UTILIZATION OF SALINE MUD FLATS FOR FISH CULTURE—AN EXPERIMENT IN MARINE FISH FARMING

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Introduction

The scope for economically feasible fish farms in brackish water areas in India has long been realised and practically demonstrated by the numerous fish and prawn farms adjoining the backwaters of Cochin along the west coast. Apart from these even some of the other low-lying saline coastal mud flats of the south-east coast of the Indian Peninsula, which periodically get flooded with sea water but usually with a relatively low biological productivity owing to certain inherent ecological drawbacks, also show potentialities for development. Attempts at fish culture in similar marine environments have not been many in this country except for the earlier enterprises by the Madras Fisheries Department as reviewed by Chacko and Mahadevan (1956). A project was recently undertaken at the Central Marine Fisheries Research Station in order to determine to what extent these apparently low productive areas can be brought under more effective utilization for fish culture purposes and the preliminary results are given in this account.

The scheme was initiated by Dr. N. K. Panikkar while he was the Chief Research Officer of this research station. To him and to Dr. S. Jones, the present Chief Research Officer, the author is grateful for their interest in the work. Dr. V. K. Pillay has been helpful in the analysis of a few mud samples while Sarvashri P. A. Abraham and K. Ramachandran Nair have helped in the routine analyses of plankton and water samples. The construc ion of the ponds was carried out through the Central Public Works Department.

The Experimental Ponds

The site chosen for the experiment forms part of the saline lagoon on the Palk Bay coast near Mandapam and is more or less typical of the coastal lagoons in this region. Figure 1 shows the general outlay of the experimental pond system. The series of seven ponds are fed by sea water by means of a common supply channel leading directly from the Palk Bay. The in and out flow is controlled by a main sluice near the seaward end of the supply channel while a similar sluice at the farthest point helps to regulate the supply of water during the mons:on season when the surrounding areas get inundated. The shutters of these two principal sluices slide within grooves built in the masonry work on ei her side and are operated on the screw system on a central shaft. Besides the main sluices there are smaller subsidiary sluices connecting the ponds independently with the feeder canal, each of which is guarded by a pair of shutters, one with a velon screen and the other of wood for completely closing the gates. The ponds are formed by the excavation of the earth and the clay thus obtained is stabilised into bunds. The inset in Fig. 1 shows a cross section of the bund which is provided with nearly 3 feet of coral stone pitching at the base of the slope resting on a

