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An experimental study on the impact of clam dredging on soft sediment macroinvertebrates

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AN EXPERIMENTAL STUDY ON THE IMPACT OF CLAM DREDGING ON SOFT SEDIMENT MACROINVERTEBRATES

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ABSTRACT

The impact of clam dredging on intertidal invertebrate fauna has been assessed by undertaking an experimental study using a modified oyster dredge. A study area was established in Langstone Harbour at a site known as Chalkdock Lake. Six sites were sampled, three in a control area and three in a trial dredged area. The control site was sampled on two occasions, at the beginning and end the study. The trial site was sampled on three occasions, at the beginning and end of the study and soon after the dredging was undertaken.

Samples were taken for faunal and sediment particle size analysis. In situ measurements were made of redox levels.

The sediment type for the area was muddy gravel. The results clearly indicate that the removal of the top 15cm of sediment by the dredge revealed a substratum with a different particle size distribution. Although only small differences were noted in the level of silt, the gravel fraction was clearly seen to be reduced.

Faunal similarity between the control and trial sites was within the normal range for the muddy gravel habitat, although the dominant species at the control site, <u>Cirriformia tentaculata</u> was completely absent from the trial site.

The fauna were seen to be either completely removed or considerably reduced by the action of the dredge. This was statistically demonstrated using community structure measures and individual abundance values. The annelids were seen to be most badly affected by the action of the dredge with the exception of <u>Tubificoides benedeni</u> and a Phyllodocid. The abundance of the bivalve species was greatly reduced, but some individuals were found in the post-dredge samples. These were all small specimens and were thought to have been disturbed by the dredge and re-deposited afterwards. No clear recovery of the fauna was evident over the period of the study.

The principal species colonising after dredging are predicted to be the small opportunistic annelids and the small re-deposited bivalves. It was concluded that the re-colonisation of the dredged areas would be poor, in terms of the value to avifauna, if intensive dredging was to be undertaken.

CONTENTS

1. INTRODUCTION

The Solent Harbours system, consisting of Portsmouth, Langstone and Chichester Harbours (Fig.1), is of international importance as a wildfowl and wader feeding site. The majority of the area is within Sites of Special Scientific Interest and is included in the Ramsar convention and Special Protection Areas. The natural environment in all three harbours is under considerable pressure from numerous sources including industrial pollution, land reclamation, recreational activities and sewage pollution. Clearly any further stress factors need to be assessed in detail.

The American Hard Shell Clam Mercenaria mercenaria was originally introduced into Southampton Water in 1925 (Mitchell, 1974). It was noted as common within the River Itchen from as early as 1935. Although a small fishery developed during the early years it was not until 1965 that a commercial fishery had developed. Fishing for this species was originally undertaken using an oyster dredge which was subsequently modified for greater efficiency. During the mid 1980's extensive use of hydraulic dredges was made in Southampton Water. This led to a catastrophic decline in the numbers of clams and resulted in local fishermen attempting to exploit populations further afield, including the Solent Harbours.

Sheader's (1986) study of intensive dredging within Southampton Water demonstrated that some of the dominant benthic species showed a marked decline in abundance over a period of several years. Although the use of the hydraulic dredges in the Solent Harbours was prevented by English Nature, fishing has been undertaken using a variety of modified oyster dredges. Within the sheltered fine sediment conditions of the Solent Harbours, English Nature anticipated that considerable damage could occur. In an attempt to provide a baseline against which future dredging can be monitored or controlled the present survey was commissioned.

FIG. 1 SOLENT HARBOURS COMPLEX

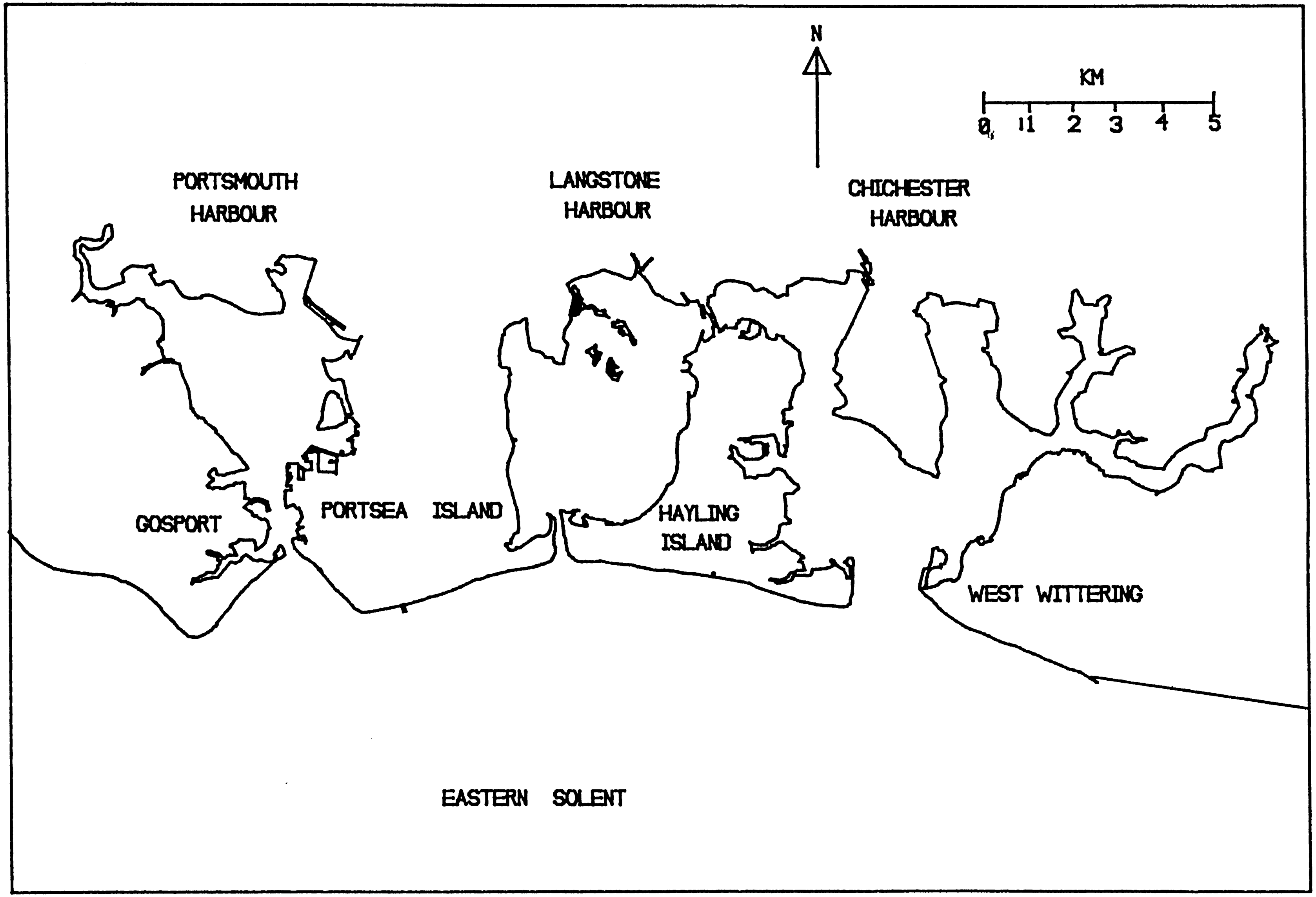


FIG. 2 STUDY AREA WITHIN LANGSTONE HARBOUR

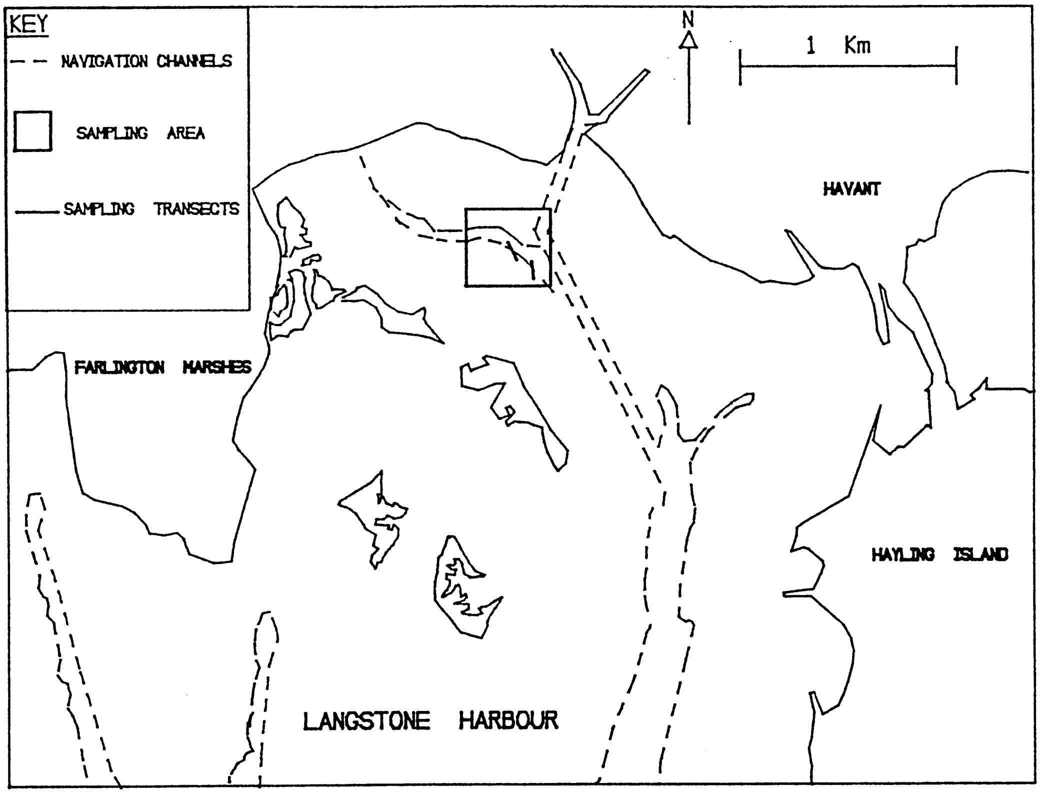
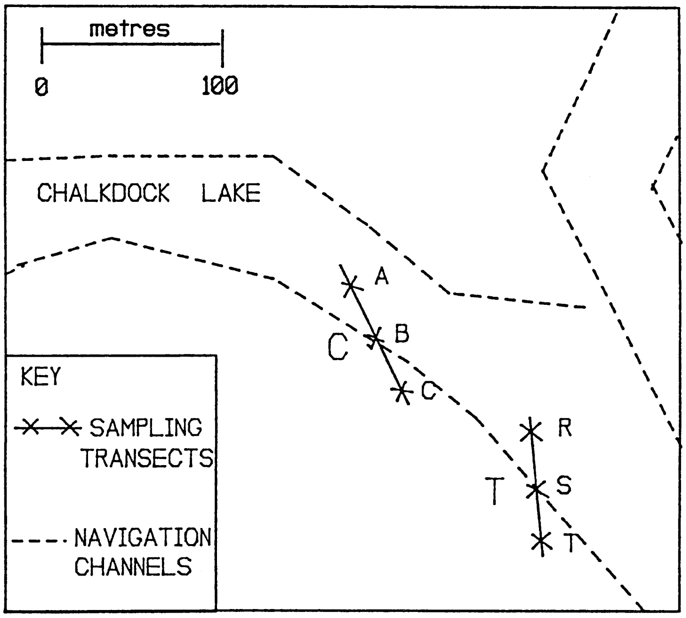


FIG. 2A SAMPLING AREA WITHIN CHALKDOCK LAKE



2. METHODS

2.1 Survey Design

The methodology for this study follows that of Moore (1991).

The area to be investigated was selected by R.S.P.B. in collaboration with English Nature and Southern Science. It was located at the northern end of Langstone Harbour at a site called Chalkdock Lake (Fig. 2), within the R.S.P.B Langstone Harbour Reserve. Two study areas were established, one site served as a control (C), whilst the other was dredged (T). The study areas were not more than 50m apart, although they were placed at an angle to one another to ensure access for the dredging (Fig. 2). The areas were marked at low water mark with buoys and the locations recorded by taking compass bearings from land marks.

2.2 Sampling Regime

Three sampling sites, approximately 10m apart, were established within each of the two areas. The sites were sampled at various times over an 8 day period, pre- and post-dredging (Table 1). At low water 5 core samples were taken for faunal analysis at each of the sampling sites within each study area. An additional core sample was taken at each site for subsequent particle size analysis. The core used had an area of $0.064m^2$ and was inserted into the sediment to a depth of 15cm. In addition to the sediments collected, Redox. potential was also measured on the surface and at depths of 1cm, 5cm, and 10cm. All sediment samples were frozen until ready for analysis.

2.3 Dredging

Following the initial sampling on Day 1, area T was dredged at the approximate position of the three sampling stations using a modified oyster dredge. Two passes of the dredge on different bearings were made at each of the three sampling stations in an attempt to form a point of maximum disturbance. The catch from each dredge was analysed for numbers of bivalve species caught and the percentage of individuals damaged by the dredge.

2.4 Sediment Analysis

The core samples taken for sediment analysis underwent full particle size analysis using the following methods:-

A representative portion of wet sediment was transferred to a 500ml round bottom flask and 10ml of sodium hexametaphosphate solution +200-300ml distilled water were added. The flask was stoppered and shaken automatically for 2 hours.

Contents of flask were transferred to 63µm sieve and washed through with distilled water such that the total volume collected did not exceed 1 litre. The fraction retained on the sieve was transferred to a glass or foil dish and dried at 100°C.

The litre of filtrate containing the <63µm fraction was allowed to equilibrate in a water bath at 20°C. The clay fraction was resuspended and at specific time intervals 20ml was removed from a predetermined depth and transferred to a preweighed evaporating basin (see Table below)

TIME (mins)	DEPTH (cm)	FRACTION (µm)
0	20	<63
8	10	<15.6
124	10	<3.9

The samples were then dried at 100°C and weighed

The dried sediment retained on the 63µm sieve described earlier was graded using a stack of 8 sieves with apertures ranging from 1600 µm to 63µm and automatically shaken for 20 mins. The fraction retained on each sieve was weighed and recorded. The data was analysed using inhouse computer software.

2.5 Faunal Analysis

The core samples taken for faunal analysis were washed through a 500µm sieve and the greater than 500µm fraction retained. All specimens were preserved in 10% formalin and stained with Rose Bengal. Animals were sorted initially to family and where possible to species.

2.6 Statistical Analysis

Data was logged onto a Statsgraphics programme and summary statistics calculated. Significant differences in statistical populations were tested using the non-parametric Mann-Whitney U test (Elliot, 1977).

Similarity analysis was undertaken using Czecanowski's coefficient, C_2

$$S = \sum \left(\frac{2W}{A + B}\right)$$

where A = abundance of species n in sample A
B = abundance of species n in sample B
W = lowest abundance value for species n in samples A and B

Complete similarity is represented by 1 and complete dissimilarity by 0.

Diversity was calculated using Shannon's diversity index H, where;

$$H = - \sum \frac{ni}{N} x \ln \frac{n^i}{N}$$

and ni = importance value of each species in sample
N = sum of importance values

High H values represent diverse species composition and even distribution of individuals amongst species. To separate these two components an evenness index J was employed;

$$J = \frac{H}{\ln S}$$

where H = Shannon's diversity index
S = number of species

High values represent well distributed individuals amongst species and low values a high degree of dominance.

TABLE 1

SAMPLING REGIME

	DAY 1 30/1/92	DAY 2 31/1/92	DAY 3 7/2/92
SITE C Control	15 FAUNAL SAMPLES + 3 SEDIMENT SAMPLES	NO SAMPLES	15 FAUNAL SAMPLES + 3 SEDIMENT SAMPLES
SITE T Dredge	15 FAUNAL SAMPLES + 3 SEDIMENT SAMPLES	DREDGING (HIGH WATER) 15 FAUNAL SAMPLES + 3 SEDIMENT SAMPLES (LOW WATER)	15 FAUNAL SAMPLES + 3 SEDIMENT SAMPLES

3. RESULTS

3.1 Introduction

The data will be considered in relation to the physical characteristics of the sediment and faunal composition. The raw data for the sediment character and fauna are in Appendix 1 and 2 respectively. Due to difficult field conditions the final post-dredge site was not sampled.

3.2 Sediment Character

Two aspects of the sediment character were analysed; particle size and redox. profile.

3.2.1 Particle size analysis

In general the sediments were composed of a mixed muddy gravel and were of a homogeneous appearance throughout the sampling area. The data (Table 2) indicate that although the majority of the sediment was comprised of fines, hence the small median diameters, a significant proportion of the sediment consisted of gravel.

Figures 3 to 5 illustrate the differences in sediment type which occurred due to the dredging activity. The median particle size diameter and percentage sediment less than 63µm showed little difference between the control, trial, and sampling times (Figs. 3 and 4). The values were broadly overlapping indicating that the dredging has not affected the fines content nor the overall particle size. Figure 5 in contrast clearly shows that the coarse sediments have been removed from the trial sampling sites.

3.2.2 Redox. Profile

Redox. values taken during the survey are recorded in Appendix 2a. These data are summarised in Figs. 6 and 7. Figure 6 illustrates the redox. profile at the control sites on both sampling occasions. With one exception profiles are fairly similar, a value of -250 mV occurring by 1cm and maximum values of between -300 and -400 mV at 10cm depth. The trial sites in contrast were less clear (Fig. 7). No data were recorded at the first post-dredge sampling occasion and considerable variation was evident in the pre-dredge sites. Despite this the profiles seem to indicate that the sediments after dredging are more anoxic. However, these variations are encompassed by the variation evident at the control sites, therefore no clear differences can be implied.

3.3 Faunal Composition

3.3.1 Introduction

Two aspects of the faunal composition have been examined. These are comparisons of community structure parameters and individual species abundances. Summary statistics sheets for the most abundant species and community parameters are presented in Appendix 3. No animals were retained by the dredge due to the large mesh size of the retaining bag.

A summary of faunal information and a full species list including mean abundances, are presented in Tables 3 and 4 respectively. It can be seen from Table 3 that several differences

Table 2. **SUMMARY SEDIMENT DATA**

a) Mean particle size (μm)

Sites

	A	B	C	Mean
C				
PRE	21.15	8.86	13.16	14.39
POST	11.35	14.10	15.53	13.66
	R	S	T	Mean
T				
PRE	9.49	23.84	9.63	14.32
POST 1	10.80	11.29	30.98	17.69
POST 2	--	12.19	8.52	10.36

b) % sediment <63 μm

Sites

	A	B	C	Mean
C				
PRE	78.81	87.99	83.11	83.30
POST	67.25	61.79	61.38	63.10
	R	S	T	Mean
T				
PRE	75.72	73.71	74.38	74.60
POST 1	79.65	62.12	90.42	78.00
POST 2	--	75.96	92.24	84.10

c) % sediment > 4mm

Sites

	A	B	C	Mean
C				
PRE	3.78	4.63	8.57	5.66
POST	15.43	3.73	5.66	8.13
	R	S	T	Mean
T				
PRE	5.33	1.79	15.89	7.67
POST 1	0.0	0.98	0.64	0.54
POST 2	--	0.00	1.81	0.90

FIG.3 MEDIAN SEDIMENT DIAMETER BEFORE AND AFTER DREDGING (± LIMITS)

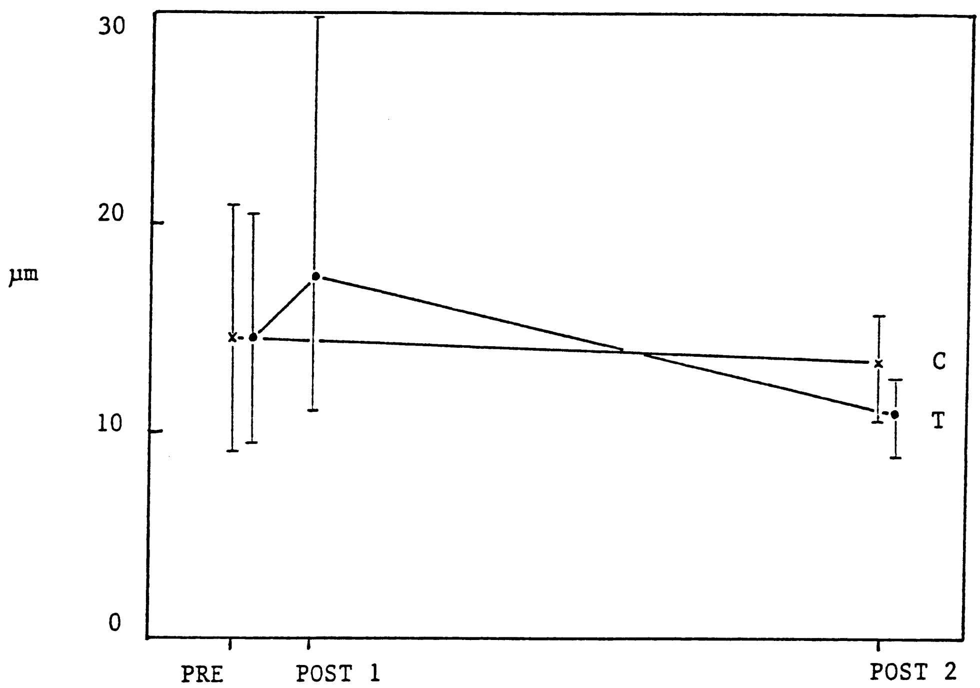


FIG.4 PERCENTAGE OF SEDIMENT LESS THAN 63µm (± LIMITS)

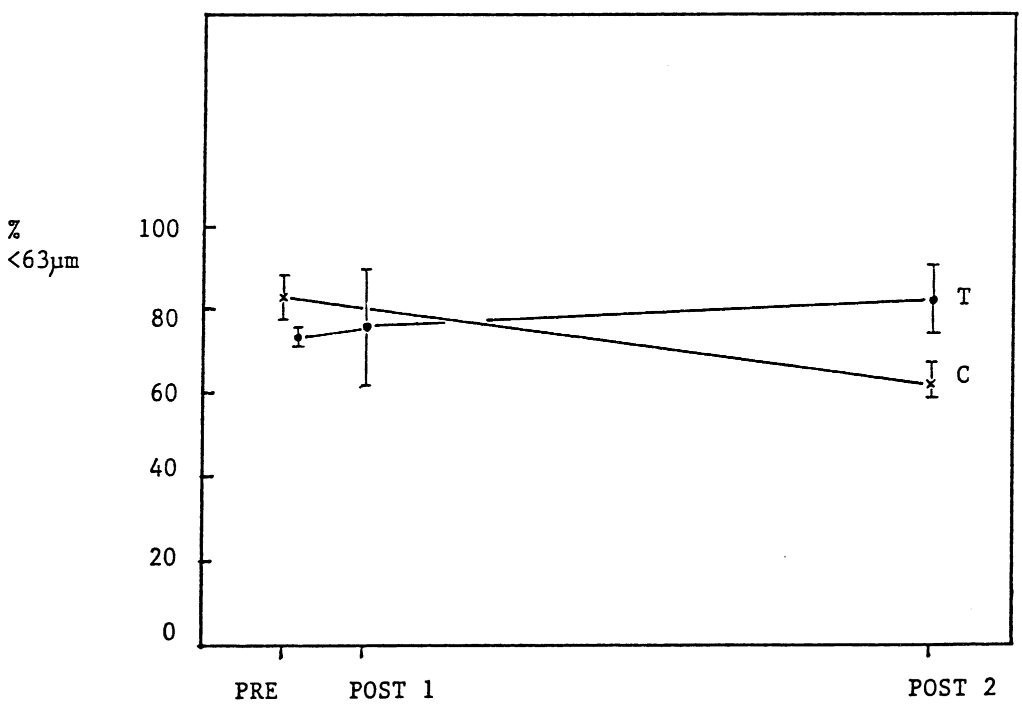


FIG.5 PERCENTAGE OF SEDIMENT GREATER THAN 2mm (± LIMITS)

