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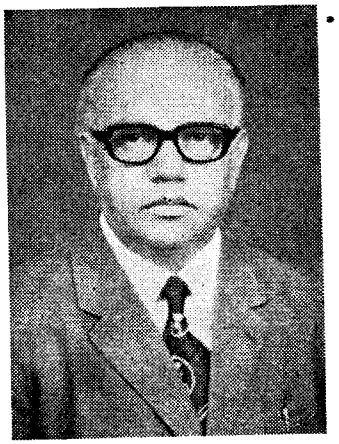
RECENT TRENDS IN MARICULTURE IN INDIA



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Though the green revolution has helped to a large extent in stepping up food production in our country we are yet to reach self-sufficiency in food. Many of the research institutes in our country are currently engaged in research activities to find out ways and means of increasing food production. One of the potential fields where food production could be increased to supplement the requirements of our people is marine resources. At present our fishery resources are not fully exploited. Regular supply of food cannot be guaranteed from the sea as marine fish catches are influenced by many environmental factors which cannot be controlled. Further there are definite limits for the yields which could be obtained from capture fisheries, whether these are from inshore waters or from the offshore and oceanic waters. Fish production could be substantially increased by adopting mariculture practices. In recent years mariculture has come into prominence and has become a profitable commercial proposition. Much progress has been made in several countries of the world in mariculture and methods have been developed to culture a number of species of fishes, prawns, lobsters, molluscs and seaweeds.

In broad outline mariculture may be classified under four major categories, viz., 1) culturing fish and other animals in hatcheries for release with the expectation of increasing commercial catches, 2) capture of young ones and rearing them in confinement to marketable size, 3) raising of the young from eggs obtained from wild parents and their retention and feeding in enclosures until they attain marketable size and 4) hatching of young from eggs obtained from brood stock maintained for the purpose and raising of young in confined enclosures until they reach marketable size. Culture methods are improved by modifications and adoption of new techniques to suit the local conditions. In India, mariculture is mainly carried out by adopting the second category mentioned above. Research work is under way to implement the third and fourth categories. Mariculture can be practised in the nearshore shallow areas, lagoons, estuaries and backwaters. One of the advantages of mariculture is that not only the bottom and topmost layers but also the entire water column could be utilised for culture which is otherwise known as 'three dimensional culture'.

Some of the recent trends in mariculture and the progress achieved in the culture of marine fishes, eels, prawns, edible oysters, mussels, pearl oysters and seaweeds in India are outlined in the following pages.

Marine Fish Culture

Culture of marine fishes is practised successfully in different parts of the world, including many developing countries. In India, attention for the culture and propagation of marine fishes has not been paid till recently. But in the present context of the increasing demand for marine fish and since the direct harvest from the sea cannot increase indefinitely, we have no other alternative but to maks use of the vast stretches of fallow coastal areas, estuaries, lagoons, backwaters, etc. for generating new resources. The niches suitable for marine fish farming may broadly be classified into (1) the shore areas along the sea coasts; estuaries, deltaic marshes, swamps etc. (2) the intertidal zone between the high and low water including bays, inlets, etc. (3) the sublittoral area outside the intertidal region and (4) the open sea. From the productivity side and the economics involved, the shore areas may be considered as the most ideal for mariculture. Apart from the basic need of a suitable locality, the other prerequisites for successful marine fish culture are the availability of clean unpolluted water, young ones of the species required for culture, etc. In India we have many species of fishes ideal for coastal culture, such as the milkfish, *Chanos chanos*, mullets, *Mugil cephalus* and *Rhinomugil corsula*, the giant perch *Lates calcarifer*, etc. The fry of most of these species are also found abundantly in our coastal waters and estuaries.

Commercial culture of mullets in the lowlying areas of Bengal has been in existence for quite a long time. But the management procedures have been far from satisfactory. The unsatisfactory supply of water, inadequate stocking, failure to eradicate predators and lack of proper food are some of the factors responsible for the slow growth of the mullet culture there. The establishment of a mullet farm at Narakkal near Cochin during the forties, has given encouraging results.

Realizing the potentialities of culturing *Chanos*, some experiments have been carried out in India in the course of the past few decades. The work carried out in Krusadai Island by the Madras Fisheries Department has shown high growth rate of this species in culture ponds. Subsequent work done by the Central Marine Fisheries Research Institute at Mandapam Camp during the fifties and at Tuticorin last year, has shown that the production of *Chanos* in saline lagoons and in salt-pan areas can be increased considerably by resorting to proper management procedures. In the experiments carried out at the salt-pan areas at Tuticorin, a production rate of 857.5 kg. per hectare has been obtained, without resorting to manuring the ponds and feeding the stock artificially (Fig. 1). The fingerlings depend invariably on the food present in the sea water pumped into the salt-pans and on the detritus and thin growth of algae present at the bottom of the salt-pan. The experiments have shown that the unused water masses in the salt-pan areas can be utilized profitably for culturing *Chanos*, even without extensive preparation of the ponds, manuring and supplementary feeding.

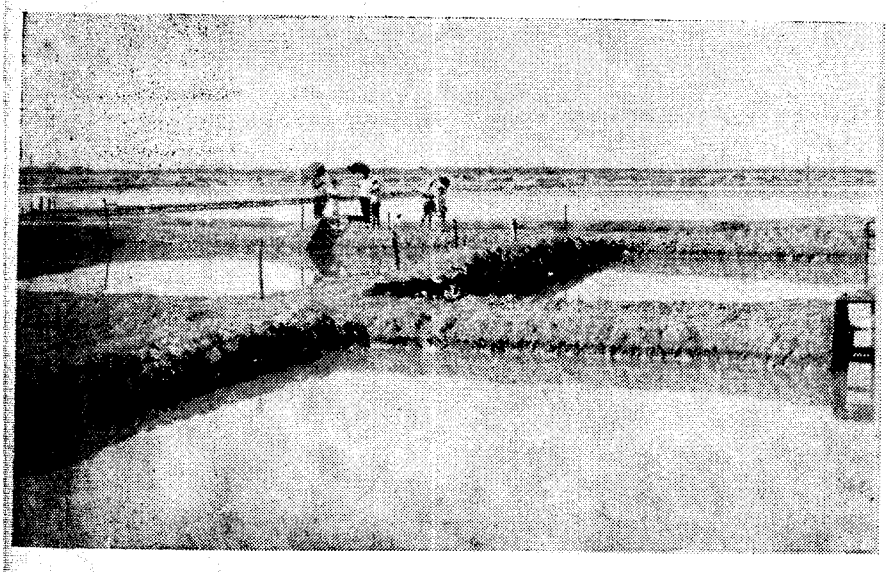

Fig. 1.
A general view of the culture tanks at Veppalodai near Tuticorin where salt pan fish culture is being carried out.

