Journal of the
Marine Biological Association of India

ABBREVIATION: *J. Mar. biol. Ass. India*

VOL. 1 December 1959 No. 2

THE ECOLOGICAL AND FISHERIES CHARACTERISTICS OF A SALT WATER LAGOON NEAR MANDAPAM[1]

By P. R. S. TAMPI

Central Marine Fisheries Research Station, Mandapam Camp

INTRODUCTION

THE existence of vast, saline, water-logged areas along the Indian coast and the possibilities of developing some of these for increasing our fish resources have been brought to the attention of the public from time to time. Owing to their peculiar physical and chemical characteristics, these bodies of water constitute distinct categories of biological environment often different from the backwaters along the south-west coast of the Indian Peninsula. However, a closer study would reveal the productive potential of even these lagoons which, in their own way, indicate some scope for further development and greater utilization. Situated along the south-east coast of Madras State near Mandapam (09° 17′N, and 79° 06′E) in the Ramanathapuram district is one such lagoon typical of the low-lying areas along this part of the coast. Because of the importance of this lagoon in the economy of the villages in its immediate vicinity it was considered desirable to undertake a general survey of its existing biological and fishery characteristics which are presented in this report so as to furnish a general background while considering any organised programme of utilization and management of its resources.

The author wishes to thank Dr. S. Jones, Chief Research Officer and Dr. R. Raghu Prasad, Marine Biologist, for their critical comments in the presentation of this paper. He also wishes to record his sincere appreciation of the active help rendered by Shri P. A. Abraham for the routine maintenance of data on salinity, pH and oxygen and also by Shri K. Ramachandran Nair for the analyses of water samples for phosphates. The staff attached to the Marine Fish Farm section have rendered it possible to obtain regular collections of plankton and other material.

[1] Published with the permission of the Chief Research Officer, Central Marine Fisheries Research Station, Mandapam Camp.

Physiography and Climatology of the Region

A rough sketch map of the lagoon together with its general location is given in Fig. 1 in order to help in the description of the salient features. Being located on the narrowing cape-like part of the main land, pointing east towards the Rameswaram Island, and at an altitude scarcely 10 feet above mean sea level, the influence of the surrounding sea on the region is evident. The lagoon is bound by the Palk Bay shore line on the north and the Ramnad-Mandapam rail road on the south. It extends for a length of nearly 6 kilometres from the village of Monacaud (near Mandapam) on the east up to Pullamadam on the west. During high water the lagoon spreads over nearly 360 hectares (900 acres) and at the time of the monsoon it might extend further westward to become contiguous with other low-lying areas around the Vaigai estuary. But these upper reaches cannot be regarded as an integral part of the main lagoon as these usually remain far from tidal influence and consist almost of fresh water. On the contrary, at the time of severe drought, water in this region will be confined to its deepest portion opposite Pullamadam in the form of a small blind creek leaving the rest of the lagoon in a semi-dried state and some times with thick salt deposits. The approximate contour of the lagoon during high and low water periods are indicated in the map as H.W.M. and L.W.M. respectively.

The monthly average atmospheric temperature at Mandapam for 1950-54 is given by Prasad (1957). Starting with a low temperature between 25° and 26°C. in January there is a progressive increase until it reaches its maximum of nearly 30°C. in April or May and then registers a slight decrease of one or two degrees during the next four months under the influence of the winds associated with the S.W. monsoon. After September there is a further decline for the remaining months of the year. This general pattern of the temperature curve holds good for the year 1958 under discussion. The monthly averages of the atmospheric temperature recorded at noon in the open at the site of the lagoon is shown in Fig. 2. The trend of the curve is almost the same as described above. The annual range in noon temperature is from about 27° to 31° C. and the latter value is attained in the month of May. It has also been found that the difference between the highest and lowest temperatures of the day varied from about 1.5°C. in the colder months to nearly 4°C. in summer. The relative humidity for the region based on the meteorological reports from Pamban Port shows a high percentage of over 84 in most of the months and might attain nearly one hundred per cent in the months of May, July and October.

The mean annual rainfall shows a variation from 762-1270 mm. in the different years. The rains are concentrated over a short period of the year between October and November when the N.E. monsoon winds become active. Compared to the rest of the east coast Ramanathapuram district, and particularly the Mandapam zone, is much less affected by the monsoons. The rains become scarce and scattered after November but usually again a few showers of moderate intensity occur in March and April on the commencement of the S.W. winds. It may be mentioned that during the year 1958 the rainfall had been rather unusual owing to relatively heavy rains in April-May (Fig. 2).

The two important winds that influence this region are the North-East winds (locally known as *Vada kondal*) which prevail from the middle of September to March and the South-West winds (*Chōla kachan*) which generally start from March and last until about September.

