STUDIES ON THE MACROBENTHOS OF MUDBANKS OF SOUTHWEST COAST OF INDIA

C. HRIDAYANATHAN, M. Sc.

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CERTIFICATE

This is to certify that this thesis is an authentic record of the work carried out by Mr. C.Hridayanathan, under my supervision at the Department of Marine Sciences, University of Cochin and Central Institute of Fisheries Technology, Cochin and that no part thereof has been presented before for any other degree in any University.

Ernakulam,
AUGUST 1981.

Dr.C.V.Kurian
Supervising Teacher

Prof. (Dr.) C. V Kurian,
Emeritus Scientist (ICAR)
Pelagic Fisheries Laboratory (CMFRI)
COCHIN - 682 016.

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I. INTRODUCTION

India with her long coast line and fairly wide continental shelf and slope occupies a prominent place among the fishing nations of the world. Of the total fish landings in India, about seventy five per cent is recorded from the West Coast. The coastal area of Kerala having a distance of 560 kms north-south is characterised by a narrow strip of land betwen the Arabian sea and a chain of backwaters and lagoons with access to the sea at different points through outlets. The continental shelf of this coast has a gradual slope up to ten fathoms, beyond which there is a steep fall. The climatic condition is influenced by two monsoons, the south west monsoon and north-east monsoon respectively. The distance of the 100 fathom line from the shore varies from 82 km at the north to 45 km at south. The more important south-west monsoon breaks over the Kerala normally during the first week of June and continues till the end of August or early September. The south-west coast of Kerala supports a rich fishery especially demorsal in nature where one of the richest prawn fishing grounds is located. The large sized species of prawns suitable for export trade are comparatively more abundant in the southern section of southwest coast where the substratum conditions with nutrient laden mud banks present ideal environment for prawns to thrive.

Fishing in Indian seas is generally confined to a narrow coastal belt and the offshore and deep sea waters are practically unexploited. On the east coast, the sea is rough and surf beaten and the fish landing centres are few in number scattered far between on the open coast. On the west coast, the sea is comparatively calm except during the months of June, July and August due to heavy south west monsoon. Fishing in the coastal waters of south west coast of India especially bottom trawling for the valuable species of prawns commenced two and half decades back, intensified in the succeeding years extending upto a depth of 25 to 40 metres. In the earlier years fishing commended by November or December and ended in May. But in recent years the fishing operations are suspended only during the peak of monsoon and hence the fishing commences by September and continue to June.

Emphasis in the marine fisheries sector and its modernisation resulted on the mechanisation of fishing crafts in large numbers and the evolution of better and more efficient fishing gears. In the inshore waters of south west coast of Kerala a large number of mechanised vessels of class 32 - 36 feet (overall length), operate continuously. The intensity of the fishing activity at the dangerous level in the inshore areas can be estimated by the occasional clashes between the mechanised and indigenous fishermen forcing the Government of Maritime States to introduce legislation. Large varieties of specialised bottom trawl nets have been developed for the exploitation of bottom fishery and most of the fishing units are of a high operational efficiency in the coastal waters. The heavy bottom trawl nets with the accessories like other boards sweep the entire area disturbing the environment of the bottom dwelling animals. Indiscriminate trawling, in addition to reducing the catch per unit effort of the bottom trawlers upset the environmental balance of the bottom dwelling animals affecting the fishery also. On this hypothesis, while the pelagic trawls are large with large mesh openings in the frontal area of the gear, compared to the otter trawls, it may be less harmful because (a) it has a natural filtrage (b) it does not directly damage the environment, a credit which cannot be claimed by the other trawl with its heavy ground gear and otter boards continuously churning up the sea bed(Garner, 1977). After the state of Maharastra the largest number of trawl gears are operated along the Kerala Coast (Anon, 1978). Shelter from excessive bottom disturbance is a condition for the survival of many forms of animals (Holme, 1961). It should be realised that it is not only pollution of streams, lakes and the surrounding seas that is threatening the country and the fishing industry in particular, but equal attention must be given by benthic ecologists for the protection of sea bed from heavy disturbance.

The significance of substratum and the role of benthos as important factors of sea productivity and their contribution to the economy of the sea have been the field of investigation in different parts of the world. The knowledge of animal benthic populations also contributes to a better understanding of the ecological factors affecting commercial species of fish and crustaceans. After Petersen and Boysen Jensen (1911), Petersen (1913, 1918) and his co-workers in Denmark have stressed the part played by the bottom animals in the economy of the sea, a number of workers have investigated the benthic fauna in the different parts of the world. Kirsop (1922), Shelford et al (1935) and Hartman (1955) have investigated the Pacific fauna. Parker (1956) made a detailed series of studies on the fauna in the gulf of Mexico. The studies on the Atlantic fauna date back to the qualitative surveys of Sumner et al (1913) followed by those of Cowles (1930) and Allee (1934). The earliest investigation in the English channel off Plymouth is that of Allen (1899) who made a qualitative survey of the bottom fauna in that area. Several other past and recent studies by different workers have contributed to the knowledge of the bottom fauna, the important among them being those of Ford (1923), Davis (1923, 1925), Smith (1932), Sparck (1935), Dexter (1944, 1947), Holme (1950, 1953, 1961, 1967), Jones (1950, 1951, 1952), Ursin (1952), Sanders (1956, 1958, 1960), Wigley (1956), Stickney and Stringer (1957), Weiser (1960), McIntyre and Eleftheriov (1968), Kempf (1970), Fishelson (1971), Savich (1972), Gage (1972b, 1974) In addition to the above works, the more recent studies of Masse (1972), Gage (1972a), Buchanan and Warwick (1974), Buchanan et al (1974), Warwick and Price (1975) and Makato Tsuchiya and Yasushi Kurihara (1980) dealt with the bottom fauna with special reference to the macrobenthos.

The earlier studies on bottom fauna in Indian waters were those of Annandale and Kemp (1915, 1916) and that of Sewell and Annandale (1922). Later Samuel (1944) described the animal communities of the sea bottom of the Madras coast followed by other works on the bottom fauna of the Bay of the Bengal coast by Ganapati and Lakshmana Rao (1959) and Sokolova and Pasternak (1964). The other important works on the benthos of the lakes and bays of East coast includes those of Radhakrishna and Ganapati (1968), Patnaik (1971), Rajan (1971), and the comparative study of Ansari et al (1977) of the qualitative distribution of benthos in the Bay of Bengal with those of the Arabian Sea.

In the Arabian Sea Kurian (1953) operating a dredge collected fauna and related their occurrence and distribution to the bottom deposits of the Travancore coast. The qualitative studies of Seshappa (1953) dealt with the benthos of the inshore sea bottom of Malabar coast. Later Kurian (1966, 1971, 1973) and Neyman (1973) carried out investigations on the bottom fauna on the south-west coast of India and shelf benthos of the northern part of Arabian sea respectively.

Parulekar (1973) described the fauna of Goa and Bombay coasts while Parulekar and Wagh (1975) dealt with the qualitative aspects of benthic macrofauna. Dwivedi et al (1975) studied the environs of a sewage outfall for distribution and abundance of benthos and bacteria in Panjim, Later Ansari et al (1977) and Harkantra et al (1980) conducted investigations on the qualitative distribution of macrobenthos in five shallow bays of the Central west coast of India and benthos of the shelf region along the west coast respectively. The estimation of benthic production in the estuaries has been carried out by different workers (Desai and Krishnankutty (1967), Harkantra (1975), Parulekar and Dwivedi (1975), Ajmal Khan et al (1975), and Parulekar et al (1980).

Benthic marine animals are classified into two ecologically different groups, epifauna and infauna as described by Petersen (1913) and further defined by Thorson (1956, 1957a, 1958). The animals of epifauna living on the bottom surface are abundantly seen in the shallow coastal waters especially in the inter-tidal zone and are subjected to great fluctuations in environ-mental conditions. They depend upon the occurrence of suitable substrate for their establishment. The infauna live in the substratum on the level bottom portions of the sea floor.

Benthic animals are divided into three groups according to size (1) Macrobenthos (2) Meiobenthos and (3) Microbenthos (Mare 1942). Because of the variation in the mesh size of the sieve used by different workers, there is no clear demarcation to separate the three categories of benthos and the finest sieve used for lower size limit of macrobenthos ~~used~~, lie in the range between 3.0 and 0.5 mm. Damodaran (1973) in his studies on the benthos of the Narakkal mud bank used a 1.00 mm round mesh sieve for screening the grab contents and categorised the animals retained in it as macrobenthos.

Except for the benthic studies done in eight stations of a mud bank in Narakkal by Damodaran (1973), no detailed investigation of benthos has been carried out in the other mud banks appearing along the Kerala Coast. The present study was undertaken with the following objectives: (1) To study the distribution and population density of macrofauna of the coastal belt of south west coast of Kerala within a maximum depth of 45 metres from Malippuram (Cochin) in the north to Alleppey in the south, which is one of the most intensively exploited regions. (2) To evaluate whether there is significant difference in the number and distribution of animals in the mud bank regions and other intermittent stations. (3) To examine the effect, if any, of the bottom stability, on the distribution of fauna in the region. (4) To study the influence of the environmental parameters on the distribution pattern of fauna. (5) To study the nature and depthwise distribution of the benthic fishery. The fifth profile (profile E) was selected for this purpose.

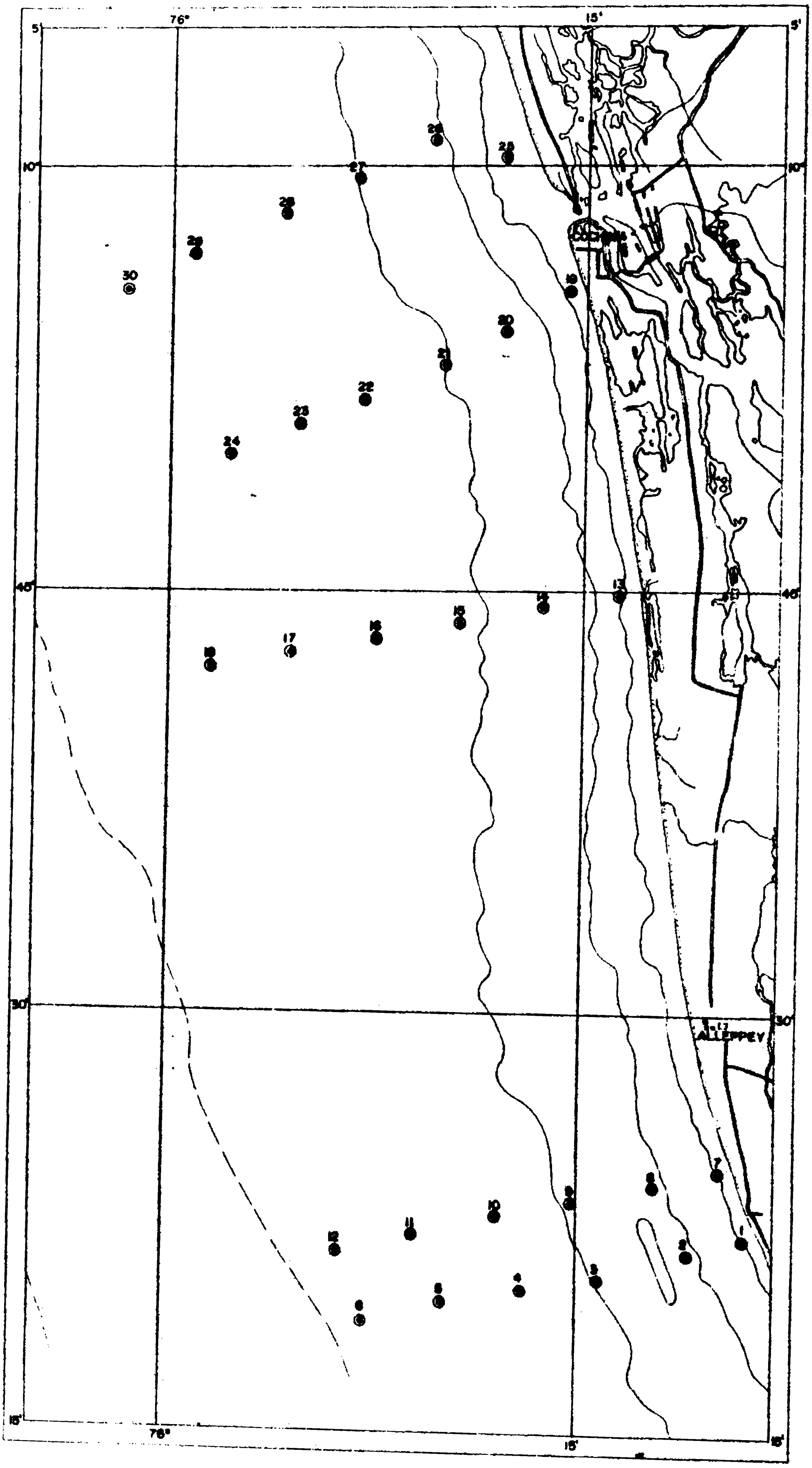
2. MATERIALS AND METHODS

2.1. Location of stations

The sites of samples collection were fixed along five transects at right angles to the coast (Fig.1). Among the five transects, starting from south, the first, second, fourth and fifth were in the three mud bank regions at Alleppey, Saudi and Malippuram. The position of the third transect was fixed in between Alleppey and Saudi mud banks with a view to examine whether there is any significant difference in the faunal assemblage and the texture of the sediments of the substratum, from the stations selected for study in the mud bank region. The area chosen for the study covered a total distance of about sixty kilometers.

Each transect consisted of six stations located at 5,10, 20, 30, 35 and 45 metres depth making a total number of thirty sampling stations. The stations located beyond 20 m depth are outside the mud bank regions. The stations near the coast were fixed with the help of land bearings and the distant ones towards the sea by dead reckoning. As the stations extended to a distance of about 60 km. and suitable vessels were not available during all the seasons, each of the station was sampled three times in a year.

Fig. 1. Map showing the positions of the stations.


76°
15'
5'
10'
45'
30'
15'
76°
15'
COCHIN
ALLEPPEY
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
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22
23
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26
27
28
29
30

FIG. 1.

The sampling was conducted on board a 50' research cum fishing vessel fitted with an engine of 160 H.P. The samples for benthic animals were collected by operating a Petersen grab of 0.1 m^2 area. Important environmental parameters such as temperature, salinity and dissolved oxygen were studied from both surface and bottom at each station. The physico-chemical nature of the sediment was also studied. The collection of data was done in the years 1972 and 1973 and in each year, sampling was done during the months of April, August and December corresponding to premonsoon, monsoon and postmonsoon respectively.

2.2. Hydrography

Surface water temperature and the bottom sediment temperature were observed in each station along with the collection of benthos. The surface water temperature was recorded dipping an ordinary centigrade thermometer. The bottom temperature from the sediment was recorded by inserting the ordinary thermometer in the mud as soon as the grab was hauled up and emptied on board the vessel. The bottom water temperature was not recorded because of the observation that there was not any significant difference between sediment temperature and the bottom water temperature.

Water samples for the estimation of dissolved oxygen and salinity were collected together with temperature observations from the surface and bottom. The water samples from bottom were collected by lowering a Nansen reversing water bottle as close to the bottom as possible. The chlorinity of the water was estimated using the Mohr method (Barnes, 1959) and from chlorinity, the salinity was calculated using Knudsen's table. The dissolved oxygen was determined by Winkler method (Barnes, 1959).

2.3. Sediment

A total number of 180 mud samples were collected for the study of sediment, six series of samples from each station.

The sediment samples were subjected to particle size analysis by the combined sieving and pipette method described by Krumbein and Petti John (1938). Weighed quantities of dried sediment were dispersed in 0.025 N solution of sodium hexametaphosphate and was allowed to soak overnight. The silt clay fractions were separated by thoroughly breaking up the sediments and washing the sediment suspension through a 62 u sieve. The coarse fractions retained in the sieve considered as sand were dried in an oven at 100°C and recorded the weight. The dispersed silt-clay fraction was transferred to the litre cylinder with distilled water to make a suspension of exactly 1 litre and analysed by pipette method. The sample taken by the pipette was dried at 100°C, cooled in a desiccator and weighed accurately.

2.4. Bottom fauna

As stated by Thorson (1957a) and later supported by Holme (1964), the Petersen grab was found working satisfactorily for the collection of the benthic fauna as many of the grounds were muddy and soft. A naturalist dredge of 28 x 47 cm size was operated to collect the epifauna. Since the number of stations were many, two grab hauls were taken from each station as against the method suggested by Holme and McIntyre (1974) where they have suggested five samples from each station. Further the recent survey strategy adopted by Cuff and Coleman (1979) has recommended minimal sampling at a local area with more stations than intense sampling or multiple grab samples per station for mean estimate of organisms with the smallest possible variance. A small portion of the grab sample was saved for the analysis of the texture of the sediment and organic content. The remaining portion was washed through a sieve of 0.5 mm aperture screen and the animals retained in it categorised as macrofauna (Birkot and McIntyre, 1971, Dwivedi et al 1973) were carefully removed and preserved in 4% formaldeh for later identification as far as possible to species level and quantitative study. No dead organisms or dead shells of mollusc fauna were counted. Numerical abundance, wet weight and dry weight have been used as the basis of faunal evaluation for this study. The wet weight of macrofauna was taken in the laboratory after preservation in formaldehyde which included the weight of hard parts like shells of molluscs and gut contents. The wet weight was always taken six weeks after preservation and is not likely to be influenced by the changes during preservation. The dry weight was estimated by the method described by Lovegrove (1966) where the animals were dried at 60°C for sixteen hours. The animals belonging to the group of Mollusca were very small and since it was difficult to remove hard parts, the weight of these species was taken separately including the shell (Damodaran 1973). The gut contents of bigger species like the echiuroid Ochaetostoma septemyotum were removed before determining the dry weight.

The method described by El Wakeel and Riley (1956) was used for the estimation of organic carbon in the sediment. The organic carbon percentages were multiplied by a factor of 1.74 to get the percentage of organic matter (Trask, 1955).

2.5. Fishery

The data on the fishery from the regions of the present study was collected by two methods. (1) Visiting the fish landing centre at Porakkad mud bank and gathering information on the composition of the fishery from the country crafts landed there. (2) As the vessel operated for the collection of benthos was suitable for stern trawling, a four seam commercial bottom trawl of size 32 metre head rope length was operated in six stations of the Malippuram mud banks. The trawl gear was towed for one hour duration in each station from 5 m depth onwards immediately after the collection of bottom deposits and water samples, care being taken that the vessel during trawling kept the depth of ground constant. As soon as the gear was hauled up and spilled the catch on the deck, fishes and prawns were sorted, identified and weighed.

Location of stations

Profile	Station	Latitude	Longitude	Depth (m)
A	1	9° 22'N	76° 22'E	5
	2	9° 21.4'N	76° 19'E	10
	3	9° 20.5'N	76° 15.8'E	20
	4	9° 20.2'N	76° 13'E	30
	5	9° 19.5'N	76° 10.2'E	35
	6	9° 18.8'N	76° 8.2'E	45
B	7	9° 24.5'N	76° 21'E	5
	8	9° 23.8'N	76° 17.8'E	10
	9	9° 23.2'N	76° 14.8'E	20
	10	9° 22.5'N	76° 12'E	30
	11	9° 21.9'N	76° 9'E	35
	12	9° 21.2'N	76° 6.2'E	45
C	13	9° 44.6'N	76° 16.5'E	5
	14	9° 44.2'N	76° 13.5'E	10
	15	9° 43.5'N	76° 10.5'E	20
	16	9° 43.0'N	76° 7.5'E	30
	17	9° 42.5'N	76° 4.5'E	35
	18	9° 42'N	76° 1.5'E	45
D	19	9° 55.5'N	76° 14.4'E	5
	20	9° 54.0'N	76° 12'E	10
	21	9° 52.75'N	76° 9.5'E	20

Profile	Station	Latitude	Longitude	Depth (m)
	22	9° 52.5'N	76° 7.0'E	30
	23	9° 50.5'N	76° 4.5'E	35
	24	9° 49.5'N	76° 2.0 E	45
E	25	10° 2'N	76° 12'E	5
	26	10° 08'N	76° 9.5'E	10
	27	9° 59.5'N	76° 6.8'E	20
	28	9° 58.2'N	76° 4'E	30
	29	9° 57.0'N	76° 1.2'E	35
	30	9° 55.5'N	75° 58.5 E	45

3. MUD BANKS

3.1. Appearance of mud banks

In certain localities of the southwest coast of India, the inshore areas have got a special property of damping the wave action and produce areas of calm water even during the rough monsoon seasons due to the "dissipation of wave energy in the large quantity of colloidal suspension in the regions". These areas are generally known as mud banks and locally in the name of "Chakara" which exists during the period June to September annually.

The phenomenon of the appearance of the mud banks along the coast of Kerala from time immemorial, unique in its formation and function, makes a good contribution to the fishery potential of the state and economic condition of the coastal fishermen. The mud banks, in addition to affording protection to the coastal areas from severe sea erosion, have proven to be fertile grounds for the exploitation of large quantities of fish and prawns for the local fishermen especially, when other regions in the sea will be turbulent and unsafe for fishing operations to be carried out from country crafts and other small mechanised fishing vessels.

3.2. History of the mud banks

The earliest written account of the mud banks dates back as early as 1678 to 1723 which appear in an extract from

Hamilton's account of the East Indies in Pinkerton's collection of voyage and travels given in the Administrative Report for Travancore, 1860. Dr. King of the Geological Survey of India, in his report "Consideration of the smooth water anchorages or Mud banks of Narakkal and Alleppey on the Travancore coast" has given an account on the migration and formation of the above two mud banks. According to him the range of movement of the Alleppey mud banks is about 24 kms between Alleppey and Porakkad and that of Narakkal mud bank is nearly 20 kms from Narakkal to Cochin outlet. Bristow (1938) studied the nature and formation of these mud banks which has shed some light on the origin, movement, calming effect and other features of this phenomenon.

Apart from the earlier records and probable theories describing the origin, shifting and calming effect of the mud banks, the more recent studies on the physical, chemical and biological aspects of this phenomenon include those of Seshappa (1953), Seshappa and Jayaraman (1956), Rama Sastry and Myrland (1959), Hiranandani and Gole (1959), and Rao et al (1980).

3.3. <u>Calming effect</u>

The mud banks appear close to the shore more or less semicircular in shape with the onset of southwest monsoon. The boundaries of the mud banks which stretch along the shore can be demarcated very clearly by walking along the seashore. The boundaries normally fall between 3 to 6 kms. The mud banks extend seaward to a depth of 10 to 15 m. The mud banks can easily be distinguished by the absence of waves, while heavy breakers lash upon the shore on the boundaries of the bank during the southwest monsoon. The bottom sediment in the mud bank region undergoes considerable changes in its consistency and composition during this period.

The most prominent feature of calmness, which characterises the appearance of mud banks, has been described by different workers. While some earlier observers attributed the damping of waves in the mud bank regions to the presence of oil in the mud and to its very soft and plastic nature, Keen and Russel (Du Cane, et al, 1938) were of opinion that oil is not present in the sediments of mud banks, and a thin film of oil if at all present, could not produce the calming effect. The generally accepted view is that the mud when in suspension increases the ratio of viscosity of the medium to its density, which causes the propagation of waves difficult and their subsequent damping. The turbulent sea during the southwest monsoon provides sufficient and continuous source of energy which keeps the mud in suspension.

3.4. Theories of mud bank formation

The exact mechanisms of mud bank formation, the damping of wave action, calmness, shifting of the banks and disappearance are not clearly known. According to the available records there are about twenty places where the mud banks have appeared sometime or other. At four regions along the coast, viz. Calicut, Malippuram, Saudi and at Alleppey/Porakkad in the south, the appearance of the mud banks is an annual phenomenon. Of these the most important and well delineated mud banks are the Malippuram mud bank north of Cochin and the Porakkad mud bank appearing south of Alleppey.

The formation of the mud banks have been explained by various theories. According to the earliest explanations found in the compiled report of Du Cane et al (1938) the mud banks are found by the flow of mud from the backwaters by hydraulic pressure through some subterranean channels in the narrow strip of land that separates the backwaters from the sea. Water level rises in the backwaters during the southwest monsoon months due to the discharge of flood waters from a large number of rivers. The continuous stretch of backwaters separated from the sea by the narrow strip of land and reports of 'mud volcanoes' or cones of mud bursting up over the surface of the Alleppey mud banks are considered as evidence in support of the theory. But the results of the analysis of the mud sample from the Narakkal and Alleppey mud banks and those from the backwaters did not show any such similarity in the texture of the sediment. Coggin Brown

(Du Cane et al 1938) analysed the boring conducted at Alleppey and Cochin and stated that "the character of the sediment as revealed by the boring records is sufficient to rule out the possibility of subterranean channel through them by means of which some earlier observers sought to explain the origin of the mud banks". In the present observations in 1972 and 1973 the Alleppey mud bank appeared in the second week of June after the onset of monsoon. The water level in the backwaters was not much higher than the pre-monsoon level to cause an increase in hydraulic pressure so as to bring a flow of mud from the backwaters. Similarly the Saudi and Malippuram mud banks appear very close to the Cochin barmouth where there is no significant difference in the water level in the backwaters during monsoon.

The second theory suggests that the rivers and coastal currents play a significant role in the formation of the mud banks. The areas where the mud banks appear are within a small distance from the mouth of the rivers except at Alleppey, where no river exists now, eventhough it is believed that an opening had once existed (Du Cane et al 1938). These rivers discharge plenty of sediment along with flood waters and the low salinity content of the water during monsoon keeps the sediments in suspension for long periods. It is also possible that the fine sediment brought by the rivers is carried along the coast by the coastal currents for some distance before settling down as deposits. But the occurrence of some of the mud banks along the coast far away from the river mouths does not allow to accept this theory conclusively.

As the mud bank formation is very characteristic of the Kerala coast and of economic significance, some recent workers have attempted to explain its appearance and other related aspects. Rama Sastry and Myrland (1959) attributed the formation of the mud banks to the "upwelling and divergence near the bottom between 20-30 m along the coast line" which produce vertical accelerations resulting in the lifting of bottom waters and bottom mud. Hart and Curie (1960) reported that upwelling can lift up bottom sediments as occurring in the Benguela upwelling region. But the more recent studies of Varma and Kurup (1969) states that it is doubtful whether an overturning of subsurface water as occurs along this coast can bring up large quantities of mud from the bottom and keep it in suspension for a sufficiently long period. According to their field observations and wave refraction studies, regions of the mud banks formed a zone of converging littoral currents for higher period waves, which in turn form rip currents carrying finer sediments offshore preventing the onshore transport of sediments by waves. This results in the localiation of the finer suspended sediment at the rip head. The onshore transport of bed load by higher period waves might be occurring all along the coast just before the monsoon and during the monsoon period. The formation of the mud banks takes place in the region where the onshore transport of bed load meets with the offshore transport of suspended matter by the rip flows, Kurup (1977).

Recently Rao et al (1980) has classified mud banks mainly into four types based on the source of mud for their formation: (1) Mud banks are formed of subterranean mud and the example is the mud banks at Alleppey. This mud bank exhibit a slow movement from one place to other mostly to southward in direction. The mud is supplied from the underground sources, and the Vembanad lake system provides the mud for its formation (2) Mud banks are formed by the aggregation of coastal mud which are very extensive but are purely temporary. The bottom mud present in the coastal mud belt is churned up during southwest monsoon. But there may not be perfect calmness as the quantity of mud in suspension may not be enough to absorb all the wave energy (3) The occurrence of the mud banks are caused by the sediments and organic debris discharged from rivers and estuarie. The huge quantities of sediments and other organic matters brought by heavy rains of the southwest monsoon are aggregated at the estuary and bar mouths, usually south of their openings. These sediments are kept in position by the southerly flow and the local eddy currents without being spread out. These mud banks are of transient nature. Eg.: Narakkal mud bank

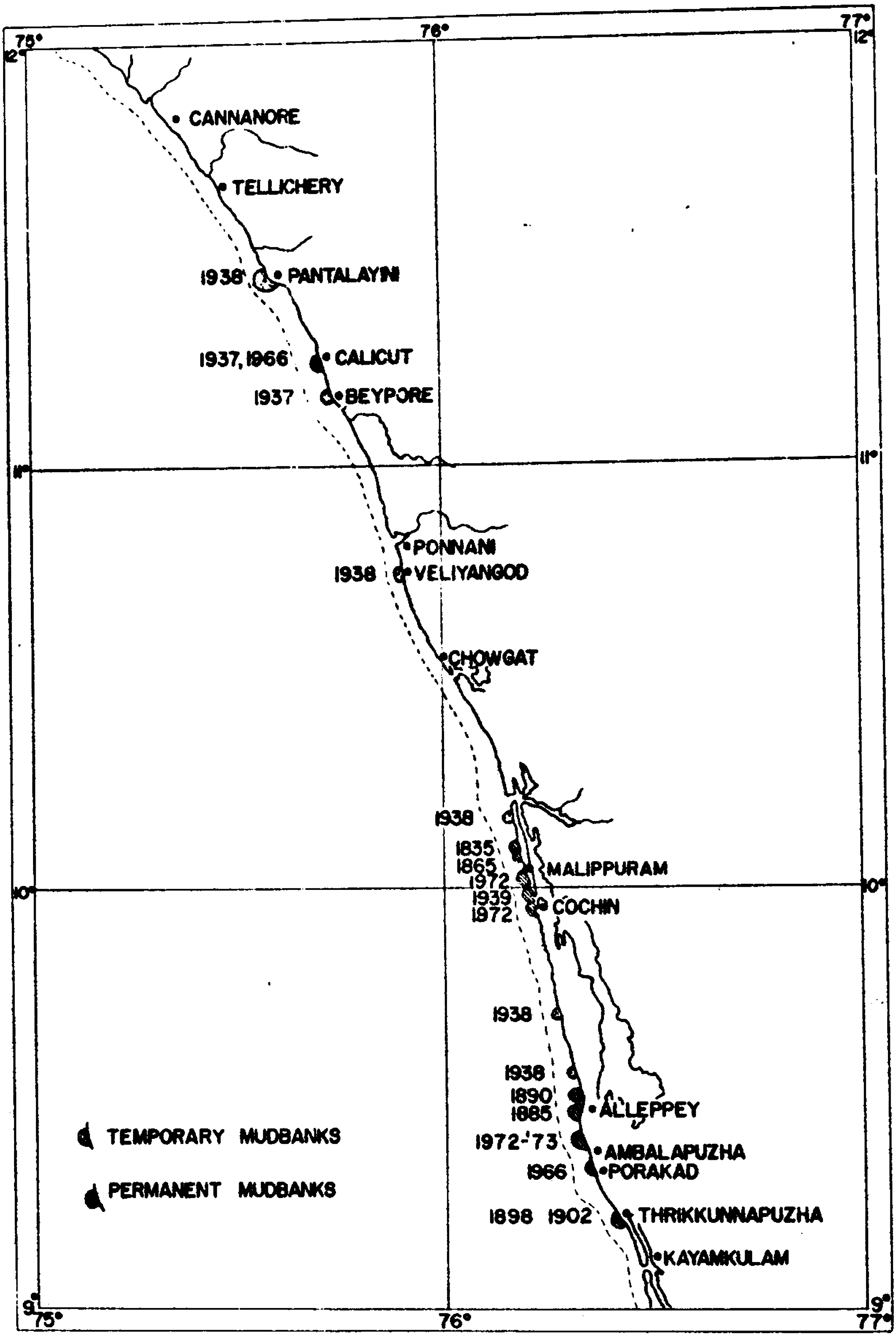
(4) Mud banks are formed by the accumulation of mud resulting from dredging operations. The source of mud is from the dredging operations, periodically done for deepening the navigation channel. Eg.: Mud bank at Vypeen, north of Cochin bar mouth. According to them, the calming effect of the wave motion is due to the mud particles in colloidal solution in water and not due to mud itself.

In the present investigation a survey was carried out along the coast of Kerala from north Calicut to south Porakkad (Alleppey) before the out-break of southwest monsoon in the latter half of the month of May to identify the probable localities of mud bank formation. Again these places were visited immediately after the onset of monsoon towards the end of May or first week of June to locate the position of the mud bank formation and their extent and disappearance (Fig.2).

3.5. Porakkad mud bank (Alleppey)

The mud bank in Porakkad is an annual phenomenon. In 1972 and 1973 the mud banks appeared during the second week of June. The position of the mud bank in 1972 and 1973 was between Porakkad and Ambalapusha. The mud banks at Alleppey and Calicut were of mobile in nature. But during the period of the investigation, the mud banks were more or less stationary. The length

Fig. 2. Positions where mud banks appeared along the Kerala Coast between 1835 and 1973.



75°
76°
77°
12°
11°
10°
9°
CANNANORE
TELLICHERY
1938
PANTALAYINI
1937, 1966
CALICUT
1937
BEYPORE
PONNANI
1938
VELIYANGOD
CHOWGAT
1938
1835
1865
MALIPPURAM
1972
1939
1972
COCHIN
1938
1938
1890
1885
ALLEPPEY
1972-'73
AMBALAPUZHA
1966
PORAKAD
1898 1902
THRIKKUNNAPUZHA
KAYAMKULAM
TEMPORARY MUDBANKS
PERMANENT MUDBANKS

FIG. 2.

of the mud banks in both the years were found to be about 6.5 to 7 kms and had a seaward extent upto a depth of 12 m. In 1972 the mud bank gradually disappeared by the end of November and in 1973 it disappeared by the middle of December.

3.6. Malippuram mud bank (North of Cochin)

The mud bank was not as prominent as that of Porakkad and it was found difficult to demarcate the boundaries clearly in 1972. In 1973 the mud bank appeared during the third week of June and it extended to a length of about 9 kms. The mud bank disappeared completely by the middle of November during both the years.

3.7. Saudi mud bank (South of Cochin)

The Saudi mud bank occupies the third place in the order of importance among the three mud banks selected, because of its indistinct nature and the absence of clear well demarcated boundaries in both the years of observation. In 1972 the mud bank appeared late in the first week of July after the onset of monsoon. It extended to a length of about 5 kms along the coast and the seaward extension was upto a depth of 12 m. In 1973 the mud bank appeared very late in the third week of July and its boundaries were very indistinct and disappeared by the secon week of September. The seaward extent of the mud bank could be traced upto about 15 m depth.

4. HYDROGRAPHY

The hydrographic investigation in the Indian waters started in the early years of the 20th century. Annandale and Kemp (1915) and Sewell (1929) investigated the hydrographical conditions of the Chilka Lake on the Orissa Coast and of the Andaman and Laccadive seas respectively. The later important works on the hydrographical parameters of east coast of India were those of Menon (1931), Jayaraman (1951), Ramamurthy (1953), Thirupad and Reddi (1959) along Madras Coast, Prasad (1952) for the Bay of Bengal Waters in general, Jayaraman (1954), at Mandapam; Ganapati and Rao (1953), Ganapati and Murthy (1954, 1955), Ganapati and Sarma (1958), Lafond (1954, 1958 a,b), Lafond and A.T.Moore (1972), Rao and Rao (1962) at Waltair Coast. Carruthers et al (1959) studied the layer of minimum oxygen off Bombay and its influence on marine biology and fisheries. Banse (1959, 1968) and Darbyshire (1967) studied the coastal waters of south west coast in general. Chidambaram and Menon (1945), George (1953), Seshappa and Jayaraman (1956), Subrahmanyan (1959), Ramasastry and Myrland (1959) made observations on the hydrographical features of the Malabar coast. Ramamritham and Jarayaman (1960) made observations on the hydrographical features of the continental shelf waters off Cochin. Studies on the upwelling along the west coast of India by Ramamritham and Rao (1973), observations by Rao et al (1973) on the oceanographic features and abundance of pelagic fisheries, Rao and Ramamritham (1974) on the seasonal variations in the hydrographic features, Damodaran and Hridayanathan (1966) and Damodaran (1973) on some of the hydrographical features of the Narakkal mud bank region and the influence of hydrographical features on the physical aspects of the mud banks by Kurup (1977) are some of the recent studies.

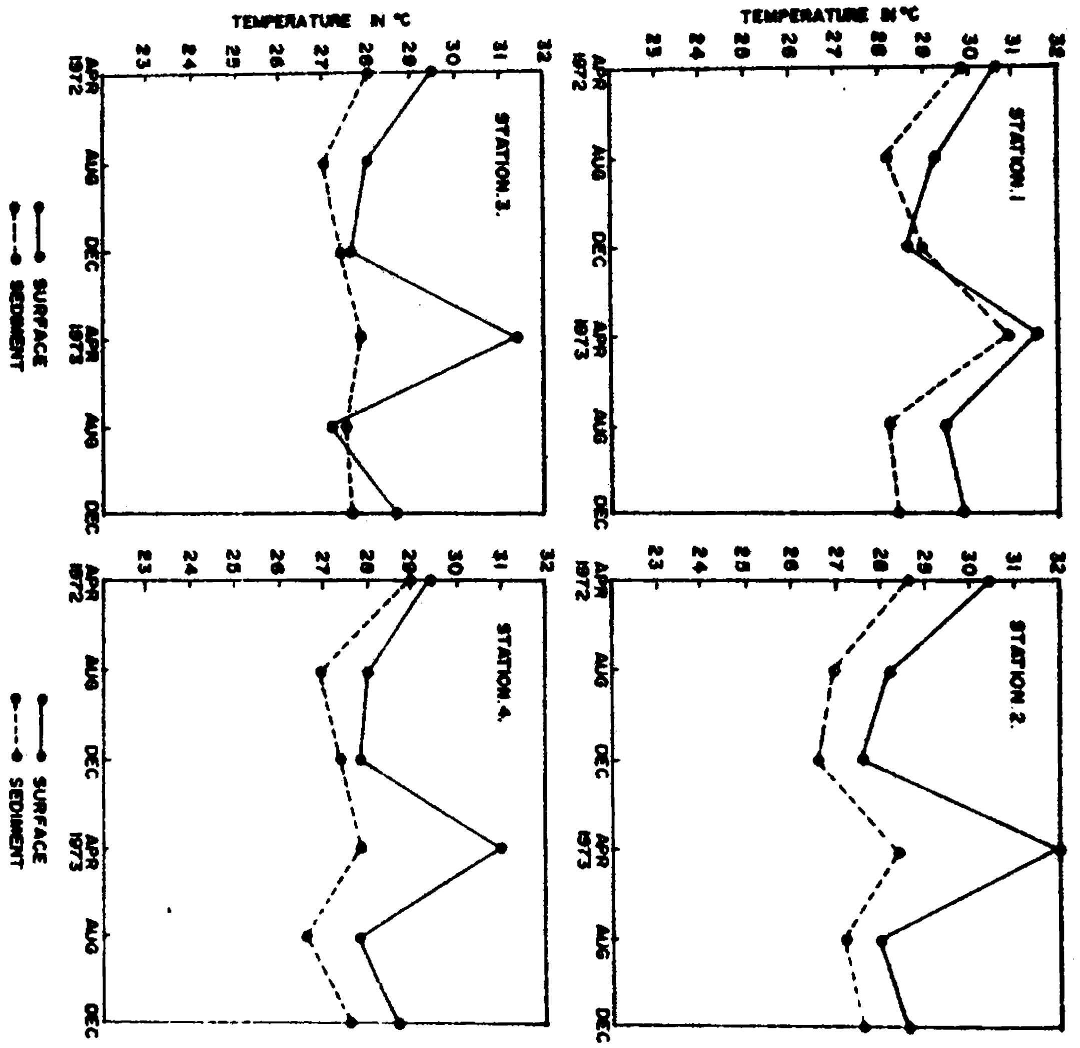
4.1. Results and discussion

4.1.1. Temperature: The details of surface water temperature and bottom sediment temperature are given in Figs. 3 - 12. The fluctuations in the surface temperature are very wide in the Arabian Sea whereas the usual range along the Indian Coast is from 23°C to 29°C. In the Bay of Bengal the usual range of surface temperature is between 27°C to 29°C and the fluctuations here is much less than in the Arabian sea. In the southwest coast of India, the minimum surface and bottom temperature has been observed during the period of southwest monsoon and the influence of the monsoon on the hydrography of the Kerala inshore waters and on the mud bank regions have been investigated (Damodaran and Hridayanathan 1966, Damodaran 1973, and Kurup 1977).