Marine fish culture has been progressing remarkably well in different parts of the world and strictly marine species including even pelagic ones have been adopted for culture in intertidal enclosures and / or floating net-cages. These ventures would involve costly constructions and hence, in India the culture of truly marine species in the sea itself may have to wait till a more propitious time. In the meanwhile, the cheaper methods of fish culture in the shore areas may be given due attention for increasing production.

Eel Culture

Eel culture is being practised on a large commercial scale in many Asian and European countries. The European eel *Anguilla anguilla* is cultured commercially in Italy, Denmark, West Germany, U. S. S. R., France, Holland, Ireland, Israel and United Arab Republic and the Japanese eel *Anguilla japonica* in Japan, Taiwan and South Korea. Even though eel culture has developed very rapidly and is flourishing as a profitable commercial enterprise in several countries, it is yet to make a beginning in India. However in 1971 for the first time as a part of a research project of Central Marine Fisheries Research Institute, an investigation was taken up at Mandapam to explore the possibilities of culturing the short-finned eel, *Anguilla bicolor* in running water. In India two species of *Anguilla*, viz., *A. bicolor* and *A. bengalensis* occur along the east coast of India; the former is more abundant in River Tambraparni and the latter in Rivers Godavari and Hooghly.

The life cycle of *Anguilla* species is very interesting. They breed in the open sea at a depth of about 400–500 m and the eggs hatch into tiny larvae, the leptocephali; their journey from the open sea to the nearshore regions is effected by oceanic and coastal currents. The leptocephali metamorphose into elvers and approach the coasts and on entering brackish and fresh waters metamorphosis is completed and the elvers become young eels. The latter live in freshwaters for some years and on attaining sexual maturity the adult eels migrate back to the sea and from there to their spawning ground in open sea for breeding, after which they die.

For culture purposes seed elvers are to be collected from the mouths of rivers. During the rainy season when water overflows anicuts and establishes connection with the sea, the elvers ascend the rivers during night time and congregate near the anicuts unable to cross the closed sluice gates. At that time they are captured with the help of velon nets and scoop nets.

At the Regional Centre of Central Marine Fisheries Research Institute at Mandapam Camp experimental eel culture is being carried out in large tanks provided with continuous running water facility (Fig. 2.) Initially each tank is stocked with more or less same sized elvers in different densities and their monthly growth rate is determined. Experiments are also being conducted to determine the conversion ratio of different varieties of food such as sardines, clams, prawns, silver bellies and mixed food. Eels are fed daily twice at a ration of about 10% of their body weight. The experimental culture of the short-finned eel, *Anguilla bicolor* in running water has shown, that the eels grow very rapidly during the first year. Growth rate is slow during the second year. The average monthly increases in weight in the first and second years were 8.6 gms. and 4.5 gms. respectively. As the eels reach marketable size and weight at the end of first year it was suggested that it could be profitable to harvest them at the end of the first year itself. The experimental culture of *A. bicolor* in running water has given a production rate of 3.8 kg per sq. metre or 38,000 kg/hectare in two years which is comparable to the yields obtained in other countries.

The Central Marine Fisheries Research Institute is taking up a pilot project to survey the major rivers along the east coast of India to determine the magnitude of elver resources, their peak period of abundance and best collection places. Culture on a pilot scale is also contemplated to demonstrate the economics of this profitable method of culturing eels.

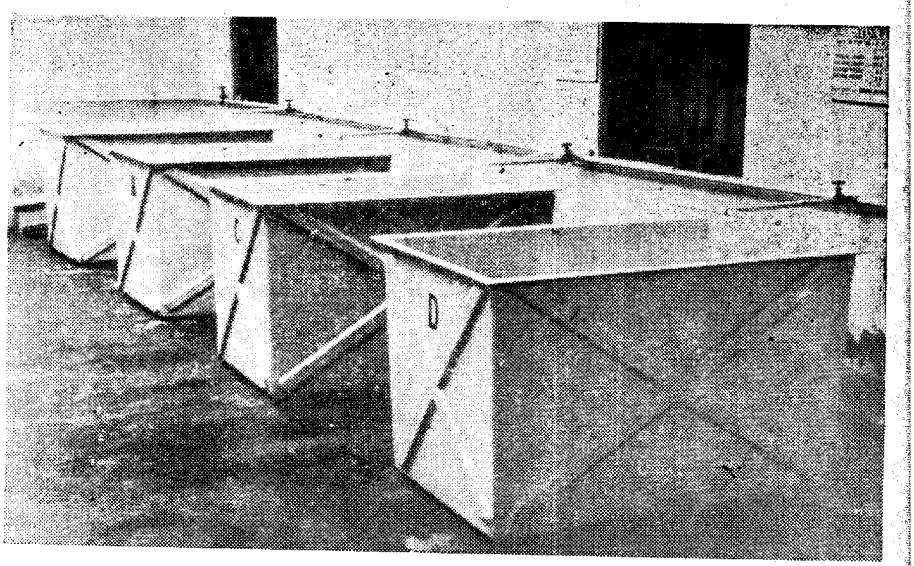

Fig. 2.
A portion of the eel culture laboratory at Mandapam Camp.

