore, these banks are also likely to represent an important feeding area for diving-bird species. A survey undertaken upon the habitat of terns in the Irish Sea showed that Kish Bank had significant numbers of auks (guillemots, razorbills etc.) and terns in the area. Roseate, common and Arctic terns were recorded roosting on the Kish Lighthouse and peaked in numbers during late August and early September (Newton & Crowe, 2000). The presence of these bird species is indicative of feeding resources in the area. There is also a substantial population of wintering common scoter off the Wexford Coast in the waters adjacent to the Blackwater Bank (Coveney Wildlife Consulting Ltd, 2004).

The Irish Sea supports a relatively large population of both grey and harbour seals (Kiely *et al.*, 2000). The main haul-out sites are the Saltees and several near-shore islands in Dublin Bay. Whilst there is no evidence that either species haul-out on banks within the Irish Sea, it can be presumed, since hauling out on and feeding around immersed banks is typical behaviour for both species, that on the occasion when small sections of banks within the Irish Sea are immersed that they form a component of the feeding and resting resource.

A number of species of cetaceans have been recorded in the Irish Sea with harbour porpoise being the most numerous (IWDG, 2004). However, Risso's dolphin, minke whale and common dolphin are all observed frequently in the area. The greater primary production rate generally observed over sandbanks suggest that cetaceans should congregate around such areas. However, there appears to be little variation in the incidence of harbour porpoises around the Arklow Bank (Fehily & Timoney & Co., 2001).

c) Habitat characterisation

The Irish Sea Pilot (Vincent *et al.*, 2004) describes the Irish Sea as having 18 marine landscapes with 8 associated biotope complexes. There is a high incidence of recognised ecologically important habitats in the area. A moderate biodiversity of benthic macrofauna has been broadly mapped in the area; this is an expected result for sandbanks. The general area contains what are termed 3-5 "nationally important sites" although the precise nature is not specified. It has also been rated very highly for "irreplaceability" and was listed as a strong candidate for 'locking in biodiversity'. However, it should be noted that the Irish Sea Project focussed primarily on collating existing data and sources for these data are not well presented within the 2004 report.

The Department of the Environment, Heritage and Local Government (DEHLG) commissioned surveys of two discrete subtidal benthic areas at the Kish Bank and the Blackwater Bank which satisfy the required physical characterisations of sandbanks and have been associated with ecologically important features. Aqua-Fact International Services Ltd. (henceforth Aqua-Fact) was contracted by the DEHLG to carry out both of these subtidal benthic biological and granulometric surveys.

2. METHODOLOGY

2.1. Sampling Procedure and Processing

Twelve sample stations were identified at both the Kish and Blackwater Banks which were judged to maximise spatial and biological coverage whilst remaining within safe water depths for a suitable vessel. The locations of the Kish Bank stations and the Blackwater Bank can be seen in Figures 1 and 2 respectively. The accompanying co-ordinates for these stations can be seen in Tables 1 and 2 respectively. Sampling at the Kish Bank took place on the 31st May 2005 and sampling at the Blackwater Bank took place on the 8th June 2005. Stations were located using a differential Global Positioning System (dGPS) accurate to within c. 1m. A 0.1m^2 Day grab was used to collect the benthic samples. Five replicate samples were taken at each of the 12 stations at both locations. Measurements of sediment depth were taken in a diagonal transect across the grab surface using a plexiglass ruler. Data on each sample (e.g. station number, date, time, depth of sediment, surface features and visible macrofauna) were logged in a field notebook. The faunal returns were sieved on a 1 mm mesh sieve, stained with rhodamine dye, fixed with 10% buffered formalin and preserved in 70% alcohol. Samples were then sorted under a microscope (x 10 magnification) into four main groups: Polychaeta, Mollusca, Crustacea and others. The 'others' group consisted of cnidarians, echinoderms and other lesser phyla. The taxa were then identified to species level where possible. (The absolute abundance of each species and taxa/group present within grouped station samples is presented in the Appendix I).

An additional sample was taken at each station for sedimentological analyses. The sediment samples were taken through the opening on the top of the grab. Two sub samples (c. 250g each) were collected from each sample, for organic carbon and granulometric analysis. Both sub-samples were collected using a plastic spoon and placed in labeled plastic bags. All these samples were stored immediately in a cold room on board the vessel and were frozen at –20^{o}C on return to the lab.

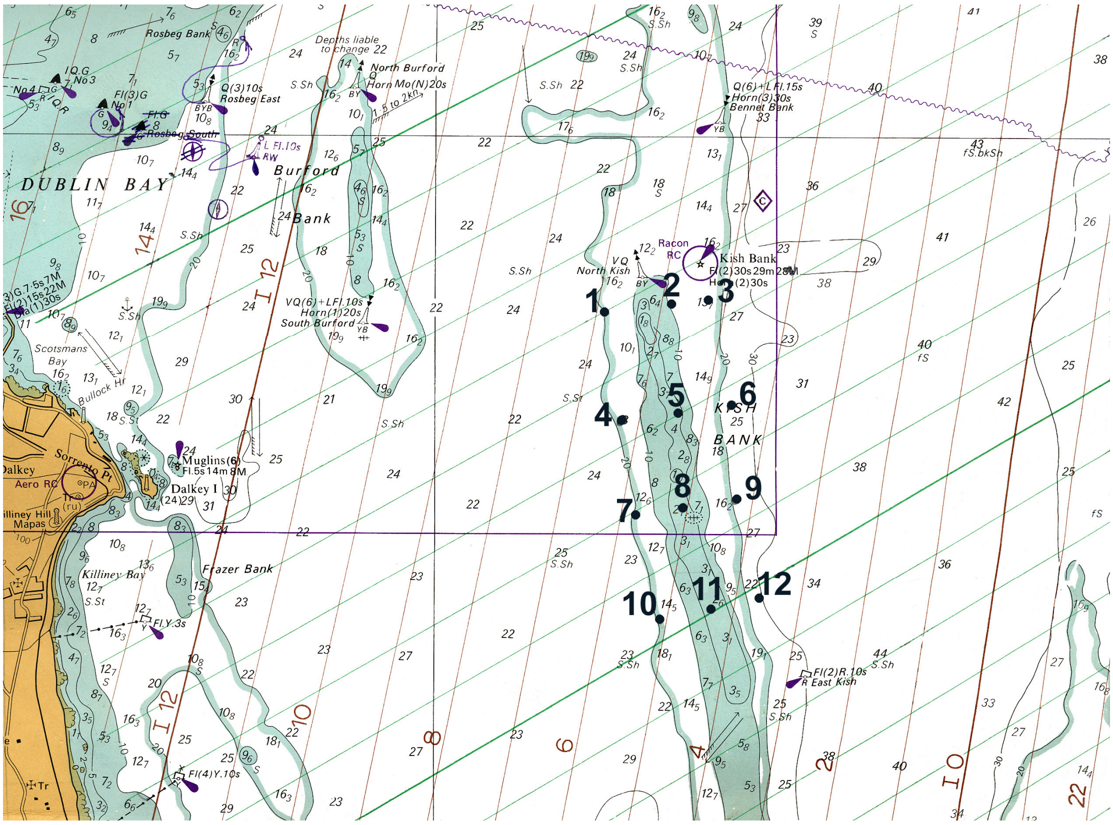


Figure 1: Station locations sampled at the Kish Bank on the 31st May 2005 (reproduced under Copyright Licence Agreement Number 7391 from the UK Hydrographic Office)

Table 1: Station co-ordinates at the Kish Bank, sampled on 31st May 2005.

Station Number	*Latitude*	*Longitude*
KB1	53° 18.08′	5° 57.00′
KB2	53° 18.12′	5° 55.42′
KB3	53° 18.16′	5° 55.00′
KB4	53° 17.00′	5° 56.10′
KB5	53° 17.05′	5° 55.60′
KB6	53° 17.07′	5° 54.60′
KB7	53° 15.95′	5° 55.90′
KB8	53° 16.00′	5° 55.50′
KB9	53° 16.10′	5° 55.55′
KB10	53° 14.95′	5° 55.60′
KB11	53° 15.00′	5° 55.00′
KB12	53° 15.06′	5° 53.60′

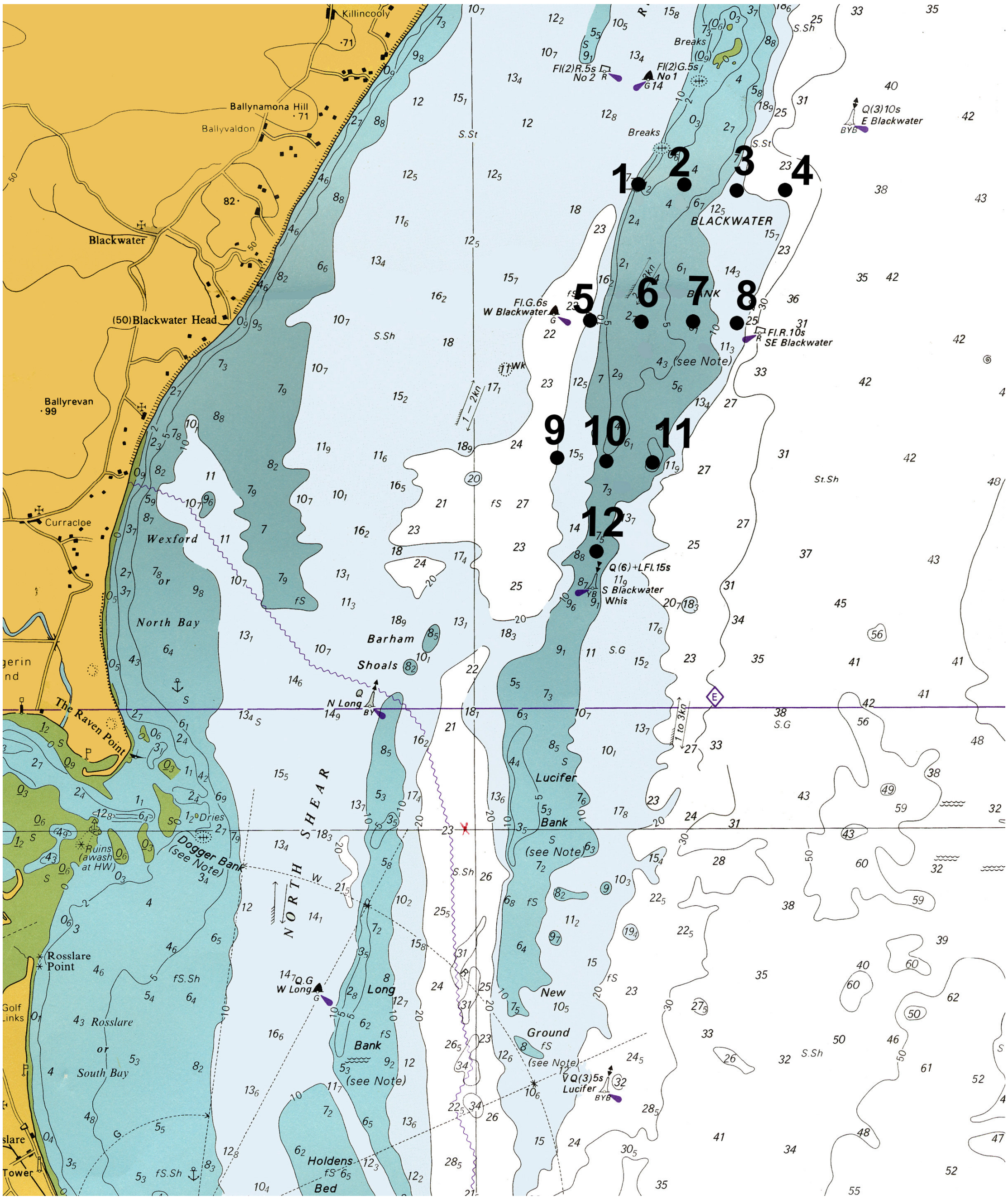


Figure 2: Station locations sampled at the Blackwater Bank on the 8th June 2005 **(**reproduced under Copyright Licence Agreement Number 7391 from the UK Hydrographic Office)

.

Table 2: Station co-ordinates at the Blackwater Bank, sampled on 8th June 2005.

Station Number	*Latitude*	*Longitude*
BB1	52° 27.22′	6° 11.90′
BB2	52° 27.22′	6° 11.10′
BB3	52° 27.22′	6° 10.17′
BB4	52° 27.22′	6° 09.20′
BB5	52° 25.75′	6° 12.81′
BB6	52° 25.75′	6° 11.80′
BB7	52° 25.75′	6° 10.95′
BB8	52° 25.75′	6° 10.10′
BB9	52° 24.17′	6° 13.50′
BB10	52° 24.17′	6° 12.60′
BB11	52° 24.17′	6° 11.60′
BB12	52° 23.05′	6° 12.65′

Particle size analysis was carried out using the traditional granulometric approach (Wentworth, 1922). Traditional analysis involved the dry sieving of approximately 100g of sediment using a series of Wentworth graded sieves. The process involved the separation of the sediment fractions by passing them through a series of sieves. Each sieve retained a fraction of the sediment that was later weighed and a percentage of the total was calculated. Table 3 shows the classification of sediment particle size ranges into size classes. Sieves, which corresponded to the range of particle sizes, were used in the analysis.

Table 3: The classification of sediment particle size ranges into size classes (adapted from Buchanan, 1984)

Range of particle size	*Classification*	*Phi Unit*
<63 µm	Silt/Clay	>4 ∅
63-125 µm	Very Fine Sand	4 ∅, 3.5 ∅
125-250 µm	Fine Sand	3 ∅, 2.5 ∅
250-500 µm	Medium Sand	2 ∅, 1.5 ∅
500-1000 µm	Coarse Sand	1 ∅, 0.5 ∅
1000-2000 µm	Very Coarse Sand	0 ∅, -0.5 ∅
>2000 µm	Gravel	-1 ∅, -1.5 ∅, -2 ∅, -3 ∅, -4 ∅

Organic carbon analysis was carried out the Central Marine Services Unit (CMSU) at the National University of Ireland, Galway using the chromic acid oxidation value (CAOV) method. This process involved oven-drying the samples to a constant weight. The samples were then ground and analysed using the chromic acid oxidation technique described by Walkley & Black (1934). This method differentiates humic matter from extraneous sources of organic carbon such as graphite and charcoal (Brannick, 1982). The percentage recovery of this method varies between 75-90%, according to sediment type. Results are presented as percentage organic carbon, chromic acid oxidation values (CAOV).

2.2. Data Processing

2.2.1. Sediment

Principal component analysis (PCA), using a Euclidean distance dissimilarity matrix, was used to elucidate sediment data. The data matrix included all available environmental parameters, i.e. sediment particle size percentage distributions (% sand, %silt-clay etc) and sediment organic carbon concentrations. These data sets were square root transformed to reduce the "outlier" effect. Organic carbon values were $\log_{10}$ transformed. If any significant (pair-wise correlation >0.95) correlations existed between variables, only one variable from that correlated group was included in the analysis, to prevent the correlation being exaggerated in the analysis.

Following transformations, data were normalised to equalise variance and standardise contributory importance of each variable. Resulting data matrices were subjected to correlation based PCA using PRIMER® program PCA (Clarke & Warwick, 1994), to identify the parameters that accounted for a large proportion of the variance in the original data set. Variances of principal components (eigen values), the proportion and cumulative proportion of the total variance, explained by each principal component, and the coefficients for each principal component (eigen vectors) were calculated.

A two-dimensional PCA ordination of the data was constructed. The PCA plot defined the positions of samples in relation to each axes, which represented the full set of variables. Each station acquired a place on this graph and the location depended on a number of variables significant to that station and which set it apart from all the rest.

