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A Preliminary Survey of Benthos from the *Nephrops norvegicus* Mud Grounds in the North-western Irish Sea

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A preliminary survey of benthic infauna from an extensive basin of soft mud in the Irish Sea was carried out in 1992. A total of 110 taxa were recorded of which polychaete worms (Phylum Annelida) constituted 77·8% of all taxa recorded. Hierarchical classification and detrended correspondence analysis divided the area studied into five regions which could be correlated to the differences in superficial sediments and depth across the basin. Although much of the fauna was ubiquitous, a change in trophic structure was observed, with tubiculous polychaetes becoming progressively less common in deeper softer sediment areas where surface and non-selective deposit-feeding taxa predominated.

Introduction

A key feature of the North-western Irish Sea is an extensive area of soft mud (Figure 1) found in a deep basin (maximum depth approximately 140 m) in a region of low tidal energy (Bowden, 1980). Fishing effort over this muddy ground is higher than any other part of the Irish Sea with the Dublin Bay prawn *Nephrops norvegicus* (Linnaeus) the most valuable component of the local mixed demersal fishery (Dickson, 1987). Approximately 85% (some 8300 tonnes per annum) of the total Irish Sea landings of *Nephrops* were taken from this area over the period 1981–90 (Stewart *et al.*, 1993). Despite the importance of the mud basin megafauna, however, a recent review by Mackie (1990) indicated that the majority of benthic studies to date have concentrated on local or shallower areas (Jones, 1956), or potentially anthropogenically impacted sites (see Eagle, 1973; Swift, 1993). Although the Irish Sea has been the subject of scientific interest for some 200 years, quantitative data for large areas are lacking; the only large-scale surveys that have been carried out are the qualitative studies of Dickie (1858) and Massy (1913). This paper reports on the data obtained from the mud basin during a preliminary grab sampling survey of the western Irish Sea in 1992.

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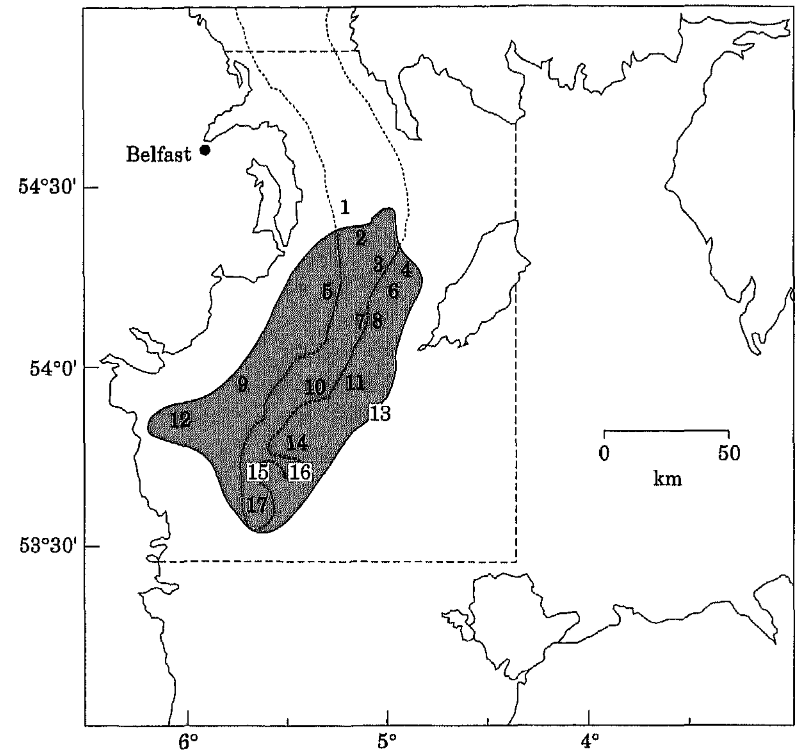

Figure 1. The Irish Sea benthos survey area showing location of mud basin sampling stations and the 100 m depth contour. – – –, Irish Sea survey area; 100 m contour; shaded area, extent of mud basin.

