BENTHIC MACROFAUNAL PRODUCTIVITY AND DIVERSITY OF THE RED SEA COAST AROUND TEWALIT (MASSAWA)

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ABSTRACT

The Diversity and Productivity of benthic macrofauna around the shallow waters of Tewalit (Massawa) were investigated at three stations from October 28,1986 to April 14,1987. Eight major groups and 50 taxa were encountered. Polychaetes with 23 taxa were the most diverse group followed by gastropods with 8 taxa, and crustaceans with 6 taxa.

Physical and chemical parameters show no significant variation and regulatory effect over the distribution and abundance of the taxa. The taxa indicate a high species diversity, biomass diversity and equitability. There is significant variation in similarity indices, but no variation in species composition among the stations. Productivity is estimated to be 10.16g/m2. This with mean biomass 6.9g/m2 resulted in a turnover rate (P:B ratio) of 1.5.

I. INTRODUCTION

There is a voluminous literature on benthic macrofauna, but most of the literature on the ecology of marine coastal waters is from temperate areas, for much attention has been paid to the study of them. The scantiness of the information on the ecology of marine coastal waters of tropical zones is attributed to the inextensive nature of the beach studies made on the density and biomass of the fauna (McIntyre, 1968).

Investigations on the benthic fauna, especially those on the coastal areas of the Red Sea are exceptionally few. The benthic macrofauna which is a food source of demersal predatory fish and other species, constitutes a major part of the food web of coastal areas (Leuven et.al.,1985;Steimle, 1985).

The macrobenthic fauna of the Ethiopian Red Sea coast around Massaw is almost unstudied, though it presumably plays a major part in the cycle of materials in the sea. The study of its diversity and productivity (changes in standing crop) enables one to estimate the food available for the commercially caught fish around a given area. The objective of this study is, therefore, to investigate the diversity of the benthic macrofauna and to assess the available stock (standing crop) in the shallow waters of the Red Sea coast around Tewalit (Massawa).

2) LITERATURE REVIEW

2.1) Biological Studies of the Red Sea

According to Mergner (1984), the earliest biological studies around the coast of Massawa were conducted by Ehernberg and Hemprich between 1820-1824 and 1834;Ruppel between 1831 and 1833;Kossman in 1866 and 1875;some Italian captains in 1870 and between 1884 and 1887 and in 1891 and by various larger expeditions. Except some of the larger expeditions, that included oceanographic and marine biological studies, all the others were involved in collecting fishes and various invertebrates. This shows their works to be taxonomic as Halim (1969) has indicated.

Considering the investigations on marine benthic communities of the Red Sea, again most of them were taxonomic works. Almost all studies were conducted on the Northern part of the Red Sea (e.g., Fishelson, 1971), especially localized in the Gulf of Aqaba (e.g., Ismail, 1986). These facts, in general, indicate that there are lots of things unknown about the benthic fauna of the coasts of the Red Sea, specifically along the Ethiopian Red Sea coast.

The most important work on the Ethiopian Red Sea coast is that of Fishelson (1971), which summarizes the investigations conducted over the past 20 years. Nevertheless, this piece of work includes only Melit Bay in the Gulf of Zula, south of Massawa near the mainland. All the other studied places are various islands of the Dahlak Archiplago, including Abiad Bay, Goliath Bay and Landing Bay of Entedebir island and several bays around Musseri island.

Therefore, these data do not fully manifest the biological knowledge of the benthic fauna of the Ethiopian Red Sea coast. There are lots of things to be studied and investigated, for the ecological knowledge we have is scanty.

2.2) Macrobenthic Fauna

Mare (1942;cited in Perkins, 1974;McIntyre, 1969;Parsons et.al., 1979 and Martius and Schockaert, 1986), suggested the division of benthic fauna into three categories based on size, as macrofauna, meiofauna, and microfauna. The macrofauna are those organisms with body size >1000µm and are too large to pass through a 1mm mesh. The meiofauna are those with body size 100-1000µm and are retained by sieves of mesh size 0.04-0.1mm, while the microfauna are the ones with body size 1-100µm and pass through 0.1mm mesh. This categorization is useful for practical purposes but can have no biological meaning, being arbitary. This is so, because there are certain benthic fauna (e.g., turbellarians) that are larger than 2mm in body size but are nevertheless considered as meiofauna.

Modifying Mare's (1942) categorization, Martins and Schockaret (1986) propose to redefine meio- and macrofauna on the basis of biological criteria and body size after reviewing the work of Warwick (1968). Warwick (1968), concluded animals larger than 45µg dry weight having planktonic development, dispersed in larval stages, having a continuous growth throughout life with a generation time of more than one year and feeding in indiscriminate fashin on particles but often selecting on particle size basis to be termed as macrofauna different from the meiofauna. The latter are species of smaller than 45µg dry weight having planktonic development, dispersing in the adult stage, having an asymptotic growth of less than one year and feeding by selection on size but also on shape or quality of particles.

In most benthic communities the bulk of the standing crop or biomass, is present as macrobenthos, but the number of individuals, rates of metabolism and reproduction are much greater among the meiobenthos and microbenthos (McConnaughey, 1978). Compared to the zooplankton many benthic organisms are much bigger, live longer-years rather than weeks;so the rate of turnover is lower relative to the weight of standing stock (Tait, 1981).

2.3) Sampling Macrobenthic Fauna for Quantitative Study

Various bottom samplers are known to be used for the quantitative study of macrobenthic fauna. Some of them are the Ekman grab, the Peterson grab, the PONAR, Corers,... etc. However, Drach (1960) argues that sea-bottom samplers are not capable of giving a sure quantitative or valid qualitative picture of the benthic population of the sediments of the continental shelf. This argument is in agreement with that of McIntyre's (1971;cited in Tyler and Shackley, 1978), who also commented on the low reliability of grab samplers.

There are various commonly occurring problems with the use of grab samplers. These include variable sediment penetration, variable sample volume, sample loss after closure, failure of release mechanisms to function properly and the inadequate closure of buckets (Grizzle and Stegner, 1985;personal observations). Due to these failures Kajak (1971), advises one to be sure that the sampler penetrates deeply enough into the substrate and the jaws close very tightly just at the bottom and not on the way up when using grabs.

Reviewing various works done in freshwater ecosystems, Dowing (1984a) pointed out that the Peterson grab is the least accurate but a precise device to estimate population density compared to van Veen, Smith-McIntyre and PONAR grabs. The most precise samplers are found to be corers and Ekman grabs. Taking the efficiency of samplers into consideration, Frithsen et.al. (1983), indicated coring devices and suction samplers to be considered generally as more efficient samplers for the benthos than are grabs. However, except in very shallow waters grabs are more commonly used for quantitative benthic works due to man power, water depth, cost and other constraints (Grizzle and Stegner, 1985). Problems of sampler efficiency have motivated the development of new devices by various researchers (e.g., Boulton, 1985;Grizzle and Stegner, 1985; Jackson, 1986).

2.4) Diversity and Productivity of Benthic Fauna

Diversity is related to the distribution of the present biomass and to its complexity at a given time (Margalef, 1969). According to Rugg (1985), it is a function of the number of species present and evenness with which individuals are distributed among the species. Its advantage lies in increasing stability because the more species present, the greater possibilities for adaptations to changing conditions, whether these be short-term or long-term changes in climate or other factors (Odum, 1963).

Diversity measured as bits per individual, reaches its upper limit at around 5 (Margalef, 1969). On a geographical basis, the gradient of diversity (Thorson, 1978;Parsons et.al., 1979), increases in benthic communities as one moves from the arctic to the tropics.

Various indices have been used to measure diversity, including K-dominance curves, Shannon-Wiever, log-normal (Platt and Lambshead, 1985), and Simpson's Index of Diversity (Poole, 1974). For their applications different workers use different types of indices, e.g., Crossman and Cairns (1974) followed the technique of Wilhm and Dorris (1968) and the Sequential Comparison Index of Cairns and Dickson (1971). Rugg (1985) used the equation given by Hurlbert (1971). Poole (1974) stresses Simpson's Measure of diversity as an appropriate index if one is interested in the relative dominance of a few species. However, Platt and Lambshead (1985), after criticizing all the available indices proposed another alternative - the Neutral Model Analysis.

Whatever different types of measurements are utilized, the most commonly used index to measure diversity in benthic communities is the Shannon-Wiever Index (Kendeigh, 1980; Rugg,1985). This differs from Pielou (1977) who indicated the existence of much debate on whether this can be a suitable measure of ecological diversity and equated diversity to uncertainty.

Secondary production of invertebrates is the amount of tissue elaborated per unit time per unit area (Downing, 1984b). Production is estimated by various methods, one is the Size-Frequency method (Hymen and Coleman, 1968), but this is said to have some errors (Hamilton, 1979). Gillespie and Benke (1979) listed a number of different types of methods that enable one to estimate secondary production. In field researches, the production to biomass ratio (P/B ratio), is also used to estimate the production of animal population when growth and mortality patterns or age composition are not known. In support of this, Banse (1984), suggested the rules relating to biomass to be the most suitable method for making estimates of production, for planning field researches or for developing the theory of food web relations.

3) STUDY AREA

The Red Sea (Fig. 1) is found in a region situated between the African and Arabian Deserts and is characterized by an arid climate. The Ethiopian Red Sea coast is about 1000km long. Massawa lies along this coastline on a flat sandy plain at the northern point of Hargigo Bay. It is an island port connected to Tewalit with a road bridge.

Laor (1971), described the climatic condition of the sea shore of Massawa as among the worst existing on earth with very high temperature, the highest relative humidity in the world and scarce rainfall. Evaporation from its water surface greatly exceeds its small precipitation which is due to its relatively high temperature. Its evaporation rate is approximately 235 cm/year (Fishelson, 1971). It is a sea of exceptionally high salinity because of intense evaporation. Its mean salinity is 40.35‰ (Morcos, 1970), although values as high as 41‰ were reported by Fishelson (1971) and Kinne (1972).

The study area included three stations, I, II, and III (Fig. 2). The sampling stations are situated around Tewalit, south of Massawa, towards the northern entrance of Hargigo Bay where the small Green Island is found. Station I is located at about 600m south of the bridge and 200m north of station II which is found at a distance of 400m from station III near the shore of Green Island.

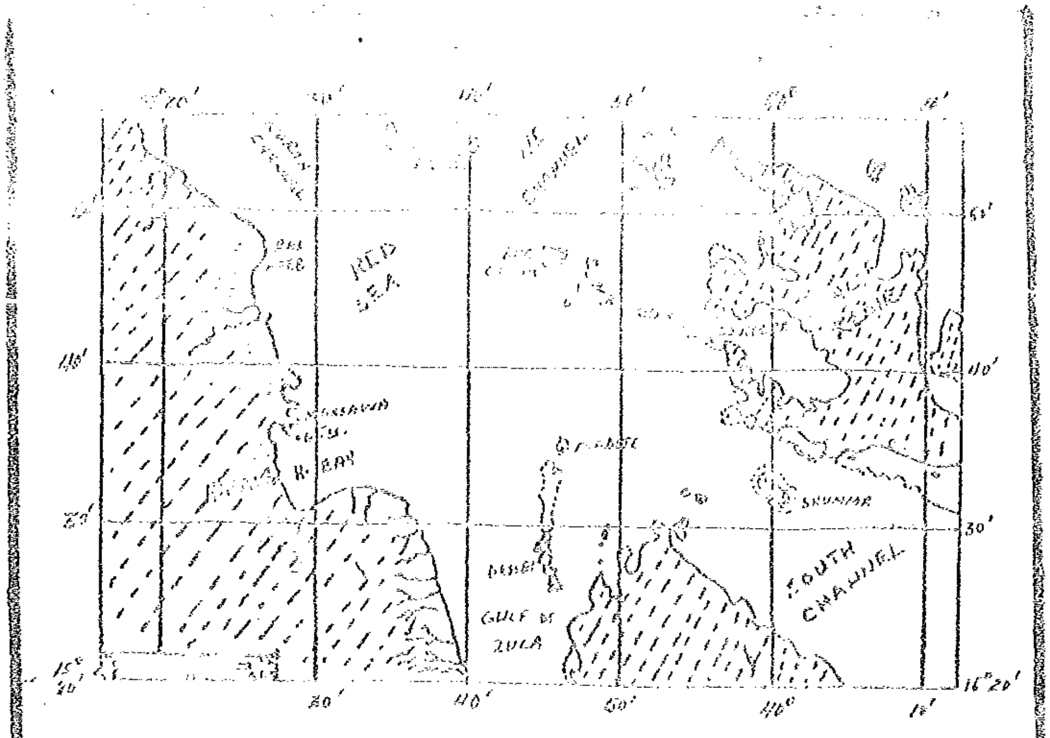


Fig. 1 - MAP SHOWING PART OF THE RED SEA

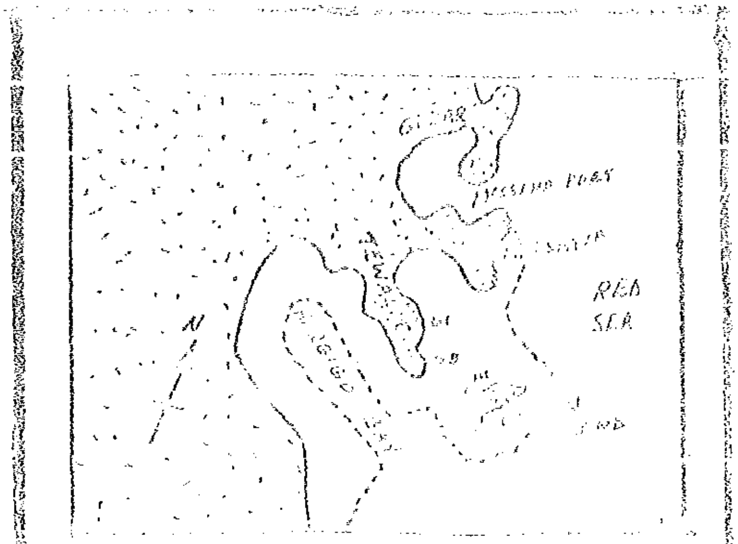


Fig. 2 - MAP SHOWING [illegible] AREA AND THE THREE STATIONS [illegible]

The study area is sandy with widely distributed corals, mostly old & the only living corals being the fungiids. The corals, which are abundant on shallow bottoms form reefs and banks in the open sea, around the island and along the shores (Ben-Yami, 1964). This impelled Mergner (1984), to consider the Red Sea as an exemplary Coral Sea. Though no significant environmental pollution is observed, it is an area where human interference is very common for leisure boating and fishing.