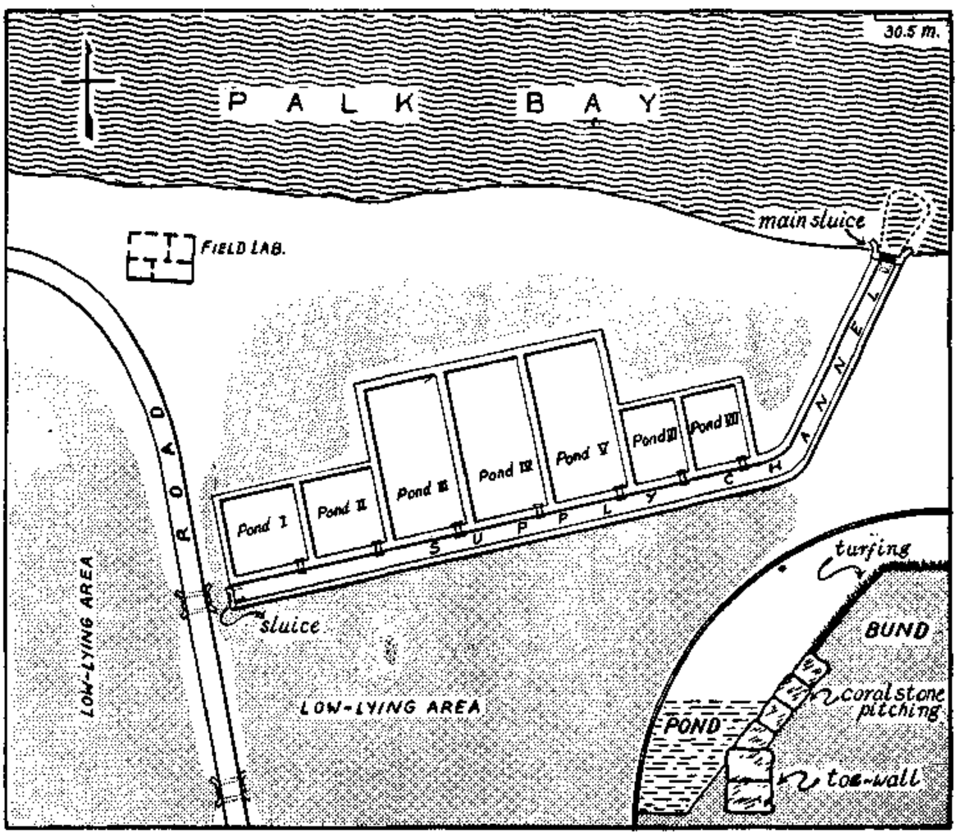

FIG. 1. General outlay of the experimental marine fish ponds. The inset shows one half of a bund in section.

toe-wall, also of coral stones. This has been found to be helpful in preventing the constant silting and caving in of the bunds at the water-level and thereby minimising the cost of labour in maintenance. As an additional protection the surface of the bunds above this is covered up with turfing because it has not been successful in stabilising the surface otherwise by means of sand-binding plants owing to the highly saline nature of the soil.

The dimensions of the seven ponds are as given in Table I.

TABLE I

Pond No.	Length (meters)	Breadth (meters)	Av. depth (meters)	Water area (sq. meter)
I	30·5	30·5	0·5	930
II	30·5	30·5	0·5	930
III	61·0	30·5	1·0	1860
IV	61·0	30·5	1·0	1860
V	61·0	30·5	1·0	1860
VI	30·5	22·0	0·5	700
VII	30·5	22·0	0·5	700

It might be mentioned here that the pond system is not organised into separate nurseries and rearing ponds and for purposes of experimental convenience the different tanks are also not interconnected. Complete drainage of the ponds using only the tidal flow is also not possible in the existing system because of the low elevation of the land from the mean sea level and the poor tidal amplitude in this region of the coast.

Some of the ecological characteristics of the area which exert their influence on pond life have been discussed in an earlier paper by the author (1959). The pattern of annual fluctuations in characteristics of the water in the ponds as indicated in Fig. 2 largely reflects the changes in the surrounding lagoon. The surface temperature in ponds is highest (32°–33° C.) during the summer months of March to May. A lowering of the temperature takes place during the next few months followed again by a slight rise in August to September. Thereafter there is a drop with the commencement of the monsoon and the temperature remains low through the succeeding months until the beginning of the next summer. The salinity usually remains above 30‰ and towards the latter half of the summer period until the beginning of the monsoon the water becomes hypersaline attaining a value around 45‰. Periodical replenishments of water from the sea minimises extreme increase in salinity during this part of the year when evaporation is at its maximum. pH is more or less steady throughout the year, remaining