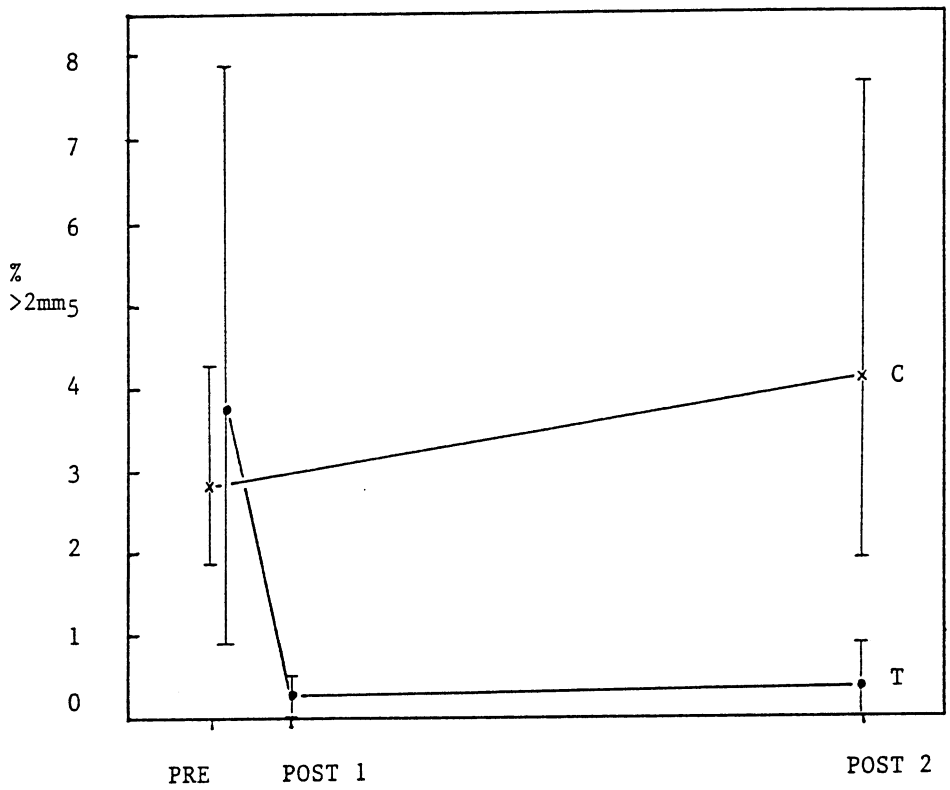


FIG.6 REDOX. PROFILES AT THE CONTROL SITES

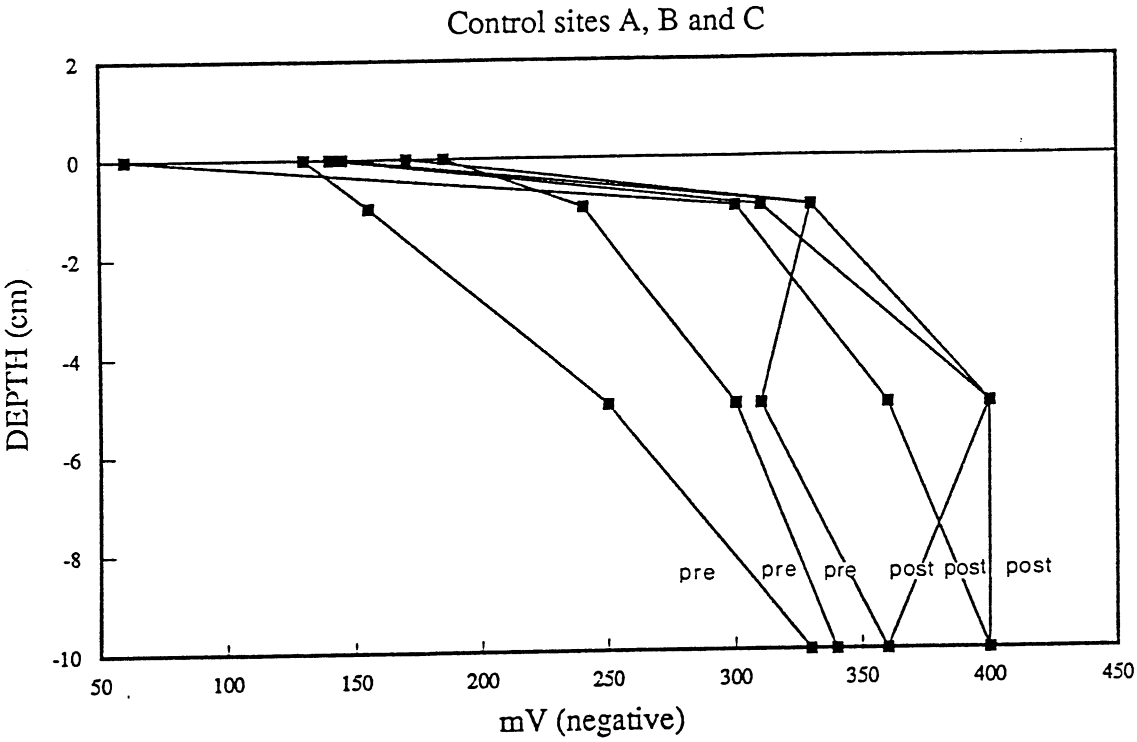
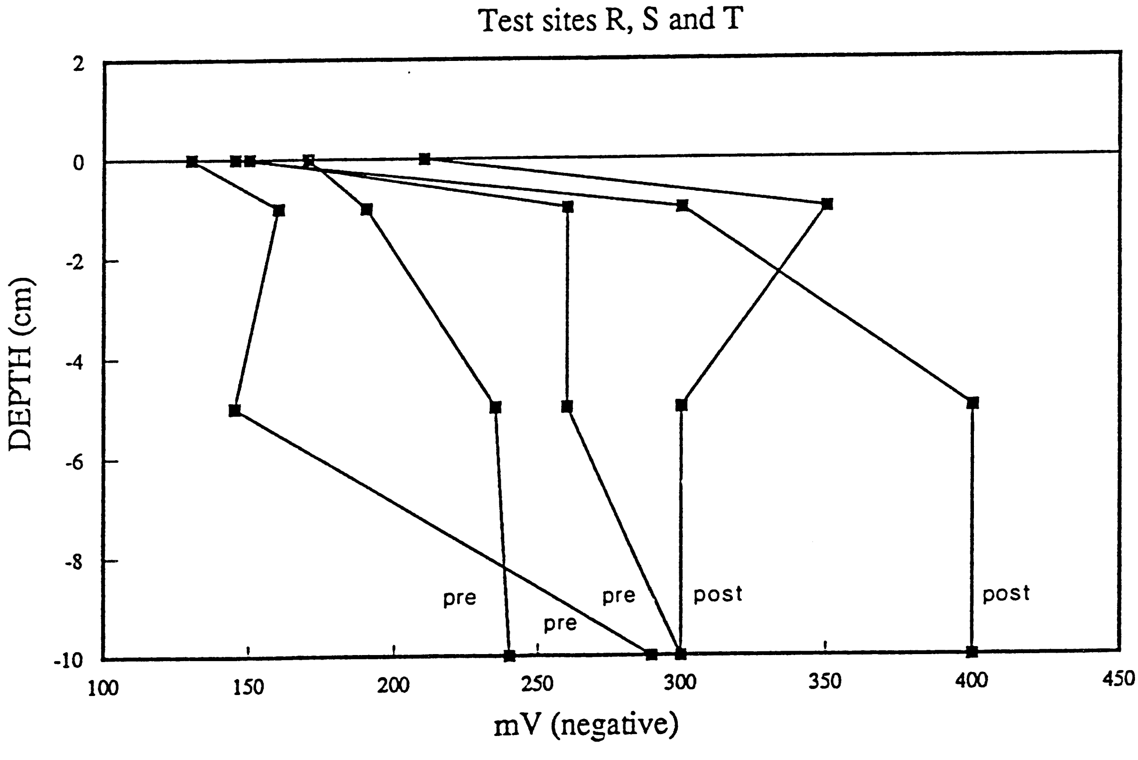


FIG.7 REDOX. PROFILES AT THE DREDGED SITES



were evident between the control sites and trial sites. The total number of species at the control sites was greater. This was primarily due to the greater number of polychaete species. In general the mean number of species per site was also greater at the control sites.

From Table 4 and Appendix 2 it can be seen that the polychaete species which were present at the control sites, but not the trial sites, were generally in small numbers. The exception to this was Cirriformia tentaculata which was dominant in the control sites but absent from the trial sites. Excluding C. tentaculata the overall differences between the control and trial sites before dredging were not unusual for this type of environment. This will be demonstrated more fully in the following sections.

TABLE 3. SUMMARY OF FAUNAL INFORMATION

	SITES							
	A	B	C	ALL	R	S	T	All
Total number of species	12	9	15	20	12	7	14	16
Mean number of species	6.0	5.6	6.6	6.5	4.0	3.4	5.8	4.4
Total number Oligochaeta	1	1	1	1	1	0	1	1
Total number Polychaeta	8	5	9	12	5	3	8	8
Total number Mollusca	3	2	5	6	6	4	5	7
Total number Crustacea	0	1	0	1	0	0	0	0

3.3.2 Community Structure

Differences between the control and dredge sites using a range of community structure measures are demonstrated in Table 5 a to d and Figs. 8 to 11. Table 5 illustrates whether there is a significant difference (Mann-Whitney U test) between the median values for each of the measures on all the sampling occasions.

Where a significant difference was noted between the pre-dredge control and trial samples subsequent comparison was based purely on within trial data.

Clear differences were evident between the pre-dredge and post-dredge data. This is most evident for the number of species and diversity H (Table 5a and c). At the control sites the mean number of species remained constant pre- and post- dredging (Fig. 8a). In contrast the trial sites showed a dramatic and significant reduction in the number of species. This is further illustrated by the frequency histogram for the trial sites (Fig. 9 a & b). A similar level of significance was shown in the differences using H (Table 5c & Fig. 10a). Less clear statistical differences were evident for the abundance and evenness index values due to the differences evident between the control and trial sites. However, Fig. 8b, 10b and 11 clearly show the differences which occurred at the pre- and post-dredge trial sites for abundance and evenness. In all cases the dredging activity has caused a reduction in the abundance and evenness.

It is important to note that for all the community structure measures no significant difference was evident between the two post-dredge samples. This is clearly shown in Table 6 which gives the results of the tests for similarity. Values in excess of 0.40 were shown between all the undredged sites and between the two post-dredge sampling occasions. This compares to the similarity values of 0.29 or less between the dredged and undredged sites.

3.3.3 **Individual Species**

Much of the data for individual species contained too many zero counts to be of value. Analysis was, therefore, concentrated on the most abundant species and at higher taxonomic levels. Table 7 a to c illustrates the differences evident for the oligochaete Tubificoides benedeni, the polychaete Nephtys hombergi and the polychaetes as a group.

A small but significant drop in abundance was evident for T. benedeni after the first dredge but this showed an apparent recovery by the second sampling occassion. However, abundances were very low and the accuracy of the test correspondingly limited.

A more pronounced difference can be shown for N. hombergi (Table 7b) with a significant reduction occurring after dredging. The polychaetes in general show a distinct reduction after dredging has taken place (Table 7c & Fig. 12). Only one species appears to have been unaffected by the dredging and this was the Phyllodocid indet. (Table 4). This species was present at uniformly low abundance both before and after dredging.

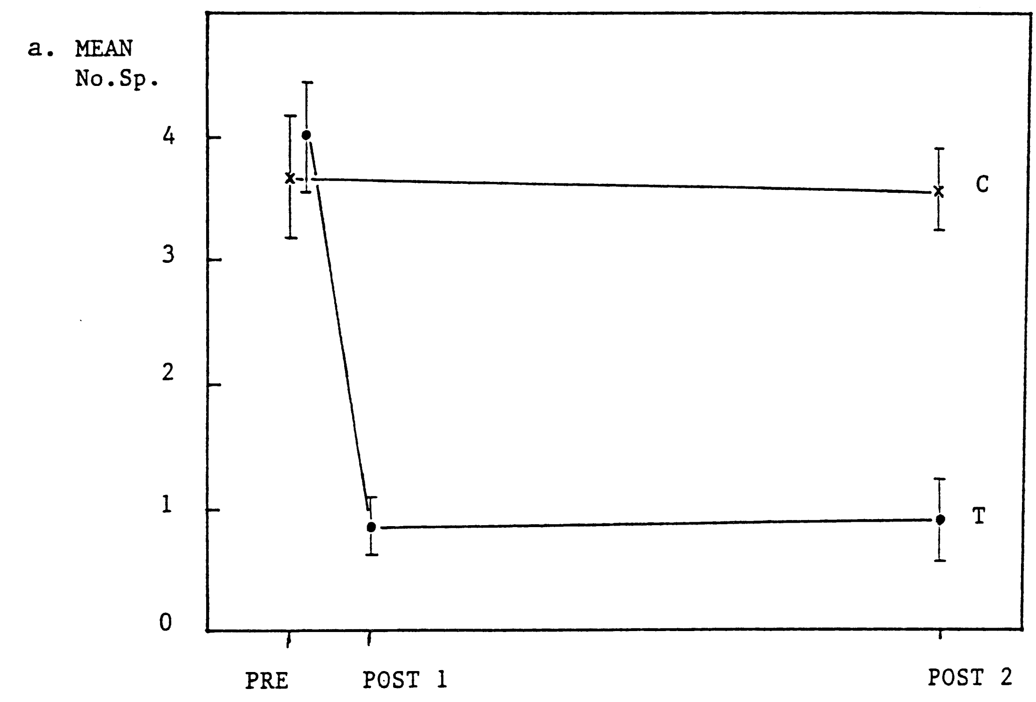
Within the molluscs the epifaunal species were completely absent from the dredged site. However, their frequency and abundance were so low in the pre-dredge site that no significant differences could be shown. In contrast significant differences can be shown for some of the bivalves (Table 7a to c). Abra tenuis was significantly reduced after the first dredge but the subsequent sample was not shown to be different from the pre-dredge condition. Figure 13, indicates that the two post-dredge populations were very similar and no sign of recovery can be implied.

No clear recovery was evident for Cerastoderma edule either (Table 7b). A significant reduction after dredging occurred when compared with all undredged sites. In general the bivalves show a less distinct difference between the dredged and undredged samples (Table 8c). This can be further confirmed when considering Table 4 which shows that three species, although reduced in number, remained or reappeared after dredging had taken place.

Table 4 SPECIES LIST WITH MEAN ABUNDANCES (Nos m^2)

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
OLIGOCHAETA					
Tubificoides benedeni	305	153	70	0	53
POLYCHAETA					
Cirriformia tentaculata	834	1034	0	0	0
Melinna palmata	94	23	23	0	0
Tharyx marioni	70	70	47	0	0
Nephtys hombergii	59	82	106	0	0
Spionid indet.	47	0	0	0	0
Manayunkia aestuarina	35	0	82	0	0
Phyllodocid indet.	35	12	23	12	53
Amphitrite figulus	12	0	0	0	0
Capitella sp.	12	0	0	0	0
Ampharete acutifrons	0	12	35	0	17
Neanthes virens	0	12	0	0	0
Sthenelais boa	0	12	0	0	0
Syllid indet.	0	0	12	0	0
Eteone longa	0	0	23	0	0
MOLLUSCA					
Crepidula fornicata	35	0	0	0	0
Lepidochitona cinereria	0	12	0	0	0
Limapontia sp.	0	12	0	0	0
Littorina littorea	0	0	23	0	0
Hydrobia ulvae	0	0	59	0	0
Retusa obtusata	0	0	12	0	0
Cerastoderma edule	141	199	141	23	0
Abra tenuis	23	82	211	47	106
Mya arenaria	23	23	70	35	0
Macoma balthica	0	0	12	0	0
CRUSTACEA					
Gammarid indet.	0	12	0	0	0
TOTAL ABUNDANCE	1729	1748	950	117	228

FIG.8 CHANGES IN COMMUNITY STRUCTURE MEASURES (a. NUMBER OF SPECIES ± 1.S.E., b. ABUNDANCE ± 1.S.E.)



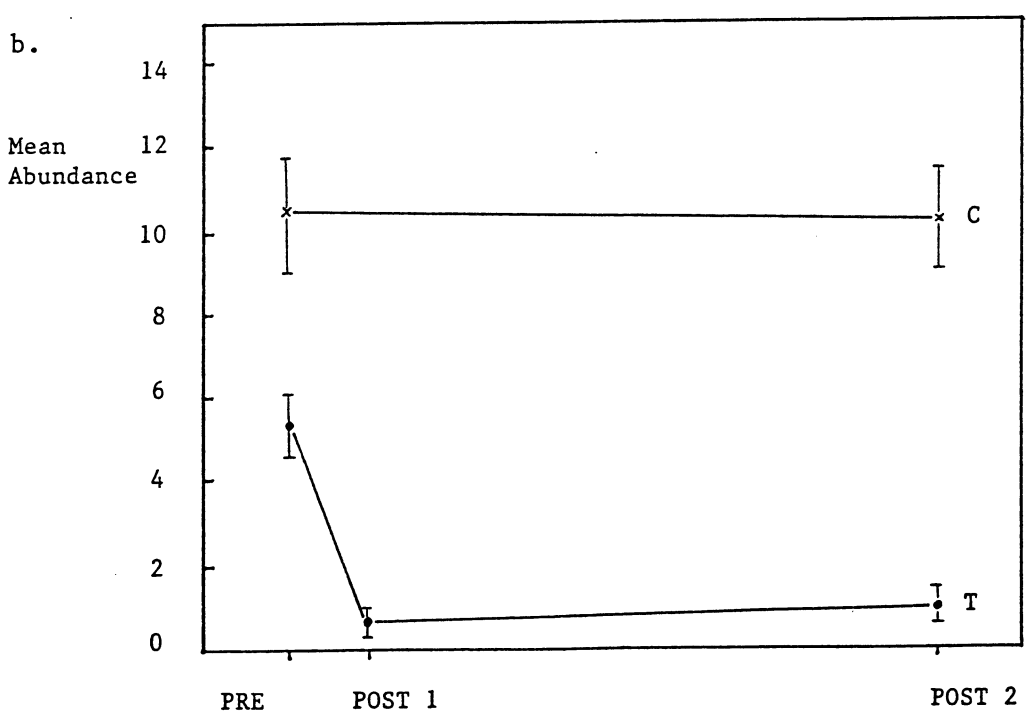


FIG.9 FREQUENCY HISTOGRAM OF NUMBERS OF SPECIES AT THE TRIAL SITES

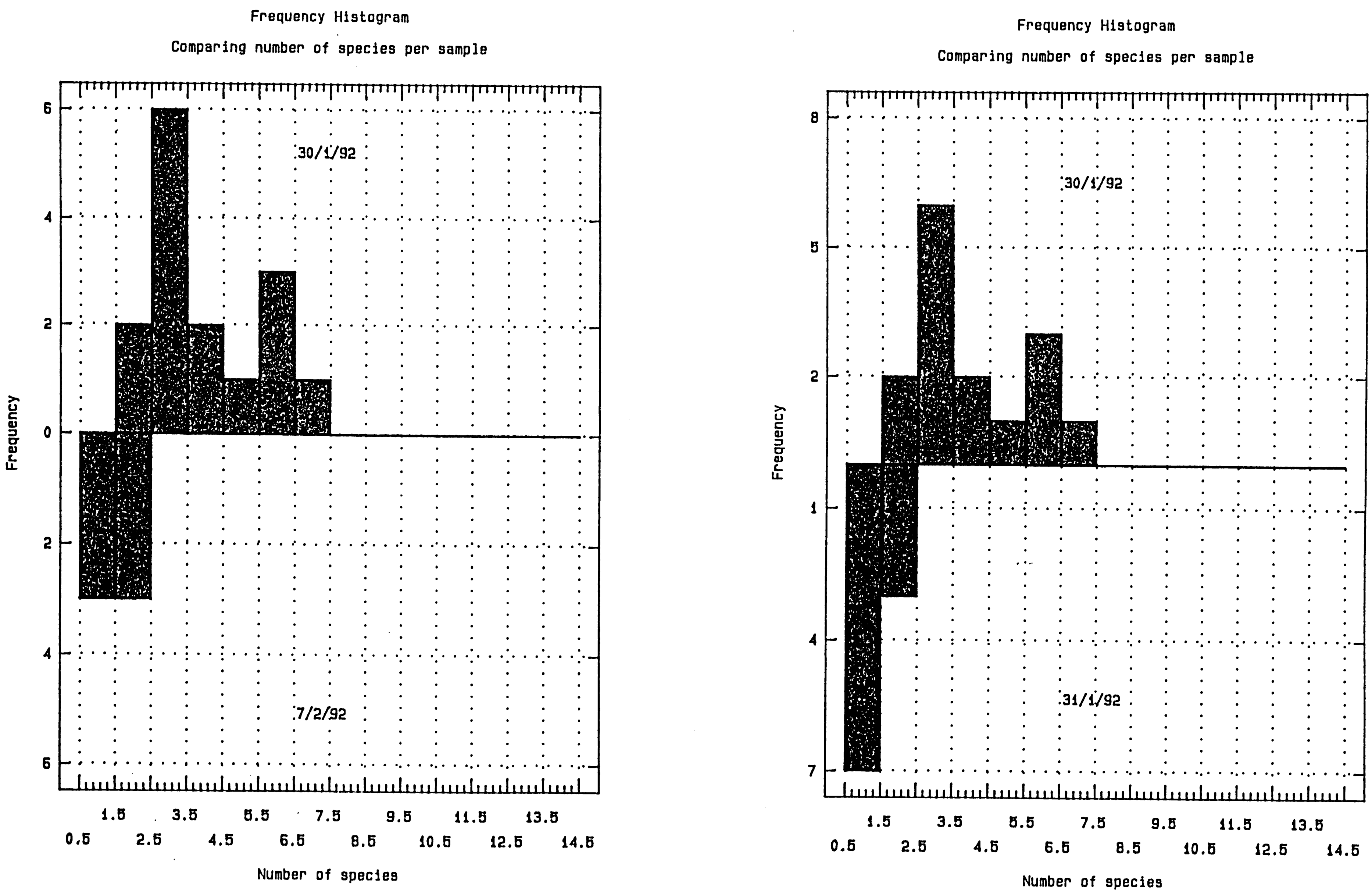
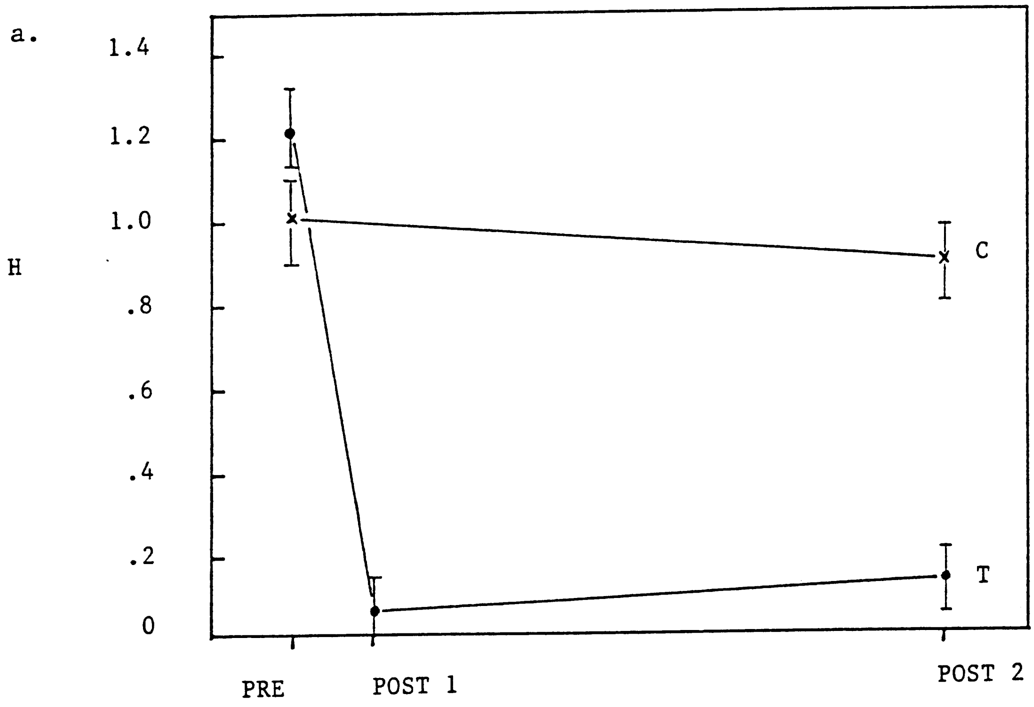


FIG.10 CHANGES IN COMMUNITY STRUCTURE MEASURES
(a. DIVERSITY H ± 1 S.E; b. EVENNESS J ± 1 S.E)



