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AN ECOLOGICAL STUDY OF SOME POOLS NEAR MANDAPAM (SOUTH INDIA) FORMED AS A RESULT OF THE CYCLONE AND TIDAL WAVE OF 1964*

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INTRODUCTION

A SEVERE cyclone and tidal wave[1] hit the south-eastern part of India on December 23, 1964 causing unprecedented devastation. Weather forecast for December 21 had indicated that a severe cyclonic storm had formed in the Bay of Bengal and was centred about 1,200 km. south-east of Madras and was expected to move in a westerly or west-north-westerly direction. By the morning of December 23 the cyclonic storm had crossed northeast coast of Ceylon and was lying over the Gulf of Mannar centred about 50 km. east of Tondi when north-westerly gales exceeding 75 km. per hour began lashing the coastal areas of Ramanathapuram district. The storm raced from the small hours of the morning and continued unabated till about 8 a.m. After a brief lull the direction of the gale abruptly changed to a south-westerly one bringing in further havoc. The cyclonic storm coupled with the high tide brought forth a huge tidal wave of about 25 feet height engulfing Dhanushkodi—a good part of Rameswaram Island, and the low-lying areas of the mainland (see Fig. 1, inset). With the reversal of the direction of wind during the cyclonic storm the flood waters receded leaving behind several pools teaming with living organisms. The ecological study of these pools was taken up about a month later when bioluminescence was noticed in some of the pools. The normal stimulus for the emission of living light being mechanical, the agitation of water by throwing a stone and by the swimming movements of fishes and prawns produced intense luminescence. A cursory examination of the water sample taken from one of the pools revealed an abundance of littoral diatoms and many Dinophyceae especially *Pyrocystis* which is normally found in the high seas in the tropics and also cause of bioluminescence (*cf.* Fritsch, 1948). Therefore a detailed investigation of the populations in these sheltered pools was taken up at the suggestion of Dr. S. Jones, Director, Central Marine Fisheries Research Institute, Mandapam Camp. The authors wish to express their sincere thanks for the profound interest he took in this work and also for giving valuable help and guidance. The authors are indebted to Dr. R. Raghu Prasad, Deputy Director and Dr. R. Subrahmanyan, Senior Research Officer for critically going through the manuscript and offering valuable suggestions. The authors thank Mr. K. J. Joseph, for assistance in the analysis of water samples and Mr. K. L. Kesavan for drawing the text figures.

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[1] It has been suggested by some meteorologists that it was not a tidal wave in the strict sense but the normal high tide water whipped up by a high-velocity wind.

After a preliminary survey of the area around Mandapam where several pools had formed, five of them spread over a distance of 2 km. were selected (Fig. 1). Though these pools were selected at random further analysis indicated that there is some divergence in the nature of the pools in their hydrological, planktological and faunistic characters. Pools 1, 2 and 4 were more saline and were akin to the adjoining lagoon, whereas 3 and 5 were of brackish nature. As the whole low-lying area was flooded by the tidal water it is not known how pools 3 and 5 maintained a lower salinity than the other three pools. It is possible that slow percolation from the lagoon and sea might have influenced the salinity in pools 1, 2 and 4 while in 3 and 5 there would have been greater dilution due to run off which is evidenced by the higher silicate content also. Pool 5 showed no trace of bioluminescence initially but with the blooming of *Pyrocystis* by the third week of March it became highly luminescent.

Weekly collections were made from all the pools, lagoon and the sea (Palk Bay). Water samples were analysed for salinity, phosphate and silicate using standard analytical techniques (Table I). Colour comparisons were made visually. 500 ml. of the water samples were sedimented and centrifuged and were made up 10 ml. and 1 ml. aliquots were counted on Sedgewick-Rafter type counting chamber. For the smaller and abundant organisms haemocytometer counts were taken. Continuous observations of a few factors were also made at regular intervals from the lagoon and pool 2 for a whole day so as to cover both the high and low tides (Fig. 2).

Prawns and fish were collected from all the pools on the same days using a drag-net (*kondodi-valai*) making a single haul from each pool. Regular observations were carried out for over two months from the beginning of February 1965 to the first week of April 1965. Thereafter, although the weekly collections were continued till all the pools dried up by about 19-5-1965 the water samples were analysed for salinity only.

Discussion of Results

Hydrology: The salinity varied widely from the initial to the final stage with the progress of summer and consequent evaporation. The slight fall on 16-2-1965 and 20-4-1965 was due to the rainfall on the previous days. Pools 1, 2 and 4 initially were of sea water-type (30-40‰) reaching hypersalinity (40-80‰) after about a month and ended up as brine water (>80‰). Pools 3 and 5 were brackish initially (<30‰). But in the final stage, pool 3 was hypersaline and pool 5 of brine water. The silicate concentration also was distinctly higher in the latter two pools. The high increase of silicate at the end of March might be due to the continuous churning of the bottom while fishing. The silicate values obtained here for the sea water were also higher than in the previous observations (Jayaraman, 1954), presumably because these samples were taken from very near the shore. The concentration of silicates together with salinity seemed to have influenced the composition of the dinophycean population.

Phosphate values were not found to vary significantly between the pools. Within the limits of experimental errors the depletion by the developing population was evident in all the pools. However, the values are by no means absolute and need be considered only as arbitrary, as the colour comparisons were very difficult due to the influence of detritus.