Prawn Culture

The penaeid prawns are very much in demand in the external markets. Kerala

which accounts for over 60% of the catch of these prawns in the country offers ideal conditions for culturing them. The State has an extensive net-work of backwaters and brackish-water fields, which also form important nursery grounds of the marine prawns for the first 6–10 months of their life. The influence of the tide which carries the post-larvae and early juveniles from the sea extends many miles inland. The life-history of the marine prawns of Kerala is suited for profitable culture practices. They breed in the relatively deeper regions of the littoral zone where their planktonic larval stages are completed. When they attain post-larval stages they are carried by tide into the coastal bays and estuaries. In the low saline environment of the estuaries and backwaters they feed and grow but they never attain maturity there. When they reach a specific size they migrate into the sea to attain maturity and to spawn. The combination of these favourable circumstances has in fact led to the development of a simple traditional form of prawn culture in the State, consisting of trapping the juveniles and keeping them in enclosures for varying periods of time. These prawn fields are of two types: seasonal and perennial. In the seasonal fields, prawns are cultured from November to May after which the fields are used for paddy cultivation. In the perennial fields, prawns are of course cultured throughout the year.

The research conducted by the Central Marine Fisheries Research Institute shows that a yield of 500–2000 kg of prawns could be obtained per hectare over a period of 6 months from prawn culture in such low-lying areas, depending entirely on natural stocking and without the use of artificial feeds. A rough estimate has been made that the traditional form of culture exists over an area of about 4500 hectares in Central Kerala. There is no doubt that the State has tremendous potential for boosting prawn production through culture practices. Two steps may be envisaged for this:

(i) Increasing the productivity of the existing prawn culture fields, and

(ii) Extension of prawn cultivation to other areas in the State.

The prawn production per hectare could be increased considerably by the introduction of modern culture practices. Stocking which at present is entirely dependent on tidal action, could be replaced by a system of selective stocking, where the stocking density and the species to be stocked may be determined on scientific lines. As mentioned earlier, the seeds for stocking are abundant in the backwaters. Prevention of the entry of carnivorous fishes and other predators and increasing the primary production through manuring and fertilisation are some of the other steps which could be envisaged. Regarding the extension of prawn culture to new areas there can be no doubt about the potential, as the North Kerala and South Kerala backwaters practically remain virgin in this regard.

In order to assess the effectiveness of the suggested improvements, the I. C. A. R. has sanctioned an *ad hoc* scheme on marine prawn culture and propagation. This scheme has started experimental studies on prawn culture from a 4 ha brackish water plot at Narakkal made available for this purpose by the Government of Kerala from January, 1974 (Fig. 3). One of the achievements of this project is the discovery of large numbers of post-larval prawns *(P. indicus)* in the surf regions of the sea near Narakkal (Fig. 4). It was also found out that the post-larva that are abundant in the

surf region can be transferred to the properly prepared culture ponds without much of acclimation.

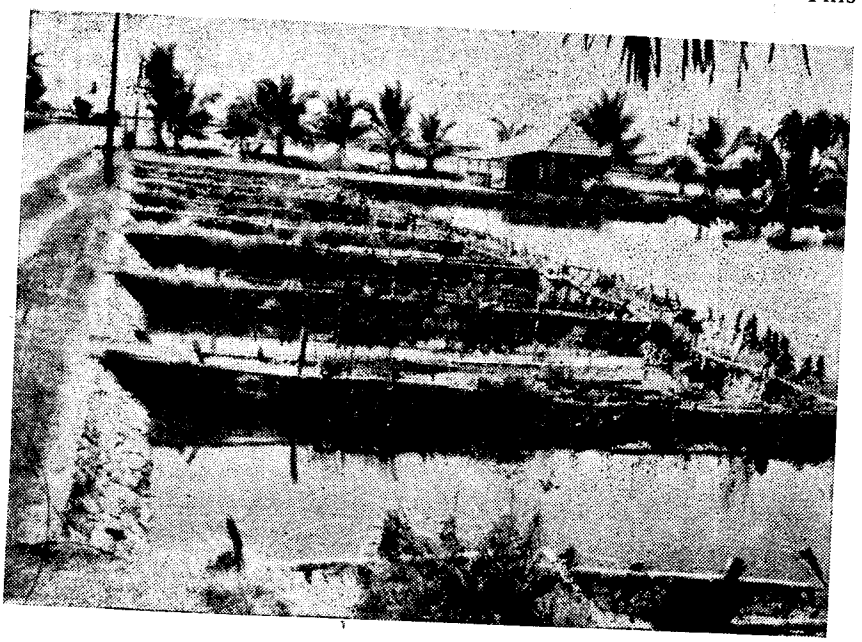

Fig. 3. Prawn culture tanks at Narakkal. The temporary Field Laboratory is seen in the background.

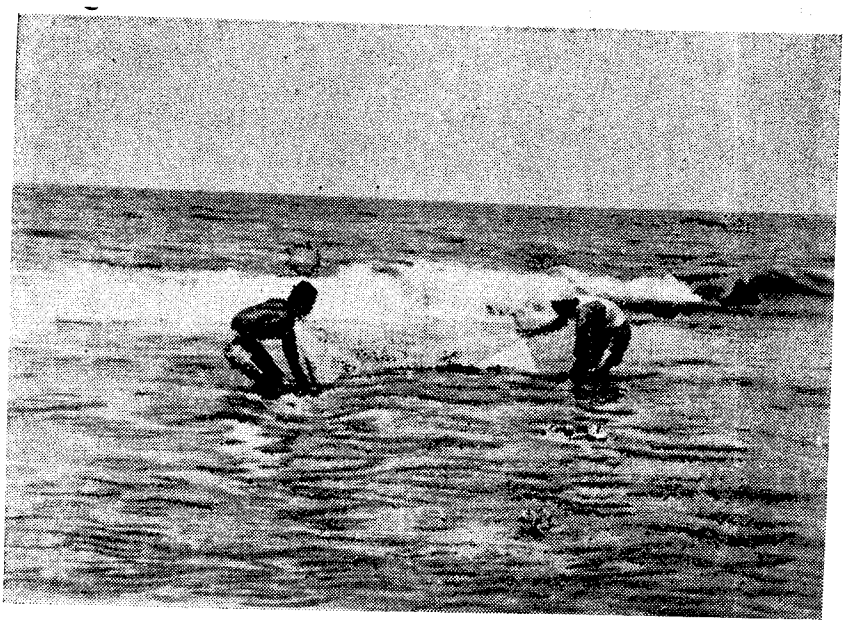

Fig. 4. Surf collection for prawn post-larvae at Narakkal.

