# THE RIVER COLNE ESTUARY

# SUBTIDAL BIOLOGICAL SURVEY 1992

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## CONTENTS

## 1 SUMMARY

The October 1992 subtidal survey of the River Colne has revealed the estuary to be of poor to moderate biological quality.

A comparison with the neighbouring Blackwater estuary which is generally of good quality showed the Colne invertebrate community to be inferior with regard to diversity and its dominance by oligochaete worms.

Quality is poorest in the upper reaches where organic inputs from Colchester stw are thought to be responsible. Dredging to maintain navigation channels was also found to impact the fauna around Haven Quay.

## 2 INTRODUCTION

This report details information gathered from a subtidal benthic survey of the River Colne estuary during October 1992. Although intertidal surveys have previously been carried within the estuary, this represents the first investigation of subtidal biological conditions within the estuary.

The Colne estuary receives a variety of discharges, the most notable of which is Colchester stw effluent. Although a fully treated effluent, it can cause deoxygenation problems in the upper estuary. Other consented discharges include, Fingringhoe stw, Thames and Colne gravel washings, and Brightlingsea stw.

No major fin fishery exists in the estuary. However there are extensive oyster lays located within the Pyefleet channel. The fishery is run by Colchester Oyster Fishery Ltd.

The lower section of the estuary receives protection as a biological Site of Special Scientific Interest. This includes tidal creeks, saltings, intertidal mud, sand spits and stretches of open water. The Essex Wildlife Trust also manage reserves at Fingringhoe Wick, Rat Island and Colne Point.

### 3i) DETAILS OF SURVEY

In October 1992, a series of 10 subtidal sites were sampled throughout the Colne estuary (Fig. 1 and 2). Samples were collected using a $0.1m^2$ Day Grab operated from the NRA survey vessel, Sea Vigil. A total of three replicates were taken at each site for subsequent biological analysis. A small subsample from each site 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 analysis included washing the samples thoroughly to remove formalin traces, and sorting using a low power binocular microscope. Sorted samples were identified to species wherever possible and enumerated. Laboratory analysis was undertaken by Unicomarine Ltd.

Particle size analysis was undertaken by Hull University using the technique of Laser Diffraction.

Site location and depth was by Sea Vigil's GPS and echo sounder respectively.

### 3ii) STATISTICAL ANALYSIS

The large data matrix produced from benthic macroinvertebrate surveys necessitates the use of multivariate statistics to analyse multispecies 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 matrix was processed using the 'Primer' suite of programmes developed by Plymouth Marine Laboratory. There are four basic stages in the analysis process:-

(1) 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.

(2) 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.

(3) 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.

(4) Ordination

Multi Dimensional Scaling (MDS) produces an ordination of N stations in a specified number of dimensions (Kruskal and Wish 1978). This complements cluster 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.

## 4. RESULTS

A total of 47 taxa were recorded from the 10 subtidal sites throughout the River Colne estuary. The data matrix is presented in Appendix 1, with numbers expressed as individuals per grab.

Figures 3 and 4 show total numbers of taxa and total numbers of individuals per site. Species richness was lowest at site 1 (3 species) and highest at Site 9 (26 species). Invertebrate abundance was also lowest at site 1 (150 individuals $m^{-2}$) and highest at site 2 (27,000 per sq. metre).

The three most upstream sites (sites 1, 2, and 3) were dominated by oligochaetes, notably , *Tubifex costatus*, with polychaetes, *Nereis diversicolor* and *Streblospio shrubsolii* being sub dominant at sites 2 and 3. The middle estuary sites (sites 4,5 and 6) were again dominated by oligochaetes. However a species shift was noted with *Tubificoides pseudogaster* becoming the dominant species. *Streblospio shrubsolii* was co dominant at site 4. Towards the outer estuary, at sites 7, 8 and 9, the polychaete, *Tharyx sp.* became the dominant species, with oligochaetes only occasional.

Substrate composition was variable throughout the estuary. The most downstream sites (sites 6, 7, 8, 9, and 10) were dominated by silt, as was site 1 (Haven Quay). The remaining sites (sites 2, 3, 4 and 5) between Rowhedge and Marsh Farm, Wivenhoe contained a greater percentage of sand and cobbles although silt was also present. Organic carbon content was generally highest where silt was the dominant substrate. Thus highest levels were recorded at site 1 (Haven Quay), Site 7 (U/S Alresford Creek), and Site 9 (Colne at Geedon Creek).

### STATISTICAL ANALYSIS

The cluster analysis of the River Colne invertebrate data produced 2 principle clusters at a 35% or greater level of similarity (Fig. 5).

Group 1 linked sites 8, 9 and 10 (ie. all sites in the outer estuary). Group 2 linked sites 2, 3, 4, 5, 6 and 7. These sites were situated from Rowhedge to Alresford Creek. Site 1 (Haven Quay) was a slight outlier from this second group.

The MDS ordination plot (Fig 6) independently reinforced the results from the cluster analysis and showed similar site groupings. Site 1 was again an outlier from group 2.

### FAUNAL CONSTITUENTS OF THE MAIN GROUPS

Group 1

Invertebrates that were most characteristic of this group were the polychaetes, *Tharyx sp.*, *Nephtys hombergi*, and *Chaetozone setosa*. *Tharyx sp.* was the dominant organism at sites 8 and 9, occurring at densities of 3795 and 1080 individuals per square metre respectively. The most common invertebrate at site 10 was *Chaetozone setosa* but this only occurred at an abundance of 61 $m^{-2}$.

Species diversity was moderate, averaging 22 species per site.

Group 2

This group incorporated sites 1 to 7. Species that characterised these sites were the polychaete worms , *Nereis diversicolor* and *Streblospio shrubsolii* and tubificid worms (either *Tubifex costatus* or *Tubificoides pseudogaster*).

Species diversity was poor, averaging only 9.5 species per site.

## 5 DISCUSSION

The 1992 subtidal survey of the River Colne has revealed the estuary to be of poor biological quality, particularly in its upper reaches. Invertebrate diversity was poor to moderate at the majority of sites.Furthermore, productivity of pollution tolerant tubificid worms was high,particularly at sites 2 and 3 (ie. locations in closest proximity to the Colchester stw outfall). At site 2 (Rowhedge), tubificid worms accounted for more than 90% of the total invertebrate community.

A number of factors are involved which determine which invertebrates colonize particular areas. Reduced salinities obviously preclude fully marine species from colonizing the upper sections of estuaries. As such diversity is generally lower in these areas as a result. Similarly dredging to maintain navigation channels can periodically affect communities. Within the Colne estuary, dredging is an ongoing exercise concentrated around Haven Quay and St Edwards Quay (Colne Harbour Master-*pers comm.*)

It would appear that site 1 (Haven Quay), with only three species and 45 individuals recorded from the three grab samples, has been affected by recent dredging. The large oligochaete populations which were recorded from site 2 and 3 suggest that there has been no recent dredging disturbance and that these two sites are suffering from elevated organic loadings.

Further down the estuary, diversity generally increased with productivity decreasing. However no sites within the estuary could be considered anything more than of moderate biological quality. A comparison with other south east coast estuaries reveals the Colne estuary to support the fewest number of species per grab. That is , the Colne supported 8 per grab, whereas the estuaries Deben, Stour and Blackwater all supported in excess of 20 species (Fig.7). An examination of the overall invertebrate community in the Colne estuary has shown it to be dominated by oligochaete and polychaete worms (>99%) with other groups (molluscs, crustacea *etc.*) poorly represented (<1%). Conversely the neighbouring Blackwater estuary supports a more balanced community with molluscs, crustacea and "others" accounting for 3%, 6%, and 8% respectively (Fig.8).

## 6 REFERENCES

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

7 FIGURES

Fig. 1 River Colne Estuary Sample Locations

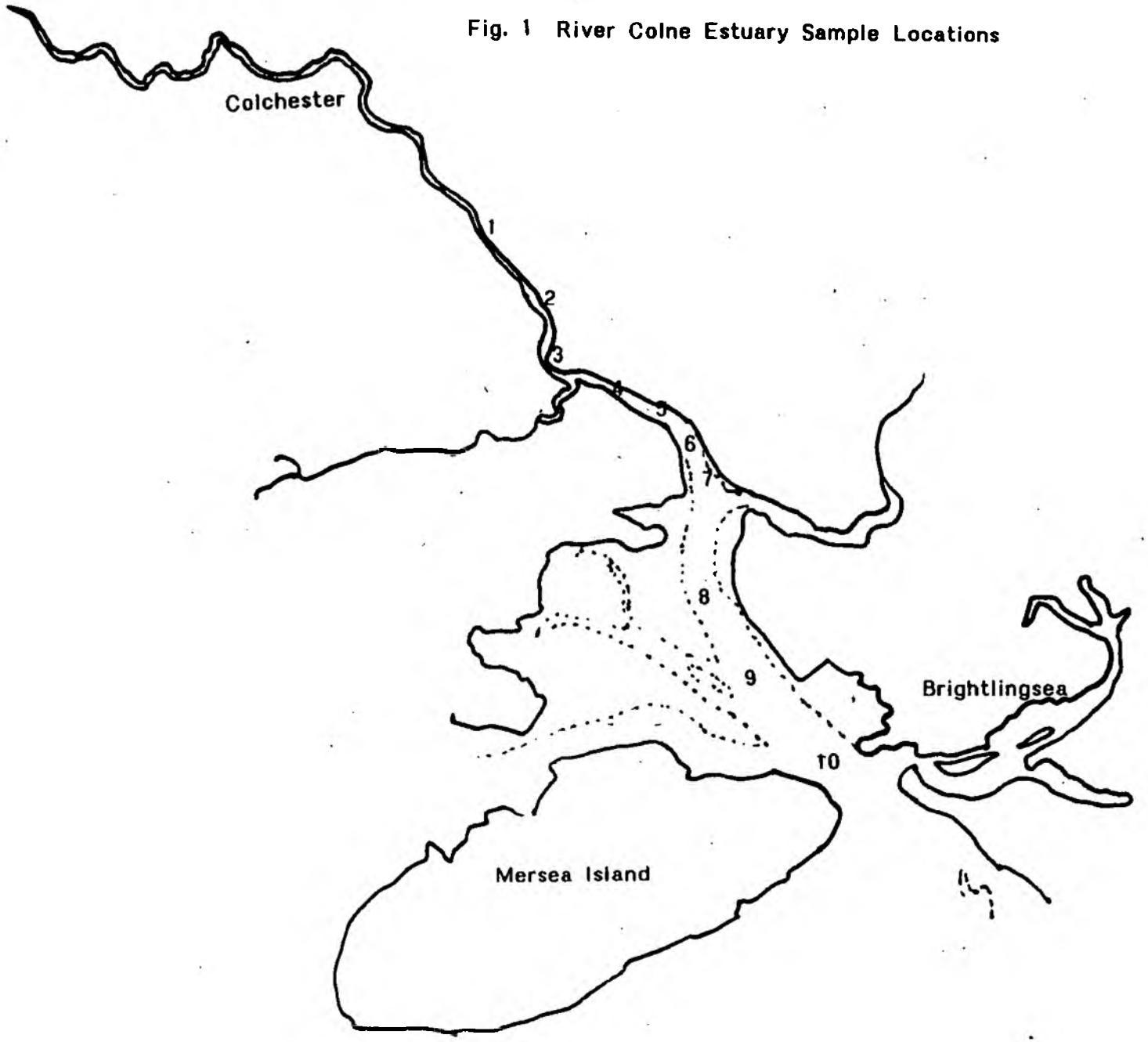
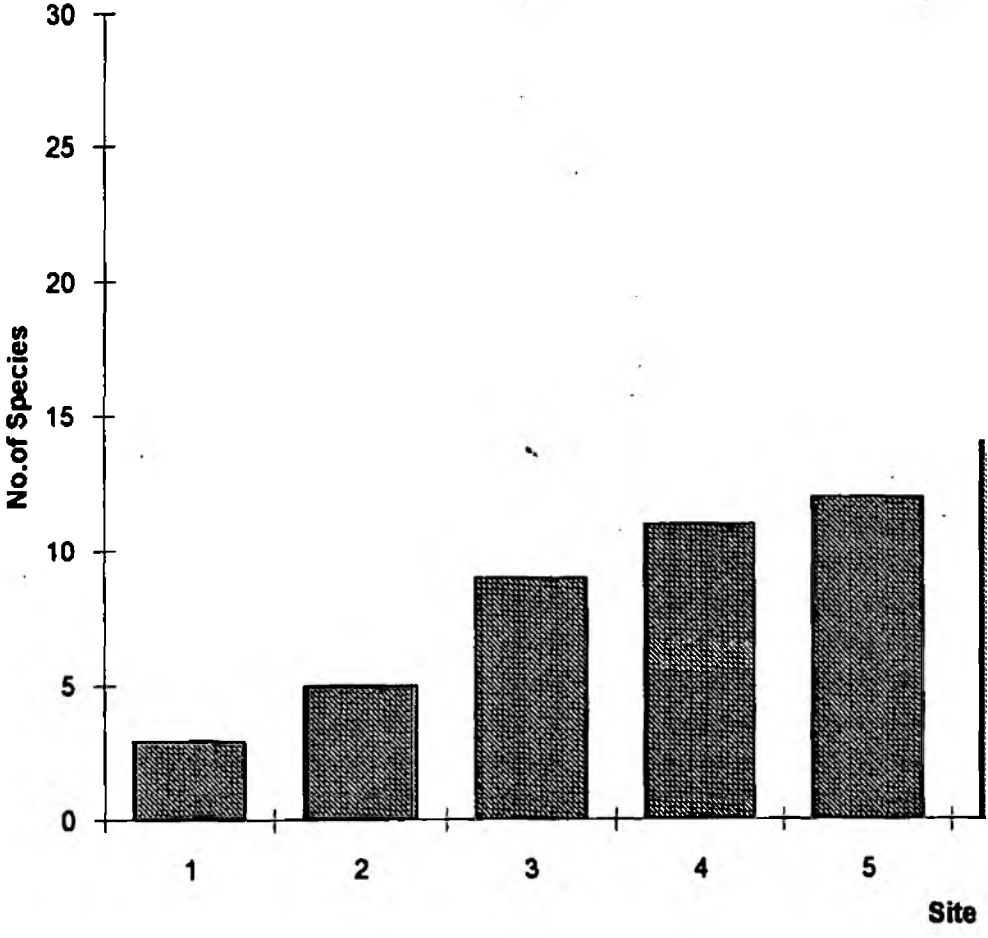