In the present investigation the maximum surface temperature observed was during the month of April 1972 and 1973. The maximum surface temperature of 32.0°C was observed in station

No.2 of profile A and station No. 19 of profile D, and the minimum surface temperature of 27.1°C was recorded in station No.25 of the profile E in 1973. The maximum bottom temperature of 31.4°C was observed in station No.7 in profile B during April 1973. In this station both the surface and bottom temperature were almost the same. The minimum bottom temperature of 23°C was observed at stations 22, 23, 24 of profile D and station 30 of the profile E. During December 1972 on the whole the surface and bottom temperature in all the 30 stations of the 5 profiles varied from the minimum of 27.1°C to a maximum of 28.7°C and from 26.6°C to 28.4°C respectively. In April 1972, the surface temperature varied from a minimum of 29.2°C to a maximum of 31.7°C and the bottom temperature from a minimum of 27.9°C to the maximum 31°C. In August 1972, the minimum surface temperature observed was 27.4°C and the maximum was 30.2°C. The temperature in the bottom sediment varied from a minimum of 23°C to a maximum of 31.4°C. Except in a very few stations, the bottom temperature recorded was always below that of surface temperature. In station where the bottom temperature was above the surface temperature, the difference of temperature varied from 0.2°C in station 13 during August, 1972 to 1.6°C in station 20 during August 1972.

Figs. 3 - 12. Surface water and bottom sediment temperatures at stations 1 to 30.



TEMPERATURE IN °C
STATION. 1
STATION. 2
STATION. 3
STATION. 4
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 3.

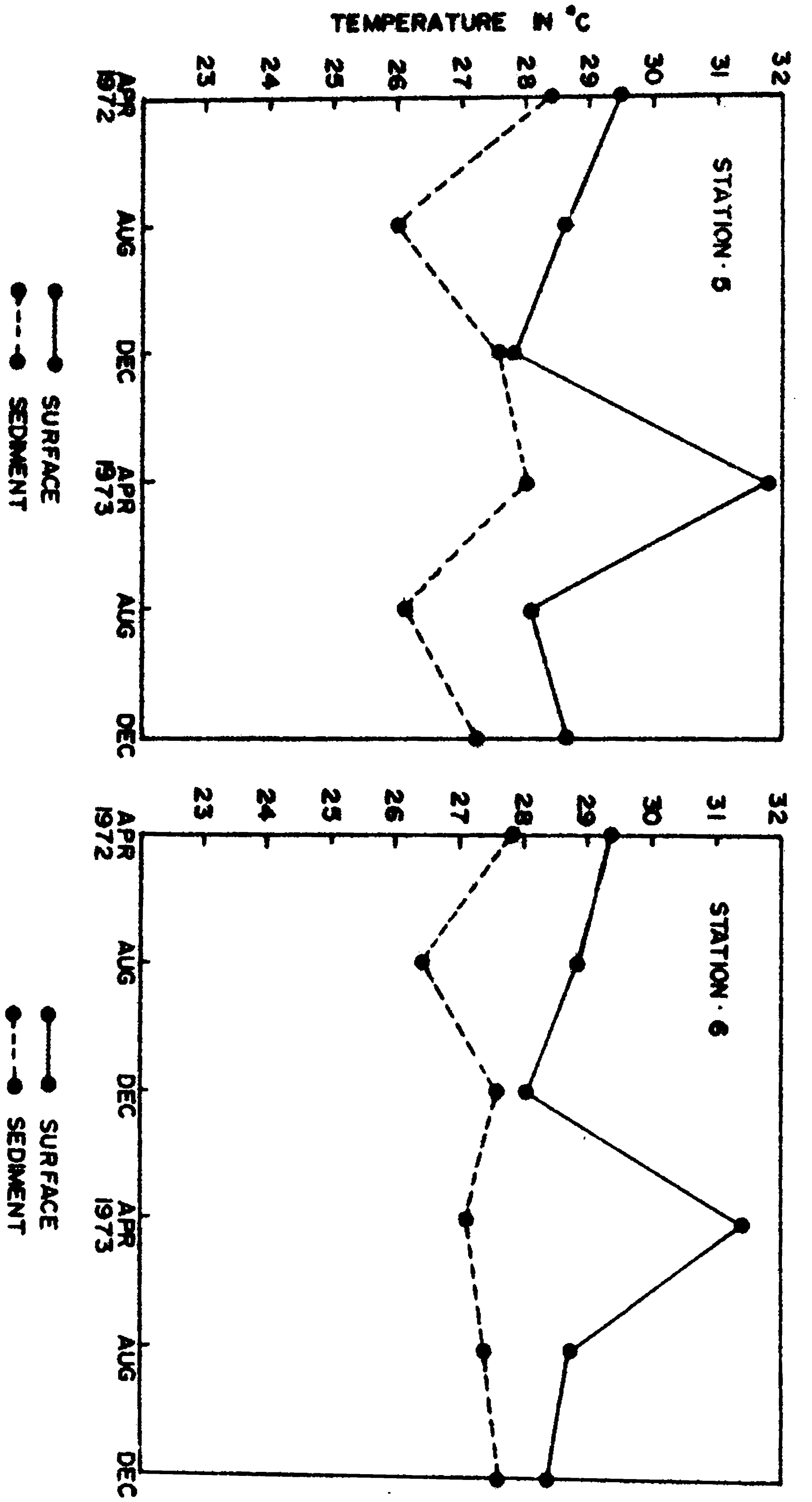

TEMPERATURE IN °C
STATION · 5
STATION · 6
23
24
25
26
27
28
29
30
31
32
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 4.

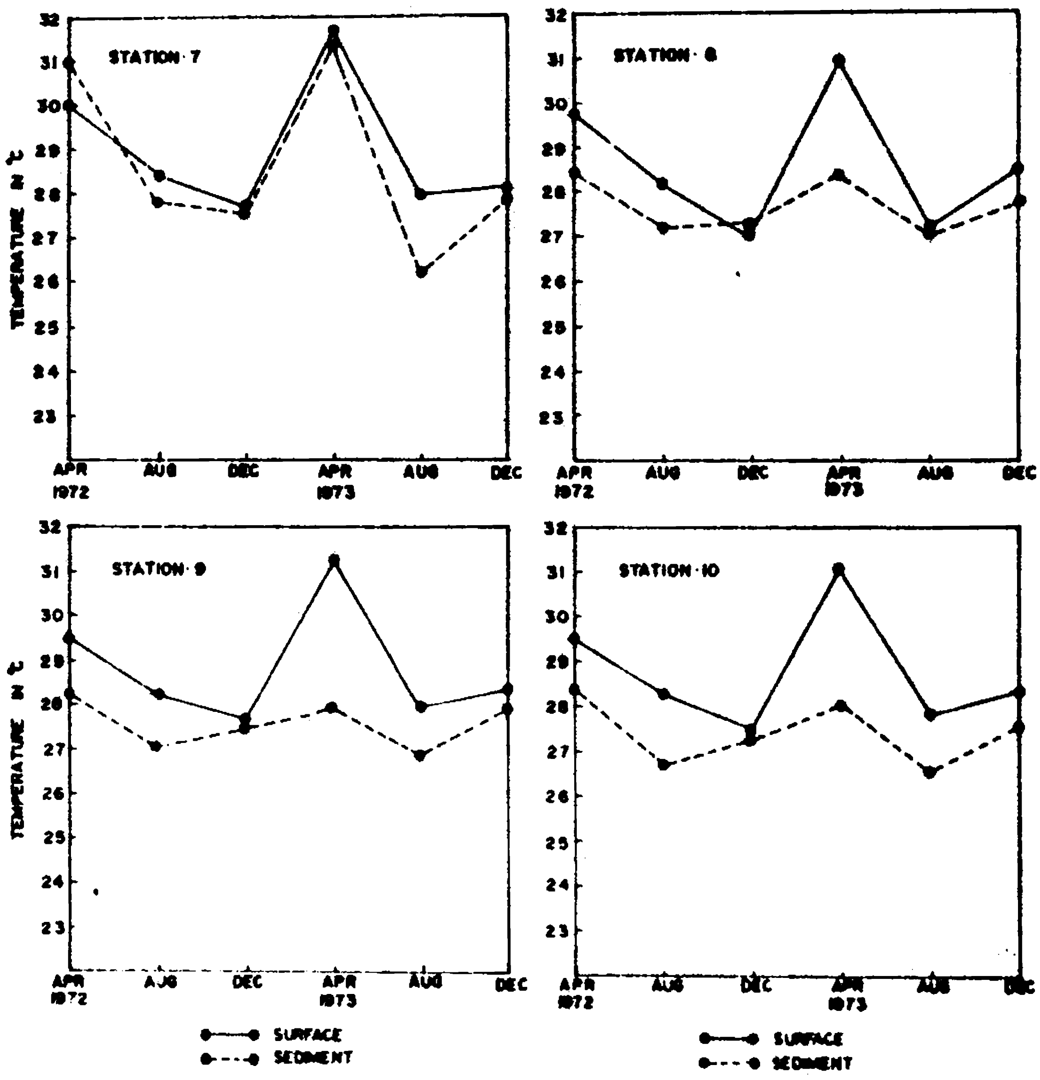

STATION · 7
STATION · 8
STATION · 9
STATION · 10
TEMPERATURE IN °C
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 5

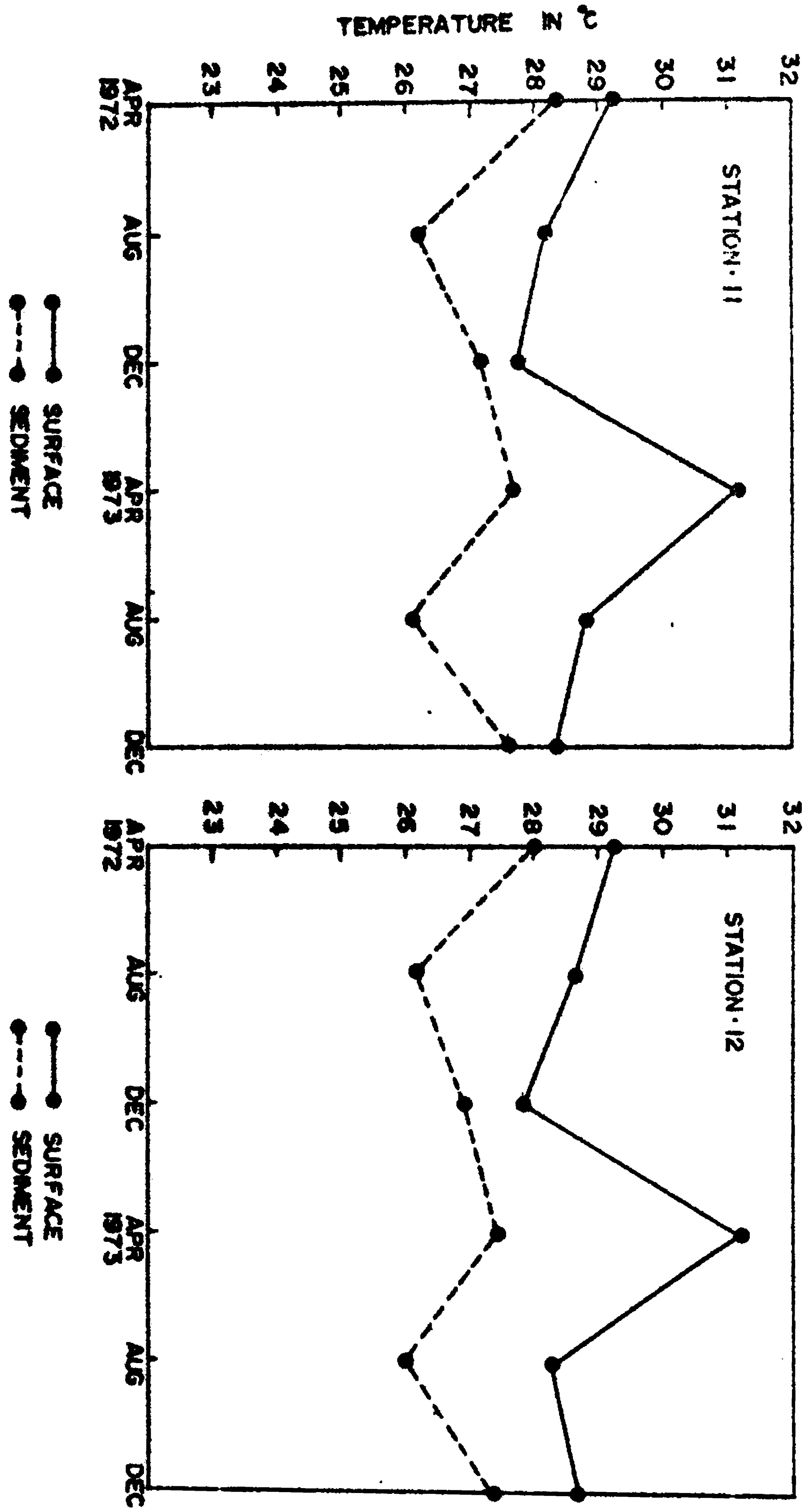

TEMPERATURE IN °C
23
24
25
26
27
28
29
30
31
32
STATION-11
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT
23
24
25
26
27
28
29
30
31
32
STATION-12
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 6

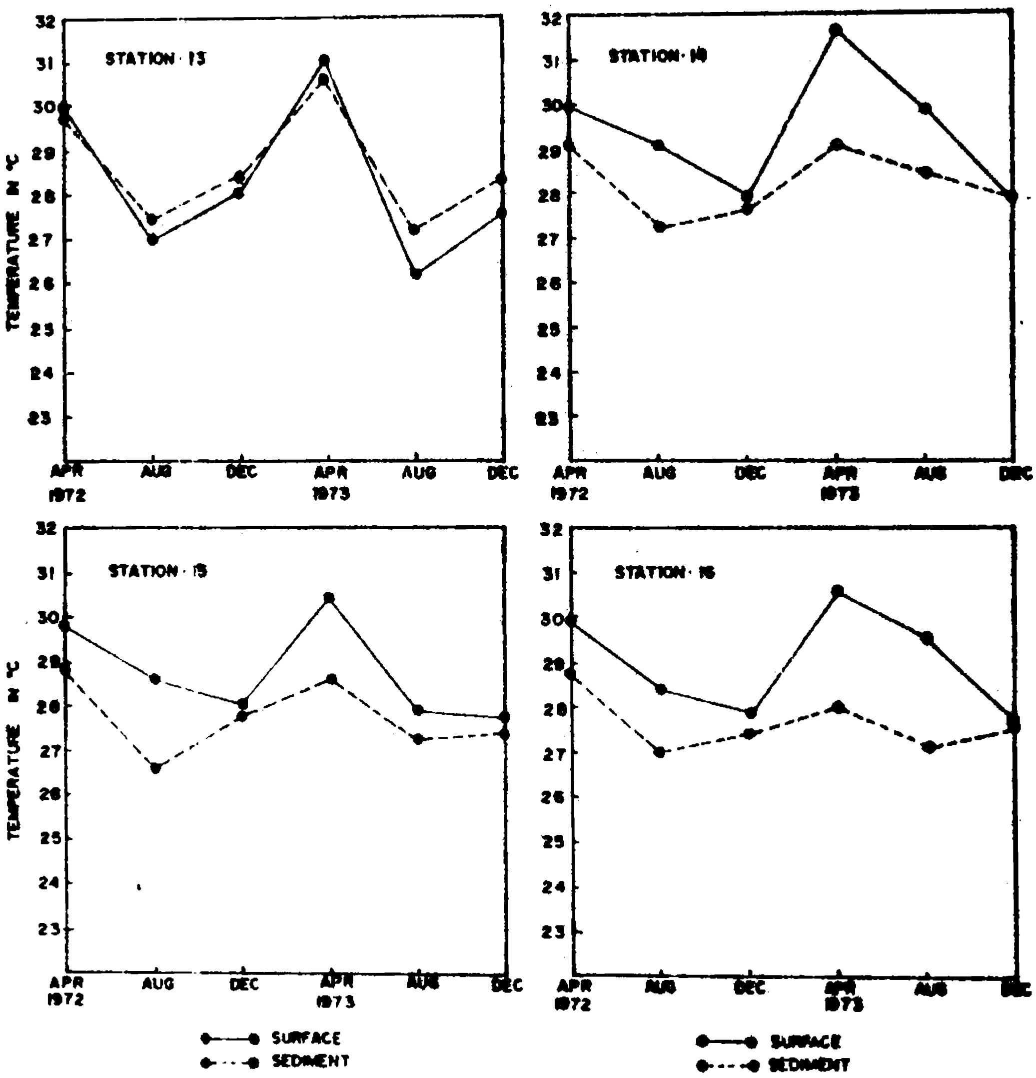
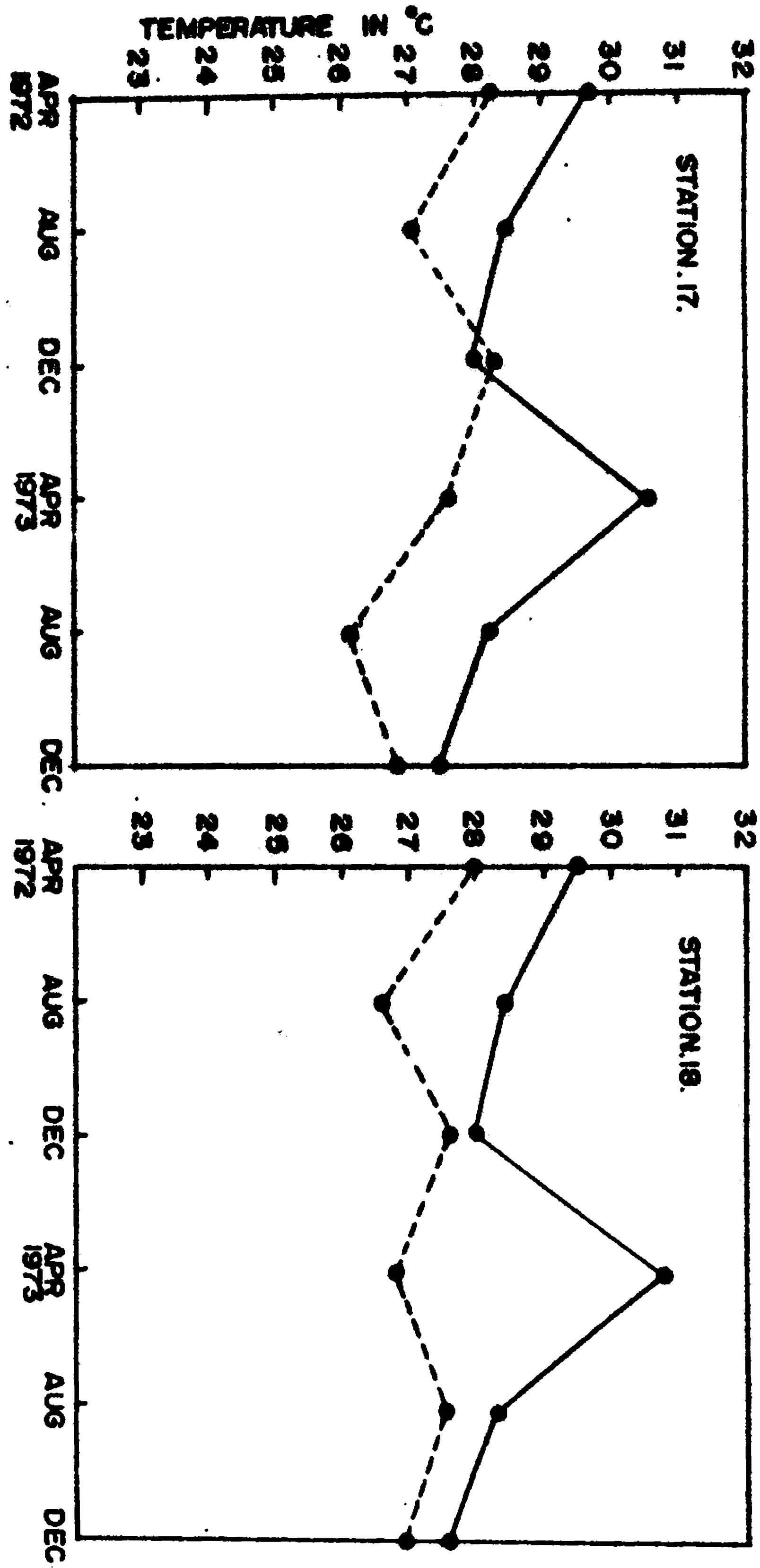
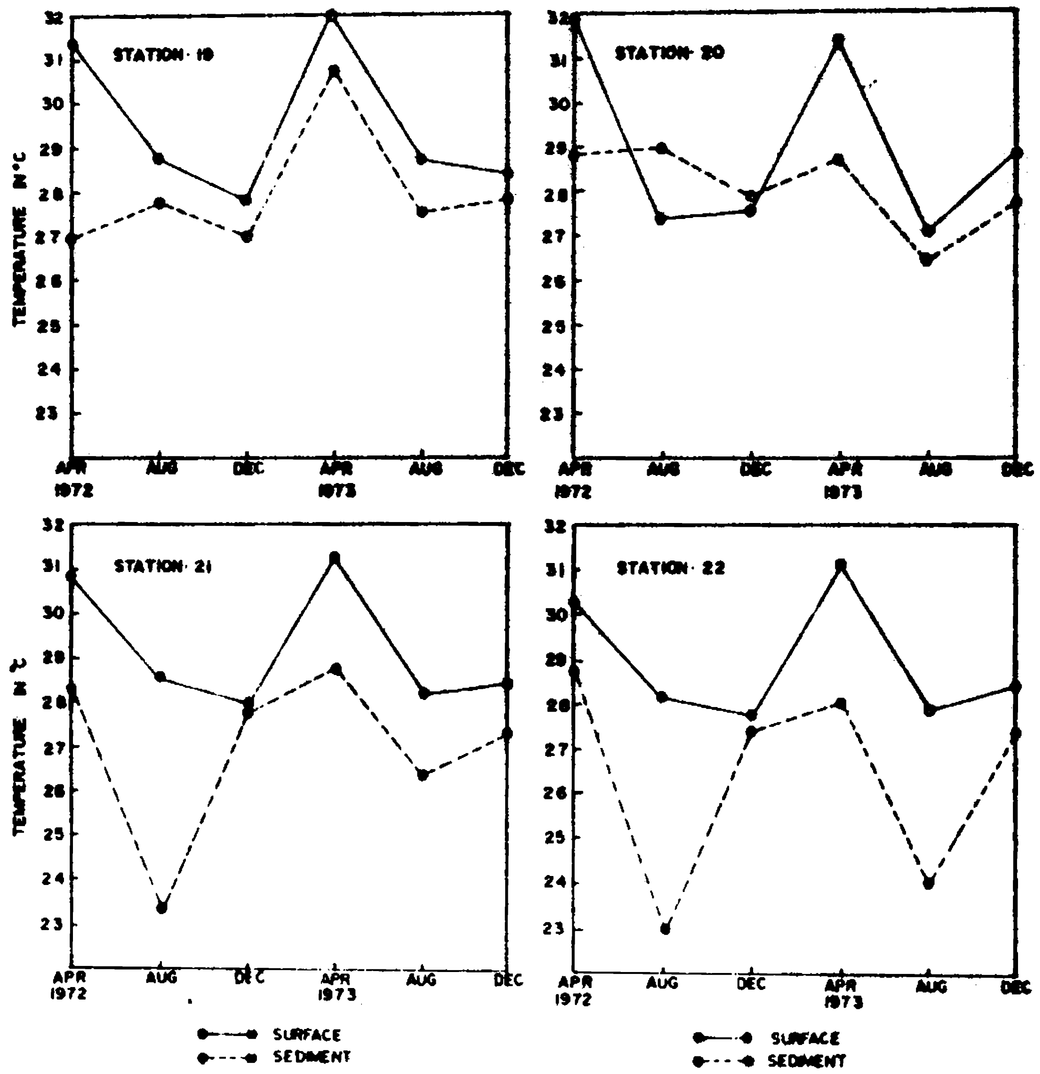

STATION 13
STATION 14
STATION 15
STATION 16
TEMPERATURE IN °C
32
31
30
29
28
27
26
25
24
23
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 4



TEMPERATURE IN °C
STATION. 17.
STATION. 18.
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT
23
24
25
26
27
28
29
30
31
32

FIG. 8.



STATION-19
STATION-20
STATION-21
STATION-22
TEMPERATURE IN °C
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 9.

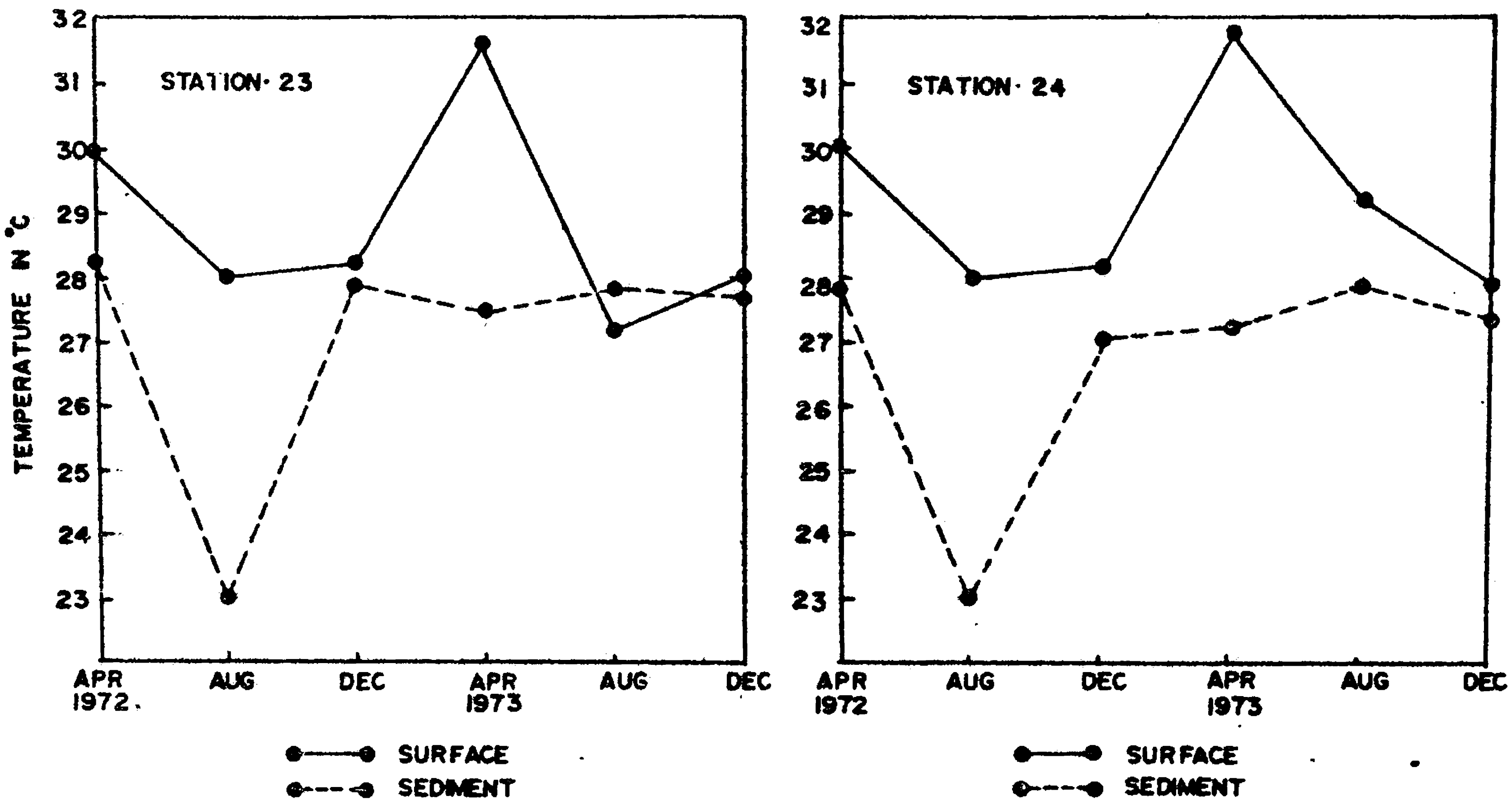

TEMPERATURE IN °C
STATION· 23
STATION· 24
32
31
30
29
28
27
26
25
24
23
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 10.

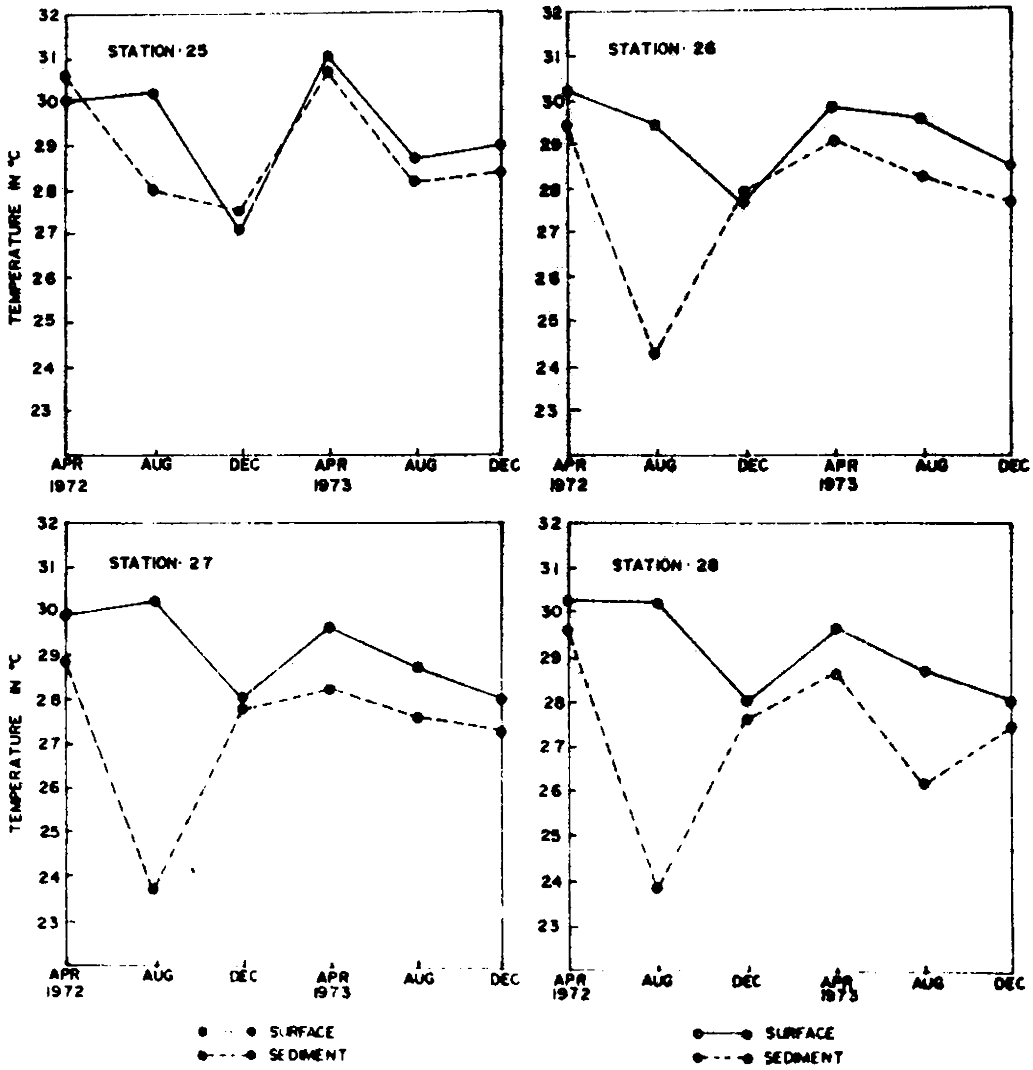

STATION · 25
STATION · 26
STATION · 27
STATION · 28
TEMPERATURE IN °C
32
31
30
29
28
27
26
25
24
23
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 11.

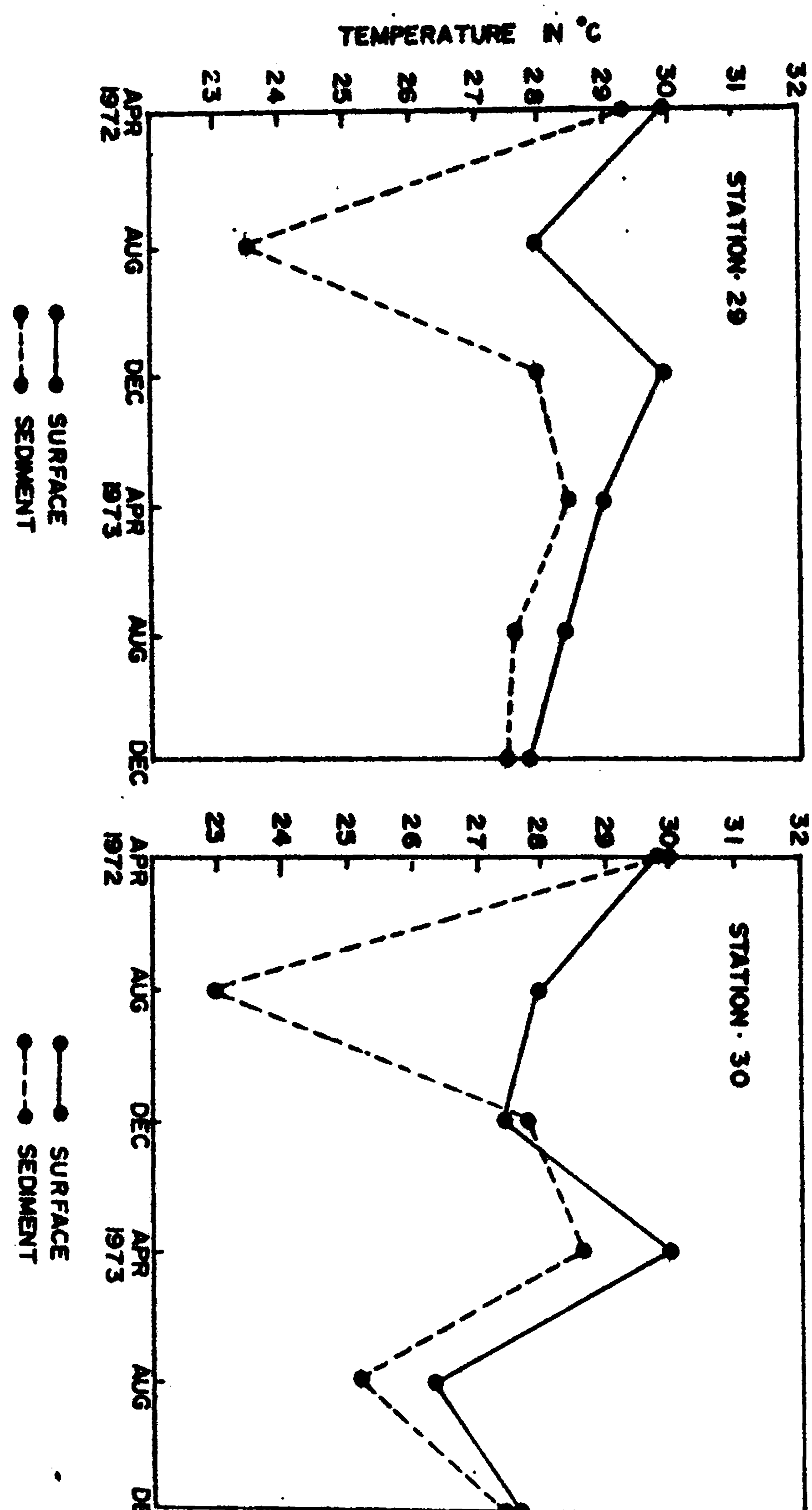

TEMPERATURE IN °C
23
24
25
26
27
28
29
30
31
32
STATION· 29
STATION · 30
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SURFACE
SEDIMENT

FIG. 12.

During April, the atmospheric temperature is high and there is no rainfall which accounted for the highest surface and bottom temperature observed during this period.

4.1.2. Salinity:

The surface and bottom salinity values are given in Figs. 13 - 22.

The maximum surface and bottom salinity was observed during December 1972 at all the stations and while in the succeeding year, the maximum salinity was recorded during April. The bottom salinity was slightly more than the surface salinity in majority of the stations.

In the present investigation, the first three profiles lie away from the vicinity and influence of any river, with the discharge of flood waters during the monsoon season. The fourth and fifth profiles lie near the bar mouth of the Cochin Port. Except at shallow water stations of 4 m and to a small extent in 8 m depth, the bottom salinity is not greatly affected in the Njarackal mud bank during the monsoon season (Damodaran, 1973). The salinity values in the deeper waters did not show any substantial change from that of the near shore waters in any of the profiles during the period of investigation.