Now-a-days production technologists em phasise the necessity of planned and integrat use of land. This is a concept particular relevant to Kera where the availabili of farmland is limite and the State has t press into service a available areas fo diversified food pro duction. In coasta tracts an integrate approach for utilisa tion of the available low-lying areas fo cultivation of cereals, prawns and fishes would certainly pay very good dividends. The idea is that areas whether on land or in water which re main barren even for limited periods should be utilised for pro ductive purposes at a comparatively low cost.

Oyster culture

Oyster culture is carried out extensi vely in several coun tries like U. S. A., Japan, France, Korea, Mexico, Taiwan, Australia, Canada, Holland and Philip pines where oysters are very much relished as a delicacy. Oyster

culture is not carried out commercially in India except for collection of small-sized oysters at Bombay and Pulicat and growing them to marketable size for supplying to a few hotels in Bombay and Madras. At present oysters are used mainly to manufacture lime in our country. It is necessary to make use of oysters as food in India as they are highly nutritious. As in the case of other commercially important bivalve and gastropod molluscs it is essential to culture edible oysters as harvesting from natural beds will lead to rapid depletion of resources. Edible oyster resources are present in fair abundance along Indian coasts and oyster beds are found in shallow coastal areas, backwaters and estuaries of most of the maritime states. Ten species of oysters have been recorded in India, of which four species, *Crassostrea madrasensis*, *C. cucullata*, *C. gryphoides* and *C. discoidea* form large beds and are suitable for culture. *Crassostrea madrasensis* occurs at Sonapur, deltas of Godavari and Krishna, Gokulapalli, Pulicat, Ennur, Madras, Cuddalore, Athankarai and Kanchanagudi near Mandapam, on Kerala coast and at Port Blair. *C. cucullata* popularly known as the rock oyster, as it is a prominent member of the fauna on rocks in intertidal zone is distributed on rocky parts all along the east and west coasts. *C. gryphoides* and *C. discoidea* are found from Kutch to Karwar on west coast.

Oyster larvae settle on submerged hard substrata like stones, shells of dead oysters, coral stones and even firm muddy bottom, attach themselves to the substratum and become spats which eventually grow into adult oysters. In oyster culture, oyster spat are collected using different materials like shells of oysters and other molluscs, stones, tiles, bamboo poles and tree branches which are known as cultch and the spat are reared in protected enclosures. In France and Britain tiles with a coating of lime or a mixture of lime, mud and sand are used as cultch. Of late, veneer rings with a coating of cement are used as cultch in Canada while cement asbestos structure and ferro concrete structures are used for the purpose in New Zealand. In France it has been observed that plastic structures of different shapes could be laid in coastal waters for settling of spat. The cultch are scattered on the bottom or suspended from rafts or racks in the vicinity of breeding oysters.

When the young oysters attain a size of about 3–4 cm. they are separated from the cultch and sown on firm, hardened substratum for further growth, or reared in trays or cages. In stick culture the young oysters are allowed to grow on the sticks themselves. Periodical cleaning of the surfaces of cultured oysters to control fouling of the shellfish by sedentary organisms like hydroids, weaving mussels, barnacles, plychaetes and seaweeds is very essential. Predators like crabs, starfishes and fishes are eliminated and if necessary a palisade made of bamboo poles is set up to prevent entry of predatory animals into the culture area.

Research work on oyster culture has been started recently by the Central Marine Fisheries Research Institute at Mandapam Camp and encouraging results have been obtained. A variety of cultch have been tried to obtain spat of *Crassostrea madrasensis* in Athankarai Estuary near Mandapam Camp and there was setting of oyster spat in good numbers on oyster shells given a coating of cement, tied to bamboo strips or nylon ropes and kept in the estuary (Fig. 5). There was good settling of spat

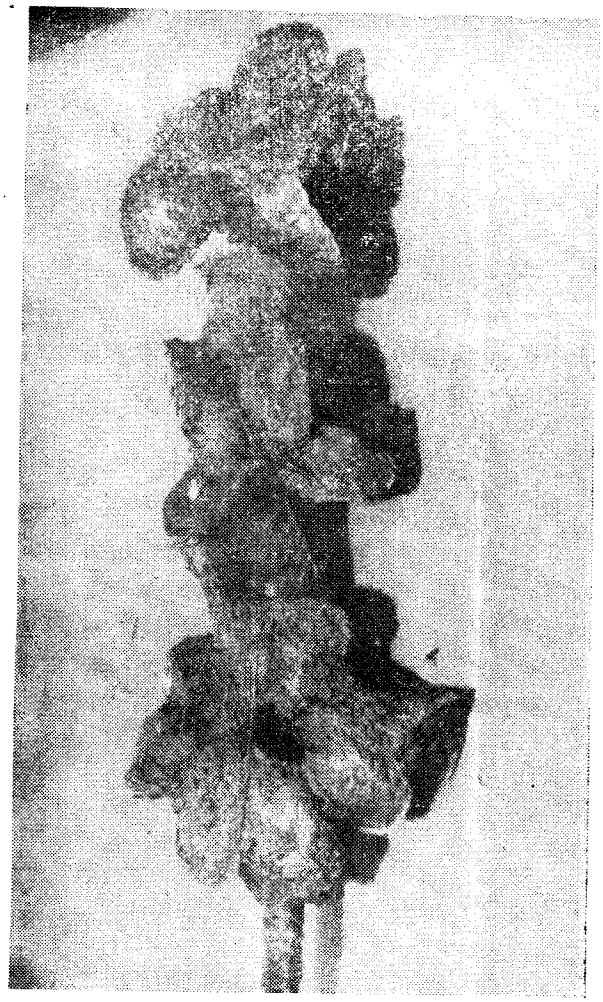

Fig. 5. *Crassostria madrasensis* cultured on bamboo sticks at Athankarai estuary, near Mandapam Camp.

on concrete pieces also. The spats grew rapidly and the cultured oysters reached average sizes of 86 mm and 89 mm at the end of ten months and fourteen months respectively. Experimental oyster culture has been started by C.M.F.R. Institute in Tuticorin also recently. There are very good possibilities for culturing Indian species of edible oysters on a commercial scale in the numerous backwaters, lagoons and estuaries of our coasts as they thrive well and grow rapidly in the brackish waters.

