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RECENT OBSERVATIONS ON PHYSICO-CHEMICAL CHARACTERISTICS OF THE LAGOON ALONG THE PALK BAY AT MANDAPAM WITH A NOTE ON THE POSSIBILITY OF ITS UTILIZATION FOR LARGE SCALE FISH CULTURE

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ABSTRACT

The paper deals with the physico-chemical characteristics of water in the Pillaimadam Lagoon along the Palk Bay and their relationship with variations in the abundance of fish seed in the lagoon. Seven stations have been fixed covering the vast expanse of the lagoon and one at the bar mouth in the sea for collection of data at fortnightly intervals. Detailed observations have been made on variations in depth, direction of the movement of water in and out of the lagoon, atmospheric and surface water temperature, salinity, dissolved oxygen and pH from October 1978 onwards. In addition, data on the rate of evaporation, seepage and the effect of tidal influence on the depth of the water in the adjacent fish farm are also included.

In general, the physico-chemical characteristics of the water in the lagoon from October to March have been found to be different from those during the period April to September. During the former period, the Palk Bay remains rough with the connection to the lagoon well established, rain water entering into the lagoon from the land-ward sides mainly during the North-East monsoon period (October-December), whereas in the latter period, the connection to the sea is cut-off resulting in altogether different conditions.

The present observations have been compared with previous observations on the lagoon. The relationship between the physico-chemical characteristics of the water and the variations in the abundance of fish seed in the lagoon has been studied. The data indicate that fishes like mullets, milkfish and prawns, the seed of which is abundant in the area, could be cultured in the lagoon with the application of suitable management practices.

INTRODUCTION

IN THE RECENT PAST, emphasis is being laid on the development of aquaculture to increase fish production in fresh water, back-waters, brackish water lakes, lagoons and coastal waters in different parts of the country. Before any large scale culture of fish is attempted in an area, it is necessary to know the topography, physico-chemical and biological characteristics of the area concerned. With this objective, Tampi (1959) gave an account of the ecological and fisheries characteristics of the salt water lagoon near Mandapam. In view of the recent proposal to develop the lagoon into a fish farm by the Central Marine Fisheries Research Institute, the hydrological conditions and the availability of fish seed in the vicinity for large scale culture have been studied during the period October, 1978 to September, 1979. The results of this study are presented in this paper.

DESCRIPTION OF THE AREA

Location

Pillaimadam lagoon (long 79°06'E ; lat 9°15' N) is situated along the coast of Palk Bay, in the vicinity of Mandapam. The lagoon

has a rectangular shape, its long axis being parallel to the coast. It is connected to the sea by a narrow bar mouth (Fig. 1). The lagoon is connected to the river Vaigai on its western side only in the rainy season. During the North-East monsoon months of October, November and December vigorous waves associated with high tides break the sand bar and establish the connection with sea. The lagoon covers a vast area of about 360 hectares (Tampi, 1969) and forms a saline habitat enabling fish seed like those of mullets, milkfish, prawn, *etc.* to enter and grow for certain periods. For most of the year, except monsoon months mentioned above, the entire lagoon remains isolated as a vast shallow saline pool. In pre-monsoon months (July-September), the entire area gets dried up due to high evaporation and lack of connection with the sea.

Air temperature

The hottest months in the area are April to June when the maximum air temperature reaches 32.76°C. Colder period extends from October to December, the minimum temperature being 26.22°C.

Rainfall

The total annual rainfall of this region is about 1235 mm (Fig. 1) most of it falling during North-East monsoon months.

Seasons

With reference to the North-East monsoon, it is convenient to divide the year into the following four seasons for understanding hydrographical changes in the area and their relation to fishing activities.

Monsoon	:	October, November and December
Post monsoon	:	January, February and March
Summer	:	April, May and June
Pre-monsoon	:	July, August and September.