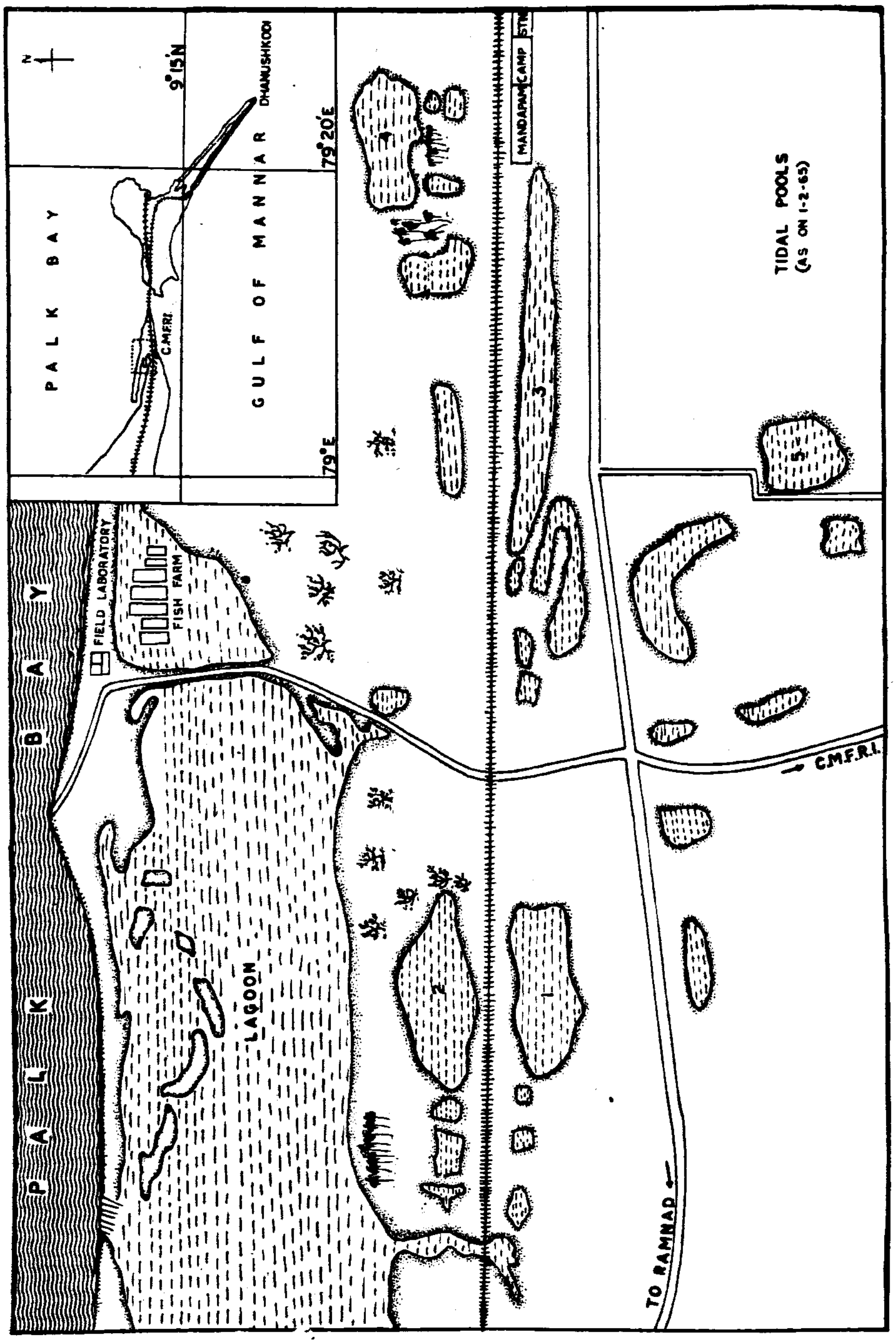

FIG. 1. Location of the tidal pools as at the beginning of the observations. Inset shows Pamban Island and part of the mainland which was worst hit by the cyclone. The dotted area has been enlarged.

There was a definite diurnal rhythm in the concentration of the oxygen following more or less the temperature pattern—with an afternoon maximum and a predawn minimum. The oxygen concentration in the pools was significantly lower

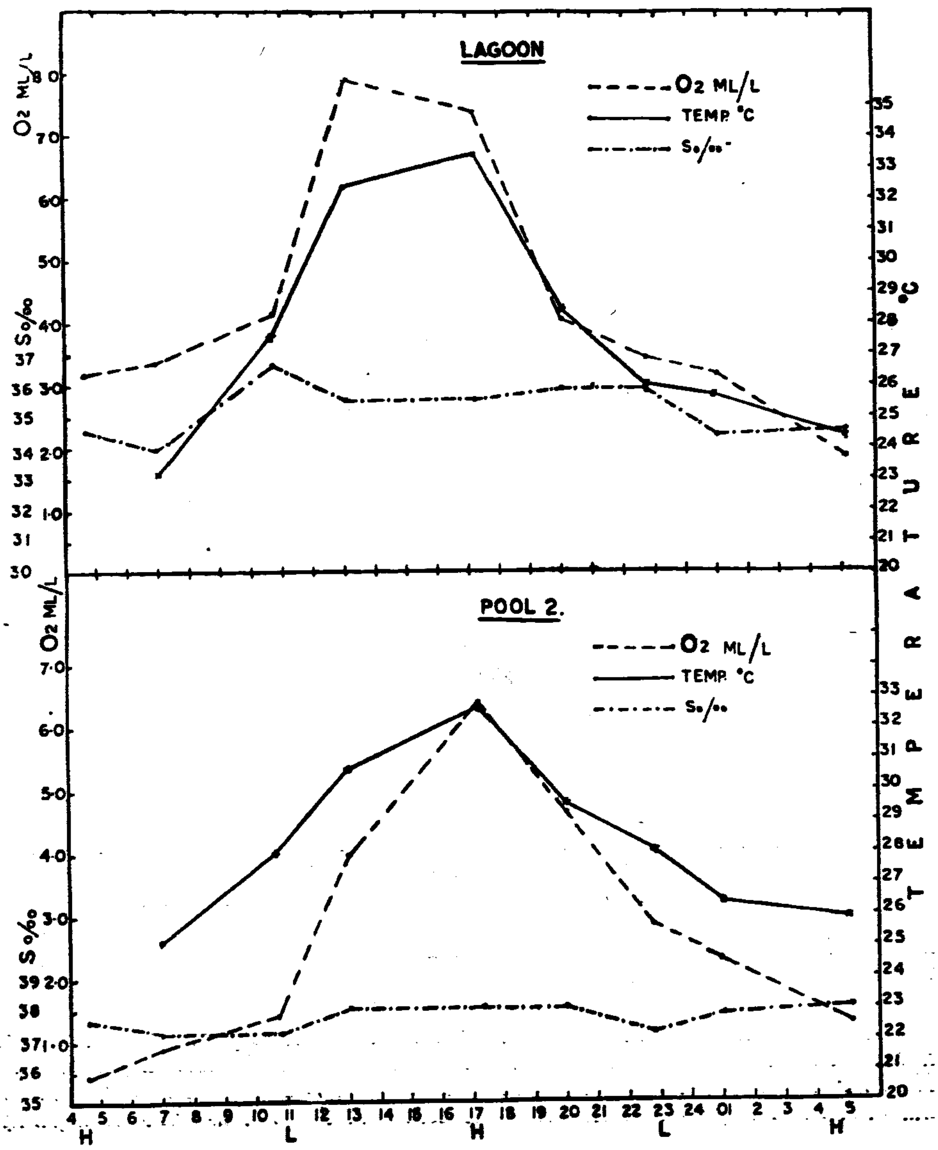

FIG. 2. Diurnal variation of oxygen, temperature and salinity in the lagoon and pool 2 from 0400 hours on 20-2-1965 to 0500 hours on 21-2-1965. L-Low Tide. H-High Tide.