Methods

Sample collection

Three 0·1 m^2 Day-grab samples were taken at 16 sampling stations drawn at random from a 5 nm × 5 nm grid superimposed over the area (see Figure 1). One grab was sub-sampled for granulometric analysis by the removal of approximately 0·5 l of material (from a total volume of 7 l) which was frozen at − 20 °C prior to freeze drying. Sediment samples were dry-sieved according to Buchanan (1985). Fauna were preserved in buffered 4% formaldehyde containing Rose Bengal stain. Animals retained by a 1·0 mm mesh were identified to species level wherever possible. An additional station from the northern periphery of the mud basin was included (Station 1; 53% silt–clay). Co-ordinates, depths and granulometric data for each station are given in Table 1.

Statistical analyses

The replicate grab data from each station were pooled rather than analysed separately. This was because the samples were generally found to be species poor (see below) with occasional ‘ patches ’ of dominant species in moderate numbers. The variation in species abundance between grabs at each station was therefore high, rendering statistical comparisons between replicate grabs on a species-by-species basis meaningless. Grab samples from which sediment sub-samples had been removed were not found to show a

TABLE 1. Position, depth, granulometry, total number of taxa (T) and total number of individuals (A) for each sampling station

Station	Position	Depth (m)	Median particle	% Silt–Clay	T (0·3 m^{-2})	A (0·3 m^{-2})
1	54 27·52 05 12·41	133	4·48	53·0	40	317
2	54 21·00 05 07·52	127	5·89	94·24	26	399
3	54 17·48 05 02·55	135	4·64	73·61	18	89
4	54 16·03 04 52·73	63	4·48	58·67	32	284
5	54 12·49 05 17·60	90	5·70	91·21	27	202
6	54 12·51 05 57·60	86	5·32	84·71	33	525
7	54 07·50 05 07·69	120	4·35	70·79	14	32
8	54 07·44 05 02·14	90	4·16	46·69	23	207
9	53 57·62 05 42·39	63	4·16	64·68	20	125
10	53 57·37 05 22·48	97	3·50	43·61	16	97
11	53 57·55 05 07·52	60	5·01	69·85	37	488
12	53 52·45 06 02·53	33	4·24	38·21	20	119
13	53 52·47 05 02·41	71	3·75	19·86	45	465
14	53 47·54 05 27·46	94	5·32	82·99	19	157
15	53 42·85 05 37·80	93	5·13	77·07	22	181
16	53 42·47 05 27·46	100	4·54	53·48	20	62
17	53 37·56 05 37·53	100	4·81	60·59	25	103

reduced total number of individuals when compared to the other grabs taken at each station (Chi-square test with Bonferroni adjusted significant level of $P>0·003$).

Two-way indicator species analysis (TWINSPAN) (Hill, 1979) and detrended correspondence analysis (DECORANA) were carried out on untransformed species abundance data to ascertain if clusters of sampling stations could be delineated on the basis of faunal distributions. Spearman rank correlation coefficients were calculated to determine the relationship between DCA axes 1 and 2, and depth, median particle size (M_Z) and percentage silt–clay (%s–c).

As the number of grabs per station was limited, it was felt to be inappropriate to produce species abundance curves and diversity comparisons at this stage.

Results

Granulometric data

The granulometric data for all stations are given in Table 1. From these data it is evident that the mud ground was not comprised of a homogeneous sediment type. Silt–clay content was seen to range from 19·85% (Station 13) at the south-eastern edge to 94·24% (Station 2) at the northern end. The rank correlation coefficients for the granulometric data did not show any relationships between grain size and depth. The lack of correlation between grain size and depth was due to a lack of fines in samples from the deep stations at the centre of the mud channel (Stations 10, 14, 15 and 7) when compared to other stations of comparable depth (Stations 5, 3 and 2).

Species composition

The fauna at all stations (species list and abundance data available from the author) was dominated by polychaetes, which constituted 77·80% of all individuals recorded. Sedentary polychaetes were the largest group representing 41·88% of the total (errant polychaetes=35·92%). Crustaceans and molluscs totalled 11·89% and 6·64%, respectively. Values for total taxa (T) and total number of individuals (A) for each station were generally low (Table 1). The lowest values for T were found at four stations (3, 7, 10, 14) which occur in the middle of the mud area (Figure 1). The highest values for T were observed at Stations 1 (T=40), 11 (T=38) and 13 (T=45).