In December the surface salinity varied from a minimum value of 33.48‰ to a maximum value of 34.78‰. The bottom salinity varied from a minimum value of 33.47%° to a maximum value of 34.78%°. During the month of April the minimum surface salinity observed was 33.73%° and the maximum value was 34.11%°, while the bottom water recorded a minimum value of 33.73%° and a maximum value of 34.38%°. In August a drastic drop in the surface and bottom water salinity was noticed in some of the stations of the fourth and fifth profiles. The stations 19 and 20 of the fourth profile showed a surface salinity of 21.5%° and 24.36%° and the stations 25, 26, 27, 28 in the fifth profile a surface salinity of 21.53%°, 23.69%°, 25.17%° and 26.78%° respectively. Except in stations 19 and 25 where the bottom salinity was 23.84%° and 21.40%° respectively, the bottom values in all the remaining stations were high. The fall in salinity value of the near shore stations of the fourth and fifth profiles during August can be attributed to the proximity of the outlet of backwaters and mixture of flood waters during the monsoon period.

4.1.3. Dissolved oxygen:

The dissolved oxygen values in the surface and bottom waters are shown in Figs. 13 - 22.

In December a maximum surface value of 6.451 ml/l was observed in station No.11 of the 2nd profile. In all the other stations the surface oxygen value varied from a maximum of

Figs. 13 - 22. Salinity and dissolved oxygen values in the surface and bottom water at stations 1 - 30.

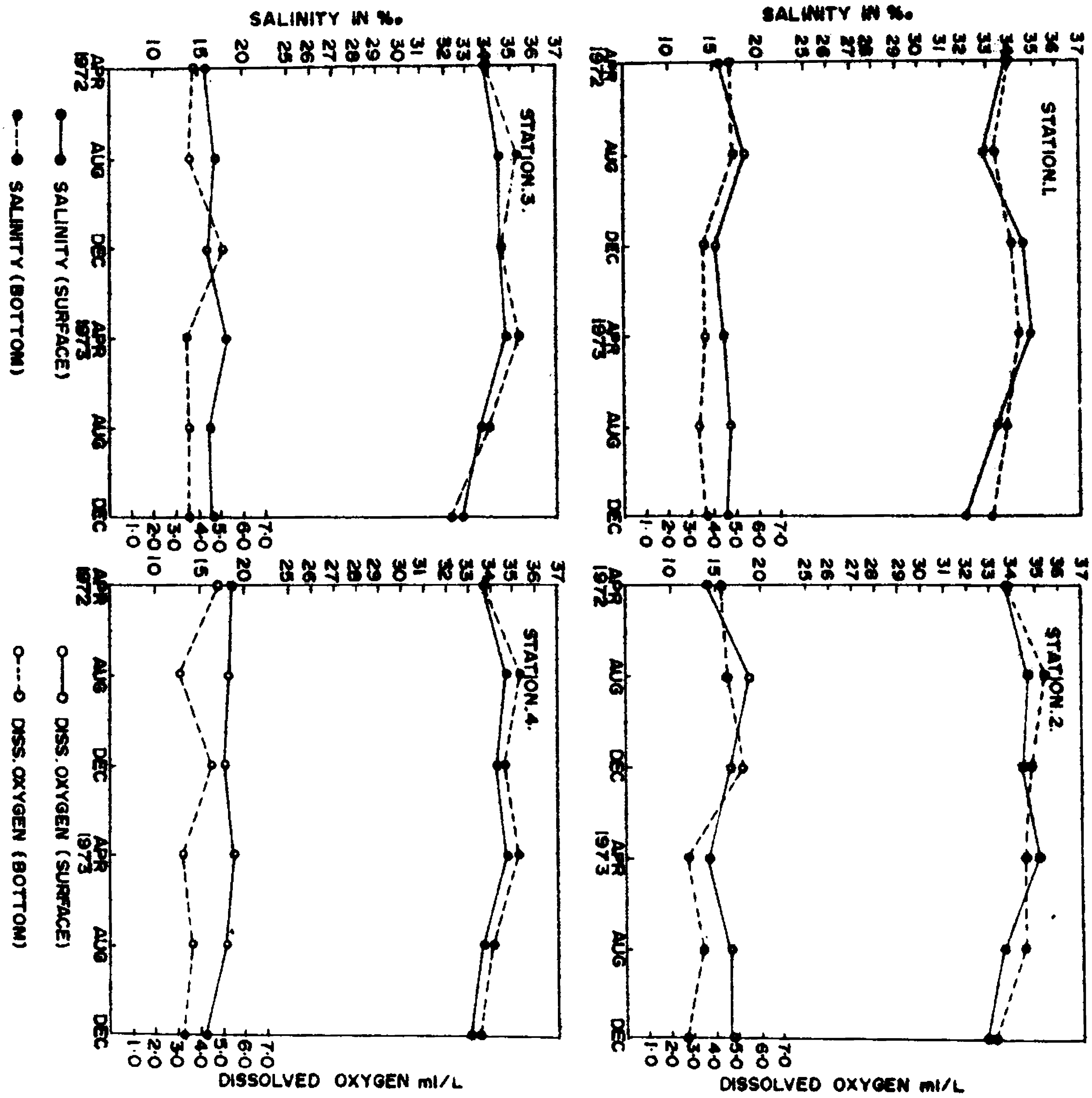

STATION.1
STATION.2
STATION.3.
STATION.4.
SALINITY IN ‰
DISSOLVED OXYGEN ml/L
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS. OXYGEN (SURFACE)
DISS. OXYGEN (BOTTOM)

FIG. 13.

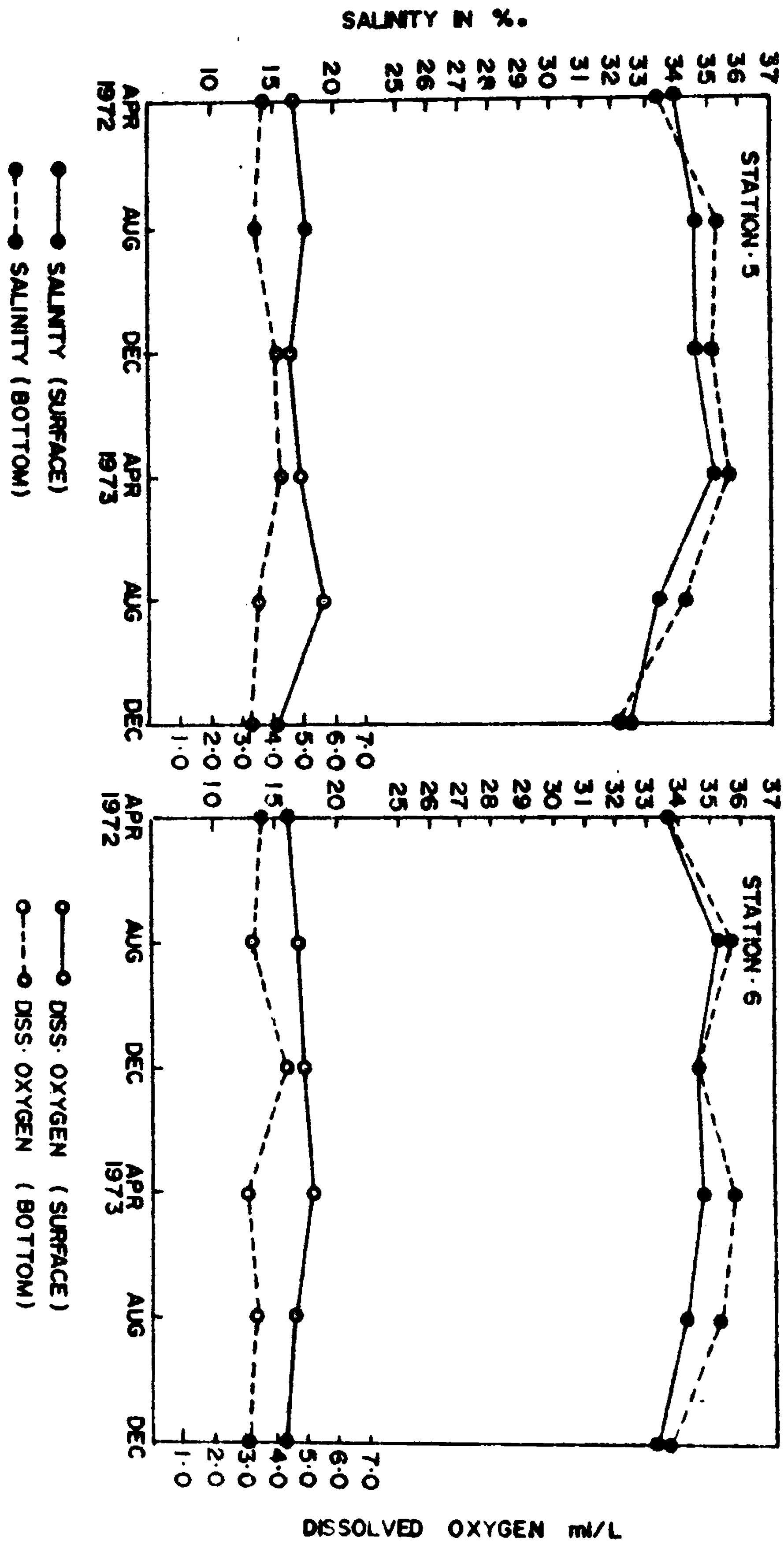

SALINITY IN ‰
STATION·5
STATION·6
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS· OXYGEN (SURFACE)
DISS· OXYGEN (BOTTOM)
DISSOLVED OXYGEN ml/L

FIG. 14.

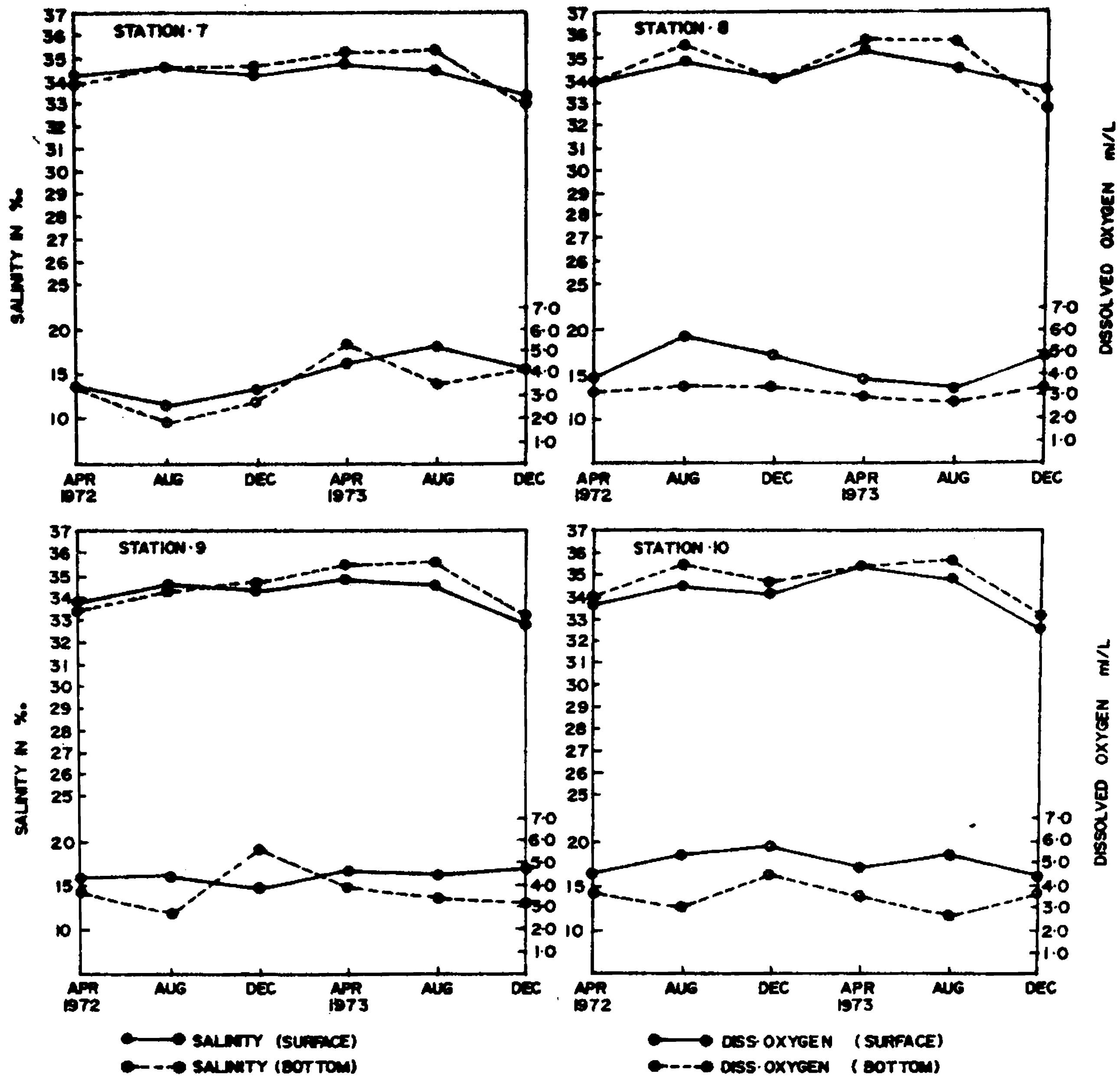

STATION 7
STATION 8
STATION 9
STATION 10
SALINITY IN ‰
DISSOLVED OXYGEN ml/L
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS·OXYGEN (SURFACE)
DISS·OXYGEN (BOTTOM)

FIG 18

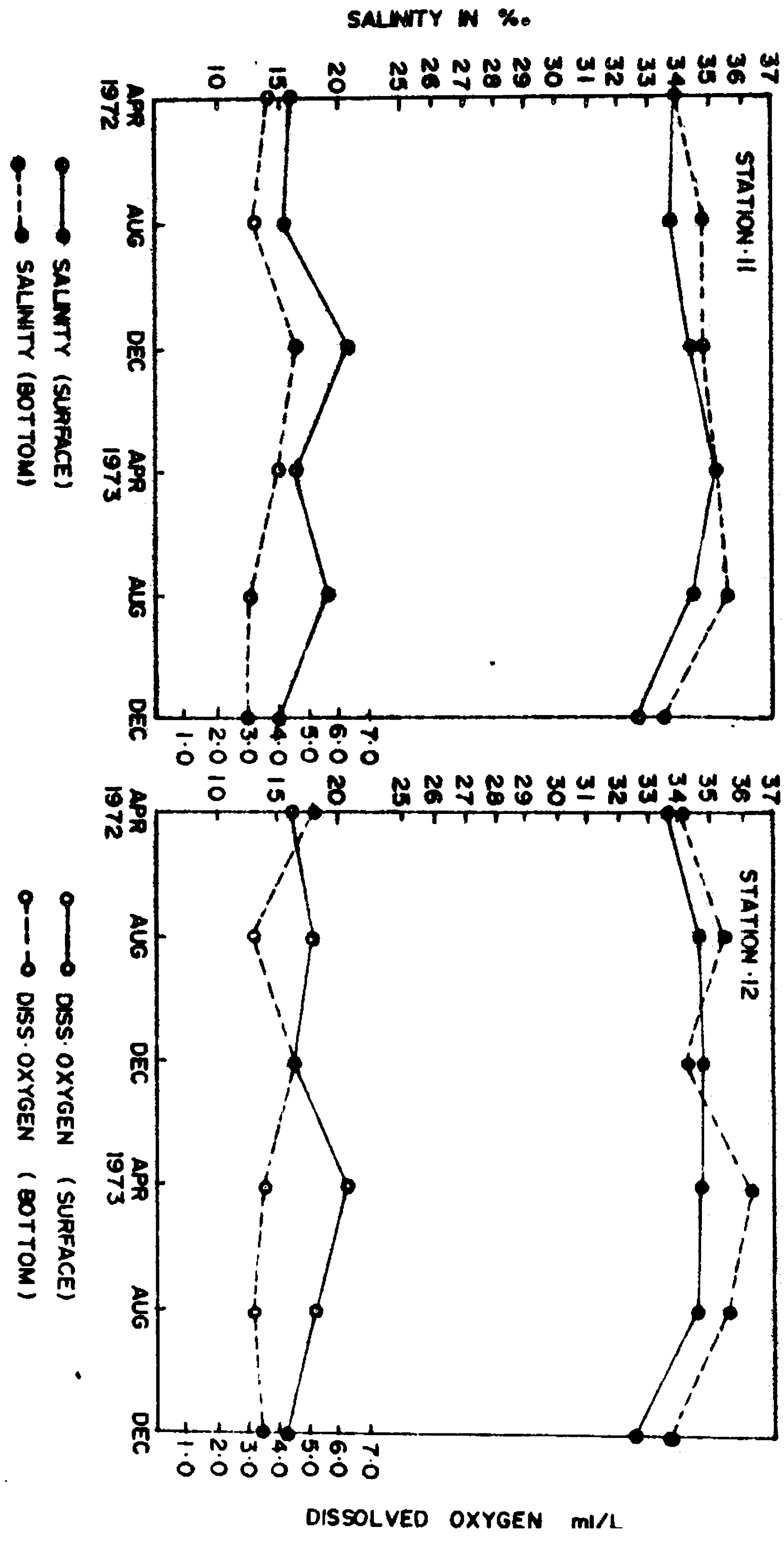

SALINITY IN ‰
STATION·11
STATION·12
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS·OXYGEN (SURFACE)
DISS·OXYGEN (BOTTOM)
DISSOLVED OXYGEN ml/L

FIG. 16.

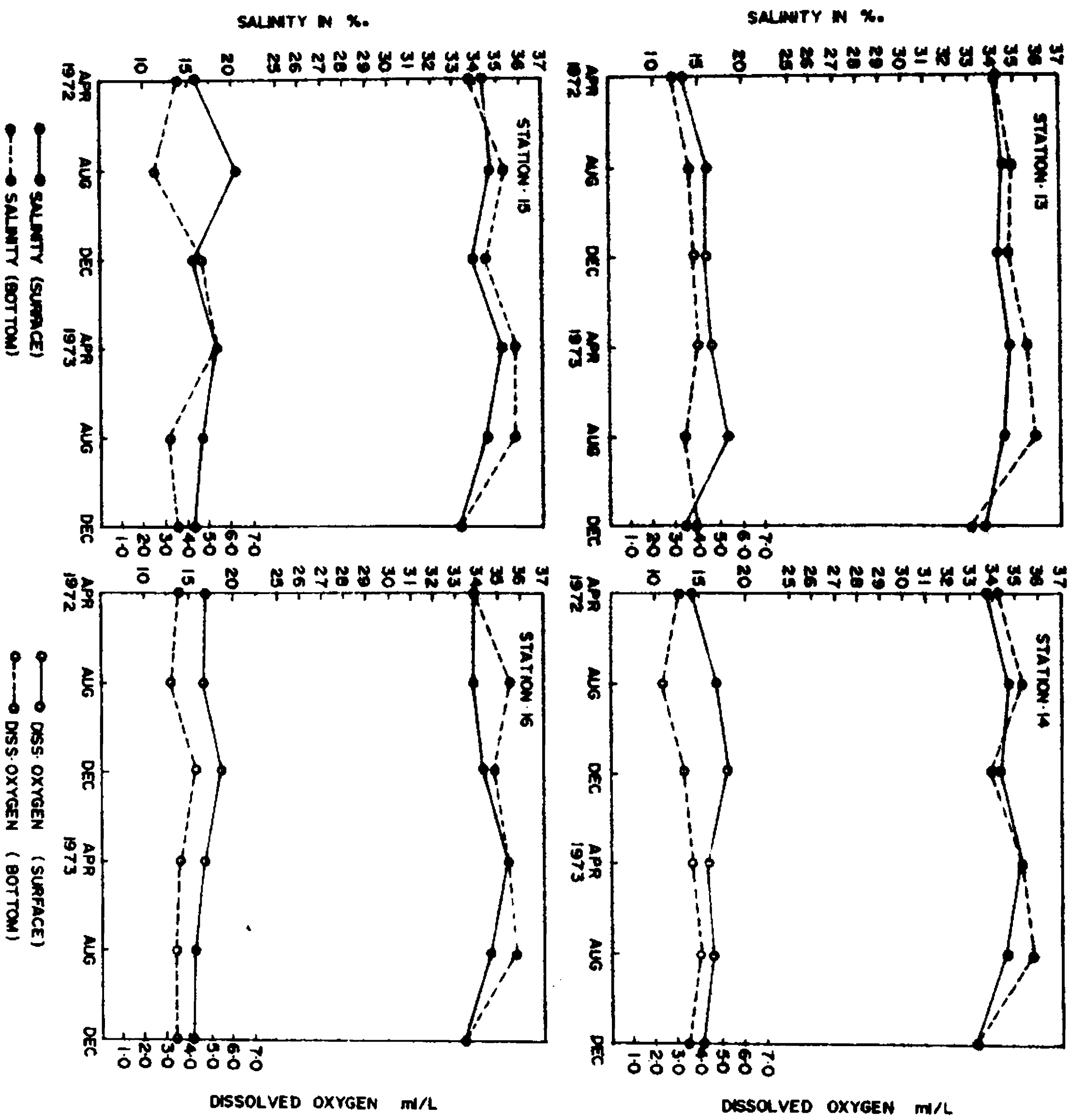

STATION·13
STATION·14
STATION·15
STATION·16
SALINITY IN ‰
DISSOLVED OXYGEN ml/L
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS·OXYGEN (SURFACE)
DISS·OXYGEN (BOTTOM)

FIG. 11.

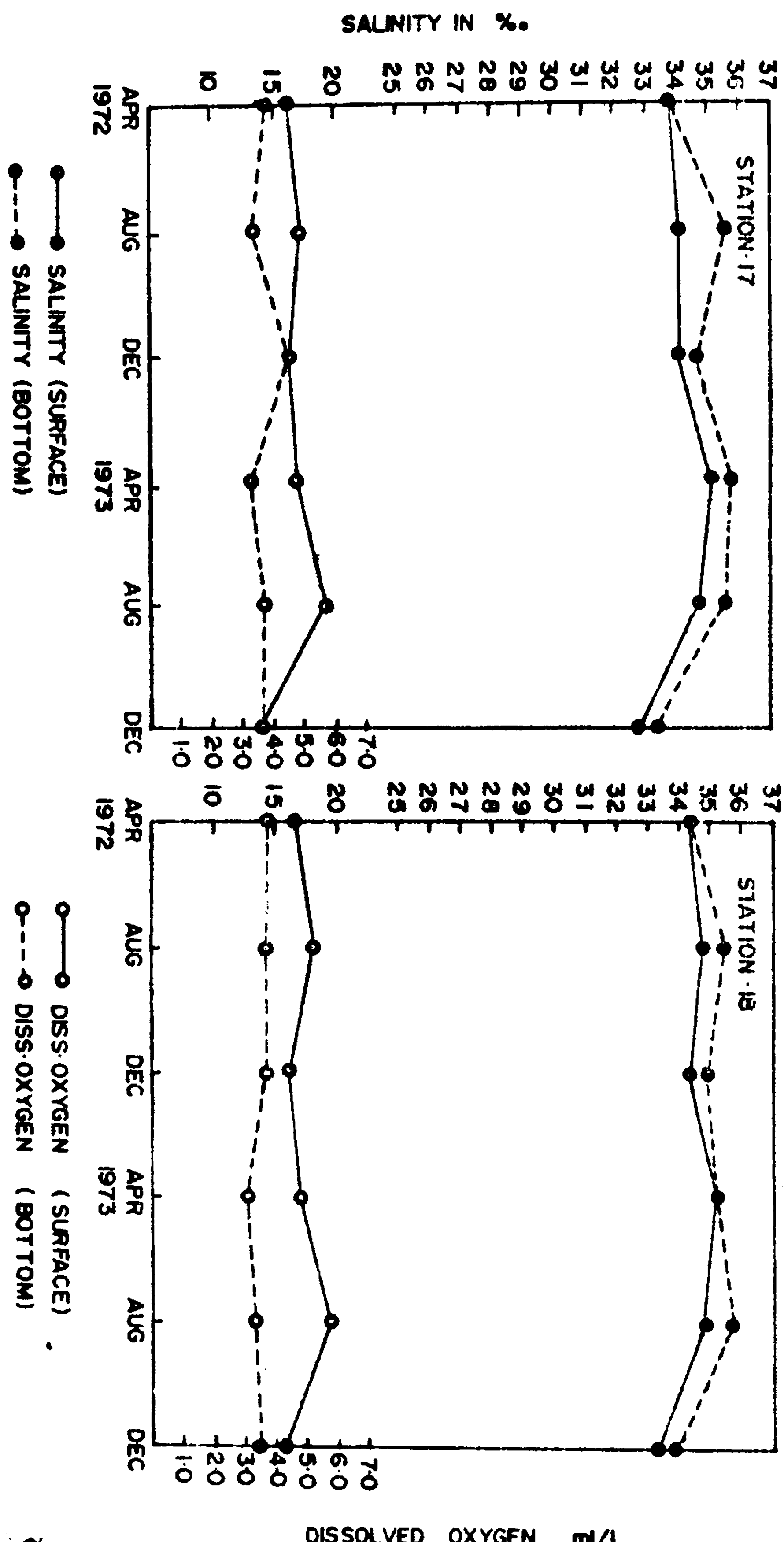

SALINITY IN ‰
STATION-17
STATION-18
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS-OXYGEN (SURFACE)
DISS-OXYGEN (BOTTOM)
DISSOLVED OXYGEN ml/L

FIG. 18

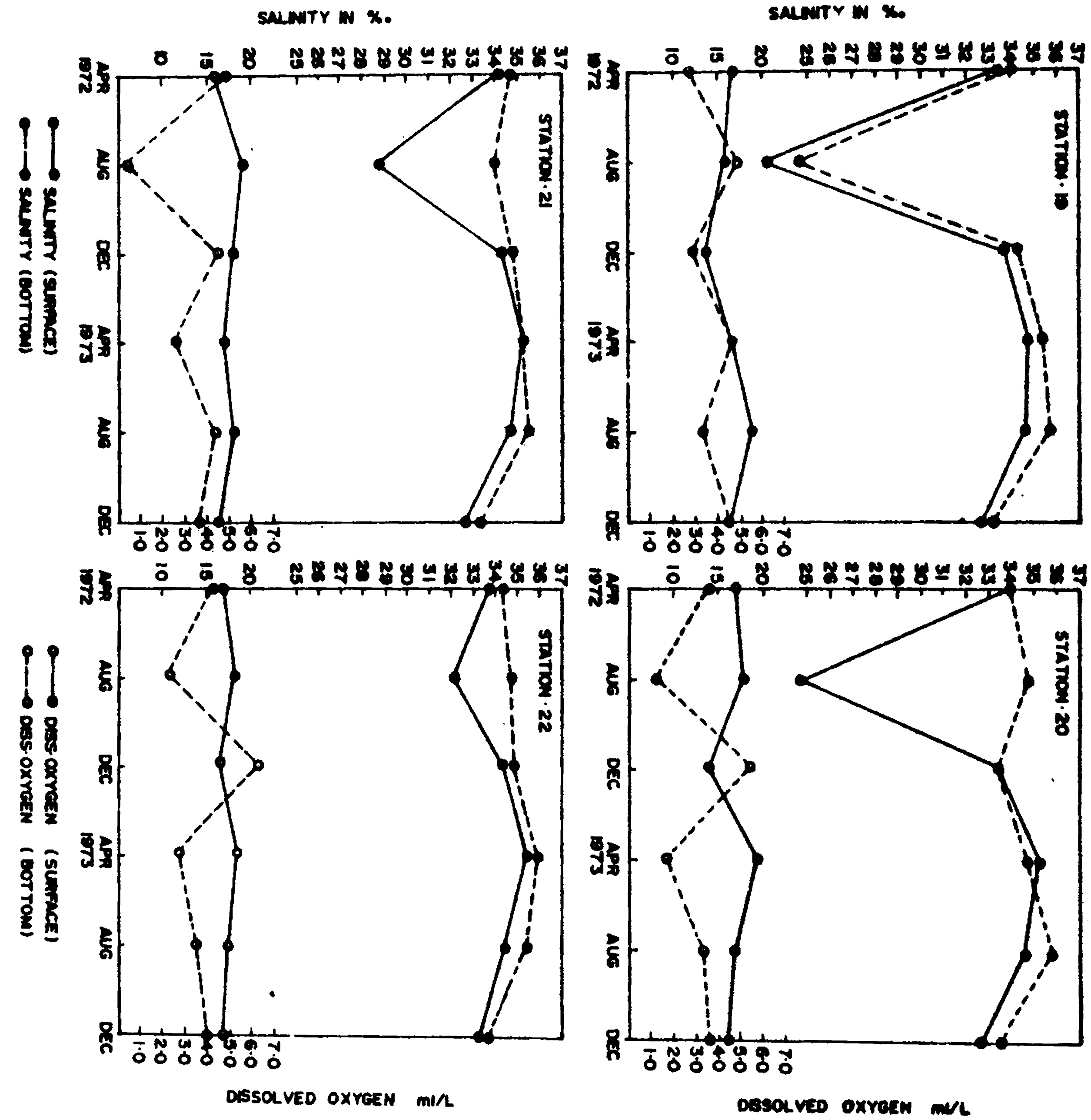
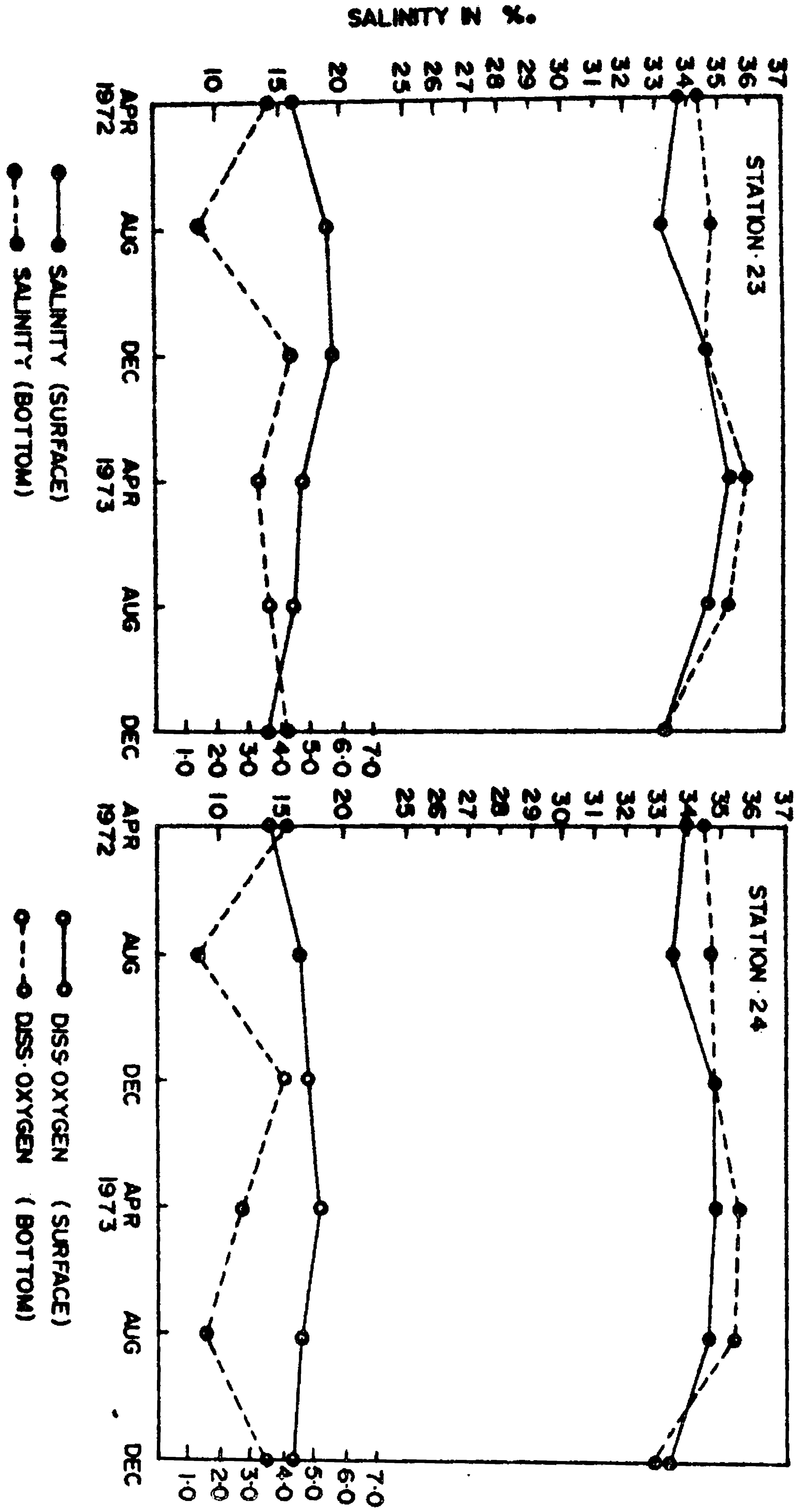
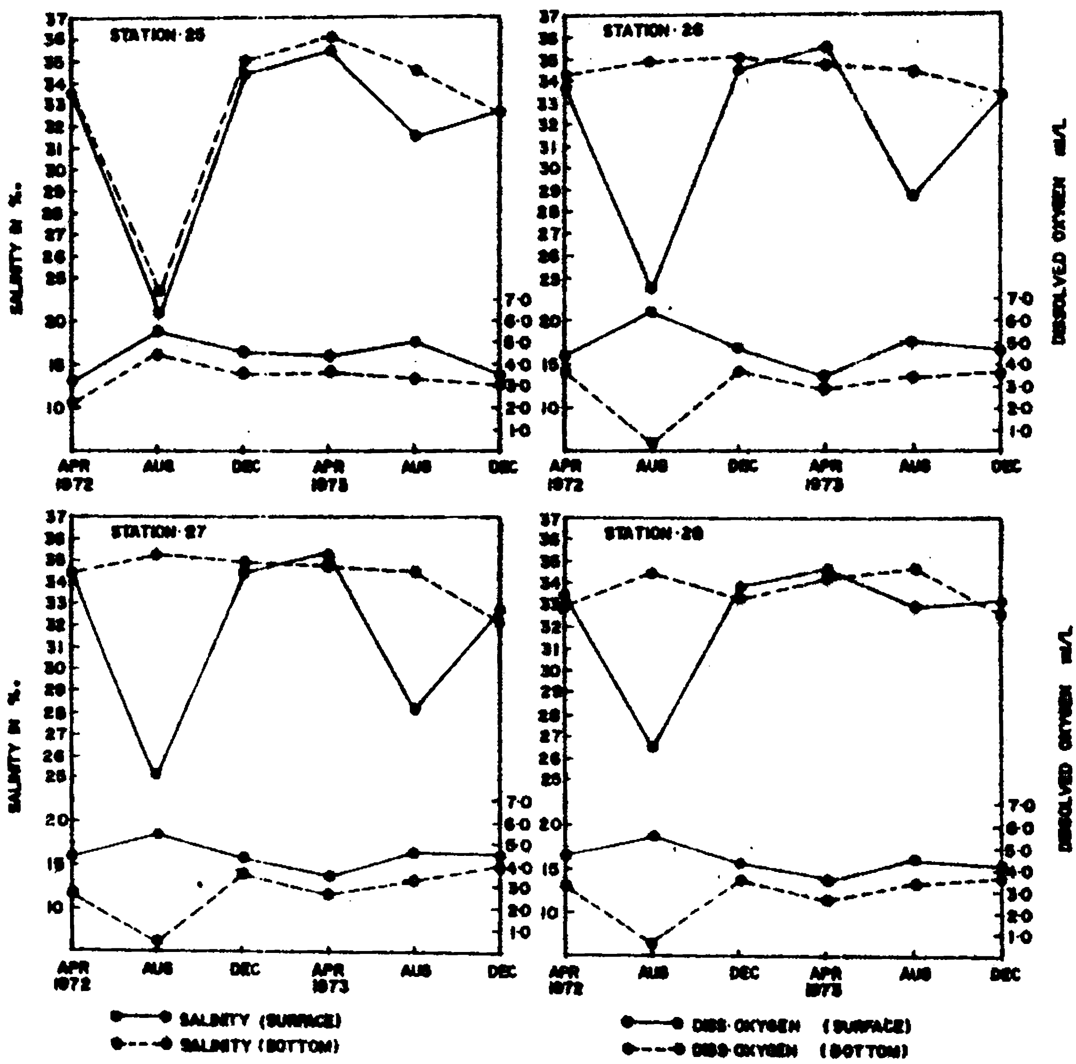

SALINITY IN ‰
STATION 19
STATION 20
STATION 21
STATION 22
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS-OXYGEN (SURFACE)
DISS-OXYGEN (BOTTOM)
DISSOLVED OXYGEN ml/L

FIG. 19.



SALINITY IN ‰
STATION 23
STATION 24
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS·OXYGEN (SURFACE)
DISS·OXYGEN (BOTTOM)
DISSOLVED OXYGEN ml/L

FIG. 20.



STATION 25
STATION 26
STATION 27
STATION 28
SALINITY IN ‰
DISSOLVED OXYGEN ml/L
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS. OXYGEN (SURFACE)
DISS. OXYGEN (BOTTOM)

FIG. 21.