than that of the sea which is an indication of the difference in the concentration of organisms between a natural environment and a special environment.

The temperature and oxygen values recorded here for the lagoon are lower and those of salinity and phosphate higher than those recorded by Tampi (1959). The differences observed may be due to the difference in the time of observations, the shallower nature of the lagoon and the influx of soil from surrounding areas after flooding of the lagoon during cyclone.

Phytoplankton : The phytoplankters were mostly composed of two members of Dinophyceae (*Pyrocystis* and *Peridinium*) and littoral diatoms belonging to the genera *Pleurosigma* and *Navicula* (Table II). Apart from these *Nitzschia, Cymbella* and also the blue green alga *Oscillatoria* were noticed occasionally. Since the commencement of the investigations, it was noticed that there was a distinct succession of the organisms with the progressive onset of summer and increase in salinity. The dominance of diatoms noticed in the first week of February was followed by members of Dinophyceae. In pool 3, *Pyrocystis* was noticed in abundance even at the start of the investigations but in pool 5, the appearance of this species took place only later. *Pyrocystis pseudonoctiluca* is a member of the Dinophyceae and is an abundant planktonic form occurring in most tropical and subtropical seas and is one of the diverse organisms responsible for bioluminescence. The individual cell is large and spherical with a pale yellow colour due to the presence of numerous small yellow-brown chromatophores. The organism responsible for bioluminescence in pools 1, 2 and 4 was *Peridinium*, whereas in 3 and 5 it was *Pyrocystis* though some others like *Ceratium, Gymnodinium* etc. also were noticed in very small numbers in all. In this connection it may be mentioned that several Dinophyceae are known to be luminescent viz. *Noctiluca, Pyrodinium, Ceratium, Peridinium, Prorocentrum, Gonyaulax, Blepharocysta* and *Gymnodinium* (Harvey 1952).

Pool 4 can be taken as a typical example where succession of organisms was found to have a definite pattern of sequence. From a preponderance of diatoms especially *Pleurosigma* of about 235,000 cells/1, *Peridinium* sp. gained dominance and attained an intensity of 246,000 cells/1 by the third week of February when the diatom intensity dwindled to a mere 6,000 cells. This was followed by the appearance of a flagellate *Carteria* (Chlamydomonadineae) in large numbers when the pool was drying up and the water reached hypersalinity. This flagellate developed almost to the exclusion of all other forms of phytoplankton and flourished even when the salinity was over 100‰. This, however, is not surprising since some flagellates, Cyanophyceae and shrimps are known to exist in brine water with salinities exceeding even 200‰ (*cf.* Kinne, 1964). The climax of the sequence of succession of organisms in pool 1 was also formed by the same flagellate, whereas in pool 2 it was by *Chilomonas* (Cryptomonadaceae), a colourless, saprophytic flagellate lacking in chromatophores.

It may be mentioned here that the conditions in these pools were of a special nature and were subject to the extremes from the initial to the final drying up stage. Hence it is possible that salinity and perhaps the silicate content too would have influenced to a large extent the succession and dominance of the various organisms.

Prawns : Penaeid prawns formed a good portion of the catches. They were identified and measured. Most of them were young ones which could hardly be differentiated as males and females. The total number, size range, dominant size groups and total weight were recorded for each sample. These are given in Table III.

A sizeable-portion of the weekly catches was composed of prawns, the species represented being *Penaeus indicus* Milne Edwards, *P. merguiensis* de Man, *P. semisulcatus* de Haan, *P. monodon* Fabricius, *Metapenaeus affinis* (Milne Edwards) and *M. dobsoni* (Miers). In addition to them a few specimens of *Metapenaeus burkenroadi* (Kubo)[1], 2 specimens of *M. lysianassa* de Man[2] and a solitary specimen of *Penaeus canaliculatus* Olivier were collected. The presence of prawns in these pools was quite incidental.

During the initial stages of observation fairly large-sized prawns were available in good numbers. Prawns were relatively more in pools 1, 2 and 4 than in 3 and 5. It gives further evidence of the divergence in the nature of the pools as indicated by the hydrological and phytoplanktological characteristics discussed earlier. In pools 1 and 2 *Penaeus* spp. and in pool 3 *Metapenaeus* spp. were common. By that time intensive fishing was commenced by local people using all sorts of devices and the prawns started decreasing in numbers in the collections. From 2-3-1965 onwards only a few specimens occurred in the catches which were mainly composed of specimens of *Penaeus indicus*. By this time the water was nearing hypersalinity. It appears that *P. indicus* has a higher salinity tolerance than the other species of prawns met with in the pools. On 6-4-1965 it was found that almost all the prawns were dead in pool 1 and some of them were in a decayed condition, indicating their inability to survive in hypersaline water. Depletion of oxygen and the high heating during daytime might have also influenced it.

No progress in the modal length groups of prawns was observed. Besides constant fishing, the rigours of a unique environment where conditions change from one extreme to the other in quick succession would not have been congenial for growth processes of these animals as in their natural habitat.

Crabs : The crabs collected comprised of *Neptunus pelagicus* Linnaeus, which is a common species occurring in this area. They were also common in pools 1, 2 and 4 just as the prawns. The number of specimens present in different pools, their size range etc. are given in Table IV. They did not occur in catches from 30-3-1965 onwards. Later, many of them were found dead in the dried areas of pools 1, 2 and 4.