The highest numbers of any species were for the spionid *Prionospio fallax* (Soderstrom) at Stations 6, 11 and 13 (115, 329 and 269 individuals 0·3 m^{-2}, respectively) with a similarly high number of *Capitella* spp. at Station 2 (146 individuals 0·3 m^{-2}). The most commonly encountered families were the sedentary polychaetes Capitellidae, Cirratulidae, Paraonidae and Spionidae. Errant polychaetes from the families Glyceridae, Lumbrineridae and Nephtydae were also present at most locations, but in lower numbers than the sedentary species. Species from the sedentary families listed above were dominant at all but one location (Station 9), where *Nephtys incisa* (Malmgren) was present in the highest numbers (33 individuals 0·3 m^{-2}). In all instances, the ' populations ' of the dominant sedentary species[*Prionospio fallax, Capitella* spp., Cirratulid spp. and *Monticellina dorsobranchialis* (Kirkegaard)] were comprised of small individuals. Large individuals of any polychaete species were rare. Notable examples of large specimens were 1 *Panthalis oerstedi* (Kinberg) (1·062 g wet weight) found at Station 5, and a patch of large sabellids (sp. undetected) (1·330 g mean wet weight per individual) from Station 4. Of the non-polychaete taxa, the decapod *Calocaris macandreae* (Bell) was present at the majority of stations in numbers ranging from 1–7 individuals 0·3 m^{-2}, the species was not found at Stations 1, 8, 11, 12, 13 and 16. The bivalve *Nucula* was found at all but five stations (4, 8, 9, 11, 12), their abundance ranged from 1–13 individuals 0·3 m^{-2}. Amphipods were generally rare, a notable exception being *Eriopisa elongata* (Bruzelius) which was found at Stations 2, 3, 5, 7, 14 and 15 with up to five individuals 0·3 m^{-2}. These species' composition data were similar to those given by Southward (1957), who indicated that Polychaeta were the dominant fauna (62% of the population studied) on muddy grounds before the late 1950s when trawling specifically for *Nephrops norvegicus* commenced (R. Briggs, pers. comm.). Southward also reports that the most commonly recorded polychaete species were either the active predators, *Nephtys incisa, Glycera rouxii* (Audouin & Milne-Edwards) and *Lumbriconereis hibernica* (=*Lumbrineris tetraura:* Schmarda) or the sedentary non-selective deposit-feeder *Tharyx* (=*Aphelochaeta*) *marioni* (Saint-Joseph). The species composition and trophic structure of the population therefore appears to be essentially the same as 40 years ago.

The results of the TWINSPAN analysis is illustrated as a dendrogram (Figure 2). The figure clearly shows the separation of Stations 11 and 13 from the main body of the mud at the first division level. Seventeen taxa were unique to the 11/13 cluster, including the

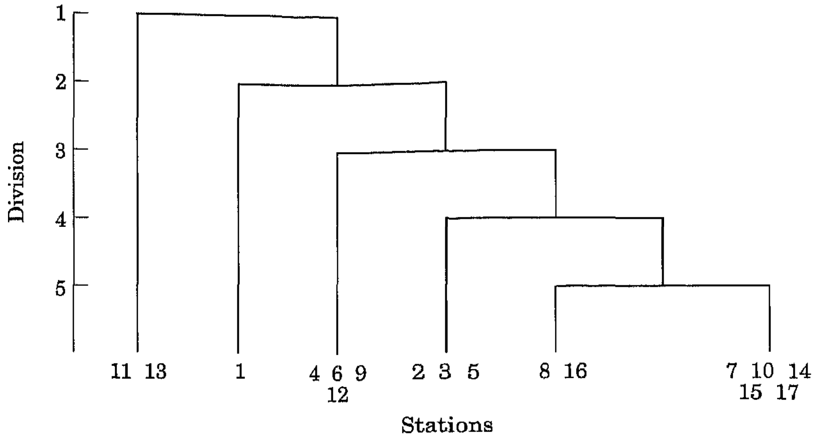

Figure 2. TWINSPAN classification dendrogram for Irish sea mud stations.

decapod *Goneplax rhomboides* (Linnaeus) and the polychaetes, *Euclymene affinis* (M. Sars) and *Nephtys hombergii* (de Savigny). The most significant positive indicator species is the amphipod *Harpinia pectinata* (Sars) which occurred in equal numbers at Stations 13 and 11, but was absent from any other location. Other species of significance were *Spiophanes kroyeri* (Grube), *Notomastus latericeus* and *P. fallax.* The division of the remaining 15 stations separates the northerly ' non-mud ' location, Station 1. In this case, the highest ranking indicator species was *Kefersteinia cirrata* (Keferstein) which was unique to Station 1 as were the polychaete *Myriochele heeri* (Malmgren) and the ophiuroid Acrocnida brachiata (Montagu). The third division separated Stations 4, 6, 9 and 12 on the basis of high numbers of cirratulids and low incidence of *Nucula* spp. Three northerly stations (2, 3, 5) were distinguished largely due to high counts of the cirratulid polychaete *Monticellina dorsobranchialis.* At the fifth division, Stations 8 and 16 were distinguished again, primarily due the presence of a low number of *M. dorsobronchialis* which was absent from the remaining five stations.