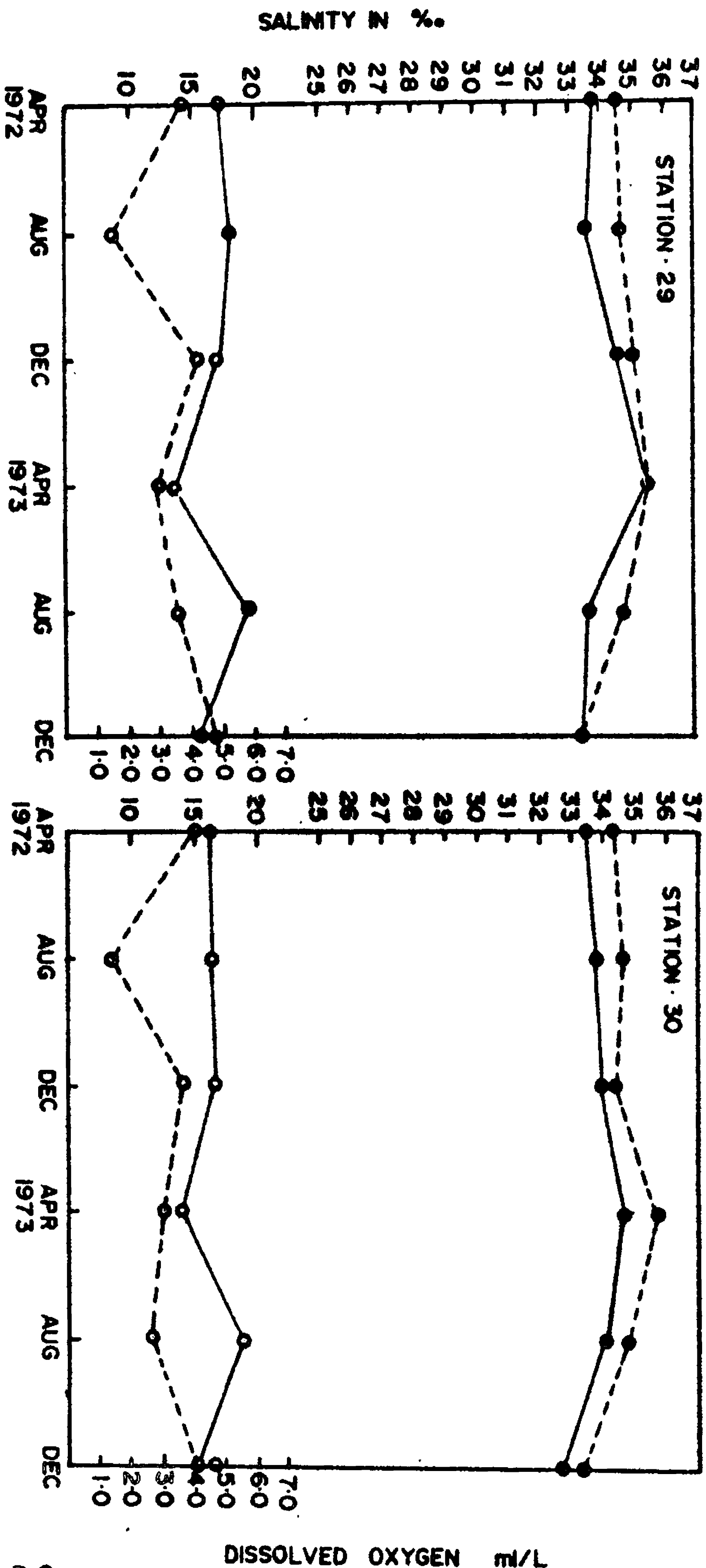

SALINITY IN ‰
STATION · 29
STATION · 30
APR 1972
AUG
DEC
APR 1973
AUG
DEC
SALINITY (SURFACE)
SALINITY (BOTTOM)
DISS·OXYGEN (SURFACE)
DISS·OXYGEN (BOTTOM)
DISSOLVED OXYGEN ml/L

FIG. 22.

5.644 ml/l to a minimum of 3.350 ml/l. In December 1972 a maximum bottom value of 6.451 ml/l was observed in station 22. The oxygen values in the surface and bottom showed more or less the same trend in the corresponding month in the succeeding year. In April, the surface and bottom values showed more or less the same trend except in station 19 and 27 where the bottom value touched a very low level of 2.923 ml/l and in station 25 where the surface value was 2.630 ml/l. The values in the corresponding month of the succeeding year showed the same trend except in station 20 and 28 where the bottom value was less than 1.12 ml/l and 2.968 ml/l respectively.

In August the surface value of the oxygen was observed to vary within a range of maximum 6.450 ml/l to a minimum of 4.16 ml/l except a very low value of 2.679 ml/l in station 7. The bottom value showed invariably less values in almost all the stations except in some of the near shore stations. The bottom value of oxygen touched a very low level of 1.20 ml/l in some of the deeper stations.

The hydrographic conditions along the west coast of India undergo considerable changes with season. The distribution of temperature and oxygen during July and August reveals that the intensity of the upwelling phenomenon is maximum around 11° and 13°N latitudes (i.e. off Calicut and off Mangalore). The upwelling with the accompanying hydrographical changes extends to the remaining part of the southwest coast of India with lesser intensity in the region south of Quilon by September. The low value of bottom oxygen during August can be attributed to this factor. During November the effect of southwest monsoon appears to have completely disappeared and by January, a clearly demarcated mixed layer which is mostly isothermal, is observed between 0 and 60 m along the southwest Coast of India (Ramamritham and Rao 1973).

5. SEDIMENT

Marine deposits are sub-divided into two major groups termed pelagic and terrigenous. The pelagic deposits are those found in deeper waters far from shore and may be predominantly either organic (oozes) or inorganic in origin (red clay). The terrigenous deposits are found near shore and generally contain at least some coarse fractions, (Sverdrup et al 1942).

The nature and the composition of the sediment is determined by the interaction of a large number of factors which are classified in three categories as described by Buchanan (1971) They are (1) factors determining source and supply of sedimentary material (ii) factors determining the transportation and (iii) factors determining deposition. The physico-chemical aspects of the sediment and their distribution along the continental shelf of the Arabian sea have been investigated by a number of workers. (Stacklberg 1972, Shepard, 1973, Veerayya 1972, Mattiat et al 1973). The investigations made on the sediments collected from the mud banks have assisted in studying their textural composition and source of origin of Narakkal and Alleppey mud banks (Dora et al 1968, Kurup, 1977).

Many workers have attempted to relate the distribution and abundance of benthic organisms to the characteristics of the sediment and the physical nature of the bottom acting as a limiting factor (Thorson 1957b, 1958, Sanders 1959, Soklova 1959, Savilov 1959, Brett 1963, Mills 1967, Mangum et al 1968, Nichols 1970, Young and Rhoads 1971, Rhoads and Young 1971, Bloom et al 1972, Driscoll 1975, Tenore 1976, Hughes 1979 a,b). As part of the study of the ecology of benthic animals, an examination of the sediment that forms the habitat and food for some of the benthic animals was undertaken. The sediments, collected from the stations have been analysed for grain size composition and organic content.

Table 1

Sand-silt-clay fraction (%) in Sediments at stations 1 to 30 (wt.)

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 1		
5.4.1972	3.527	8.756	87.717	2.15
8.8.1972	4.252	9.023	86.725	2.87
6.12.1972	89.120	5.538	5.342	2.76
8.4.1973	3.501	8.976	87.523	2.30
9.8.1973	14.959	5.804	79.237	2.85
5.12.1973	4.432	9.113	86.455	3.40

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
Station 2				
5.4.1972	72.526	6.020	21.454	3.45
8.8.1972	42.748	6.237	51.015	3.00
6.12.1972	12.036	7.558	80.406	3.47
8.4.1973	5.123	10.312	84.565	3.12
9.8.1973	15.733	9.326	74.941	3.10
5.12.1973	14.123	9.363	76.514	2.37
Station 3				
5.4.1972	8.955	6.641	84.404	1.98
8.8.1972	11.257	8.122	80.621	2.40
6.12.1972	6.606	9.372	84.022	2.33
8.4.1973	8.125	7.154	84.721	2.74
9.8.1973	6.752	9.272	83.976	2.23
5.12.1973	53.745	9.612	36.643	3.20
Station 4				
5.4.1972	3.433	8.711	87.856	3.23
8.8.1972	12.324	10.217	77.459	2.98
6.12.1972	13.038	7.921	79.041	3.12
8.4.1973	5.823	8.547	85.630	2.51
9.8.1973	11.766	9.850	78.384	3.82
5.12.1973	5.760	7.952	86.288	2.76

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 5		
5.4.1972	43.949	6.419	49.632	3.12
8.8.1972	72.366	6.322	21.312	2.89
6.12.1972	8.048	9.516	82.436	2.32
8.4.1973	76.527	6.732	16.741	2.74
9.8.1973	82.233	9.642	8.125	2.80
5.12.1973	85.273	7.283	7.444	2.75
		Station 6		
5.4.1972	64.318	16.566	19.116	3.00
8.8.1972	70.127	7.341	22.532	2.94
6.12.1972	72.222	5.187	22.591	3.11
8.4.1973	93.234	2.532	4.234	2.92
9.8.1973	71.283	6.257	22.460	2.45
5.12.1973	66.428	15.674	17.898	2.87
		Station 7		
5.4.1972	6.763	5.732	87.505	3.12.
8.8.1972	12.832	5.602	81.566	2.12
6.12.1972	14.959	5.804	79.237	3.76
8.4.1973	5.644	7.667	86.689	2.67
9.8.1973	9.344	12.534	78.122	2.82
5.12.1973	9.763	8.823	81.414	2.69

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
Station 8				
5.4.1972	29.202	5.737	65.061	3.02
8.8.1972	5.022	10.223	84.755	3.12
6.12.1972	3.866	10.592	85.542	3.40
8.4.1973	15.433	9.327	75.240	2.74
9.8.1973	14.000	9.911	76.089	2.65
5.12.1973	5.396	8.454	86.150	2.77
Station 9				
5.4.1972	4.125	8.643	87.232	3.56
8.8.1972	25.256	9.868	64.876	3.27
6.12.1972	8.963	6.751	84.286	2.91
8.4.1973	11.163	8.192	80.645	1.54
9.8.1973	8.722	6.643	84.635	1.32
5.12.1973	12.747	8.099	79.154	2.83
Station 10				
5.4.1972	13.139	7.881	78.980	3.32
8.8.1972	3.633	8.722	87.645	3.75
6.12.1972	12.335	10.128	77.537	2.34
8.4.1973	12.432	14.675	72.890	2.34
9.8.1973	3.993	9.766	86.241	2.99
5.12.1973	5.963	7.993	86.044	2.78

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 11		
5.4.1972	43.989	7.532	48.479	2.91
8.8.1972	87.959	6.066	5.975	2.87
6.12.1972	88.179	7.370	4.451	3.12
8.4.1973	72.581	4.723	22.696	2.97
9.8.1973	8.023	10.694	81.283	3.19
5.12.1973	44.853	6.599	48.548	2.16
		Station 12		
5.4.1972	70.300	5.338	24.362	3.10
8.8.1972	69.217	15.533	15.250	3.02
6.12.1972	72.210	8.463	19.327	3.25
8.4.1973	71.799	8.463	19.738	2.82
9.8.1973	82.640	6.144	11.216	2.94
5.12.1973	68.530	7.227	24.243	2.91
		Station 13		
6.4.1972	5.763	7.935	86.302	1.32
9.8.1972	6.722	9.443	83.835	2.01
7.12.1972	4.382	8.817	86.801	2.12
9.4.1973	11.872	8.642	79.486	2.22
10.8.1973	3.732	8.914	87.354	1.78
6.12.1973	12.932	6.904	80.164	1.98

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 14		
6.4.1972	15.221	9.447	75.332	2.31
9.8.1972	41.947	7.127	50.926	1.97
7.12.1972	14.000	9.367	76.633	2.19
9.4.1973	12.874	7.733	79.393	2.09
10.8.1973	14.232	8.794	76.974	2.17
6.12.1973	15.224	8.974	75.802	1.87
		Station 15		
6.4.1972	27.355	7.968	64.677	1.98
9.8.1972	11.847	8.099	80.054	2.03
7.12.1972	30.028	7.023	62.949	2.44
9.4.1973	9.823	3.343	86.834	2.32
10.8.1973	12.923	7.432	79.645	2.30
6.12.1973	13.424	5.250	81.326	2.15
		Station 16		
6.4.1972	5.860	8.701	85.439	2.12
9.8.1972	3.432	8.611	87.957	1.87
7.12.1972	4.276	8.732	86.992	2.21
9.4.1973	12.213	9.128	78.659	1.99
10.8.1973	5.640	5.851	88.509	2.10
6.12.1973	13.037	7.911	79.052	1.96

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 17		
6.4.1972	8.038	9.416	82.546	1.98
9.8.1972	44.949	5.609	49.442	1.78
7.12.1972	5.463	6.832	87.705	3.12
9.4.1973	74.461	4.882	20.657	2.12
10.8.1973	88.451	4.924	6.625	2.32
6.12.1973	88.178	7.471	4.351	2.12
		Station 18		
6.4.1972	89.730	6.077	4.193	2.11
9.8.1972	82.731	9.074	8.195	2.13
7.12.1972	69.482	7.493	23.025	2.12
9.4.1973	70.321	5.438	24.241	2.20
10.8.1973	72.210	8.463	19.327	2.12
6.12.1973	65.318	16.466	18.216	2.23
		Station 19		
6.4.1972	3.844	10.582	85.574	3.21
9.8.1972	12.036	7.548	80.416	3.10
7.12.1972	5.013	10.313	84.674	2.91
9.4.1973	15.221	9.447	75.332	2.85
10.8.1973	11.424	6.367	82.209	2.93
6.12.1973	5.129	10.323	84.548	2.87

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 20		
6.4.1972	30.790	5.847	63.363	2.63
9.8.1972	27.345	7.864	64.791	2.74
7.12.1972	4.850	9.713	85.437	2.54
9.4.1973	8.864	6.661	84.475	2.02
10.8.1973	12.717	7.098	80.185	2.12
6.12.1973	11.747	8.089	80.164	1.98
		Station 21		
6.4.1972	12.224	10.127	77.649	3.40
9.8.1972	5.961	8.811	85.228	3.52
7.12.1972	3.433	8.711	87.856	2.78
9.4.1973	5.273	8.501	86.226	2.12
10.8.1973	13.038	7.821	79.141	2.01
6.12.1973	3.433	8.711	87.856	2.92
		Station 22		
6.4.1972	3.287	8.457	88.256	2.73
9.8.1972	5.293	5.871	88.836	2.58
7.12.1972	5.340	5.951	88.709	2.66
9.4.1973	5.664	8.793	85.543	3.12
10.8.1973	12.246	9.987	77.767	2.98
6.12.1973	13.118	7.712	79.170	3.81

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 23		
6.4.1972	87.527	6.033	6.440	2.87
9.8.1972	88.032	7.293	4.675	2.92
7.12.1972	74.461	4.825	20.714	2.91
9.4.1973	8.048	9.516	82.436	3.00
10.8.1973	82.874	4.183	12.943	2.94
6.12.1973	76.465	4.923	18.612	3.03
		Station 24		
6.4.1972	70.015	7.241	22.744	1.93
9.8.1972	73.320	5.438	21.242	2.43
7.12.1972	72.926	7.185	19.889	2.77
9.4.1973	91.180	3.573	5.247	2.89
10.8.1973	72.222	5.187	22.591	2.86
6.12.1973	69.328	15.568	15.104	2.91
		Station 25		
8.4.1972	3.501	9.724	86.775	3.12
11.8.1972	4.381	8.771	86.848	3.67
10.12.1972	3.609	9.106	87.285	3.34
12.4.1973	9.859	5.803	84.338	4.12
12.8.1973	4.773	9.917	85.310	1.82
11.12.1973	3.709	9.087	87.204	2.89

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 26		
8.4.1972	12.912	7.448	79.640	3.12
11.8.1972	15.191	4.573	80.236	1.98
10.12.1972	5.885	8.813	85.302	2.74
12.4.1973	3.955	9.692	86.353	2.86
12.8.1973	14.121	8.793	77.086	2.85
11.12.1973	28.723	3.257	68.020	2.73
		Station 27		
8.4.1972	92.090	3.651	4.259	3.12
11.8.1972	27.766	7.858	64.376	3.00
10.12.1972	11.172	8.293	80.535	2.86
12.4.1973	6.656	9.371	83.973	2.87
12.8.1973	30.028	7.013	62.959	2.91
11.12.1973	4.852	9.613	85.535	3.43
		Station 28		
8.4.1972	13.028	7.821	79.151	3.05
11.8.1972	5.864	8.701	85.435	3.01
10.12.1972	5.830	7.864	86.306	2.91
12.4.1973	12.283	8.921	78.796	2.65
12.8.1973	5.464	6.134	88.402	2.66
12.12.1973	3.443	8.711	87.846	2.91

Date of sampling	Sand %	Silt %	Clay %	Organic matter (%)
		Station 29		
8.4.1972	75.321	4.825	19.854	2.02
11.8.1972	64.637	6.033	29.330	1.87
10.12.1972	85.273	8.283	6.444	1.97
12.4.1973	54.964	5.409	39.627	1.92
12.8.1973	8.048	9.516	82.436	2.22
11.12.1973	81.169	7.320	11.511	1.91
		Station 30		
8.4.1972	70.290	5.328	24.382	1.98
11.8.1972	64.318	16.466	19.216	1.74
10.12.1972	96.190	3.786	0.024	2.01
12.4.1973	72.221	5.187	22.592	2.22
12.8.1973	67.218	13.564	19.218	2.43
11.12.1973	72.234	8.453	19.313	1.91

5.1. Results and discussion

The sediments hauled up by the grab from each station were subjected to visual observation for colour and felt its consistency by touching with hand. The sediments were found very soft and loose in consistency upto the 10 m line especially in profiles A,B,D and E where the mud banks appeared. The colour of the sediments of the mud bank region varied from brown to dark grey. The sediments of the profile C in the near shore area were comparatively hard to touch and dark grey in colour.

Kurian (1966) has described four zones of bottom deposits in the continental shelf region off the Kerala coast. These are the sandy deposit in the near shore region upto a depth of 3.5 m (Except in the mud bank regions), muddy deposit with small quantities of sand beyond 3.5m depth extending upto 18 m line, sandy zone extending from the 18 m line to a depth of 100 to 120 m, in which the silt clay fraction decreases and that of sand increases gradually, and the hard bottom zone beginning from 100-120 m line and extending upto a 260 m depth where deposits of grey or black and white sand mixed with fine shell fragments and very small percentage of silt are present.

5.1.1. Profile A (Stations 1 to 6)

The sediments at stations 1, 2 and 3 are sandy clay while the station 4 was predominantly clayey. In the deeper stations 5, and 6 the substratum was predominantly of sand with small percentage of silt and clay.

5.1.2. Profile B (Stations 7 to 12)

The sediments at stations 7 to 10 were very fine in nature. However, small seasonal variation in the sand fraction was observed in some of the stations. The percentage of sand recorded a high value in deeper stations 11 and 12 except in station 11 during the month of August where the sand value was as low as 8.023%. Even though these two deeper stations were predominantly sandy, the sediments were composed of good percentage of clay and silt.

5.1.3. Profile C (Stations 13 to 18)

The samples from stations 13 to 16 showed higher percentage of clay. But the sand fractions showed comparatively a higher value than the first four stations of the previous two profiles. The deeper two stations of the profile recorded higher values in sand fractions with some seasonal difference.

5.1.4. Profile D (Stations 19 to 24)

The first four stations of this profile also recorded a higher value of the finer particles with a good percentage of sand with marked seasonal difference. The deeper two stations showed high values of sand particles without much seasonal variations in the composition.

5.1.5. <u>Profile E (Stations 25 to 30)</u>

The distribution of the different particles in the sediments showed more or less the same trend in the near shore and deeper stations.

Table No. 1 gives the weight percentages of sand (> 62μ), Silt (4μ - 62μ) and Clay (<4μ) in the bottom deposits at stations 1-30 during the different periods of observation.

The data of sediment analysis provides a distinct picture of the nature of percentage distribution of the different fractions and the region of investigation can be broadly divided into two zones. (1) Region within 30 m depth (2) Region beyond 30 m to 45 m depth. The stations within 30 m depth showed high values of clay content with good percentage of sand. The amount of sand was always less than 20% in all the stations within this depth. However the stations 1, 2, 3, 8, 15, 20, 27 showed high value of sand fractions in certain months. The maximum percentage value of sand of 89.120, 72.526 and 92.020% were observed in the near shore stations 1, 2 and 27 respectively. These high values were recorded at stations 2 and 27 during April 1972 and station 1 during December 1972. The higher percentage of clay and the absence of coarse fraction as the important characters

Figs. 23 - 27. Sand, silt and clay percentages of the sediments from stations 1 to 30.

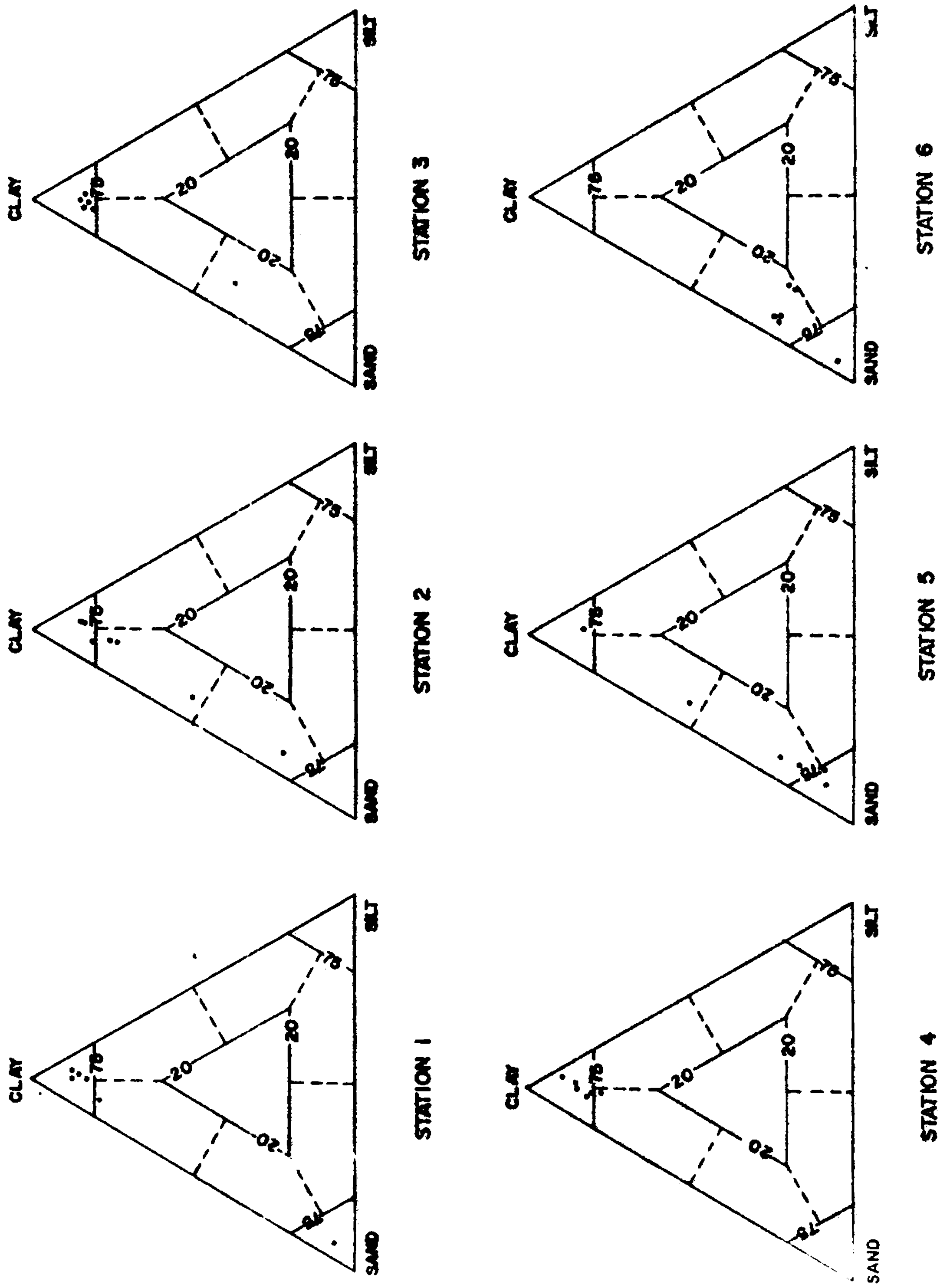

CLAY
SAND
SILT
75
20
STATION 1
STATION 2
STATION 3
STATION 4
STATION 5
STATION 6

FIG. 23.

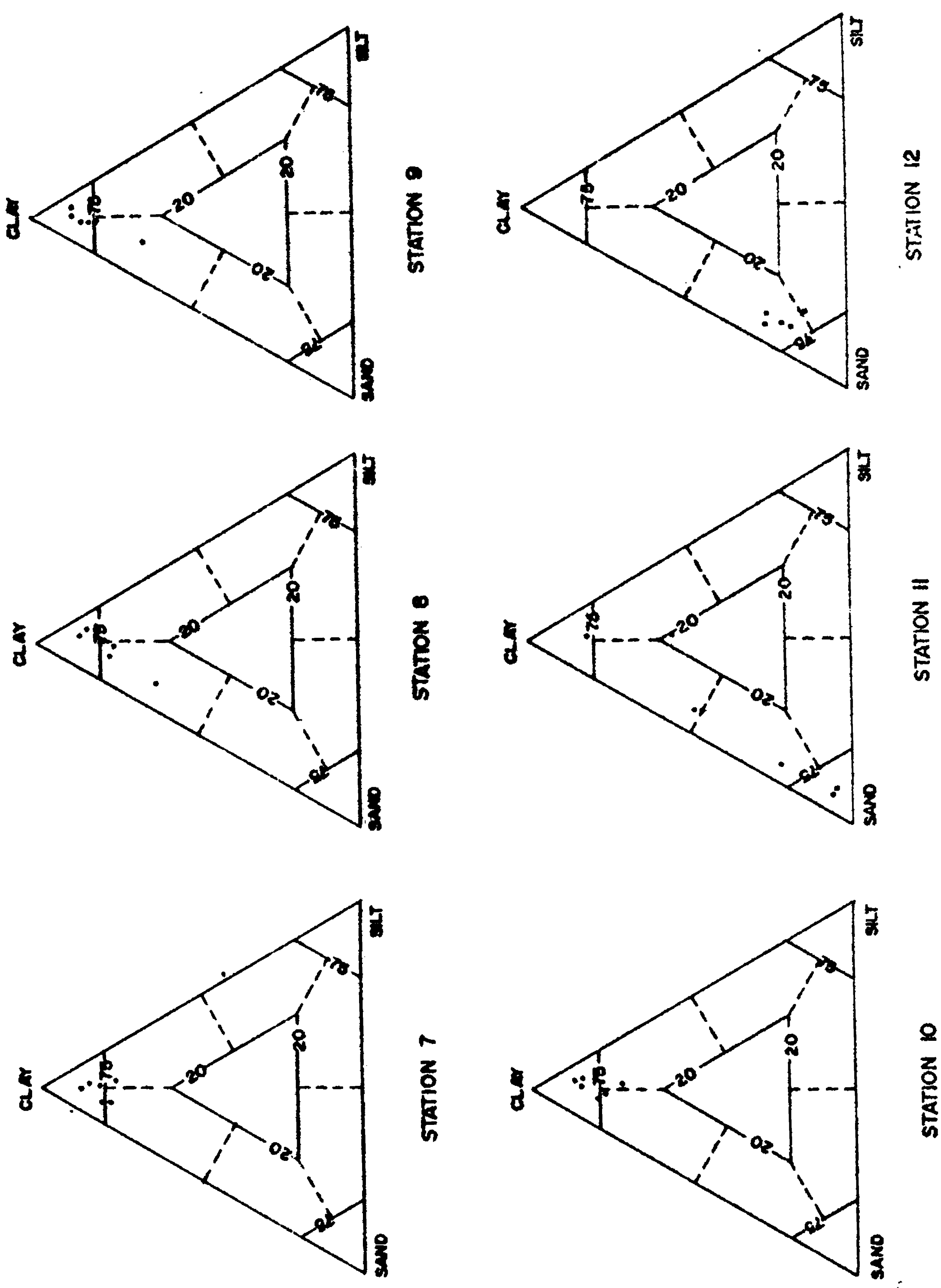

CLAY
SAND
SILT
75
20
STATION 7
STATION 8
STATION 9
STATION 10
STATION 11
STATION 12

FIG. 24.

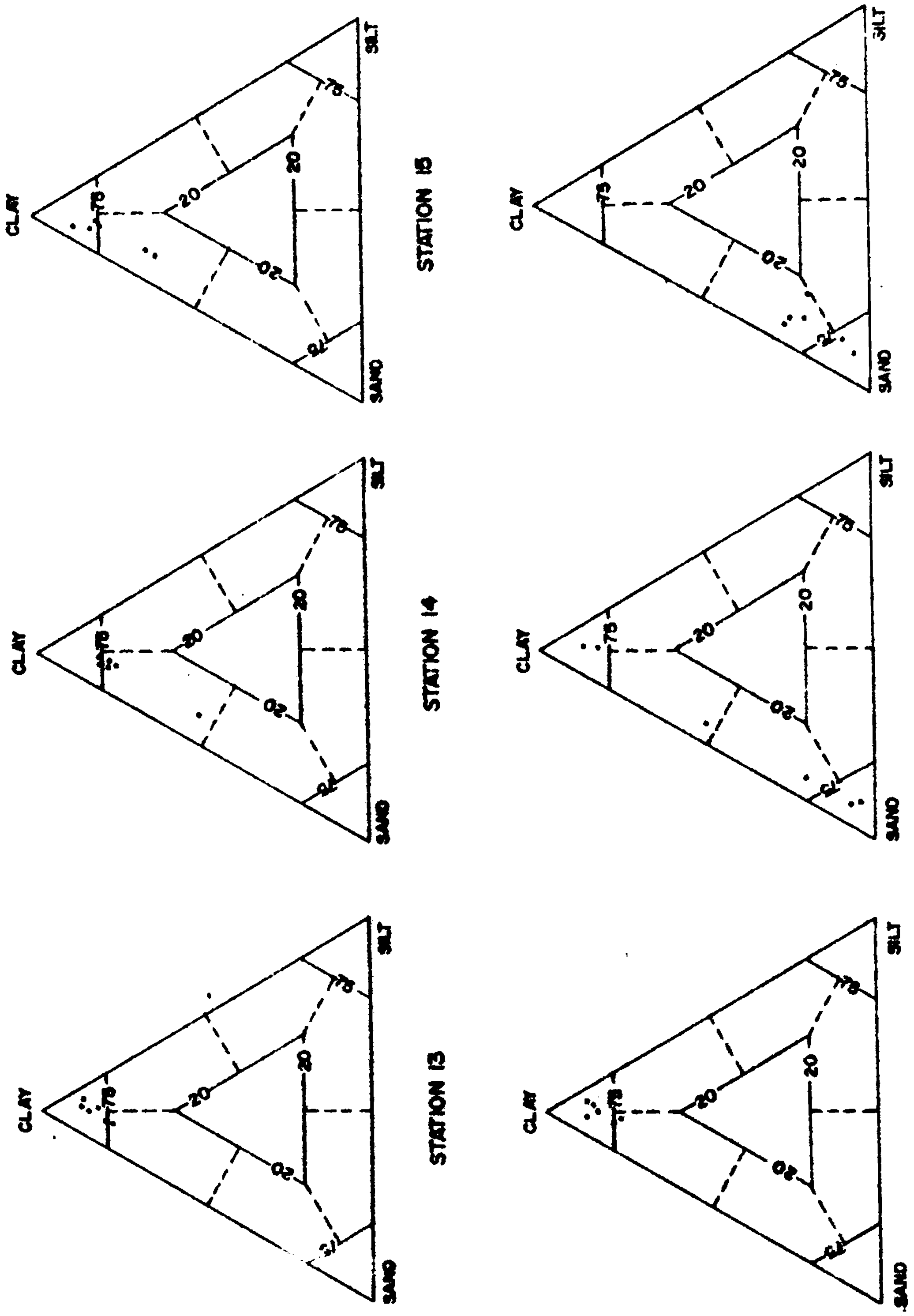

CLAY
SILT
SAND
75
20
STATION 13
STATION 14
STATION 15
STATION 16
STATION 17
STATION 18

FIG. 25.

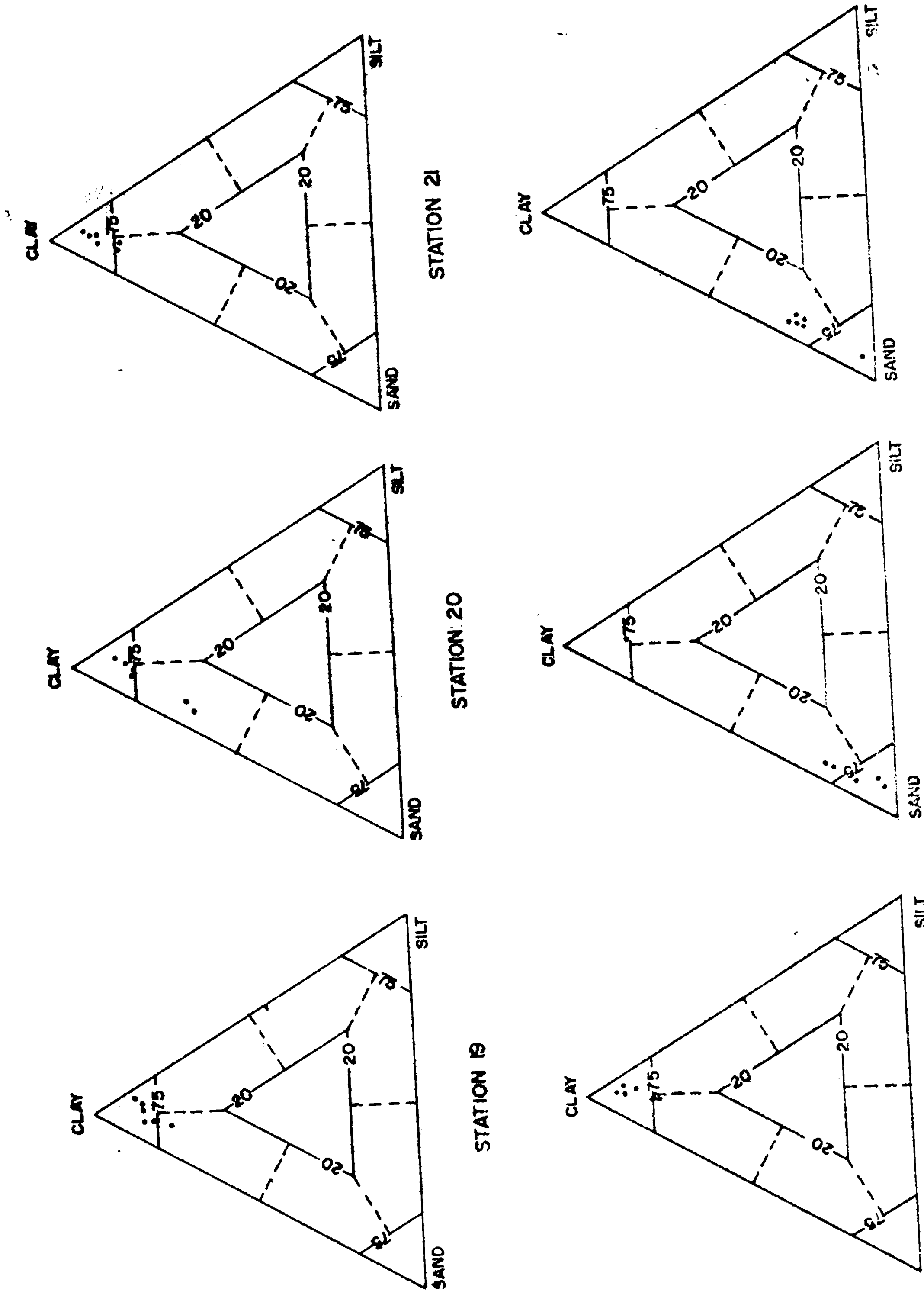

CLAY
SILT
SAND
75
20
STATION 19
STATION 20
STATION 21
STATION 22
STATION 23
STATION 24

FIG. 26.

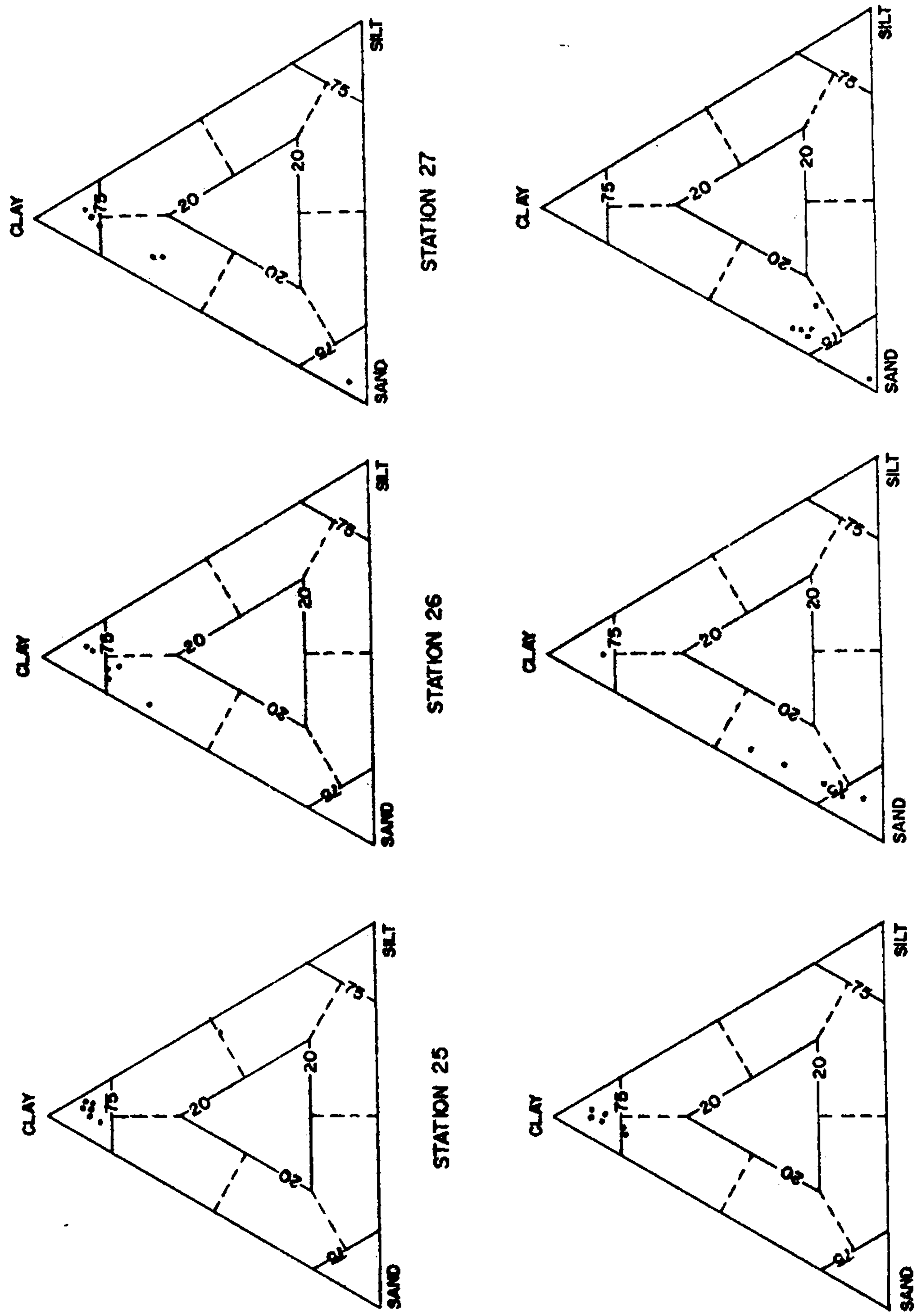

CLAY
SAND
SILT
75
20
STATION 25
STATION 26
STATION 27
STATION 28
STATION 29
STATION 30

FIG. 27.

of the mud bank sediments have been reported by earlier investigators. Dora, et al (1968) and later Kurup (1977) have reported that the mud bank sediments are predominantly clays or silty clays whereas outside the mud banks, the deposits are silty clays or clayey silts and less commonly sand-silt clays or sandy silts. Though the results of the present investigations from the different mud banks support the predominance of clay in the sediments, sand particles are also well represented to the level of silt.