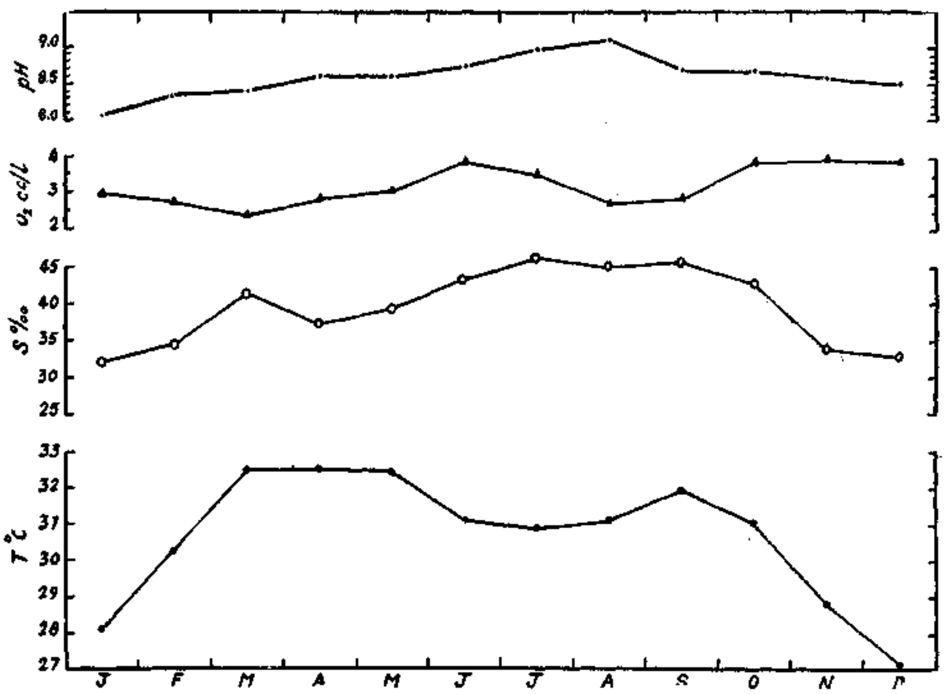

FIG. 2. Graph showing the pattern of annual fluctuation in temperature, salinity, dissolved oxygen and pH of the water in the experimental marine fish ponds.

between 8·1 and 8·6. Dissolved oxygen shows an average value of 3·0 ml./l. and often fluctuates between 2·0 and 5·0 ml./l. The highly silt-laden nature of the mud increases the inorganic suspension in the water during the severe winds and often limits the Secchi disc reading between 40 and 70 cm. at midday. The water becomes clearest after the monsoon when much of the suspended matter tends to settle down. The levels of total and inorganic phosphorus in the water remain around 60·0 mg.P/l. and 5·0 mg.P/l. respectively throughout the major part of the year. Compared to the more open lagoon or the sea-water these values might be said to be somewhat higher. Information on other nutrients are not available at present. Similarly any detailed analysis of the mud in the ponds has not been carried out beyond obtaining an ave age value which shows a low organic content indicated by a loss of 12·4% on ignition. The phosphorus and nitrogen values are of the order of 0·033% P/m^3 and 0·35–0·46% $N m^3$.

A variety of diatoms, chief among which are Pleurosigmoids, Naviculoids and Nitzschioids, occur throughout the year. Besides these many other marine species also find their way into the ponds along with the sea-water but do not constitute a permenent feature of the plankton. The blue-green algæ belonging to the genera *Phormidium*, *Microcoleus*, *Lyngbia* and *Spirulina* also are major constituents while small amounts of *Chætomorpha* can be seen growing attached to stones and the sluice embankments. Higher forms of seaweeds have been introduced into some of the ponds where they have begun to colonise. Swarms of Peridinians occur in these ponds during early summer periods and similarly some amount of sulphur bacteria ha also been noticed near the bottom of the ponds at this part of the year. The chief constituents among the zooplankters are the copepods, particularly the calanoids and harpacticoids. Besides these, nauplii of copepods and barnacles, larvæ of decapods and also mysids are important. Mention may also be made of polychæte and veliger larvæ, nematodes and a few ciliates. The composition of the plankton varies considerably during different periods of the year and the detailed analysis is not given in this account. Nevertheless, it should be pointed out that the period following the monsoon and before the summer shows the maximum standing crop.

Preparation of Ponds, Fish Collection and Experimental Stocking

Pillay (1956) in his analysis of mud from these regions had pointed out that the surface layers are relatively rich in organic matter and nutrients. However, during excavation most of this nutrient-laden soil has been removed and a compensation for this loss has been the first step in the preparation of the ponds for initial stocking of fish. A compost prepared out of seaweeds and cow-dung in equal proportion by wet weight is uniformly broadcast on the surface of water. Both seaweeds and cow-dung are available locally in large quantities and their composting in pits is also an easy process. A treatment with 500 pounds (wet weight) of compost per acre of water area in the initial stages has been necessary while after the first two treatments at monthly inte vals this might be advantageously reduced to nearly one-fourth the quantity. A slight increase in the pH of the water of the order of 0·3 might occur following the application of this compost but this condition normally corrects itself in the course of about ten days. Although the initial stocking of the ponds with fish is deferred for a fortnight after the treatment with compost it appears that the fish are not affected during subsequent manuring. The significance of this type of compost manure in increasing the biological productivity of saline waters has been discussed by Pillay (1955). Besides this occasional use of green manure (locally avai'able plants for this purpose are *Thephrosia* and *Pithecolobium*) has also been helpful. The water in the ponds invariably shows a noticeable effect as indicated by a change in colour almost within a week after these treatments. An increase in phytoplanktonic organisms, predominantly the Myxophyceæ and the diatoms, seems primarily responsible for this change in colouration. Changes are also observed at the bottom of the pond and the mud shows a layer of greenish scum consisting of blue-green algæ, diatoms and sometimes rich bacterial flora. Analysis of the chemical cycle undergone at various stages of manuring and other critical results of manuring experiments will be published in due course. The use of chemical fertilizers ha not so far been attempted in these ponds. Sulit *et al.* (1957) claim to have used commercial fertilizers to economic advantage in the preparation of *Chanos* nursery ponds in the Philippines.