Other crustaceans collected included a few specimens of *Acetes* sp. and amphipods.

A few specimens of squid belonging to the genus *Sepioteuthis* were collected from pool 2.

A few nauplii were occasionally met with in the centrifuged samples. Tintinnids were very commonly found.

Fishes : Forty-six species of fish belonging to thirty-six genera and twenty-eight families have been collected during this study. All the species listed were not available on the first collection day ; a few occurred intermittently and certain other species only once either solitarily or in a few numbers. Even when a species

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[1] This is the first record of this species from the east coast of India. The authors are thankful to Mr. M. J. George for the identification.

[2] A note on the occurrence of *M. lysianassa* in the south east coast of India is under publication by one of the authors (C.A.).

was collected on the last date of observation only, it is to be considered that the species concerned was present in the pool from the commencement of the studies since there was no scope for fresh entry. The non-availability of a species from a particular date onwards cannot be attributed to its inability to withstand changes in the hydrological conditions since it could have been fished out. Only the occurrence of dead fish in the pools could indicate the lethal limits in the environmental conditions. A few such instances noted have been indicated in Table V wherein the data on the specimens collected viz., the last date of occurrence, total size range, and the total number obtained for each species have been presented poolwise.

An analysis of the data for the incidence of the different species showed 24 species in pool 1, 32 in pool 2, 21 in pool 3, 10 in pool 4 and 21 in pool 5. Out of the total number of 1914 specimens of all species collected from all the pools 550 (29%) fish from pool 1, 408 (21%) from pool 2, 237 (12%) from pool 3, 52 (3%) from pool 4 and 667 (35%) from pool 5 were available.

The fish met with in the collections were mostly young ones and almost coastal in habitat and in a few cases extending to estuaries, backwaters, tidal rivers and also fresh water. Out of the 46 species of fish, those which formed 1% and above in the total for all fish for all the pools and over the whole period are as follows : *Nematalosa nasus* and *Tilapia mossambica* were the most numerically abundant species forming 26% and 23% respectively. Next in the order were, *Liza macrolepsis* (14%) *L. parsia* (10%), *Leiognathus brevirostris* (7%), *Pelates quadrilineatus* (3%) *Gerres oyena* (2%), *Mugil cephalus* (1%) and *Torquigener oblongus* (1%). In a study of the ecological and fisheries characteristics of the salt water lagoon near Mandapam, Tampi (1959) stated that mullets (*Mugil* spp.), threadfin gizzard shad (*Nematalosa nasus*) and milkfish (*Chanos chanos*) are of fishery importance. The total absence of milkfish in the present collections possibly indicates its absence in the inshore waters in this area during the cyclone period. The presence of *Tilapia mossambica* in the pools, particularly its abundance in pool 5 which may be due to the fresh and brackish water environment it provided in the initial period of observation is noteworthy.

A total number of 24 species collected when salinity was above (41‰) that of sea water type have been listed in Table VI, wherein their state of occurrence (alive or dead) in the different salinity values have been mentioned. All the species listed seem to tolerate hypersaline conditions although a few dead specimens of *Thysanophyrs indicus* were noted ; but a few more seem to have survived and later died when salinity rose above 80‰. Quite a large number of species were found dead in salinity range of 81-87‰ ; only a few species survived in salinity above 87‰. *Liza macrolepis*, *L. parsia*, *Tilapia mossambica* and *Gerres abbreviatus* were the only species found alive in brine water ; however, a few specimens of *L. macrolepis* and *L. parsia* were found dead as also a few specimens of *Mugil cephalus*. Recently Durve and Alagarswami (1964) have reported mass mortality of fish, prawns, and clams in the shallow waters of Athankarai estuary and they have attributed the mortality of these animals to the excessive rise in salinity (96-97‰). In the present study the high salinity, diurnal variation of oxygen, particularly the pre-dawn minimum and the high afternoon temperature towards the later part of observations when the pools were very shallow would all have had their inimical influence on the survival of the fish.

SUMMARY

1. Ecological study of populations in five pools at Mandapam formed as a result of the cyclone and tidal wave was conducted for over a three-month period.

2. Three pools with higher salinity and lower silicate content were colonised by *Peridinium* while two pools with lower salinity and higher silicate content were colonised by *Pyrocystis*, both causing bioluminescence in the pools.

3. All the pools showed clear succession of organisms with the progressive onset of summer and increase in salinity. Diatoms were succeeded by dinoflagellates in abundance and the climax of succession was marked by the appearance of flagellates belonging to either autotrophic Chlamydomonadineae or saprophytic Cryptomonadaceae.

4. Nine species of penaeid prawns, one species of crab, a few specimens of amphipods, and *Acetes* were the crustaceans collected. Size range, dominant size groups and total weight of the prawns are given. A few specimens of *Sepioteuthis* and a number of tintinnids were also recorded.

5. Forty-six species of fish which are mainly coastal in their habitat occurred in the pools. Size range, total number and the dates on which dead ones were noticed are given.

6. Twenty-four species of fish were found to tolerate hypersaline conditions of which four were found alive even in brine water (92‰).

7. The conditions in the pools were of a special nature. Salinity together with the diurnal variation of oxygen, with a pre-dawn minimum and the high temperature in the afternoon are considered as having affected the survival of the fauna consisting of fish, prawns and crabs.