The region extending beyond the 30 m line showed decreasing values in silt-clay fractions and increase of sand particles. The value of sand fraction varied between 43.949% and 96.100% while the stations 5, 11, 17, 23 and 29 showed low values in the range of 5.463% and 8.048%. The silt fractions in the deeper stations showed a minimum value of 2.532% and a maximum value of 16.566% while the minimum and maximum values of clay fraction were 0.023% and 82.436% respectively.

The sediment samples for organic matter estimation were washed through a 0.5 mm sieve to remove the macrobenthos. The sand retained in the sieve and the sediment which passed through the 0.5 mm aperture were dried and washed to remove salts, which are likely to interfere in the determination of organic matter.

In the present study the highest percentage of organic matter was noticed in stations 2, 4, 7, 8, 25 and the lowest in stations 13, 14, 15, 16, 17, 18, 20, 29, and 30. The observation of higher percentage of organic matter in the near shore stations, especially in the mud bank regions supports the view that all clay mineral except kaolin bind organic matter and the area with a high percentage of clay is capable of holding a high content of organic matter (Sanders 1956). The maximum organic matter observed in sediments with maximum clay can be explained by the findings that organic matter is trapped mainly by clays and to a lesser extent by fine silt, coarse silt and sand (Russel 1950). The low organic matter value (1.32 to 2.44) in the near shore stations in profile C marked by the absence of any mud bank formation, may be due to high wave action which does not allow settling of humus as explained by Ganapati and Rao (1962). However high values of organic carbon varying between 0.32% to 6.10% have been reported in the open sea beaches at Calangute (Dwivedi _et al_ 1975).

Damodaran (1973) in his estimation of the organic content percentage in the sediment section has reported no significant difference in the core sample with increasing depth upto 6cm. According to Sanders (1960) the organic matter content in the deeper layers of the sediment "being separated from the source of detritus both in time and space, may be refractory or "fossil" in nature and thus less utilisable as food source". Sanders further concluded that the free small chain sugars found in the upper 2 cm. of the sediment may be serving the purposes of food source for deposit feeders.

6. BOTTOM FAUNA

Many studies on the food habits of demersal group of fishes and prawns have been carried out on the east coast as well as the west coast of India. A wide variety of benthic organisms have been found forming the constituents of food of the bottom fishes and prawns of economic importance. Since mechanisation in Indian fishery started with much emphasis on bottom trawling a precise knowledge of the favourite food components of the different species of demersal groups will be of much assistance in the prediction, location, exploitation and conservation of the fishery resources. Malpas (1926) has reported a general account of the food items encountered in the stomach of fishes trawled from the Wadge bank which was one of the earliest investigation of this nature. Subsequently a number of workers have analysed the food items of bottom fishes and prawns in Indian waters.

In the Bay of Bengal, Rao (1964) has described the food and feeding habits of fishes from trawl catches with diurnal variation, and he has observed wide variations in the food preference of different species of fishes within the same group. Karandikar and Thakur (1951) observed sciaenids as carinivorous feeding on molluscs, annelids, crustaceans and other small fishes. In the Arabian Sea, Venkataraman (1960) noted polychaetes, bivalves and ophiuroids among the stomach contents of the inshore fishes off Calicut on the Malabar Coast. Suseelan and Somasekharan Nair (1969) in their detailed study on the food and feeding habits of the bottom fishes off Bombay have examined the stomach contents of 1038 specimens belonging to seventeen different species and found that most of the fishes are feeding on the benthic invertebrates. Seshappa and Bhimachar (1955) in their investigation on the fishery and biology of the Malabar sole Cynoglossus semifasciatus have found the fish essentially a bottom feeder, polychates being the dominant components of their food during the months following south-west monsoon. It is further noted that the amphipods and lamellibranchs became important in the gut contents whenever polychaetes were poorly represented. Rao (1967) has observed lamellibranches, crustacean remains especially appendages of amphipods besides the organic detritus in the gut contents of prawns belonging to the species of Penaeus indicus and P. monodon. Mohammed (1955), Kagwade (1965), Kuthalingam (1963 a,b), Kuthalingam and Chellam (1970), and Rangarajan (1970) have made investigations on the fishery and food items of different bottom fishes.

The extensive studies made by different research workers on the food components of fishes are based on the material collected from the trawl net or gill net catches from fishing boats without referring to areas in which the gears have been operated. The significance of recording the depth of operation, time of operation, distance covered and conditions of the bottom of the sea when the food of fishes are analysed are important to derive a clear nutritional picture of the environment from which material has been obtained (Qasim, 1972). The present work is an attempt towards delienating a picture of the benthic faunal distribution in different depths of one of the most important fishing grounds of southwest coast of India with special reference to the macrofauna which has been observed in the stomach content analysis of bottom fishes by the earlier studies.

6.1. Species composition

The important benthic faunal groups belonged to the main animal groups of Annelida, Crustacea and Mollusca followed by a few species of Coelenterata, Nemertinea, Echinodermata and Echiuroidea. Polychaeta, Crustacea and Mollusca were present in all the thirty stations with fluctuations in their intensity of distribution. The less important groupswere either sparsely found or totally absent in some of the stations and they were included under "other groups".

6.1.1. Annelida

The most dominant species were represented by polychaetes *Amphicteis gunneri*, *Sternaspis scutata*, *Lepidonotus jacksoni*, *Lumbriconereis biflaris*, *Glycera longipinnis*, *Eunice indica*, Magelona longicornis and Disoma sp. Eventhough A. gunneri and M. longicornis were absent in some of the stations, these annelids were recorded from all the profiles. Prionospia pinnata described as a good source of food for the Malabar sole C. semifasciatus by Seshappa (1953), has been observed in near shore stations 1, 3, 7, 11 and 25 with the exception of the deep water station 14. The presence of the next dominant species L. biflaris was rather erratic though it was observed in appreciable numbers in deeper stations 5, 11, 22 and 28. The two species Euphrosyne sp. and Eunice indica were observed only in very few stations. The former was recorded from stations 12, 15, 20, and 29 while the latter was present in stations 12, 16, and 24. Lepidonotus jacksoni was noticed only in station 17. Sternaspis scutata, another common species of polychaete was noticed in stations 1, 2, 7, 8, 9, 13, 16, 19, 21, 25 and 28.

6.1.2. Crustacea

The crustacean fauna observed in the samples was contributed significantly by the amphipod species Ampelisca scabripes, A. tridens, A. brevicornis, A. cyclops, Byblis gaimardi and Idunella sp. Although the crustaceans formed the next important group, their number and weight were far less compared to polychaetes. A. scabripes and A. tridens were present in most of the stations of all the five profiles. A. brevicornis and

A. cyclops were noticed absent in three profiles. While A. brevicornis was absent in the fourth profile, the latter was totally absent in all the stations of the 1st and 2nd profiles. B. gaimardi and Idunella sp. were observed in all the profiles but in deeper stations only. The decapod group was supported by two species belonging to Charybdis sp. and young ones of the prawn Parapenaeopsis stylifera. The other groups of crustaceans were represented by one species of Stomatopoda, two species of Cumacea, one species of Isopoda, and one species of Mysidacea.

6.1.3. Mollusca

The Mollusca fauna included species belonging to the two groups Gastropoda and Lamellibranchiata. There were altogether three species of gastropods and seven species of bivalves. The most dominant species was the bivalve Nucula sp. which was present in sufficiently large numbers in stations 21, 27 and 28. As observed by Damodaran (1973) all the Nucula sp. collected were juveniles with soft shells measuring between 1 and 1.5 mm except in station 2 where a large specimen was recorded measuring about 3.5 mm. The other bivalves collected which included species namely Tellina emarginata, Chione tiara, Arca inaequivalvis, A. tortuosa, Barnea sp. Macoma sp. Modiolus sp. and Solariella sp. were very less in number. Of these eventhough A. inaequivalvis was present in all the profiles it was not recorded in stations

2, 4, 5, 8, 9, 10, 12, 15, 16, 19, 20, 27, 28 and 29. A. tortuosa was noticed only in profiles 1 and 2 while T. emarginata was recorded in most of the stations of all the profiles. Chione tiara was noticed only in one or two stations in profiles A to D and totally absent from all the stations in Profile E. The tender shelled Barnea sp. was available from all the profiles but they were mostly confined to shallower stations. The Solariella sp. was meagerly represented in all the profiles except the first profile, while Modiolus sp. and Macoma sp. were still rare in majority of the stations. The contribution of gastropod fauna to the Molluscan group was insignificant, in as much as they were represented by only Conus sp. and Nassarius sp. The former was observed in stations 2 and 24 while the latter was recorded only in station 27. The dead shells of Turitella attenuata and Dentalium sp. were collected in large numbers from the near shore stations of profiles D and E.

6.2. "Other groups" of animals

6.2.1. Coelenterata

During the period of investigation anthozoan belonging to the species Cavernularia sp. was recorded from stations 3, 11, 21 and 29. Animals of this group were not present in any of the stations of profile C.

6.2.2. Nemertinea

Species belonging to the group Nemertini were recorded in all the profiles. Identification of the nemertines proved difficult because the body fragmented into pieces during collection.

6.2.3. Echinodermata

Two species of echinoderm were collected from stations 4, 11 and 17. These species were collected from deep water stations.

6.2.4. Echiuroidea

Ochaetostoma septemyotum was the single species representing this group which was recorded from stations 2, 8 and 11. As suggested by Lie(1969) the wet weight of the ~~other~~ animals included in the "other groups" was not converted into dry weight, because this group of animals played an insignificant role in the total standing crop except in few stations. At the stations, where the "other group" of animals was of any importance, the major part of the weight was contributed by species belonging to the Anthozoa and Echiuroidea. Sanders (1956) found that bigger animals are often long lived and slow growing and their contribution to the turnover of organic matter may be out of proportion to their standing crop.

Table 2

Station 1

Number of animals in m^2 during the period from 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri Sars	10	20	60	-	20	80	190
Cossura sp.	30	-	-	-	40	-	70
Diopatra neapolitana (delle Chiaje)	-	-	10	-	-	-	10
Glycera longipinnis (Grube)	-	-	-	10	-	-	10
Lumbrinereis sp.	-	-	10	90	-	70	170
Magelona longicornis (Johnson)	20	-	-	10	-	-	30
Prionospio pinnata (Ehlers)	-	-	130	-	80	110	320
Sternaspis scutata (Renier)	-	-	-	10	-	-	10
Unidentified polychaets	10	-	-	-	20	-	30
CRUSTACEA							
Ampelisca scabripes (Walker)	-	10	-	-	-	10	20
Ampelisca tridens (Walker)	-	-	10	-	-	-	10
Eocuma sp.	-	10	-	-	10	-	20
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	-	10	-	-	-	-	10
Barnea sp.	10	10	-	-	-	-	20
Tellina emarginata (Sowerby)	20	-	-	-	-	-	20
OTHER GROUPS							
Nemertines	10	-	10	-	-	-	20
Total	110	60	230	120	170	270	960

Table 3

Station 2

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	-	10	-	-	-	-	10
Cossura sp.	10	-	-	-	-	-	10
Diopatra neapolitana (delle Chiaje)	-	-	-	-	-	-	0
Glycera longipinnis (Grube)	10	-	-	-	-	-	10
Lumbrinereis sp.	80	-	30	20	-	80	210
Magelona longicornis (Johnson)	-	-	-	520	-	50	570
Sternaspis scutata (Renier)	-	-	10	40	-	-	50
Unidentified polychaets	20	-	20	20	40	10	110
CRUSTACEA							
Ampelisca scabripes (Walker)	-	-	-	-	-	20	20
Ampelisca brevicornis (Costa)	-	-	-	-	10	20	30
Charybdis sp.	-	-	-	-	-	20	20
MOLLUSCA							
Barnea sp.	-	-	-	-	10	-	10
Conus sp.	-	10	-	-	-	-	10
Macoma sp.	-	-	-	-	10	-	10
Nucula sp.	-	80	-	-	-	10	90
OTHER GROUPS							
Nemertines	-	-	10	-	-	-	10
Ochaetostoma septemyotum Dutta Gupta, Menon & Johnson	-	-	-	10	-	590	600
Total	120	100	70	610	70	800	1770

Table 4

Station 3

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
COELENTERATA							
Cavernularia sp.	-	10	-	-	-	-	10
POLYCHAETA							
Disoma sp.	70	-	20	-	40	-	130
Glycera sp.	20	90	-	50	40	-	200
Lumbriconereis biflaris (Ehlers)	40	30	-	-	-	-	70
Nephtys sp.	-	-	20	10	-	-	30
Nereis sp.	10	-	-	10	-	-	20
Ninoe sp.	-	70	-	40	-	-	110
Prionospio pinnata (Ehlers)	-	40	10	-	-	-	50
CRUSTACEA							
Ampelisca cyclops (Walker)	-	10	-	-	-	-	10
Ampelisca scabripes (Walker)	-	10	10	20	10	-	50
Squilla nepa Latreille (Bigelow)	10	-	10	-	-	-	20
MOLLUSCA							
Arca inaequivvalvis (Bruguiere)	-	-	-	10	-	-	10
Barnea sp.	-	10	-	-	10	-	20
Modiolus sp.	10	-	-	-	-	-	10
Nucula sp.	-	20	-	50	20	10	100
Tellina emarginata (Sowerby)	-	-	-	-	10	20	30
Total	160	290	70	190	130	30	870

Table 5

Station 4

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Disoma sp.	-	20	40	-	-	-	60
Diopatra neapolitana (delle Chiaje)	10	-	-	20	-	-	30
Glycera sp.	60	10	20	30	10	20	150
Euclymene sp.	-	-	30	70	-	-	100
Lumbrenereis sp.	-	-	-	-	-	270	270
Lumbriconereis sp.	-	20	-	40	30	-	90
Nephtys sp.	-	10	10	10	10	140	180
Nereis sp.	-	10	10	-	10	-	30
CRUSTACEA							
Ampelisca tridens (Walker)	60	-	-	10	-	30	100
Ampelisca sp.	-	10	20	10	10	30	80
Idunella sp.	20	-	10	-	-	40	70
Charybdis sp.	-	-	-	-	-	10	10
MOLLUSCA							
Arca sp.	-	-	-	10	-	20	30
Tellina sp.	-	-	-	10	-	-	10
Nucula sp.	40	-	-	-	-	-	40
OTHER GROUPS							
Nemertines	-	-	-	-	-	10	10
Ophiuroids	-	-	-	-	-	20	20
Total	190	80	140	210	70	590	1280

Table 6

Station 5

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	-	-	50	-	80	-	130
Euphrosyne sp.	70	-	-	-	10	50	130
Lumbriconereis biflaris (Ehlers)	-	20	410	-	20	290	740
Ninoe sp.	10	-	20	270	70	-	370
Nereis sp.	10	20	-	90	50	10	180
Paraheteromastus sp.	-	-	-	120	40	-	160
Magelona longicornis (Johnson)	50	90	-	-	-	-	140
CRUSTACEA							
Ampelisca brevicornis (Costa)	30	-	-	10	50	70	160
Ampelisca tridens (Walker)	60	-	-	90	110	90	350
Byblis gaimardi (Kroyer)	-	20	-	20	-	50	90
Lucifer sp.	-	10	10	40	-	-	60
Charybdis sp.	10	-	-	10	-	-	20
Prawns larvae	30	-	-	-	20	-	50
MOLLUSCA							
Arca sp.	10	10	-	80	10	20	130
OTHER GROUPS							
Nemertines	10	-	-	-	-	10	20
Total	290	170	490	730	460	590	2730

Table 7

Station 6

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Glycera longipinnis (Grube)	130	-	-	-	-	-	130
Glycera sp.	50	70	300	180	60	-	660
Magelona sp.	40	110	20	190	40	-	400
Nereis sp.	30	20	60	40	20	20	190
Paraheteromastus sp.	-	10	-	-	-	-	10
Unidentified polychaetes	10	40	20	40	110	-	220
CRUSTACEA							
Ampelisca tridens (Walker)	-	-	-	70	10	-	80
Ampelisca brevicornis (Costa)	-	-	-	40	-	-	40
Ampelisca sp.	10	20	-	10	40	-	80
Byblis gaimardi (Kroyer)	40	10	-	-	-	-	50
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	20	-	-	-	-	-	20
Chione tiara (Dillwyn)	-	-	10	-	-	-	10
Modiolus sp.	-	10	-	20	-	-	30
Unidentified gastropods	10	10	-	-	20	-	40
Total	340	300	410	590	300	20	1960

Table 8

Station 7

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	-	-	-	-	-	50	50
Cossura sp.	-	-	-	-	-	10	10
Diopatra neapolitana (delle Chiaje)	50	10	-	30	20	-	110
Glycera longipinnis (Grube)	-	-	-	-	10	-	10
Lumbriconereis sp.	40	-	-	-	-	-	40
Magelona longicornis (Johnson)	-	-	20	-	-	10	30
Prionospio pinnata (Ehler)	-	10	-	-	-	-	10
Paraheteromastus sp.	-	-	30	20	-	-	50
Sternaspis scutata (Renier)	110	-	-	180	20	-	310
CRUSTACEA							
Ampelisca scabripes (Walker)	10	-	-	-	-	-	10
Ampelisca tridens (Walker)	-	-	-	-	-	10	10
Ampelisca sp.	20	40	-	-	-	10	70
Eocuma sp.	-	-	10	-	-	-	10
Lucifer sp.	10	-	-	-	10	-	20
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	-	20	-	-	-	-	20
Barnea sp.	-	10	5310	-	-	-	5320
Tellina emarginata (Sowerby)	10	-	-	-	-	-	10

Cont.......2

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
Solariella sp.	-	-	10	-	-	10	20
Unidentified bivalves	10	-	-	-	-	-	10
OTHER GROUPS							
Nemertines	-	-	-	10	-	-	10
Total	260	90	5380	240	60	100	6130

Table 9

Station 8

Number of animals in m^2 during the period from 1972 - '73

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Cossura sp.	50	-	-	-	-	-	50
Disoma sp.	70	40	10	410	-	-	530
Glycera longipinnis (Grube)	-	-	-	10	-	10	20
Magelona longicornis (Johnson)	10	10	-	-	-	-	20
Ninoe sp.	20	-	-	-	-	20	40
Nephtys sp.	20	-	10	10	-	50	90
Sternaspis scutata (Renier)	-	-	20	40	-	10	70
CRUSTACEA							
Ampelisca brevicornis (Costa)	10	-	-	-	20	-	30
Ampelisca sp.	10	-	-	-	20	-	30
Charybdis sp.	40	-	-	30	-	10	80
Lucifer sp.	20	-	-	-	10	-	30
Mysidacea	-	-	-	10	-	-	10
MOLLUSCA							
Arca sp.	10	-	-	-	-	-	10
Nucula sp.	-	10	-	-	-	-	10
Tellina emarginata (Sowerby)	-	-	-	10	-	-	10
Barnea sp.	-	10	-	-	-	-	10

Cont....2

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
OTHER GROUPS							
Nemertines	-	-	-	10	-	-	10
Ochaetostoma septemyotum Dutta Gupta, Menon & Johnson	-	-	20	70	-	430	520
Total	260	70	60	600	50	530	1570

Table 10

Station 9

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Disoma sp.	-	10	-	120	10	-	140
Glycera sp.	10	30	10	10	10	20	90
Lubriconereis biflaris (Ehlers)	10	-	60	-	10	-	80
Nereis sp.	-	-	10	20	-	-	30
Ninoe sp.	-	10	60	-	-	-	70
Sternaspis scutata (Renier)	-	-	30	10	-	-	40
CRUSTACEA							
Ampelisca tridens (Walker)	10	-	10	-	-	-	20
Lucifer sp.	-	10	-	-	-	10	20
Alpheus sp.	-	-	-	10	-	-	10
Unidentified Isopod	10	10	10	-	10	-	40
MOLLUSCA							
Barnea sp.	10	-	-	-	-	-	10
Solariella sp.	-	-	-	30	-	10	40
Unidentified bivalves	-	30	-	-	-	10	40
Total	50	100	190	200	40	50	630

Table 11

Station 10

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Disoma sp.	-	-	10	90	60	-	160
Diopatra neapolitana (delle chiaje)	-	10	20	30	10	-	70
Euclymene sp.	20	-	-	10	-	20	50
Lubriconereis biflaris (Ehlers)	30	40	-	-	-	50	120
Magelona longicornis (Johnson)	10	-	430	-	-	10	450
Nephtys sp.	-	10	-	20	-	60	90
Ninoe sp.	10	-	10	-	30	-	50
Nereis sp.	10	10	-	-	10	40	70
Panaheteromastus sp.	-	-	-	10	50	10	70
CRUSTACEA							
Ampelisca tridens (Walker)	10	-	-	-	-	-	10
Ampelisca sp.	10	10	70	10	30	40	170
Idunella sp.	20	10	-	10	-	-	40
Lucifer sp.	-	-	-	20	-	70	90
Prawn larvae	-	-	-	-	-	10	10
MOLLUSCA							
Tellina emarginata (Sowerby)	-	-	-	-	10	70	80
Arca sp.	20	-	-	-	-	10	30
Chione sp.	-	-	10	-	-	10	20

Cont...2

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
<u>OTHER GROUPS</u>							
Ophiuroids	-	-	10	-	-	-	10
Total	140	90	560	200	200	400	1590

Table 12

Station 11

Number of animals in m^2 during the period from 1972 - '73

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
COELENTERATA							
Cavernularia sp.	-	-	20	-	-	-	20
POLYCHAETA							
Amphicteis gunneri (Sars)	30	-	-	-	-	-	30
Euclymene sp.	-	-	60	80	60	-	200
Disoma sp.	-	-	30	30	-	-	60
Lubriconereis biflaris (Ehlers)	-	-	250	-	-	-	250
Magelona longicornis (Johnson)	-	-	30	-	90	-	120
Nephtys sp.	30	50	-	-	-	140	220
Mesochaetopterus sp.	-	-	100	-	10	-	110
Nereis sp.	10	-	10	-	20	60	100
Prionospio sp.	-	-	1400	-	-	-	1400
Paraheteromastus sp.	-	-	50	-	-	-	50
CRUSTACEA							
Ampelisca sp.	50	20	10	180	20	-	280
Byblis gaimardi (Kroyer)	30	-	-	30	-	-	60
Idunella sp.	10	10	-	10	-	40	70
Charybdis sp.	10	-	-	-	-	10	20
Lucifer sp.	-	20	-	-	-	70	90
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	-	-	-	10	-	-	10

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
Arca tortuosa (Linnaeus)	-	-	-	-	-	10	10
Nucula sp.	-	-	10	-	-	-	10
Tellina sp.	10	-	-	-	30	20	60
Nemertines	-	-	-	20	-	-	20
OTHER GROUPS							
Oechaetostoma septemyotum Dutta Gupta, Menon & Johnson	-	-	-	-	-	100	100
Total	180	100	1970	360	230	450	3290

Table 13

Station 12

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	-	-	80	140	-	-	220
Eunice indica (Kinberg)	-	10	-	10	-	-	20
Euphrosyne sp.	-	20	-	-	-	-	20
Glycera sp.	90	140	20	30	180	-	460
Magelona longicornis (Johnson)	40	-	20	-	70	430	560
Mesochaetopterus sp.	-	-	-	40	20	320	380
Nephtys sp.	20	10	-	20	-	-	50
Nereis sp.	60	10	30	10	10	20	140
Paraheteromastus sp.	60	-	50	-	-	-	110
CRUSTACEA							
Ampelisca scabripes (Walker)	50	-	10	-	-	-	60
Ampelisca brevicornis (Costa)	-	-	10	-	-	70	80
Byblis gaimardi (Kroyer)	-	10	20	-	50	-	80
Idunella sp.	-	-	10	40	10	-	60
Charybdis sp.	10	-	10	-	-	-	20
MOLLUSCA							
Arca sp.	-	10	-	-	-	-	10
Macoma sp.	-	10	20	-	-	-	30
Modiolus sp.	-	-	-	20	10	-	30

Cont...2

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
Unidentified bivalves	20	-	-	-	-	40	60
Unidentified gastropods	-	-	-	10	30	-	40
<u>OTHER GROUPS</u>							
Unidentified ophiuroid	-	-	10	-	-	-	10
Total	350	220	290	320	380	880	2440

Table 14

Station 13

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	-	-	1620	-	-	50	1670
Glycera sp.	-	40	200	-	110	20	370
Disoma sp.	40	-	20	10	-	30	100
Lumbriconereis biflaris (Ehlers)	-	-	-	-	-	20	20
Nereis sp.	10	-	-	-	-	10	20
Prionospio pinnata (Ehlers)	-	-	-	20	-	-	20
Paraheteromastus sp.	30	100	-	-	60	60	250
Sabellaria sp.	-	50	-	-	10	-	60
Sternaspis scutata (Renier)	90	-	-	50	10	-	150
CRUSTACEA							
Ampelisca scabripes (Walker)	10	-	-	-	20	-	30
Ampelisca tridens (Walker)	-	-	-	10	-	-	10
Ampelisca cyclops (Walker)	10	20	-	10	-	-	40
Eocuma sp.	-	-	-	10	10	-	20
Lucifer sp.	30	-	-	-	-	-	30
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	20	-	-	-	-	-	20
Arca sp.	-	-	-	10	-	-	10

Cont....2

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
Barnea sp.	10	20	-	-	-	-	30
Tellina emarginata (Sowerby)	10	-	-	20	-	-	30
Solariella sp.	-	-	-	10	20	-	30
OTHER GROUPS							
Nemertines	-	10	-	-	-	-	10
Total	260	240	1840	150	240	190	2920

Table 15

Station 14

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphictois gunneri (Sars)	-	160	430	-	-	-	590
Euclymene sp.	-	-	430	-	-	-	430
Glycera sp.	-	-	30	-	-	30	60
Magelona longicornis (Johnson)	150	-	-	-	40	-	190
Mesochaetopterus sp.	-	-	-	-	-	40	40
Ninoe sp.	40	-	-	10	-	-	50
Paraheteromastus sp.	-	-	90	-	-	-	90
Prionospio sp.	-	-	-	10	-	10	20
CRUSTACEA							
Ampelisca brevicornis (Costa)	-	-	-	-	10	-	10
Ampelisca tridens (Walker)	-	10	-	10	-	40	60
Ampelisca sp.	-	-	-	-	20	-	20
Lucifer sp.	20	10	-	-	10	10	50
Parapenaeopsis stylifera larva	-	10	-	-	-	10	20
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	-	-	-	-	-	10	10
Barnea sp.	-	40	10	-	20	-	70
Nucula sp.	80	-	150	-	-	-	230
Nassarius sp.	-	-	-	10	-	10	20
OTHER GROUPS							
Nemertine	-	20	-	-	-	-	20
Total	290	250	1140	80	60	160	1980

Table 16

Station 15

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Disoma sp.	60	-	10	-	30	10	110
Euphrosyne sp.	10	-	10	-	-	-	20
Glycera sp.	-	70	40	30	20	10	170
Lumbriconercis sp.	50	20	930	20	20	830	1870
Nereis sp.	10	10	60	20	40	20	160
Nephtys sp.	-	-	10	-	-	-	10
Unidentified polychaets	40	40	-	20	-	20	120
CRUSTACEA							
Ampelisca scabripes (Walker)	10	-	40	-	-	-	50
Ampelisca sp.	10	10	50	10	10	-	90
Eocuma sp.	-	-	10	-	-	-	10
Lucifer sp.	10	10	-	-	-	10	30
Parapeneopsis stylifera (Milne Edw.)	-	10	10	-	-	-	20
MOLLUSCA							
Arca tortuosa (Linnaeus)	-	-	10	-	10	-	20
Chione tiara (Dillwyn)	20	-	-	-	-	-	20
Modiolus sp.	-	-	-	10	-	-	10
Total	220	170	1180	110	130	900	2710

Table 17

Station 16

Number of animals in m^2 during the period from 1972 to 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Disoma sp.	70	-	-	-	-	-	70
Diopatra neapolitana (delle Chiaje)	-	30	-	-	40	10	80
Glycera sp.	60	-	10	90	30	60	250
Eunice indica (Kinberg)	10	-	-	-	-	-	10
Lubriconereis biflaris (Ehlers)	-	-	-	-	-	320	320
Magelona longicornis (Johnson)	-	-	930	-	10	-	940
Nereis sp.	-	30	10	10	10	-	60
Sternaspis scutata (Renier)	-	-	10	-	-	90	100
CRUSTACEA							
Ampelisca brevicornis (Costa)	-	-	-	-	30	110	140
Ampelisca sp.	10	30	10	-	20	60	130
Idunella sp.	-	-	-	-	-	20	20
Eocuma sp.	-	-	-	-	-	10	10
Prawns larva	-	-	20	-	-	10	30
MOLLUSCA							
Tellina sp.	-	-	-	-	-	20	20
Chione sp.	-	10	10	20	-	10	50
Arca sp.	-	-	10	10	-	-	20
Unidentified bivalves	20	10	-	-	-	-	30
Total	170	110	1010	130	140	720	2280

Table 18

Station 17

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Diopatra neapolitana (delle Chiaje)	10	20	40	-	40	10	120
Glycera sp.	10	-	230	20	-	-	260
Lepidonotus jacksoni (Kinberg)	-	-	-	60	-	-	60
Lumbrenereis sp.	290	-	100	-	-	-	390
Lumbriconereis biflaris (Ehlers)	70	-	110	-	-	-	180
Magelona longicornis (Johnson)	-	-	-	870	-	2210	3080
Nephtys sp.	-	-	10	-	-	10	20
Nereis sp.	-	20	-	20	30	10	80
Paraheteromastus sp.	60	10	-	-	-	-	70
CRUSTACEA							
Ampelisca scabripes (Walker)	-	-	-	-	-	30	30
Ampelisca brevicornis (Costa)	40	20	20	10	-	10	100
Ampelisca tridens (Walker)	10	-	30	10	-	20	70
Idunella sp.	20	10	40	-	-	10	80
Charybdis sp.	-	-	-	10	-	-	10
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	-	-	-	20	-	-	20
Arca sp.	10	-	-	-	-	-	10
Tellina sp.	20	-	-	-	-	10	30

Cont.....2

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
<u>OTHER GROUPS</u>							
Nemertines	-	-	-	-	10	-	10
Ophiuroids	-	-	40	-	-	-	40
Total	540	80	620	1020	80	2320	4660

Table 19

Station 18

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	40	-	-	-	-	-	40
Cossura sp.	940	70	-	-	-	-	1010
Glycera sp.	-	30	40	330	160	-	560
Lubriconereis sp.	-	-	280	190	-	10	480
Magelona longicornis (Johnson)	-	40	-	10	-	-	50
Nephtys sp.	-	-	20	20	40	30	110
Paraheteromastus sp.	-	-	-	20	40	-	60
Prionospio pinnata (Ehlers)	-	-	80	-	-	-	80
Unidentified polychaetes	-	-	-	-	-	30	30
CRUSTACEA							
Ampelisca tridens (Walker)	-	-	70	-	-	10	80
Ampelisca sp.	-	-	50	-	70	140	260
Byblis gaimardi (Kroyer)	-	-	30	-	-	30	60
Idunella sp.	-	10	-	-	-	-	10
Unidentified isopod	-	-	10	-	-	-	10
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	20	-	10	-	-	10	40
Tellina emarginata (Sowerby)	-	-	10	-	-	-	10
Unidentified bivalves	-	10	-	-	-	-	10
Unidentified gastropods	-	-	-	10	-	-	10
Total	1000	160	600	580	310	260	2910

Table 20

Station 19

Number of animals in m^2 during the period from 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	-	-	130	-	-	-	130
Diopatra neapolitana (delle Chiaje)	40	20	-	90	50	-	200
Magelona longicornis (Johnson)	-	-	760	-	10	680	1450
Mesochaetopterus sp.	70	10	-	-	-	-	80
Nereis sp.	10	-	110	20	10	-	150
Ninoe sp.	10	-	-	-	-	-	10
Prionospio pinnata (Ehlers)	-	-	-	-	-	560	560
Paraheteromastus sp.	-	10	-	-	-	50	60
Sternaspis scutata (Renier)	40	-	-	20	10	-	70
CRUSTACEA							
Ampelisca scabripes (Walker)	-	10	-	-	-	60	70
Ampelisca tridens (Walker)	-	-	10	-	-	-	10
Ampelisca cyclops (Walker)	-	10	-	10	-	-	20
Eocuma sp.	10	10	-	-	-	20	40
Lucifer sp.	-	-	-	-	10	-	10
Mysidacea	10	-	-	-	10	-	20
MOLLUSCA							
Arca sp.	-	-	-	-	10	-	10
Barnea sp.	-	10	-	-	20	-	30

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
Tellina emarginata (Sowerby)	20	-	10	-	-	-	30
Solariella sp.	-	-	-	-	-	10	10
Unidentified gastropod	-	10	10	-	-	-	20
OTHER GROUPS							
Nemertinea	-	20	-	-	-	-	20
Total	210	110	1030	140	130	1380	3000

Table 21

Station 20

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Euclymene sp.	20	20	-	-	-	-	40
Euphrosyne sp.	10	-	-	-	-	-	10
Glycera longipinnis (Grube)	10	-	-	-	-	10	20
Mesochaetopterus sp.	10	10	-	-	10	10	40
Nephtys sp.	50	-	-	-	-	10	60
Ninoe sp.	-	-	-	10	40	-	50
Nereis sp.	-	-	-	10	-	-	10
Paraheteromastus sp.	-	-	10	-	-	10	20
CRUSTACEA							
Ampelisca cyclops (Walker)	-	-	10	-	10	-	20
Ampelisca sp.	-	-	10	-	-	-	10
Mysidacea	-	-	-	-	10	-	10
Lucifer sp.	-	-	30	10	10	-	50
Squilla nepa Latreille (Bigelow)	10	-	-	-	-	-	10
MOLLUSCA							
Arca sp.	60	-	-	-	-	-	60
Chione tiara (Dillwyn)	10	-	-	-	-	-	10
Nucula sp.	-	70	-	-	10	-	80
Tellina emarginata (Sowerby)	20	-	-	-	-	-	20
OTHER GROUPS							
Nemertines	-	10	-	-	-	10	20
Total	200	110	60	30	90	50	540

Table 22

Station 21

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
COELENTRATA							
Cavernularia sp.	-	10	-	-	-	20	30
POLYCHAETA							
Amphicteis gunneri (Sars)	-	-	8210	-	50	70	8330
Cossura sp.	-	20	-	-	-	-	20
Euclymene sp.	-	20	-	-	-	-	20
Diopatra neapolitana (delle Chiaje)	20	30	10	20	10	10	100
Glycera sp.	10	-	-	-	-	10	20
Magelona longicornis (Johnson)	10	30	-	-	-	-	40
Nephtys sp.	10	10	20	-	10	50	100
Sternaspis scutata (Renier)	-	-	10	10	-	-	20
CRUSTACEA							
Ampelisca scabripes (Walker)	10	-	-	20	-	10	40
Ampelisca sp.	-	-	-	10	-	-	10
Eocuma sp.	-	-	10	-	-	-	10
Unidentified isopod	10	10	-	-	-	-	20
MOLLUSCA							
Arca sp.	10	-	30	-	-	-	40
Nucula sp.	-	-	1190	20	210	-	1420
Unidentified bivalves	10	20	40	20	10	-	100
Unidentified gastropods	-	-	-	10	-	-	10
Total	90	150	9520	110	290	170	10330

Table 23

Station 22

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Euclymene sp.	-	110	10	210	-	30	360
Glycera sp.	-	10	-	40	30	190	270
Lumbriconereis sp.	-	-	-	-	120	-	120
Lubriconereis biflaris (Ehlers)	-	-	-	10	-	730	740
Nereis sp.	10	10	10	20	-	-	50
Paraheteromastus sp.	20	-	20	-	-	20	60
CRUSTACEA							
Ampolisca sp.	10	10	-	70	10	190	290
Idunella sp.	10	-	-	10	-	10	30
Lucifer sp.	-	-	10	-	10	-	20
Eocuma sp.	10	-	10	-	-	-	20
MOLLUSCA							
Arca sp.	-	-	-	30	20	10	60
Solariella sp.	-	-	-	-	-	10	10
Nucula sp.	-	-	-	-	-	10	10
Tellina sp.	-	-	-	-	-	10	10
Total	60	140	60	390	190	1210	2050

Table 24

Station 23

Number of animals in m^2 during the period from 1972 - '73

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphecteis gunneri (Sars)	10	10	-	70	10	-	100
Lumbriconereis sp.	-	-	-	510	2630	-	3140
Magelona longicornis (Johnson)	-	110	70	-	-	130	310
Nereis sp.	20	10	10	-	-	10	50
Nephtys sp.	10	20	10	-	-	-	40
Unidentified polychaets	-	-	30	180	-	-	210
CRUSTACEA							
Ampelisca tridens (Walker)	-	-	10	-	20	50	80
Byblis gaimardi (Kroyer)	-	-	-	90	50	10	150
Ampelisca sp.	10	10	20	60	-	-	100
Eocuma sp.	-	-	-	-	-	30	30
MOLLUSCA							
Arca inequivalvis (Bruguiere)	-	20	-	-	10	-	30
Arca sp.	10	10	-	-	-	-	20
Tellina emarginata (Sowerby)	-	-	10	-	-	-	10
Nucula sp.	-	-	-	-	-	10	10
Total	60	190	160	910	2720	240	4280

Table 25

Station 24

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphictois gunneri (Sars)	-	-	90	-	-	-	90
Eunice indica (Kinberg)	-	40	-	-	-	-	40
Glycera sp.	270	40	10	-	70	380	770
Magelona longicornis (Johnson)	120	-	-	-	100	-	220
Nereis sp.	20	10	40	10	30	90	200
Paraheteromastus sp.	-	-	80	-	-	-	80
CRUSTACEA							
Ampelisca sp.	40	10	90	-	-	10	150
Byblis gaimardi (Kroyer)	10	-	50	-	-	-	60
Lucifer sp.	-	20	-	-	-	-	20
Charybdis sp.	-	10	-	10	-	-	20
Unidentified cumacean	20	-	-	-	-	-	20
Unidentified isopods	-	-	20	-	-	10	30
MOLLUSCA							
Arca inaequivalvis (Brugiere)	10	-	-	-	-	-	10
Conus sp.	10	-	-	20	-	-	30
Macoma sp.	-	-	-	10	-	90	100
Unidentified bivalve	-	-	-	-	30	20	50
OTHER GROUPS							
Nemertines	-	10	10	-	-	-	20
Total	500	140	390	50	230	600	1910

