MACROBENTHOS OF A TROPICAL ESTUARY

By

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THESIS

submitted to the University of Cochin, in partial
fulfilment of the requirements for the
degree of Doctor of Philosophy.

1978

CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Mr. N. Gopalakrishna Pillai, M.Sc., under my supervision in the Department of Marine Sciences of the University of Cochin and that no part thereof has been presented before for any other degree in any university.

Dr. R. Damodaran,
Supervising Teacher.

Cochin-16,
28-12-1978.

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CONTENTS

Part -I

CONTENTS (contd.)

List of Figures

<u>List of Figures</u> (<u>contd</u>.)

List of Tables

P A R T - I

1. INTRODUCTION

In recent years, studies on benthos have attained considerable importance concurrent with the increasing realisation of their significant role in the trophic cycle. Almost half of the world's commercial catch from the sea consists of shell fish and demersal fish, whose main food comes from benthos. A detailed knowledge of the bottom fauna is essential for the determination of the potentialities of the demersal fisheries of an area. Zoobenthic studies also play a major role in base line research on pollution in marine, coastal, and estuarine environments (Lie, 1968; Wolff, 1973). Another important application of studies on benthic animals has been to use their numbers and diversity as a key to environmental disturbances caused by oil spills (Parker, 1975). It has also been proved that quantitative benthic faunal studies are extremely valuable for determining the damage resulted from major industrial effluents. Diversity and abundance of infauna species can be used to judge the dynamics or stability of aquatic environments (Parker, 1975).

The pioneering intensive quantitative investigation of the bottom fauna is that of Petersen (1913, 1915) in Danish waters. Since then, quite a lot of work has been done in temperate and arctic waters to elucidate the part played by benthos in the benthic fishery of these regions. Earlier works on benthos have shown the importance of the estimation of benthic biomass in evaluating their utilization as food for higher animals and fishes. (Petersen, 1918; Blegvad, 1930; Bristow, 1938; Jones, 1950, 1951, 1952 and 1956; Sanders, 1956; Stickney and Stringer, 1957; Mulicki, 1957; Konstantinov, 1960; Segerstrale, 1960; Holme, 1961, 1966; Kurian, 1967; Eagle, 1973; Damodaran, 1973; McIntyre and Murison, 1973).

Benthic fauna has been divided into (i) animals that spend much of their time in the upper layers of the water and descend to the bottom for breeding, feeding or resting, (ii) animals that spend most of their lives on the bottom, and (iii) burrowers (Allee et al., 1961). Of these, the first group consists of demersal fishes, many crustacean and other mobile invertebrates. The second and third categories correspond to Petersen's epifauna and infauna respectively (Petersen, 1913).

According to size, benthic animals can also be divided into three categories: (i) macrobenthos, (ii) meiobenthos, and (iii) microbenthos (Mare, 1942). The size limits of the three groups of benthic animals are arbitrary and vary according to the workers and type of substratum under investigation. The lower size limit of macrobenthos depends upon the mesh size of the sieve used and usually varies between 3.0 and 0.5 mm. The upper limit of meiobenthos depends upon the mesh size of the sieve used for separating macrobenthos from meiobenthos and its lower limit is between 0.1 and 0.04 mm (McIntyre, 1969). The microbenthos include those organisms that are not retained in the finest sieve used for meiobenthos separation and include bacteria and most of the protozoans. Because of the variation in the mesh size of the sieves used by different workers, there is no strict size range for each of the above groups.

There is an increasing interest in the study of the estuarine environment as a distinct entity. Estuaries as a rule are biologically more productive than the adjoining bodies of fresh water and sea water (Abbott et al., 1971). The dynamic nature of the environment, with its great natural fertility and its potential role as sites for fish farming has stimulated considerable interest in estuarine investigations in recent years.

According to Pritchard (1967), "an estuary is a semi-enclosed coastal body of water, which has a free connection with the open sea, and within which sea water is measurably diluted with fresh water derived from land drainage". The estuarine ecosystem is unique, intermediate between the sea and fresh water and inhabited by distinct fauna and flora, which are well adapted in their physiology and ecology to cope with the dynamic environment. The environment of the estuaries and adjoining backwaters is important to human welfare as they play a vital role in the production of food resources, waste disposals and transportation. The ecosystem formed by estuaries and backwaters acts as nursery grounds for many marine and fresh water species.

India has a coast line of about 5600 Kms.and a large number of rivulets, rivers and its tributaries open into the sea. There are a number of estuaries distributed along the east and west coasts of India, covering an area of approximately two million hectares. Though many of these estuaries are being used for fishing and transportation, only very few are scientifically managed for better utilisation. However, in recent years, studies on the tropical estuaries in India have covered some of the management problems of this special environment.

Though marine biological investigations are being carried out in India for more than half a century, only very little attention has been paid to the study of the bottom fauna and bottom deposits, both in inland and marine environments.

In India, Annandale (1907) and Annandale and Kemp (1915) are the pioneers in the field of estuarine bottom fauna studies. They carried out studies on the ecology of

Gangetic Delta and on the fauna of Chilka Lake. Panikkar and Aiyar (1937) studied the bottom fauna of the brackish water areas near the Madras city. Seshappa (1953) and Kurian (1953) have given an account of the bottom fauna of the inshore and central regions of the Malabar and Travancore areas respectively. Balasubramanyan (1961) conducted a preliminary survey of the bottom fauna of the Vellar estuary. Desai and Krishnankutty (1967a) have studied the bottom fauna of the Cochin backwaters. Desai and Krishnankutty (1967b) also conducted a comparative study of the marine and estuarine benthic fauna of the nearshore regions of the Arabian Sea. Rajan (1965) made an extensive study of the benthic animal communities of the Chilka Lake. Another observation in the Chilka Lake is that of Patnaik (1971), who studied the seasonal abundance and distribution of the bottom fauna. Kurian (1972) made an investigation on the bottom fauna of the Cochin Estuary. Jayasree (1971) conducted a preliminary observation on the meiobenthos of the Cochin Harbour area. Parulekar and Dwivedi (1974) have investigated standing crop and faunal composition in relation to bottom salinity distribution and substratum characteristics in the estuary of Mandovi river. Parulekar and Dwivedi (1975) have also studied the ecology of benthic production during the South West Monsoon in the Goan estuarine complex. Kurian et al. (1975) have studied the distribution of bottom fauna in the Vembanad Lake. Ajmalkhan *et al*., (1975) have studied the bottom fauna of the Vellar Estuary. The distribution and seasonal abundance of the macrobenthos of the Cochin Backwaters were studied by Pillai (1977).

Cochin Estuary is a system of shallow brackish water lagoons along the Kerala coast. It is well known for its role as a nursery ground for many of the commercially important prawns and fishes. The estuary supports an extensive prawn fishery and forms the main nursery ground for certain commercially important penaeid prawns such as *Metapenaeus dobsoni*, *M. affinis*, *M. monoceros*, and *Penaeus indicus*.

During the last few years, various aspects such as geology, hydrography and organic production of the Cochin Estuary have been the subject of intensive study. However, a detailed investigation on the benthos of the Cochin Estuary is lacking. The present work is intended to provide information on the qualitative and quantitative distribution of macrobenthos and its relationship to the bottom feeding fishes and prawns of the estuarine regions around Cochin.

In the present study, a detailed sampling was conducted using grabs and dredges to assess the qualitative and quantitative nature of the macrobenthos. All the animal contributing to the fauna are identified and their pattern of distribution and seasonal abundance are discussed. Affinity and diversity of polychaete fauna have also been studied. Importance of different benthic forms and their contribution to the standing crop are studied in detail. Trophic relationship between macrofauna and bottom feeding commercially important fishes and prawns are also given attention.

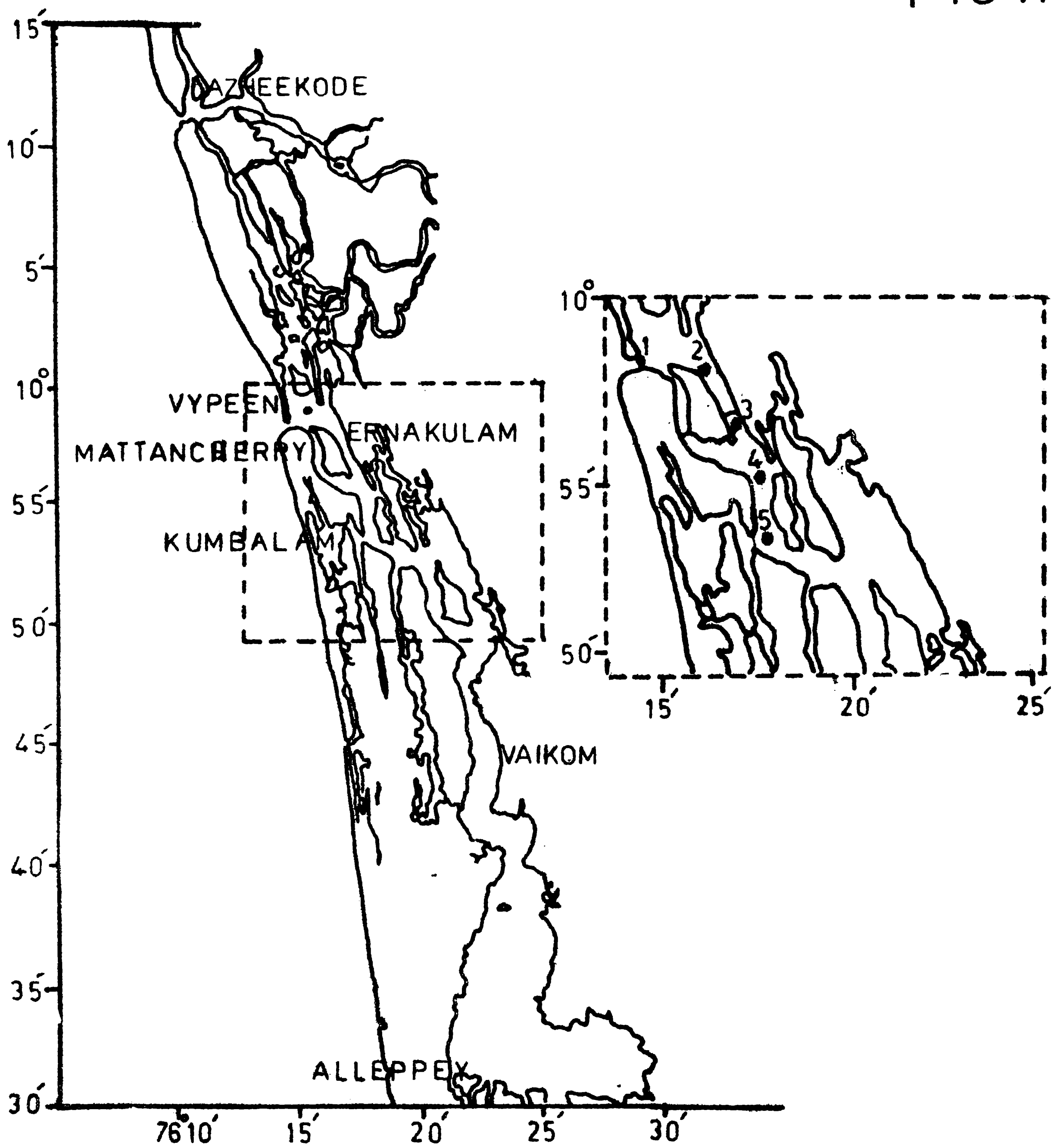
The physico-chemical aspects of the environment have been studied and their relation to the distribution and abundance of bottom fauna has been discussed. Environmental parameters such as temperature, salinity and dissolved oxygen, both in bottom and in the overlying waters, and rainfall were studied along with the benthos investigations. The physico-chemical nature of the sediments was also subjected to investigation. Influence of all these ecological parameters on the bottom fauna is discussed.

A detailed quantitative faunal list of macrobenthic species and a brief systematic account of the Polychaeta are also given.

2. PHYSIOGRAPHY OF THE VEMBANAD LAKE

The Vembanad Lake, the largest on the west coast of India, comprising a chain of shallow brackish water lagoons and swamps, is situated between latitudes 9°28' and 10°N, and longitudes 76°13' and 76°31' E (Fig.1). The length of the lake, which extends from Cranganore in the north to Alleppey in the south, is about 96.5 kms. It covers an area of 256 sq. kms (Shetty, 1963). The depth of the backwaters varies considerably. It is deeper in the harbour area, close to the sea, the depth being about 12 m., which is maintained for navigational purposes and shallower in the upper reaches with a depth of about 1-5 m. A narrow channel of about 500 m. width at Cochin gut makes a permanent connection with the Arabian Sea and transmits the tidal energy and sea salts into the lake. The major sources of fresh water emptying into the backwaters are two large rivers - Periyar in the north and Pampa in the south. Another river, Moovatupuzha, with its tributary, Ittupuzha, also joins the lake about mid way between Cochin and Alleppey. Three other small rivers, namely, Achankoil, Manimala and Meenachil also flow into the lake. These rivers discharge large quantities of fresh water into the estuary during the South West and North East Monsoons. The inflow of fresh water, particularly during the monsoon months

FIG .1


AZHEEKODE
VYPEEN
ERNAKULAM
MATTANCHERRY
KUMBALAM
VAIKOM
ALLEPPEY
15′
10′
5′
10°
55′
50′
45′
40′
35′
30′
76°10′
15′
20′
25′
30′
10°
55′
50′
15′
20′
25′
1
2
3
4
5

is considerably high and the influx of this large scale fresh water run-off extends far beyond the harbour mouth. During the South West Monsoon, the backwater receives an average rainfall of 3300 mm and the estuary is virtually converted into a fresh water basin.

The fresh water discharge from the rivers makes the lake, a typical estuary as per Pritchard's classification (Pritchard, 1967). The run off plus precipitation exceeds evaporation and it is a positive type estuary (Balakrishnan, 1957), which is synonymous with the description of Pritchard's "Estuary".

Tides of the Cochin region are of mixed semi diurnal type, and two successive high and low water appears each day, with an average height of about 90 cm. The discharge of the fresh water from various rivers and the inflow of sea water into the estuary bring about dynamic conditions which make the backwater extremely interesting and ecologically an intriguing environment.

3. MATERIAL AND METHODS

The materials for the present study were collected from March 1974 to March 1976 from five selected stations almost equidistant from one another (Fig.1). Stations I and II were situated in the more saline zone of the estuary and the other three stations at Thevara, Kumbalam and Aroor were situated in the southern portions of the Cochin Harbour representing a typical estuarine condition. The stations were fixed with the help of land bearings. The samplings were done during high tide at fortnightly intervals in the first year and at monthly intervals in the second year. Along with the bottom fauna, hydrographical samples were taken from each station. Sediment samples were also collected simultaneously from each station in order to study the physico-chemical nature of the bottom. The detailed technique employed in each case is given below.

3.1. Hydrography

The physico-chemical parameters studied side by side with benthos were surface water and bottom sediment temperature, surface water and bottom water salinity, dissolved oxygen, rainfall, station depth and substratum. Surface water samples were collected, using a plastic bucket and a bottom sampler (Cheriyan, 1967) was used for the bottom samples. The depth was also noted using plummet and string. Water temperature was measured using an ordinary centigrade thermometer. The sediment temperature was taken by inserting the thermometer in the centre of the grab samples, as soon as the sample was taken on board.

Water samples for dissolved oxygen and salinity data were collected from both surface and bottom. Winkler technique (Strickland and Parsons, 1965) was used for the estimation of dissolved oxygen. Chlorinity of the water was estimated using the Mohr method (Barnes, 1959) and salinity calculated using Knudsen's table.

3.2. Sediment

3.2.1. Grain size

Sediment samples were taken at monthly intervals from each station and a total of 125 samples were analysed. Samples were taken from a van Veen grab haul. From each station two grab samples were taken, portions of sediments from each were mixed together and a representative sample was used for analysis. The general features of the sediment like colour, texture and plasticity were recorded in the field.

In the laboratory, each sediment sample was thoroughly mixed and a representative sample was taken and dried in an air oven around 70°C. Then a portion of the sample was taken for grain size analysis and the other portion pulverised for chemical analysis. All the sediment samples were subjected to particle size analysis by the combined sieving and pipette method, given by Krumbein and Pettijohn (1938). Known quantities of oven dried sediments were dispersed over-night in 0.025 N solution of sodium hexametaphosphate. The silt-clay fractions were separated by washing the dispersed sediment through a 230 mesh sieve (with an aperture opening of 1/16 mm). The coarser fractions retained in the sieve were dried and analysed using a set of standard Endecott sieves. The finer fractions were analysed down to a micron size (10 ø) by the pipette method (Krumbein and Pettijohn, 1938). The sand, silt and clay per cent of sediments from different sedimentological areas were plotted in triangular diagrams (Shepard, 1954).

3.2.2. Organic matter

In all, the silt-clay fractions (less than 62 microns) of 125 bottom sediments from five stations, were subjected to chemical analysis for the determination of their organic matter content. The portions of dried sediment samples used for chemical analysis were washed with distilled water repeatedly to remove salts.

Grout (1925) expressed the view that the chemical composition varies from one size fraction of the sediment to another of the same deposit. El Wakeel and Riley (1961) have emphasised the need for taking up a restricted size grade of deposits and studying them separately instead of the entire bulk sediments as it is. In view of these and in order to avoid the effect of coarse fraction and large quantity of terrigenous material and macrobenthos on the chemical composition of deposits, the organic matter has been determined in the silt-clay fractions of the estuarine sediments.

In the present study, the organic carbon present in the sediment sample was estimated by the wet oxidation method of El Wakeel and Riley (1957), which consists of oxidising the organic carbon present in the sample by a known quantity of chromic acid and determining the amount of acid consumed by titration against ferrous ammonium sulphate. The amount of organic matter in the sediment is obtained by multiplying the organic carbon values by a factor of 1.724, which has been recommended by soil chemists (Trask, 1955).

3.3. Bottom fauna

In recent years, several reviews have appeared (Gunter, 1957; Thorson, 1957a; Holme, 1964; Hopkins, 1964; Reys, 1964) in which the sampling instruments and techniques used for sampling the benthos are discussed. The selection of an instrument depends largely on local conditions - the size of the research vessel, depth of water, nature of bottom deposits and the type of sample required.

The selective sampling of bottom is still the main technique employed in the study of benthos. The inadequacy of the present sampling instruments and the need for considerable improvements, particularly in quantitative sampling techniques has been pointed out by many workers (Birkett, 1958; Holme, 1964). Modern techniques and equipments like under-water photography, television and scuba diving are coming into common use at least in certain regions of the world. Still for many workers on benthos, grabs, dredges, beam trawls and corers are the main equipments even today.

For the present study, quantitative samples of the macrofauna were taken using a van Veen grab with an effective sampling area of 0.1 m^2. Fortnightly samplings were done in the first year and monthly samplings in the second year. Altogether twenty-five fortnightly and twelve monthly samples were taken from selected stations. Holme and McIntyre (1971) suggested that five samples with a 0.1 m^2 grab are desirable from each station for quantitative work. Before routine sampling of macrofauna, a pilot survey was conducted and five grab samples were collected from each selected station. From the 't-test' conducted, it has been shown that two grab samples from each station were enough for quantitative study. Along with the grab samplings a few dredge hauls were also taken from each station using a dredge of 28 x 47 cm size. The dredge was mainly employed to collect epifauna and also species which are poorly distributed.

As soon as the grab was hauled up, the volume of the contents of the grab was measured in a graduated bucket, since this helped to assess the performance of the gear. Hand sieving was employed for separating the animals from the sediment. The mesh size of the sieve used is of critical importance and in general, it is suggested that 0.5 mm sieve should be used for macrofauna (Birkett and McIntyre, 1971). The grab contents were screened through a 0.5 mm square mesh sieve. The square mesh sieve is to be preferred, since it has a higher percentage of open area. After a cursory examination, the residue retained on the sieve was preserved in 5% neutral formalin and was taken to the laboratory for detailed sorting.

In the laboratory, samples were re-sieved and washed with fresh water to remove residual sediment and formalin. Materials retained on the sieve were then transferred into a black tray and were sorted by hand, making use of a stereo-microscope. All animals in each sample were identified up to species level, counted and stored in 4% neutral formalin for further studies. To facilitate comparison of values, the numbers of animals per haul were converted into values per square metre. This facilitates a fair comparison with quantitative surveys of the benthos from other areas (Thomson, 1957a).

Biomass of aquatic organisms is usually measured by weighing the organisms after removing the external water and emptying the water from cavities (Crisp, 1971). Biomass values of macrobenthos are presented in wet and dry weight measurements. Both wet and dry weights were taken after preservation in formalin.

The wet weights of macrobenthos belonging to different groups of animals were taken separately. The shells of molluscs and the tubes of tube building species were removed before weighing. Lovergrove (1966) has shown that preservation can affect changes in biomass. The changes are marked during the first few days of preservation and thereafter an equilibrium is attained. Therefore the wet weight for the present study was always taken eight weeks after preservation, facilitating a uniform change during preservation in all cases.

The dry weight of the different animal groups was separately taken. Lovegrove (1966) recommended drying the animal tissue at 60°C for 16 hours as the best method for determining the dry weight of plankton and this procedure was followed for determining the dry weight of macrobenthos. The animals were washed in distilled water to remove extraneous salt and formalin before estimating the dry weight. Dry weight of animals weighing more than 100 mg was taken and treated separately. For comparison of values, both wet and dry weights of animals per haul were converted into values per square metre.

4. HYDROGRAPHY

The hydrography of the Cochin Estuary has been investigated by Balakrishnan, 1957; Ramamritham and Jayaraman, 1963; George and Kartha, 1963; Cheriyan, 1967; Qasim et al., 1968; Qasim and Gopinath, 1969; Josanto, 1971a; Nair and Tranter, 1971; Haridas et al., 1973; Sreedharan and Salih, 1974; Joseph, 1974 and Unnithan et al., 1975. Most of these works have been based on a single sampling or restricted to a single season. A detailed investigation of the hydrography of the Cochin Estuary for all the seasons of the year was carried out to establish the proper correlation of the hydrography with the bottom fauna. In the present study, hydrographical parameters such as surface water and bottom sediment temperature, surface water and bottom water salinity and dissolved oxygen and rain-fall were studied during the period from March 1974 to March 1976.

Results and Discussion

Hydrographical conditions of the estuarine system depend on the interaction of the sea and the fresh water, the sea water dominating the system in summer and fresh water during monsoon months. A seasonal pattern is thus evident in the variation of the parameters. Based on the hydrographical parameters of the Cochin Estuary studied, three definite seasons can be recognized, a pre-monsoon period (February to May) of high salinity, a monsoon period (June to September) of very low salinity, and a post-monsoon period (October to January) of progressively increasing and fluctuating salinity. Similar observations were also made by Goerge and Kartha (1963) and Nair (1965).

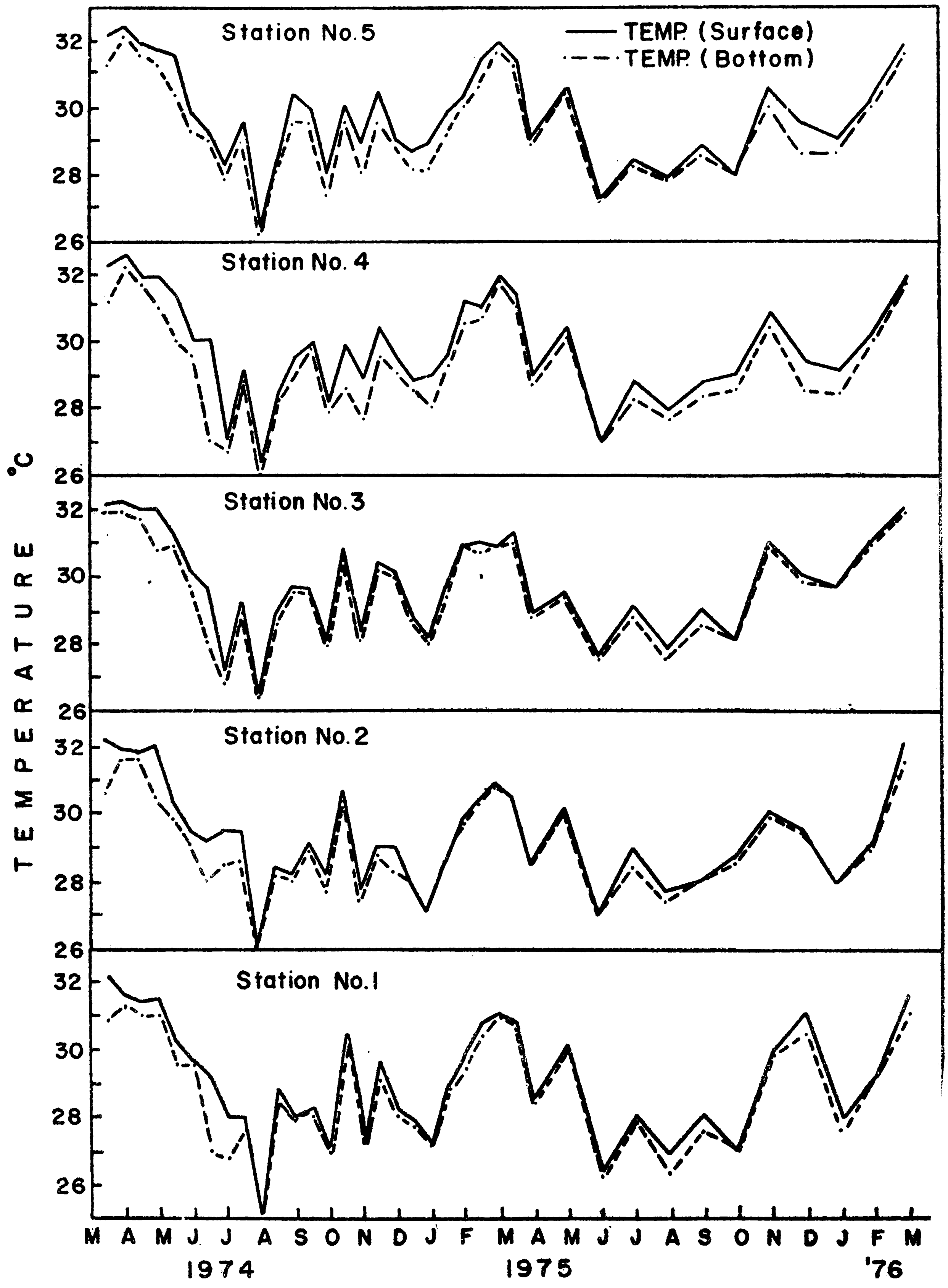
4.1. Temperature

The details of surface water and sediment temperature are given in Fig.2.

Pre-monsoon (February to May):

In both the years there was a progressive increase in temperature as the summer advanced, from February to April. In January, the surface water temperature at station I near the mouth of the estuary was 27.2°C and the sediment temperature was 27.1°C. In February and March, the surface temperature increased to 29.8 and 31.0°C respectively. The sediment temperature also correspondingly increased to 29.4 and 30.9°C. The variation in sediment temperature in station I, at the mouth of the estuary was 29.5 to 31.3°C. At station III, in the middle region of the estuary, it ranged from 30.9 to 31.9°C and in station V, at the fresh water side of the estuary the range was from 30.3 to 32.1°C. For the region as a whole, the maximum temperature of surface water (32.5°C) and sediment

FIG.2


Station No.5
TEMP. (Surface)
TEMP. (Bottom)
Station No. 4
Station No.3
Station No.2
Station No.1
TEMPERATURE °C
32
30
28
26
M A M J J A S O N D J F M A M J J A S O N D J F M
1974
1975
'76

(32.2°C) was recorded in April at station IV.

Monsoon (June to September)

The period of South West Monsoon coincides with the period of minimum surface and sediment temperature. From June onwards, with the onset of South West Monsoon, the temperature began to fall and the lowest temperature for surface and sediment occurred in the month of August in the first year, and June in the second year. In May, the temperature at station I was 31.5°C at the surface and 31°C at bottom sediment. The lowest temperature of 25.1°C at the surface water and 25°C at the bottom sediment was recorded during the month of August at station I. The fall in temperature in this station was 6.4°C in the surface layers and upto 6°C in the bottom sediment. In the other stations, it ranged from 5.7 to 6.2°C at bottom sediment. Bottom sediment temperature varied from 25 to 28.4°C at station I near the mouth of the estuary, from 26.4 to 29.5°C at station III in the middle region and 26.1 to 29.5°C at station V in the fresh water end of the estuarine system.

Post-monsoon (October to January)

A steady increase in surface water and sediment temperature was observed during the post-monsoon period at all the stations. The variation in bottom sediment temperature in station I was 26.9 to 30.3°C. At Station III, in the middle region, it ranged from 27.9 to 30.6°C, and in station V, the range was from 27.3 to 29.5°C.

Temperature of the estuary is seldom constant and the variations are, to a large extent, due to changes in season, depth and physiography. The distribution of temperature in the Cochin Estuary is mainly affected by South West Monsoon. For the estuarine system as a whole, the pattern of variation of temperature is bimodal. A similar bimodal type of oscillation of temperature was noticed by other workers in the Cochin Estuary (Haridas et al.,1973). For all the stations put together, the lowest temperatures of surface and bottom sediment recorded were 25.1 and 25°C respectively at station I at the mouth of the estuary during August and the highest 32.5 and 32.2°C respectively at station IV, in the upper reaches of the estuarine system during April. The temperature usually decreased with depth. It was found during the present study, that in stations having shallow water, the temperature did not exhibit much difference between the surface water and bottom sediment.

During March-April, the atmospheric temperature is high and there is practically no rainfall. This results in high surface water and sediment temperature during this period. From June onwards, with the onset of the monsoon, changes in the water temperature become apparent. The months of June, July, and August can be considered as the active period of South West Monsoon in the area under investigation. These are accompanied by a gradual fall at the surface water temperature and bottom sediment temperature. As is evident from the data, from the beginning of the monsoon, temperature shows a decrease. The decline in surface water and bottom sediment temperature during the monsoon were highly significant. Sankaranarayanan and Qasim (1969) stated that the influx of fresh water into the estuarine system is not the sole factor in bringing down the bottom water temperature in the estuary, but the intrusion of a tongue of cold water from the sea may also be a significant factor. It has also been reported that cold water from the upwelled area entering on the shelf may contribute to the decrease in temperature at the mouth of the estuarine system (Ramamritham and Jayaraman, 1963).

4.2. Salinity

Salinity distribution in the estuary is a result of the combined action of water movement induced by fresh water discharge, tidal variation and mixing process. Depending upon the degree of mixing between the fresh water and salt water, the estuary may vary from well mixed type to a stratified type.

The distribution of surface and bottom salinity values are given in Figs. 3 and 4.

Fig. 3. Rainfall (mm) and salinity (‰) values of surface and bottom waters at station I.