Material and Methods

During the period October 1978 to September 1979, observations on physico-chemical characteristics of the lagoon were made at fortnightly intervals in the morning hours between 6.30 and 8.30 hrs. Eight stations were selected, one of them at the bar mouth in the sea representing oceanic conditions and all the others in the lagoon (Fig. 1) covering the entire area of the lagoon. Surface water samples were collected from these stations using a plastic bucket and analysed for salinity, dissolved oxygen and pH by the methods outlined by Strickland and Parsons (1968). The monthly mean value of each parameter for stations 1 to 8 as well as average values of all lagoon stations 2 to 8 were taken and plotted (Fig. 2). Data on the rate of evaporation in the lagoon for the period July to September (Pre-monsoon), seepage and the effect of tidal influence on the depth of the water in the adjacent fishfarm for the months August and September are also included (Fig. 3). Rate of evaporation was calculated using the formula (Etter, 1976)

$$E = \frac{0.621\ P_a\ c_E\ (e_s - e_a)W}{Pa}$$

where e_a is the saturation vapour pressure of air, e_s is the saturation vapour pressure of air over sea water, Pa is atmospheric pressure, Pa is density of air, W is wind speed at 10 meter level and c_E is dimensionless coefficient of latent heat transfer.

Results

Hydrographic characteristics

The hydrographic characteristics in the lagoon are best described with reference to the four seasons mentioned above.

Monsoon

During the monsoon period (October-December) the lagoon receives large amounts of flood

