43

Polychaeta of the German Bight from the 1987 cruise of the R/V "Senckenberg"

Dieter FIEGE & M. Nechana BEN-ELIAHU***

*Forschungsinstitut Senckenberg, Sektion Marine Evertebraten II
Senckenberganlage 25 D-6000 Frankfurt/M., Germany
**The Life Sciences Collections, The Hebrew University of Jerusalem
91904 Jerusalem, Israel

ABSTRACT

The present paper reports on the collections of Polychaeta of the 1987 cruise to the German Bight, "DEB 1987". Fifty-one samples from 25 stations covering a depth range from 14 to 46 m were analyzed. The samples contained about 1,500 polychaetes in 46 genera in 29 families. Altogether, 67 separate taxa were determined, of which 63 were identified to species. As many as 26 species per sample were found. The distribution of species in the samples is discussed.

RÉSUMÉ

Polychètes de la grande baie allemande récoltées par le R/V "Senckenberg" au cours de la campagne de 1987

Dans cette note les résultats des récoltes des polychètes de l'expédition 1987 dans le golfe allemand, "DEB 1987", sont présentés. Cinquante et un échantillons provenant de 25 stations, dont les profondeurs varient entre 14 et 46 m, ont été analysés. Les échantillons contenaient environ 1500 polychètes appartenant à 46 genres de 29 familles. Soixante sept espèces ont été distinguées, dont 63 ont pu être déterminées. On a trouvé jusqu'à 26 espèces par échantillon. La distribution des espèces dans les échantillons est discutée.

INTRODUCTION

Benthic communities and species distribution in the North Sea have been studied by various authors (STRIPP, 1969; STRIPP & GERLACH, 1969; GLÉMAREC, 1973; McINTYRE, 1978; RACHOR & GERLACH, 1978; ZIEGELMEIER, 1978; SALZWEDEL *et al.*, 1985; BASFORD *et al.*, 1989; FRAUENHEIM *et al.*, 1989; KÜNITZER, 1990). Investigations with special emphasis on the distribution of Polychaeta in the area have been carried out by MICHAELSEN (1897), FRIEDRICH (1938), HARTMANN-SCHRÖDER & STRIPP (1968), and KIRKEGAARD (1969).

FIEGE, D. & M. N. BEN-ELIAHU, 1994. — Polychaeta of the German Bight from the 1987 cruise of the R/V "Senckenberg". *In*: J.-C. DAUVIN, L. LAUBIER & D.J. REISH (Eds), Actes de la 4ème Conférence internationale des Polychètes. *Mém. Mus. natn. Hist. nat.*, **162** : 413-423. Paris ISBN 2-85653-214-4.

The latter reviews the previous collections in the North Sea. Earlier investigations were often limited to particular areas within the North Sea (TÜRKAY, pers. comm.). The fauna of the northern North Sea is still poorly known in regards to both in- and epifaunal benthic invertebrates (BASFORD *et al.* (1989).

The Senckenberg Research Institute began a long-term study of epizoobenthos in the North Sea in 1977 in order to obtain a comprehensive view of the distribution of different taxa and to establish baseline data for monitoring possible changes in the future.

Fifteen annual cruises have been carried out during summers to different areas within the North Sea. More than 200 stations have been sampled to date. The present paper reports on the collections of Polychaeta made during the 1987 expedition to the German Bight "DEB 1987".

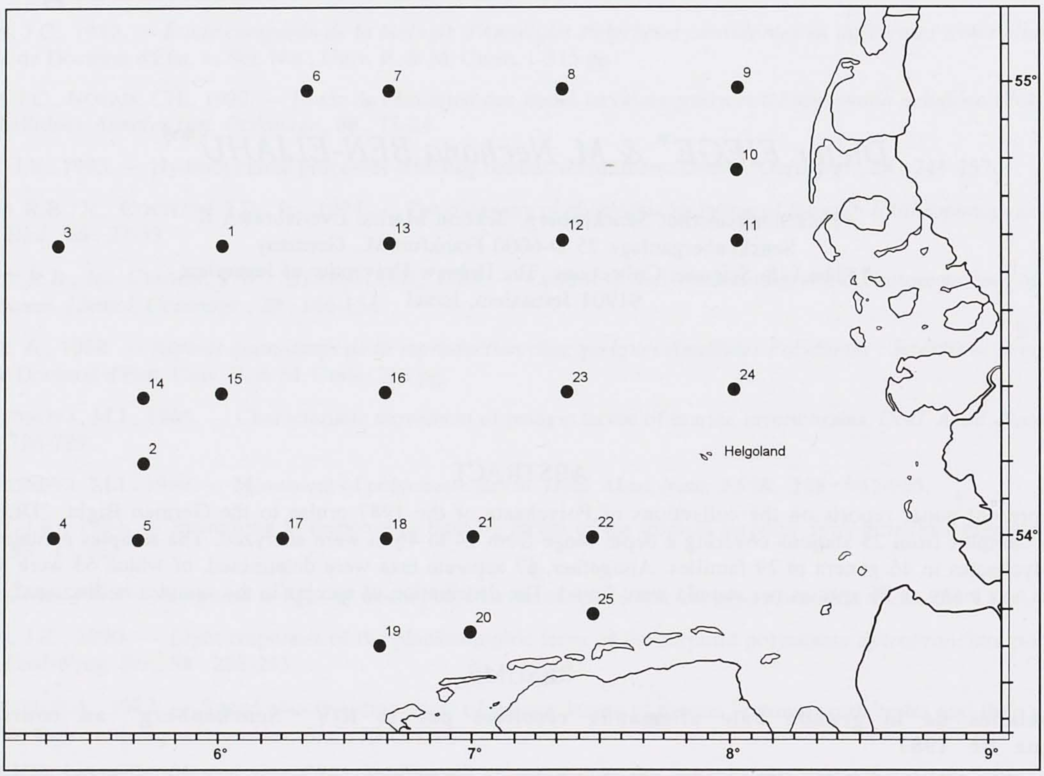

FIG. 1. — Map of stations of the DEB 1987 expedition.