Fig. 2 RIVER COLNE SUBTIDAL SURVEY : OCTOBER 1992

| Site No. | Site Name | Position | Depth | Substrate |
|---|---|---|---|---|
| 1 | Haven Quay | 51 52 52N<br>000 56 28E | 3.1 | Brown over black silt/mud |
| 2 | Rowhedge | 51 51 86N<br>000 56 99E | 3.6 | Muddy gravel |
| 3 | Rowhedge Quay | 51 51 25N<br>000 57 17E | 3.4 | Mud/Sand/Pebbles |
| 4 | 100m D/S Colne Barrage | 51 51 05N<br>000 58 01E | 3.4 | Sand/Pebbles |
| 5 | Marsh Farm Wivenhoe | 51 50 87N<br>000 58 62E | 3.3 | Muddy/Gravel |
| 6 | Alresford Grange | 51 50 62N<br>000 58 92E | 3.3 | Shelly/Mud |
| 7 | U/S Alresford Creek | 51 50 28N<br>000 59 04E | 3.1 | Brown fluid mud overlying black |
| 8 | Fingringhoe Pier | 51 49 60N<br>000 58 92E | 2.9 | Mud/Cockle shells |
| 9 | Colne at Geedon Creek | 51 48 99N<br>000 59 29E | 6.2 | Brown overlying black mud |
| 10 | Colne at Pyefleet Channel | 51 48 39N<br>000 59 98E | 6 | Clay/mud |

Fig. 3

**RIVER COLNE ESTUARY 1992**



:SPECIES DIVERSITY

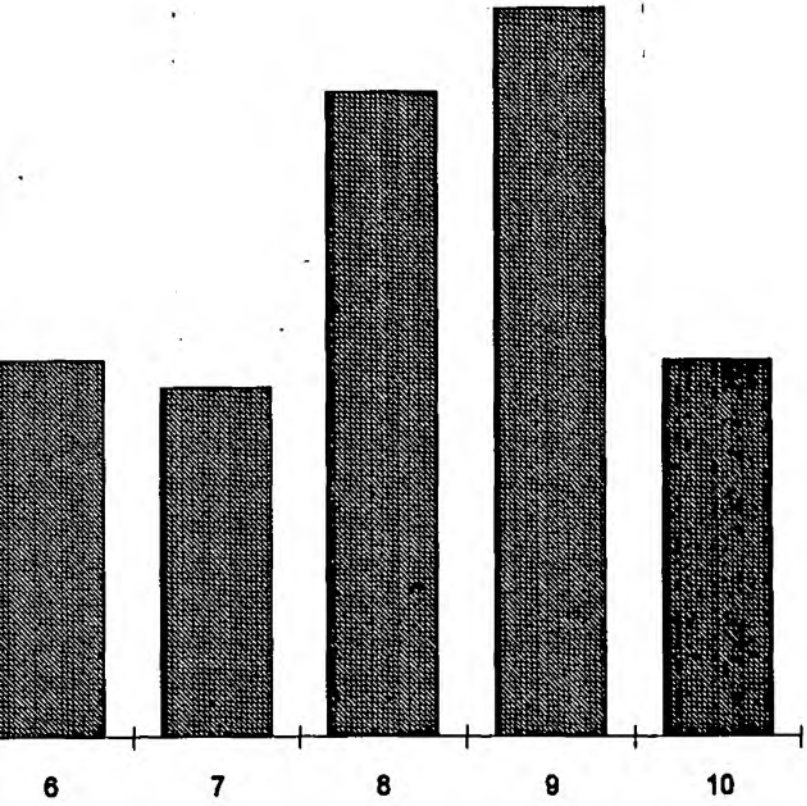
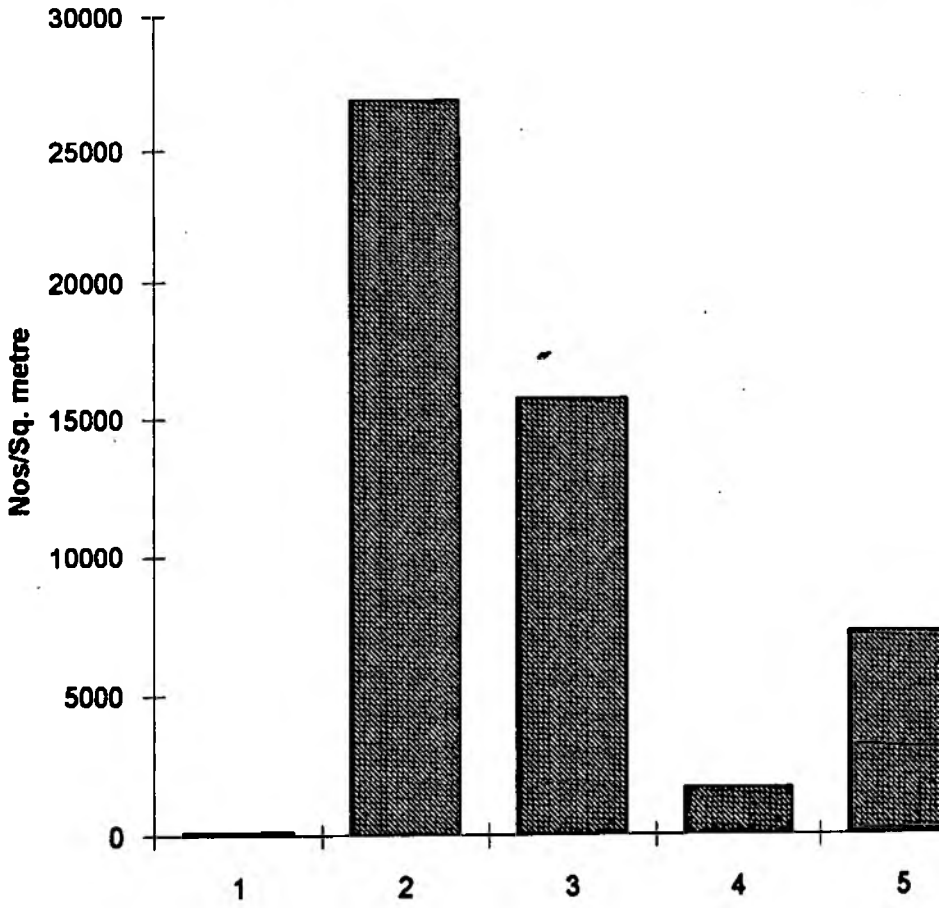
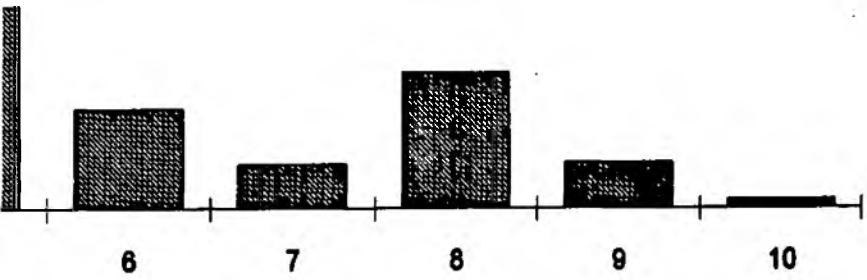


Fig. 4

RIVER COLNE 1992 :



## INVERTEBRATE ABUNDANCE



RIVER COLNE SURVEY 1991 :(Replicates combined)

Fig. 5

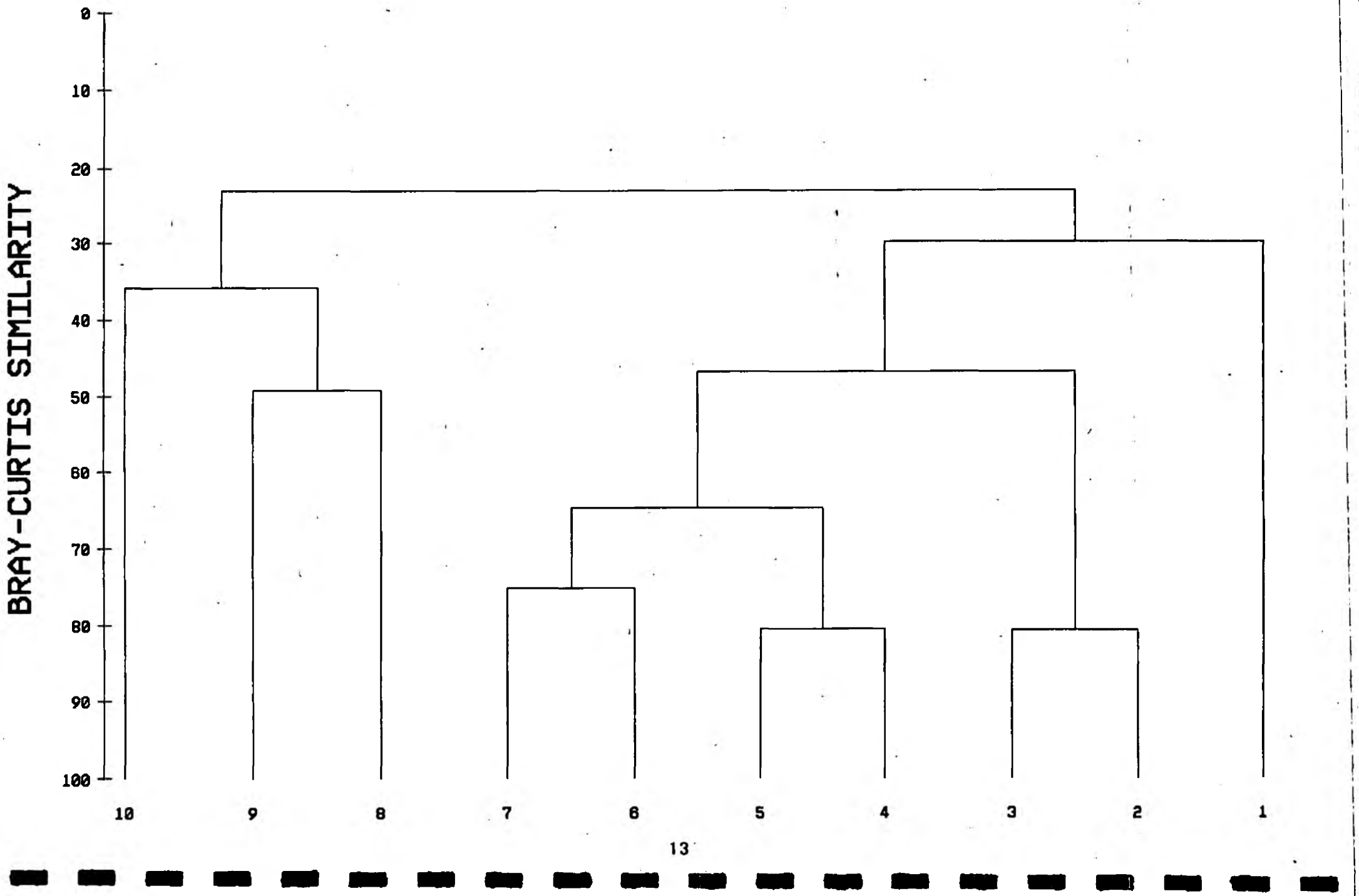


Fig. 6 RIVER COLNE 1992 MDS PLOT (REPLICATES COMBINED)