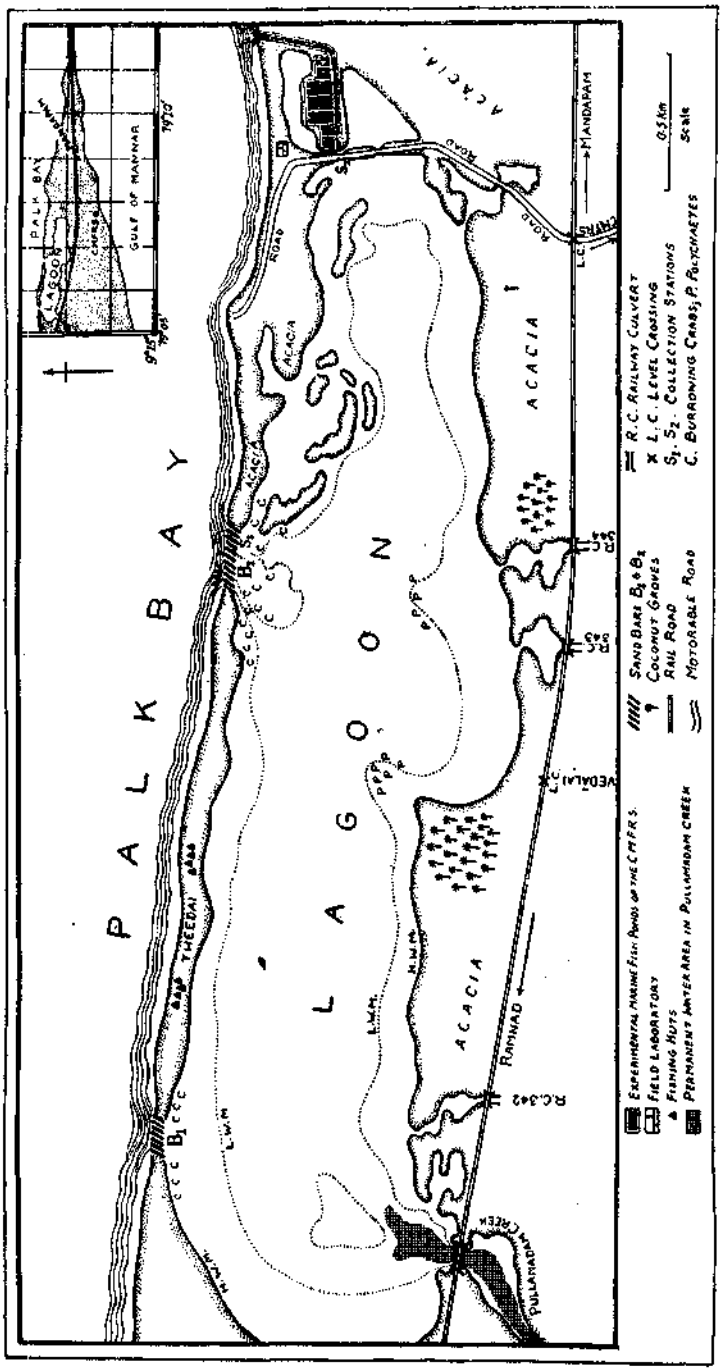

FIG. 1. Sketch map of the lagoon near Mandapam. The inset shows the general location of the lagoon.

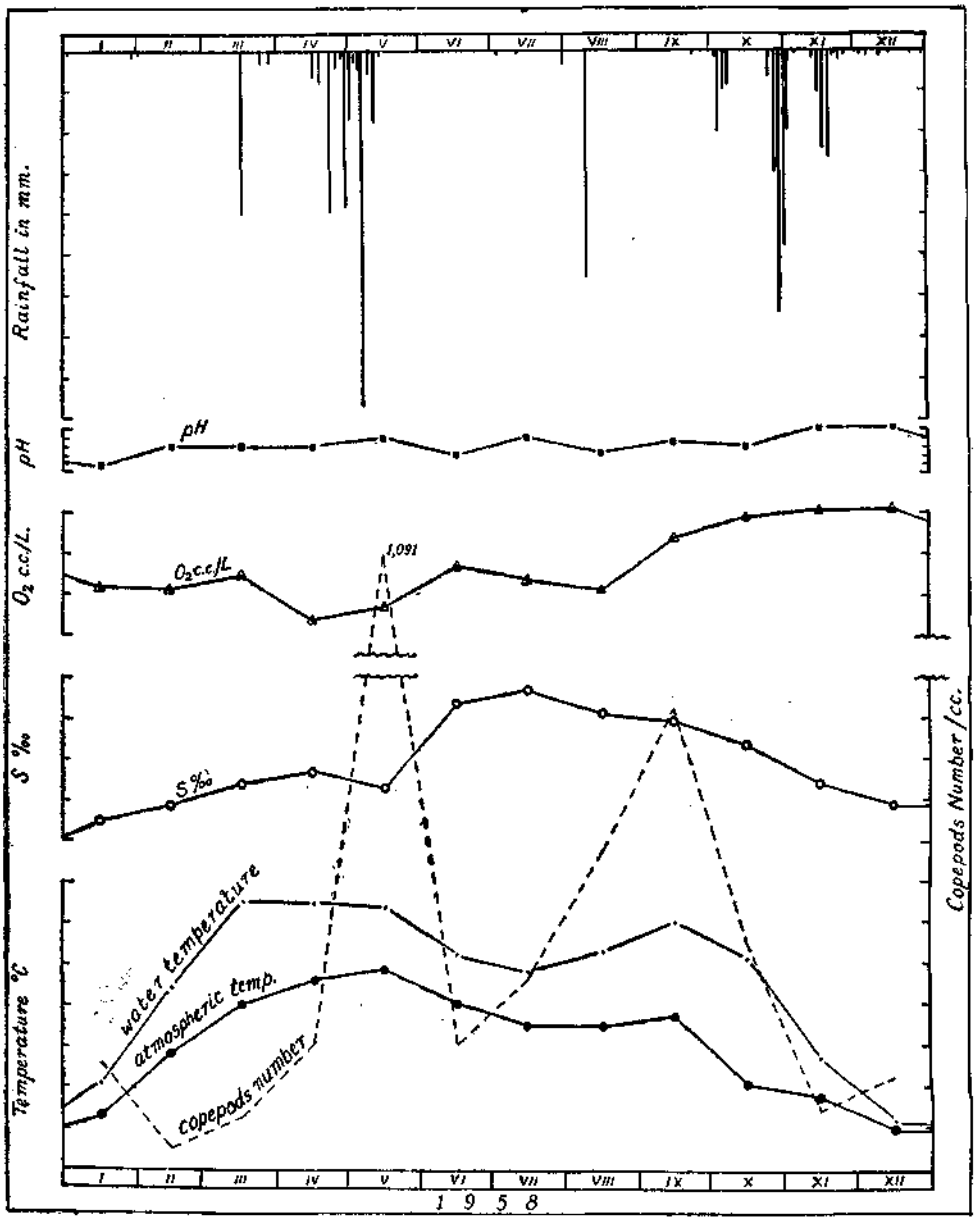

FIG. 2. Graph showing annual variations in temperature, salinity, dissolved oxygen, pH and copepod population in the lagoon during 1958. The noon temperature and rainfall for the region during the year are also indicated.

The graduations along the vertical axis are as follows :—

Temperature : 26-33 ; $S\,^{o}/_{oo}$: 25-45 ; O_2 : 2-5 ; *pH :* 8.0-8.5 ; *Copepods number* for each division is 50, and for *Rainfall* each division represents 100, graduated from top to bottom.