Pearl Culture

One of the most notable achievements of the Central Marine Fisheries Research Institute is the development of techniques, indigenously for the production of cultured pearls. To-day India is among the very few countries in the world which have the technical know-how of pearl culture. Japan was the first country to develop the techniques of production of spherical cultured pearls in 1907, and she built up a world trade for cultured pearls. Australia, Philippines, Burma, Indonesia and Hong Kong have established pearl culture industry in technical collaboration with Japan.

India has been well known for the production of natural pearls since time immemorial and these pearls, popularly called the oriental pearls, are amongst the best in the world. Traditionally, pearl fisheries have been conducted in the Gulf of Mannar along the Tamil Nadu coast and in the Gulf of Kutch along the Gujarat coast. However, the natural pearl oyster resources in both the regions have been subjected to wide fluctuations, particularly so in the Gulf of Mannar. Hence, pearl fisheries in the past have been sporadic and conducted at intervals of about 1 to 40 years, depending on the availability of sufficient stocks of pearl oysters. There has been no pearl fishery in the Gulf of Mannar after 1961 and in the Gulf of Kutch after 1968. Hence, if India has to make the best use of the resources and to retrieve her past glory for pearls, the only way is to culture the pearl oysters in the sea and to produce pearls in them.

This Institute started a Research Project on pearl culture in 1972 at its Substation at Tuticorin, with a field laboratory at Veppalodai. The modern method of raft culture w

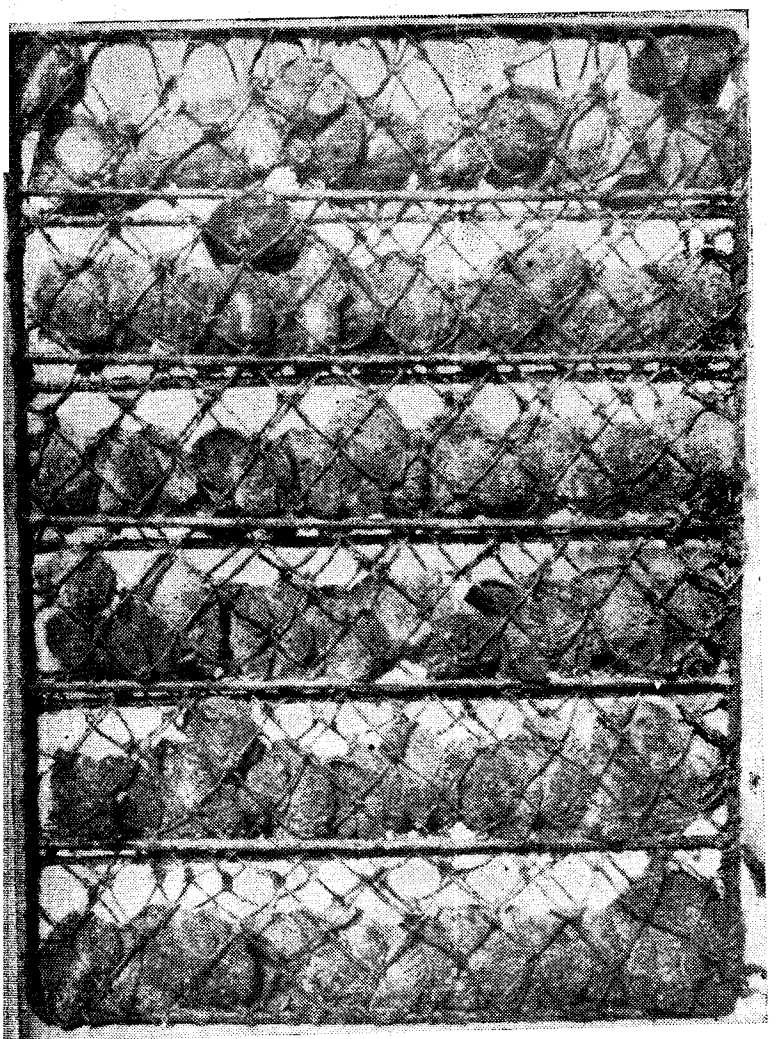

Fig. 6. The book type cage used at Tuticorin and Vizhinjam for pearl oyster culture.

employed for the first time in rearing the pearl oysters in the farm, which was located in the sea about 2 km. from the shore. Pearl oysters of the species *Pinctada fucata* were collected from the pearl banks in the Gulf of Mannar both by SCUBA-diving and skin-diving. These oysters were arranged in sandwich-type frame nets and suspended from rafts at a depth of about 4 metres (Fig. 6). The rafts consisted of wooden frame work buoyed up with wooden barrels and anchored (Fig. 7). The oysters had to be cleaned periodically to remove fouling organisms.

It is well known that a natural pearl is produced as a means of biological defence of the pearl oyster against the irritation caused by intruding tiny organisms like parasites, larvae etc. or inorganic materials like sand grains, silt or mineral compositions. The epithelial cells of the mantle form a so-called pearl sac around the foreign material, which forms the nucleus, and this epithelial sac secretes nacre which is deposited around the nucleus. Finally, it turns into a bright, lustrous natural pearl. For the production of cultured pearls, both the nucleus and the mantle tissue are introduced into the body of the pearl oyster by a skilful operation. The processes of pearl-sac formation and secretion of nacre take place in the same manner as in the case of natural pearls. The pearl produced in this manner is called a cultured pearl. This scientific principle was applied in the pearl culture experiments at Veppalodai farm, near Tuticorin.