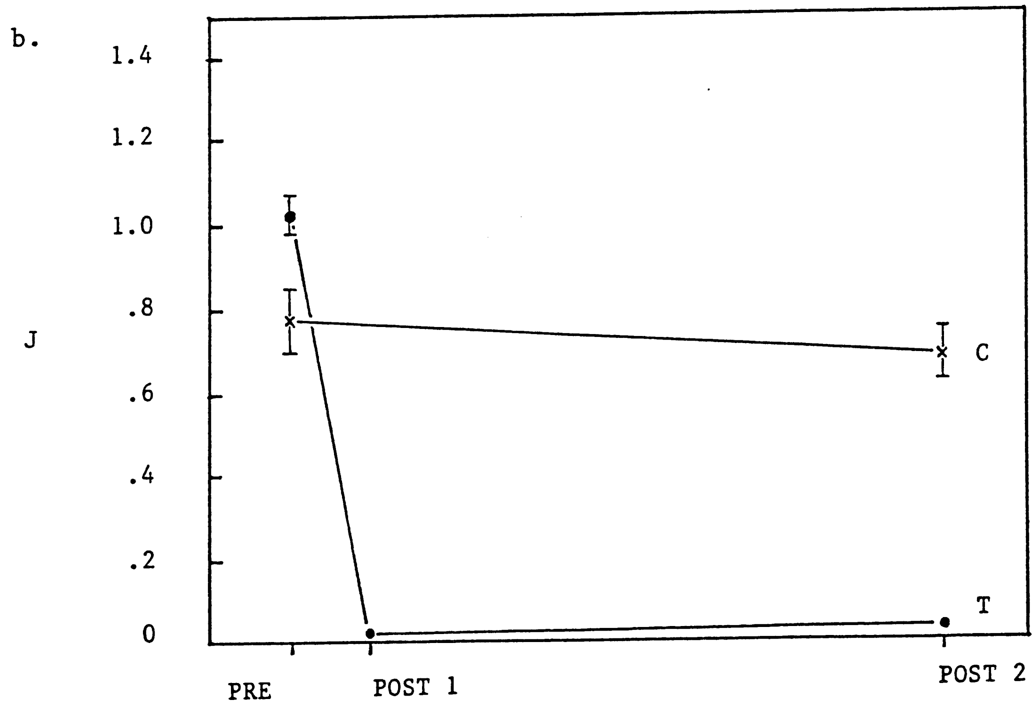


FIG.11 FREQUENCY HISTOGRAM OF ABUNDANCE AT THE TRIAL SITES

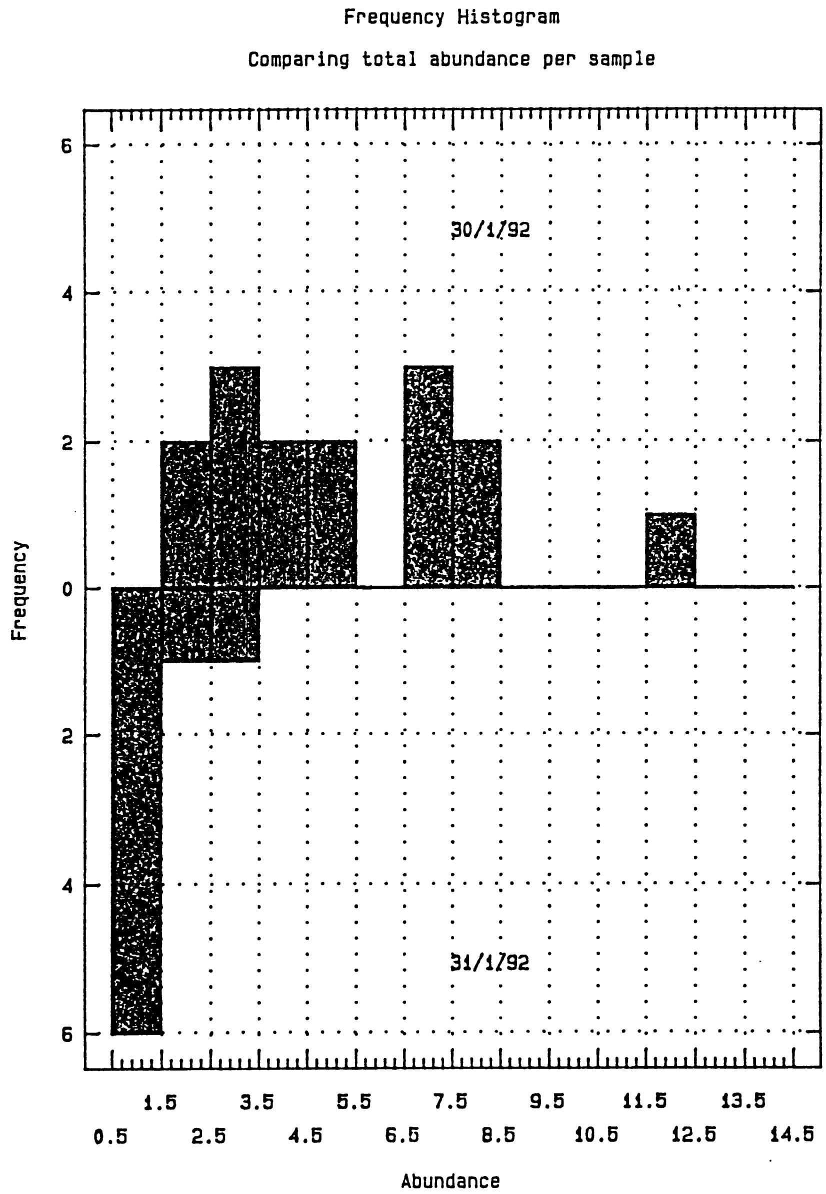


Table 5 a   Significant differences between community structure measures. Probability values upper right. Significance lower left (* = 0.05, ** = 0.01, *** = 0.001)

TOTAL NO SPECIES

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.983	0.751	<0.001	<0.001
POST	N.S		0.670	<0.001	<0.001
T. PRE	N.S	N.S		<0.001	<0.001
POST 1	***	***	***		0.976
POST 2	***	***	***	N.S	

Table 5 b

ABUNDANCE

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.934	0.003		
POST	N.S				
T. PRE	**			<0.001	<0.001
POST 1			***		0.424
POST 2			***	N.S	

Table 5 c

DIVERSITY H

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.455	0.329	<0.001	<0.001
POST	N.S		0.135	<0.001	<0.001
T. PRE	N.S	N.S		<0.001	<0.001
POST 1	***	***	***		<0.326
POST 2	***	***	***	N.S	

Table 5 d

EVENNESS J

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.198	0.009		
POST	N.S				
T. PRE	**			<0.001	<0.001
POST 1			***		--
POST 2			***	N.S	

Table 6 Similarity analysis values

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		.63	.48	.18	0.20
POST			.59	.25	0.29
T. PRE				.22	.26
POST 1					.43
POST 2					

Table 7 á Significant differences between abundance values of annelids (symbols as table 5)

TUBIFICOIDES BENEDENI

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.58	0.006		
POST	N.S				
T. PRE	**			0.018	0.57
POST 1			*		0.087
POST 2			N.S	N.S	

Table 7 b

NEPHTYS HOMBERGI

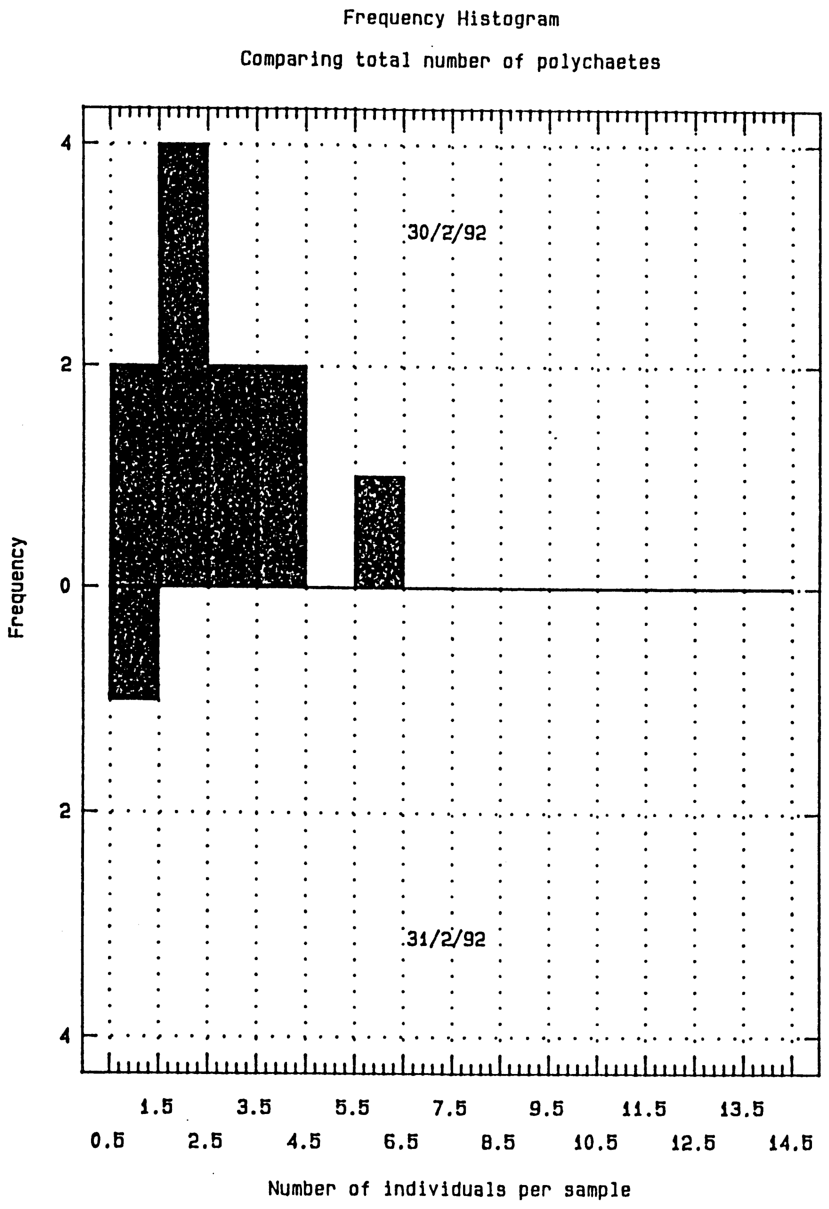
	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.660	0.180	0.038	0.089
POST	N.S		0.438	0.018	0.051
T. PRE	N.S	N.S		0.0001	0.0007
POST 1	*	*	***		0.317
POST 2	N.S	N.S	**	N.S	

Table 7 c

TOTAL POLYCHAETES

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.350	0.766	<0.001	0.007
POST	N.S.		0.287	<0.001	0.060
T. PRE	N.S.	N.S.		<0.001	0.013
POST 1	***	***	***		0.128
POST 2	**	N.S.	**	N.S	

FIG.12 FREQUENCY HISTOGRAM OF POLYCHAETE ABUNDANCE AT THE TRIAL SITES



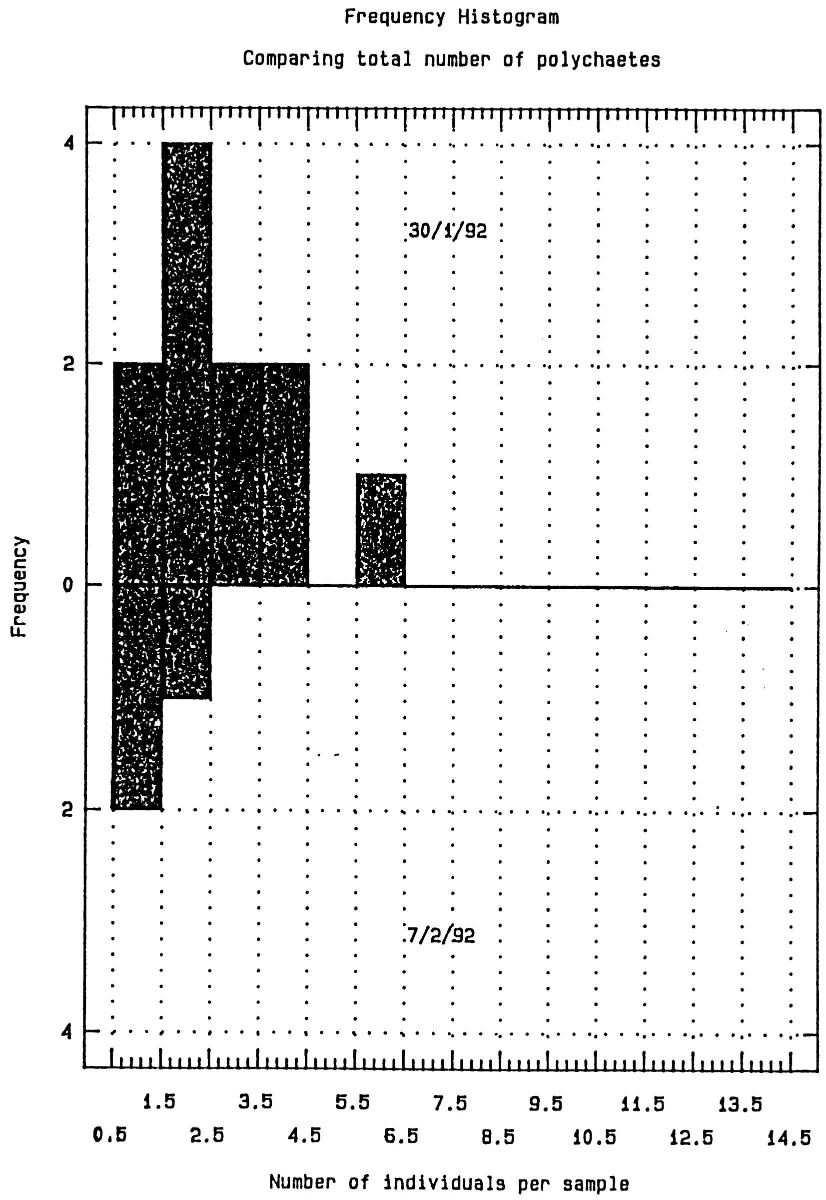


Table 8 a Significant difference between abundance values of bivalve species (symbols as table 5)

ABRA TENUIS

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.100	<0.001		
POST	N.S				
T. PRE	***			0.003	0.156
POST 1			**		0.276
POST 2			N.S.	N.S.	

Table 8 b

CERASTODERMA EDULE

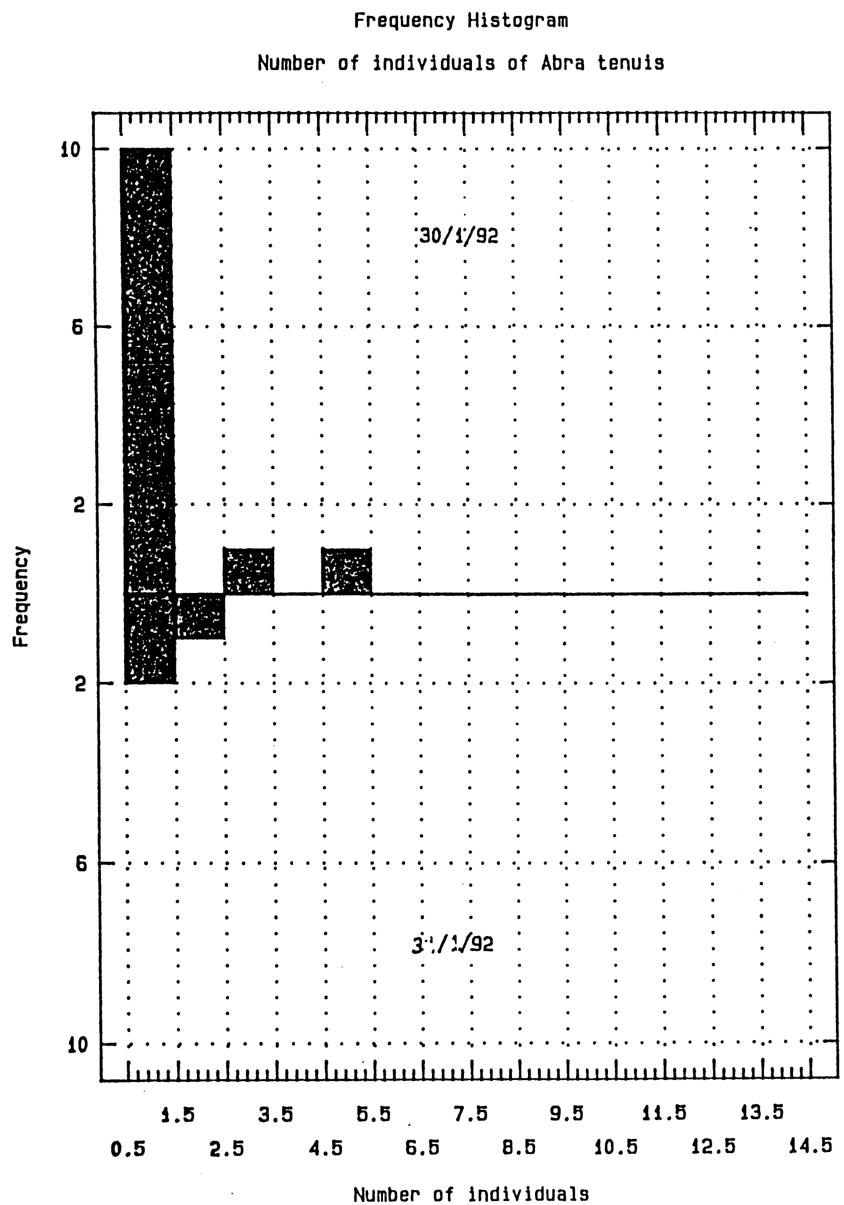
	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.200	1.0	0.044	0.015
POST	N.S		0.216	0.002	0.002
T. PRE	N.S	N.S		0.044	0.015
POST 1	*	**	*		0.262
POST 2	*	**	*	N.S	

Table 8 c

TOTAL BIVALVES

	Control		Trial		
	PRE	POST	PRE	POST 1	POST 2
C. PRE		0.221	0.022	0.329	0.255
POST	N.S		0.230	0.185	0.025
T. PRE	N.S	N.S		0.002	0.002
POST 1	N.S	N.S	**		0.745
POST 2	N.S	*	**	N.S	

FIG.13 FREQUENCY HISTOGRAM OF ABRA TENUIS ABUNDANCE AT TRIAL SITES



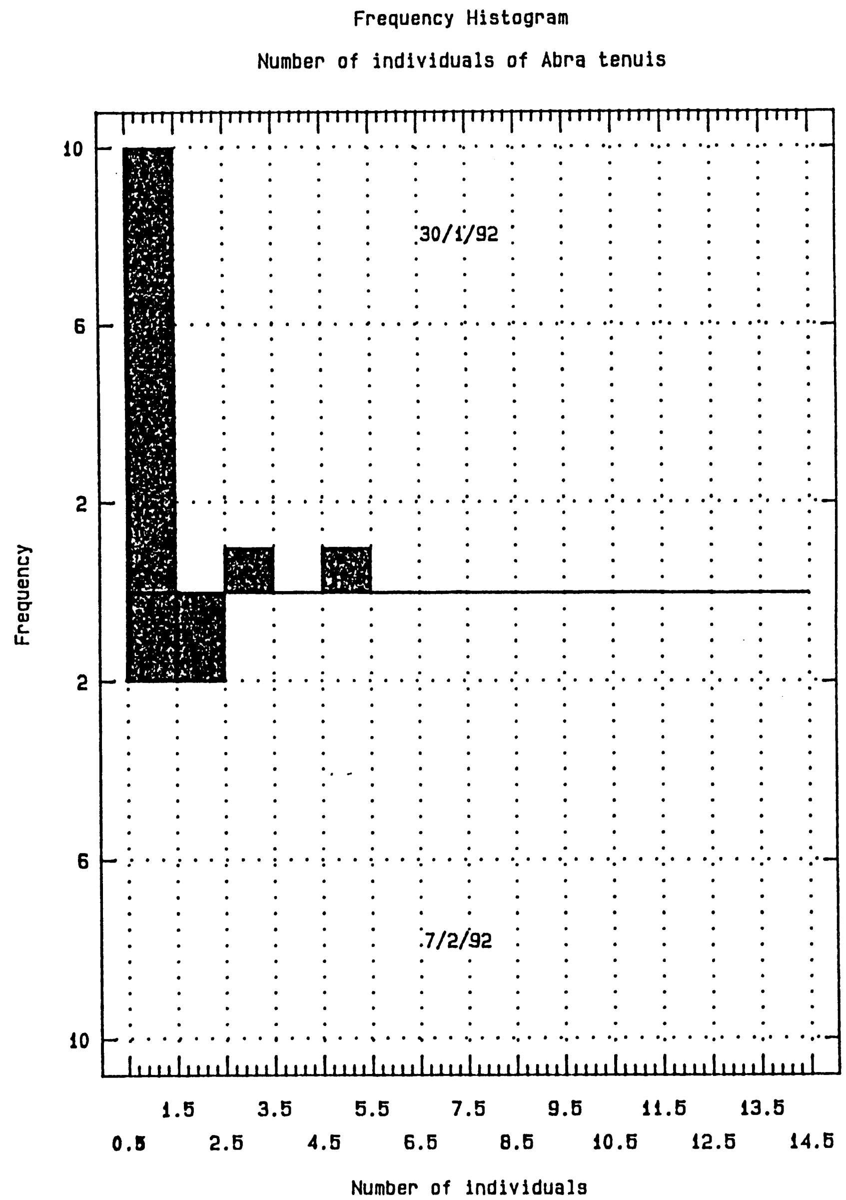
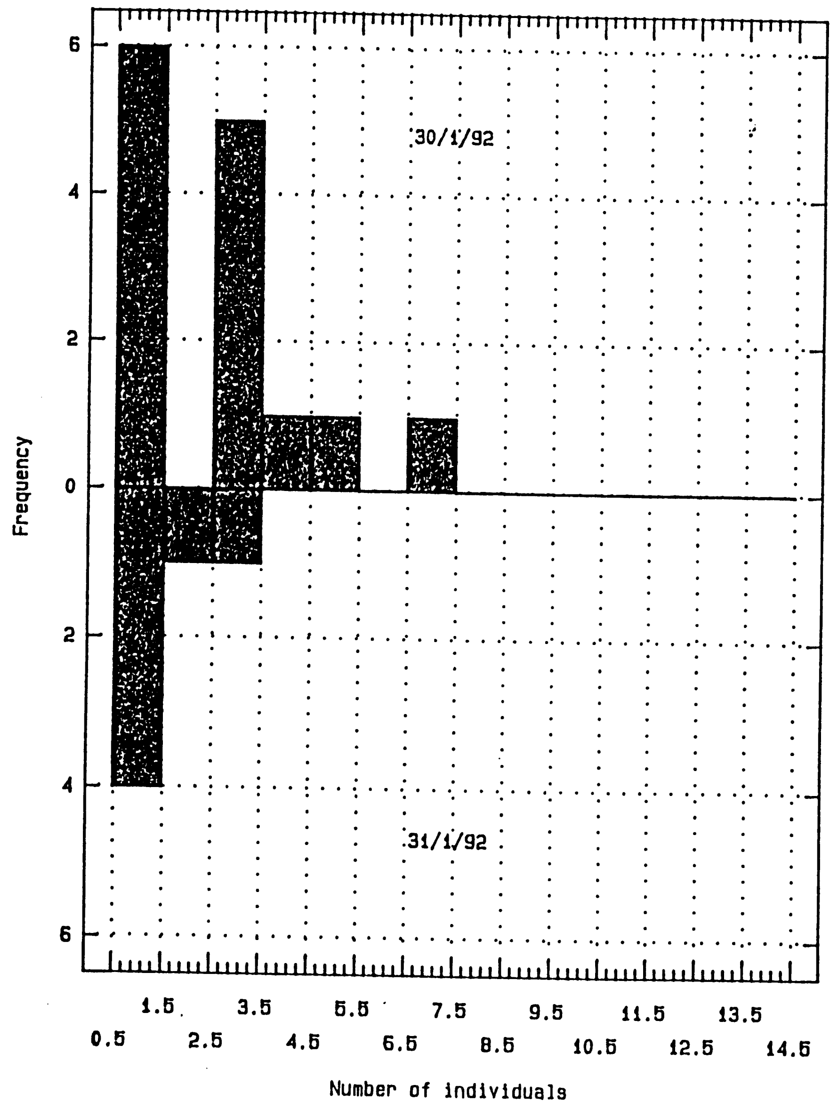


FIG.14 FREQUENCY HISTOGRAM OF TOTAL BIVALVE ABUNDANCE AT TRIAL SITES

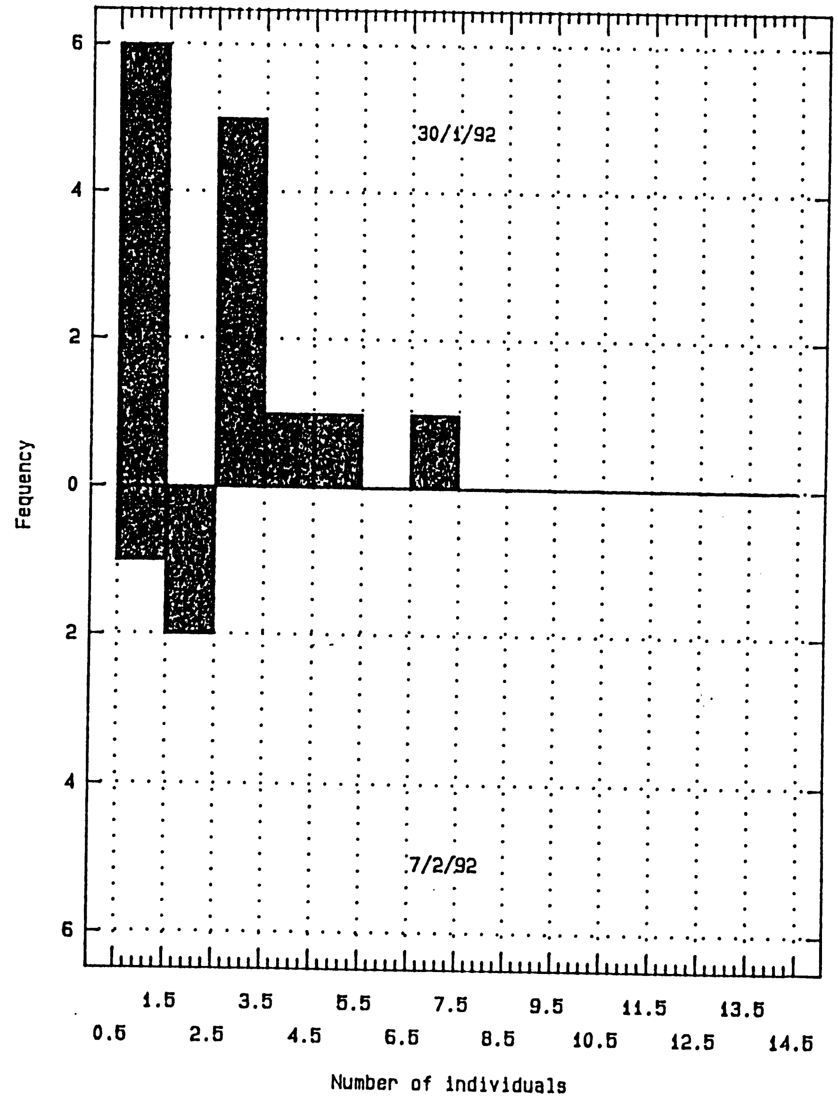
Frequency Histogram

Comparing total number of bivalves



Frequency Histogram

Comparing total number of bivalves



4. DISCUSSION

4.1 Introduction

The following discussion will consider the direct effects the clam dredging has been shown to have and is likely to have, on the sediment environment and associated macroinvertebrate community.