A plot of detrended correspondence analysis axis 1 (eigenvalue=0·4899) versus axis 2 (eigenvalue=0·1768) is given in Figure 3 with TWINSPAN groupings superimposed. Axes 3 and 4 will not be discussed because of their low eigenvalues (0·0598 and 0·0180, respectively). Figure 3 illustrates both the separation of Stations 11, 13 and 2, 3, 5 and the isolation of Station 1. The figure also serves to illustrate the similarity between the remaining stations which were divided by TWINSPAN into two peripheral groups (Stations 4, 6, 9, 12 and 8, 16) and a central group (Stations 7, 10, 14, 15, 17).

Spearman rank correlations for axes 1 and 2 against sediment parameters indicated that axis 1 was negatively correlated to depth ($r_{s(2)} = -0{\cdot}733$, $P<0{\cdot}01$) and percentage silt–clay ($r_{s(2)} = -0{\cdot}613$, $P<0{\cdot}05$) whilst axis 2 showed a positive correlation with the total number of taxa recorded per station ($r_{s(2)}=0{\cdot}593$, $P<0{\cdot}05$). These results indicated the importance of depth and sediment characteristics in determining species distributions in the area. From Figure 3, it is evident that the shallowest stations with the coarsest sediment (Stations 11, 13) are widely separated from the deeper stations with high percentage silt–clay estimates (Stations 2, 3, 5). Stations which were intermediate in terms of depth and/or sediment type and do not contain higher proportions of differential taxa are clustered at the centre of the graph with the ' peripheral ' stations (4,

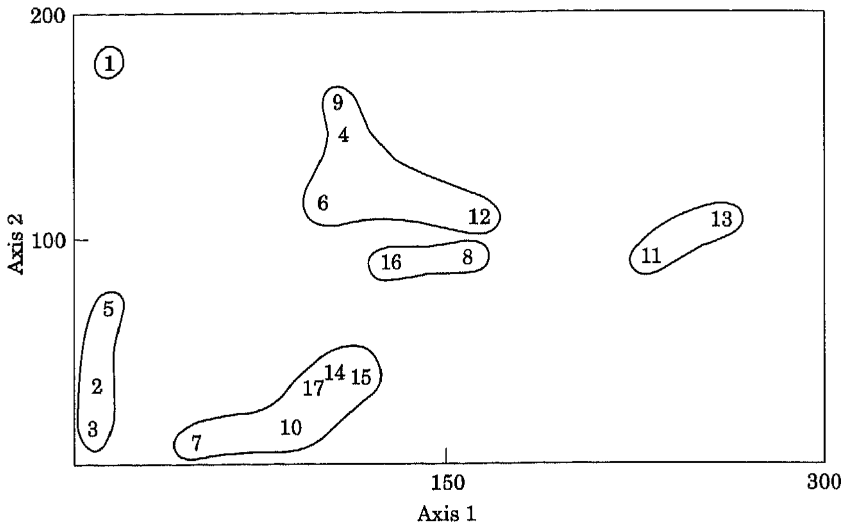

Figure 3. Plot of DECORANA axes 1 and 2 with TWINSPAN groupings superimposed.

6, 9, 12) tending towards the 11/13 cluster and the remaining (' central ') stations (7, 10, 14, 15, 17) being positioned towards the 2/3/5 cluster.

The intermediate classification of the two peripheral group stations arose because the species data contained non-differential taxa which were characteristic of more than one region. In the case of Station 16, for example, these species were *Notomastus latericeus, Nephtys incisa* and *Diplocirrus glaucus* (Malmgren) which were components of both the ' frontal ' and ' peripheral ' groups.