Pearl oysters of suitable size were brought to the laboratory and conditioned, using

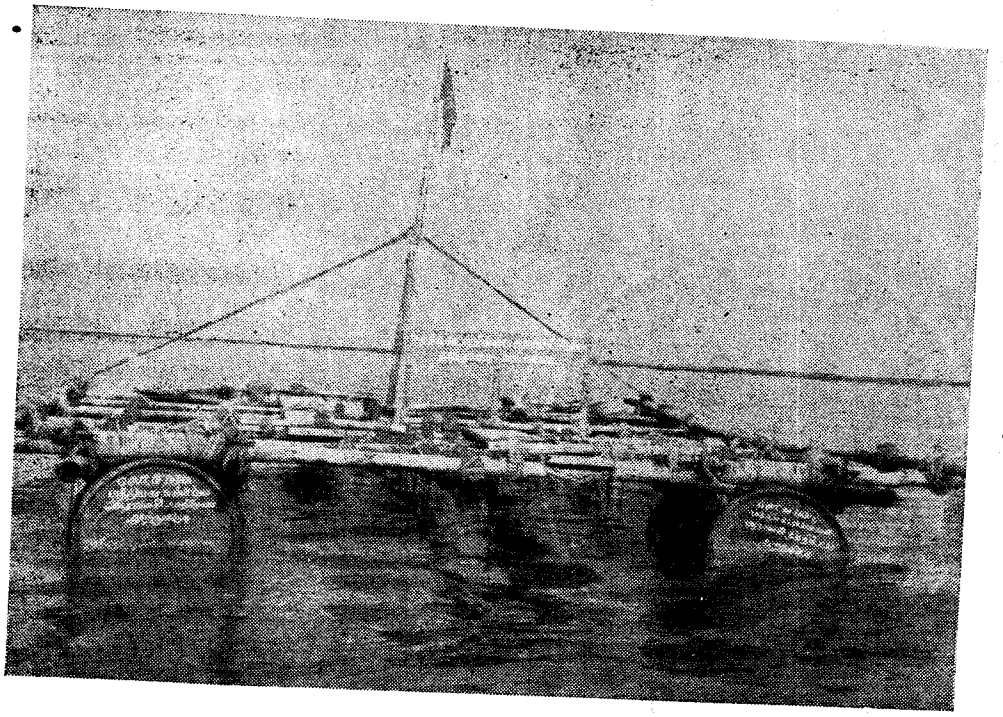

Fig. 7.
The raft used
for pearl cultu
at Tuticorin

menthol, for carrying out the nucleus implantation operation. A spherical shell bead nucleus was introduced into the gonad of an oyster along with a piece of mantle tissue which was cut from another oyster. After the operation, the oysters were returned to the farm for further growth. Secretion of nacre was observed within 30 days after the operation and, after 43 days, good, spherical cultured pearls have been produced. Very bright pearls have been produced in a minimum period of about 3 months. Pearls of different colours, including white, silvery, golden yellow and gray, have also been produced. The breakthrough in the development of techniques was achieved as early as July 1973, in a very short period since the commencement of the project. Species other than *P. fucata* are also being brought under culture for the production of pearls.

An important auxiliary development was the experimental production of spherical beads from the shells of the Indian conch, *Xanc pyrum*, for use as nuclei for cultured pearls. the experiments at Veppalodai, both Japane and indigenously produced shell-bead nuc have been used in producing cultured pea successfully.

The natural resources of the traditional known pearl banks being unpredictable as th are, finding adequate resources of pearl oyste for culture engaged our immediate attentio Settlement of pearl oyster spat in the farm Veppalodai fortified our hopes for generati additional resources through a programme spat collection and mother-oyster culture practised in Japan.

The discovery of pearl oyster spat Vizhinjam, near Trivandrum, along the Kera coast by this Institute is another very importa land mark for the development of pea culture in the country. The discovery

sensational since pearl oysters have been known till now to occur only along the coasts of Tamil Nadu and Gujarat. Research work carried out at Vizhinjam shows that nylon ropes with free filamentous suspensions and basket type collections are most suitable for collecting spats. Heavy settlement of spats was observed during the peak spawning periods in March-April and September-October. These spats have been reared to adult size in about six months and bright cultured pearls have been produced within about 55 days. In addition to imported Japanese shell beads and Indian shell beads, plastic beads were successfully used as nuclei for producing pearls.

The tremendous progress made by this Institute within a brief period of commencing researches on pearl culture has enabled the formulation of two Pilot Projects, one at Tuticorin in collaboration with the Fisheries Department of Government of Tamil Nadu and the other at Vizhinjam in collaboration with Fisheries Department of Government of Kerala, both of which will be implemented shortly. It is hoped that our country which is importing pearls worth over Rs. 8 million annually, would soon become self-sufficient in the needs of pearls and would also be able to export cultured pearls to other countries.

Mussel Culture

In mariculture mussels occupy a unique position because of their high rate of production reaching upto about 600 tonnes per hectare. Mussel culture is practical as an advanced industry in several countries like Spain, Britain, Denmark, Germany, Netherlands, France, Greece, Philippines and Korea.

In India, mussel culture was undertaken for the first time in 1971 by the Central Marine Fisheries Research Institute at Vizhinjam. The results have shown that annual production of about 150 tonnes of mussels per hectare can be achieved by adopting raft-culture method, where mussels are grown on nylon ropes suspended from rafts (Fig. 8); It will be of interest to point out here that in the natural beds at Vizhinjam, the average production of mussels has been estimated to be only four tonnes per hectare.

Fig. 8. Rope culture of mussel at Vizhinjam.