The site investigated was selected by the R.S.P.B., who own the land down to low water mark. It was chosen on the basis of minimum disturbance to the reserve area and because of its potential to contain Mercenaria mercenaria. However, once the dredging was embarked on it became evident that no M. mercenaria were present. The area did contain the edible soft shell clam Mya arenaria, a species which dominated the upper channels of the Solent harbours prior to the winter of 1963, (Juniper, 1963). It would appear that the Mya arenaria found at this site are an isolated population which have not been replaced by Mercenaria mercenaria.

The open netting of the dredge prevented these and other bivalve species from being retained. Although Mya arenaria were evident in the core samples no assessment could be made of the population structure due to the low numbers present. This study, therefore, may only be considered to be appropriate to macroinvertebrate communities present in similar habitats to those occupied by Mercenaria mercenaria.

4.2 Impact on sediments

The results of the particle size analysis indicate that the sediment type within the area was of a mixed muddy gravel. This is typical of many areas in the Solent Harbours (Thomas, 1987; Thomas, Bruce, Auckland and Culley 1989; Thomas, Culley, Bruce and Auckland, 1989).

At the sampling sites over which the dredge was used a clear removal of sediment down to a depth of 15 to 20 cm was evident. The removal of the surface layer revealed sediment with a smaller gravel fraction and a larger sand and fine sediment fraction. No clear influx of sediment occurred in the short period following the dredging. However, on the basis of observations on bait dug areas in the vicinity and in associated areas (Thomas et. at. 1989) the dredged tracks are most likely to re-fill with predominantly fine sediments. Within these muddy gravels, discrete habitat variation will be created.

A consideration of the redox. profile comparing the pre-dredge and second post-dredge occasion illustrates that a rapid re-establishment of conditions is likely. The sediments in general were very anoxic and even superficial sediments gave values of -100 to -150mV. The potential of the sediment to recover in more aerobic conditions be effected.

Other impacts of the dredging activity are related to the dispersion of the sediments removed by the dredging. This particular problem was not addressed in the study but may be an important consideration in future work. The release of large quantities of fine sediments into shallow water columns may have serious implications for the survival of species which are unable to deal with a heavy suspended sediment load. Within the lower shore muddy gravel habitats, similar to those at the sampling sites, these may include species such as the barnacles Balanus spp. and Elminius modestus and the sponge Hymeniacidon sanguinea.

4.3 Impacts on Fauna

The majority of the fauna within the muddy gravel habitat occupy the top 15 cm of sediment, with only the larger polychaetes and bivalves penetrating to great depths. The removal, therefore, of the sediment down to 15 cm is clearly capable of eliminating nearly all the fauna present. This is evident in the impact the modified oyster dredge has had on the community. The community structure changes consisted of considerable reductions in species numbers and abundance. The questions that arise from this are:

- what type of fauna are removed?;
- are they of importance as prey species to birds?;
- what fauna will be able to recolonise the disrupted sediment and how quickly will they achieve abundances and biomass suitable for avifauna?

Each of these may be addressed separately.

What type of fauna are removed?

In general all fauna, with the exception of the bivalves, were removed completely in the short-term. The three bivalve species which were present in any numbers were Cerastoderma edule, Abra tenuis and Mya arenaria. Each of these was present in the immediate post-dredge samples. In all cases, however, the individuals found were of a small size, either juveniles or A. tenuis which rarely exceeds 8mm. It would seem most likely that these individuals were dislodged by the action of the dredge and redeposited within the sediment. Alternatively they may have migrated or passively dispersed into the dredged areas from adjacent mudflats. A. tenuis in particular has been observed to move readily through mud and is able to utilize algal mats for passive dispersion (Thomas, 1987).

Are they of importance as prey species?

Of the species that were removed by the dredge the most important in terms of avifaunal prey species is likely to be C. edule. This species frequently achieves high densities and biomass in the Solent Harbours (Thomas, 1987) and is a preferred species for many wading birds including Knot and Oystercatchers (Bryant, 1979; Prater, 1981).

The food value of the polychaetes in general is also great, due to the large numbers in which they occur and to the large individual biomass of some species. Cirriformia tentaculata, a large cirratulid species which was dominant at the control site, is not known as an important food item, but Nephtys hombergii, which can achieve a similar size was generally well represented. Smith, Haynes and Thomas, (1986) demonstrated that this species was probably a favoured item for Redshank in the Kench, Langstone Harbour. They also concluded that the many small polychaete species and the oligochaete Tubificoides benedeni when found in high numbers could be important food sources, particularly to species such as Dunlin.

What fauna will be able to recolonise and how quickly?

The fauna that will be able to recolonise the sediment will be regulated by two main factors; ie. ability to survive the dredging and time of year. Clearly the bivalves are likely to become the first colonisers due to their ability to survive the dredging process. Their potential to thrive in the long term, on the basis of the experimental study reported here, is not clear.

However, Sheader (1986) has shown that Cerastoderma edule increased dramatically in Southampton Water during periods of intensive clam dredging.

The polychaetes and oligochaetes in the dredged areas are likely to demonstrate a recovery much like other disturbed mudflats (Pearson and Rosenberg, 1978) with the small opportunists species such as Capitella capitata and Tubificoides benedeni appearing in great numbers first, followed by more stable habitat species, including Tharyx marioni and Cirriformia tentaculata during their dispersive phase. In addition the more active polychaete species such as the phyllodocids (eg. Eteone longa, and the Phyllodocid indet.) may occupy the area rapidly. However their continued presence will rely on the availability of prey species which in most cases are small polychaetes or oligochaetes (Fauchald and Jumars, 1979).

Continual disturbance will not favour the stable habitat species. This has been indicated by Sheader (1986), who noted a marked decline in the numbers of C.tentaculata and other cirratulids following intensive dredging. The development of high biomass communities may occur, therefore, but these are unlikely to contain individual species of high biomass, which are of most use to bird species. Given conditions of limited dredging activity Cerastoderma edule and Abra tenuis biomass might achieve levels approaching adjacent populations but the establishment of stable populations of large polychaetes will require greater stability.

4.4 Conservation implications

The effect on the infauna of the modified oyster dredge is clearly important at the local level however the extent to which this type of dredge damages large areas is not known. During the experimental dredge it was seen to take an initial scoop and then bounce off the sediment. In several areas grooves produced by the dredge rake were the only evidence of surface disruption. The use of this type of modified oyster dredge within the Solent Harbours and Southampton Water, according to local fishermen, is now quite limited. The newer forms of dredge are capable of excavating depths of sediment up to 60 cm. This type of dredge will clearly create considerably more damage than the modified oyster dredge. In some cases it could be expected to reveal the underlying hard clay sediments. These sediment types are frequently afaunal.

Various studies have indicated that most dredging impacts are short term in areas of high sediment mobility (Hall, Basford and Robertson, 1990; Moore, 1991). However, erosion effects, due to dredging, have been shown to be considerable in stable sediment conditions (Perkins, 1988), or where dredging activity is intense (Sheader, 1986; Cook, 1991). The sediments within the Solent Harbours system will therefore be particularly prone to the destabilising effects of the dredges.

The present study has demonstrated the short-term effects on the muddy gravel habitats. This type of habitat is one of several within the Solent Harbours system. The other habitats of importance for bird populations include Zostera marsh, stable upper shore mud, lower shore mud and algal covered mud (Thomas, 1987). The impact of the dredge on these habitats, particularly the structurally complex Zostera marshes, could be considerable.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Changes in sediment structure occured due to the dredging activity. This consisted of the removal of the coarse fraction of the sediment. The low energy nature of the environment is unlikely to lead to a rapid recreation original of the mixed muddy gravel habitat.

Clear elimination and reduction of fauna occurs after dredging has taken place using the modified Oyster dredge. This was most pronounced for the polychaete species and epifaunal molluscs. Reductions in the number of bivalves were evident but some of the smaller individuals were apparently redeposited on the dredged areas.

Recolonisation is predicted to be poor, in terms of value to avifauna, if intensive dredging occurs in the future.

5.2 Recommendations for Future Work.

1. Undertake the study using more recent and potentially more damaging clam dredges.
2. Undertake the study over a longer time scale.
3. Establish the study sites in an area which is known to contain Mercenaria mercenaria.
4. Undertake a survey of known dredged sites to observe spatial effects, eg. sediment heterogeneity, community structure variation.
5. Observe experimental impacts on the more delicate habitat types, particularly Zostera marsh.
6. Analyse, in all the above, the effects on biomass.
7. Assess peripheral impacts of heavy suspended sediment load.

6. ACKNOWLEDGEMENTS

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APPENDIX 1

a) Sediment Character
b) Redox. values

LANGSTONE - SITE A (30.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	2.61	1.86	1.86	Coarse Gravel	3.78
4000	-2	2.7	1.92	3.78		
2000	-1	2.49	1.77	5.55	Gravel	1.77
1000	0	4.1	2.92	8.47	Coarse Sand	2.92
500	1	2.6	1.85	10.32	Medium Sand	3.49
250	2	2.3	1.64	11.96		
125	3	3.95	2.81	14.77	Fine Sand	9.24
63	4	9.03	6.43	21.19		
15.6	6	0	0.00	21.19	Coarse Silt	0.00
3.9	8	103.55	73.70	94.89	Fine Silt	73.70
1	10	7.18	5.11	100.00	Clay	5.11
	Tot. Wt. =	140.51	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	21.15	5.56
Graphic Mean (MZ)	23.88	5.39

	Value	Inference
Sorting Coeff.	2.47	V. Poorly sorted
Skewness	-0.30	Coarse skewed
Kurtosis	1.41	Leptokurtic

LANGSTONE - SITE A (07.02.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	9.88	12.70	12.70	Coarse Gravel	15.43
4000	-2	2.12	2.73	15.43		
2000	-1	1.06	1.36	16.79	Gravel	1.36
1000	0	3	3.86	20.65	Coarse Sand	3.86
500	1	2.45	3.15	23.80	Medium Sand	5.26
250	2	1.64	2.11	25.91		
125	3	1.9	2.44	28.35	Fine Sand	6.84
63	4	3.42	4.40	32.75		
15.6	6	2.07	2.66	35.41	Coarse Silt	2.66
3.9	8	49.2	63.26	98.67	Fine Silt	63.26
1	10	1.036	1.33	100.00	Clay	1.33
	Tot. Wt. =	77.776	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	11.35	6.46
Graphic Mean (MZ)	56.76	4.14

	Value	Inference
Sorting Coeff.	4.94	Ext. Poorly Sorted
Skewness	-0.80	Strongly Coarse Skewed
Kurtosis	1.26	Leptokurtic

LANGSTONE - SITE B (30.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	1.19	0.97	0.97	Coarse Gravel	4.63
4000	-2	4.5	3.66	4.63		
2000	-1	1	0.81	5.44	Gravel	0.81
1000	0	1.82	1.48	6.92	Coarse Sand	1.48
500	1	1.47	1.19	8.11	Medium Sand	2.16
250	2	1.19	0.97	9.08		
125	3	2.59	2.11	11.19	Fine Sand	5.93
63	4	4.7	3.82	15.01		
15.6	6	6.12	4.97	19.98	Coarse Silt	4.97
3.9	8	90.28	73.39	93.37	Fine Silt	73.39
1	10	8.16	6.63	100.00	Clay	6.63
	Tot. Wt. =	123.02	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	8.86	6.82
Graphic Mean (MZ)	12.51	6.32

	Value	Inference
Sorting Coeff.	2.36	V. Poorly sorted
Skewness	-0.56	Strongly Coarse Skewed
Kurtosis	3.02	ERR

LANGSTONE - SITE B (07.02.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	1.95	1.97	1.97	Coarse Gravel	3.73
4000	-2	1.75	1.76	3.73		
2000	-1	2.87	2.89	6.62	Gravel	2.89
1000	0	8.23	8.30	14.92	Coarse Sand	8.30
500	1	6.48	6.53	21.45	Medium Sand	11.07
250	2	4.5	4.54	25.99		
125	3	6.26	6.31	32.30	Fine Sand	12.27
63	4	5.91	5.96	38.26		
15.6	6	7.92	7.98	46.24	Coarse Silt	7.98
3.9	8	50.15	50.56	96.80	Fine Silt	50.56
1	10	3.17	3.20	100.00	Clay	3.20
	Tot. Wt. =	99.19	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	14.10	6.15
Graphic Mean (MZ)	41.17	4.60

	Value	Inference
Sorting Coeff.	3.27	V. Poorly sorted
Skewness	-0.63	Strongly Coarse Skewed
Kurtosis	0.73	Platykurtic

LANGSTONE - SITE C (30.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	2.54	3.10	3.10	Coarse Gravel	8.57
4000	-2	4.47	5.46	8.57		
2000	-1	0.67	0.82	9.39	Gravel	0.82
1000	0	0.72	0.88	10.27	Coarse Sand	0.88
500	1	0.75	0.92	11.18	Medium Sand	2.09
250	2	0.96	1.17	12.36		
125	3	1.55	1.89	14.25	Fine Sand	4.53
63	4	2.16	2.64	16.89		
15.6	6	22.16	27.09	43.98	Coarse Silt	27.09
3.9	8	39.79	48.63	92.61	Fine Silt	48.63
1	10	6.044	7.39	100.00	Clay	7.39
	Tot. Wt. =	81.814	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	13.16	6.25
Graphic Mean (MZ)	17.31	5.85

	Value	Inference
Sorting Coeff.	2.81	V. Poorly sorted
Skewness	-0.45	Strongly Coarse Skewed
Kurtosis	1.83	V. Leptokurtic

LANGSTONE - SITE C (07.02.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	3.57	3.14	3.14	Coarse Gravel	5.66
4000	-2	2.87	2.52	5.66		
2000	-1	6	5.28	10.94	Gravel	5.28
1000	0	11	9.67	20.61	Coarse Sand	9.67
500	1	7.73	6.80	27.41	Medium Sand	10.98
250	2	4.76	4.19	31.60		
125	3	3.53	3.10	34.70	Fine Sand	7.03
63	4	4.46	3.92	38.62		
15.6	6	12.69	11.16	49.78	Coarse Silt	11.16
3.9	8	55.51	48.82	98.60	Fine Silt	48.82
1	10	1.59	1.40	100.00	Clay	1.40
	Tot. Wt. =	113.71	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	15.53	6.01
Graphic Mean (MZ)	50.37	4.31

	Value	Inference
Sorting Coeff.	3.54	V. Poorly sorted
Skewness	-0.65	Strongly Coarse Skewed
Kurtosis	0.67	V. Platykurtic

LANGSTONE - SITE R (30.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	0	0.00	0.00	Coarse Gravel	5.33
4000	-2	5.39	5.33	5.33		
2000	-1	1.33	1.32	6.65	Gravel	1.32
1000	0	2.63	2.60	9.25	Coarse Sand	2.60
500	1	2.5	2.47	11.72	Medium Sand	6.23
250	2	3.8	3.76	15.48		
125	3	4.26	4.22	19.70	Fine Sand	8.80
63	4	4.63	4.58	24.28		
15.6	6	1.027	1.02	25.30	Coarse Silt	1.02
3.9	8	69.34	68.61	93.91	Fine Silt	68.61
1	10	6.16	6.09	100.00	Clay	6.09
	Tot. Wt. =	101.067	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	9.49	6.72
Graphic Mean (MZ)	21.83	5.52

	Value	Inference
Sorting Coeff.	2.99	V. Poorly sorted
Skewness	-0.67	Strongly Coarse Skewed
Kurtosis	2.11	V. Leptokurtic

LANGSTONE - SITE R (31.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	0	0.00	0.00	Coarse Gravel	0.00
4000	-2	0	0.00	0.00		
2000	-1	0.68	0.71	0.71	Gravel	0.71
1000	0	4.28	4.45	5.15	Coarse Sand	4.45
500	1	5.65	5.87	11.03	Medium Sand	9.58
250	2	3.57	3.71	14.74		
125	3	2.08	2.16	16.90	Fine Sand	5.61
63	4	3.32	3.45	20.35		
15.6	6	13.74	14.28	34.63	Coarse Silt	14.28
3.9	8	55.51	57.68	92.31	Fine Silt	57.68
1	10	7.4	7.69	100.00	Clay	7.69
	Tot. Wt. =	96.23	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	10.80	6.53
Graphic Mean (MZ)	20.48	5.61

	Value	Inference
Sorting Coeff.	2.61	V. Poorly sorted
Skewness	-0.52	Strongly Coarse Skewed
Kurtosis	1.30	Leptokurtic

LANGSTONE - SITE S (30.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	0	0.00	0.00	Coarse Gravel	1.79
4000	-2	2.16	1.79	1.79		
2000	-1	4.92	4.08	5.87	Gravel	4.08
1000	0	10.23	8.47	14.34	Coarse Sand	8.47
500	1	6	4.97	19.31	Medium Sand	7.77
250	2	3.38	2.80	22.11		
125	3	2.25	1.86	23.97	Fine Sand	4.18
63	4	2.79	2.31	26.29		
15.6	6	0	0.00	26.29	Coarse Silt	0.00
3.9	8	82.33	68.20	94.49	Fine Silt	68.20
1	10	6.65	5.51	100.00	Clay	5.51
	Tot. Wt. =	120.71	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	23.84	5.39
Graphic Mean (MZ)	48.37	4.37

	Value	Inference
Sorting Coeff.	3.19	V. Poorly sorted
Skewness	-0.42	Strongly Coarse Skewed
Kurtosis	1.13	Leptokurtic

LANGSTONE - SITE C (30.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	2.54	3.10	3.10	Coarse Gravel	8.57
4000	-2	4.47	5.46	8.57		
2000	-1	0.67	0.82	9.39	Gravel	0.82
1000	0	0.72	0.88	10.27	Coarse Sand	0.88
500	1	0.75	0.92	11.18	Medium Sand	2.09
250	2	0.96	1.17	12.36		
125	3	1.55	1.89	14.25	Fine Sand	4.53
63	4	2.16	2.64	16.89		
15.6	6	22.16	27.09	43.98	Coarse Silt	27.09
3.9	8	39.79	48.63	92.61	Fine Silt	48.63
1	10	6.044	7.39	100.00	Clay	7.39
	Tot. Wt. =	81.814	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	13.16	6.25
Graphic Mean (MZ)	17.31	5.85

	Value	Inference
Sorting Coeff.	2.81	V. Poorly sorted
Skewness	-0.45	Strongly Coarse Skewed
Kurtosis	1.83	V. Leptokurtic

LANGSTONE - SITE S (31.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative
16000	-4	0	0.00	0.00
4000	-2	1.06	0.98	0.98
2000	-1	8.14	7.55	8.53
1000	0	11.71	10.86	19.39
500	1	7.96	7.38	26.77
250	2	5.35	4.96	31.73
125	3	3.82	3.54	35.27
63	4	2.82	2.61	37.89
15.6	6	5.895	5.47	43.35
3.9	8	0	0.00	43.35
1	10	61.09	56.65	100.00
Tot. Wt.	=	107.845	100	

Fraction Name	%
Coarse Gravel	0.98
Gravel	7.55
Coarse Sand	10.86
Medium Sand	12.34
Fine Sand	6.16
Coarse Silt	5.47
Fine Silt	0.00
Clay	56.65

RESULTS :

	microns	phi units
Mean Diameter (MD)	11.29	6.47
Graphic Mean (MZ)	31.05	5.01

	Value	Inference
Sorting Coeff.	3.98	V. Poorly sorted
Skewness	-0.45	Strongly Coarse Skewed
Kurtosis	0.61	V. Platykurtic

LANGSTONE - SITE S (07.02.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	0	0.00	0.00	Coarse Gravel	0.00
4000	-2	0	0.00	0.00		
2000	-1	0.82	0.79	0.79	Gravel	0.79
1000	0	4.93	4.74	5.53	Coarse Sand	4.74
500	1	8.47	8.14	13.67	Medium Sand	12.23
250	2	4.25	4.09	17.75		
125	3	2.72	2.61	20.37	Fine Sand	6.30
63	4	3.83	3.68	24.05		
15.6	6	16.12	15.50	39.55	Coarse Silt	15.50
3.9	8	60.74	58.39	97.93	Fine Silt	58.39
1	10	2.15	2.07	100.00	Clay	2.07
	Tot. Wt. =	104.03	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	12.19	6.36
Graphic Mean (MZ)	28.16	5.15

	Value	Inference
Sorting Coeff.	2.70	V. Poorly sorted
Skewness	-0.61	Strongly Coarse Skewed
Kurtosis	1.06	Mesokurtic

LANGSTONE - SITE T (30.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	10.14	9.96	9.96	Coarse Gravel	15.89
4000	-2	6.04	5.93	15.89		
2000	-1	1.54	1.51	17.41	Gravel	1.51
1000	0	0.76	0.75	18.15	Coarse Sand	0.75
500	1	2.21	2.17	20.32	Medium Sand	3.58
250	2	1.43	1.40	21.73		
125	3	1.48	1.45	23.18	Fine Sand	3.89
63	4	2.48	2.44	25.62		
15.6	6	0.508	0.50	26.12	Coarse Silt	0.50
3.9	8	69.63	68.39	94.51	Fine Silt	68.39
1	10	5.59	5.49	100.00	Clay	5.49
	Tot. Wt. =	101.808	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	9.63	6.70
Graphic Mean (MZ)	56.17	4.15

