OBSERVATIONS ON THE PHYSICAL AND BIOLOGICAL FEATURES OF THE INSHORE SEA BOTTOM ALONG THE MALABAR COAST[1]

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(Communicated by Dr. N. K. Panikkar, F.N.I.)

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CONTENTS.

1. INTRODUCTION.

The features of the sea bottom—physico-chemical as well as biological—form aspects of the environment of marine fishes which have long been recognized as important in any programme of comprehensive research on fisheries. Since Petersen's construction (Petersen and Boysen Jensen, 1911) of the now well known grab sampler which he used for extensive quantitative surveys of the sea bottom in Danish waters, several workers have carried out studies in different parts of the world, using this sampler in one form or another either by itself or in combination with other devices like the dredge and the trawl. Investigations on the fauna of the inshore sea bottom of the Malabar Coast were taken up as part of the programme of the Calicut Sub-Station of the Central Marine Fisheries Research Station, with the aim of (1) obtaining the necessary general picture of the environment, (2) understanding the qualitative and quantitative variations in the distribution of the fauna in the fishing grounds during different periods of the year, and their possible relationship with the fishery of the Malabar sole, *Cynoglossus semifasciatus*, a bottom food fish of considerable commercial importance on this coast, and (3) assessing ultimately, the exact part played by the different species and by the bottom fauna as a whole in fish-food production.

The part of the sea in the immediate neighbourhood of West Hill (Calicut) was selected for intensive study as it was conveniently near the Research Station and was also considered more or less typical of the Malabar Coast in its general features. No quantitative survey of this type has been attempted in Indian waters before and the only previous work that may be cited in this connection is that of Samuel (1944) who, using the naturalists' dredge, studied the fauna of the level sea bottom at Madras to examine the animal communities and was able to recognize three of them depending on whether the bottom material was pure sand, pure clay or a mixture of both.

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2. The general features of the Malabar coast.

The Malabar Coast which is more or less straight without any large bays, is characterized by a number of short rivers joining the sea after running through the comparatively narrow belt of low land separating the sea from the Western Ghats. The plains over which these rivers flow consist geologically of laterite formation fringed on the seaward side by a narrow belt of recent alluvium (Bristow, 1938). These rivers discharge into the sea every year immense volumes of water which must bring with it large quantities of organic and inorganic substances collected along its course.

The shore along this coast is mainly sandy but there are some low cliffs or reefs of laterite here and there, as at Cannanore, Tellicherry, Elathur and Beypore. The submerged sea bottom is predominantly muddy and devoid of weeds with very few rocky and sandy patches. Hornell (1908) states: 'With a few unimportant exceptions the bottom from about a mile from the shore out to 30 fathoms from Ponnani northwards to Mangalore is composed of soft dark grey mud with small dead shells, chiefly bivalves, more or less sparsely distributed through it. As a rule the sedentary fauna of this area outside the 10 fathom line is extremely scanty ....and algae are of course entirely absent'.

A special feature of the Malabar and Cochin inshore sea bottom as distinct from other mud bottoms is the presence of what are called '*mud banks*' scattered at various places along the coast, e.g. Alleppey, Narakal, Calicut, Quilandi, Pantalayani, Beypore, Munambam, Chellanam and off Cochin (Du Cane, Bristow, Brown and Keen, 1938). These have been known for a very long time as areas where the sea remains calm even when the roughest weather prevails and the water is very rough in the neighbouring areas. The fine mud of such banks is in an unconsolidated state and the banks themselves have been known to shift from place to place now and then. The physical properties of one such bank near Cochin were the subject of investigation by a committee of experts in 1938. A great agitation of the bottom mud was noticed during the rough weather season in many parts along the coast during the years 1949 and 1950 and judging from the regularity of the South-West monsoon here, such an agitation seems to occur every year though variable in intensity and extent.

Climatically, Malabar has four distinct periods in the year. From June to the beginning of September is the characteristic South-West monsoon season with strong westerly winds, rough weather and heavy surf on the seashore. There is heavy rainfall, especially in June and July. September and October constitute a transitional period with a fairly dry weather but occasional rains. Next comes the cool North-East monsoon period from November to February (inclusive), with land winds and a calm sea. In February the wind veers to the north and from March to May (inclusive) come the hot, dry months with continued calm sea and light breezes from the north-west and north north-west. By the end of May transitional conditions set in and in June the South-West monsoon is in full swing again.

3. Physical and Hydrographical features of the area selected for intensive studies.

(*a*) *Physical features*: West Hill (Calicut) lies approximately in the Latitude 11° 17′ N. and Longitude 75° 46′ E. and the region selected was in its immediate neighbourhood extending from the shore down to the 10 fathom line and covering an area of about 10 square miles. In rainfall Calicut is more or less typical of coastal Malabar with an annual normal of 121 inches; during the year 1950 the total rainfall was 128·9 inches nearly half of which fell during the months of June and July. Fig. 1 shows the contour of the coastline in the region and the positions of the 3, 5,

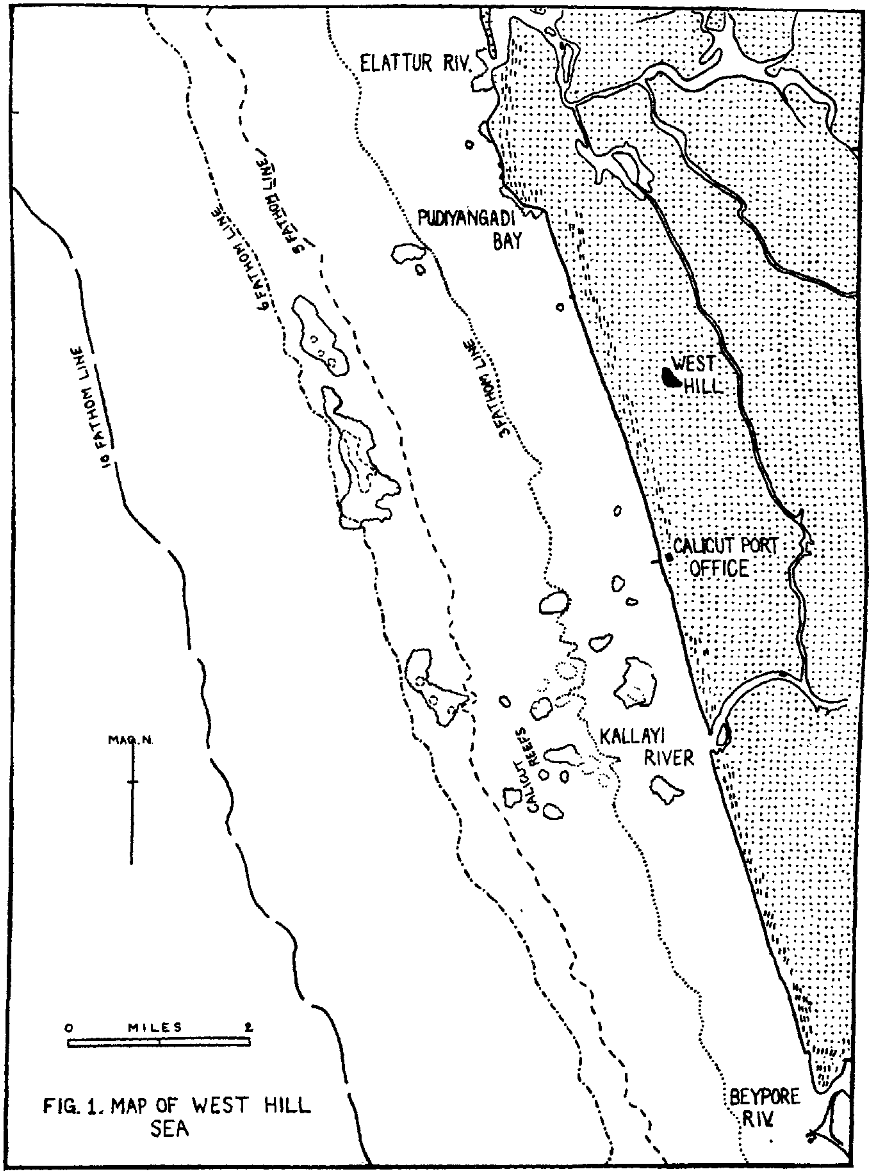

FIG. 1. MAP OF WEST HILL SEA

6 and 10 fathom lines as shown in the Admiralty Chart. The West Hill sea is subject to the influence of three considerably large rivers namely the Elathur river, the Kallayi river and the Beypore river entering the sea at about 5 miles north, 5 miles south and 10 miles south of West Hill respectively. The shore is throughout sandy, some cliffs of rock occurring only near Elathur. Just about the Low

Water Spring level the coarse sand gives place to a mixture of fine sand and mud and a few yards further down, to soft fine mud of the type found over the rest of the submerged bottom. Between the 5 and 6 fathom lines due west of West Hill there is a patch of rocky ground which in some places rises a short distance above the bottom level.