Following the PCA analysis, the faunal data were linked to the environmental data using a procedure called BIOENV (Clarke & Ainsworth, 1993; Clarke & Warwick, 1994). The premise adopted for this procedure is that if the suite of environmental variables responsible for structuring the community were known, then samples having similar values for these variables would be expected to have similar species composition, and an ordination based on this abiotic information would group sites in the same way as for the biotic plot (Clarke & Warwick, 2001). If key environmental variables were omitted, the match between the two plots would deteriorate, in much the same way as it would if abiotic data, irrelevant to the community structure, were included. BIOENV is an iterative procedure, which is limited to 10,000 combinations of environmental variables. In reality, this limits the number of environmental variables to 12 that can be linked to faunal data at any one time. In this case, only eight environmental variables were available for inclusion in this analysis therefore they could all be analysed as one group.

The faunal (Bray-Curtis) and environmental (Euclidean distance) rank similarity matrices were compared using the weighted Spearman correlation coefficient (ρ_w). The environmental variables that produced the best match to the faunal data, were represented two dimensionally using an MDS ordination. This MDS ordination was then visually compared to the combined replicate faunal MDS plot to examine how well the environmental variables influenced the faunal community structure.

2.2.2. Fauna

A data matrix of all the faunal abundance data was compiled for statistical analyses. Only specimens that were successfully identified to species level were included in the statistical analyses. The faunal analysis was carried out using the PRIMER® (Plymouth Routines in Multivariate Ecological Research) programme.

Univariate statistics in the form of diversity indices were calculated on the combined replicate data. The following diversity indices were calculated:

1) Margalef's species richness index (D), (Margalef, 1958).

$$D = \frac{S-1}{\log_2 N}$$

where: N is the number of individuals
S is the number of species

2) Pielou's Evenness index (J), (Pielou, 1977).

$$J = \frac{H^{'} \text{(observed)}}{H^{'}_{max}}$$

where: $H^{'}_{max}$ is the maximum possible diversity, which could be achieved if all species were equally abundant (= $\log_2 S$)

3) Shannon-Wiener diversity index (H'), (Pielou, 1977).

$$H^{'} = -\sum_{i=1}^{S} p_i(\log_2 p_i)$$

where: p_I is the proportion of the total count accounted for by the i^{th} taxa

Species richness is a measure of the total number of species present for a given number of individuals. Evenness is a measure of how evenly the individuals are distributed among different species. The diversity index incorporates both of these parameters. Richness ranges from 0 (low richness) to 12 (high richness), evenness ranges from 0 (low evenness) to 1 (high evenness), diversity ranges from 0 (low diversity) to 5 (high diversity).

The PRIMER® manual (Clarke & Warwick, 2001) was used to carry out multivariate analyses on the station-by-station faunal data. Species that were present in less than three samples in the survey were excluded from the multivariate analysis. All species/abundance data were fourth root transformed and used to prepare a Bray-Curtis similarity matrix in PRIMER®. The fourth root transformation was used in order to down-weigh the importance of the highly abundant species and allow the mid-range and rarer species to play a part in the similarity calculation. The similarity matrix was then used in classification/cluster analysis. The aim of this analysis was to find "natural groupings' of samples, i.e. samples within a group that are more similar to each other, than they are similar to samples in different groups (Clarke & Warwick, *loc. cit.*). The PRIMER® programme CLUSTER carried out this analysis by successively fusing the samples into groups and the groups into larger clusters, beginning with the highest mutual similarities then gradually reducing the similarity level at which groups are formed. The result is represented graphically in a dendrogram, the x-axis representing the full set of samples and the y-axis representing similarity levels at which two samples/groups are said to have fused.

The Bray-Curtis similarity matrix was also subjected to a non-metric multi-dimensional scaling (MDS) algorithm (Kruskall & Wish, 1978), using the PRIMER® program MDS. This programme produces an ordination, which is a map of the samples in two- or three-dimensions, whereby the placement of samples reflects the similarity of their biological communities rather than their simple geographical location (Clarke & Warwick, 2001). With regard to stress values, they give an indication of how well the multi-dimensional similarity matrix is represented by the two-dimensional plot. They are calculated by comparing the inter-point distances in the similarity matrix with the corresponding inter-point distances on the 2-d plot. Perfect or near perfect matches are rare in field data, especially in the absence of a single overriding forcing factor such as an organic enrichment gradient. Stress values increase not only with the reducing dimensionality (lack of clear forcing structure), but also with increasing quantity of data (it is a sum of the squares type regression coefficient). Clarke and Warwick (*loc. cit.*) have provided a classification of the reliability of MDS plots based on stress values, having compiled simulation studies of stress value behaviour and archived empirical data. This classification generally holds well for 2-d ordinations of the type used in this study. Their classification is given below:

- Stress value < 0.05: Excellent representation of the data with no prospect of misinterpretation.
- Stress value < 0.10: Good representation, no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups.
- Stress value < 0.20: This provides a useful 2-d picture, but detail may be misinterpreted particularly nearing 0.20.
- Stress value 0.20 to 0.30: This should be viewed with scepticism, particularly in the upper part of the range, and discarded for a small to moderate number of points such as < 50.
- Stress values > 0.30: The data points are close to being randomly distributed in the 2-d ordination and not representative of the underlying similarity matrix.

Each stress value must be interpreted both in terms of its absolute value and the number of data points. When a moderate number of data points is observed the stress value can be interpreted approximately directly. The classification is arbitrary, however, it has been demonstrated to provide a useful framework in these type of analyses.

2.2.3. Biotope classification

Communities of marine species can be classified into specific biotopes according to the species present, prevalent substrate, exposure and proximity to the littoral zone. A biotope may be defined as an area that is uniform in environmental conditions and in its distribution of animal and plant life. In most cases habitats can be considered as mosaics of biotopes (JNCC, 2003). The accepted current standard is described in "Marine biotope classification for Britain and Ireland" (Connor *et al.* 2004). The marine habitat classification for Britain and Ireland provides a tool to aid the management and conservation of marine habitats. It is one of the most comprehensive marine benthic classification systems currently in use, and has been developed through the analysis of empirical data sets, the review of other classifications and scientific literature, and in collaboration with a wide range of marine scientists and conservation managers. It is fully compatible with and contributes to the European EUNIS habitat classification system

3. Results

3.1. Kish Bank

3.1.1. Sediment

The results from the traditional granulometric analysis can be seen in Table 4. The sediment sampled during the Kish Bank survey was classified as sand, ranging from medium to very fine sand. The majority of stations were dominated by fine sand (KB1, KB2, KB3, KB5, KB6, KB7 and KB8). Station KB12 was dominated by very fine sand and stations KB4, KB10 and KB11 were dominated by medium sand. Station KB10 contained the highest percentage of gravel (16.48%), station KB12 contained the

Table 4: Granulometry results for the 12 stations sampled at the Kish Bank on the 31st May 2005. Granulometric data were not available (n/a) for Station KB 9.

	Gravel (%)	*Very Coarse Sand (%)*	*Coarse Sand (%)*	*Medium Sand (%)*	*Fine Sand (%)*	*Very Fine Sand (%)*	*Silt/Clay (%)*
KB1	0	1	0.63	38.96	53.86	5.33	0.22
KB2	3.44	5.02	0.74	2.25	78.37	10.08	0.09
KB3	0	0.13	0.43	1.47	87.28	10.41	0.28
KB4	0	0.91	0.95	55.34	41.59	0.99	0.27
KB5	1.11	0.85	0.85	3.45	84.36	9.04	0.36
KB6	1.21	1.34	1.01	1.61	67.85	26.08	0.88
KB7	12.32	15.37	1.84	8.04	51.67	10.68	0.79
KB8	3.65	3.11	4.1	26.03	57.15	5.47	0.34
KB9	n/a	n/a	n/a	n/a	n/a	n/a	n/a
KB10	16.48	7.68	10.62	41.34	23.45	0	0.43
KB11	0	2.62	6.65	47.17	40.85	2.32	0.39
KB12	0	20.43	15.36	15.25	19.92	23.35	5.7

highest percentage of very coarse sand (20.43%), coarse sand (15.36%) and silt-clay (5.7%). Station KB4 contained the highest percentage of medium sand (55.34%). Station KB3 contained the highest percentage of fine sand (87.28%) and station KB6 contained the highest proportion of very fine sand (26.08%).

The results from the organic carbon analysis can be seen in Table 5. Organic carbon values at the Kish Bank ranged from 0.032 (Station 4) to 0.12 CAOV (Station 10).

Table 5: Organic carbon results for the 12 at the Kish Bank on the 31st May.

Station	*Organic Carbon (CAOV)*
KB1	0.063
KB2	0.051
KB3	0.078
KB4	0.032
KB5	0.076
KB6	0.083
KB7	0.045
KB8	0.065
KB9	0.069
KB10	0.120
KB11	0.098

KB12	0.060

Figure 3 shows the PCA ordination of the sediment data analysed from the Kish Bank. The variation seen in this 2-D ordination accounted for 68.7% of the overall variation, PC1 accounted for 41.2% of the variation, whereas PC2 accounted for 27.4% of the variation. The stations at the Kish Bank were divided into medium sand (MS), fine sand (FS) and very fine sand (VFS) by the granulometric analysis. This broad grouping has been observed in the PCA plot. Within the fine sand grouping, stations KB2, KB3 and KB5 grouped closest together due to having the highest proportions of fine sand. KB6 separated due to it having the highest very fine sand (VFS) proportion. KB7 separated due to its high gravel (G) and very coarse sand (VCS) proportions. KB1 and KB8 grouped separately due to their high medium sand proportions. In the medium sand (MS) grouping, KB10 grouped away from KB4 and KB11 due to its higher proportions of gravel and organic carbon compared with the other stations. In the very fine sand (VFS) grouping, station KB12 formed a group of its own. It had the highest proportions of very coarse sand, coarse sand and silt-clay.

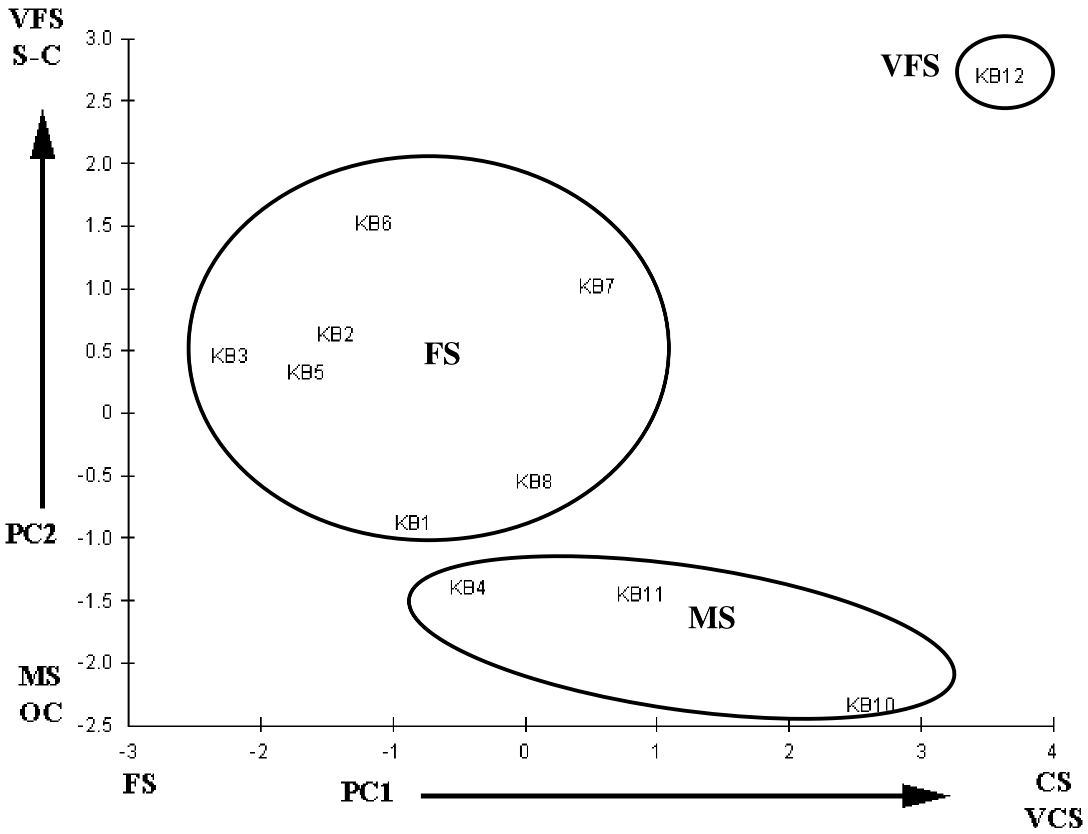


Figure 3: PCA ordination of the environmental data sampled at the Kish Bank on the 31st May 2005. Very Coarse Sand (VCS); Coarse Sand (CS); Medium Sand (MS); Fine Sand (FS); Very Fine Sand (VFS); Silt-Clay (S-C); Organic Carbon (OC).

The BIOENV procedure selected the following four variables at a correlation of 0.607, as those that best reflected the faunal distribution patterns:

- Medium Sand (MS
- Fine Sand (FS)
- Very Fine Sand (VFS)
- Silt-Clay (S-C))

A correlation of 0.8-0.9 or greater would have resulted in a very good match between the faunal and environmental data, a correlation of 0.607 will show a match regarding the more obvious characteristics i.e. overall sediment type, but the finer detail i.e. relative proportions of the grain size categories, will not be matched by the environmental data. Figures 4 and 5 shows a comparison between a MDS plot based on the combined replicate faunal data and a MDS plot based on the environmental variables respectively. The stress level of the faunal data based MDS was 0.09, this indicated a good representation of the data with no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups. The stress level for the environmental data based MDS was 0.01; this indicated an excellent representation of the data with no prospect of misinterpretation. It can be seen from the MDS plots that some similarity was present i.e. KB12 grouped away from the other stations in both plots; however, the similarities seen within the remaining stations was not duplicated in the environmental data MDS plot. The environmental data MDS plot did show a grouping based on sediment type; stations KB4, KB10 and KB11 were classified as medium sand and they can be seen to group together. The remaining stations were classified as fine sand, however while stations KB2, KB3, KB5, KB6 and KB7 grouped together, stations KB1 and KB8 grouped

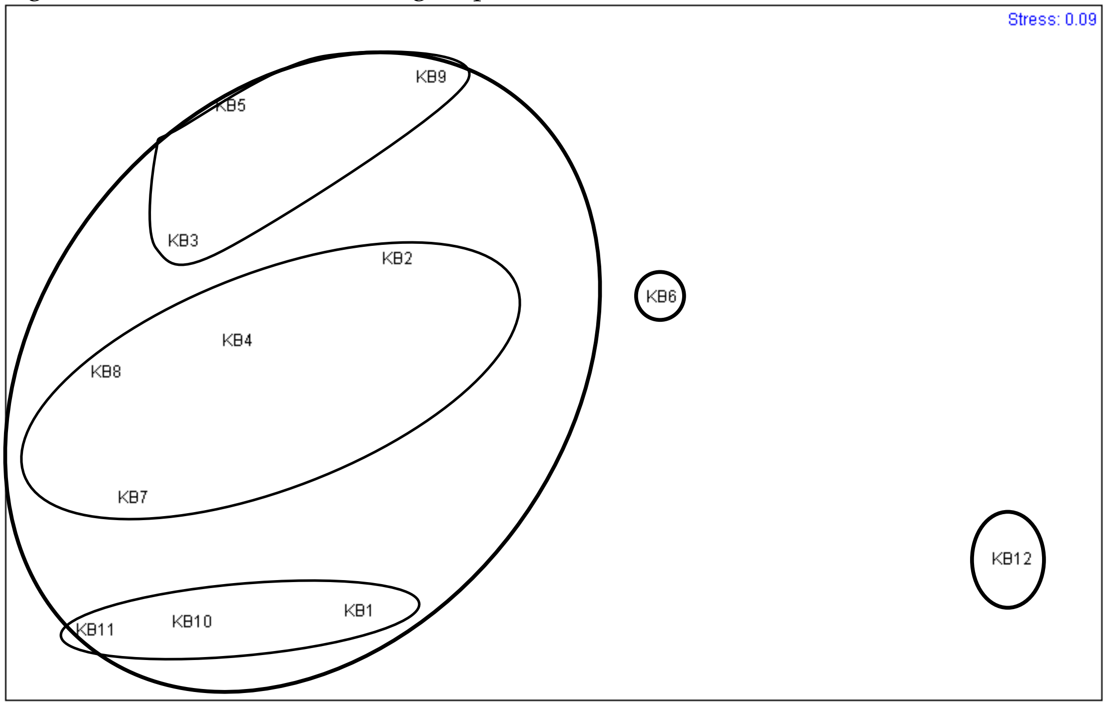


Figure 4: MDS plot based on the combined replicate faunal data for the Kish Bank.