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TABLE I

	Date	Salinity ‰	Oxygen ml/l	Phosphate µg. at. P/l	Silicate µg. at. Si/l	Temp. °C.	Depth (inches)
Pool 1	2-2-65	35.01	—	—	—	—	—
	9-2-65	40.30	0.784	2.50	33.33	25.6	27
	16-2-65	27.98	0.672	1.00	50.00	23.6	25
	23-2-65	34.92	0.112	0.40	50.00	24.5	23
	2-3-65	37.86	1.400	0.64	41.67	25.8	20
	9-3-65	41.82	0.952	0.91	50.00	25.1	15
	16-3-65	44.77	1.008	0.57	50.00	25.9	14
	23-3-65	55.51	1.736	0.34	29.41	27.0	12
	30-3-65	65.55	1.568	0.44	33.33	26.7	10
	6-4-65	77.29	0.952	0.14	41.67	27.6	—
	12-4-65	88.48	0.672	—	—	—	—
	20-4-65	75.59	—	—	—	27.0	—
	27-4-65	89.90	—	—	—	28.0	—
	5-5-65	124.66	—	—	—	28.4	—
	12-5-65	dried	—	—	—	—	—
Pool 2	2-2-65	36.07	1.904	0.45	—	—	—
	9-2-65	36.42	0.896	0.77	19.00	25.9	23.5
	16-2-65	33.43	2.576	0.10	29.55	24.1	26
	23-2-65	39.02	0.672	0.48	44.64	25.4	25
	2-3-65	41.46	1.568	0.61	55.56	26.0	19
	9-3-65	46.15	0.784	0.46	41.67	25.0	19
	16-3-65	53.89	1.036	0.33	45.46	26.0	14
	23-3-65	61.46	0.448	0.10	35.71	27.5	12
	30-3-65	71.15	Nil	0.20	71.43	26.9	13
	6-4-65	82.16	Nil	0.20	35.71	27.9	—
	12-4-65	91.72	Nil	—	—	—	—
	20-4-65	77.91	—	—	—	27.5	—
	27-4-65	89.09	—	—	—	28.1	—
	5-5-65	127.31	—	—	—	28.3	—
	12-5-65	dried	—	—	—	—	—
Pool 3	2-2-65	22.00	2.688	1.10	—	—	—
	9-2-65	22.71	0.672	1.00	32.05	26.5	21
	16-2-65	18.31	4.200	0.18	100.00	26.0	23
	23-2-65	19.72	0.728	0.67	41.67	26.5	21
	2-3-65	20.03	2.240	1.00	71.43	26.3	18
	9-3-65	21.47	1.232	0.57	41.67	25.5	18
	16-3-65	24.71	1.344	0.60	62.50	26.7	15
	23-3-65	28.85	0.728	0.13	100.00	28.0	11
	30-3-65	35.41	2.352	0.70	250.00	28.5	10
	6-4-65	46.06	1.288	0.39	125.00	28.6	—
	12-4-65	47.50	1.568	—	—	—	—
	20-4-65	55.98	—	—	—	28.0	—
	27-4-65	68.23	—	—	—	28.1	—
	5-5-65	77.51	—	—	—	28.5	—
	12-5-65	dried	—	—	—	—	—

TABLE I (*Contd.*)

	Date	Salinity ‰	Oxygen ml/l	Phosphate µg. at. P/l	Silicate µg. at. Si/l	Temp. °C.	Depth (inches)
Pool 4	2-2-65	30.44	3.528	0.82	—	—	—
	9-2-65	32.55	0.728	2.00	30.49	27.2	19
	16-2-65	30.27	2.800	0.18	31.25	24.4	22
	23-2-65	36.48	0.504	0.91	33.33	25.2	20
	2-3-65	40.57	0.672	0.67	31.25	26.0	13
	9-3-65	47.59	0.168	0.42	35.71	24.2	11
	16-3-65	63.80	Nil	0.42	41.67	25.1	16
	23-3-65	76.21	0.280	0.09	50.00	—	—
	30-3-65	107.97	Nil	0.30	100.00	28.5	—
	6-4-65	dried	—	—	—	—	—
Pool 5	2-2-65	19.54	3.920	1.04	—	—	—
	9-2-65	22.71	0.672	1.00	32.05	28.5	26
	16-2-65	20.07	4.480	0.34	108.33	25.1	25
	23-2-65	22.64	0.728	0.75	147.05	26.5	21
	2-3-65	23.44	2.128	1.38	100.00	26.4	20
	9-3-65	25.25	1.848	0.58	62.50	26.5	21
	16-3-65	28.49	2.128	0.35	71.43	25.1	16
	23-3-65	32.64	0.728	0.11	100.00	28.0	12
	30-3-65	38.30	1.680	0.35	125.00	29.0	12
	6-4-65	45.34	Nil	0.29	100.00	29.0	12
	12-4-65	51.65	1.400	—	—	—	—
	20-4-65	51.38	—	—	—	27.5	—
	27-4-65	57.19	—	—	—	28.6	—
	5-5-65	78.72	—	—	—	28.2	—
	12-5-65	72.06	—	—	—	28.4	—
	19-5-65	91.34	—	—	—	27.6	—
Lagoon	2-2-65	33.06	—	—	—	—	—
	9-2-65	36.25	3.248	0.96	12.50	25.4	—
	16-2-65	30.44	4.368	0.20	10.00	24.0	—
	23-2-65	37.07	1.400	2.00	20.00	24.4	—
	2-3-65	40.03	3.240	0.58	33.33	25.0	—
	9-3-65	46.51	1.904	0.43	38.46	24.0	—
	16-3-65	53.17	2.520	0.23	41.67	24.5	—
	23-3-65	64.88	2.408	0.11	27.78	26.0	—
	30-3-65	84.32	2.128	0.29	21.25	27.0	—
	6-4-65	107.61	2.128	0.20	15.00	27.6	—
	12-4-65	159.95	1.512	—	—	—	—
Palk Bay	2-2-65	28.51	—	—	—	—	—
	9-2-65	29.57	2.408	0.83	6.25	—	—
	16-2-65	29.04	4.704	0.44	17.50	25.5	—
	23-2-65	31.81	1.568	1.11	28.13	25.5	—
	2-3-65	29.58	4.312	0.67	38.46	26.0	—
	9-3-65	29.39	4.008	0.35	31.25	26.0	—
	16-3-65	29.75	3.808	0.25	31.25	26.5	—
	23-3-65	30.11	4.088	0.14	12.50	29.0	—
	30-3-65	31.44	4.032	0.45	10.00	27.0	—
	6-4-65	32.16	3.368	0.28	8.75	28.8	—
	12-4-65	32.70	3.248	—	—	—	—