A mud bank of the type mentioned in the previous chapter has been known to occur near Calicut and seems to have shifted to the West Hill area during the course of the present investigations, but its actual extent is not known with any definiteness.

(*b*) *Sea Temperature*: Chidambaram (1950) gives the mean surface temperatures of the sea at West Hill for different months of the year taken over a period of 11 years from 1932-33 to 1942-43. Records of surface temperature, salinity and *p*H as well as the bottom salinity taken periodically at the 8 fathom zone have been maintained from 1948 onwards in the Central Marine Fisheries Research Sub-Station, and from these are derived the monthly mean temperatures for the period December, 1949 to November, 1950, shown in Table I in comparison with Chidambaram's figures. There is a slight difference between the two sets of values, the present ones being slightly lower throughout, but there is general agreement in the seasonal trends. It is seen that the lowest temperature is recorded in July, the months of June to September (inclusive) standing out as the months of low values and that the highest temperature was recorded in April, the months of March to May (inclusive) standing out as the months of high values. The year of the present investigations thus appears to have been normal in this respect.

(*c*) *Salinity and pH*: Table II shows for the period December to November the monthly mean values and the monthly range of variation of the periodical salinity readings for the surface and the bottom samples of seawater at West Hill taken at the 8 fathom region.

March, April and May were the months of high surface salinity, the highest being in April. The monsoon months gave very low mean values the lowest being in August (26·9$^0/_{00}$), though the lowest values for individual observations was noticed in July when the extreme values were 16·13$^0/_{00}$ and 34·03$^0/_{00}$. The months of widest variation were July and August and of the least variation were January, February and March.

TABLE I.

Monthly average surface temperature of the seawater at West Hill (Calicut).

Months.	Average for 11 years (Chidambaram, 1950).	Average during Dec., 1949–Nov., 1950.	Extreme values during Dec., 1949–Nov., 1950.
December ..	28·29	27·57	27·0–28·3
January ..	28·14	27·41	26·7–27·9
February ..	28·66	28·0	27·2–28·5
March ..	29·98	29·28	28·5–29·8
April ..	30·31	29·96	29·5–30·4
May ..	30·12	29·0	27·2–30·1
June ..	27·27	26·85	25·3–28·8
July ..	25·91	24·87	23·2–25·7
August ..	26·37	25·08	23·4–27·0
September ..	26·67	25·16	23·7–27·9
October ..	28·18	27·25	26·2–28·4
November ..	28·52	27·98	26·6–28·9

While the bottom salinity showed much less variation than the surface salinity, the effects of the seasons could still be seen in its values also. Its maximum range was in June (31·16 to 35·02$^0/_{00}$). The mean value was highest in April (36·15$^0/_{00}$)

and dropped down to 35·36‰ in May, 33·86‰ in June and 33·71‰ in July. There was a gradual rise from August onwards with a slight drop in October.

The salinity of the water collected a few yards away from the shore was also determined for the months of August to November, 1950 and the values are shown in the same Table.

TABLE II.

Salinity of seawater at West Hill (Calicut) during the period December, 1949 to November, 1950.

Months.	Surface salinity (8 fathom region).		Bottom salinity (8 fathoms).		Salinity of shore water.	
	Mean.	Extremes.	Mean.	Extremes.	Mean.	Extremes.
December .	34·42	33·45–35·23	34·55	33·8 –35·4	..	..
January ..	33·91	33·5 –34·26	33·83	33·6 –34·24	..	..
February ..	34·12	33·8 –34·23	34·03	33·8 –34·15	..	..
March ..	35·42	34·9 –35·77	35·47	35·2 –35·8	..	..
April ..	36·06	35·1 –37·0	36·15	35·4 –36·9	..	..
May ..	35·05	31·3 –36·1	35·36	33·3 –36·3	..	..
June ..	31·63	28·62–33·85	33·86	31·16–35·02	..	..
July ..	27·55	16·13–34·03	33·71	32·8 –35·1	..	..
August ..	26·9	19·06–34·81	34·36	33·63–34·9	28·58	20·87–33·21
September ..	32·43	28·15–35·03	34·7	33·43–35·23	31·93	30·4 –34·0
October ..	31·02	25·97–33·83	34·14	33·23–35·0	31·16	28·05–33·83
November ..	34·06	31·97–35·0	34·93	34·23–35·6	32·78	27·65–34·23

Table III shows the range of *p*H values for the period of the quantitative investigations under review. June, July and August are seen to be the months of lowest *p*H values. The transition to these values from the pre-monsoon high values is seen to be sudden.

TABLE III.

Range of pH values of the surface seawater (8 fathom region) at West Hill (Calicut) for the period December, 1949 to November, 1950.

Months.	*p*H range.	Months.	*p*H range.
December ..	8·4 –8·6	June ..	8·0–8·2
January	8·3 –8·5	July ..	7·9–8·2
February ..	8·35–8·6	August ..	7·9–8·3
March	8·35–8·5	September ..	8·3 (3 readings only).
April	8·4 –8·6	October ..	8·2–8·5
May	8·4 –8·6	November ..	8·4–8·5

4. METHODS.

Quantitative samples were taken in a locally made light grab sampler of the Petersen type weighing about 30 lbs. and scooping an area 40 cm. by 25 cm. (0·1 m.^{2}). As the bottom mud was throughout fine and soft this light grab was always able to cut through the bottom very easily and to come up thoroughly filled in with the mud. As the samples had to be taken in an ordinary dug-out canoe and the hauling done manually, the lightness of the apparatus was a great advantage.

The quantitative data treated here refer to the period December, 1949 to November, 1950 (inclusive) thus covering one full year. But along with these are also considered some qualitative data collected by examination of dredge samples, taken on a few occasions in April, 1949 and periodically from July to October, 1949, as well as information collected in October-November, 1949 from experimental samples obtained with the grab-sampler which was then under trial.

The qualitative samples mentioned above were obtained from the fishing grounds between the Low Water Level and the 4 fathom zone. The quantitative grab samples were taken at regular intervals of depth along three imaginary transects running about half a mile apart from the shore seaward. The depths at first chosen were 4 fathoms, 10 fathoms and just below the Low Water Level; but from January, 1950, the 2, 8 and 6 fathom regions were also added on. As the slope of the sea-bottom was gradual, the horizontal distance between successive levels was more or less the same, and the stations were thus equidistant. No special equipment was used for fixing the stations, and they were reached each time by taking frequent soundings of depth, and keeping along the transect—which was necessarily quite wide (about half-a-mile)—, by sighting certain known landmarks. It may be assumed that no two samples—at least successive ones—were obtained in one and the same 0·1 $m.^2$ area, and also that the samples were never so far away from one another as to make the results of the different weeks uncomparable.