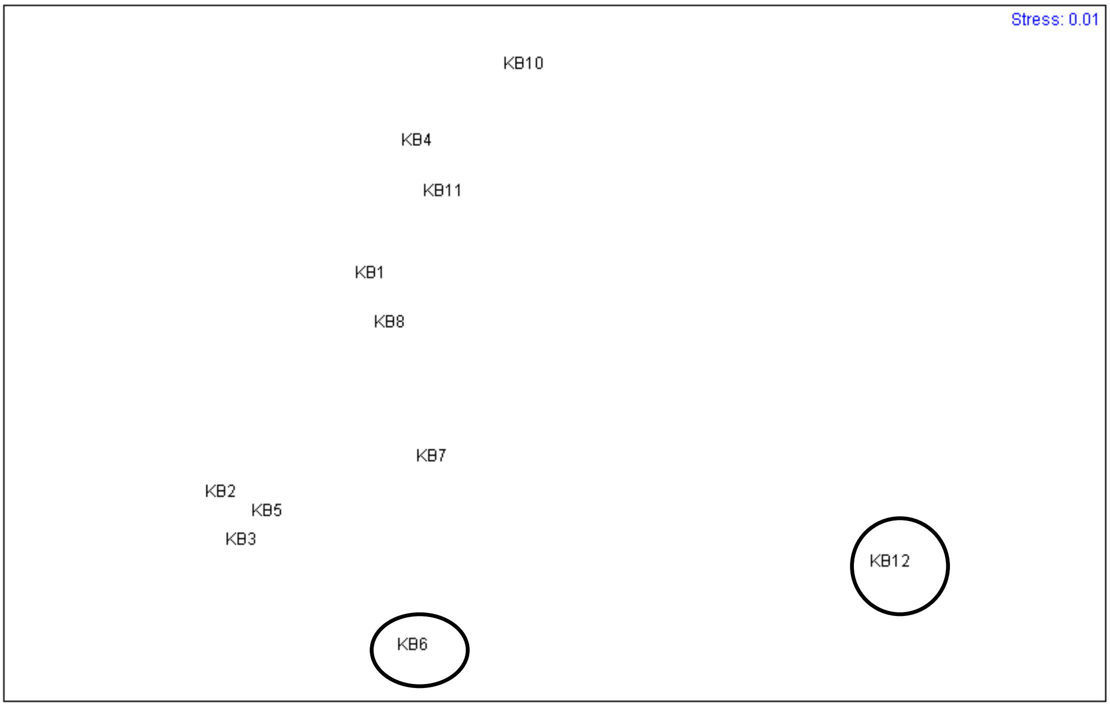


Figure 5: MDS plot based on the environmental data, medium sand, fine sand, very fine sand and silt-clay for the Kish Bank

closer to the medium sand grouping due to the relatively high proportions of medium sand present at these stations. However, the faunal data MDS plots did not show a clear grouping of stations based on sediment type as the environmental data MDS plot did.

3.1.2. Fauna

The taxonomic identification of the benthic infauna across all 12 stations sampled in the Kish Bank survey yielded a total count of 101 species, ascribed to 12 phyla. A complete listing of these species abundance is provided in Appendix I, Table 13. Of the 101 species enumerated, 56 were polychaetes (segmented worms), 22 were crustaceans (crabs, shrimps, prawns), 19 were molluscs (mussels, cockles, snails etc.), 3 species were echinoderms (brittlestars, sea cucumbers) and 1 species was an echiuran (spoonworm).

Univariate analyses

Univariate statistical analyses were carried out on the combined replicate station-by-station faunal data. The following parameters were calculated and can be seen in Table 6; species numbers, number of individuals, richness, evenness and diversity. Species numbers ranged from 13 (KB1) to 49 (KB12). Number of individuals ranged from 51 (KB1) to 351 (KB12). Richness ranged from 3.05 (KB1) to 8.19 (KB12). Evenness ranged from 0.69 (KB3) to 0.91 (KB10). Diversity ranged from 1.91 (KB3) to 2.89 (KB12).

Table 6: Diversity indices for the 12 stations sampled at the Kish Bank on the 31st May 2005.

Station	*Species*	*Individuals*	*Richness*	*Evenness*	*Diversity*
KB1	13	51	3.05	0.82	2.12
KB2	37	203	6.78	0.76	2.76
KB3	16	115	3.16	0.69	1.91
KB4	27	86	5.84	0.82	2.71
KB5	24	148	4.60	0.71	2.24

KB6	27	89	5.79	0.83	2.74
KB7	22	121	4.38	0.86	2.66
KB8	16	91	3.33	0.80	2.23
KB9	20	80	4.34	0.85	2.54
KB10	17	67	3.81	0.91	2.57
KB11	22	88	4.69	0.83	2.57
KB12	49	351	8.19	0.74	2.89

Multivariate analyses

The dendrogram and the MDS plot can be seen in Figures 5 and 6 respectively. The classification analyses delineated four distinct groupings, arbitrarily labeled:

- Group I (KB1A, KB1B, KB1C, KB1D, KB1E, KB2A, KB2C, KB3A, KB3E, KB4A, KB4C, KB4E, KB5A, KB5D, KB5E, KB7A, KB7B, KB7D, KB7E, KB8A, KB8B, KB8C, KB8D, KB10B, KB10C);
- Group II (KB2E, KB3B, KB3D, KB4B, KB4D, KB5B, KB7C, KB8E, KB10A, KB10D, KB11A, KB11B, KB11D, KB11E);
- Group III (KB6C, KB12A, KB12B, KB12C, KB12D, KB12E);
- Group IV (KB2B, KB2D, KB3C, KB5C, KB6A, KB6B, KB6D, KB6E, KB9A, KB9B, KB9C, KB9E).

Groups I and II separated from Groups III and IV at c. 22% similarity. Groups I and II separated from each other at c. 27% similarity and Groups III and IV separated from each other at c. 23% similarity. Group I had a similarity level of c. 31%, Group II had a similarity level of c. 30%, Group III had a similarity level of c. 40% and Group IV had a similarity level of c. 30%. These delineations were also preserved in the MDS plot. The stress value of the MDS ordination is 0.23; as a result the ordination should be viewed with scepticism as some of the detail can be misinterpreted.

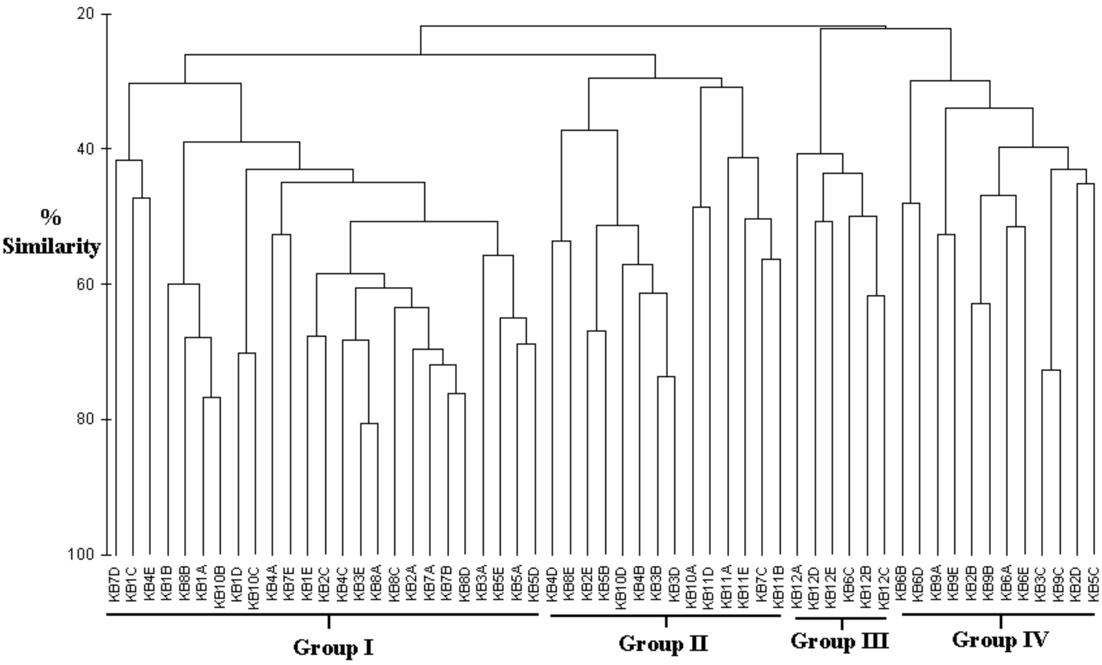


Figure 5: Dendrogram showing each replicate sample from the 12 stations sampled at the Kish Bank on the 31st May 2005.

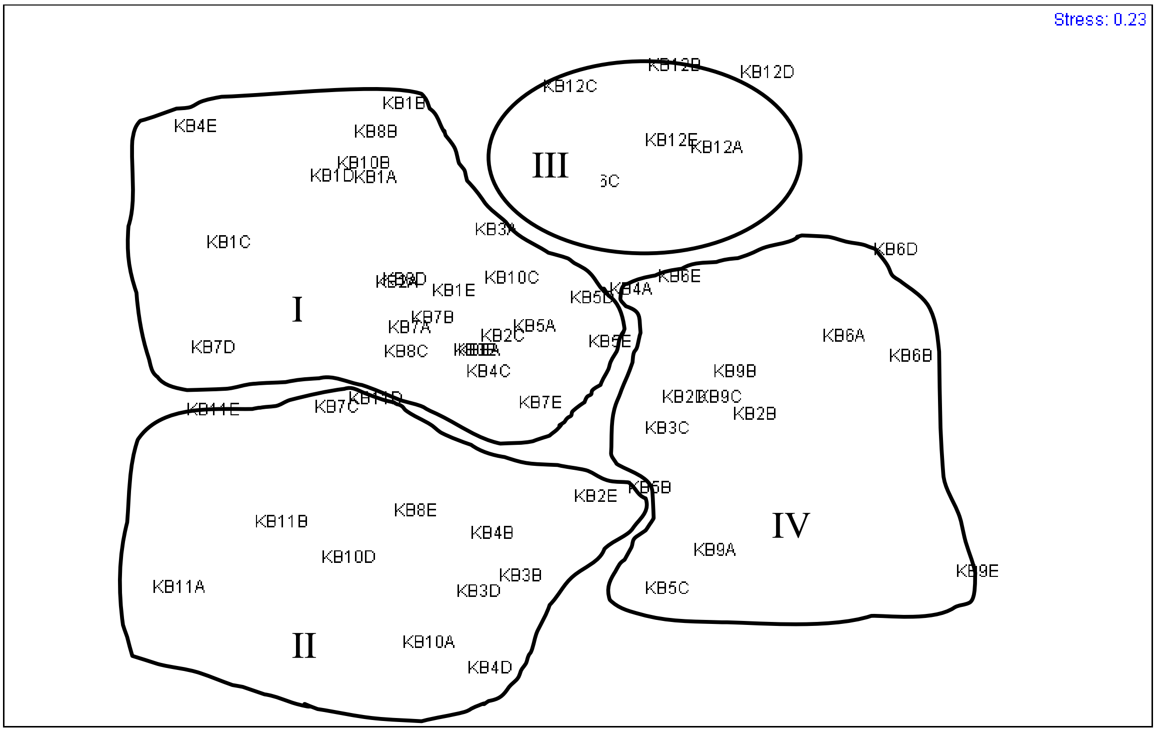


Figure 6: MDS ordination showing each replicate sample from the 12 stations sampled at the Kish Bank on the 31st May 2005.

3.1.3. Biotope classification

Four different assemblages were highlighted by the classification/cluster analysis. Group I was identified as a mosaic of two different biotopes, typical of medium to fine sandy sediments subject to physical disturbances due to wave action and tidal streams. The marine habitat biotopes present include "*Glycera lapidum* in impoverished infralittoral mobile gravel and sand" (SS.SCS.ICS.Glap) and "*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand" (SS.SSA.CFiSa.ApriBatPo). Twenty-eight species comprised this group. The amphipod *Bathyporeia elegans* and the polychaete *Nephtys longosetosa* were dominant. The following species were also present and typical of the above mentioned biotopes: the polychaetes *Spiophanes bombyx, Scoloplos armiger, Ophelia borealis, O. neglecta, Glycera lapidum, Magelona miriabils,* the crustaceans *Pontocrates arenarius, Urothoe brevicornis, Gastrosaccus spinifer* and the bivalves *Spisula elliptica, Abra prismatica and Abra alba.* It is possible that SS.SCS.ICS.Glap is not a true biotope, rather an impoverished, transitional community, which in more settled conditions develops into other more stable communities that are often characterised by long lived and slow growing species. The majority of the stations in this group had a fine sand substratum.

Group II was identified as the "*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand" (SS.SSA.IFiSa.NcirBat) biotope, typical of well-sorted medium and fine sands. This biotope occurs in sediments subject to physical disturbances; typically wave action or strong tidal streams. Twenty-eight species comprised this group. This group was dominated by *Nephtys cirrosa* and *Bathyporeia elegans*. Other species present were also typical of mobile sandy areas: the polychaetes *Scoloplos armiger, Ophelia borealis, Glycera lapidum, Lumbrineris gracilis, Nephtys longosetosa, Spiophanes bombyx, Ophelia neglecta, Spio armata,* the bivalves *Spisula elliptica* and *Abra prismatica* and the crustaceans *Pontocrates arenarius* and *Urothoe brevicornis*. There is considerable overlap between the species found in this group and in Group I, suggesting that while difference with respect to the dominants are evident, the bulk of the species are relatively consistent between the two groups. The stations, which comprised this group, had either fine or medium sand substrata.

Groups III and IV were more similar to themselves that to Groups I and II. Group III was comprised of twenty-six species. The dominants were the bivalve *Nucula sulcata* and the polychaetes *Captiomastus minimus.* A higher proportion of silt-clay was evident from this group and this was reflected by the dominant species present. The overall faunal assemblage reflects both elements of a muddy and a sandy habitat. The species present were as follows: the polychaetes *Glycera lapidum, Lumbrineris gracilis, Spiophanes bombyx, Aphelochaeta multibranchiis, Pholoe inornata, Scalibregma inflatum,* the bivalves *Abra alba, Nucula nitidosa, Phaxas pellucidus, Spisula elliptica, Gari fervensis, Mya arenaria, Fabulina fabula* and the crustaceans *Gammaropsis nitida, Ampelisca spinipes, Atylus vedlomensis, Bathyporeia elegans* and *Urothoe brevicornis.* This group was identified as the "*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment" (SS.SSA.CMuSa.AalbNuc) with elements of the sandier biotopes mentioned above. Group III was composed of station KB12 in its entirety and 1 replicate from station KB6. Station 12 was classified as having a very fine sand substratum and therefore the species present are typical of a finer sediment type.