FIG.3

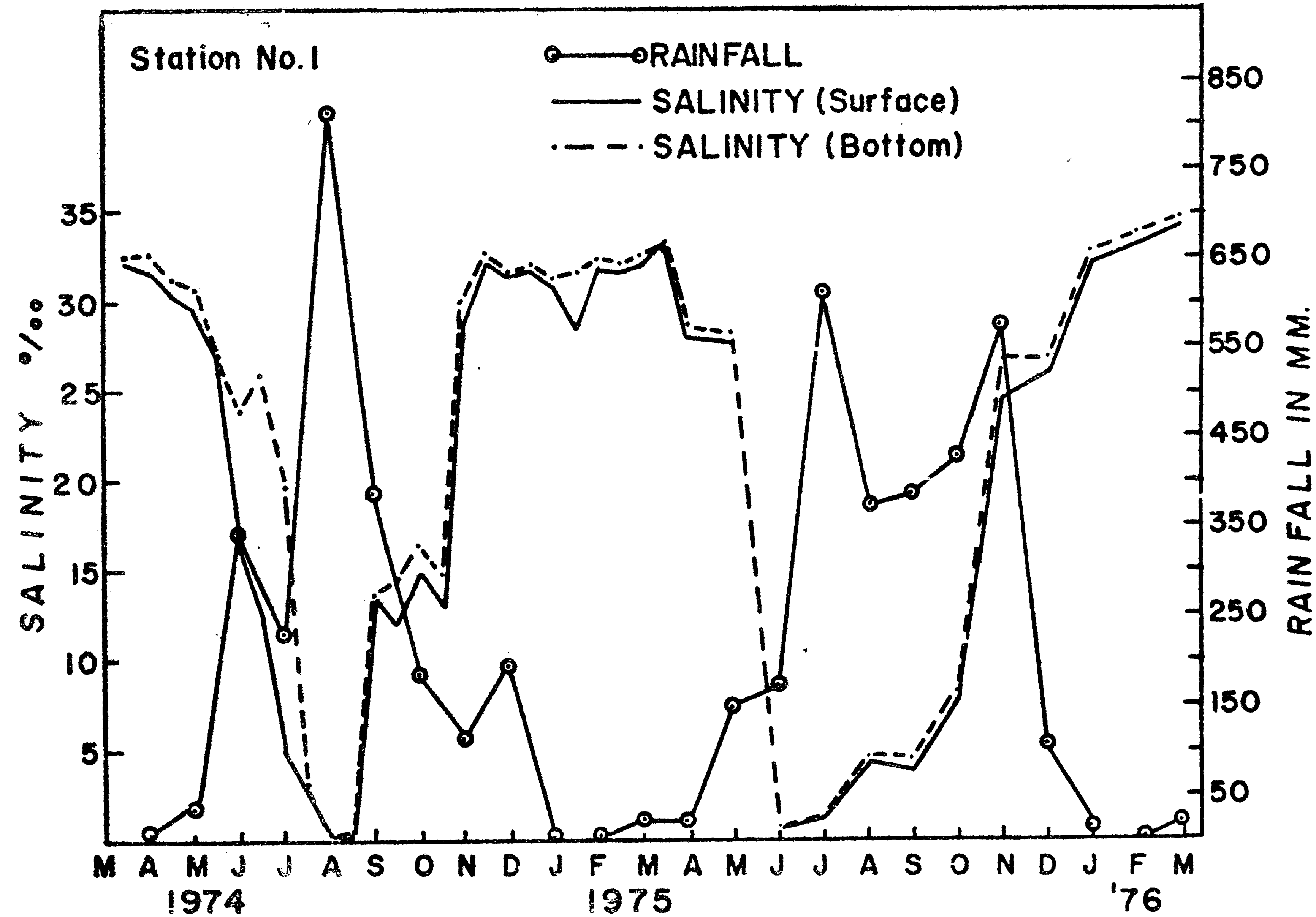
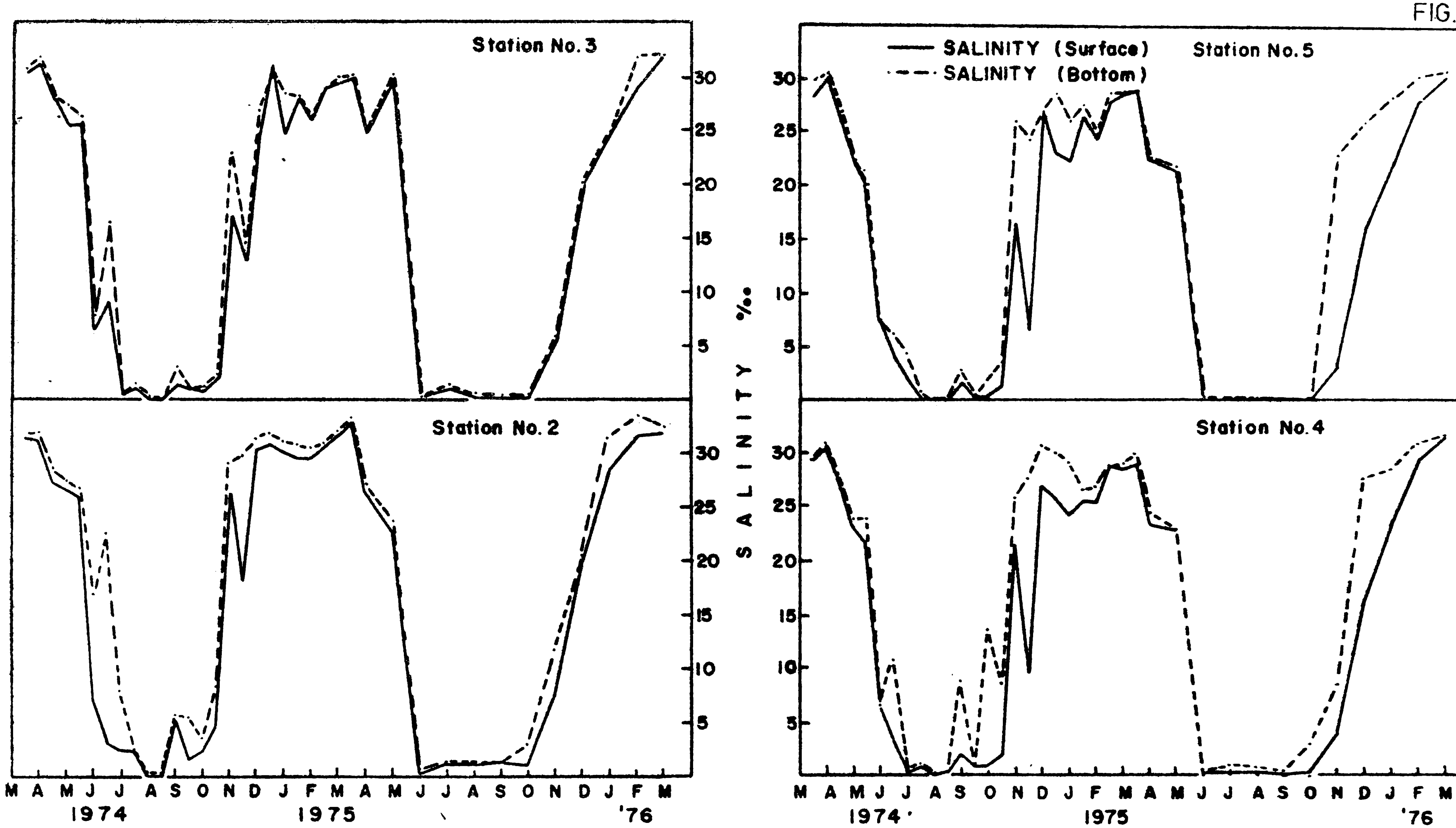

Station No.1
RAINFALL
SALINITY (Surface)
SALINITY (Bottom)
SALINITY ‰
35
30
25
20
15
10
5
RAIN FALL IN MM.
850
750
650
550
450
350
250
150
50
M A M J J A S O N D J F M A M J J A S O N D J F M
1974
1975
'76

Fig. 4. Mean salinity (‰) values of the surface and bottom waters at stations II to V.

FIG. 4


Station No. 3
Station No. 2
Station No. 5
Station No. 4
SALINITY (Surface)
SALINITY (Bottom)
S A L I N I T Y ‰
30
25
20
15
10
5
M A M J J A S O N D J F M A M J J A S O N D J F M
1974
1975
'76

Pre-monsoon (February to May)

The pre-monsoon period exhibited relatively stable salinity in the estuary. The influence of the sea water was very much pronounced as the intrusion of saline water was traceable upto the head of the estuary (Haridas *et al.*, 1973). At the mouth of the estuary (station I), the bottom salinity varied from 32.0 to 33.13°/... In the middle region (station III), the bottom salinity varied from 26.22 to 29.96°/.. and from 24.88 to 28.89°/.. at the upper reaches (station V). The pre-monsoon period is dry with minimum rainfall, and the maximum salinity was observed during this period at all the stations. For the region as a whole, the maximum bottom salinity of 33.13°/.. was recorded during March at station I, located closer to the barmouth.

Monsoon (June to September)

Drastic changes in salinity structure were observed with the onset of the South West Monsoon. There is a considerable lowering of salinity both in the surface and bottom waters at all the stations during the commencement of the South West Monsoon. Salinity began to fall with the onset of the South West Monsoon and for the region as a whole, the lowest salinity values both for the surface and bottom waters were recorded during the month of August in the first year and June in the second year. During the years of observations, very low saline conditions at bottom water (0.13 to 2.81‰) prevailed at all the stations during June to August, when the South West Monsoon reached its peak.

Post-monsoon (October to January)

A steady and gradual increase in salinity at all stations was observed during the post-monsoon period. The salinity steadily re-established from the mouth towards the head of the estuarine system. By November, the bottom salinity increased from 16.38‰ in October to 31.55‰ at the mouth of the estuary. A corresponding increase could also be observed at all the other stations, both in the surface and along the bottom. The variation in salinity in station I at the mouth of the estuary was from 14.89 to 32.31‰. At station III, in the middle region it ranged from 1.26 to 31.02‰ and in station V, at the fresh water side of the estuary, the range was from 0.42 to 28.62‰.

Among all the hydrographical parameters studied, salinity was found to be the most fluctuating factor. The salinity, in general, decreases from the mouth of the estuary towards the head. The extent of intrusion of saline water depends on the strength of the tidal influx and fres water discharge which differ with seasons. A higher bottom salinity was always observed, which showed the penetration of high saline sea water along the bottom and indicating a two-layered flow. This extension of high saline sea water into the estuary has also been noted by Ramamritham and Jayaraman (1963). The pre-monsoon period exhibited relatively stable saline environment and the influence of the sea water was very much pronounced as the intrusion of saline water can be traced upto the head of the estuary. There was a progressive increase in salinity at all the stations with the advancement of summer. Kendall's rank correlation coefficient matrix (Sokal and Rohlf, 1969) shows that the salinity of the estuary was found to be significantly positively correlated with the temperature (Tables 1 to 10). The salinity at all the stations exhibited considerable increase in March and April and this period may be interpreted as the season of the highest salinity, when the influence of sea water and rate of evaporation was at its maximum throughout the estuary.

The South West Monsoon is characterized by heavy rainfall and there is a decrease in salinity values both in the surface and bottom waters at all the stations during this season. This is because of the strong fresh water flow pushing back the high saline sea water and the penetration of sea water was restricted. During the peak of the South West Monsoon (June to August), the estuary becomes completely filled with fresh water. The quantity of fresh water discharged in the backwater through the rivers and land run off is greater, so that the tidal influence becomes almost negligible.

A steady increase in surface water and bottom water salinity was observed at all the stations during the post-monsoon period. With the termination of the monsoon season (in October) and the decrease in fresh water flow, a high saline condition begins to develop all over the estuarine system. During the post-monsoon period, the salinity distribution is unstable, which is probably due to the continued vertical mixing process.

The salinity variations clearly indicate a bimodal fluctuation in the region of study. The fluctuations in the salinity of the surface layers are well correlated with the rainfall of the period of investigation (Fig.3).

4.3. Dissolved oxygen

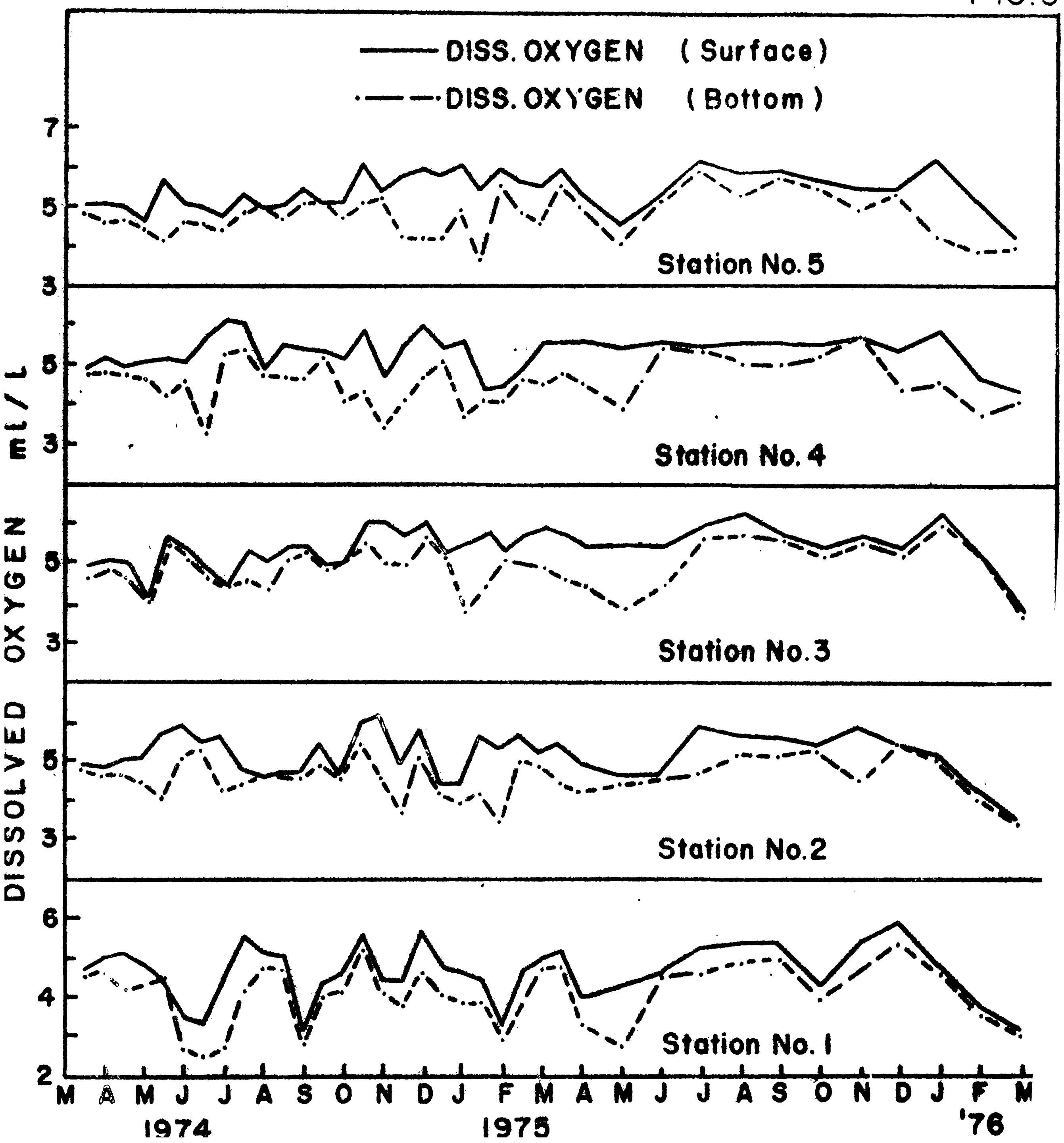
The values for dissolved oxygen in the surface and bottom waters are given in Fig.5.

Pre-monsoon (February to May)

In general, the higher oxygen values were observed in the late pre-monsoon period and the lower values were

Fig. 5. Mean dissolved oxygen (ml/L) values of the surface and bottom waters at stations I to V.

FIG. 5



DISS. OXYGEN (Surface)
DISS. OXYGEN (Bottom)
DISSOLVED OXYGEN ml/L
Station No. 5
Station No. 4
Station No. 3
Station No. 2
Station No. 1
M A M J J A S O N D J F M A M J J A S O N D J F M
1974
1975
'76

found during the early pre-monsoon periods, when the salinity and temperature are high. Dissolved oxygen values of bottom water varied from 4.2 to 4.6 ml/L at the mouth of the estuary, from 4.0 to 5.4 ml/L at the middle region and 4.1 to 4.8 ml/L at the upper reaches.

Monsoon (June to September)

The influence of South West Monsoon could be felt in the distribution of oxygen values also. During the South West Monsoon, high dissolved oxygen values were obtained for the surface water throughout the estuarine system. At the bottom water, for the region as a whole, the maximum value of 5.4 ml/L was recorded at station IV in the month of July. However, at the mouth of the estuary at station I, dissolved oxygen content of bottom water showed a decrease during South West Monsoon and the minimum value of 2.42 ml/L was recorded in June 1974. Dissolved oxygen values at bottom water varied from 2.42 to 4.7 ml/L at station I near the mouth of the estuary, 4.4 to 5.23 ml/L at station III in the middle region, and 4.4 to 5.12 ml/L in station V at the upper reaches.

Post-monsoon (October to January)

Just after the monsoon period, a slight decrease in the dissolved oxygen values was observed throughout the estuarine system. The decrease in dissolved oxygen at bottom water in station I at the mouth of the estuary was from 5.21 to 3.76 ml/L . At station III, in the middle region, it ranged from 5.67 to 4.98 ml/L and in station V, at the fresh water side the range was from 5.25 to 4.21 ml/L .

Like salinity and temperature, dissolved oxygen values also show seasonal variations. Dissolved oxygen, both in the surface layers and bottom waters, showed a distinct pattern of seasonal fluctuations in the entire area of study. The higher values of dissolved oxygen were found at surface and bottom waters during the South West Monsoon periods in all the stations except station I. The precipitation, the increase in fresh water influx, and decrease in temperature were favourable for an increase in the dissolved oxygen values during this period. Qasim et al., (1969) stated that the higher oxygen concentration during this period could be due to the higher primary production occurring in the surface layers during the monsoon period. Nutrient concentrations are also higher during the South West Monsoon in the Cochin Estuary (Sankaranaray and Qasim, 1969). The bottom water at station I showed a decline in dissolved oxygen values between June and August This could be due to the decomposition of organic matter and the influx of cold sea water from the upwelled areas. The dissolved oxygen content at the mouth of the estuary is relatively lower. A similar situation has also been reported by Sankaranarayanan and Jayaraman (1972) at the Mandovi and Zuari estuaries at Goa. After the peak of the South West Monsoon, there was a decrease in dissolved oxygen values in September and December. Then onwards, a stable condition is observed which continued throughout the post-monsoon period.

5. SEDIMENT

Amongst the physical environmental factors, the nature of the substratum has the greatest influence on the distribution and abundance of the benthic population. The significance of sediments as an important abiotic factor in the qualitative and quantitative distribution of bottom fauna has been recognised by several workers (Thorson, 1957b, 1958; Sanders, 1959; Brett, 1963; Muus, 1967; Johnson, 1971; Bloom et al., 1972). The granulometric composition and the percentage of organic matter in the substratum are the most important factors which influence the distribution and abundance of bottom fauna. The nature of the sediment in any particular area is determined by the complex interaction of a large number of factors, namely, (1) factors determining the source and supply of sedimentary material; (2) factors determining the transportation, and (3) factors determining the deposition. If the interaction of the various factors remains stable over a period of time, the nature of the sediment will continue substantially unchanged. Any short term or long term change taking place in any one of these factors will be followed by alteration in the nature and composition of the sediment. During the process of transportation and deposition, the sediment is subjected to physical and chemical adjustment which are reflected in its characters. Thus the sedimen of any particular region is a unique assemblage of matter retaining its own character and complexity (Nelson, 1962). The nature of the sediment in an area, may in turn give an indication of the factors operating in the transportation and deposition of sediments in that particular region. All these clearly show the importance of the study of sediments in understanding the complex of ecological factors significant to benthic organisms.

Studies on the physico-chemical aspects of the sediments in the Cochin Estuary are very few. Josanto (1971b) conducted an investigation on the grain size distribution of sediments of the Cochin Backwaters. Veerayya and Murty (1974) have also studied the distribution of sediments in the Vembanad Lake. Murty and Veerayya(1972) have given an account of the distribution of orgenic matter in the Vembanad Lake. However, a detailed investigation on the sediments of the Cochin Estuary covering all the seasons of the year is lacking. The present study covers an year-round investigation of the grain-size characteristics and percentage of organic matter of the sediments in the Cochin Estuary.

Results and Discussion

5.1. Grain Size:

The details of the texture of the sediments are given in Tables 11 to 15 and figures 6 and 7. The nature of the bottom observed during the course of the present investigation showed that the composition of the sediment varies markedly from station to station (Fig.6). From the type of the sediment studied, the area under study comes under four different categories:

(1) Stations covered by clayey-silt with very little sand fraction - stations I and II;

(2) Station with a dominance of sand fraction - station III;

(3) Station covered by sand, silt and clay in more or less equal proportions - station IV;

(4) Station covered by sandy mud - station V.

Percentage Distribution of Different size Fractions of Sediments:

Station I

At the mouth of the estuary in station I, the sediments are of clayey silt. The silt content varies between 41.26 to 72.33%. The clay content of the sediment ranges from 21.10 to 49.15%. In station I, sand percentage is low and it varies between 0.34 to 23.99. The sand percentage was relatively high during pre-monsoon period in both the years of investigation.

Station II

The sediment was characterized by high fraction c

Fig. 6. Sand, silt and clay percentage of the sediments from stations I to V.

FIG.6

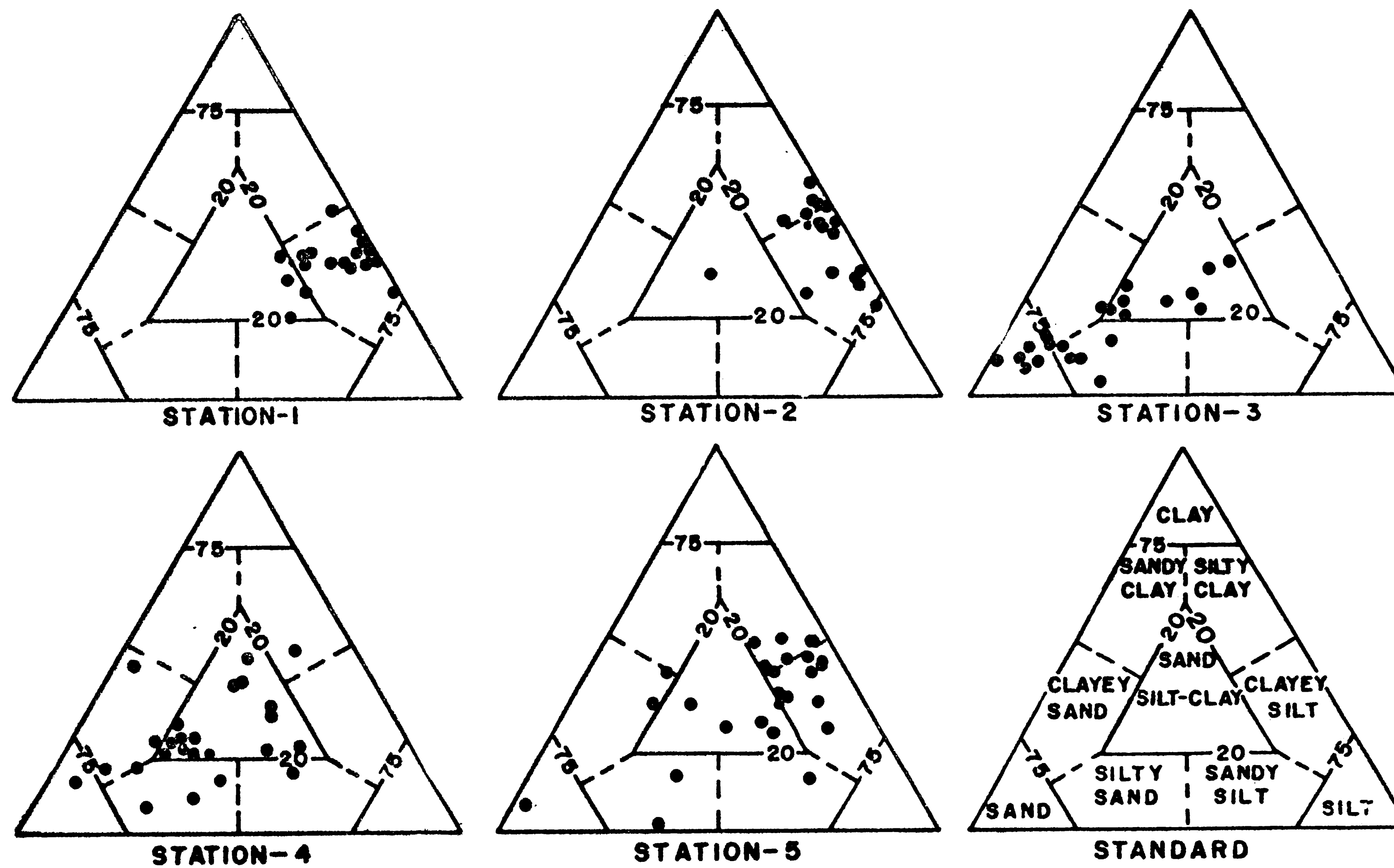
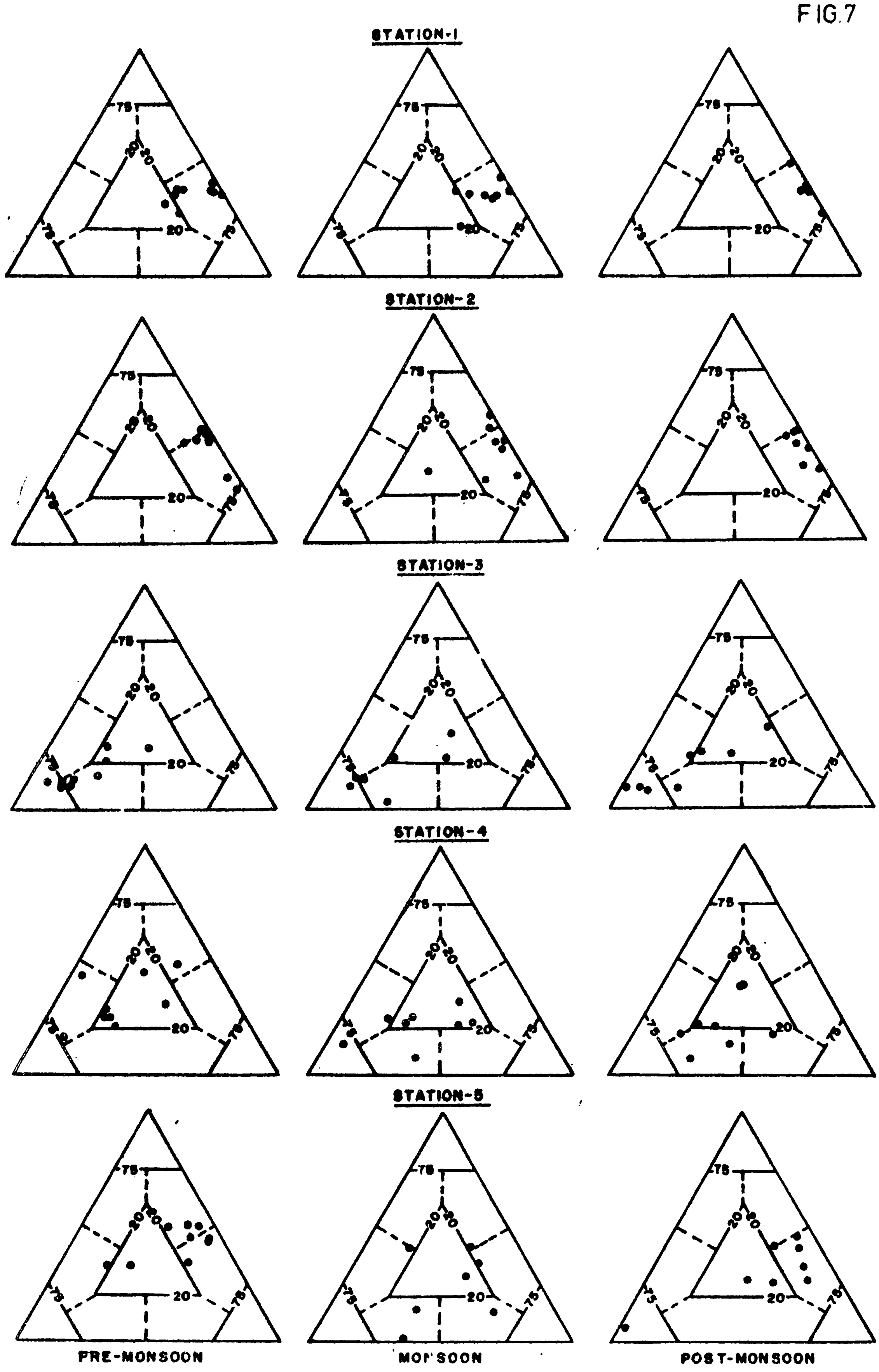

STATION-1
STATION-2
STATION-3
STATION-4
STATION-5
STANDARD
CLAY
SANDY CLAY
SILTY CLAY
SAND SILT-CLAY
CLAYEY SAND
CLAYEY SILT
SILTY SAND
SANDY SILT
SAND
SILT
75
20

Fig. 7. Seasonal variations in the sand, silt and clay percentage of the sediment at stations 1 to V.

FIG.7


STATION-1
STATION-2
STATION-3
STATION-4
STATION-5
75
20
PRE-MONSOON
MONSOON
POST-MONSOON

silt and clay (clayey silt in terms of texture). The percentage of silt and clay content varies between 32.56 to 75.03 and 22.12 to 55.75 respectively. The sand percentage is very low and it varies from 0.55 to 17.30.

Station III

Composition of sediment at this station differed drastically from that of stations I and II. The percentage distribution of sand in the region under study indicates that higher percentage values occur only in the sediments of station III near Thevara region and the sand fraction varies between 28.40 and 89.19%. Percentage of silt content varies between 1.26 and 45.42 and that of clay between 3.03 and 33.66.

Station IV

In station IV, sand, silt and clay percentage is more or less equal in proportion - and it ranges from 13.59 to 80.48, 4.20 to 53.91, and 6.43 to 47.90 respectively.

Station V

The station V comes under the category of substratum with sandy mud. The percentage of silt and clay is somewhat equal in proportion and it ranges from 11.95 to 63.03% and 1.60 to 49.90% respectively. In majority of the samples, sand percentage is low and it ranges from 4.81 to 81.70. The high percentage of sand is observed only in a few samples during South West Monsoon period in the second year of observation.

The sediment distribution pattern of an estuary depends on the sediment source, the texture of the sedimentary material supplied, the bottom topography and hydrographic features of the estuary. The bottom sediments in an estuary comprise the sediment load brought from the rivers as well as the material transported from the sea into the estuary by the flooding tide. Percentage distribution of different size fractions of the sediments varies from coarse to fine components. In terms of the texture of the sediments, sand is more confined to the middle region of the area under study, at station III, near Thevara. One conspicuous feature in the mouth of the estuary is that the sand fraction shows a decreasing trend. On the other hand, the silt and clay percentages show an increasing trend towards the mouth of the estuary. Clayey silt is mostly confined to the stations I and II. The presence of predominantly finer fractions of the sediments, especially silt and clay (clayey silt in terms of texture) in the mouth of the estuarine region is understandable as when the sedimentary material enters the marine conditions, it gets flocculated (Postma, 1967) and settles to the bottom. Gopinath and Qasim (1971) have already reported that silt in the estuarine area occurs during the pre-and post-monsoon periods, while the flushing of finer materials from the estuarine region to the sea takes place during the monsoon period.

5.2. Organic matter

A review of the earlier works shows that detailed accounts on the distribution of the organic matter content of the sediments in the Cochin Estuary is very scanty. Murty and Veerayya (1972) have given an account of the organic matter content of the sediments in relation to the distribution pattern of the sediments and hydrographic features.

The composition of sediment varies markedly from place to place. Therefore it is envisaged that there is a variation in the degree of concentration of organic matter in the silt-clay fraction of the sediment collected during the period of investigation. The organic matter contents of the sediment of the estuarine region range from 2.95 to 5.02%. The values are given in Tables 11 to 15. On an average, the sediments from the station I (with an average of 3.95%) and station II (with an average of 3.89%) near the mouth of the estuary have the highest content of organic matter. The sediments from station IV with an average of 3.67% have the lowest concentration of organic matter.

In general, the percentage of organic matter present in the estuarine sediment is high. All clay minerals except kaolin bind organic matter (Sanders, 1956) and the area with a high percentage of clay is capable of having a high proportion of organic matter. Since organic matter is trapped predominantly by clays and to a lesser degree by fine silts, coarse silts, and sands (Russel, 1950), the maximum organic matter is to be expected in the sediment with maximum clay. Thus there is a correlation between organic matter and clay content. The main reason for such a close correlation between organic matter content and texture of sediment has been attributed to the similar settling velocities of organic matter and fine minerogenous particles.

In the present study, although there is a certain amount of overlapping of values, it can be seen that finer sediments have higher percentage of organic matter than coarser sediments. This is quite in agreement with the findings of several workers (Emery and Rittenberg, 1952; Bader, 1954; Van Andel and Postma, 1954; Trask, 1955; Rao, 1960, 1967; Naidu, 1968; Murty et al.,1969; Murty and Veerayya, 1972; Dora and Borreswara Rao, 1975). The present data clearly show that the silty clay in stations I and II near the barmouth of the estuary contains a higher percentage of organic matter than in station IV, where sand, silt and clay fractions are more or less in equal proportions. The distribution of organic matter in the estuarine sediments follows broadly the grain-size distribution pattern, in that the finer sediments, viz., silty clays and clayey silts have higher percentage of organic matter and the sands have a lower percentage of organic matter content with the other type of sediments sharing values in between.