4) MATERIALS AND METHODS

4.1) Field and Laboratory Works

Bottom samples were quantitatively taken from the shallow coastal area around Tewalit with an Ekman grab (225cm2) and a Peterson's grab (256cm2) every two weeks for six months from October 28,1986 to April 14,1987. Three replicates were sampled with each sampler from each station.

Each of these samples was sieved using Canadian Standard Sieve Series, No. 10 (2mm openings), No. 18 (1mm openings), No. 35 (0.5mm openings) and 5mm openings. This is to separate the sediment from the macrofaunal organisms and abiotic constituents of the substrate (Ziegelmeier, 1972). All were then preserved in 5% sea water formaldehyde solution for further laboratory processing.

In addition to these, one sediment sample was collected from each station every sampling time for water content, organic matter content and particle size analysis of the bottom sediment. These were preserved in 5% sea water. formaldehyde solution.

In the laboratory, the preserved sieve contents were sorted and selected in a white pan and petri-dishes using a dissecting microscope (20X);which were grouped and identified to the lowest possible taxon according to Pettibone (1963 and 1971), Day (1967a and 1967b), Riedl (1970), Humpfry (1975), Fauchald (1977), and Fischer and Bianchi (1984).

Specimens were counted. Wet and dry weights were measured with an S2000 electric balance accurate to 0.0001g. The wet and dry weight measurements were done without the external hard covering of all the benthic fauna. Determination of wet weight was done after blotting the specimens for about 3 min. and the determination of dry weight was done after putting them in an oven for 24 hours at 105°C and in a dessicator for 1 1/2 to 2 hours.

For the determination of sediment water content, organic matter content and particle size, bottom sediments were washed with distilled water to remove the preservative and drained. Fifty grams of each sediment sample were weighed and put into an oven with the rest for 24 hours at 105°C and for 1 1/2 to 2 hours in a dessicator. This is to determine the water content. Of the other dried sediment samples 20g of each was put in a muffle furnace for 6 hours at 550°C, cooled in a dessicator and weighed to determine the organic matter content. Following the procedures of Griffths (1967) and Folk (1980), particle size of the sediments were assessed by weighing 75g and sieving them. Three sieves (No. 10, 18 and 35) were used to separate the particles into four categories.

4.2) Analysis of Data

Diversity of the benthic macrofauna was calculated using the Shannon-Weiver Diversity Index (Pielou,1966) as given by:

$$H' = - \Sigma Pi \log_2 Pi$$

where Pi = proportion of total sample belonging to the ith species.

H' = Index of species diversity.

The greatest possible value of the diversity ($H'max$) is calculated by (Pielou, 1966, 1977),

$$H'max = - \Sigma 1/S \log 2\ 1/S = \log 2S$$

where S = number of species .

The collection's evenness ($J=(E')$) is then determined by

$$J = H' / H'max$$

The biomass diversity (Wilhm, 1968;cited in McCullough and Jackson, 1985) is determined by the equation given as:

$$\hat{d}\ bm = - \Sigma (wi / w) \log 2\ (wi / w)$$

where wi = the weight of individuals in the ith taxon

w = the total weight of individuals in the sample

$\hat{d}\ bm$ = the biomass diversity

This model is identical to the species diversity model, but its value reflects the distribution of biomass among taxonomic groups.

To estimate production of the benthic fauna during the study period, production of each taxon is calculated using the growth increment summation method (Edmondson, 1971; Benke, 1979;Rigler and Downing, 1984), as given by:

$$P = Nt + Nt+1 / 2 (\bar{\bar{W}}\ t+1 - \bar{W}\ t)$$

where Nt = No. of individuals at time t.

$Nt+1$ = No. of individuals at time t+1.

$\bar{W}\ t$ = mean weight of an individual at sampling time t.

$\bar{W}\ t+1$ = mean weight of an individual at sampling time t+1.

Production as well as turnover rate of the macrobenthic fauna from biomass data is then estimated by the P/B as indicated by Banse and Mosher (1980) and Banse (1984).

To get a quantitative measure of similarity between three stations, Jaccard's Community Coefficient (cc) and Index of similarity (s) as given by Ropper (1977) were calculated.

Jaccard's Community Coefficient (cc):-

$$cc = j / a + b - j \times 100$$

where a = the number of species occuring in a station.

b = the number of species occuring in another station.

j = the number of species common to both.

This represents only the presence or absence of species and not their abundance (Tudoranchea et.al., 1979). On the scale values 100% represents identical species composition, 0, represents no relationship and 85% is the limit of similarity (Lu and Ropper, 1979).

The index of Similarity (s) is also calculated as given by:

$$S = 2c / a + b$$

where c = the number of species common to both.

As a value, 0.85 is considered the lowest limit of similarity, and values below this indicate that the compared stations are dissimilar (Lu and Ropper, 1979).

5) RESULTS

5.1) Efficiency of Sampling Devices

Efficiency of the sampling devices is given as shown in Table 1. These data are based on the various samples collected from October 28,1986 to April 14,1987.

Table 1

Efficiency of Sampling Devices used During the Study

SAMPLER	Peterson grab	Ekman grab
Area covered/sampler	$256 cm^2$	$225 cm^2$
Sieve (lowest mesh size)	0.5mm	0.5mm
No. of samples	117	117
Total area sampled (cm^2)	29952	26325
Mean No/sample ($\bar{X} \pm \delta$)	35.98 ± 25.59	30.76 ± 18.01
Mean No/m^2	1400.70±1002.76	455.75±266.84

Higher density of all organisms was achieved by the Peterson grab. This resulted taking the same number of samples and the same sieve of mesh size 0.5mm (Table 1). However, due to difference in areas covered by the two different samplers the total area sampled is greater in the case of the Peterson grab. Analysis of variance (ANOVA) at $P<0.1\%$ resulted in $F_{cal} = 21.748$. This shows quite significant variation among the two samplers. Therefore, the Peterson grab is relatively more efficient than the Ekman grab.

Nevertheless, the Peterson grab has a higher standard deviation (SD = 1002.76) compared to 266.84 of the Ekman grab. This high value of standard deviation shows inconsistency to be much greater when using the Peterson grab than the Ekman. The results also show a higher standard error (SE = 92.68) and a higher coefficient of variation (CV = 71.59%) for the Peterson grab than the Ekman grab (SE = 24.66) and CV = 58.55%, respectively). The higher value of CV using the Peterson grab indicates a relatively substantial variation in the samples.

5.2) Benthic Macrofauna

The list of macrobenthic organisms encountered in this work are given in Table 2.

Table 2

List of benthic macrofauna of the Red Sea around Tewalit (Massawa).

(October 28,1986 to April 14, 1987)

Taxa	Station I	Station II	Station III
ANTHOZOA			
Anthozoan (unid.)	---	R (7) * **	---
POLYCHAETA			
Sabella spp.	O (852)	O (432)	C(4330)
Trebella spp.	C (2863)	O (229)	O(560)
Cirratulus sp.	O (281)	C (2446)	O(433)
Syllis sp.	C (3454)	R (162)	R(38)
Nephthys sp.	R (135)	C (2065)	O(1171)
Capitella spp.	O (1991)	O (1322)	O(952)

Table 2 (Cont'd.)

Taxa	Station I	Station II	Station III
Amphinome sp.	O (549)	O (408)	O (730)
Nereis spp.	O (285)	O (241)	O (237)
?*Aricidea* sp.	O (1639)	O (655)	O (1017)
Glycera spp.	O (698)	O (782)	O (415)
Pectinaria ? capensis	---	O (392)	O (1084)
?*Hyalinoecia* sp.	R (8)	O (168)	R (70)
Maldanidae spp.	O (1766)	R (146)	R (57)
Arenicola sp.	R (77)	R (69)	R (34)
Armanida sp.	R (179)	R (30)	O (427)
Magelona sp.	R (50)	R (21)	R (7)
?*Stygocapitella* sp.	R (14)	---	---
?*Ctenodrilinae* sp.	R (13)	---	---
Phalacophorus sp.	R (46)	R (14)	---
Chaetopterus ?varieopedatus	R (7)	---	---
Cossura sp.	R (13)	---	---
Trichobranchus sp.	---	R (7)	---
?*Heterospio* sp.	---	R (7)	---
OLIGOCHAETA			
Oligochaeta (Unid.)	---	O (207)	R (20)
GASTROPODA			
Antillophos ? candei	R (75)	O (35)	O (510)
Oliva ? reticularis	R (65)	R (45)	R (160)
?*Cancellaria* sp.	R (23)	O (185)	R (55)
Conus sp.	---	R (8)	R (7)
Natica sp.	R (8)	R (8)	R (7)
Bulla [illegible]	[illegible]	[illegible]	[illegible]

Table 2 (Cont'd.)

Taxa	Station I	Station II	Station III
Gastropod a (Unid.)	R (7)	O (222)	R (22)
Gastropod b (Unid.)	---	---	R (16)
BIVALVIA			
Tellina ? punicea	R (88)	O (812)	R (181)
T. ?radiata	R (49)	R (68)	O (599)
T. ?virgata	R (14)	R (121)	C (2914)
Anadaria sp.	R (88)	R (20)	R (14)
Macoma sp.	R (7)	O (289)	R (36)
Tellina sp.	R (14)	---	R (14)
Bivalve (Unid.)	----	----	R (7)
CRUSTACEA			
Pagurus spp.	C (2044)	O (862)	O (775)
?Pinnotheres sp.	(116)	R (22)	R (42)
?Ethusa sp.	R (133)	R (98)	R (72)
Gammarus spp.	R (1607)	C (2660)	C (2437)
Metapenius stebbingi	R (23)	R (7)	R (15)
Tanaidacea spp.	R (37)	O (646)	O (277)
ECHINODERMTA			
Ophiuroidea (Unid.)	---	R (7)	R (47)
Echinoidea (Unid.)	R (7)	R (21)	R (28)
Asteroidea (Uni.)	R (7)	---	R (7)
CEPHALOCHORDATA			
Branchiostoma sp.	O (869)	R (139)	O (522)

*Relative numerical abundance:- Dominance (D,100-50%), Abundant (A,49-30%), Common (C,29-10%), Occasional (O,9-1%), Rare (R,<1%).

** Numbers in brackets indicate total number of organisms collected.

A total of 50 taxa belonging to 8 major groups were found to exist in the shallow waters of Tewalit (Massawa). Of the taxa 23 are polychaetes, 1 anthozoan, oligochaet 8 gastropods, 7 bivalves, 6 crustaceans, 3 echinoderms and cephalochordate. This shows the study area to accommodate 46% polychaetes and 16% gastropods.

Table 2 shows that, the taxa are largely rate and occassional in their relative numerical abundance. There are only three common taxa (in their relative abundance) in each station of different groups of all the total number. These are *Trebella* spp., *syllis* sp., and *Pagurus* sp. at Station I; *Cirratulus* sp., *Nephthys* sp., and *Gammarus* spp. at Station II and *Sabella* spp., *T.?virgata* , and *Gammarus* spp. at Station III.

5.3) Physical and Chemical Parameters

The results of bottom water temperature and depth, sediment water content and organic matter content are given in Table 3. The highest mean depth (3.27 ± 0.48) is recorded in Station II and the highest mean temperature (29.02 ± 1.24) in Station I with range of 2.50-4.50m and $27.0^{\circ}C$ - $30.5^{\circ}C$ respectively. The coefficient of variation (CV) of the two parameters is high in Sta. I (CV of depth=40.28%;

Table 3

Some Physical and Chemical Parameters of the Study Area

(Data based from Oct. 28,1986-Apr. 14,1987)

(1= bottom water depth (m), 2=bottom water temperature (^{o}C), 3=sediment water content (%), 4=sediment organic matter content (%), S.T.=sampling time).

S.T.	Sta. I				Sta. II				Sta. III			
	1	2	3	4	1	2	3	4	1	2	3	4
to	0.75	30.0	50.0	4.75	3.25	29.5	53.6	9.46	3.50	28.5	47.8	6.04
t1	0.80	30.0	54.4	4.00	3.50	28.5	58.2	5.07	3.75	28.0	54.0	3.21
t2	0.80	30.0	53.5	2.52	3.50	28.5	57.1	4.17	3.75	28.0	41.7	3.72
t3	0.80	28.5	54.0	4.71	3.50	28.0	55.7	4.17	3.75	28.0	55.7	2.62
t4	0.50	28.0	54.6	2.51	3.00	28.5	55.9	4.70	3.25	28.8	53.5	4.08
t5	0.80	27.5	53.8	2.57	2.75	27.8	54.5	4.12	3.00	28.0	54.0	3.92
t6	0.50	27.0	56.5	2.94	2.75	27.8	58.0	4.77	2.80	28.0	55.1	3.80
t7	0.30	27.0	54.2	3.90	3.30	27.5	57.8	4.60	2.00	28.5	54.0	4.10
t8	1.50	29.8	54.9	3.02	4.50	28.5	56.8	4.41	3.60	28.5	53.8	3.49
t9	0.50	30.5	54.1	1.66	2.50	29.5	55.7	2.49	2.00	29.5	53.8	2.95
t10	0.60	29.0	55.0	3.74	3.20	28.5	55.7	4.35	2.60	28.8	54.1	2.87
t11	0.50	29.5	53.8	1.72	3.20	29.0	57.2	2.90	2.30	29.5	53.7	3.01
t12	1.00	30.5	55.7	3.57	3.60	30.5	56.9	4.20	2.75	30.5	55.0	2.83

parameters is high in Station I (CV of depth = 40.28%; Temperature = 4.27%). These show higher variability at this station than the rest. The mean temperature and depth has no significant differences between Station II and III, but has significant differences from Station I. Analysis of Variance (ANOVA) with alpha = 0.05 and d.f. = 36 show no significant variation in bottom water temperature (F = 0.5518), but have great variation in depth (F=15.258).

Among the three stations, the highest mean water content is at Station II (56.40% ± 1.32). The lowest mean is at Station III (52.77% ± 3.68). Station II again has the lowest CV (2.34%) compared to the others, while Station III (CV = 6.97%) has substantial variability. Analysis of variance (ANOVA) with alpha = 0.05, shows the sediment water content to be quite significantly different (F = 7.57) among the stations.