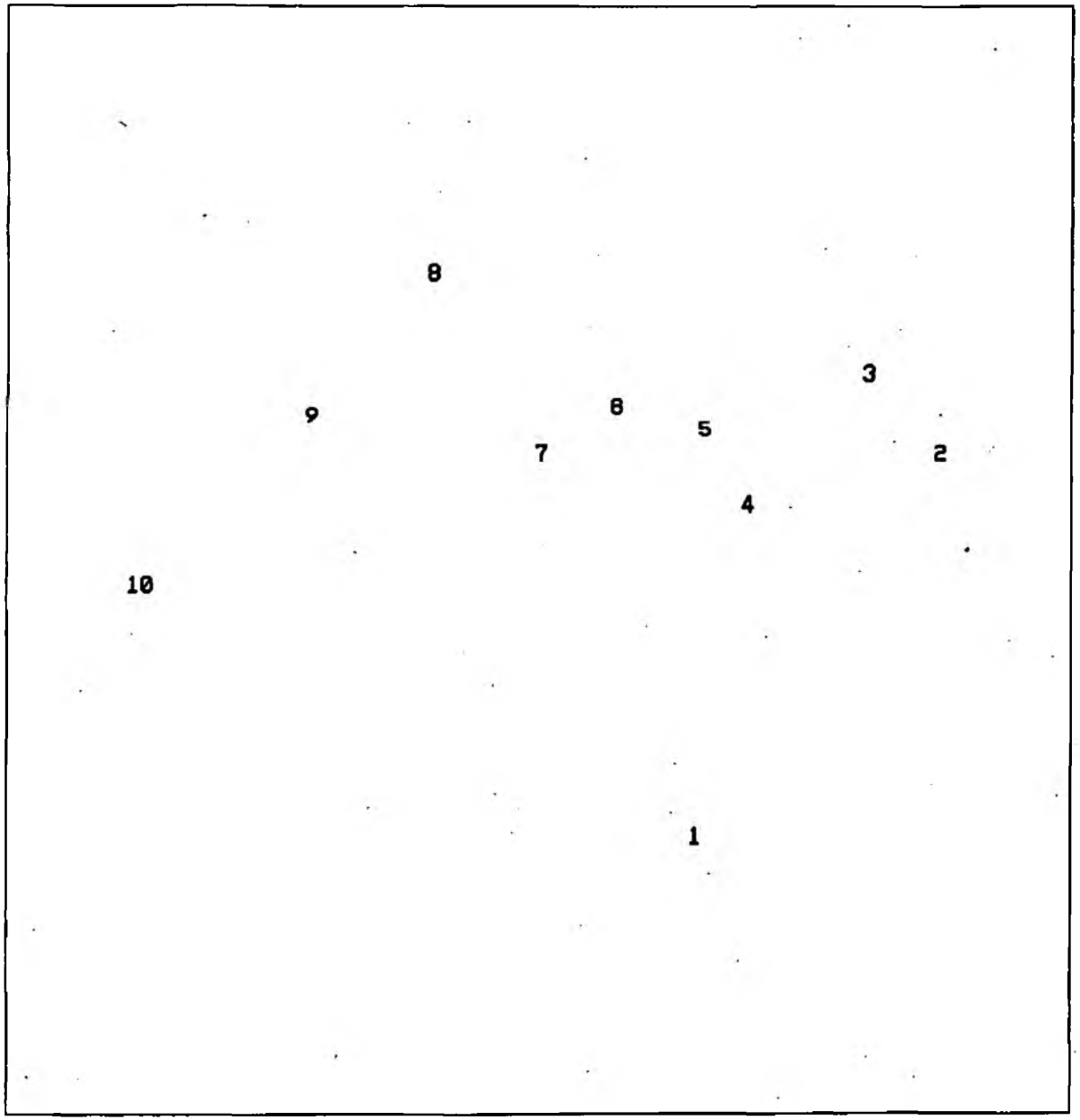


Fig. 7 COMPARISON OF SUBTIDAL DIVERSITY WITH OTHER EAST COAST ESTUARIES

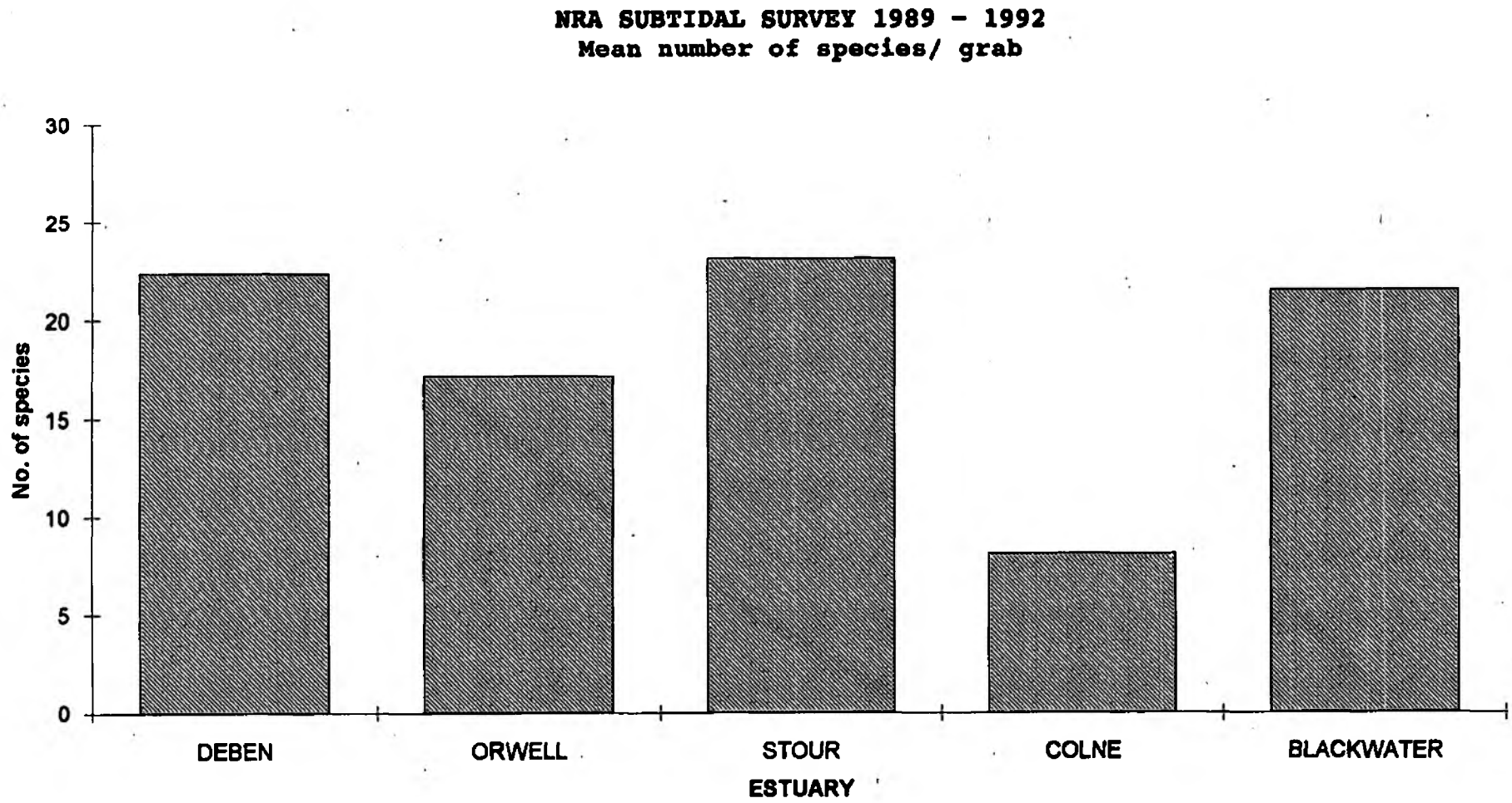
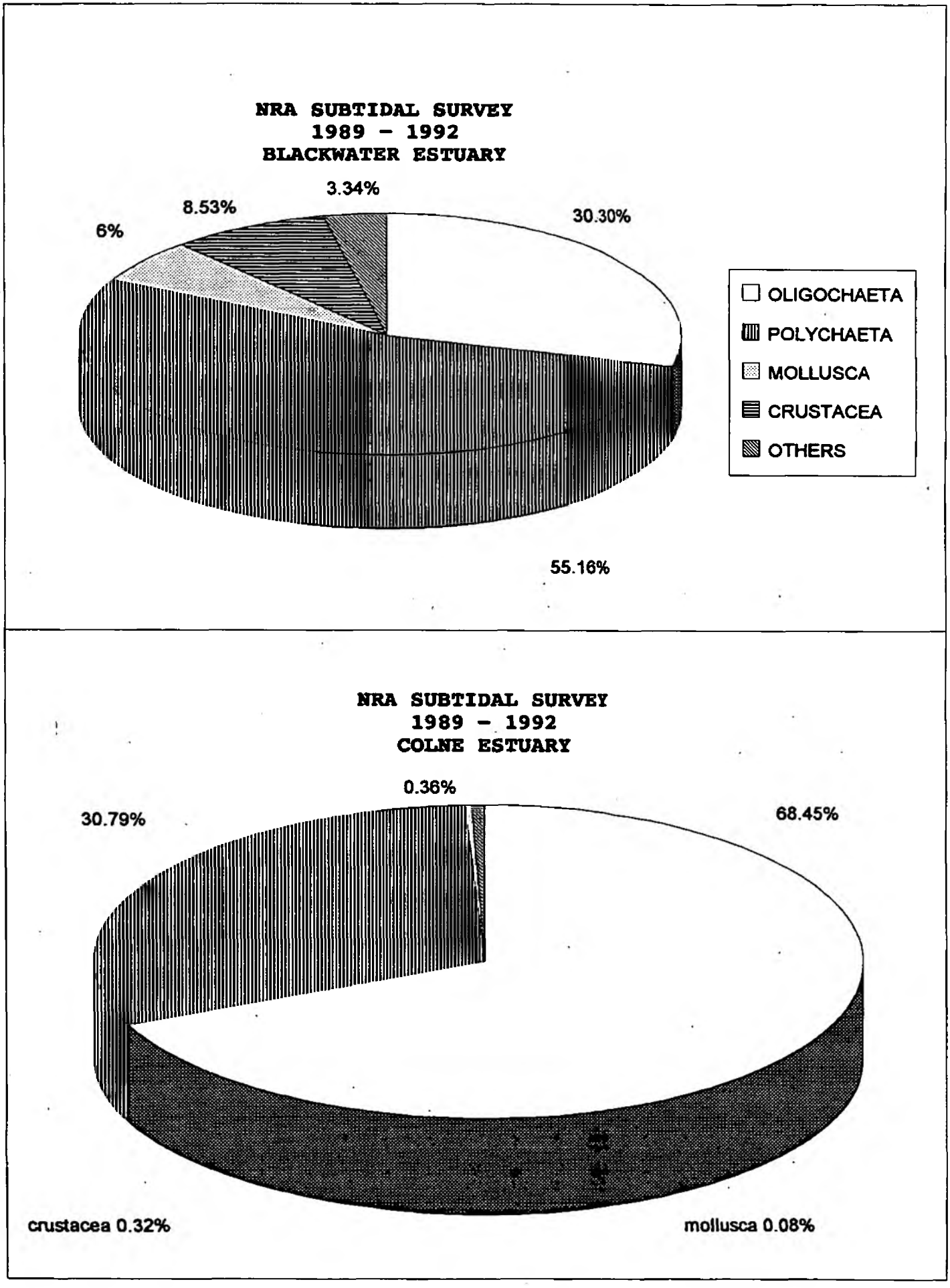