Each of the depths mentioned was sampled once in a fortnight (January, 1950 to third week of June, 1950) or a week (the remaining period), three samples being taken each time, one along each transect. The material was pooled together and screened through a 0·5 mm. mesh sieve and sievings were brought to the laboratory with the animals alive. After qualitative examination the animals were preserved in weak formalin and taken out later on for weighing and counting. The total rough wet weights of the animals of each pooled sample was determined after removing as much fluid as possible from the killed animals with the use of a blotting paper. Whenever the samples were too large or had much fine foreign material to be carefully eliminated before the weights could be taken, a good fraction (by weight) was taken, cleaned and reweighed, this latter weight being used for estimating the total weight. Animals with hard shells were negligible in the shallower levels and where they were large as in the case of *Pholas orientalis* at 4 and 6 fathoms, the shell weight has also been determined separately. In the 8 and 10 fathom regions where small gastropods and very tiny Lamellibranchs were frequent, the soft animals and the others were weighed separately. No attempt has been made to determine the dry organic weight.

The fractional method was used for counting also, whenever the samples were too large for counting as a whole.

The present sampling method differs from the customary method used in bottom fauna investigations mainly in that the samples are not all taken within a brief period of time in one or more seasons of the year, but spread over the entire year. It has consequently the defect of limiting the degree of accuracy of any estimation of the 'stock of the moment' (Blegvad, 1930) as the different samples in any series that may be taken into account in such an estimation would be considerably separated in time. Monthly and seasonal averages can, however, be calculated reliably and the method has the advantage of permitting a continuous and close observation of the cycle of events—physical as well as biological—in the bottom environment.

5. Results.

(*a*) *Dredge and Grab collections during the period from July, 1949 to November, 1949*: The results of the qualitative examination of the dredge and grab collections made during the months of July to November, 1949 are summarized in Table IV. *Cynoglossus semifasciatus* though really a bottom species, was at no time captured in the gear used in these investigations and hence does not find a place in the Tables.

TABLE IV.

Animal contents of the Qualitative Samples taken from July to November, 1949.

(*p* and *a* indicate *present* and *abundant* respectively; blank space indicates absence of the species).

Months.	July.	August.	September.	October.	November.
Total number of samples ..	11	12	6	20	24
Gear used	Dredge ..	Dredge ..	Dredge ..	Dredge for 6 & grab for 14 samples.*	Grab only.*
Depth	1, 1½, 2 and 3 fms.	L.W.M. to 2 fms.	2 fms.	L.W.M. to 2 fms.	L.W.M. to 4 fms.
1. *Prionospio pinnata* ..			*p a**	*p a* young ones	*p a* dominant.
2. *Sternaspis scutata* ..				*p* young ones	*p*
3. Other polychaetes ..			*p**	*p* young ones	*p*
4. *Cavernularia* sp. ..	*p*	*p*	*p*	*p* in dredge only	
5. *Lucina vesicula* ..		*p*	*p*	*p* in dredge only	
6. *Theora opalina* ..		*p*	*p*	*p*	*p*
7. *Metapenaeus affinis* ..	*p*	*p*	*p*	*p* in dredge only (5-10-1949).	
8. Other prawns ..	*p*				
9. *Diogenes* sp. ..		*p*			
10. *Matuta victor* ..		*p*			
11. *Cheiriphotis megacheles*.		*p*	*p*	*p*	*p*
12. *Trypauchen vagina* ..	*p*	*p*			
13. *Solea ovata* ..		*p*	*p*	*p* in dredge only	
14. *Tetrodon* sp. ..	*p*				
15. *Nemertine species* ..	*p*	*p*	*p*	*p*	*p*
16. Egg masses of Cuttlefish.			*p a*	*p* on 5-10-1949 only	
Remarks	7 of the samples (taken on 6th, 19th, 26th and 28th) had no animals at all.	5 samples taken on 2-8-1949 between L.W.M. & 4 fms. had no animals.	*Newly settled and very young; first noticed on 7-9-1949	*Dredge used till 14-10-1949 & grab thereafter.	*Exploratory quantitative hauls.

Until September the bottom fauna was extremely poor and there were practically no animals to constitute an infauna, several of the samples showing no animals of any kind at all after the material was washed through a sieve of 0·5 mm. mesh. Such absence of animals could not be ascribed to deficiencies in the sampling method. Occasionally however, individuals of *Cavernularia* sp., *Lucina vesicula, Theora opalina* (only once before September), and a Nemertine species made their appearance in the collections. The few other forms that occurred very occasionally included *Solea ovata, Tetrodon* sp., *Trypauchen vagina* and *Metapenaeus* spp. During the first half of September, polychaetes—dominated by *Prionospio pinnata*—began recolonizing the area, and by the middle of November a rich infauna had developed in the shallow area of the sea bottom forming a belt along the shore. This belt was made up largely of polychaetes but its shoreward margin—the zone of fine mud mixed with some fine particles of sand—was dominated by species of *Phoronis* and *Polydora*.

It seems probable that a fairly dense fauna existed in the shallow area during April, 1949 also, but the samples examined in that month (trial hauls with the dredge) were all taken from the 4 fathom zone (which proved to be the poorest in fauna during the entire period of these investigations) and these indicated a very poor fauna, some of them showing no animals at all and others showing just a small number of polychaetes and small hermit crabs (*Diogenes* sp.). In the sand between the Low Water Neap and Spring levels, however, there was a very rich population of *Donax cuneatus* and *Emerita asiatica* until they were destroyed completely in the monsoon season that followed, when there was a great agitation of the inshore sea bottom. It may be mentioned here that these species completely failed to recolonize the West Hill sands during the succeeding seasons and that only in October-November, 1950, were they seen again to have successfully settled down here.

(*b*) *Results of Grab Samples during the period December, 1949 to November, 1950:*

1. *Nature and distribution of the members of the fauna at different levels during the different seasons.* It is not proposed in this paper to enter into details regarding the ecology of individual species. The main features of the fauna at the different levels during the different seasons, as judged by an analysis of the more common elements will be given below. The occurrence of the common forms during the different months of the year, and at different levels of the sea bottom respectively has been summarized in Tables V and VI.

During the season of commencement of the quantitative studies the inshore sea bottom had a fauna as mentioned above, with a specially rich belt in the shallow region dominated by polychaetes chief of which was *Prionospio pinnata*. The densest population was found at two fathoms and just below the Low Water Level. The other important animals of this zone were *Phoronis* sp. (dominant near the Low Water Level) and *Polydora* sp., *Glycera alba*? and certain other polychaete species of the syllid, Nereid and Terebellid groups and the Amphipod *Cheiriphotis megacheles* were also occurring frequently. The forms that occurred occasionally, included small individuals of *Modiolus undulatus, Theora opalina, Meretrix casta, Siliqua radiata, Arca* (*Scapharca*) *gubernaculum* ?, *Diopatra variabilis, Pectinaria* (*Amphictene*) *Crassa, Lumbriconereis latreilli* and a large Nemertine species. The four fathom zone was very poor both in the number of individuals and in the number of species and on several occasions there were no animals at all noticeable in the collections from this region. Some patches of *Pholas orientalis* were discovered in the 4 and 6 fathom regions during February but the form occurred only in two collections. From six to ten fathoms there was a change in the composition of the fauna though the species as well as individuals remained numerically small and some species such as *Prionospio pinnata, Lumbriconereis latreilli, Sternaspis scutata* and *Cheiriphotis megacheles* were common to all the depths. The samples from this region were distinct by the fact that the material left on the 0·5 mm. mesh

TABLE V.

Occurrence of some of the Bottom Animals in the West Hill Sea during different months of the period December, 1949 to November, 1950.

(All levels have been taken together; *p* indicates *presence* and blank space indicates *absence* of species).