In sediment organic matter content, the high mean (4.53% ± 1.58) is from Station II followed by Station III and I (3.59% ± 0.86 and 3.20% ± 0.97, respectively). The ranges of organic matter content at the stations (Table 3) are found to be 1.66% - 4.75% (Sta. I), 2.49% - 9.46% (Sta. II) and 2.62% - 6.04% (Sta. III). Analysis of variance (ANOVA) at alpha = 0.05 resulted in F = 3.30, which shows differences over all the study area.

The analysis of sediment grain size distribution (Fig. 3) among the three stations resulted in relatively

Fig. 3 SEDIMENT GRAIN SIZE DISTRIBUTION OF THE THREE STATIONS
Data from October 28, 1986 to April 14, 1987

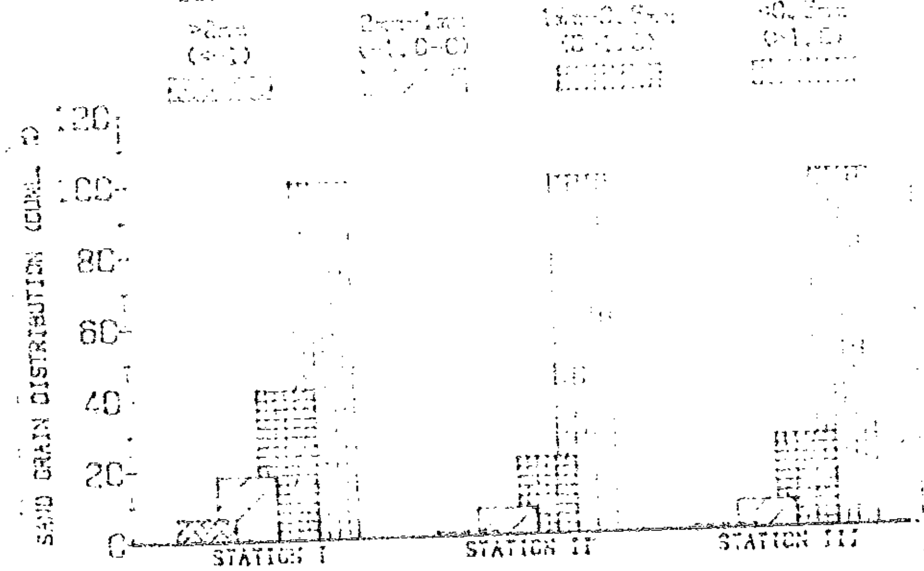
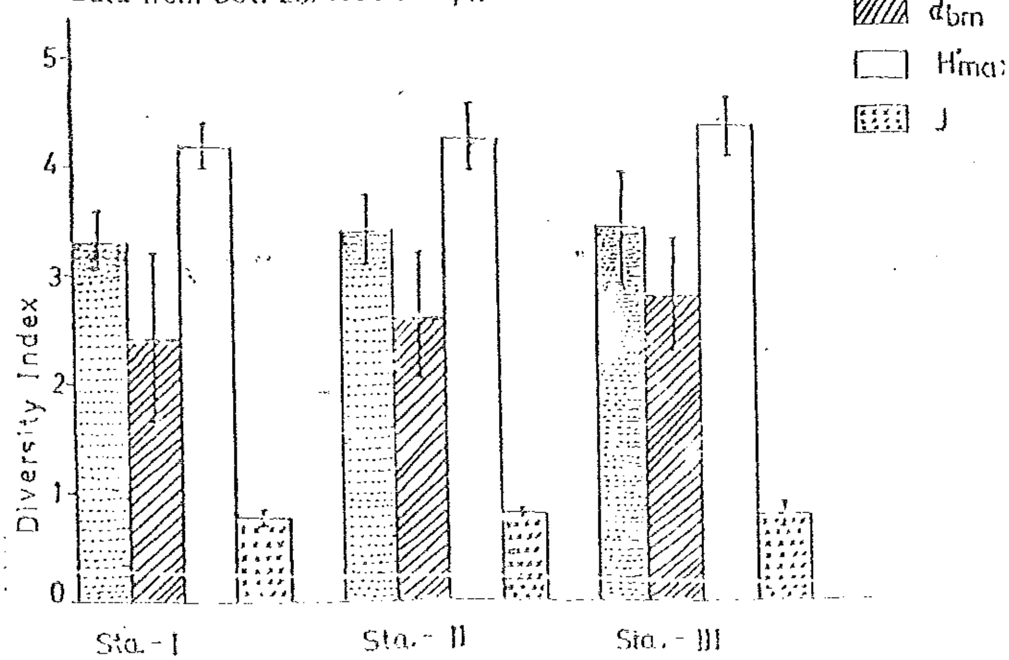


Fig. 4 Mean Macrobenthic Diversity
Data from Oct. 28/1986 to Apr. 14/1987



high mean % of granules (>2mm), very coarse sand (2mm - 1.0 mm), and coarse sand (1.0mm - 0.5mm) at Station I. The mean % of other components of sand (<0.5mm, including medium sand, fine sand, silt and clay) is relatively higher in Station II than the others. The analysis of variance (ANOVA) for the overall study area resulted in no significant differences with F = 0.0009, 0.0062, 0.0004 and 0.0017 respectively at alpha = 0.05.

5.4) Diversity Indices of Macrobenthic Fauna

The mean H' for Station III (Fig. 4) is found to be higher than the remaining two stations. Comparing their ranges Station III (Table 4) has a wider range (1.79 - 3.77) than the rest 2.64 - 3.90, and 2.57 - 3.81 Stations II and I, respectively. The high mean H' values are correlated with a high coefficient of variation, i.e., 15.20% for Station III, 9.41% for II and 8.16% for I. Though, no significant differences in mean H' is observed between Station II (3.40) and Station III (3.42), a higher CV (14.42%) for III shows substantial diversity among its constituents. Analysis of variance (ANOVA) at alpha = 0.05 shows no significant differences among the three stations, with F = 0.2760.

Mean biomass diversity, showing distribution among the taxa, is higher for Station III (Fig. 4) than the rest. The range is greater (Table 4) in Station I followed by II and III. The CV value correlated with the range being

Table 4

Diversity Indices of the Three Stations

(Data from Oct. 28,1986 to Apr. 14, 1987).

(H' = Shannon-Wiever diversity index, H'max = maximum diversity, J'(E) = Equitability index, $\hat{\partial}$ bm = biomass diversity).

	STATION I				STATION II				STATION III			
T	H'	H'max	J'	$\hat{\partial}$ bm	H'	H'max	J'	$\hat{\partial}$ bm	H'	H'max	J'	$\hat{\partial}$ bm
to	3.35	3.92	0.85	3.10	2.64	3.47	0.75	1.31	2.95	3.47	0.84	2.50
t1	3.33	4.18	0.79	3.06	3.27	4.37	0.74	2.76	3.30	4.60	0.72	3.04
t2	3.10	4.40	0.62	3.16	3.02	3.92	0.70	2.14	3.54	4.33	0.71	3.00
t3	3.34	4.34	0.77	2.03	3.76	4.54	0.83	2.80	1.79	4.47	0.40	2.89
t4	3.26	4.25	0.77	2.32	3.24	4.17	0.78	2.32	3.60	4.32	0.83	2.89
t5	3.53	4.39	0.80	0.34	3.90	4.70	0.83	3.50	3.62	4.52	0.80	2.76
t6	3.13	3.70	0.85	2.27	3.55	4.39	0.81	2.79	3.77	4.39	0.86	3.28
t7	3.81	4.52	0.84	2.90	3.64	4.59	0.79	2.14	3.55	4.46	0.80	3.13
t8	2.57	4.17	0.62	1.52	3.37	4.00	0.84	2.00	3.76	4.39	0.86	2.61
t9	3.37	4.17	0.81	2.64	3.65	4.46	0.82	3.41	3.62	4.46	0.81	1.26
t10	3.38	4.17	0.81	3.22	3.50	4.09	0.86	3.06	3.46	4.39	0.79	2.44
t11	3.50	4.25	0.82	2.45	3.30	4.00	0.83	2.39	3.76	4.46	0.84	3.24
t12	3.41	4.00	0.85	2.71	3.30	4.32	0.76	2.98	3.73	4.39	0.85	3.34

31.56% (Sta. I), 22.87% (Sta. II), and 18.57% (Sta. III). This shows variation in $\hat{d}$ bm to be more substantial in Station I than the others. Analysis of variance (ANOVA) at alpha = 0.05 results in no significant variation with F = 0.9678.

The index of biomass diversity is found to have a direct relationship with H' and H'max. As H' increases, H'max increases, the same being true of $\hat{d}$ bm. Nevertheless, H' is affected by the number of species while $\hat{d}$ bm is based on the biomass of individual species.

Examination of the eveness of the collections (J) shows that J mean is slightly higher for Station II (0.80±0.04) with the other two having the same mean index (0.78) but differing in SD as 0.78±0.08 (Sta. I) and 0.78±0.12 (Sta. III). The range of J is narrowest for Sta. II and increases in I and III. However, II and III had an equal maximum J value (0.86) on 17/III/87, Sta. II and 20/I/87, Sta. I (Table 4).

Of all the H' measurements, the lowest (1.79) is from Station III (on t3, 9/XII/86) and the highest (3.90) is from Station II (on t5, 6/I/87). The lowest biomass diversity is 0.34 (Sta. I on t5, 6/I/87) and the highest 3.50 (Sta. II on t5, 6/I/87). The highest H', $\hat{d}$ bm and the lowest $\hat{d}$ bm were recorded from the samples of the same date, Station II having both the highest H' and $\hat{d}$ bm.

5.5) Quantitative Measures of Faunal Similarity and Composition

The quantitative measures of similarity and composition between the three stations are summarized in Table 5.

Table 5

Summarized quantitative measures of similarity and composition.

Data from October 28,1986 to April 14,1987.

S / C C	I	II	III
I			
II	0.70 / 54.84%		
III	0.72 / 56.08%	0.78 / 61.42%	

All these summarized values of S (Coefficient of similarity) show the stations to be dissimillar. However, of the total records; S values of 0.87 and 0.94 were recorded on Dec. 9/86 and Jan. 6/87 respectively between Stations II and III. Similarly S=0.86 was recorded between Stations I and II on Dec. 23/86. The highest S mean is 0.78 ± 0.09 between Stations II and III with range of 0.62-0.94. This seems not to be far greater than the value between Stations

I and II(0.70$\pm$0.11). The highest S value (0.94) between II and III and the lowest (S=0.41) between Stations I and II were recorded on the same date.

The results of cc (Jaccard's Coefficient of Similarity) are also found to be very much lower than the limit of similarity as given by Lu and Ropper (1979). The highest mean cc value is 61.42% $\pm$ 11.44 between Stations II and III (range 46.67% - 88.50%). This range is with the maximum cc (88.50%) recorded of all the sampling times. This is followed by 56.08% $\pm$ 8.85 between Stations I and II(range 25.9% - 76.20). The range is with the lowest cc value recorded of all the sampling times. The results show the lowest S(0.41) to be recorded on the same sampling time with the lowest cc(25.9%) on Jan. 20/87. Similarly, the highest S (0.94) is recorded with the maximum cc (88.5%) on Jan. 6/87.

5.6) Standing Stock and Productivity

The variations in standing stock (dry weight) of the major groups are given in Figs. 5A-M and 6. In station I the dry weight of the standing stock (DSS) was highly dominated by the crustaceans, except on Nov. 11/86 by the gastropods (54.21%) and on Jan. 6/87 by the echinoderms (96.60%). At Station II the bivalves DSS is dominant (on to,t1,t3,t5-t8, and t12) followed by the crustaceans (on t2,t4,t9-t11). At Station III, DSS is largely dominated by the gastropods except on "to" (by bivalves), t9 (by echinoderms), and t10 (by polychaetes).

The variations in Standing Stock (Wet weight and Dry weight) of the different sampling times are presented in Table 6.

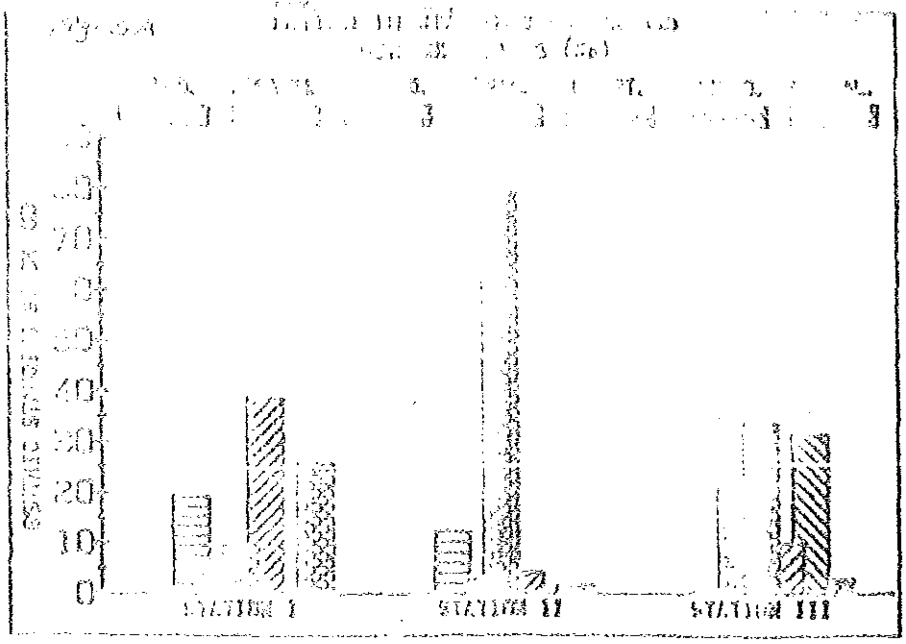


Fig 5a
0
10
20
30
40
50
70
STATION I
STATION II
STATION III

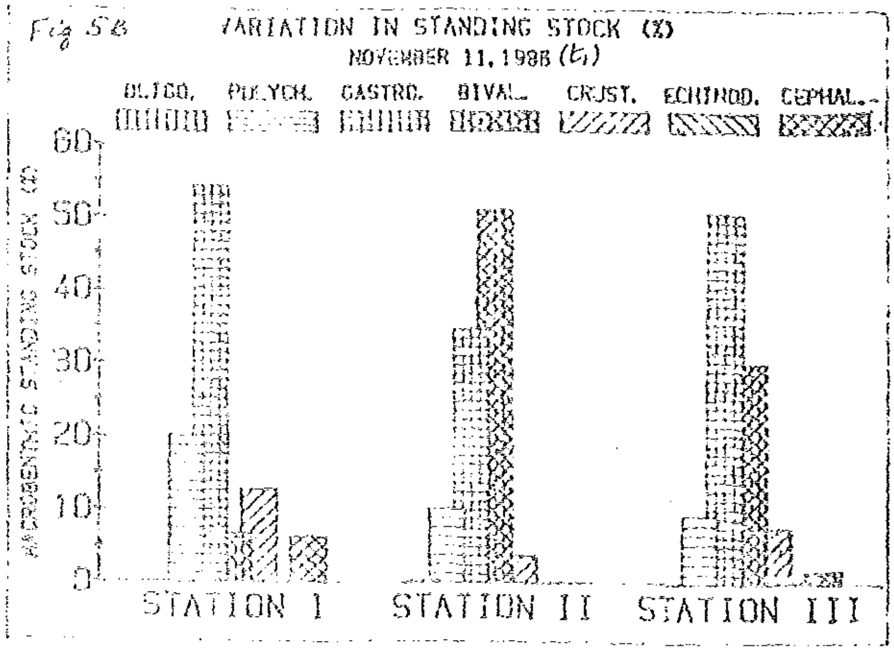


Fig 5b
VARIATION IN STANDING STOCK (%)
NOVEMBER 11, 1986 (t1)
OLIGO.
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
0
10
20
30
40
50
60
STATION I
STATION II
STATION III