MATERIALS AND METHODS

The DEB 1987 sampling sites are given in Table 1 and Figure 1. The sampling was done with a van Veen grab (0.2 m^2), beam trawl (2 m wide, 1 cm mesh size in cod end), and ring dredge (1 m diameter, 1 cm mesh size). Twenty-four, 21, and 6 samples, respectively, were taken with these samplers; three stations were sampled with all three gear (Table 1). Trawling was usually carried out for 20 minutes at each station (except stn. 6 [21'] and stn. 7 [26']) at 1-2 knots after the gear had reached the bottom. An area of about 1 nautical mile length and 2 m width was covered with each trawl. Samples were sieved through 0.63 mm mesh size and fixed in 10 % formaldehyde. In the laboratory, polychaetes were determined to species level whenever possible (Table 2).

Faunistic attributes were analyzed separately for both types of samples. Van Veen grab samples are more comparable than beam trawl samples, since the beam trawl passes through different patches of the sea floor which may obliterate differences between benthic assemblages. Therefore, only those samples taken with the grab were considered here. We used the statistical package for comparing marine samples, PRIMER ver. 3.1 (GRAY *et al.*, 1988; MED POL, 1992a, b), to compute the following univariate indices: N (the number of individuals in the sample), S species richness (the number of species in a sample), H' species diversity (the Shannon-Wiener information index computed to the base e), and J' the evenness corollary of the Shannon-Wiener index.

TABLE 1. — List of stations of North Sea expedition to German Bight DEB 1978

Station	Date V 1987	Depth (m)	Sampling gear[1/]	Coordinates Latitude	Longitude	Silt/Clay[2/] (%)	Sand-grain size[2/] (μm)	Rank[3/]
1	24	43	Bt, vV	54°39,9'N	6°00'E	5-10	63-250	2
2	24	44	Bt, vV	54°10'N	5°39,5'E	n.d.[5/]	n.d.	n.d.
3	24	46	Bt, vV, Rd	54°40'N	5°20'E	n.d.	n.d.	n.d.
4	24	43	Bt, vV	54°00'N	5°20'E	n.d.	n.d.	n.d.
5	24	44	Bt, vV	54°00,03'N	5°40,02'E	n.d.	n.d.	n.d.
6	24	46	Bt, vV	55°00,02'N	6°20,02'E	11-20	63-250	1
7	24	41	vV, Rd[4/]	55°00'N	6°40,1'E	<5	63-250, +	3
8	24	31	Bt, vV	55°00'N	7°20'E	<5	63-250	3
9	24	17	Bt, vV	55°00,01'N	8°00,01'E	<5	63-250, 500-2000	6
10	24	16	Bt, vV	45°50'N	8°00'E	<5	500-2000	7
11	24	14	vV	54°40'N	8°00,02'E	<5	500-2000	7
12	25	25	Bt, vV	54°39,9'N	7°20,0'E	<5	63-250, 500-2000	6
13	25	40	Bt, vV	54°40'N	6°39,5'E	5-10	63-250	2
14	25	42	Bt, vV	54°20,02'N	5°40'E	n.d.	n.d.	n.d.
15	25	41	Bt, vV	54°20,02'N	6°00,2'E	5-10	63-250	2
16	25	38	Bt, vV	54°20'N	6°40E	5-10	63-250	2
17	25	33	Bt, vV,Rd	54°00,04'N	6°16'E	<5	63-250, 250-500	4
18	25	29	Bt, vV	54°00,01'N	6°40,02'E	5-10	63-250	2
19	25	25	Bt, vV, Rd	53°45,04'N	6°37,03'E	<5	500-2000	7
20	26	18	vV	53°47'N	7°03'E	<5	250-500	5
21	26	30	Bt, vV	54°00'N	6°59,9'E	<5	63-250	3
22	26	36	Bt, vV	54°02'N	7°30'E	5-10	63-250	2
23	26	43	Bt, vV	54°20,01'N	7°20,01'E	5-10	63-250	2
24	26	22	Bt, Rd	54°20,01'N	8°00,01'E	<5	500-2000	7
25	26	19	vV	53°49,5'N	7°29'E	<5	63-250, 250-500	4

[1/] Bt (beam trawl); vV (van Veen grab); Rd (ring dredge). [2/] According to information in FIGGE, 1981. +: gravel. [3/] Ranked from 1-7 (class 7 with largest sand grain size 500-2000 μm; class 6 with largest sand grain size 500-2,000 μm and also with smaller grains; class 5 with sand grain size 250-500 μm; class 4 with sand grain size 250-500 μm and also with smaller grains; class 3 with sand grain size 63-250 μm; class 2 with sand grain size 63-250 μm and also with 5-10% clay; class 1 with sand grain size 63-250μm and also with 11-20% clay). [4/] Two samples. [5/] n.d.: no data available, i. e., station not on sediment map.

A one-way analysis of variance (ANOVA) was done of S and H' against depth using the Statgraphics package to test the hypothesis that faunal attributes reflect depth. The DEB 1987 sampling program did not encompass replicate sampling; thus, for ANOVA, samples were sorted into four depth classes (I: 14-19 m, II: 20-29 m, III: 30-39 m, and IV: 40-46 m), regardless of their location. Members of a depth class served as "replicates".

To discriminate between samples on the basis of their faunistic attributes, we used the PRIMER package to carry out hierarchical agglomerated classification based on the Bray-Curtis similarity coefficient calculated on square root transformed abundances, employing group average sorting (GRAY *et al.*, 1988). An ordination analysis, multidimensional scaling (MDS), which expresses the rank order of the dissimilarities was done based on the ranked Bray-Curtis similarity matrix and plotted with the superimposed scaled environmental variables of depth and substrate type (MED POL, 1992a, b; GRAY *et al.*, 1992). Van Veen samples 3 and 5 seemed to prevent other samples from clustering, i.e. they are "degenerate samples"; according to accepted practise they were omitted from the respective analyses (MED-POL, 1992a, b; M.R. CARR, pers. comm.). A non-parametric analysis of variance was used to compare the Bray-Curtis similarities with the depth categories.