	Value	Inference
Sorting Coeff.	4.50	Ext. Poorly Sorted
Skewness	-0.79	Strongly Coarse Skewed
Kurtosis	1.54	V. Leptokurtic

LANGSTONE - SITE T (31.01.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	0	0.00	0.00	Coarse Gravel	0.64
4000	-2	0.4	0.64	0.64		
2000	-1	0.01	0.02	0.65	Gravel	0.02
1000	0	0.29	0.46	1.12	Coarse Sand	0.46
500	1	1.24	1.98	3.10	Medium Sand	4.28
250	2	1.44	2.30	5.40		
125	3	1.14	1.82	7.22	Fine Sand	4.18
63	4	1.48	2.36	9.58		
15.6	6	49.998	79.83	89.41	Coarse Silt	79.83
3.9	8	0	0.00	89.41	Fine Silt	0.00
1	10	6.63	10.59	100.00	Clay	10.59
	Tot. Wt. =	62.628	100			

RESULTS :

	microns	phi units
Mean Diameter (MD)	30.98	5.01
Graphic Mean (MZ)	30.98	5.01

	Value	Inference
Sorting Coeff.	1.38	Poorly Sorted
Skewness	-0.01	Symmetrical
Kurtosis	2.06	V. Leptokurtic

LANGSTONE - SITE T (07.02.92)
PARTICLE SIZE ANALYSIS

Aperture (microns)	Aperture (phi unit)	Weight retained (gms.)	Percent Fractional	Cumulative	Fraction Name	%
16000	-4	1.36	1.44	1.44	Coarse Gravel	1.81
4000	-2	0.35	0.37	1.81		
2000	-1	0.32	0.34	2.14	Gravel	0.34
1000	0	0.47	0.50	2.64	Coarse Sand	0.50
500	1	0.37	0.39	3.03	Medium Sand	1.08
250	2	0.65	0.69	3.72		
125	3	2.88	3.04	6.76	Fine Sand	4.04
63	4	0.94	0.99	7.76		
15.6	6	5.55	5.86	13.62	Coarse Silt	5.86
3.9	8	78.72	83.18	96.80	Fine Silt	83.18
1	10	3.03	3.20	100.00	Clay	3.20
	Tot. Wt. =	94.64	100			

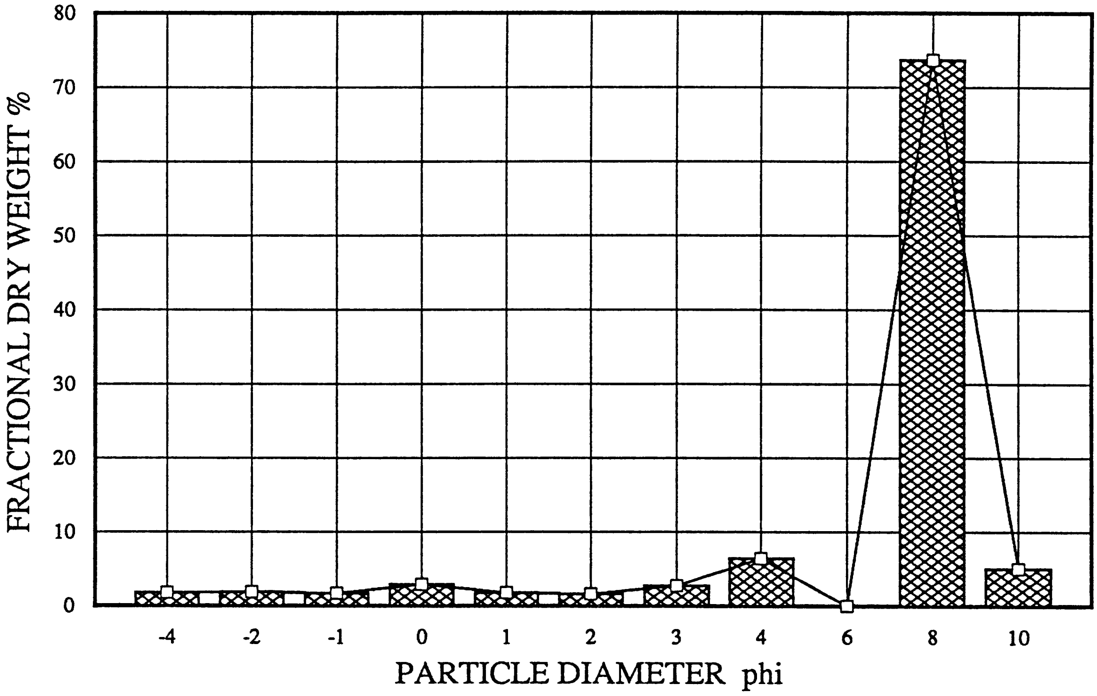
RESULTS :

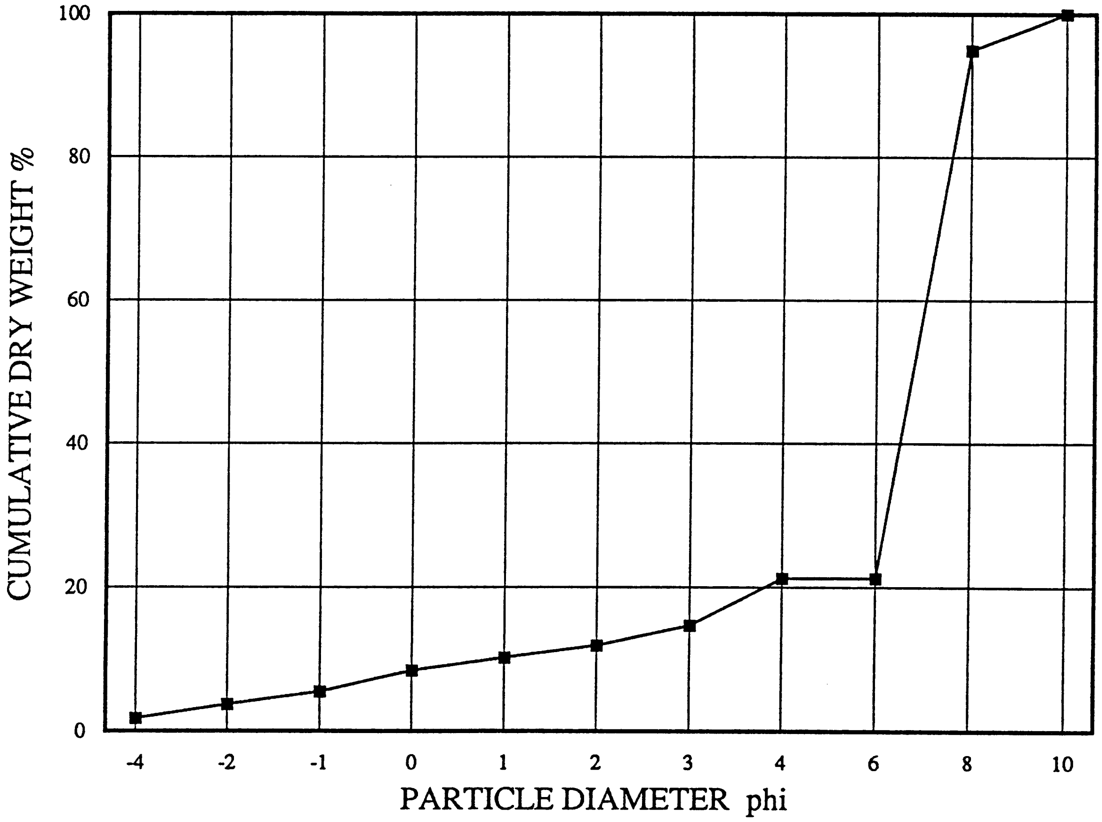
	microns	phi units
Mean Diameter (MD)	8.52	6.87
Graphic Mean (MZ)	8.52	6.87

	Value	Inference
Sorting Coeff.	1.25	Poorly Sorted
Skewness	-0.30	Strongly Coarse Skewed
Kurtosis	1.89	V. Leptokurtic

LANGSTONE - SITE A (30.01.92)

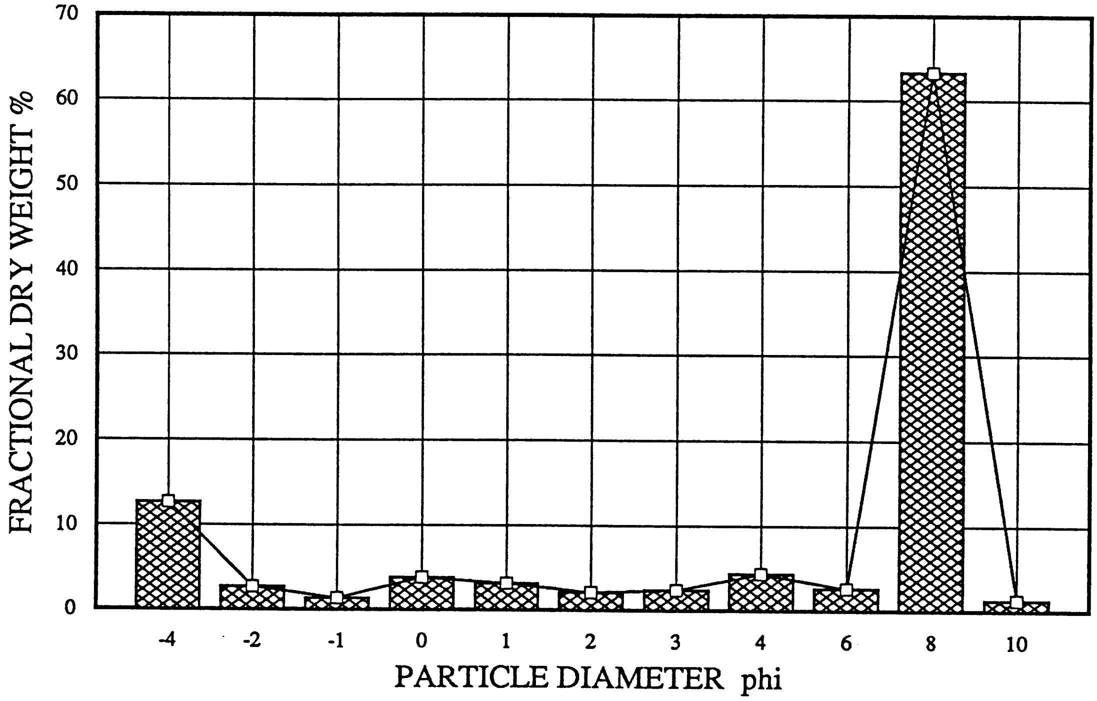
PARTICLE SIZE ANALYSIS

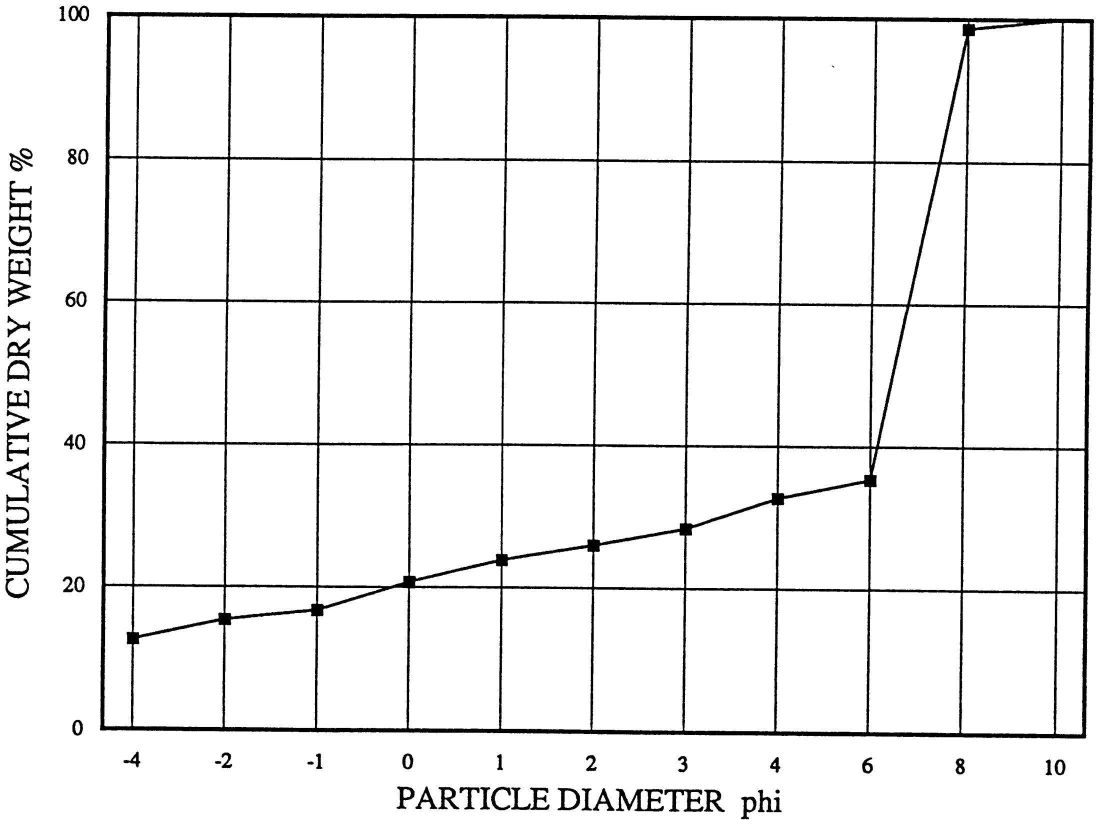




LANGSTONE - SITE A (07.02.92)

PARTICLE SIZE ANALYSIS





LANGSTONE - SITE B (30.01.92)

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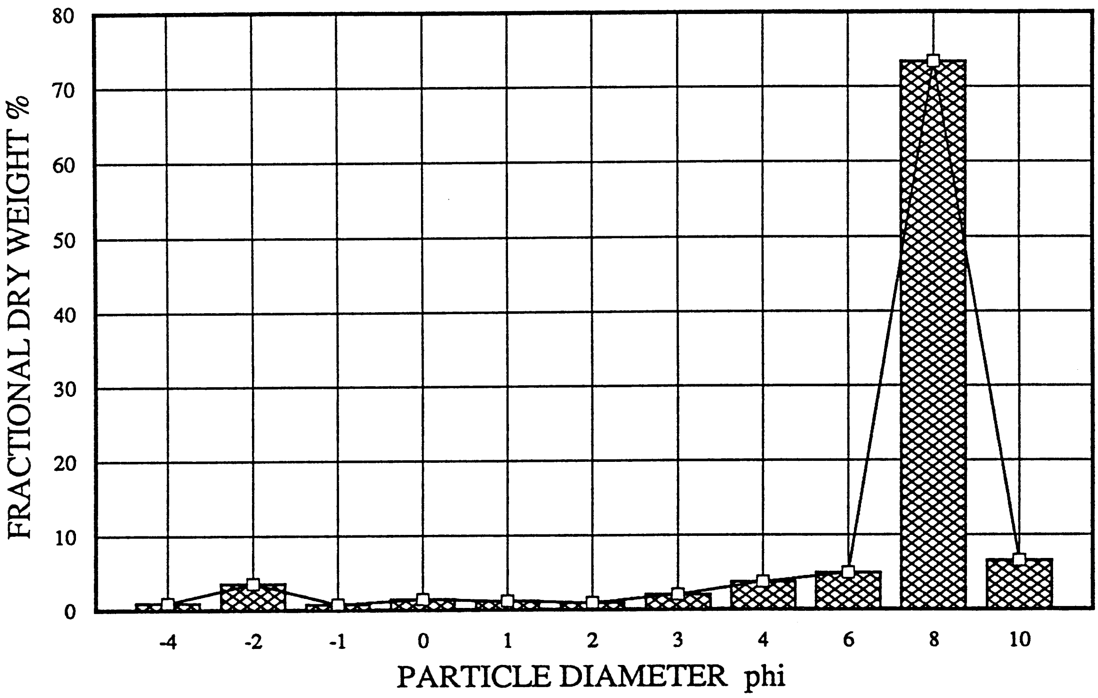