The organic matter content of the estuarine sediment is generally dependent on sources like (i) land - through run off, and (ii) overlying waters - through organic productivity. With the influence of five rivers joining at different points, the source from the land is evident.

A comparison made with the sediments of the Chilka Lake on the east coast of India shows that, in general, the sediments of Cochin Estuary have a higher percentage of organic matter than the sediments of Chilka Lake. The average organic matter content of the Chilka Lake is 1.38% (Venkataratnam, 1967) which is much lower than the average for Cochin Estuary (3.78%).

6. BOTTOM FAUNA

6.1. Distribution and composition of bottom fauna

The estuarine fauna generally consists of marine, brackish water and fresh water forms. The estuarine animals must be able to tolerate wide-ranging variations in salinity. The number of marine species, which live in estuaries decline rapidly from the mouth of the estuary towards the head. Similarly, the number of fresh water species, which live in estuaries also decline from the head of the estuary towards the mouth.

The important macrobenthic groups obtained during the present investigations are Polychaeta, Crustacea and Mollusca. Altogether 91 taxa were identified during the sampling period from March 1974 to March 1976. These taxa included 4 species of coelenterates, 35 species of polychaetes, 28 species of crustaceans, 17 species of molluscs, 4 species of fishes, one species of Sipunculoidea, one species of Echiuroidea and one species of Echinodermata.

6.1.1. Coelenterata

They were distributed all over the estuary. Altogether four species were collected and among them *Cirianthus* sp. and *Milne-Edwardsia* sp. were abundant numerically. *Milne-Edwardsia* sp. was collected from all the stations and it was abundant at station IV. *Obelia bicuspidata* was also recorded from all over the estuary.

6.1.2. Polychaeta

Among the various animal groups represented in the estuary, Polychaeta was the dominant group and these animals were present in all the stations throughout the period of investigation. Altogether 35 species of polychaetes belonging to 28 genera were identified. Of these, 8 species can be considered as rare, since they were present only in very small numbers in a few samples. Sixteen species of polychaetes were distributed in all the stations and of these, *Ancistrosyllis constriata*, *Diopatra neapolitana*, *Lumbriconereis latreilli*, *Lumbriconereis* sp., *Nephthys oligobranchia*, *Paraheteromastus tenuis*, *Prionospio pinnata* and *P.polybranchiata* were dominant numerically. Among these, only six species, viz., *A.constricta*, *L.latreilli*, *Lumbriconereis* sp., *N.oligobranchia*, *P.tenuis* and *P.polybranchiata* were recorded throughout the seasons. In general, most of the polychaete species showed a preference for a substratum, where sand-silt percentage is high as evidenced by the occurrence of maximum numbers of them in stations III, IV and V. As far as the number of species are concerned, a maximum of 29 species of polychaetes were recorded from station IV. The polychaete fauna as a whole showed a decrease in number during the

South West Monsoon season. The maximum numbers of polychaetes were recorded during the post-monsoon period. This is mainly due to the recruitment of some of the species of polychaetes after the South West Monsoon season. In the case of Diopatra neapolitana, Fabricia sp., Lumbriconereis latreilli, Lumbriconereis sp., Paraheteromastus tenuis, Prionospio pinnata, P.cirrifera, P.polybranchiata, Polydora kempi and Nephthys oligobranchia, a variation in the numerical abundance was noticed due to recruitment. The largest numbers of polychaetes - 3600 and 5290/m^2 - were recorded from station III in November, 1974 and December, 1975 respectively.

6.1.3. Crustacea

Crustacean fauna was rich in terms of number of animals present in the grab collections. This group of animals were represented mainly by amphipods, isopods, tanaids, cumaceans, penaeid prawns, stomatopods, brachyurans and members of the family Alphedae.

6.1.3.1. Amphipoda

The amphipods were widely distributed in the estuary and they were relatively more abundant at stations III and IV and the highest number of them were recorded during December, 1974 and January, 1976 at station IV. Altogether four species, viz., Ampelisca zamboangae, Corophium triaenonyx, Eriopisca chilkensis and Grandidierell gilesi were collected from the estuary. Of these, only two - Eriopisca chilkensis and Grandidierella gilesi - were recorded throughout the seasons from all the stations. As far as Ampelisca zamboangae is concerned, the largest number of $6790/m^2$ was recorded from station IV in December, 1975.

6.1.3.2. Isopoda

Only two species, viz., Synidotea variegata and Cirolana fluviatilis were collected from the estuary. Both these species were recorded from all the stations and the highest number of $1650/m^2$ was recorded from station IV in January, 1976. Of the two, only Cirolana fluviatilis was collected throughout the seasons. Since Cirolana fluviatilis has been recorded from all the stations and throughout the seasons, it can be considered as a highly euryhaline form. Cherian (1977) has also considered Cirolana fluviatilis as a highly euryhaline form.

6.1.3.3. Tanaidacea

Tanaids were widely distributed in the estuary. Only two species, viz., Apseudes chilkensis and A. gymnophobia were collected from all the stations. Of these, A.gymnophobia was recorded throughout the seasons. A.chilkensis was very abundant in station II during the months of August to November, 1975. Of the total fauna in station II, 63.72% was constituted by crustaceans, when the percentage of the constituent groups was calculated for the entire period of investigation. In the case of A. chilkensis, the largest number of 10740/m^2 was recorded from station II in October, 1975.

6.1.3.4. Cumacea

The cumacea, though present in all the stations, were small in numbers at stations I and II. In the case of Iphinoe sp , an increase in number was noticed in November and December, 1974. The maximum number of 570/m^2 was observed in station III during November 1974.

6.1.3.5. Decapoda

The decapod fauna, especially prawns, were very rich in the estuary, but only a very few were obtained in the grab collections. Important species which were collected during the present investigation were Penaeus indicus, Metapenaeus dobsoni and M. affinis. Five species of Alphidae were collected and among them Alpheus malabaricus is dominant in terms of number and was recorded from all over the estuary. Brachyuran crabs were widely distributed in the estuary and they were relatively dominant in stations III and V. Altogether, 8 species of brachyuran crabs were identified and among them Ebalia *malefactrise*, *Litochetra* sp., *Rynchoplax* sp., and *Viaderiana* sp. were most common. Of these, *Viaderiana* sp. was dominant in terms of number and the maximum numbers were collected from station III, the recorded number being 210/m^2 during July, 1974.

6.1.3.6. Stomatopoda

This group was represented by a single species, *Squilla nepa*, which was obtained from stations I and II during November to March 1976. It was found only occasionally and even when present, was few in number.

6.1.4. Mollusca

The molluscan fauna in the estuary was very rich (Fig. 8 & 9). A total of 19 species of molluscs were collected from the five stations. Of these, only two - *Modiolus undulatus* and *Nuculana mauritiana* were abundant in terms of number. *Solen* sp. was collected from station V in comparatively big numbers during 1974. All the other species were rare as they were present only in small numbers. *M.undulatus* appeared in large numbers at stations I, IV and V. A good number of them were present in station I during May to July, 1974. The largest recorded number of this species was 1059/m^2 from station I. *M. undulatus* was also abundant in stations IV and V during the pre-monsoon period. *N.mauritiana* was collected from stations IV and V during March to August and the largest number of 39310/m^2 was recorded during June 1974 from station V.

6.1.5. Pisces

The fish fauna was very rich in the estuary, but only very few occurred in the grab collections. Only four species of fishes were collected and among them *Trypauchen vagina* was recorded from all the stations and it was abundant at station I.

6.1.6. Other Groups

The rest of the fauna consists of one species of Sipunculoidea, one of Echiuroidea and one of Echinodermata. Sipunculoids were more common and they were recorded from all the stations.

6.2. Number of individuals

The number of animals present in each sample taken from the five stations is given in Tables 16 to 20 and Figs.8 and 9.

The total number of macrofauna from individual samples showed considerable variations. Fig.10 shows the percentage of polychaetes, crustaceans and molluscs in the

Fig. 8. Number and dry weight (g) of macrobenthos per 0.1 m^2 at stations I to IV.

FIG.8

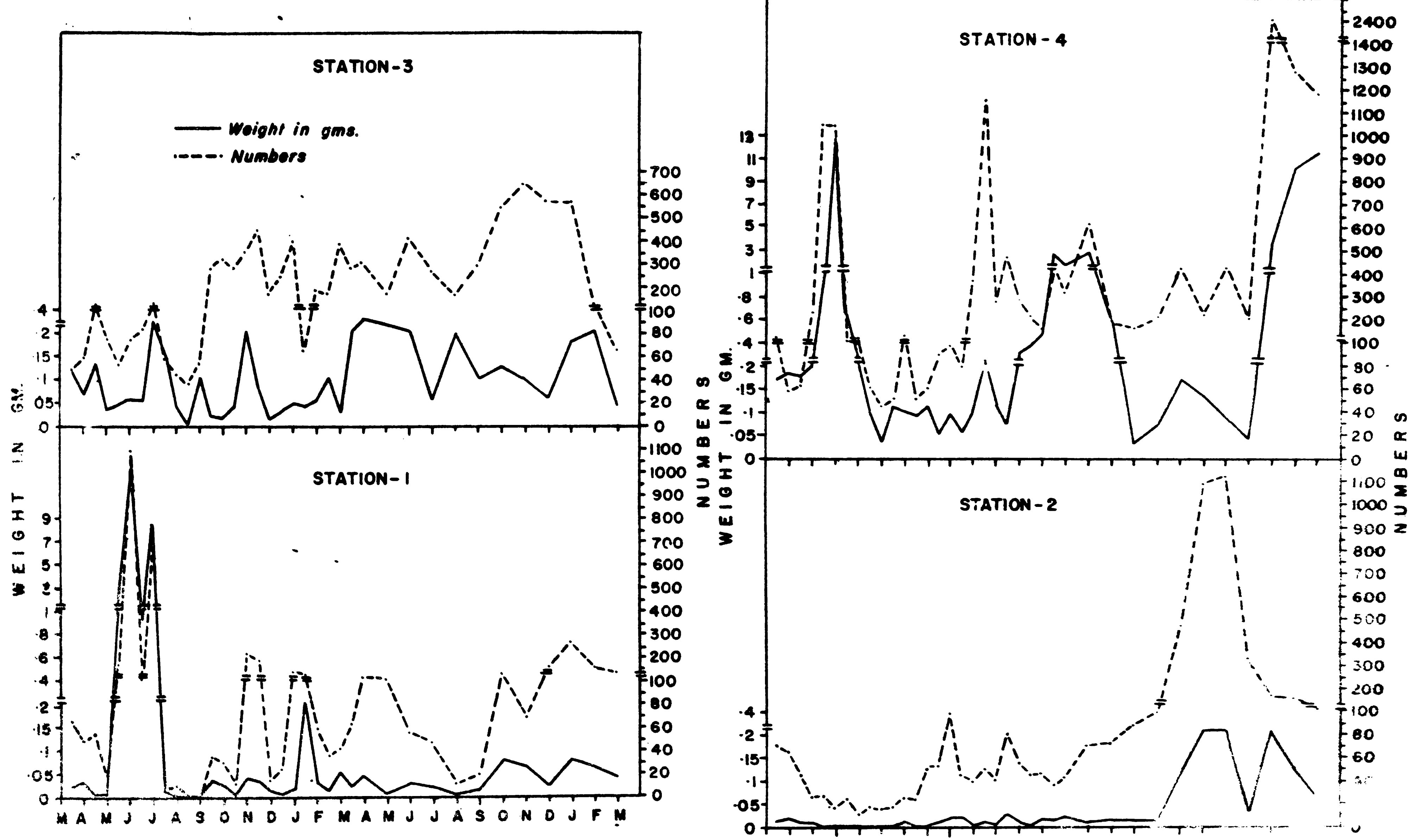
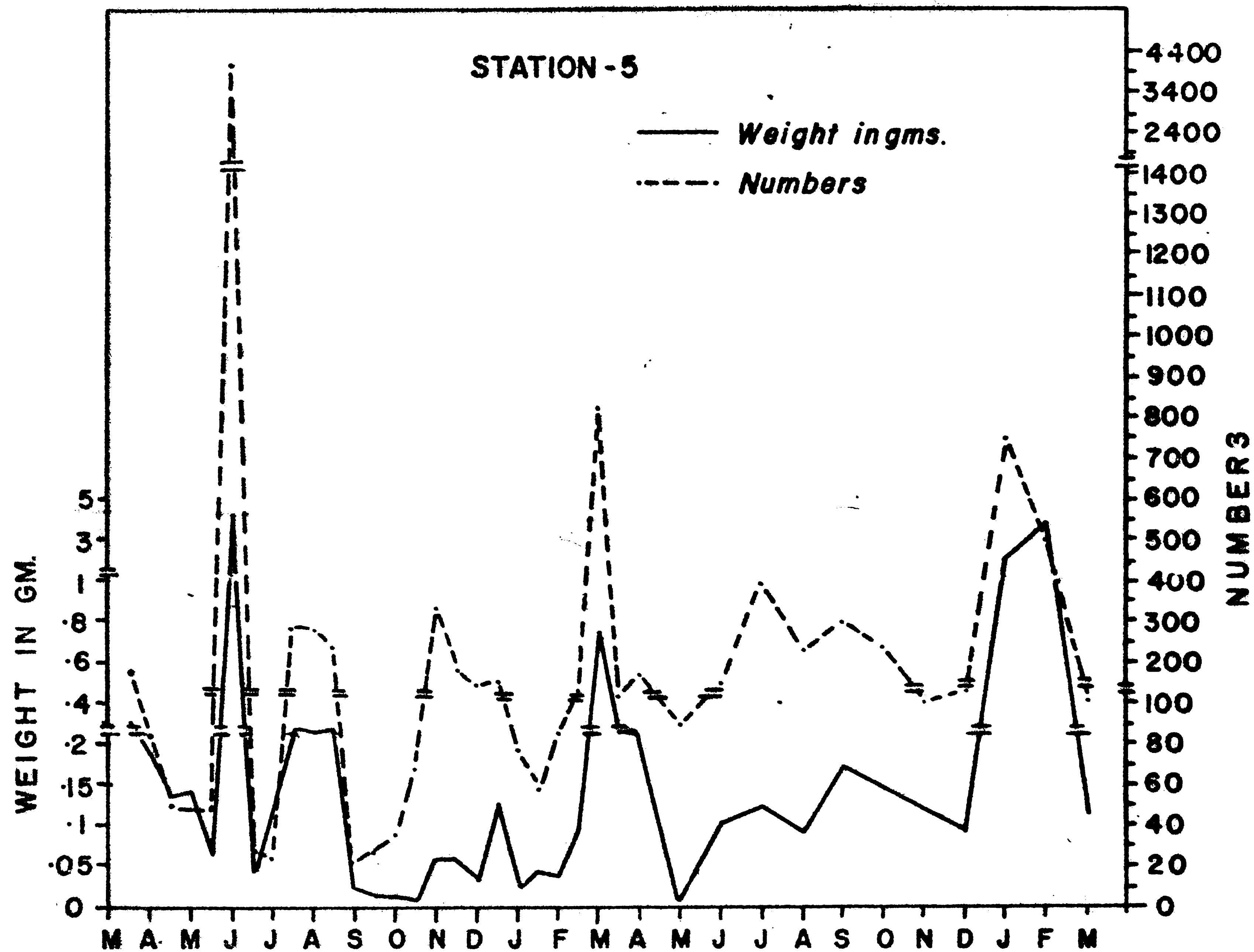

STATION-3
Weight in gms.
Numbers
STATION-1
STATION-4
STATION-2
WEIGHT IN GM.
NUMBERS
M A M J J A S O N D J F M A M J J A S O N D J F M

Fig. 9. Number and dry weight (g) of macrobenthos per $0.1\ m^2$ at station V.

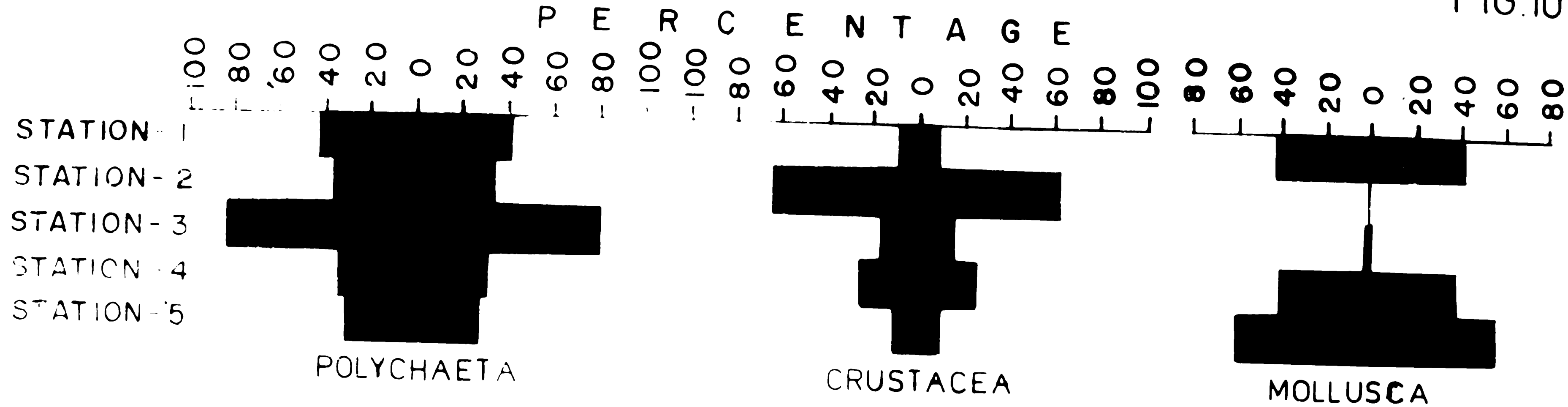
FIG. 9


STATION - 5
Weight in gms.
Numbers
WEIGHT IN GM.
NUMBERS
0
·05
·1
·15
·2
·4
·6
·8
1
3
5
0
20
40
60
80
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
2400
3400
4400
M A M J J A S O N D J F M A M J J A S O N D J F M

total fauna from each station. Polychaetes, crustaceans and molluscs constituted the bulk of the fauna and formed about 93 to 98% of the total in all the stations. In station I, polychaetes and molluscs formed 84.8% of the total population. But in the case of station II, polychaetes and crustaceans constituted 98.3% of the total with the crustaceans forming 63.7% of the total population. This is due to the very large number of Apseudes chilkensis collected during August to November 1975 and the largest number observed being 10740/m^2 in October. In station III, polychaetes constituted the bulk of the fauna and formed about 81.5% of the total population. This is mainly due to the recruitment of some of the species of polychaetes like Lumbriconereis sp., Paraheteromastus tenuis and Prionospio polybranchiata. In the case of station IV, polychaetes, crustaceans and molluscs formed 32.2, 26.2 and 38.9% respectively. But in station V, polychaetes and molluscs formed 88.7% of the total population. The number of individuals ranged from 10 to 10930/m^2 in station I at the mouth of the estuary and from 220 to 39870/m^2 in station V at the upper reaches of the estuary. It was observe that the maximum population density was in stations IV and V and the minimum was in station I. In station II, the fauna were comparatively poor in the first year of observation, but during the second year it showed a marked enrichment. This change was mainly due to the appearance

Fig. 10. Percentage of total polychaetes, crustaceans and molluscs at stations I to V.

FIG.10



PERCENTAGE
STATION - 1
STATION - 2
STATION - 3
STATION - 4
STATION - 5
100 80 60 40 20 0 20 40 60 80 100
100 80 60 40 20 0 20 40 60 80 100
80 60 40 20 0 20 40 60 80
POLYCHAETA
CRUSTACEA
MOLLUSCA

of large number of Apseudes chilkensis during August to November 1975.

There was a clear-cut variation in the number of organisms in the various regions of the estuary (represented by stations I to V). The results reveal that the stations with the highest number of organisms are located on the middle region of the estuary, that is, at stations III, Iv and V. In the stations with the highest population density, a dominance of five species of polychaetes, viz., Prionospio polybranchiata, Lumbriconereis sp., Paraheteromastus tenuis, Fabricia sp., Diopatra neapolitana, three species of amphipods, Ampelisca zamboangae, Grandidierella gilesi, Corophium triaenonyx, one of isopod Apseudes chilkensis and two species of bivalves Modiolus undulatus and Nuculana mauritiana were observed.

6.3. Faunal homogeneity of Polychaetes

It is obviously necessary in a community study to demonstrate that the species components of the included samples show faunal similarity (Sanders, 1960). The fauna of an estuary may be considered as occurring in biotic assemblage or as communities. These communities are usually populated by numerous individuals of a few species plus a few individuals of many species. The boundaries of these assemblages are controlled by salinity, substrate, oxygen and other environmental stresses. The similarity or homogeneity of the animals comprising these communities or the boundaries of these communities can be measured by gradient analysis techniques such as Jaccard's Coefficient (Whittaker, 1967), Kendall's rank correlation coefficient (Lie and Kelley, 1970) or the index of affinity (Sanders, 1960). Of these methods, Sanders' matrix method, the "trellis diagram" was adopted, because it is one of the best qualitative measurements of the relative abundance of species in two samples. This semiquantitative method has been applied by several workers in benthic community studies (Sanders, 1960; Wieser, 1960; Jayasree, 1976; Ristich et al., 1973). The trellis design is a convenient graphic expression of the index of affinity (Sanders,1960; Boesch, 1971).

The affinity analysis of polychaetes from the five stations during the first year was carried out by calculating the sum of the minimum per cents-in-common between all possible pairs of samples within stations and by arranging these values in a trellis diagram. (See Figs.11 & 12). (For details about the method, see Sanders, 1960; Wieser, 1960).

The affinity values or the faunal element common to each pair of samples within station I varied from 0 to 86 (September 2 - October 1 pair). At station II, the

Fig. 11. Trellis diagram showing the degree of affinity amongst the polychaete community at stations I to IV during the fortnightly sampling period.

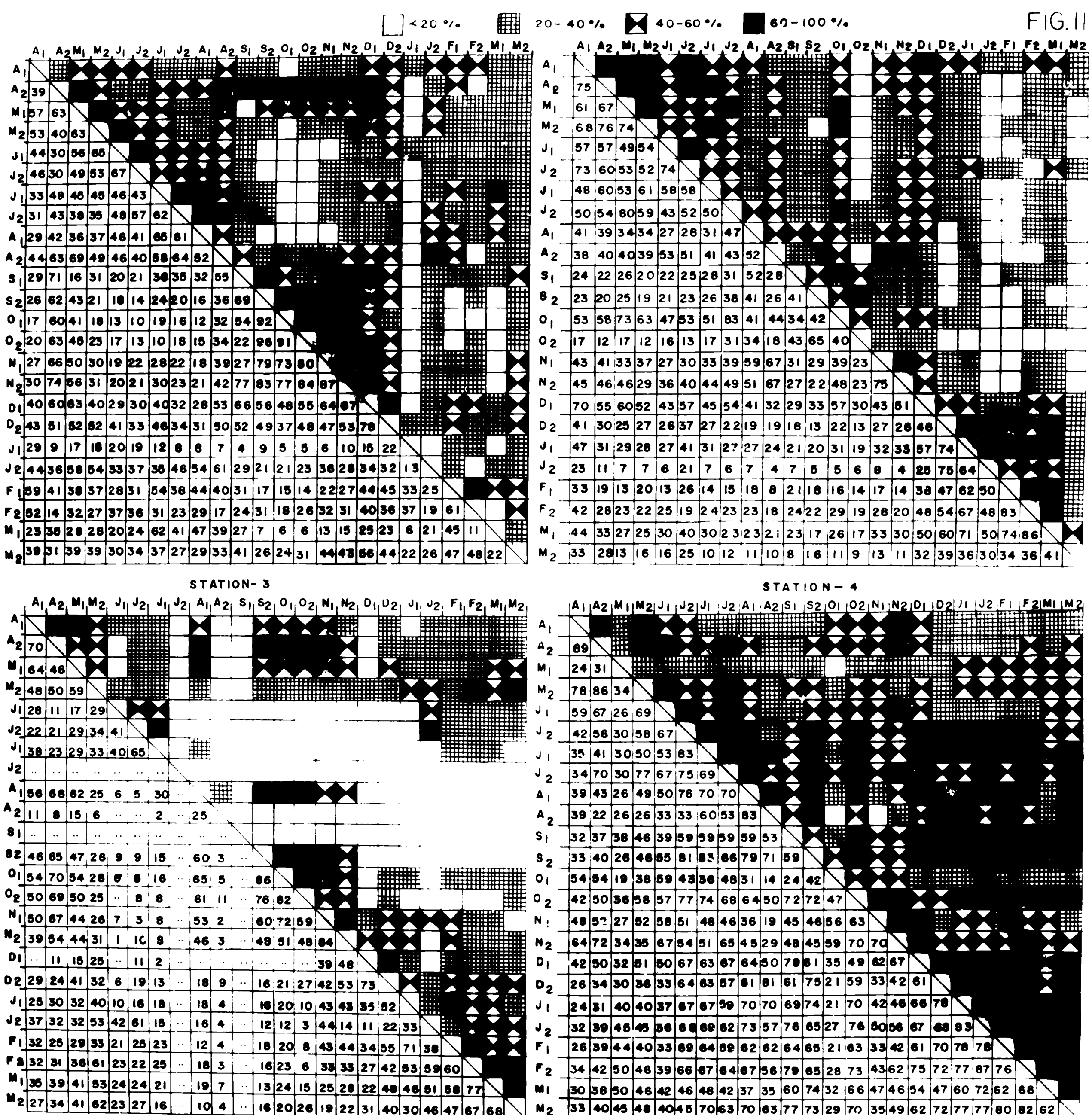


FIG. 11

Fig. 12. Trellis diagram showing the degree of affinity amongst the polychaete community at station V during the fortnightly sampling period.

FIG.12

□ < 20 %   ▦ 20–40 %   ⧗ 40–60 %   ■ 60–100 %

	A_1	A_2	M_1	M_2	J_1	J_2	J_1	J_2	A_1	A_2	S_1	S_2	O_1	O_2	N_1	N_2	D_1	D_2	J_1	J_2	F_1	F_2	M_1	M_2
A_1																								
A_2	69																							
M_1	62	51																						
M_2	62	54	61																					
J_1	48	60	40	69																				
J_2	49	44	58	64	39																			
J_1	42	57	24	34	53	35																		
J_2	35	25	10	41	60	24	39																	
A_1	31	26	..	27	37	6	42	59																
A_2	33	26	..	19	22	6	44	29	64															
S_1	30	26	..	27	37	6	23	59	70	40														
S_2	37	32	6	33	36	12	51	38	42	78	42													
O_1	24	22	..	8	11	6	44	18	58	78	28	75												
O_2	29	26	5	13	15	11	49	22	47	76	37	77	81											
N_1	42	31	11	17	20	9	22	31	36	47	37	28	29	31										
N_2	43	30	13	20	23	12	20	34	42	42	44	28	35	39	67									
D_1	50	37	17	35	36	22	34	40	51	52	53	41	39	46	54	77								
D_2	44	36	14	35	35	20	25	42	50	51	43	40	35	33	64	65	77							
J_1	42	35	13	21	24	19	44	29	46	50	46	45	42	47	62	53	64	65						
J_2	37	30	8	16	21	20	40	25	39	47	37	38	35	51	54	40	53	57	82					
F_1	39	40	17	26	30	15	35	31	33	44	51	29	28	38	53	57	65	60	68	54				
F_2	42	41	22	32	32	26	33	35	34	40	51	24	32	39	49	64	78	68	64	51	80			
M_1	47	48	18	29	31	24	39	37	28	39	52	30	26	45	54	52	63	58	68	60	76	78		
M_2	50	42	18	43	49	23	32	57	50	48	50	45	26	44	49	59	71	63	61	60	67	69	75	

STATION – 5

minimum affinity value was 14 (August 2 - October 1 pair) and the maximum 89 (April 1 - April 2 pair). In the case of station III, the minimum value was 4 (September 1 - January 1 pair) and the maximum value was 96 (September 2 - October 2 pair). In station IV, the minimum value was 4 (August 2 - January 2 pair, and November 2 - January 2 pair) and the maximum value was 86 (February 2 - March 1 pair) and at station V, the minimum value was 0 (May 1 - August 1, August 2, September 1 and October 1 pairs) and the maximum value was 82 (January 1 - January 2 pairs). The trend in the overall stability of the polychaete community at each station was found to be in an ascending order from stations I to III. The maximum stable community occurred at station III in the middle region of the estuary. The station nearest to the barmouth (station I) and at the fresh water side of the estuary (station V) were having the least stable community. From the trellis diagram it has also been observed that the faunal affinity between stations I and V is greater than the other three stations.

6.4. Species Diversity of Polychaetes

One of the major features of animal communities is their diversity, which describes the organization of a community in terms of species richness and species abundance. Species diversity varies from one environment to another. It has long been recognized that tropical regions support a more diverse fauna than the temperate and arctic regions. It has also been evident that the marine environment supports a larger number of species than the brackish water environment. The reasons why certain environments harbour different kinds of organisms, while others support a limited number of species are still unclear. Various theories based on time (Fischer, 1960; Simpson, 1964), climatic stability (Klopfer, 1959; Fischer, 1960; Dunbar, 1960); spatial heterogeneity (Simpson, 1964), competition (Dobzhansky, 1950; Williams, 1964), predation (Paine, 1966) and productivity (Connell and Orias, 1964) have been proposed to explain these differences.

A diversity index is a measure of the way in which individuals in an ecological community are distributed among species. It has two components, the total number of species and the equitability or evenness of distribution of individuals among the different species (Lloyd and Ghelardi, 1964). Diversity is usually held to encompass the variety of species in a sample and the abundance of individuals within each species. Diversity is at a minimum when all the individuals belong to the same species and at a maximum when each individual belongs to different species. A wide variety of indices have been proposed to measure diversity of samples. The two diversity indices which have been most widely used on benthic data are the Sanders (1968) rarefaction index and the information statistics of Shannon-Weaver, (Shannon and Weaver, 1963). After comparing a variety of indices Sanders (1968) concluded that only these two indices were independent of sample size. Therefore, Shannon-Weaver index method has been applied for the present work. It has been recently applied in many of the benthic community studies (Poore _et al._, 1975; Whitlatch 1977; Ankar and Elmgren, 1976).

The Shannon-Weaver index, derived from information theory,

$$H' = - \sum_{i=1}^{s} pi \log pi$$

where H' = diversity

S = total number of species

pi is the proportion of individuals in the population represented by the i^{th} of 's' specie

This function has the attribute of being influenced by both the number of species present and how evenly or unevenly the individuals are distributed among the constituent species. In other words H' is sensitive to both species and dominance diversities. Theoretically, the H' value obtained by this method can vary from zero (i.e. N individuals, all belonging to one species) to N (i.e. one individual each belonging to 'N' number of species). Thus a lower H' value is directly correlated with both a lesser number of species (i.e. lower species diversity) and a higher rate of species dominance and vice versa. Since the H' value is not variable with the total number of individuals in the sample, this method was found advantageous in comparing the species diversity and their mix amongst the stations investigated.

The H' values obtained for the polychaete fauna from all the five stations are given in Table 21 together with the total number of individuals and species. The H' values for stations I (0 to 2.21813) and II (0 to 2.13485) were lower than those of the other three stations, thus highlighting the prevailing lower number of species per given number of individuals and a higher number of species dominance at these stations. The diversity values for station III (0.57758 to 2.36257), IV (0.93280 to 2.55777), and V (0.46203 to 2.65218) were very close to one another.

A high number of species is a reflection of mature biological community and one under minimum stress. Boesch (1972), Johnson (1970), and Sanders (1960) have demonstrated that substrate, water depth and salinity are factors mediating fluctuations in community diversity. The estuarine habitat, in general, is considered to be ecologically severe, as a result, species diversity is low (Hedgpeth, 1957). In the present study, comparatively high diversity index values were observed at stations III, IV and V, where the substratum is composed of fine sand with small percentage of silt and clay. It is clearly evident from the table that species diversity of polychaete was greater during the high saline period (pre-monsoon) than the low saline period (monsoon). The lowest species diversity values were observed at all the stations during the South West Monsoon. It has also been observed that species diversity index is increasing from the mouth of the estuary towards the upper reaches. Diversity is related to environmental stability, thus the rapidly fluctuating environmental conditions of narrow shallow estuaries promote low diversity.