Mussel culture can be done in two ways; 1) by collecting large number of spat on ropes and rearing them to marketable size and 2) by transplanting young mussels collected from the natural beds and culturing them on ropes to marketable size. Mussel culture is usually done by adopting raft culture method. The rafts are made of bamboo poles, 5 m x 5 m dimensions, with 50 ropes of ten metre length each, suspended from the raft. During the peak spawning period July to October when the rafts are kept in the sea, spats settle on the nylon ropes and grow. If the spat settlement on the rope is not adequate, transplantation could be done during September-October by collecting young mussels of 15 to 20 mm size from the natural beds and tying them to the ropes with cotton nets which will disintegrate within a week during which period the mussels will get firmly attached to the ropes. About 60% of the total transplanted young mussels reach a size of above 60 mm by May and are ready for harvest. The productton of mussel per metre works out to about 15 kg. If the cultured mussels are harvested and marketed annually, the same rafts and ropes could be utilized next year also. It has been proved that mussel culture at Vizhinjam is a profitable commercial enterprise, and a pilot project will soon be implemented at Vizhinjam for demonstration purposes.

Recently the staff of the C.M.F.R.I. have discovered the settlement of several millions of mussel spats in the granite boulder groynes laid in the sea at regular intervals over a distance of about 40 km between Pattanakad and Cochin (Fig. 9). Hitherto it was known that along the Kerala coast mussels exist in exploitable quantities only in the coastal stretches of Trivandrum-Quilon and Kozhikode-Cannanore zones. The density of spat settlement on boulders is very high, there being on an average 220 spat per 100 sq. cm.

Fig. 9
A general view of the groynes put up near Shertallai to prevent erosion by the sea.

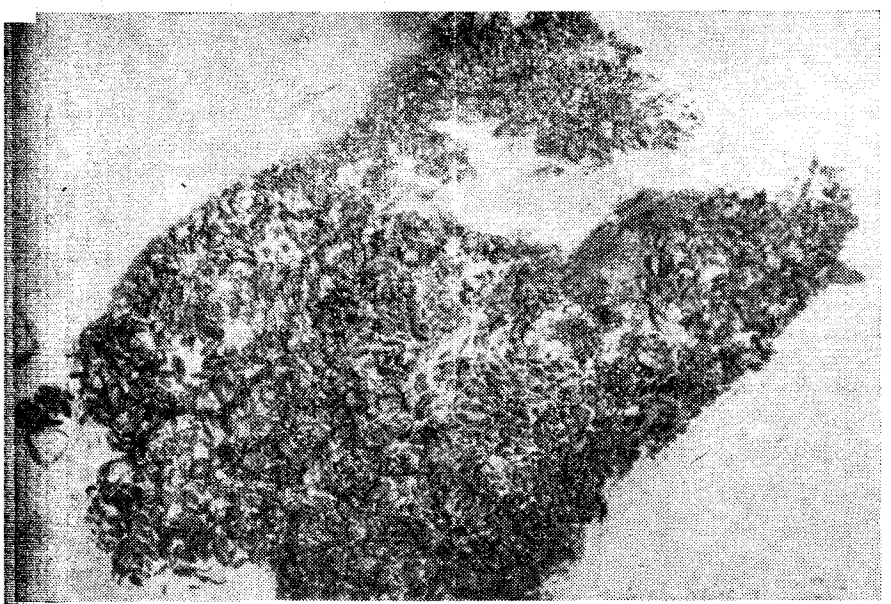

Fig. 10. *Mytilus* spats on a boulder of the groynes near Shertallai. The boulder is almost covered by sand due to wave action.

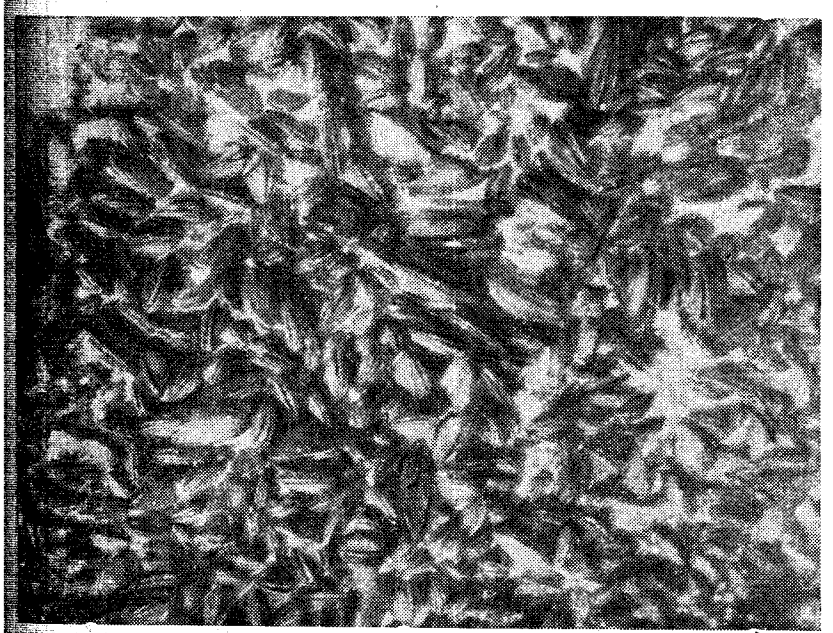

Fig. 11. A portion of the boulder enlarged to show the uniform size of the mussel spats.

area or 9,240 spat on each boulder (Fig. 10 and 11). On a numerical average count made of boulders in a single groyne in the intertidal region at Andakaran Azhi beach about 40 large exposed boulders were seen. This would mean a total population of approximately 3,69,000 mussel spats on these boulders. Calculated on this basis the population of mussel spats in the 200 and odd groynes laid between Pattanakad and Cochin would work out to several millions. Because of certain marine environmental factors affecting the topographical structure of this area these mussel spats have only a short span of life. Therefore it is very essential that these mussel spats should be collected before they perish due to natural vicissitudes. This seasonal mussel seed resource can support extensive culture operations not only in Cochin area but in other coastal areas of the country as the young

mussels can be easily conditioned for transporting to distant places.

Seaweed Culture

Seaweeds are one of the most important marine living resources of our country and they yield valuable phycocolloids like agar-agar and algin which are widely used in many industries. They are also utilized as food, fodder and manure. There is luxuriant growth of seaweeds on the south-east coast of Tamil Nadu and Gujarat coast and around Lakshadweep, Andaman and Nicobar Islands. Fairly rich seaweed beds occur also in the vicinity of Bombay, Karwar, Ratnagiri, Goa, Varkala, Kovalam, Vizhinjam, Visakhapatnam and some other places like Chilka and Pulicat lakes.

