RIVER DEBEN ESTUARY
SUBTIDAL BIOLOGICAL SURVEY
MARCH 1992

M W JOHNSON
MARINE BIOLOGIST

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CONTENTS

1 SUMMARY

A sub-tidal biological survey of the River Deben estuary was undertaken during March 1992.

Biological quality in terms of invertebrate diversity was good throughout the middle and lower estuary. In the upper estuary, diversity was moderate. This was attributed to the transient low salinities that this part of the estuary experiences.

Invertebrate production was high in comparison to other Eastern Area estuaries, suggesting a general enrichment of the estuary.

2 INTRODUCTION

This report details the current biological status of the sub tidal River Deben Estuary, Suffolk.

Previous surveys of the invertebrate animal communities of the Deben Estuary have been limited to the intertidal zone (Unicomarine, 1990). In addition this survey was limited to just three sites and formed part of the 1990 NRA survey of all eastern area estuaries.

The present survey is part of NRA eastern area's rolling programme of marine surveillance. Since it is the first subtidal survey of the estuary, it can be regarded as a baseline against which future changes can be measured.

Recent enhanced monitoring of the River Deben estuary has shown it to be the most enriched of the Eastern area estuaries, in terms of TON concentrations and Chlorophyll a values. As such, it has been forwarded for designation under the Urban Waste Water treatment Directive (UWWD). Whether conditions in the water column have an effect on the subtidal community can be addressed by comparison with data from other nearby estuaries, (eg. River Stour).

The upper river drains a predominantly agricultural catchment. However, treated sewage effluent from Woodbridge and Melton sewage works enters the estuary in its upper reaches, possibly contributing to its eutrophic conditions.

In common with other East coast estuaries, the River Deben has a high conservation profile. It is an internationally important site for waders and wildfowl, in particular Redshank and Brent Geese. There are SSSIs at Ramsholt Cliff and Ferry Cliff. The estuary also forms part of the Suffolk River Valley Environmentally Sensitive Area.

Commercial activities on the estuary are negligible, there being no major fin or shell fisheries.

3i DETAILS OF SURVEY

In March 1992, a series of 12 subtidal sites on the River Deben were sampled (Fig. 1). Samples were collected using a 0.1m^2 Day Grab operated from the NRA survey vessel Sea Vigil. A total of four replicates were taken at each site for subsequent biological analysis. A small sub-sample from each replicate was also taken for particle size analysis.

Grab samples were sieved on deck through a 0.5mm mesh sieve and preserved in 4% formalin. Laboratory processing included thoroughly washing the samples to remove formalin traces and sorting using a low power binocular microscope. Laboratory analysis was undertaken by Rosemary Fair Services Ltd. Particle size analysis was undertaken using the technique of Laser Diffraction (contracted to Hull University).

Site location and depth was by Sea Vigil's Global Positioning System (GPS) and echo sounder respectively.

3ii STATISTICAL ANALYSIS

The large data matrix produced from benthic macroinvertebrate surveys necessitates the use of multivariate statistics to analyze multi species distributions. Basically a comparison is being sought between assemblages which may differ in species composition, but also in the numbers of individuals of those species present.

The raw data was processed using the primer suite of programmes developed by Plymouth Marine Laboratory. There are four basic stages in the analytical process.

a) Transformation of the data

Given the potentially wide variation of numbers of particular species, a means of condensing the data is needed. The root root (√√) transform was chosen since it lessens the importance of numerically dominant taxa compared to untransformed

data. The technique of standardisation was used for analysis of species similarities.

b) Similarity Matrix

Each sample is compared with every other sample resulting in a percentage similarity matrix. The Bray Curtis measure of similarity was chosen because this measure is not affected by joint absences of species.

c) Classification

A dendrogram is produced from the similarity matrix . The 'group average sorting' technique was chosen. This technique joins groups of samples together at the average level of similarity between all members of one group with all members of the other.

d) Ordination

Multi Dimensional Scaling (MDS) produces an ordination of N stations in a specified number of dimensions (Kruskal & Wish, 1978). This complements dendrogram analysis in that samples are grouped together using an independent technique. Therefore, should the two analyses give similar groupings, then a relationship can be inferred between the samples.

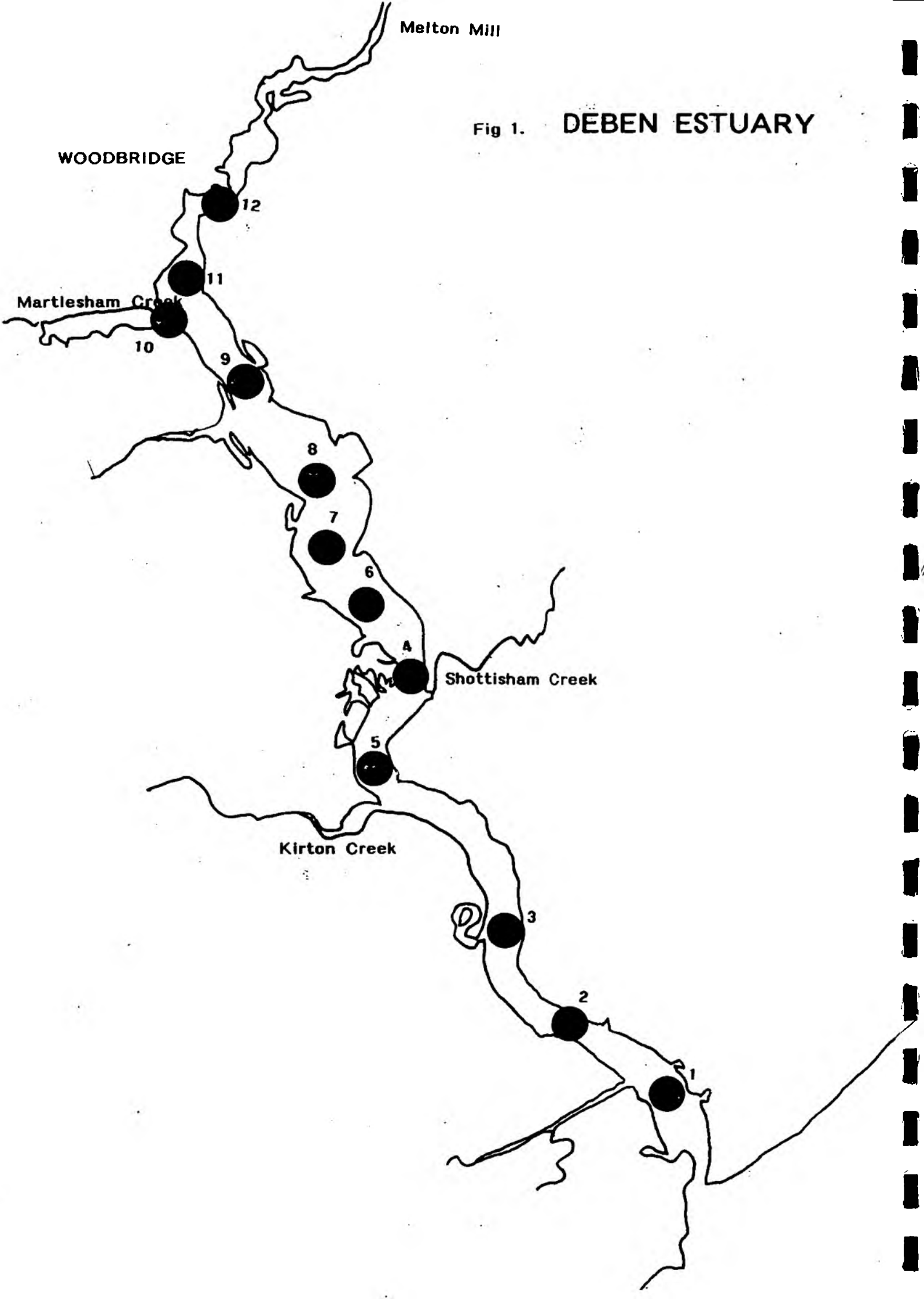


Fig 1. DEBEN ESTUARY

4 RESULTS

A total of 124 taxa were recorded from the twelve subtidal sites throughout the River Deben. The data matrix is presented in Appendix 1, with numbers expressed as numbers per grab.

Figures 2 and 3 show total numbers of taxa and total numbers of individuals per site. Species richness was lowest at site 11 (10 species) and highest at site 5 (52 species). Invertebrate abundance was also lowest at site 11 (1500 individuals /square metre) and highest at site 5 (27000 individuals / square metre).

The dominant organism throughout the majority of the estuary was the polychaete worm, *Tharyx sp.*. Figure 4 illustrates the abundance of this worm throughout the Deben estuary. The three upstream sites (Sites 10, 11 & 12) supported a fairly uniform, undiverse fauna.

Substrate composition was fairly similar throughout the estuary, being dominated by silts and clays. The two exceptions were site 1 (Felixtowe Ferry) and site 12 (Woodbridge) where mixed sands formed the principle substrate. Results of the sediment analyses are presented in Appendix 2.

4i STATISTICAL ANALYSIS

The cluster analysis of the River Deben invertebrate data produced two principle clusters at a 45% or greater level of similarity (Fig 5). Group 1 linked sites 12, 11, & 10 (ie the upper estuary sites). Group 2 linked sites 9, 8, 7, 6, 5, 4, 3 & 2. Site 1 had a similarity of < 30% with any other site.

The MDS ordination plot (Fig 6) independently reinforced the results from the cluster analysis and showed similar site groupings. Site 1 was again found to be an outlier from both groups.

Fig 2.

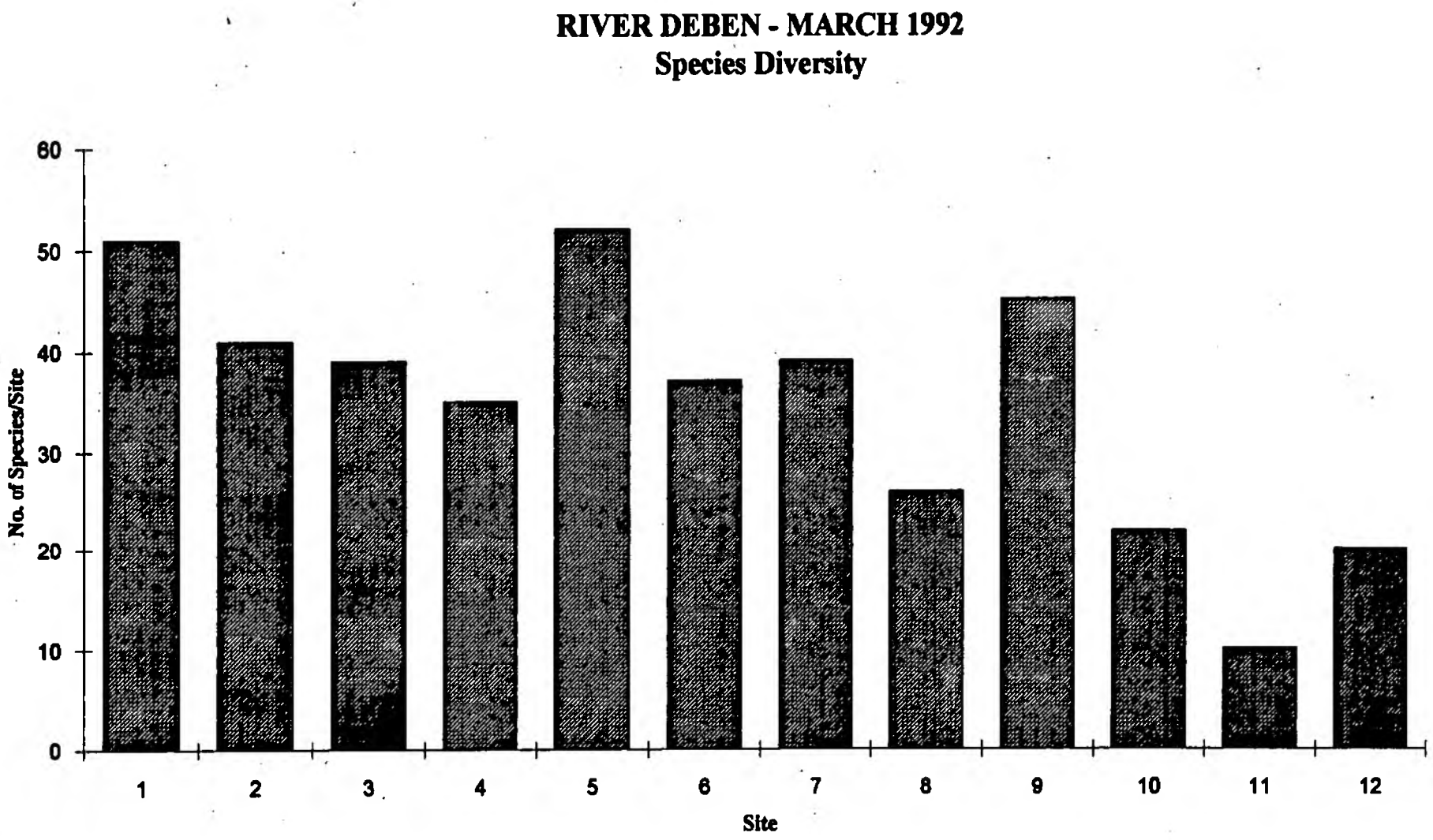
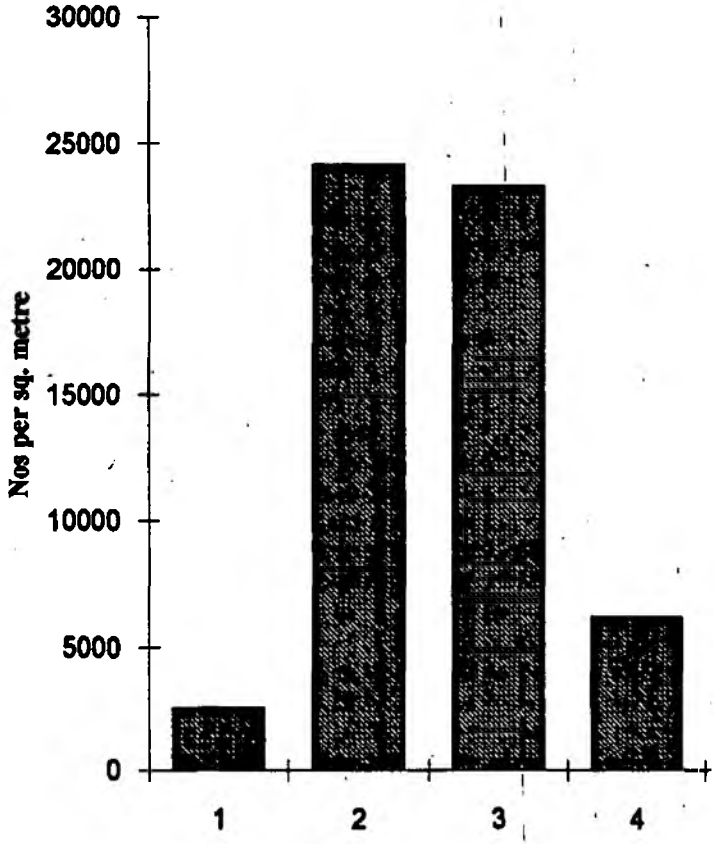

RIVER DEBEN - MARCH 1992
Species Diversity
No. of Species/Site
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Site

Fig 3.