6.5. The Biomass

The quantitative distribution of benthic faunal groups as determined by both wet weight and dry weight is shown in Figs. 8 and 9 and Tables 22 to 26. Analysis of the basic data provides information on distribution of bottom fauna in relation to hydrography and substratum of the Cochin Estuary and also enables an assessment of benthic resources.

The maximum biomass was recorded from stations I, IV and V and the minimum from stations II and III. There are mainly three reasons for the increase in biomass in stations I, IV and V. First is the occurrence of large number of *Modiolus undulatus* and *Nuculana mauritiana* in the samples from these stations. Secondly, the contribution of individual specimens weighing above 100 mg was greater in station I. This was chiefly due to the presence of a gobid fish, Trypauchen vagina in these samples. Thirdly, the presence of large number of Diopatra neapolitana in the samples from these stations, particularly at station IV.

The total biomass from individual samples showed considerable variation (Figs. 8 and 9). Percentage contribution to the total biomass by the different groups is represented as bar diagrams (Figs.13 & 14). Only few species contributed significantly to the total benthic biomass, viz., two species of molluscs, three species of polychaetes, two species of crustaceans and two species of pisces made up the maximum percentage (roughly 95%) of the total macrobenthic biomass. Suspension feeders dominated in few samples at stations I, IV and V and were found to live mostly, strongly aggregated (eg., M. undulatus and M.mauritiana). Deposit feeders made up only a small percentage of the total biomass and were distributed more evenly in all stations.

The dry weight of the fauna from individual sample ranged from 0.018 g/m^2 to 141.521 g/m^2. The maximum biomass value of 141.521 g/m^2 was recorded from station I, during June 1974. Out of the total biomass value of

141.521 g/m^2, 98.87% of the biomass was constituted by molluscs alone. This was due to the large quantity of M. undulatus recorded from this station. Desai and Krishnankutty (1967a) have also observed dominance of molluscs in the benthic population of nearshore region, off Cochin on the South West Coast of India. M. undulatus ranked first and contributed maximum to the total benthic biomass. It is an epibenthic suspension feeder and occurs during pre-monsoon and early monsoon periods (January to July). Next to M. undulatus, N. mauritiana contributed much to the total biomass, especially at station V. Molluscs, second in importance in terms of number, contributed the highest percentage of biomass in stations I, IV and V. Their contribution to the total biomass in these stations varied from 70.79 (at station I) to 87.95% (at station V).

Following Holme's work (1953) the biomass values shown in Table 27 were taken as an index of standing crop of benthos. In terms of annual mean standing crop (dry weight) of bottom fauna, the station IV ranks first, showing 16.8563 g/m^2, followed by the station I, showing 7.7881 g/m^2 and station V, showing 4.4177 g/m^2.

As shown in the Table 27, in the study area as a whole, the average annual production during the first year of observation was 5.0881 g/m^2/yr and in the second year was 7.4948 g/m^2/yr. This increase in standing crop during the second year was due to the abundance of _M.undulatus_ and _N.mauritiana_ recorded in stations IV and V. In the stressed environment of the estuary significant year-to-year fluctuations in the standing crop of benthic species are to be expected. Success of spat fall of important species like _M.undulatus_ and _N.mauritiana_ was highly variable. Station II with maximum clay content of the sediment, observed throughout the period of investigation, exhibited a low standing crop and was poor in species number.

In terms of population density, polychaetes form the most dominant group. Though polychaetes were recorded in large numbers in all stations, particularly at stations III and IV, their contribution to the biomass was considerably low in all stations. The six species with the highest numerical densities, viz., _Nephthys oligobranchia_, _Lumbriconereis_ sp., _Prionospio polybranchiata_, _P.pinnata_, _Paraheteromastus tenuis_ and _Fabricia_ sp., hardly contributed to the total biomass, due to their small individual weights. Polychaete species, which were important in terms of biomass were _Diopatra neapolitana_, _Dendronereis aestuarina_, _Lumbriconereis simplex_ and _Prionospio pinnata_. The maximum biomass of polychaete was recorded from station IV. This was mainly due to the abundance of _D.neapolitana_ present in this station.

Crustaceans were recorded from all the stations and particularly they were abundant at stations II, III and IV, but their contribution to total biomass was considerably low. The three species with the highest numerical densities, viz., Apseudes chilkensis, Ampelisea samboangae and Corophium triaenonyx, hardly contributed to the total biomass due to their small individual weight. Two species of crabs, viz., Viaderiana sp. and Rynchoplax sp., which were abundant at stations III and V contributed much to the biomass values.

The other constituents of the macrobenthic fauna, which supported the biomass value were coelenterates (sea anemones), sipunculoids and two species of fishes belonging to the family Gobidae.

The maximum biomass as well as the population density was recorded from station IV. Leaving out station IV, when all the other stations were compared, from station I, the minimum number of animals were recorded. But when the biomass values were calculated (in terms of dry weight), station I ranked first among the other four stations. This was due to the large number of M. undulatus recorded in station I from May to July in the first year of observation.

The biomass showed a direct relationship with salinity. In all the stations, there was a decrease in biomass during the active period of the South West Monsoon. This decrease was more evident in stations I and II, near the mouth of the estuary. There was an increase in biomass in all the stations during the pre-monsoon period (Figs. 8 and 9).

The observation on the benthic biomass in the study area as a whole and of individual station gives a diversified picture of the distribution of benthic fauna. From the Figs. 8 and 9 it can be seen that the region of confluence of two different water masses (stations I and II) coincides with the zone of low benthic production. It is in this section that mixing of sea and fresh water is at its maximum and the ecosystem is therefore most unstable. Parulekar and Dwivedi (1975) have made similar conclusions with reference to benthic production in an estuarine complex of Goa.

7. DISCUSSION

7.1. Hydrography and Bottom fauna

Jones (1950) stated that the significant factors which may influence the distribution of bottom fauna are temperature, salinity and nature of bottom deposit. The most obvious basic characteristics of estuaries are the increased gradients and fluctuations of environmental factors relative to the more stable situation in the neighbouring sea and fresh water areas. The physico-chemical properties of estuarine waters vary considerably. They depend on volume and contents of the river water released, structural components of the estuarine bed, tides and macroclimate of the general geographic area. (Kinne, 1966). Odum (1970) identified five important characteristics of the estuarine environment (a) the nutrient trap effect, (b) the unique structure of estuarine water, (c) the harsh nature of the physical conditions and the resultant vulnerability of the estuarine organisms, (d) sedimentary control of estuarine waters, and (e) the key role of fresh water inflow.

With the onset of the South West Monsoon, the hydrographic conditions of the Cochin Estuary are subjected to rapid changes. Salinity and sediment temperature decreased and the former reached near zero values in July-

August. Of the three hydrographical parameters of the estuary studied, salinity is the most fluctuating factor and which had the greatest impact on the distribution and abundance of the bottom fauna. During the South West Monsoon period, salinity of the water at all the stations decreased to such a low level that it became fresh. The marked fluctuations in salinity brought about remarkable changes in the occurrence and distribution of the bottom fauna. Only few species of bottom fauna were observed in the estuary during the monsoon period. This showed that most of the marine species perished or migrated to the neighbouring marine environment during the active period of South West Monsoon. Along with the reduced species diversity (Table 21), there was also a decrease in total number and biomass in all the stations during the active period of South West Monsoon. Therefore the poor faunal composition and abundance during the South West Monsoon in all the stations, particularly at stations I and II (near the barmouth) could only be attributed to the wide fluctuation in salinity. Seshappa (1953, Desai and Krishnankutty (1967a) and Kurian (1967) have also observed that wide fluctuations in salinity resulted in considerable variations in the abundance and species composition of the bottom fauna in the inshore areas of Malabar and in Cochin backwaters.

Salinity is the principal environmental factor limiting the distribution of animal species in estuaries. Kendall's rank correlation coefficient matrix (Tables 1 to 10) shows that, in all stations the salinity is significantly positively correlated with the total fauna, polychaetes, crustaceans and molluscs.

Sediment particle size is a function of the mixing and dilution of salt water by fresh water, and therefore particle size can be considered to be dependent on salinity. The presence of predominantly finer fractions of the sediments, especially silt and clay (clayey silt in terms of texture) in the mouth of the estuarine region is understandable as when the sedimentary material enters the marine conditions, it gets floculated (Postma, 1967) and settles to the bottom. Kendall's rank correlation coefficient in Tables 1 to 10 shows that the salinity is significantly positively correlated with the clay percentage.

Recent reviews on the effect of salinity on marine and brackish water invertebrates and fishes have been published by Beadle (1957), Black (1957), Pearse and Gunter (1957), Robertson (1957, 1960), Moore (1958), Remane and Schieper (1958), Kinne (1966, 1967), Nicol (1960), Prossar and Brown (1961) & Lockwood (1962). Kinne (1966) has emphasized the frequently reported view that salinity is the 'ecological master factor' controlling the life of estuarine animals. McClusky (1968) conducted a study of the effect of salinity on the distribution and abundance of amphipod Corophium volutator in the estuary of the River Ythan, Aberdenshire, indicated that 2%. is the critical minimum salinity controlling the distribution. He also reported that for breeding to occur, salinity greater than 7.5%. may be required. Oglesby (1969) has pointed out that salinity is the principal controller of the distribution of estuarine worms, and their distribution can be linked to their osmoregulatory ability.

Estuarine mouth coincided with the zone of low benthic production. It is in this section that mixing of sea and fresh water was at its maximum and the ecosystem was unstable. Poor fauna at stations I and II near the barmouth during South West Monsoon compared to stations III, IV and V in the middle and upper reaches of the estuary is mainly due to the rapid fluctuation in salinity due to tidal mixing at the former.

The estuarine environment is characterised by steep and variable gradient in environmental factors, and has been colonised largely by marine animals able to tolerate these conditions. There is a reduction in species diversity, compared to adjacent marine or fresh water habitats, which appear to be linked to tidal variations, substrate type and especially salinity. It was observed that specie diversity of polychaetes was greater during the high salin period (pre-monsoon) than during the low saline period (monsoon). (See chapter 6). A few truly estuarine species, viz., *Nephthys oligobranchia*, *Paraheteromastus tenuis* and *Prionospio polybranchiata* were present throughout the period.

The possible effect of other environmental factors such as temperature and dissolved oxygen can be discussed as follows: The temperature was more or less uniform at all the five sampling stations. It ranged between 25 to 32.2°C, during the period of observation. The maximum temperature (32.2°C) was recorded in the pre-monsoon period (February-May) and the minimum (25°C) in the monsoon period (June-September). The monthly variations in both surface and bottom temperature is shown in Fig.2. The results showed that the temperature is generally higher in the marine zone of the estuary than in the fresh water zone. The temperature did not fall below 25°C and rise above 32.2°C during the observation. Besides, the faunal composition and abundance were not correlated with the fluctuation in temperature. Therefore, temperature is not a significant factor in the distribution of the bottom fauna of the Cochin Estuary.

Dissolved oxygen ranged from 2.42 to 5.67 ml/L. Oxygen contents of both surface and bottom water at different stations are shown in Fig.5. The oxygen content does not show any marked seasonal variation, though it is generally higher during monsoon months. Oxygen values are also higher in the upper reaches of the estuary than in the lower reaches. The availability of dissolved oxygen is an important hydrological factor controlling the distribution and abundance of the bottom fauna in the inshore waters of Cochin (Damodaran, 1973). Owing to the shallow nature of the Cochin Estuary and mixing of the water at the bottom, there is an enrichment of oxygen and hence the oxygen content does not limit the faunal distribution.

Of the three hydrological parameters studied, only salinity plays a major role in limiting the distribution and abundance of bottom fauna in the Cochin Estuary. Temperature and dissolved oxygen do not show any significant effect on the faunal distribution in the area.

7.2. Substratum and Bottom Fauna

It has been well established that the qualitative and quantitative distribution of benthic fauna has a direct relationship with the type of bottom deposits. The physical nature of the substratum acts as a limiting factor to a greater extent. (Thorson, 1957b; 1958; Sanders, 1958, Johnson 1971, Bloom *et al*., 1972). The extensive work in recent years on benthic communities has shown that many species are restricted to certain types of sediment and settlement of their larvae appears to be far from random (Spark 1935; Jones 1951; Thorson 1955, 1957b). The investigation of Sanders (1956, 1958), McNulty et al., (1962) and Brett (1963) showed a close relationship between feeding habits of infauna and gross organic matter content and texture of the sediment.

The substrate within an estuary is usually different from that of adjacent marine coast. Whereas, marine coasts are typically of a rocky or sandy nature, most of the estuarine areas are muddy in nature. The nature of the bottom observed during the course of the present investigation showed that the composition of sediment varied markedly from station to station. Based on the present investigation (as shown in Fig.6), the region under study can be differentiated into four major sedimentological divisions: (i) area covered by clayey silt with very little sand fraction (clayey silt) - stations I and II; (ii) area with dominance of fine sand fraction (sandy) - station III; (iii) area covered by fine sand, silt and clay in more or less equal proportions (sand-silt-clay) - station IV; and (iv) area covered by sandy mud - station V.

Analysis of the data on the qualitative and quantitative distribution of the macrobenthic fauna of the Cochin Estuary reveals that the faunal assemblage exhibits a relationship with a particular type of sediment. Fig. 10 shows the percentage of polychaetes, crustaceans and molluscs in the total fauna from each station. If the total number and biomass of animals are taken into account, stations III, IV and V recorded the maximum, whereas the station II recorded the minimum. The poor faunal composition of the stations I and II in comparison with other stations is due to the thick clay substratum of the former. The exception being in station I during May to July 1974 (which is mainly due to the large number of Modiolus undulatus) when the substratum exhibited a higher percentage of sand. That the substratum plays a vital role in the distribution of macrobenthos is further confirmed from the fact that station III, which shows dominance of fine sand fraction, and station IV, where the substratum consists of fine sand, silt and clay in more or less equal proportion, and station V, where the substratum is sandy mud, supported dense and varied benthic population. A reference to the Figs. 8 and 9 also reveals that higher biomass values are associated with a substratum having a higher percentage of fine sand with small percentage of silt, followed by silty bottom and the minimum biomass is found in clayey bottom. Desai and Krishnankutty (1967a) and Kurian (1972) have made similar observations from Cochin Backwaters. Eggleton (1931) found complete absence of bottom animals on a substrate of clean sand. However, there are reasons to accept that if there is a strong current bringing nutrients or if the productivity of the water column lying above is high, then denser population can exist. Panikkar and Aiyar (1937) observed the absence of animals on substrate of thick clay and their greater abundance on substratum with a higher percentage of fine sand. The presence of silty clay substratum at stations I and II may be one of the major factors responsible for its having a poor fauna in comparison to the other stations. Kendall's rank correlation coefficient matrix (Tables 5 and 10) shows that, in stations III and V, clay is significantly negatively correlated with the polychaetes and the total fauna. Although mud may be nutritionally very rich, as Yonge (1953) emphasized, it is a difficult environment to colonise due to its soft nature. Locomotion is difficult both over and through the mud and fine particles of silt or clay may readily clog the respiratory and feeding mechanism of many animals, especially the filter feeders.

The polychaetes occur at all the stations, but exhibit a preference for sandy mud with decreasing abundance in silty-clay. Maximum number of polychaete species were recorded from station IV, where the substratum consists of fine sand with small percentage of silt and clay. Wilson (1952) observed that polychaete larvae, when ready to settle, will critically examine the substratum and postpone metamorphosis until they find one suitable for adult life.

The crustacean fauna as represented by the sub-groups, namely, amphipods, isopods, tanaids, decapods, and stomatopods, which are truly epifaunal elements. Being detritophages (Neymann, 1971) the distribution of such animals is more related to the availability of detritus in the substratum rather than to the physical nature of the sediment (Savich, 1972). The occurrence of crustaceans at all the stations revealed a lack of substratum preference and emphasised the true epifaunal nature of these crustaceans. Such a relationship has been reported earlier by Parulekar and Dwivedi (1975) in the estuarine complex of Goa. McClusky (1968) concluded that above 5‰ s, the abundance and distribution of the amphipod Corophium volutator is controlled by sediment types. Meadows (1964) has shown experimentally that C.volutator selects and colonises only in suitable substrates. These substrates may be delimited as mud or muddy sand, with a plentiful supply of detritus; but without excessive organic matter. An allied species of Corophium, C.triaenonyx, was present in stations III and IV, where the substratum consists of fine sand with small percentage of silt and clay.

Molluscs, particularly Modiolus undulatus and

Nuculana mauritiana were present in stations IV and V, where the substratum is sandy mud. In station I, *M.undulatus* was recorded in large numbers only during May, June and July 1974, when the substratum was sandy mud. After July 1974, the substratum in station I changed to silty-clay and *M.undulatus* bed completely disappeared. This clearly indicates the substratum preference (i.e. for sandy mud) of *M.undulatus*. Sanders' studies in Long Island Sound (Sanders, 1956) and Buzzards Bay (Sanders, 1958, 1960) have shown that suspension feeders constituted the major fauna in coarser sediments, whereas selective and non-selective deposit feeders dominated in the fine sediments. Many workers have already reported that suspension feeders are abundant in well sorted fine grain deposit and decrease in abundance as the silt clay content increases. (Sanders, 1956, 1958; Parker, 1956; McNulty, *et al*., 1962; Muus, 1967; Nichols, 1970; Bloom, *et al*., 1972). Coarse grain sediment by virtue of its stable nature and the overlying water current, which brings sufficient food material supports the highest density of suspension feeders. Sanders (1958) and Driscoll (1967) have attributed the reduction in the density of suspension feeders in fine deposit due to the reduced amount of suspended food on silty clay, which is unfavourable to suspension feeders and thereby allowing deposit feeders a competitive advantage. The preponderance of *M.undulatus* in stations IV and

V (with sandy mud as substratum) during both the years of observation and in station I, only during May, June and July 1974, when the substratum was sandy mud is in accordance with its suspension feeding habit.

In general, the percentage of organic matter (Tables 11 to 15) present in the estuarine sediment is high. Though the quantum of organic matter readily utilized by the bottom fauna is not known, the dominance of polychaetes and crustaceans in fine sediment could only be due to the higher percentage of organic matter in these sediments.

Experimental evidence for the substratum preference of marine and brackish water invertebrates have been given by many workers. Mortensen (1921) was the first to show experimentally the substratum preference of echinoid larvae. He found that the larvae of the echinoid Mellita sexiesperforata did not metamorphose until sand was placed in the culture tanks. Similar observations have been made on the polychaete, Owenia fusiformes (Wilson, 1932).

In the present study, there are only few known filter feeders or carnivores. In stations I, IV and V, samples collected during January to August consisted of large numbers of bivalves and thereby increased the percentage of filter feeders. But the majority of the fauna in all the stations were composed of deposit or detritus feeders.

It was not surprising that substrate characteristic was the major environmental factor controlling the spatial distribution of macrobenthic communities within the study area of the Cochin Estuary. In fact this finding agrees well with the studies by Sanders (1958), Rhoads and Young (1970), Young and Rhoads (1971) and Boesch (1973).

7.3. Seasonal Variation

The species-wise distribution of bottom macrofauna during the three seasons at different stations is given in Tables 16 to 20.

Studies on the seasonal distribution of macrobenthic components revealed that with the onset of South West Monsoon, a quick and marked change in the composition of the macrofauna took place at all the stations. The monsoon directly affects the salinity distribution. Salinity acts as the major factor controlling the distribution and abundance of the organisms in the estuary. The entire estuary becomes saline and rich in animal life during the premonsoon period. A rich bottom fauna is present in all the stations during the pre- and post-monsoon periods.

During the pre-monsoon period, the important faun groups were polychaetes, bivalves, amphipods, isopods, tanaids, and brachyuran crabs. Among the polychaetes *Nephthys oligobranchia*, *Lumbriconereis* sp., *Paraheteromastus tenuis*, *Prionospio polybranchiata*, *Diopatra neapolitana* were recorded in large numbers. Among the bivalves *Modiolus undulatus* and *Nuculana mauritiana* were recorded in large numbers from stations I, IV and V and thereby increased the total biomass during the pre-monsoon period. About 90% of the common species in the estuary registered their peak abundance during this period. Also the species exhibited a definite spatial distribution. The optimum habitat conditions of these estuarine species were found in the middle reaches, away from the mouth. These middle reaches represent a more stable environment, when compared to the mouth, which is subjected to disturbances due to tidal mixing. This may be one of the reasons for the higher densities of bottom fauna in the middle reaches.

During the monsoon period, lesser number of species of polychaetes, amphipods, tanaids, cumaceans and brachyuran crabs were recorded when compared to the pre-monsoon period. The estuary became scantly populated, when compared to the other seasons. Only a few species able to tolerate low salinities such as polychaetes (*Nephthys oligobranchia*, *Prionospio polybranchiata*, *Lumbriconereis* sp., and *Paraheteromastus tenuis*), amphipods (*Eriopisca chilkensis*, *Grandidierella gilesi*), tanaids (*Apseudes gymnophobia*, *A. chilkensis*), cumaceans (*Iphinoe* sp.), Brachyuran crab

(Viaderiana sp.) and species belonging to Sipunculoidea thrived in the estuary. A gradual repopulation of the estuary following a recovery of salinity began in the post-monsoon season. In this season polychaetes, amphipods, tanaids, and other crustaceans formed the important groups in order of their abundance. Among the polychaetes, P. neapolitana and Fabricia sp. were recorded in large numbers from stations III and IV.

When the seasons were compared with regard to productivity, pre-and post-monsoon seasons were found to be the most productive. Eventhough there was a general decrease in the number and biomass of macrofauna during South West Monsoon in all the five stations studied, it was more evident at stations I and II near the marine end of the estuary. This could be due to the rapid fluctuation in selinity during the active period of South West Monsoon. Devassy and Gopinath (1970) have also reported an increase in the benthic biomass from marine to fresh water region during monsoon in the Vembanad Lake, which they attributed to the disappearance or transition from marine to fresh water condition. Desai and Krishnankutty (1967a) also reported a severe decline of macrofauna during the South West Monsoon in Cochin Backwaters. Kumaran and Rao (1975) reported that phytoplankton count was high during the pre-monsoon months and low during the active period of South West Monsoon months, increasing again after the monsoon.

Recolonization by macrofauna started during the beginning of the post-monsoon and steadily increased, the maximum was during pre-monsoon period (December to May). Seshappa (1953) working off Calicut reported a severe decline in the shallow water macrobenthos during South West Monsoon. He also reported the subsequent recolonisation during the post-monsoon periods, which was rather 'slow and unsteady'. Seshappa had attributed the decrease during the South West Monsoon as due to the lowering of salinity in the inshore regions during the active periods of South West Monsoon. Thus the decrease in salinity and the loose nature of the sediment together might have contributed for the diminution of the bottom fauna in Cochin Estuary. A resume of the present investigation brings out the vital role of salinity and substratum in the distribution of benthic organisms of Cochin Estuary. Of these two factors, salinity can be singled out as an 'ecological master factor'. (See also Kinne, 1966).

7.4. Trophic relationships

Cochin Estuary is well known for its role as a nursery ground for many of the commercially important prawns and fishes. Among fishes, mullets (*Mugil cephalus*, *Liza parsia*, *L. macrolepis*) pearl spots (*Etroplus suratensis*, *E. maculatus*), sciaenids and *Chanos chanos* are more important. All these species together constitute a major fishery in this region. The estuary supports an extensive prawn fishery and forms the main nursery ground for certain important penaeid prawns such as Metapenaeus dobsoni, M.monoceros, M.affinis, and Penaeus indicus. In addition to this, a large quantity of live clams and dead mollusc shells are collected annually. The food and feeding habits of many of these species have been worked out by different workers.

The majority of benthic molluscs are not predated by fishes and prawns due to their very hard shells. But it is possible that juvenile molluscs, prior to shell hardening, may form an important food of fishes and prawns. This could apply to the most abundant species such as Modiolus undulatus and Nuculana mauritiana present in the estuary. Other than the juvenile molluscs, the polychaetes and crustaceans are the major groups which contribute to the fish and prawn food potential of the Cochin Estuary. Seshappa (1953) working off Calicut correlated the polychaete, Prionospio pinnata settlement and the subsequent abundance of the flat fish, Cynoglossus semifasciatus. In the present study during both the years of observation, the settlement of Diopatra neapolitana, Lumbriconereis latreilli, Lumbriconereis sp., Nephthys oligobranchia, Paraheteromastus tenuis, Prionospio polybranchiata and P.pinnata were high.

As far as the benthic production is concerned, the area under observation is quite rich. In the area under study, the production of macrobenthos, in terms of annual mean standing crop (wet weight) is 35.205 g/m^2 (352.05 kg/ha). Townes (1938) considers a natural lake yielding 300 kg/ha of bottom fauna to be 'at least normally rich'. When compared to this standard, Cochin Estuary appears to be quite rich. A comparison made with the benthic production of Chilka Lake on the east coast of India shows that in general benthic production of Cochin Estuary is very high. The annual mean standing crop (wet weight) of the whole Chilka Lake was 135.72 kg/ha (Patnaik, 1971), which is much lower than the average for Cochin Estuary (352.05 kg/ha).

From the study area as a whole, the average number of macrofauna recorded is 2332/m^2. Thienemann (1925) has classified a lake bed producing 1000 animals or less per m^2 as oligotrophic, one producing above 2000/m^2 as eutrophic and one producing a number between 1000 and 2000 as mesotrophic. Based on this classification (which takes into account benthic productivity alone) Cochin Estuary may be described as eutrophic. Sokolova and Pasternak (1962) have already reported, that benthic production in the tropical region of the Indian Ocean seems to be richer than that of the tropical Pacific Ocean.

The benthic organisms are dependent upon the fertility of the overlying water for their food supply, and factors which control the planktonic production in any area are likely to have an indirect influence upon the abundance of the benthic fauna. Jones (1956) from his studies conducted at Irish Sea reported that phosphate concentration in the overlying water influenced the biomass of the bottom fauna. The nutrient cycle governing the productivity of the Cochin Estuary has been studied by Sankaranarayanan and Qasim (1969) and Sreedharan and Salih (1974). The maximum value of phosphate observed by Sankaranarayanan and Qasim (1969) has been around 2 to 2.5 μg at/L, while values exceeding 15 μg at/L have been reported by Nair et al. (1975) during monsoon and pre-monsoon periods. Phosphate values from the Cochin Estuary suggest that enough of this nutrient is available for phytoplankton production. Therefore, phosphate is not a significant limiting factor in the phytoplankton production and thus may not have any direct influence on the bottom fauna production.

Nair et al., (1975) using C^{14} technique estimated an average annual rate of gross production ranging from 150 to 650 g $c/m^2/yr$ at different regions and the total annual gross production of 100,000 tonnes of carbon for the entire Vembanad Lake. Unlike in the inshore regions of the west coast, where maximum production occurs during monsoon period, in the Vembanad Lake relatively higher rate of production is observed during the pre-and post-monsoon periods. Of the gross production, 20 to 45% can be considered to be used for respiration and of the net production available to the next trophic level only a very small portion is used by the zooplankton (30 gc/m^2/yr) leaving a large surplus of basic food in estuary (Qasim et al., 1969). The turbidity of the estuary remains high throughout the year and hence the euphotic zone becomes narrow (Qasim and Reddy, 1967). Since the euphotic zone is considerably less in the estuary, a good part of the phytoplankton production sinks below the euphotic zone and forms as detritus. It appears that the detritus from phytoplankton forms a major source of food for bottom fauna. This probably might be a contributing factor for the greater benthic biomass found in the estuary. Another interesting correlation observed in the present study is that the maximum benthic production occurs in pre-and post-monsoon periods, when the primary production is also very high. Thus a direct correlation between the benthic production and organic production in the Cochin Estuary could be attributed.

The annual standing crop of the macrobenthos of the area under study is 6.2914 g/m^2/yr. Most of the macrobenthic species of the region live for a period of one year and if we accept Sanders' (1956) suggestion of a production of about twice the standing crop for these animals, we get an annual production of 12.5828 g dry weight/m^2/yr.

If the annual production of macrobenthos is 12.5828 g/dry wt/m^2/yr or 6.2914 gc/m^2/yr (fat, protein and carbohydrate together constituted roughly about 50% of the body constituent of the bottom fauna, Damodaran, 1973), an ecological efficiency of 10% (Slobodkin, 1962) would call for a demand of about 62.914 gc/m^2/yr for production. It has already been pointed out that due to the relative shallowness of the area a good proportion of the surface water production is available for the benthic animal communities. To this should be added the meiobenthic production and the bacterial production by photosynthetic bacteria on the bottom. This clearly indicates adequate supply of carbon for benthic production.

In the food web of the estuary, amphipods, isopods, tanaids, cumaceans and polychaetes are important links, they feed on mud and organic matter, and in turn are predated by bottom feeding fishes and prawns. The food and feeding habits of the commercially important fishes, viz., mullets, pearl spots, sciaenids and flat fishes were also investigated in the present study. Among these fishes, sciaenids and Cynoglossus sp. are strictly zoobenthic feeders. Sciaenids mainly feed on crustaceans especially isopods and cumaceans. Cynoglossus sp., which is abundant in the estuarine mouth feeds on polychaetes (particularly Prionospio pinnata) and crustaceans.

From the analysis of the stomach content of five species of commercially important penaeid prawns of Cochin Estuary (vis. Metapanaeus dobsoni, M.affinis,M.monoceros, Panaeus indicus, and P.monodon), it was found that all the five species may be considered as omnivores and detritus feeders depending much on benthos (Table 28). Occurrence of benthic forms such as amphipods, isopods, polychaetes, juvenile bivalves and gastropods, foraminiferans and also sand grains and mud,indicates the pronounced bottom feeding habit of the prawns. Kuttyamma (1971) observed 22% of the animal matter (mainly polychaetes, crustaceans, juvenile bivalves and gastropods, nematodes, foraminiferans) from the gut content of Penaeus indicus. Gopalakrishnan (1952) observed that vegetable matter and crustaceans formed the bulk of the food consumed by P.indicus. P.mondon mainly feeds on organic detritus present in the mud and crustaceans (amphipods, decapods, copepods) and polychaetes. Rao (1967) examined the stomach content of P.monodon from Chilka Lake and observed large percentage of molluscs.

All the above information clearly suggests that, macrobenthos plays an important role in the food chain of Cochin Estuary. Most of the macrobenthic species are actively predated by fish and prawns. The high biomass of macrobenthos contributed predominantly by polychaetes, crustaceans and bivalves appear to form an important component of the food of fish and prawns in the estuary.

P A R T - II

SYSTEMATICS OF BENTHIC POLYCHAETES

The first important work on the systematics of Polychaeta of the Indian region is that of Willey (1905) based on the collections of Prof.Herdman from the Gulf of Mannar. In this paper he has described 111 species, of which 37 species and 2 varieties are new to science. Later, Souhern (1921) and Gravely (1927) described the Polychaeta occurring in the Gangetic Delta, Cochin Backwaters, Chilka Lake and Krusadi Islands. These were followed by the work of Fauvel (1930, 1932 and 1940) on the polychaete collections of the Madras Government Museum and the Indian Museum. In 1953, Fauvel published a comprehensive account of the Polychaeta of India in the Fauna of India Series. Altogether he has described 462 species, of which 283 are from the coasts of India. This consists of 47 brackish water species and 236 marine forms. Most of the brackish water species are from the Chilka Lake, Ennore Backwaters and Adayar Lake on the east coast of India. From the west coast of India (Vembanad, Veli, Kayamkulam and Ashtamudi Backwaters) he has recorded only 18 species. Later, Cheriyan (1966) described six species of polychaetes collected from the Cochin Harbour area. A detailed systematic work on the complete polychaete fauna of the Cochin Estuary is lacking.