Group IV was identified as the SS.SSA.CMuSa.AalbNuc biotope with elements of the SS.SSA.IFiSa.NcirBat biotope. Thirty-eight species characterised this group. The most dominant species of this group was the bivalve *Nucula nitidosa.* This is the characteristic species of the biotope SS.SSA.CMuSa.AalbNuc, which is typically found on non-cohesive muddy sands or slightly shelly/gravelly muddy sand. Other species characteristic of this biotope are *Abra alba, Nephtys* spp., *Spiophanes bombyx* and *Fabulina fabula.* The amphipod *Bathyporeia elegans* was the second most dominant species present in this group. This species, along with *Nephtys cirrosa, Pontocrates arenarius* and *Magelona mirabilis,* typify the SS.SSA.IFiSa.NcirBat biotope, which is generally associated with well-sorted medium and fine sands in physically disturbed areas. The stations, which comprised this group, were classified as fine sand, with the exception of station KB9 (no granulometric data were available for this station).

The diversity indices calculated were considered to be low; station KB12 had the highest species numbers (49), number of individuals (351), richness (8.19) and diversity (2.89). Station 12 had the highest proportion of very fine sand and as a result there was an additional niche for the fauna to exploit and therefore the diversity indices were slightly better at this station.

An attempt was made at linking the faunal and environmental characteristics. The four environmental variables, which best matched the faunal data were medium sand, fine sand, very fine sand and silt-clay. However, MDS plots used to compare the groupings of the faunal and environmental data only shared one similarity. Station KB12 grouped away from the other stations in both MDS plots, this was due to it being the only station classified as very fine sand and as a result its faunal composition was different to the other stations. The remaining stations had varying proportions of medium sand and fine sand and as a result the weighted Spearman correlation coefficient was not good enough to allow the prediction of the faunal assemblage in these instances.

3.2 Blackwater Bank

3.2.1. Sediment

The results from the traditional granulometric analysis can be seen in Table 7. The sediment sampled during the Blackwater Bank survey was classified as fine sand. Station BB3 contained the highest percentage of very fine sand (24.96%). Station BB11 contained the highest percentage of fine sand (91.22%). Station BB9 contained the highest percentage of medium sand (20.77%) and silt-clay (0.55%). Station BB7 contained the highest percentage of gravel (8.64%), very coarse sand (3.33%) and coarse sand (2.4%).

Table 7: Granulometry results for the 12 stations sampled at the Blackwater Bank on the 8th June 2005.

	Gravel	*Very Coarse Sand*	*Coarse Sand*	*Medium Sand*	*Fine Sand*	*Very Fine Sand*	*Silt/Clay*
BB1	0	0	0.35	2.17	86.3	11.19	0.06
BB2	0	0	0.36	4.59	89.44	5.15	0.47
BB3	0	0.08	0.24	1.25	73.06	24.96	0.37
BB4	0	0	0.32	0.83	81.76	16.99	0.12
BB5	0	0.06	0.29	0.76	83.88	13.83	0.2
BB6	0	0.28	0.59	5.54	76.35	16.91	0.29
BB7	8.64	3.33	2.4	17.29	65.58	2.4	0.36
BB8	0	1.47	0.8	12.89	78.65	5.97	0.22
BB9	0	0.25	0.53	20.77	72.82	4.78	0.55
BB10	0	0.03	0.68	1.1	78.59	19.48	0.12
BB11	0.41	0.47	1.05	3.24	91.22	3.78	0.27
BB12	0	0.14	0.73	11.14	78.41	9.13	0.45

The results from the organic carbon analysis are shown in Table 8. Organic carbon values at the Blackwater Bank ranged from 0.018 (Station 8) to 0.072 CAOV (Station 9). Figure 7 shows the PCA ordination of the sediment data analysed from the Blackwater Bank. The variation seen in this 2-D ordination accounted for 74.7% of the overall variation, PC1 accounted for 53.2% of the variation, whereas PC2 accounted for 21.5% of the variation. As all stations at the Blackwater Bank were classified as fine sand by the granulometric analysis; the variations seen between the stations in the PCA plot are due to some other variable(s). It is clear from the PCA plot that stations BB1, BB3, BB4, BB5 and BB10 grouped together due to the high proportion of very fine sand (VFS) at these stations.

Table 8: Organic carbon results for the 12 at the Blackwater Bank on the 8th June 2005.

Station	*Organic Carbon (CAOV)*
BB1	0.022
BB2	0.031
BB3	0.020
BB4	0.019
BB5	0.025
BB6	0.033
BB7	0.024
BB8	0.018
BB9	0.072
BB10	0.041

BB11	0.039
BB12	0.041

BB2, BB6 and BB12 grouped away from the VFS group based upon the relatively high medium sand (MS) proportions found at these stations. BB8 grouped separately due to the high proportions of very coarse sand (VCS) and medium sand present at this station. BB7 had the largest proportion of gravel (G) and very coarse sand and therefore grouped separately. BB9 had the highest proportions of silt-clay (S-C) and medium sand and the highest concentration of organic carbon and therefore grouped away from the other stations.

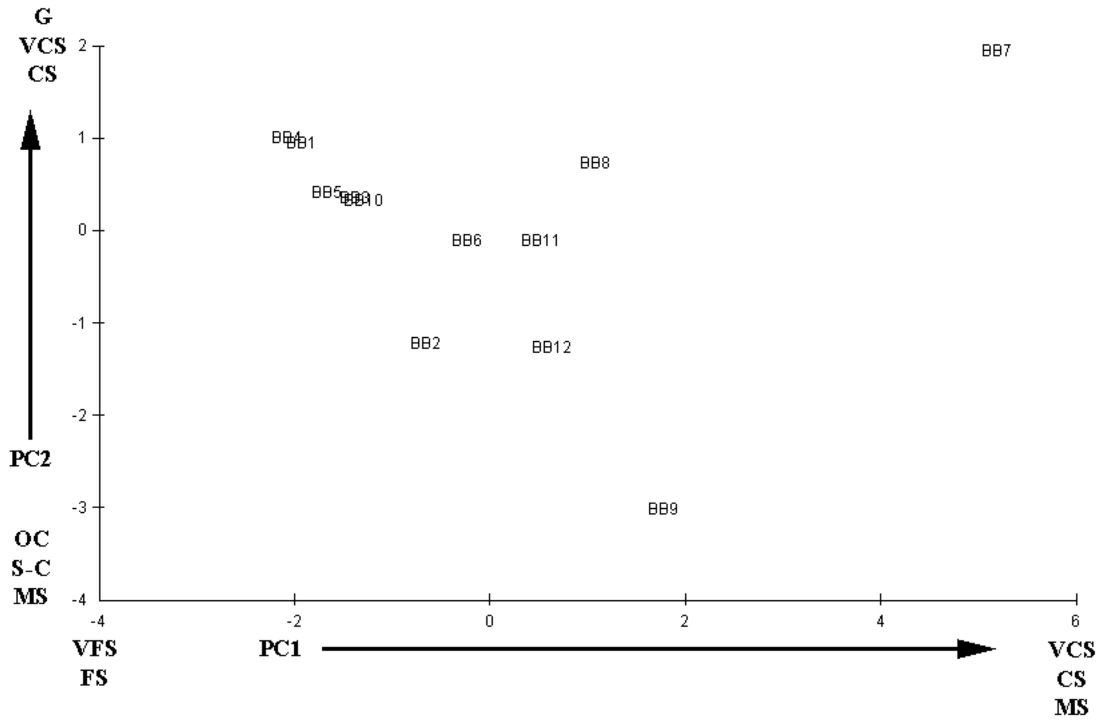


Figure 7: PCA ordination of the environmental data sampled at the Blackwater Bank on the 8th June 2005. Gravel (G); Very Coarse Sand (VCS); Coarse Sand (CS); Medium Sand (MS); Fine Sand (FS); Very Fine Sand (VFS); Silt-Clay (S-C); Organic Carbon (OC).

The BIOENV procedure selected the following three variables, at a correlation of 0.303, as those that best reflected the faunal distribution patterns:

- Very Coarse Sand (VCS)
- Silt-Clay (S-C)
- Organic Carbon (OC)

Figures 8 and 9 show a comparison between a MDS plot based on the combined replicate faunal data and a MDS plot based on the environmental variables, respectively. The stress level of the faunal data based MDS was 0.15 and this indicated a useful 2-D picture, but detail may be misinterpreted particularly nearing 0.20. The stress level for the environmental data based MDS was 0.08 and indicated a good representation of the data with no real prospect of misinterpretation of overall structure, but very fine detail may be misleading in compact subgroups. The weighted Spearman correlation coefficient of 0.303 was too low to obtain accurate matching of the two MDS ordinations. It can be seen from the MDS plots that some similarity was present i.e. BB 7 and BB8 formed groupings in both MDS plots, however in the faunal MDS, stations BB7 and BB8 were part of a larger group containing all the stations except BB1. In the environmental MDS, stations BB7 and BB8 formed a group separate to the other groups. Sediment granulometry and organic carbon data were not sufficient to accurately match the faunal distribution.

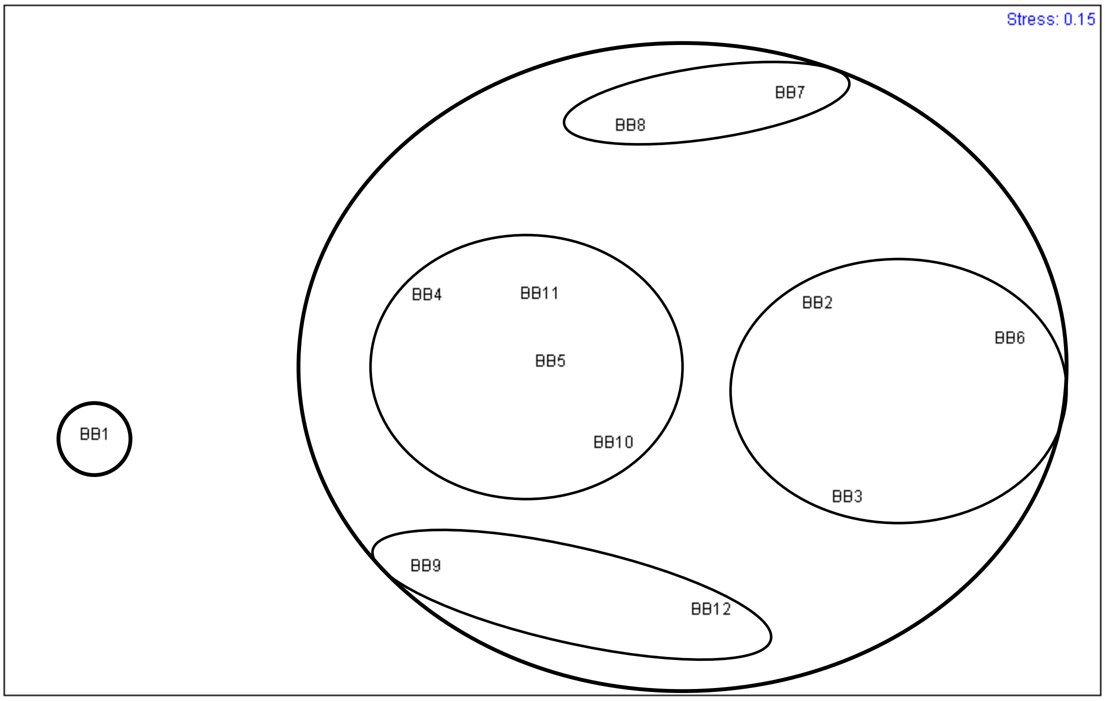


Figure 8: MDS based on the combined replicate faunal data for the Blackwater Bank.

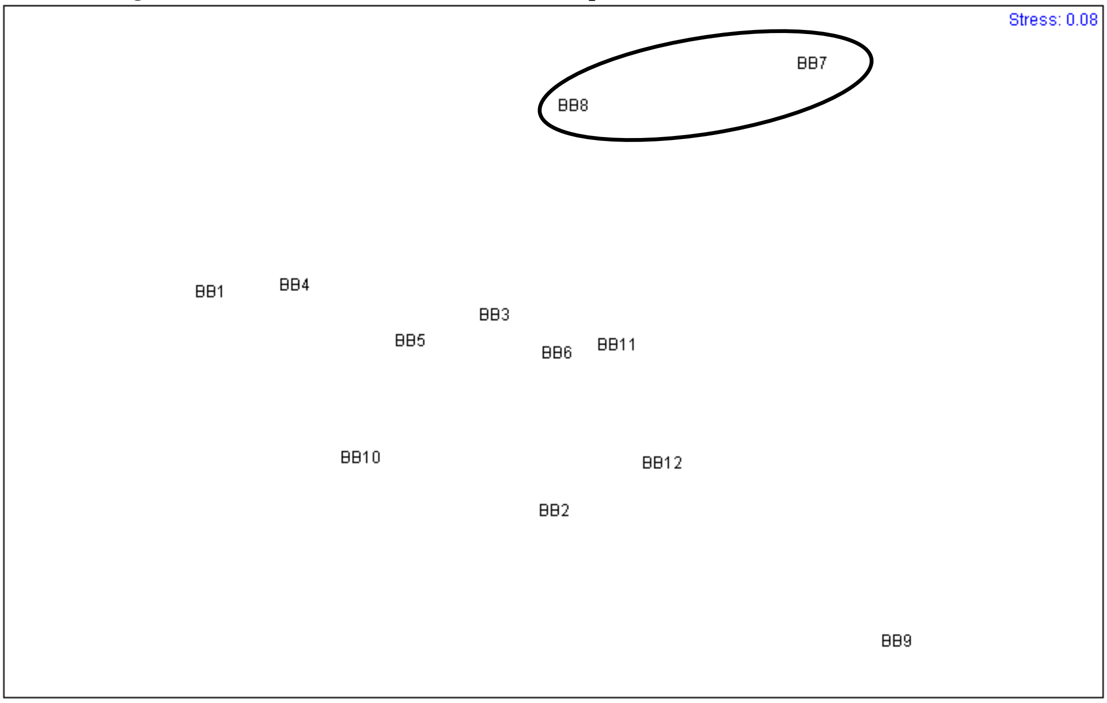


Figure 9: MDS based on the environmental variables, very coarse sand, silt-clay and organic carbon at the Blackwater Bank.

3.2.2. Fauna

The taxonomic identification of the benthic infauna across all 12 stations sampled in the Blackwater Bank survey yielded a total count of 35 species, ascribed to 4 phyla. A complete listing of these species abundance is provided in Appendix I, Table 14. Of the 35 species identified, 22 were polychaetes (segmented worms), 9 were crustaceans (crabs, shrimps, prawns), 3 were molluscs (mussels, cockles, snails etc.) and 1 was a fish.

Univariate Analyses

Univariate statistical analyses were carried out on the combined replicate station-by-station faunal data. The following parameters were calculated and can be seen in Table 9: species numbers, number of individuals, richness, evenness and diversity. Species numbers ranged from 8 (BB7) to 12 (BB2, BB8 and BB9). Number of individuals ranged from 23 (BB6) to 80 (BB9). Richness ranged from 2.07 (BB3) to 3.07 (BB2). Evenness ranged from 0.34 (BB10) to 0.92 (BB6). Diversity ranged from 0.78 (BB10) to 2.21 (BB2).

Multivariate Analyses

The dendrogram and the MDS plot can be seen in Figures 10 and 11 respectively. The classification analyses delineated four distinct groupings. One grouping comprised of 4 sub-sets. The groupings were arbitrarily labelled:

- Group I (BB6C, BB8C);
- Group II (BB1C, BB1D, BB7E, BB10D, BB11E);
- Group III (BB2E, BB6B, BB7A);
- Group IV

Table 9: Diversity indices for the 12 stations sampled at the Blackwater Bank on the 8th June 2005.