RIVER DEBEN - MARCH 1992
Invertebrate Abundance

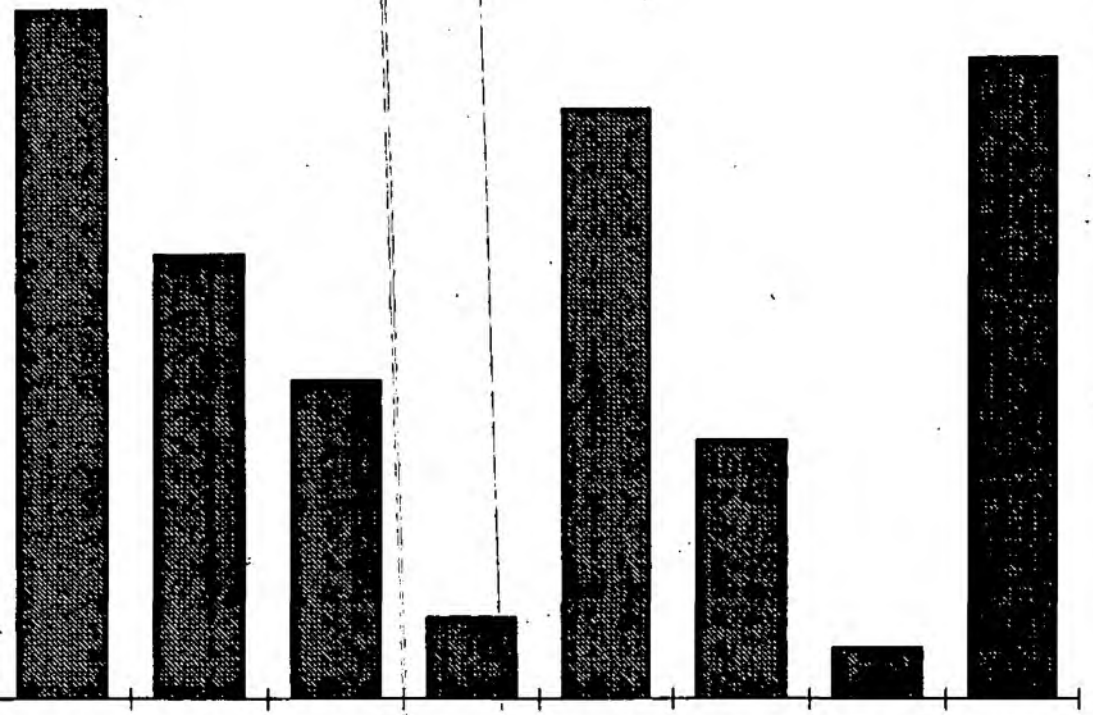


Fig. 4

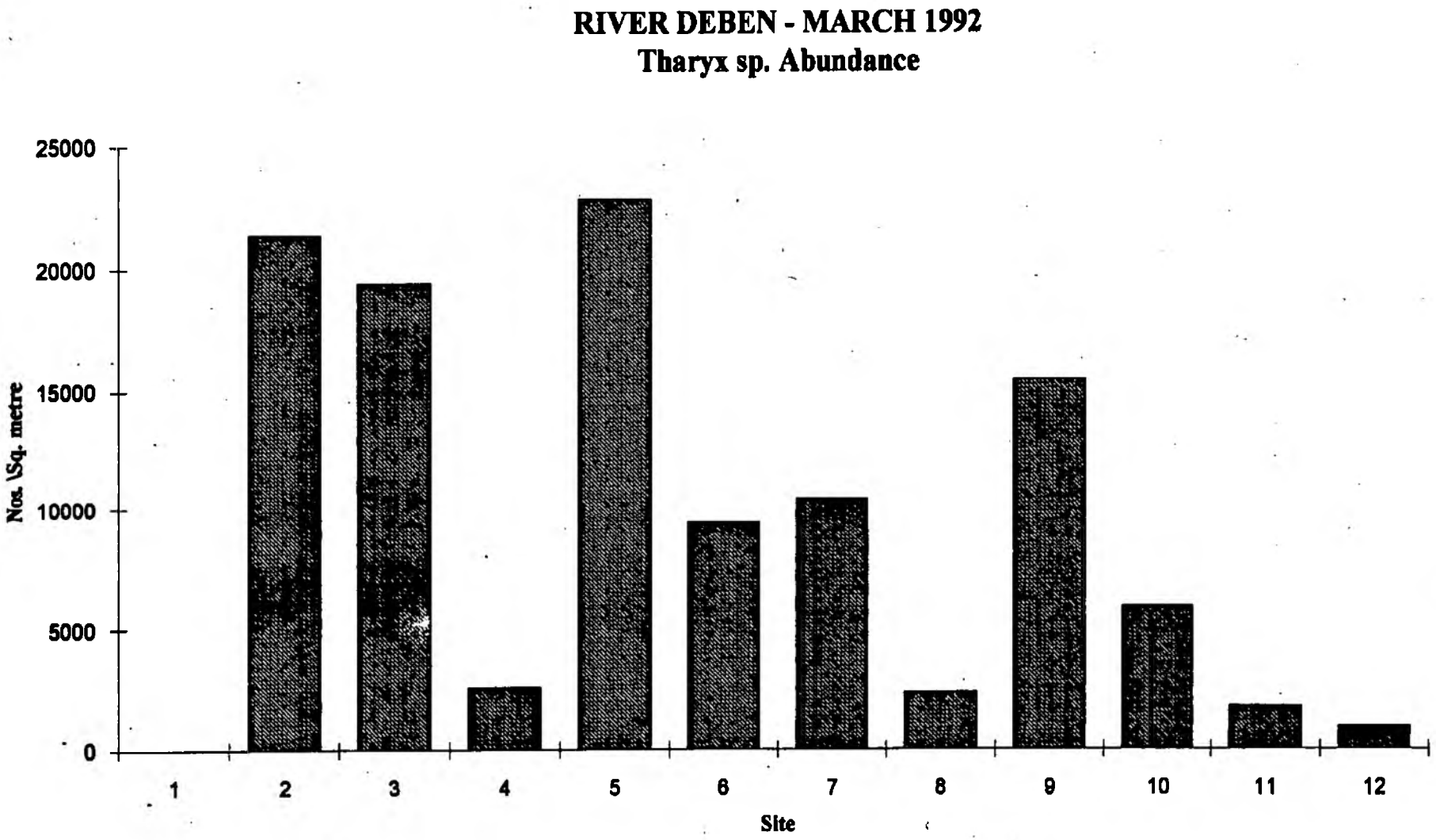

RIVER DEBEN - MARCH 1992
Tharyx sp. Abundance
25000
20000
15000
10000
5000
0
Nos. \Sq. metre
1
2
3
4
5
6
7
8
9
10
11
12
Site

Fig 5. RIVER DEBEN – SIMILARITY BETWEEN SITES

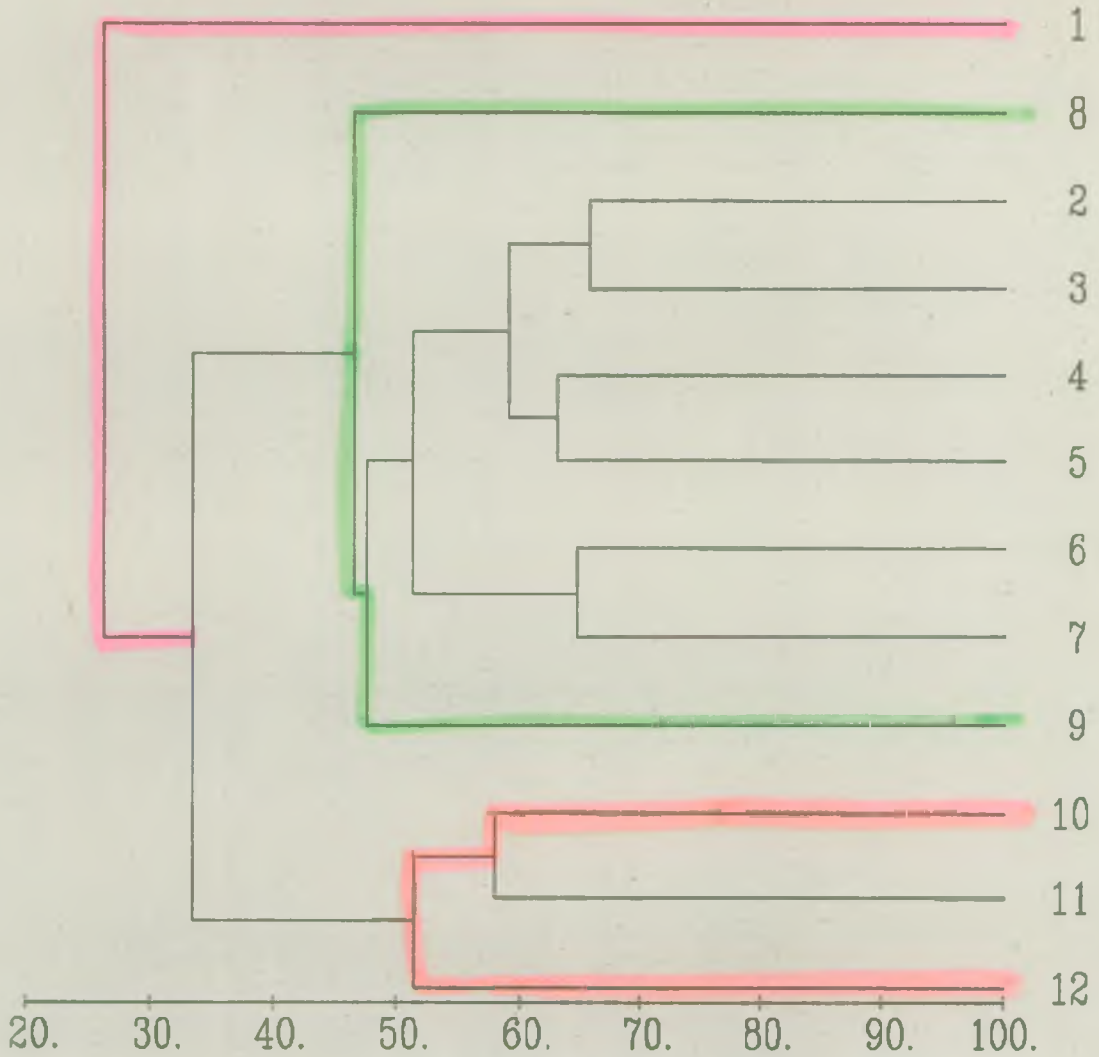
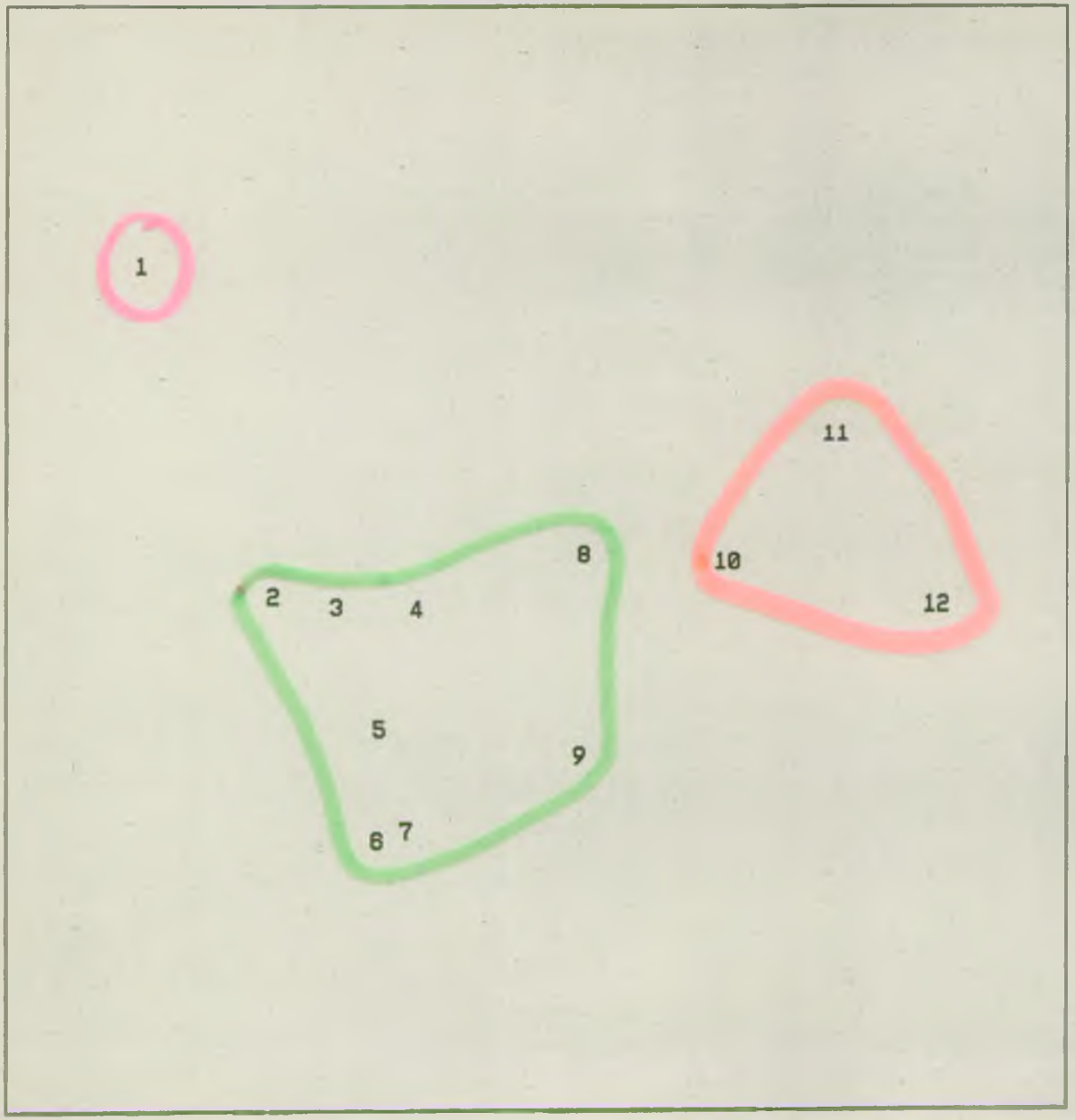


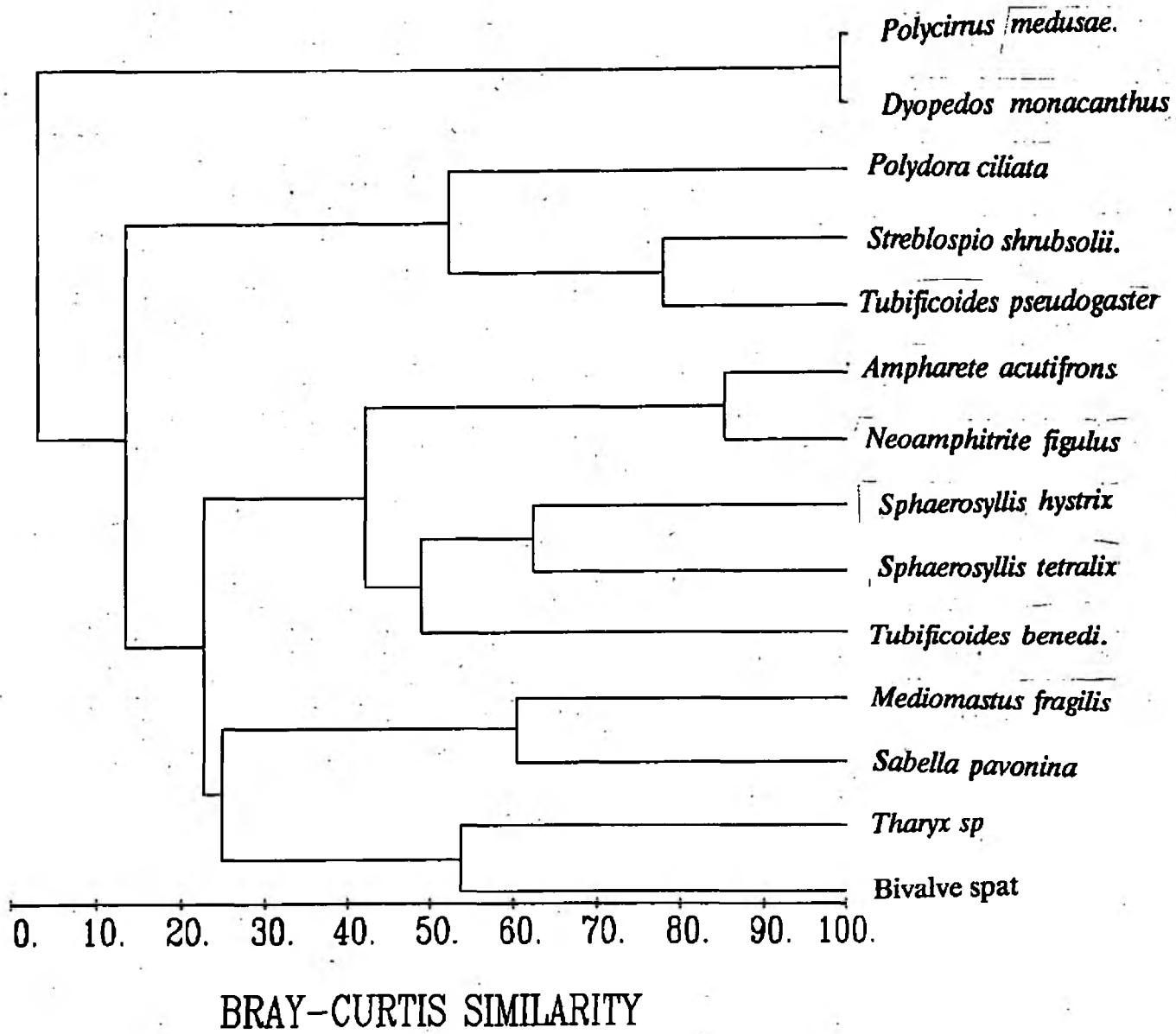
FIG 6. MDS PLOT OF RIVER DEBEN SITES



4ii FAUNAL CONSTITUENTS OF THE MAIN GROUPS

Figure 7 illustrates a cluster analysis of species occurring at >5% at any particular site. These species clustered into five groups (with similarities of greater than 45%). Species group 1 included the amphipod, *Dyopedos monacanthus* and polychaete *Polycirrus medusae*. The site that typified this assemblage was site 1 (ie. Felixtowe Ferry). Species group 2 included the oligochaete worm *Tubificoides pseudogaster* and the polychaetes, *Polydora ciliata* and *Streblospio shrubsolii*. This assemblage (Group 2) characterised sites 10, 11 and 12 (ie. the upper estuary at Martlesham Creek and around Woodbridge). Species group 3 included the polychaetes *Ampharete acutifrons*, *Neoamphitrite figulus*, *Sphaerosyllis hystrix* and *Sphaerosyllis tetralix*; and the oligochaete *Tubificoides benedi*. These characterised sites within the middle estuary. Species group 4 included the polychaetes, *Sabella pavonina* and *Mediomastus fragilis*. These species typified the silty sites 7 and 8.

Fig 7. RIVER DEBEN – SPECIES SIMILARITY (> 5% ABUNDANCE)



5 DISCUSSION

The 1992 subtidal survey of the River Deben has revealed the estuary to be of generally good biological quality. Invertebrate diversity (in terms of numbers of species/site) was high (> 35) in 8 of the 9 middle and outer estuary sites. In the upper estuary around Woodbridge and Martlesham Creek, diversity was lower. This was attributed mainly to the transient reduced salinity conditions in this part of the estuary. No relationship was clear when environmental variables such as median particle size; % clay/silt ; % organic carbon and depth were superimposed on the multi dimensional scaling plot of the sample sites (Appendix 4). Had interstitial salinities been measured it was considered likely that this parameter would have been the principle factor influencing community structure.

Invertebrate production fluctuated throughout the estuary. However most silty sites supported communities of between 15000 and 30000 individuals per square metre. In comparison with other Eastern area estuaries, this was considered to be high, suggesting a general enrichment of the estuary. That is, invertebrate abundance was of a similar magnitude to the upper Orwell estuary which is known to suffer from organic enrichment. The polychaete worm *Tharyx sp.* was dominant at most sites, often exceeding 90% of the total individuals for the site. However, a variety of other species were always present thus maintaining diverse communities at these sites.

Figures 8 and 9 compare the faunal composition of the Deben estuary with results from other NRA surveys of east coast estuaries. Figure 9 shows the Deben to compare well with the Blackwater and Stour (good quality estuaries) in terms of invertebrate diversity. Figure 8 illustrates the dominance of polychaete worms in the Deben (81% of total individuals). This is greater than any other Eastern Area estuaries (largely caused by the enhanced numbers of *Tharyx sp.*).