Very few aquatic organisms injurious to fish are found to thrive in these ponds. Midge larvæ (*Chironomus*) have been reported to be a serious pest in the milkfish ponds of Taiwan (Tang and Chen, 1959) who have also pointed out the paucity of these pests during season of high salinity. The usually high saline environments of the ponds should be responsible for such absence of some of the common pests. However, the problem of predatory fish finding their way into these ponds has been a serious one which has not been satisfactorily solved. Among others which cause damage to the fish are the Portunid crabs and the numerous avian predators.

Chanos fry from 15 mm. onwards up to fingerlings of about 120 mm. are obtainable in large numbers from the surrounding lagoon throughout the months of March to July. For these culture experiments, however, only fingerlings have been made use of and these are collected by means of the *konda valai* (a rectangular strip of net with spreader sticks at intervals). The entire requirement of fingerlings for stocking the ponds is collected from the immediate vicinity which minimises problems of their transport and this unique advantage the location of the farm enjoys may specially be pointed out. Soon after collection the fingerlings are carried to the ponds and retained in velon net boxes or cloth hapas before they are carefully sorted out and released into the ponds.

The rate of stocking of the ponds has guided some earlier trials according to which the ponds were stocked at two density levels of 2,500 and 5,000 fingerlings (of 80–100 mm. length) per acre of water surface. While a high rate of stocking may not be justifiable for these waters whose biological productivity is low, factors such as the loss due to predation and the consequent low survival of the fish had to be taken into consideration. The rate of 500–3,000 fish per hectare adopted by the fish growers of the Eastern countries as given by Schuster (1958) does not seem to be applicable to the present local conditions.

GROWTH OF FISH, SURVIVAL AND YIELD

Chanos fingerlings with an average length of 80 mm. at the time of stocking attained a length of 300 mm. at the end of one year in these ponds. Figure 3 indicates the growth pattern of the fish in these experimental tanks from which it may be seen that the progress is relatively rapid during the

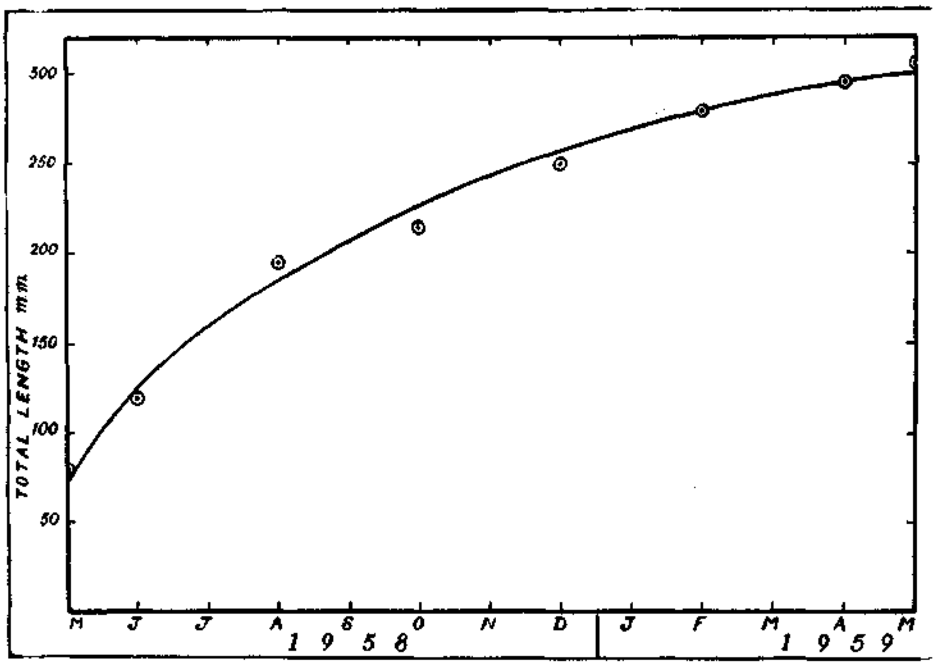

FIG. 3. Growth of milkfish (*Chanos chanos*) in ponds during the twelve months from May 1958.