Hydrological Conditions in the Lagoon

The sources of water in the lagoon are the rains and a direct supply from the sea together with some water derived from percolation. The hydrological cycle in the lagoon may be briefly described as follows :—With the onset of the monsoons towards the close of October the whole low-lying area gets inundated with rain water. Eventually with continuous rains and with the increasing force of the breakers on Palk Bay coast under the influence of the winds, two major openings of the sand bars at B_1 and B_2 along Theedai (Fig. 1) are formed. These lead to connections with the sea and a consequent uninterrupted tidal flow into and from the lagoon. Thus, during the succeeding three or four months the water level in the lagoon is at its maximum as indicated by the high water mark in the figure. With calmer conditions prevailing in Palk Bay by about March the level in the lagoon goes down to the low water mark and then gradually begins to dry up with advancing summer. The sand bars widen and ultimately result in cutting off the lagoon from the sea although most often a narrow connecting channel persists at B_2 through which there is a negligible tidal flow. When both the sand bars are closed and the lagoon is completely isolated from the sea, as it happened in the years 1949-51 and 1954, the drying up of the lagoon had resulted in the formation of dense layers of natural salt with the whole area presenting the appearance of an extensive salt pan. Till the advent of the monsoon again the whole lagoon remains exposed in a semi-dried state.

The tidal influence from the sea is of considerable biological significance and is greatly responsible for minimising fluctuations in physico-chemical conditions in this area. The maximum amplitude of the tides in Palk Bay during any time of the year is only about 1 metre, but in the lagoon the difference between the high and low tide levels is usually even less.

Surface Temperature. On account of the significance of the higher temperatures of the medium to life of organisms living in shallow waters of the tropical regions, attention is largely bestowed in this discussion to the noon temperatures. The curve shown in Fig. 2 of the monthly averages of noon temperature of lagoon water closely follows the atmospheric temperature curve at this time but remains higher than the latter. The difference is at its maximum during the summer months and least in December-January when the two curves almost coincide. Records of the diurnal changes in water temperature show that the difference between the maximum and minimum of the day varies from about 2.5°C in December to nearly 4.5°C in April. Compared to the surface temperature of the Bay the fluctuations in the lagoon are more marked, apparently due to the relative shallowness of this body of water.

Salinity. The salinity values during the different months of the year as well as of samples taken from different places in the lagoon at the same time might vary considerably depending on the time of opening of the sand bar and the tidal flow. During periods of stagnation in summer salinity ranging from 35‰ to 73‰ have been recorded at different stations in the lagoon but what is described below is based on samples collected periodically from stations S_1 and S_2 indicated in Fig. 1. The average values at these stations for the different months show a steady increase from January to reach the maximum in June-August and again a fall during the rains. The somewhat abrupt drop in the salinity curve during April-May of

1958 is due to the unusual heavy showers which occurred at that time. In normal years the salinity goes higher than that of sea water by about the latter half of April and continues to remain hypersaline until the outburst of the N.E. monsoon after which the salinity is either that of sea water or even less than 30‰ as is the case from November to February.

pH. Although the monthly averages of pH of the water remain between 8.3 and 8.4 during the major part of the year, a tendency for the values to increase up to 8.7 during the late summer is seen. On the other hand, the values tend to go down to nearly 8.0 immediately after the flood season by about the middle of February.

Dissolved Oxygen. The level of dissolved oxygen does not showany abnormal decrease at any time of the year except occasionally in May-June when it might fall below 2 cc/l whereas at other times it remains between 3 and 4 cc/l. From late September to about November there is a tendency for a further increase of oxygen in the surface waters. The considerable organic decay during the dry summer months, the increase in temperature and the absence of strong winds seem to be contributing factors for the low level of oxygen in the summer periods. A slight amount of hydrogen sulphide and other noxious gases are liberated during the process of organic decay but these do not assume significant proportions as to be toxic to the fauna inhabiting the area.

Dissolved Nutrients. The phosphates in the lagoon is highest in the beginning of the year and the level gradually declines towards the latter half of the year. A fluctuation between 0.23 and 0.42 μg. at. P/l in the monthly average is noticeable during the first half of the year and, since then it maintains a lower, but more steady level in the neighbourhood of 0.15 μg. at. P/l for the remaining months. It may be seen that the waters of the lagoon, at least for some part of the year, show a relatively greater amount of phosphates than in Palk Bay (0.12-0.25 μg. at.P/l) as given by Jayaraman (1954) while at other times the values compare favourably with that of the sea water in these regions. The low level of water and a possible quick release of phosphates from the bottom might explain the high values although there is no direct evidence to support this. The phosphate cycle followed during the different seasons in this area would by itself form an important line of study in determining the biological productivity of the lagoon. No information is available on other nutrients dissolved in the water such as nitrates and silicates.

Soil Conditions

The bottom soil is largely an admixture of calcarious sand and a small amount of fine clay. Shell fragments of marine molluscs, coral deposits and foraminifera together with sand grains constitute a large fraction of the soil while the proportion of clay is relatively little. Both the physical as well as chemical properties of the soil change rapidly as we proceed from the surface to the deeper layers. At the surface is deposited a layer of fine, grey silt, extending to about 5 cm. beneath which the colour changes to blackish owing to the chemical reactions during decomposition of organic matter. The proportion of mud also decreases towards the deeper strata and beyond about 20 cm. the soil is mostly sandy with poor cohesive properties and increasing porosity.

Our knowledge of the chemical nature of the lagoon mud is due to the exhaustive analyses by Pillai (1954 & 1956) who has also discussed its significance in the organic production of the area. According to him the mud shows a high chloride content up to October and a fall during periods of inundation. The dry season is characterised by the alkaline nature of the mud which is said to limit the organic decomposition but the low moisture content at this time is sufficient for bacterial activity. The surface layers are relatively rich in organic content whereas towards the bottom there is a tendency for its decrease. This is due to the fresh deposits of organic matter that are brought into the lagoon periodically during inundation. The amount of nutrients brought down by drainage from the surrounding regions into this basin or the nitrogenous wastes from the castings of numerous avian visitors and cattle that graze around can only be of subsidiary importance in enriching the lagoon. Although the organic nutrients present in the mud might vary with seasons and locality of sampling, the average values for phosphates and nitrates seem to be low in the lagoon mud as compared with other natural regions.

Ecological and Biological Features

Following the high water mark especially along the southern side is a wild and fairly dense growth of *Acacia* spp. while the rest of the region is overgrown with other less useful shrubs, herbaceous plants and creepers. The northern border is sandy and mostly barren excepting for the growth of some dune plants such as *Spinifex* along with some xerophytic plants whereas the lower swampy flats show a vegetation consisting of *Salicornia* and other plants characteristic of such saline environments.