Fig 8 Comparison of Deben community with other estuaries

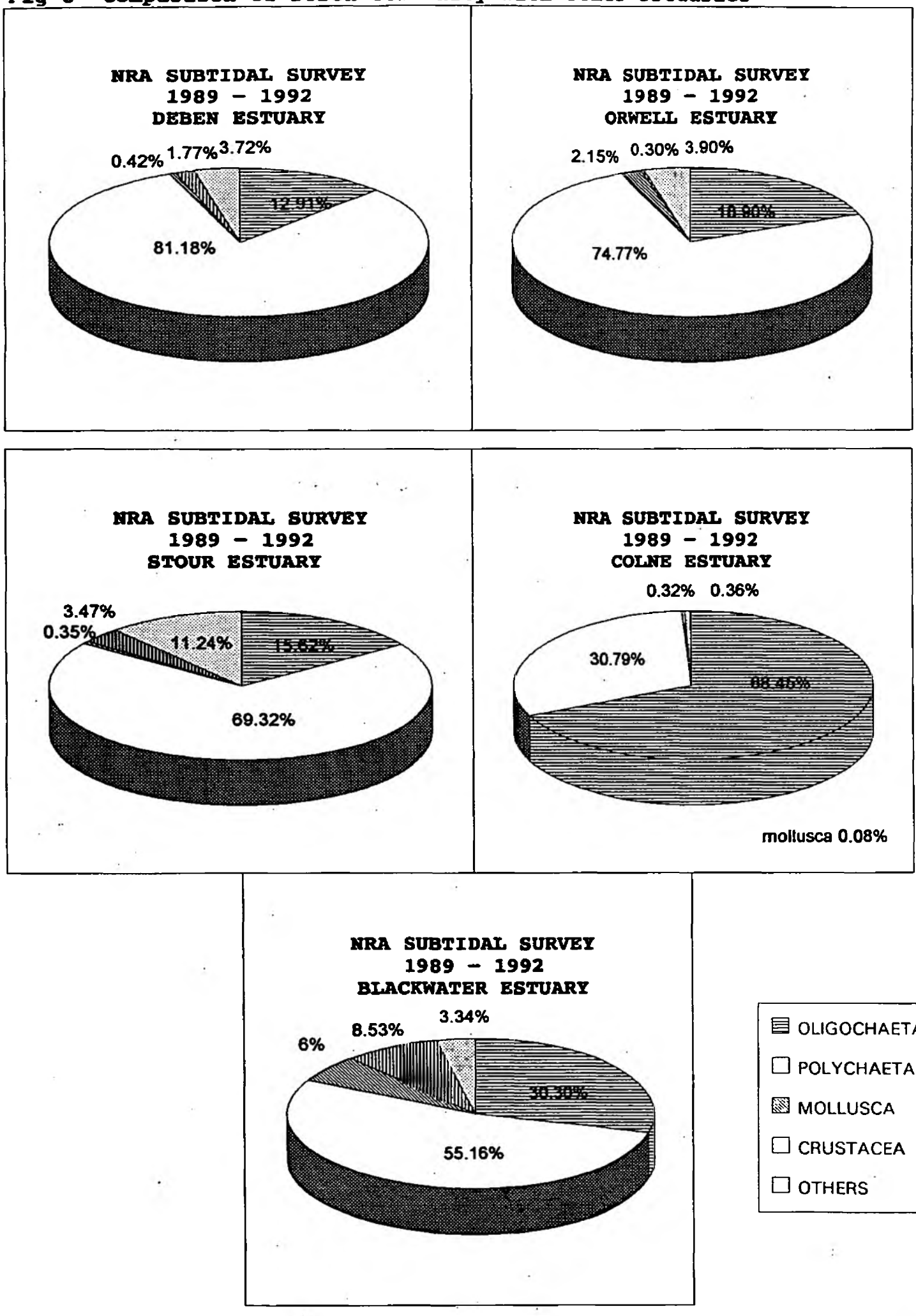
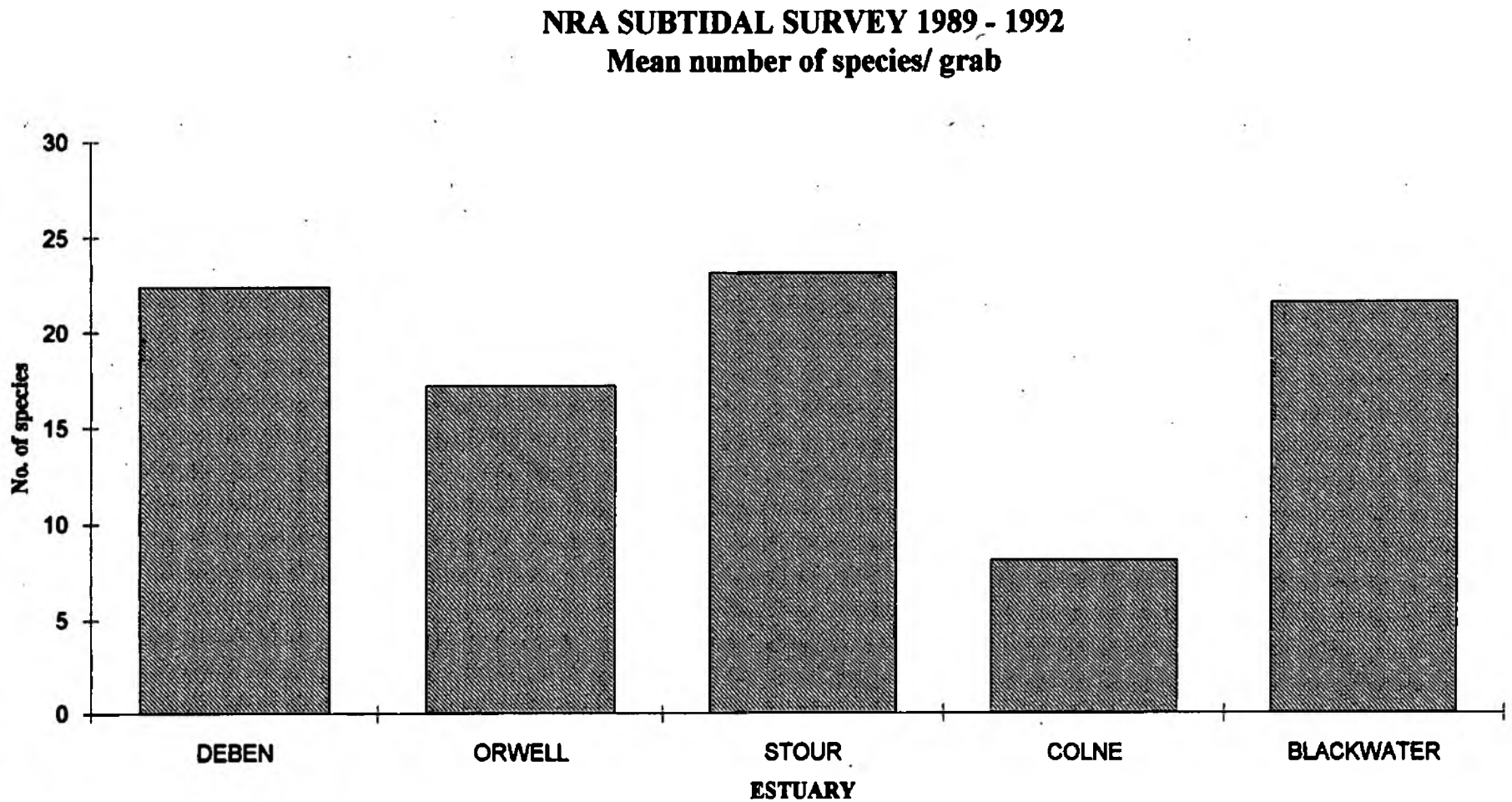


Fig. 9 COMPARISON OF SUBTIDAL DIVERSITY WITH OTHER EAST COAST ESTUARIES



6 REFERENCES

1. Kruskal and Wish (1978). Multi Dimensional Scaling. Sage Publications, Beverly Hills, California.

7 APPENDICES

Appendix 1.

DEBEN ESTUARY - MARCH 1992
(No.s. per 0.4m2)

SITES SPECIES	1	2	3	4	5	6	7	8	9	10	11	12
Turbellaria	1	4	0	1	0	0	0	0	0	0	0	0
Nemertinea	4	2	0	0	0	6	3	0	0	4	0	1
Lepidonotus squamatus	4	0	2	0	0	0	0	0	0	0	0	0
Harmothoe imbricata	0	0	0	0	0	1	0	0	0	0	0	0
H. impar	4	0	0	0	3	6	4	0	2	0	0	0
Harmothoe sp	0	0	0	0	2	0	0	0	0	0	0	0
Gattyana cirrosa	0	0	0	0	0	0	2	0	0	0	0	0
Pholoe synophthalmica	4	2	1	0	0	1	0	0	1	0	0	0
Sthenelais boa	0	0	0	0	0	0	1	0	0	0	0	0
Eteone longa	0	0	0	4	0	0	1	0	0	1	0	0
Eumida sanguinea	5	0	0	0	0	0	0	0	0	0	0	0
Kefersteinia cirrata	1	0	0	0	0	0	0	0	0	0	0	0
Brania clavata	0	0	0	0	0	0	0	0	2	0	0	0
Sphaerosyllis bulbosa	13	0	0	0	0	0	0	0	0	0	0	0
S. erinaceus	0	1	2	2	1	3	0	0	23	0	0	0
S. hystrix	317	28	99	43	159	53	13	5	284	0	0	0
S. tetralix	0	36	34	50	46	42	10	3	183	0	0	0
Sphaerosyllis sp	0	0	5	0	1	0	1	0	3	0	0	0
Exogone dispar	0	0	0	0	0	0	0	0	1	0	0	0
E. hebes	0	0	0	0	2	4	0	0	0	0	0	0
E. naidina	5	12	25	30	90	46	15	3	64	2	0	0
Autolytus langerhansi	3	0	0	1	7	1	0	0	21	0	0	0
Proceraea cornuta	0	0	0	0	2	0	0	1	3	0	0	0
Nereis longissima	1	0	0	0	0	0	0	0	0	0	0	0
N. diversicolor	0	0	0	0	2	0	0	0	23	28	18	203
Nephtys caeca	0	1	0	0	0	0	0	0	0	0	0	0
N. cirrosa	1	0	0	0	0	0	0	0	0	0	0	0
N. hombergii	0	16	4	0	11	5	2	9	1	6	1	0
Nephtys sp (juv)	0	8	0	3	3	0	0	0	1	0	0	0
Sphaerodorum gracilis	0	0	0	0	1	0	0	0	1	0	0	0
Glycera lapidum	2	0	0	0	0	0	0	0	0	0	0	0
G. tridactyla	0	4	0	0	0	0	0	0	0	0	0	0
Glycera sp	0	0	0	1	0	0	0	0	0	0	0	0
Marphysa sanguinea	0	0	0	1	0	0	4	0	0	0	0	0
Protodorvillea kefersteini	2	0	0	0	0	1	0	0	0	0	0	0
Ophryotrocha sp	0	0	0	0	0	4	4	0	0	0	0	0
Scoloplos armiger	3	13	5	0	2	0	1	1	0	0	0	0
Aricidea minuta	9	23	3	3	2	0	0	13	2	1	0	0
Polydora ciliata/ligni	3	0	15	102	0	0	0	0	169	1	10	280
Polydora flava	7	1	0	0	0	0	0	0	0	0	0	0
Pygospio elegans	9	16	5	57	1	0	1	6	3	5	1	4
Streblospio shrubsolii	0	1	0	2	3	0	0	126	200	102	15	2985
Caulleriella sp	2	0	1	0	0	0	0	0	0	0	0	0
Cirriformia tentaculata	0	0	0	0	0	20	38	0	0	0	0	0
Tharyx sp	1	6420	5823	778	6833	2838	3151	715	4619	1778	535	283
Chaetozone sp (n)	0	17	30	44	48	5	2	0	0	0	0	0
Cossura longocirrata	0	46	9	1	5	100	4	0	0	0	0	0

Scalibregma inflatum	0	7	0	0	0	0	0	0	0	0	0	0
Ophelina acuminata	1	0	0	0	0	0	0	0	0	0	0	0
Capitella capitata	1	11	17	61	39	10	5	1	23	6	0	0
Mediomastus fragilis	10	26	15	31	106	282	122	0	3	3	0	0
Notomastus latericeus	2	0	0	0	0	0	0	0	0	0	0	0
Arenicola marina	1	0	0	0	0	0	0	0	0	2	0	0
Myriochele heeri	0	0	5	19	3	2	0	11	0	0	0	0
Melinna palmata	0	0	1	2	62	1	16	0	3	0	0	0
Ampharete acutifrons	1	4	0	1	6	9	4	1	204	12	3	1
Neoamphitrite sp	0	0	0	0	1	1	23	0	256	0	0	0
Polycirrus medusa	45	0	0	0	0	0	0	0	0	0	0	0
P. norvegicus	0	0	5	0	50	40	0	0	91	0	0	0
Polycirrus sp	0	1	0	0	0	0	3	2	0	0	0	0
Sabellaria spinulosa	16	1	0	0	0	0	0	0	0	0	0	0
Sabella pavonina	0	0	0	0	2	1032	155	0	0	0	0	0
Manayunkia aestuarina	0	0	0	0	0	0	0	0	0	1	0	0
Pomatoceros lamarckii	35	1	1	0	1	0	0	0	0	0	0	0
Tubifex costatus	0	0	0	0	0	0	0	0	0	1	0	12
Tubificoides pseudogaster	0	0	3	3	8	134	5	21	31	933	11	3146
T. swirencoides	0	6	3	6	69	43	0	1	1	0	0	0
T. benedeni	6	4	12	34	173	580	194	12	604	181	14	337
Enchytraeidae	1	0	0	0	0	0	0	0	0	0	0	0
Oligochaeta UD *	0	285	44	0	0	0	1	0	0	0	0	0
Anoplodactylus pygmaeus	0	0	0	0	0	0	0	0	1	0	0	0
Nymphon sp	0	0	0	0	0	0	0	0	5	0	0	0
Achelia echinata	0	0	3	0	2	0	0	0	0	0	0	0
Halacaridae	0	0	0	1	0	1	0	0	9	0	0	0
Pseudocuma gilsoni	1	0	0	0	0	0	0	0	0	0	0	0
Diastylis bradyi	1	0	0	0	0	0	0	0	0	0	0	0
D. lucifera	0	2	0	0	0	0	0	0	0	0	0	0
Diastylidae	0	0	0	0	1	0	0	0	0	0	0	0
Eudorella truncatula	0	6	0	1	1	0	0	0	0	0	0	0
Bodotria scorpioides	0	0	0	3	6	0	0	0	5	0	0	0
Bodotria sp	0	0	0	0	0	0	0	1	0	0	0	0
Cumella pygmaea	0	0	0	0	3	2	1	0	0	0	0	0
Eurydice pulchra	1	0	0	0	0	0	0	0	0	0	0	0
Janira maculosa	1	0	0	0	0	0	0	0	0	0	0	0
Sphaeroma monodi	32	0	6	0	1	0	0	0	3	0	0	9
Cyathura carinata	0	0	0	0	0	0	0	0	22	1	0	107
Paragnathia formica	0	0	0	0	0	0	0	0	0	0	0	1
Caprella sp	0	2	2	19	49	1	3	9	66	0	0	0
Cheirocratus intermedius	6	0	0	0	1	0	0	0	0	0	0	0
Atylus guttatus	8	1	1	0	0	0	0	0	0	0	0	0
Dyopedos monacanthus	1	2	1	0	0	0	0	0	0	0	0	0
Unicola crenatipalma	122	0	1	0	0	0	0	0	0	0	0	0
Corophium arenarium	4	0	0	0	0	0	0	0	0	0	0	0
C. volutator	29	0	0	2	1	0	1	0	16	0	0	0
Corophium sp	0	0	0	0	0	0	2	0	1	0	0	1
Harpinia pectinata	2	8	1	0	1	0	0	0	0	0	0	0
Aora gracilis	4	0	0	0	1	0	1	0	0	0	0	0
Photis reinhardi	0	1	2	1	6	0	0	2	3	0	0	0
Gitana sarsi	0	0	0	0	3	2	1	0	1	0	0	0

Jassa falcata	0	0	0	0	1	0	3	0	0	0	0	0
Microprotopus maculata	0	0	0	0	7	0	0	4	47	0	0	0
Melita palmata	0	0	0	0	0	0	0	0	6	1	0	270
Leptocheirus pilosus	0	0	0	0	0	0	0	0	0	0	0	1
Amphipod UD	0	0	0	0	1	0	0	0	0	0	0	0
Retusa obtusa	2	0	4	1	9	0	0	0	0	0	0	0
Hydrobia ulvae	0	0	0	0	1	1	1	1	5	24	0	0
Crepidula fornicata	0	0	0	0	4	0	3	0	34	0	0	0
Nucula sp	0	0	0	0	0	2	0	0	0	0	0	0
Mytilidae sp (juv)	1	1	2	0	0	0	1	0	0	0	0	0
Cerastoderma edule	0	0	0	0	0	1	0	1	4	0	0	1
Veneracea	0	1	0	0	0	0	0	0	0	0	0	0
Abra alba	1	0	0	0	0	0	0	0	0	0	0	0
A. prismatica	0	1	0	0	0	0	0	0	0	0	0	0
Abra sp (juv)	0	5	0	0	0	0	0	0	0	0	0	2
Macoma balthica	3	6	15	3	1	21	2	2	3	15	3	7
Ensis sp	0	0	0	0	0	0	0	0	1	0	0	0
Mya arenaria	0	0	0	0	0	0	0	1	0	0	0	1
Mya sp (juv)	0	1	3	3	2	0	1	1	3	0	0	2
Bivalve UD (spat)	0	8	0	0	1	1	0	0	0	0	0	0
Phoronis sp	0	213	791	538	386	5	1	1	0	0	0	0
Ascidean	0	0	0	0	1	0	0	0	0	0	0	0
Ophiothrix fragilis	0	0	2	0	0	0	0	0	0	0	0	0
Ophiura affinis	0	0	1	0	0	0	0	0	0	0	0	0
Ophiura sp (juv)	6	0	0	0	0	0	0	0	0	0	0	0
TOTAL NUMBER OF SPE	51	41	39	35	52	37	39	26	45	22	10	20
TOTAL ABUNDANCE	745	7255	7004	1852	8234	5307	3806	954	7057	3108	611	7654