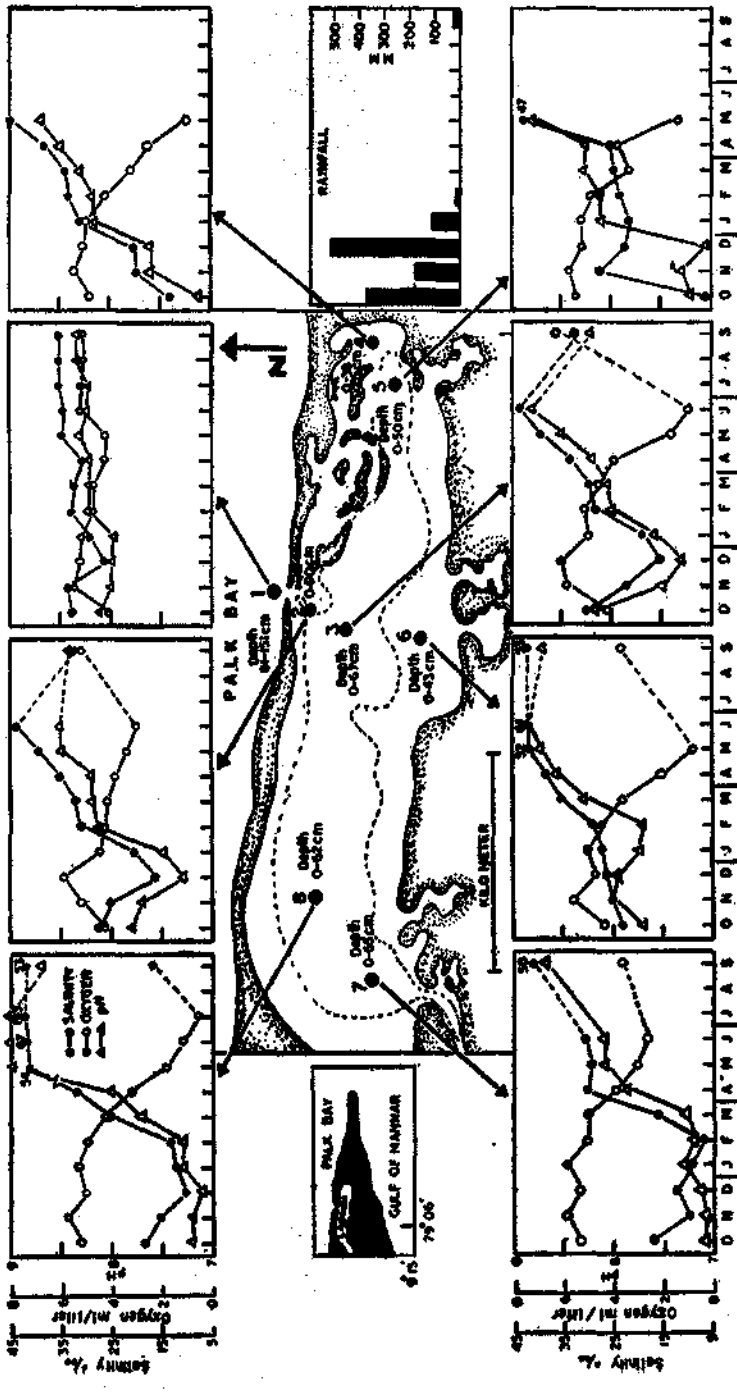

Fig. 1. Pillaimadam lagoon near Mandapam (Southeast coast of India) indicating the location of eight observation stations, variations in physico-chemical characteristics at individual stations and data on rainfall.

water from the river and run off water from the surrounding land on the southern side of the lagoon. Towards the end of October, when the monsoon commences, the connection to the sea is established. Consequently, sea water rushes into the lagoon creating certain special conditions at this time. It is obvious, from field observations made at station 2 on the direction of the movement of water, that water flows from the lagoon into the sea, this process prevailing upto the end of the period.

Surface water temperature during the period varied between 27.07°C and 29.70°C. The air temperature was almost same as the surface water temperature. The surface water temperature in the lagoon was slightly lower (28.10—29.75°C) than that of the inshore station 1. This may be attributed to the influx of colder fresh water from the river Vaigai and run off water from the land.

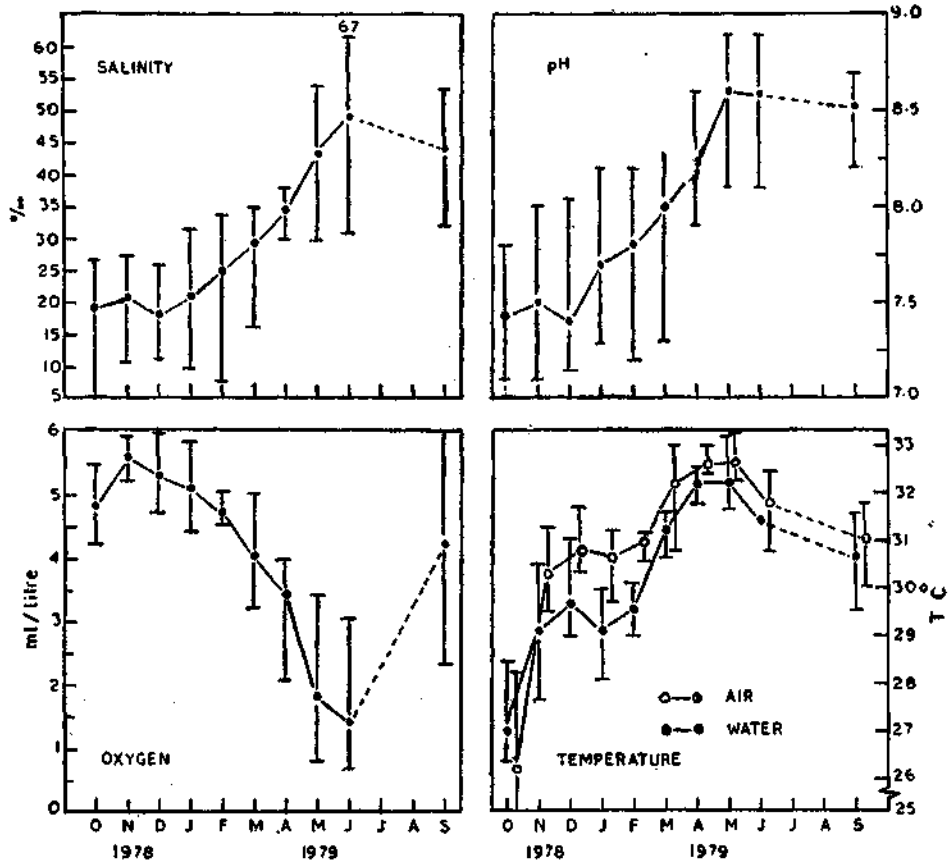

Fig. 2. Range and mean values for salinity, dissolved oxygen, pH and temperature (air and surface water).