Fig. 8

COMPARISON OF SPECIES DIVERSITY BETWEEN
THE BLACKWATER AND COLNE ESTUARIES



# 8 APPENDICES

**NRA Colne survey 1992 - data matrix**

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | S13 | S14 | S15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **1A** | **1B** | **1C** | **2A** | **2B** | **2C** | **3A** | **3B** | **3C** | **4A** | **4B** | **4C** | **5A** | **5B** | **5C** |
| ud Anthozoan A | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Eteone longa | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| Phyllodoce mucosa | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Autolytus langerhansi | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nereis diversicolor | - | 1 | - | 174 | 249 | 105 | 171 | 103 | 214 | 107 | 63 | 68 | 14 | 32 | 61 |
| Nereis succinea | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nereis virens | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ud Nephtys (juv.) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nephtys cirrosa | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Nephtys hombergii | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| Marphysa sanguinea | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Polydora ligni | - | - | - | - | - | - | - | - | - | - | - | - | - | 6 | 2 |
| Pygospio elegans | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Spiophanes bombyx | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Streblospio shrubsolii | - | - | - | 85 | 108 | 121 | 192 | 104 | 167 | 70 | 217 | 491 | 270 | 217 | 281 |
| Chaetozone setosa | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Tharyx marioni | - | - | - | - | - | - | - | - | - | - | 1 | - | 3 | - | - |
| Cossura longocirrata | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Melinna palmata | - | - | - | 2 | - | - | - | 4 | 3 | 3 | - | 1 | - | 2 | 2 |
| Ampharete acutifrons | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Sabella pavonina | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Tubifex costatus | 19 | 6 | 9 | 3720 | 1760 | 2760 | 2312 | 574 | 973 | 17 | 107 | 21 | 6 | 94 | 80 |
| Tubificoides benedeni | - | - | - | - | - | - | 6 | - | - | 16 | 2 | 11 | 2 | 4 | 10 |
| Tubificoides pseudogaster | - | - | 10 | - | - | - | - | - | - | 19 | - | 244 | 147 | 497 | 436 |
| Achelia echinata | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Anoplodactylus pygmaeus | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pycnogonum littorale | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Mesopodopsis slabberi | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Neomysis integer | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| ud gammaridae | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Atylus swammerdami | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Atylus vedlomensis | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Gammarus salinus | - | - | - | - | - | - | 1 | - | - | 1 | 1 | - | - | - | - |
| ud Corophium sp. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Corophium volutator | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ud Caprellid | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Eurydice pulchra | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - |
| Bodotria scorpioides | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Eudorella truncatula | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Diastylis rathkei | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Crangon crangon | - | - | - | 1 | - | 1 | - | - | 1 | - | - | - | - | - | - |
| Carcinus maenas | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| Crepidula fornicata | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Cerastoderma edule | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| Ensis ensis | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Macoma balthica | - | - | - | - | - | - | - | - | - | 2 | - | - | - | 1 | - |
| Phoronis muelleri | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total species** | 1 | 2 | 2 | 5 | 3 | 4 | 7 | 4 | 5 | 9 | 7 | 6 | 7 | 9 | 8 |
| **Total individuals** | 19 | 7 | 19 | 3982 | 2117 | 2987 | 2684 | 785 | 1358 | 236 | 392 | 836 | 443 | 854 | 873 |

**NRA Colne survey 1992 - dat**

| Species | S16 6A | S17 6B | S18 6C | S19 7A | S20 7B | S21 7C | S22 8A | S23 8B | S24 8C | S25 9A | S26 9B | S27 9C | S28 10A | S29 10B | S30 10C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ud Anthozoan A | - | - | - | - | - | - | 1 | - | - | - | - | 4 | - | - | - |
| Eteone longa | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Phyllodoce mucosa | - | - | - | - | - | - | - | 1 | 1 | - | - | - | - | - | - |
| Autolytus langerhansi | - | - | - | - | - | - | - | 2 | - | - | - | 2 | - | - | - |
| Nereis diversicolor | 8 | 28 | - | 7 | - | - | - | - | 1 | - | - | - | - | - | - |
| Nereis succinea | - | - | - | - | - | - | 1 | - | - | - | - | - | - | - | - |
| Nereis virens | - | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - |
| ud Nephtys (juv.) | - | - | - | - | - | - | 1 | - | - | 11 | - | 7 | - | - | - |
| Nephtys cirrosa | - | - | - | - | 4 | - | - | 1 | - | - | - | - | - | - | 3 |
| Nephtys hombergii | 3 | 2 | 13 | 27 | 8 | 6 | 1 | - | 1 | 16 | 18 | 12 | 11 | 8 | 1 |
| Marphysa sanguinea | - | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - |
| Polydora ligni | 4 | 2 | - | - | - | 5 | 28 | 21 | 5 | - | 1 | - | - | - | - |
| Pygospio elegans | - | - | 5 | - | - | - | - | - | - | - | - | - | - | - | - |
| Spiophanes bombyx | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Streblospio shrubsolii | 81 | 94 | 230 | 72 | 17 | 7 | - | - | - | - | 1 | - | - | - | - |
| Chaetozone setosa | 13 | 1 | - | 2 | 4 | - | 42 | - | 22 | - | 8 | 13 | 3 | 14 | 16 |
| Tharyx marioni | - | 11 | 79 | 134 | 38 | 34 | 570 | 300 | 280 | 103 | 49 | 175 | 4 | 2 | 13 |
| Cossura longocirrata | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - |
| Melinna palmata | 1 | 10 | 13 | 1 | - | - | 26 | 15 | 17 | 1 | - | - | - | - | - |
| Ampharete acutifrons | - | - | - | - | - | - | 2 | - | 3 | 2 | - | 4 | - | 1 | - |
| Sabella pavonina | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Tubifex costatus | - | 27 | 3 | 58 | - | - | 2 | 4 | 1 | - | 2 | - | - | - | - |
| Tubificoides benedeni | - | - | 2 | 2 | - | 1 | 11 | 42 | 13 | - | - | 2 | - | - | - |
| Tubificoides pseudogaster | 80 | 280 | 75 | 26 | 11 | 7 | 1 | - | - | - | 2 | 1 | - | - | - |
| Achelia echinata | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - |
| Anoplodactylus pygmaeus | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | - |
| Pycnogonum littorale | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Mesopodopsis slabberi | 1 | 1 | 3 | 1 | - | - | 14 | 3 | 1 | - | - | - | - | - | - |
| Neomysis integer | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ud gammaridae | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| Atylus swammerdami | - | - | - | - | - | - | - | - | - | - | - | 1 | - | 1 | - |
| Atylus vedlomensis | - | - | - | - | - | - | - | - | - | - | - | 1 | 1 | - | - |
| Gammarus salinus | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| ud Corophium sp. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Corophium volutator | - | - | - | - | - | - | 2 | 1 | 3 | - | - | - | - | - | - |
| ud Caprellid | - | - | - | - | - | - | - | - | - | 1 | - | 4 | - | - | 1 |
| Eurydice pulchra | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Bodotria scorpioides | - | - | - | - | - | - | - | - | - | - | - | 2 | - | - | - |
| Eudorella truncatula | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1 |
| Diastylis rathkei | - | - | - | - | - | - | - | - | - | - | - | 1 | - | - | - |
| Crangon crangon | - | - | - | - | - | - | 2 | - | - | - | - | - | - | - | - |
| Carcinus maenas | - | 1 | - | - | - | - | 5 | 2 | 1 | - | - | 1 | - | - | - |
| Crepidula fornicata | - | - | - | - | - | - | 3 | - | - | - | - | - | - | - | - |
| Cerastoderma edule | - | - | - | - | - | - | 5 | - | 1 | - | - | - | - | - | - |
| Ensis ensis | - | - | - | - | - | - | - | - | - | 1 | - | - | - | - | - |
| Macoma balthica | - | - | - | - | 1 | - | - | - | 1 | - | - | 2 | - | - | - |
| Phoronis muelleri | - | - | - | - | - | - | - | - | - | 22 | 2 | 25 | 11 | 7 | - |
| **Total species** | 8 | 12 | 9 | 10 | 7 | 6 | 18 | 12 | 15 | 8 | 9 | 21 | 6 | 8 | 7 |
| **Total individuals** | 191 | 458 | 423 | 330 | 83 | 60 | 717 | 394 | 351 | 157 | 84 | 262 | 31 | 36 | 36 |

## NRA ANGLIAN R. COLNE SEDIMENT DATA

| SAMPLE | MEAN µm | MEDIAN µm | % CLAY& SILT | MEAN Ø | SD Ø | SKEW | KURTOSIS | % ORGANIC CARBON | LOI at 400° | % COAL CONTENT |
|---|---|---|---|---|---|---|---|---|---|---|
| C1A | 19.1 | 18.6 | 80.3 | 5.7 | 1.53 | -0.14 | 1.68 | 3.15 | 7.00 | 3.00 |
| C1B | 17.9 | 17.7 | 83.5 | 5.8 | 1.48 | -0.18 | 1.82 | 3.38 | 2.00 | 5.00 |
| C1C | 19 | 20 | 82.2 | 5.7 | 1.44 | -0.04 | 1.67 | 1.62 | 4.00 | 4.00 |
| C2A | 1366.7 | 1877.8 | 11.4 | -0.5 | 3.06 | 0.88 | 2.97 | 0.24 | NEG | NEG |
| C2B | 2728.4 | 5545.5 | 7.5 | -1.4 | 3.02 | 1.15 | 3.61 | 0.41 | 6.00 | 2.00 |
| C2C | 1903.7 | 7421.2 | 18.3 | -0.9 | 3.94 | 0.93 | 2.44 | 0.47 | 7.00 | NEG |
| C3A | 572.9 | 467.3 | 21.4 | 0.8 | 3.5 | 0.33 | 2.1 | 0.16 | 3.00 | NEG |
| C3B | 445.9 | 446.6 | 15.6 | 1.2 | 2.67 | 0.4 | 3.14 | 0.31 | 5.00 | NEG |
| C3C | 726.3 | 471.5 | 14.1 | 0.5 | 3.13 | 0.29 | 2.4 | 0.63 | 5.00 | NEG |
| C4A | 273.3 | 405.9 | 21.7 | 1.9 | 2.96 | 0.72 | 2.66 | 0.63 | 1.00 | NEG |
| C4B | 1225.8 | 845.4 | 6.1 | -0.3 | 2.99 | 0.34 | 2.48 | 0.24 | 3.00 | NEG |
| C4C | 1155.4 | 849.2 | 9.7 | -0.2 | 3.27 | 0.58 | 2.7 | 0.08 | 8.00 | NEG |
| C5A | 838.9 | 477.7 | 18.2 | 0.3 | 3.69 | 0.35 | 1.94 | 1.1 | 1.00 | NEG |
| C5B | 1036.6 | 912.8 | 10.7 | -0.1 | 2.85 | 0.72 | 2.81 | NEG | 4.00 | NEG |
| C5C | 526.7 | 458.3 | 13.6 | 0.9 | 2.85 | 0.1 | 2.78 | NEG | NEG | 2.00 |