Carikker (1967) reviewed the role of systematics in the estuarine benthic ecological research works. Hedgpeth (1957) suggested that the first procedure in ecological research is 'exercise in systematics'. Among the various animal groups represented in the macrobenthic fauna studied in Part I, Polychaeta was the dominant group, and was present all over the estuary throughout the period of investigation. Altogether, 91 taxa were identified from the bottom fauna and out of this, 35 species were polychaetes. Among these, 30 species belonging to 25 genera are briefly described in the following account. Of these 30 species, 17 are new records from the Cochin Estuary. They are:-

1. *Lepidonotus tenuisetosus*
2. *Sthenelais boa*
3. *Ancistrosyllis constricta*
4. *Phyllodoce gracilis*
5. *Syllis cornuta*
6. *Marphysa sanguinea*
7. *Lumbriconereis latreilli*
8. *Glycera longipinnis*
9. *Polydora kempi*
10. *Prionospio cirrifera*
11. *Cossura coasta*
12. *Disoma orissae*
13. *Paraheteromastus tenuis*
14. *Sabellaria cementarium*
15. *Sternaspis scutata*
16. *Loimia medusa*
17. *Mercierella enigmatica*

Of these 17 new records from Cochin Estuary, most of them are recorded from an estuarine environment for the first time. Spatial and temporal distribution of polychaetes present in the Cochin Estuary are also given along with the species description. A complete list of synonyms of species recorded in Indian waters are also furnished. The classification followed in the present study is that of Day (1967).

Family APHRODITIDAE Savigny, 1818

Sub family HERMIONINAE Grube, 1875

Genus LEPIDONOTUS Leach, 1816

1. *Lepidonotus tenuisetosus* (Gravier, 1901).

Euphione tenuisetosa Gravier, 1901: p.122, pl.viii, figs 123-125.

Lepidonotus tenuisetosus, Fauvel, 1953: p.36, figs.14 c-f.

Lepidonotus tenuisetosus, Day, 1962: p.632.

Body oblong upto 15 mm long. Elytra oval, slightly reniform with a small fringe, covered with a few large and a number of smaller rounded papillae. Parapodia short and ventral setae with a rather long smooth tip and a few fringes.

Locality: Station I.

Season : June

Occurrence: Jack and Una Islands, Mergui-Archipelago, Port Canning, off Puri, Orissa, Madras, Cochin Estuary

Distribution: Indian Ocean, Persian Gulf, Red Sea, Madagascar

Family APHRODITIDAE Savigny, 1818.

Sub family SIGALIONINAE Malmgren, 1867

Genus STHENELAIS Kinberg, 1855.

2. *Sthenelais boa* (Johnston, 1839)

Sigalion boa, Johnston, 1839: p.439.

Sthenelais boa, Fauvel, 1953: p.61, figs. 28 a-k.

Body 100 to 150 mm long. Colour grey. Elytra reniform and overlapping over the back with a number of minute papillae and a fringe on the outer border. Surface covered with minute rounded tubercles. Ventral ramus of the feet with 2-3 simple bipectinate setae. Compound setae with a short sickle-shaped appendix and a smooth shaft, others with a pluri articulate appendix and on the anterior feet a few compound setae with a spinulose shaft.

Locality: Station IV

Season: June

Occurrence: Ceylon, Galle, Cape Comorin, Krusadi, Amiranti, Cochin Estuary.

Distribution: Indian Ocean, Mediterranean Sea, Atlantic Ocean.

Family HESIONIDAE Malmgren, 1867

Genus HESIONE Savigny, 1818

3. *Hesione pantherina* Riso

Hesione eugeniae, Kinberg, 1857: p.57, pl. xxiii, fig.8

Hesione ceylonica, Grube, Willey, 1905: p.266.

Hesione pantherina, Fauvel, 1953: p.104, figs. 49 a-g.

Hesione pantherina, Cheriyan, 1966: p.43.

Body 45 mm long, dorso-ventrally flattened and slightly tapered towards both ends. 16 setigerous segments and an anal segment devoid of parapodia. Dorsal surface of body light brown, while pale yellow ventrally.

Locality: Station IV

Season : March

Occurrence: Banka Strait, Nankauri Harbour; Nicobar Islands, Andaman Islands, Chilka Lake, Orissa coast, Krusadi Islands, Rameswaram Island, Ceylon, Arabian Sea, Cochin Estuary.

Distribution: Pacific, Indian and Atlantic Oceans.

Family HESIONIDAE Malmgren, 1867

Genus ANCISTROSYLLIS McIntosh, 1879

4. *Ancistrosyllis constricta* Southern, 1921.

Ancistrosyllis constricta Southern, 1921: p.573, pl. xix, fig.1.

Ancistrosyllis constricta, Fauvel, 1930: p.64.

Ancistrosyllis constricta, Fauvel, 1953: p.111, figs.54 a-d.

Body colourless, 25 mm long. A distinct neck at 4th setigerous segment, after which body becomes flat. Peristomium distinct from prostomium and bears two pairs of tentacular cirri. Flattened palps with a palpostyle. Median tentacle twice as long as the laterals, which project a little beyond the palps. Dorsal cirri on the first setigerous segment very long and tapering. An enclosed dorsal slender aciculam and, between the 30th and 40th feet, a stout sickle-shaped seta. Ventral setae capillary.

Locality: Throughout the stations.

Season: Throughout the seasons.

Occurrence: Chilka Lake, Visagapatam, Cochin Estuary.

Distribution: India.

Family PHYLLODOCIDAE Williams, 1851

Sub family PHYLLODOCINAE Williams, 1851

Genus PHYLLODOCE Savigny, 1818.

5. *Phyllodoce gracilis* Kinberg 1857.

Phyllodoce gracilis Kinberg, 1857: p.55, pl.xxii, fig.2.

Phyllodoce gracilis, Fauvel, 1932: p.69, fig.12.

Phyllodoce gracilis, Fauvel, 1953: p.117, figs. 57 a-g.

Body long and slender, reaching 30 mm. Colour uniformly bluish-green. Prostomium heart-shaped. Two large eyes, tentacular cirri long. Base of the proboscis covered with irregularly arranged papillae. Dorsal cirri small, oval in shape.

Locality: Stations I, III and IV.

Season: November to January.

Occurrence: Andaman Islands, Cochin Estuary.

Distribution: Australia, Society Islands, Andaman Islands.

Family SYLLIDAE Grube, 1850

Sub family SYLLINAE

Genus SYLLIS Savigny, 1818.

6. *Syllis* (*Langerhansia*) *cornuta* Rathke, 1843.

Syllis cornuta Rathke, 1843: p.164.

Syllis (*Ehlersia*), *cornuta* Fauvel, 1953: p.153, figs 79 g-i.

Body very slender, 10-15 mm long. Prostomium with four eyes. Dorsal cirri long with 12 to 20 clearly marked joints. Compound setae of two kinds present on the same feet.

Locality: Station IV

Season : April to June

Occurrence: Gulf of Mannar, Krusadi Islands, Cochin Estuary.

Distribution: Indo-China, India, Arabian Sea, Persian Gulf, Atlantic Ocean, Mediterranean Sea.

Family NEREIDAE Johnston, 1865

Genus LYCASTIS Savigny, 1818

7. *Lycastis indica* Southern, 1921

Lycastis indica Southern 1921: p.578, pl. xix, fig.2

Lycastis indica, Fauvel, 1932: p.82, pl.ii, figs. 1-2

Lycastis indica, Fauvel, 1953: p.167, figs. 84 a-b.

Body slender, upto 100 mm long. Colour reddish-brown.

'rostomium slightly grooved and ending in a pit. Eyes ıituated in a line and provided with lenses. Dorsal cirri ıarrow, very long and recurved towards back on posterior :egion. Dorsal setae very few. Hemigomph and hetrogomph ıpinigerous setae.

ocality: Stations I, III, IV and V.

ieason : June to December

)ccurrence: Calcutta water works, Salt lakes, Calcutta, Chilka Lake, Madras, Brackish waters of India, Andaman Islands, Euryhaline from fresh water to brackish and sea water, Cochin Estuary.

)istribution: Macassar, India.

Family NEREIDAE Johnston, 1865

Genus <u>DENDRONEREIS</u> Peters, 1854

8. <u>Dendronereis aestuarina</u> Southern, 1921.

<u>Dendronereis aestuarina</u> Southern, 1921: p.598,pl.xx, fig.4.

<u>Dendronereis aestuarina</u>, Fauvel, 1932: p.86.

<u>Dendronereis aestuarina</u>, Feuvel, 1953: p.173, figs. 86-b.

<u>Dendronereis aestuarina</u>, Cheriyan, 1966: p.43.

Length about 45 mm. Colour pale with red gills when alive. Prostomium deeply indented in front. Four large eyes present. Proboscis with soft conical papillae. Dorsal cirri bearing lateral pinnate gills from 14th-16th to 19th-21st segment. Setae homogomph with long sarrated terminal piece.

Locality: Throughout the stations.

Season: Throughout the seasons.

Occurrence: Gangetic delta (in brackish water), Madras, Travancore, Cochin Estuary.

Distribution: Gulf of Siam, India.

Family NEREIDAE Johnston, 1865

Genus PERINEREIS Kinberg.

9. *Perinereis cavifrons* Ehlers, 1920.

Nereis (*Perinereis*) *cavifrons* Ehlers, 1920: p.47, pl.1, figs.6-10.

Perinereis cavifrons, Fauvel, 1953: p.210, figs.108 a and b.

Perinereis cavifrons, Cheriyan, 1966: p.43.

Length about 60 mm. Body dorso-ventrally flattened and slightly tapering to both ends. Prostomium broader than long, notched between the tentacles. Palps and tentacular cirri short. Dorsal cirri about the length of the dorsal ligule.

Locality: Stations I, III, IV and V.

Season : Throughout the seasons.

Occurrence: North Andaman Islands, Arabian Sea, Cochin Estuary.

Distribution: New Caledonia, New Hebrides, Andaman Islands, Arabian Sea.

Family NEPHTHYDIDAE Grube, 1850.

Genus NEPHTHYS Cuvier, 1817.

10. *Nephthys oligobranchia* Southern, 1921.

Nephthys oligobranchia Southern, 1921: p.610, pl.xxiv, fig.12.
Nephthys oligobranchia, Fauvel, 1932: p.119.
Nephthys oligobranchia, Fauvel, 1953: p.228, figs.115 d-f.

Body 20 mm long. Prostomium with four tentacles and two small eyes. The branchiae occur fully developed on the sixth foot, disappear on 20th or 23rd foot and with a single vascular loop.

Locality: Throughout the stations.
Season : Throughout the seasons.
Occurrence: Calcutta water works and salt lakes, Chilka Lake, Vizagapatam, Cochin Backwaters.
Distribution: Taleh-Sap; Kiangsee; Mergui; Bay of Bengal, India.

Family EUNICIDAE Savigny, 1818
Sub-family EUNICINAE Savigny, 1818
Genus MARPHYSA Quatrefages, 1865

11. *Marphysa sanguinea* (Montagu, 1815).
Nereis sanguinea Montagu, 1815: p.20.
Marphysa sanguinea, Gravely, 1927: p.18.
Marphysa sanguinea, Fauvel, 1953: p.245, figs. 123 a-h.

Body stout, upto 250 mm long. In life pink-gray, bright red gills. Prostomium bilobed and tentacles short. Gills noted from 16th to 30th foot, reach a maximum of 4 to 7 filaments. Dorsal setae capillary and ventral setae compound with long knife-like terminal piece. Acicular setae slender and irregularly present in the posterior part of the body.

Locality: Station IV.

Season : March

Occurrence: Visagapatam, Pondicherry, Gulf of Mannar, Tuticorin, Travancore, Mormugao Bay, Goa, Cochin Estuary.

Distribution: Australia, New Caledonia, Indian Ocean, Red Sea, Atlantic Ocean, Mediterranean Sea.

Family EUNICIDAE Savigny, 1818

Sub-family ONUPHIDINAE Kinberg, 1855.

Genus DIOPATRA Audiouin and Milne-Edwards.

12. *Diopatra neapolitana* Delle Chiaje.

Diopatra amboinensis, Willey, 1905: p.274, pl.iv, figs.95-97.

Diopatra variabilis, Southern, 1921: p.611, pl.xxv, figs.1-4.

Diopatra neapolitana, Fauvel, 1953: p.252, figs.126 a-h.

Diopatra neapolitana, Cheriyan, 1966: p.45.

Body very long, reaching a length of 165 mm. Tubes are straight with shell fragments. Sand particles and debris attached. Palps small and globular, two anterior tentacles shorter than the three posterior ones. Eyes absent. Gills appear on the fifth foot, with fairly long filaments covering the back, but decrease in size and disappear between 50th and 70th foot. Simple winged setae and pseudocompound bristles present on the first 4-5 setigerous segments. In succeeding feet, simple setae with two wings and comb setae with numerous fine teeth. Hooded acicular setae bidentate. Body of the fresh specimen reddish brown in colour, with a deeper tint towards the anterior end.

Locality: All stations.

Season : January to June and October to November.

Occurrence: Burma, Mergui, Gangetic Delta, Orissa coast, Madras coast; Ceylon, Gulf of Mannar, Maldive Archipelago, Cochin Estuary.

Distribution: Pacific Ocean, China Sea, Gulf of Siam, Indian Ocean, Arabian Sea, Gulf of Oman, Persian Gulf, Red Sea, Atlantic Ocean, Mediterranean Sea.

Family EUNICIDAE Savigny, 1818.

Sub-family LUMBRICONEREINAE Malmgren, 1867.

Genus LUMBRICONEREIS Blainville, 1828.

13. *Lumbriconereis simplex* Southern, 1921.

Lumbriconereis simplex Southern, 1921: p.625, pl.xxvi, fig.16.

Lumbriconereis simplex, Fauvel, 1953: p.264, figs.133 g-i.

Body long, often reaching 150 mm. Live specimens with light reddish colour. Prostomium triangular, parapodia vascular with full of blood. Anterior lobe rounded and posterior lobe blunt conical. All setae are simple capillary and broadly winged. No hooks. There are only five setae, two in the anterior and three in the posterior lobe.

Lobality: All the stations.

Season : Throughout the seasons

Occurrence: Chilka Lake, Cochin Backwaters.

Family EUNICIDAE Savigny, 1818.

Sub-family LUMBRICONEREINAE Malmgren, 1867.

Genus LUMBRICONEREIS Blainville, 1828.

14. *Lumbriconereis latreilli* Audouin and Milne-Edwards,1834.

Lumbriconereis japonica,Marenzeller,1879:p.137,pl.v.fig.3.

Lumbriconereis latreilli,Fauvel, 1953: p.266,figs.134 m-r.

Body slender, upto 40 mm long. Pink in colour. Prostomium bluntly conical. Anterior feet with winged capillary setae and compound hooks, extended from 1st to 50th foot. Capillaries disappear from between 40th and 60th feet. Compound hooks appear on third foot and extend to 25th foot where they are replaced by simple hooks.

Locality: All the stations.

Season: Throughout the seasons

Occurrence: Ceylon, Tuticorin Pearl-oyster banks, Cochin Estuary.

Distribution: Cosmopolitan in temperate and tropical seas.

Family EUNICIDAE Savigny, 1818

Sub-family LUMBRICONEREINAE Malmgren, 1867.

Genus LUMBRICONEREIS Blainville, 1828.

15. *Lumbriconereis heteropoda* Marenzeller, 1879.

Lumbriconereis heteropoda Marenzeller, 1879: p.30, pl.vi, fig.1.

Lumbriconereis heteropoda, Fauvel, 1930: p.30

Lumbriconereis heteropoda, Monro, 1937: p.297.

Lumbriconereis heteropoda, Fauvel, 1953: p.268, figs.135 g-h.

Body long, reaching 60 mm. Prostomium conical and simple capillary setae on the anterior feet, followed by winged capillaries and unjointed hooks. Feet increase in length posteriorly.

Locality: Stations III, IV and V.

Season: January to June and October to December.

Occurrence: India, Mormugo Bay, Persian Gulf, Cochin Estuary.

Distribution: Japan, Indo-China, India, Persian Gulf, Red Sea.

Family GLYCERIDAE Grube, 1850.

Genus GLYCERA Savigny, 1818.

16. Glycera longipinnis Grube, 1878.

Glycera longipinnis Grube, 1878:p.182, pl.viii, fig.9

Glycera longipinnis, Fauvel,1932:p.125,pl.iv,figs 11-14.

Glycera longipinnis, Fauvel,1953: p.291, figs.148 a-d.

Body about 20 mm long, tapered towards both ends. White in colour. Prostomium a slender cone with about 12 rings. Proboscis covered with long and cylindrical papillae, destitute of terminal nail-like appendages. Branchiae simple, large, present from the 20th foot. Parapodia elongated with two anterior subequal, cirriform lobes and a single posterior rounded or faintly emarginate lobe.

Locality: All the stations.

Season: January to June and October to December

Occurrence: Bay of Bengal, Cochin Estuary.

Distribution: Philippine Islands, Bay of Bengal, Persian Gulf, Arabian Sea.

Family Glyceridae Grube, 1850

Genus GLYCERA Savigny, 1818.

17. Glycera alba Rathke

Nereis alba Muller, 1788: p.217, pl.2, figs. 6-7.

Glycera alba var. *cochinensis* Southern, 1921: p.627, pl.xxvii, fig. 17.

Glycera alba, Fauvel, 1953: p.292, figs.149 i-m.

Body about 45 mm long, white in colour. Prostomium with 9 rings. Papillae of proboscis obliquely truncated. Branchiae simple, appear on the 20th foot and inserted on the dorsal edge of the foot. Parapodia with two anterior, sub-equal, triangular or cirriform lobes and two posterior lobes; the upper one triangular, shorter than the anterior, the lower rounded and still shorter.

Locality: Stations II, III, IV,& V.

Season : Throughout the seasons.

Occurrence: Ganjam coast, Cochin Backwaters, Mormugao Bay.

Distribution: Indian Ocean, India, Red Sea, Atlantic Ocean.

Family SPIONIDAE Grube, 1850

Genus *POLYDORA* Bosc, 1802

18. *Polydora kempi* Southern, 1921.

Polydora kempi Southern, 1921: p.636, pl.28, figs.20 a-j.

Polydora (*Carazzia*) *kempi*, Fauvel, 1953: p.317, figs.167 a-c.

Length about 15 mm, colour white in life. Prostomium small, broad and faintly notched anteriorly with a large erect occipital tentacle. Four eyes. No dorsal setae on the first foot, a ventral lobe with a row of slender capillary setae. Branchiae appear on the 7th segment. Fifth setigerous segment with normal notopodial capillaries, a double row of specialized setae and normal neuropodial setae. The specialized setae with dorsal superior setae long and narrow capillaries, the inferior dorsal setae consist of two rows of modified setae, the anterior setae are bi-limbate capillaries, short with broad wings, rapidly tapering. The posterior row consists of stout hooks with curved lips. The ventral setae lance-shaped.

Locality: Stations I, IV and V.

Season: January to July

Occurrence: In a canal at Chingrighatta, Calcutta salt lakes,
Cochin Estuary.

Distribution: India.

Family SPIONIDAE Grube, 1850

Genus PRIONOSPIO Malmgren, 1867.

19. *Prionospio pinnata* Ehlers, 1901

Prionospio pinnata Ehlers, 1901: p.613

Prionospio pinnata, Monro, 1937: p.299

Prinospio pinnata, Fauvel, 1953: p.323, figs 174 e.

Length about 50 mm. White colour in life. Prostomium bluntly pointed and enclosed between two upturned membraneous wing-like lateral expansions of the peristome.

Four pairs of large pinnate gills beginning on the first setigerous segment. Gills of the second pair generally smaller.

Locality: All the stations.

Season : January to May and November to December.

Occurrence: Vizagapatam, Cochin Estuary.

Distribution: Vancouver, India, Atlantic Ocean, Arctic Ocean.

Family SPIONIDAE Grube, 1850

Genus PRIONOSPIO Malmgren, 1867.

20. *Prionospio polybranchiata* Fauvel, 1929.

Prionospio polybranchiata, Fauvel, 1929: p.184.

Prionospio polybranchiata, Fauvel, 1930:p.39, figs.10 a-g.

Prionospio polybranchiata, Fauvel, 1953:p.324, figs.170, a-g.

Body slender, only 15 mm long. Colour white in life. Anterior region flattened, enlarged, tapering forwards, posterior region cylindrical. Prostomium elongate, anterior border rounded. No eyes present. Two long palps reaching backwards to the 25th-30th segment. Gills appear on the second setigerous segment, the first five pairs filiform and the rest foliaceous, subtriangular, elongate. Anteriorly, both dorsal and ventral setae are capillary.

Locality: All the stations.

Season: Throughout the stations.

Occurrence: Gulf of Mannar, Cochin Estuary.

Family: SPIONIDAE Grube, 1850.

Genus: PRIONOSPIO Malmgren, 1867.

21. *Prionospio cirrifera* Wiren, 1883.

Prionospio cirrifera, Fauvel, 1953: p.324.

Length about 30 mm. Prostomium rounded in front with a keel posteriorly which extends to the 2nd setigerous segment. No membraneous prostomial wings. Long, smooth, simple gills 6-13 pairs, beginning at the 2nd setigerous segment. Anterior dorsal lamellae very large, and from 3rd to 6th feet sharp pointed. Ventral lamellae oval.

Locality: All the stations.

Season: Pre-monsoon and post-monsoon.

Occurrence: Vizagapatam.

Distribution: Vancouver, India, Atlantic Ocean, Arctic Ocean.

Family: SPIONIDAE Grube, 1850.

Genus: DISOMA Ocrstad

22. *Disoma orissae* Fauvel, 1932.

Disoma orissae, Fauvel, 1932: p.174, fig.29, a-m.

Disoma orissae, Fauvel, 1953: p.327, fig. 172, a-m.

Body about 20-25 mm long. Prostomium elongated and slightly notched in front, bulging in the middle and ending behind in a crest reaching to the 2nd setigerous segment. On the raised part 4 small eyes. On the first setigerous segment a large lanceolate subulate, dorsal cirrus and a ventral one directed forwards, a small bundle of capillary setae in front of the dorsal cirrus and a fan-shaped ventral bundle of setae extending beyond the peristomium. On the 2nd setigerous segment dorsal and ventral cirri, triangular, smaller than the first ones, and a ventral setae of two types: (1) an anterior row of very fine capillary setae and (2) a posterior row of stouter shorter bristles with blunt curved tips. On the third segment a large lanceolate chopper-like, dorsal cirrus, a triangular ventral cirrus, smaller than the dorsal one. The dorsal setae disappear about 11th foot. From the 9th segment backwards the dorsal cirri become filiform and the ventral ones are modified about 11-12th feet. Beyond the 11th foot long filiform ventral papillae make their appearance, a single one at first under each foot. From 9th foot backwards, the ventral setae are of (1) stout straight, bodkin-shaped and (2) very slender capillaries.

Locality: Station I

Season: Pre-monsoon.

Occurrence: Off Puri, Orissa. South West Coast of India, Cochin Estuary.

Family: COSSURIDAE Day, 1963.

Genus: COSSURA Webster and Benedict, 1887.

23. *Cossura coasta* Kitamori, 1960.

Cossura coasta Kitamori, 1960: p.1082, figs 1, a-f.

Cossura coasta, Thomas 1964: p.754.

Body 15 mm long, thread-like and white colour in life. Prostomium clearly demarcated with a blunt depressed cone and without eyes or appendages. Peristome and second segments partly fused, apodous and achaetous. Distinct parapodial lobes absent and the setae arise directly from the side of the body. Segment three has a single bundle of setae, but all subsequent segments with two separate bundles. The setae are all simple capillaries. A single, long slender gill arises from the dorsal surface of the setiger three. Last few segments lack setae and the pygidium bears three long filiform anal cirri.

Locality: Stations I and II.

Season: January to June and October to December.

Occurrence: Seto inland sea, Japan, Arabian Sea, Cochin Estuary.

Distribution: South-west Africa, Cape, Natal, Japan, India.

Family: CAPITELLIDAE Grube.

Genus: PARAHETEROMASTUS, Monro.

24. *Paraheteromastus tenuis* Monro, 1937.

Paraheteromastus tenuis Monro, 1937: p.536, fig. 2b.

Paraheteromastus tenuis, Fauvel, 1953: p.369, figs. 194 c-f.

Body upto 20 mm long. Prostomium conical, without eyes. First four setigerous segments carry only short widely bordered capillary bristles, the remaining seven thoracic segments with large hooks. Abdominal hooks smaller than the thoracic. The body in the abdominal region is externally almost as featureless and homogeneous as that of an Oligochaete. The parapodial ridges are not well developed.

Locality: All the stations.

Season: Throughout the seasons.

Occurrence: Maungmagan, Burma, Cochin Estuary.

Distribution: Burma, India.

Family: SABELLARIIDAE Johnston, 1865.

Genus: SABELLARIA Savigny, 1818.

25. *Sabellaria cementarium* Moore, 1906.

Sabellaria cementarium Moore, 1906: p.248, pl.xii, figs.45-51.

Sabellaria cementarium, Fauvel, 1932: p.209, fig. 34.

Sabellaria cementarium, Fauvel, 1953: p.395, figs.205 a-g.

Length reaching 30 mm. Tubes very hard, made of quartz grains firmly cemented together. Outer paleae end in a long slender, sharp, smooth spine arising between shorter, smooth spines. Middle paleae short, smooth, spoon-like. Inner paleae hollow, elongated, smooth.

Locality: Station IV.

Season: January to June.

Occurrence: Tuticorin beach, Cochin Estuary.

Distribution: Pacific Ocean, India.

Family: STERNASPIDIDAE Carus

Genus: STERNASPIS Otto, 1821.

26. *Sternaspis scutata* (Renier, 1807).

Sternaspis scutata Renier, 1807: p.34

Sternaspis scutata, Moore, 1903: p.487.

Sternaspis scutata, Fauvel, 1927: p.216, figs.76 a-g.

Body swollen, about 10 mm long, sausage-like, narrowed in the middle, expanding at both ends. Mouth subterminal. Prostomium reduced to a small knob. Anterior bristles are short and stout. Branchial filaments are numerous, often rolled into spirals.

Locality: Stations I, II, III and V.

Season: March to June

Occurrence: Burma, Mergui, Andaman Islands, Chilka Lake, Ganjam Coast, Madras, Cochin Estuary.

Distribution: Pacific Ocean, Japan, Petchili, New Zealand, Australia, Indian Ocean, Atlantic Ocean, Mediterranean Sea, Arctic Seas.

Family: AMPHICTENIDAE Malmgren

Genus: PECTINARIA Lamarck.

Sub-genus LAGIS Malmgren

27. Pectinaria (Lagis) abranchiata, Fauvel, 1932.

Pectinaria (Lagis) abranchiata, Fauvel, 1932: p.215, pl.viii, Figs.10-14.

Pectinaria (Lagis) abranchiata, Fauvel, 1953: p.405, figs 212, a-e.

Body upto 15 mm long and 16 setigerous segments with capillary setae. Dorsal capillary setae winged. Unicini pectinate, with several ventral rows of numerous teeth. The hooks at the base of the scapha, about 10-12 are short, stout and set in a curved row on either side. Branchiae absent. The tube is made of single layer of transparent quartz grains held together by a yellowish cement.

Locality: Stations I, III and IV.

Season: February, May and October to December.

Occurrence: Cochin Backwaters.

Family: TEREBELLIDAE Grube, 1850.

Sub-family TEREBELLINE Grube 1850.

Genus: LOIMIA Malmgren, 1866.

28. *Loimia medusa* (Savigny, 1820)

Terebella medusa Savigny, 1820: p.95.8

Loimia medusa, Willey, 1905: p.320, pl.vi, figs.155-159.

Loimia medusa, Fauvel, 1953: p.416, figs. 218 a-f.

Length upto 40 mm, with a swollen thorax and long slender abdomen. Tentacular lobe short and collar-like. Lateral lobes of the first segment large and foliaceous. Three pairs of branched sub-equal gills present. The unicini are flat pectinate plates with 4-5 long curved teeth set in a single row. Dorsal setae are capillary and winged. The tube membraneous coated with sand and debris.

Locality: Stations III and IV.

Season: January to June and December.

Occurrence: Burma, Andaman Islands, Bay of Bengal, Ceylon, Gulf of Mannar, Cochin Estuary.

Distribution: Pacific Ocean, California, Japan, Indochina, Indian Ocean, Persian Gulf, Red Sea, Atlantic Ocean.

Family SERPULIDAE Savigny, 1818.

Genus: MERCIERELLA Fauvel, 1923.

29. *Mercierella enigmatica* Fauvel, 1923.

Mercierella enigmatica Fauvel, 1923: p.124, fig.1.

Mercierella enigmatica, Fauvel, 1953: p.474, figs.249 a-o.

Body upto 20 mm long. Seven thoracic segments. Branchial filaments each with six to ten stout, radioles ending in naked tips, variable in length. Operculum somewhat fig-shaped, edged with about 20 blackish chitinous spines. Opercular stalk stout, thick and triangular in section. Collar setae of two kinds, (1) fine capillaries and (2) serrated setae with two longitudinal rows of teeth. Unicini with a gouge and single row of five to seven teeth. Abdominal setae are geniculate capillaries with fine blades. The tube is cylindrical and made of calcareous whitish, thin, wrinkled and bell-shaped at the entrance.

Locality: Station I.

Season: April.

Occurrence: Ennur Backwater, on oyster shells, Cochin Estuary.

Distribution: Worldwide in warm estuaries.

Family: TEREBELLIDAE Grube, 1851.

Sub-family: TEREBELLINAE Grube, 1850.

Genus: PISTA Malmgren, 1866.

30. *Pista indica*, Fauvel, 1940.

Pista indica, Fauvel, 1940.

Pista indica, Fauvel, 1953: p.422, figs. 221 a-d.

About 15 mm long. Body rather short and plumb. Abdomen cylindrical with numerous short segments. Sixteen thoracic setigerous segments present. Three pairs of branchiae. Prostomium with long and thick grooved tentacles. Dorsal setae are capillary with narrow wings and a finely serrated tip. Unicini start on the 2nd setigerous segment.

Locality: Station IV.

Season: January and June

Occurrence: West Narakkal, Chepparam, Cochin Backwaters.

SUMMARY

An investigation on the macrobenthos of the Cochin Estuary on the South West Coast of India was carried out during March 1974 to March 1976 from five selected stations, almost equidistant from one another and having depths ranging from 1.5 to 4 m. The samplings were done during high tide at fortnightly intervals in the first year and at monthly intervals in the second year. Along with the bottom fauna water samples for hydrographical studies were taken from each station. Sediment samples were also collected from each station in order to study the physico-chemical nature of the bottom.

A study of the hydrographical conditions of the region showed that there was marked seasonal variation in the salinity. The pre-monsoon period is dry with less rain fall and the maximum salinity (33.13‰) was observed during this period. The South West Monsoon is characterised by heavy rainfall and low salinity values, both in the surface and bottom waters. During the peak of the monsoon season, the estuary becomes completely filled with fresh water.

The seasonal variations were well reflected in the temperature pattern also. For the estuarine system as a whole, the pattern of variation of temperature was bimodal, and the lowest temperature of surface water and bottom sediment recorded were 25.1 and 25.0°C respectively during monsoon period and the highest temperature were 32.5 and 32.2°C, respectively during the pre-monsoon period.

Annual variations of both surface and bottom water dissolved oxygen content were not considerable, except at station I, near the barmouth, where the recorded values were as low as 2.42 ml/L during the South West Monsoon and this is attributed to the influence of upwelled water. But in all the other stations higher values of dissolved oxygen were found at surface and bottom waters during the monsoon period.

The nature of the bottom deposit showed that the composition of sediment varies markedly from station to station. Based on the investigation,the region under study was differentiated into four sedimentological divisions: (1)area covered by clayey silt with very little sand - stations I and II; (2) area with dominance of fine sand fraction - station III; (3)area covered by sand, silt and clay in more or less equal proportion - station IV; (4)area covered by sandy mud - station V.

In general, the percentage of organic matter present in the estuarine sediment was high. The organic matter in the sediment varied from 2.86 to 5.02%, the maximum being in stations with high percentage of clay.

The important macrobenthic groups observed during the present investigations are Polychaeta, Crustacea and Mollusca. Altogether 91 taxa were identified. Among the various animal groups represented in the estuary, Polychaeta was the dominant one. Altogether 35 species of polychaetes belonging to 28 genera were identified. The largest number of polychaetes ($5290/m^2$) was recorded from station III in December 1975. Crustacean fauna was rich in terms of number and consisted of mainly amphipods, tanaids, isopods, cumaceans and brachyuran crabs. Amphipods were widely distributed and the maximum number of $6790/m^2$ was recorded from station IV in December 1975. In the case of tanaids, a seasonal increase was noticed, the maximum recorded number being $10740/m^2$ during October 1975. A total of 19 species of molluscs were collected. Of these, only two, Modiolus undulatus and Nuculana mauritiana were abundant and the maximum recorded numbers were $1059/m^2$ and $39310/m^2$ respectively.