TABLE 2.— Distribution of taxa in samples. All gears. N° of individuals taken for each depth category (% of samples at each depth category containing species in question)

Depth: Number of samples: Species	Gear	14-19 m 7	20-29 m 9	30-39 m 11	40-46 m 24	Total: = 51
APHRODITIDAE						
Aphrodite aculeata Linné, 1761	vV,Bt,Rd[1/]	-	1 (11.2)	8 (36.4)	69 (45.8)	78 (31.4)
POLYNOIDAE						
Lepidonotus squamatus (Linné, 1767)	Bt	-	-	1 (9.1)	-	1 (2)
Harmothoe antilopes McIntosh, 1876	Bt	-	-	-	1 (4.2)	1 (2)
Harmothoe imbricata (Linné, 1767)	Bt	-	-	2 (9.1)	1 (4.2)	3 (3.9)
Harmothoe lunulata (Delle Chiaje, 1841)	vV	-	-	3 (18.2)	-	3 (3.9)
Harmothoe longisetis (Grube, 1863)	vV	-	-	-	2 (8.4)	2 (3.9)
Harmothoe (Eunoe) nodosa (Sars, 1860)	vV, Bt	-	-	3 (18.2)	19 (25)	22 (15.7)
Polynoe (Enipo) kinbergi Malmgren, 1865	vV	-	-	-	4 (16.7)	4 (7.8)
SIGALIONIDAE						
Pholoe minuta (Fabricius, 1780)[2/]	vV, Bt	-	3 (22.3)	17 (18.2)	163 (41.7)	183 (27.5)
Sthenelais limicola (Ehlers, 1864)	vV, Bt	-	-	1 (9.1)	10 (16.7)	11 (9.8)
PISIONIDAE						
Pisione remota (Southern, 1914)	Bt	-	1 (11.2)	-	-	1 (2)
PHYLLODOCIDAE						
Eteone longa (Fabricius, 1780)	vV	-	1 (11.2)	-	-	1 (2)
Eteone foliosa Quatrefages, 1865	vV	-	-	-	1 (4.2)	1 (2)
Phyllodoce groenlandica (Oersted, 1842)	Bt	-	1 (11.2)	-	-	1 (2)
Eumida sanguinea (Oersted, 1843)	vV, Bt	9 (28.6)	3 (11.2)	33 (54.5)	1 (4.2)	46 (19.6)
HESIONIDAE						
Ophiodromus flexuosus (Delle Chiaje, 1822)	vV, Bt	-	-	1 (9.1)	7 (16.7)	8 (9.8)
PILARGIDAE						
Synelmis klatti (Friedrich, 1950)	vV	-	-	-	1 (4.2)	1 (2)
SYLLIDAE						
Eusyllis blomstrandi Malmgren, 1867	Bt	-	1 (11.2)	-	-	1 (2)
Autolytus langerhansi Gidholm, 1967	Bt	-	-	-	1 (4.2)	1 (2)
Autolytus edwarsi Saint Joseph, 1887	Bt	-	-	1 (9.1)	221 (16.7)	222 (9.8)
NEREIDIDAE						
Nereis zonata Malmgren, 1867	Bt	-	-	-	1 (4.2)	1 (2)
Nereis (E.) longissima Johnston, 1840	vV	-	-	-	1 (4.2)	1 (2)
NEPHTYIDAE						
Nepthys cirrosa Ehlers, 1868	vV	4 (14.3)	-	2 (9.1)	-	6 (3.9)
Nephtys hombergii Savigny, 1818	vV, Bt, Rd	7 (14.3)	2 (11.2)	11 (36.4)	15 (37.5)	35 (29.4)
Nephtys incisa Malmgren, 1865	vV	-	-	-	3 (12.5)	3 (5.9)
Nephtys caeca (Fabricius, 1780)	vV, Bt, Rd	5 (57.1)	6 (45)	2 (18.2)	1 (4.2)	14 (21.6)
Nephtys longosetosa Oersted, 1843	vV, Rd	8 (57.1)	25 (45)	5 (9.1)	6 (8.4)	44 (21.6)
Nepthys assimilis Oersted, 1843	vV, Bt	1 (14.3)	-	2 (18.2))	8 (20.8)	11 (15.7)
GLYCERIDAE						
Glycera rouxii Aud.& M.-Edwards, 1833	vV	-	-	-	7 (8.4)	7 (3.9)
Glycera alba (O. F. Müller, 1776)	vV, Bt	-	-	-	13 (20.8)	13 (9.8)
GONIADIDAE						
Glycinde nordmanni (Malmgren, 1865)	vV, Bt	-	-	-	6 (16.7)	6 (7.8)
Goniada maculata Oersted, 1843	vV	-	-	3 (27.3)	1 (4.2)	4 (7.8)
Goniadella bobretzkii (Annenkova, 1929)	vV, Bt	3 (42.9)	1 (11.2)	-	2 (8.4)	6 (11.8)
LUMBRINERIDAE						
Lumbrineris cf. *gracilis* (Ehlers, 1868)	vV, Bt	-	1 (11.2)	-	3 (12.5)	4 (7.8)
Lumbrineris type A	vV	-	-	-	2 (8.4)	2 (3.9)

TABLE 2 (continued)