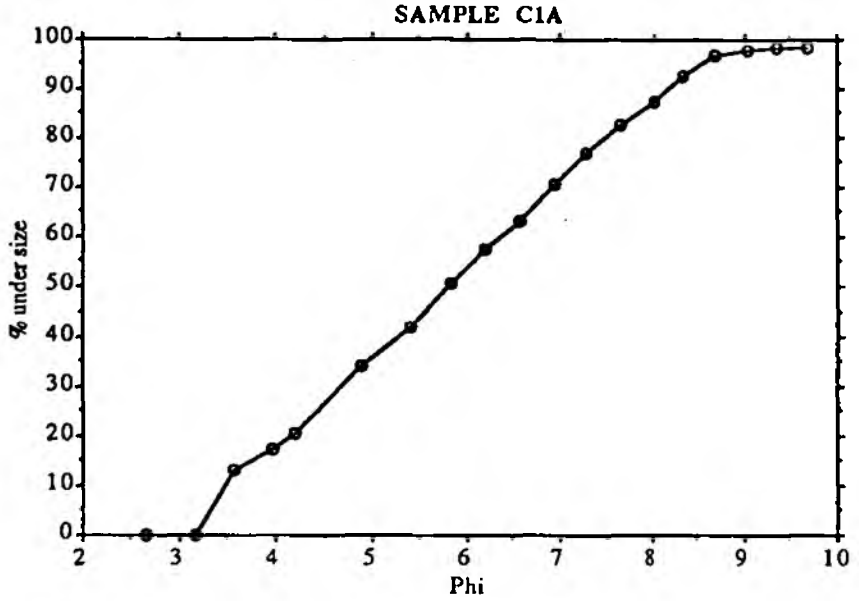
NB NEG=NEGLIGIBLE

## NRA ANGLIAN R. COLNE SEDIMENT DATA

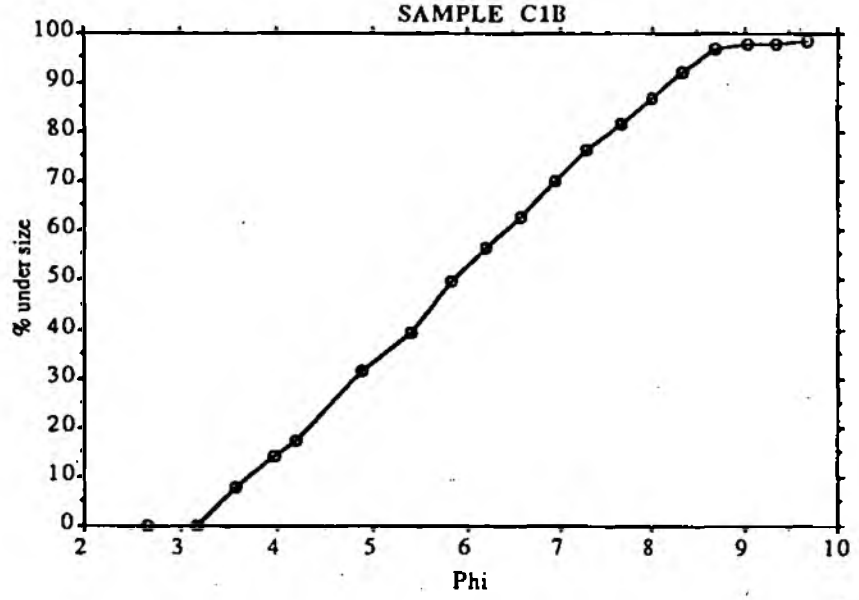
| SAMPLE | MEAN µm | MEDIAN µm | % CLAY& SILT | MEAN Ø | SD Ø | SKEW | KURTOSIS | % ORGANIC CARBON | LOI at 400° | % COAL CONTENT |
|---|---|---|---|---|---|---|---|---|---|---|
| C6A | 73.5 | 56.7 | 50.3 | 3.8 | 2.64 | -0.08 | 1.73 | 0.73 | 3.00 | NEG |
| C6B | 81 | 73.1 | 45.8 | 3.6 | 2.6 | -0.06 | 2.04 | 0.57 | NEG | 1.00 |
| C6C | 106.4 | 73.8 | 44.3 | 3.2 | 2.97 | -0.48 | 2.59 | 0.94 | NEG | NEG |
| C7A | 17.5 | 18.7 | 88.2 | 5.8 | 1.34 | -0.02 | 1.69 | 2.44 | 10.00 | 2.00 |
| C7B | 20.5 | 22 | 79.5 | 5.6 | 1.52 | -0.07 | 1.93 | 2.03 | NEG | 3.00 |
| C7C | 19.1 | 19.8 | 81.7 | 5.7 | 1.48 | -0.11 | 1.73 | 2.11 | 11.00 | 3.00 |
| C8A | 30.6 | 24.4 | 73.3 | 5 | 2.29 | 0.78 | 2.67 | 0.79 | 3.00 | 2.00 |
| C8B | 21.7 | 17.1 | 81.5 | 5.5 | 2.06 | -0.99 | 3.28 | 0.86 | 2.00 | NEG |
| C8C | 21.5 | 20 | 84.3 | 5.5 | 1.91 | -1.26 | 5.01 | 1.02 | 2.00 | 3.00 |
| C9A | 15.5 | 13.8 | 86.2 | 6 | 1.46 | -0.3 | 1.7 | 2.51 | 3.00 | 2.00 |
| C9B | 15.1 | 15 | 90.5 | 6 | 1.38 | -0.16 | 1.64 | 2.67 | 2.00 | 2.00 |
| C9C | 15.8 | 14.5 | 85.7 | 6 | 1.45 | -0.27 | 1.7 | 2.67 | 8.00 | 4.00 |
| C10A | 16.3 | 15.8 | 87.5 | 5.9 | 1.51 | -0.51 | 2.89 | 1.38 | 5.00 | 2.00 |
| C10B | 17.1 | 16.5 | 89.3 | 5.9 | 1.55 | -1.03 | 5.27 | 0.89 | 6.00 | 1.00 |
| C10C | 16.3 | 16.7 | 88.3 | 5.9 | 1.4 | -0.08 | 1.64 | 1.42 | 8.00 | 3.00 |

NB NEG=NEGLIGIBLE

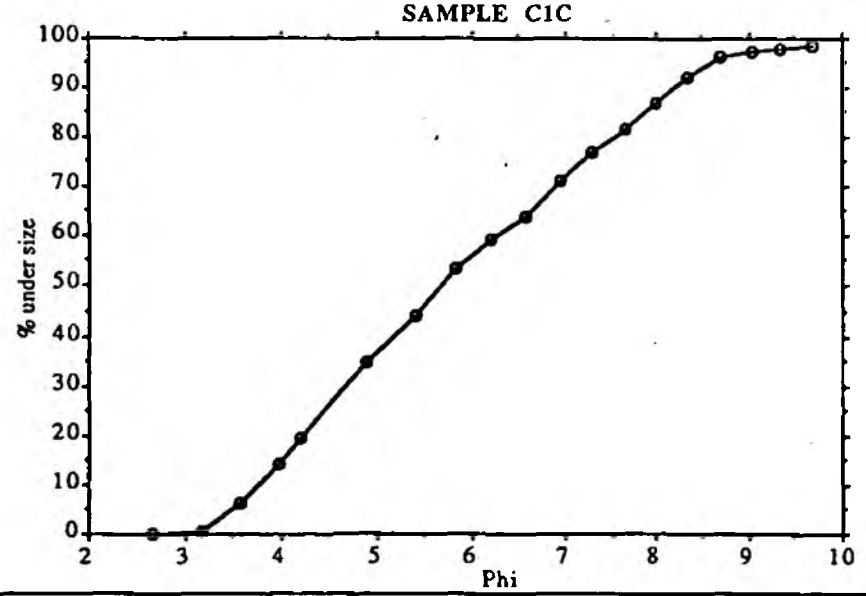
SAMPLE C1A




SAMPLE C1B




SAMPLE C1C

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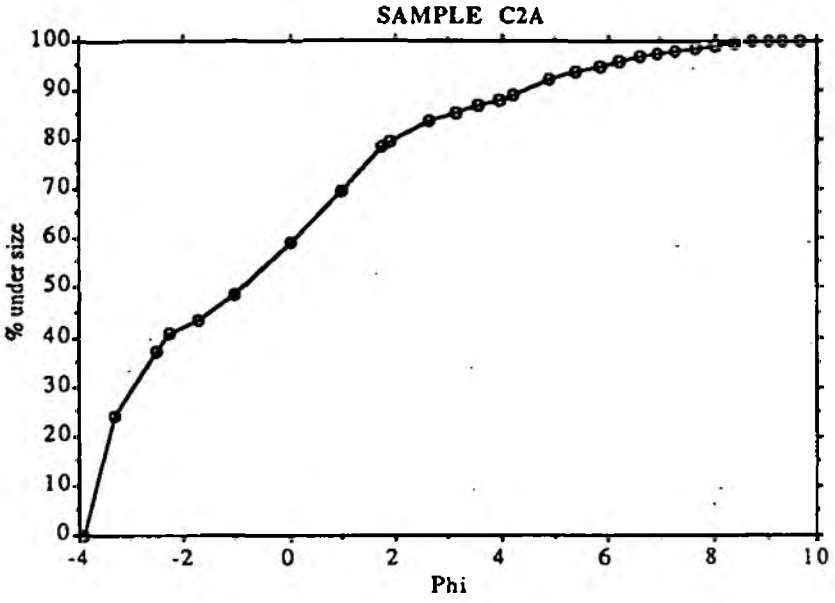
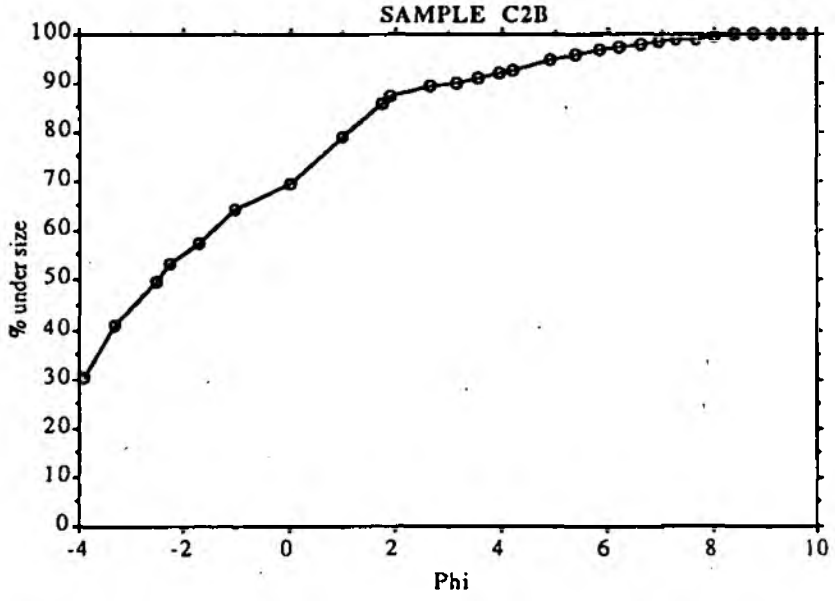
|---|---|
| Grain Size Distribution | University of Hull |