From the study area as a whole, the average number of macrofauna recorded is $2332/m^2$ and hence according to Thienemann's classification, Cochin Estuary may be described as euphotic.

The affinity analysis of the polychaete fauna showed that the station nearest to the barmouth exhibited the least stable community.

Species diversity of Polychaeta was low in stations located at the mouth of the estuary and a higher species diversity was observed in stations at the middle region of the estuary. It was also observed that the species diversity was greater during the high saline period (pre-monsoon) than during the low saline period (monsoon).

The observation on the benthic biomass in the study area as a whole showed a high benthic production. The average annual production (dry weight) during the first year of observation was 5.0881 g/m^2 and in the second year it was 7.4948 g/m^2. This increase in standing crop during the second year was due to the abundance of *Modiolus undulatus* and *Nuculana mauritiana*.

Correlation between the physico-chemical parameters and distribution and abundance of bottom fauna were tested by using Kendall's Rank Correlation Method. Of the various hydrographical parameters of the estuary studied, salinity is the most fluctuating factor, which had the greatest influence on the distribution and abundance of the bottom fauna. The poor faunal composition during the South West Monsoon (July-September) in all stations, particularly at stations I and II near the barmouth could only be due to the wide fluctuations in salinity. Temperature and dissolved oxygen do not show any significant effect on the faunal distribution in the area.

Animal-sediment relationship clearly indicated that a particular animal assemblage flourished only in a certain kind of substratum, where favourable conditions prevail. It was observed that higher biomass values were associated with a substratum having a higher percentage of fine sand with small percentage of silt, followed by silty bottom and the minimum biomass was found in clayey bottom.

Studies on the seasonal variation of macrobenthic components revealed that the largest benthic population occurred during the pre- and post-monsoon seasons and the minimum during South West Monsoon period (July-September). This decrease is attributed to the steep decline in salinity.

The maximum benthic production occurs in the pre- and post-monsoon period, when the primary production is also very high. It appears that there is a direct correlation between the benthic production and organic production in the Cochin Estuary.

As far as the benthic production is concerned, the area under observation is quite rich. In the study areas as a whole the production of macrobenthos, in terms of annual mean standing crop (wet weight) is 352.05 kg./ha and can be considered as rich in benthic production.

In the food web of the estuary polychaetes, amphipods, isopods, tanaids and cumaceans are important links; they feed on mud and organic matter and in turn are predated by bottom feeding fishes and prawns.

Gut content analysis of commercially important penaeid prawns present in the estuary showed that all these species are omnivores and detritus feeders depending much on benthos.

The high benthic production suggests that the macrobenthos may be important as the food of bottom feeding forms - especially prawns which form an important fishery in the Cochin Estuary.

In an attempt to identify the benthic fauna of the estuary, systematics of the polychaetes, the most dominant group in the area of investigation is given as part II of this thesis. A total of 30 species belonging to 25 genera are briefly described and among them 17 are new records from the Cochin Estuary.

REFERENCES

REFERENCES

Abbott, C.E., C.E.Dawson and C.H.Oppenheimer 1971 Chemical, Physical and Biological Characteristics of Estuaries. In Water and Water Pollution Handbook (ed.) L.L.Caiccio, Marcel Dekker, Inc., New York, pp.51-140.

Ajmalkhan, S., E.Vivekanandan and K.Balasubramanyan. 1975 Bottom fauna in two regions of the Vellar Estuary. Recent researches in estuarine biology. (ed.) R.Natarajan, Hindustan Publishing Corp., New Delhi, pp.255-272.

Alee, W.C., O.Park, A.E.Emerson, T.Park and K.P.Schmidt. 1961 Principles of Animal Ecology, Saunders Co., Philadelphia and London.

Ankar, S. and R.Elmgren 1976 The benthic macro- and meio-fauna of the Asko-Landsort area (Northern Baltic Proper) A stratified random sampling survey. No.11, Askö Laboratory, Trosa, Sweden, pp.1-115.

Annandale, N. 1907 Fauna of brackish ponds of Port Canning, Lower Bengal. Rec. Indian Mus. 1.

Annandale, N. and S. Kemp. 1915 Fauna of the Chilka Lake. Mem. Indian Mus. 5, 1-28.

Audouin, J.V. and H.Milne-Edwards 1834 Researches pour servir a l'histoire naturelle dulittoral de la France, 2 Annelides. pp.290.

Bader, R.G. 1954 The role of organic matter in determining the distribution of pelecypods in marine sediments. J. Mar. Res., 13, 32-47.

Balakrishnan, A. 1957 Variations of salinity and temperature in the Ernakulam Channel. Bull. Cent. Res. Inst., 2, 7-9.

Balasubrahmanyan, K. 1961 Studies on the ecology of Vellar Estuary. I.A.Preliminary survey of the estuarine bottom. J. Zool. Soc. India, 12, 209-215.

Barnes, H.	1959	Apparatus and Methods of Oceanography. Part-I. George Allen & Unwin, London.
Beadle, L.C.	1957	Comparative physiology. Osmotic and ionic regulation in aquatic animals. Ann. Rev. Physiol., 19, 329-354.
Birkett, L.	1958	A basis for comparing grabs. J. Cons. perm. int. Explor. Mer., 23, 202-207.
Birkett, L. and A.D.McIntyre	1971	Treatment and sorting of samples. In Methods for the study of marine benthos. IBP Handbook No.16. Blackwel Scientific Publications, Oxford and Edinburgh, pp.156-168.
Black, V.S.	1957	Excretion and osmoregulation. In The Physiology of Fishes, (ed.) M.E.Brown Academic Press, New York, Vol.1, pp.163-205.
Blainville, H.de.	1828	Dictionnaire des Sciences naturelles, 57, 368-501.
Blegvad, H.	1930	Quantitative investigations of bottom invertebrates in the Kattegats with special reference to plaice food. Rep. Danish. Biol. Stat., 36, 1-16.
Bloom, S.A., V.L.Simon and V.D.Hunter	1972	Animal-sediment relations and community analysis of a Florida estuary. Mar. Biol., 13, 43-56.
Boesch, D.F.	1971	Distribution and structure of benthic communities in a gradient estuary. Ph.D.Thesis, College of Williams and Mary, Dept.of Marine Science, pp.120.
Boesch, D.F.	1972	Species diversity of marine macrobenthos in the Virginia area. Chesapeake Science, 13, 206-211.
Boesch, D.F.	1973	Classification and community structure of macrobenthos in Hampton Roads Area, Virginia. Mar. Biol., 21, 226-244.

Bosc, L.A.G.	1802	Histoire naturelle des vers Contenant leur description et leur moeurs avec figures desinees dapres nature, Paris, 1, 113-187
Brett, E.C.	1963	Relationships between marine invertebrate infauna distribution in Bogue Sound, North Carolina (Doctoral Thesis) Univ.of North Carolina, Chapell Hill, North Carolina.
Bristow, R.C.	1938	History of Mud Banks, Vols. I and II, Cochin Government Press.
Carrikar, M.R.	1967	Ecology of estuarine benthic invertebrates: A perspective. In Estuaries pp.442-487 (ed.) G.H.Lauff,American Association for the Advancement of Science, Washington.
Cherian,C.J.	1977	Studies on some boring and fouling crustaceans. Ph.D.Thesis, University of Cochin (unpublished) pp.158.
Cheriyan, P.V.	1966	Polychaetes from the Cochin Harbour area. Bull. Dept. Mar. Biol.Oceanogr. Univ. Kerala, 2, 41-50.
Cheriyan, P.V.	1967	Hydrobiological studies in and around the Cochin Harbour. Bull. Dept. Mar. Biol. Oceanogr. Univ. Kerala, 3,9-17.
Connel, J.H. and E. Orias	1964	The ecological regulation of species diversity Amer. Natur.,98, 399-414.
Crisp, D.J.	1971	Energy flow measurements. In Methods for the study of marine Benthos IBP Handbook No.16, pp.197-279 Blackwell Scientific Publication, Oxford and Edinburgh.
Cuvier, G.	1817	La Regne Animal distribue apres son organisation, pour servirde base a'e histoire. naturelle des animaux etl, introduction a l anatomie comparee, Paris, 2, 515-532.
Damodaran, R.	1973	Studies on the Benthos of the Mud Banks of the Kerala Coast, Bull. Dept.Mar.Sci. Univ. Cochin,6, 1-126.

Day, J.H.	1962	Polychaetae from several localities in the western Indian Ocean. Proc. Zool. Soc., Lond., 139, 627-656.
Day, J.H.	1963	The Polychaete faune of South Africa. Part 7. Species from depths between 1000 and 3,300 metres west of Cape Town. Ann. S.Afr. Mus., 46, 353-371.
Day, J.H.	1967	Polychaeta of Southern Africa. Parts 1, 2. Br. Mus. Nat. Hist. Publs., 656-VIII, pp.878.
Desai, B.N. and M.Krishnankutty	1967a	Studies on the benthic fauna of Cochin Backwaters. Proc. Ind. Acad. Sci., 66, 123-142.
Desai, B.N. and M.Krishnankutty	1967b	A comparison of the marine and estuarine benthic fauna of the nearshore regions of the Arabian Sea. Symposium on Indian Ocean - Bulletin of the National Institute of Science of India, 38, 677-683.
Devassy, V.P. and C.K.Gopinath	1970	Hydrobiological features of the Kerala backwaters during pre-monsoon and monsoon months. Fish. Tech., 7, 190-194.
Dobzhansky, T.	1950	Evolution in the tropics. Amer. Sci., 38, 209-221.
Dora, Y.L. and C.Borreswara Rao	1975	Organic matter content of the Vasishta Godavari River sediments. Bull. Dept. Mar. Sci. Univ. Cochin, VII, 945-952.
Driscoll, E.G.	1967	Attached epifauna - substrate relations, Limnol. Oceanogr., 12, 633-641.
Dunbar, M.J.	1960	The evolution of stability in marine environments. Natural selection at the level of the ecosystem. Amer. Natur., 94, 129-136.
Eagle, R.A.	1973	Benthic studies in the South East of Liverpool Bay Estuarine and Coastal Marine Science, 1, 285-299.

Eggleton, F.E.	1931	"A Limnological study of the profundal bottom fauna of certain fresh water lakes". Ecological Monograph, 1, 223-332.
Ehlers, E.	1901	Die Polychaeten des Magellanischen und Chilenischen strands. Festschr. Ges. Gottingen, pp.1-232.
Ehlers, E.	1920	Polychaeten von Java Und Amboi na. Ein Boit ragzur Kinntnis der malaiischen strand fauna Abh. Ges. Wiss. N.F. Gottingen, 10, 1-73.
El Wakeel, S.K. and J.P.Riley	1957	The determination of organic carbon in marine muds. J. Cons. perm. int. Explor. Mer., 22, 180-183.
El Wakeel, S.K. and J.P.Riley	1961	Chemical and minerological studies of deep sea sediments, Geochim Cosmochim Acta, 25, 110-146.
Emery, K.O. and S.C.Rittenberg	1952	Early diagenesis of California basis sediments in relation to origin of oil. Bull. Am. Assoc. Petrol. Geologists, 36, 735-806.
Fauvel, P.	1923	Un nouveau Serpulien d'eau douce, Mercierella n.g. enigmatica n.sp. Bull. Soc. Zool. France, Paris, 47, 424-430.
Fauvel, P.	1927	Polychaetes Sedentares, in Fauna de France, Paris, 16, 1-494.
Fauvel, P.	1929	Polychaetes nouvelles due Golfe de Mannar, Inde Bull. Soc. Zool., 54, 180-186.
Fauvel, P.	1930	Annelid Polychaeta supplement to the Littoral Fauna of Krusadi Island in the Gulf of Mannar. Bull. Mad. Govt. Mus., I, 1-72.
Fauvel, P.	1932	Annelida Polychaeta of the Indian Museum, Calcutta. Mem. Indian. Mus., 12, 1-262.

Fauvel, P. 1940 On a small collection of Annelida Polychaeta of the Indian Museum, Calcutta. Rec. Indian. Mus., 42, 253-268.

Fauvel, P. 1953 Annelida Polychaeta. The Fauna of India including Pakistan, Ceylon, Burma and Malaya. pp.507.

Fischer, A.G. 1960 Latitudinal variations in organic diversity. Evolution, 14, 64-81.

George, M.G. and Kartha, K.N.K. 1963 Surface salinity of Cochin Backwaters with reference to tide. J.Mar Biol. Ass. India, 5, 178-184.

Gopalakrishnan, V. 1952 Food and feeding habits of the prawn Penaeus indicus. J.Madras. Univ., 22, 69-75.

Gopinathan, C.K. and S.Z.Qasim 1971 Silting in the navigational channels of the Cochin Harbour area. J.Mar. biol. Ass. India, 13, 14-26.

Gravely, F.H. 1927 Chaetopoda. The Littoral Fauna of Krusadi Island in the Gulf of Mannar with Appendices on the vertebrates and plants. Bull. Mad. Govt. Mus. New Ser. Nat. Hist. Sect. 1, 55-86.

Gravier, C. 1901 Contribution a' l' e'tude des annelides polychaetes de la Mer Rouge. Nouv. Archs. Mus. Hist., Nat., Paris, (ser.4) 3, 147-268.

Grout, F.F. 1925 Relation of texture and composition of clays. Bull. Geol. Soc. Amer., 36, 393-416.

Grube, A.E. 1850 Beschreibung neuer oder weing bekamten Anneliden Arct. Naturgesch.

Grube, A.E. 1875 Bemerkungen uber die Familie der Aphroditeun (Gruppe Hermionea and Sigilionea) Fber. Schles. Ges. Vaterl. Kult., 52, 57-79.

Grube, A.E. 1878 Annulate Semperiana Beitrag Zur Kenntniss der Anneliden fauna der Philippinen nach den von Herrn Prof. Semper mitgebrachten Sammulungen Mem. Acad. Sci. S. Peterb. 25, 1-300.

Gunter, G. 1957 Dredges and trawls. Mem. Geol. Soc. Amer., 67, 73-80.

Haridas, P. M. Madhupratap and T.S.S.Rao 1973 Salinity, temperature, oxygen and zooplankton biomass of the backwaters from Cochin to Alleppey. Indian J. Mar. Sci., 2, 94-102.

Hedgpeth, J.W. 1957 Estuaries and Lagoons. II Biological aspects In Treatise on marine ecology and paleocology, 1, 693-729.

Holme, N.A. 1953 The biomass of the bottom fauna in the English Channel off Plymouth. J. Mar. biol. Ass. U.K., 32, 1-49.

Holme, N.A. 1961 The bottom fauna of the English Channel, J.Mar. biol. Ass. U.K., 41, 397-461.

Holme, N.A. 1964 Methods of sampling the benthos. Advan Marine Biol., 2, 171-260.

Holme, N.A. 1966 The bottom fauna of the English Channel. J.mar. biol. Ass. U.K., 46, 401-493.

Holme, N.A. and A.D.McIntyre 1971 Methods for the study of marine Benthos IBP Hand book No.16. pp.334. Blackwell Scientific Publications, Oxford and Edinburgh.

Hopkins, T.L. 1964 A survey of marine bottom samples. Prog. Oceanogr., 2, 213-256.

Jayasree, K. 1971 Preliminary observations on the meiobenthos of the Cochin Harbour area. Bull. Dept. Mar. Biol. Oceangr., Univ. Kerala, 2, 61-68.

Jayasree, K. 1976 Systematics and Ecology of Freeliving Marine Nematodes from Polluted intertidal sand in Scotland. Ph.D.Thesis, Univ. of Aberdeen, pp.179.

Johnson, R.G. 1970 Variations in diversity within benthic marine communities, Amer. Natur., 104, 285-300.

Johnson, R.G. 1971 Animal-sediment relations in shallow water benthic communities, Mar.Geol., 11, 93-104.

Johnston, G. 1839 Miscellanea zoologica. The British Aphroditidae Ann. Mag. nat. Hist., (ser.I) 2, 424-441.

Johnston, G. 1865 A catalogue of the British non-parasitic worms in the collection of the British Museum, pp.366.

Jones, N.S. 1950 Marine bottom communities Biol. Rev., 25, 283-313.

Jones, N.S. 1951 The bottom fauna of the South of the Isle of Man, J.Anim. Ecol., 20, 132-144.

Jones, N.S. 1952 The bottom fauna and the food of the flat fish off the Cumberland Coast. J. Anim. Ecol., 21, 182-205.

Jones, N.S. 1956 The fauna and biomass of a muddy sand deposit off Port Erin. J. Anim. Ecol., 25, 217-252.

Josanto, V. 1971a The bottom salinity characteristics and the factors that influence the salt water penetration in the Vembanad Lake. Bull.Dept.Mar. Biol.Oceanogr., Univ. Cochin, 5, 1-16.

Josanto, V. 1971b On the grain size distribution of the Cochin backwater sediment. Bull.Dept. Mar. Biol. Oceanogr. Univ. Cochin, 5, 109-122.

Joseph, P.S. 1974 Nutrient distribution in the Cochin Harbour and in the vicinity. Indian J. Mar. Sci., 3, 28-32.

Kinberg, J.G.H. 1855 Nya slagten och arten af Annelider. Ofvers. K. Vetensk. Akad. Forh., 12, 381-388.

Kinberg, J.G.H. 1857 Nya slagten och after af Annelider Ofvers. K. Vetensk Akad. Forh. 14, 11-14.

Kinne, O. 1966 Physiological aspects of animal life in estuaries with special reference to salinity. Neth. J. Sea Res., 3, 222-244.

Kinne, O. 1967 Physiology of estuarine organisms with special reference to salinity and temperature: General aspects. In Estuaries (ed.) G.H.Lauff, American Association for the Advancement of Science, pp.525-548.

Kittamori, R. 1960 Two new species of Cirratulidae and Nephthydidae (Annelida Polychaeta), Bull. Jap. Soc. Scient. Fish., 26, 1082-1085.

Klopfer, P.H. 1959 Environmental determinants of faunal diversity. Amer. Natur., 93, 337-342.

Konstantinov, A.S. 1960 Method of estimating the production of organisms serving as food for fishes, Nauch. Dokl. Vyssh Shk., 4, 59-62.

Krumbein, W.C. and F.J. Pettijohn 1938 Manual of Sedimentary Petrography, Appleton Century - Crofts, New York, pp.549.

Kumaran, S. and T.S.S.Rao 1975 Phytoplankton distribution and abundance in the Cochin Backwaters during 1971-72. Bull. Dept. Mar. Sci., Univ. Cochin, 7, 791-799.

Kurian, C.V. 1953 A preliminary survey of the bottom fauna and bottom deposit of the Travancore coast within the 15 fathom line. Proc. Nat. Inst. Sci. India, 19, 746-775.

Kurian, C.V. 1967 Studies on the benthos of the South West Coast of India. Bull. Nat Inst. Sci. India, 38, 649-656.

Kurian, C.V. 1972 Ecology of benthos in a tropical estuary. Proc.Indian.Nat.Sci.Acad., Part B, 38 (3-4), 156-163.

Kurian, C.V., R.Damodaran and A.Antony. 1975 Bottom fauna of the Vembanad Lake. Bull. Dept. Mar. Sci., Univ. Cochin, 7, 987-994.

Kuttyamma, V.J. 1971 Observations on the food and feeding of some Penaeid prawns of Cochin area. J. Mar. Biol. Ass. India, 15, 189-194.

Leach, W.E. 1816 Vermes Polychaeta. In Encyclopedia Britanica. Ed. 4 Suppl. Edinburgh. 6, 451-452.

Lie, U. 1968 A quantitative study of the benthic infauna in Puget Sound, Washington, U.S.A., in 1963-1964. Fisk Dir. Skr. Ser. HavUnders., 14, 229-556.

Lie, U. and J.C. Kelley 1970 Benthic infauna communities off the coast of Washington and in Puget Sound. Identification and distribution of the communities. J. Fish. Res. Bd.,Canada, 27, 621-651.

Lloyd,M., and R.J. Ghelardi 1964 A table for calculating the "Equitability" Components of Species diversity. J. Anim. Ecol., 33, 217-225.

Lockwood,A.P.M. 1962 The Osmoregulation of Crustacea. Biol. Rev., 37, 257-305.

Lovegrove,T. 1966 The determination of the dry weight of plankton and the effect of various factors on the values obtained. In Some contemporary studies in Marine Sciences (ed.) Harold Barnes, pp. 429-467.

Malmgren, A.J. 1866 Nordiska Hafs Annulater Ofvers k. vetensk.Akad.Forh.Stockholm, 21,51-119, 181-192, 22, 355-410.

Malmgren, A.J.	1867	Annulata Polychaeta Spetsbergiae, Groenlandiae, Islandiae et Scandinaviae hactenus cognita. Ofvers. K. vetensk. Akad. Forh. Stockholm, 24, 127-235.
Mare, M.F.	1942	A study of marine benthic community with special reference to the micro-organisms. J. Mar. Biol. Ass. U.K., 25, 517-554.
Marenzeller, E.von	1879	Sudjapanische Anneliden. I.Denkschr Acad. Wiss. Wien., 41, 109-152.
McLusky, D.S.	1968	"Some effects of salinity on the distribution and abundance of Corophium volutator in the Ythan estuary", J. Mar. Biol. Ass. U.K.,48,443-454.
McIntosh, W.C.	1879	On the Annelids obtained during the cruise of H.M.S.Valorous in the Davis Straits in 1875 Trans. Linn. Soc., Lond., 1, 499-511.
McIntyre, A.D.	1969	Ecology of marine meiobenthos. Biol. Rev., 44, 245-290.
McIntyre, A.D. and D.J.Murison	1973	The meiofauna of a flat fish nursery ground. J. Mar. Biol. Ass. U.K., 53, 93-118.
McNulty,J.K., R.C.Work and M.B.Moore	1962	Level sea bottom communities in Biscayne Bay and neighbouring areas. Bull. Mar. Sci.,Gulf Caribb., 12, 204-233.
Meadows, P.S.	1964	Substrate selection by Corophium Species: the particle size of subtrates, J.Anim. Ecol., 33, 387-94.
Milne - Edwards,G.	1838	Le regne animal distribute d'apre s son organisation (By.G.Cuvier) vol. 9. Paris.
Monro, C.C.A.	1937	Notes on a collection of Polychaeta from South Africa, with the description of a new species belonging to the family Sabellidae. Ann. Mag. Nat. Hist., (Ser.10) 19, 366-370.

Montagu, G.	1815	Descriptions of several new or rare animals, principally marine, found on the South Coast of Devonshire. Trans. Linn. Soc., Lond., 11, 18-21.
Moor, H.B.	1958	Marine ecology, John Wiley and Sons, New York.
Moore, J.P.	1903	Description of two new species of Polycnaete from Woods Hole, Mass. Proc. Acad. Nat. Sci., Philad., 55, 720-726.
Moore, J.P.	1906	Additional New species of Polycnaeta from the North Pacific. Proc. Acad. Nat. Sci. Philad. 58, 217-260.
Mortensen, T.H.	1921	Studies on the development and larval forms of echinoderms. pp.266.
Mulicki, Z.	1957	Ecology of the more important benthic invertebrates in the Baltic Sea. Pr. morsk. Inst. rub. Gdyni., 9, 313-379.
Muller	1788	S Peterb. 21, 1-300.
Murty, P.S.N. C.V.G.Reddy and V.V.R.Varadachari	1969	Distribution of organic matter in the marine sediments off the West Coast of India. Proc. Nat. Inst. Sci., India, 35, 377-384.
Murty, P.S.N. and M. Veerayya.	1972	Studies on the sediments of Vembanad Lake, Kerala State. Part I, Distribution of Organic matter. Indian J. Mar. Sci., 1, 45-51.
Muus, B.J.	1967	The fauna of Danish estuaries and lagoons: distribution and ecology of dominating species in the shallow water of the mesohaline zone. Medd. Danm. Fisk-og Havunders. N.S. 5, 1-316.
Naidu, A.S.	1968	Some aspects of texture, minerology and geochemistry of modern deltaic sediments of the Godavari River, India. Ph.D.Thesis, Univ.of Andhra, pp. 486.

Nair, N.B. 1965 Seasonal settlement of marine wood boring animals in Cochin Backwaters, South West of India. Int. Revueges Hydrobiol., 50, 411-420.

Nair, K.K.C. and D.J.Tranter. 1971 Zooplankton distribution along Salinity gradient in the Cochin backwaters before and after the monsoon. J.Mar. biol. Ass. India, 13, 203-210.

Nair, P.V.R., K.J.Joseph, V.K.Balachandran & V.Kunjukrishna Piaali 1975 A study on the primary production in the Vembanad Lake, Bull. Dept. Mar. Sci. Uni. Cochin, 7, 161-170.

Nelson, B.W. 1962 Important aspects of estuarine sediment chemistry for benthic ecology. In symposium on the Environmental chemistry of Marine Sediment (ed.) N.Marshall, Occ. Publ. No.127-41. Narragansett Marine Lab., Univ. Rhode Island, Kingston, Rhode Island.

Neymann, A.A. 1971 Shelf benthos in the Northern part of the Indian Ocean. (52-61) in A.S. Bogdanow (ed.) Soviet Fisheries Investigations in the Indian Ocean, Izdatelstvo Fisheyava Promyshelennost, Moskva.

Nichols, F.H. 1970 Benthic polychaete assemblages and their relationship to the sediment in Port Madison, Washington. Mar. Biol., 6, 48-57.

Nicbl, J.A.C. 1960 The biology of marine animals. Interscience (Publ. Inc.) New York, pp.707.

Odum, W.E. 1970 Insidious alteration of the estuarine environment. Tran. Amer. Fish Soc., 99, 836-847.

Oglesby, L.C. 1969 'Salinity stress and desiccation in intertidal worms', Am. Zoologist., 9, 319-331.

Otto, A.W. 1821 Animalium maritimours nodum editorum genera duo. Nov. Acta. Acad Caesar Leop Carol., 10, 618-634.

Paine, R.T. 1966 Food web complexity and species diversity, Amer. Natur., 100, 65-75.

Panikkar, N.K. and R.G.Aiyar 1937 The Brackish water fauna of Madras. Proc.Ind. Acad. Sci., 6, 284-337.

Parker, R.H. 1956 Macro-invertebrate assemblages as indicators of sedimentary environments in the east Mississippi Delta region, Bull. Am. Assoc. Petrol. Geologists, 40, 295-376.

Parker, R.H. 1975 The Study of Benthic Communities. A modal and a Review. Elsevier Oceanography Series, 9. Elsevier Scientific Publishing Company, Amsterdam - Oxford - New York. pp. 279.

Parulekar, A.H. and S.N.Dwivedi 1974 Benthic studies in Goa Estuaries, Part I - Standing crop and faunal composition in relation to bottom salinity distribution and substratum characteristics in the Estuary of Mandovi River. Indian J. Mar Sci., 3, 41-45

Parulekar, A.H. and S.N.Dwivedi 1975 Ecology of benthic production during South-West Monsoon in an Estuarine complex of Goa. In Recent Researches in Estuarine Biology (ed.) R.Natarajan Hindustan Publishing Company, New Delhi. pp.21-30.

Patnaik, S. 1971 Seasonal abundance and distribution of bottom fauna of the Chilka Lake. J. Mar. biol. Ass. India, 13, 106-125.

Pearse, A.S. and G.Gunter 1957 Salinity Mem. Geol. Soc. Am., 67, 129-157.

Peters, W.C. 1854 Uber die Gattung Bdella Savigny, (Limnatus, Moquin Tandon) und die in Mossambique beobachteten Anneliden Mber. Akad Wiss. Berlin, pp.610-614.

Petersen, C.G.J. 1913 Valuation of the Sea. II. The animal communities of the sea bottom and their importance for marine zoogeography. Rept.Dan.Biol.Sta.,21, 1-44.

Petersen, C.G.J. 1915 On the animal communities of the sea bottom in the Skagerak, the Christ's area Fjord and the Danish waters, Rep. Dan. Biol. Sta., 23, 3-28.

Petersen, C.G.J. 1918 The sea bottom and its production of fish food. Rep. Danish Biol. Sta., 25, pp.62.

Pillai, N.G.K. 1977 Distribution and seasonal abundance of macrobenthos of the Cochin Backwaters, Indian J. Mar. Sci., 6, 1-5.

Poor, G.C.B., S.F.Rainer, R.B.Spies and E. Ward 1975 The Zoobenthos Programme in Port Philip Bay, 1969 - 73. Fisheries and Wild Life Paper, Victoria, No.7. pp.1-78. Published by the Fisheries and Wild Life Division, Victoria, Australia.

Postma, H. 1967 Sediment transport and sedimentation in the estuarine environment. In Estuaries (ed.) G.H.Lauff, Publ. No.83 American Association for the Advancement of Science. pp.158-179.

Pritchard, D.W. 1967 What is an Estuary: Physical view point. In Estuaries (ed.) G.H.Lauff, Publ. No.83, American Association for the Advancement of Science. pp. 3-5.

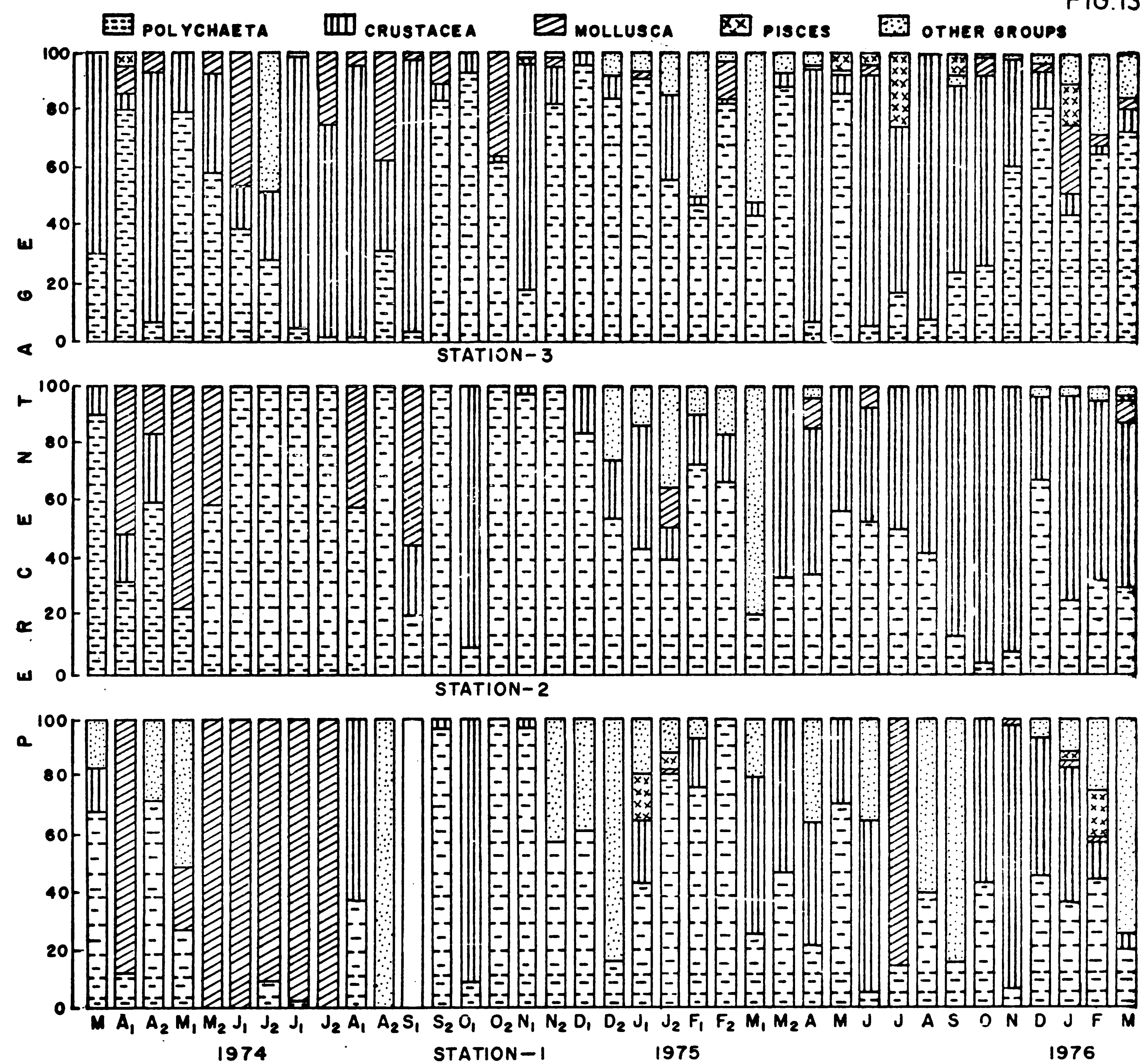
Prosser, C.L. and F.A.Brown 1961 Comparative animal physiology, 2nd ed. W.B.Saunders & Co., Philadelphia, London, pp.688.