TABLE II

Date	Species	Pools 1	2	3	4	5
2-2-1965	Dinophyceae ..	..	1,600	45,200	1,600	..
	Bacillariophyceae					
	Pleurosigma spp.	..	43,200	62,000	232,000	18,000
	Navicula spp.	..	1,360	3,200	3,600	6,000
	Others ..	..	2,000	3,600	800	2,800
9-2-1965	Dinophyceae ..	100,000	2,000	20,000	..	..
	Bacillariophyceae					
	Pleurosigma spp.	16,000	7,200	67,200	17,600	1,200
	Navicula spp.	2,000	4,400	4,000	2,400	1,200
	Others ..	1,200	400	1,600	..	800
16-2-1965	Dinophyceae ..	86,000	100,800	44,000	124,800	2,400
	Bacillariophyceae					
	Pleurosigma spp.	800	5,200	1,600	22,400	3,200
	Navicula spp.	..	4,800	1,200	4,000	3,600
	Others ..	..	..	3,600	..	800
23-2-1965	Dinophyceae ..	4,800	168,400	82,000	246,800	..
	Bacillariophyceae					
	Pleurosigma spp.	4,000	8,000	400	4,800	..
	Navicula spp.	4,000	4,800	..	400	2,800
	Others ..	..	400	400	1,600	2,000
2-3-1965	Dinophyceae ..	50,000	6,000	1,600	172,000	178,000
	Bacillariophyceae					
	Pleurosigma spp.	10,000	8,000	..	32,000	2,000
	Others ..	1,200	4,800	..	800	1,600
9-3-1965	Dinophyceae ..	400,000	12,800	..	133,000	241,000
	Bacillariophyceae					
	Pleurosigma spp.	8,000	4,000	..	28,000	1,600
	Navicula spp.	800	2,000	..	2,000	400
	Others ..	..	1,600	..	1,600	400
16-3-1965	Dinophyceae ..	38,800	48,000	800	89,000	280,000
	Bacillariophyceae					
	Pleurosigma spp.	5,600	3,200	800	2,800	800
	Navicula spp.	400	..	400	..	..
	Flagellates .. (Chlamydomonadineae—*Carteria*) ..	..	..	..	26,000,000	..

TABLE II (*Contd.*)

Date	*Species*	Pools 1	2	3	4	5
23-3-1965	Dinophyceae	8,000	125,200	..	..	276,000
	Bacillariophyceae ..					
	Pleurosigma spp. ..	3,200	400	..	4,000	400
	Navicula spp. ..	1,200	..	..		2,800
	Others	400	..	400	..	..
	Flagellates (Chlamydomonadineae—*Carteria*)	..	..	..	30,000,000	..
30-3-1965	Dinophyceae	5,200	6,800	..	..	140,000
	Bacillariophyceae ..					
	Pleurosigma spp. ..	400	1,600	1,500	..	3,600
	Navicula spp. ..	400	..	1,200	..	87,200
	Others	..	..	4,000	800	400
	Flagellates .. .. (Chlamydomonadineae—*Carteria*)	..	..	..	40,000,000	..
7-4-1965	Dinophyceae	800	1,200	..	..	200,000
	Bacillariophyceae ..					
	Pleurosigma spp. ..	800	4,400	..	..	2,800
	Navicula spp. ..	400	..	..	..	24,000
	Others	..	..	..	..	1,200
	Flagellates					
	1. Chlamydomonadineae—*Carteria*	18,000,000	..	..	..	..
	2. Chryptomonadaceae—*Chilomonas* ..	..	1,200,000		..	..

TABLE III

Date	Species*	Pool 1				Pool 2				Pool 3				Pool 4				Pool 5			
		No. of specimens	Size range in mm.	Dominant size group in mm.	TOTAL WEIGHT	No. of specimens	Size range in mm.	Dominant size group in mm.	TOTAL WEIGHT	No. of specimens	Size range in mm.	Dominant size group in mm.	TOTAL WEIGHT	No. of specimens	Size range in mm.	Dominant size group in mm.	TOTAL WEIGHT	No. of specimens	Size range in mm.	Dominant size group in mm.	TOTAL WEIGHT
2-2-1965	*Penaeus indicus*	42	95-120	111-115	1,463 gms.	..	..	..	198 gms.	18	51-66	56-60	49 gms.	..	..	..	380 gms.	21	60-85	71-75	100 gms.
	P. merguiensis	92	55-126	111-115		21	66-112	91-95		9	45-101	46-50		52	48-74	61-65		9	54-105	56-60	
	P. semisulcatus	24	49-125	101-105		11	40-106	41-45		8	42-54	..		73	48-99	61-65		11	41-90	41-45	
	Metapenaeus affinis	34	30-78	56-60		3	48-66	..		10	27-44	36-40		255	29-56	36-40		27	26-52	31-35	
	M. dobsoni	6	26-65	31-35		..	..	..		..	..	..		50	29-79	31-35		..	..	..	
9-2-1965	*P. indicus*	3	66-75	71-75	457 gms.	2	94-106	..	266 gms.	24	48-88	56-60	73 gms.	33	53-89	81-85	345 gms.	3	75-85	..	53 gms.
	P. merguiensis	15	56-120	56-60		14	45-112	101-105		19	44-102	51-55		32	51-107	61-65		5	60-102	..	
	P. semisulcatus	38	52-126	111-115		87	37-93	46-50		12	43-62	46-50		1	56	..		3	56-110	..	
	P. monodon	..	..	..		..	..	..		..	..	..		..	..	..		1	76	..	
	M. affinis	23	38-84	36-40		8	40-73	51-55		38	21-55	31-35		209	32-66	36-40		1	56	..	
	M. dobsoni	..	..	..		..	..	..		..	..	..		26	48-59	51-55		..	..	..	
19-2-1965	*P. indicus*	16	61-104	71-75	196 gms.	7	89-122	..	94 gms.	59	56-74	61-65	96 gms.	11	55-81	71-75	228 gms.	4	54-66	..	60 gms.
	P. merguiensis	2	62-92	..		3	77-95	..		2	46-55	..		4	51-66	51-55		8	80-103	91-95	
	P. semisulcatus	14	45-77	51-55		3	51-101	..		5	61-69	65-16		..	..	..		..	..	..	
	P. monodon	3	72-138	71-75		..	..	..		1	115	..		..	..	..		1	102	..	
	M. affinis	62	32-71	41-45		15	52-68	61-65		4	37-64	61-65		203	31-52	41-45		..	..	..	
	M. dobsoni	15	41-69	56-60		1	68	..		..	..	..		1	58	..		..	..	..	