Months.	Dec. 1949	Jan. 1950	Feb. 1950	Mar. 1950	Apr. 1950	May 1950	June. 1950	July. 1950	Aug. 1950	Sept. 1950	Oct. 1950	Nov. 1950
1. *Prionospio pinnata* ..	*p*	*p*	*p*	*p*	*p*	*p*	*p*			*p*	*p*	*p*
2. *Sternaspis scutata* ..	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*
3. *Lumbriconereis latreilli* ..	?	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*
4. *Diopatra variabilis* ..			*p*	?	*p*	*p*						
5. *Clymene* sp. ..	?	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*
6. *Pectinaria* (*Amphictene*) *Crassa*	*p*	?	*p*	*p*	*p*	*p*						
7. *Sabellaria spinulosa* ..						*p*						
8. *Polydora* sp. ..	*p*	*p*										
9. *Phyllochaetopterus* sp. ..				?	*p*	*p*	*p*	*p*	*p*	*p*		
10. *Phoronis* sp. ..	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*				*p*
11. *Nemertine species* ..	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*		*p*	*p*	*p*
12. *Pholas orientalis* ..			*p*		*p*	*p*			*p*	*p*		*p*
13. Nuculid species ? ..			?	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*
14. *Lucina vesicula* ..				*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*
15. *Theora opalina* ..	*p*	*p*	*p*	*p*	*p*	*p*					*p*	*p*
16. *Siliqua radiata* ..		*p*			*p*	*p*						
17. *Modiolus undulatus* ..	*p*	*p*				*p*						
18. *Meretrix casta* ..			*p*			*p*	*p*					
19. *Acteocina Townsendi* ..				*p*	*p*	*p*	?	*p*	*p*	*p*		
20. *Turricula javana* .				*p*	*p*	*p*		*p*	*p*	*p*	*p*	*p*
21. Small ophiuroids ..		*p*	*p*	*p*	*p*	*p*	*p*			*p*	*p*	
22. *Cheiriphotis megacheles* ..	*p*	*p*	*p*	*p*	*p*	*p*	*p*	*p*		*p*	*p*	
23. *Alpheus malabaricus* ? ..		*p*	*p*	*p*	*p*	*p*						
24. Pycnogonids ..		*p*	*p*	*p*	*p*	*p*						

I am indebted to Dr. H. C. Ray of the Zoological Survey of India for help in the identification of some of the Molluscs mentioned in this work.

TABLE VI.

Vertical Distribution of some of the Bottom Animals of the West Hill Sea during the period December, 1949 to November, 1950.

(All months have been taken together; *p* indicates *presence* and blank space indicates *absence* of species.)

Levels.	↓ L.W.M.	2 fms.	4 fms.	6 fms.	8 fms.	10 fms.
1. *Prionospio pinnata* ..	*p*	*p*	*p*	*p*	*p*	*p*
2. *Sternaspis scutata*	*p*	*p*		*p*	*p*	*p*
3. *Lumbriconereis latreilli* ..	*p*	*p*	*p*	*p*	*p*	*p*
4. *Diopatra variabitis*	*p*	*p*		*p*	*p*	
5. *Clymene* sp.				*p*	*p*	*p*
6. *Pectinaria* (*Amphictene*) *Crassa*		*p*		*p*	*p*	*p*
7. *Sabellaria spinulosa* ..				*p*		*p*
8. *Polydora* sp.	*p*	*p*				
9. *Phyllochaetopterus* sp. ..				*p*	*p*	*p*
10. *Phoronis* sp.	*p*	*p*				
11. *Nemertine species*	*p*	*p*	*p*	*p*	?	*p*
12. *Pholas orientalis*			*p*	*p*		
13. Nuculid species ?				*p*	*p*	*p*
14. *Lucina vesicula*				*p*	*p*	*p*
15. *Theora opalina*	*p*	*p*				
16. *Siliqua radiata*	*p*	*p*				
17. *Modiolus undulatus* ..	*p*	*p*		*p*		
18. *Meretrix casta*	*p*	*p*				
19. *Acteocina Townsendi* ..	*p*	*p*	*p*	*p*	?	*p*
20. *Turricula javana*					*p*	*p*
21. Small Ophiuroids				*p*	*p*	*p*
22. *Cheiriphotis megacheles* ..	*p*	*p*	*p*	*p*	*p*	*p*
23. *Alpheus malabaricus* ? ..	*p*	*p*				
24. Pycnogonids				*p*	*p*	*p*

sieve after washing away the finer material was always dominated by fine shining Lamellibranch shell pieces, empty gastropod shells such as those of *Turritella*, *Turricula*, *Nassa* and *Umbonium* species and tubes of Maldanid polychaetes. *Clymene* sp. was common in these samples and this and a minute Nuculid (?) bivalve were characteristic animals of the deeper levels during the subsequent months. From January onwards some Pycnogonids and a few small ophiuroids were also found now and then in this region. There was thus a clear zonation in the vertical distribution of the organisms among different depths of the sea bottom, the deeper zone and the shallower zone being separated by the 4 fathom region which had a poor population of animals. This kind of differentiation existed in all the seasons of the year. Table VI gives some idea of the general zonation taking the whole year into account for the purpose of assigning limits for the vertical distribution of the different animals.

During the hot dry season (March, April and May) the fauna of the shallower region remained more or less the same in composition although there was some gradual decline in the density of the dominant species and a few disappeared altogether (see Table V). *Prionospio* was absent in the 10 fathom region during all the three months and in the 8 fathom region after March. The 4 fathom region remained poor but the deeper levels recorded an increase and animals of Nuculid (?) species, *Turricula javana*, and *Phyllochaetopterus* sp. made their appearance in the collections regularly. The individuals of the Nuculid (?) species, were extremely minute and though they occurred consistently in large numbers during the latter part of the season (the number more or less gradually increasing from March onwards and reaching a figure of 8,900 per $m.^2$ on the 26th of May) their mass was almost negligible on account of their extremely minute size. *Pholas orientalis* occurred only in one collection during the season, namely on the 10th April in the 6 fathom sample. This is a species with a very uneven distribution.

In the South-West monsoon months the inshore bottom animals suffered a severe decline and in the shallower levels—4 fathoms inward—there was a sudden and almost total disappearance of all macroscopic bottom animals. *Prionospio* and *Phoronis* disappeared completely, only a few bits of the latter (without the tubes) occurring now and then till July and the former not occurring at all after the first week of June. The mud-goby *Trypauchen vagina* began to appear frequently in the West Hill inshore area after the commencement of the rainy season. In the deeper levels, Ophiuroids and Chaetopterids completely disappeared and only the Maldanid *Clymene*, the Nuculid (?) species and *Lumbriconereis* continued throughout. Occasional members of this region during the season included *Sternaspis scutata*, *Nephthys* sp., *Dentalium* sp., *Turricula javana*, *Nassa* sp., *Acteocina Townsendi*, *Oliva* sp., and *Lucina vesicula*.

The recolonization of the shallower region started when the post-monsoon conditions were established in the sea but was slow and unsteady. Various species of polychaetes, again dominated by *Prionospio pinnata* started settling in September, the young ones kept on fluctuating in numbers at a low level during the succeeding weeks, and by the end of November, the population had not yet reached any considerable density as compared with the corresponding period of the previous year. The only Lamellibranch forms that had settled during the season as could be seen from grab samples were *Pholas orientalis*, *Theora opalina* and *Siliqua radiata*. The first of these was fairly common but the latter two were rather rare. Nuculid (?) bivalves in the 8 and 10 fathom region showed a large decline in numbers during the latter half of the season. *Clymene* sp., *Lucina vesicula* and *Lumbriconereis latreilli* were the commonest components of the fauna of this region during this season.

2. *Total wet weights of animals.* The result of estimations of the total wet weights of the animal contents of the grab samples studied during the period from different levels of the sea bottom and from the area as a whole, are abstracted in Table VII as monthly averages in terms of weight in grammes per square meter area and are depicted graphically in Fig. 2. The weights given there include those of the hard parts also (wherever present), and weights excluding hard parts will be referred to in the text, in the cases where they were determined. The average for each level for each month and for the whole year has been determined by dividing the total relevant weight by the total relevant number of samples and converting it to the required scale, but as the number of samples at the different levels during a month were not always the same, the mean value for the entire region is derived by taking the mean of the mean values of the different levels.