Qasim, S.Z. and C.V.G.Reddy. 1967 The estimation of plant pigments of Cochin Backwater during the monsoon months. Bull. Mar. Sc. Gulf of Caribb 17, 95-110.

Qasim, S.Z., P.M.A.Bhatathiri and S.A.H.Abidi 1968 Solar radiation and its penetration in a tropical estuary. J.Exp. Mar. Biol. Ecol., 2, 87-103.

Qasim, S.Z. and C.K.Gopinath 1969 Tidal cycle and environmental features of Cochin Backwaters. Proc. Indian Acad.Sci., 6913, 336-348.

FIG.13


POLYCHAETA
CRUSTACEA
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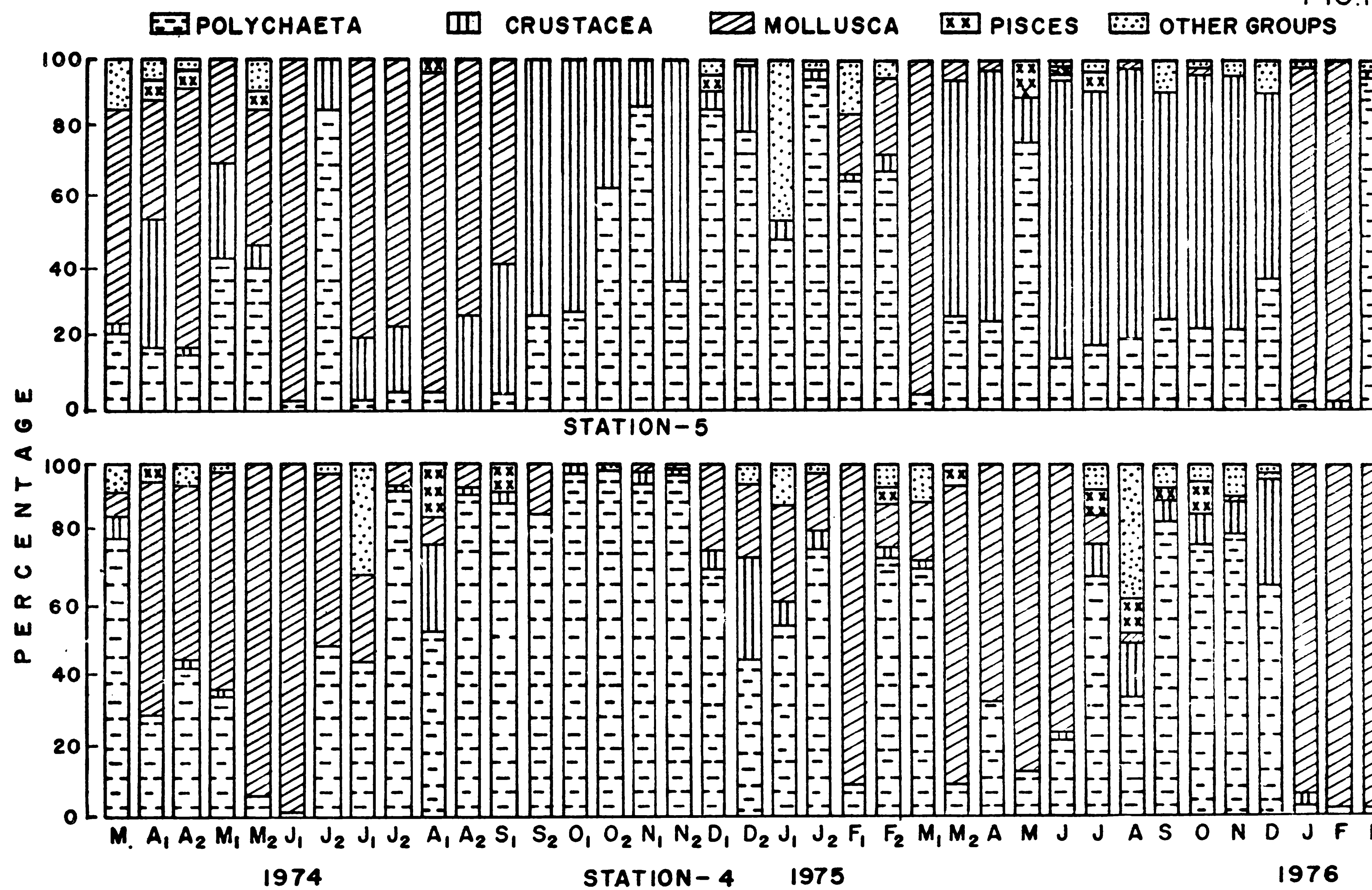
PISCES
OTHER GROUPS
PERCENTAGE
STATION-3
STATION-2
STATION-1
M A1 A2 M1 M2 J1 J2 J1 J2 A1 A2 S1 S2 O1 O2 N1 N2 D1 D2 J1 J2 F1 F2 M1 M2 A M J J A S O N D J F M
1974
1975
1976

Fig. 14. Percentage contribution to the total biomass by polychaetes, crustaceans, molluscs and other groups at stations IV and V.

FIG.14



POLYCHAETA
CRUSTACEA
MOLLUSCA
PISCES
OTHER GROUPS
PERCENTAGE
100
80
60
40
20
0
STATION-5
STATION-4
M. A1 A2 M1 M2 J1 J2 J1 J2 A1 A2 S1 S2 O1 O2 N1 N2 D1 D2 J1 J2 F1 F2 M1 M2 A M J J A S O N D J F M
1974
1975
1976

Qasim, S.Z., S.Wellershaus, P.M.A.Bhatathiri and S.A.H.Abidi. 1969 Organic production in a tropical estuary. Proc. Indian Acad. Sci., 69, 51-94.

Quatrefages, A.D.E. 1865 Histoire naturelle des Anneles marine et d'eau douce Anne'lides et Gephriens. Paris, Vol.I.

Rajan, S. 1965 Environmental studies of the Chilka Lake. 2, Benthic Animal Communities. Indian J. Fish , 7, 492-499.

Ramamritham, C.P. and R.Jayaraman 1963 Some aspects of the hydrographical conditions of the backwaters around Willingdom Island (Cochin), J. Mar. biol. Ass. India, 5, 170-177.

Rao, A.V.P. 1967 Some observations on the biology of Penaeus indicus H.M.Edwards and Penaeus monodon. Fabricius from the Chilka Lake. Indian J. Fish.,14, 251-270.

Rao, M.S. 1960 Organic matter in marine sediments off east coast of India. Bull. Am. Assoc. Petroleum Geologists, 44, 1705-1712.

Rao, M.S. 1967 Studies on the Kakinada Bay on the east coast of India. Quart. Jour. Geol. Min. Metal Soc. India, 39, 75-91.

Rathke, H. 1843 Beitrage Zur Fauna Norwegens Nova Acta Acad. Caesar Leop. Carol., 20,

Remane, A. and C. Schlieper 1958 Die Biologie des Brack wassers Schweizerbart, stuttgart, pp.348 (Die Binnenge Wasser. Bd. 22).

Renier, S.A. 1807 Tavole per scrvire alla classificazione a connoscensa degil animali padua.

Reys, J.P. 1964 Les prelevements quantitatifs du benthos de substrats meubles Terre vie. 1, 94-105.

Rhoads, D.C. and D.K. Young 1970 The influence of deposit freeding organisms on settlement stability and community trophic structure. J. mar. Res., 28, 150-178.

Ristich, S.S., J.Fortier and M.Crandall 1973 Benthic community. In Maintenance of a Functional Environment in the Hudson River Estuary, pp.1-33. Boyce, Thompson Inst., 2nd Annual Rept.to The Rock Feller Foundation Yonkers, New York.

Robertson, J.D. 1957 Osmotic and ionic regulation in aquatic invertebrates. In Recent Advances in Invertebrate Physiology, pp.229-246. Publication of the University of Oregon, Eugene, Oregon.

Robertson, J.D. 1960 Osmotic and ionic regulation. In The Physiology of Crustacea, Vol.I (ed.) T.H.Waterman Academic Press, New York, pp.317-339.

Russell, E.J. 1950 Soil conditions and plant Growth. Longmans, Green and Co., New York.

Sanders, H.L. 1956 Oceanography of Long Island Sound 1952-54, Biology of Marine Bottom Communities. Bull Bingham Oceanogr. Coll., 15, 345-414.

Sanders, H.L. 1958 Benthic studies in Buzzards Bay. I. Animal-sediment relationships. Limnol Oceanogr., 3, 245-258.

Sanders, H.L. 1959 Sediments and the structure of bottom communities. In International Oceanographic Congress. Reprints (ed.) Mary Sears. American Association for the Advancement of Science, Washington D.C., pp.583-584.

Sanders, H.L. 1960 Benthic studies in Buzzards Bay.III. The structure of the soft bottom community. Limnol.Oceanogr.,5, 138-153.

Sanders, H.L. 1968 Marine benthic diversity: A comparative study. Am. Nat., 102 (925), 243-282.

Sankaranarayanan, V.N. and S.Z. Qasim. 1969 Nutrients of Cochin Backwaters in relation to environmental characters, Mar. Biol., 2, 236-247.

Sankaranarayanan, V.N. and R. Jayaraman 1972 Intrusion of upwelled water in the Mandovi and Zuari estuaries. Curr. Sci., 41, 204-206.

Savich, M.S. 1972 Quantitative distribution and food value of benthos from the West Pakistan shelf Oceanology, 12, 113-117.

Savigny, J.C. 1818 Annelids. In J.B. Lamarck (ed.) Histoire naturelle des animaux sans vertebres Paris, pp.612.

Savigny, J.C. 1820 Systeme des annelides, principalement de Celles des Cotes de l' Egypte et de la Syrie etc, Paris pp.128.

Segerstrale, S.G. 1960 Fluctuations in the abundance of benthic animals in the Baltic Sea. Soc. Scient. Fenn. Consment Biol., 23, 1-19.

Seshappa, G. 1953 Observations on the physical and biological features of the inshore sea bottom along the Malabar Coast. Proc. Nat. Inst. Sci. India, 19, 257-279.

Shannon, C.E. and W. Weaver 1963 The mathematical theory of communication, University of Illinois Press Urbana, pp.117.

Shepard, F.P. 1954 Nomenclature based on sand-silt-clay ratios. J. Sedim Petrol, 24, 151-158.

Shetty, H.P.C. 1963 A preliminary fishery survey of the Vembanad Backwaters, Kerala. Surv. Rep. cent. Inl. Fish. Res. Inst., 2, pp.24.

Simpson, E.H. 1964 Measurement of diversity. Nature, 163, pp.688.

Simpson, G.G.	1964	Species diversity of North American recent mammals Syst.Zool., 13, 57-73.
Slobodkin, L.B.	1962	Growth and Regulation of Animal Populations. Holt Rineheart Winston, New York, pp.184.
Sokal, R.R. and F. J. Rohlf.	1969	Biometry, Freeman, San Francisco.
Sokolova, M.N. and F.A.Pasternak	1962	Dokl. Akad. Nauk. USSR, 144, 645-648.
Southern, R.	1921	Polychaeta of the Chilka Lake and also of fresh water and brackish water in other parts of India. Mem. Ind. Mus., 5, 563-659.
Spark, R.	1935	On the importance of quantitative investigations of the bottom fauna in marine biology. Journal du Conseil, 10, 3-19.
Sreedharan, M. and K.Y.Mohammed Salih	1974	Distribution characteristics of nutrients in the Estuarine complex of Cochin. Indian J. Mar. Sci., 3, 125-130.
Stickney, A.P. and L.D.Stringer	1957	A study of the invertebrate bottom fauna of Greenwich Bay, Rhode Island Ecology, 38, 111-122.
Strickland, J.D. and T.R.Parsons	1965	A Manual of Sea Water Analysis. Bull. Fish. Res. Bd. Canada, 125, 1-185.
Thienemann, A.	1925	Die Binnengewasser Mitteleuropas: Ein limnole gische Einfuhrung Binnengewasser, 1, 1-255.
Thomas, P.J.	1964	Cossura coasta Kitamori (Polychaeta Cossuridae) a new record from Indian Waters. Curr. Sci. 33, 754-755.
Thorson, G.	1955	Modern aspects of marine level - bottom animal Communities, J.Mar. Res. 14, 387-397.

Thorson, G. 1957a Sampling the benthos Mem. Geol. Soc. Amer., 67, 1, 61-73.

Thorson, G. 1957b Bottom communities (Sublittoral and shallow shelf) Geol. Soc. Am. Mem., 67, 461-534.

Thorson, G. 1958 Parallel level - bottom communities, their temperature adaptation, and their "balance" between predators and food animals. In Perspectives in Marine Biology (ed.) A.A.Buzzati-Traverso Univ. Calif. Press, Berkeley, California. pp.67-86.

Townes, H.K. 1938 Studies on the food organisms of fish. A biological survey of the Alleghemy and chemung Watersheds suppl. to 27th Ann. Reports, 1937.

Trask, P.D. 1955 Organic content of recent marine sediments. In Recent Marine Sediments (ed.) P.D.Trask. Spec. Publ. 4, pp.428-453.

Unnithan, R.V., M.Vijayan and K.N.Ramani 1975 Organic pollution in Cochin Backwaters. Indian J. Mar. Sci., 4 39-42.

Van Andel, Tj.H. and H. Postma 1954 Recent sediments of the Gulf of Paria; in Reports of the Orinoco. Shelf Expedition, Vol.1, Kon. Nederl. Akad. Wetensch Verh., 20, pp.238.

Veeraya, M. and P.S.N. Murty. 1974 Studies on the sediments of Vembans Lake, Kerala State. Part II. Distribution and interpretation of bottom sediment. Indian J. Mar. Sci. 3, 16-27.

Venkataratnam, K. 1967 Studies on some aspects of the sediments of Chilka Lake, a coastal lagoon, D.Sc.thesis. Andhra University, Waltair.

Webster, H.E. and J.E.Benedict.	1887	The Annelida Chaetopoda Eastport, Maine *Rep. U.S. Commr. Fish.*, 1885, 707-755.
Whitlatch, R.B.	1977	Seasonal changes in the community structure of the Macrobenthos inhabiting the intertidal sand and mud flats of Barnstable Harbour, Massachusetts. *Biol. Bull.*, 152, 275-294.
Whittaker, R.H.	1967	Gradient analysis of vegetation. *Biological Review*, 49, 207-264.
Wieser, W.	1960	Benthic studies in Bussards By - II. The meiofauna. *Limnol* and *Oceanogr.*, 5, 121-137.
Willey, A.	1905	Report on the polychaeta collected by Prof. Hardman at Ceylon in 1902. *Suppl. Rep. Ceylon.*
Williams, T.	1851	Report on the British Annelida. *Rep. Br. Ass. advmt. Sci.*, 21, 159-272.
Williams. C.B.	1964	Pattern in the balance of nature. Academic. New York pp.324.
Wilson, D.P.	1932	On the *Mitraria* larva of *Owenia fusimormis* Delle chiaje. *Philos. Trans.*, B, 221, 231-334.
Wilson, D.P.	1952	The influence of the nature of the substratum on the metamorphosis of the larvae of marine animals especially the larvae of *Ophelia bicornis*, Savigny *Ann. Inst. Oceanog.*, 27, 49-156.
Wiren, A.	1883	Chaetopoder fran Sibiriska Ishafvet och Barings HaXf insanlade under *Vega Expedition* 1878-79. *Veg - exped. Vetensk Lakttag* 2, 283-428.

Wolff, W.J.	1973	The estuary as a habitat. An analysis of data on the soft-bottom macrofauna of the estuarine area of the rivers Rhine, Meuse and Scheldt. Zool. Verh., 126, 1-242.
Yonge, C.M.	1953	Aspects of life on muddy shores. In Essays in Marine Biology, (ed.) S.M. Marshall and A.P. Orr. Richard Elmhirst Memorial Lectures, Oliver and Boyd, Edinburgh. pp.29-49.
Young, D.K. and D.C. Rhoads.	1971	Animal-sediment relations in Cape Cod Bay, Massachusetts. I. A transect study. Mar. Biol., 2, 242-254.

TABLES

Table 1
Station I
1974 - 1975

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta	Crustacea
Salinity	1.0000 .0000	.5758 2.6064**	.2424 1.0974	-.4848 2.1949*	-.0606 .2744	-.1515 .6859	.4545 2.0577*	.0909 .4115	.1818 .8231	.5152 2.3321*
Temperature		1.0000 .0000	.0606 .2744	-.4848 2.1949*	.2424 1.0974	-.3333 1.5090	.0909 .4115	.0303 .1372	-.0606 .2744	.3939 1.7833
Dissolved oxygen			1.0000 .0000	-.0909 .4115	-.1515 .6859	.2424 1.0974	-.0606 .2744	-.4242 1.9205	-.2121 .9603	.0000 .0000
Organic matter				1.0000 .0000	-.3333 1.5090	.4848 2.1949*	-.1818 .8231	-.3636 1.6462	-.0303 .1372	-.6667 3.0180**
Sand					1.0000 .0000	-.7879 3.5667**	-.1818 .8231	.2424 1.0974	-.0303 .1372	.2424 1.0974
Silt						1.0000 .0000	-.0303 .1372	-.2727 1.2346	.0000 .0000	-.4545 2.0577*
Clay							1.0000 .0000	.3333 1.5090	.5455 2.4692*	.3939 1.7833
Total fauna								1.0000 .0000	.6061 2.7436**	.4545 2.0577*
Polychaeta									1.0000 .0000	.3030 1.3718
Crustacea.										1.0000 .0000

*Significant
**Highly significant

Table 2
Station I
1975 - 1976

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temper-ature	Dissol-ved ox-ygen.	Organic matter	Sand	Silt	Clay	Total fauna	Poly-chaeta	Crusta-cea.
Salinity	1.0000	.4242	-.1515	.1212	.0303	.1818	.0909	.3939	.5758	.1515
	.0000	1.9205	.6859	.5487	.1372	.3231	.4115	1.7833	2.6064**	.6859
Temper-ature		1.0000	.0000	.0909	.0000	.2727	-.3030	.2424	.2424	.1212
		.0000	.0000	.4115	.0000	1.2346	1.3718	1.0974	1.0974	.5487
Dissolv-ed oxy-gen			1.0000	.3030	-.4545	.3636	.2727	-.2121	-.3333	-.0303
			.0000	1.3718	2.0577*	1.6462	1.2346	.9603	1.5090	.1372
Organic matter				1.0000	-.1818	.2727	.3030	-.0606	-.1212	-.1818
				.0000	.8231	1.2346	1.3718	.2744	.5487	.8231
Sand					1.0000	-.6667	-.4545	-.0909	.0909	-.2121
					.0000	3.0180**	2.0577*	.4115	.4115	.9603
Silt						1.0000	.1212	.2424	.0606	.3030
						.0000	.5487	1.0974	.2744	1.3718
Clay							1.0000	-.0303	-.0909	-.0303
							.0000	.1372	.4115	.1372
Total fauna								1.0000	.8182	.6364
								.0000	3.7039**	2.8808
Polych-aeta									1.0000	.4545
									.0000	2.0577*
Crusta-cea										1.0000
										.0000

*Significant; **Highly significant

Table 3
Station II
1974 - 1975

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen.	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta	Crustacea
Salinity	1.0000	.4585*	.0000	-.3333	.1212	-.0606	.2121	.5152*	.5152*	.4848*
	.0000	2.0577	.0000	1.5090	.5487	.2744	.9603	2.3321	2.3321	2.1949
Temperature		1.0000	.0606	-.0303	-.3030	.1212	-.0303	.2121	.3333	.0000
		.0000	.2744	.1372	1.3718	.5487	.1372	.9603	1.5090	.0000
Dissolved oxygen			1.0000	.2424	-.3333	.0909	-.0606	.0606	.0000	.0909
			.0000	1.0974	1.5090	.4115	.2744	.2744	.0000	.4115
Organic matter				1.0000	-.3636	.0606	.0303	-.2121	-.2727	-.1818
				.0000	1.6462	.2744	.1372	.9603	1.2346	.8231
Sand					1.0000	-.0909	-.1212	.0606	.0000	.1515
					.0000	.4115	.5487	.2744	.0000	.6859
Silt						1.0000	-.7879**	-.3030	-.2424	-.3333
						.0000	3.5667	1.3718	1.0974	1.5090
Clay							1.0000	.2727	.2727	.3030
							.0000	1.2346	1.2346	1.3718
Total fauna								1.0000	.8182**	.6667**
								.0000	3.7039	3.0181
Polychaeta									1.0000	.4848*
									.0000	2.1949
Crustacea										1.0000
										.0000

Table 4.
Station II
1975 -1976

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen.	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta	Crustacea.
Salinity	1.0000	.3939	.4242	.5455	.0909	.1515	.0303	-.2424	.1515	.1818
	.0000	1.7833	1.9205	2.4692*	.4115	.6859	.1372	1.0974	.6859	.8231
Temperature		1.0000	-.2424	.1212	.2121	.0909	.0303	.0000	-.2727	.0000
		.0000	1.0974	.5487	.9603	.4115	.1372	.0000	1.2346	.0000
Dissolved Oxygen.			1.0000	-.0303	-.3636	.0606	.2424	.3939	.0000	.4545
			.0000	.1372	1.6462	.2744	1.0974	1.7833	.0000	2.0577*
Organic matter				1.0000	-.1212	.3636	.0606	.1515	.3636	.2121
				.0000	.5487	1.5462	.2744	.6859	1.6462	.9603
Sand					1.0000	-.1515	-.3939	-.3636	.1515	-.4848
					.0000	.6859	1.7833	1.6462	.6859	2.1949*
Silt						1.0000	-.4545	.1212	.0303	.1818
						.0000	2.0577*	.5487	.1372	.8231
Clay							1.0000	.1818	-.2727	.2424
							.0000,	.8231	1.2346	1.0974
Total fauna								1.0000	.0606	.7576
								.0000	.2744	3.4295**
Polychaeta									1.0000	-.1818
									.0000	.8231
Crustacea										1.0000
										.0000

*Significant; **Highly significant

Table 5
Station III
1974 - 1975

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta.	Crustacea
Salinity	1.0000	.6667	-.0303	-.4545	.1515	-.1818	.0303	.0303	.0909	-.3636
	.0000	3.0180**	.1372	2.0577*	.6859	.8231	.1372	.1372	.4115	1.6462
Temperature		1.0000	.1818	-.4848	-.1212	.0909	.3030	-.1818	-.1212	-.2727
		.0000	.8231	2.1949*	.5487	.4115	1.3718	.8231	.5487	1.2346
Dissolved oxygen			1.0000	.1515	-.2121	.1818	.0909	.0303	-.0303	.0000
			.0000	.6859	.9603	.8231	.4115	.1372	.1372	.0000
Organic matter				1.0000	.0303	.0000	-.0909	.2727	.2121	-.0606
				.0000	.1372	.0000	.4115	1.2346	.9603	.2744
Sand					1.0000	-.9091	-.6970	.4545	.4545	-.1818
					.0000	4.1154**	3.1551**	2.0577*	2.0577*	.8231
Silt						1.0000	.6061	-.4242	-.4242	.2727
						.0000	2.7436**	1.9205	1.9205	1.2346
Clay							1.0000	-.5152	-.5152	.0000
							.0000	2.3321*	2.3321*	.0000
Total fauna								1.0000	.9394	-.3030
								.0000	4.2526**	1.3718
Polychaeta.									1.0000	-.3030
									.0000	1.3718
Crustacea.										1.0000
										.0000

*Significant; **Highly significant

Table 6
Station III
1975 - 1976

Rank correlation coefficient matrix (Kendall's' Ta $_{u}$) of environmental parameters

	Salinity	Temperature	Dissolved oxygen	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta	Crustacea
Salinity	1.0000	.5152*	-.3636	.1818	-.0606	-.0606	.2121	-.1212	-.1212	-.3636
	.0000	2.3321	1.6462	.8231	.2744	.2744	.9603	.5487	.5487	1.6462
Temperature		1.0000	-.0606	.3636	-.0606	.0000	.0303	.1212	-.0606	-.1818
		.0000	.2744	1.6462	.2744	.0000	.1372	.5487	.2744	.8231
Dissolved oxygen			1.0000	.3333	-.1515	.2121	.0606	.0909	-.0303	.3939
			.0000	1.5090	.6859	.9603	.2744	.4115	.1372	1.7833
Organic matter				1.0000	-.0909	-.0303	.0606	.3939	.1515	.3333
				.0000	.4115	.1372	.2744	1.7833	.6859	1.5090
Sand					1.0000	-.7576**	-.7273**	.1515	.1515	-.0909
					.0000	3.4295	3.2923	.6859	.6859	.4115
Silt						1.0000	.4848*	-.1515	-.0909	.0303
						.0000	2.1949	.6859	.4115	.1372
Clay							1.0000	-.0606	-.1212	.0000
							.0000	.2744	.5487	.0000
Total fauna								1.0000	.6970**	.6364**
								.0000	3.1551	2.8808
Polychaeta.									1.0000	.3333
									.0000	1.5090
Crustacea										1.0000
										.0000

*Significant; **Highly significant

Table 7
Station IV
1974 - 1975

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta	Crustacea
Salinity	1.0000	.4848*	.0000	-.4242	-.2424	-.0909	.2424	.1515	.1515	.3030
	.0000	2.1949	.0000	1.9205	1.0974	.4115	1.0974	.6859	.6859	1.3718
Temperature		1.0000	.2121	-.0303	-.3939	.0000	.3939	.1818	.3030	-.0303
		.0000	.9603	.1372	1.7833	.0000	1.7833	.8231	1.3718	.1372
Dissolved oxygen			1.0000	.3333	-.0909	.0606	.0303	.1818	-.3636	-.2121
			.0000	1.5090	.4115	.2744	.1372	.8231	1.6462	.9603
Organic matter				1.0000	.0303	.0606	-.1515	-.1212	-.0606	-.4545*
				.0000	.1372	.2744	.6859	.5487	.2744	2.0577
Sand					1.0000	-.4848*	-.5152*	-.1212	-.0606	.0303
					.0000	2.1949	2.3321	.5487	.2744	.1372
Silt						1.0000	.0000	.2121	.0303	-.0606
						.0000	.0000	.9603	1.1372	.2744
Clay							1.0000	-.0606	.0606	-.1515
							.0000	.2744	.2744	.6859
Total fauna								1.0000	.5152*	.4242
								.0000	2.3321	1.9205
Polychaeta.									1.0000	.2424
									.0000	1.0974
Crustacea										1.0000
										.0000

*Significant

Table 8
Station IV
1975 - 1976

Rank correlation coefficient matrix (Kendall's' Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta	Crustacea
Salinity	1.0000	.4545	-.4242	-.2424	.0606	-.3333	.1515	.3636	.1515	-.0606
	.0000	2.0577*	1.9205	1.0974	.2744	1.5090	.6859	1.6462	.6859	.2744
Temperature		1.0000	-.3030	-.1212	.1818	-.2121	.0303	.3636	.3333	-.1818
		.0000	1.3718	.5487	.8231	.9603	.1372	1.6462	1.5090	.8231
Dissolved oxygen			1.0000	.0909	.2727	.0606	.3030	.2727	.1818	.1515
			.0000	.4115	1.2346	.2744	1.3718	1.2346	.8231	.6859
Organic matter				1.0000	.0303	.1212	-.0606	-.1515	.0606	-.2727
				.0000	.1372	.5487	.2744	.6859	.2744	1.2346
Sand					1.0000	-.4848	-.3636	.2121	.3636	.0909
					.0000	2.1949*	1.6462	.9603	1.6462	.4115
Silt						1.0000	-.1515	-.3636	-.2121	.0000
						.0000	.6859	1.6462	.9603	.0000
Clay							1.0000	-.0606	-.3939	-.1818
							.0000	.2744	1.7833	.8231
Total fauna								1.0000	.3636	.3333
								.0000	1.6462	1.5090
Polychaeta									1.0000	.3030
									.0000	1.3718
Crustacea										1.0000
										.0000

*Significant

Table 9
Station V
1974 - 1975

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta.	Crustacea
Salinity	1.0000	.5455	-.1515	.0000	-.5758	-.2424	.4545	.2121	.5152	.1212
	.0000	2.4692*	.6859	.0000	2.6064**	1.0974	2.0577*	.9603	2.3321*	.5487
Temperature		1.0000	-.0606	.1515	-.3030	-.1515	.4242	.0000	.1818	-.2121
		.0000	2744	.6859	1.3718	.5859	1.9205	.0000	.8231	.9603
Dissolved oxygen			1.0000	-.2424	-.0909	.3030	-.2121	.0909	.1515	-.1212
			.0000	1.0974	.4115	1.3718	.9603	.4115	.6859	.5487
Organic matter				1.0000	.0000	-.0909	.1818	.0606	-.1212	-.0909
				.0000	.0000	.4115	.8231	.2744	.5487	.4115
Sand					1.0000	-.0606	-.3939	-.2727	-.5758	-.1212
					.0000	.2744	1.7833	1.2346	2.6064**	.5487
Silt						1.0000	-.5455	.0000	.0000	.0303
						.0000	2.4692*	.0000	.0000	.1372
Clay							1.0000	.2727	.2121	.0606
							.0000	1.2346	.9603	.2744
Total fauna								1.0000	.3939	.4848
								.0000	1.7833	2.1949*
Polychaeta									1.0000	.1818
									.0000	.8231
Crustacea										1.0000
										.0000

*Significant; **Highly significant

Table 10
Station V
1975–1976

Rank correlation coefficient matrix (Kendall's Tau) of environmental parameters

	Salinity	Temperature	Dissolved oxygen	Organic matter	Sand	Silt	Clay	Total fauna	Polychaeta	Crustacea
Salinity	1.0000	.4545	-.4242	.3030	-.6667	.5455	.4242	-.1212	-.4545	-.1515
	.0000	2.0577*	1.9205	1.3718	3.0180**	2.4692*	1.9205	.5487	2.0577*	.6859
Temperature		1.0000	-.3030	.2424	-.4848	.2424	.3636	-.1818	-.3939	-.3333
		.0000	1.3718	1.0974	2.1949*	1.0974	1.6462	.8231	1.7833	1.5090
Dissolved oxygen			1.0000	-.0909	.3333	-.2121	-.3333	.1515	.4848	.0000
			.0000	.4115	1.5090	.9603	1.5090	.6859	2.1949*	.0000
Organic matter				1.0000	-.2727	.0909	.2727	.0303	.0000	-.1818
				.0000	1.2346	.4115	1.2346	.1372	.0000	.8231
Sand					1.0000	-.5152	-.7576	.0909	.4242	.0606
					.0000	2.3321*	3.4295**	.4115	1.9205	.2744
Silt						1.0000	.2727	.2121	-.1818	.2424
						.0000	1.2346	.9603	.8231	1.0974
Clay							1.0000	-.2121	-.4848	-.2424
							.0000	.9603	2.1949*	1.0974
Total fauna								1.0000	.6061	.5455
								.0000	2.7436**	2.4692*
Polychaeta									1.0000	.3333
									.0000	1.5090
Crustacea										1.0000
										.0000

*Significant; **Highly significant.

Table 11

Percentage of sand, silt, clay and organic carbon in sediment samples collected from Station I during the period from March 1974 to March 1976.