Salinity variations in the lagoon (18.16—21.22‰) were considerably lesser than at sea (26.65—32.64‰) : minimum (5.85‰) occurred at station 7 because of mixing of river water and maximum (26.86‰) at station 2 because of seawater flow. The total annual rainfall in this region was estimated to be 1235 mm, most of it falling during this period. As a

result of it, a reduction in salinity was observed in almost all stations. In addition, the river water along with run off water from the land reduces the salinity further, though the soil of the lagoon contains salt deposits stored in summer. The pH varied between 7.38-7.69.

Generally, dissolved oxygen content in the lagoon was observed to be more than that at the inshore station. More or less similar values in dissolved oxygen content were recorded at all stations throughout the period and a steady increase of the same was noticed from October to December.

Post-monsoon

The tidal effect was more pronounced during this period (January-March). This is of considerable biological significance and is greatly responsible for controlling physico-chemical characteristics in the area during the period (Tampi, 1959). Towards the beginning of post-monsoon, when the North-East wind is strong, seawater rushes into the lagoon. As a result of this process, oceanic conditions prevail in the lagoon also, particularly of temperature, salinity, oxygen and pH.

Surface water temperature in the lagoon ranged from 29.10 - 31.24°C while it ranged from 29.00 - 31.25°C in the sea. There is a slight deviation in the temperature curves as surface water temperature differs from air temperature from January onwards due to the blowing of dry wind.

Salinity values at stations 2 - 6 were uniform throughout the period (Fig. 1). Variation in salinity is accompanied by variation in pH which ranged from 7.69-8.03. A slow decrease in dissolved oxygen content was noticed from January (5.11 ml/l) to March (4.02 ml/l) and this drop in oxygen content may be due to the absence of strong winds thus decreasing the solubility of atmospheric gases associated with increasing surface water temperature (31.24°C) as summer approaches by the end of March.

Summer

The period extends from April to June during which the maximum temperatures of air (32.67°C) as well as of water (32.20°C) were recorded.

From April onwards, a steady increase in salinity (34.65—49.23‰) above normal condition at sea was noticed at all the stations as the bar mouth gets closed. Due to the prevalence of high South-West wind and to the rather high atmospheric temperature, there is a certain amount of evaporation which causes the rise in salinity of the shallow lagoon and that of the inshore during the period (Jayaraman, 1954). Consequently, small saline pools were formed. With the rise in salinity, pH showed marked changes (8.26 - 8.61). A steady decline in dissolved oxygen content occurred from April onwards reaching a minimum (1.469 ml/l) by June. Tampi (1959) attributed the low level of oxygen to organic decay during the dry summer months, increase in temperature and the absence of strong wind.

Pre-monsoon

From July onwards, the entire lagoon remains dry except at station 8 where a pocket of water stands. This condition prevails upto the commencement of next monsoon. Hyper saline conditions were observed only in the month of July at station 8 (193.63‰) with simultaneous rise in pH to 9.00 and no dissolved oxygen at all. The absence of dissolved oxygen content in the small body of water at station 8 can be attributed to the liberation of hydrogen sulphide during the process of organic decay observed at the station. In the beginning of September, salinity of the water in the lagoon varied from 50.48 - 53.48‰ at stations 6 to 8 when there was little rainfall. Towards the end of September, salinity gradually decreased due to the influx of some rain water.