* Oligochaetes with hair chaetae, bifid setae, no papillations although there is some sub-dermal brown banding posteriorly.
Aora typica = Aora gracilis
□□□□□□□□□□□□□□□

NRA ANGLIAN R. DEBEN SEDIMENT DATA

SAMPLE	MEAN µm	MEDIAN µm	% CLAY& SILT	MEAN Ø	SD Ø	SKEW	KURTOSIS	% ORGANIC CARBON	LOI at 400°	% COAL CONTENT
D1A	39.3	50	58.7	4.7	1.4	1.04	3.43	0.36	1.00	1.00
D1B	212.2	95.7	36.1	2.2	3.84	-0.46	1.87	NEG	NEG	NEG
D1C	44.5	21	75.2	4.5	3.87	-1.43	3.84	1.9	NEG	2.00
D1D	16	19.4	91.8	6	1.51	0.47	2.3	2.17	2.00	3.00
D2A	49.2	30.2	65.5	4.3	3.16	-0.65	2.38	2.11	3.00	3.00
D2B	16.1	18.5	92.4	6	1.46	0.33	2.33	2.67	4.00	3.00
D2C	12.1	13.2	97.8	6.4	1.51	0.24	2.5	2.67	3.00	4.00
D2D	14.8	15.3	92.5	6.1	1.73	-0.62	4.75	2.95	6.00	2.00
D3A	10.6	11.1	99.7	6.6	1.42	0.3	2.29	3.21	7.00	3.00
D3B	17.6	20.8	89.2	5.8	1.52	0.4	2.62	2.83	4.00	3.00
D3C	12.3	12.5	92.9	6.3	1.48	0.04	2.55	2.95	6.00	3.00
D3D	17	19.4	90.8	5.9	1.45	0.37	2.2	2.67	4.00	5.00
D4A	16.6	18.6	96.7	5.9	1.4	0.03	3.53	1.3	1.00	2.00
D4B	15.5	18	90.2	6	1.51	0.35	2.26	2.74	7.00	3.00
D4C	19.2	21.2	83.7	5.7	1.61	0.21	2.38	2.46	4.00	3.00
D4D	19.79	20.09	89.4	5.66	1.78	-0.65	4.15	1.81	NEG	2.00
D5A	14	13.7	93.5	6.2	1.67	-0.85	5.12	2.44	3.00	5.00
D5B	55.8	22.1	71.9	4.2	3.91	-0.87	2.33	2.95	4.00	4.00
D5C	25.8	12.2	81.4	5.3	3.47	-1.26	3.32	3.3	5.00	3.00
D5D	17.2	16.2	89.6	5.9	2.09	-1.18	5.63	2.95	3.00	3.00
D6A	12	12	96.9	6.4	1.43	-0.17	2.98	4.08	6.00	3.00
D6B	15.3	17.6	95	6	1.44	0.42	2.16	4.77	4.00	8.00
D6C	14.7	17.1	90.8	6.1	1.55	0.33	2.21	3.87	5.00	3.00
D6D	15	17.4	96.8	6.1	1.4	0.42	2.15	3.54	5.00	6.00

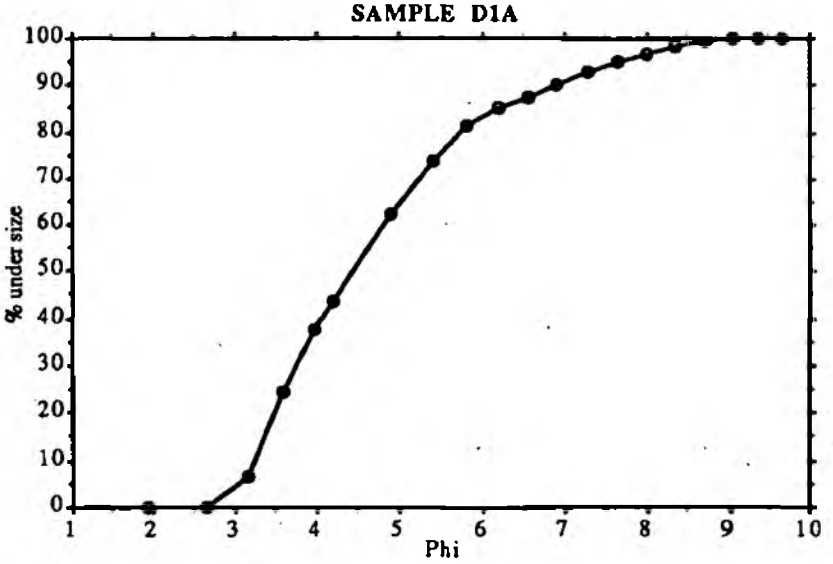
NB NEG=NEGLIGIBLE

NRA ANGLIAN R. DEBEN SEDIMENT DATA

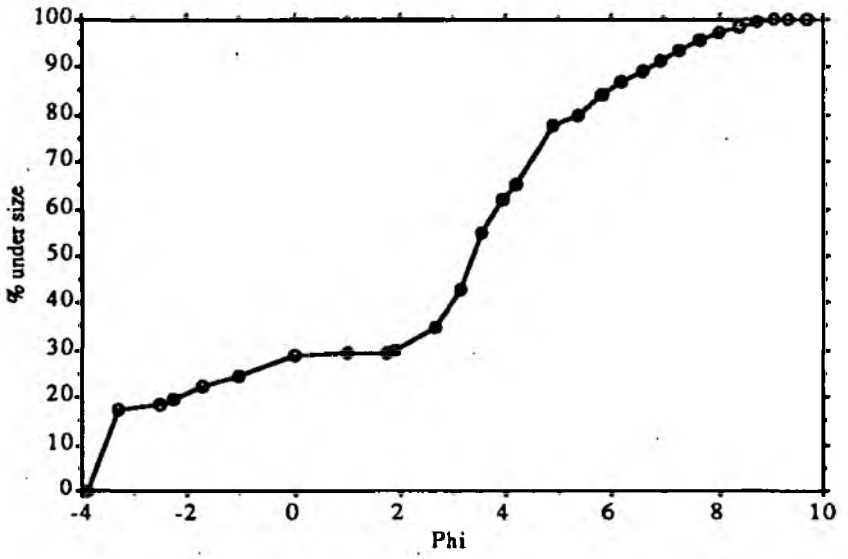
SAMPLE	MEAN µm	MEDIAN µm	% CLAY& SILT	MEAN Ø	SD Ø	SKEW	KURTOSIS	% ORGANIC CARBON	LOI at 400°	% COAL CONTENT
D7A	29.8	19.7	83.6	5.1	3.02	-1.42	4.28	2.81	8.00	3.00
D7B	26.5	17.9	78.9	5.2	2.91	-1.02	3.34	1.3	4.00	5.00
D7C	35.47	20.29	78.72	4.82	3.2	-1.13	3.22	2.74	6.00	5.00
D7D	513.8	1955.3	40.5	1	4.65	0.27	1.32	2.67	3.00	2.00
D8A	22.6	23.9	79.6	5.5	1.7	0.11	2.47	0.29	11.00	2.00
D8B	24.9	22	76.2	5.3	2.14	-0.49	2.8	0.77	1.00	2.00
D8C	12.9	13	93.1	6.3	1.43	-0.01	2.39	1.55	5.00	4.00
D8D	13.2	13.8	93.9	6.2	1.42	0.13	2.16	1.62	3.00	1.00
D9A	50.5	39.3	60.6	4.3	2.68	-0.42	2.48	1.12	NEG	NEG
D9B	36.7	23.8	69.2	4.8	2.63	-0.46	2.17	1.48	3.00	4.00
D9C	45	22.1	72.3	4.5	3.45	-1.06	3.05	2.07	NEG	3.00
D9D	58.3	24.3	70.5	4.1	3.8	-0.97	2.73	1.48	3.00	1.00
D10A	15.2	18.4	94.7	6	1.56	0.3	2.59	5.38	10.00	4.00
D10B	10	10.6	99.5	6.6	1.36	-0.03	3.89	4.5	5.00	4.00
D10C	16	17.7	92.2	6	1.42	0.31	2.11	4.85	7.00	3.00
D10D	11.6	12	97.1	6.4	1.47	-0.28	4.04	4.89	7.00	5.00
D11A	44.3	45.2	61	4.5	1.99	0.06	2.31	3.38	3.00	2.00
D11B	18.8	16.7	83.4	5.7	1.92	-0.7	3.49	2.63	2.00	3.00
D11C	18.6	19.3	84	5.7	1.65	0	2.33	0.98	2.00	2.00
D11D	19.7	19.2	83.3	5.7	1.79	-0.31	2.66	1.4	NEG	2.00
D12A	261.31	398.33	18.82	1.94	2.16	0.92	3.24	0.29	NEG	2.00
D12B	184.1	295.7	28	2.4	2.6	0.26	2.88	0.36	NEG	NEG
D12C	161	286.2	35.8	2.6	3.01	0.12	2.27	0.3	3.00	1.00
D12D	164.6	269.92	27.17	2.6	2.28	0.45	2.61	1.05	3.00	2.00

NB NEG=NEGLIGIBLE

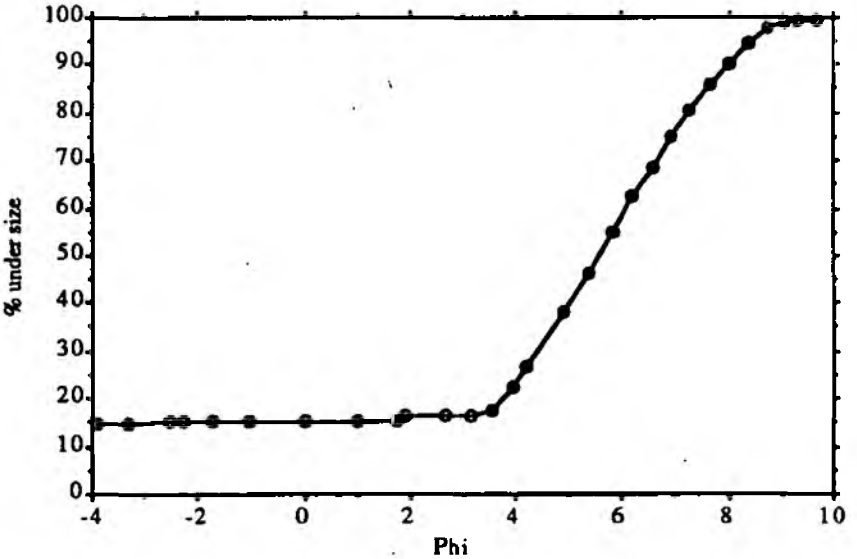
SAMPLE D1A



SAMPLE D1B

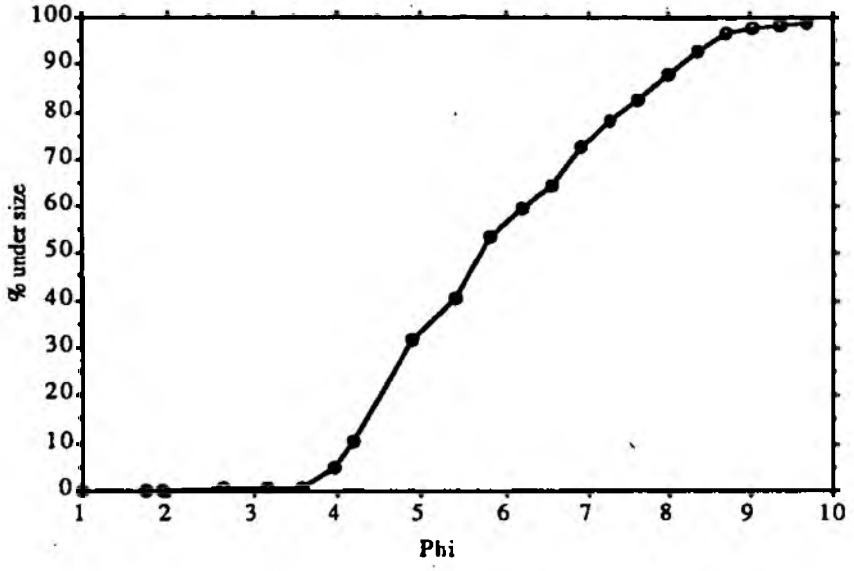


SAMPLE D1C

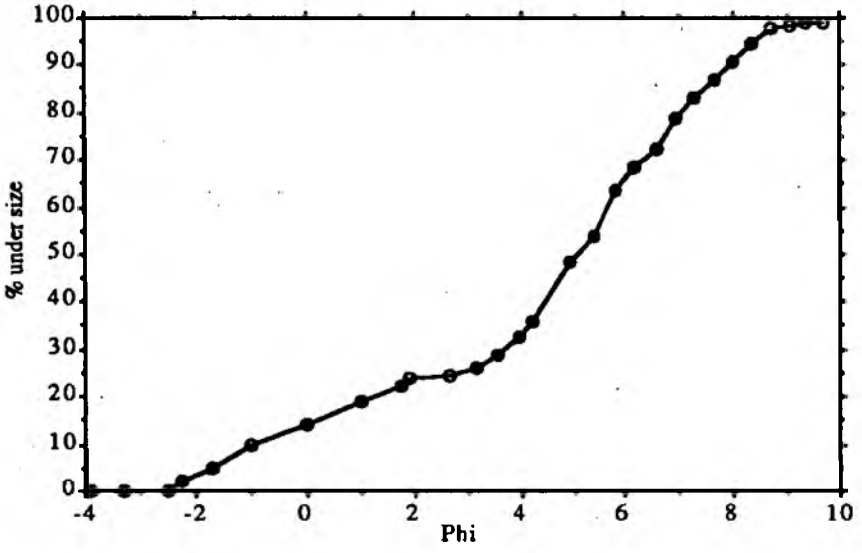


NRA Anglian Region - River Deben Survey 1992	**Institute of Estuarine and Coastal Studies**
Grain Size Distribution	**University of Hull**

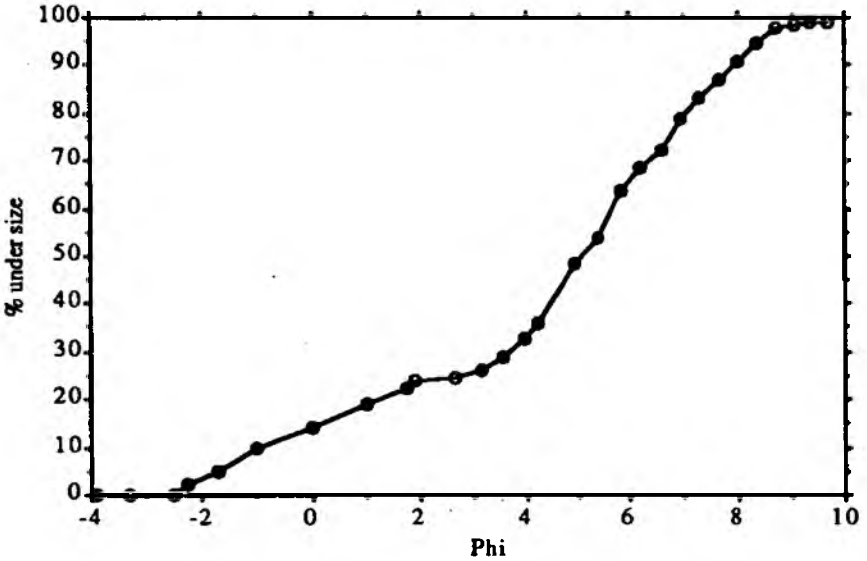
SAMPLE D1D



SAMPLE D2A

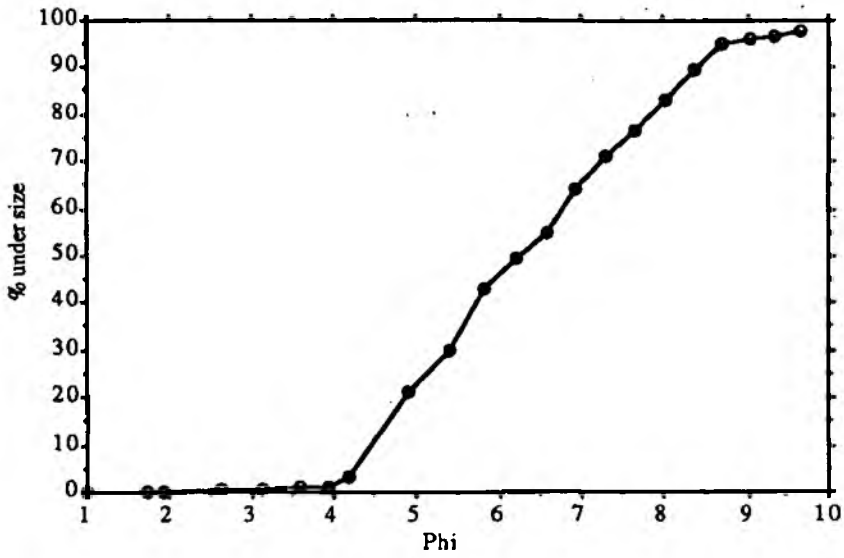


SAMPLE D2B

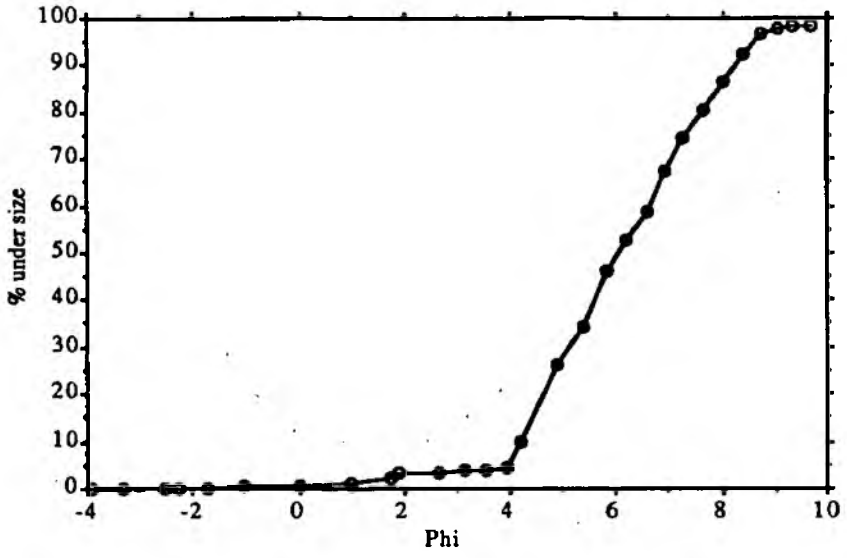


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies University of Hull
Grain Size Distribution	