Table 26

Station 25

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphictois gunneri (Sars)	-	-	270	-	20	-	290
Diopatra neapolitana delle Chiaje	-	-	10	-	-	-	10
Glycera sp.	-	-	-	170	-	-	170
Lumbriconereis sp.	40	-	-	-	20	-	60
Magelona longicornis (Johnson)	30	-	20	-	10	50	110
Prionospio pinnata (Ehlers)	-	-	-	-	-	20	20
Paraheteromastus sp.	-	-	-	10	30	-	40
Sabelleria sp.	10	-	20	-	-	-	30
Sternaspis scutata (Renier)	10	10	-	-	-	-	20
CRUSTACEA							
Ampelisca tridens (Walker)	-	-	-	-	10	-	10
Ampelisca cyclops (Walker)	-	-	-	-	10	-	10
Ampelisca sp.	30	20	10	-	-	40	100
Eocuma sp.	-	-	-	-	10	10	20
Lucifer sp.	-	10	-	-	10	-	20
MOLLUSCA							
Arca inaequivalvis (Bruguieri)	10	-	-	-	-	-	10
Barnea sp.	20	-	10	-	-	-	30
Tellina emarginata (Sowerby)	-	-	-	-	20	-	20
Nucula sp.	-	-	-	-	-	10	10

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
Solariella sp.	-	10	-	-	-	-	10
Unidentified gastropods	10	-	-	-	10	-	20
OTHER GROUPS							
Nemertines	-	-	10	-	-	-	10
Total	160	50	350	180	150	130	1020

Table 27

Station 26

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Diopatra neapolitana (delle Chiaje)	-	-	40	-	-	-	40
Disoma sp.	-	-	10	-	10	10	30
Lubriconereis biflaris (Ehlers)	-	300	-	-	-	90	390
Magelona sp.	40	-	20	-	-	-	60
Nephtys sp.	-	-	20	-	10	10	40
Nereis sp.	-	-	10	-	10	-	20
Prionspio pinnata (Ehlers)	-	-	50	-	-	-	50
Unidentified polychaetes	40	10	10	20	10	10	100
CRUSTACEA							
Ampelisca sp.	-	-	-	-	-	10	10
Ampelisca cyclops (Walker)	-	10	-	10	10	-	30
Eocuma sp.	-	-	10	-	-	-	10
Squilla nepa Latreille (Bigelow)	-	-	-	10	-	-	10
Lucifer sp.	-	-	10	-	-	10	20
MOLLUSCA							
Arca sp.	-	-	-	20	-	-	20
Arca inaequivalvis (Bruguiere)	20	-	-	-	-	-	20
Macoma sp.	10	-	-	-	-	-	10
Nucula sp.	-	30	-	-	20	-	50
OTHER GROUPS							
Nemertines	-	-	10	-	-	-	10

Table 28

Station 27

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Amphicteis gunneri (Sars)	-	10	10	-	-	-	20
Disoma sp.	20	420	-	-	-	20	460
Glycera sp.	60	-	-	40	20	-	120
Magelona longicornis (Johnson)	20	-	-	500	160	10	690
Nereis sp.	10	10	20	20	-	10	70
Paraheteromastus sp.	100	-	-	10	-	70	180
CRUSTACEA							
Ampelisca scabripes (Walker)	10	-	10	-	-	-	20
Ampelisca sp.	10	-	-	10	10	-	30
Charybdis sp.	-	10	-	10	-	-	20
Eocuma sp.	-	10	-	10	-	-	20
Lucifer sp.	10	10	-	10	-	-	30
Unidentified isopod	-	-	-	10	-	-	10
MOLLUSCA							
Nucula sp.	-	490	-	-	-	10	500
Solariella sp.	-	-	20	10	-	-	30
Nassarius sp.	-	-	-	10	-	-	10
Total	240	960	60	640	190	120	2210

Table 29

Station 28

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Disoma sp.	10	-	-	30	-	110	150
Glycera sp.	-	140	-	70	90	220	520
Lubriconereis biflaris (Ehlers)	-	740	3500	-	-	410	4650
Magelona longicornis (Johnson)	10	-	60	70	-	-	140
Nereis sp.	20	100	10	40	10	-	180
Nephtys sp.	20	-	-	20	10	-	50
Sabellaria sp.	-	10	-	-	10	-	20
Sternaspis scutata (Renier)	10	-	-	110	-	-	120
CRUSTACEA							
Ampelisca tridens (Walker)	-	20	-	240	-	10	270
Ampelisca sp.	10	60	-	330	-	110	510
Idunella sp.	-	20	-	20	10	30	80
Byblis gaimardi (Kroyer)	-	10	-	-	-	-	10
Eocuma sp.	-	-	-	10	-	-	10
MOLLUSCA							
Arca tortuosa (Linnaeus)	-	-	-	30	-	20	50
Arca sp.	-	20	-	-	-	10	30
Tellina sp.	-	-	-	10	-	-	10
Nucula sp.	-	-	670	-	-	-	670
Total	80	1120	4240	980	130	920	7470

Table 30

Station 29

Number of animals in m^2 during the period 1972 - 1973

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
COELENTERATA							
Cavernularia sp.	-	-	-	-	-	10	10
POLYCHAETA							
Amphictcis gunneri (Sars)	-	-	40	150	-	150	340
Disoma orissae (Fauvel)	20	-	-	-	-	-	20
Euphrosyne sp.	-	-	70	10	40	10	130
Glycera sp.	10	-	20	100	60	100	290
Magelona longicornis (Johnson)	100	-	-	120	-	120	340
Ninoe sp.	30	-	-	-	20	-	50
Nereis sp.	30	-	80	-	50	-	160
CRUSTACEA							
Ampelisca scabripes Walker	-	-	10	360	-	10	380
Ampelisca sp.	70	-	70	320	50	40	550
Byblis gaimardi (Kroyer)	20	-	-	10	-	-	30
Idunella sp.	30	-	-	210	-	-	240
Isopod (unidentified)	-	10	-	-	-	-	10
Charybdis sp.	-	-	10	-	-	-	10
Unidentified Cumaceans	-	-	20	30	10	-	60
Prawn larvae	20	-	-	20	-	-	40

Cont.......2

	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
MOLLUSCA							
Nucula sp.	-	-	20	30	-	-	50
Tellina sp.	20	-	10	10	-	20	60
Unidentified bivalves	10	-	10	30	20	10	80
OTHER GROUPS							
Unidentified ophiuroids	-	10	-	-	-	-	10
Total	360	20	360	1400	250	470	2860

Table 31

Station 30

Number of animals in m^2 during the period 1972 - 1973

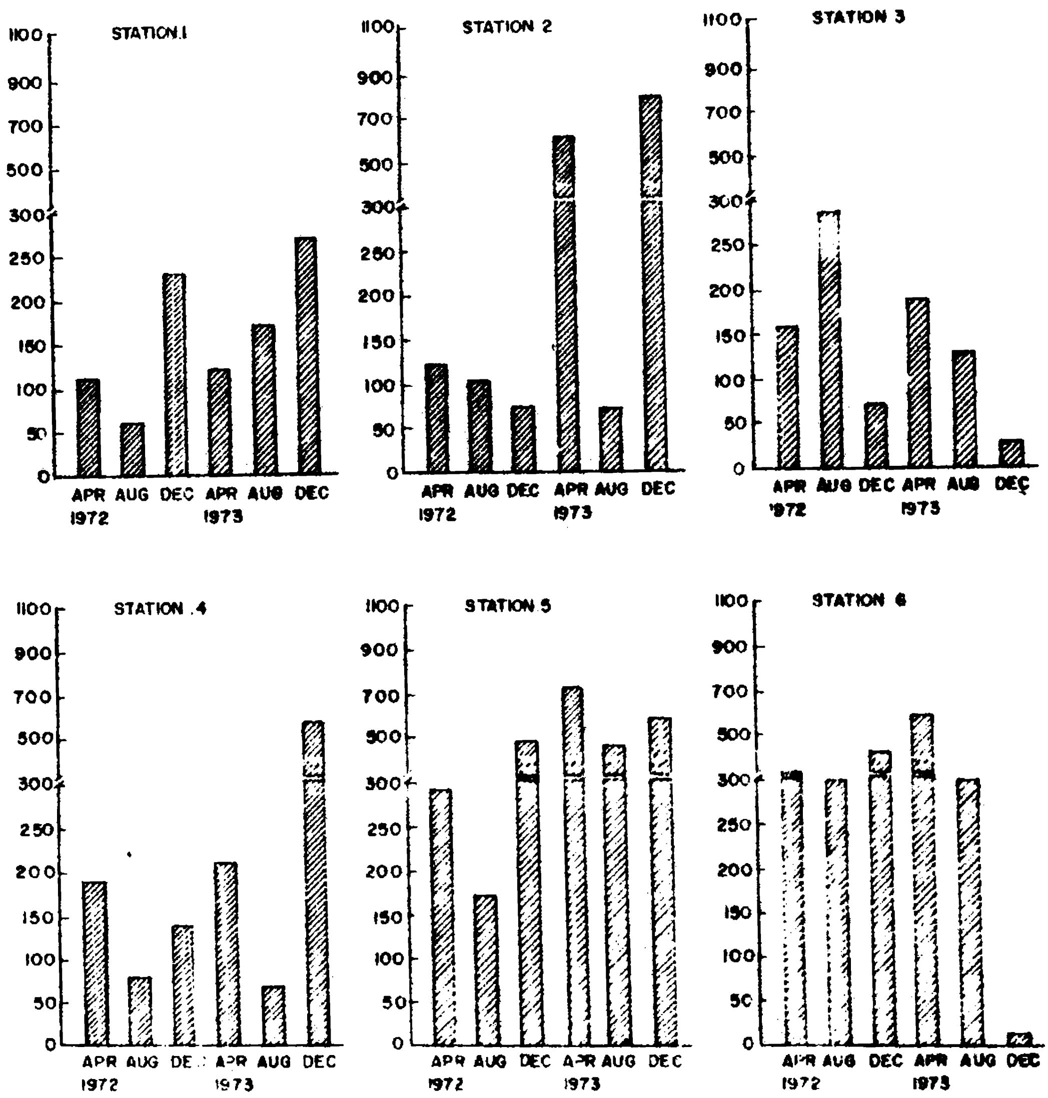
	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
POLYCHAETA							
Disoma sp.	10	10	-	-	-	-	20
Glycera sp.	310	290	-	-	-	-	600
Eunice indica (Kinberg)	-	20	-	-	10	10	40
Lubriconereis biflaris (Ehlers)	-	-	-	-	-	620	620
Nephtys sp.	30	140	20	-	-	-	190
Paraheteromastus sp.	-	-	-	70	-	30	100
CRUSTACEA							
Ampelisca brevicornis (Costa)	20	-	-	-	10	-	30
Ampelisca sp.	10	10	40	80	-	-	140
Idunella sp.	-	-	20	10	-	30	60
Lucifer sp.	-	-	-	-	30	-	30
Eocuma sp.	10	-	-	-	-	-	10
Unidentified isopods	20	10	-	10	10	-	50
MOLLUSCA							
Arca inaequivalvis (Bruguiere)	-	10	-	-	-	-	10
Macoma sp.	40	10	-	-	-	20	70
Tellina sp.	-	10	10	-	-	-	20
Unidentified bivalves	10	20	-	-	10	-	40
Unidentified gastropods	-	-	-	20	-	10	30
Total	460	530	90	190	70	720	2060

6.3. Number, weight and distribution

The quantitative distribution of macrobenthos in all the thirty stations in numerical abundance is given in the tables 2 to 31 and Figs. 28 - 32.

The population density in the six stations of profile 1, varied from an average minimum of 145 to an average maximum of 455/m^2. The minimum number of animals was recorded in station 3 and the maximum was observed in station 5 at a depth of 20 m and 35 m respectively. In the stations of the second profile the number of animals varied from an average minimum value of 105/m^2 in station 9 at a depth of 20 m to a maximum average value of 1021/m^2 at a depth of 5 m in station 7. The very high value in station 7 was due to the occurence of a single species of *Barnea* sp. in large numbers constituting 85% of the total number of animals. The largest number of the animals in the station 11 was contributed by the *Prionspio* sp. In profile 3, the population of the animals recorded a maximum average number of 776/m^2 in station 17 at 35 m depth to a minimum of 330/m^2 at station 14 in 10 m depth. *Magelona longicornis* constituted 66% of the total number of animals in station 19. The total number of animals in the fourth profile varied between the maximum average range of 1721/m^2 in station 21 at 20 m depth to a minimum of 90/m^2 in station 20 at a depth of 10 m. The polychaete *Amphicteis gunneri* and the bivalve *Nucula* sp. were the two organisms which constituted 80% and 13% respectively of the total number of fauna recorded from station 21. In the

Figs. 28 - 32. Population density of important groups of macrobenthic fauna at different depths in the 5 transects.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STATION 2
STATION 3
STATION 4
STATION 5
STATION 6
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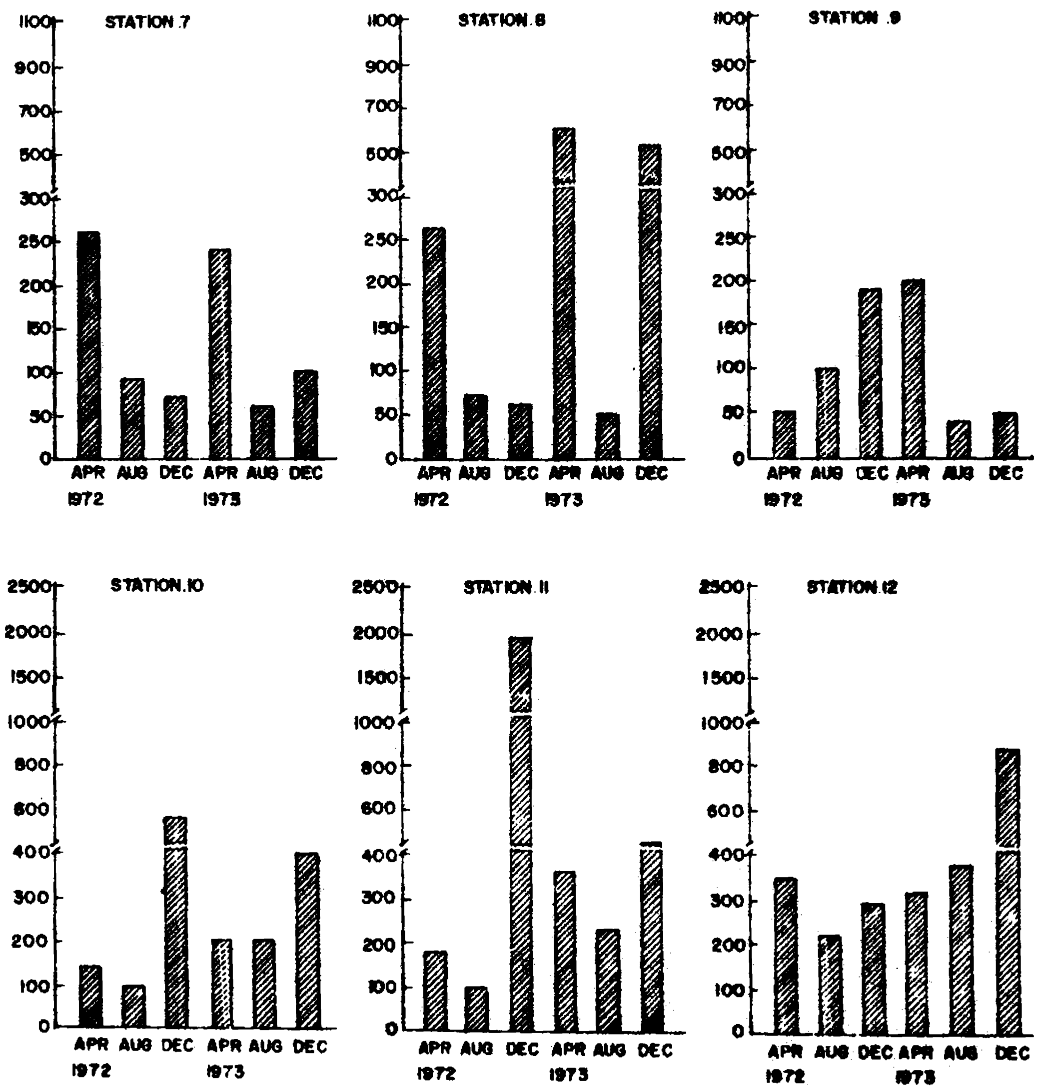
700
500
300
250
200
150
100
50
0
APR AUG DEC APR AUG DEC
1972
1973

FIG. 28.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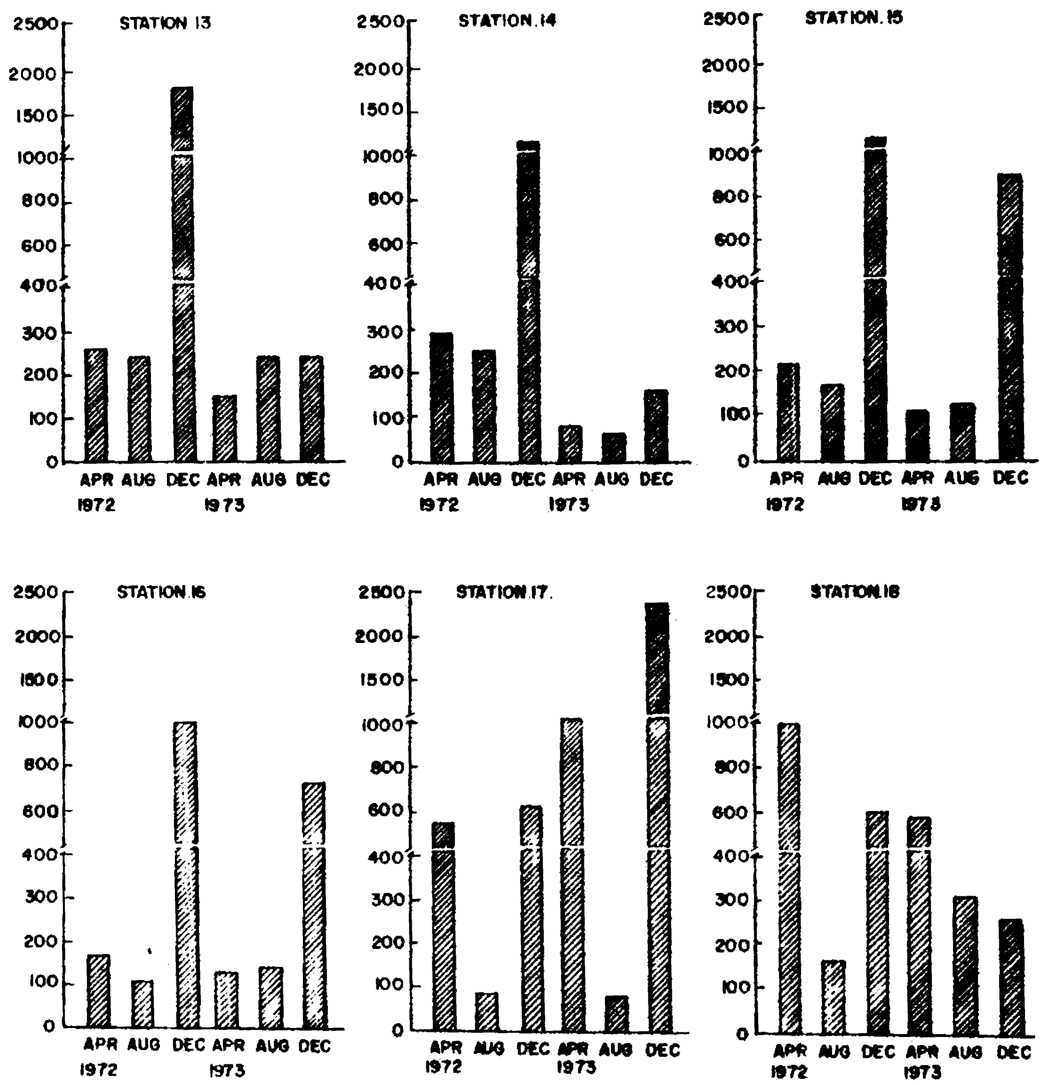
STATION 8
STATION 9
STATION 10
STATION 11
STATION 12
APR AUG DEC APR AUG DEC
1972 1973

FIG. 29.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STATION.15
STATION.16
STATION.17.
STATION.18
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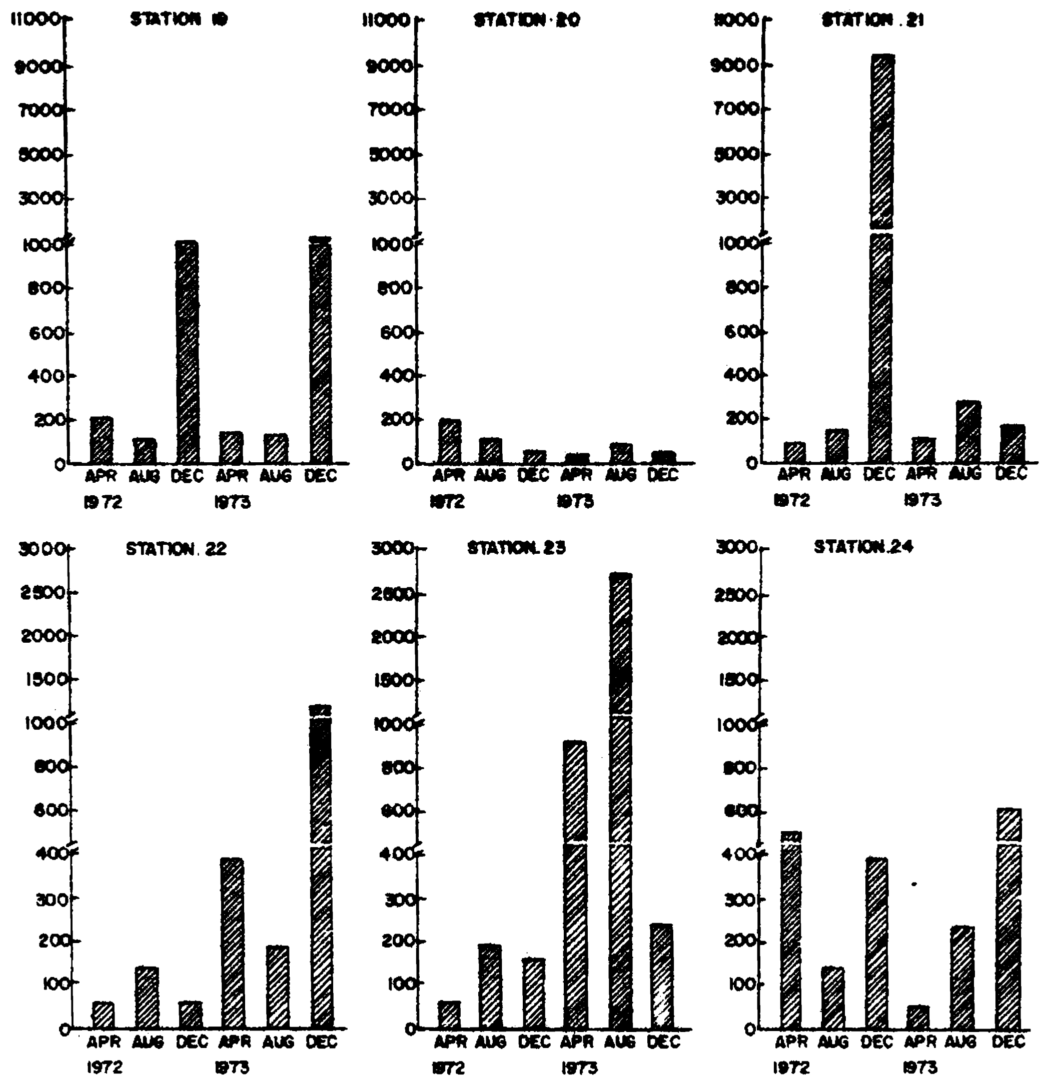
2000
1500
1000
800
600
400
300
200
100
0
APR AUG DEC APR AUG DEC
1972
1973

FIG. 30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STATION 20
STATION 21
STATION 22
STATION 23
STATION 24
APR AUG DEC APR AUG DEC
1972 1973

FIG 31

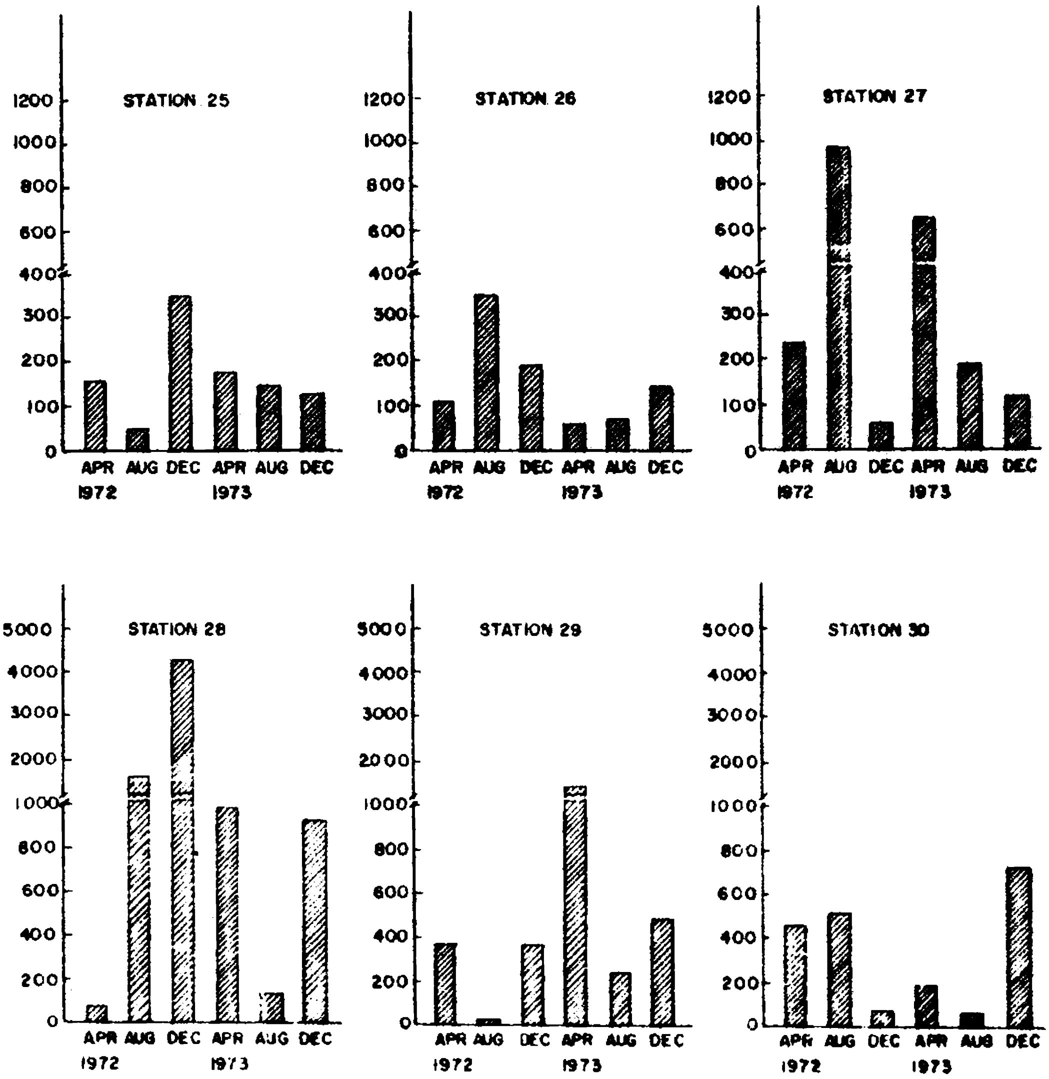
STATION 25
STATION 26
STATION 27
STATION 28
STATION 29
STATION 30
1200
1000
800
600
400
300
200
100
0
5000
4000
3000
2000
1000
800
600
400
200
APR AUG DEC APR AUG DEC
1972
1973

FIG. 32

fifth profile, station 28 recorded the maximum average number of 1411 animals and the minimum average number of 153 animals in m^2 area was observed in station 26 at depths 30 m and 10 m respectively. Lumbriconereis biflaris formed 62% of the total number of animals in station 28.

It is evident from the population density picture described that the occurrence of maximum average number of organisms were in the deeper stations, which was in 35 m contour line in the first three profiles and in the fourth and fifth profiles at 20 m and 30 m depth respectively. The density of the fauna was comparatively poorer in shallow water stations at depths 5-10 m. On closer examination it is apparent that there does not exist significant variation in the faunal assemblage and intensity in the different profiles and further, it is interesting to note that the maximum number of animals was recorded from a station in the third profile which is located outside the mud bank.

The *biomass values of the benthic fauna is given in the table 32. The biomass generally indicated higher value in the deeper stations. The values were the highest in deeper stations 5 and 6 in profile A except in station 2 of profile A where the value was 202.965 gm/m^2 during December 1973. But the higher values in this station is due to the occasional presence of large species of Ochaetostoma septemystum which need not be included in the actual estimation of the dry weight, Lie (1969). The maximum

*wet weight

Table 32

Biomass of macrofauna - gm/m^2

Station	APRIL 1972 Wet Weight	APRIL 1972 Dry Weight	AUGUST Wet Weight	AUGUST Dry Weight	DECEMBER Wet Weight	DECEMBER Dry Weight	APRIL 1973 Wet Weight	APRIL 1973 Dry Weight	AUGUST Wet Weight	AUGUST Dry Weight	DECEMBER Wet Weight	DECEMBER Dry Weight
1.	0.545	0.044	0.097	0.012	0.610	0.074	0.347	0.052	0.082	0.016	0.251	0.023
2.	0.151	0.030	0.382	0.078	0.011	0.003	7.672	1.534	0.029	0.058	202.965	0.890
3.	0.511	0.046	0.101	0.132	1.637	0.065	3.103	0.962	0.021	0.049	2.466	0.518
4.	0.233	0.019	0.213	0.066	1.681	0.387	0.771	0.069	0.011	0.024	0.612	0.067
5.	3.390	1.390	2.136	0.449	2.115	0.190	4.041	0.485	0.199	0.219	3.103	0.465
6.	2.321	0.209	2.213	0.420	4.924	0.886	5.210	0.625	0.110	0.044	0.1442	0.245
7.	0.253	0.030	0.212	0.032	180.102	161.222	0.693	0.215	0.020	0.038	0.331	0.040
8.	0.212	0.019	0.006	0.001	0.184	0.022	96.637	19.664	0.001	0.001	123.563	2.241
9.	0.404	0.125	0.059	0.005	0.571	0.080	3.103	0.341	0.008	0.024	0.912	0.109
10.	0.451	0.149	0.215	0.026	1.637	0.507	1.245	0.149	0.114	0.252	13.038	5.346

Cont.......

Station	APRIL 1972		AUGUST		DECEMBER		APRIL 1973		AUGUST		DECEMBER	
	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight
11.	0.205	0.084	0.173	0.033	20.297	1.827	3.144	0.377	0.637	0.134	52.75	1.079
12.	3.210	0.610	0.773	0.317	3.637	0.691	3.912	0.430	0.149	0.046	22.450	9.094
13.	16.121	1.773	4.546	1.409	24.846	7.702	1.521	0.608	1.673	0.141	0.211	0.025
14.	0.621	0.125	9.881	1.977	4.280	0.642	0.087	0.010	0.085	0.008	3.083	0.462
15.	1.910	0.172	0.911	0.282	2.730	0.545	0.847	0.102	0.532	0.112	1.446	0.059
16.	0.341	0.031	0.213	0.049	5.441	1.088	2.305	0.277	1.465	0.601	2.941	0.588
17.	0.955	0.191	0.893	0.179	1.637	0.196	4.875	1.024	0.077	0.024	2.941	0.731
18.	0.922	0.101	0.912	0.246	0.851	0.128	2.767	0.526	2.120	0.445	1.641	0.128
19.	0.871	0.078	1.351	0.162	5.510	1.708	0.964	0.222	1.174	0.270	3.544	0.461
20.	0.637	0.076	0.042	0.005	0.145	0.020	0.136	0.014	0.045	0.008	0.032	0.003

Cont ....

Station	APRIL 1972		AUGUST		DECEMBER		APRIL 1973		AUGUST		DECEMBER	
	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight	Wet Weight	Dry Weight
21.	4.293	0.515	8.612	1.086	2.840	0.312	1.137	0.136	0.771	0.162	16.337	1.797
22.	0.331	0.036	0.411	0.181	0.131	0.010	0.511	0.020	0.190	0.078	2.543	0.381
23.	0.300	0.045	8.597	1.032	0.148	0.022	2.145	0.193	0.052	0.185	0.155	0.050
24.	2.791	0.443	0.761	0.098	1.873	0.150	0.217	0.038	2.129	0.789	3.990	1.117
25.	0.072	0.008	0.132	0.012	0.064	0.013	0.124	0.015	0.047	0.004	0.062	0.005
26.	0.213	0.013	0.102	0.007	0.225	0.027	0.325	0.036	0.321	0.035	0.071	0.009
27.	5.273	0.037	1.372	0.144	0.883	0.079	0.737	0.081	0.440	0.136	0.143	0.017
28.	1.201	0.180	3.132	0.971	15.809	1.897	6.442	0.966	0.416	0.171	9.511	1.997
29.	3.843	0.461	0.005	0.001	2.213	0.420	9.105	1.093	2.254	0.451	5.287	3.700
30.	5.510	0.882	3.110	0.852	0.812	0.032	0.651	0.059	0.227	0.078	1.262	0.151

biomass of 5.210 g/m^2 was recorded in station 6 during April 1973 and the minimum value of 0.082 g/m^2 recorded in station 1 during August 1973. The higher values observed in stations 8 and 11 of profile B were contributed again by O. septemyotum. The highest values otherwise were observed in stations 11 and 12 while the minimum was in the shallow water station 7 except in the month of December 1972. This higher value in this station was contributed by a single species of bivalve Barnea sp. But in the third profile the biomass value was high in the shallowest station 13 and lowest in the deepest station. The greater value in station 13 was contributed by the polychaete Amphictois gunneri which was present in large numbers. The values were lower in the shallower stations in the fourth and fifth profiles except in station 19 where the biomass showed higher value.

The annelids represented by the polychaetes were the most dominant group of the population of the macrobenthic fauna in the stations. The percentage composition study indicated that the polychaetes formed an average value of 75.[illegible]% of the total faunal assemblage. The minimum value of 46.3% was recorded in station 20 and the maximum value of 91.3% was observed in station 17.

Crustacea constituted the next important group of the macrobenthos. The group was not dominated by any particular species. The percentage composition of the crustaceans varied from a minimum of 0.8% in station 21 to a maximum of 46.15% almost equal to the polychaete composition in station 29. The higher value of crustacean fauna in this station was contributed by a large number of *Ampelisca scabripes* and other amphipods. Although the crustacean group of animal was recorded from all depths the maximum number of animals, constituting this group belonged to amphipods which was mostly confined to the 20 to 45 m belt of the sea.

The molluscan group of animals representing the third important group varied from a minimum percentage of 1.3% at station 17 to a maximum of 31.4% at station 20. A distinct concentration of the fauna in any particular depth zone could not be established as the faunal intensity fluctuated without any regularity.

There was noticed a general decline in the numerical abundance and biomass in all the stations during the monsoon period. But there is no distinct variation in total number of individuals or wet weights of animals in the samples that can be attributed to pre-monsoon or post-monsoon seasonal changes. There seems to be no prominent differences between numbers for the species identified during the two years of study. However, the large number of animals contributed by the polychaete *Amphicteis gunneri* in station 21 was probably due to a local aggregation. It seems probable, therefore, that there has been little change in the composition of the fauna during the period of two year study.

6.4. Substratum and the bottom fauna

"Ocean food web is predominantly detrital". It is a well known fact that sediments of lakes, estuaries, rivers and oceans function as food source for bottom feeding invertebrates. The relative role of living and non living organic fraction in the nutrition of such animals has been topic of wide ranging discussion in different parts of the world. Darnell (1967) discussed the role of organic "detritus" as a nutrient source of aquatic animals. Tenore (1977) observed thatthere has been no study which has definitely established a link between detritus and exploitation of a commercially important fishery, although a number of investigations have emphasised relationship between organic detritus and benthic organisms. A large and active microbial community is associated with the detritus and microbes are consumed by mieofauna and macrofauna. Thus Brown and Sibert (1977) has established a direct link between detritus, microbes and a commercially important fishery. Furthermore, according to Pomeroy (1974) the concept of the classical oceanic food chain, that is, phytoplankton - Zooplankton - carnivores, is being challenged by an alternate food chain of detritus - microbe-consumer. The new theories of the oceanic food chain dynamics is of considerable importance and will assist for the better and improved management of the marine ecosystem.

The occurrence of bivalves in comparatively large number within the 30 m line can be attributed to the availability of microorganism in the fine grained sediments. Similar conclusions have been arrived at by Newell (1965) who attributed an increase in population density of deposit feeding molluscs in fine grained sediments. But the quantity of ingestion of organic material by the deposit feeders is still a debatable question. Hargrave (1970) in his radiotracer laboratory experiments on fresh water benthic amphipod to study the assimilation efficiency of living and non living organic matter by feeding them on sediments, found it as low as 6 to 15%. Similar observations were made by Heywood and Edwards (1962), George, (1964), and Hobson, (1967). Based on the above findings, although higher values of organic materials are recorded from the sediments of mudbank regions, the percentage utilised by the different species of deposit feeders of this area have to be individually assessed. The absence of any significant difference in the number and weight of animals in the stations of profiles A, B, D, E (mudbanks included) and profile C (outside mud banks) explains that higher organic materials available is not the only decisive factor which determines the standing crop. It has also been indicated that non-living organic material absorbed on to sediment particles may be an important food source for deposit feeders. Fox, (1950) Wilson (1968) and Gordon (1966), however have observed that the polychaete Pectinaria gouldii absorbed 45% of the organic carbon from the ingested sediments.

The other important factor in the environment is the texture of the deposit which can influence each species and decide the grades of the sediment upon which it will settle and colonise. Sanders (1958) observed that sand sediments have a relatively high percentage of filter feeders and epifauna, whereas muddy sediments have the greatest number of the infaunal deposit feeders. The fauna including a number of members among Annelida, Crustacea, Mollusca, Echinodermata and other groups of animals form a significant part of the food of many demersal fishes.

Since polychaetes were the most dominant group of animals in the present investigation of macrobenthic population, and they were fairly well represented in all the depths, it is rather difficult to draw a categorical conclusion regarding their occurrence with respect to any particular grade of sediment. The evidence to show that the depth of the water in the inshore waters has any influence on the composition of the fauna is also not great. In the region within 30 m depth, where the sediment was predominantly of fine particles with a good percentage of sand, polychaetes constituted an average number of 74.6%, while crustacean fauna constituted an average of 19.4%. The average contribution of the molluscan fauna mainly consisting of bivalve was 10.4%. The fauna in the region between 30 m and 45 m was dominated again by polychaetes and constituted an average of 76.9%. The average values of crustacea and mollusca were 17.4% and 4.93% respectively.