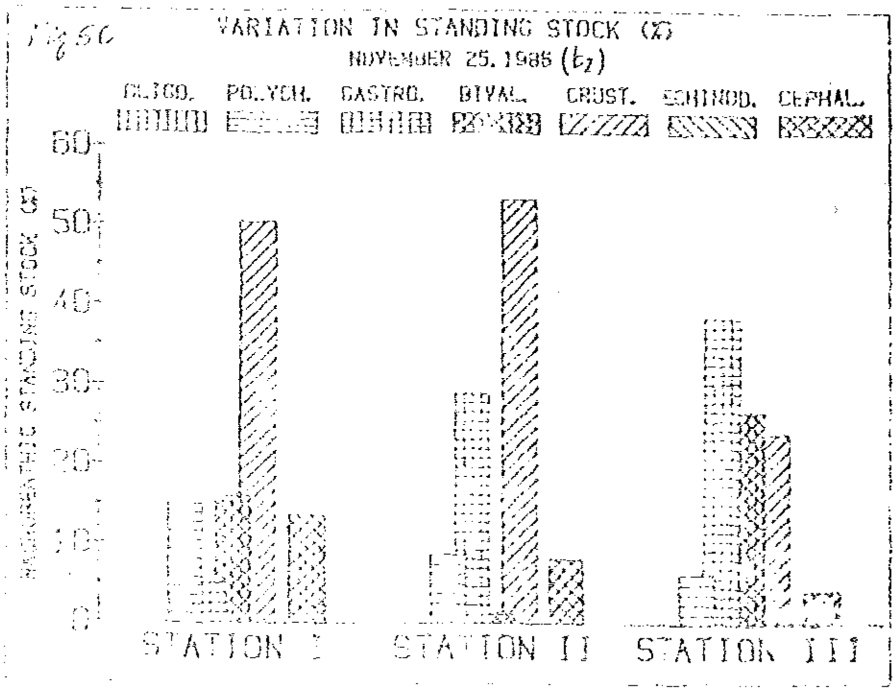
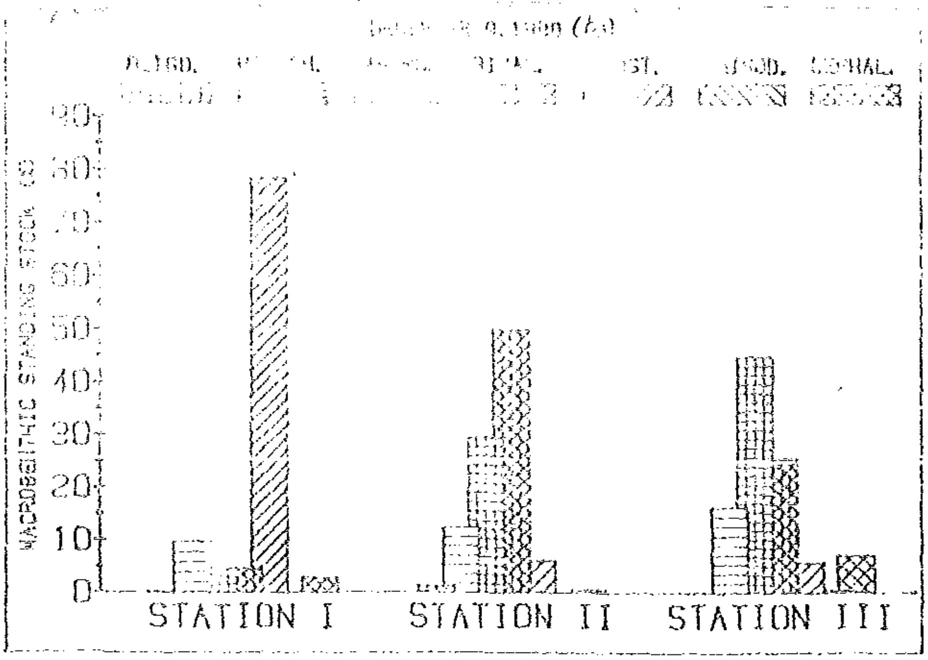


Fig 5c
VARIATION IN STANDING STOCK (%)
NOVEMBER 25, 1986 (t2)
OLIGO.
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
0
10
20
30
40
50
60
STATION I
STATION II
STATION III


MACROBENTHIC STANDING STOCK (%)
90
80
70
60
50
40
30
20
10
0
STATION I
STATION II
STATION III

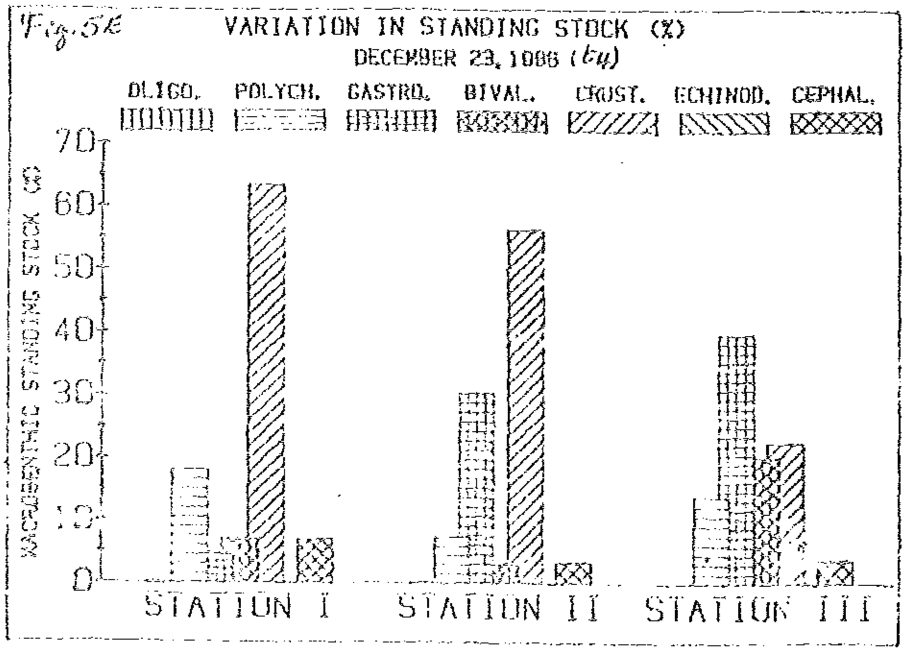


Fig. 5E
VARIATION IN STANDING STOCK (%)
DECEMBER 23, 1986 (b4)
OLIGO.
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
70
60
50
40
30
20
10
0
STATION I
STATION II
STATION III

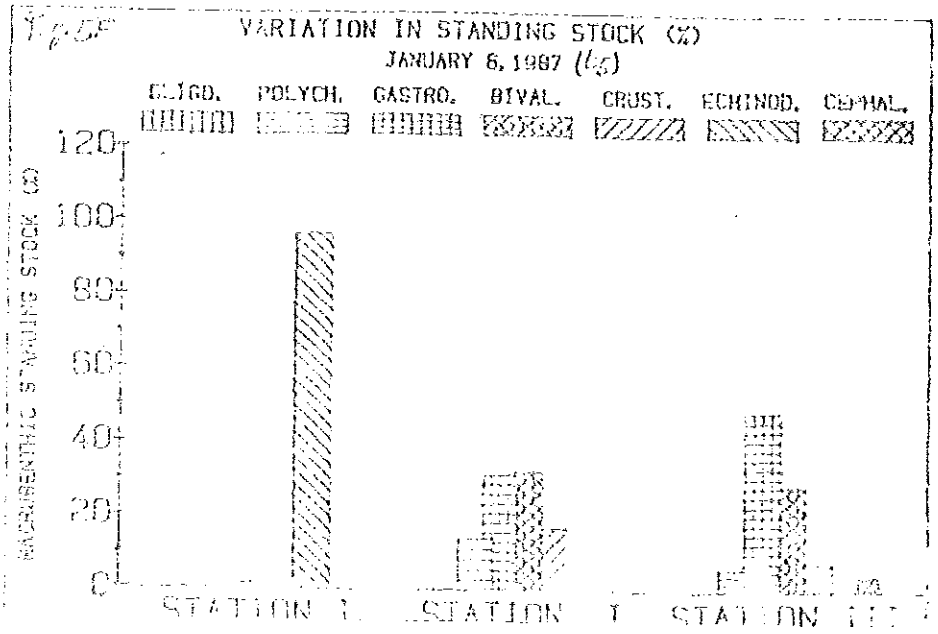


Fig. 5F
VARIATION IN STANDING STOCK (%)
JANUARY 6, 1987 (b5)
OLIGO.
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
120
100
80
60
40
20
0
STATION I
STATION II
STATION III

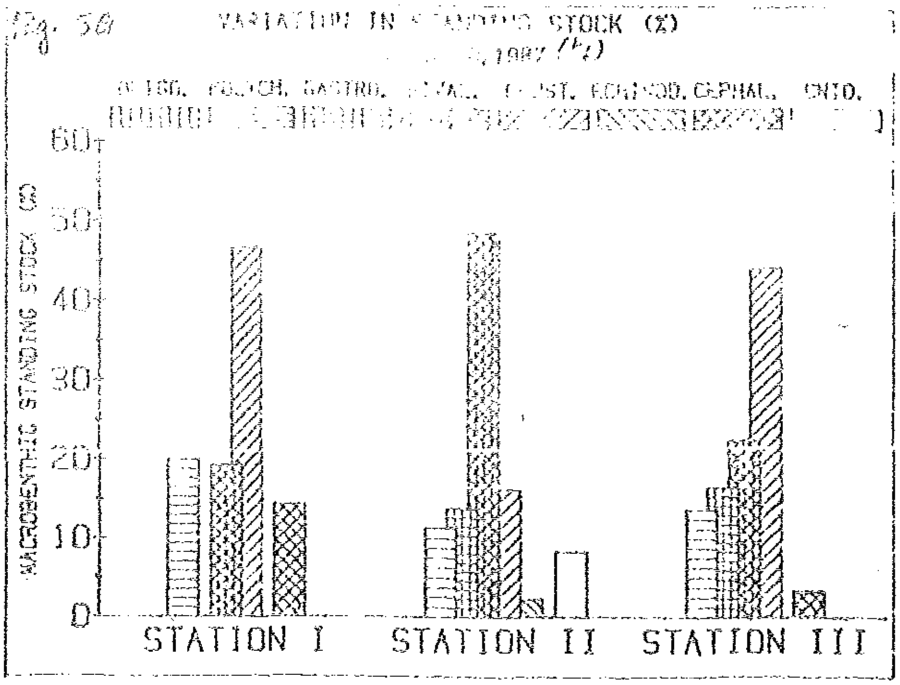


Fig. 5G
STOCK (%)
MACROBENTHIC STANDING STOCK (%)
60
50
40
30
20
10
0
STATION I
STATION II
STATION III

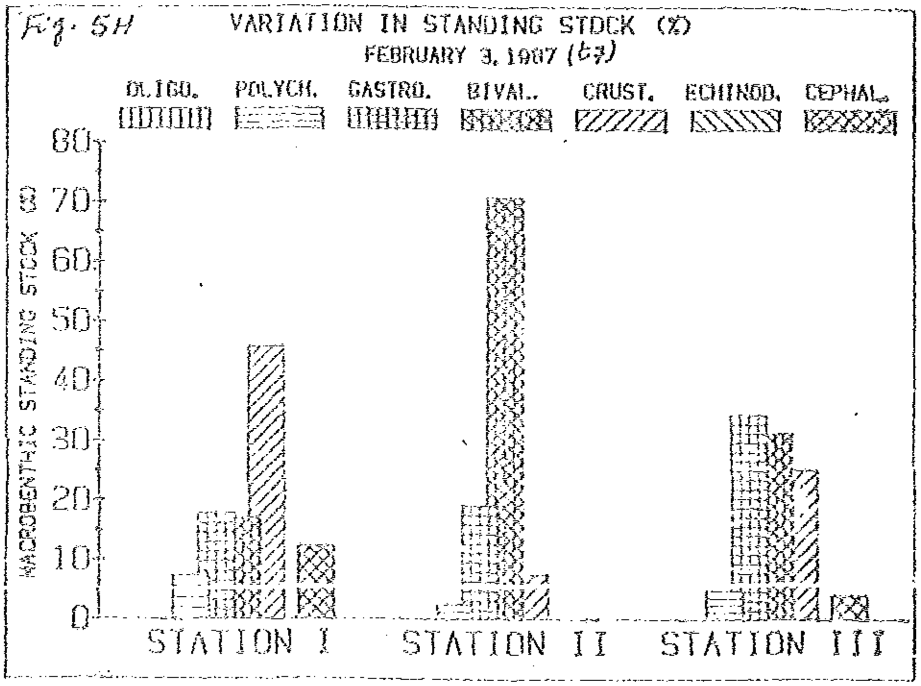


Fig. 5H
VARIATION IN STANDING STOCK (%)
FEBRUARY 3, 1987 (b7)
OLIGO.
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
80
70
60
50
40
30
20
10
0
STATION I
STATION II
STATION III