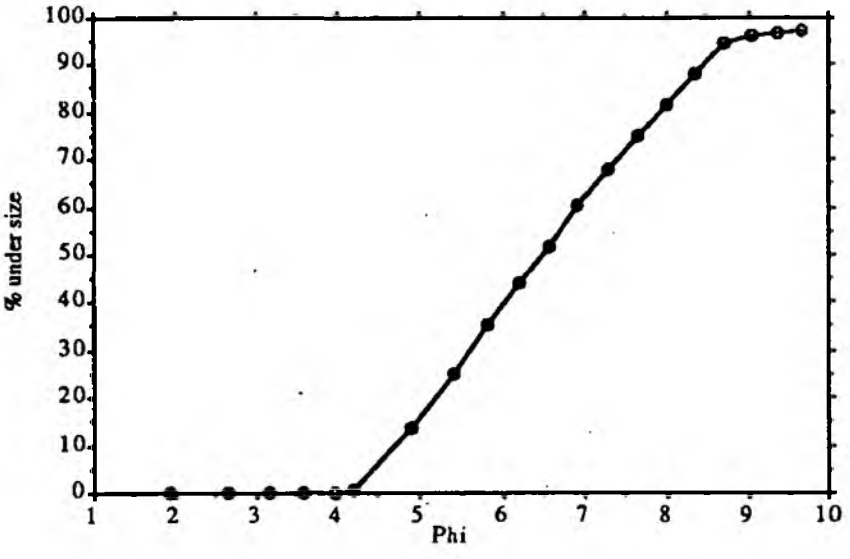
SAMPLE D2C



SAMPLE D2D

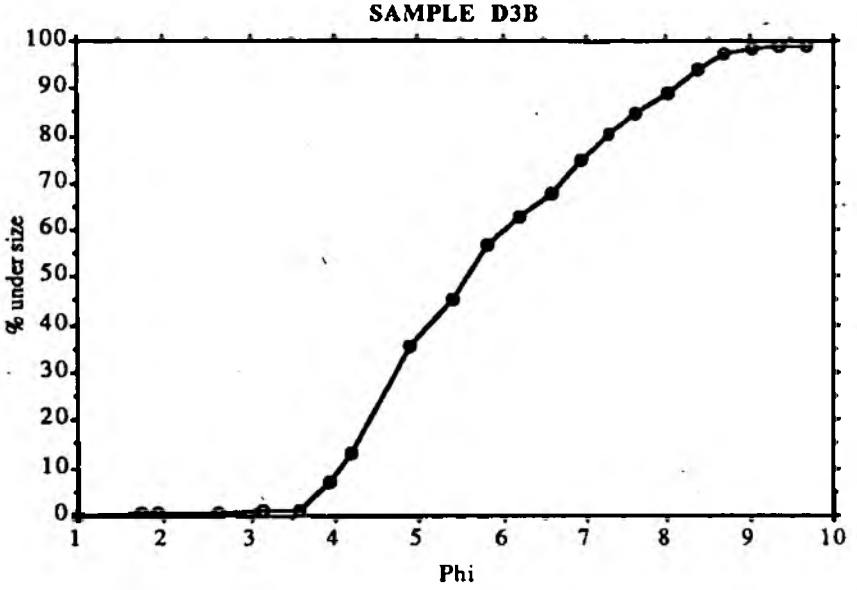


SAMPLE D3A

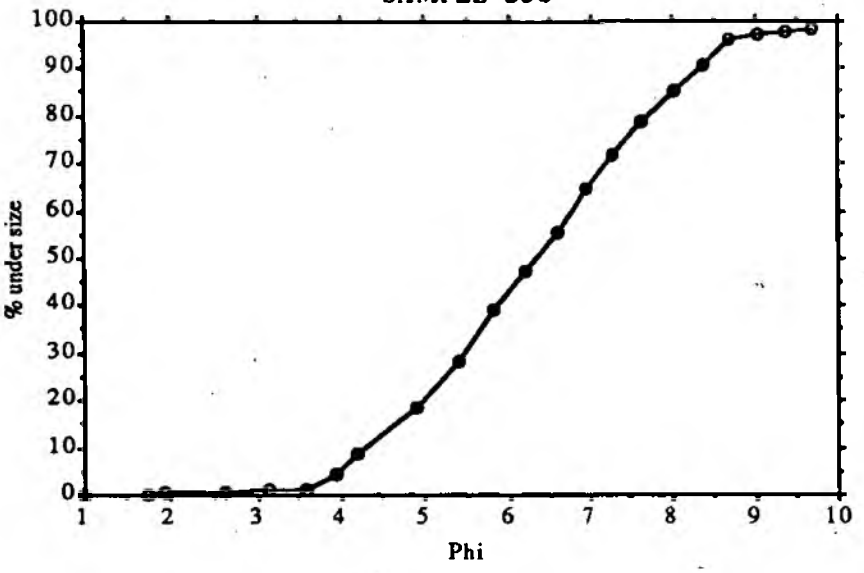


NRA Anglian Region - River Deben Survey 1992	**Institute of Estuarine and Coastal Studies**
Grain Size Distribution	**University of Hull**

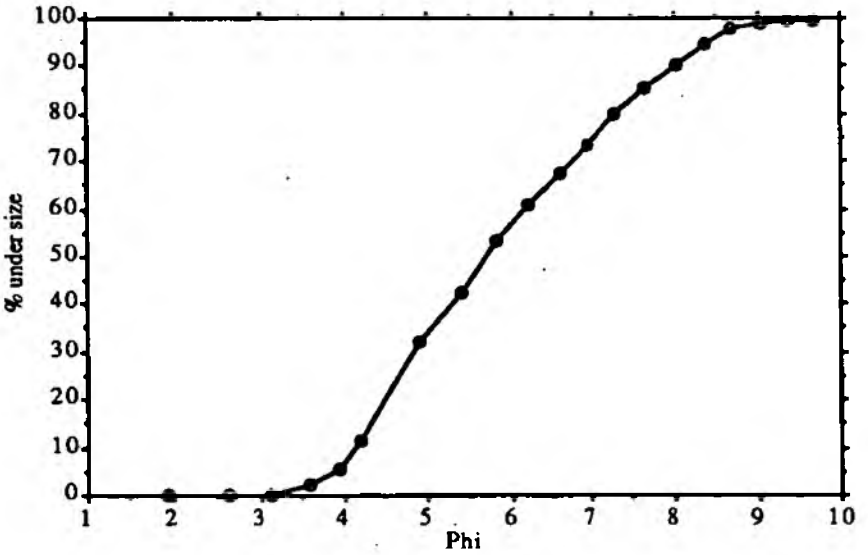
SAMPLE D3B



SAMPLE D3C

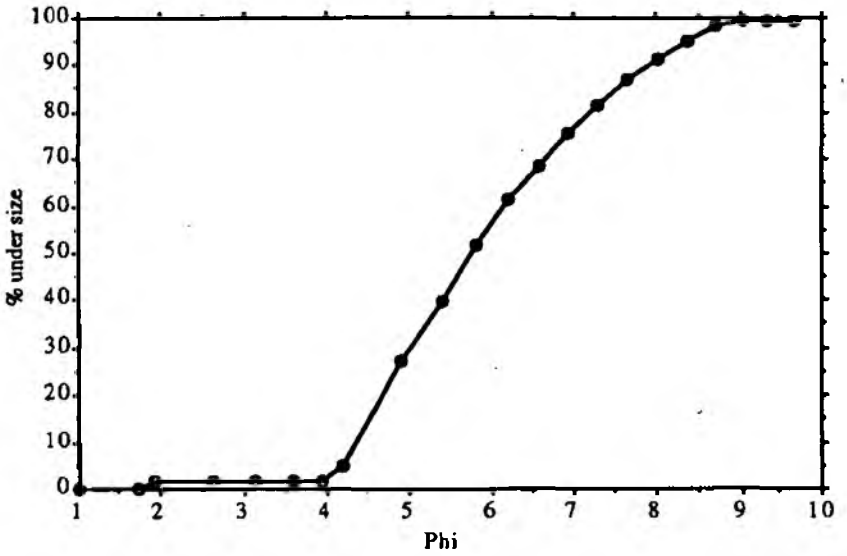


SAMPLE D3D

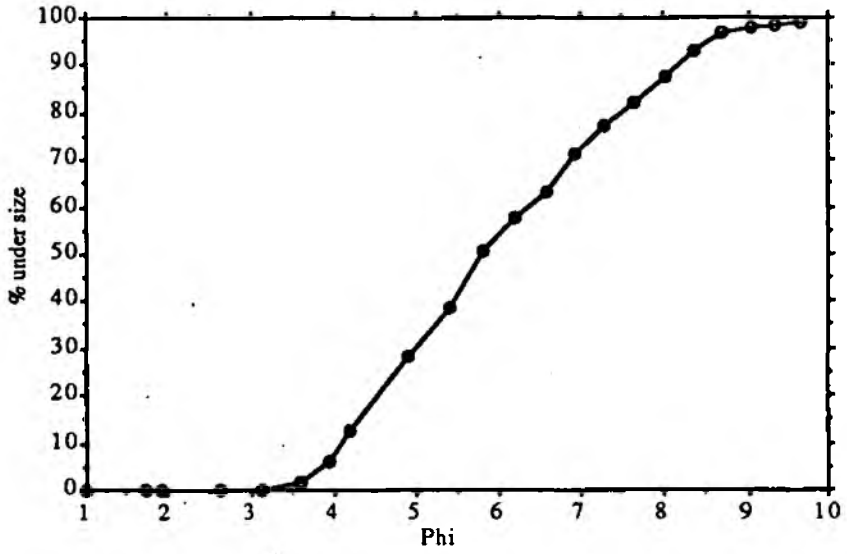


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies University of Hull
Grain Size Distribution	

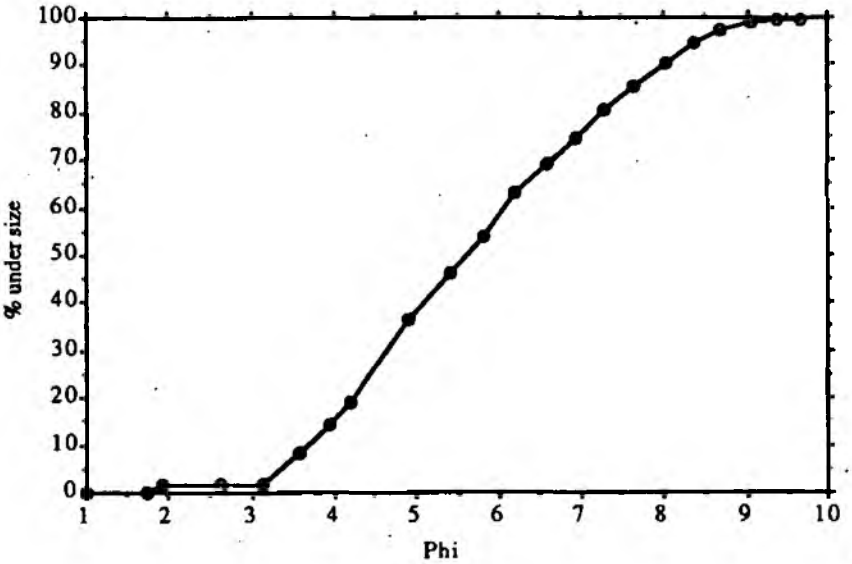
SAMPLE D4A



SAMPLE D4B

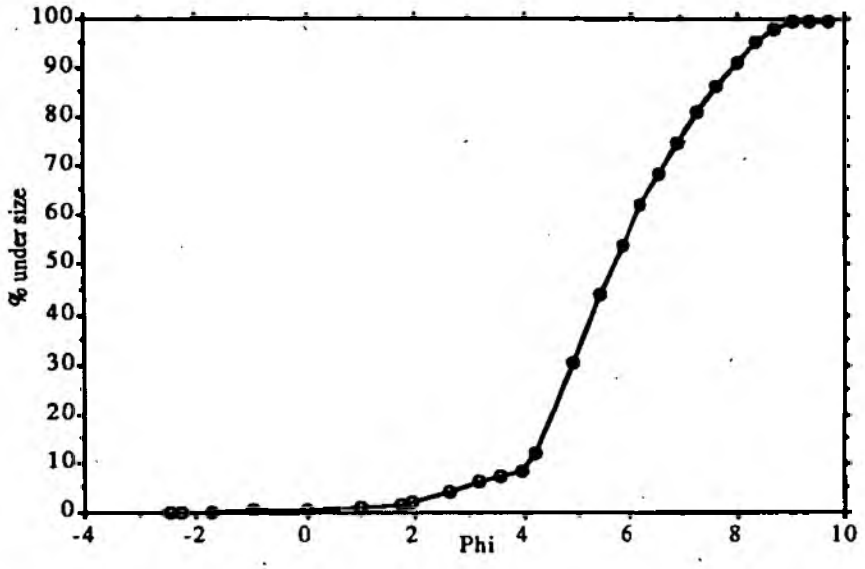


SAMPLE D4C

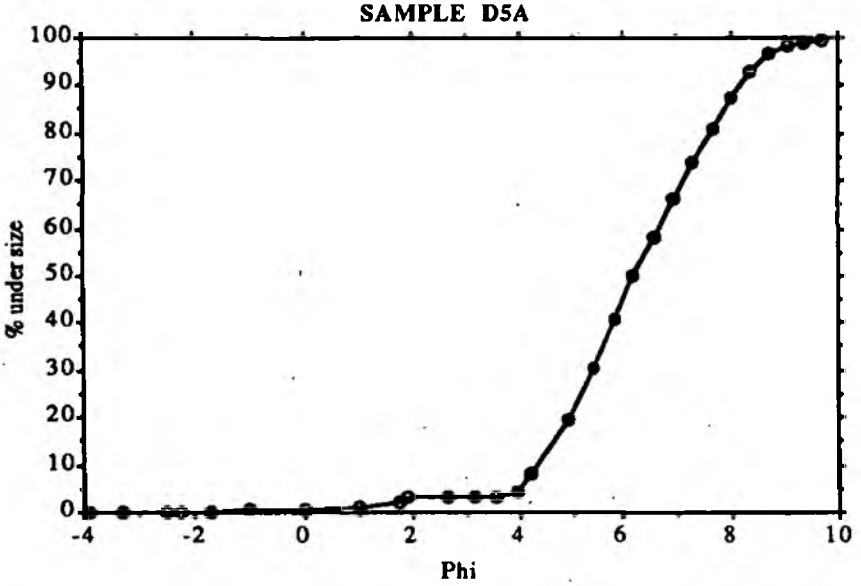


NRA Anglian Region - River Deben Survey 1992	**Institute of Estuarine and Coastal Studies**
Grain Size Distribution	**University of Hull**