Depth: Number of samples: Species	Gear	14-19 m 7	20-29 m 9	30-39 m 11	40-46 m 24	Total: = 51
ORBINIIDAE						
Scoloplos armiger (O. F. Müller, 1776)	vV, Bt	52 (71.4)	22 (22.3)	45 (45.5)	42 (29.2)	161 (37)
PARAONIDAE						
Paraonis gracilis (Tauber, 1879)	vV	-	-	-	3 (4.2)	3 (2)
POECILOCHAETIDAE						
Poecilochaetus serpens Allen, 1904	vV	-	-	1 (9.1)	3 (8.4)	4 (5.9)
SPIONIDAE						
Spio filicornis (O. F. Müller, 1776)	vV	-	-	4 (9.1)	-	4 (2)
Polydora ciliata (Johnston, 1838)	Bt	-	-	-	1 (4.2)	1 (2)
Scolelepis bonnieri (Mesnil, 1896)	vV	2 (14.3)	2 (22.3)	6 (36.4)	1 (4.2)	11 (15.7)
Spiophanes kröyeri Grube, 1860	vV	-	-	-	1 (4.2)	1 (2)
Spiophanes bombyx (Claparède, 1870)	vV	9 (57.1)	4 (33.6)	33 (18.2)	51 (37.5)	97 (35.3)
Aonides paucibranchiata Southern, 1914	vV, Bt	-	2 (11.2)	7 (27.3)	1 (4.2)	10 (9.8)
MAGELONIDAE						
Magelona alleni Wilson, 1958	vV	-	-	-	1 (4.2)	1 (2)
Magelona mirabilis (Johnston, 1865)	vV, Bt	37 (42.9)	12 (33.6)	20 (18.2)	25 (20.8)	94 (25)
Magelona type A	vV	1 (14.3)	-	3 (18.2)	3 (8.4)	7 (9.8)
Magelona type B	vV	-	-	-	3 (12.5)	3 (5.9)
Magelona type C	vV	-	-	-	3 (8.4)	3 (3.9)
CHAETOPTERIDAE						
Chaetopterus variopedatus (Renier, 1804)	vV	-	-	-	5 (8.4)	5 (3.9)
FLABELLIGERIDAE						
Diplocirrus glaucus (Malmgren, 1867)	vV	1 (14.3)	-	-	12 (12.5)	13 (7.8)
CIRRATULIDAE						
Chaetozone setosa Malmgren, 1867	vV, Bt	4 (28.6)	7 (22.3)	9 (36.4)	21 (29.2)	41 (29.4)
Dodecaceria concharum Oersted, 1843	vV, Bt	-	10 (22.3)	-	-	10 (3.9)
SCALIBREGMATIDAE						
Polyphysia crassa (Oersted, 1843)	Bt	-	-	-	1 (4.2)	1 (2)
Scalibregma inflatum Rathke, 1843	vV	-	-	-	1 (4.2)	1 (2)
OPHELIIDAE						
Ophelia limacina (Rathke, 1843)	vV, Bt, Rd	37 (42.9)	88 (67)	25 (36.4)	10 (16.7)	160 (33.4)
Ophelina acuminata Oersted, 1843	vV	-	-	1 (9.1)	2 (8.4)	3 (5.9)
CAPITELLIDAE						
Capitella capitata (Fabricius, 1870)	Bt	-	-	-	2 (4.2)	2 (2)
Notomastus latericeus Sars, 1851	vV	-	-	-	4 (8.4)	4 (3.9)
OWENIIDAE						
Owenia fusiformis Delle Chiaje, 1841	vV, Bt, Rd	-	-	-	16 (20.8)	16 (9.8)
PECTINARIIDAE						
Pectinaria belgica (Pallas, 1766)	Bt	-	-	-	1 (4.2)	1 (2)
Pectinaria koreni Malmgren, 1865	vV, Bt, Rd	-	-	1 (9.1)	44 (33.4)	45 (17.6)
Pectinaria auricoma (O. F. Müller, 1776)	vV, Bt, Rd	-	-	-	52 (33.4)	52 (15.7)
AMPHARETIDAE						
Ampharete finmarchica (Sars, 1864)	vV	-	1 (11.2)	-	17 (12.5)	18 (7.8)
TEREBELLIDAE						
Lanice conchilega (Pallas, 1776)	vV, Bt	3 (14.3)	-	7 (18.2)	-	10 (5.9)
Lysilla loveni Malmgren, 1865	vV, Bt	-	-	-	6 (20.8)	6 (9.8)
SABELLIDAE						
Sabella penicillus Linné, 1767	vV, Bt	-	-	-	2 (8.4)	2 (3.9)

1/ vV = van Veen grab, Bt = beam trawl, Rd = ring dredge. 2/ sensu HARTMANN-SCHRÖDER (1971).

Analysis of samples with respect to the sediment was done by cluster analysis. The information on substrate grain size is from a map, "Sedimentverteilung in der Deutschen Bucht" (FIGGE, 1981) (Table 1). Sediment was divided into 7 classes ranked by decreasing size (for raw data and ranks see Table 1). A correlation between depth and substrate classes was made.

RESULTS AND DISCUSSION

Polychaetes were analyzed from 51 samples taken at 25 stations and covered a depth range from 14 to 46 m. There were about 1,500 specimens in 46 genera and 29 families. Sixty-seven species were determined of which 63 were identified to species (Table 2).

For analysis of depth distributions samples were arbitrarily grouped into four depth categories. Fourteen species were present in the entire depth range, including the most frequently encountered species; these were, *Scoloplos armiger*, *Spiophanes bombyx* and *Ophelia limacina*, which were present in >30 % of the samples; *Nephtys hombergii*, *N. caeca*, *N. longosetosa*, *Magelona mirabilis* (presumably mistaken for *M. papillicornis* previously, see JONES, 1977) and *Chaetozone setosa*, which were present in 20-30 % of the samples; *Eumida sanguinea*, *Nepthys assimilis*, *Goniadella bobretzkii*, *Scolelepis bonnieri*, which were present in 10-19 % of the samples. Two species, *Magelona* type A and *Diplocirrus glaucus*, were present in all the depth ranges sampled but present in fewer than 10 % of the samples. Among the abundant species, *Aphrodite aculeata* and *Pholoe minuta* (>20 % of the samples), were found only below the depth of 20 m; *Harmothoe (Eunoe) nodosa*, *Pectinaria koreni* and *Pectinaria auricoma* (10-19 %) were found only below the depth of 30 m. Altogether, five species were found only at depths less than 30 m (*Pisione remota*, *Eteone longa*, *Eusyllis blomstrandi*, *Phyllodoce groenlandica*, *Dodecaceria concharum*), whereas 32 species were found only at depths greater than 30 m, with 29 of these present only at depths greater than 40 m (Table 2).