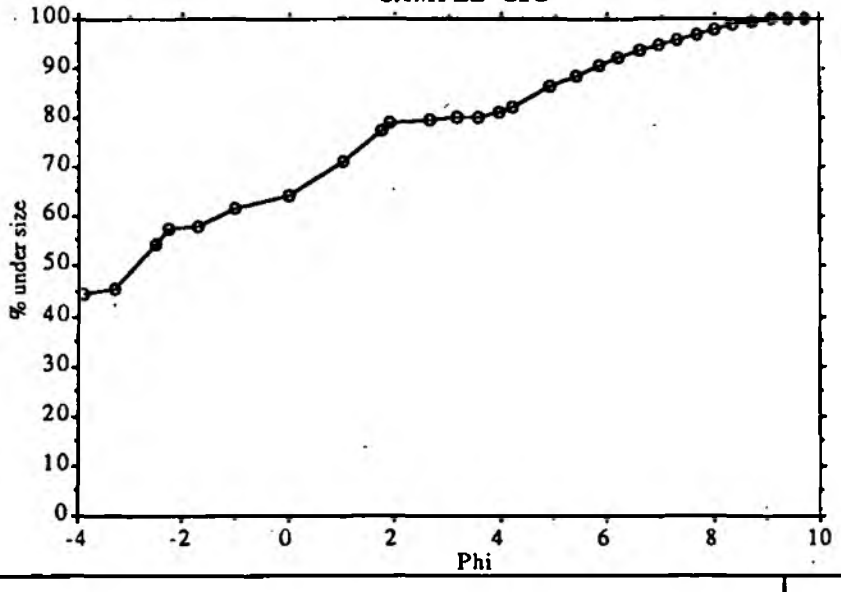
SAMPLE C2A




SAMPLE C2B




SAMPLE C2C

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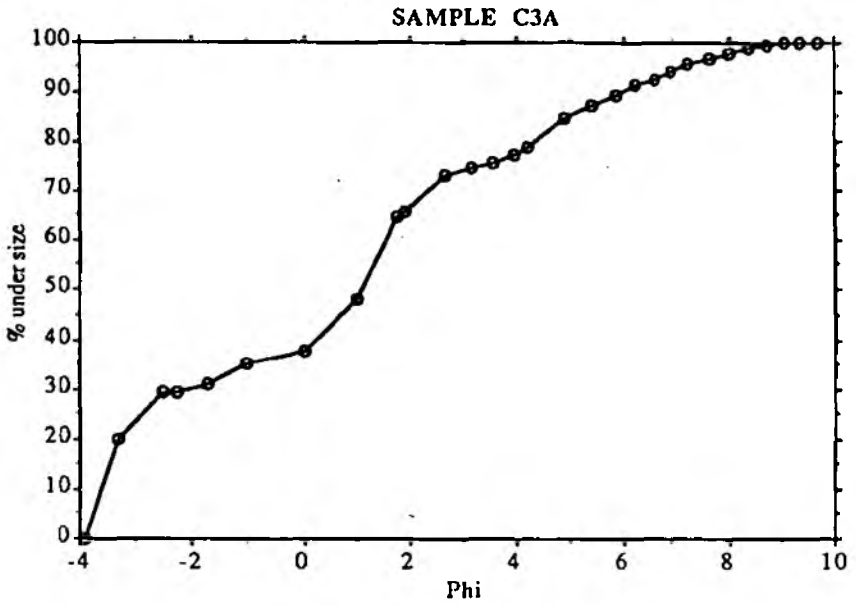
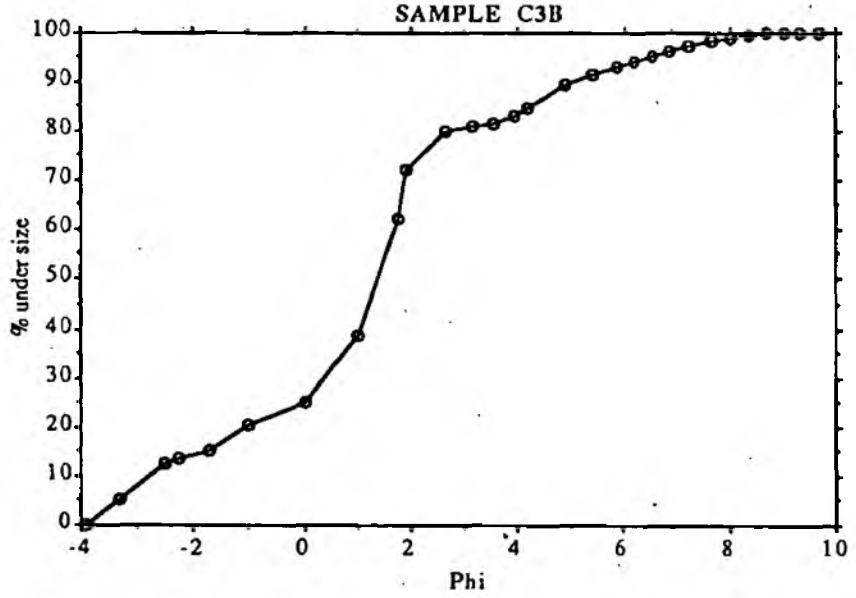
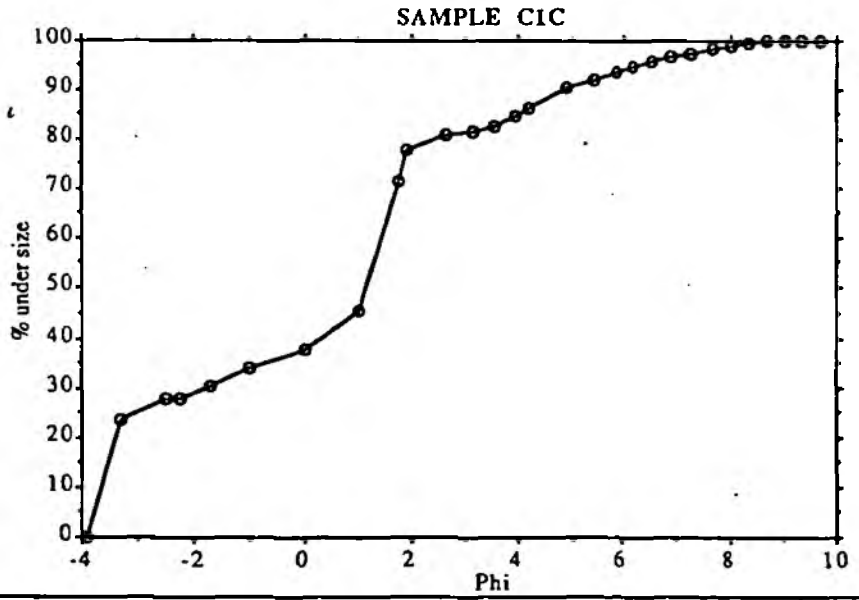
| Grain Size Distribution | University of Hull |

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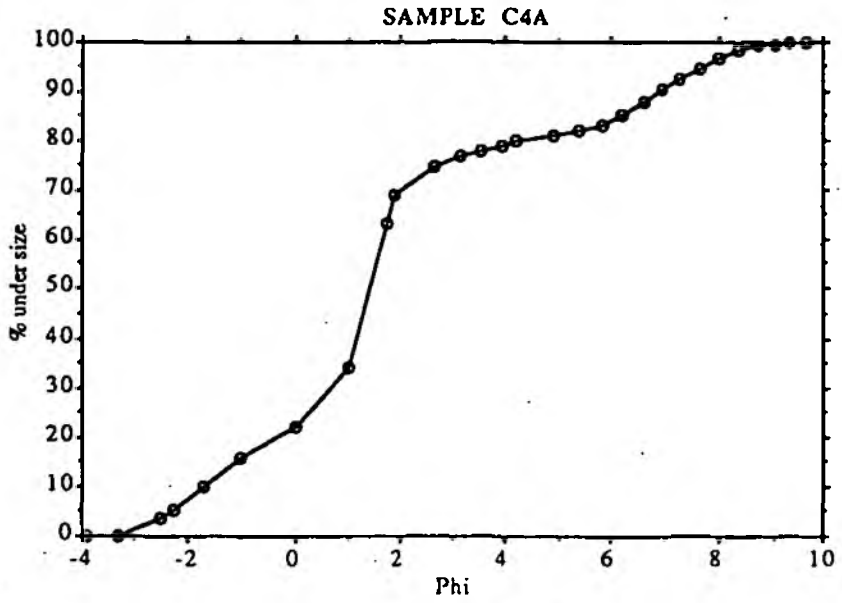
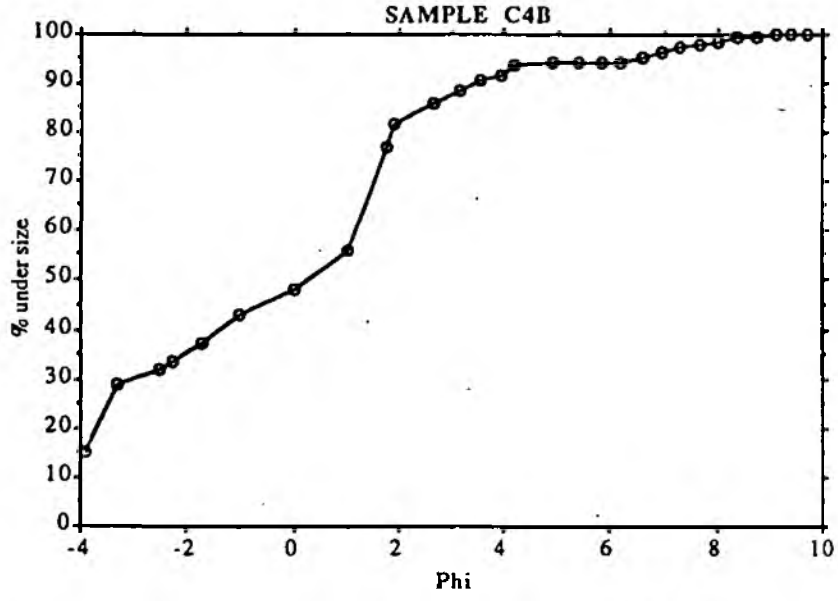
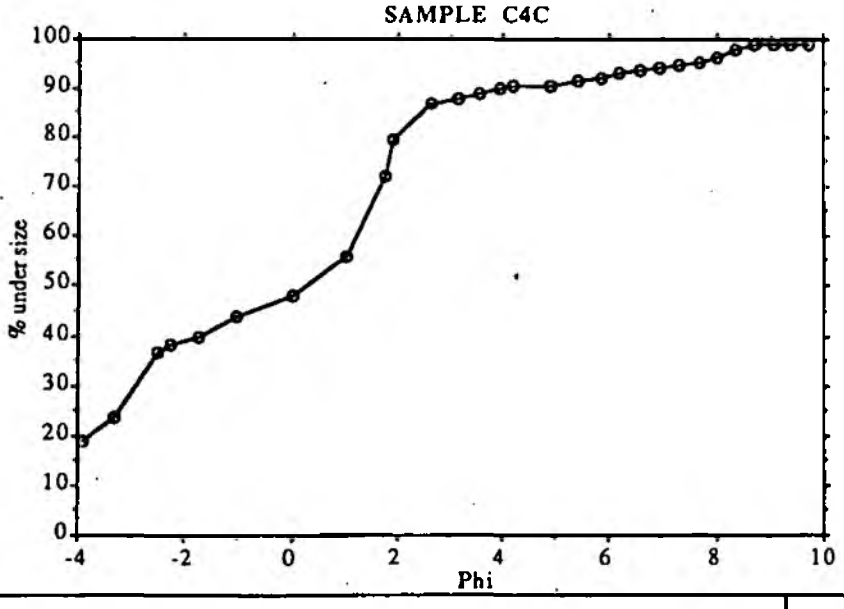
| Grain Size Distribution | |

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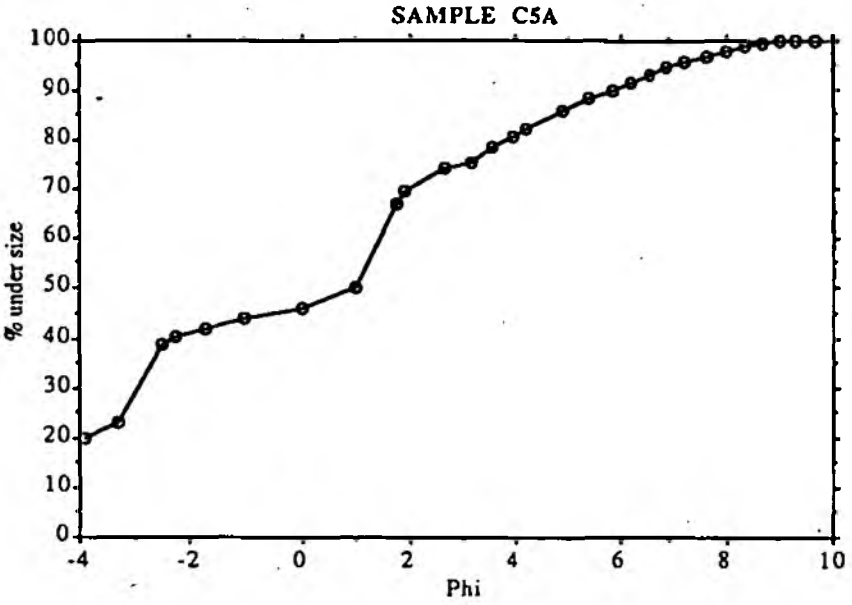
SAMPLE C5A

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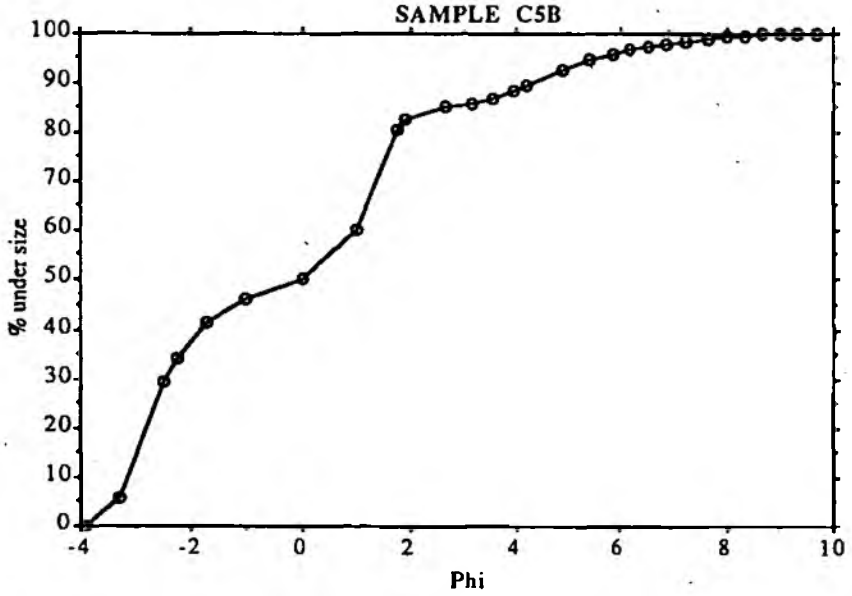
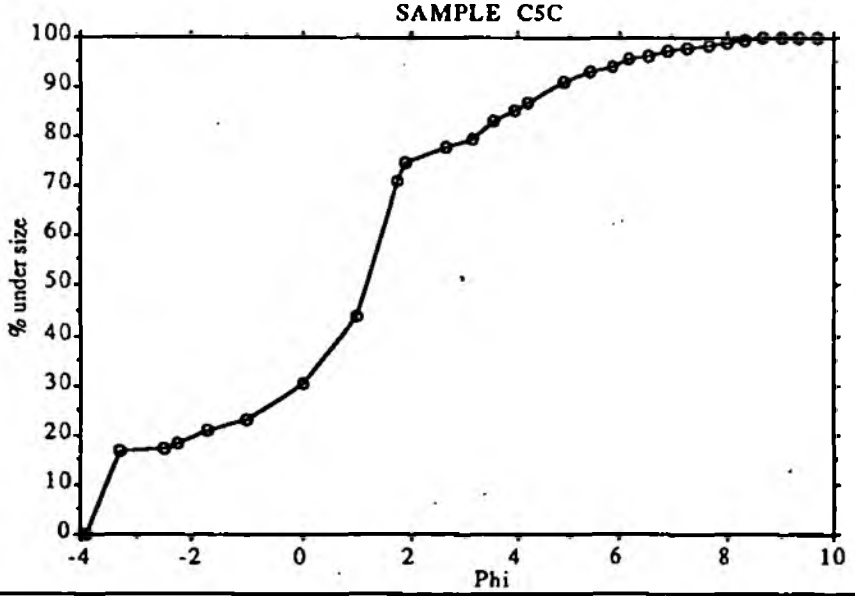