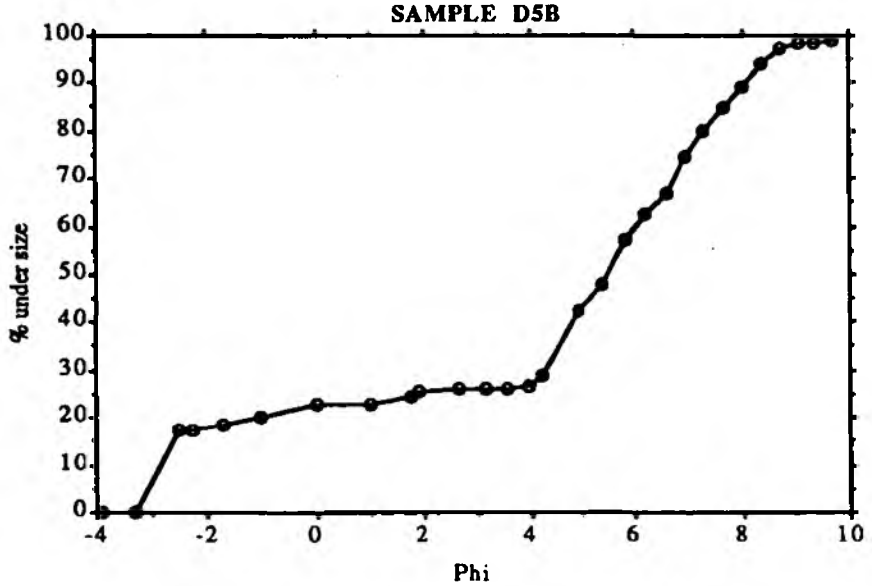
SAMPLE D4D



SAMPLE D5A

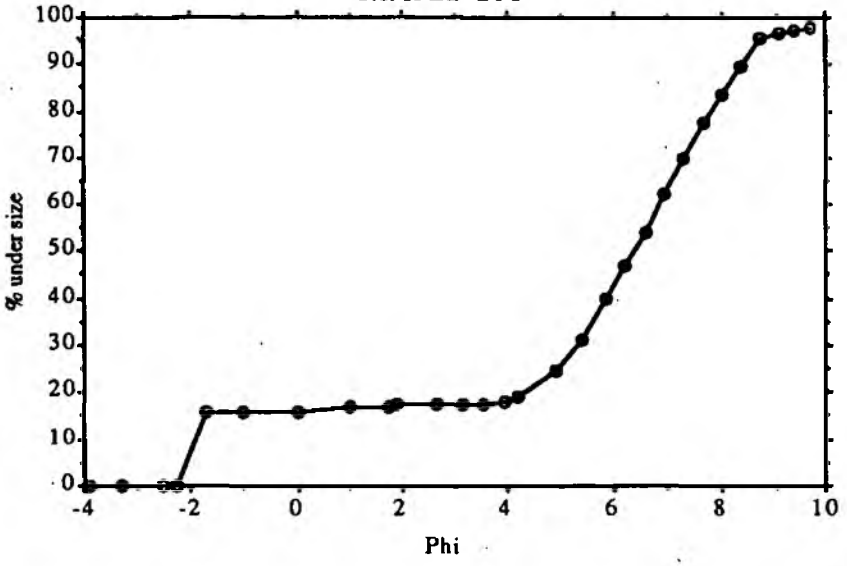


SAMPLE D5B

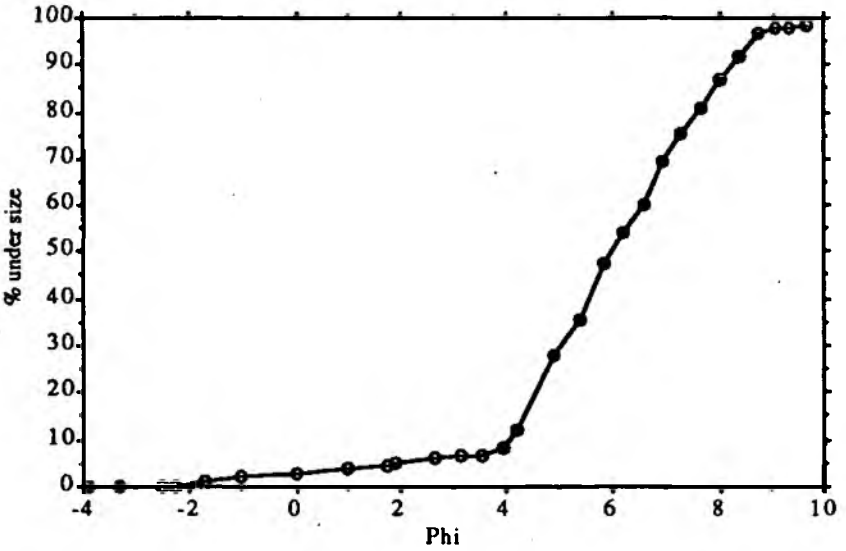


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull

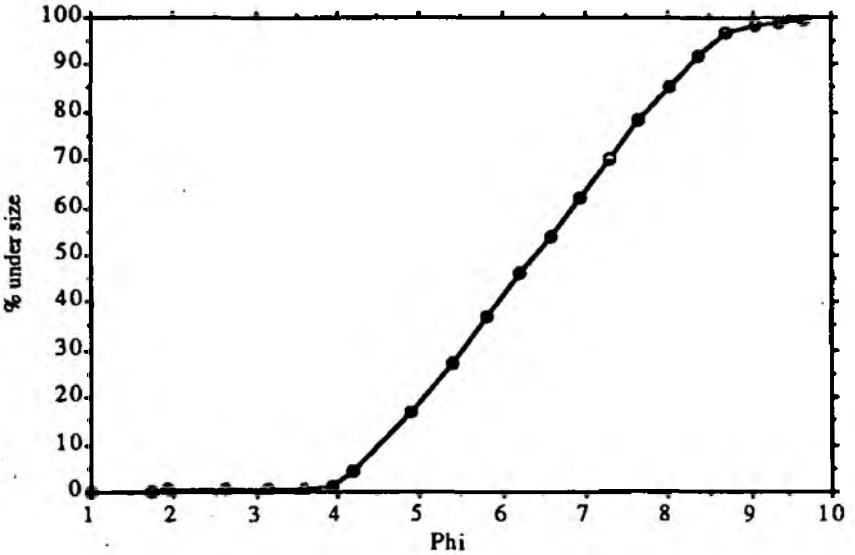
SAMPLE D5C



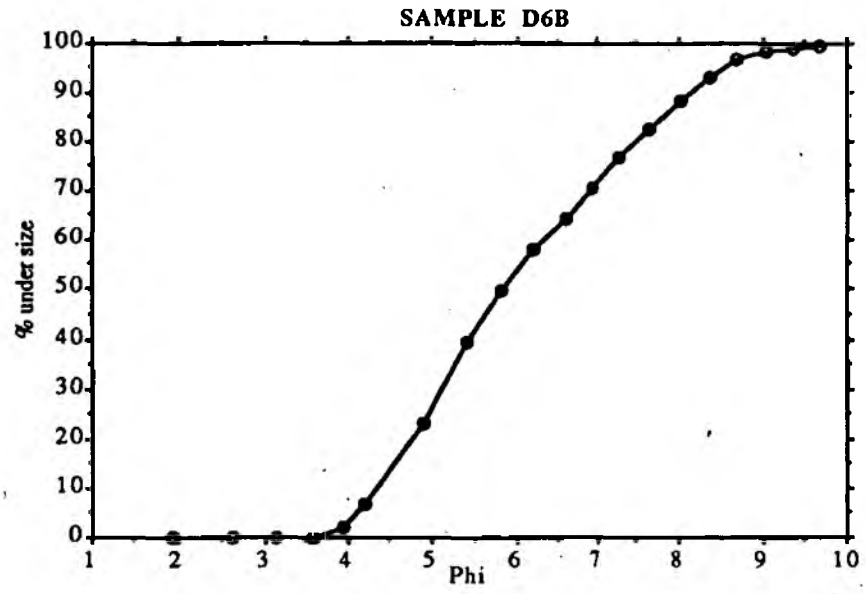
SAMPLE D5D

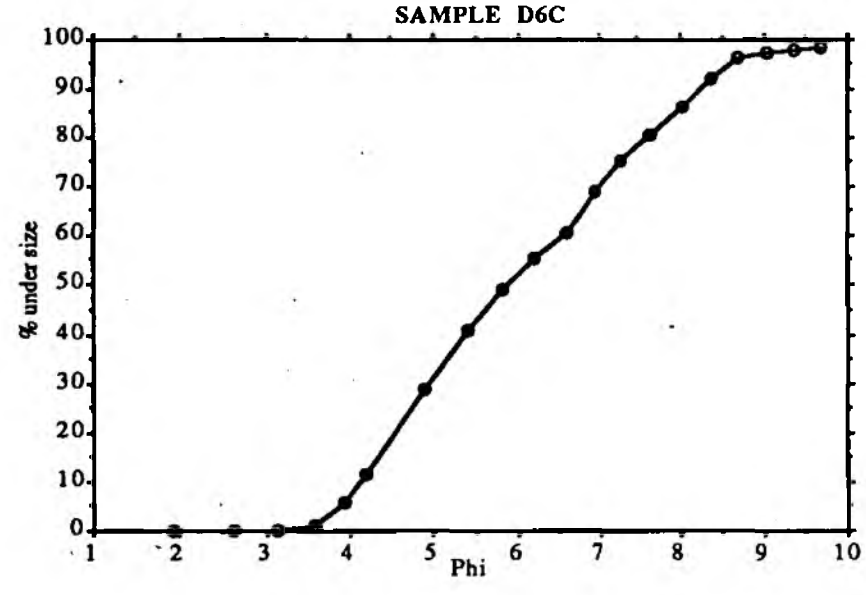


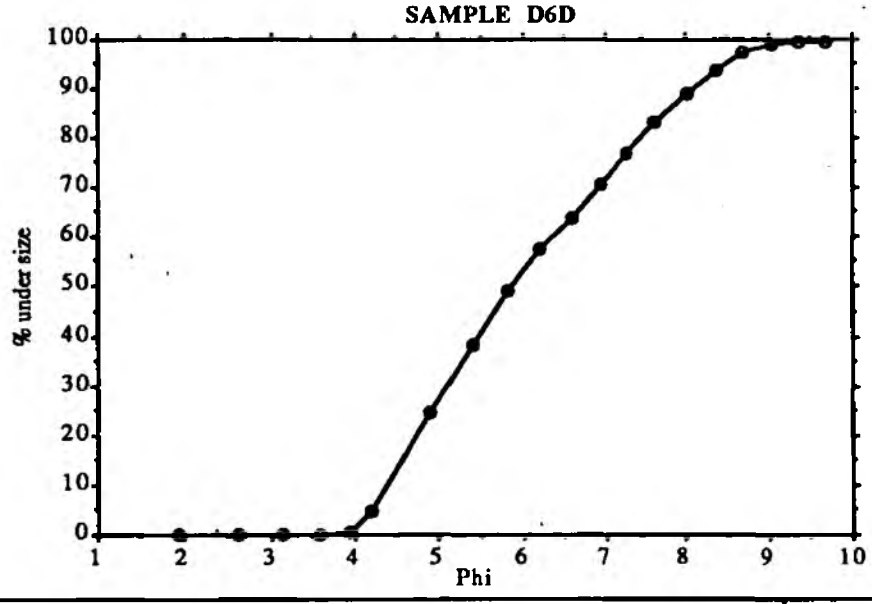
SAMPLE D6A



NRA Anglian Region - River Deben Survey 1992	**Institute of Estuarine and Coastal Studies**
Grain Size Distribution	**University of Hull**

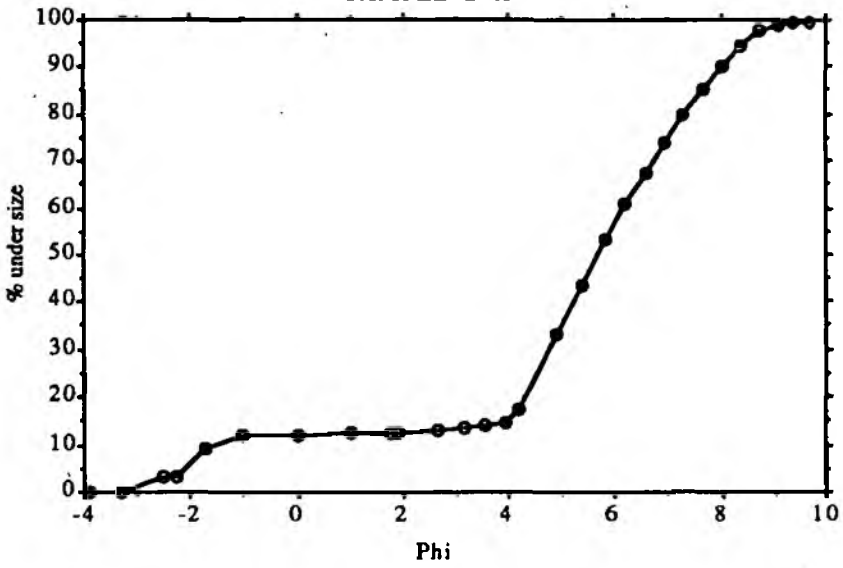




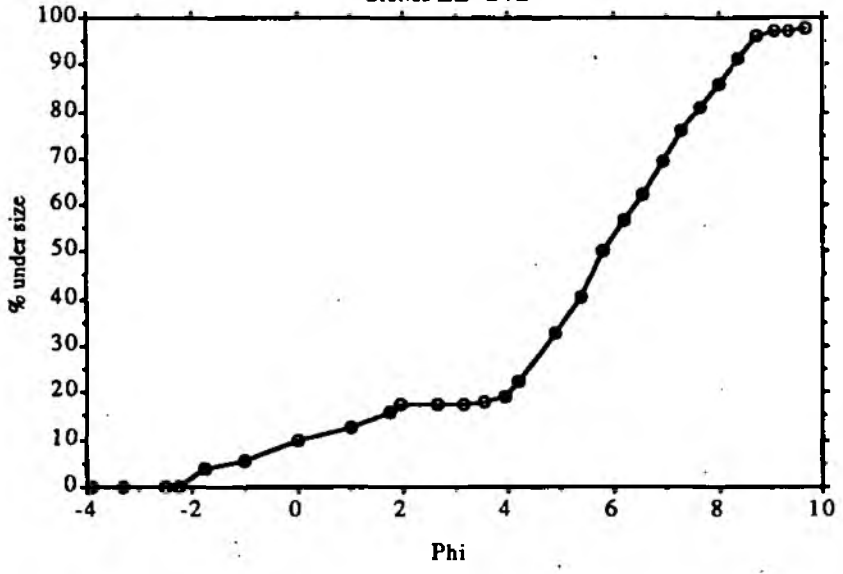


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull

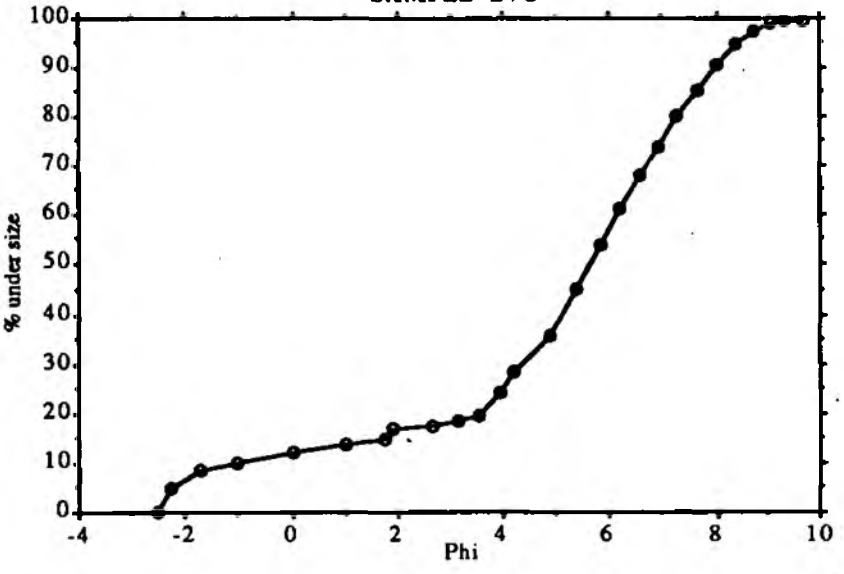
SAMPLE D7A



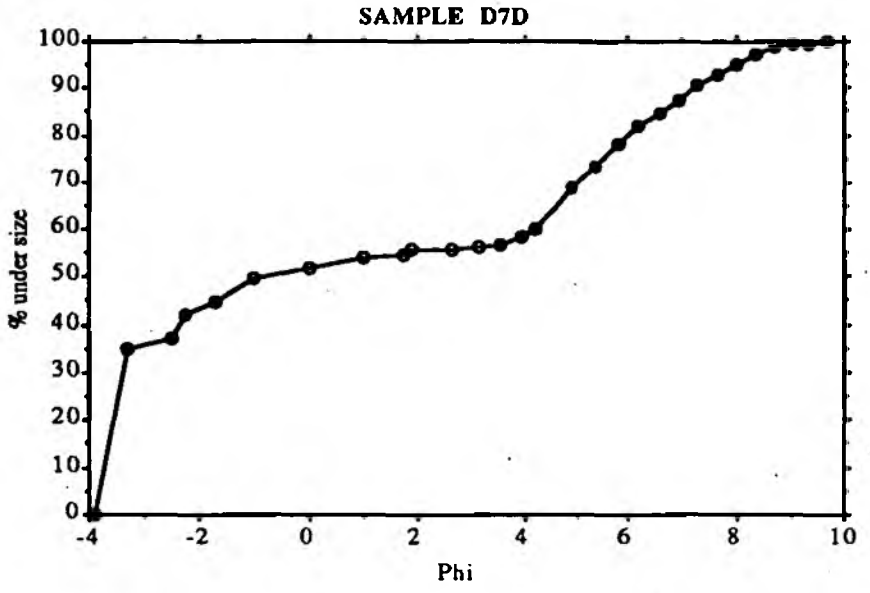
SAMPLE D7B

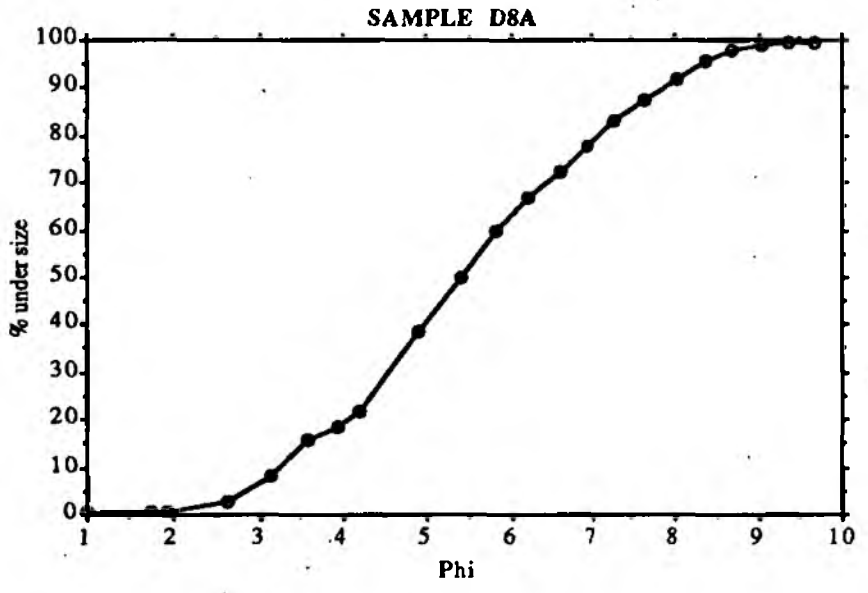


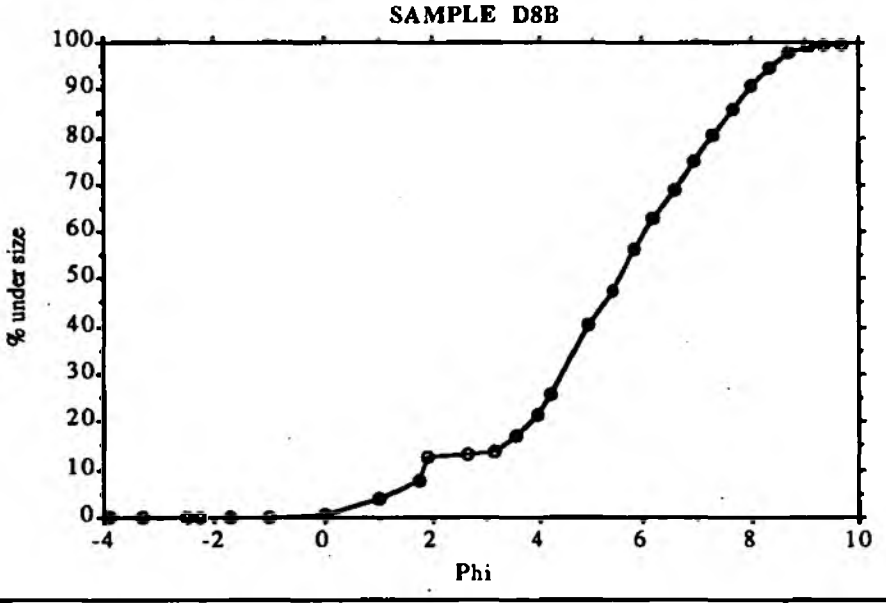
SAMPLE D7C



NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull







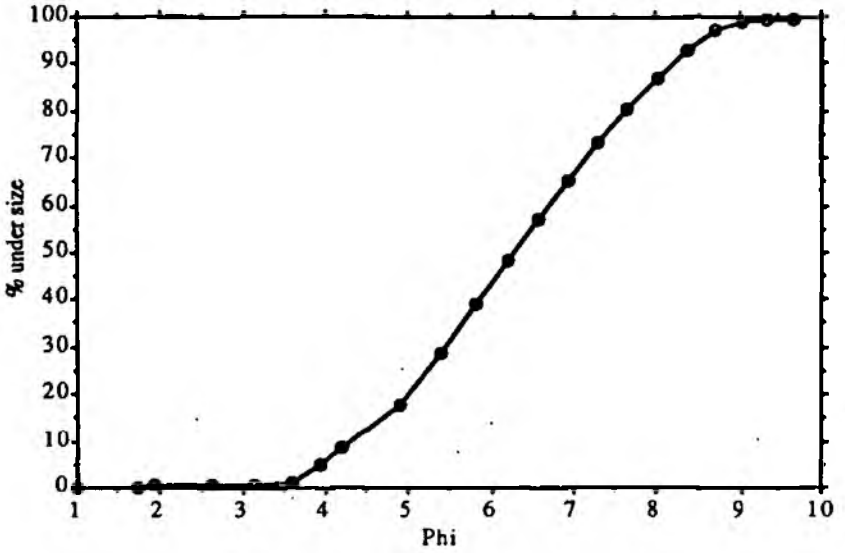
NRA Anglian Region - River Deben Survey 1992