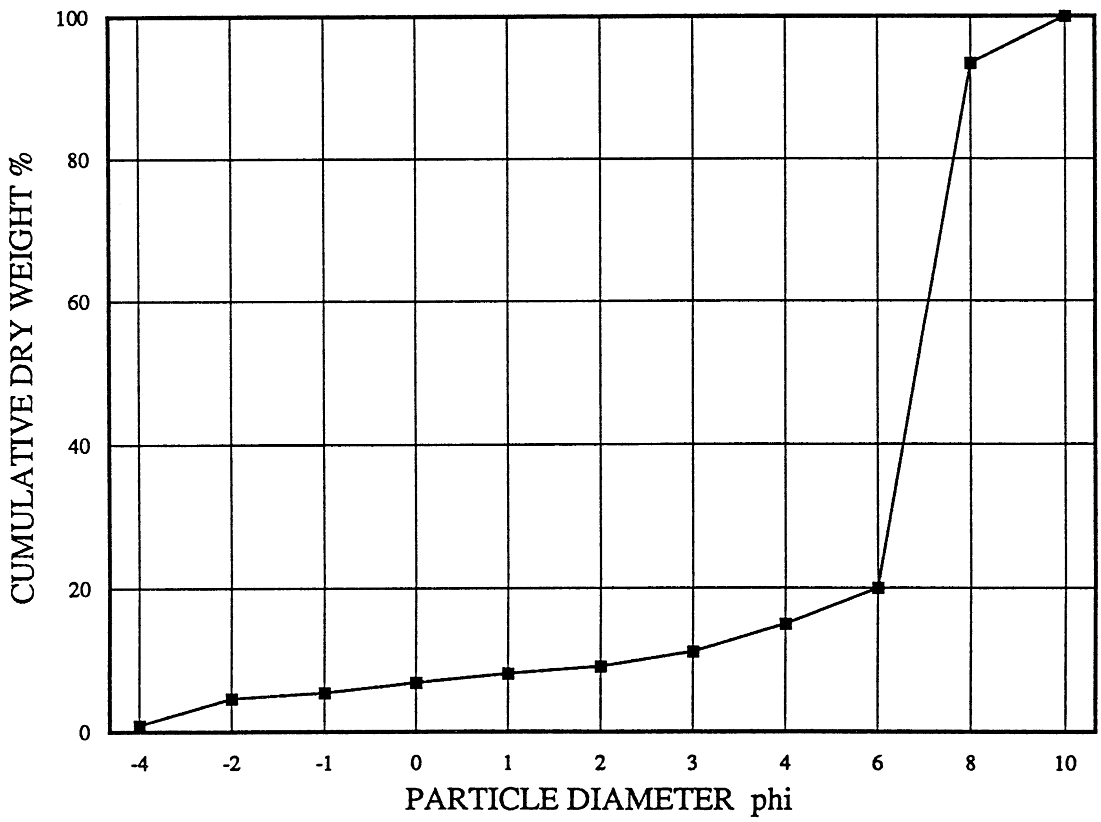

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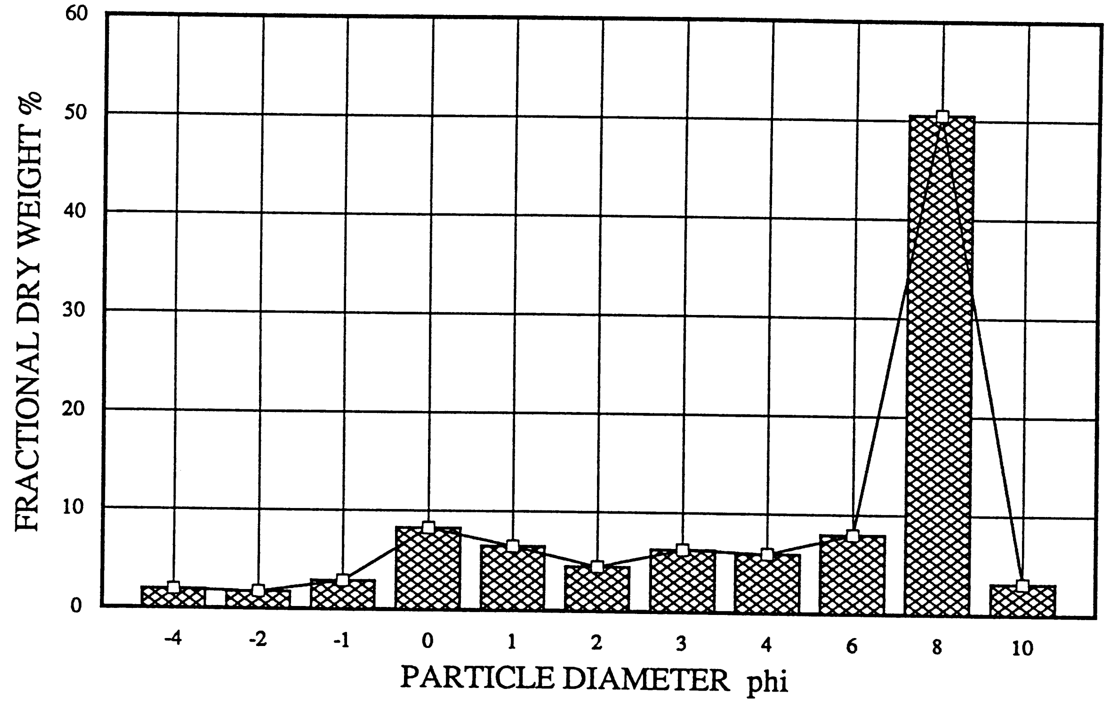
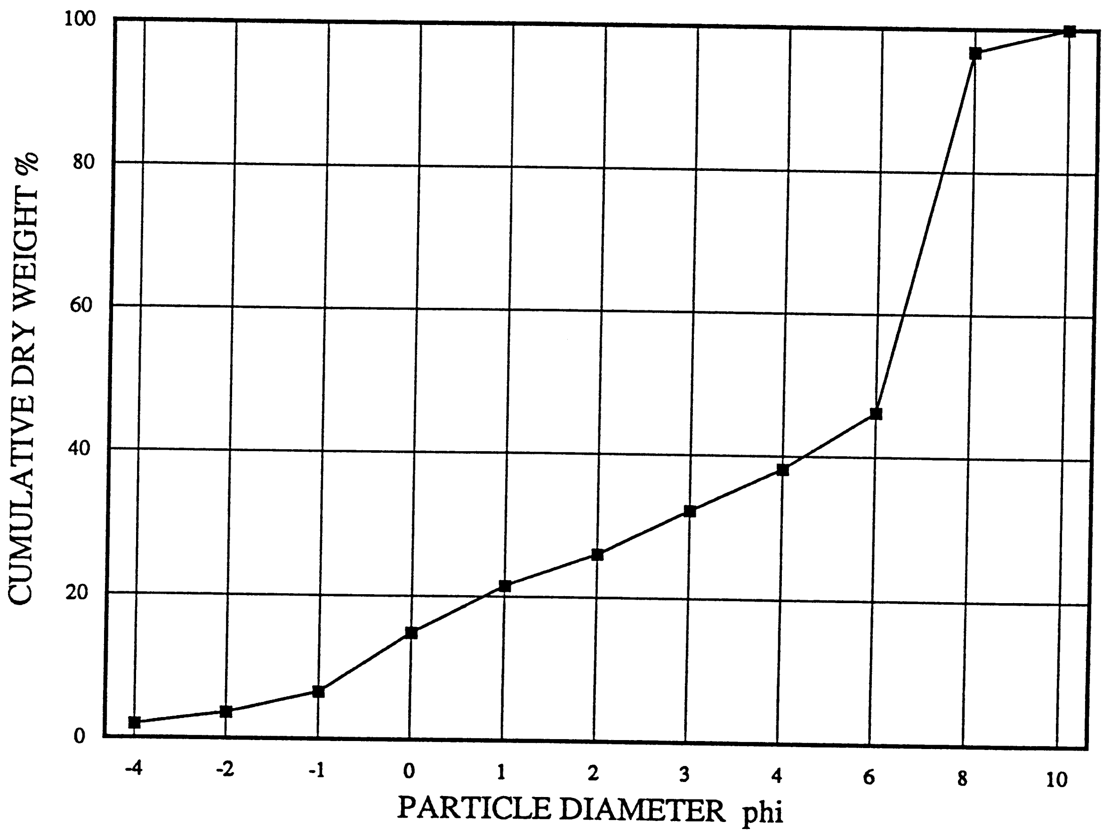
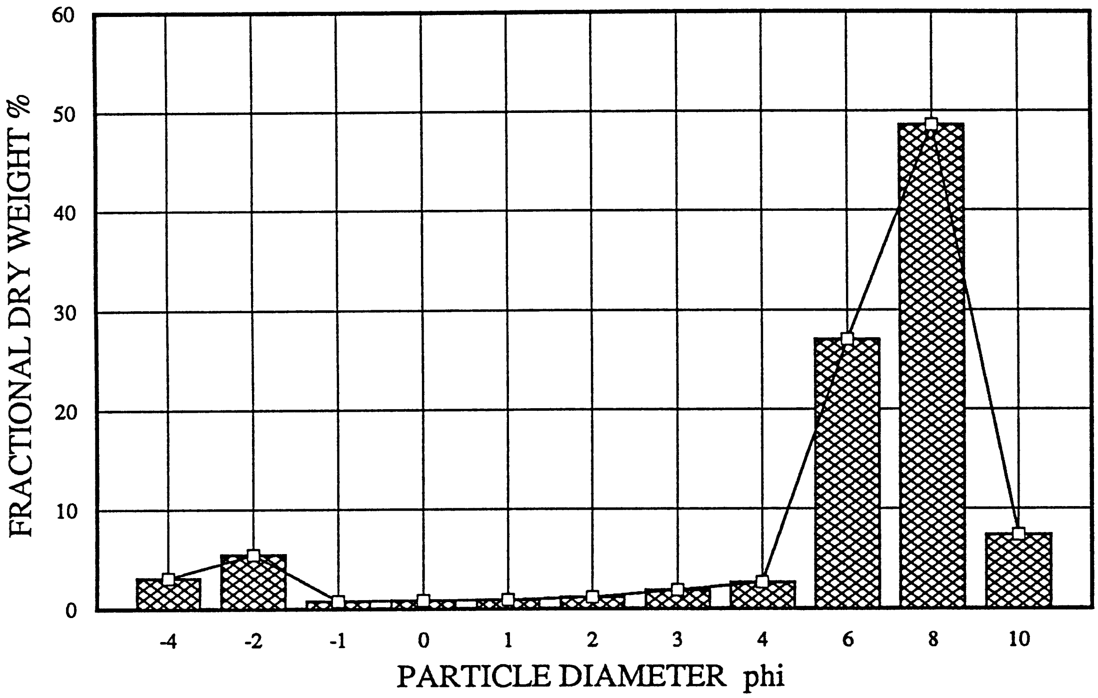
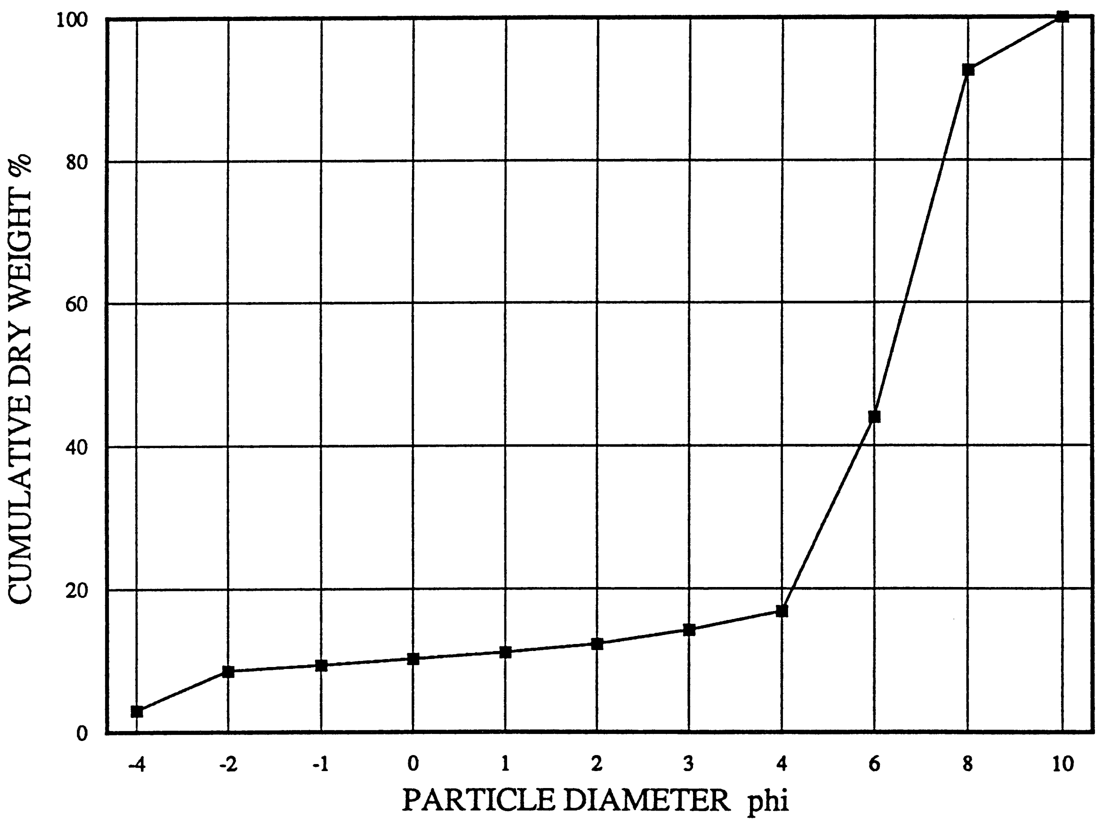




LANGSTONE - SITE C (30.01.92)

PARTICLE SIZE ANALYSIS





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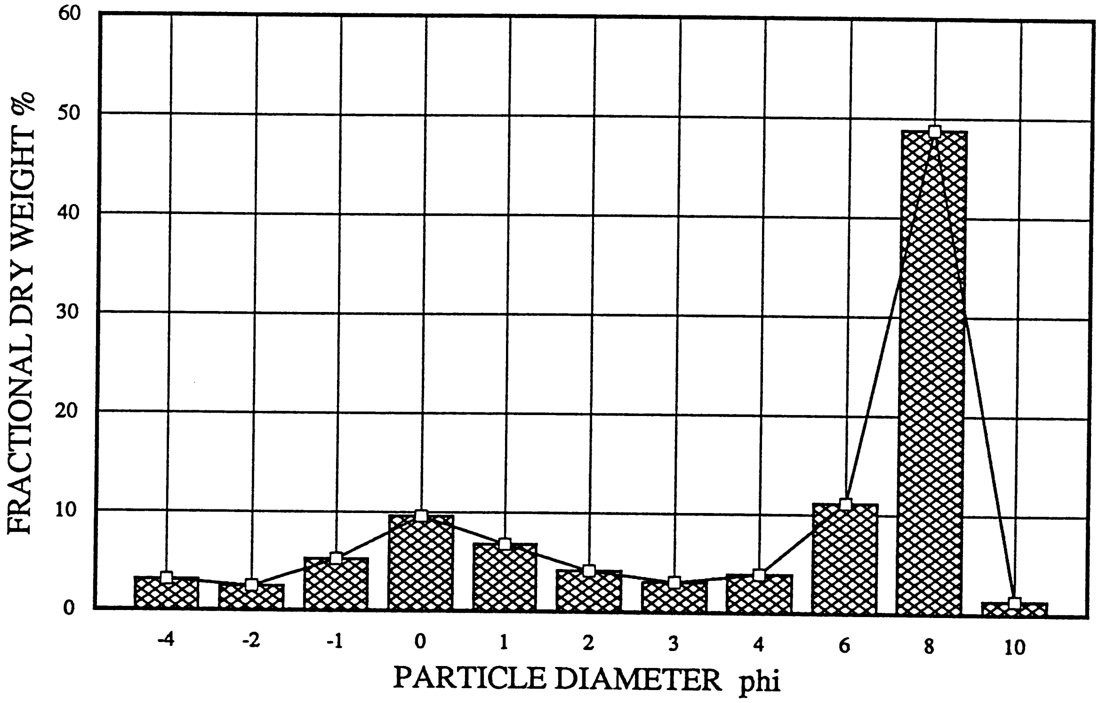

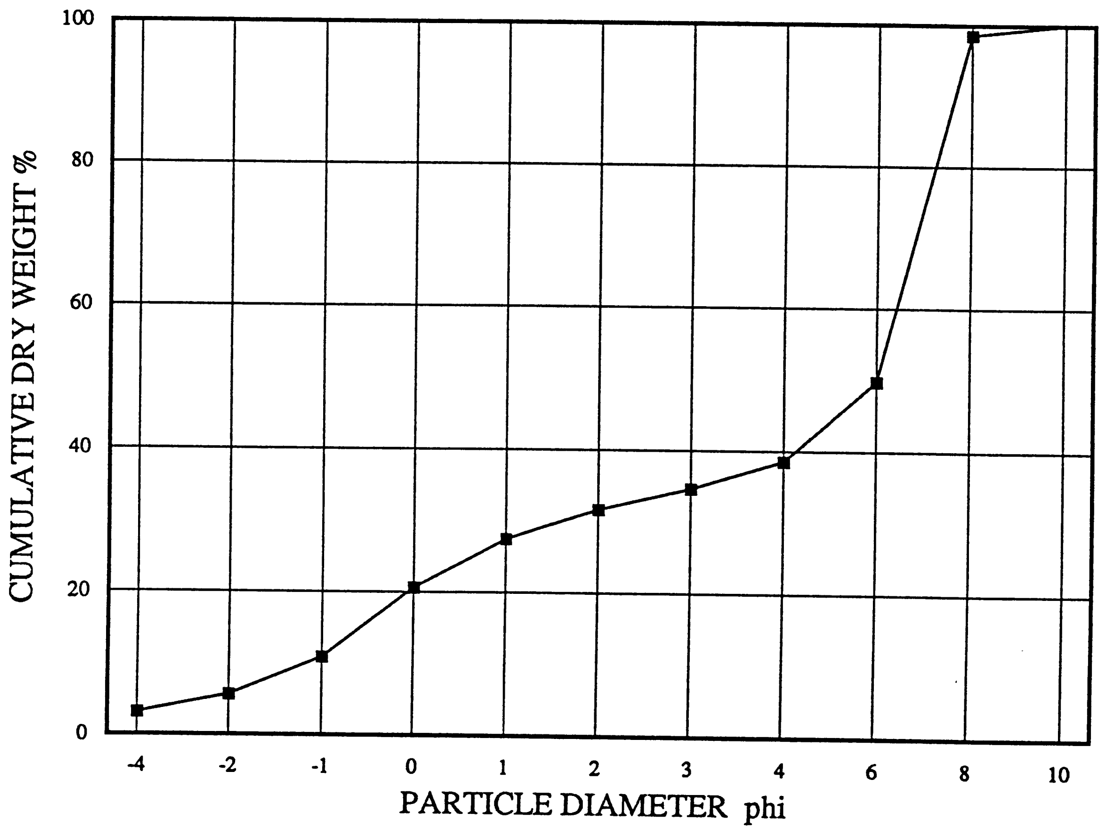

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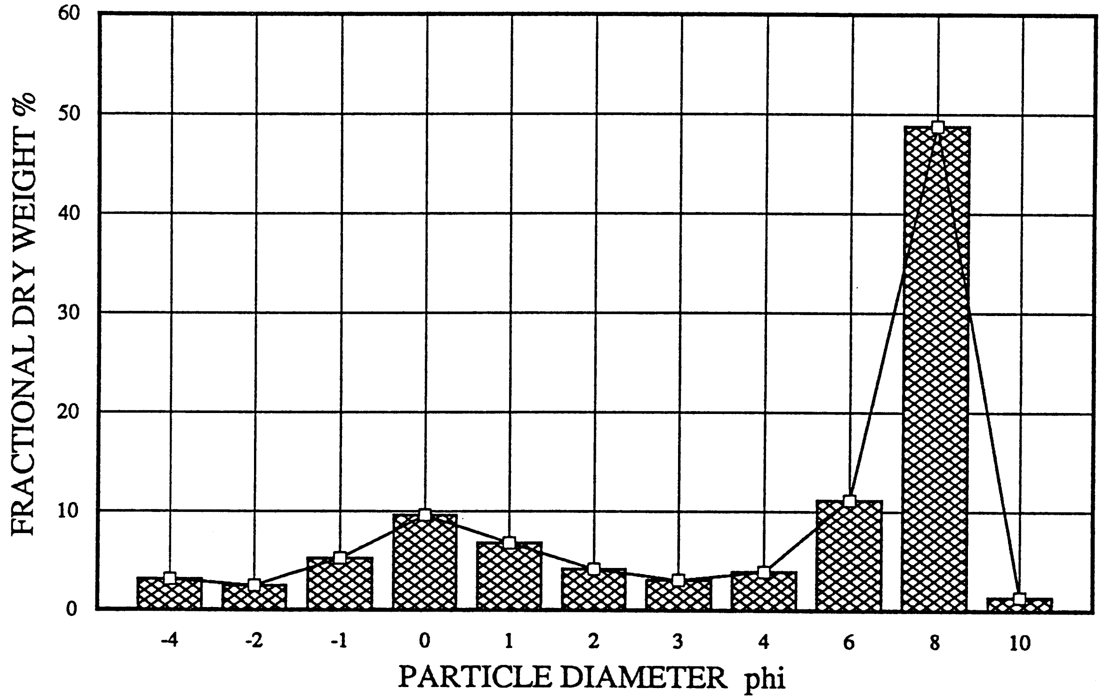
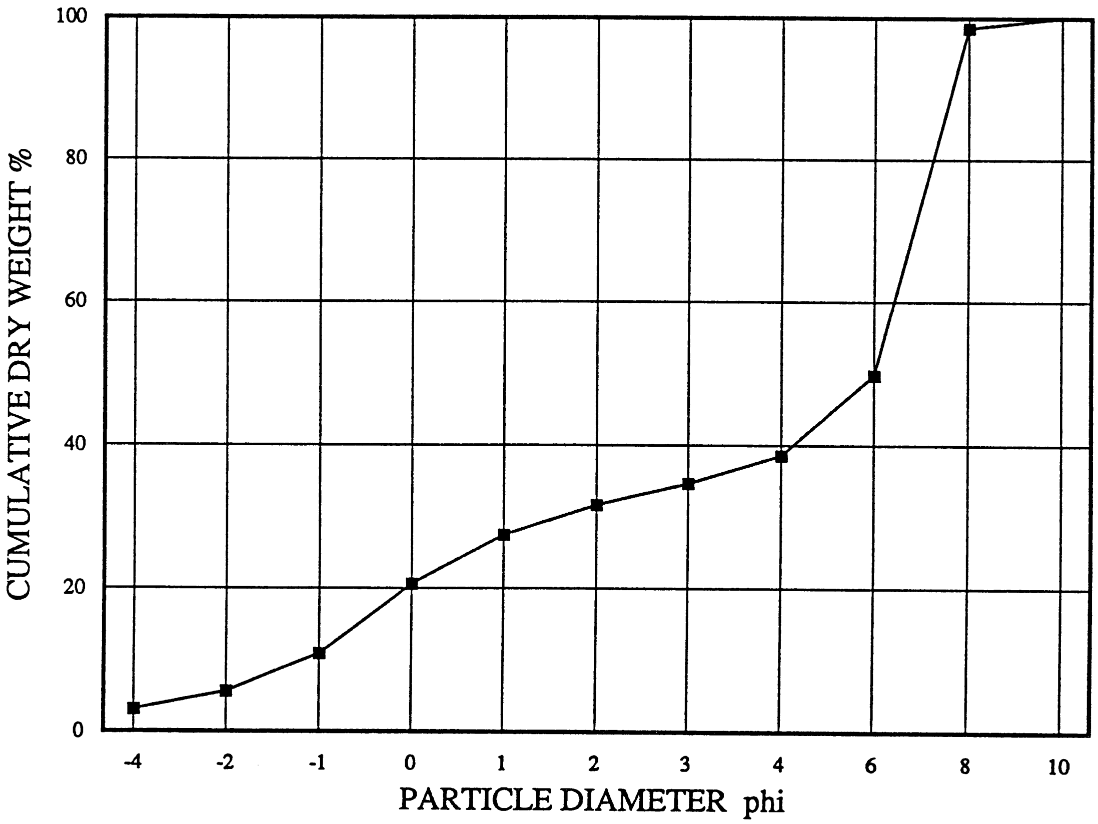
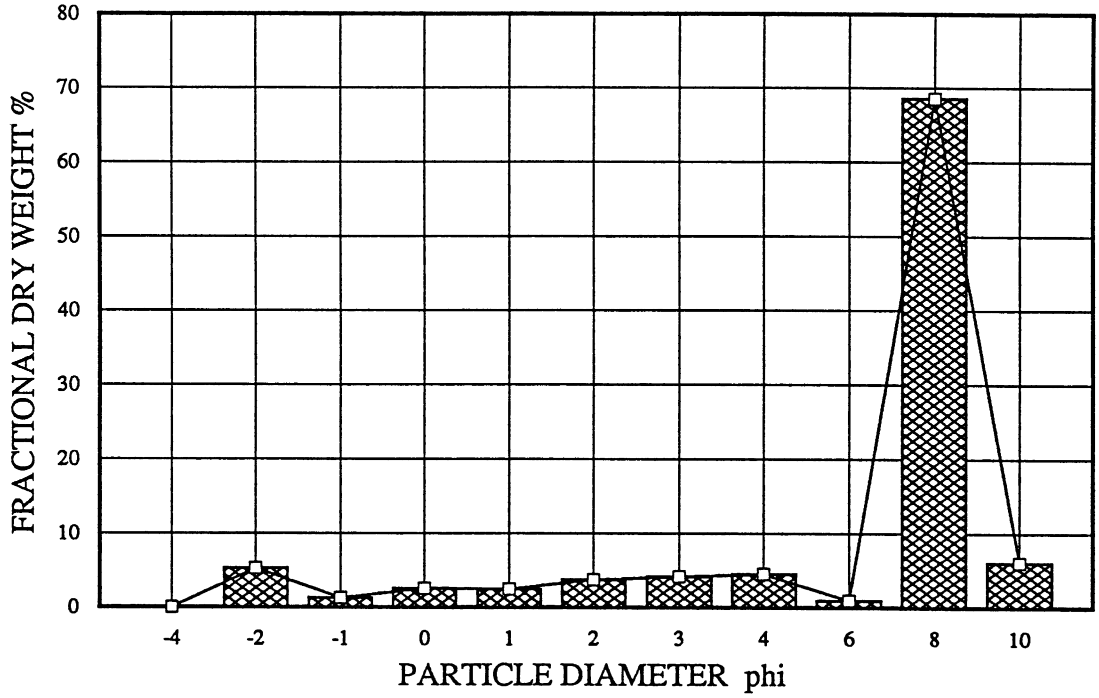
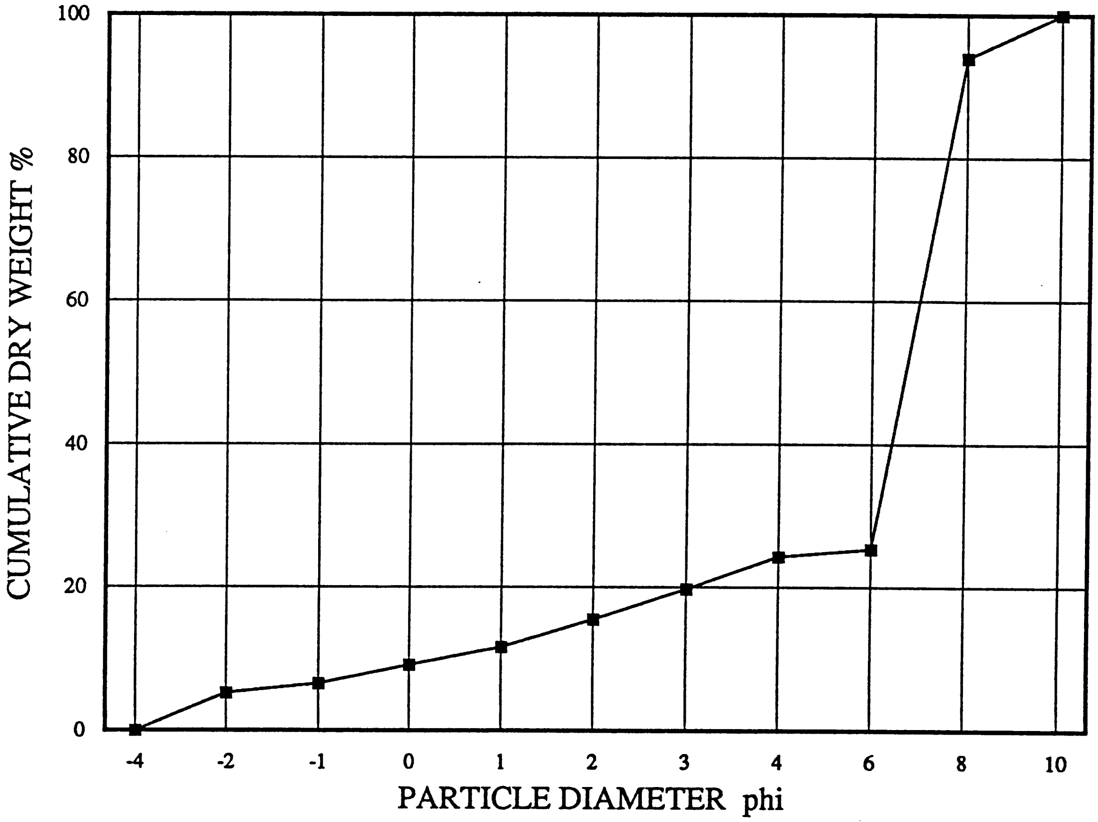




LANGSTONE - SITE R (30.01.92)