Seventy-six percent of the species, i.e., 51, were found in fewer than 10 % of the samples and are thus comparatively rare (Table 2). The six most abundant species were *Autolytus edwarsi*, *Pholoe minuta*, *Scoloplos armiger*, *Ophelia limacina*, *Spiophanes bombyx*, and *Magelona mirabilis*. These comprised 8.9 % of all species. The large species, *Aphrodite aculeata*, was also abundant in deeper waters with 78 individuals (Table 2). Fifteen species (22.4 % of the total) were represented by 11-55 individuals. Eighteen species (26.9 %) were represented by two individuals and 18 species (26.9 %) by only one.

ZIEGELMEIER (1978) found that about two-thirds of all polychaetes sampled belonged to *Spiophanes bombyx*, *Magelona papillicornis*, and *Scoloplos armiger*. *Magelona papillicornis* also was the most common species in the study of RACHOR & GERLACH (1978). *Magelona papillicornis* in both these studies was probably *M. mirabilis* (see JONES, 1977).

Table 2 lists the gear used to collect the material. Most of the individuals of *Aphrodite aculeata* and some additional polychaetes such as polynoids were taken with the beam trawl. *Spiophanes bombyx* was only collected with the grab. The number of polychaete species per sample was 3 to 26 for the van Veen collections, 1 to 18 for beam trawl collections, and 1 to 4 for the ring dredge collections (Table 3).

Comparison of the mean species richness S indicated an increase with increasing depth (7.2 ± 4.0 in depth class I, 8.0 ± 4.6 in depth class II, 13.0 ± 6.6 in depth class III, and 11.4 ± 6.3 in depth class IV for the van Veen grab samples). However, an ANOVA test, carried out with the data from the van Veen grabs found that the difference in number of species with depth was not statistically significant. The species diversity index, H', also increased with depth (Table 3); while the ANOVA test for significance with H' calculation was higher than for S, the difference between the depth classes with H' was not significant ($p > 0.05$; d.f. 3.47). The richest van Veen sample was number 6 from a high fraction of clay at 46 m with 26 species and the highest species diversity (H'= 2.9) (Table 1). According to HARTMANN-SCHRÖDER (1971), species found at this station either prefer muddy substrate or are not known to have any substrate preference. STRIPP (1969) and KÜNITZER (1990) also found that species richness, respectively number of individuals of macro- and meiofauna, increased from coarse to fine sediment. Regarding only the van Veen collections of this study, those with the fewest species include stations 9 and 19 at a depth of 17-25 m (3-4 species each). These stations had the largest substrate grain size. However, there were also stations with few species in deeper waters with fine grain size (stations 7 and 14, 41 and 42 m, respectively). According to ZIEGELMEIER (1978) the poorest stations with lowest biomass were situated close to the coast of Schleswig-Holstein, which he attributed to the fine to coarse sand, which is very mobile due to the strong tidal currents in this area. Among the stations of the present study sampled with vV, 9, 10 and 11 are aligned with 8°E along the coast of Schleswig-Holstein in quite shallow water. They belong to those with the largest substrate grain size. Stations 9 and 11 show low species diversity (three and four species, respectively).

Station 10 is also very shallow, and has the same substrate as the other two but shows a higher diversity (8 species). According to HARTMANN-SCHRÖDER (1971), species found at these stations either prefer sandy substrate (*Goniadella bobretzkii*, *Spiophanes bombyx*, and *Ophelia limacina*) or are not known to have any preference (*Nephtys caeca*, *N. longosetosa*, and *Scoloplos armiger*).

TABLE 3. — Number of individuals (N), species richness (S), species diversity (H') and evenness (J') in individual samples.

Gear		van		Veen		beam	trawl	ring	dredge
Station	Depth (m)	N	S	H'	J'	N	S	N	S
A (≤ 19m)									
11	14	21	4	0.695	0.494	-	-	-	-
10	16	28	8	1.589	0.768	3	2	-	-
9	17	41	3	0.629	0.572	2	1	-	-
20	18	16	8	1.836	0.883	-	-	-	-
25	19	58	13	1.718	0.670	-	-	-	-
B (20-29m)									
24	22	-	-	-	-	4	3	1	1
12	25	21	7	1.325	0.681	18	8	7	1
19	25	17	4	1.038	0.748	2	2	83	3
18	29	88	13	1.470	0.573	1	1	-	-
C (30-39m)									
21	30	25	12	2.256	0.908	5	2	-	-
8	31	121	13	1.916	0.747	7	3	-	-
17	33	33	7	1.189	0.664	2	2	4	2
22	36	14	9	1.965	0.894	18	4	-	-
16	38	11	24	2.073	0.900	7	5	-	-
D (≥40 m)									
13	40	45	17	2.630	0.928	7	2	-	-
7	41	9	4	1.215	0.876	-	-	-	-
15	41	91	10	1.089	0.473	2	2	-	-
14	42	4	4	1.386	1.000	7	2	-	-
1	43	28	10	2.004	0.870	21	7	-	-
4	43	47	10	1.644	0.714	8	2	-	-
23	43	74	15	2.014	0.785	18	9	-	-
2	44	14	11	2.305	0.961	6	1	-	-
5	44	53	11	1.897	0.791	10	7	-	-
3	46	12	7	1.699	0.873	7	4	16	4
6	46	78	26	2.866	0.890	347	18	-	-
No. of indiv. (Total N=1562)		949				502		111	