Near the Low Water Level the weight was highest in December and it gradually declined during the subsequent months. While the table shows that the average weight in gms. per m.^{2} decreased from 381·0 in January to 202·0 in February and rose to 251·6 in March, it is likely that there was no large decline in February and the value seen is less reliable than for the other months as it is derived from only three samples. The average value for May was 192·2 gms. but in June it suddenly fell down to 0·8 gms. coincident with the commencement of the South-West monsoon season. The low value continued till September when it rose to 7·5 gms. A slight rise recorded in July was due mainly to a single specimen of a large Nemertine worm. The September increase was due to a specimen of *Trypauchen vagina* in one of the collections. Otherwise this value would have also been very low, the next rise being only in November caused by a real increase in the bottom fauna, chiefly *Prionospio*. But even here it reaches only 9·0 gms., a value less than 1/50th of the previous December value. *In the 2 fathom level,* no samples were taken in December. The values from

TABLE VII.

Estimated rough wet weights of animals (including hard parts when present) per m² area, in the West Hill sea bottom during different months.

Months.		Dec. 1949	Jan. 1950	Feb. 1950	Mar. 1950	Apr. 1950	May 1950	June. 1950	July. 1950	Aug. 1950	Sept. 1950	Oct. 1950	Nov. 1950	Whole year.
Just below L.W.M.	No. of samples	4×3	3×3	1×3	2×3	2×3	3×3	3×3	2×3	5×3	4×3	5×3	4×3	38×3
	Wt. in gm. per m^2	491·1	381·0	202·0	251·6	217·5	192·2	0·78	2·6	0·53	7·5	0·4	9·0	128·9
2 fms.	No. of samples	..	3×3	3×3	2×3	2×3	2×3	4×3	2×3	5×3	4×3	5×3	4×3	36×3
	Wt. in gm. per m^2	..	162·7	232·0	248·3	155·0	114·2	5·8	22·3	0	Negligible	Negligible	Negligible	63·1
4 fms.	No. of samples	3×3	4×3	2×3	2×3	2×3	3×3	2×3	1×3	5×3	3×3	4×3	5×3	36×3
	Wt. in gm. per m^2	2·3	1·6	111·7	Negligible	0·3	1·6	0·3	0	Negligible	Negligible	0·17	0·33	6·81
6 fms.	No. of samples	..	1×3	3×3	2×3	2×3	2×3	3×3	1×3	5×3	3×3	4×3	5×3	31×3
	Wt. in gm. per m^2	..	9·6	65·2	11·0	382·3	24·5	4·0	Negligible	5·1	0·55	Negligible	0·87	35·0

8 fms.	No. of samples	..	2×3	2×3	3×3	2×3	2×3	2×3	3×3	4×3	4×3	4×3	4×3	32×3
	Wt. in gm. per m²	..	12·7	0·5	3·7	13·8	43·5	34·5	19·1	10·8	13·6	2·5	3·3	12·5
10 fms.	No. of samples	5×3	2×3	2×3	2×3	2×3	2×3	3×3	3×3	4×3	4×3	4×3	4×3	37×3
	Wt. in gm. per m²	15·8	8·5	4·0	7·5	18·3	25·8	18·2	13·8	4·6	2·8	4·5	4·3	10·0
All levels	No. of samples	12×3	15×3	13×3	13×3	12×3	14×3	17×3	12×3	28×3	22×3	26×3	26×3	210×3
	Wt. in gm. per m²	169·7	96·0	102·6	87·0	131·2	67·0	10·6	9·6	3·5	4·1	1·3	3·0	44·1

January to March show a trend reverse to that seen for the Low Water Level, and gradually increases from 162·7 gms. to 248·3 gms. It, however, declines subsequently and falls down to 5·8 gms. per sq. m. in June. This value again would have been only 0·7 gm. but for the one specimen of *Trypauchen vagina*. The value shows a

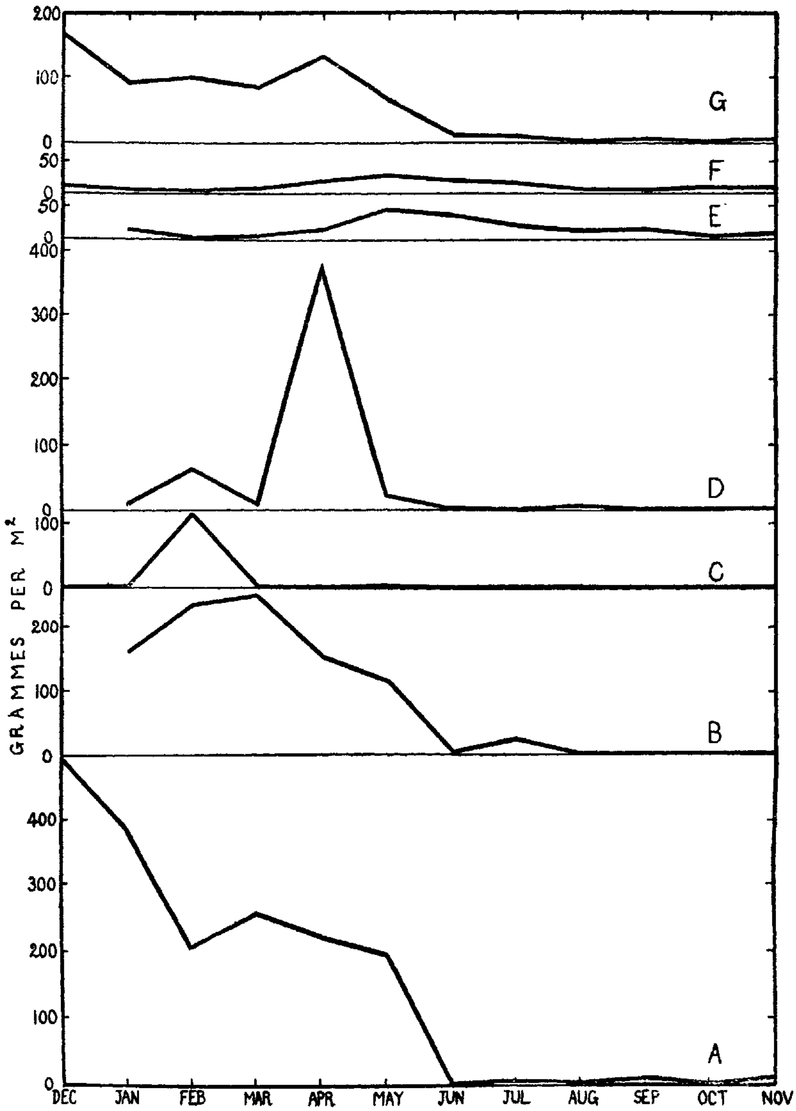

FIG. 2.—Average wet weights of animals (in gms. per m²) at different levels of the sea bottom during the different months of the year (December, 1949 to November, 1950).
A.—Just below Low Water Mark; *B.*—2 Fathoms; *C.*—4 Fathoms; *D.*—6 Fathoms; *E.*—8 Fathoms; *F.*—10 Fathoms; *G.*—All levels together.

further rise to 22·3 in August. This was mainly due to seven unusually large specimens of the Nemertine species; otherwise the fauna was negligible and continued to be practically zero during all the subsequent months under report.