Aquatic Biota

For the sake of this discussion the aquatic biota is dealt with under two categories as (i) planktonic, and (ii) non-planktonic, but excluding the fish and prawns which are separately described.

(i) *Planktologic Characteristics :*

An attempt has been made in this section to give an account of the more important constituents of the lagoon plankton and the general pattern of their periodic occurrence. Collections were made twice a week in the morning hours at stations S_1 and S_2, at the bar mouth and near the eastern end of the lagoon, respectively. For routine collections the net was suitably set against the tidal flow for one hour but when the flow was negligible, as during summer, the net was towed for the same duration. These collections were made mostly at the time of ebb tide while the water recedes from the lagoon. Any quantitative reference to the standing crop based on these samples would be erroneous as it would be marred by several factors, among which the variable volume of water filtered through the net, depending on the speed of the flow, is important.

The Pennate diatoms and to a much lesser extent the Centrales and the smaller Myxophyceae are the more important among the phytoplankters. Pleurosigmoid, Nitzschioid and Naviculoid diatoms in varying intensities are a permanent feature of the plankton throughout the year. Among these, the Nitzschioids, mainly *Nitzschia longissima* (Brébisson) Ralfs, are the most dominant during March and

July. Species of *Chaetoceros, Rhizosolenia* and *Biddulphia* might be regarded as next in importance. Of these only *Chaetoceros lorenzianus* Grunow has been found to assume swarming proportions to the exclusion of most other organisms so as to constitute rich blooms during May, June, July and November and clog the meshes of the plankton net. However, as is the case with most phytoplankton blooms, it lasts only for a few days in the months it occurs while at other times its intensity is much less. Abundance of *Rhizosolenia imbricata* Brightwell and *R. alata* Brightwell is also noticed at about the same period and these continue to occur until about the beginning of the rainy season. *Thallassiothrix frauenfeldii* Grunow, *Climacosphenia elongata* Bailey, *Thallassionema nitzschioides* Grunow, *Coscinodiscus gigas* Ehrenberg, *Hemiaulus sinensis* Greville and *Hemidiscus hardmannianus* (Greville) Mann also occur in the lagoon but are scarce. Besides these diatoms a few desmids are present. The green algae are rare while the blue-greens, particularly *Chroococcus* and *Merismopedia*, are more common. *Trichodesmium erythraeum* Ehrenberg, which often comes up in swarms in Palk Bay and adjacent seas at different times of the year, has seldom been observed in any great intensity in the lagoon. Minor blooms of these have been noticed in the months of August and November while in Palk Bay, according to Prasad (1956), the seasons seem to be February to May and again from September to November. Among the other filamentous forms mention may be made of *Phormidium, Microcoleus, Lyngbya* and *Spirulina* that occur in the plankton. Although these grow on the substratum they get detached during the spring tide flow and occur in plankton collections.

Dinophyceae, particularly the peridinians, are encountered in great numbers during November-December and again in May-June. One or two species of *Ceratium* (*C. trichoceros* (Ehrenb.) Kofoid and *C. massiliense* (Gourret) Jörg.) also occur in very small numbers at infrequent intervals. *Noctiluca miliaris* Suriray is present only during January-March and sometimes in May and July but at no time have they been observed in swarms.

Among the zooplankters the protozoans are represented mainly by the ciliates rotifers and tintinnids. The plankton is usually rich in ciliates almost throughout the year and is particularly so when the level of water is low before the monsoon and late in summer. The occurrence of rotifers (*Brachionus* sp.) in relatively large numbers also coincides with this period and they continue to occur during the early phases of the monsoon but become rare after the sea water begins to flow in. Tintinnids (mainly *Cyttarocylis ehrenbergi* Claparède & Lachmann, and *Tintinnus* sp.), on the other hand, become numerous in the plankton only at the time of strong tidal flow just after the cessation of the rains.

Large numbers of free-living nematodes come up in the plankton throughout November, December and January. Very often during this season and especially after the flooding following a period of intense drought, these form an important constituent of the lagoon plankton. These continue to be present, although in much lesser numbers, during the warmer months of the year.

Coelenterates are only poorly represented in the lagoon plankton except on certain days during May-November when medusoid forms of *Obelia* sp. and other hydroids are obtained in limited numbers. Small detached colonies of *Obelia* and *Lytocarpus philippinus* (Kirchenpauer) are found in collections. The latter

seems to be entering the lagoon from the sea where colonies of these are known to exist among the algal bed, corals and rocks while *Obelia* grows sometimes in the lagoon attached to floating plants and debris. An intense swarm of hydromedusae was observed to be washed into the lagoon from the sea during May-June 1958. These consisted almost entirely of *Phialucium virens* Mass. The ctenophore *Pleurobrachia globosa* Moser which also occurs in the adjacent seas is occasionally washed into the lagoon at about the same period while siphonophores are only rarely seen.

Polychaete larvae are of some importance in the lagoon plankton. Trochophores and free-swimming larvae of Eunicids and Nereids are commonly seen after the monsoon. Numerous jelly-like egg cases of the mud dwelling *Marphysa* can be seen at the bottom in the shallower margins of the lagoon. The other conspicuous group is the Spionid, consisting mostly of *Prionospio* and *Polydora*. These, however, are more common during the warmer months. Smaller numbers of Chaetopterid larvae (probably of *Phyllochaetopterus*) are also collected at about the same time. The post-larvae of the Terebellid *Loimia medusa* Savigny are rarely seen in May.

Veligers of gastropods and some lamellibranch larvae occur mostly during August-December months. Lamellibranch larvae are comparatively fewer than the gastropod veligers and the latter sometimes occur in large numbers in September and continue to come up at intervals during October, November and March. The pelagic pteropod *Cresis acicula* Rang is obtained in good numbers during a short period in the month of May although the main season in Palk Bay is said to end by about April (Prasad, 1956).

Chaetognaths occur at infrequent intervals throughout the year but they are invariably present and in good numbers during August, September and October months while at other times they are somewhat rare.

Echinoderm larvae are seen in the lagoon collections very rarely in October and are totally absent in other months.