Station	*Species*	*Individuals*	*Richness*	*Evenness*	*Diversity*
BB1	10	33	2.57	0.77	1.78
BB2	12	36	3.07	0.89	2.21
BB3	9	48	2.07	0.48	1.05
BB4	11	53	2.52	0.72	1.74
BB5	10	44	2.38	0.71	1.64
BB6	10	23	2.87	0.92	2.11
BB7	8	24	2.20	0.86	1.78
BB8	12	49	2.83	0.76	1.90
BB9	12	80	2.51	0.45	1.11
BB10	10	69	2.13	0.34	0.78
BB11	10	41	2.42	0.78	1.80
BB12	11	76	2.31	0.42	1.01

- Group IVa (BB4E, BB5D, BB8B, BB11D);
- Group IVb (BB2C, BB9D, BB10D, BB12D);
- Group IVc (BB2A, BB2B, BB2D, BB3A, BB3D, BB3E, BB4A, BB4B, BB4C, BB5B, BB9A, BB9B, BB10A, BB10C, BB11B, BB12A, BB12B, BB12C, BB12E);
- Group IVd (BB1A, BB1B, BB1E, BB3B, BB3C, BB4D, BB5A, BB5C, BB5E, BB6A, BB6D, BB6E, BB7B, BB7C, BB8A, BB8D, BB8E, BB9C, BB10E, BB11A, BB11C).

Group I separated from the other groups at a level of c. 3% similarity. Group II separated from Groups III and IV at a level of c. 8% similarity. Groups III and IV separated at a similarity level of c. 12%. Group IVa separated from the rest of Group IV at a similarity level of c. 28%. Group IVb separated from Groups IVc and IVd at a similarity level of c. 35%. Groups IVc and IVd separated from each other at a similarity level of c. 41%. Group I had a similarity level of c. 62%, Group II of c. 20% and Group III of c. 41%. Groups IVa and IVb had similarity levels of c. 46%, Group IVc of c. 47% and Group IVd of c. 43%. These delineations were also preserved in the MDS plot (Figure 9). The stress value of 0.18 is indicative of a useful 2-d picture, but detail can be misinterpreted as the stress value is nearing 0.20.

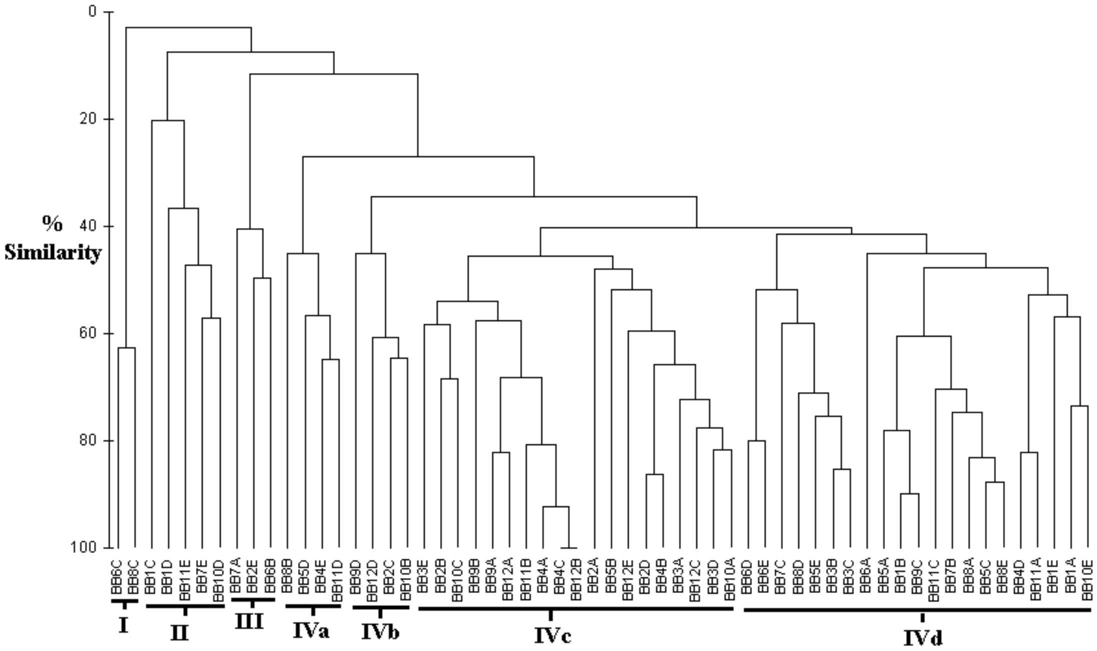


Figure 10: Dendrogram showing each replicate sample from the 12 stations sampled at the Blackwater Bank on the 8th June 2005.

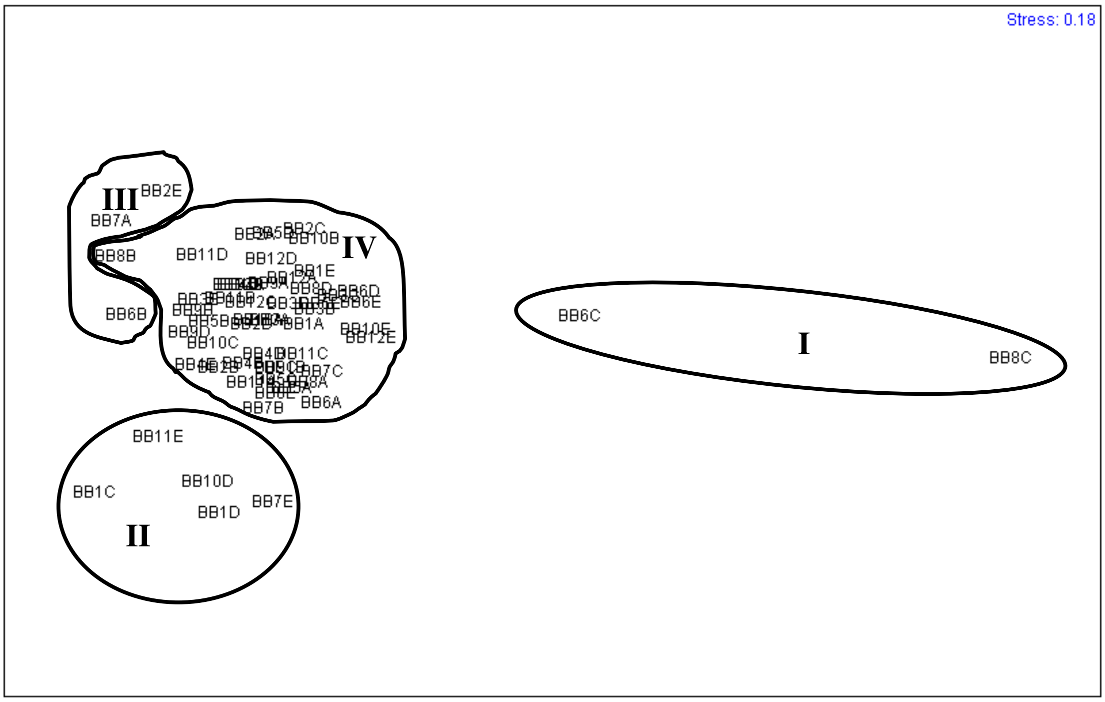


Figure 11: MDS ordination showing each replicate sample from the 12 stations sampled at the Blackwater Bank on the 8th June 2005.

3.2.3. Biotope classification

Four different assemblages were highlighted by the classification/cluster analysis. Group I contained 2 species, the polychaetes *Spio filicornis* and the crustacean *Gastrosaccus spinifer.* The presence of *Gastrosaccus spinifer* accompanied by the overall low return from this group indicates a resemblance to the *infralittoral mobile clean sand with sparse fauna biotope* (SS.SSa.IFiSa.ImoSa). This biotope is typical of medium to fine sandy sediments on exposed or tide-swept coasts where the poor infaunal assemblage is the result of the mobility of the substratum. *Gastrosaccus spinifer* can survive these conditions due to its presence on or above the sediment surface and not within the sediment.

Group II contained 5 species, the polychaetes *Nephtys cirrosa, Spio armata, Magelona johnstoni, Glycera tridactyla* and the bivalve *Parvicardium minimum.* Due to the poor faunal assemblage in this group, it resembled the biotope SS.SSa.IFiSa.ImoSa. This is indicative of the strong tidal regime in the area and the resultant high level of mobility of the substratum.

Group III contained 5 species, the polychaetes *Nephtys longosetosa, Levinsenia gracilis, Scolelepis squamata, Ophelia borealis* and the crustacean *Urothoe elegans*. While the faunal return was poor for this group there is evidence of a sandy *Ophelia* community linked with the biotope SS.SSa.IFiSa.ImoSa reflected by the sparse fauna.

Group IV was divided into 4 sub-groups. Group IVa contained 8 species. These were the polychaetes *Spio armata, Magelona mirabilis, Spiophanes bombyx, Nephtys longosetosa, Nephtys cirrosa* and the crustaceans *Bathyporeia elegans, Pontocrates altamarinus* and *Urothoe elegans*. Group IVb contained 6 species, the polychaetes *Spiophanes bombyx, Ophelia borealis, Glycera tridactyla*, the crustaceans *Bathyporeia elegans, Urothoe elegans* and *Corytes cassivelaunus.* Group IVc contained 17 species. The dominants of this group were the crustacean *Bathyporeia elegans, Pontocrates altamarinus* and *Portumnus latipes*, the polychaetes *Nephtys longosetosa, Magelona johnstoni, Scolelepis squamata* and *Nephtys cirrosa.* Group IVd contained 12 species. The dominants were the crustacean *Bathyporeia elegans, Portumnus latipes* and *Gastrosaccus spinifer,* the polychaetes *Scolelepis squamata, Nephtys cirrosa, Magelona mirabilis and Magelona johnstoni* and the bivalve *Parvicardium minimum.*

All Group IV sub-groups show elements of the SS.SSA.IFiSa.NcirBat and SS.SSA.IMoSa biotopes. Both of these biotopes are characteristic of medium to fine sandy sediments subject to physical disturbances such as wave exposure resulting in little fauna due to the mobility of the substratum. It is important to note that although each sub-group differed, the overall assemblage characteristics did not.

The diversity indices calculated are low; the highest species numbers recorded was 12 at stations BB2, BB8 and BB. Station BB9 had the highest number of individuals (80). Station BB2 had the highest richness (3.07) and the highest diversity (2.21). Station 6 had the highest evenness (0.92).

An attempt was made at linking the faunal and environmental characteristics. The three environmental variables, which best matched the faunal data were very coarse sand, silt-clay and organic carbon. However, the weighted Spearman correlation coefficient of 0.303 was too low to obtain accurate matching of the two MDS ordinations. Therefore, it can be said that sediment granulometry and organic carbon concentrations were not sufficient to accurately match the faunal distribution.

4. DISCUSSION

4.1. Comparison of Irish Sandbanks

The format of the current survey was designed to give greatest information relating to the benthic communities and prevailing sediment conditions at two sandbank complexes in the Irish Sea. The results of the present survey will benefit from comparison with previous surveys undertaken in this geographical area. Although there have been some comprehensive environmental surveys (e.g. Long Bank/Ballyteigue Bay (Aqua-Fact, 1989), Arklow Bank (Fehily & Timoney Ltd. 2001), Kish/Bray Banks (Saorgus Energy Ltd. 2005)) undertaken in the Irish Sea, there are few that have followed the methodology of the current survey.

Data were collected during the current survey to assess the mean composition of sediment samples for both the Blackwater and Kish Bank. Both banks are predominantly composed of sand ranging from very fine to coarse sand (1mm to 0.062mm). Unfortunately granulometric analysis was not included for the Arklow Bank or Kish/Bray Banks surveys. However, sediment analysis was undertaken along the Long Bank (Figure 13). It is obvious that there is some variance in sediment type between the Banks.

The organic carbon content of the series of samples taken during both the current survey and those taken over the Long Bank showed that there was a significant difference between banks (ANOVA $_{2,47,\ P < 0.001}$ F = 25.11). Blackwater Bank exhibited significantly lower values. Variations in organic carbon and granulometric values may indicate habitat quality but are as likely to vary due to differences in local conditions (tidal current, presence of adjacent rivers *etc.*).

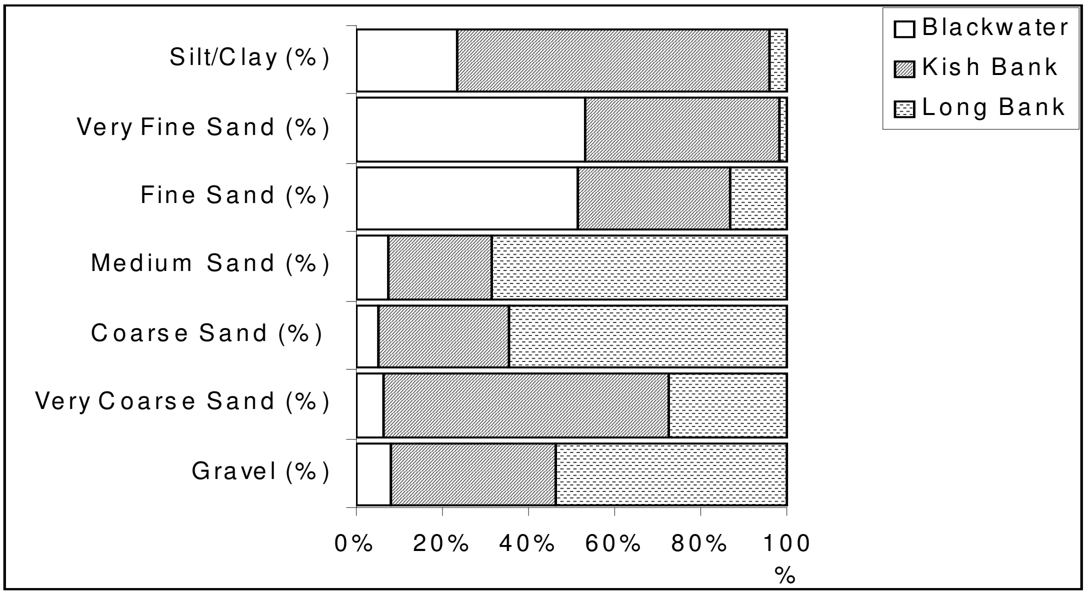


Figure 13: Granulometric analysis of three sandbanks in the eastern Irish Sea.

There have been few surveys in the Irish Sea that have used benthic grabs and fewer where the raw data were available. Both the Saorgus Energy Ltd. (2005) and Fehily & Timoney & Co. (2001) surveys used benthic dredges that tend to sample epifauna and some infauna. To illustrate the difference in community structure between sandbanks and surrounding areas additional analyses were undertaken. A survey carried out on Long Bank (Aqua-Fact, 1989), using grabs, showed that the latter coastal site recorded 41.1% (37 vs. 90 species) of species diversity (S). During 2002, dredges taken directly over Kish & Bray Banks (Saorgus Energy Ltd., 2005) showed a diversity (S) of only 17% of that in the surrounding areas (only 14 species compared to the total of 82 encountered). The Arklow Bank (Fehily & Timoney & Co., 2001) survey showed that this bank had a faunal diversity of just 9.4% of surrounding areas (6 vs. 64 species). A survey undertaken near Courtown, Co. Wexford (Aqua-Fact, 2005) was used to illustrate the difference between coastal grab samples and nearby sandbanks (in this case Blackwater and Long Bank). Statistical comparison showed that species richness (d) and diversity (H) were significantly higher for the coastal site ($P< 0.001$ & $P< 0.006$ respectively). Therefore, further comparison with coastal communities offers little insight into the expected communities of sandbanks.