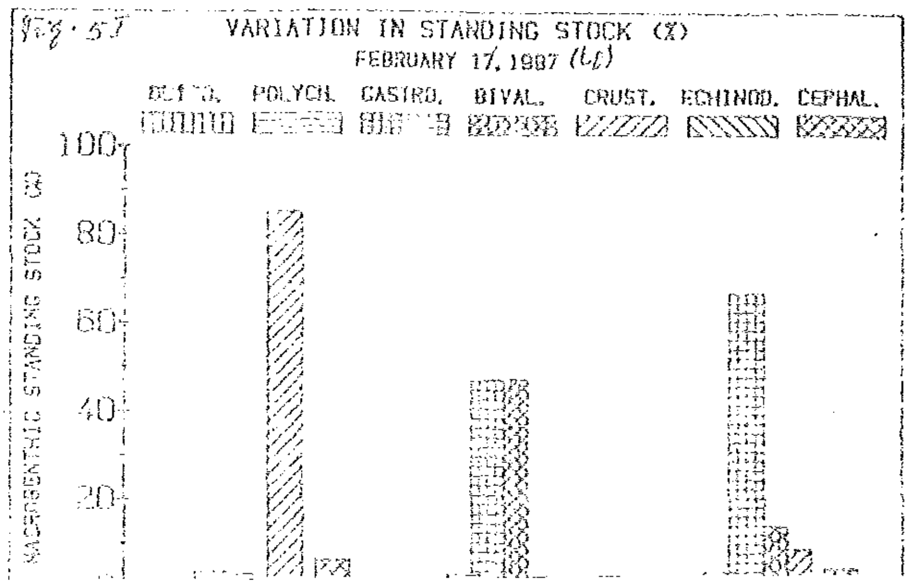


Fig. 5I
VARIATION IN STANDING STOCK (%)
FEBRUARY 17, 1987 (b8)
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
100
80
60
40
20

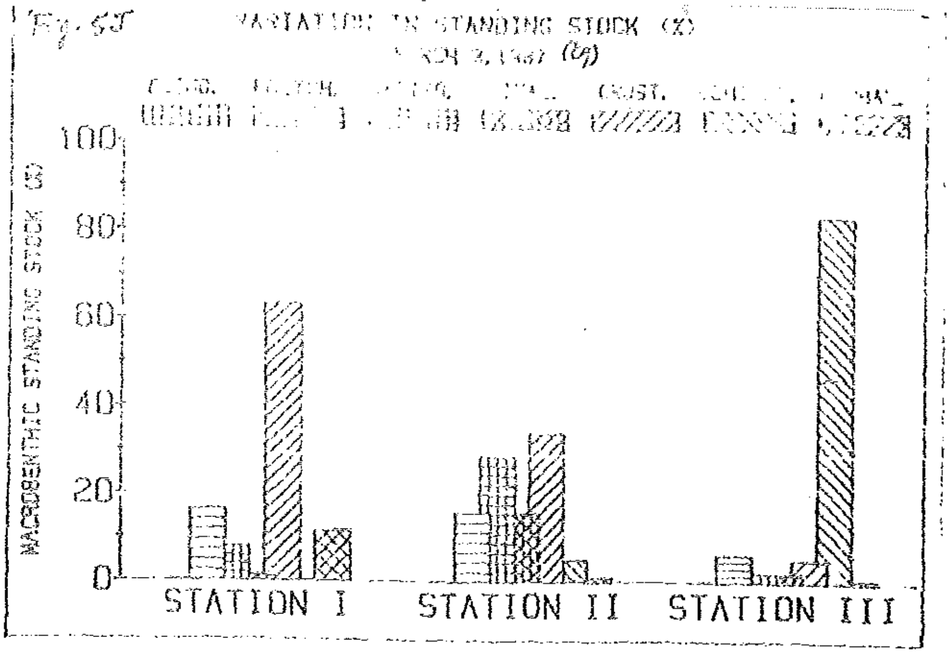


Fig. 5J
VARIATION IN STANDING STOCK (%)
MACROBENTHIC STANDING STOCK (%)
100
80
60
40
20
0
STATION I
STATION II
STATION III

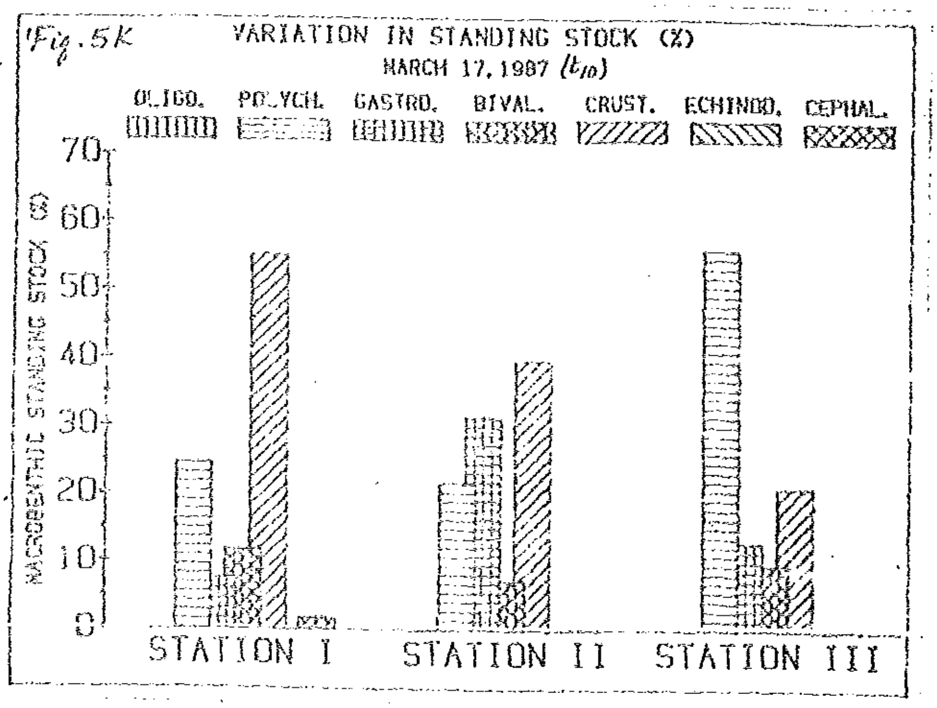


Fig. 5K
VARIATION IN STANDING STOCK (%)
MARCH 17, 1987 (t_{10})
OLIGO.
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
70
60
50
40
30
20
10
0
STATION I
STATION II
STATION III

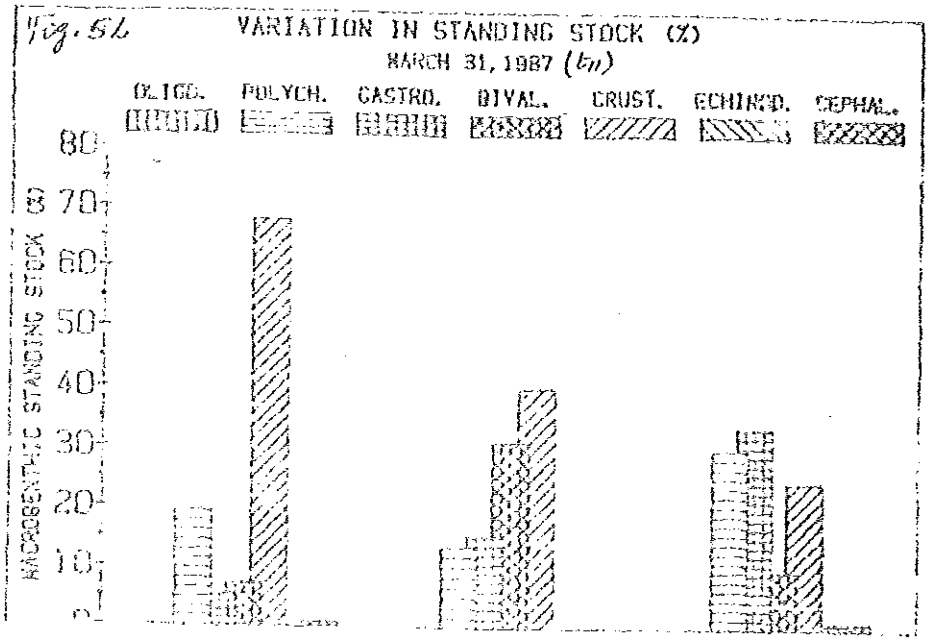
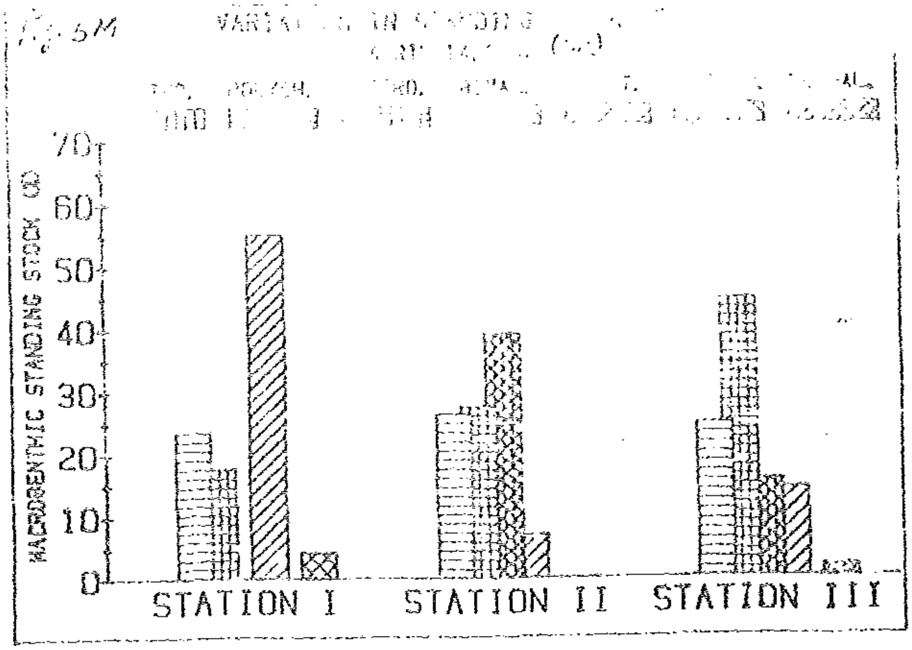


Fig. 5L
VARIATION IN STANDING STOCK (%)
MARCH 31, 1987 (t_{11})
OLIGO.
POLYCH.
GASTRO.
BIVAL.
CRUST.
ECHINOD.
CEPHAL.
MACROBENTHIC STANDING STOCK (%)
80
70
60
50
40
30
20
10



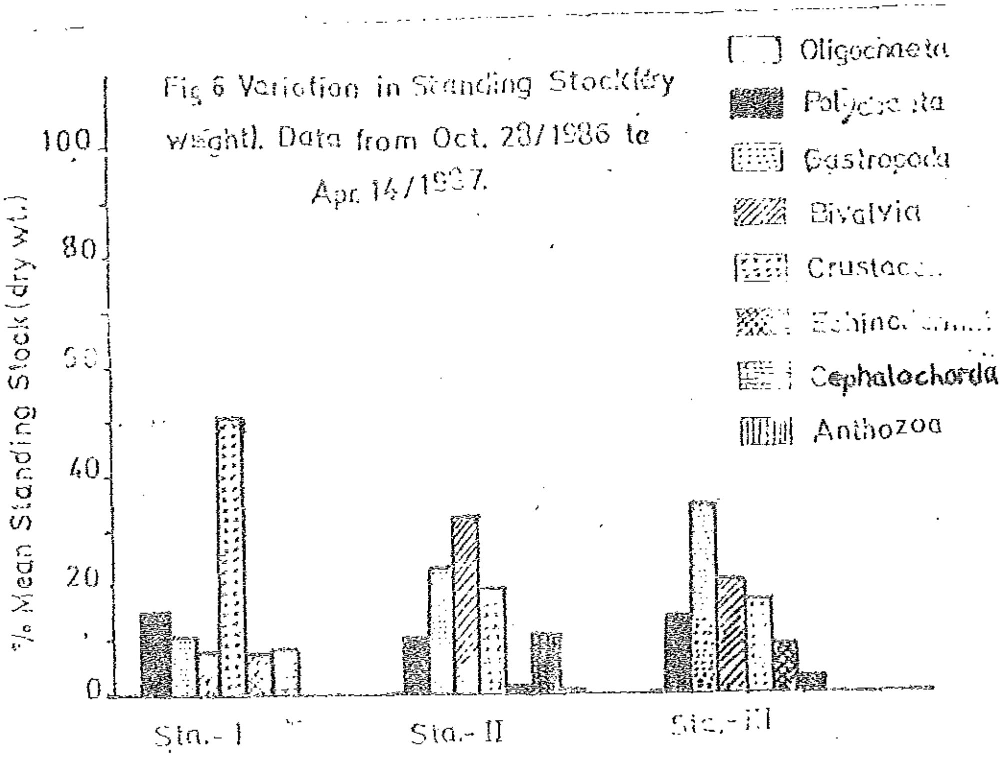


Fig 6 Variation in Standing Stock(dry weight). Data from Oct. 28/1986 to Apr. 14/1987.

Table 6

Total wet weight and dry weight standing stock variation (g/m^2). Data from October 28/86 to April 14/87.