Crustacea, represented largely by copepods, decapod larvae and nauplii, are the most significant group of zooplankters. Copepods are most conspicuous during the major part of the year when they constitute the bulk of the standing crop. In general it may be said that the beginning of the year until about the middle of April is a season of uniformly low copepod population but for the succeeding months up to the beginning of the rains there is a periodic fluctuation in their abundance in individual samples. The highest peak was observed in the month of May after which there is a steep fall in June and again a gradual increase to attain another less pronounced maximum in September. The level drops subsequently during the colder months of the year. This general pattern indicated by the curve in Fig. 2 is more or less parallel to the changes observed in copepod numbers in the plankton of Palk Bay (Prasad, 1956 & 1958). Calanoids dominate in all the collections while harpacticoids and cyclopoids are only next in importance. Swarms of the harpacticoid *Metis jousseumi* have been observed at intervals during the months following the flooding and become almost absent in the summer period when other forms such as *Acartia erythraea* Giesbrecht, *Paracalanas parvus* Giesbrecht, *Eucalanus* sp. and *Oithona* sp. are more common.

Among the crustacean larval forms nauplii are the most important. While these are of common occurrence during the major part of the year their intense swarming is observed in April, May, June, August and December. An abundance of zoea larvae of various crabs, particularly those of some Ocypods and Portunids occur at intervals during the colder months of October to February. Among others, mention may be made of the few cypris larvae that are seen in March and November, large numbers of protozoeae of Sergestids and other decapods, and some Stomatopod larvae which occur from September to October and again rarely in January. A few ostracods occur at infrequent periods in February-May and again in August-September months. Post-larvae of Penaeids together with their juveniles are abundant during and immediately after the monsoons. Swarms of *Acetes* spp. usually occur in the lagoon during December and January whereas *Lucifer* sp. are seen in small numbers during August-October.

Pelagic chordates are rare, except for *Oikopleura* sp., which are occasionally found in September.

(ii) *Non-planktonic organisms.*

During the beginning of summer, when the water level in the lagoon is low, a green scum is found to develop at the bottom in the shallow areas and puddles. This consists essentially of a rich growth of *Phormidium* and *Oscillatoria* and other forms such as *Microcoleus*, *Lyngbya* and *Spirulina*, which also harbour a variety of littoral diatoms, desmids, ciliates, rotifers, nematodes, planarians, small annelids, amphipods and a few insect larvae besides considerable quantities of organic detritus and associated bacterial flora. Thus, these constitute a biological complex comparable to the ' lab-lab ' formation described in the salt water tambaks of the East Asian countries. A low water level and good sunshine seem to be factors conducive for the growth of this scum which is not formed in the relatively deeper areas. Salinities higher than that of sea water up to about $45°/_{oo}$ do not inhibit its growth while it does not flourish in salinities lower than about $15°/_{oo}$. After a period of active growth it acquires yellowish brown colour. Eventually when photosynthetic oxygen and other gas bubbles get trapped among the meshes, the whole scum is lifted up from the bottom in the form of a thick mat that may be seen floating at the surface, especially near the eastern end of the lagoon. The fish culturists of Philippines and Indonesia consider this biological complex as an ideal source of food for the growing fry and fingerlings of *Chanos* and therefore encourage the growth of this 'lab-lab' in their fish pond nurseries.

While a variety of marine algae and phanerogams grow in Palk Bay adjacent to the bar mouth, very few or none at all have established themselves in the lagoon apparently because of the unfavourable ecological conditions. However, during the high water season just within the bar mouth may be seen small colonies of *Chaetomorpha*, *Enteromorpha*, *Ulva* and a few other species growing attached to coral stones. Besides only algal washings are brought into the lagoon periodically during spring tides.

Among the non-planktonic animal forms that are of ecological significance the following groups deserve special mention. The list is by no means exhaustive as regards the fauna but is intended to include only the more common forms.

Coelenterates : Only the sea anemone *Bunodactis* has been collected and even this is but rarely found near the bar mouth after the flood season is over when the

high water begins to recede. These or other anemones have not been collected from regions in the lagoons away from the bar mouth.

Annelids : Annelids are represented largely by Eunicids, Nereids, Spionids, Cirratulids, Sabellids and Serpulids. Seven genera belonging to *Marphysa, Nereis, Prionospio, Polydora, Audouinia, Dasychone* and *Hydroides* have been collected, among which *Marphysa sanguinea* Montague and *Nereis* spp. are common all over the shallow margin of the lagoon. Areas indicated by the letter ' P ' in the sketch map show the places where these polychaetes are particularly concentrated in small beds. Cirratulids are collected along with these and also in the muddy flats near the bar mouth. Spionids, however, have a more restricted distribution as they occur on dead coral stones or shells only when the salinity is not very high. *Dasychone cingulata* Grube and *Hydroides norvegica* Gunnerus thrive during the low salinity season and are found in small numbers attached to the concrete pillars of the railway bridge across the Pullamadam creek. A few juvenile Opheliids were collected just at the region of the sand bar on the seaward side but have not been obtained from the lagoon itself.

Crustaceans : These form the most important group of invertebrates in the lagoon. *Balanus amphitrite communis* Darwin is the more common species of barnacle growing along with a few *B. amphitrite variegatus* Darwin on the concrete embankments of the culverts. Living animals can be seen only during a brief season following the inundation while in the summer their shells are often empty.

The more common amphipods occurring in this region are *Podocerus brasiliensis* (Dana) and *Thalorchestia gracilis* Dana.

A small number of alpheids, two stomatopods *Squilla wood-masoni* Kemp, and *S. latereillei* (Eydoux & Souleyet), and one or two of the smaller palaemonids have been collected. *Penaeus indicus* Milne-Edwards, *P. carinatus* Dana (de Man) and two or three species of *Metapenaeus* occur in the lagoon and since these constitute a fishery they are dealt with in the appropriate section. Mention has already been made of the occurrence of *Acetes* which swarm in the lagoon immediately after the rainy season.

Nearly a dozen species of brachyuran crabs have been identified from the lagoon collections. These are *Matuta victor* Fabricius, *Ocypoda macrocera* M.-Edwards, *Uca* (*Gelasimus*) *annulipes* Latreille *Scopimera pilula* Kemp, *Macrophthalmus depressus* Rüppell, *Dotilla myctiroides* (M.-Edwards), *Dorippe dorsipes* (Linnaeus) Miers, *Grapsus strigosus* (Herbst), *Scylla serrata* (Forskal) de Haan, *Thalamita crenata* Latreille and *Neptunus pelagicus* (Linnaeus). The fiddler crabs *Uca* seem to be restricted more to the mud flats near the sand bar while the ocypods and other burrowing forms are widely distributed on the sandy shore along the northern border and only seldom seen in the southern regions. *Grapsus strigosus* occur among the stones and shells under the culverts. The portunids can be met with all over the lagoon and among these *Scylla* is comparatively rare. There is a preponderance of juvenile *Neptunus* during the colder months when these crabs are believed to have their breeding period (Prasad and Tampi, 1953). *Clibanarius padavansis* de Man and *Diogenes* sp. are commonly seen on the mud flats when they are partially exposed during low tides.