Although the total percentage distribution of the polychaetes exhibited a rather uniform picture in the two types of substrata a close examination of their pattern of distribution revealed the occurrence of certain species in more numbers in certain depths showing their preferance to particular grade of sediments. The polychaete Sternaspis scutata was observed to prefer a substratum of finer particles, since this species was totally absent in stations beyond 30 m, where finer fraction gave way to sand particles. Similarly, although the species Amphicteis gunneri was recorded in all depths, those organisms were found more concentrated within the 30 m line.

From the tables it can be seen that the distribution of the amphipod species generally exhibited a tendency of being concentrated more in deeper stations. The species Byblis gaimardi and Idunella sp. were recorded at stations of 20 m depth only. Since the other amphipods which includes different Ampelisca sp. are largely limited to the sandy sediments, it is clear that they must procure their food predominantly from suspended matter in the water by creating current with the assistance of pleopods. It has been noticed that within each feeding type, a few species are numerically dominant, which in the present study was supported by the occurrence of *Ampelisca tridens* and *Ampelisca scabripes* in large numbers.

The data on the deposits has suggested that the clay content of the sediment is very important for the distribution of deposit feeding organisms, Clays are much smaller in size than the silt particles and therefore have a relatively much larger surface area to bind organic matter, the source of food for deposit feeders. But large concentration of organic matter may reduce the oxygen content in the sediments and can ultimately limit the environment for deposit feeders (Yonge (1949).

6.5. Relation between the fauna and bottom stability

The effect of bottom stability in determining the distribution of benthos has been well established in both tropical and temperate waters (Sanders (1958), Newell *et al* (1959), Purdy (1964), Jackson (1972), Johnson (1970), Rhoads and Young (1970),. Levinton and Bambach (1970). Aller and Dodge (1974) define unstable sediments as those sediments which are highly mobile and have low cohesion or shear strength. They have further related many macrobenthic species in the Discovery Bay, Jamaica to a gradient in bottom stability. Similarly the investigation of Estcourt (1968) in New Zealand demonstrated a sparse fauna in Cook strait, which has been attributed to sediment mobility.

The comparatively lower values in the population density of macrofauna in the near shore regions especially in the mud bank region, which has proved to be a rich store-house of nutrients, further emphasises the earlier findings that a stable substratum free from undue disturbance is necessary for the benthic life to flourish. A stable substratum in the mud bank regions is not possible due to the fluid nature of the mud, mobility of the mud banks and possibly due to heavy fishing activity particularly bottom trawling. The loose mud in the inshore mud bank regions are incohesive and the sediment cohesion may affect the biology of infaunal species in a variety of ways (Probert, 1975). If the substratum is not firm enough the animal finds difficulty in maintaining the inhalent depression, while the foot becomes clogged in this medium. Pedal anchorage and movement of the shell in the burrowing behaviour of bivalve molluscs may also require a certain firmness of the substratum (Quayle, 1949, Nair and Ansell, 1968).

6.6. <u>Community</u>

It is necessary in a community study to demonstrate that the various species included in the samples should show faunal similarity. Sanders (1960) by adopting the method of "index of affinity", the percentage of faunas common to a pair of samples was measured. Hanks (1964) observed that being the infaunal environment more stable than the epifaunal environment the infauna characteristically comprises few genera having an extremely uniform distribution over broad areas. Jones (1956) has stated that the environmental conditions for example, salinity and temperature of the water should be great enough to cause differentiation into assemblages or communities observed in the fauna. From the figures of hydrography it can be observed that the salinity and temperature vary within narrow limits in all the stations except stations 19, 20 and 25, 26 of the 4th and 5th profiles. Since these stations are located adjacent to the Cochin barmouth, a decrease in temperature and salinity has been noticed. But these variations are very temporary and lasts only in the month of August of peak monsoon. In all the other stations, most of the environmental conditions, away from the influence of the rivers or other fresh water discharge, are uniform and vary within narrow limits. Furthermore the environmental condition do not change sufficiently from year to year so as to cause much variation in the total numbers or weights of animals in a single locality.

It follows then that the variation in the number of animals observed in the present study may be as a result of difference in the physical composition of the sediments. As already pointed out, the occurrence of certain species of polychaetes and amphipods may be due to the effect of the physical and organic properties of the deposit. The absence of any predominant species and the occurrence of other animals in smaller numbers rule out the possibility of any clear indication of particular community existence in the area. Shifting and high fluxes resuspended sediment may clog filtering mechanisms of suspension feeders and prevent efficient feeding (Loosanoff, 1962). An unstable bottom observed in the mud bank regions may maintain community development in an inmature state and reduce diversity and may require constant recolonisation by organism as a result of mortality (Margelof, 1968).

7. FISHERY

7.1. Composition of Marine Fishery resources of India

The availability and distribution pattern of the fish in India is typical of tropical waters. Indian fishery resources is constituted by large varieties of species of fish and shell fish. The marine fishery resources of the country comprise mainly (i) major pelagic resources such as oil sardine, mackerels, seer fish, tuna and other pelagic resources such as lesser sardine, anchovies and ribbon fishes (ii) demersal fishery resources such as perches, sciaenids, cat fishes, polynemids, flat fishes, pomfrets, eels, sharks, skates, rays and fishes which are captured chiefly by trawl nets (iii) midwater fishery resources constituted by Bombay duck, silver bellies and horse mackerel (iv) Crustacean fishery resources consisting of prawns, shrimps, lobsters and crabs (v) Molluscan fishery resources comprising chanks, oysters, mussels, clams, squids and cuttle fishes and (vi) Sea weed resources of economic importance (Anon, 1977). George et al (1977) has divided Indian coast into five broad divisions namely north-west coast (Gujarat and Maharashtra), South-west coast (Goa, Karnataka and Kerala), lower east coast (Tamil Nadu, Pondicherry and Andhra Pradesh) and upper east coast (Orissa and West Bengal). Most of the fishing activity in the country at present is confined to the near shore waters upto about 50 m depth. The exploratory surveys carried out have brought to light potentially good fishing grounds for demersal fishes and shell fishes, at different depths along the continental shelf edge and upper continental slope, Silas (1969), Menon and Joseph (1969), Tholasilingam et al (1973), Mohammed and Suseelan (1973) Rao and George (1973) and Menon et al (1977). The fishing season begins by about September and extends upto May . During monsoon, fishing occurs only in restricted regions.

7.2. Fishing Crafts and Gears

The fishing crafts in India includes both indigenous crafts, small mechanised vessels and large trawlers. The indigenous crafts chiefly consist of the plank-built boats of the North West Coast, dug out cannoes of the south-west coast and the characteristic catamarans of the East Coast. The indigenous fishing gears in the country consists of gill nets, bag nets, boat seines, beach seines and different types of lines besides the other locally developed gears. Initially the mechanised vessels operated the indigenous gears before introducing the bottom trawl nets in large numbers for prawn fishing. Even though considerable development has taken place in mechanised fishing, the small scale fisheries practiced by artisnal fishermen play a significant role in the Indian fisheries which contributes 65 to 70% of the total marine fish production in the country. The fishermen engaged in the traditional fishing carry out fishing in the inshore waters extending upto 10-15 km from the shore.

7.3. Fishery in Kerala

The continental shelf region of Kerala has an average width of 60 km covering an area of about 38000 sq. km. for the exploitation of different fishery resources. The marine fish landings of Kerala constituted about thirty per cent of the total marine fish production in India. There are about 3000 mechanised boats and 33000 traditional fishing crafts in use in Kerala. The dominant fishery in this region is contributed by oil sardine, mackerel and prawns. The vast majority of the mechanised fishing vessels operating along the Kerala coast are of 32 ft. (9.8 m) overall length fitted with engines of 50 to 60 H.P. and almost all of them are stern trawlers engaged in bottom trawling for the valuable species of prawns.

7.4. Mudbank fishery

The mud bank fishery locally known as 'Chakara' is unique and the duration, location and the quantity of the fish and prawns available show variations from year to year. The boat seine known as 'thanguvala' is the important gear used by the fishermen to capture fish and prawns from the mud bank areas. Valuable informations have been gathered by different workers on the mud bank fishery. In their early studies, Damodaran and Hridayanathan

(1966) examined the composition of the fisheries in the Alleppey, Saudi, Narakkal and Calicut mud bank regions. Monthly collections from the Alleppey mud banks showed that prawns mostly belonging to the species *Metapenaeus dobsoni*, *M. affinis*, *M. monoceros* and *Parapenaeopsis stylifera* dominated the catches in the first two and half months since the appearance of the mud bank after the onset of southwest monsoon. Later prawn fisheries declined and the pelagic fisheries constituted by species like *Sardinella longiceps*, *Rastrelliger kanagurta* and *Trichiurus* sp. appeared. The other mud banks also gave a similar picture of the dominance of different fisheries in different periods, though catches were comparatively poor. Rao (1967) analysed the catch composition in the Alleppey mud bank and has found that the fisheries is comprised of penaeid prawns, oil sardine, other sardines, scianeids, mackerels and soles. The average fish catch per landing centre per day in the mud bank was higher compared to that of other parts of the country.

In the present study, the Alleppey mud bank region was selected for field observations of the fish landings. The species-wise composition and the quantity landed by each canoe were observed for three consecutive days in the second weeks of June, July and August of 1972 and 1973 which are the active periods of mud bank formation.

7.4.1. Fish landings - June 1972

The fish landings were observed from 11.00 A.M. to 16.00 P.M. There were about an average of 225 country crafts bringing the catch to the shore. On the first day eventhough the pattern of fish distribution did not show dominance of any particular fishery, on the second day the prawns belonging to the species Metapenaeus dobsoni and Parapenaeopsis stylifera were the major constituents. Penaeus indicus was present in small quantities in some of the crafts. The fishes were composed of both bottom and off bottom varieties represented by Cynoglossus puncticeps, Trichiurus sp., Leiognathus sp. and Sciaenids. On the third day the prawn landings generally picked up and the dominant species were again M. dobsoni and P. stylifera, followed by fishes of both demersal, column and pelagic realms.

7.4.2. Fish landings - July 1972

The fishery was dominated by pelagic species like Sardinella sp. followed by Trichiurus sp. Leiognathus sp. and Rastrelliger kanagurta. The crafts bringing the catch were less in number, (about 150 to 175). Each craft was carrying an average of about 300 to 400 kg of fish and prawns. The prawns were poorly represented in the first two days of observation. On the third day prawns of the varieties of M. dobsoni and P. stylifera dominated the catches. The species contributing to the fish catch consisted of Chirocentrus dorab, Sardinella sp. and other clupeoids, Trichiurus sp., Caranx sp. Leiognathus sp. and sciaenids were fairly present on all the three days of observation.

7.4.3. Fish landings - August 1972

The catch decreased on the whole in the month of August, possibly due to the landing by less number of crafts. But there was a clear pattern of change in the fish landings. On the first day there was a mixed type of fish catch, prawns being present only in very small quantities. The fish landed were composed of sardines, silver bellies and other miscellaneous fishes. On the second and third days the dominant species was M. dobsoni. The species next in importance was P. stylifera followed by fishes Sardinella longiceps, Leiognathus sp. Trichiurus sp. and Cynoglossus puncticeps.

7.4.4. Fish landings - June 1973

The fish landings were less compared to the corresponding month of the previous year and there were only about 100 to 125 crafts bringing the catch to the shore.

Although the landings on the whole showed a declining trend the abundance of the different species showed again dominance of certain varieties of prawns and fishes in different days. On the first day majority of the crafts landed substantial quantities of P. stylifera which was the most dominant species followed by small quantities of prawns mostly belonging to the species M. dobsoni and P. indicus. The fishes were composed of the common species of sole like C. puncticeps, Trichiurus sp., Otolithus sp., Lactarius lactarius, Anodontostoma chacunda, Chirocentrus dorab and elasmobranchs like Chiloscyllium sp. and Scoliodon sorrakowh. On the second day the catch was of mixed type represented by different varieties of fishes like Leiognathus sp., Otolithus ruber and other sciaenids, C. puncticeps, Trichiurus sp. etc. The prawns were chiefly represented by P. stylifera. On the third day, the catches were dominated by P. stylifera. The other species of prawns were present in small quantities. The fishes were comprised of species like S. longiceps followed by the other miscellaneous fishes.

7.4.5. Fish landings - July 1973

During the three days of observation, the catches were dominated by M. dobsoni followed by P. indicus. The fishes were composed of mixed type consisting of Otolithus sp., Leiognathus sp., Trichiurus sp., L. lactarius, Saurida tumbil and other miscellaneous fishes.

7.4.6. Fish landings - August 1973

The dominant species on the first day was S. longiceps. The next important species was Leiognathus sp. followed by other miscellaneous fishes. Prawns were present in very small quantities represented by 5 to 10 Kg of P. stylifera in a few crafts. S. longiceps, Trichiurus sp., Leiognathus sp. and a large quantity of sciaenids were present in the second day. On the third day also the catch was dominated by S. longiceps and the other species in order of abundance were P. stylifera, silver bellies, ribbon fishes, and sciaenids. Larger prawns were represented by P. indicus and M. affinis which were present in small quantities varying between 5 to 10 Kg in some of the canoes.

7.5. Results of the bottom trawl net operation

A four seam commercial bottom trawl net of size 32 metre head rope length was operated from the 50' OAL research cum fishing vessel of 160 B.H.P. at depths ranging from 5 to 45 metres at profile E where the Malipuram mud bank was located. The trawl gear was towed for one hour duration in each station immediately after the collection of bottom deposits and water samples. The catch was sorted, identified and weighed species-wise. The analysis of the catches showed that the different species belonged to the three major groups: Elasmobranchii, Teleostomii and Crustacea. The present observation and the collection of data assisted to evaluate the fishery qualitatively and quantitatively from depths where the mud banks stretch and the stations spread beyond its influence. The depth-wise distribution of the different species and the catch rate are given in tables 33 to 38.

Table 33

Composition of the catch by bottom trawl at 5 m depth (quantity in Kilograms)

Name of the species	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
ELASMOBRANCHII							
Chiloscyllium sp.	-	1	-	2	4	2	9
Scoliodon sorrakowah (Cuvier)	2	1	-	2	-	-	5
Rhinoptera sp.	2	-	-	-	-	-	2
TELEOSTOMI							
Opisthopterus tardoore (Cuvier)	1	2	5	4	3	2	17
Thrissocles sp.	-	-	-	5	-	-	5
Ambassis sp.	3	-	-	2	2	2	9
Leiognathus sp.	1	1	3	4	3	3	15
Otolithus ruber (Schneider)	2	-	4	-	2	3	11
Otolithus sp.	1	2	2	3	2	2	12
Cynoglossus puncticeps (Richardson)	4	6	10	4	8	6	38
CRUSTACEA							
Metapenaeus dobsoni (Miers)	2	3	4	-	2	3	14
Metapenaeus affinis (Milne Edw)	-	1	1	-	1	2	5
Penaeus indicus (Milne Edw)	-	-	-	-	1	1	2
Parapenaeopsis stylifera (Milne Edw.)	6	4	3	5	10	5	33
Scylla serrata (Forskal)	1	-	1	-	-	2	4
Portunus pelagicus (Linnaeus)	5	-	4	2	3	-	14
Total	30	21	37	33	41	33	195

Table 34

Composition of the catch by bottom trawl at 10 m depth (quantity in Kilograms)

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
ELASMOBRANCHII							
Scoliodon palasorrah (Cuvier)	1	4	2	-	2	-	9
Scoliodon sp.	3	3	-	2	1	2	11
Rhinoptera sp.	3	-	-	-	1	-	4
Sphyraena zygaena (Linnaeus)	2	-	-	-	-	-	2
TELEOSTOMI							
Opisthopterus tardoore (Cuvier)	1	-	-	3	1	1	6
Thrissocles sp.	-	-	-	1	1	2	4
Ambassis sp.	-	2	-	-	-	-	2
Leiognathus sp.	1	-	1	-	2	2	6
Lactarius lactarius (Schneider)	-	-	1	2	-	3	6
Johnius dussumieri (Cuvier)	2	4	2	1	1	-	10
Otolithus sp.	2	1	4	-	2	2	11
Platycephalus indicus (Linnaeus)	2	1	-	-	1	-	4
Cynoglossus puncticeps (Richardson)	4	2	4	2	2	-	14
Trypauchen vagina (Bloch and Schneider)	1	-	-	-	1	-	2
Rastrelliger kanagurta (Cuvier)	-	-	-	-	1	-	1
Anodontostoma chacunda (Hamilton-Buchanan)	2	-	1	-	1	-	4

Cont......

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
CRUSTACEA							
Metapenaeus dobsoni (Miers)	3	-	2	3	2	3	13
Metapenaeus affinis (Milne Edw.)	2	-	2	-	2	1	7
Penaeus monodon (Fabricius)	-	-	1	-	-	-	1
Penaeus indicus (Milne Edw.)	2	-	-	-	-	-	2
Paraponaeopsis stylifera (Milne Edw.)	4	5	3	1	3	3	19
Scylla serrata (Forskal)	-	1	-	-	-	-	1
Portunus pelagicus (Linnaeus)	1	-	2	-	2	-	5
Total	36	23	25	15	26	19	144

Table 35

Composition of the catch by bottom trawl at 20 m depth (quantity in Kilograms)

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
ELASMOBRANCHII							
Chiloscyllium sp.	2	-	-	2	-	1	5
Galeocerdo sp.	-	-	-	2	-	1	3
Scoliodon sorrakowah (Cuvier)	1	4	-	1	2	2	10
Dasyatis sp.	-	1	-	-	-	-	1
Rhinoptera sp.	-	1	1	-	-	-	2
TELEOSTOMI							
Chirocentrus dorab (Forskal)	1	2	-	5	2	3	13
Saurida tumbil (Bloch)	1	2	1	1	1	2	8
Tachysurus sp.	1	-	2	2	-	-	5
Ambassis sp.	1	-	1	-	-	1	3
Muraenesox sp.	1	-	-	-	-	-	1
Hemiramphus sp.	1	-	-	-	-	-	1
Sphyraena sp.	1	-	-	-	-	2	3
Megalaspis cordyla (Linnaeus)	1	2	1	-	-	1	5
Lactarius lactarius (Schneider)	4	-	2	-	1	2	9
Nemipterus japonicus (Bloch)	1	3	-	-	2	1	7
Leiognathus splendens (Cuvier)	2	-	-	-	-	-	2
Leiognathus sp.	-	-	2	2	3	1	8
Johnius dussumieri (Cuvier)	1	2	3	2	2	2	12

Cont.....

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
Otolithus sp.	1	1	-	1	1	4	8
Caranx sp.	2	2	1	2	1	1	9
Psettodes erumei (Bloch)	2	-	2	-	-	-	4
Trichiurus sp.	4	-	-	2	-	-	6
Rastrelliger kanagurta (Cuvier)	-	1	-	-	-	-	1
Pampus argenteus (Euphrasen)	2	-	1	-	-	2	5
Parastromateus niger (Bloch)	-	-	-	2	-	3	5
Miscellaneous fishes	5	5	2	2	2	3	19
CRUSTACEA							
Metapenaeus dobsoni (Miers)	2	-	4	3	1	1	11
Metapenaeus affinis (Milne Edw.)	-	-	-	-	1	-	1
Penaeus indicus (Milne Edw.)	-	-	1	-	-	1	2
Parapenaeopsis stylifera Milne Edw.)	2	4	8	4	-	5	23
Total	39	30	32	33	19	39	192

Table 36

Composition of the catch by bottom trawl at 30 m depth (quantity in Kilograms)

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
ELASMOBRANCHII							
Chiloscyllium sp.	-	1	-	1	1	4	7
Scoliodon sorrakowah (Cuvier)	-	2	4	2	1	2	11
Dasyatis sp.	-	-	2	1	1	2	6
Sphyraena zygaena (Linnaeus)	1	-	1	-	-	-	2
Rhinoptera sp.	-	-	-	-	1	-	1
Rhynchobatus sp.	-	-	1	-	1	-	2
TELEOSTOMI							
Chirocentrus dorab (Forskal)	-	2	-	2	2	4	10
Tachysurus sp.	3	-	4	2	1	2	12
Rastrelliger kanagurta (Cuvier)	-	-	1	-	-	2	3
Muraenesox sp.	-	1	-	-	-	-	1
Sphyraena sp.	2	1	-	-	1	2	6
Megalaspis cordyla (Linnaeus)	1	2	2	-	2	1	8
Lactarius lactarius (Schneider)	2	1	-	3	2	3	11
Nemipterus japonicus (Bloch)	5	-	4	5	1	3	18
Leiognathus splendens (Cuvier)	-	5	3	1	2	-	11
Leiognathus sp.	2	2	-	-	5	2	11
Johnius dussumieri (Cuvier)	4	2	-	3	-	-	9
Otolithus ruber (Schneider)	1	3	5	1	1	1	12

Cont....

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
Caranx carangus (Bloch)	1	1	2	1	2	1	8
Caranx sp.	4	-	1	1	2	2	10
Psettodes erumei (Bloch)	-	1	1	2	-	1	5
Trichiurus savala (Cuvier)	5	1	2	2	2	3	15
Pampus argenteus (Euphrasen)	1	1	2	2	1	2	9
Parastromatus niger (Bloch)	2	-	2	1	-	-	5
Anadontostoma chacunda (Hamilton-Buchanan)	1	2	2	1	2	2	10
Cynoglossus puncticeps (Richardson)	3	2	3	3	5	7	23
Cynoglossus sp.	2	1	1	5	-	2	11
Miscellaneous fishes	2	2	3	2	2	3	14
CRUSTACEA							
Metapenaeus dobsoni (Miers)	3	2	2	2	1	5	15
Metapenaeus affinis (Milne Edw.)	-	1	1	2	1	2	7
Metapenaeus sp.	-	1	1	-	-	-	2
Penaeus indicus (Milne Edw.)	-	1	1	1	-	-	3
Penaeus monodon (Fabricius)	-	-	1	-	-	-	1
Parapeneopsis stylifera (Milne Edw.)	-	2	5	7	3	2	19
Total	45	40	57	53	43	60	298

Table 37

Composition of the catch by bottom trawl at 35 m depth (quantity in Kilograms)

Name of the species	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
ELASMOBRANCHII							
Chiloscyllium sp.	-	1	-	1	1	1	4
Galeocerdo sp.	-	-	-	1	-	-	1
Scoliodon palasorrah (Cuvier)	2	2	-	1	1	1	7
Scoliodon sorrakowah (Cuvier)	2	2	-	2	1	2	9
Dasyatis sp.	-	-	1	-	1	-	2
Rhinoptera sp.	-	-	-	-	-	1	1
Rhynchobatus sp.	-	-	-	-	-	2	2
TELEOSTOMI							
Chirocentrus dorab (Forskal)	2	1	3	-	2	-	8
Saurida tumbil (Bloch)	2	-	-	2	2	1	7
Tachysurus sp.	3	-	3	1	3	2	12
Rastrelliger Kanagurta (Cuvier)	1	-	-	-	1	-	2
Megalaspis cordyla (Linnaeus)	2	-	-	-	-	-	2
Lactarius lactarius (Schneider)	2	-	-	2	1	1	6
Nemipterus japonicus (Bloch)	6	3	9	5	2	5	30
Johnius dussumieri (Cuvier)	2	1	2	1	1	2	9
Caranx sp.	1	2	-	2	1	2	8
Psettodes erumei (Bloch)	-	-	-	2	1	1	4

Name of the species	April 1972	Aug.	Dec.	April 1973	Aug.	Dec.	Total
Caranx carangus (Bloch)	2	5	4	2	1	2	16
Caranx sp.	1	-	2	1	2	2	8
Psettodes erumei (Bloch)	2	-	3	1	1	-	7
Trichiurus savala (Cuvier)	2	3	9	-	3	3	20
Pampus argenteus (Euphrasen)	2	-	4	-	2	3	11
Parastromateus niger (Bloch)	1	-	-	2	-	1	4
Saurida tumbil (Bloch)	1	1	2	1	3	-	8
Miscellaneous fishes	-	4	4	3	1	6	18
CRUSTACEA							
Metapenaeus dobsoni (Miers)	2	1	1	-	-	3	7
Metapenaeus affinis (Milne Edw.)	2	1	2	-	2	2	9
Penaeus monodon (Fabricius)	-	-	2	-	-	-	2
Penaeus indicus (Milne Edw.)	1	-	-	1	1	-	3
Parapenaeopsis stylifera (Milne Edw.)	2	1	5	2	1	4	15
Total	43	31	56	35	36	49	250

Table 38

Composition of the catch by bottom trawl at 45 m depth (quantity in Kilograms)

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
ELASMOBRANCHII							
Chiloscyllium sp.	-	1	-	1	-	-	2
Galeocerdo sp.	-	-	-	1	-	-	1
Scoliodon palasorrah (Cuvier)	2	2	-	1	1	1	7
Scoliodon sorrakowah (Cuvier)	2	2	-	2	1	2	9
Dasyatis sp.	-	-	1	-	-	-	1
Rhinoptera sp.	-	-	-	-	-	1	1
Rhynchobatus sp.	-	-	-	-	-	2	2
TELEOSTOMI							
Chirocentrus dorab (Forskal)	2	1	1	-	2	-	6
Saurida tumbil (Bloch)	2	-	-	2	2	1	7
Tachysurus sp.	4	-	1	1	4	2	12
Rastrelliger kanagurta (Cuvier)	1	-	-	-	1	-	2
Megalaspis cordyla (Linnaeus)	2	-	-	-	-	-	2
Lactarius lactarius (Schneider)	2	-	-	2	1	1	6
Nemipterus japonicus (Bloch)	8	2	8	5	2	4	29
Johnius dussumieri (Cuvier)	2	1	1	1	2	2	9
Otolithus ruber (Schneider)	-	2	-	2	1	1	6
Caranx sp.	1	1	-	2	1	2	7
Psettodes erumei (Bloch)	-	-	-	2	1	1	4
Trichiurus sp.	-	1	5	-	2	2	10

Cont.....

Name of the species	Apr. 1972	Aug.	Dec.	Apr. 1973	Aug.	Dec.	Total
Pampus argenteus (Euphrasen)	-	1	-	-	2	1	4
Parastromatus niger (Bloch)	2	1	1	-	-	-	4
Miscellaneous fishes	4	5	5	5	3	5	27
CRUSTACEA							
Metapenaeus dobsoni (Miers)	2	1	4	2	-	1	10
Metapenaeus affinis (Milne Edw.)	-	1	-	-	2	3	6
Penaeus indicus (Milne Edw.)	-	-	2	-	-	-	2
Penaeus monodon (Milne Edw.)	1	-	-	-	-	-	1
Parapeneopsis stylifera (Milne Edw.)	5	2	5	-	3	5	20
Total	42	24	34	29	31	37	197

7.6. Abundance of fish catches by depth

7.6.1. 5 M depth

The average catch per hour return using the above trawl was 32 Kg. On the whole the catch was better in the year 1973 and the maximum catch of 41 Kg was recorded during August 1973. The minimum catch of 21 Kg was observed in August 1972. The combined catch composition was dominated by *C. puncticeps*, *Opisthopterus tardoore* and prawns belonging to the species *P. stylifera* and *M. dobsoni*. There were two species of crabs, *Portunus pelagicus* and *Scylla serrata*.

7.6.2. 10 M depth

The average catch per hour return was as low as 24 Kg. The maximum catch of 36 Kg was recorded in April 1972 and the minimum during August 1973. Apart from all the dominant species which were present at 5 m depth, *L. lactarius*, *A. chacunda* and *Penaeus monodon* were also recorded.

7.6.3. 20 M depth

The average catch per hour return was 32 Kg. The maximum value of 39 Kg was recorded in April 1972 and December 1973, while the minimum of 19 Kg was in August 1973. The catches were dominated by *Scoliodon sorrakowah*, *Chirocentrus dorab*, *Saurida tumbil*, *Megalaspis cordyla*, *L. lactarius*, *Nemipterus japonicus*, Pampus argenteus, Parastromateus niger, M. dobsoni, and P. stylifera. However, there were seasonal fluctuations in the abundance of the different species as evident from the tables.

7.6.4. 30 M depth

The average catch per hour return showed a higher value of 49 Kg., the maximum of 62 Kg recorded in December 1973 and the minimum of 34 Kg in August 1972. The high average value was contributed by the occurance of C. dorab, S. tumbil, L. lactarius, N. japonicus, Caranx sp., Trichiurus sp., C. puncticeps, sciaenids and prawns of the species M. dobsoni and P. stylifera.

7.6.5. 35 M depth

The average catch per hour return showed a higher value of 41 Kg. The maximum value of 56 Kg was recorded in December 1972 and the minimum of 31 Kg was in August of the same year. The important species which contributed to the higher average catch were S. sorrakowah, C. dorab, Tachysurus sp., L. lactarius, N. japonicus, C. carangus, Trichiurus sp., P. argenteus, S. tumbil, Sciaenids and prawns of the species M. affinis and P. stylifera.

7.6.6. 45 M depth

The average catch per hour return showed a declining trend and the value was 33 Kg. The maximum value of 42 Kg was recorded in April 1972 and the minimum value of 24 Kg was observed in the same year during August. Eventhough almost all the major species were recorded here, N. japonicus, Tachysurus sp., and Trichiurus sp. dominated the catches M. dobsoni and P. stylifera were the dominant of species of prawns.

7.7. Depth-wise distribution pattern

The comparative richness of the grounds, surveyed from the view point of different constituents of the catch has been evaluated. The catch mainly consisted of elasmobranchs, bony fishes and crustaceans with percentage composition of 11%, 69% and 20% respectively. Based on the abundance and catch per hour return of the different species, the fishing ground trawled can be broadly divided into three zones viz. (i) 5-20 m zone (ii) 30-35 m (iii) 45 m. The second depth zone is found more productive contributing 43% of the total catch which is lying beyond the influence of the mud bank formation. The catch composition and abundance of fishery from near shore depths in other fishing grounds have also been examined from other fishing vessels of the institute which does not show any significant difference, from the profile selected for the present study. It is seen that the average catch in two years combined, recorded higher values in April and December corresponding to premonsoon and postmonsoon periods than the average catch value in August which corresponds to the monsoon period. In April the mean value ranged between a maximum of 49 Kg at 30 m depth to a minimum value of 26 Kg at 10 m depth. In December the maximum mean value was 60 Kg at 30 m depth and the minimum value was 22 Kg at 10 m depth. The catches in August showed a maximum value of 41 Kg at 30 m depth and a minimum value of 25 kg at 10 m and 20 m depth.

The studies conducted by the Central Marine Fisheries Research Institute (CMFRI) has indicated that the fishing is showing a regular declining trend in the Alleppey mud bank from 1973 onwards, even though the occurrence of the mud bank is an annual phenomenon, proving that the formation of the mud bank and the fishery in these regions are not inter-dependent (Table 39). Rao et al (1980) in their recent studies on the physical and biological aspects of the mud banks have observed that a major portion of the catch landed at the mud banks belong to areas far away from the limits of the mud banks. According to their observation, the success of the fishery depends on the movement of the fish shoals and the professional efficiency and skill of the fishermen to locate them and catch. Since the mud banks are calm during the south-west monsoon, the fishermen are able to catch fish from these regions especially during the monsoon without getting involved in risk to their life and fishing implements. It is further reported that the dominance of different species of prawns and fishes are not characteristic features of the mud bank region alone but occuring in other areas also if fishing could be undertaken there.

Table 39

Trends of production of prawns in the mud bank fishery at Porakkad Thottappally (Alleppey) area during 1972 - 1979

Years	Prawn catch in tonnes	Fishing effort in hours	CPUE in Kg.
1972	1186.9	75,505	15.7
1973	4284.8	45,009	95.2
1974	444.0	10,680	41.6
1975	1171.4	58,819	19.9
1976	489.9	47,169	10.4
1977	154.6	45,367	3.4
1978	69.8	49,040	1.4
1979	29.2	18,346	1.6

Source: Marine Fisheries Information Service (CMFRI) No. 12, October 1979

8. SUMMARY

1. The present study was undertaken with the objectives to assess the distribution and density of population of benthic animals with special reference to macrofauna from the south west coast of India from Malippuram in the north to Alleppey in the south, to evaluate significant difference, if any, in the number and distribution of animals in the mud bank regions and other intermittant stations, to examine the influence of bottom stability on the distribution of fauna, to observe the effect of the environmental parameters on the distribution pattern of macrofauna, and to evaluate the nature and depth-wise distribution of the benthic fishery. The region selected for the investigation is one of the most important fishing grounds in India for bottom fishing especially for prawns, covering a distance of about 60 kms in length.

2. A total number of thirty stations in five transects at right angles to the coast, each consisting of six stations were surveyed. The six stations in a transect were at depths of 5 m, 10m, 20m, 30m, 35m and 45m respectively. Bottom deposits and water samples from surface and bottom have also been collected from each station to study the environmental parameters. The investigation was carried out during the years 1972 and 1973 and the collection of the samples corresponded to pre-monsoon, monsoon and post-monsoon periods.

3. The formation of the mudbanks, popularly known as 'Chakara' in the local language, is a peculiar phenomenon along the coast of Kerala and provides a good fishing ground. The profiles of the present study consisted of three mudbanks and an intermediate region so as to make comparisons in the abundance of macrofauna in the two types of grounds. The mudbanks at Alleppey was observed to be the most prominent. The various theories put forward by different workers and other aspects of the problem have been discussed.

4. The hydrographic studies showed that the maximum surface temperature of 32.0°C was recorded at station No.2 of the first profile and station No.19 of the fourth profile during the premonsoon period in 1973. The minimum bottom temperature of 23°C was recorded at stations 22, 23, 24 of the fourth profile and station 30 of the fifth profile which lie near the Cochin bar mouth. The salinity values dropped appreciably in the surface and bottom waters of some stations in the fourth and fifth profiles, which can be attributed to the proximity of these stations to the outlet of backwaters and flood waters (Cochin) during the monsoon period. The oxygen values were lower during August which may be due to upwelling and its effect on the hydrographic conditions.

5. The sediments were found very soft and loose in consistency up to the 10 m line especially in the first, second,

fourth and fifth profiles, where the mudbanks appeared. Based on the nature of the percentage distribution of the different fractions of the sediment, the region of investigation was broadly divided into two zones: i.e. region within 30 m depth and region beyond 30 m to 45 m depth. The stations within 30 m depth showed high values of clay content with good percentage of sand. The amount of sand was always less than 20% in all the stations within this depth. The values of clay fractions decreased and sand particles increased in the stations beyond the 30 m line. The value of sand fraction varied between 43.94% and 96.1%. The higher values of organic matter were observed in the nearshore stations of 2,4,7,8 and 25 particularly in the mudbank regions have been discussed. The maximum value of 3.47 was recorded at station 2 and the minimum value of 1.32 was observed at station 13

6. The analysis of the bottom fauna indicated that most of the organisms belonged to three groups: Annelida, Crustacea and Mollusca. A few species of Coelenterata, Nemertini, Echinodermata and Echiuroidea were also present. The most dominant species of polychaetes were <u>Amphicteis gunneri</u>, <u>Sternaspis scutata</u>, <u>Lepidonotus jacksoni</u>, <u>Lumbriconereis biflaris</u>, <u>Glycera longipinnes</u>, <u>Eunice indica</u> and <u>Magelona longicornis</u>. The crustacean fauna was mostly constituted by amphipod species

Ampelisca scabripes, A. tridens, A. brevicornis, A. cyclops, Byblis gaimardi and Idunella sp. The molluscan fauna was represented by three species of gastropods and seven species of bivalves, the most dominant species was the bivalve Nucula sp. The other bivalves collected included Tellina emarginata, Chione tiara, Arca inaequivalvis, A. tortuosa, Barnea sp., Modiolus sp., Macoma sp. and Solariella sp. The gastropods were represented by Conus sp. and Nassarius sp. Among the 'other groups' of animals the echiuroid Ochaetostoma septemyotum was the most predominant.

7. The quantitative distribution of the macrofauna showed that the maximum number of organisms was near the 35 m contour line in the first three profiles whereas in the fourth and fifth profiles it was at 20 m and 30 m depth respectively. The density of the fauna was comparatively poor in shallow water stations at depths 5-10 m. There is no significant variation in the faunal assemblage and intensity in the different profiles. The maximum number of animals however was recorded from a station in the third profile which is located outside the influence of the mudbank. As a whole the values of biomass were higher in deeper stations except in the third profile, where the shallowest station 13 showed high value.

8. The percentage composition study of the different groups indicated that the polychaetes formed an average value of

75.5%; the crustaceans varied from a minimum of 0.8% to a maximum of 46.15%, while the value of molluscan fauna varied from a minimum of 1.3% to a maximum of 31.4%.

9. There was a general decline in the numerical abundance and biomass of the bottom fauna in all the stations during the monsoon period. There has been very little yearly change in the composition of the fauna during the two years' study.

10. The influence of organic matter and the different fractions of the sediment composition on the fauna has been discussed. The absence of any significant difference in the number and weight of animals in the stations of profiles A, B, D, E (mud banks included) and profile C (outside mud banks) showed that higher content of organic materials available in the sediment was not the only decisive factor which determined the standing crop. The effect of bottom stability on the distribution of benthos has been studied. The comparatively lower values in the population density of macrofauna in the near shore regions especially in the mudbank regions, emphasises that a stable substratum free from undue disturbance is necessary for the benthic life to flourish. A stable substratum in the mud bank regions is not possible due to the fluid nature of the mud, mobility of the mudbanks and possibly due to heavy fishing activity particularly bottom trawling.

11. The absence of any predominant species and the occurrence of other animals in smaller numbers rule out the possibility of any clear indication of any particular community existence in the area. The role of the environmental parameters and the stability of the bottom have been discussed with reference to the maintenance of community development.

12. In the context of describing the fishery from the region of the investigation, general composition of the marine fisheries resources of India has been dealt with. In the present study, the Alleppey mudbank was selected for field observations of the fish landings. The dug-out canoes and the boat seines known as 'thanguvala' were the indigenous crafts and gears used by the local fishermen to capture fish and prawns from the mudbanks and near by areas. The species-wise composition and the quantity landed by the country crafts were observed for three consecutive days in the second weeks of June, July and August in the years 1972 and 1973 which are the active periods of mud bank formation. The pattern of fish distribution showed dominance of certain species in different days. The fishes were composed of both bottom and off-bottom varieties represented by C. puncticeps, S. tumbil, Otolithus sp. and other sciaenids, elasmobranchis like S. sorsakowah and Chilscyllium sp., L. lactarius, A. chacunda, C. dorab,

S. longiceps, *R. kanagurta*, *Leiognathus* sp., *Caranx* sp., etc. The crustaceans of commercial importance were *P. indicus*, *M. dobsoni*, *M. affinis* and *P. stylifera*.