Sampling Time	Station I		Station II		Station III	
	Wet	Dry	Wet	Dry	Wet	Dry
to	3.7	0.8	2.7	0.8	5.3	1.2
t1	9.4	2.7	19.8	7.3	13.7	4.0
t2	11.9	2.8	6.3	1.7	11.8	2.8
t3	15.1	4.8	22.2	8.0	7.8	2.5
t4	8.2	2.5	5.3	1.9	14.7	4.2
t5	217.3	68.2	17.6	6.4	12.5	4.9
t6	5.2	1.6	21.8	8.6	11.0	3.3
t7	13.7	5.1	25.7	13.2	23.4	8.7
t8	227.7	4.8	37.9	17.6	17.6	5.7
t9	12.5	4.2	14.5	5.4	82.9	31.1
t10	9.4	2.8	12.1	4.5	19.0	6.7
t11	12.8	6.1	17.0	8.1	29.3	11.2
t12	9.0	3.0	19.9	8.7	13.8	4.0

The mean WSS of the three stations are $42.8g/m^2 \pm 76.7$, $17.1g/m^2 \pm 9.1$ and $20.2g/m^2 \pm 19.1$ for Stations I, II and III, respectively. Their mean DSS are $8.4g/m^2 + 17.3$, $7.1g/m^2 \pm 4.5$ and $6.9g/m^2 \pm 7.4$, respectively. Station I has the highest mean DSS. Correlation coefficient (r) between wet weight and dry weight standing stock of the three stations is found to be 0.6746, 0.9782, and 0.9998, for Stations I, II, and II, respectively. Analysis of variance (ANOVA) at alpha = 0.05 results in no over all significant variation with $F = 0.0629$.

The productivity of the macrobenthic fauna is estimated to be $10.16 g/m^2$ (dry weight) per 6 months. The mean biomass is $6.9 g/m^2$. This mean biomass with the estimated productivity results in a 6 month turnover rate (P:B ratio) of 1.5.

6) DISCUSSION

6.1) Efficiency of Sampling Devices

Of the two sampling devices used for this investigation the Peterson grab is relatively more efficient than the Ekman grab. For the study of freshwater benthos the Ekman is said to be the most frequently used (44%) as indicated by Downing (1984). This differs from the type of samplers used to study marine benthos. Scanning a few of the published works, the following devices have been found to be utilized by various workers.

Sampler	Researcher (Year)
Corers	McLachalen (1985)
	Flint and Kalke (1986)
	Ismail (1986)
	Thrush and Townsend (1986)
Smith-McIntyre	Steimle (1985)
	Jones (1986)
Peterson grab	Morcos (1984)
Van Veen	Buchanan and Warwick (1974)
	Buchanan *et.al*. (1978).
	Levings (1975)
Suction sampler	Larsen (1985)
Ekman grab	Levings (1975)

These show the preference of sampling devices to be variable among different workers. Still many new devices are being made and modified by a number of ecologists to increase their success and efficiency.

The corers, covering a very small area, are found to be more efficient than the others in freshwater and marine environments (Tudorancea et.al., 1979; Frithsen et.al., 1983). Small size related to higher efficiency of sampling devices is reported by Tudorancea et.al. (1979) and they also cited similar reports of Kaja (1963); Staczykowska (1966); Brinkhurst (1967); Flannagan (1970); and Paterson and Fernando (1971).

Compared to these reports the small sized Ekman grab used in this investigation is less efficient than the larger Peterson grab. The differences in weight of the sampling devices and the nature of the sediments of the study area might have certain contributions to such results. The larger values of CV and SD of the Peterson grab show the need for increasing the number of replicas taken at each station and at each sampling time; however, due to time constraints and the size of sediments to be processed this was not done. Therefore, with these outcomes, there is a need for using more efficient devices for further research works to study the benthos of this area quantitatively.

6.2) Benthic Macrofauna

Based on the list of organisms found in the study area the polychaetes are more diverse numerically followed by the gastropods bivalves and crustaceans. This result of numerical representation by the various groups could be too low for the identification of the taxa was not done to the lowest possible level in some cases (e.g., Gammaridae).

This list does not include large size organisms such as sea cucumbers and sea urchins. Sea cucumbers are sparsly distributed at Station I with an approximate density of 1 individual per $2m^2$, while their distribution is highly sparse at Station II and not one was observed at Station III. The sea urchins which are found at Station I and III are always found attached to corals, small or big. One who wants to study them quantitatively must collect them by hand wherever they are found. If not the method of collection is considered biased.

The relative numerical abundance of the taxa shows no dominancy in all stations. Dominants are the most prominent species in the community, which make up its greatest mass of living material and serve as the major source of food, substrate and shelter for the animals that are present. Dominance is, therefore, the relative control exerted by organisms over the species composition of the community (Kendeigh, 1980). None of these features mentioned above can be manifested in the study area. However, this lack of dominancy by any of the benthic fauna could result from higher diversity.

Comparing with the findings of Fishelson (1971), the polychaetes of the sandy bays and shallow muddy bottoms are numerically greater than the present findings, while those of Ismail (1986) from the Gulf of Aqaba are lower. The same is true of the molluscs of the Gulf of Aqaba. Nevertheless, comparisions of such sorts may lead to wrong conclusions, for the methods of collection and the types of samplers used are different from each other.

Dicks (1984), reported 305 taxa from the Ras Budran oil field in the Gulf of Suez. This is far greater than have been reported by the above authors. The large number of taxa (or of more detailed taxonomy) in the Gulf of Suez may be due to the effect of different environmental conditions. In the present study area there is no significant problem of pollution.

6.3) Physical and Chemical Parameters

The substratum is one of the most important environmental factors in oceans and coastal waters that largely determines distribution and association of benthic animals. The variety and abundance of the bottom fauna depends greatly on the physical and chemical structure of the substratum (Kinne, 1972). Of the parameters, temperature is said to be (Tait, 1981) one that affects the distribution of benthic communities. This, however, does not appear to determine the distribution and abundance of the benthic fauna of the Massawa area.

There is considerable variation of depth among the three stations. It is found to have poor correlation with temperature. Yet, this variation has no effect on the relative abundance and distribution of the fauna.

According to Janson (1967;cited in Kinne, 1972) measurements of sediment water content or pore volume have been used as indices of available space within sediments. The highest mean value of sediment water content compared to the others, therefore, indicates Station II to have much available space. Even then this in turn does not lead to dominancy in relative abundance of the taxa at Station II.

Sands of the sea bed are not merely aggregations of grains of various sizes and shapes, but they also have organic components consisting of films of microorganisms coating the grains, and plant and animal material (Webb, 1969). Meadows and Anderson (1966) reported the presence of a wide variety of microorganisms including bacteria, blue-green algae, diatoms and yeasts, on the surface of sea bottom sediments. These are not evenly distributed, but are localized in patches between which there are large areas of bare surface.

The types of microorganisms attached to sediments of the study area are not known. Nevertheless, they are believed to have great contributions to the amount of organic matter content. The properties of the sand are highly modified by the organic matter content (Webb, 1969). Therefore, determination of it is vital before one deals with the relationships between the fauna and sand texture.

High mean organic matter content was recorded at Station II compared to the others. This record of the organic matter content of the sediment is relatively greater than has been reported by Ismail (1986) in the Gulf of Aqaba. According to Morcos (1984), sediments collected from three sites (Gulf of Aquaba, Gulf of Suez and from the Northern Red Sea) are relatively poor in organic matter content. These varying organic constituents in the sediments suggest that the sedimentary conditions of all these compared areas are quite different. Living or dead organic remains in the substrate may constitute a rich food source and provide building material. Therefore, benthos of Station II are potentially in an environment richer in food sources and building materials than the rest.

According to the report of Sverdrup et.al.(1962), marine sediments contain from 0% to about 18% organic matter with an average value of about 2.5%. The ranges in organic matter content of this study are comparable with this report, but the means are greater than the report of the above authors.

The results of the analysis of sediment grain size show no significant differences in distribution taking the overall study area into consideration. However, comparing each station, Station I is composed of corser sediments than the others. This is attributed to greater turbulence in the shallower Station I. The grain size is also said to determine the transportation of particles along the bottom by currents and the fall velocity (Dietrich, 1963). This many, thus, explain the variations in organic matter content of the three stations taking grain size as a factor.

Sand texture sometimes appears to influence the distribution of animals and at others evidently not. Its analysis has two major problems - disturbance during collection and consolidation (Webb,1969). The present analysis, if not perfect, could have faced these problems. According to these results, the distribution of the macrobenthic fauna is not found to be affected by the overall texture of the sand. This seems to agree with the findings of Webb (1969).

According to Sverdrup et.al. (1962, citing Trask, 1932, 1939;Revelle and Shepard, 1939) and Parsons et.al. (1979, citing Barder et.al., 1960;Hargave, 1972), usually there exists an inverse relationship between sediment particle size and organic matter content. This reflects the high surface area for organic incorporation in the fine grained deposits. Therefore, this may account for the relatively high organic matter content of Station II. The relatively lowest mean organic matter content is at Station I. This result agrees with what have been indicated by Sverdrup et.al. (1962). According to these authors, coarser sediments of the beach and shelf are generally low in organic matter.

6.4) Diversity Indices of Macrobenthic Fauna

Taking the whole study area into consideration, the overall range of Shannon-Wiever's diversity index is from 1.79 - 3.90 with the maximum mean of 3.42 bits per individual. The range and mean are lower than what has been reported by Dicks (1984) on the fauna of the Gulf of Suez. He found the average H' to be 5.20 and range 3.83 - 5.86. This range is lower than that of Station III (1.79 - 3.77), but higher than those of Station II and I (2.64 - 3.90) and 2.57-3.81, respectively). Even then, the minimum and maximum recorded value of this findings are greater than in this study.

On the other side, comparing the results of Ismail's (1986) work on the Gulf of Agaba, almost all H' values of the present study are much higher than his with the exception of the following (Table 3) at to - Station II - 2.64

t3 - Station III - 1.79

t8 - Station I - 2.57

These are lower than the highest H' of his Station 6M. The data show lower diversity in the Gulf of Agaba than in the present study area. However, most of the eveness indices of his study are much higher than the eveness indices in the present study. In general, dominancy is manifested in the Gulf of Agaba but not in the area around Tewalit (Massawa).

The highest and mean values of H' (5.68 and 5.20) reported by Dicks (1984) are greater than those indicated by Margalef (1969), who pointed out the upper limit of H' to be around 5. A high index of diversity reflects the existence of large numbers of species and the absence of numerical domination of the fauna by individual species. Therefore, the results reported by Dicks (1984) may be due to the above two factors which differ in magnitude from those obtained in this study.

Marcotte (1986;citing Gray, 1974 and Marcotte, 1977) pointed out diversity within shelf habitats to be lowest in mud, higher in sand, and highest in mixed muds and sands. However, the results of the present study do not fully agree with that which has been said above. In this investigation the highest mean diversity index is found at Station III with mixed muds and sands. The lowest is not from the highly muddy Station II, but from the highly sandy Station I.

According to Pielou (1966) and McIntosh (1967), for a given number of species, the diversity of a collection is at maximum when the individuals are distributed among the species as evenly as possible. Conversly, if only a few of the species contain a large majority of the individuals, the diversity is low. Equitability compares the observed distribution of individuals among species to the value of H'. It is positively correlated with diversity (Whittaker, 1975). Dominance expresses the most abundant species in a population. It is the reverse of equitability and has an inverse relationship with diversity. However, in practice J appears to be an insensitive measure of equitability, too strongly dependent on H' (Lambshead et.al., 1983).

The J's of the present study area are more or less equal with not much difference between Station I and III (J=0.78) on one hand and Station II (J=0.80) on the other. This manifests the absence of significant dominance in the assemblage of the taxa. In these stations the competetive situation is more balanced, for a diverse system is one in which not only are there more species, but in which the total number of individuals is more equitably distributed between the component species (Barnes and Mann, 1982).

The mean biomass diversity at Station III (2.80) is significantly different from the remaining two. This indicates the biomass diversity to be much higher in this station.

6.5) Faunal Similarity and Composition

Based on Lu and Ropper (1979), all the values recorded are below the limits of similarities and composition, indicating all the stations to be dissimilar. However, considering their similarity indices, there is great similarity between Station I and II. This may be attributed to the absence of any hiderance for water movement between the two stations. Because, as indicated by Tait (1981), and Martens and Schockaert (1986), of the two factors that characterize the benthic habitat one is water movement.

Station III is significantly different from Stations I and II which may be attributed to the distance between them and the presence of a coral reef that separates it from the others. Station III differing from the others, is in direct contact with Green Island. This may lead to access of allochthanous substances.

Jaccard's Coefficient shows no significant variation among the three stations. However, relatively more affinity is observed between Stations II and III. Jaccard's Coefficient reflects only the presence or absence of species and not their relative abundance. If so, the absence of any significant differences and strong affinity between the stations may be due to the possession of more or less similar species among the three stations. This result agrees with what has been given in the list of organisms (Table 1), which is found to be characterized by no dominant species among the three stations.

Similarity index according to Sorensen (1948;cited in Muller-Dombois and Ellenberg, 1974) expresses the actual measured coinciding species occurences against the theoretically possible ones including a statistical probability term. Furthermore, this index gives greater weight than Jaccard's to the species that recure in the two test areas than those that are unique to either area. Due to these, heavy weight is given to the results of the similarity index than Jaccard's Coefficient. That is why distictive differences are observed between the three stations.

6.6) Faunal Standing Stock and Productivity

Probert and Anderson (1986, citing Zerkevitch et.al., 1960), gave an average wet weight benthic biomass value in New Zealand waters of 200g/m^2 for the depth range of 0-200m. The results of the present study are not comparable to this value. According to Tait (1981), in areas of exceptional productivity, biomass dry weights are found to be as high as 100-200g/m^2. This range agrees with that reported by Mann (1982). He stresses that the best data for benthos is estimated by the Russians as about 200g/m^2 for the continental shelf (0-200m). Again the results of this study are much lower compared to these records.

The dry and wet biomasses are variable from time to time, having no regularity. According to Barnes and Mann (1982), biomass will be high at one time, low at another and is characterized chiefly by its variability. The present results, therefore, manifest its variability with no visualized regularity. The P:B ratio, which is an expression of the number of times the biomass turns over in a given interval (Mann, 1982) is 1.5. This figure shows turnover rate to be 1.5 times per 6 months.

Comparison of results of one study against another must be done with great caution, for the methods of collecting samples, the sampler utilized, and the total area covered may vary. Similarly, the duration of time and the specific time chosen for the study may differ. Temperate areas have four distinct seasons differing from tropical areas. Therefore, comparison of these two regions may lead to grave error unless precautions are taken.