SAMPLE C5C

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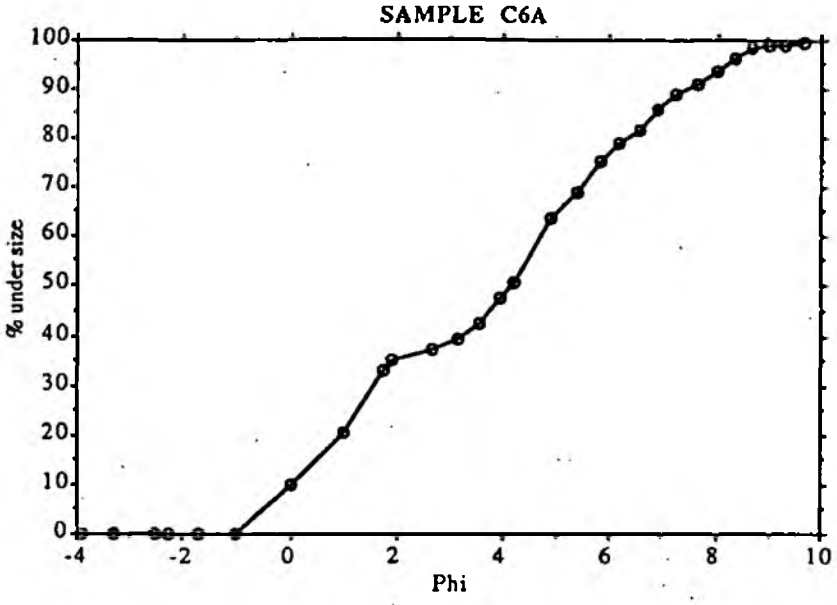
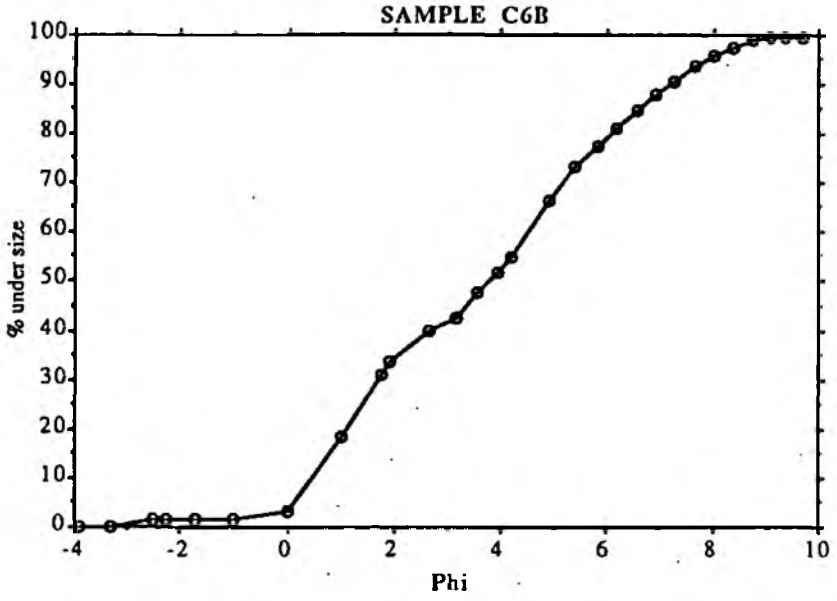
SAMPLE C6A




SAMPLE C6B

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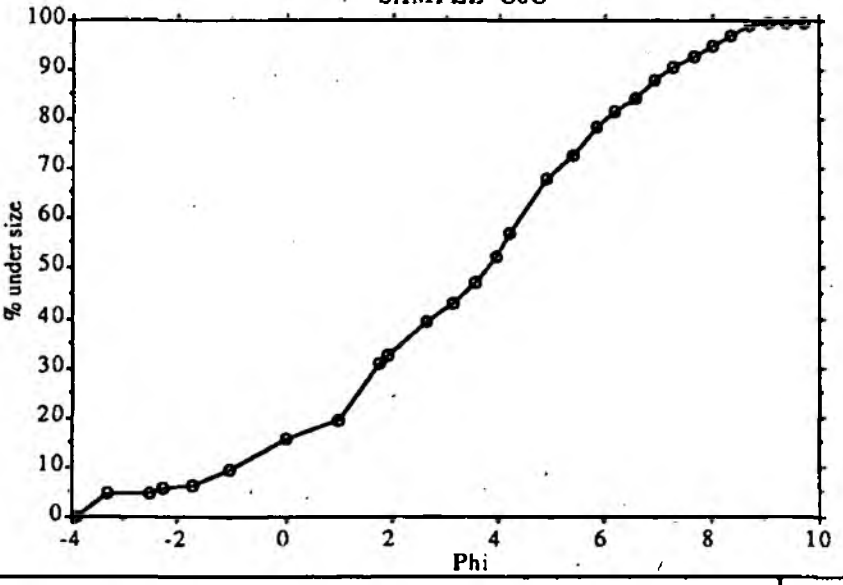


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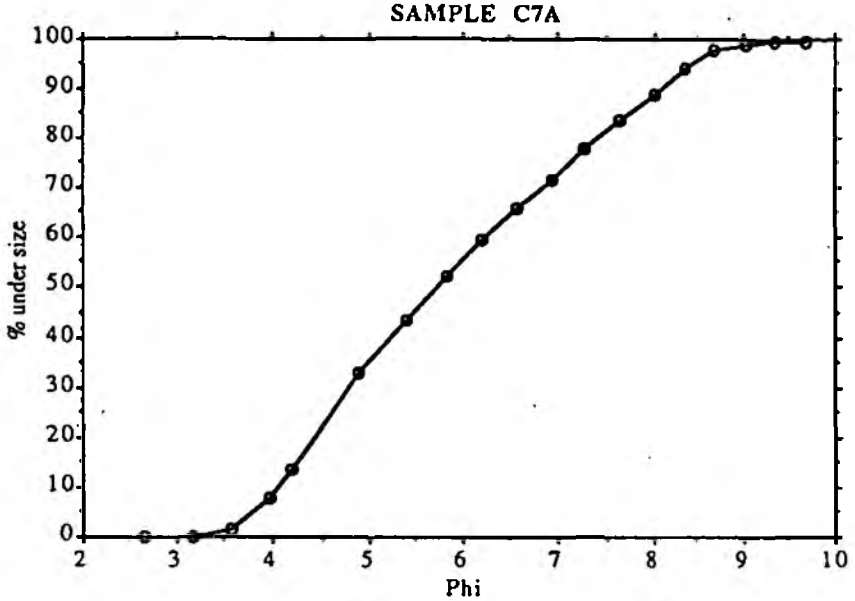
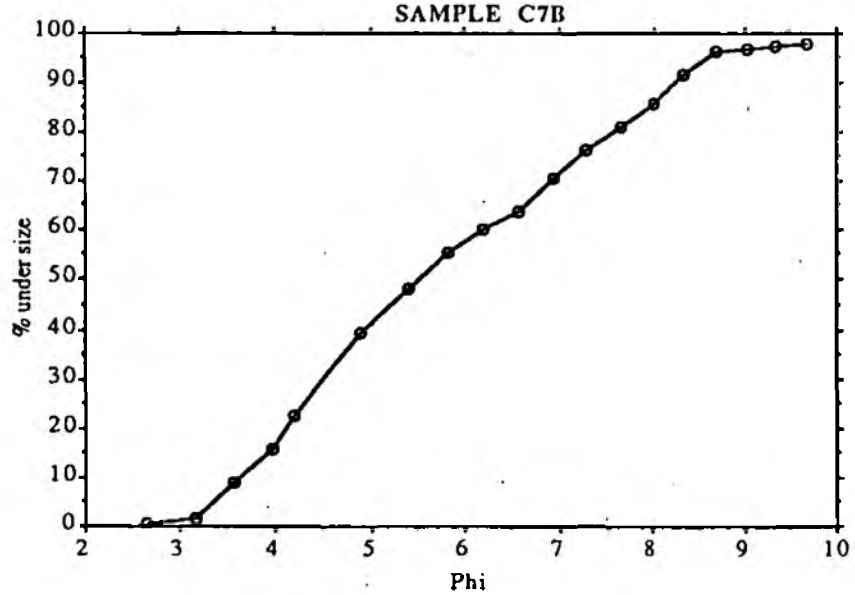
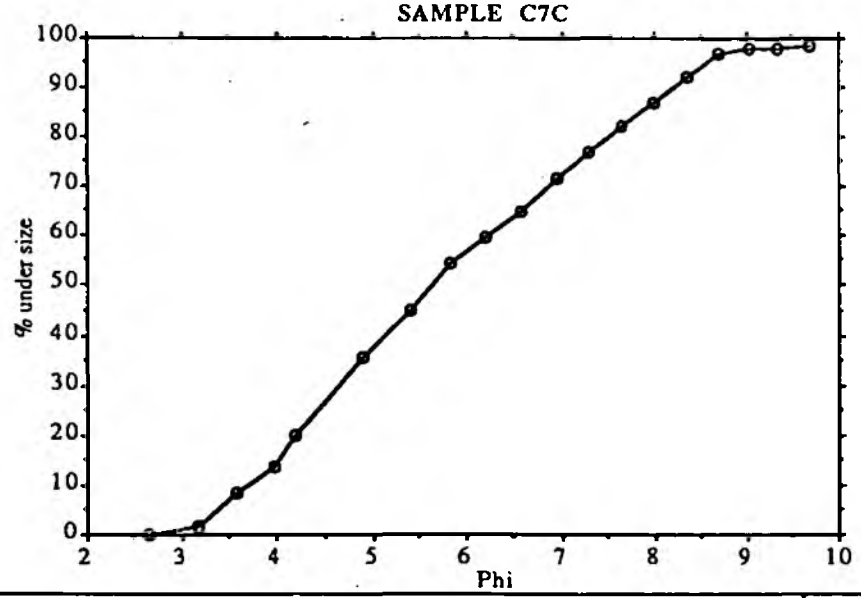
SAMPLE C7A




SAMPLE C7B




SAMPLE C7C

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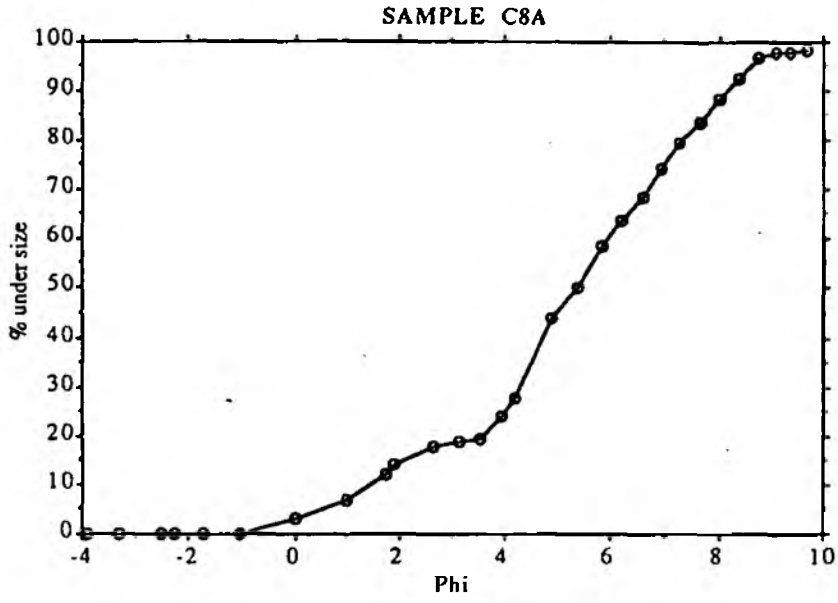