Although a total of 198 species was collected on the Kish/Bray Bank during both the current and Saorgus Energy Ltd. (2005) survey, only 9 species were common to both results. Benthic grabs collected significantly more species (126 as opposed to 83 from dredges). A Jaccard similarity matrix was constructed to illustrate the variation of sandbank communities from presence/absence data of recently surveyed banks (Figure 14). It is apparent that there is little similarity between sandbank faunal communities using different methods. Nevertheless, since Long Bank has been designated as a Natura 2000 site, it will be included in further analyses although the caveat should be noted that benthic dredges and benthic grabs are not strictly comparable. However, as the faunal communities seem to vary considerably and abundance estimates are available for Long Bank, unlike the Arklow or Kish/Bray Bank surveys, this bank will be analysed for further measures of species diversity.

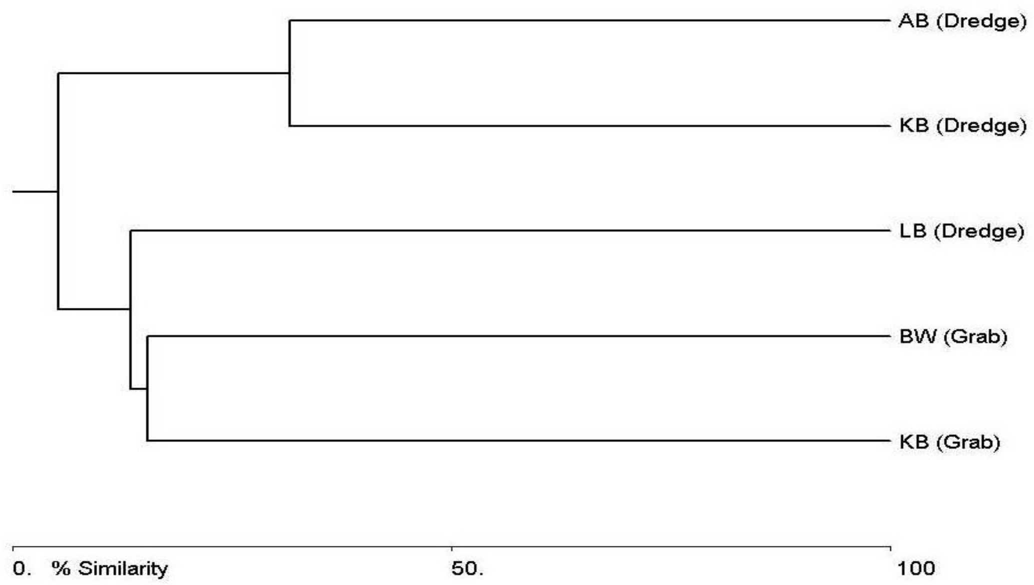


Figure 14: Jaccard Cluster analysis (single link) (AB, Arklow Bank; KB, Kish Bank; LB, Long Bank; BW, Blackwater Bank)

4.2. Analysis of Sandbanks in the Irish Sea

Three sandbanks in the western Irish Sea were compared with five sandbanks along the south west Welsh coast to assess whether similar faunal diversity would be evident.

Darbyshire *et al.* (2002) presented summary information for each of the sandbanks analysed during the survey of Welsh sandbanks including measures of species diversity for each site. Although the raw data were not presented it was possible to compare Irish sites with those in Wales using non-parametric analysis of variance. There were significant differences for diversity (d), richness (H') and evenness (J') (Kruskal-Wallis $H = 60.32$, $d.f. = 7$, $P < 0.001$; $H = 60.27$, $d.f. = 8$, $P < 0.001$; $H = 27.08$, $d.f. = 8$, $P < 0.001$) between the nine sandbanks. Summary data are presented in Table 10 for each of the sample sites. To compare whether there was an underlying difference between the Welsh and Irish sandbanks both were grouped. In this analysis there was a significant difference between diversity, richness and evenness (Kruskal-Wallis H = 25.98, d.f. = 1, P < 0.001; H = 17.21, d.f. = 1, P < 0.001; H = 13.47, d.f. = 1, P < 0.001). In both diversity and evenness the Irish sandbanks recorded a higher median value. *Post-hoc* analysis of the species richness (H') for each site (Table 11) showed that the Blackwater Bank reported significantly lower values than the other banks analysed.

Table 10: Measures of species diversity calculated for both the eastern and western Irish Sea sandbanks (diversity (d), richness (H') and evenness (J'))

Irish sandbanks	*d*	*H'*	*J'*
Kish Bank	18.82	3.79	0.83
Blackwater Bank	13.93	1.83	0.93
Long Bank	8.76	2.96	0.80
Welsh sandbanks	*d*	*H'*	*J'*
Four Fathom Bank	7.61	4.09	0.74
Tripods Bank	3.47	2.53	0.59
Devil's Ridge Bank	8.36	3.97	0.80
West New Quay	11.66	4.93	0.80
Bais Bank	2.61	2.65	0.83
Helwick's Bank	4.97	3.56	0.77

Table 11: Results of Dunn's multiple comparison post-hoc analysis of Shannon-Weiner Measure (H') for each of the study sites (***, P < 0.001; **, P < 0.005; *, P < 0.05)

	KB	*BW*	*LB*	*FF*	*TR*	*DR*	*WNQ*	*BB*	*HB*
Blackwater	***								
Long Bank									
Four Fathom		***							
Tripods									
Devil's Ridge		***							
W New Quay		***	*						
Bais Bank							*		
Helwick Bank		*							

4.3. Irish Sea benthic communities and environmental conditions

Regions of the southern part of the western Irish Sea have been variously characterised by the presence of the polychaetes such as *N. cirrosa, O. borealis* and *Lanice conchilega* and the bivalve *S. elliptica*. Keegan *et. al.* (1987) and O'Connor (1988) have shown that areas in the locality of the Kish Bank could be described as a reduced form of the *Spisula* sand community as described by Petersen (1913) & Thorson (1957) living on mobile, medium sands. Rees (in Dickson, 1987) first produced a generalised map of the faunal communities of the Irish Sea and Mackie (1990) modified it. This map characterises the Kish Bank area, as been a deep *Venus* community. This community is strongly associated with coarse sand/gravel/shell sediments at moderate depths (40-100m). Typical species included the urchin *Spantangus purpureus,* the bivalves *Glycymeris, Astarte sulcata* and *Venus* spp. This community is the most widespread in the Irish Sea. In sand-wave areas the communities often contain elements of both shallow (*Spisula* sub-community) and deep *Venus* communities.

Aqua-Fact performed a benthic survey of Long Bank, in the southwestern Irish Sea, in 1989. The sediments here were classified as being medium sands with very low values of organic carbon (Aqua-Fact, 1989). The findings indicated an area of high hydrodynamic activity with strong, tidally induced currents. Such currents would not allow for the settling out of finer particles of both organic and inorganic matter. This type of current regime would also tend to make the sediments quite mobile with material being transported over some distances during strong phases of the tidal cycle. This area was also characterised by low species numbers and densities. The low species numbers and densities in such a habitat were considered to be due to the nature of the environment, *i.e*. mobile sands, which demand a specialised lifestyle to allow the animals either cope with or escape from sand abrasion (Tyler & Shackley, 1980; Keegan *et al*., 1987). Wheeler *et al.* (2000), with the use of side-scan sonar also revealed evidence of seabed mobility on and adjacent to Irish sandbanks. They also found that sand waves increased in amplitude towards the edge suggesting that currents were highest closest to the bank edge.

The faunal community at Courtown was described by Aqua-Fact (2005) as being a sandy *Ophelia* community with the presence of *Lanice conchilega* and *Spisula elliptica*. The *Spisula* sub-community represented by *Spisula elliptica* and *Nephtys cirrosa* was seen as a sub-community of 'Boreal Offshore Sand Association', as described by Jones (1950). This community was described as a '*Spisula ellipica* and venerid bivalve in infralittoral clean sand or shell gravel' community, as described in "Marine biotope classification for Britain and Ireland" (Connor *et al.* 2004). The species present in the study were as follows: polychaetes (*Nephtys cirrosa, Spiophanes bombyx, Magelona mirabilis* & *Owenia fusiformis*), crustaceans (*Gastrosaccus spinifer*) and the bivalve *Spisula elliptica.* An element of a muddier sand environment was present at stations exhibiting a higher proportion of 'fines'. The combination of the coarse loose sands and strong water movements had the potential to make the sediments quite mobile.

An area east of the Kish Bank was surveyed by Aqua-Fact (1991) as part of a sewage sludge disposal site investigation. The sediment of the area was predominantly composed of medium sands with a low silt-clay fraction. The organic carbon concentrations recorded from the survey were low, reflecting the low silt-clay concentrations. The area was characterised by fauna that was not very diverse nor species rich. The species that dominated the area were typical of hydrodynamically active sandy areas. The dominant species recorded were as follows: the polychaetes *Scoloplos armiger, Nephtys cirrosa, Spiophanes bombyx, Lagis koreni, Spio filicornis, Ophelia borealis, Laonice cirrata, Glycera oxycephala, Glycera lapidum* and *Nephtys longosetosa,* the crustaceans *Bathyporeia elegans* and *Gastrosaccus spinifer,* the bivalves *Abra prismatica* and *Spisula elliptica.* Keegan *et al*., (1987) described a region close to the Blackwater Bank as experiencing strong tidal currents and weather induced turbulence. The low 'fines' content of the sediment in the area supported this statement and also explained the low levels of organic carbon in the area. The fauna in the area was described as being impoverished as would be expected of stressed, mobile sediments. The species typical of this area were *Ophelia borealis, Nephtys cirrosa, Gastrosaccus spinifer* and *Spisula elliptica.* Elements of the *Spisula* and *Venus* sub-communities were also present in the area.

A generalised habitat map (Rees *in Dickson*, 1987, Mackie, 1990; 2004) characterised the Blackwater Bank area, as been a shallow *Venus* community. This faunal community occurs at depths of 5-40m in near-shore sands. These communities are typically found in areas subjected to strong currents and the sand formations consisting of sandbanks or sand-wave systems. This *Venus* community can be delineated into two sub-communities according to sediment composition and stability. The *Tellina* sub-community occurs in fine stable sands and typical species include the bivalve *Tellina fabula* and the polychaetes *Magelona mirabilis.* The *Spisula* sub-community occurs in medium to coarse sands subject to disturbance and typified by the bivalve *Spisula elliptica* and the polychaetes *Nephtys cirrosa.* The shallow *Venus* community is widely distributed around the Irish Sea coastline. A survey carried out by Aqua-Fact (2000) off Rosslare Harbour revealed a medium fine sand habitat colonised by the polychaetes *Lagis koreni* and *Lanice conchilega,* the bivalves *Abra alba* and *Fabulina fabula* and the echinoderm *Amphiura branchiata.*

4.4 Underlying ecological considerations for sandbank communities

The topics of succession and what represents a climax community in subtidal sands, gravels and maerl have not received much attention in the scientific literature. Kenny & Rees (1994; 1996) presented findings on the effects of marine gravel extraction on macrofaunal communities and showed that although re-colonisation by dominant taxa such as *Dendrodoa* and *Balanus* proceeded rapidly, the community at the site had not returned to pre-dredge conditions two years later. They attribute this to alterations in sedimentary characteristics. Dernie *et al.* (2003) carried out some disturbance experiments on muddy sand and sands in Wales and commented that clean sand communities had a faster recovery rate than muddy sands. They were, however unable to show any consistent, statistically significant pattern as densities of species in such communities were low.

Virtually all other discussion on such topics are with reference to subtidal muds, muddy sands and rocky substrates and also relate to disturbance events such as organic enrichment e.g. Pearson & Rosenberg (1978). The succession model in subtidal muds and muddy sands is based on the concept that, after a disturbance event, early settlers through biological activity such as bioturbation and bioirrigation, prepare the sediment for the settling of higher sere species with the ultimate establishment of infaunal long-lived bioturbating/ bioirrigating species such as callianasids, brittle stars, holothurians and echinoids. Opportunistic polychaete species (*Capitella, Malacoceros*) that can tolerate low oxygen conditions are the first macrofaunal species to colonise such sediments and through their bioturbation and bioirrigation activities, they depress the redox layer. As the redox continues to be depressed lower into the sediment, other deeper burrowing taxa and/or head-down feeders can colonise the sediment. These feeding types are not present in the taxa recorded on sand or gravel banks.

This biologically-regulated explanation for succession in soft sediments cannot be applied to sands and gravels for a number of reasons: for instance, due to low levels of organic material in sands and gravels, there is no food resource for head down or burrowing macrofauna; additionally, as sediments are reworked every tidal cycle, redox conditions are very different in such sediments with oxygen-rich water being able to freely flow through such open fabric sea beds. Such habitats more closely fit the concept promoted by Gleason (1917; 1926) who considered plant communities as being regulated by their physical environment. The characteristics of sedimentary environments reflect the overlying physical oceanography and local seabed morphology and, in high velocity sites (i.e. >50 cms^{-1}), the distribution of sands and gravels are closely related to these physical attributes. The seabed is subjected to daily tidal disturbance that can rework the surface sedimentary layers 4 times a day and under the highest Spring tides, velocities can reach c. 2 m sec.

Factors such as redox depth, successional stage, surface and subsurface structures have been used to determine the quality of muddy sand communities for sediment profile images (Rhoads, 1978; Rhoads & Germano, 1982; Nilsson & Rosenberg,1997). As none of these features are applicable to sands and gravels, the Nilsson-Rosenberg BHQ index cannot be applied to sands and gravels (see Table 12). Features such as type of bed forms present, types of algae or phanaerogams present and epifauna are regular features in sediment profile images from such habitats.

Table 12. Criteria used by Nilsson & Rosenberg (1997) to calculate Benthic Habitat Quality Index (BHQ). BHQ = $\sum A + \sum B + C$.

A : Surface structures	*Faecal pellets*	*1*
	Tubes ≤ 2 mm in diameter	1
	Tubes > 2 mm in diameter	2
	Feeding pit or mound	2
B : Subsurface structures	Infauna	1
	Burrows 1 – 3	1
	Burrows > 3	2
	Oxic void at ≤ 5 cm depth	1
	Oxic void at > 5 cm depth	2
C : Mean depth of apparent RPD	0 cm	0
	0.1 – 1.0 cm	1
	1.1 – 2.0 cm	2
	2.1 – 3.5 cm	3
	3.6 – 5.0 cm	4
	5 cm	5

Jansson (1967), working on interstitial fauna described grain size as an excellent parameter as it controls other factors such as permeability, porosity and oxygen content. Grain size has also been found to be an important factor in determining the distribution of some polychaete genera *e.g. Nephtys* (Clark & Haderlie, 1960; Clark *et al.,* 1962) and *Glycera* (B.O'Connor, pers. obs.). Gray (1974) comments that data from substrate selection studies and descriptive work suggest that sediment type plays a large part in determining the species composition of a community and adds that, if this is the case, it should be possible to relate community structure to sediment type. As grain size is to a large part regulated by current velocity, we suggest that if the physical oceanography of an area is known, it may be possible to predict what sediments occur and additionally what species may be present.

The concept of ascribing a successional stage to macrobenthic faunal communities in regularly reworked sediments needs consideration. In such sediments, the number of taxa that occur varies greatly; in some highly disturbed sediments, macrofauna may be extremely impoverished or, as in the case of faunal assemblages of dead maerl communities, may be very rich (Connor *et al.* 2004). We suggest that in such physically reworked sediments, the group of species that is found there represent a climax sere and should therefore be ascribed a stage 3 status *sensu* Rhoads & Germano (1982).

Such sand/gravel sediments are typically low in organic carbon levels since deposition of organic-rich muds and muddy sands cannot occur. One exception to this is the sandy areas off western South Africa and Namibia that is affected by the highly productive Benguela current, a system that generates so much primary production that it causes the benthos to collapse due to low oxygen/high hydrogen sulphide levels.