Discussion

The analysis of the benthic data presented above indicated that the soft-sediment area under investigation was not homogeneous either in terms of faunal composition or superficial sediments. With the exception of Station 1, hierarchical classification divided the study area into five groups: ' frontal ' (Stations 11, 13), ' peripheral ' (Stations 4, 6, 9, 12) ' northern ' (Stations 2, 3, 5), second ' peripheral ' (Stations 8, 16) and ' central ' (Stations 7, 10, 14, 15, 17). Initially, the division of the stations into these groups arose due to the presence of distinct fauna over and above differences in ubiquitous species abundance. The principal division resulted from the presence in moderate numbers of tube-building maldanids and spionids. For the remaining divisions, the taxa of key importance were the burrow occupying, surface feeding cirratulids. The ' central ' stations did not contain cirratulids, were poor in terms of total taxa and abundance, but did contain the bivalve *Nucula* spp. In addition to the changes in species composition, estimates of total taxa and total counts of individuals per $0{\cdot}3\ m^2$ derived for the TWINSPAN groups (Table 2) suggested a trend of declining ' species richness ' nearer to the central mud channel stations. The results of rank correlation analysis indicated that the change from tubicolous species around the periphery of the basin to mobile burrowers in the centre could be attributed (at least in part) to the variation in sediment type and depth across the region. The data therefore reflect a common trend reported

TABLE 2. Number of taxa (T) and total number of individuals (A) for TWINSPAN-derived groups

Station	T ($0{\cdot}3\ m^{-2}$)	A ($0{\cdot}3\ m^{-2}$)
1	40	317
2, 3, 5	24	230
11, 13	41	477
4, 6, 9, 12	26	263
8, 16	21	135
7, 10, 14, 15, 17	19	114

from a number of previous benthic studies (for example, Thouzeau *et al.*, 1991; Kunitzer *et al.*, 1992). Creutzberg *et al.* (1984) suggested that a region of high benthic production in the North Sea was attributable to increased deposition of organic matter relative to adjacent areas. They speculated that either the organic material was derived from primary production in the vicinity of a seasonal front, or that hydrographic conditions lead to the accumulation of organic matter in the area of benthic enrichment. Stations 11 and 13 from the present study are close to the frontal boundary which extends from south of the Isle of Man to Dublin Bay, separating thermally stratified and mixed water during the summer months (Simpson & Hunter, 1974). The highest number of individuals per unit are was recorded at these two stations (attributable to the very high counts of the spionid *P. fallax*). An unusually rich benthic community in the vicinity of this front was also observed by Holme and Rees (1986) during a photographic survey. However, it is not clear whether the data from this survey or those of Holme and Rees are indicative of benthic enrichment in response to enhanced phytoplankton growth at a frontal zone, or a benthic response to the deposition of organic material (irrespective of source) along the boundary of a low tidal velocity area.

In contrast to the peripheral areas, the deep channel stations contained relatively few surface-feeding species such as cirratulids which are more likely to be distributed in the upper 5–6 cm of the sediment. This surface distribution does not necessarily apply to general burrowing species which are not so depth-restricted and may burrow more deeply as they get larger (Hayashi, 1991). The paucity of surface-dwelling species could be attributable to bioturbation by common burrowing species such as *Calocaris macandreae* and/or sea-bed disturbance by fishing activity (reviewed by Jones, 1992). However, the data from the present study are not sufficient to address these processes. In addition, it should be noted that Kershaw (1986) reported that the layer of ' bioturbation ' in the mud channel extended down some 55 cm. It is very likely therefore, that the depth of biological activity exceeds the penetration depth of the grab used for the survey. It is clear that significant elements of the fauna such as *Nephrops norvegicus* and *Brissopsis lyrifera* (Forbes) were not sampled due to their deep burrowing habit. If species are distributed at greater depth in the soft muds than the courser, peripheral grounds, then the reduced species abundance and biomass in the central basin may be attributable to non-representative sampling by the grab. This coupled with the loss of small species such as spionids and paraonids through the 1·0 mm sieve mesh gives rise to the possibility that the numbers of species from some areas may be artificially low. The apparent paucity of species in this area will be investigated in the near future by means of an intensive box coring study at a number of soft mud stations.

Conclusions

The data from the preliminary survey suggest that the macrofauna of the soft mud basin area is dominated by small, deposit-feeding polychaetes. Surface-feeding species such as cirratulids appear to be less common toward the centre of the basin which is species poor when compared to the peripheral areas. There is a clear need to sample key sites more intensively to determine whether the observed lack of fauna in the centre of the basin is an artifact of the sampling procedure or whether the data reflect the impact of processes such as bioturbation and sea-bed trawling.

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