This study was conducted during the winter season of the area for 6 months. The results may not represent the overall picture of a year. Taking the results and converting them per year basis may give an exaggerated or lowered estimate. It is far better, therefore, to record them as they are for further references and studies.

7) CONCLUSIONS AND RECOMMENDATIONS

The shallow waters along the Red Sea coast around Tewalit (Massawa) are characterised by benthic macrofauna widely distributed and with no dominant species. The macrofauna has high species diversity, high biomass diversity and high equitability. The studied parameters seem to have no regulating effect on the abundance and distribution of the macrobenthic fauna. The species composition and similarity are below the limits of similarity, but there are variabilities in similarity indices. The macrofauna is, therefore, assembled differently among various microhabitats. Estimated production is relatively high, while the biomass is relatively low.

The study was conducted during one season (the winter season) of the region. This season is the time when fishing activities are at their highest. However, it may not represent the overall ecological picture of the area. Therefore,

1) Further study of the macrobenthic fauna on a long range basis (e.g., annual) is essential.
2) Secondary productivity is influenced by primary productivity. A study of phytoplankton production is thus required.
3) There is nothing known concerning how the macrobenthos are related to the microbenthos and meiobenthos. Investigation of their ecological interactions will also make it possible to better visualize the ecological systems of the area.

4) Physical and chemical parameters are said to influence benthic fauna. A study of the variability of pH, salinity, oxygen concentration and especially water dynamism is crucial to an understanding of those factors that determine the distribution, abundance and productivity of the macrobenthic fauna.

5) The relationships between the benthos and the fish fauna is not known. Therefore, investigation on their relationships is required.

8) REFERENCES

Barnes, R.S.K. and Mann, K.H. 1982. Prologue. In: Fundamentals of Aquatic Ecosystems. R.S.K. Barnes and K.H. Mann (eds.). Blackwell Scientific Publications, Oxford, P. 1-3.

Banse, K. 1984. Singular, Mass-Specific P/B ratios cannot be used to estimate Copepod production. Reply. Can. J. Fish. Aquat. Sci., 41(5):833-834.

Banse, K. and Mosher, S. 1980. Adult body mass and annual production/biomass relationships of field populations. Ecol. Monogr., 50:355-379.

Benke, A.C. 1979. A modification of the Hynes method for estimating Secondary Production with particular significance for multivoltine populations. Limnol. Oceanogr., 24:168-171.

Ben-Yami, M'Nakhem. 1964. Report on the Fisheries in Ethiopia, Department of Fisheries, Ministry of Agriculture, Jerusalem, 106p.

Boulton, A.J. 1985. A Sampling device that quantatively collects benthos in flowing or standing waters. Hydrobiologia, 127:31-39.

Buchanan, J.B. and Warwick, R.M. 1974. An estimate of benthic macrofaunal production in the offshore mud of the Northumberland coast. J. mar. biol. Ass. U.K. 54: 197-222.

Buchanan, J.B., Sheader, M. and Kingston, P.F. 1978. Source of variability in the benthic macrofauna off the South Northumberland coast, 1971-1976. J.mar.biol.Ass.U.K., 58: 191-209.

Crossman, John S. and Cairns, John Jr. 1974. A Comparative study between two different Artificial Substrate Samples and regular sampling techniques. Hydrobiologia. 44(4): 517-522.

Day, J.H. 1967a. A Monograph on the Polychaeta of Southern Africa. Part I - Errantia, British Museum (Natural History), London, 1-468p.

--------- (1967b). A Monograph on the Polychaeta of Southern Africa. Part II - Sedentaria. British Museum (Natural History), London, 459-878p.

Dicks, Brian. 1984. Oil pollution in the Red Sea - Environmental Monitoring of an oil field in a coral area, Gulf of Suez. In:Deep Sea Researchers, Part A:Oceanographic Research Papers, 31:833-854.

Dietrich, Günther. 1963. General Oceanography:An Introduction, Intersience Publishers, New York, 588p.

Downing, John A. 1984a. Sampling the benthos of standing waters. In: A manual on methods for the Assessment of Secondary Production in Freshwaters. John A. Downing and Frank H. Rigler (eds.). 2nd. ed., IBP Handbook No. 17, Blackwell Scientific Publications, Oxford, pp. 87-130.

Downing, John A. 1984b. Assessment of Secondary Production: The First Step. In:A manual on methods for the Assessement of Secondary Productivity in Freshwaters. John A. Downing and Frank H. Rigler (eds.), 2nd. ed., IBP Handbook, No. 17, Blackwell Scientific Publications, Oxford, pp. 1-18.

Drach, Pierre. 1960. Perspectives in the study of benthic fauna of the continental shelf. In:Perspectives in Marine Biology. A.A. Buzzati-Traverso (ed.), University of California Press, Berkely and Los Angeles. pp. 33-46.

Edmondson, W.T. (ed.), 1971. A Manual on methods for the Assessment of Secondary Productivity in Freshwaters. IBP Handbook, No. 17, Blackwell Scientific Publications, Oxford and Edinburgh, 358p.

Fauchald, Kristian. 1976. The Polychaete Worms:Definitions and Keys to the orders, Families and Genera. Natural History Museum of Los Angeles, County Sciences Series, 28:190p.

Fischer, W. and Bianchi, G. (eds.). 1984. FAO Species Identification Sheets for fishery purposes, Western Indian Ocean (Fishing Area 51). Prepared and Printed with the support of the Danish International Development Agency (DANIDA). Roam, FAO, Vols., 1-6:pag. var.

Fishelson, L. 1971. Ecology and distribution of the benthic fauna in the shallow waters of the Red Sea. Marine Biology, 10:113-133.

Flint, Warren R. and Kalke, Richard D. 1986. Niche characterization of dominant Estuarine benthic species. Estuarine, Coastal and Shelf Science, 22:657-674.

Folk, Robert L. 1980. Petrology of Sedimentary Rocks, Hemphill Publishing Company, Austin, Texas, pp. 15-47.

Frithsen, J.B., Rudnick, D.T. and Elmgen, R. 1983. A new, flow-through corer for the quantitative sampling of surface sediments. Hydrobiologia, 99:75-79.

Gillespie, D.M. and Benke, A.C. 1979. Methods of calculating cohort production from field data - some relationships. Limnol. Oceanogr., 24:171-176.

Griffiths, John C. 1967. Scientific method in analysis of sediments, McGraw-Hill Book Company, New York, 508p.

Grizzle, Raymond E. and Stegner, William E. 1985. A new quantitative grab for sampling benthos. Hydrobiologia, 126:91-95.

Halim, Youssef. 1969. Plankton of the Red Sea. Oceanogr. Mar. Biol. Ann. Rev., 7:231-275.

Hamilton, A.L. 1969. On estimating annual production. Limnol. Oceanogr., 14:771-782.

Humfry, Michael. 1975. The Sea Shells of the West Indies, Collins, London, 351p.

Hynes, H.B.N. and Coleman, M.V. 1968. A simple method of assessing the annual production of stream benthos. Limnol. Oceanogr., 13:569-573.

Ismail, Naim S. 1986. Community Structure of macrobenthic invertebrates in Sandy Beaches of the Jordan Gulf of Aqaba, Red Sea. Int. Revue ges. Hydrobiol., 71(2): 225-232.

Jackson, D. 1986. A manually operated core-sampler suitable for use on fine-particulate sediments. Estuarine, Coastal and Shelf Science, 23:419-422.

Jones, A.R. 1986. The effects of dredging and spoil disposal macrobenthos, Hawkesbury Estuary, N.S.W. Marine Pollution Bulletin, 17(1):17-20.

Kajak, A. 1971. Methods of collection:Benthos of standing water. In:A manual on methods for Assessment of Secondary Productivity in Freshwaters. W.T. Edmondson (ed.), IBP Handbook, No. 17, Blackwell Scientific Publications, Oxford and Edinburgh, pp. 25-65.

Kendeigh, S. Charles. 1980. Ecology: With special reference to animals and man. Prentice-Hall of India Private Limited, New Delhi, 474p.

Kinne, Otto. (ed.). 1972. Marine Ecology, Wiley-Interscience, London.

Lambshead, P.J.D.;Platt, H.M. and Shaw, K.M. 1983. The detection of differences among assemblages of marine benthic species based on an assessment of dominance and diversity. Journal of Natural History. 17:859-874.

Laor, Asher. 1971. Report on Ad hoc consultation on Fisheries education and training, Massawa, 10p. (Unpublished).

Larsen, Peter F. 1985. The benthic macrofauna associated with the Oyster Reefs of the James River Estuary, Virginia, U.S.A. Int. Revue ges. Hydrobiol., 70(6): 797-814.

Leuven, Rob S.E.W., Brock, Theo C.M. and van Druken, Hans A. M. 1985. Effects of preservation on dry - and ash-free dry weight biomass of some common aquatic macro-invertebrates. Hydrobiologia, 127(2):151-159.

Levings, Colin D. 1975. Analysis of Temporal Variation in the structure of shallow-water benthic community in Nova scotia. Int. Revue ges. Hydrobiol., 60(4):449-470.

Lu, C.C. and Ropper, Clyde F.E. 1979. Cephalopods from Deepwater Dumpsite 106 (Western Atlantic):Vertical Distribution and Seasonal Abundance. Smithsonian Contribution to Zoology, No. 288, Smithsonian Institution Press, Washington, 36p.

Mann, K.H. 1982. Benthic Secondary Production. In: Fundamentals of Aquatic Ecosystems, R.S.K. Barnes and K.H. Mann (eds.), Blackwell Scientific Publications, Oxford, pp. 103-118.

Marcotte, Brain Michael. 1986. Sedimentary particle sizes and the ecological gain of food resources for meiobenthic Copepods. Estuarine, Coastal and Shelf Science, 23: 423-427.

Margalef, Ramon. 1969. Diversity and Stability: A practical proposal and model of interdependence. In:Diversity and Stability in ecological systems. Report of Symposium held May 26-28,1969. Biology Department, Brookhaven National Laboratory (ed.), No. 22, Upton, New York, pp.235337.

Martens, Paul M. and Schockaert, Ernest R. 1986. The importance of turbullarians in the marine meiobenthos: A revies. Hydrobiologia, 132:295-303.

Mayer, Lawrence M.;Rahaim, Peter T.;Guerin, William;Marcko, Stephen A.;Walting, Les, and Anderson, Franz E. 1985. Biological and Granulometric controls on sedimentary organic matter of an intertidal mudflat. Estuarine, Coastal and Shelf Science. 20(4):491-503.

McConnaughey, Bayard H. 1978. Introduction to Marine Biology, 3rd ed., The C.V. Mosby Company, Saint Louis.

McCullough, Jack D. and Jackson, Douglas W. 1985. Composition and Productivity of the benthic macro-invertebrate community of a subtropical reservoir, Int. Revue ges. Hydrobiol., 70(20:221-235).

McIntosh, Robert P. 1967. An Index of Diversity and the relation of certain concepts to diversity. Ecology, 48(3): 382-404.

McIntyre, A.D. 1968. The meiofauna and macrofauna of some tropical beaches. J. Zool. Lond., 156:377-392.

McIntyre, A.D. 1969. Ecology of marine meiobenthos. Biol. Rev., 44: 245-290.

McLachalan, Anton. 1985. The biomass of macro and intertidal fauna of clean and wrack-covered beaches in Western Australia. Estuarine, Coastal and Shelf Science, 21(4): 587-599.

Meadows, P.S. and Anderson, J.G. 1966. Micro-organisms attached to marine and freshwater sand grains. Nature, Lond., 212:1059-1060.

Mergner, Hans. 1984. The Ecological Research on coral reefs of the Red Sea. In: Deep Sea Researches, Part A: Oceanographic Research Papers, 31:6-8, pp. 855-884.

Morcos, Selim A. 1970. Physical and Chemical Oceanography of the Red Sea. Oceanogr. Mar. Biol. Ann. Rev., 8: 73-202.

---------- 1984. The Egyptian Expedition of the Red Sea 1934/35. in: Deep Sea Researches, Part A:Oceanographic Research papers, 31:6-8, pp. 599-616.

Mueller-Dombois, Dieter. and Ellenberg, Heinz. 1974. Aims and Methods of vegetation ecology, John Wiley and Sons, New York, 547p.

Odum, Eugene P. 1963. Ecology, Modern Biology Series, Holt, Rinehart and Winston, New York, 152p.

Parsons, T.R.;Takahashi, M. and Hargave, B. 1979. Biological Oceanographic processes, 2nd. ed., Pergamon Press, Oxford, 332p.

Pettibone, Marian H. 1971. Revision of some species referred to Leptonereis, Nicon, and Laeonereis, (Polychaeta: Nereidedae), Smithsonian contributions to Zoology, No. 104, Smithsonian Institution Press, Washington, 53p.

---------- 1983. Marine Polychaete worms of the New England Region. I - Aphroditidae through Trochochaetidae, Smithsonian Institution, Washington.

Perkins, E.J. 1974. The biology of Estuarines and coastal waters, Academic Press, London, 678p.

Pielou, E.C. 1966. The measure of Diversity in different types of biological collections. J. Theoret. Biol., 13:

---------- 1977. Mathematical Ecology, John Wiley and Sons New York, 385p.

Platt, H.M. and Lambshead, P.J.D. 1985. Neutral model analysis of patterns of marine benthic species diversity. Mar. Ecol. Prog. Ser., 24:75-81.

Poole, Rovert W. 1974. An Introduction to Quantitative Ecology, McGraw-Hill, Inc., New York, 532p.

Probert, P.K. and Anderson, P.W. 1986. Quantitative distribution of benthic macrofauna off New Zealand, with particular reference to the west coast of the South Island. New Zealand Journal of Marine and Freshwater Research, 20:281-290.

Riedl, Rupert. 1970. Fauna und Flora der Adria, Verlag Paul Parey, Hamburg und Berlin, 702p.

Rigler, Frank H. and Downing, John A. 1984. The calculation of secondary productivity. In:A manual for the Assessment of Secondary Productivity in Freshwaters. John A. Downing and Frank H. Rigler (eds.), 2nd ed., Blackwell Scientific Publications, Oxford, pp. 19-58.

Ropper, C.F.E. 1977. Comparative catures of Pelagic Cephalopds by midwater trawls. Sympo. Zool. Soc., Lond., 38:61-87.