Depth frequently correlates with substrate characteristics as indicated by THORSON (1957) and HYLLEBERG & NATEEWATHANA (1984). We looked for indications that this might apply to the present material. First we considered the relationship between the depth classes and substrate grain size and found them to be positively correlated ($r= 0.641$, d.f. 20, $p < 0.01$). There was a significant relationship between the depth classes and the ranked grain size classes (one way ANOVA, $p < 0.01$, d.f. 3.18). Actually, there was very little difference between the mean grain size ranks of the first two depth classes (5.8 ±1.3, 5.5 ± 2.4, 2.8 ±0.8, 2.1 ± 0.7).

Next we conducted a cluster analysis for faunistic similarity between samples. The dendrogram of the van Veen samples (Fig. 2a), showed three clusters (marked A, B, and C). Cluster A comprises samples only from depth category IV, cluster B comprises some samples from depth category IV and all the samples from depth category III, while cluster C comprises all vV samples from depth categories II and I. The dendrogram thus broadly classifies the samples according to the depth categories and, similarly, according to the substrate size. The corresponding 2-dimensional ordination plots based on the Bray-Curtis similarities with superimposed depth (Fig. 2b) and substrate grain size (Fig. 2c) show this clearly. An indication of the goodness of fit of the plot is given by its stress value (an expression of the deformation necessary to transform the model from a 3-dimensional one to a 2-dimensional one); the lowest stress value for the van Veen MDS plot was 0.172 (0.182, 0.218). Lower stress values (0.1) would indicate a more accurate presentation of the samples (M.R. CARR, pers. comm.). Due to these somewhat higher stress values, we must conclude that the plots of the samples' Bray-Curtis similarity based on their faunal attributes is a fair (rather than an excellent) representation, and it reflects the correspondence between the faunistic attributes of the samples and their depth distributions as well as the grain size parameters. The correspondence with both these parameters is most obvious for cluster C - the shallowest samples with the coarsest grains - but also holds true for cluster A with the finest grain size (Fig. 2b-c). The non-parametric analysis of similarity *vis a vis* depth for the van Veen samples showed significant differences ($p < 0.05$) only between samples less than 20 m deep and those deeper than 40 m. The fact that the grain size data was obtained from a map, and not from analysis of substrate collected with the samples must introduce error, the extent of which we cannot know. The impact of any local sediment patchiness on the faunal attributes actually measured cannot be determined. Presumably, the actual correspondence with substrate is better than that shown on the plot.

The van Veen samples contained 80.5 % of the 67 species collected by the expedition. The nature of the samples themselves with as many as 50 % of the species represented by only one individual contributed to the low similarities between samples (Fig. 2a). For greater significance, larger samples or replicate sampling with similarities computed on the mean abundance data has been suggested (M.R. CARR, pers. comm.)

Among the common species, some occur in considerably higher numbers in certain samples than in the others (*Aphrodite aculeata, Pholoe minuta, Scoloplos armiger, Spiophanes bombyx, Magelona mirabilis, Ophelia limacina*) (Table 4). Station 6 was the richest in species and in number of individuals with both the van Veen and the beam trawl samplers. At this station *Autolytus edwarsi* was found in large numbers, but it was not collected at many stations (Table 4).

TABLE 4. — Species of DEB 1978 found in great number (% of individuals = % of all individuals of this species taken at all stations)

Species	Sample/Gear	No. of individuals	% of individuals
Aphrodite aculeata	6Bt	32	41
Pholoe minuta	15vV	61	34
	6Bt	40	22
Scoloplos armiger	8vV	37	23
	9vV	33	20.5
Spiophanes bombyx	8vV	32	33
Magelona mirabilis	23vV	20	21.3
	25vV	30	32
Ophelia limacina	19Rd	59	36.9
Autolytus edwarsi	6Bt	213	95

Although the stations overlapped with some of those sampled by HARTMANN-SCHRÖDER & STRIPP (1968), it is not possible to compare species composition and abundances between the two studies since a smaller sieve mesh size was used by them. HARTMANN-SCHRÖDER & STRIPP (1968) included some meiobenthic species lacking in the present study, which might have been lost because of the greater mesh size used here: *Hesionura augeneri, Microphthalmus similis, M. listensis, Sphaerosyllis hystrix, S. tetralix,* but also *Anaitides subulifera, Eumida bahusiensis, E. punctifera, Polydora (Pseudopolydora) pulchra,* and *Tharyx marioni*. Among the common species mentioned by HARTMANN-SCHRÖDER & STRIPP (1968), *Sthenelais limicola, Goniadella bobretzkii, Scolelepis bonnieri, Aonides paucibranchiata,* and *Ampharete finmarchica* were found in the present DEB sampling but in no more than 7-16% of the samples.

Among the interesting species collected by the expedition, *Lysilla loveni* (DEB-stations 1, 2, 6, and 15) has only been found twice earlier in the North Sea, i.e., off Oostende/Belgium (Channel) and close to the Norwegian Trough (HARTMANN-SCHRÖDER & STRIPP, 1968). According to MICHAELSEN (1897), this species does not occur in the North Sea proper, but in the Skagerrak, Kattegat, the Sound, and the Belts. HOLTHE (1985) showed a map with the location of living specimens which were primarily from the Scandinavian coast. The type locality is Bohuslän/ Sweden.