Grain Size Distribution

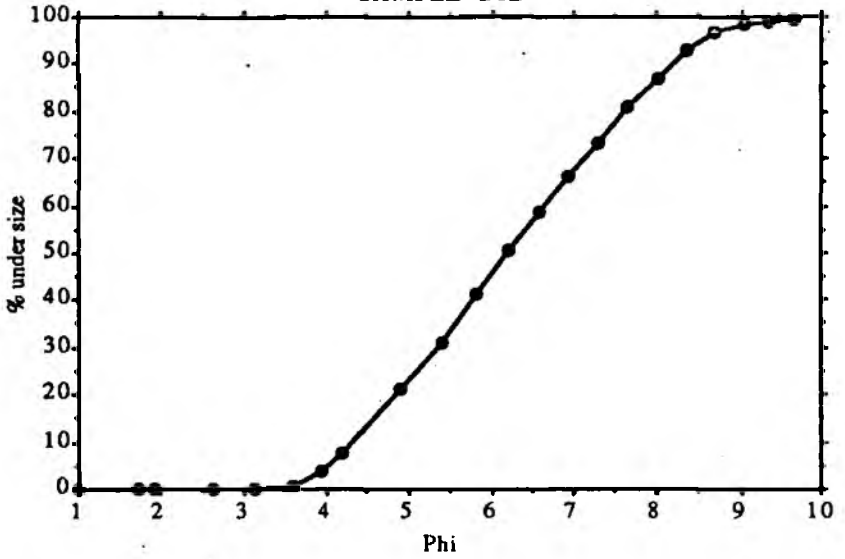
Institute of Estuarine and Coastal Studies