13. A four seam commercial bottom trawl net of size 32 m head rope length was operated at depths ranging from 5 to 45 metres at profile E where the Malipuram mudbank is located to collect data for evaluating the fishery qualitatively and quantitatively. The bottom trawl net was operated for one hour duration at each station. The data was helpful to make a comparative productivity study of the different stations in the mudbank region and outside its influence.

14. The analysis of the trawl catch at different depths showed that the fishery was composed of three major groups, Elamobranchii, Teleostomii and Crustacea-with percentage composition of 11%, 69% and 20% respectively. The important species of elasmobranchii collected belonged to the species *S. sorrakowah*, *S. palasorrah*, *S. zygaena*, *Galeocerdo* sp., *Dasyatis* sp. *Rhinoptera* sp. and *Rhyncobatus* sp. The Teleostomii was represented by a number of species, the important among them being *N. japonicus* *C. dorab*, *J. dussumieri*, *Otolithus* sp., *S. tumbil*, *Tachysurus* sp., *T. savala*, *L. lactarius*, *M. cordyla*, *P. crumei* *Leiognathus* sp., *Caranx* sp., *P. argenteus*, *P. niger*, *C. puncticeps*,

A. chacunda, Tachysurus sp. and other miscellaneous fishes. The crustaceans were dominated by the important commercial species composed of P. indicus, P. monodon, M. affinis, M. dobsoni, and P. stylifera.

15. The maximum, minimum and mean values of catch per hour return in each station have been recorded for the two years of observation. It is seen that the average catch in two years combined recorded higher values in April and December correspondingly to premonsoon and postmonsoon periods than the average catch value in August which corresponds to the monsoon period. In April the mean value ranged between a maximum of 49 Kg at 30 m depth to a minimum value of 26 Kg at 10 m depth. In December the maximum mean value was 60 Kg at 30 m depth and the minimum value was 22 Kg at 10 m depth. The catches in August showed a maximum value of 41 Kg at 30 m depth and a minimum value of 25 Kg at 10 m depths.

16. Based on the abundance and catch per hour return of the different species, the fishing ground trawled was divided into three zones viz. (1) 5-20 m zone (ii) 30-35 m zone (iii) 45 m zone. The second depth zone was found to be more productive contributing 43% of the total catch which was lying beyond the influence of the mudbank formation. The catch composition of the fishery from near shore depths in other fishing grounds have

also been examined from other fishing vessels of the institute which does not show any significant difference from the profiles selected for the present study.

17. The analysis of the trawl fishery data emphasises the observation made by other workers that the formation of the mudbank and the fishery in these regions are not interdependent.

9. REFERENCES

Ajmal Khan, S, E. Vivekanandan and K. Balasubrhamanyan 1975 Bottom fauna in two regions of the Vellar Estuary. Recent Researches in Estuarine Biology. . Natarajan (Ed.) Hindustan Publishing Corporation, Delhi-1.

Allen, E.J 1899 On the fauna and bottom deposits near the thirty-fathom line from the Eddystone to Start Point. J. mar. biol. Assoc. U.K. 5: 365-542.

Allee, W.C 1934 Concerning the organisation of marine coastal communities. Ecological Monograph; 4: 541-554.

Aller, R.C. and R.E. Dodge 1974 Animal-sediment relations in a Tropical Lagoon, Discovery Bay, Jamaica. J. Mar. Res. 32(2): 209-232.

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

Annandale, N. and S. Kemp 1916 'Fauna of the Chilka Lake. Mollusca, Gastropods and Lamellibranchiata, with an account of the anatomy of the common solon. Mem. Indian Mus. 5(4): 327-374.

Anon 1977 Indian Fisheries, 1947-1977. Issued on the occasion ofthe Indian Ocean Fishery Commission held at Cochin from 19th to 26th October, 1977.

Anon 1978 All India marine fisheries census Frame survey 1973-'77. Mar. Fish. Infor. Serv. T & E. Ser. 3: 1-14.

Ansari, Z.A, A.H. Parulekar, S.N.Harkantra and S. Ayyappan Nair	1977	Shallow water macrobenthos along the Central West Coast of India. Mahasagar (10 (3 & 4): 123-127.
Ansari, Z.A, S.N. Harkantra, S.A. Nair and A.H. Parulekar	1977	Benthos of the Bay of Bengal. A preliminary account. Mahasagar 10: (1 & 2) 55-60.
Bader, R.G	1954	The role of organic matter in determining the distribution of pelecypods in marine sediments. J. mar. Res. 13: 32-47.
Banse, K	1959	On upwelling and bottom trawling off the South West Coast of India. J. mar. biol. Ass. India. 1: 33-49.
Banse, K	1968	Hydrography of the Arabian Sea shelf of India and Pakistan and effects on demersal fishes. Deep Sea Res., 15: 45-79.
Barnes, H	1959	Apparatus and methods of Oceanography Part I. George Allen and Unwin, London.
Birkett, L. and A.D. McIntyre	1971	Methods for the study of marine benthos, IBP handbook No.16. Treatment and sorting of samples, Blackwell Scientific Publications, Oxford and Edinburgh, 157 pp.
Bloom, S.A, J.L. Simon and V.D.Hunter	1972	Animal sediment relation and community analysis of a Florida estuary. Mar. Biol. 13: 43.
Blegvad, H	1928	Quantitative investigations of bottom invertebrates in Limfjord 1910-1927 with special reference to the plaice-food Rept. Dan. Biol. Sta. 34: 33-52.

Blegvad, H	1951	Fluctuations in the amounts of food animals of the bottom of the Limfjord in 1928-1950. Rept. Dan. Biol. Sta. 53: 3-16.
Brett, E.C	1963	Relationship between marine invertebrate infauna distribution and sediment type distribution on Bogue Sound, North Carolina (Doctoral Thesis) Univ. of North Carolina, Chapel Hill, North Carolina.
Bristow, R.C	1938	History of Mud Banks, 1 and 2. Cochin Government Press, Ernakulam.
Brown, T.J. and J.R. Sibert	1977	Food of some benthic harpacticoid copepods. J. Fish. Res. Board Can. 34: 1028-1031.
Bruce, S.M	1967	Stomach contents of adult starry flounder and sand sole in East Sound Orcas Island, Washington. J. Fish. Res. Bd. Can. 24(12): 2515-2526.
Buchanan, J.B	1971	Sediments. In Methods for the Study of Marine Benthos. N.A. Holme and A.D. McIntyre (ed). Blackwell Scientific Publications, Oxford and Edinburgh. I.B.P. Hand Book 16: 30-52.
Buchanan, J.B. and R.M. Warwick	1974	An estimate of benthic macrofaunal production in the offshore mud of the Northumberland coast. J. mar. biol. Ass. U.K. 54: 197-222.
Buchanan, J.B, P.F.Kingston and M. Sheader	1974	Long term population trends of the benthic macrofauna in the offshore mud of the Northumberland coast. J. mar. biol. Ass. U.K. 54: 785-795.

Carruthers, J.N, S.S.Gogather, J.R.Naidu and T.Leevastu — 1959 — Shoreward upslope of the layer of minimum oxygen off Bombay: its influence on marine biology, especially fisheries. Nature Lond. 183: 1084-1087.

Chidambaram, K and M.D.Menon — 1945 — The correlation of West Coast fisheries with plankton and certain oceanographic factors Proc. Indian Acad. Sci. B., 22: 335-367.

Cowles, R.P — 1930 — A biological study of the offshore waters of Chesapeake Bay. Bull. of the U.S. Bureau of Fisheries. 46: 277-381.

Cuff, W and N. Coleman — 1979 — Optimal survey design: Lessons from a stratified random sample of macrobenthos. J. Fish. Res. Board Can. 36: 351-361.

Damodaran, R. and C. Hridayanathan — 1966 — Studies on the mud banks of the Kerala Coast. Bull. Dept. Mar. Biol. Oceanogr. Univ. Kerala, 2: 61-68.

Damodaran, R — 1973 — Studies on the benthos of the mud banks of the Kerala Coast. Bull. Dept. Mar. Sci. Univ. Cochin, 6: 1-126.

Darbyshire, M. — 1967 — The surface waters off the coast of Kerala, South-west India Deep Sea Res., 14: 295-320

Darnell, R.M. — 1967 — Organic detritus in relation to the estuarine ecosystem Estuaries (Ed) by G.H.Lauft Publs. Am. Ass. Advant. Sci. 83: 376-382.

Davis, F.M — 1923 — Quantitative studies on the fauna of the sea bottom No.1. Preliminary investigations of the Dogger Bank Min. Agric. Fish. Fish. Invest. Ser. 11, 6(2): 1-54.

Davis, F.M — 1925 — Quantitative studies on the fauna of the sea bottom No.2 Results of the investigations in the southern North sea, 1921-24. Min. Agric. Fish. Fish. Invest. Ser. 2, 8(4): 1-50.

Desai, B.N. and M. Krishnankutty	1967	A comparison of the marine and estuarine benthic fauna of the near-shore regions of the Arabian sea, symposium on the Indian Ocean. Bull. Nat. Inst. Sci. India, 1969 38(II), 677-683.
Dexter, R.W	1944	The bottom community of Ipswich Bay, Massachusetts. Ecology 25(3) 325-359.
Dexter, R.W	1947	The marine communities of a tidal inlet at Cape Ann, Massachusetts: a study in bio-ecology. Ecological monographs, 17: 261-294.
Dora, Y.L, R.Damodaran and V. Jos Anto	1968	Texture of the Narakkal mud bank sediments. Bull. Dept. Mar. biol. Oceanogr. Univ. Kerala, 4: 1-10
Driscoll, E.G	1975	Sediment - animal - water interaction Buzzards Bay, Massachusetts J. Mar. Res. 33(3): 275-302.
Ducane, C.G, R.C. Bristow, C. Coggin Brown, B.A.Keen and E.W. Russel	1938	Report of the Special Committee on the movement of Mud Banks. Cochin Government Press 57 pp.
Dwivedi, S.N, A. Rahim and S. Ayyappan Nair	1973	Ecology and production of intertidal sand fauna during south-west monsoon along Mandovi estuary (Goa) Recent Researches in Estuarine Biology, R. Natarajan (Ed). Hindustan Publishing Corporation, Delhi
Dwivedi, S.N, P.A.Lokabharathi and V.M.A.Hakkim	1975	Benthic studies in the envirous of a sewage outfall Panjim, Goa. Shipping and Marine Industries Journal, 3(3): 63-64.
El Wakeel, S.K and J.P. Riley	1956	The determination of organic carbon in marine muds. J. Cons. Perm. Unit. Explor. Mer. 22: 180-183.

Estcourt, I.N 1968 A note on the fauna of a ripple-marked sandy sediment in Western Cook Strait, New Zealand New Zealand Journal of Marine and Fresh Water Research, 2: 654-658.

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

Ford, E 1923 Animal communities of the level sea-bottom in the waters adjacent to Plymouth. Journ. mar. biol. Assoc. U.K. 13: 164-224.

Fox, D.L 1950 Comparative metabolism of organic detritus by inshore animals. Ecol. 31: 100-108.

Frederick Grassle, J and Judith P. Grassle 1974 Opportunistic life histories and genetic systems in marine benthic polychaetes. J. Mar. Res. 32(2): 253-284.

Gage, J 1972a A preliminary survey of the benthic macrofauna and sediments in lochs Etive and Creran sea-lochs along the west coast of Scotland. J. mar. biol. Ass. U.K. 52: 237-276.

Gage, J 1972 b Community structure of the benthos in Scottish sea-lochs - 1 Introduction and species diversity Mar. Biol. 14: 281-297.

Gage, J 1974 Shallow water zonation of sea-loch benthos and its relation to hydrographic and other physical features. J. mar. biol. Ass. U.K., 54: 223-249.

Ganapati, P.N. and C. Gopinatha Rao 1953 Observations on the seasonal variation on phytoplankton production on Indian Coast with special reference to the Waltair Coast. Proc. 40th Indian Sci. Congr. Part III, Abs. p. 184.

Ganapati, P.N. and V.S.R. Murthy	1954	Salinity and temperature variation of the surface waters off Visaghapatnam Coast. Andhra Univ. Mem. Oceanogr. 1: 125-141.
Ganapati, P.N. and V.S.R. Murthy	1955	Preliminary observations on the hydrography and inshore plankton in the Bay of Bengal of Visaghapatnam coast. Indian J. Fish., 2: 84-95.
Ganapati, P.N. and D.V.E. Rama Sarma	1958	Hydrography in relation to the production of plankton off the Vishaghapatnam Coast. Andhra Univ. Mem. Oceanogr. 2: 168-192.
Ganapati, P.N. and M.V. Lakshmana Rao	1959	Preliminary observation on the bottom fauna of the continental shelf of the north-east coast of India. Proceedings of the First All India Congress of Zoology, Part III 8-13.
Ganapati, P.N. and G. Chandrasekhara Rao	1962	Ecology of the interstitial fauna inhabiting the sandy beaches of Waltair coast. J. Mar. biol. Ass. India, 4: 44-57.
Garner, J	1977	Conservation and the choice of fishing gear. Fishing News International 16(9): 50-51.
George, P.C	1953	The marine plankton of the coastal waters off Calicut with observations on the hydrological condition. Jour. Zool. Soc. India, 5: 76-107.
George, J.D	1964	Organic matter available to the polychaete Cirriformia tentaculata (Montagu) living in an intertidal mud flat. Limnol. Oceanogr. 9: 453-455.

Hobson, K.D	1967	The feeding and ecology of two north Pacific Abarenicola species (Arenicolidae, Polychaeta) Biol. Bull. 133: 343-354.
Holme, N.A	1950	The bottom fauna of Great West Bay. J. mar. biol. Ass. U.K. 29: 163-183.
Holme, N.A	1953	The biomass of the bottom fauna in the English channel off Plymouth. J. mar. biol. Ass. U.K. 32(1): 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 Adv. mar. biol. 2: 171-260.
Holme, N.A	1967	Changes in the bottom fauna of Weymouth Bay and Poole Bay following the severe winter of1962-63. J. mar. biol. Ass. U.K. 47: 397-405.
Holme, N.A. and A.D.Mc Intyre	1971	Methods for the Study of Marine Benthos. IBP Hand Book No.16. Blackwel Scientific publications Oxford and Edinburgh.
Hughes, T.G	1979 a	Studies on the sediment of St.Margaret's Bay, Nova Scotia. J. Fish. Res. Board. Can. 36: 529-536.
Hughes, T.G	1979 b	Mode of life and feeding in maldanid polychaetes from St. Margaret's Bay, Nova Scotia J. Fish. Res. Board. Can. 36: 1503-1507.
Jackson, J.B.C	1972	The ecology of the molluscs of Thalassia communities. Jamaica, West Indies II. Molluscan population variability along an environmental stress gradient. Mar. Biol. 14: 304-337.
Jayaraman, R	1951	Observation on the chemistry of the waters of the Bay of Bengal off Madras City during 1948-49. Proc. Indian Acad. Sci. B. 33: 92-99.

Jayaraman, R	1954	Seasonal variations in salinity, dissolved oxygen and nutrient salts in the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam (S. India) Indian J. Fish. 1: 245-364.
Johnson, R.G	1970	Variation in diversity within benthic marine communities. Am. Nat. 104: 285-300.
Jones, N.S.	1950	Marine bottom communities Biol. Rev. 25: 283-315.
Jones, N.S	1951	The bottom fauna off the south of the Isle of Man Journ. Anim. Ecol. 20: 132-144.
Jones, N.S	1952	The bottom cauna and the food of flat fish off the Cumberland coast. Journ. 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.
Kagwade, P.V	1965	Study on the biology and fishery of Polynemus heptadactylus Cuv. and Val. Ph.D. Thesis, Bombay University.
Karandikar, K.R and S.S. Thakur	1951	Sciaenoides brunneus Day (anatomy with notes on distribution and bionomics) Zool. Mem. Univ. Bombay. 3: 1-89.
Kempf.M	1970	Notes on the benthic bionomy of the N-NE Brasilian shelf. Mar. biol. 5: 213-224.
Kirsop, F.M	1922	Preliminary study of methods of examining the life of the sea bottom. Publication of the Puget Sound Marine (Biological) station of the University of Washington. 3: 129-139.

Krumbein, W.C. and F.J. Pettijohn 1938 Manual of Sedimentary Petrography, Appleton Centuary - Crafts, Newyork, pp. 549.

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

Kurian, C.V 1966 Studies on the benthos of the South-west coast of India Bull. Nat. Inst. Sci. India, 38(2): 649-656.

Kurian, C.V 1971 Distribution of benthos on the south-west coast of India. In: Fertility of the Sea Vol. 1 J.D. Costlow (Jr.) (Ed), Gordon and Breach Scientific Publication, Newyork, 225-239.

Kurian, C.V 1973 The problems of the littoral region of the south-west coast of India Journal of the Indian Fisheries Association 3: 108-112.

Kurup, P.G 1977 Studies on the physical aspects of the mud banks along the Kerala Coast with special reference to the Purakkad Mud Bank. Bull. Dept. Mar. Sci. Univ. Cochin. 8: 1-72.

Kurup, N.S 1979 The mud bank prawn fishery of Kerala - Declining trend. Mar. Fish. Infor. Serv. T & E Ser. No. 12: 12-13.

Kuthalingam, M.D.K 1963a Observations on the fishery and biology of the Pomfret, Pampus argenteus Euphrasen from the Bay of Bengal. Indian J. Fish. 10(1) A: 59-74.

Kuthalingam, M.D.K 1963b Some observations on the fishery and biology of Kurtus indicus. Indian J. Fish. 10(1) A: 159-166.

Kuthalingam, M.D.K. and A Chellam	1970	Results of the Exploratory Trawl Fishery off Cannanore by the Indo Norwegian Project vessels. Indian J. Fish. 17(1): 156-164.
Lafond, E.C	1954	On upwelling and sinking of the east coast of India. Andhra Univ. Mem. Oceanogr. 1: 117-121.
Lafond, E.C	1958a	Upwelling in the Bay of Bengal. Proc. Ninth Pacif. Sci. Congr. 1957: 16.
Lafond, E.C	1958b	Seasonal cycle of sea surface temperature and salinities along the east coast of India Pacific Sci. Congr. 1957: 12-21.
Lafond, E.C. and A.T.Moore	1972	Sea temperature variations off the east coast of India Indian J. Mar. Sci. 1: 63-65.
Levinton, J.S. and R.K.Bambach	1970	Some ecological aspects of bivalve mortality patterns. Amer. J. Sci. 268: 97-112.
Lie, U	1969	Standing crop of benthic infauna in Puget Sound and off the coast of Washington J. Fish. Res. Bd. Can. 26: 55-62
Longbottom, M.R	1970	The distribution of Arenicola marina (L) with particular reference to the effect of particle size and organic matter in the sediment J. Exp. Mar. Biol. Ecol. 5: 138-157.
Loosanoff, V.L	1962	Effect of turbidity on some larval and adult bivalves. Proc. Gulf. Caribb. Fish. Inst. 14th Ses: 80-95
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 Science Ed. Harold Barnes pp.429-467.

Makato Tsuchuja and Yasuchi Kurihara	1980	Effect of the feeding behaviour of macrobenthos on changes in environmental conditions of intertidal flats. J. Exp. mar. Biol. Ecol. 44: 85-94.
Malpas, A.H	1926	The marine biological survey of the litteral waters of Ceylon. Ceylon J. Sci. Section C. Fisheries 2: 13-165.
Mangum, C.P, S.L. Santos and W.R. Rhodes	1968	Distribution and feeding in the Onuphid polychaete, Diopatra cuprea (Bosc). Marine Biol. 2: 33-40.
Mare, M.F	1942	A study of a marine benthic community with special reference to the macro-organisms. J. Mar. biol. Ass. U.K. 25: 517-554.
Margelof, R	1968	Perspectives in ecological theory. Univ. Chicago Press, Chicago, 111 pp.
Masse, H	1972	Quantitative investigations of sand bottom macrofauna along the Mediterranean north-west coast. Mar. Biol. 15: 209-220.
Mattiat, B, J. Peters and F.J. Eckhard	1973	Results of petrographical analyses on sediments from the Indian Pakistan continental margin(Arabian Sea) Meteor Forschung sergebruisse, Reiche C, No. 14 1-50.
McIntyre, A.D. and A. Eleftheriov	1968	The bottom fauna of a flat fish nursery ground. J. mar. biol. Ass. U.K. 48:113-142.
Menon, K.S	1931	A preliminary account of the Madras plankton. Rec. Indian Mus. 33: 489-516.
Menon, M.D. and K.M. Joseph	1969	Development of Kalava (Rock Cod) fishery of South West Coast of India - A prospectus. Sea Food exp. Jour. 1(2) 7-28.

Menon, M.D, C.P. Varghese and C. Haridas	1977	Development of trap fishing for rock Cod off South west coast of India. Sea Food exp. Jour. 9(1): 5-13
Mills, E.L	1967	The biology of an ampeliscid amphipod crustacean siblina species pair. J. Fish. Res. Bd. Can. 25: 305-355.
Mohammed, K.H	1955	Preliminary observations on the biology and fishery of the threadfin Polydactylus indicus in the Bombay and Saurashtra waters. Indian J. Fish. 2: 164-179.
Mohamed, K.H. and C.Suseelan	1973	Deep-sea prawn resources off the southwest Coast of India. Proc. Symp. Living Resources off the seas around India, Spl. Pub. CMFRI: 614-633.
Naiman, R.J. and J.R.Sibert	1979	Detritus and juvenile salmon production in the Nanaimo Estuary III. Importance of detrital carbon to the estuarine ecosystem. J. Fish. Res. Board. Can. 36: 504-520.
Nair, N.B. and A.D. Ansell	1968	Characteristics of penetration of the substratum by some marine bivalve molluscs. Proc. Malac. Soc. Lond. 38: 179-197.
Newell, N.D, J. Imbrie, E.G. Purdy and D.L. Thurber	1959	Organism communities and bottom facies Great Bahama Banks Bull. Am. Mus. Nat. Hist. 117:183-228.
Newell, R	1965	The role of detritus in the nutrition of two marine deposit feeders, the Prosobranch Hydrobia ulvae and the bivalve Macoma baltica. Proc. Zool Soc. Lond. 144: 25-45.
Neyman, A.A	1973	Shelf benthos in the northern part of the Indian Ocean. Soviet Fisheries Investigations in the Indian Ocean (Ed) by A.D. Bogdanov. I.P.S.T. Jerusalem 52-61.

Nichols, F.H	1970	Benthic polychaete assemblages and their relationships to the sediment in Port Madison, Washington Mar. Biol. 6: 48-57.
Parker, R.H	1956	Micro invertebrate assemblages as indicators of sedimentary environments in East Mississippi Delta region. Bull. American Ass. Petrol. Geol. 40(2): 295-376.
Parulekar, A.H	1973	Quantitative distribution of benthic fauna on the inner shelf of Central West Coast of India. Indian J. Mar. Sci. 2: 113-115.
Parulekar, A.H. and S.N. Dwivedi	1974	Ecology of benthic production during South-west Monsoon in an estuarine complex of Goa. In Recent Researches in Estuarine Biology, Hindustan Publishing Corporation (1), New Delhi. 21-30.
Parulekar, A.H. and A.B. Wagh	1975	Quantitative studies on benthic macrofauna of North-Eastern Arabian Sea-shelf. Indian J. mar. sci. 4(2): 174-176.
Parulekar, A.H, S.A.Nair, S.N. Harkantra and Z.A.Ansari	1976	Some quantitative studies on the benthos off Bombay. Mahasagar (9) (1 & 2): 51-56.
Parulekar, A.H, V.K.Dhargalkar and S.V.S.Singbal	1980	Benthic studies in Goa estuaries. Part III - Animal cycle of macrofaunal distribution, production and trophic relations. Indian J. Mar. Sci. 9: 189-200.
Patnaik, S	1971	Seasonal abundance and distribution of bottom fauna of the Chilka lake. J. mar. biol. Ass. India 13(1): 106-125.
Petersen, C.G.J and P. Boysen-Jensen	1911	Animal life of the sea bottom, its food and quantity Rep. Danish biol. St. 20: 1-81.

Petersen, C.G.J 1913 The animal communities of the sea bottom and their importance for marine zoogeography. Rep. Danish Biol. Stn. 21: 1-44.

Petersen, C.G.J 1918 The sea bottom and its production of fish food. Rep. Danish. Biol. Stn. 25: 1-62.

Pomeroy, L.R 1974 The Ocean's food web, a changing paradigm. Bio Science. 24: 499-504.

Prasad, R.R 1952 Preliminary observations of the temperature gradients and light penetration in upper 200 feet of water in the Bay of Bengal. Proc. Indian Acad. Sci. 4(36): 61-69.

Probert, P.K 1975 The bottom fauna of China clay waste deposits in Mevagissey Bay. J. mar. biol. Ass. U.K. 55: 19-44.

Purdy, E.G 1964 Sediments as substrates. In Approaches to Paleoecology, J. Imbric and N.D. Newell, 238-271.

Qasim, S.Z 1972 The dynamics of food and feeding habits of some Marine fishes Indian J. fish. 19 (1 & 2): 11-28.

Quayle, D.B. 1949 Movements in Venerupis (Paphia) Pullastra (Montagu) Proc. Malac. Soc. Lond. 28: 31-37.

Radhakrishna, Y and P.N.Ganapati 1968 Fauna of the Kakinada Bay. Bull. of Nat. Inst. Sci. India (38): 49-79.

Rajan, S 1971 Environmental studies of the Chilka Lake -2. Indian J. Fish. 12(2): 492-499.

Ramamurthy, S 1953 Seasonal changes in the hydrogenation concentration and dissolved oxygen content of the surface waters of Madras Coast. J. Madras Univ. 23: 52-60.

Ramasastry, A.A. and P. Myrland	1959	Distribution of temperature, salinity, and density in the Arabian sea along South Malabar Coast (South India) during the post-monsoon season *Indian J. Fish*. 6(2): 223-255.
Ramamirtham, C.P. and R. Jayaraman	1960	Hydrographical features of the continental shelf waters off Cochin during the years 1958 and 1959 *J. mar. biol. Ass. India*. 2: 199-207.
Ramamirtham, C.P. and D.S.Rao	1973	Studies on upwelling along the west coast of India *J. mar. biol. Ass. India*. 15(1): 306-317.
Rangarajan, K	1970	Food and feeding habits of the snapper *Lutianus kasmira* (Forskal) from the Andaman Sea *Indian J. Fish*. 17(2): 43-52
Rao, S.V.S. and V.C.Rao	1962	Studies on diurnal variation in the hydrobiological condition of the Waltair coast. *J. mar. biol. Ass. India*. 4: 23-43.
Rao, K.S	1964	Food and feeding habits of fishes from trawl catches in the Bay of Bengal with observations on diurnal variation in the nature of the feed *Indian J. Fish*. 11(1): 277-314
Rao, D.S	1967	The mud banks of the West Coast of India. *Souvenir*: 20th Anniversary Central Marine Fisheries Research Institute (Government of India) 99-102. (pp 1-132)
Rao, A.V.P	1967	Some observation on the biology of *Penaeus Indicus* H. Milne Edwards and *Penaeus monodon* Fabricius from the Chilka Lake *Indian J. Fish*. 14(1): 251-270.
Rao, P.V. and M.J.George	1973	Deep sea spring lobster, *Puerulus sewelli* Ramadan; its commercial potentialities *Proc. Symp. Living resources of the seas around India Spl. Pub. CMFRI*. 634-640.

Rao, D.S, C.P.Ramamirtham and T.S.Krishnan	1973	Oceanographic features and abundance of Pelagic fisheries along the west coast of India Proc. Symp. Living Resources of the seas around India Spl. Pub. CMFRI 400-413.
Rao, D.S. and C.P.Ramamirtham	1974	Seasonal variations in the hydrographic features along the south west coast of India Indian J. Fish. 21(2) 514-524.
Rao, D.S, K.J. Mathew, C.P.Gopinatham, A.Reghunathan and A.V.S.Murty	1980	Mud banks and coastal erosion in relation to fisheries Mar. Fish. Infor. Serv. T & E Ser. (19): 1-6.
Reddy, M.P.M. and V.V.R. Varadachari	1972	Sediment movement in relation to wave refraction along the west coast of India J. Indian Geophys. Univ. 10: 169-191.
Rhoads, D.C. and D.K. Young	1970	The influence of deposit - feeding organisms on sediment stability and community trophic structure J. Mar. Res. 28: 150-178.
Rhoads, D.C. and D.K. Young	1971	Animal-sediment relations in Cape Cod Bay, Massachusetts. II. Reworking by Molpadia oolitica (Holothuroidea) Mar. Biol. 2: 255-261.
Russell, E.J	1950	Soil conditions and Plant Growth Longmans, Green and Co. New York 635
Samuel, M	1944	Preliminary observations on the animal communities of the level sea bottom of the Madras Coast. J. Madras Univ. 5(2): 45-71.
Sanders, H.L	1956	Oceanography of Long Island Sound 1952-1954, Biology of marine bottom communities Bull. Bingham Oceanogr. Coll. 15: 345-414

Sanders, H.L	1958	Benthic studies in Buzzards Bay I. Animal sediment relationship. Limnol. Oceanogr. 3(3): 245-258.
Sanders, H.L	1959	Sediments and the structure of bottom communities. In International Oceanographic congress Preprints edited by Mary Sears; pp. 583-584.
Sanders, H.L	1960	Benthic studies in Buzzards Bay III. The structure of the soft bottom community Limnol. Oceanogr. 5(2): 138-153
Sanders, H.L	1968	Marine benthic diversity: A comparative study Am. Nat. 102(925): 243-282.
Savilov, A.I	1959	Biological aspects of the bottom fauna groupings of the north Okhotsk Sea, In Marine Biology pp. 67-136. B. N. Nikitin, Editor. Trans. Inst. Oceanol. 20: 302 pp.
Savich, M.S	1972	Quantitative distribution and food value of benthos from West Pakistan shelf. Oceanology, 12(1): 113-117
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.
Seshappa, G. and B.S.Bhimachar	1955	Studies on the fishery and biology of the Malabar Sole, Cynoglossus semifasciatus Day Indian J. Fish. 2(1): 180-230.
Seshappa, G. and R. Jayaraman	1956	Observations on the composition of bottom mud in relation to phosphate cycle in the inshore waters off Malabar Coast. Proc. Indian Acad. Sci. B: 288-301.

Sewell, R.B.S — 1929 — Geographic and oceanographic research in Indian waters. Part V. Temperature and salinity of the surface waters of the Bay of Bengal and Andaman Sea with reference to the Laccadive Sea. Mem. Asiatic Soc. Bengal, 9: 207-356.

Sewell, R.B.S. and N. Annandale — 1922 — Fauna of the Chilka Lake. The hydrography and invertebrate fauna of Rambha Bay. Mem. Indian. Mus. 5(10): 677-710.

Shelford, V.E, A.O. Weese Lucile A Rice, I. Daniel, Rasmussen, N.M.Wisaner and J.H. Sawanson — 1935 — Some marine biotic communities of the Pacific Coast of North America Ecological Monographs. 5: 249-354.

Shepard, F.P — 1973 — Submarine Geology, 3rd Ed., Harper and Row, 557 pp.

Silas, E.G — 1969 — Exploratory trawl fishing by R.V. Varuna Bull. Cent. Mar. Fish. Res. Inst. No. 12, 86 pp.

Smith, J.E — 1932 — The shell gravel deposits and the infauna of the Eddystone grounds. J. mar. biol. Assoc. U.K. 18:243-278.

Sokolova, M.N — 1959 — On the distribution of deep water bottom animals in relation to their feeding habits and character of sedimentation. Deep.Sea.Res. 6: 1-4.

Sokolova, M.N. and F.A. Pasternak — 1964 — Quantitative distribution and tropic zonation of the bottom fauna in the Bay of Bengal and Andaman Sea. Trud. Inst. Okeanol Moskvo. 64: 271-296.

Sparck, R — 1935 — On the importance of qualitative investigations of the bottom fauna in marine biology. Journ. Du. Cons. 10(1): 3-19.

Stackelberg, Von. V.V	1972	Facies of sediments of the Indian Pakistan continental margin (Arabian Sea), Meteor Forschungsergebnisse, Reiche C. 9: 1-73.
Steven, G.A	1930	Bottom fauna and food of fishes. J. mar. biol. Ass. U.K. 16: 677-705.
Stickney, Alden P, and Louis D. Stringer	1957	A study of the invertebrate bottom fauna of Greenwich Bay Rhode Island. Ecology, 38(1): 111-122.
Subrahmanyan, R	1959	Studies on the phytoplankton of the West Coast of India: Part II. Physical and Chemical factors influencing the production of phytoplankton with remarks on the cycle of nutrients and on relationship of the phosphate content to fish landings. Proc. Indian Acad. Sci. B. 50:189-252.
Sumner, Francis B, Raymond C. Osburn and Leon J. Cole	1913	A biological survey of the waters of Woods Hole and vicinity. Bull. U.S. Bureau of fish. 31: 1-860.
Suseelan, C. and K.V.Somasekharan Nair	1969	Food and feeding habits of the demersal fishes off Bombay. Indian J. Fish. 16(1): 56-74.
Svedrup, H.U, M.W. Johnson and R.H. Flemming	1942	The Oceans, Their Physics, Chemistry and General Biology, Prentice-Hall, 972 pp.
Tenore, K.R	1976	Detrital utilisation by the polychaete Capitella capitata. J. Mar. Res. 33: 261-274.
Tenore, K.R	1977	Food chain pathways in detrital feeding benthic communities. A review with new observations on sediment resuspension and detrital recycling. In Ecology of Marine Benthos. B.C. Coull (ed) Univ. South. Carolina Press, S.C.: 37-53.

Thirupad, P.U.V. and C.V.G.Reddy	1959	Seasonal variations of the hydrographical factors of the Madras Coastal waters. Indian J. Fish. 6: 298-305.
Tholasilingam, T, K.C.George, M.G.Dayanandan, P. Karunakaran Nair and K.Nandakumaran	1973	Exploratory trawl fishing and ground fish resources along the Kerala Coast and adjacent waters. Proc. Symp. Living Resources of the seas around India Spl. Pub. CMFRI: 241-257.
Thorson, G	1956	Marine level-bottom communities of recent seas, their temperature adaptation and their "balance" between predators and food animals Transaction of the New York Academy of Sciences Section II, 18(8):695-700.
Thorson, G	1957a	Sampling the benthos Mem. Geol. Soc. Amer. 67(1): 61-73.
Thorson, G	1957b	Bottom Communities (sub littoral or shallow shelf). Geol. Soc. Am. Mem. 67(1): 461-534.
Thorson, G	1958	Parallel level-bottom communities, their temperature adaptation and their "balance" between predators and food animals. Perspectives in Marine Biology edited by A.A.Bussati - Traverso., pp. 67-86. Univ. Calif. Press. Berkeley, California.
Trask, P.D	1955	Recent Marine Sediments. The American Association of Petrolium Geologist, Oklahama, U.S.A.
Ursin,E	1952	Change in the composition of the bottom fauna of the Dogger Bank area. Nature, Lond. 170: 324.
Varma, P.U. and P.G.Kurup	1969	Formation of the Chakara (mud bank) on the Kerala Coast. Curr. Sci. 38(23): 559-560.

Venkataraman, G	1960	Studies on the food and feeding relationships of the inshore fishes off Calicut on the Malabar Coast. Indian J. Fish. 7(2): 275-306.
Veerayya, M	1972	Textural characteristics of Calangute Beach Sediments, Goa Coast. Indian J. Mar. Sci. 1: 28-44.
Warwick, R.M. and R. Price	1975	Macrofauna production in an estuarine mudflat. J. mar. biol. Ass. U.K. 55: 1-18.
Wieser, W	1960	Benthic studies in Bussards Bay II The meiofauna. Limnol. Oceanogr. 5(2): 121-137.
Wigley, R.L	1956	Food habits of Georges Bank haddock. U.S. Department of the Interior, Fish and wild life Service, special Scientific report. Fisheries No. 165: 1-26.
Wilson, D.P	1968	Some problems in larval ecology related to the localised distribution of bottom animals. Perspectives in Marine Biology (ed.) by A.A.Bussati - Traverso pp. 87-103. Berkeley, California.
Yonge, C.M	1946	On the habits of Turitalla communis Risso J. mar. biol. Ass. U.K. 26: 377-380.
Yonge, C.M	1949	On the structure and adaptation of the Tellinacea, Deposit-Feeding Eulamellibranchia Philosphical Transaction of the Royal Society of London Series B. Biological Science, 234 (609) 29-76.
Young, D.K. and D.C.Rhoads	1971	Animal-sediment relation in Cape Cod Bay, Massachusetts 1. A transect study. Mar. Biol. 2: 242-254.

George, P.C, B.T. Antony raja and K.C. George	1977	Fishery resources of the Indian economic zone Souvenir: Issued on the occasion of the silver jubilee celebrations of the Integrated Fisheries Project, Cochin, India - October, 1977.
Gorden, D.C	1966	The effect of the deposit feeding polychaete Pectinaria gouldii on the intertidal sediments of Barnstable Harber. Limnol. Oceanogr. 11: 327-332.
Hanks, R.W	1964	A benthic community in the Sheepscot River estuary, Maine. Fish. Bull. 63(2): 343-353.
Hargrave, B.T	1970	The utilisation of benthic microflora by Hyalella azteca (Amphipoda). J. Anim. Ecol. 39(1): 427-437.
Harkantra, S.N	1975	Benthos of the Kali estuary, Karwar. Mahasagar - 8(1 & 2): 55-58.
Harkantra, S.N, S. Ayyappan Nair, Z.A. Ansari and A.H. Parulekar	1980	Benthos of the shelf region along the West-Coast of India Indian J. Mar. Sci. 9(2): 106-110.
Hartman, O	1955	Quantitative survey of the benthos of San Pedro Basin, Southern California Part I, Preliminary results. Allen Han Cock Pacific Expedition, 19(1): 1-185.
Hart, T.J. and R.I. Currie	1960	The Benguela current. Discovery Reps. 13: 123-124.
Heywood, J. and R.W. Edwards	1962	Some aspects of the ecology of Potamopyrgus Jinkinsi Smith J. Anim. Ecol. 31: 239-250.
Hiranandani, M.G. and C.V.Gole	1959	Formation and movement of mud banks and their effect on south westerly coast of India. Abstract in preprints international oceanographic congress Amer. Assoc. Advancement of Science Wash. D.C. 623-624.