A look at the Table reveals that the *4 fathom region* is completely negligible as regards animals, the average weights during the various months ranging from practically zero to 2·3 gms. per m.², except for a value of 111·7 gms. per m.² in February which was due to the occurrence of a number of *Pholas orientalis* in a single sample. If the shell weight of these bivalves were removed this average would be 26·6 gms. per m.²

The 6 fathom zone is a little better than the 4 fathom region. This level was not sampled in December, had an average of 9 6 gms. of animals per m.² in January and 11·0 gms. per m.² in March, the values for February and April being 65·2 and 382·3 gms. respectively per m.² Both these peaks in the apparent productivity of this region were due to the occurrence of *Pholas orientalis* in considerable numbers in a single sample in each of the months. If the shell weights were removed these averages would be 20·4 and 91·0 gms. respectively. In May the average value was 24·5 gms. and this was also high mainly due to a single sample with an unusual number of Ophiuroids, *Modiolus undulatus, Mactra* sp. and Polychaetes such as *Sabellaria spinulosa, Pectinaria* (*Amphictene*) *Crassa,* and *Diopatra variabilis.* This was a very unusual occurrence and was perhaps the result of some currents. These forms did not appear in the subsequent samples and from June onwards the values were low, reaching nearly zero in some of the months.

There were no forms of such erratic or patchy occurrence in *the 8 and 10 fathoms levels.* The values for both these regions were, however, throughout rather low, though the 8 fathom region was slightly better in general and a slight rise was recorded in both regions during the months of April to May. This was due to the occurrence of *Turricula javana, Phyllochaetopterus* sp. and such other forms which appeared in the collections only by about April and disappeared with the commencement of the monsoon weather. The highest average wet weight of animals for the 8 and 10 fathom regions were 43·5 gms. and 25·8 gms. respectively and occurred in May. A distinctive feature of these deeper regions was that the monsoon set-back was not so severe as in the shallower regions and while a decline occurred, the lowest weights were reached only after the monsoon months. The 10 fathom level showed a higher decline than the 8 fathom level. The mean weights of animals estimated for the entire area for the different months are given in the last horizontal column (Table VII).

For the whole region, the mean value of 169·7 gms. in December fell to 96·0 gms. in January but rose to 102·57 gms. in February and again fell to 87·02 gms. in March. In April a sudden rise to 131·2 gms. per m.² was recorded. This and the February rise were due to the sudden contribution of *Pholas orientalis* from the 4 and 6 fathom levels. In June there was a sudden fall in weight to 10 6 gms. per m.² In July the value was 9·6 gms. per m.² but during the subsequent months the weight reached almost negligible figures.

From an average of all the months taken together it is possible to assess the importance of the different regions sampled with reference to production of bottom animals. The highest mean density is near the Low Water Level (128·9 gms. per m.²) and the next is at two fathoms (63·1 gms. per m.²). The 4 fathom level has the lowest value (less than 3% of the total) but the 6 fathom level gets better credit due to the occurrence of *Pholas orientalis* and gets a value of 35·0 gms. per m.² Without the shells of Pholas, however, this value would be only 11·9 gms. The 8 and 10 fathom levels had an average weight of 12·5 and 10 0 gms. respectively and contributed but little to the fish food of the area as most of the animals had hard skeletons, and though Nuculids (?) formed frequent articles of the diet of *Cynoglossus semifasciatus* during the monsoon months and occurred in a few thousands per m.² in some of the months the minuteness of these and the relative thickness of their shells made them rather unimportant.

The average values of the total wet weights for the four different seasons of the year for different levels of the sea bottom are shown in Fig. 3 and give a concise and ready picture of the variations in the richness of the fauna in terms of weight during the four periods of the year which are rather distinct along this coast climatically.

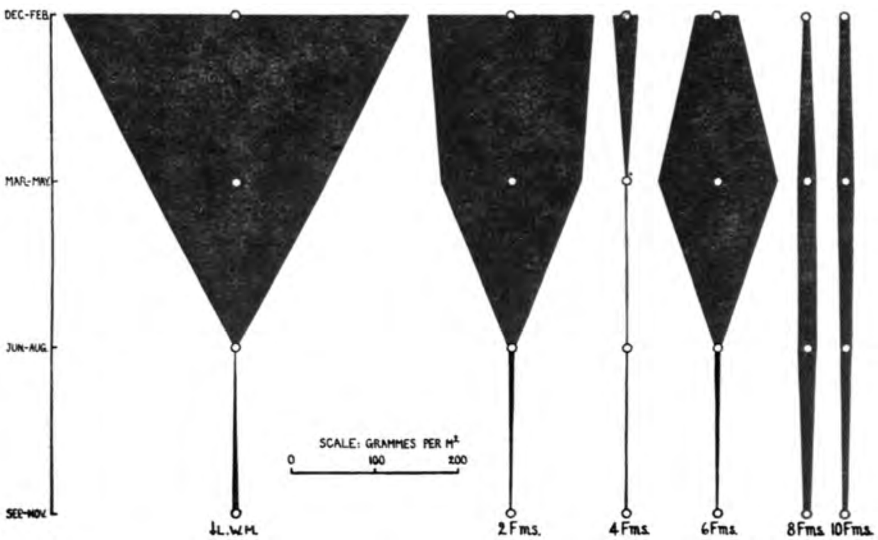

FIG. 3.—Histogram showing the seasonal averages of the wet weights or animals (in gms. per m.²) on the sea bottom at different levels.

3. *Numerical density of Prionospio pinnata.* The results of the present investigations have proved that *Prionospio pinnata* is about the most important member of the bottom infauna of the West Hill sea both from the point of view of abundance and from the point of view of value as fish food. A more detailed account of this species will, therefore, be not out of place. Table VIII shows the variations in the numerical abundance of this species as between different months of the year as well as different depths of the sea bottom. During the subsequent months there was a gradual decline in its numbers in the deeper levels and a final disappearance from the 10 and 8 fathom regions in March and April respectively. During all the months from December to May, however, the two fathom level and the region just below the Low Water Mark contribute the bulk of the species. There is gradual decline in numbers in the 2 fathom level even from the beginning while near the Low Water mark there is a slight rise from January to February and a gradual fall subsequently. This decline in numbers is perhaps the result of the cessation of recruitment of younger individuals to the population combined with removal of existing ones by the predatory activity of other animals. The disappearance of the species in June, however, cannot be considered the result of the continuation of the declining tendency already seen because of its suddenness and also of the simultaneous disappearance from the inshore area of its apparently chief predator species, *Cynoglossus semifasciatus*.

Resettlement of the species started in September but the number was only 12·5 per m.² during that month. It again occurred at all the levels, but more abundantly in the shallowest zone and though there was a gradual increase in the numbers (864·2 per m.² near the Low Water Level and 195·9 per m.² in the entire region in November) they were very inconsiderable when compared to the previous December numbers which were 4,666·7 per m.² near the Low Water Level and

TABLE VIII.

Estimated numerical distribution of Prionospio pinnata at different levels of the seabottom during the various months.

(The figures indicate numbers per m.²).

Months.	December 1949	January 1950	February 1950	March 1950	April 1950	May 1950
L.W.M. ..	4,666·7	4,011·1	5,166·7	4,555·0	4,308·3	2,477·7
2 fms. ..	..	6,983·3	5,350·0	4,470·0	2,550·0	1,806·7
4 ,, ..	168·9	26·7	0	1·7	0	1·1
6 ,, ..	..	283·3	171·1	211·1	70·0	23·3
8 ,, ..	..	183·3	23·3	32·3	0	0
10 ,, ..	532·0	75·0	41·1	0	0	0
All levels ..	1,789·2	1,927·1	1,792·0	1,545·0	1,154·7	718·1
Months.	**June**	**July**	**August**	**September**	**October**	**November**
L.W.M. ..	0	0	0	12·5	109·3	864·2
2 fms. ..	0	0	0	0	5·3	7·5
4 ,, ..	0	0	0	0	38·3	13·8
6 ,, ..	35·6	0	0	0	0	137·5
8 ,, ..	0	0	0	3·3	5·0	74·2
10 ,, ..	0	0	0	0	10·8	77·5
All levels ..	5·9	0	0	2·6	28·1	195·8

1,789·2 per m.² in the whole region. Another feature in this recolonization was that the two fathom zone showed smaller numbers than even the deeper levels.