Date of sampling	Sand(%)	Silt(%)	Clay (%)	Organic carbon(%)	Organic matter (%)
21-3-1974	14.25	48.00	37.75	1.89	3.26
18-4-1974	16.35	46.25	37.40	1.91	3.29
17-5-1974	18.75	45.85	35.40	1.92	3.31
1- 6-1974	17.24	47.16	35.60	1.99	3.43
20-7-1974	21.84	41.26	36.90	2.07	3.56
3- 8-1974	6.78	58.82	34.40	2.58	4.45
4- 9-1974	11.50	53.90	34.60	2.61	4.49
5-10-1974	1.66	61.02	37.32	2.91	5.02
7-11.1974	4.35	58.40	37.25	2.72	4.69
9-12-1974	0.49	62.61	36.90	2.55	4.39
13-1-1975	2.32	48.53	49.15	2.38	4.10
17-2-1975	1.82	58.13	40.05	2.51	4.32
31-3-1975	3.71	61.34	34.95	2.79	4.81
30-4-1975	23.99	45.01	31.00	2.01	3.46
26-5-1975	20.04	52.71	27.25	1.86	3.21
26-6-1975	27.63	52.27	20.10	1.91	3.29
24-7-1975	8.67	57.23	34.10	2.50	4.31
28-8-1975	0.58	56.32	43.10	2.12	3.65
26-9-1975	0.34	62.11	37.55	2.58	4.45
30-10-'75	0.52	61.58	37.90	2.14	3.69
29-11-'75	0.97	62.63	36.40	2.21	3.81
29-12-'75	0.47	72.33	27.30	2.03	3.49
27-1-1976	1.29	59.81	38.90	2.42	4.17
29-2-1976	0.53	64.32	35.15	2.28	3.93
28-3-1976	2.15	60.40	37.45	2.48	4.27

Table 12

Percentage of sand, silt, clay and organic carbon in sediment samples collected from Station II during the period from March 1974 to March 1976.

Date of sampling	Sand (%)	Silt (%)	Clay (%)	Organic Carbon (%)	Organic matter (%)
21-3-1974	1.49	51.01	47.50	2.20	3.79
18-4-1974	2.51	50.99	46.50	2.13	3.67
17-5-1974	3.60	67.50	28.90	2.05	3.53
1 -6-1974	3.48	66.92	29.60	2.21	3.81
20-7-1974	3.53	55.72	40.75	2.64	4.55
3- 8-1974	2.96	47.49	49.55	2.19	3.78
4- 9-1974	4.81	51.24	43.95	2.31	3.98
5-10-1974	2.13	66.19	31.68	2.24	3.86
7-11-1974	7.29	47.11	45.60	2.13	3.67
9-12-1974	5.34	51.66	43.00	2.09	3.60
13-1-1975	7.99	60.29	31.72	1.89	3.25
17-2-1975	6.23	47.72	46.05	1.98	3.41
31-3-1975	3.04	46.46	50.50	2.21	3.81
30-4-1975	2.85	75.03	22.12	2.18	3.76
26-5-1975	12.72	42.33	44.95	2.00	3.44
26-6-1975	17.30	42.56	30.14	1.91	3.29
24-7-1975	17.34	56.21	26.45	2.38	4.10
28-8-1975	0.55	43.70	55.75	2.17	3.74
26-9-1975	0.75	54.25	45.00	2.20	3.79
30-10-'75	1.22	50.23	48.55	2.01	3.47
29-11-'75	1.82	49.93	48.25	2.52	4.34
29-12-'75	1.52	57.78	40.70	2.61	4.49
27-1-1976	1.28	49.37	49.35	2.69	4.60
29-2-1976	2.91	52.49	44.60	2.74	4.72
28-3-1976	1.62	50.23	48.15	2.78	4.79

Table 13

Percentage of sand, silt, clay and organic carbon in sediment samples collected from Station III during the period from March 1974 to March 1976.

Date of sampling	Sand(%)	Silt(%)	Clay(%)	Organic carbon(%)	Organic matter(%)
21-3- 1974	69.92	16.73	13.35	1.66	2.86
18- 4- 1974	75.25	12.00	12.75	1.98	3.41
17-5- 1974	75.71	13.04	11.25	2.00	3.44
1 -6- 1974	75.30	12.05	12.65	2.10	3.62
20-7- 1974	79.47	11.33	9.20	2.17	3.74
3 -8- 1974	56.89	21.11	22.00	2.19	3.77
4 -9- 1974	35.71	41.19	23.10	2.62	4.51
5-10- 1974	82.86	9.74	7.40	2.51	4.33
7-11- 1974	69.55	20.72	9.73	2.03	3.49
9-12- 1974	84.07	6.53	9.40	2.11	3.63
13-1- 1975	89.19	1.26	9.55	2.20	3.79
17-2- 1975	54.17	25.08	20.75	2.18	3.76
31-3- 1975	60.42	25.42	14.16	2.21	3.81
30-4- 1975	80.11	6.54	13.35	1.99	3.43
26-5- 1975	50.28	21.62	28.10	1.97	3.39
26-6- 1975	74.92	11.81	13.27	2.01	3.46
24-7- 1975	72.23	15.47	12.30	2.29	3.94
28-8- 1975	28.40	37.94	33.66	2.00	3.45
26-9- 1975	68.53	28.44	3.03	1.96	3.37
30-10-1975	32.37	32.88	34.75	2.12	3.65
29-11-1975	57.20	19.35	23.45	2.78	4.79
29-12-1975	41.27	33.73	25.00	2.33	4.02
27-1- 1976	52.59	21.81	25.60	2.41	4.15
29-2- 1976	35.95	37.55	26.50	2.22	3.83
28-3- 1976	72.15	17.30	10.55	2.31	3.98

Table 14

Percentage of sand, silt, clay and organic carbon in sediment samples collected from Station IV during the period from March,1974 to March,1976.

Date of sampling	Sand(%)	Silt(%)	Clay(%)	Organic carbon(%)	Organic matter (%)
21- 3-1974	13.59	38.51	47.90	2.03	3.49
18- 4-1974	26.96	27.59	45.45	2.19	3.77
17- 5-1974	27.05	42.05	30.90	2.12	3.65
1 - 6-1974	26.85	40.75	32.40	2.27	3.91
20- 7-1974	32.40	45.54	22.06	2.55	4.39
3 - 8-1974	57.31	18.94	23.75	2.51	4.33
4 - 9-1974	53.52	25.08	21.40	2.58	4.45
5 -10-1974	32.46	28.99	38.55	1.91	3.29
7 -11-1974	48.09	38.05	13.86	2.03	3.49
9 -12-1974	50.07	29.03	20.90	1.90	3.27
13- 1-1975	31.05	29.85	39.10	1.93	3.32
17- 2-1975	51.49	24.16	24.35	2.07	3.56
31- 3-1975	72.76	10.39	16.85	2.24	3.86
30- 4-1975	51.61	27.33	21.06	2.11	3.64
26- 5-1975	50.86	20.84	28.30	2.03	3.49
26- 6-1975	48.25	26.57	25.18	2.09	3.60
24- 7-1975	25.61	51.64	22.75	2.31	3.98
28- 8-1975	80.48	6.07	13.45	2.17	3.74
26- 9-1975	55.99	35.31	8.70	2.27	3.91
30-10-1975	56.66	21.89	21.45	1.97	3.39
29-11-1975	67.67	25.90	6.43	2.00	3.45
29-12-1975	29.86	53.91	16.23	1.81	3.12
27- 1-1976	64.90	18.65	16.45	1.98	3.41
29- 2-1976	51.60	4.20	44.20	2.01	3.47
28- 3-1976	52.14	23.26	24.60	2.21	3.81

Table 15

Percentage of sand, silt, clay and organic carbon in sediment samples collected from Station V during the period from March 1974 to March 1976.

Date of sampling	Sand (%)	Silt (%)	Clay (%)	Organic carbon (%)	Organic matter (%)
21- 3-1974	10.29	39.81	49.90	2.72	4.69
18- 4-1974	17.98	32.92	49.10	2.30	3.96
17- 5-1974	17.65	47.60	34.75	2.44	4.20
1 - 6-1974	18.72	46.73	34.55	2.19	3.77
20- 7-1974	26.71	44.53	28.76	2.31	3.98
3 - 8-1974	18.72	46.41	34.87	2.29	3.95
4 - 9-1974	23.24	63.63	13.13	2.14	3.68
5 -10-1974	35.46	37.18	27.36	2.17	3.74
7 -11-1974	12.17	61.07	26.76	2.31	3.98
9 -12-1974	17.65	40.45	41.90	1.98	3.41
13- 1-1975	10.60	56.52	32.88	1.96	3.37
17- 2-1975	11.94	43.81	44.25	2.07	3.57
31- 3-1975	4.81	45.99	49.20	2.58	4.44
30- 4-1975	39.36	27.84	32.80	2.14	3.68
26- 5-1975	49.38	18.12	32.50	1.97	3.39
26- 6-1975	41.36	17.19	41.45	2.10	3.62
24- 7-1975	64.68	33.72	1.60	2.31	3.98
28- 8-1975	18.05	39.45	42.50	1.91	3.29
26- 9-1975	53.03	33.55	13.42	1.89	3.25
30-10-1975	81.70	11.95	6.35	1.71	2.95
29-11-1975	7.19	47.26	45.55	1.89	3.25
29-12-1975	25.90	48.90	25.20	1.88	3.24
27- 1-1976	8.12	50.63	41.25	2.08	3.58
29- 2-1976	5.64	50.21	44.15	2.13	3.67
28- 3-1976	5.73	50.77	43.50	2.31	3.98

Table - 27

Mean Standing Crop (Dry weight g/m^2)

Stations	First year	2nd year	Mean value for 2 years
1	13.7417	1.8345	7.7881
2	0.2776	1.7730	1.0253
3	0.9358	1.8036	1.3697
4	7.5045	26.2082	16.8563
5	2.9807	5.8548	4.4177
The average annual mean standing crop (for the whole area under examination)	5.0881	7.4948	6.2914

Table - 28

Animal matter present in the gut content of five species of prawns present in the Cochin Estuary.

Species	Polychaetes	Crustaceans	Molluscs	Other groups
Metapenaeus dobsoni	*Nephthys* sp. other polychaete remains.	Amphipods decapod larvae, copepods; other crustaceans	Juvenile bivalves and gastropods.	Foraminiferans nematodes, fish remains.
M. affinis	*Prionospio* sp., other polychaetes	Amphipods, copepods, decapod larvae.	Juvenile bivalves and gastropods.	Fish remains
M. monoceros	Polychaete remains	Amphipods, ostracods, decapods, copepods.	Juvenile bivalves and gastropods.	Foraminiferans, fish remains, fish larvae.
Penaeus indicus	Polychaetes	Amphipods, decapod larvae.	Juvenile bivalves and gastropods.	Foraminiferans, nematodes, fish remains.
P. monodon	Species of different polychaetes	Amphipods, decapod larvae.	Juvenile bivalves	Fish remains

21- 3-1974	.4238	.0480	1.2105	..	.2580	1.9403	.0710	.0085	.1951
3- 4-1974	.2330	.5810	.3060	.0810	.0650	1.2660	.0346	.0692	.0637
18- 4-1974	.1450	.0070	.4870	.0470	.0250	.7110	.0224	.0012	.1014
4- 5-1974	.4090	.2720	.2850	..	.0040	.9700	.0602	.0380	.0407
17- 5-1974	.1943	.0340	.1580	.0280	.0342	.4485	.0279	.0046	.0261
1- 6-1974	.0240	.6990	17.6895	.0140	.0890	18.5155	.0039	.1276	3.9210
19- 6-1974	.2820	.0330	..	..	..	.3150	.0370	.0060	..
6- 7-1974	.0220	.0630	.3985	..	..	.4835	.0030	.0180	.0797
20- 7-1974	.1960	.2105	1.0140	..	..	1.4205	.0201	.0460	.2080
3- 8-1974	.0070	.7660	1.1760	.0720	..	2.0210	.0007	.0140	.2448
16- 8-1974	.0060	.4090	1.1690	..	..	1.5840	.0010	.0760	.2014
4- 9-1974	.0130	.0360	.0780	..	..	.1270	.0012	.0082	.0134
23- 9-1974	.0120	.0520	..	..	..	.0640	.0030	.0080	..
5-10-1974	.0160	.0740	..	..	..	.0900	.0034	.0088	..
21-10-1974	.0250	.0100	..	.0640	..	.0990	.0053	.0031	..
7-11-1974	.2400	.0510	..	..	..	.2910	.0491	.0076	..
22-11-1974	.1880	.1990	..	..	..	.3870	.0190	.0329	..
9-12-1974	.1965	.0110	..	.0112	.0140	.2327	.0292	.0013	..
27-12-1974	.5670	.1710	..	..	.0180	.7560	.0958	.0240	..
13-1- 1975	.0825	.0090	..	..	.0700	.1615	.0129	.0012	..
31- 1-1975	.2970	.0130	..	..	.0110	.3210	.0434	.0015	..
17- 2-1975	.1460	.0020	.0405	..	.0400	.2285	.0248	.0004	.0068
28- 2-1975	.4230	.0230	.1215	..	.0500	.6175	.0663	.0052	.0205
15- 3-1975	.2200	.0110	3.6450	..	.0170	3.8930	.0336	.0021	.7028
31- 3-1975	.2210	1.0431	.0810	.4420	.0150	1.8021	.0648	.1702	.0136
30- 4-1975	.4450	1.4137	.0640	..	.0050	1.9277	.0648	.1820	.0094
26- 5-1975	.0940	.0250	..	.0180	..	.1370	.0140	.0022	..
26- 6-1975	.0930	.5412	.0087	.0219	.0090	.6738	.0152	.0870	.0014
24- 7-1975	.1840	.7410	..	.0450	.0180	.9880	.0232	.0920	..
28- 8-1975	.1020	.2520	..	..	.0110	.3650	.0180	.0731	..
26- 9-1975	.2130	.5260	..	.3218	.0420	1.1028	.0435	.1090	..
30-10-1975	.2170	.5440	.0045	..	.0150	.7805	.0341	.1095	.0012
29-11-1975	.1940	.4150	..	..	.0280	.6270	.0304	.0960	..
29-12-1975	.7470	.2460	..	..	.0400	1.0330	.0359	.0511	..
28- 1-1976	.2690	.0240	8.8773	.0820	.0730	9.3253	.0430	.0024	1.9431
25- 2-1976	.1500	.2450	20.1612	.2080	.0600	20.8242	.0269	.0442	3.7206
30- 3-1976	.6350	.0050	..	.5418	.0300	1.2118	.1122	.0013	..

I.COELENTERATA																														
1.Cirianthus sp.	4	2	2	4	2	-	1	1	2	2	-	-	-	2	1	-	1	1	-	-	2	2	-	3	3	-	-	1	4	1
2.Milne-Edwardsia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-
3.Obelia bicuspidata.Clarke	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-
4.Sea anemone	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	-	-	-	-
Total	4	3	2	4	2	-	2	1	2	2	-	-	-	2	1	-	1	1	-	-	11	2	-	5	6	-	1	2	4	1
II.POLYCHAETA																														
1.Ancistrosyllis constricta Southern	9	2	4	2	2	1	2	12	-	1	-	-	2	2	-	2	1	-	1	6	12	4	5	3	3	8	7	1	10	-
2.Cossura coasta Kitamori	2	-	2	1	1	-	2	1	-	-	-	-	-	-	1	2	2	1	1	-	1	-	-	1	6	15	12	3	1	-
3.Dendronereis aestuarina Southern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
4.Diopatra neapolitana Delle Chiaje	-	2	-	-	1	4	22	24	-	-	-	-	1	-	-	1	1	-	-	-	39	2	1	-	1	1	1	-	-	-
5.Disoma orissae Fauvel	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	2	7	-	-	-	5	-	-	-	-
6.Fabricia sp.		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7.Glycera longipinnis Grube	4	2	1	-	1	1	-	-	-	-	-	-	-	-	-	2	-	-	-	1	4	3	2	2	2	1	-	-	-	-
8.Lepidonotus tenuisetosus(Gravier)	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9.Lumbriconereis heteropoda Marenzeller		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
10.L.latreilli Audian & Milne Edwards	3	1	2	1	4	1	1	1	-	-	-	-	-	-	-	-	-	-	-	1	15	1	7	4	12	14	5	1	1	-
11.L.simplex Southern	-	-	-	-	-	8	2	2	-	-	-	-	-	-	-	-	-	-	-	-	4	2	1	1	1	-	-	-	-	-
12.Lumbriconereis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	6	-	-	-	-	7	-	2	-	3	7	7	11	2
13.Lycastis indica Southern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14.Mesochaetopterus sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15.Mercierella enigmatica Fauvel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
16.Nephthys oligobranchia Southern	4	2	3	2	1	-	-	1	-	1	1	-	1	1	1	4	5	-	1	2	2	2	1	2	2	4	7	10	1	4
17.Owenia sp.	2	1	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
18.Paraheteromastus tenuis Monro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3	6	5	7	9	18	15	11	3
19.Perinereis cavifrons Ehlers	-	1	-	-	-	-	1	4	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20.Phyllodoce sp.	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
21.Polydora kempi Southern	-	-	-	1	1	1	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.Prionospio cirri-	4	6	19	4	1	-	-	2	-	2	-	-	25	14	6	118	73	-	-	1	-	-	-	-	-	-	1	-	1	-

2. *A. malabaricus* Fabricius	1	-	-	1	2	-	-	-	-	-	-																						
3. *A. paludicola* Kemp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
4. *Apseudes chilkensis* Chilton	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	4	-	-	-	-	-	-	-	-	-	-	4	8	5
5. *A. gymnophobia*	4	-	-	-	-	1	1	4	-	-	-	-	-	-	-	-	-	2	4	8	-	-	-	-	-	-	-	1	-	-	-	4	11
6. *Ampelisca zamboangae* Stebbing	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	29	-
7. *Cirolana fluviatilis* Stebbing	-	-	-	-	-	2	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	8	-
8. *Eriopisca chilkensis* Chilton	3	5	4	-	-	4	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	3	-	4	3	-	-	-	-	8	-
9. *Eriphia smithia* Macheay	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
10. *Grandidierella gilesi* Chilton	-	-	2	6	9	2	-	7	1	-	-	-	-	-	-	2	-	-	2	4	3	-	-	2	1	-	2	1	-	-	-	12	-
11. *Iphinoe* sp.	1	18	6	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12. *Litocheira* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
13. *Metapenaeus dobsoni* (Miers)	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
14. *Penaeus indicus* Milne-Edwards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15. *Rynchoplax* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
16. *Squilla nepa* Latreille (Bigelow)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
17. *Scylla serrata* Forskal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
18. *Synidotea variegata* Collinge	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	11	23	12	7	11	10	2	13	1	1	-	-	2	3	-	3	-	4	9	19	7	3	-	7	5	5	6	8	-	-	4	71	17
IV. MOLLUSCA																																	
1. *Arca bistrigata* Dunker	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1
2. *Arca* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
3. *Modiolus metacalfei* (Hansley)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
4. *M. undulatus* (Dunker)	-	2	-	-	136	1059	64	633	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. *Paphia* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
6. *Standella* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
7. *Tellina* sp.	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	2	-	1	136	1059	64	633	2	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	1	-	2	-	1	-	-	1	
V. PISCES																																	
1. Gobidae	2	-	-	-	-	1	-	3	-	-	-	-	-	1	-	1	-	-	-	2	1	2	-	-	-	-	-	-	-	-	-	-	
2. *Solea ovata* Richardson	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	
3. *Trypauchen vagina* (bl. Sehn)	2	2	2	3	3	2	1	4	2	-	-	1	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	
Total	4	2	2	3	3	3	1	7	2	-	-	1	1	4	-	1	-	-	-	2	1	2	-	-	-	-	-	1	1	-	-	5	

	M	A		M		J		J		A		S		O		N		D		J		F		M		A				
√Sipunculoidea	5	-	-	-	-	1	1	-	-	1	1	-	-	1	-	1	8	2	2	4	11	-	2	2	-	2	-	-	-	-
Total	5	-	-	-	-	2	1	1	1	2	1	-	-	1	-	1	8	5	4	65	11	-	2	2	-	2	-	-	-	-
G.Total	65	48	54	28	168	1093	107	705	8	9	2	1	34	30	10	216	181	13	24	136	124	59	35	41	62	109	103	54	46	10

I. COELENTERATA																															
1. *Cirianthus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	1	.	-	-	-	-	-	-
2. *Milne-Edwardsia* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
3. *Obelia bicuspidata* Clarke	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Sea anemone	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	1	-	-	1	-	1	-	-	-	-	-
II. POLYCHAETA																															
1. *Ancistrosyllis constricta* Southern	3	-	1	1	1	-	1	2	1	-	-	-	1	1	2	5	1	1	2	2	6	2	2	2	1	2	3	8	2	-	-
2. *Cossura coasta* Kitamori	-	1	1	-	-	-	-	-	-	-	-	-	-	1	1	-	1	-	2	-	1	-	2	2	2	1	5	4	2	-	1
3. *Dendronereis aestuarina* Southern	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-
4. *Diopatra neapolitana* Delle chiaje	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-
5. *Glycera alba* Rathke	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	3	2	-	2
6. *G. longipinnis* Grube	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. *Lumbriconereis heteropoda* Marenzeller	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. *L. latreilli* Audain & Milne-Edwards	2	1	2	-	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	-	1	-	-	-
9. *L. simplex* Southern	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
10. *Lumbriconereis* sp.	-	-	-	-	-	-	-	-	-	-	-	2	-	1	5	5	5	4	1	3	8	2	2	11	-	-	3	18	21	10	14
11. *Lycastis indica* Southern	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
12. *Mesochaetopterus* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
13. *Nephthys oligobranchia* Southern	28	12	11	6	8	5	13	6	9	10	14	9	17	7	25	9	11	18	29	21	38	32	20	16	19	11	9	15	28	40	34
14. *Owenia* sp.	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	11	2	6	3	1	1	-	-	-	-
15. *Paraheteromastus tenuis* Monro.	3	1	1	-	1	-	-	-	-	-	-	2	-	1	3	2	2	1	-	2	6	3	5	5	2	1	3	4	7	2	7
16. *Phyllodoce gracilis* Kimberg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

19. P. polybranchiata Fauvel	1	1	1	-	1	2	2	1	-	-	-	-	4	23	5	7	2	-	-	-	1	-	-	3	-	12	38	14	15	1	6
20. Sternaspis scutata (Renier)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	50	54	42	23	25	15	22	10	17	12	14	17	24	49	49	48	39	36	36	30	67	52	36	46	30	33	65	68	77	55	65
III. CRUSTACEA																															
1. Alpheus malabaricus Fabricius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-
2. Apseudes chilkensis Chilton	1	2	-	-	-	-	-	-	-	-	-	2	1	1	-	2	-	3	11	5	3	-	-	-	3	2	1	1	3	42	397
3. A. gymnophobia	20	4	-	-	-	-	-	-	-	-	2	3	-	1	-	7	1	-	2	4	5	2	7	-	1	2	1	2	1	1	5
4. Cirolana fluviatilis Stebbing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Corophium triaenonyx Stebbing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	21	2	1	-	-	-	-	-	-	-	-	-	-	-
6. Eriopisa chilkensis Chilton	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
7. Eriphia smithii Macheay	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
8. Grandidierella gilesi Chilton	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	14	-	-	-	-	-	2	1	-	1	-	-	-	3		
9. Iphinoe sp.	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10. Litocheira sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	
11. Macrophthalmus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
12. Metapenaeus affinis Milne Edwards	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	
13. Synidotea variegata Collinge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
14. Squilla nepa Latreille (Bigelow)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
15. Viaderiana sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	
Total	21	6	3	-	-	1	-	-	-	1	2	5	1	2	4	49	3	4	13	9	8	4	8	-	6	6	3	3	11	44	40
IV. MOLLUSCA																															
1. Arca sp.	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
2. Nuculana mauritiana (Sowerby)	-	5	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3. Solen sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	
4. Standella sp.	-	-	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
5. Tellina sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	

V. PISCES																															
1. *Gobidae*	-	-	-	-	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	-	1
2. *Trypauchen vagina* (bl. Sehn)	-	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Total	-	-	-	1	-	1	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	1	1	1
VI. OTHER GROUPS																															
1. Sipunculoidea	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1	2	-	2	-	3	-	3	-	-	1	1	-	-	-	-
Total	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1	2	-	2	-	3	-	3	-	-	1	1	-	-	-	-
Gr. Total	71	65	46	26	26	17	24	11	17	16	17	25	25	51	53	99	45	40	51	40	81	56	47	47	36	42	71	73	89	100	47

-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	1	-	-	6
-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	3	-	1	-	-	-	-	-	-	-	1	2	1	34
-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	4
-	-	-	-	-	-	-	-	-	-	1	-	2	2	2	-	-	-	-	-	-	-	-	-	-	-	-	3	10
-	-	-	-	-	-	-	-	-	1	2	-	2	10	2	5	-	2	-	-	-	-	-	-	1	3	2	4	54
-	2	-	1	-	-	-	-	4	1	4	10	4	3	4	7	12	11	2	1	-	-	-	-	-	2	4	2	103
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	8	-	-	-	-	-	-	-	-	-	-	14
-	-	-	5	4	7	3	2	2	1	1	-	2	1	-	1	-	-	-	1	-	8	-	9	3	4	-	2	58
-	-	-	-	-	-	1	2	4	4	55	-	56	55	-	24	-	18	1	-	-	-	-	2	2	38	52	20	352
-	-	-	-	-	-	-	4	-	4	229	-	-	-	-	-	-	-	-	-	-	-	-	-	-	327	-	-	564
-	1	-	-	-	-	-	6	3	6	1	-	4	1	-	4	5	3	1	-	-	-	-	-	-	2	1	2	75
-	1	-	-	-	-	1	3	1	4	11	1	3	8	1	4	1	2	1	-	-	-	-	-	4	15	5	3	86
-	-	-	-	-	-	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	1	1	6
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	2	5	2	11
2	1	-	12	4	4	3	3	-	5	16	-	4	24	1	10	4	4	35	5	-	4	3	16	1	-	-	-	217
-	-	-	-	1	-	2	-	-	-	-	1	-	-	-	7	1	2	-	-	1	-	-	-	-	-	1	-	22
4	6	6	5	-	11	22	36	27	31	1	3	58	6	314	29	44	17	125	88	58	85	273	6	274	5	7	3	1659
-	1	4	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	5	2	4	1	1	2	-	-	24
-	-	-	-	-	2	-	-	1	1	-	1	-	1	-	1	-	1	-	-	-	-	-	-	-	12	5	3	37
4	6	2	3	2	1	6	2	1	-	4	19	7	2	35	12	19	24	69	61	36	22	9	11	12	4	5	7	432
-	-	-	-	-	1	-	5	8	21	24	3	10	10	1	5	-	-	-	-	-	-	-	-	-	-	-	-	118
-	-	6	45	40	44	75	71	31	20	3	-	11	30	3	137	109	41	76	67	23	104	77	127	23	1	3	2	1174
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3	1	-	-	-	-	-	1	-	1	-	1	10
-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2

[illegible] Fauvel	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25. <u>Sternaspis scutata</u> (Renier).	-	-	-	-	1	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Total	30	48	120	59	39	44	54	101	25	12	25	35	267	304	258	309	360	146	166	358	49	168	148	367	262
III. CRUSTACEA																									
1. <u>Alpheus malabaricus</u> Fabricius	1	2	-	-	3	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. <u>Alpheus</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. <u>Ampelisca zamboangae</u> Stebbing	-	-	-	-	-	-	-	-	-	-	-	-	2	-	5	-	-	-	-	-	-	-	-	4	-
4. <u>Amseudes chilkensis</u> Chilton	1	-	-	-	-	-	-	-	-	1	1	6	-	1	1	5	-	-	-	-	-	-	-	1	-
5. <u>A. gymnophobia</u>	3	2	-	2	1	4	1	1	3	1	-	-	-	-	-	2	-	-	9	1	2	4	2	2	4
6. <u>Cirolana fluviatilis</u> Stebbing	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
7. <u>Corophium triaenonyx</u> Stebbing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. <u>Ebalia malefactrix</u> Kemp	-	-	-	-	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9. <u>Eriopisca chilkensis</u> Chilton	-	-	-	1	-	2	3	-	-	-	2	-	-	-	-	2	1	3	3	-	-	-	-	3	-
10. <u>Grandidierella gilesi</u> Chilton	2	1	-	1	-	3	15	4	2	6	2	4	1	6	11	6	18	6	19	-	4	-	1	2	1
11. <u>Iphinoe</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	5	-	4	4	57	17	38	-	-	-	-	-	-
12. <u>Macrophthalmus</u> sp.	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13. <u>Rynchoplax</u> sp.	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14. <u>Synidotea variegata</u> Collinge	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
15. <u>Viaderiana</u> sp.	6	1	3	7	5	2	1	21	12	20	-	3	-	-	-	5	4	-	-	-	4	1	-	2	1
Total	15	6	3	12	10	11	25	26	18	30	8	14	8	7	21	27	80	26	69	1	10	5	3	15	6
IV. MOLLUSCA																									
1. <u>Arca</u> sp.	1	-	1	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. <u>Bithina</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. <u>Dosinia histrio</u> (Gmelin)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. <u>Mactra corbiculoides</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
5. <u>Modiolus undulatus</u>	-	-	-	-	-	4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. <u>Nassa ovalensis</u>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
7. <u>Nuculana mauritiana</u> (Sewerby)	-	-	-	-	-	-	-	-	9	2	1	2	3	-	-	6	2	-	-	-	-	-	-	-	-
8. <u>Paphia</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
9. <u>Solen</u> sp.	-	2	1	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10. <u>Standella</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3	2	-	-	-	-	-	-	2	-	-
11. <u>Tellina</u> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Total	1	2	2	-	1	10	-	-	12	2	1	2	4	-	5	8	2	-	-	1	-	-	6	-	-

1	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	2	-	1	-	-	3	1	-	1	17
1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	8
2	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	3	-	1	-	-	3	1	-	1	25
·	-	-	-	-	-	-	-	-	-	2	24	1	1	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-	33
·	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
·	-	-	1	-	-	-	4	3	-	4	6	4	6	-	3	2	-	-	-	-	-	-	2	-	4	2	6	-	48
·	-	-	1	-	-	-	4	3	-	6	30	5	7	2	3	2	1	-	-	-	-	-	2	-	4	5	6	-	82
'	44	35	53	279	311	284	349	445	172	242	392	64	182	169	387	275	301	171	407	262	168	298	542	544	573	567	121	65	8505

S		O		N		D		J		F		M	A	M	J	J	A	S	O	N	D	J	F	M	Avge
-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2
-	-	-	-	-	-	5	-	-	6	5	8	31	9	3	-	-	-	-	-	1	1	4	2	1	159
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1	27	2	7	17	15	31	16	6	11	14	13	3	16	11	-	2	1	4	-	1	2	3	-	3	405
-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-	-	-	3
-	-	-	4	3	7	8	6	7	4	-	5	2	1	-	2	-	3	3	5	2	1	5	7	1	80
-	-	-	1	-	9	81	52	186	181	106	72	45	61	19	4	-	-	12	4	192	50	62	112	75	1363
-	-	-	-	-	-	98	18	217	-	-	-	-	-	-	-	-	-	-	-	52	15	2	-	-	402
1	1	1	1	2	-	-	-	-	-	-	3	-	4	2	1	-	-	-	-	2	1	4	-	-	69
-	-	-	10	3	2	5	4	-	7	4	3	4	9	3	-	-	-	-	-	2	3	11	2	-	87
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	-	-	-	2	1	-	-	3	3	1	3	4	-	-	-	-	-	-	-	-	-	-	22
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17	5	14	1	-	7	8	9	12	16	10	5	2	3	2	68	19	24	53	43	7	1	1	-	1	360
5	7	3	7	4	5	16	7	2	5	13	9	8	15	7	6	1	-	-	1	-	-	-	-	5	253
-	-	1	-	2	1	4	2	1	1	1	2	1	-	-	3	5	10	26	11	19	38	2	3	-	187
-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	6	2	-	1	-	-	-	15
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	3	-	-	16
2	4	5	27	27	-	1	1	1	-	-	-	-	6	7	9	49	18	10	14	7	25	6	-	-	256

-	-	-	-	1
-	-	-	1	2
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5	-	-	-	11
6	6	3	-	54
-	-	-	3	247
-	5	7	-	152
-	-	-	-	5
-	-	-	-	2
152	154	301	141	4676
-	-	1	-	2
-	-	-	-	1
-	482	-	-	1385
-	-	-	-	32
9	12	3	4	182
4	165	97	59	422
-	594	-	-	596
-	2	1	-	14
2	6	1	2	176
-	-	-	-	4
26	242	-	-	609
1	-	-	-	191
2	2	-	-	43
2	13	1	-	44
-	-	-	2	2
-	-	-	-	1
[illegible]	518	104	67	3804
-	-	-	-	3
-	-	-	-	13
-	-	-	-	2
-	-	-	-	2
-	-	-	-	41
-	766	854	968	4065