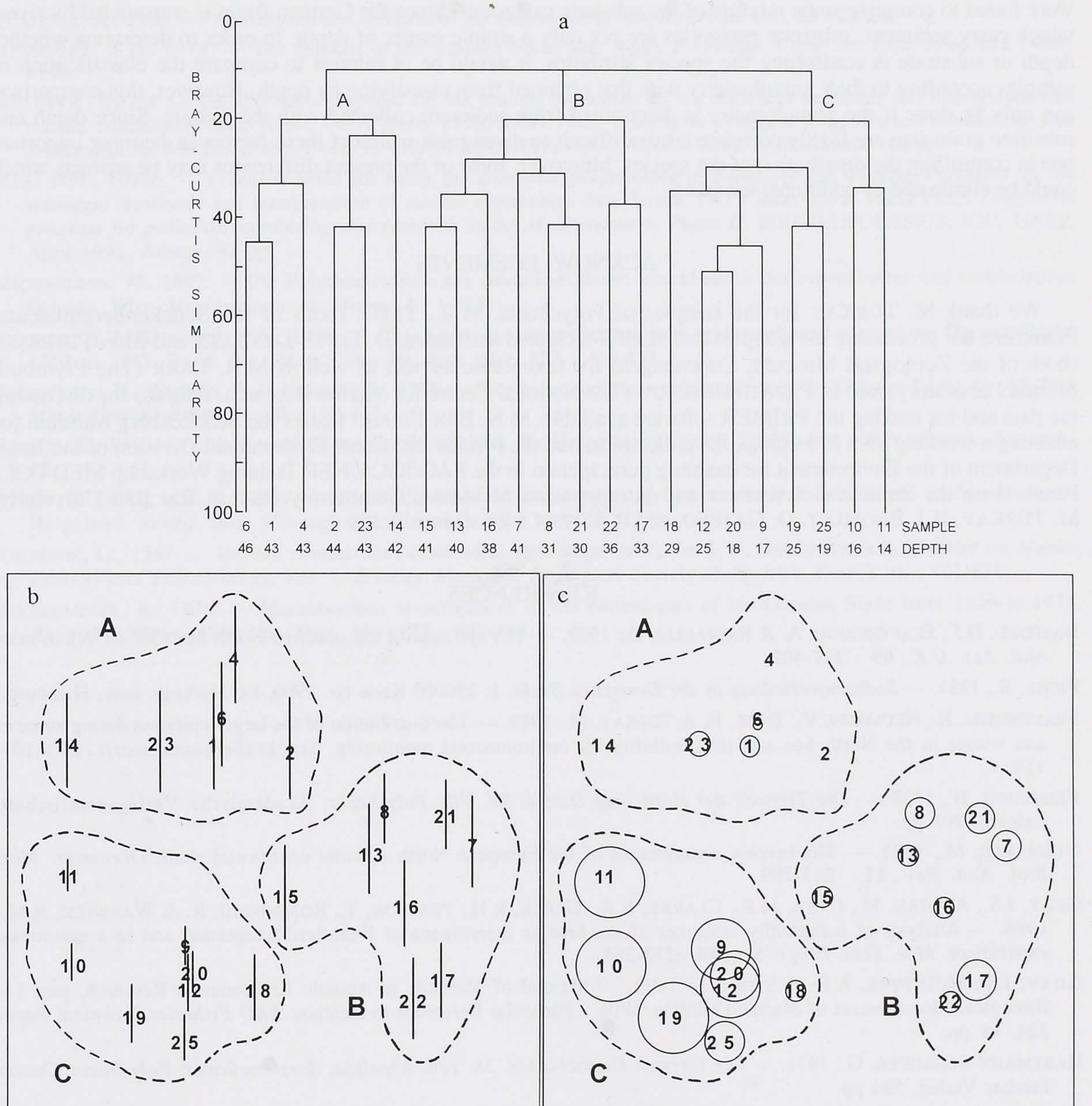

FIG. 2. — DEB 1987 van Veen samples (stations 3 and 5 omitted). a. Classification analysis of polychaete data from DEB 1987 expedition (square root-transformed data with Bray-Curtis dissimilarities). The sample numbers and corresponding depths are shown on the abscissa. b and c. MDS ordination plot of the same data with grouping showing clustering of samples based on species faunistic attributes and with superimposed corresponding scaled environmental parameters. b: depth of samples. The shallowest samples with the shortest lines (cluster C); the deepest samples (cluster A) with the longest lines. c: substrate grain size. The sediment was ranked into seven classes (see Table 1). The largest circles (cluster C) represent the coarsest grain size.

In conclusion, the depth range sampled was sufficiently broad to identify differences in the distribution of some species. The faunal attributes separated broadly both by depth and by substrate type. The selected depth categories were found to comprise some mixture of the substrate categories. Since the German Bight is surrounded by rivers which carry sediment, substrate categories are not only a simple matter of depth. In order to determine whether depth or substrate is controlling the species attributes, it would be of interest to compare the classification of samples according to their granulometry with that obtained from classifying by depth. However, this comparison can only be done if the granulometry is determined from sediment collected with the sample. Since depth and substrate grain size are highly correlated, it is difficult to distinguish which of these factors is the most important one in controlling the distribution of the species. Moreover, some of the present differences may be artifacts which could be eliminated by additional sampling.

ACKNOWLEGEMENTS

We thank M. TÜRKAY for the samples of Polychaeta, M.-L. TRITZ (both of the Senckenbergmuseum, Frankfurt) for processing the samples and skillful technical assistance, D. EIBYE-JACOBSEN and M.E. PETERSEN (both of the Zoological Museum, Copenhagen) for taxonomic advice, as well as M.R. CARR (The Plymouth Marine Laboratory) and E. PAPATHANASSIOU (The National Centre for Marine Research, Athens) for discussing the data and for making the PRIMER software available. M.N. BEN-ELIAHU thanks the Senckenberg Museum for enabling a working visit to examine the collections, and the Marine and Coast Environment Division of the Israel Department of the Environment for enabling participation in the FAO/IOC/UNEP Training Workshop MED POL-Phase II on the Statistical Treatment and Interpretation of Marine Community Data at Bar Ilan University. M. TÜRKAY, H.J. BROMLEY, D. GATEÑO, and R. LOTAN read various drafts.