Rate of evaporation

Evaporation rate in the area has been calculated for a period of three months (July, August and September) as the whole area of the lagoon begins to dry up from July onwards. The maximum value was obtained in August (2.289 cm/day), the values for July and September being 1.495 and 1.55 cm/day respectively. The excess evaporation during August may be attributed to the prevalance of dry South-West wind accompanied by heat liberated from the dried salt deposits.

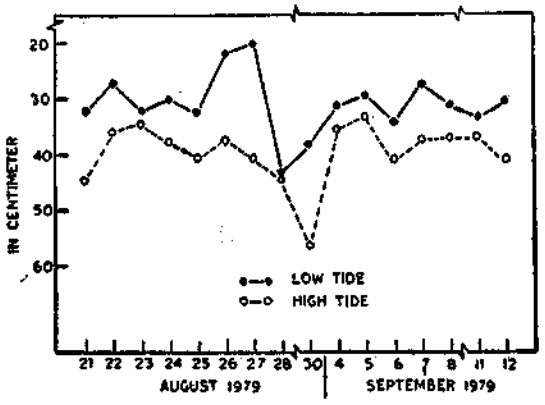

Fig. 3. The influence of high and low tides on the depth in a fish pond adjacent to the lagoon.

Influence of tides on the depth of water in coastal ponds

Observations on the variations in depth of the water in the adjacent fish farm with reference to the tides were made during the months of August and September. Experiments were conducted in one of the culture ponds with an initial water level of 32 cm. Daily variations in the water level at high tide as well as low tide were recorded (Fig. 3). Data indicate that there is an increase in water level in the pond to 56 cm at high tide and a decrease to 21 cm at low tide.

Relationship between the physico-chemical characteristics of the water in the lagoon and variations in the abundance of fish seed

Survey of the fish seed resources in and around the lagoon indicated the occurrence of abundance of the fry of mullets *Ellochelon waigiensis* (most abundant: 10.8 to 85 mm), *Liza macrolepis* (10 to 105 mm), *Valamugil seheli* (13 to 44 mm), *Therapon* sp. (20 to 30 mm), *Chanos chanos* (40 to 80 mm), *Sillago sihama* (50 to 80 mm), *Tachysurus thalassinus* (50 to 80 mm), *Nematolosa nasus* (60 to 90 mm), *Leiognathus brevirostris* (30 to 40 mm), *Hemirhamphus* sp. (17-23 mm), gobids (30 to 40 mm) and belonids (80 to 102 mm). Prawn seed was represented by *Penaeus indicus* (25 to 30 mm) and *Metapenaeus burkenroadi* (30 to 50 mm). Quantitative studies revealed that greater quantities of fry and juveniles were available in January, February, May, June and November. These observations indicate that seed of commercially important species of fishes and prawns could be collected in the vicinity of the lagoon itself for large scale culture of the same in the lagoon by the development of the lagoon into a suitable fish farm.

Discussion

In general, in all the stations in the lagoon during monsoon salinity has been found to be low ranging from 10.63‰ to 30.26‰ thereafter the values of salinity have been found to increase gradually upto a maximum of 67.50‰ in June. However, at station 7, salinity has been generally found to be lower than the other stations, ranging from 7.50‰ to 30.50‰, which is attributed to the fact that this station is located close to the river mouth. At station 8, hypersaline condition (193.63‰) was noticed in the month of July. In the month of September, although salinity values showed a decrease from June (in July, August the lagoon dries up) the values are higher than those for normal sea water, probably because the salt deposits are washed by the rains during this month as well as their dilution by the influx of sea water through the bar mouth. Dissolved oxygen values were high during

monsoon and post-monsoon months ranging from 3.238 to 5.94 ml/l whereas in summer and pre-monsoon months, the values were lower, ranging from 0.673 to 3.959 ml/l except stations 2 and 3 when the values were found to be 5.210 and 6.215 ml/l respectively in the month of September which are attributed to fresh showers of rain.