University of Hull

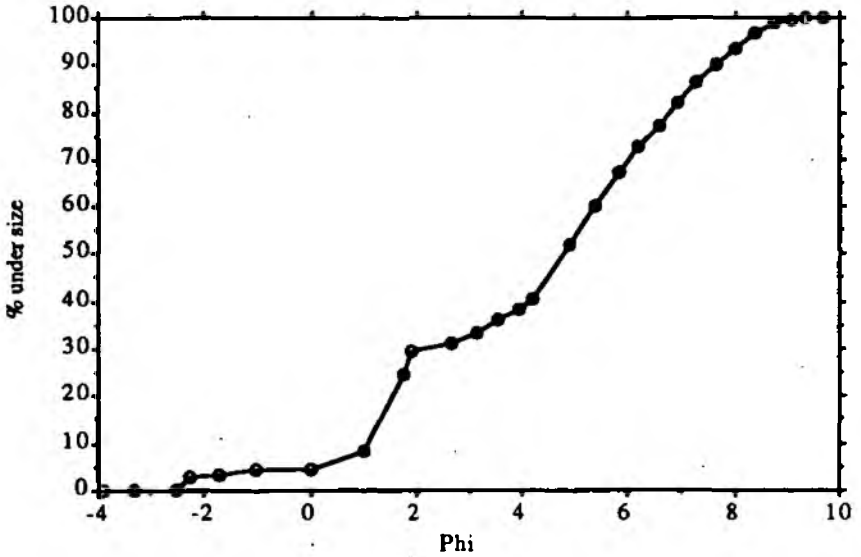
SAMPLE D8C



SAMPLE D8D

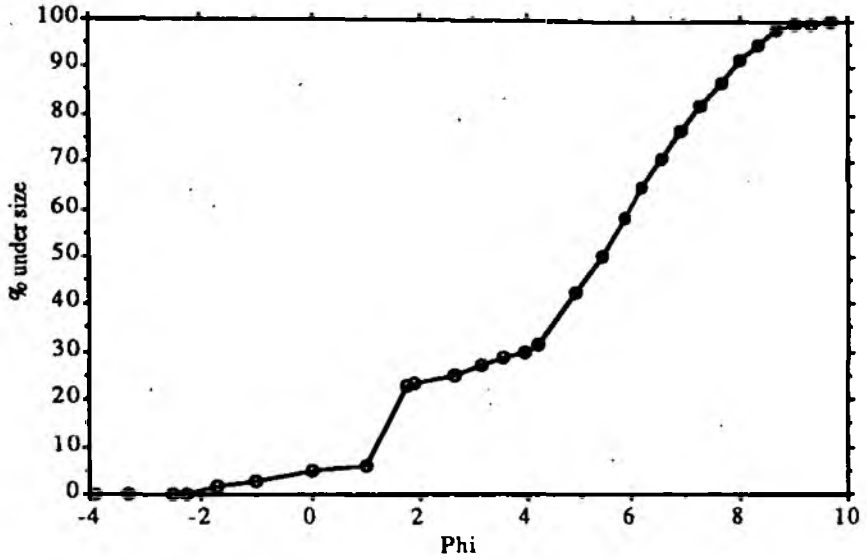


SAMPLE D9A

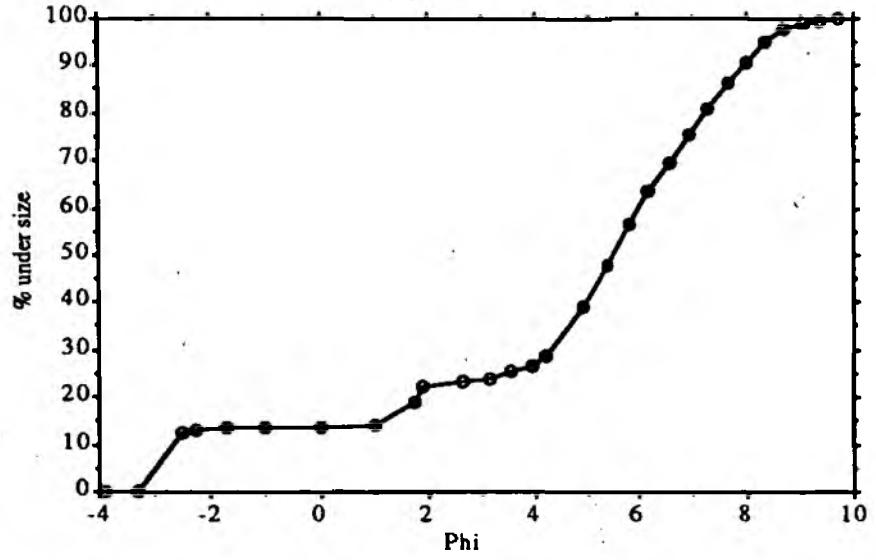


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull

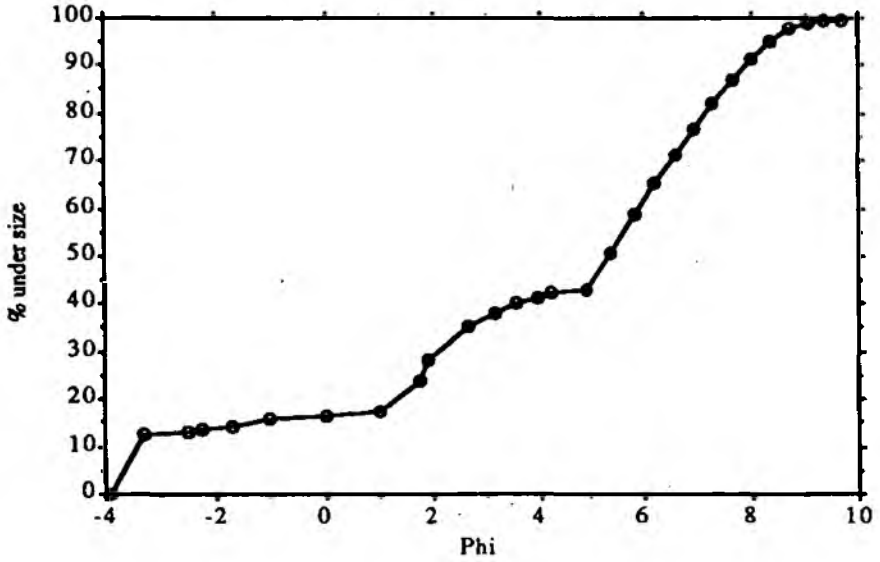
SAMPLE D9B



SAMPLE D9C

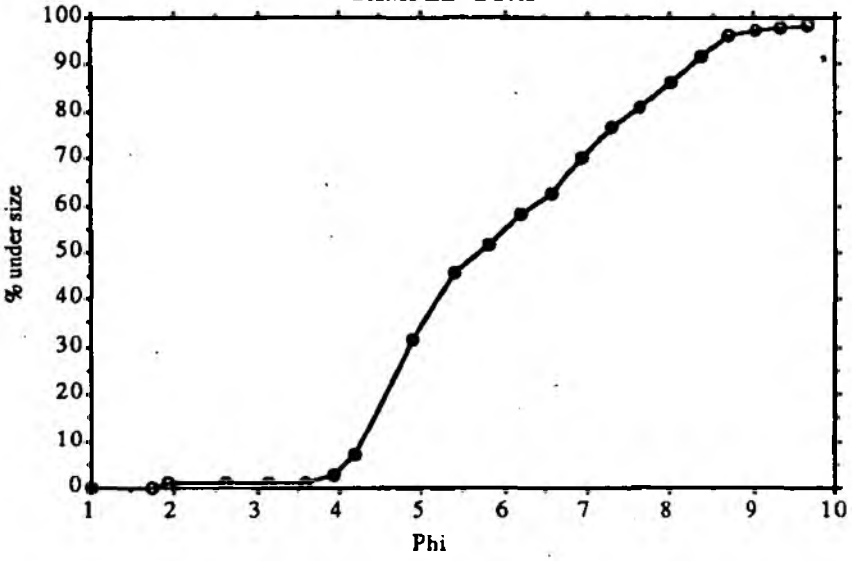


SAMPLE D9D

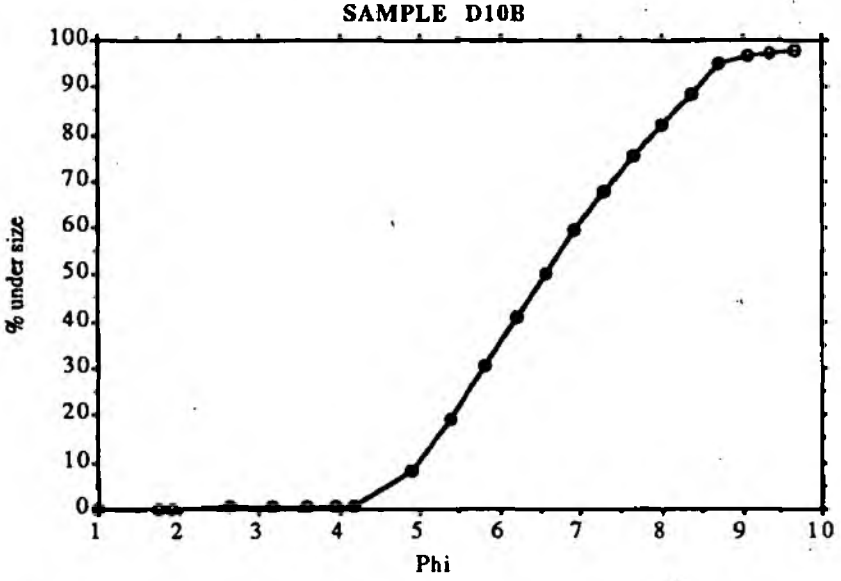


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull

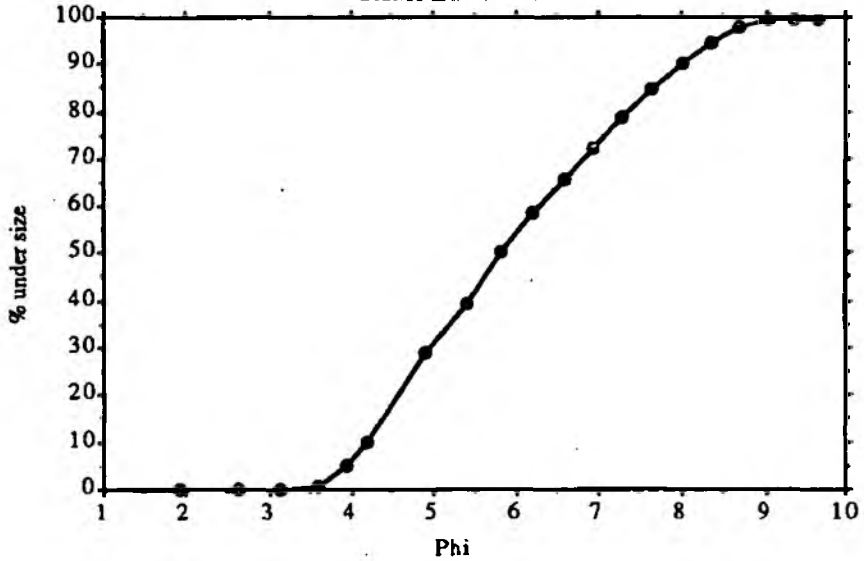
SAMPLE D10A



SAMPLE D10B

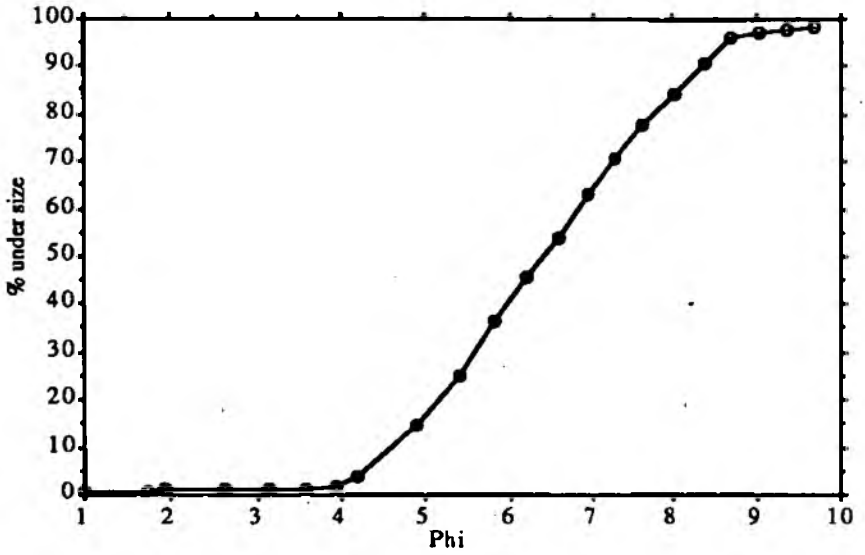


SAMPLE D10C

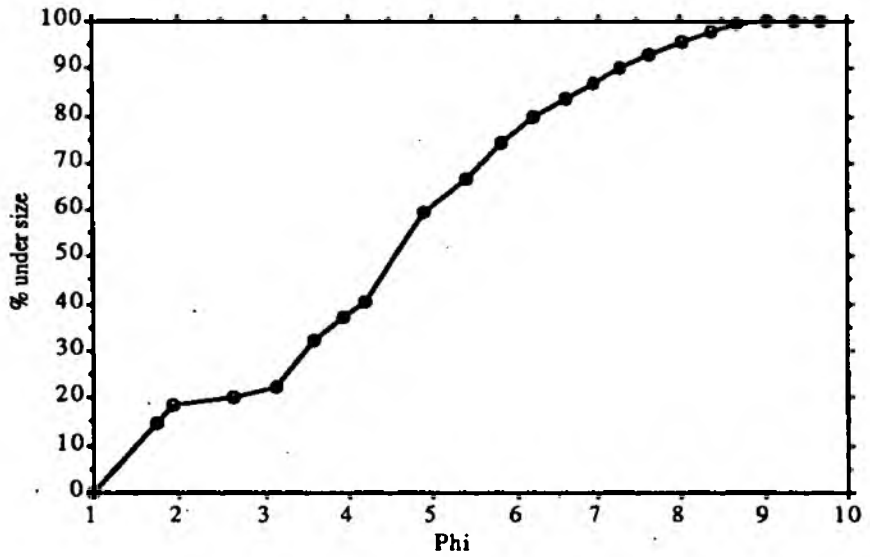


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull

SAMPLE D10D



SAMPLE D11A



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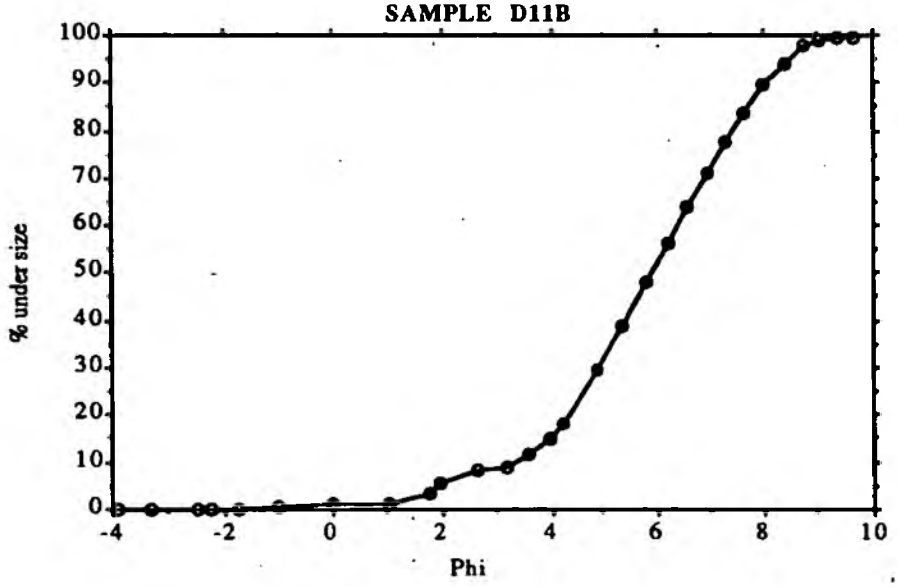
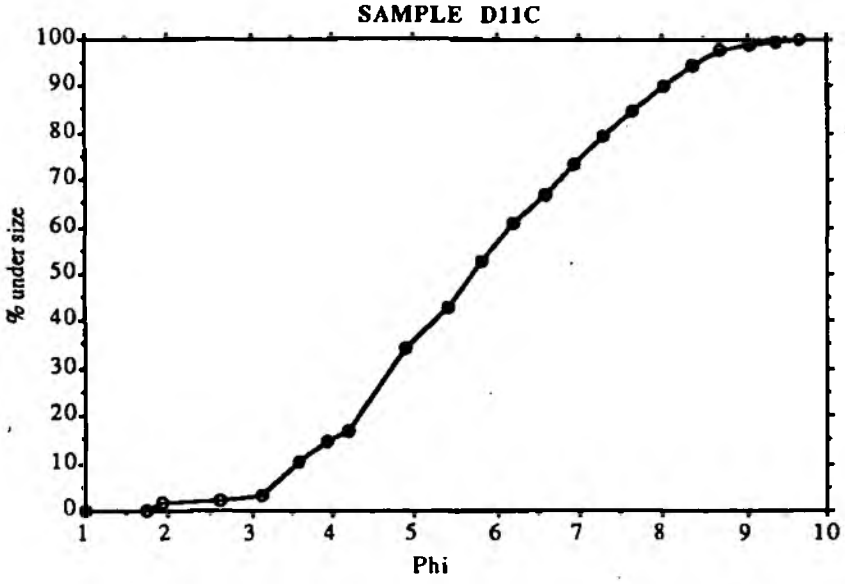
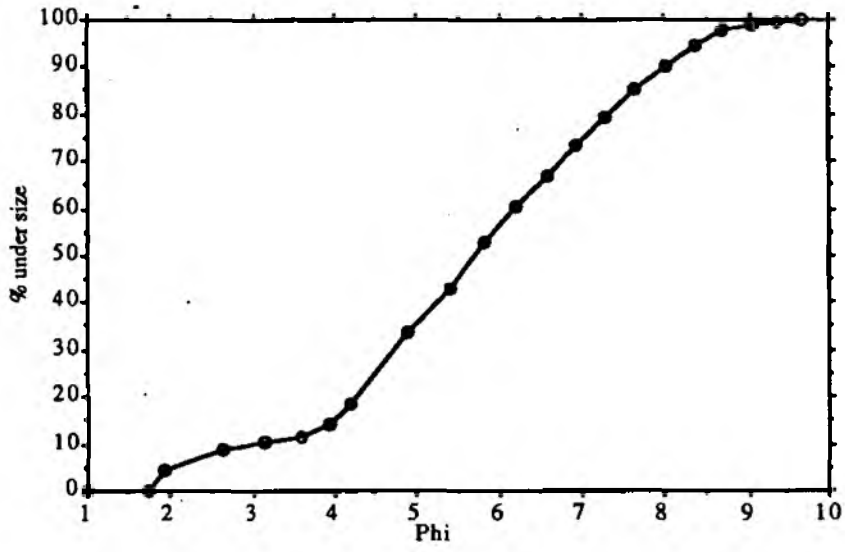


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull

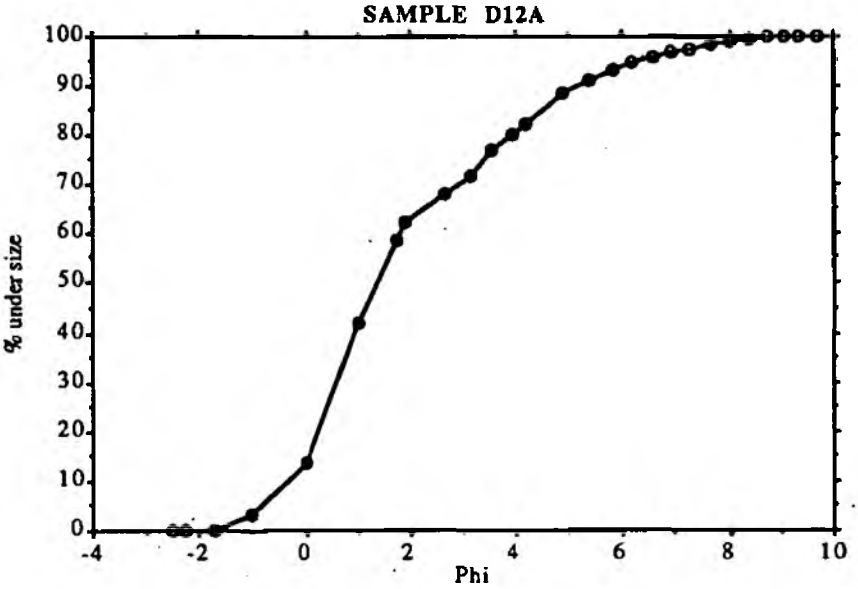
SAMPLE D11C



SAMPLE D11D

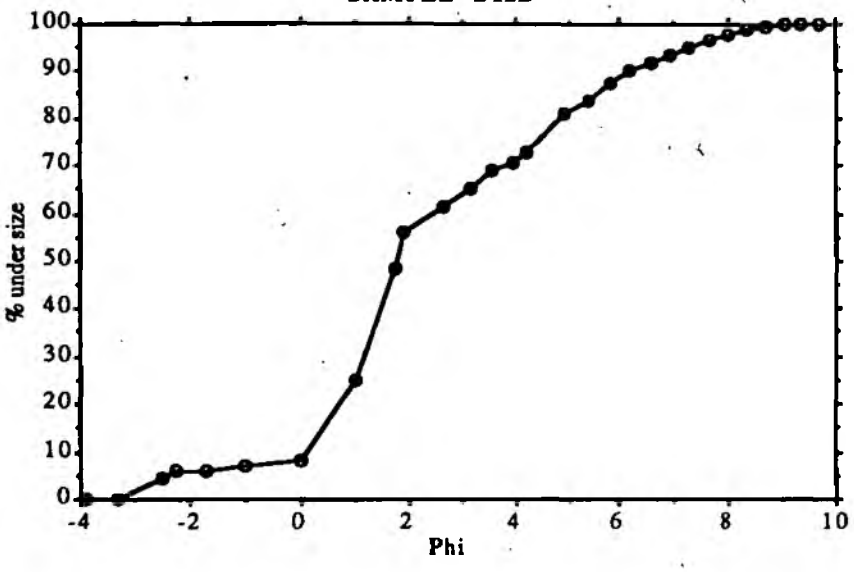


SAMPLE D12A

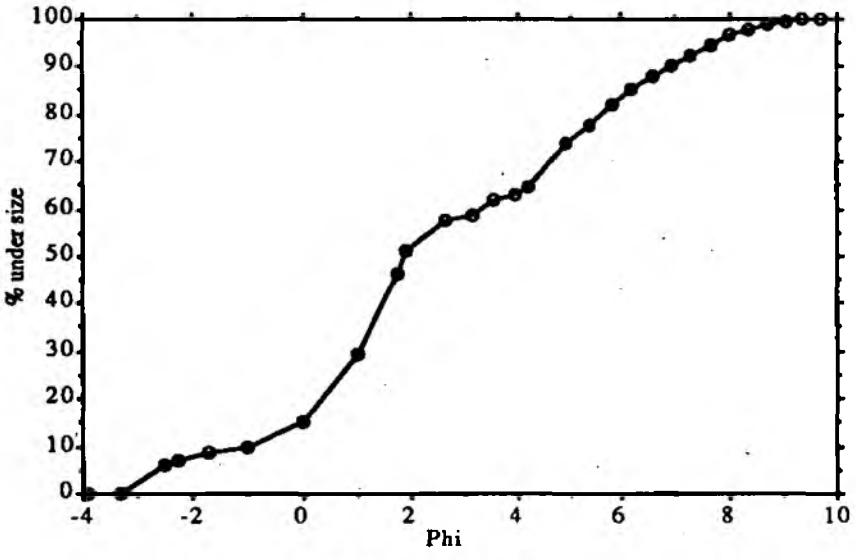


NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies
Grain Size Distribution	University of Hull

SAMPLE D12B



SAMPLE D12C



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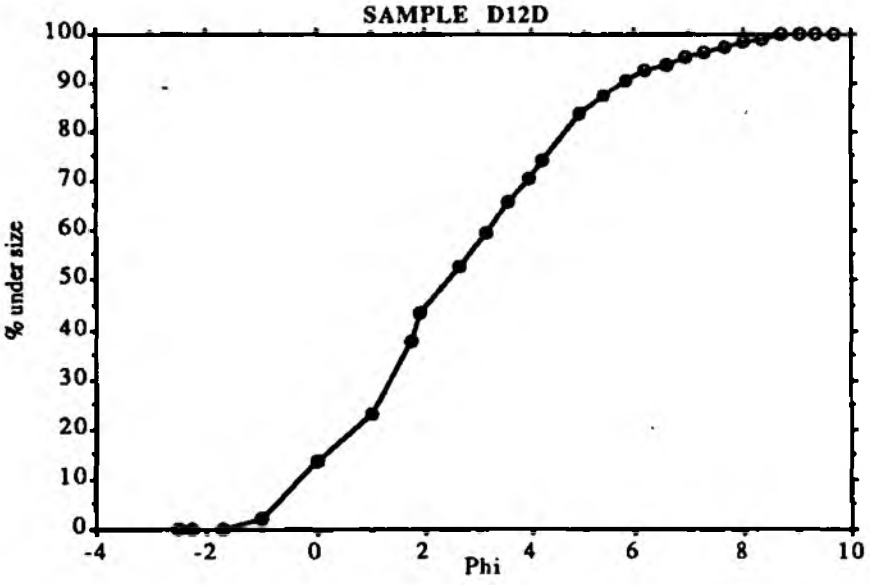


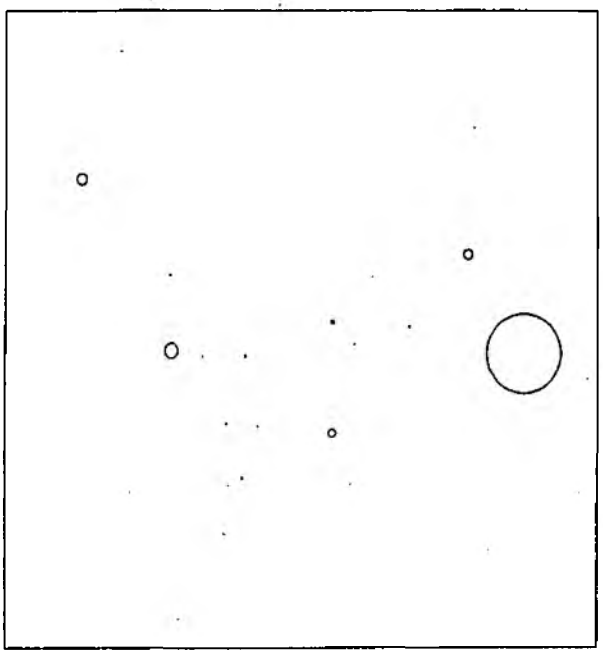
NRA Anglian Region - River Deben Survey 1992	Institute of Estuarine and Coastal Studies University of Hull
Grain Size Distribution	

APPENDIX 3

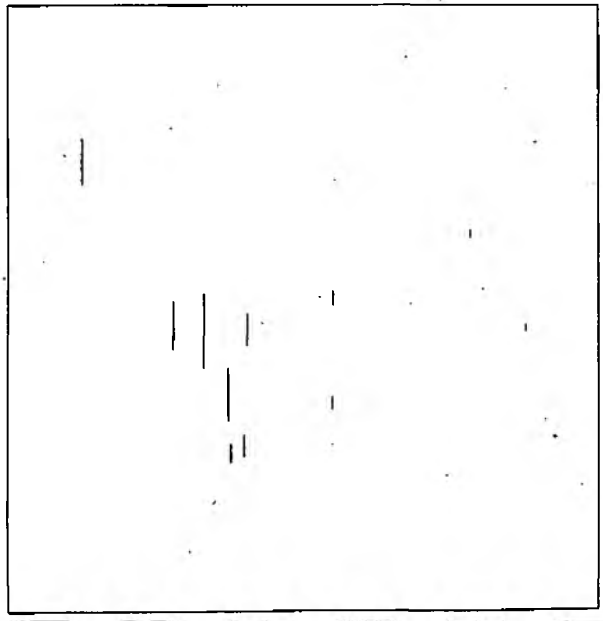
RIVER DEBEN SUBTIDAL SURVEY – MARCH 1992

SITE	LOCATION	DEPTH	SUBSRTATE
1	51 59 80N 001 23 50E	6.5	Clay/mud & sandy gravel
2	52 00 14N 001 22 65E	7	Mud with some stones
3	52 00 68N 001 21 78E	9.5	Clay/mud
4	52 02 42N 001 21 49E	5.3	Clay/mud
5	52 01 90N 001 20 60E	7.3	Clay/mud
6	52 02 61N 001 21 005E	4	*Sabella* community/mud
7	52 03 06N 001 20 16E	4.3	*Sabella* community/mud
8	52 03 69N 001 20 40E	3.6	Mud
9	52 04 32N 001 19 54E	3.4	Clay/mud mixed with some stones
10	52 04 09N 001 19 01E	2.2	Mud
11	52 04 85N 001 19 00E	2.9	Mud
12	52 05 30N 001 19 57E	2.9	Mud with some sand

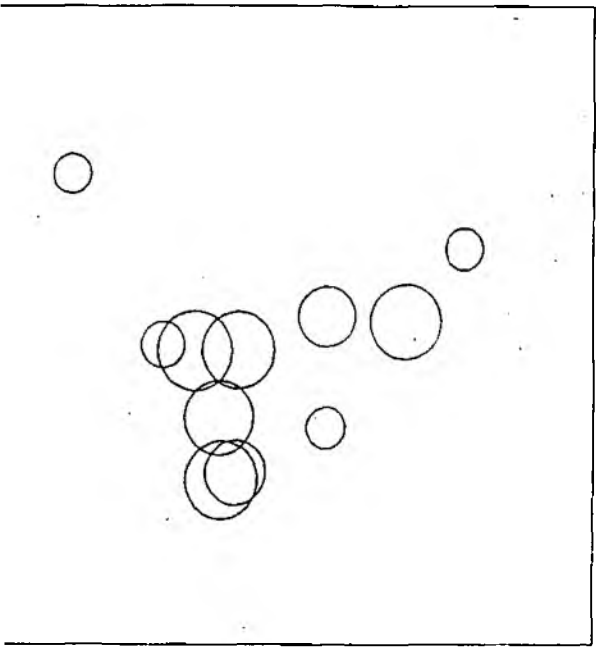
MDS PLOT OF RIVER DEBEN SITES (MEDIAN PARTICLE SIZE)



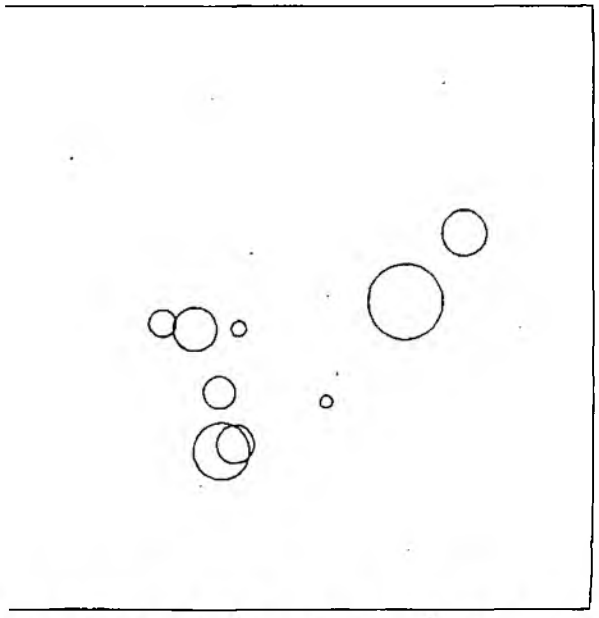
MDS PLOT OF RIVER DEBEN SITES (DEPTH)



MDS PLOT OF RIVER DEBEN SITES (% CLAY / SILT)



MDS PLOT OF RIVER DEBEN SITES (%.ORGANIC CARBON)



Appendix 4.