first three or four months. In the marine fish ponds in Krusadai Island (Madras State) Chacko and Mahadevan (1956) have reported that fish of

50–85 mm. in average length attained 235 and 240 mm. respectively at the end of twelve months. The results obtained in our preliminary experiments are by no means comparable to those that have been produced elsewhere, particularly in the East Asian countries where the conditions are extremely different. Even in those regions widely different rate of growth has been observed depending on the type of ponds in which the fish are cultured. Schuster (1958) has summarised the influence of the various factors such as availability of food and space, salinity and temperature on the growth rate of *Chanos* which reveals the complicated nature of the problem.

The ultimate survival of *Chanos* in these experimen al tanks varied from 9–11%. The survival during the different months have not been ascertained but it is believed that the loss has been greatest during the early phases following stocking. Apart from any natural mortality the loss due to predation by birds and fish (mainly *Elops* and *Therapon*) has been largely responsible for bringing the survival to such a low level. While discussing the question of improving the survival rate of fish under cultivation, Schuster (1958) gives a wide range from 20–80% from place to place depending on the care bestowed and, among other factors, has specially pointed out the possible oss due to predators.

Under the conditions described above, the yield of fish obtained in the different ponds during the experiment of 1958–59 varied between 212 and 455 kg. per hectare (195 and 405 pounds per acre). Figures on the average annual production from the different regions of the Indo-Pacific available from reliable records show great variations and up to nearly 2,000 kg. of fish per hectare has been reported in the ponds in Taiwan where heavy manuring and artificial feeding of fish has been resorted to (Tang and Chen, 1957).

Discussion

The primary object of this report is to indicate the fish culture potentialities of an area that is usually regarded as an inferior biological environment. Apart from the poor and porous so l which is largely responsible for inhibiting the fertility of the ponds and for increasing the labour involved in maintaining the bunds, the possible danger of high water-levels during some years imposes certain practical problems. This might enhance the capital outlay of the scheme as it did in the present attempt. Lack of a source of freshwater supply in the immediate vicinity also can be a handicap although the increase in water salinity in the ponds during summer periods can be minimised with improved sea-water supply systems.

In so far as the possible fish production in the ponds are concerned the data obtained from the present experiments show a several fold increase from the natural yield from the region (Tampi, 1959). Even this value of about 400 pounds of fish per acre is admittedly low, but considering the effort spent in attaining this increase the prospects for further improvement in results are evident.

Besides the actual output of fish there are other factors that are significant while considering a marine fish farm in this area on an economic basis. The area in question is an excellent collection ground for milkfish and mullet fingerlings during definite seasons of the year and would therefore justify the establishment of a centre for salt water fish fry trade. This can constitute an important subsidiary industry. Accessibility of the place by road and sea and its proximity to rail road communication increases facilities for fish transport. The occurrence of *Nematalosa nasus* in sufficient numbers in this area and the possibilities of utilizing such less exploited species for culture work are also to be explored. Its ability to withstand wide environmental changes and the fact that the fish has been observed to breed in ponds deserve special mention in this connection as only few species in the tropics are known to breed in confined waters. In the practical management of the farm, availability of cheap organic manure in the form of seaweeds washed ashore in immense quantities also would be of considerable advantage. Lastly, it must be said that in some kind of co-operative management where collective effort is possible the initial outlay of an extended project of this type can be substantially minimised with the extremely low cost of land in this region and can therefore be worked out on a profitable level.

SUMMARY

The first results of marine fish culture experiments in Mandapam are reviewed here indicating the possible means of increasing the yield of fish in a region that is normally a poor biological environment. The drawbacks as well as the advantages in organising a marine fish farm scheme in this locality are briefly discussed.

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