(*c*) *Agitation of the sea bottom during the South-West monsoon season.* During the monsoon months of both the years 1949 and 1950 the bottom mud of the inshore sea was frequently agitated and the water was generally turbid. During the year 1949 the turbidity reached the maximum on the 24th June when the water near the shore along the entire stretch of the coast between Calicut and Pudiapa six miles north of it had turned into a thick slush of fine mud. As a result of this the rich intertidal population of *Emerita asiatica* was completely destroyed. In trying to get away from the slush, swarms of this animal migrated upwards from the usual zone and were found stranded at and above the high tide level where they formed a thick mat of dead and dying individuals. Random samples taken in a specially thick and a rather thin areas of this mat of mole-crabs showed averages of 5,407 and 513 individuals respectively *per square foot.* Other animals that were seen dead or dying and cast ashore on this day were: *Scylla serrata, matuta victor, Neptunus sanguinolentus, Neptunus pelagicus, Cavernularia* sp. and species of hermit-crabs. Two days later when the area was examined again, the slush had disappeared completely though the water remained slightly turbid. Detailed examination of the area during subsequent days revealed the total absence of both *Emerita* and *Donax* along the entire stretch of the shore between Calicut and Pudiapa. As already mentioned, it was not until October-November, 1950, that the region was colonized again by these two species. A similar but in some respects unprecedented phenomenon occurred during July, 1950. This consisted in the emergence of a wide mud flat near the shore extending above the general water level, and spreading out for four to five miles along the shore. This appeared on the 5th July, following a few days of rough weather when an agitation of the sea bottom in the 2 and 4 fathom regions was reported as occurring due to an undercurrent ('Adiyilakam').

The flat thus formed seems to have remained in that condition for several days but had diminished in extent by about the 18th of July the seaward extent then being only about half a furlong. During the subsequent days there was a gradual dissolution of the flat from both the north and the south and it had finally completely disappeared by the morning of 23rd July.

Examination of the material of the mud flat mentioned above showed that it had a fine, soft, slimy consistency and resembled in this as well as in its greenish brown colour the mud of the inshore area of the previous weeks. The particles were very fine and almost all passed through a 100 mesh sieve. The animal contents of the mud were *Trypauchen vagina*, *Sternaspis scutata*, *Lumbriconereis latreilli*, a Syllid species and a nemertine species all of which were characteristic of the inshore fauna. Large numbers of shells of *Pholas orientalis* were present and a high frequency of *Trypauchen vagina* which had appeared in the marine inshore area with the onset of the monsoon conditions, was characteristic of the mudflat. It seems obvious that the whole phenomenon was the result of a shoaling up of a large quantity of mud from the inshore area due to some mechanical disturbance. During the subsequent period most of the area inward of the 8 fathom depth was characterized by 'liquid mud' at the bottom, the mud particles of the flat mentioned above having spread out in the area and remaining unconsolidated for a long time. From about the middle of September the 'liquid mud' was less frequently noticed but whenever there were strong tidal currents there was a disturbance of the fine mud and the grab brought up only slush and no clumpy mud of the usual consistency.

During the mudflat formation mentioned above no large scale mortality of animals of the type seen on 24th June, 1949, was noticed although some fish and crabs were trapped and suffocated to death. But if a population of *Emerita asiatica* were present before the phenomenon, as during the period before the slush formation of the previous year, there might perhaps have been a similar mortality of the species. But apart from the trapping or choking effect in the case of animals engulfed in the mudflat, the formation of the latter was not apparently accompanied by any release of substances deleterious to animal life in the neighbourhood and it was in fact noticed that, when the last remains of the mudflat finally dissolved away at West Hill, it was immediately followed by considerable fishing activity and a good miscellaneous catch of prawns, crabs, rays, soles and other fish was available just about 50 yards from the shore in the identical area.

6. Discussion.

(*a*) *Features of the fauna.* From the results summarized above it is possible to make out certain marked features in the bottom fauna of the area investigated. The most important of these is that the animals are not uniformly distributed at all the depths even within the limited inshore fishing area, there being a zonation in vertical distribution both qualitatively and quantitatively although the nature of the bottom is practically the same. The reasons for the existence of such zonation must be sought in the differences in the complex of environmental conditions such as salinity, temperature and *p*H ranges, the incidence of light, the incidence of currents and turbulence effects on the bottom, between the deeper and the shallower zones. The deeper region has a more stable environment in that the range of variation of these factors is more limited there than in the shallower regions. In Table II are given the salinity values of the shore water (which may be considered as having roughly the same salinity as the bottom water up to a few fathoms) and the 8 fathom bottom water during the months of August to November. There is considerable difference between the two sets of values. That the 8 and 10 fathom levels are not probably affected by turbulence effects is seen by the fact that during the mudflat formation in July, 1950, these two levels were undisturbed while the mud from the 4 fathom zone and inwards was disturbed and transported shoreward. That there was no material derived from the deeper levels in the mudflat material was evidenced by the fact that there was no trace of the Nuculids (?) or their shell pieces and the Maldanid worms or their tubes, in the material left on the sieve after washing the sample. These should have occurred if the material had been derived from the deeper level. Moreover the fact that the 8 and 10 fathom levels did not suffer a disappearance of their fauna shows that there was no large mechanical or other disturbance at the bottom there. The 4 fathom region has revealed itself in these studies as the boundary between the shallower and deeper zones but why the species and numbers must be so few there is not clear, though an indication is obtained by the fact that on some occasions 'liquid mud' was reported from this level even during the earlier months of these investigations. But for some adverse factor we should have expected the number of species to increase in the transitional zone, some of the members of the zones on either side of it persisting. The occurrence of 'liquid mud' indicates a loose bottom which is a bad substratum.

The second important feature of the fauna is that its seasonal behaviour is different in the two different zones mentioned above. The animals in the shallower region are almost all likely to disappear in every South-West monsoon season. Such disappearance has been noticed in two successive monsoon seasons and a successful recolonization of the region has been noticed in 1949, while in 1950 although a recolonization commenced, certain other factors inhibited its success. Fig. 4 shows the curves of the surface and bottom salinity in the 8 fathom region and those of the total wet weights of animals for the 2 fathom and near low water mark levels taken together and the 8 and 10 fathoms taken together. The value of the surface salinity of the 8 fathom region may be expected to be nearer to the shallow zone bottom salinity than would be the 8 fathom bottom salinity. A rough correlation can be seen from these curves between a *steep drop* in the surface salinity and the disappearance of the shallow level fauna on the one hand and between the *slight* change in the bottom salinity and the non-disappearance of the deep level fauna on the other. Although there was already a tendency towards a decline in density before the monsoon period began, the disappearance was sudden after the commencement of the monsoon and the main factors responsible for this can probably be fixed as the drop in salinity (and the pH and temperature) consequent on the coming in of fresh-water floods into the sea. The suddenness of the disappearance of the fauna appears to rule out any argument that the disappearance may be the result of continued action of some predator species, as already mentioned.

The third important feature is that the main bulk of the fauna for the entire region is contributed from the region between the Low Water Mark and a little beyond two fathoms. The animals from this region consisted mostly of polychaetes and were dominated by *Prionospio pinnata*. As animals with hard parts were only occasional and even then small and negligible in proportion, the total of the wet weights given for these two levels would be very near the total wet weight of the fish food of the inshore region, some extra quantities being, however, available from *Pholas orientalis* of the 4 and 6 fathom regions. The 8 and 10 fathom levels contribute very little directly to the fish food on account of the shelled animals. As in the near shore regions all the animals are destroyed and a new generation is developed each year, the 'stock of the moment' if estimated at any given time will be equivalent to the total annual production minus the possible increase due to growth and recruitment during the remaining part of the year and the loss due to predators and other causes.