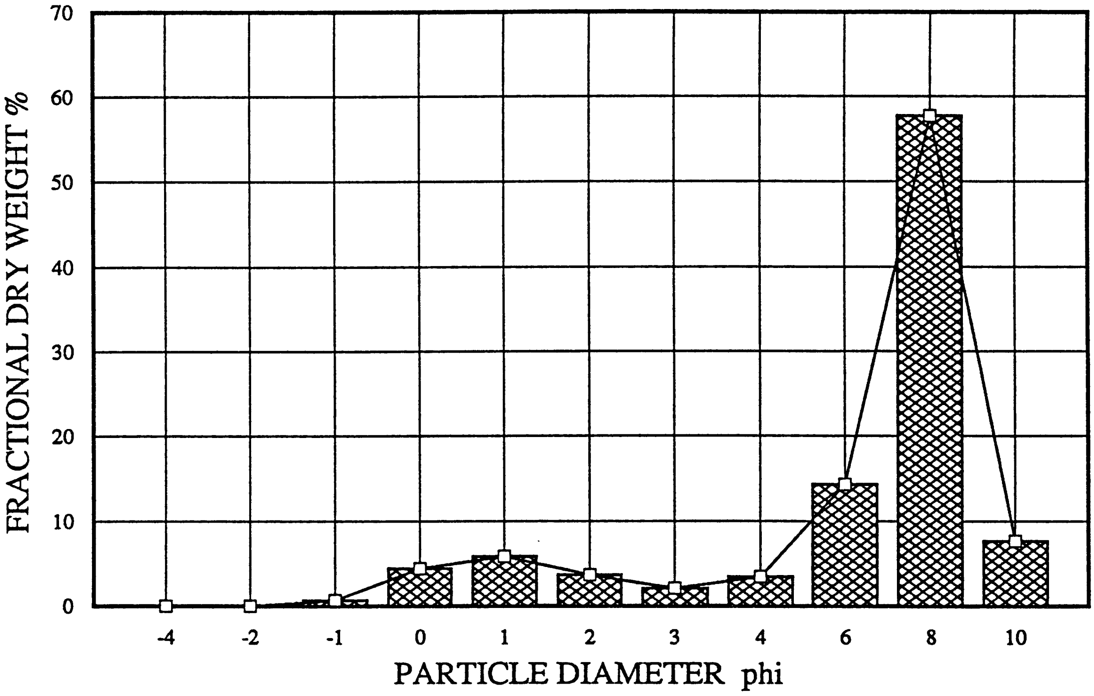
PARTICLE SIZE ANALYSIS

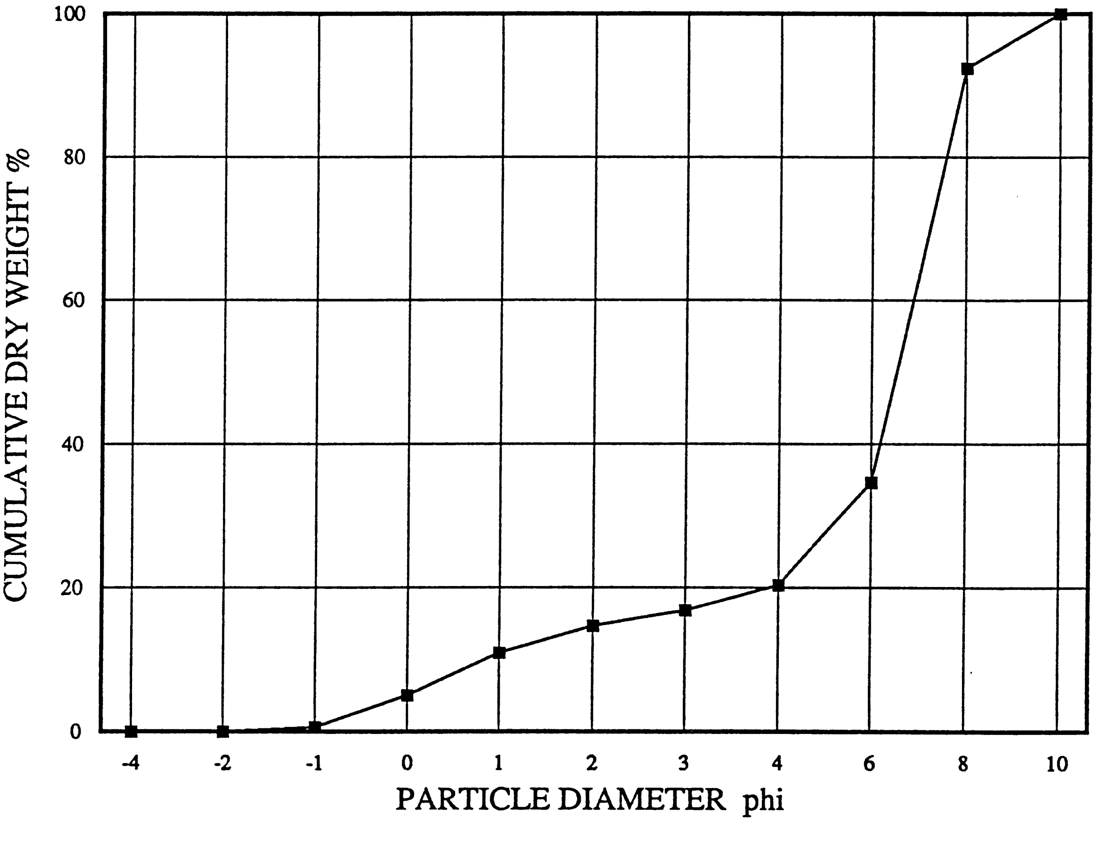




LANGSTONE - SITE R (31.01.92)

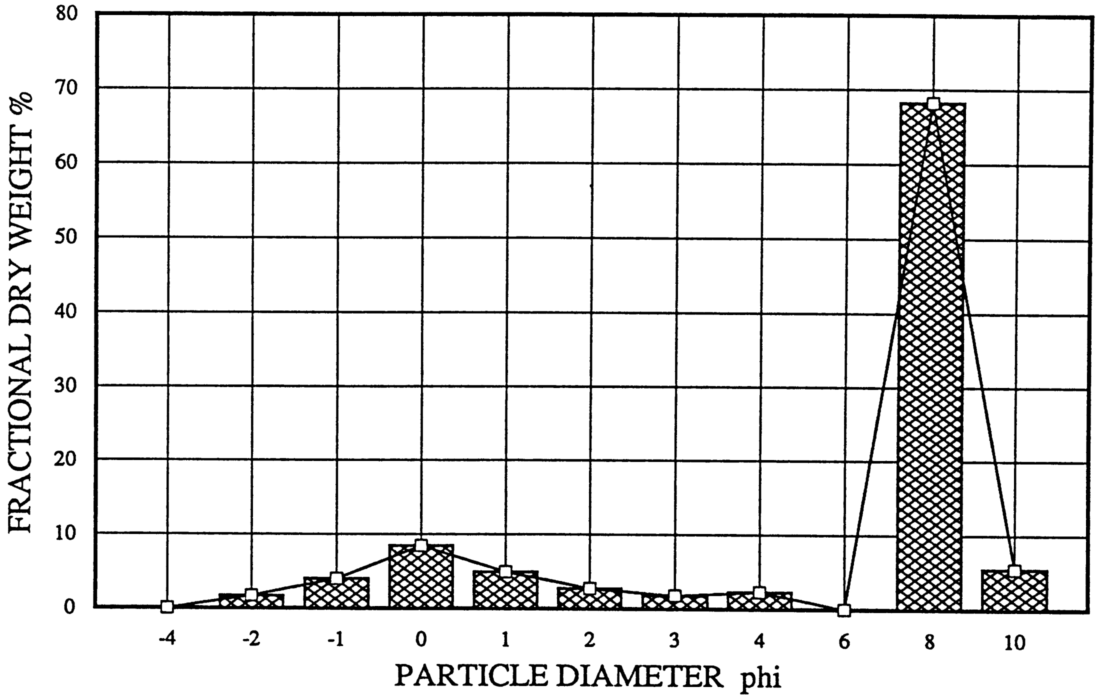
PARTICLE SIZE ANALYSIS

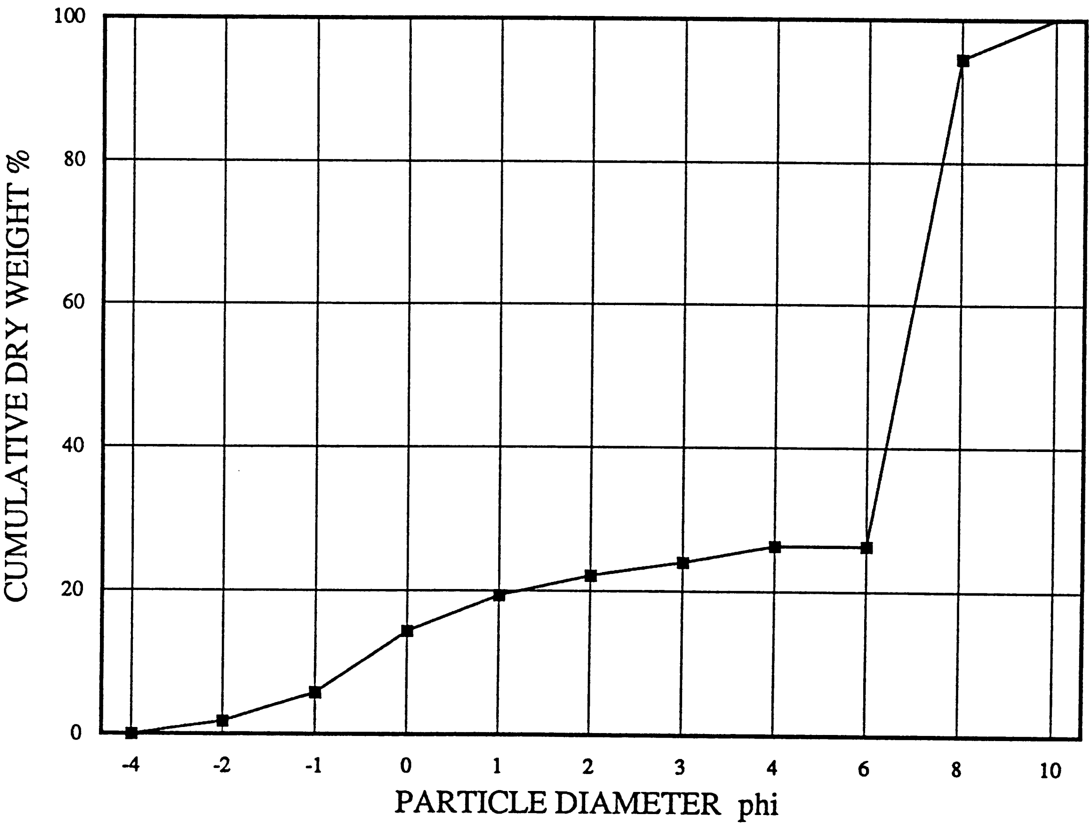




LANGSTONE - SITE S (30.01.92)

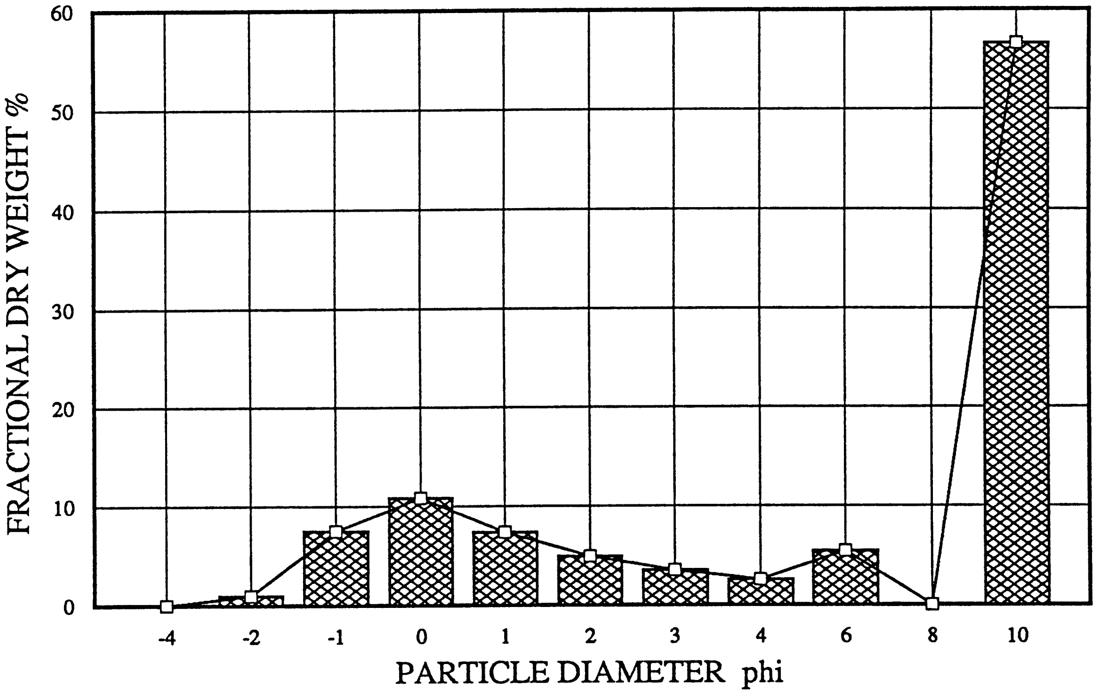
PARTICLE SIZE ANALYSIS

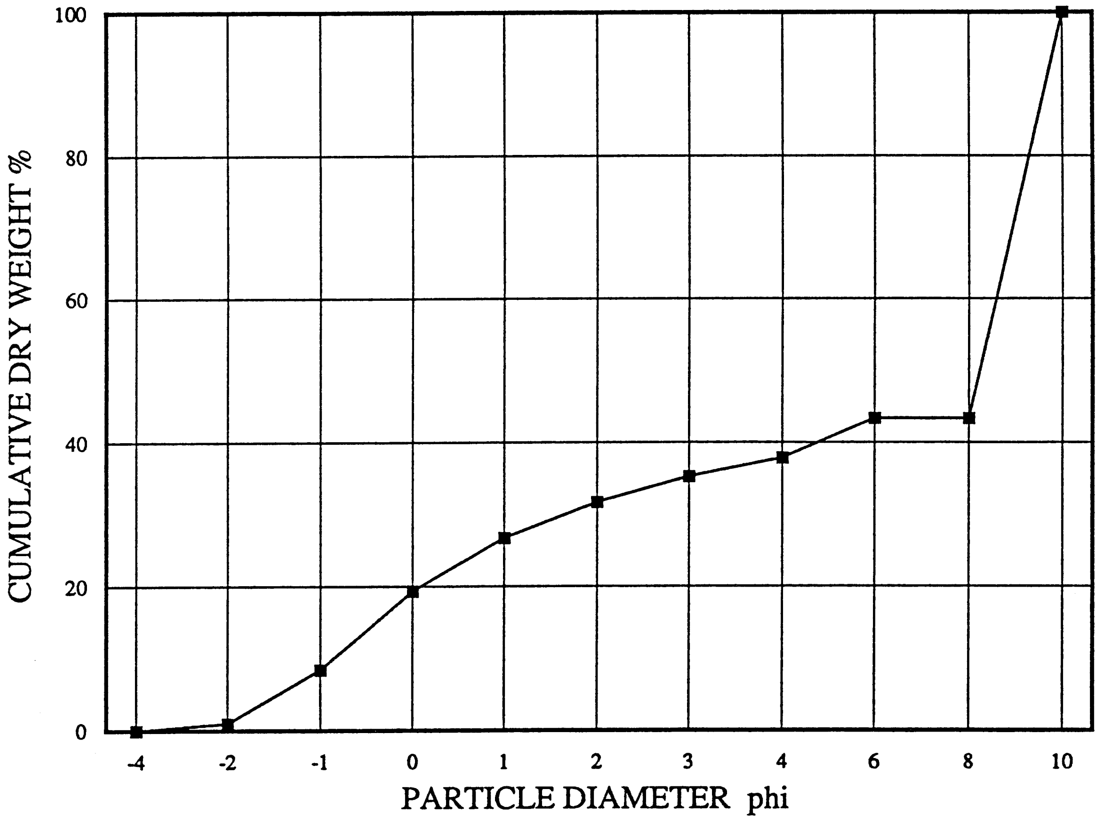




LANGSTONE - SITE S (31.01.92)

PARTICLE SIZE ANALYSIS





LANGSTONE - SITE S (07.02.92)

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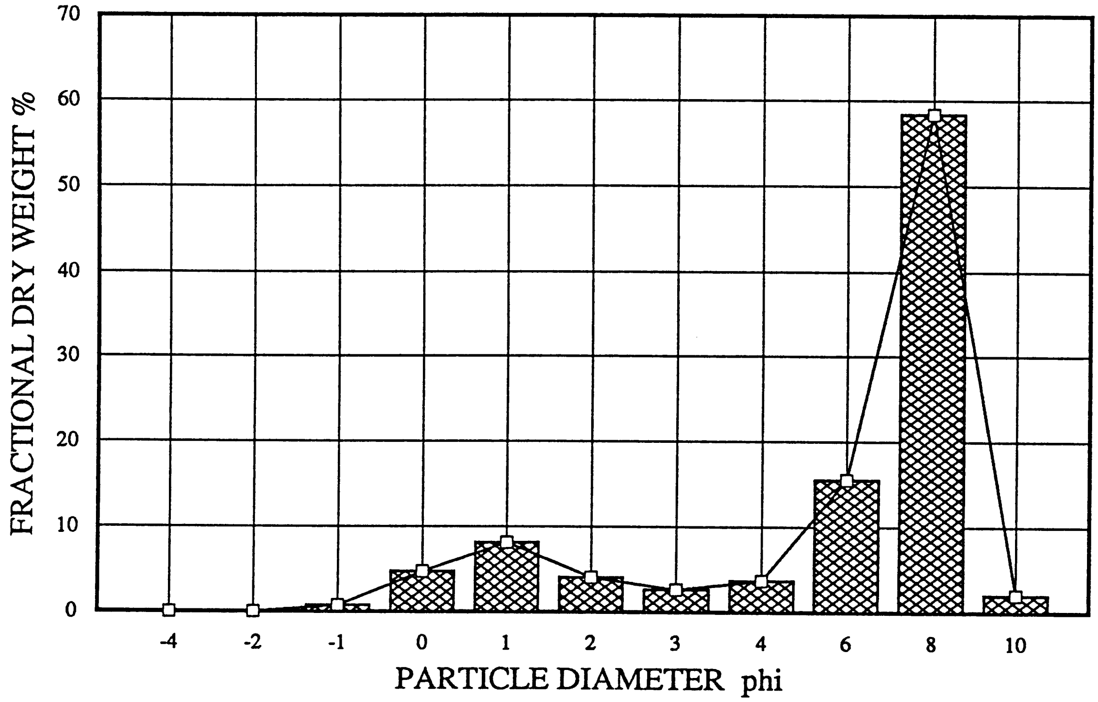
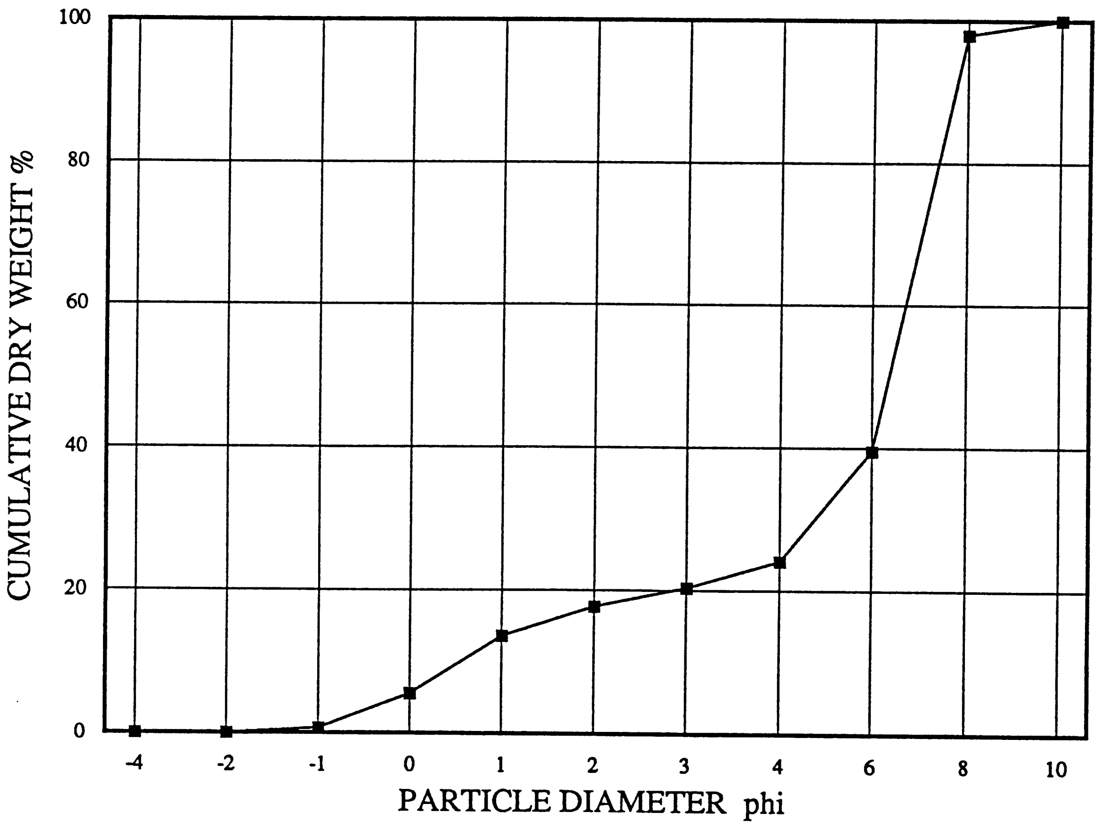
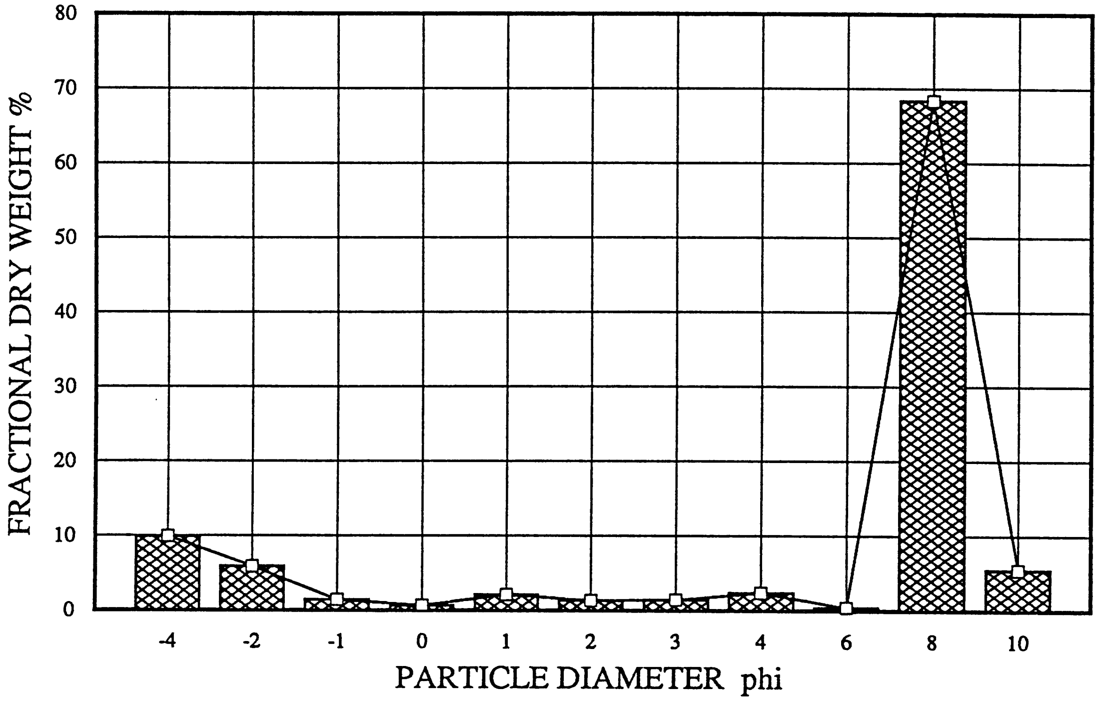
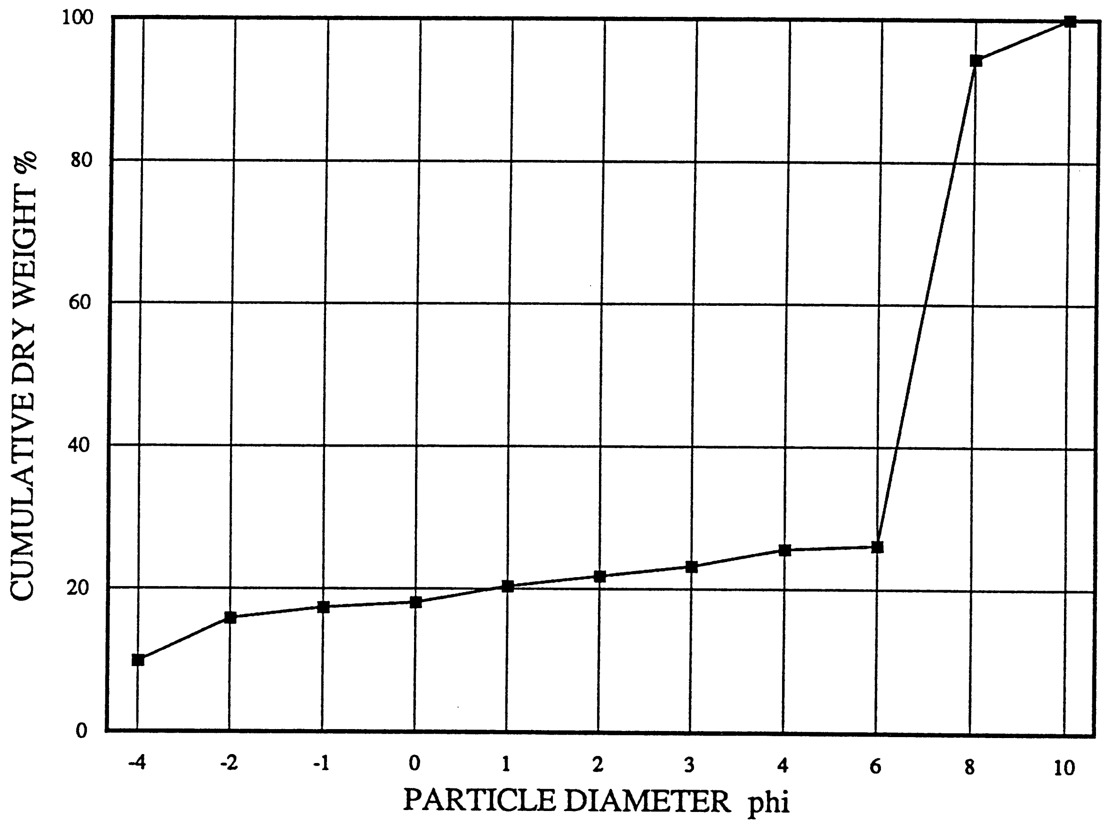