REFERENCES

BASFORD, D.J., ELEFTHERIOU, A. & RAFFAELLI, D., 1989. — The epifauna of the northern North Sea (56°-61°N). *J. mar. biol. Ass. U.K.*, **69** : 387-407.

FIGGE, K., 1981. — *Sedimentverteilung in der Deutschen Bucht.* 1: 250000 Karte Nr. 2900, Dt. Hydrogr. Inst., Hamburg.

FRAUENHEIM, K., NEUMANN, V., THIEL, H. & TÜRKAY, M., 1989. — The distribution of the larger epifauna during summer and winter in the North Sea and its sensibility for environmental monitoring. *Senckenbergiana marit.*, **20** : 101-118.

FRIEDRICH, H., 1938. — *Die Tierwelt der Nord- und Ostsee. Bd. VIb. Polychaeta.* Akademische Verlagsgesellschaft, Leipzig, 201 pp.

GLÉMAREC, M., 1973. — The benthic communities of the European North Atlantic continental shelf. *Oceanogr. Mar. Biol. Ann. Rev.*, **11** : 263-289.

GRAY, J.S., ASCHAN, M., CARR, M.R., CLARKE, K.R., GREEN, R.H., PEARSON, T., ROSENBERG, R. & WARWICK, R.M., 1988. — Analysis of community attributes of the benthic macrofauna of Frienfjord/Langesund and in a mesocosm experiment. *Mar. Ecol. Progr. Ser.*, **66** : 285-288.

GRAY, J.S., MCINTYRE, A.D. & STIRN, J., 1992. — Manual of Methods in Aquatic Environment Research, part 11-Biological Measurement of Marine Pollution. With a Particular Reference to Benthos. *FAO Fisheries Technical Paper* 324, 48 pp.

HARTMANN-SCHRÖDER, G., 1971. — *Die Tierwelt Deutschlands. 58. Teil. Annelida, Borstenwürmer, Polychaeta.* Gustav Fischer Verlag, 594 pp.

HARTMANN-SCHRÖDER, G. & STRIPP, K., 1968. — Beiträge zur Polychaetenfauna der Deutschen Bucht. *Veröff. Inst. Meeresforsch. Bremerh.*, **11** : 1-24.

HOLTHE, T., 1985. — Polychaeta Terebellomorpha. Marine Invertebrates of Scandinavia No. 7. *Norwegian University Press*, 194 pp.

HYLLEBERG, J. & NATEEWATHANA, A., 1984. — Responses of polychaetes to monsoon and offshore mining associated sediment disturbance. In : P. HUTCHINGS (ed), *Proc. First International Polychaete Conference*. Linnean Society of New South Wales : 279-291.

JONES, M.L., 1977. — A redescription of *Magelona papillicornis* O.F. Müller. In : D. REISH & FAUCHALD, K. (eds), *Essays on polychaetous annelids in memory of Dr. Olga Hartman.* Allan Hancock Foundation, University of Southern California, Los Angeles : 247-266.

KIRKEGAARD, J.B., 1969. — A quantitative investigation of the central North Sea Polychaeta. *Spolia Zool. Mus haun.*, **29** : 1-284.

KÜNITZER, A., 1990. — The infauna and epifauna of the central North Sea. *Meeresforsch.*, **33** : 23-37.

MCINTYRE, A.D., 1978. — The benthos of the western North Sea. *Rapp. P-v. Réun. Cons. int. Expl. Mer,* **172** : 405-417.

MED POL, 1992a. — Lecture notes prepared for the training workshop on the statistical treatment and interpretation of marine community data. Israel, 14-19 June, 1992. MED POL: *Long-term program for pollution monitoring and research in the Mediterranean. Phase II.* FIR/MEDPOL/ISR/3. IOC, UNEP, April 1992, Athens, 148 pp.

MED POL, 1992b. — Practical notes for using the computer programmes prepared for the training workshop on the statistical treatment and interpretation of marine community data. Israel, 14-19 June, 1992. MED POL: *Long-term program for pollution monitoring and research in the Mediterranean. Phase II.* FIR/MEDPOL/ISR/3. IOC, UNEP, April 1992, Athens, 92 pp.

MICHAELSEN, W., 1897. — Die Polychaetenfauna der deutschen Meere einschließlich der benachbarten und verbindenden Gebiete. *Wiss. Meeresunters. dt. Meere.*, **2** : 1-215.

RACHOR, E. & GERLACH, S.A., 1978. — Changes of the macrobenthos in a sublittoral sand area of the German Bight, 1967 to 1975. *Rapp. P-v. Réun. Cons. int. Expl. Mer,* **172** : 418-431.

SALZWEDEL, H., RACHOR, E. & GERDES, D., 1985. — Benthic macrofauna communities in the German Bight. *Veröff. Inst. Meeresforsch. Bremerh.*, **20** : 199-267.

STRIPP, K., 1969. — Die Assoziationen des Benthos in der Helgoländer Bucht. *Veröff. Inst. Meeresforsch. Bremerh.*, **12** : 95-141.

STRIPP, K. , GERLACH, A., 1969. — Die Bodenfauna im Verklappungsgebiet von Industrieabwässern nordwestlich von Helgoland. *Veröff. Inst. Meeresforsch. Bremerh.*, **12** : 149-156.

THORSON, G., 1957. — Bottom communities (sublittoral or shallow shelf). *In*: J. W. HEDGPETH (ed), *Treatise on Marine Ecology and Paleoecology, Vol. 1. Ecology*, Mem. **67**, Geological Society of America, New York : 461-534.

ZIEGELMEIER, E., 1978. — Macrobenthos investigations in the eastern part of the German Bight from 1950 to 1974. *Rapp. P-v. Réun. Cons. int. Expl. Mer*, **172** : 432-444.