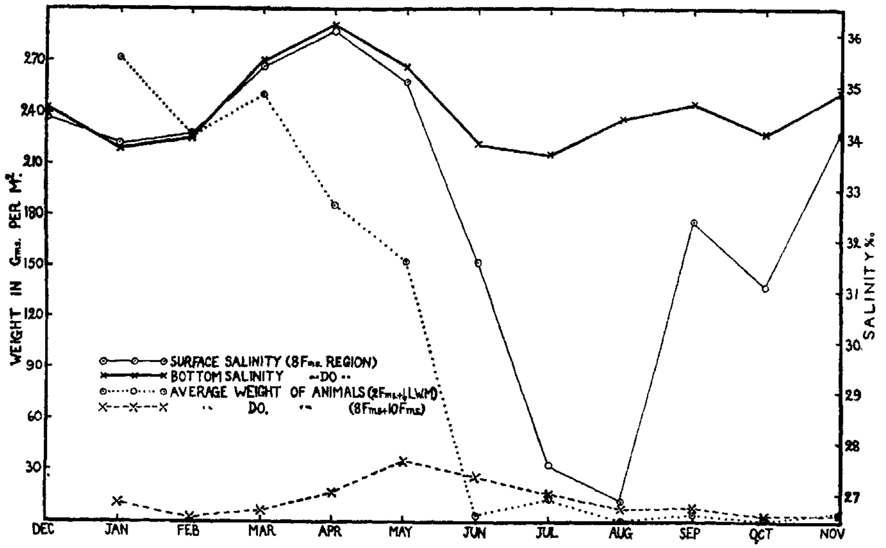

FIG. 4.—Correlation between the density of the bottom fauna and the salinity of the sea water (see text).

(*b*) *Failure of recolonization of the shallow area after the monsoon season of 1950.* While during the year 1949 an establishment of the post monsoon conditions and a rising salinity were accompanied by a rapid settlement and development of the organisms in the shallow area, during the year 1950, there was a long delay in recolonization and as there were no considerable numbers of either species or individuals even at the end of November, this may be interpreted as a failure also. An examination of the available data points to the occurrence of 'liquid mud' in the sea bottom for several weeks after the monsoon ended, as an important difference between the previous year and this one and as all the other conditions seem to be satisfied, namely the presence of suitable temperature and salinity conditions judging from the conditions prevailing during the corresponding season of the previous year, and the presence of settling larval forms in the relevant months, it has to be concluded that the nature of the bottom material must have been responsible for the failure of the recolonization. Thus it appears that the nature of the bottom material is the most important in determining the behaviour of the fauna in this region. That the substratum is one of the important factors influencing the general ecology of any aquatic fauna is fairly well known (e.g. see Pearse, 1939; Jones, 1950; Hora, 1936 and Hora and Nair, 1943). The importance of the nature of the substratum in the metamorphosis and settlement of several species of bottom invertebrates has been brought out by the work of Mortensen (see Thorson, 1946), Thorson (1946), and particularly Wilson (1937 and 1948) and Day and Wilson (1934) who worked on polychaetes. Further work on the influence of the bottom material on the bottom fauna of the Malabar coast would be of considerable interest and value.

A mud bank has long been known to be present at Calicut and to be shifting now and then between West Hill and Calicut. The last time it was seen was in 1937 'when the north pier at which there is generally fifteen feet or so of water at its outer end suddenly appeared high and dry above a mud bank' (Bristow, 1938).

It was then said that it extended 'also from the north pier to Elathur Cape' (see Fig. 1). No information is available about its subsequent movements. It seems obvious that the mudflat that appeared in July, 1950, was a manifestation of one of the movements of the Calicut mud bank, and it now seems to have settled down near West Hill as can be judged by the fact that the sea was calmest here during the months following mudflat dissolution, even when the weather was bad and the neighbouring areas of the sea were rough. There have been many theories in the past about the origin and movement of these mud banks (Bristow, 1938). Du Cane, Bristow, Brown and Keen (1938) after examining the problem in some detail have stated as follows, regarding the mode of formation of these banks: 'the banks are formed in two ways, acting separately or together, viz.—(*a*) by the depositing of material directly derived from detritus brought down by the rivers, (*b*) by the throwing up and redepositing of areas of similar mud from the sea bed during rough seas'. The present observations on the mud bank formed at West Hill go to prove that the material of the bank was derived from the inshore sea bottom mud itself and to this extent support the opinion advanced by the authors mentioned above.

(*c*) *Applicability of the general results of this work to the Malabar Coast as a whole.* In the climatic and other features, West Hill seems to be typical of coastal Malabar. The same is true of the sea bottom except for the fact that the mud bank has now extended into the area of investigations. While it is not possible without examining some more regions, to make any generalization about the productivity of bottom fauna in the inshore waters along the Malabar Coast as a whole, it seems justifiable to expect the fauna to have the same general features in the other regions of the coast also, the formation of the fauna being regular and cyclical wherever there is a relatively stable mud at the bottom but showing considerable fluctuations wherever there are mud banks. These exist at several other places along the coast and the effect of the Calicut mud bank on the fauna, when more fully known, will help in assessing the influence of the mud banks along the coast in general on the production of the bottom fauna and also on the inshore fisheries.

7. Summary.

1. Qualitative and quantitative studies have been made, of weekly or fortnightly samples taken with the Petersen Grab at different depths of the inshore sea bottom during the year December, 1949 to November, 1950, and along with these are considered the results of some qualitative samples examined during the months July to November, 1949.

2. The general features of the Malabar coast and the physical and hydrographical features of the area selected for intensive studies are described. A special feature of the Malabar coast is the occurrence of peculiar *mud banks* at various places along the coast. A great agitation of the sea bottom was noticed in the south-west monsoon season during 1949 and 1950.

3. There was a vertical zonation in the distribution of the fauna in the inshore fishing grounds. The 10, 8 and 6 fathom levels formed one zone while the 2 fathom and the near low water levels formed another zone, the intervening 4 fathom region being very poor in fauna.

4. The zone in the shallow region was rich in fauna during the premonsoon months and was dominated by polychaetes and phoronids. During the monsoon months this rich belt disappeared altogether while the fauna of the deeper levels also declined.

5. Recolonization of the shallow region started when the postmonsoon conditions were fully established but was very slow and the density of the fauna was very low even by the end of November. Among the factors determining the behaviour of the fauna, the nature of the bottom material is probably the most important.

8. References.

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9. Appendix.

Systematic List of the Species Cited.

1. ANNELIDA

Polychaeta

Sternaspis scutata Ranzani
Diopatra variabilis Southern
Prionospio pinnata Ehlers
Lumbriconereis latreilli Audouin and Milne Edwards
Glycera alba Rathke
Pectinaria (*Amphictene*) *Crassa* Grube.
Sabellaria spinulosa Leuckart

2. MOLLUSCA

Lamellibranchiata

Lucina vesicula (Gould)
Theora opalina (Hinds)
Donax cuneatus Linnaeus
Pholas orientalis Gmelin
Modiolus undulatus (Dunker).
Meretrix casta Deshayes
Arca (*Scapharca*) *gubernaculum* Reeve
Siliqua radiata (Linnaeus)

Gastropoda

Turricula javana (Linnaeus)
Acteocina Townsendi (Melvill)
Duplicaria duplicata (Linnaeus)

3. ARTHROPODA

Crustacea

Cheiriphotis megacheles (Giles)
Metapenaeus affinis (Milne-Edwards)
Alpheus malabaricus Fabricius
Emerita asiatica (Milne-Edwards)
Matuta victor Fabricius
Neptunus pelagicus (Linnaeus)
Neptunus sanguinolentus (Herbst)
Scylla serrata (Forskal)

4. PISCES

Trypauchen vagina (Bl. Schn.)
Solea ovata Rich.
Cynoglossus semifasciatus Day.

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