Molluscs : A few gastropods of the genera *Cerithedia cingulata* Gmelin, *Umbonium vestiarum* L. and *Thias* sp. occur in certain localities. Among the lamellibranchs *Cardium flavum* Linné., *Meretrix casta* (Chemnitz), *Catalysia opima*

(Gmelin) and *Gafrarium tumidum* Roding may be considered important although their extensive occurrence has not been noticed. Absence of the wedge clam *Donax* (*Latona*) *cuneatus* L. which is very common along the Palk Bay coast is noteworthy. Some oysters (*Ostrea cucullata* Born) are found to grow on the concrete embankments of the culverts but most often their shells are empty. A variety of other lamellibranch shells occur in the lagoon which are washed into this area from the sea. The young ones of the squid *Sepioteuthis arctipinnis* Gould and occasionally *Loligo* sp. occur early in the year when the water level is high. The former species is known to constitute a fishery in Palk Bay (Rao, 1954).

Summarising the general biological characteristics of the lagoon it might be added that there are two phytoplanktonic maxima in the year. The first and the more sustaining one begins from about the close of May and lasts until the end of July while the less intense period is from the end of October through November. The zooplankters, and particularly the larval forms, usually follow the phytoplanktonic maxima and might be responsible for the rapid reduction of the phytoplankton population. During other periods of the year as in January, April, May, September and December, the total volume of both the zoo- and phytoplankton is at a low level. Occasional collections during spring tides have shown a relatively large volume of plankton in the incoming water. Of the numerous organisms that thus enter the lagoon some of them might return to the sea during ebb tides while others constitute food for the higher animals or perish in the lagoon. The general fauna is largely allochthonous and only few are permanent dwellers of this area. The peculiar physiological environment created by the hypersaline nature of the water combined with high temperatures during a major part of the year followed by a reversal of the conditions at other times of the year permit the survival of only the highly euryhaline and eurythermal species. The general paucity of organisms in this area will be partly explained by these fluctuating environmental factors. The absence of definite animal communities at the bottom, excepting a few annelids, molluscs and crustaceans which are concentrated more near the bar openings, is also a noteworthy feature. The seasonal influence of the sea is evident in the closely parallel picture in planktonic and other changes both in the sea and in the lagoon.

Fish and Fisheries

A. Fish and Prawns, with notes on species of fishery importance

Soon after the outbreak of the monsoon and the consequent flooding of the lagoon there is a sporadic appearance of several post-larval fishes. While the Bay at this time of the year is very rough these young fish find a relatively calmer habitat in the lagoon. Countless numbers of the glassy post-larvae of *Ambassis* and those of *Gerres* are usually the first ones to appear. These are followed by the Tholychthys stage of *Scatophagus argus*, the young ones of *Tetrodon*, *Mugil*, *Hemirhamphus*, *Atherina* and sometimes of *Tylosurus*. Although the occurrence of *Mugil* fry is a regular feature throughout the year there is a noticeable abundance during December to March and again in June to July. Fry and fingerlings of *Chanos* also occur during March to June and sometimes a less significant season of occurrence is noticed in November. The young ones of all these species seem to be those that enter the lagoon from the sea while there is direct evidence to show that *Nematalosa nasus* spawns in this area. Excepting for this and some Gobiid fish the spawning

of other species in the lagoon seems uncertain although a few pelagic eggs and larvae of some Carangids have been occasionally obtained in plankton collections during spring tides.

The following is a list of species of fish collected so far from the lagoon

Elops saurus Linnaeus
Megalops cyprinoides (Broussonet)
Chanos chanos (Forskal)
Nematalosa nasus (Bloch)
Plotosus arab Bleeker
Arius sp.
Mugil cephalus Linnaeus
M. troschelii Smith
M. seheli Forskal
M. waigiensis Quoy & Gaimard
Hemirhamphus gaimardii Cuv. & Val.
Tylosurus strongylurus van Hasselt
Atherina forskali Rüppel
Sphyraena picuda Bloch
Gerres filamentosus Day
G. abbreviatus Bleeker
Gazza minuta (Bloch)
Caranx kalla Cuv. & Val.
Leiognathus spp.
Platax sp.
Sillago sihama (Forskal)
Saurida tumbil (Bloch)
Therapon puta (Cuvier)
T. jarbua Forskál
Ambassis myops Gunther
Platycephalus scaber Day
Psammoperca waigiensis (Cuvier)
Teuthis marmorata Gunther
Scatophagus argus (Bloch)
Ctenogobius sp.
Gobius spp.
Tetrodon spp.
Diodon sp.
Triacanthus sp.

It might be pointed out here that most of these fish with only a few exceptions have been recorded from the lagoon in their post-larval or juvenile stages. Despite the number of species that occur in this area, which is even fewer than that recorded from Silavathurai Lagoon near Tuticorin by Whitehouse (1923), only the mullets, threadfin gizzard shad and milkfish are of fishery importance.

The Mullets.

These rank first among the commercially exploited fishes of the lagoon and commonly include the four species listed above. Of these, *waigiensis* is relatively few while the others dominate in the catches. The fishery starts from about the middle of January and continues almost until July although the fish is available in smaller numbers at other times of the year. The average size of fish caught during the season ranges between 200 and 250 mm. Mullets are generally known to be bottom feeders and in the lagoon the juveniles invariably show a large quantity of organic detritus in their alimentary canal besides littoral diatoms, algal filaments, eggs of polychaetes and crustacea, and occasionally crustacean larvae, spicules and sand grains.

The Threadfin Gizzard Shad (Nematalosa nasus).

This may be considered next in importance as regards the fishery in this area is concerned. Locally the fish are known as ' Koyi ' while in their fingerling stage, when some of the adult external characters such as the elongated last dorsal ray or the shoulder spot are not formed, these are known by the separate name ' Kochālai '. The fish constitute more or less a summer fishery. ' Koyi valai ' operations begin in the lagoon around May and continue throughout the last phase of the summer when the water level is low. The fish at this time have a size range of 190-250 mm. A variety of organisms have been met with in the stomach of the fish which include

littoral diatoms, blue-green algae and to some extent copepods, crustacean larvae, lamellibranch larvae, ostracods and nematodes besides considerable mud and detritus. In their fingerling stages too their stomach contents are more or less the same and also show other forms such as ciliates, rotifes, tintinnids, and dinoflagellates.