23-2-1965	*P. indicus*	21	66-118	89-90	217 gms.	62	58-112	71-75	246 gms.	31	56-80	61-65	57 gms.	13	70-92	76-80	49 gms.	2	55-60	..	4 gms.
	P. merguiensis	13	61-117	76-80		..	..	..		..	..	..		1	66	..		..	..	..	
	P. semisulcatus	5	53-80	56-60		..	..	..		..	..	..		..	..	..		..	..	..	
	P. monodon	1	70	..		..	..	..		..	..	..		..	..	..		..	..	..	
	M. affinis	63	32-71	41-45		15	52-62	56-60		1	49	..		11	39-44	41-45		..	..	..	
	M. dobsoni	15	41-63	56-60		1	63	..		..	..	..		..	..	..		..	..	..	
2-3-1965	*P. indicus*	39	64-101	76-80	138 gms.	29	69-114	81-85	160 gms.	50	52-74	61-65	95 gms.	3	66-77	..	379 gms.	5	51-59	..	7 gms.
	P. affinis	3	45-48	46-50		..	..	..		..	..	..		467	38-51	41-4		..	..	..	
9-3-1965	*P. indicus*	97	51-109	81-85	120 gms.	25	69-104	81-85	134 gms.	5	59-66	61-65	25 gms.	..	..	..	17 gms.	..	..	..	
16-3-1965	*P. indicus*	8	73-100	91-95	35 gms.	5	91-128	91-95	46 gms.	56	55-81	56-60	113 gms.	..	..	..		2	60-62	..	4 gms.
	P. monodon	..	..	..		1	90	..													
23-2-1965	*P. indicus*	14	76-90	86-90	76 gms.	1	98	..	4 gms.	22	55-68	61-65	36 gms.	..	..	..		2	56-62	..	5 gms.
30-3-1965	*P. indicus*	13	71-89	86-90	72 gms.	3	90-113	..	13 gms.	..	..	..		..	..	..		..	..	..	

* Only the species available on the date of collection has been mentioned.

TABLE IV

Date	Pool-1		Pool-2		Pool-3		Pool-4		Pool-5	
	No. of specimens	Size range in mm.	No. of specimens	Size range in mm.	No. of specimens	Size range in mm.	No. of specimens	Size range in mm.	No. of specimens	Size range in mm.
2-2-1965	12	29-41	—	—	1	71	38	31-53	4	29-43
9-2-1965	1	35	7	21-87	2	41-49	8	31-42	2	42-51
16-2-1965	11	25-44	5	31-64	3	31-70	12	35-66	—	—
23-2-1965	9	23-41	15	28-52	—	—	10	35-60	—	—
2-3-1965	11	31-51	1	33	1	54	8	41-64	1	40
9-3-1965	14	32-58	—	—	—	—	6	40-51	—	—
16-3-1965	7	32-75	6	34-40	1	66	15	38-55	—	—
23-3-1965	2	39-47	1	34	—	—	—	—	—	—

TABLE V

Pool No.* (1)	Last date of occurrence (2)	Total size range (T.L. in mm.) (3)	Total No. of specimens collected over the whole period (4)
	Elops machnata (Forskal)		
2.	9-2-1965	122-170	6
3.	23-2-1965	122,140	2
	Megalops cyprinoides (Broussonet)		
3.	23-3-1965	130,170	2
5.	20-4-1965	180,181	2
	Nematalosa nasus (Bloch)		
1.	9-2-1965	23-72	182
2.	30-3-1965	24-94	124
3.	23-3-1965	60-94	46
4.	9-2-1965	23-82	7
5.	16-2-1965	32-68	146
	Anchoviella indica (Van Hasselt)		
2.	16-2-1965	72	1
	Anchoviella baganensis (Hardnberg)		
2.	9-2-1965	98	1
	Mystus gulio (Hamilton-Buchanan)		
1.	2-2-1965	84,107	2
3.	30-3-1965	112	1
4.	16-3-1965	91	1
5.	20-4-1965	61-159	10
	Tylosurus strongylurus (Van Hasselt)		
2.	9-3-1965	235	1
	Hemirhamphus dussumieri Cuvier & Valenciennes		
2.	23-3-1965	144	1
	Corythoichthys fasciatus (Gray)		
1.	2-3-1965	92	1
2.	23-2-1965	109-130	3
	Mugil cephalus Linnaeus		
1.	30-4-1965	104-121	3
	*12-4-1965	106-152	9
3.	12-4-1965	50-115	16
	Mugil cunnesius Valenciennes		
3.	2-3-1965	92	1
	Liza macrolepis (Smith)		
1.	27-4-1965	30-90	140
	*12-4-1965	65-90	18
2.	27-4-1965	39-94	24
	*27-4-1965	87,106	2
3.	27-4-1965	57-104	55
5.	19-5-1965	52-114	37

* Only the pool wherein the species of fish was available has been mentioned.

TABLE V (*Contd.*)

(1)	(2)	(3)	(4)
	Liza parsia (Hamilton-Buchanan)		
1.	27-4-1965	28-99	31
	*12-4-1965	63,80	2
2.	20-4-1965	64-125	42
3.	20-4-1965	57-139	81
5.	19-5-1965	68-124	25
	Ellochelon waigiensis (Quoy and Gaimard)		
1.	30-3-1965	94	1
2.	2-2-1965	51	1
5.	20-4-1965	41-66	16
	Pranesus duodecimalis (Valenciennes)		
2.	2-2-1965	59, 76	2
4.	9-2-1965	64	1
	Eleutheronema tetradactylum (Shaw)		
1.	2-2-1965	74, 74	2
3.	9-3-1965	107-153	5
5.	16-2-1965	89	1
	Ambassis gymnocephalus (Lacépède)		
3.	23-3-1965	48	1
4.	16-2-1965	43	1
5.	5-5-1965	42-49	12
	Epinephelus tauvina (Forskal)		
3.	9-3-1965	165	1
	Pelates quadrilineatus (Bloch)		
2.	9-3-1965	22-61	45
	*6-4-1965	55-85	16
4.	9-2-1965	50	1
	Autisthes puta (Cuvier)		
2.	30-3-1965	34-68	4
	*6-4-1965	48-84	11
4.	9-2-1965	74	1
	Therapon jarbua (Forskal)		
1.	*12-4-1965	87-107	3
2.	*6-4-1965	88-120	8
3.	23-2-1965	86	1
5.	2-2-1965	65	1
	Carangoides praeustes (Bennett)		
1.	9-2-1965	36-63	6
3.	2-3-1965	74-102	4
5.	2-2-1965	45	1
	Gerres oblongus Cuvier		
2.	30-3-1965	62, 71	2
	*6-4-1965	74	1
5.	23-2-1965	43-45	3
	Gerres abbreviatus Bleeker		
1.	12-4-1965	74, 77	2
2.	23-3-1965	83	1
5.	2-2-1965	47, 75	2