Rugg, Brage. 1985. Distribution of species along pollution-induced diversity gradients in benthic communities in Norwegian fjords. Marine Pollution Bulletin, 16(12): 469-474.

Steimle, Frank W. 1985. Biomass and estimated productivity of the benthic macrofauna in the New York Bight:A stressed coastal area. Estuarine, Coastal and Shelf Science, 21(4):539-554.

Sverdrup, H.U.;Johnson, Martin W. and Fleming, Richard H. 1962. The Oceans: Their Physics, Chemistry and General Biology, Prentic Hall, Inc., Englewood Cliffs, N.J., 1087p.

Tait, R.V. 1981. Elements of Marine Ecology, 3rd. ed., Butterworths, London-Boston, 356p.

Thorson, Gunnar. 1978. Life in the Sea, McGraw-Hill Book Company, New York, 256p.

Thrush, Simon F. and Townsend, Colin R. 1986. The sub-littoral macrobenthic community composition of Lough Hyne, Ireland. Estuarine, Coastal and Shelf Science, 23:551-574.

Tudorancea, Claudiu., Roger, H. Green, and Judith, Huebner. 1979. Structure, Dynamics and (Production of the benthic fauna in Lake Manitoba. Hydrobiologia, 64(1):59-95.

Tyler, P. and Shackley, S.E. 1978. Comparative efficiency of the Day and Smith McIntyre grabs. Estuarine, Coastal and Shelf Science, 6: 439-445.

Warwick, R.M. 1984. Species size distribution in marine benthic communities. Oecologia, 61:32-41.

Webb, J.E. 1969. Biologically significant properties of submerged marine sands. Proc. Roy. Soc. Lond. B., 174: 355-402.

Whittaker, Robert H. 1975. Communities and Ecosystems, 2nd, ed., MacMillan Publishing Co., Inc., New York, 385p.

Wilhm, J.L. 1968. Use of biomass units in Shannon's formula. Ecology, 49:153-156.

Ziegelmeier, E. 1972. Bottom-Living Animals: Macrobenthos. In: Research Methods in Marine Biology, Carl Schlieper (ed.), Sidwick and Jackson, London, pp. 104-116.

APPENDIX - I

Total number of benthic macrofauna collected by each sampling device at each station during each sampling time.

a) Peterson Grab

S.T.	Sta.	Rep. I		Rep. II		Rep. III	
t0	I	19	742	11	430	15	586
	II	2	78	2	78	16	625
	III	5	195	7	273	11	430
t1	I	73	2852	30	1172	49	1914
	II	45	1758	15	586	27	1055
	III	25	977	51	1992	70	2734
t2	I	71	2773	202	7891	69	2695
	II	34	1328	40	1563	40	1563
	III	18	703	28	1094	6	234
t3	I	78	3047	0	0	37	1445
	II	37	1445	67	2617	46	1797
	III	68	2656	104	4063	139	5430
t4	I	49	1914	28	1094	24	938
	II	24	938	35	1367	30	1172
	III	43	1680	29	1133	36	1406
t5	I	24	938	20	981	26	1016
	II	48	1875	55	2148	18	703
	III	48	1875	53	2070	22	859
t6	I	20	781	19	742	6	234
	II	25	977	28	1094	30	1172
	III	42	1641	21	820	20	791
t7	I	21	820	22	859	50	1853
	II	40	1563	39	1523	43	1680
	III	26	1016	48	1875	43	1680
t8	I	10	391	33	1289	13	508
	II	41	1602	29	1133	28	1094
	III	13	508	16	625	17	664
t9	I	59	1133	68	2656	47	1836
	II	26	1016	31	1211	39	1523
	III	41	1602	32	1250	17	664

Appendix I (cont'd.)

t10	I	18	703	16	625	60	2344
	II	37	1145	28	1094	38	1484
	III	32	1250	41	1602	35	1367
t11	I	22	859	44	1719	52	2031
	II	33	1289	23	898	38	1484
	III	36	1406	38	1484	43	1680
t12	I	14	547	17	664	42	1641
	II	56	2888	35	1367	52	2031
	III	20	781	46	1797	22	859

Appendix I (Cont'd.)

b) Ekman Grab

S.T.	Sta.	Rep. 1		Rep. 2		Rep. 3	
t0	I	24	356	23	341	10	148
	II	21	311	7	104	15	222
	III	2	30	9	133	10	148
t_1	I	43	637	23	341	16	237
	II	52	770	65	963	35	519
	III	30	444	36	533	55	815
t_2	I	29	430	54	800	68	1007
	II	6	89	29	430	16	237
	III	31	459	51	756	52	770
t_3	I	68	1007	56	830	68	1007
	II	37	548	50	741	46	681
	III	66	978	21	311	69	1022
t_4	I	73	1081	96	1422	23	341
	II	22	326	13	193	21	311
	III	10	148	29	430	35	519
t_5	I	33	489	55	815	38	563
	II	20	296	42	622	31	459
	III	18	267	7	104	17	252
t_6	I	13	193	18	267	25	370
	II	32	974	29	430	0	0
	III	15	222	21	311	15	222
t_7	I	21	311	19	281	29	430
	II	18	267	40	593	41	607
	III	34	504	40	593	40	593
t_8	I	86	1274	13	193	27	400
	II	22	326	17	252	23	341
	III	22	326	17	252	20	296

Ekman Grab (cont'd.)

t_9	I	35	519	22	326	26	385
	II	45	667	22	326	31	459
	III	34	504	21	311	36	533
t_{10}	I	27	400	22	326	37	548
	II	8	119	9	133	30	444
	III	50	741	22	326	27	400
t_{11}	I	26	385	32	474	72	1067
	II	26	385	23	341	27	400
	III	38	563	45	667	40	593
t_{12}	I	14	207	17	252	24	356
	II	22	326	37	548	23	341
	III	2	30	22	326	32	474

APPENDIX - II

Sediment Grain Size distribution among the three stations in %. Data from October 28,1986 to April 14, 1987.
(A => 2mm, B = 2mm - 1mm, C = 1mm-0.5mm, D = < 0.5mm)

S.T.	Grain Size	Sta. I	Sta. II	Sta. III
to	A	2.00	2.80	0.40
	B	6.60	13.60	7.40
	C	25.60	22.40	19.40
	D	65.80	61.20	72.80
t1	A	3.64	0.29	0.55
	B	7.73	1.57	3.06
	C	15.79	5.22	7.75
	D	72.84	92.92	88.82
t2	A	3.89	2.00	0.70
	B	8.43	20.70	4.70
	C	19.48	31.10	21.30
	D	68.20	46.20	73.30
t3	A	7.47	3.07	7.20
	B	19.06	10.53	16.67
	C	35.60	29.47	27.33
	D	37.87	56.93	48.80
t4	A	3.33	0.93	0.40
	B	11.47	11.33	3.73
	C	27.73	21.87	11.47
	D	57.47	65.87	84.40
t5	A	3.33	1.07	0.40
	B	9.20	7.87	4.80
	C	21.60	19.73	20.27
	D	65.87	71.33	74.53
t6	A	9.47	0.27	0.27
	B	12.40	2.27	2.53
	C	18.00	7.60	12.13
	D	60.13	89.86	87.07

Appendix II (cont'd.)

t7	A	4.27	0.53	0.93
	B	10.53	1.61	6.80
	C	27.33	6.53	18.54
	D	57.87	91.33	73.73
t8	A	20.13	0.53	1.20
	B	10.93	1.87	15.20
	C	17.33	5.47	28.93
	D	51.61	92.13	54.67
t9	A	7.86	0.27	0.27
	B	15.87	2.13	5.87
	C	33.07	7.33	18.27
	D	43.20	90.27	75.59
t10	A	7.20	1.07	0.93
	B	12.80	6.53	8.80
	C	24.80	13.07	17.60
	D	55.87	79.33	72.67
t11	A	3.73	0.27	0.40
	B	14.00	1.47	6.00
	C	29.87	6.26	23.07
	D	52.40	92.00	70.53
t12	A	7.60	0.40	0.67
	B	11.20	1.87	3.60
	C	19.60	5.87	10.40
	D	61.60	91.86	85.33

APPENDIX - III

Total number of taxa collected at each sampling station at each time. Data from October 28,1986 to April 14,1987.

S.T.	Station - I	Station - II	Station - III
to	15	11	11
t1	18	20	24
t2	21	15	20
t3	20	23	22
t4	19	18	20
t5	20	26	23
t6	13	21	21
t7	23	24	22
t8	18	16	21
t9	18	22	22
t10	18	17	21
t11	19	16	22
t12	16	20	21

Appendix IV (Cont'd.)

t6	I & II....... 7	0.41	25.90%
	II & III......16	0.76	61.50%
	III & I........11	0.67	47.80%
t7	I & II...... 16	0.68	51.61%
	II & III..... 15	0.65%	48.39%
	III & I....... 17	0.76	60.71%
t8	I & II...... 10	0.59	41.67%
	II & III..... 14	0.76	60.87%
	III & I....... 14	0.72	56.00%
t9	I & II...... 14	0.70	53.85%
	II & III..... 16	0.73	57.14%
	III & I....... 15	0.75	60.00%
t10	I & II...... 12	0.69	52.17%
	II & III..... 13	0.68	52.00%
	III & I 12	0.62	44.00%
t11	I & II...... 12	0.69	52.17%
	II & III..... 13	0.68	52.00%
	III & I....... 15	0.73	57.69%
t12	I & II...... 14	0.78	63.64%
	II & III..... 17	0.83	70.83%
	III & I....... 14	0.76	60.87%

APPENDIX - V

Dry Standing Stock of each major group (mg/m^2) at each sampling time. Data from October 28, 1986 to April 14,1987.
(A = Oligochaeta, B = Polychaeta, C = Gastropoda, D = Bivalvia, E = Crustacea, F = Echinodermata, G = Cephalochordata, H = Anthozoa)

S.T.		Station I	Station II	Station III
to	A	---	---	---
	B	156.7	99.8	6.4
	C	53.4	23.4	260.1
	D	79.1	644.1	420.1
	E	317.6	35.0	125.0
	F	---	---	---
	G	210.9	13.3	38.0
t1	A	---	23.1	---
	B	545.7	734.9	374.3
	C	1472.3	2534.4	2026.0
	D	180.7	3714.1	1208.8
	E	346.8	274.9	306.8
	F	---	---	13.2
	G	170.3	10.4	74.5
t2	A	---	---	2.6
	B	413.5	147.8	173.2
	C	137.6	498.8	1067.8
	D	440.8	20.8	741.2
	E	1387.7	916.0	663.8

Appendix - V (cont'd.)

	F	---	---	---
	G	376.0	140.0	116.0
t3	A	---	100.0	3.5
	B	457.1	999.1	408.1
	C	217.6	2346.7	1116.5
	D	215.2	3981.5	635.3
	E	3731.3	478.2	143.4
	F	---	11.2	11.2
	G	129.5	48.1	177.6
t4	A	---	---	---
	B	455.0	138.9	582.1
	C	119.0	576.0	1676.0
	D	177.1	57.4	853.4
	E	1594.1	1076.4	953.1
	F	---	---	---
	G	173.9	65.8	159.8
t5	A	---	---	---
	B	423.1	880.0	297.6
	C	1258.4	1988.5	2408.7
	D	---	2049.8	1425.5
	E	407.4	1066.3	370.3
	F	65848.3	244.3	244.3
	G	222.6	138.6	201.6
t6	A	---	---	---
	B	316.2	958.1	577.9
	C	---	1179.8	703.7

Appendix - V (Cont'd.)

t10	A	---	---	---
	B	679.7	957.6	3760.3
	C	207.2	1390.9	869.8
	D	324.8	324.8	655.0
	E	1532.2	1762.6	1414.2
	F	---	---	---
	G	44.8	20.8	24.0
t11	A	---	---	---
	B	1155.2	1099.5	3347.0
	C	310.1	1243.4	3758.2
	D	429.8	2517.4	1080.0
	E	4102.0	3252.2	2762.6
	F	---	---	120.4
	G	54.0	---	126.0
t12	A	---	---	---
	B	705.0	2286.9	976.4
	C	530.6	2388.9	1760.2
	D	---	3391.2	614.0
	E	1655.2	607.0	562.3
	F	---	---	---
	G	128.0	16.0	70.0

APPENDIX - VI

Dry weight standing stock (DSS) and Productivity (P) of 38 taxa encountered during the study

(Data from October 28,1986 to April 14, 1987)

Taxa	DSS (g/m^2)	$P(g/m^2)$
Sabellas spp	0.2145	0.0963
Trebella spp.	0.9686	0.1459
Cirrarulus sp.	0.5856	0.1109
Syllis sp.	0.2169	-0.0155
Nephtys sp.	1.3508	-0.0398
Capitella spp.	0.3788	0.0175
Amphinome sp.	0.1259	0.0161
Nereis spp.	0.3138	0.0574
?*Aricidea* sp.	0.3518	0.0250
Glycera spp.	0.3382	0.0035
Pectinaria sp.	4.1929	0.0430
Maldanidae spp.	0.3404	0.0307
Arenicola sp.	0.0605	0.0297
Magelona sp.	0.0193	0.0024
Armanida sp.	0.0945	-0.0297
Oligochaeta Uident.	0.0488	0.0025
Antillophos sp.	7.3959	1.3825
Oliva sp.	1.9217	0.1183
?*Cancellaria* sp.	6.2035	-0.4303
Gastropod a	1.4770	0.3300

Appendix - VI (Cont'd.)

Natica sp.	0.1986	0.0677
Bulla sp.	1.0548	1.1321
Tellina ? punicea	12.9504	2.0245
T. ? radiata	3.1770	0.1938
Anadaria	0.2100	0.0507
Macoma	0.6531	0.1796
Tellina? virgata	1.7594	0.3114
Tellina sp.	0.4248	0.0447
Metapenius stebbingi	0.3026	0.0892
Tanaidacea spp.	0.1882	0.0419
Pinnotheres sp.	0.6170	0.1352
Pagurus spp.	9.5807	-0.4019
?Ethusa sp.	3.6583	0.6604
Gammarus spp.	0.3312	0.0332
Ophiuroidea sp	0.1393	-0.0833
Echinoidea sp.	0.6039	0.1063
Asteroidea sp.	25.9896	3.6228
Branchiostoma sp.	1.8973	0.05885