The Milkfish.

During April to August *Chanos* are caught in considerable numbers from the lagoon. This is particularly noteworthy because of the fact that *Chanos* does not constitute a significant fishery anywhere along the coastal regions. Entering the lagoon as the transparent post-larvae which average 15 mm. in length early in March these grow to about 40 mm. towards the end of April, about 60 mm. by June and in July and August when they are usually caught and taken to the market these have 150-200 mm. length. During the years when the lagoon is cut off from the sea by the closing of the sand bar the catch of these juvenile milkfish is higher than in other years as the fish that enter the lagoon earlier get land locked. Normally the fish is believed to return to the sea during the later phase of its growing period and even in natural tidal creeks they disappear after about 100 mm. in length is attained. The feeding habits of these juvenile milkfish have revealed that they depend mostly on the microflora and to a much less extent on other items of food. Large quantities of mud together with the smaller algal filaments and the numerous littoral diatoms have been seen in the alimentary canal of the fish examined at different months. A fuller account of the food of the fish is available in an earlier discussion by the author (Tampi, 1958).

Prawns.

Penaeus indicus Milne-Edwards, *Metapenaeus monoceros* Alcock, and *M. affinis* Alcock constitute the prawn fishery of the lagoon while a few individuals of *P. carinatus* Dana (deMan) are also found in the catches. *P. indicus* usually forms about 80% of the catch, the remaining 20% being composed of the two species of *Metapenaeus*. The former is relatively much larger in size and those that enter the fishery range up to 125 mm. in length with an average around 100 mm. At present even a rough idea of the normal increase in growth of these prawns in the lagoon has not been possible owing to difficulties in proper sampling during this preliminary survey. Fishing for prawns starts soon after the flooding period and continues until about May or June. The peak season is usually from February to April.

One significant aspect that seems common with all the fish and crustacea which support the fishery in the lagoon is that they depend either on micro-organisms or detritus. When the lagoon is more or less isolated the limited food supply in a restricted area and the different species having the same kind of feeding habits might create some interspecific competition which would affect the normal growth of the fish even when some are removed periodically by fishing.

B. Fishing Methods

The methods employed for fishing in the lagoon are simple and no craft is involved in the fishing operations in such a shallow region. The only boat that may be seen in the lagoon is a dugout canoe used by the fishermen to transport water and other requirements across the lagoon to their hutments in Theedai. The following nets are in use in the lagoon.

1. *Cast net.*

Cast nets without the central cord for hauling in, like the one commonly seen in the Gulf of Mannar and the Coromandel coast, are used. The fisherman watches for schools of fish nearer the water's edge as he wades along and the net is cast over them. Mullets and occasionally milkfish ranging in size from 20-30 cm. are caught by this method.

2. *Konda valai.*

Descriptions of this net are given by Hornell (1927) and are also referred to in subsequent publications on fishing methods of the Coromandel region. It is essentially a long strip of cotton netting, the actual dimensions of which vary according to the depth of water where it is operated. Those used in the lagoon are usually about 20 metres long, 2-3 metres wide with 30-40 spreader sticks shorter than the width of the net itself. Mesh size is 10-20 mm. on one side. Either two or four men drag the net with the lower margin along the bottom and holding the spreader sticks vertically. Sometimes scare lines are used at either ends so as to frighten fish from a larger area and lure them into the net. All types of fish are caught in this net while during the low water seasons it has been found helpful for collecting fingerlings of mullets and milkfish.

3. *Kanni valai* or *Kannikka valai.*

Two nets by the former name are mentioned by Hornell (1927) as being used along the Coromandel coast and in Cuddalore backwaters. However, the one used in the lagoon differs from both these in dimensions and principle of operation. Unlike the ones mentioned by Hornell, this net is only 1.25-1.50 metres in width and nearly 50 metres long with mesh of 15 mm. on one side. On the top is a head-line 3 mm. thick to which are attached wooden floats of 40 × 30 mm. at intervals of 25 cm. A foot-rope or weights at the bottom is absent but in its place is attached a 10 cm. wide strip of close-meshed net of heavier material like that used for the cod-end of shore seines. This more or less helps to keep the net vertical in water. Each net is operated by two men who wade in waist-deep water and pay the net across the slow tidal flow in the lagoon. Either end of the net is encircled so as to form a kind of trap near which the men squat in water. The fish which hit the wall-like net intercepting their movements tend to move along the net and finally reach the trap from where the fishermen deftly catch them with hand and put into their bags. Mullets of 15-30 cm. are mainly caught in this net.

4. *Koyi valai* and *Palmeen valai.*

These are only slight variations of the ' Kanni valai ' and the names are suggestive of the principal kinds of fish, ' Koyi ' or *Nematalosa* and ' Palmeen ' or *Chanos*, caught by the respective net. The main differences are that these nets are made of thinner yarn and neither of them have the heavier strip of net attached to their bottom as in the ' Kanni valai '. ' Koyi valai ' has a mesh size of 30 mm. bar while the ' Palmeen valai ' has a mesh of 25 mm. bar. The floats at the top also are much larger in both these nets and measure about 80 × 40 mm.

5. *Otha valai.*

This is a light cotton net and seems characteristic of the Mannar area. It measures 16-20 metres long, 5-6 metres in width and has a mesh of 10 mm.

All along the top are two rows of wider mesh (15 mm.) made of 3-6 splices of the same yarn and through which is passed a head rope of 3 mm. thickness. A similar foot-rope but without weights is present at the bottom.

The operation of the net is by two men. The net is paid in a circle. The foot rope is held at either ends by the large toe and is gradually dragged along the bottom. Soon after the ends are brought together the circle is brought narrower by shifting the feet. Finally the bottom is quickly lifted towards the top by both the men simultaneously trapping all the fish and prawns thus enclosed. Prawns are dislodged from the mud when the foot-rope is dragged along the bottom and, incidentally, a few fish that remain below are also caught in the process.