TABLE V (*Contd.*)

(1)	(2)	(3)	(4)
	Gerres oyena (Forskal)		
2.	30-3-1965	35-63	30
	*6-4-1965	78	1
3.	23-2-1965	47	1
5.	16-3-1965	49, 55	2
	Secutor insiditor (Bloch)		
1.	2-2-1965	83	1
	Secutor ruconius (Hamilton-Buchanan)		
1.	2-2-1965	37-60	3
	Leiognathus splendens (Cuvier)		
1.	2-2-1965	34, 45	2
2.	23-2-1965	33-45	4
5.	16-2-1965	34-44	5
	Leiognathus brevirostris (Valenciennes)		
1.	9-2-1965	32-79	91
2.	9-3-1965	31-69	9
3.	16-3-1965	30-78	11
4.	9-2-1965	35-39	12
5.	16-2-1965	22-69	19
	Pomadasys hasta (Bloch)		
1.	9-2-1965	58-77	8
2.	16-2-1965	47-78	12
3.	23-3-1965	80-96	4
5.	16-2-1965	50, 60	2
	Scatophagus argus (Linnaeus)		
2.	2-2-1965	37	1
	Tilapia mossambica (Peters)		
1.	12-4-1965	58-124	12
2.	27-4-1965	38-154	31
3.	23-2-1965	71	1
4.	16-3-1965	12-185	25
5.	19-5-1965	15-145	373
	Dasson variabilis Cantor		
1.	9-2-1965	75	1
2.	16-2-1965	71-83	4
	Dasson Sp.		
2.	2-2-1965	65, 83	2
	Callionymus schaapi Bleeker		
1.	9-2-1965	77, 77	2
	Ctenogobius nebulosus (Forskal)		
2.	16-3-1965	65	1
	Ctenogobius sp.		
1.	16-3-1965	38-63	7
2.	9-3-1965	36-40	5
3.	9-2-1965	25	1
4.	23-2-1965	27	1
	Grammoplites scaber (Linnaeus)		
2.	2-3-1965	60	1

TABLE V (*Contd.*)

(1)	(2)	(3)	(4)
	Thysanophrys indicus (Linnaeus)		
1.	9-3-1965	111	1
	*6-4-1965	67-140	5
2.	*6-4-1965	98-163	6
4.	2-2-1965	78	1
5.	2-2-1965	76	1
	Pseudorhombus javanicus (Bleeker)		
3.	2-3-1965	108	1
	Grammatobothus sp.		
2.	16-2-1965	44	1
	Pseudotriacanthus strigiliger (Cantor)		
1.	9-2-1965	55	1
	Triacanthus brevirostris Schlegel		
1.	9-2-1965	45-55	7
2.	16-2-1965	77	1
4.	9-2-1965	(mutilated)	1
5.	16-2-1965	35-49	4
	Triacanthus biaculeatus (Bloch)		
2.	*6-4-1965	53	1
3.	23-3-1965	42	1
5.	16-2-1965	40	1
	Torquigener oblongus (Bloch)		
1.	2-2-1965	46-75	17
2.	16-2-1965	62, 62	2
5.	16-2-1965	55, 60	3
	Arothron leopardus (Day)		
3.	23-2-1965	60	1

* Date of occurrence of dead fish.

TABLE VI

State of occurrence of 24 species of fish in different ranges (41 ‰-92 ‰) of salinity

S. No.	Species	41-60 ‰ D	41-60 ‰ A	61-80 ‰ D	61-80 ‰ A	81-87 ‰ D	81-87 ‰ A	88-92 ‰ D	88-92 ‰ A
1.	*Megalops cyprinoides*	—	A	—	—	—	—	—	—
2.	*Nematalosa nasus*	—	A	—	A	—	—	—	—
3.	*Mystus gulio*	—	A	—	—	—	—	—	—
4.	*Tylosurus strongylurus*	—	A	—	—	—	—	—	—
5.	*Hemirhamphus dussumieri*	—	—	—	A	—	—	—	—
6.	*Corythoichthys fasciatus*	—	A	—	—	—	—	—	—
7.	*Mugil cephalus*	—	—	—	A	—	—	D	—
8.	*Liza macrolepis*	—	A	—	A	—	A	D	A
9.	*L. parsia*	—	A	—	A	—	A	D	A
10.	*Ellochelon waigiensis*	—	A	—	A	—	—	—	—
11.	*Ambassis gymnocephalus*	—	A	—	A	—	—	—	—
12.	*Pelates quadrilineatus*	—	A	—	—	D	—	—	—
13.	*Autisthes puta*	—	—	—	A	D	—	—	—
14.	*Theapon jarbua*	—	—	—	—	D	—	D	—
15.	*Gerres oblongus*	—	—	—	A	D	—	—	—
16.	*G. abbreviatus*	—	—	—	A	—	—	—	A
17.	*G. oyena*	—	A	—	A	D	—	—	—
18.	*Leiognathus brevirostris*	—	A	—	—	—	—	—	—
19.	*Tilapia mossambica*	—	A	—	A	—	—	—	A
20.	*Ctenogobius nebulosus*	—	A	—	—	—	—	—	—
21.	*Ctenogobius* sp.	—	A	—	—	—	—	—	—
22.	*Grammoplites scaber*	—	A	—	—	—	—	—	—
23.	*Thysanophrys indicus*	—	A	D	—	D	—	—	—
24.	*Triacanthus biaculeatus*	—	—	—	—	D	—	—	—

D—Dead, A—Alive.