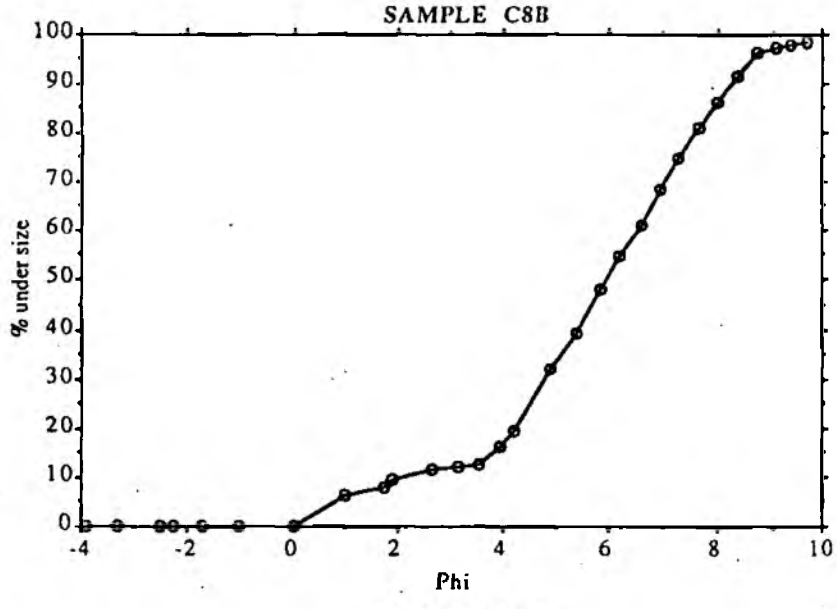


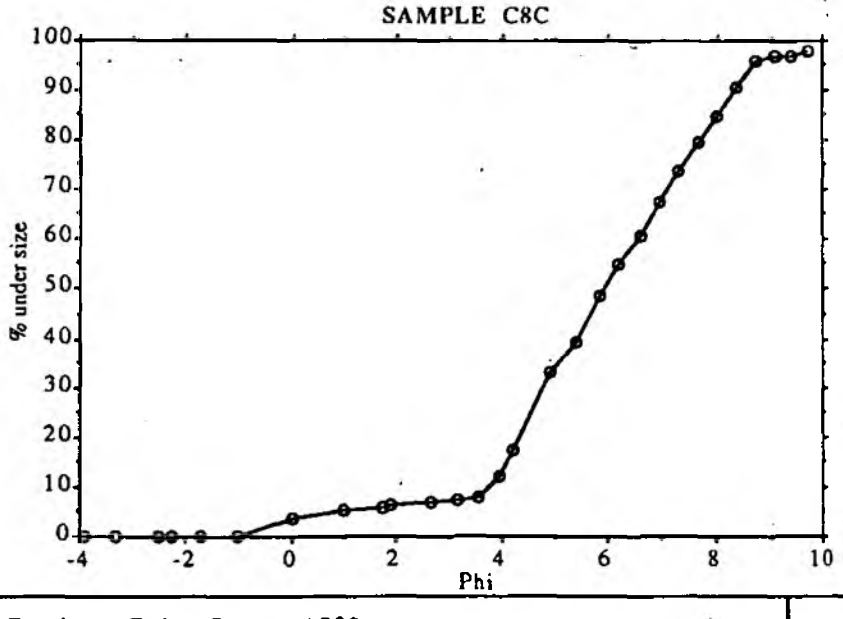


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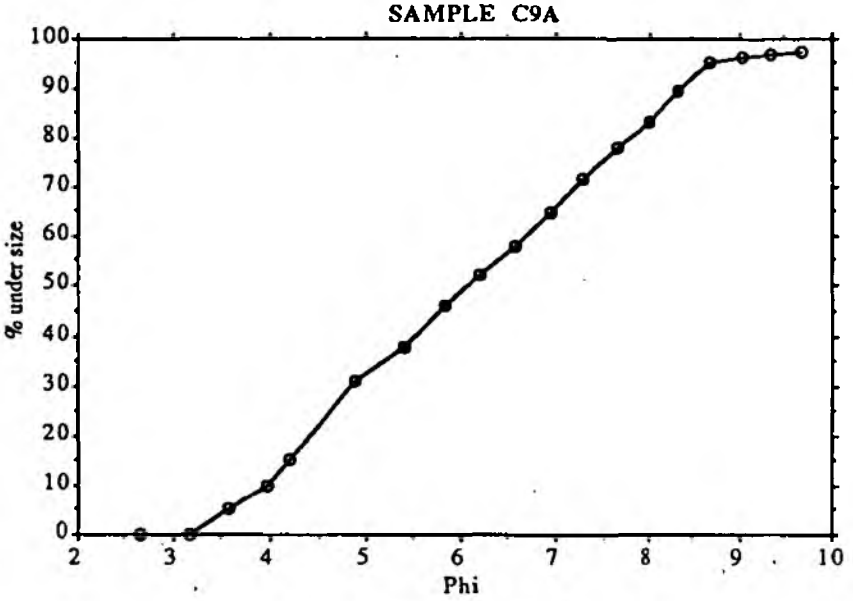
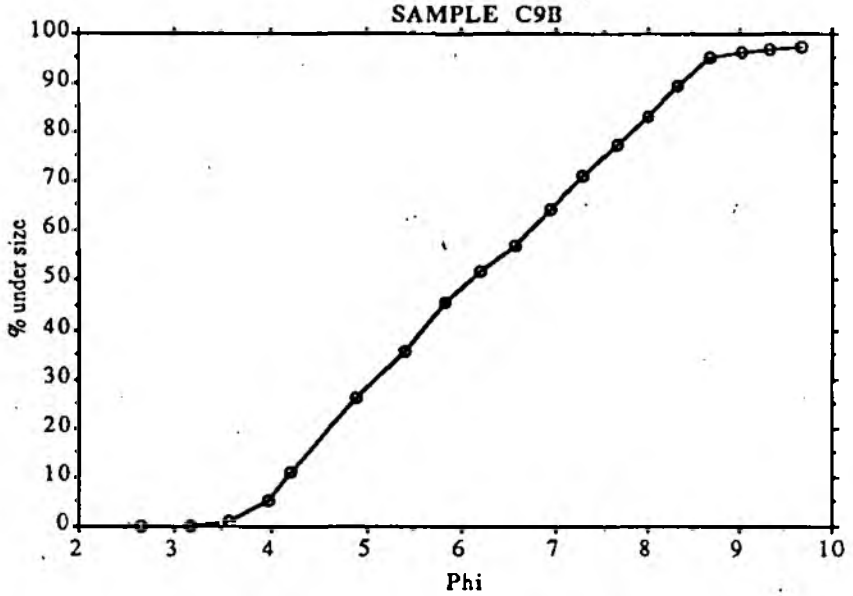
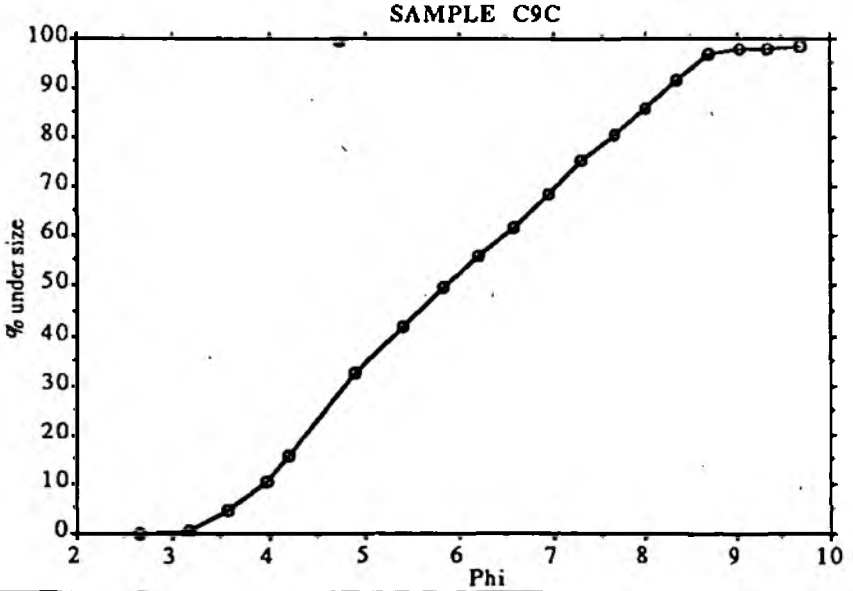
SAMPLE C9A




SAMPLE C9B




SAMPLE C9C

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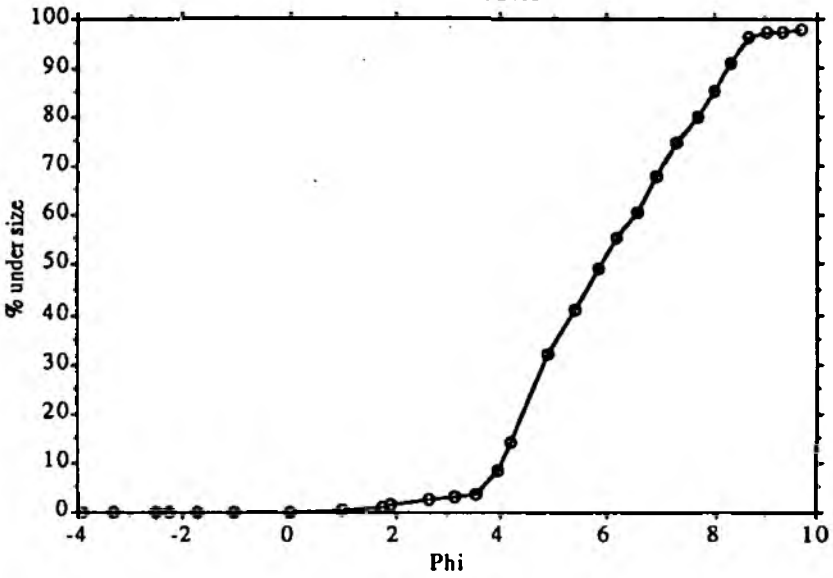
SAMPLE C10A

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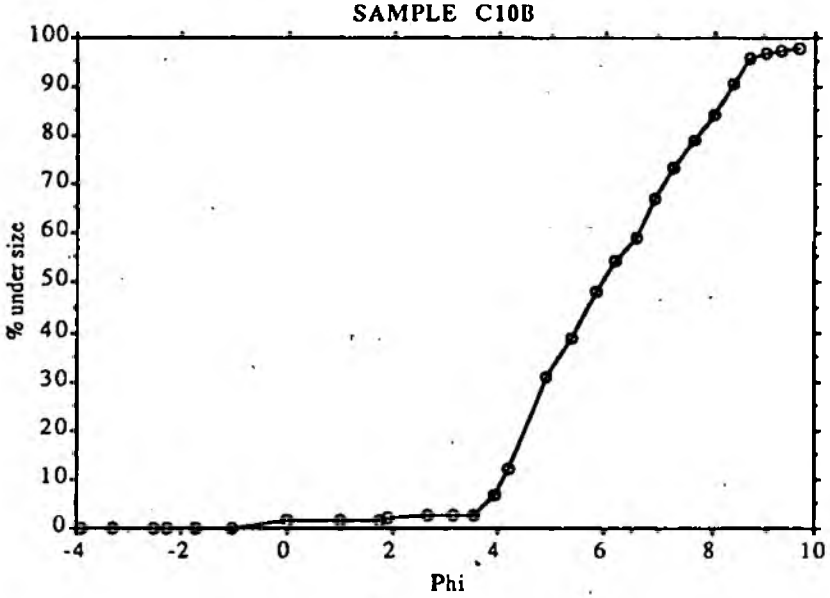
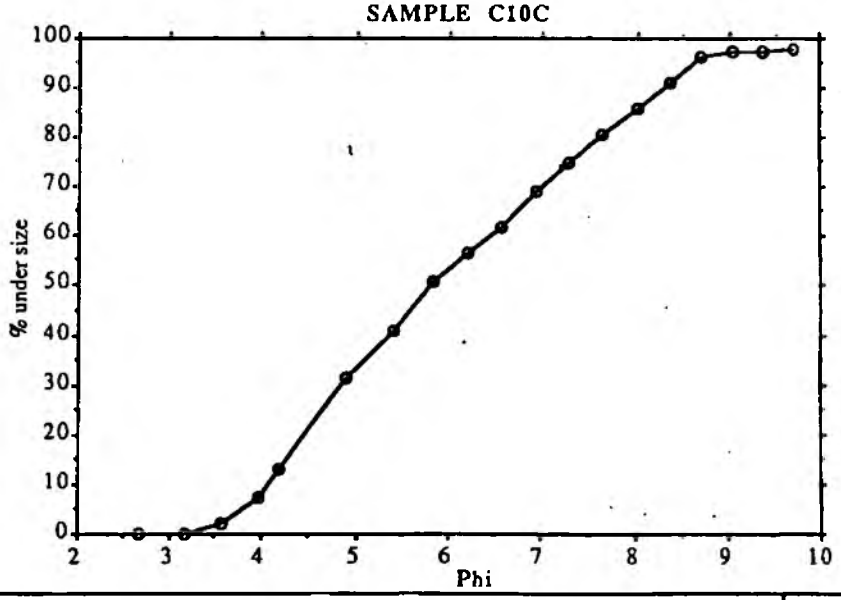



SAMPLE C10C

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