Mills (1969) comments that species are distributed along environmental gradients and adds that densities are in more or less binomial curves and Gray (1974) notes that most ecologists accept that continua rather than discrete units are a more realistic interpretation of species groupings in marine sediments. The continuum for sand and gravel assemblages is considered here as an energy gradient. As there is no time series for faunal data, it is not possible to test the multiple-stable point/poly-climax (Gleason, 1927, Gray, 1974, 1977) concept but due to low diversity and abundance levels in sands and gravels, this may be difficult to prove statistically. Sanders (1968) states that physical instability in an environment will prevent the establishment of diverse communities and this certainly holds true for the findings presented in this report, particularly so with regard to the Blackwater Bank.

5. CONCLUSION

Both of the banks surveyed are located in areas of high hydrodynamic activity with strong, tidally induced current speeds operating. This is particularly evident at the Blackwater Bank. This type of current regime tends to make the sediments quite mobile with material being transported over some distances during strong phases of the tidal cycle. The strong tidally induced current would also result in low settling and consequently low residual concentrations of organic carbon. It is difficult for macroscopic infauna, or indeed epifauna, to become established in a habitat that exhibits the combined factors of high shear stress, unstable sediments and low levels of food resources. Therefore it is not surprising that both areas were characterised by an impoverished faunal community relative to open sea sediment communities. However, the results of the present survey compare favourably with those found for similar benthic habitats in the Eastern Irish Sea. Both the Blackwater and Kish Bank broadly conform to the suggested criteria of Johnston *et al*.(2002) - typicalness, naturalness, area, biological diversity - and are consequently nationally important features.

6. References

Aqua-Fact International Services Ltd. (1989). *Benthic studies off the Wexford coast. Faunal and sedimentological studies at Long Bank and Ballyteigue Bay*.A report for Wexford County Council.

Aqua-Fact International Services Ltd. (1991) *Dublin Bay sewage sludge disposal site. Phase III. Report on benthic (physical, chemical and biological) studies at the proposed site*. A report for Dublin County Council.

Aqua-Fact International Services Ltd. (2000) *Rosslare Harbour wastewater treatment plant: environmental survey*. A report for Wexford County Council.

Aqua-Fact International Services Ltd. (2005) *Courtown beach re-nourishment project, Courtown, Co. Wexford*. A report for Wexford County Council.

Brannick, P.F. (1982) Laboratory manual. *Central Marine Services Unit, U.C.G.* pp. 141.

Buchanan, J.B. (1984) Sediment analysis. In: (eds.) Holme N. A. and A.D. McIntyre. Methods for the study of marine benthos 2nd ed. *Blackwell, Oxford*. pp. 41-65.

Clark, R. & Haderlie, E. (1960) The distribution of *Nephtys cirrosa* and *N. hombergii* on the south western coasts of England and Wales. *Journal of Animal Ecolgy*, **29**: 117 – 147.

Clark, R., Alder, J. & McIntyre, A. (1962) The distribution of *Nephtys* on Scottish coasts. *Journal of Animal Ecology*, **31**: 359 - 372.

Clarke, K.R. & Warwick, R.M. (1994) Changes in marine communities: An approach to statistical analysis and interpretation, 1st Edition. *Plymouth Marine Laboratory. Plymouth.*

Clarke, K.R. & Warwick, R.M. (2001) *Changes in marine communities: An approach to statistical analysis and interpretation*. 2nd Edition. *Primer-E Ltd.*

Clarke. K.R. & Ainsworth, M. (1993) A method of linking multivariate community structure to environmental variables. *Marine Ecology Progress Series* **92:** 205-19.

Connor, D.W., Allen, J.A., Golding, N., Howell, K.L., Lieberknecht, L.M., Northen K.O., & Reker, J.B. (2004) *The Marine Habitat Classification for Britain and Ireland* (Version 04.05). JNCC, Peterborough, UK.

Coveney Wildlife Consulting Ltd. (2004) *Seabird & Marine Mammal Survey of the Arklow Bank to Assess the Effects of the Windfarm Being Built There*. A report for Airtricity Ltd.

Darbyshire, T., Mackie, A.S.Y., May, S.J. & Rostron D. (2002) A macrofaunal survey of the Welsh sandbanks. Cyngor Cefn Gwlad Cymru (Countryside Council for Wales). *CCW Contract Science Report* **No. 539**.

Dernie, K., Kaiser, M. & Warwick, R. (2003) Recovery rates of benthic communities following physical disturbance. *Journal of Animal Ecology* **72**: 1043 – 1056.

Dickson, R.R. (1987) Irish Sea status report of the Marine Pollution Monitoring Group. *Aquatic Environmental Monitoring Report*, MAFF Direct. Fish. Res., Lowestoft **17**. pp. 83.

Fehily & Timoney & Co. (2001) Environmental Impact Statement: Arklow Bank Wind Park (Final Report). A report prepared for Sure Partners Ltd., 29 Lower Leeson St., Dublin 2.

Gleason, H. (1917) The struture and dev elopment of plant association. *Bulletin of the Torrey Botanical Club*. **43**: 463 – 481.

Gleason, H. (1927) The individualistic concert of the plant association. *Bulletin of the Torrey Botanical Club*. **53**: 7 - 26.

Gray, J. (1974) Animal sediment relationships. *Oceanography and Marine Biology Annual Review*, **12**: 223 – 261.

Gray, J. (1977) The stability of benthic ecosystems. *Helgolander wissenschaft Meeresuntersuchungen*, **30**: 427 - 444.

Hanna, J. (2002) *Dynamics of coastal and nearshore morphology in southeast Ireland*. Ph.D. Thesis. University of Ulster, Coleraine.

Irish Hydrodata Ltd. (1996) *Codling Bank site investigation*. A report to the Department of the Marine.

IWDG (2004) A review of cetacean sighting records in candidate Marine SpecialAreas of Conservation. *Irish Whale and Dolphin Group*: 7 pp.

Jansson, B.O. (1967) The importance of grain size and pore water content for the interstitial fauna of sandy beaches. *Oikos* **18:** 311- 312

JNCC (2003) *Summary of the working methodology for identifying habitat SACs in UK waters*. Joint Nature Conservation Council, Peterborough.

Johnston, C.M., Turnbull, C.G. & Tasker, M.L. (2002) Natura 2000 in UK offshore Waters: advice to support the implementation of the EC Habitats and Birds Directives in UK offshore waters. *JNCC Report,* **No. 325**.

Jones, N.S. (1950) Marine Bottom Communities. *Biological Review of the Cambridge philosophical Society* **25:** 283-313.

Kenny, A. & Rees, H. (1994) The effects of marine gravel extraction on the macrobenthos: early post-dredging recolonization. *Journal of Marine Pollution Bulletin* **28**: 442 – 447.

Kenny, A. & Rees, H. (1996) The effects of marine gravel extraction on the macrobenthos: results 2 years post-dredging. *Journal of Marine Pollution Bulletin* **35**: 615 - 622.

Kearns-Mills, N. (1996) *Offshore sand and gravel deposits*. Unpublished report for the National Parks & Wildlife Service.

Keegan B.F.K., O'Connor, B.D.S., McGrath, D., Könnecker, G. & D. Ó Foighil. (1987) Littoral and benthic investigations on the south coast of Ireland – II. The macrobenthic fauna off Carnsore Point. *Proceedings of the Royal Irish Academy,* **87B (1):** 1-14.

Kiely, O., Lidgard, D.C., McKibben, M., Baines, M.E. and Connolly, N. (2000) *Grey seals: status and monitoring in the Irish and Celtic Seas*. Marine Resource Series, Marine Institute, Dublin.

Kruskall, J.B. & Wish, M. (1978) Multidimensional scaling. *Sage Publications, Beverly Hills, California.*

Mackie, A.S.Y. (1990) Offshore benthic communities of the Irish Sea. In: The Irish Sea: An environmental Review. Part I: Nature Conservation. Irish Sea Study Group. *Liverpool University Press*. pp. 169-218.

Mackie, A.S.Y. (2004) Macrofaunal assemblages and their sedimentary habitats:working toward a better understanding. Irish Sea Forum, Seminar Report No. 32, Irish Sea sediments. *Liverpool University Press*. pp. 30-38.

Margalef, D.R. (1958) Information theory in ecology. *General Systems* **3:** 36-71.

Mills, E. (1969) The community concept in marine zoology with comments on continua and instability in some marine communities: a review. *Journal of the Fisheries Research Board of Canada* **26** : 1415 – 1428.

Molloy, J & Kennedy, J. (2001) Extraction of marine aggregates - a Rio approach. *Marine Resource Series*, Marine Institute, Dublin.

Newton, S.F. & Crowe, O. (2000) Roseate Terns –The Natural Connection. Maritime Ireland/Wales Intereg Report **No. 2**.

Nilsson H & Rosenberg, R. (1997) Benthic habitat quality assessment of an oxygen stressed fjord by surface and sediment profile images. *Journal of Marine Systems*, **11**: 249 – 264.

O'Connor, B. (1988) Marine fauna of Co. Wexford 9 – littoral and benthic Echinodermata and Sipunculida. *Irish Naturalists' Journal*, **22**: 385-387.

Pearson, T. & Rosenberg, R. (1978) Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanogr Mar Biol Annu Rev* **16**: 229 – 311.

Petersen, C. (1913) Valuation of the sea. II. The animal communities of the sea bottom and their importance for marine zoogeography. *Report of the Danish Biological Station*, **21:** 1-44.

Pielou, E.C. (1977) *Mathematical ecology*. Wiley-Water Science Publication, John Wiley and Sons.

Rhoads, D. & Germano, J. (1982) Interpreting long-term changes in benthic community structure : a new protocol. *Hydrobiologia*, **142**: 291 – 308.

Rhoads, D. McCall, P. & Yingst, J., (1978) Disturbance and production on the estuarine sea floor. *American Scientist*, **66**: 577 – 586.

Sanders, H. (1968) Marine benthic diversity: a comparative study. *The American Naturalist* **102**: 243 – 282.

Saorgus Energy Ltd. (2005) Environmental Impact Statement: Kish/Bray Wind Park. Saorgus Energy Ltd, Tralee, Co. Kerry.

Thorson, G. (1957) Bottom communities (sublittoral or shallow shelf). *Memoirs of the Geological Society of America* **67**: 461-534.

Tyler, P.A. & Shackley, S.E. (1980) The benthic ecology of linear sand banks: a modified *Spisula* sub community. In: *Industrial embayments and their environmental problems. A case study of Swansea Bay.* Ed. M.B. Collins. *Pergamon Press*. Oxford

Vincent, M.A., Atkins, S.M., Lumb, C.M., Godling, N., Lieberknecht, L.M. & Webster, M. (2004) *Marine nature conservation and sustainable development- the Irish Sea Pilot.* Report to DEFRA by the Joint Nature Conservation Committee, Peterborough.

Walkley, A. & Black, I. A. (1934) An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil Science.* **37**: 29-38.

Warren, W.P. & Keary, R. (1989) The sand and gravel resources of the Irish Sea Basin. In The Irish Sea: A resource at risk. 65-89. *Geological Survey of Ireland, Special Publications* **No**. **3**.

Wentworth, C.K. (1922). A scale of grade and class terms for clastic sediments. *Journal of Geology*. **30: 377-392.**

Wheeler, A.J., Walshe, J. & Sutton, G.D. (2000). Geological appraisal of the Kish, Burford, Bray and Fraser Banks, Outer Dublin Bay Area. *Marine Resource Series* **No**. **13**: pp. 35.

APPENDIX

Table 13: Abundance and species data for taxa and species identified during grab sampling over the Kish Bank in the Irish Sea

	KB1	*KB2*	*KB3*	*KB4*	*KB5*	*KB6*	*KB7*	*KB8*	*KB9*	*KB10*	*KB11*	*KB12*
CNIDARIA												
ANTHOZOA												
Anthozoa sp.	-	-	-	-	-	1	-	-	-	-	-	1
ECHIURA												
Echiura sp.	-	-	-	-	-	1	-	-	-	-	-	10
Thalassema thalassemum	-	-	-	-	-	1	-	-	-	-	-	-
ANNELIDA												
PHYLLODOCIDA												
POLYNOIDAE												
Harmothoe sp.	-	-	-	-	-	-	-	-	-	-	-	3
PHOLOIDAE												
Pholoe sp.	-	-	-	-	-	-	1	-	-	-	-	-
Pholoe inornata	-	-	-	-	-	-	-	-	-	-	-	6
Pholoe synophthalmica	-	-	-	-	-	-	-	-	-	-	-	1
SIGALIONIDAE												
Sigalion sp.	-	-	1	-	-	-	2	-	-	-	-	-
Sigalion mathildae	-	1	-	-	1	-	-	-	-	-	-	-
Sigalion squamosus	-	-	-	-	-	-	-	-	1	-	-	-
Sthenelais sp.	-	1	1	-	-	-	1	-	-	-	-	-
Sthenelais boa	-	-	-	-	1	2	1	-	-	-	-	-
Sthenelais limicola	1	1	-	2	-	1	-	-	-	-	-	-
Phyllodocidae												
Eteone longa	-	1	-	-	-	-	-	-	-	-	1	-
Eteone suecica	-	-	-	-	-	-	-	-	-	-	-	1
Hesionura elongata	-	-	-	-	-	-	1	-	-	-	1	-
Hypereteone foliosa	-	-	-	-	-	-	-	1	-	-	-	-
Anaitides groenlandica	-	-	-	-	-	-	-	-	-	-	-	1
Anaitides maculata	-	-	-	-	-	-	-	-	-	-	-	2
Eumida bahusiensis	-	1	-	-	-	1	-	-	-	-	-	1
Paranaitis kosteriensis	-	-	-	-	-	-	-	-	-	-	-	1
Phyllodoce laminosa	-	-	-	-	-	-	-	-	-	-	-	1
Glyceridae												
Glycera lapidum	3	2	-	-	-	1	2	-	-	6	15	29
Glycera tridactyla	-	1	-	1	-	-	-	-	-	-	1	-
Goniadidae												
Glycinde nordmanni	-	-	-	-	1	-	-	-	-	-	2	-
Goniada maculata	-	-	-	-	1	1	-	-	-	-	-	1

Table 13 (contd)**:** Abundance and species data for taxa and species identified during grab sampling over the Kish Bank in the Irish Sea

	KB1	*KB2*	*KB3*	*KB4*	*KB5*	*KB6*	*KB7*	*KB8*	*KB9*	*KB10*	*KB11*	*KB12*
HESIONIDAE												
Microphthalmus similis	-	-	-	1	-	-	-	-	-	1	-	-
Eusyllis blomstrandi	-	-	1	-	-	-	-	-	-	-	-	-
Exogone hebes	-	-	-	-	-	-	-	-	-	-	1	-
Exogone naidina	-	-	-	-	-	-	-	-	-	-	-	3
Nephtyidae												
Agalophamus rubella	-	-	-	-	-	-	-	-	-	1	1	-
Nephtys sp.	-	5	-	-	-	-	-	-	3	-	1	-
Nephtys cirrosa	-	11	13	14	16	-	4	2	3	10	12	-
Nephtys longosetosa	11	23	22	16	27	2	19	17	4	10	4	1
EUNICIDA												
LUMBRINERIDAE												
Lumbrineris gracilis	4	1	-	3	-	4	8	2	-	3	4	14
ORBINIIDA												
ORBINIIDAE												
Scoloplos armiger	2	2	3	1	1	1	10	7	2	5	11	-
Paraonidae												
Aricidea minuta	-	-	-	1	-	-	-	-	-	-	-	-
Paradoneis lyra	-	-	-	-	-	-	-	-	-	1	-	-
SPIONIDA												
POECILOCHAETIDAE												
Poecilochaetus serpens	-	-	-	-	-	-	-	-	-	-	-	1
SPIONIDAE												
Aonides paucibranchiata	-	-	-	-	-	-	-	-	-	-	1	-
Polydora sp.	-	-	-	-	-	1	-	-	-	-	-	-
Prionospio ehlersi	-	-	-	-	-	-	-	-	-	-	-	1
Scolelepis sp.	1	2	1	3	5	-	1	12	-	1	-	3
Scolelepis bonnieri	-	1	-	1	1	-	-	-	1	-	-	-
Spio sp.	-	1	-	-	-	-	-	-	-	-	-	-
Spio armata	-	-	1	1	-	-	-	5	1	-	-	-
Spio decorata	-	3	-	-	-	-	1	-	-	-	-	2
Spiophanes bombyx	6	15	4	3	11	6	9	15	5	4	3	11