C. *Economics of the Fishery*

A large number of people belonging to the neighbouring villages of Mandapam, Vedalai, Theedai, Pullamadam and even from Uchippuli covering a radius of about 5 miles seek sustenance from the fishing operations in this lagoon. This exploitation of the resources has been taking place giving rise to a minor seasonal industry since a long time. The fishery being highly unorganised, a proper assessment of its magnitude is fraught with several practical difficulties. An estimation of the catch per net on days chosen at random during the fishing season, for computing the total yield as has been done for the sake of this preliminary report, can only be a rough approximation and perhaps much lower than the actual quantity caught. Thus, the figures given in the Table I below need be considered as a very conservative estimate and are intended only to indicate the fishery potential of one of the isolated and somewhat transient water masses along our coast line.

TABLE I—*Approximate Yield of Fish from the Lagoon*

Total Area of the Lagoon : 360 Hectares (900 acres)
Effective Fishable Area : *ca.* 150 Hectares (370 acres)
Number of Active Fishing Days in a Year : 175
Average Catch of Fish & Prawns per Fishing Day : 115 Kg. (*ca.* 250 lbs.)
Total Catch during the Fishing Season : *ca.* 20 metric tons

All the catch is consumed fresh and is marketed locally in the villages of Vedalai, Mandapam and the immediate vicinity. Usually the fishermen sell their catches on the spot to one or two individuals who buy them in bulk and later arrange for their disposal in the local markets. Prawns fetch the highest price while the gizzard shad is considered inferior to both mullets and milkfish.

DISCUSSION

The biological conditions in the lagoon, as pointed out earlier, are largely governed by the physical and chemical characteristics of the area. It appears that for a great period of the year the level of available food material for fish life as indicated by the standing crop remains rather low. The annual catch of fish, however, shows a moderate yield of about 57 Kg. per hectare of fishable area spread only for

about half the year. Even this rate of yield compared to the short period of exploitation does not appear to be much inferior to that from similar uncultivated natural waters with the exception of the backwaters of the west coast. One consideration, therefore, seems to be the possibility of extending the duration of fishing activity. Since the amount of fish available in the lagoon depends largely on the number entering from the sea in their post-larval or juvenile stages and not of an autochthonous population, the time of opening of the sand bar and the satisfactory tidal flow from the sea are significant factors. Maintenance of a continued tidal flow by preventing the formation of the sand bars by means of a permanent interconnecting channel between the sea and the lagoon, although faced with some initial problems, seems worthy of consideration. A sustained level of sea water and consequent prevention of excessive rise in temperature and salinity in the summer months would help in creating a more conducive habitat for fish and other aquatic organisms to thrive in this area. A substantial increase in fish catch during years when the lagoon and sea remain connected in the late summer months would lend support to this assumption.

Although the conditions in the region are by no means ideal for the proper growth of fish, some of the inherent drawbacks can be brought under control over a period of time after a more critical study and sustained effort. Along with the change in physical factors that might be brought about by a constant supply of sea water by means of suitable channels, periodical deficiencies in essential nutrients in water and mud can be made up to some extent through organic manures or by the addition of chemical fertilizers. As these might be achieved more satisfactorily in smaller enclosed areas the conversion of portions of the lagoon into salt water fish ponds with proper sea water supply would be a possibility. Preliminary experiments conducted in this direction at the marine fish ponds located in the same region have given very encouraging results during the last two years and an average yield up to 400 Kg. per hectare (unpublished results of the author) during a 10-months' period has been obtained. With more systematic stocking and management of the ponds these values can be considerably enhanced so that the venture in this direction can prove profitable in the long run.

A third and an equally profitable aspect following the development of the region is the scope for the establishment of a centre for fish fry trade. Fry and fingerlings of cultivable species of fish are available in large numbers in the lagoon during definite seasons, as indicated earlier. Besides being able to utilize them for stocking ponds in the immediate surroundings the fry requirements of other fish culture centres can be met from these collections. Proximity to the sea, road and rail communication offers a distinct advantage in the easy transport of the fry to other centres.

SUMMARY

This account forms a preliminary ecological and biological survey of one of the saline water lagoons seen along the south-east coast of India. The salient physical and chemical characteristics in relation to the rather peculiar ecological nature of the area and its consequent low biological production are discussed. Notwithstanding some of these drawbacks, a rough estimate of the annual fish yield from this lagoon has indicated a moderate rate of fish production compared to that from other uncultivated natural waters in similar surroundings. The possible means of more organised work and effective utilization of the resources of such an area are also generally outlined.

REFERENCES

Hornell, J. 1927. Fishing methods of the Madras Presidency, Pt.I—Coromandel Coast. *Madras Fish. Bull.* **18**.

JAYARAMAN, R. 1954. Seasonal variations in salinity, dissolved oxygen and nutrient salts in the inshore waters of the Gulf of Mannar and Palk Bay near Mandapam (S. India). *Indian J. Fish.*, **1** : 354-364.

PILLAI, V. K. 1954. Some factors controlling algal production in salt water lagoons ; Symposium on marine and freshwater plankton in the Indo-Pacific, Bangkok, 1954. 78-81.

———. 1956. Chemical composition of lagoon muds. *Proc. Indian Acad. Sci.*, B **34** : 130-136.

PRASAD, R. R. 1956. Further studies on the plankton of the inshore waters off Mandapam. *Indian J. Fish.*, **3** : 1-42.

———. 1957. Seasonal variations in the surface temperature of sea water at Mandapam from January 1950 to December 1954. *Ibid.*, **4** : 20-31.

———. 1958. Plankton calendars of the inshore waters at Mandapam, with a note on the productivity of the area. *Ibid.*, **5** : 170-188.

PRASAD, R. R., AND TAMPI, P. R. S. 1953. A contribution to the biology of the blue swimming crab, *Neptunus pelagicus* (Linnaeus) with a note on the zoea of *Thalamita crenata* Latreille. *J. Bombay Nat. Hist. Soc.*, **51** : 1-16.

RAO, K. V. 1954. Biology and fishery of the Palk Bay Squid *Sepioteuthis arctipinnis* Gould. *Indian J. Fish.*, **1** : 37-66.

TAMPI, P. R. S. 1958. On the food of *Chanos chanos* (Forskål). *Ibid.*, **5** : 107-117.

WHITEHOUSE, R. H., 1923. A statistical study of young fishes from Silavatturai lagoon, Tuticorin. *Madras Fish. Bull.*, **17** : 49-103.