The pH values in the monsoon season and the beginning of the post-monsoon season were generally low, ranging from 7.10 to 8.20 whereas in the rest of the post-monsoon, summer and pre-monsoon season, the pH values were generally higher ranging from 7.20 to 8.94.

Atmospheric temperature showed a gradual increase from October to August declining thereafter to a minimum in October. Water temperature also showed a similar trend except that the values were lower than those of the air.

In the sea station, salinity values showed a gradual increase from December (26.65‰) to August (32.39‰) thereafter the values declined; the dissolved oxygen values were higher in the months November to January (5.115 to 5.534 ml/l), lower from February to May (4.703 to 4.22 ml/l), raising again with a range of 5.109 to 5.257 ml/l from June to September. In October the value was 4.76 ml/l ; the pH values ranged from 8.02 to 8.30. Air temperature varied from 28.25 to 33.00°C and water temperature gradually increased from October (28.00°C) to May (32.15°C).

Consequently, the cyclic pattern of changes in the lagoon during the year may be briefly stated as follows :

(i) Estuarine conditions prevail during the monsoon as there is free admixture of fresh water and sea water.

(ii) Near oceanic conditions occur throughout the post-monsoon as only sea water rushes into the lagoon.

(iii) Saline pools are formed due to shallowness of the lagoon and excess evaporation during summer, when the lagoon remains completely cut off from the sea.

(iv) For most part of pre-monsoon, almost the entire area of the lagoon gets dried up leaving salt deposits in some places.

One of the major factors controlling the biological productivity is salinity in the area (Tampi, 1969). The wide annual range in salinity from 18.16‰ to 193.63‰ with related fluctuations in pH and dissolved oxygen may have a combined effect on productivity. Quantitative studies revealed that greater quantities of fry and young ones of commercially important fishes were available in January, February, May, June and November when environmental conditions appear to be suitable for them. At other times, there is scarcity of fish seed, evidently due to unfavourable conditions.

Tampi (1969) estimated the rate of primary production in the lagoon to be in the range of 0.08 gC/m^3/day and 0.125 gC/m^3/day which is poor when compared with the production rate in Palk Bay, 0.435 gC/m^3/day (Nair *et al.*, 1973). In a series of fertilization experiments with artificial manures, Udaya Varma *et al.* (1963) made attempts to increase the basic production rate in fish ponds adjacent to the lagoon and found that production in the ponds improved from 0.106 gC/m^3/day to 0.955 gC/m^3/day after adding inorganic fertilizer (superphosphate). However, he concluded that the productivity of the ponds does not depend entirely on the nutrient salts, but that intensity of light and salinity may influence the productivity to a large extent.

It is proposed by the Central Marine Fisheries Research Institute to convert the saline coastal lagoon into a fish farm for large scale fish culture. Based on earlier observations and the present study, the problems which have to

be solved in this connection are controlling the wide range of salinity, improving the level of organic production by suitable methods and increasing the depth in certain parts of the lagoon by various management practices.

The abundance of fry and young ones of commercially important species of fishes like mullets and milkfish and prawns in and around the lagoon especially in the months February, May and June also in other months makes stocking of the ponds easy and inexpensive for large scale culture of fishes in the area.

Tampi (1959) estimated an annual fish production of about 20 metric tons from the lagoon based on wild stocks. He stated that a production rate of 212 to 455 kg/hectare was obtained in the adjacent fish farm for milkfish. However, based on productivity studies, Tampi (1969) indicated that the theoretical yield of fish from the lagoon would be about 11 tons. The higher production rates of fish from the lagoon based on wild stocks may be explained by the fact that large number of fishes enter the lagoon when the connection to the sea is established, thus contributing to the catches. Although the lagoon is known to be not very productive, its productivity may be improved by adopting modern fish farming techniques aided by the free flow of sea water through the bar mouth, entry of fresh water from the river and the possibility of run off from landward side carrying nutrients.

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