Table 13 (contd)**:** Abundance and species data for taxa and species identified during grab sampling over the Kish Bank in the Irish Sea

	KB1	*KB2*	*KB3*	*KB4*	*KB5*	*KB6*	*KB7*	*KB8*	*KB9*	*KB10*	*KB11*	*KB12*
Magelonidae												
Magelona filiformis	-	-	-	-	-	-	-	-	5	-	-	-
Magelona mirabilis	-	8	-	2	4	-	-	-	2	-	-	1
CIRRATULIDAE												
Aphelochaeta marioni	-	-	-	-	-	-	-	-	-	-	-	3
Aphelochaeta multibranchiis	-	-	-	-	-	-	-	-	-	-	-	8
Caulleriella alata	-	-	-	-	-	-	-	-	-	-	-	2
Caulleriella zetlandica	-	1	-	-	-	-	-	-	1	-	-	-
Chaetozone setosa	-	-	-	-	1	-	-	-	-	-	-	-
CAPITELLIDA												
Capitomastus minimus	1	-	-	-	-	1	-	-	-	3	1	51
Notomastus latericeus	-	-	-	-	-	-	-	-	-	-	1	-
Maldanidae												
Maldanidae sp.	-	-	-	-	-	-	-	-	-	-	-	1
Euclymene oerstedii	-	-	-	-	-	-	-	-	-	-	-	3
OPHELIIDA												
OPHELIIDAE												
Ophelia borealis	-	4	-	-	1	-	11	4	-	-	15	-
Ophelia celtica	-	3	-	-	-	-	-	-	-	-	-	-
Ophelia neglecta	-	-	-	1	-	-	5	-	-	8	-	-
SCALIBREGMATIDAE												
Polyphysia crassa	-	-	-	-	-	-	-	-	-	1	-	-
Scalibregma inflatum	-	-	-	-	-	-	-	-	-	-	-	6
OWENIIDA												
OWENIIDAE												
Owenia fusiformis	-	-	-	-	-	1	-	-	-	-	-	-
TEREBELLIDA												
AMPHARETIDAE												
Ampharete sp.	-	-	-	-	1	-	-	-	-	-	-	-
TEREBELLIDAE												
Lanice conchilega	-	-	1	-	-	-	-	-	-	-	-	-
Polycirrus sp.	-	1	-	-	-	-	9	-	-	12	5	4
Polycirrus medusa	-	-	-	-	-	-	7	-	-	1	1	-
SABELLIDA												
Sabella pavonina	-	-	-	-	-	-	-	-	-	-	-	2

Table 13 (contd)**:** Abundance and species data for taxa and species identified during grab sampling over the Kish Bank in the Irish Sea

	KB1	*KB2*	*KB3*	*KB4*	*KB5*	*KB6*	*KB7*	*KB8*	*KB9*	*KB10*	*KB11*	*KB12*
CRUSTACEA												
LEPTOSTRACA												
NEBALIIDAE												
Nebalia bipes	-	-	-	-	-	-	-	-	-	-	-	3
MYSIDACEA												
MYSIDAE												
Mysidacea sp.	-	-	-	-	1	-	-	-	-	-	-	-
Gastrosaccus spinifer	-	1	-	1	-	-	1	-	-	-	2	-
AMPHIPODA												
OEDICEROTIDAE												
Perioculodes longimanus	-	1	-	1	2	-	1	1	-	-	-	-
Pontocrates arenarius	-	14	12	5	31	-	4	2	9	2	-	-
Synchelidium maculatum	1	1	-	2	-	-	1	-	-	-	-	-
UROTHOIDAE												
Urothoe brevicornis	2	1	1	7	-	1	5	5	-	-	-	3
PHOXOCEPHALIDAE												
Harpinia pectinata	-	-	-	-	-	-	-	-	-	-	-	1
Metaphoxus pectinatus	-	1	-	-	-	-	-	-	-	-	-	1
Lysianassidae												
Lepidepecreum longicorne	1	-	-	-	-	-	-	-	-	-	-	-
DEXAMINIDAE												
Atylus sp.	-	-	-	-	-	-	-	-	-	-	-	1
Atylus falcatus	-	3	-	1	2	-	-	1	-	-	-	-
Atylus vedlomensis	-	1	-	-	-	-	-	-	-	-	-	6
Ampeliscidae												
Ampelisca sp.	-	-	-	-	-	-	1	-	-	-	-	-
Ampelisca spinipes	-	-	-	-	-	-	-	-	-	-	-	10
PONTOPOREIIDAE												
Bathyporeia elegans	15	49	46	13	36	3	20	24	9	4	2	5
Bathyporeia guilliamsoniana	-	-	-	-	1	-	-	-	-	-	-	-
MELPHIDIPPIDAE												
Megaluropus agilis	-	1	2	-	2	2	-	-	-	-	-	-

Table 13 (contd)**:** Abundance and species data for taxa and species identified during grab sampling over the Kish Bank in the Irish Sea.

	KB1	*KB2*	*KB3*	*KB4*	*KB5*	*KB6*	*KB7*	*KB8*	*KB9*	*KB10*	*KB11*	*KB12*
MELITIDAE												
Melita dentata	-	-	-	-	-	-	1	-	-	-	-	-
ISAEIDAE												
Gammaropsis nitida	-	-	-	-	-	-	-	-	-	-	-	18
COROPHIIDAE												
Siphonoecetes kroyeranus	-	-	-	-	-	-	2	1	-	-	-	1
Unciola planipes	1	-	-	1	-	-	-	-	-	-	-	-
ISOPODA												
GNATHIIDAE												
Paragnathia formica	-	-	-	-	-	-	-	-	-	-	-	1
CUMACEA												
Cumacean sp.	-	-	-	-	-	-	-	-	-	-	-	1
DIASTYLIDAE												
Diastyllis sp.	-	-	-	1	-	-	-	-	-	-	-	4
DECAPODA												
PAGURIDAE												
Pagurus bernhardus	-	-	-	-	1	-	-	-	-	-	1	1
PORTUNIDAE												
Liocarcinus depurator	-	-	-	-	-	-	-	-	-	-	-	1
MOLLUSCA												
POLYPLACOPHORA												
LEPTOCHITONIDAE												
Leptochiton asellus	-	-	-	-	-	-	-	-	-	-	-	2
MESOGASTROPODA												
NATICIDAE												
Polinices pulchellus	-	-	-	-	-	-	-	-	1	-	-	-
NUCULOIDA												
NUCULIDAE												
Nucula nitidosa	-	27	1	-	2	25	-	-	20	-	-	10
Nucula sulcata	-	-	-	-	-	8	-	-	-	-	-	81
VENEROIDA												
MONTACUTIDAE												
Tellimya ferruginosa	-	1	-	-	-	1	-	-	1	-	-	1
Mysella bidentata	-	-	-	-	-	1	-	-	-	-	-	-

Table 13 (contd)**:** Abundance and species data for taxa and species identified during grab sampling over the Kish Bank in the Irish Sea

	KB1	*KB2*	*KB3*	*KB4*	*KB5*	*KB6*	*KB7*	*KB8*	*KB9*	*KB10*	*KB11*	*KB12*
Mactridae												
Spisula elliptica	3	3	5	2	-	-	7	3	-	4	6	3
Pharidae												
Phaxas pellucidus	-	-	-	-	-	3	-	-	-	-	-	3
Tellinidae												
Fabulina fabula	-	7	-	1	1	6	-	-	7	-	-	-
Psammobiidae												
Gari fervensis	-	2	-	-	-	-	-	-	2	-	-	3
Semelidae												
Abra alba	-	-	-	1	2	2	-	-	4	-	2	36
Abra prismatica	-	1	-	2	-	-	1	1	-	3	-	-
Veneridae												
Chamelea gallina	-	2	-	-	-	-	-	-	-	-	-	-
Dosina lupinus	-	-	-	-	-	-	-	-	-	-	-	1
Dosina exoleta	-	-	-	-	-	1	-	-	-	-	-	-
MYOIDA												
Myidae												
Mya arenaria	-	-	-	-	-	-	-	-	-	-	-	3
PHOLADOMYOIDA												
Thraciidae												
Thracia phaseolina	-	3	1	1	1	3	-	-	1	-	-	-
Periplomatidae												
Cochlodesma praetenue	-	-	-	-	-	1	-	-	-	-	-	-
BRYOZOA												
Bryozoa sp.	-	-	-	-	-	1	-	-	-	-	-	-
PHORONIDA												
Phoronidae												
Phoronida sp.	-	-	-	-	-	2	-	-	-	-	-	-
ECHINODERMATA												
Amphiuridae												
Amphiura brachiata	-	4	1	-	1	5	-	-	-	-	-	-
Amphipholis squamata	-	-	-	-	-	-	-	-	-	-	-	3
Loveniidae												
Echinocardium cordatum	-	1	1	1	-	5	-	-	1	-	-	1
Ophiuridae												
Ophiura sp. juv.	-	2	-	1	2	1	-	-	-	-	-	1

Table 14: Abundance and species data for taxa and species identified during grab sampling over the Blackwater Bank in the Irish Sea

	BB1	*BB2*	*BB3*	*BB4*	*BB5*	*BB6*	*BB7*	*BB8*	*BB9*	*BB10*	*BB11*	*BB12*
SIPUNCULA												
GOLFINGIIFORMES												
GOLFINGIIDAE												
Golfingia sp.	-	-	-	-	-	-	-	-	-	1	-	-
ANNELIDA	-	-	-	-	-	-	-	-	-	-	-	-
PHYLLODOCIDA												
PHYLLODOCIDAE												
Eteone longa	-	-	-	-	-	-	-	-	-	-	-	1
Glyceridae	-	-	-	-	-	-	-	-	-	-	-	-
Glycera sp.	-	-	-	-	-	-	-	-	-	-	2	-
Glycera sp juvenile	-	-	-	-	1	-	-	-	-	-	-	-
Glycera tridactyla	2	-	-	-	-	-	-	-	2	-	-	-
NEPHTYIDAE												
Nephtys sp.	4	1	6	4	5	1	-	6	7	3	-	11
Nephtys cirrosa	3	2	-	3	2	-	8	2	2	1	1	-
Nephtys hystricis	-	-	-	-	-	-	-	-	1	-	-	-
Nephtys kersivalensis	-	-	-	1	-	-	-	1	-	-	-	-
Nephtys longosetosa	-	2	1	4	1	3	1	1	6	1	5	4
LUMBRINERIDAE												
Lumbrineris gracilis	-	-	-	-	-	-	-	1	-	-	-	-
ORBINIIDA												
<u>Orbiniidae</u>												
Scoloplos armiger	-	-	1	-	-	1	-	-	-	-	-	-
PARAONIDAE												
Aricidea cerrutii	-	3	-	-	-	-	-	-	-	-	-	-
Cirrophorus furcatus	1	-	-	-	-	-	-	-	-	-	-	-
Levinsenia gracilis	1	3	1	-	-	1	-	-	-	-	-	-
SPIONIDA												
SPIONIDAE												
Scolelepis squamata	-	2	1	-	1	5	6	13	-	1	3	-
Spio sp.	-	-	-	2	-	-	7	-	4	-	2	8
Spio armata	-	-	-	10	-	-	1	12	-	-	10	-
Spio filicornis	-	-	-	-	-	1	-	1	-	1	-	3
Spiophanes bombyx	-	-	-	3	1	-	-	-	2	1	3	2
Magelonidae												
Magelona filiformis	1	-	-	-	-	-	-	-	-	-	-	-
Magelona mirabilis	-	-	-	2	8	-	-	3	2	-	1	-
Magelona johnstoni	3	-	-	1	4	-	-	-	-	2	1	-

Table 14 (contd)**:** Abundance and species data for taxa and species identified during grab sampling over the Blackwater Bank in the Irish Sea

	BB1	*BB2*	*BB3*	*BB4*	*BB5*	*BB6*	*BB7*	*BB8*	*BB9*	*BB10*	*BB11*	*BB12*
CIRRATULIDAE												
Caulleriella alata	1	-	-	-	-	-	-	-	-	-	-	-
Chaetozone setosa	1	-	-	-	-	-	-	-	1	-	-	-
OPHELIIDA												
OPHELIIDAE												
Ophelia borealis	-	1	-	-	-	1	-	-	-	1	-	-
Ophelia rullieri	-	1	-	-	-	-	-	-	-	-	-	-
MYSIDACEA												
MYSIDAE												
Gastrosaccus spinifer	-	-	-	-	-	4	-	1	1	-	-	1
AMPHIPODA												
OEDICEROTIDAE												
Pontocrates altamarinus	-	5	3	2	1	-	-	-	1	2	1	2
UROTHOIDAE												
Urothoe brevicornis	-	-	-	-	-	-	-	-	-	-	-	1
Urothoe elegans	-	6	-	-	-	-	1	-	-	-	1	1
DEXAMINIDAE												
Atylus swammerdami	-	-	1	-	-	-	-	-	-	1	-	-
PONTOPOREIIDAE												
Bathyporeia sp.	1	-	-	-	-	-	1	-	-	-	-	-
Bathyporeia elegans	15	9	36	25	22	3	3	12	6-	58	15	59
COROPHIIDAE	-	-	-	-	-	-	-	-	-	-	-	-
Siphonoecetes kroyeranus	-	-	-	1	-	-	-	1	-	-	-	-
TANAIDACEA												
TANAIDAE												
Tanaidae sp.	-	-	-	-	-	2	-	-	-	-	-	-
CUMACEA												
Cumacean sp.	-	-	-	-	-	2	-	-	1	2	2	3
DECAPODA												
Decapoda sp.	-	-	1	-	-	-	-	-	-	-	-	-
Decapoda larvae	1	-	-	-	-	-	1	-	-	-	1	1
MAJIDAE												
Hyas sp.	-	-	-	-	-	-	-	-	-	-	-	-

Table 14 (contd)**:** Abundance and species data for taxa and species identified during grab sampling over the Blackwater Bank in the Irish Sea

	BB1	*BB2*	*BB3*	*BB4*	*BB5*	*BB6*	*BB7*	*BB8*	*BB9*	*BB10*	*BB11*	*BB12*
CORYSTIDAE												
Corystes cassivelaunus	-	-	1	-	-	-	-	-	1	-	-	1
PORTUNIDAE												
Liocarcinus depurator	-	-	-	-	-	-	-	-	-	-	-	-
Portumnus latipes	-	1	3	-	2	1	2	1	-	-	-	1
MOLLUSCA												
VENEROIDA												
CARDIIDAE												
Parvicardium minimum	5	-	-	-	-	3	-	-	-	-	-	-
MACTRIDAE												
Spisula elliptica	-	-	-	-	-	-	2	-	-	-	-	-
SEMELIDAE												
Abra prismatica	-	-	-	-	-	-	-	-	1	-	-	-
BRYOZOA												
CHEILOSTOMATIDA												
Flustra foliacea	-	-	1	-	-	-	-	-	-	-	-	-
ECHINODERMATA												
OPHIUROIDEA												
OPHIURIDAE												
Ophiurid sp.	-	1	-	-	-	-	-	-	-	-	-	-
Ophiura sp. juvenile	-	-	-	-	-	-	-	-	-	-	1	-
OSTEICHTHYES												
PERCIFORMES												
AMMODYTIDAE												
Ammodytes tobianus	-	1	-	1	2	-	-	-	-	-	-	-