LANGSTONE - SITE T (30.01.92)

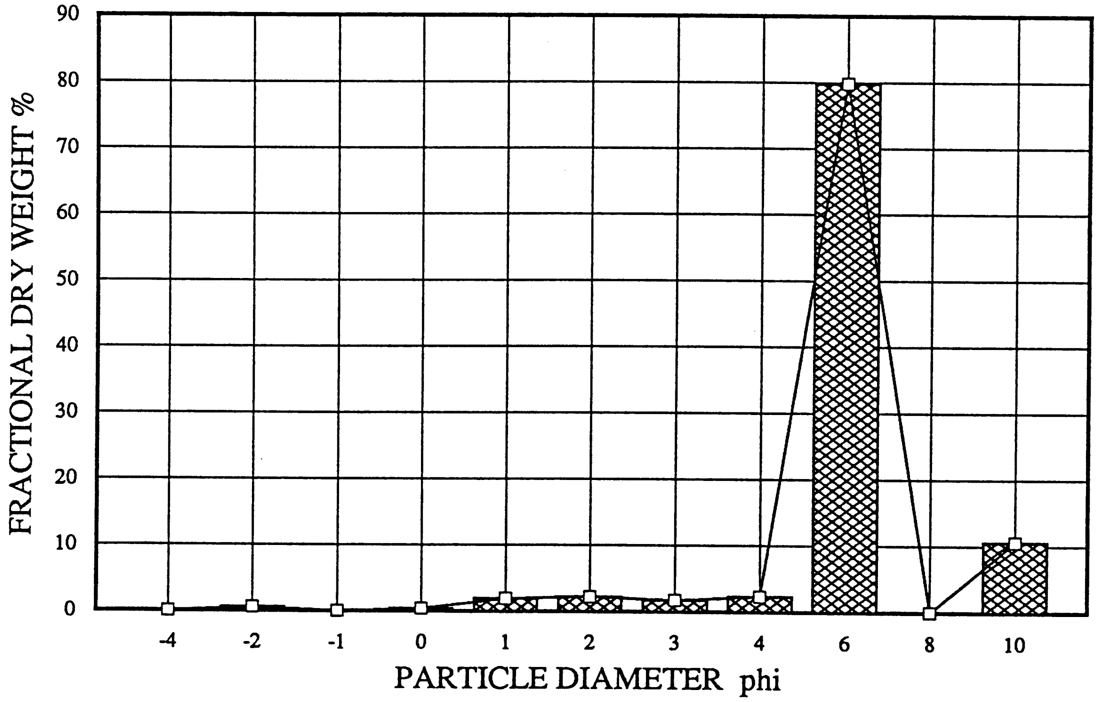
PARTICLE SIZE ANALYSIS

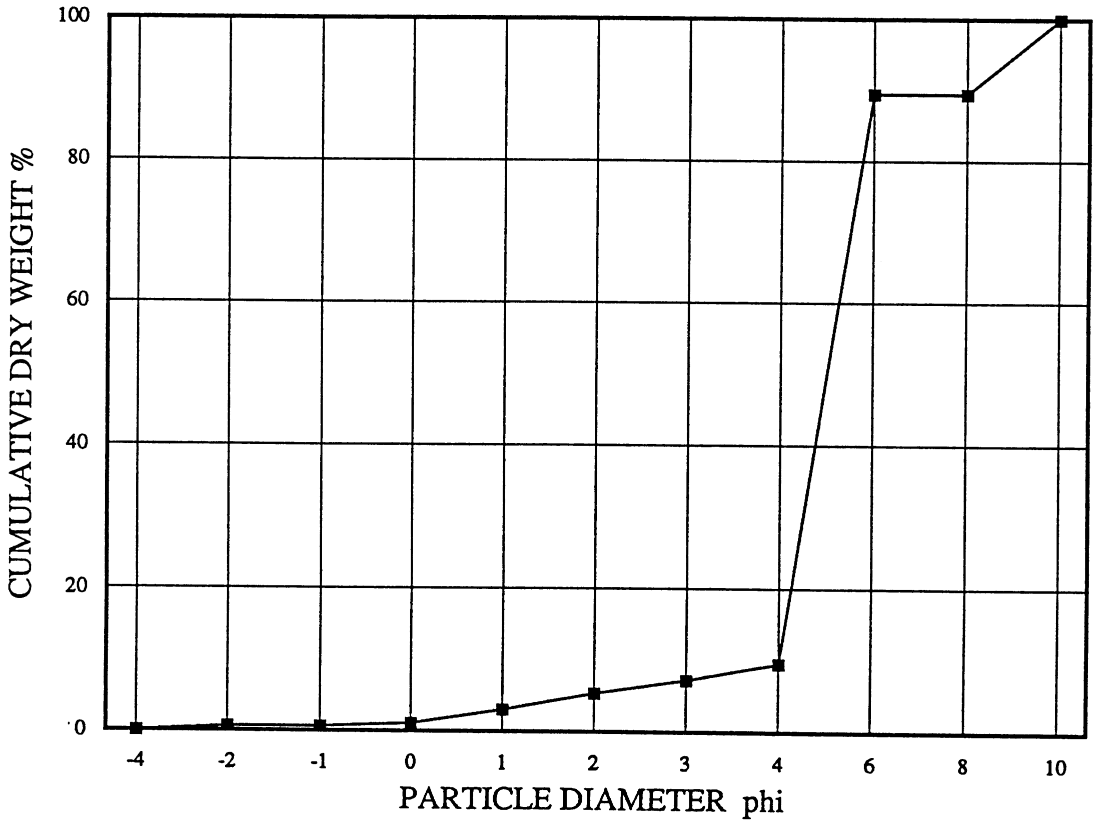




LANGSTONE - SITE T (31.01.92)

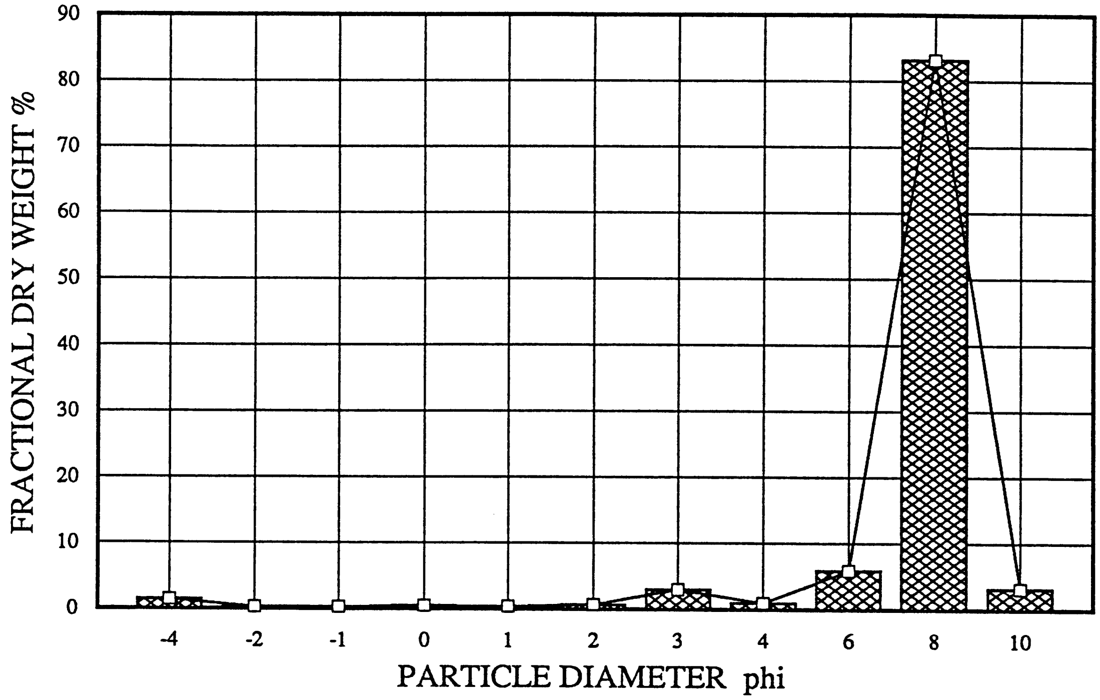
PARTICLE SIZE ANALYSIS

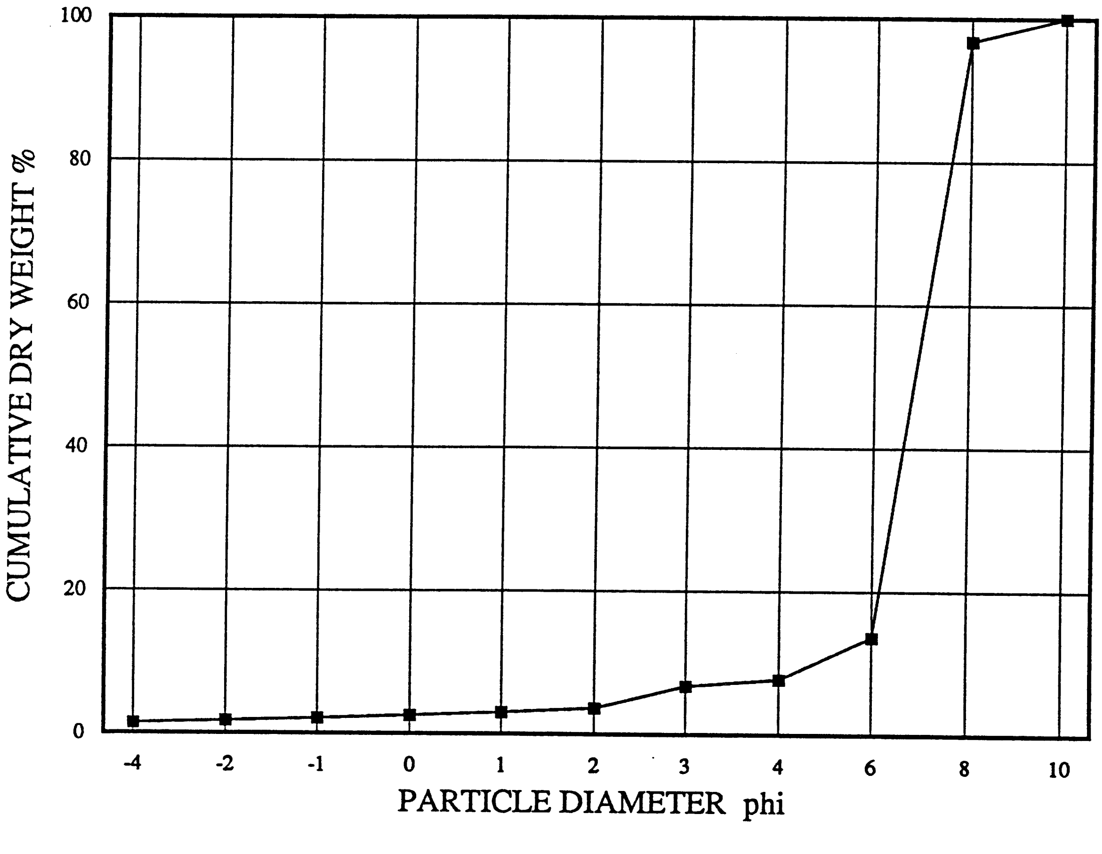




LANGSTONE - SITE T (07.02.92)

PARTICLE SIZE ANALYSIS





APPENDIX 1b.

REDOX VALUES (mV)

Controls	A	B	C
30/1/92			
SURFACE	-185	-145	-130
1cm	-240	-330	-155
5cm	-300	-310	-250
10cm	-340	-360	-330
7/2/92			
SURFACE	-060	-170	-140
1cm	-300	-330	-310
5cm	-360	-400	-400
10cm	-400	-400	-360

TRIALS	R	S	T
30/1/92			
SURFACE	-170	-130	-150
1cm	-190	-160	-260
5cm	-235	-145	-260
10cm	-240	-290	-300
7/2/92			
SURFACE	--	-145	-210
1cm	--	-300	-350
5cm	--	-400	-300
10cm	--	-400	-300

APPENDIX 2

a) Raw Faunal Data
b) Community Structure Measures

Appendix 2a

RAW FAUNAL DATA SETS. NUMBERS ON DIFFERENT DATES ARE GIVEN AS FOLLOWS (30/1/92 UPPER, 31/1/92 MIDDLE, 7/2/92 LOWER).

			A					B					C					R					S					T		
SPECIES	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
OLIGOCHAETA																														
TUBIFICOIDES	1	1	0	1	2	4	2	4	0	5	9	2	0	3	0	1	0	0	2	0	0	0	0	0	0	0	0	1	1	1
BENEDENI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	2	1	4	0	0	2	3	1	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	1	2
POLYCHAETA																														
CIRRIFORMIA	6	0	8	6	0	9	8	10	5	9	0	4	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TENTACULATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	9	9	4	9	0	8	14	8	6	0	10	4	0	3	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
MELINNA	0	0	1	0	1	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
PALMATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
THARYX	0	0	0	1	0	0	0	0	0	0	3	0	0	2	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	1
MARIONI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	1	1	1	0	0	2	0	1	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
NEPHTYS	1	1	0	0	0	0	0	0	2	0	0	1	0	0	0	2	1	0	0	1	1	0	1	0	1	0	1	1	0	0
HOMBERGI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	2	0	1	0	0	0	0	0	0	2	0	0	1	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
SPIONID	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INDET	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
MANAYUNKIA	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	2	0	0	2
AESTUARINA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
PSEUDOEULALIA	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
EXIGUA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	1	2
AMPHITRITE	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FIGULUS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
CAPITELLA SP	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
AMPHARETE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
ACUTIFRONS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	1
NEREIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VIRENS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
STHENELAIS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BOA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0

	A					B					C					R					S					T				
SPECIES	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
SYLLID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
INDET	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
ETEONE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
LONGA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
MOLLUSCA																														
CREPIDULA	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FORNICATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
LEPIDOCHITONA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CINERERIA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
LIMAPONTIA SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
LITTORINA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LITTOREA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
HYDROBIA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	1	0	1	0	0
ULVAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
RETUSA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
OBTUSATA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
CERASTODERMA	0	1	0	0	0	1	1	1	3	0	1	0	0	0	4	1	0	2	0	0	0	5	0	1	1	1	1	0	0	0
EDULE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
	0	0	3	2	0	1	1	0	1	1	2	0	3	1	2	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
ABRA	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	3	1	1	1	0	1	1	1	1	1	5	1
TENUIS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	1	0	0	0	0	0	0	2	0	1	0	0
	0	0	0	0	0	0	0	0	1	1	2	0	1	1	1	-	-	-	-	-	2	0	0	1	0	1	2	0	0	0
MYA	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	0	0
ARENARIA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
MACOMA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
BALTHICA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0

	A					B					C					R					S					T				
SPECIES CRUSTACEA	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
GAMMARID	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INDET	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0

Appendix 2b

Diversity index H

	A					B					C				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
30/1/92	0.74	1.61	0.35	1.09	1.56	1.19	1.18	0.99	1.24	0.65	1.75	0.96	0	1.50	0.67
7/2/92	0.64	0.72	1.07	1.38	1.34	0	0.35	0.85	1.22	1.23	1.10	0.30	0.86	1.39	1.01
	R					S					T				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
30/1/92	1.04	1.04	1.05	1.70	1.10	1.10	0.80	0.69	1.10	1.61	0.69	1.75	1.91	1.07	1.75
31/1/92	0	0	0	0	0	0	0	0	0	0	0.64	0	0	0	0
07/2/92	-	-	-	-	-	0	0	0	0	0	0.69	0	0	0	0.64

Enenness Index J

	A					B					C				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
30/1/92	0.67	1.00	0.50	0.79	1.13	0.74	0.73	0.71	0.89	0.94	0.84	0.87	0	0.89	0.94
07/2/92	0.58	0.66	0.77	0.86	0.75	0	0.5	0.61	0.76	0.76	1.0	0.43	0.62	1.00	0.92
	R					S					T				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
30/1/92	0.75	0.95	0.96	0.95	1.00	1.00	0.72	1.00	1.00	1.00	1.0	0.98	0.98	0.77	0.98
31/1/92	0	0	0	0	0	0	0	0	0	0	0.92	0	0	0	0
07/2/92	-	-	-	-	-	0	0	0	0	0	0.99	0	0	0	0.92

APPENDIX 3

Summary Faunal Statistics

Variable:	totsptpre	totsptpos1	totsptpos2
Sample size	15	15	10
Average	4	0.866667	0.9
Median	3	1	1
Mode	3	1	0
Geometric mean	3.71389		
Variance	2.57143	0.552381	0.766667
Standard deviation	1.60357	0.743223	0.875595
Standard error	0.414039	0.191899	0.276887
Minimum	2	0	0
Maximum	7	2	2
Range	5	2	2

Variable:	totspcpre	totspcpost
Sample size	15	15
Average	3.66667	3.6
Median	4	4
Mode	4	4
Geometric mean		3.30818
Variance	3.38095	1.82857
Standard deviation	1.83874	1.35225
Standard error	0.47476	0.349149
Minimum	0	1
Maximum	8	6
Range	8	5

Variable:	abuncpre	abuncpost
Sample size	15	15
Average	10.4	10.2
Median	10	10
Mode	8	10
Geometric mean		8.6018
Variance	30.2571	23.3143
Standard deviation	5.50065	4.82849
Standard error	1.42026	1.24671
Minimum	0	1
Maximum	23	19
Range	23	18

Variable:	abuntpre	abuntpost1	abuntpost2
Sample size	15	15	10
Average	5.33333	0.733333	1.1
Median	5	1	1
Mode	7	0	0
Geometric mean	4.68176		
Variance	7.80952	0.780952	1.21111
Standard deviation	2.79455	0.883715	1.1005
Standard error	0.72155	0.228174	0.34801
Minimum	2	0	0
Maximum	12	3	3
Range	10	3	3

Variable:	divcpre	divcpost
Sample size	15	15
Average	1.032	0.897333
Median	1.09	1.01
Mode	0.99	0.86
Geometric mean		
Variance	0.238589	0.180921
Standard deviation	0.488455	0.425348
Standard error	0.126119	0.109824
Minimum	0	0
Maximum	1.75	1.39
Range	1.75	1.39

Variable:	divtpre	divtpost1	divtpost2
Sample size	15	15	10
Average	1.22667	0.0426667	0.133
Median	1.1	0	0
Mode	1.1	0	0
Geometric mean	1.16484		
Variance	0.165524	0.0273067	0.0787567
Standard deviation	0.406846	0.165247	0.280636
Standard error	0.105047	0.0426667	0.088745
Minimum	0.69	0	0
Maximum	1.91	0.64	0.69
Range	1.22	0.64	0.69

Variable:	evecpre	evecpost
Sample size	15	15
Average	0.776	0.681333
Median	0.84	0.75
Mode	0.94	1
Geometric mean		
Variance	0.0689829	0.0640552
Standard deviation	0.262646	0.253091
Standard error	0.0678149	0.0653479
Minimum	0	0
Maximum	1.13	1
Range	1.13	1

Variable:	CLAMSP.evetpre
Sample size	15
Average	0.936
Median	0.98
Mode	1
Geometric mean	0.930434
Variance	0.0100114
Standard deviation	0.100057
Standard error	0.0258346
Minimum	0.72
Maximum	1
Range	0.28

Variable:	tbencpre	tbencpost
Sample size	15	15
Average	2.26667	0.866667
Median	2	0
Mode	0	0
Geometric mean		
Variance	6.06667	1.69524
Standard deviation	2.46306	1.30201
Standard error	0.635959	0.336178
Minimum	0	0
Maximum	9	4
Range	9	4

Variable:	tbentpre	tbentpos1	tbentpos2
Sample size	15	15	10
Average	0.4	0	0.3
Median	0	0	0
Mode	0	0	0
Geometric mean			
Variance	0.4	0	0.455556
Standard deviation	0.632456	0	0.674949
Standard error	0.163299	0	0.213437
Minimum	0	0	0
Maximum	2	0	2
Range	2	0	2

Variable:	nhomcpre	nhomcpos
Sample size	15	15
Average	0.333333	0.466667
Median	0	0
Mode	0	0
Geometric mean		
Variance	0.380952	0.552381
Standard deviation	0.617213	0.743223
Standard error	0.159364	0.191899
Minimum	0	0
Maximum	2	2
Range	2	2

Variable:	nhomtpre	nhomtpos1	nhompos2
Sample size	15	15	10
Average	0.6	0	0
Median	1	0	0
Mode	1	0	0
Geometric mean			
Variance	0.4	0	0
Standard deviation	0.632456	0	0
Standard error	0.163299	0	0
Minimum	0	0	0
Maximum	2	0	0
Range	2	0	0

Variable:	totpolcpre	totpolcpos
Sample size	15	15
Average	2.06667	1.26667
Median	1	1
Mode	1	1
Geometric mean		
Variance	6.06667	1.49524
Standard deviation	2.46306	1.2228
Standard error	0.635959	0.315725
Minimum	0	0
Maximum	10	3
Range	10	3

Variable:	totpoltpre	totpoltpo1	totpoltpo2
Sample size	15	15	10
Average	2	0.0666667	0.4
Median	2	0	0
Mode	2	0	0
Geometric mean			
Variance	3.14286	0.0666667	0.488889
Standard deviation	1.77281	0.258199	0.699206
Standard error	0.457738	0.0666667	0.221108
Minimum	0	0	0
Maximum	6	1	2
Range	6	1	2

Variable:	abracpre	abracpost
Sample size	15	15
Average	0.133333	0.466667
Median	0	0
Mode	0	0
Geometric mean		
Variance	0.12381	0.409524
Standard deviation	0.351866	0.63994
Standard error	0.0908514	0.165232
Minimum	0	0
Maximum	1	2
Range	1	2

Variable:	abratpre	abratpos1	abratpos2
Sample size	15	15	10
Average	1.2	0.266667	0.6
Median	1	0	0
Mode	1	0	0
Geometric mean			
Variance	1.6	0.352381	0.711111
Standard deviation	1.26491	0.593617	0.843274
Standard error	0.326599	0.153271	0.266667
Minimum	0	0	0
Maximum	5	2	2
Range	5	2	2

Variable:	myatpre	myatpos1	myatpos2
Sample size	15	15	15
Average	0.4	0.2	0
Median	0	0	0
Mode	0	0	0
Geometric mean			
Variance	0.257143	0.314286	0
Standard deviation	0.507093	0.560612	0
Standard error	0.130931	0.144749	0
Minimum	0	0	0
Maximum	1	2	0
Range	1	2	0

Vaable:	ceducpre	ceducpos
Sample size	15	15
Average	0.8	1.13333
Median	0	1
Mode	0	1
Geometric mean		
Variance	1.45714	1.12381
Standard deviation	1.20712	1.0601
Standard error	0.311677	0.273716
Minimum	0	0
Maximum	4	3
Range	4	3

Variable:	cedutpre	cebutpos1	cebutpos2
Sample size	15	15	10
Average	0.8	0.133333	0
Median	0	0	0
Mode	0	0	0
Geometric mean			
Variance	1.74286	0.12381	0
Standard deviation	1.32017	0.351866	0
Standard error	0.340867	0.0908514	0
Minimum	0	0	0
Maximum	5	1	0
Range	5	1	0

Variable:	totbicpre	totbicpos
Sample size	15	15
Average	1.06667	1.6
Median	1	1
Mode	0	1
Geometric mean		
Variance	1.6381	1.68571
Standard deviation	1.27988	1.29835
Standard error	0.330464	0.335233
Minimum	0	0
Maximum	4	4
Range	4	4

Variable:	totbitpre	totbitpos1	totbitpos2
Sample size	15	15	10
Average	2.46667	0.6	0.5
Median	3	0	0
Mode	1	0	0
Geometric mean			
Variance	3.55238	0.828571	0.722222
Standard deviation	1.88478	0.910259	0.849837
Standard error	0.486647	0.235028	0.268742
Minimum	0	0	0
Maximum	7	3	2
Range	7	3	2