In India seaweeds are at present used for the production of agar-agar and alginates. Agar-agar is extracted from *Gelidiella acerosa* and *Gracilaria edulis* and alginates from species of *Sargassum* and *Turbinaria*. Seaweed industries are functioning in places like Kappalur, Kovilpatti and Madras in Tamil Nadu and in Ahmedabad in Gujarat. There is great paucity of raw material which is an important problem faced by seaweed industry. In view of this it is absolutely necessary to culture commercially important seaweeds in India. There are many advantages in resorting to culture of seaweeds. A pure harvest of alga uncontaminated with other seaweeds can be obtained and the alga will also be uniform in quality.

Culture of seaweeds is carried out on a very large scale in Japan, and many species of seaweeds have been brought under commercial cultivation, the most notable being laver *Porphyra* from which *asakusanori*, an important food item, is prepared. Nets made of coconut palm or hemp fibres ropes or vinyl ropes or blinds made of split bamboo connected with rope at intervals are commonly used. The nets or blinds are spread out horizontally at a certain level in winter and they catch a large number of floating spores which grow into adult plants. Recently, based on the discovery of conchocelis phase in *Porphyra* which produces a profusion of spores, artificial seedling of *Porphyra* culture is practised and has greatly facilitated progress in laver industry.

There are two methods of culture of seaweeds, one by means of spores and the other by means of vegetative propagation using plant fragments. The first method has the disadvantage that it takes a long period for spores to develop into adult plants. Culture by means of vegetative propagation yields quick results although a large number of mother plants are employed. Experimental culture of *Gracilaria edulis* is being carried out by Central Marine Fisheries Research Institute at Mandapam Camp in the nearshore areas of Gulf of Mannar and Palk Bay and culture of *Gelidiella acerosa* in Gulf of Mannar by using culture frames fabricated with coconut fibre ropes (Figs. 12 to 15). *Gracilaria edulis* showed regeneration and rapid growth when it was cultured in Gulf of Mannar and Palk Bay. Many new shoots also developed from cut ends of plant bits and in eighty days the plants reached harvestable size. 1.25 kg of plant material introduced initially on an 8 sq. m. culture frame yielded a harvest of 43.22 kg (fresh weight). *Gelidiella acerosa* does not show easy adaptation to culture conditions and the rate of growth is also slow.

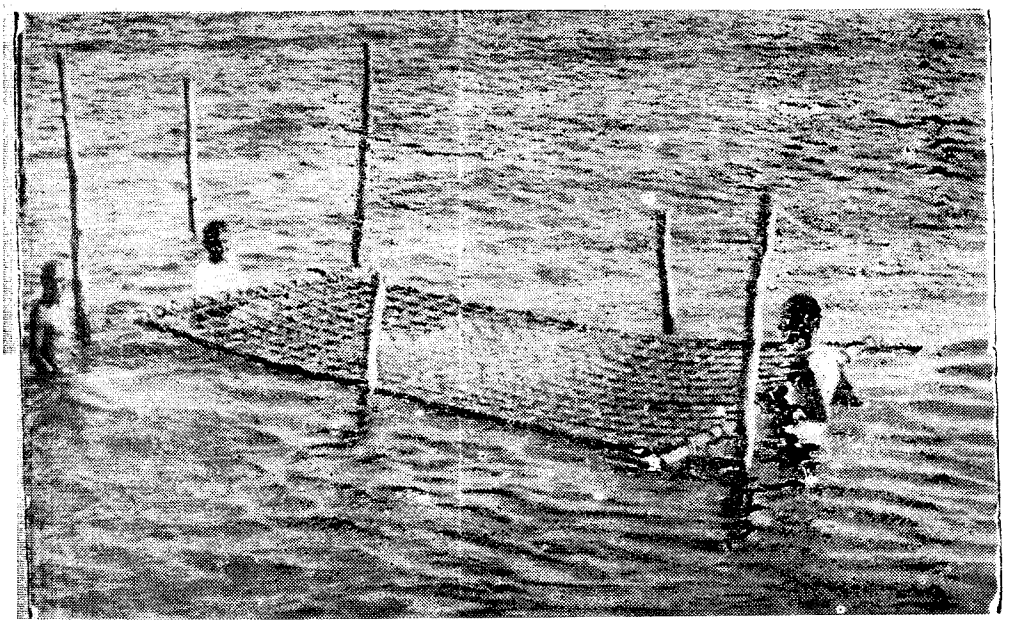

Fig
The frame used for seaweed culture at Mandapam Camp.

It is evident that *Gracilaria edulis* is suitable for culture and production of commercial quantities of the agarophyte is economically feasible in India. The nearshore areas of Gulf of Mannar and Palk Bay are highly suitable for culture of *Gracilaria edulis* during periods of the year when the sea is calm. The cost of cultured seaweed could be brought down by culturing the seaweed on a very large scale and extending the duration of culture period. The laver *Porphyra vitnamensis* available on Visakhapatnam coast should be cultured and exported on a large scale for earning valuable foreign exchange.

Remarks

From the foregoing review of the recent work in mariculture in India as well as in other countries it is evident that mariculture is receiving much attention and different culture techniques are being adopted with modification to suit the local conditions. Till now mariculture has not been attempted in India on any notable scale except for some practices like paddy-cum-prawn culture in Kerala and rearing of edible bivalves in the shallow water areas in Bombay and in Pulicat lake in Tamil Nadu. Experimental culture work conducted by this Institute has shown the economic feasibility and commercial prospects of culturing eels, prawns, edible oysters, mussels, and seaweeds, and pearl oysters for production of pearls. Shell fish farming has a distinct edge over fin fish farming, since the filter feeding molluscs are able to make a direct use of the primary production of the phytoplankton, a very short food chain, unlike the fin fishes which are at the end of a rather long food chain. This

would mean that a high percentage of organic matter contained in the phytoplankton in a given volume of water comes to the table for consumption through shell fish farming.

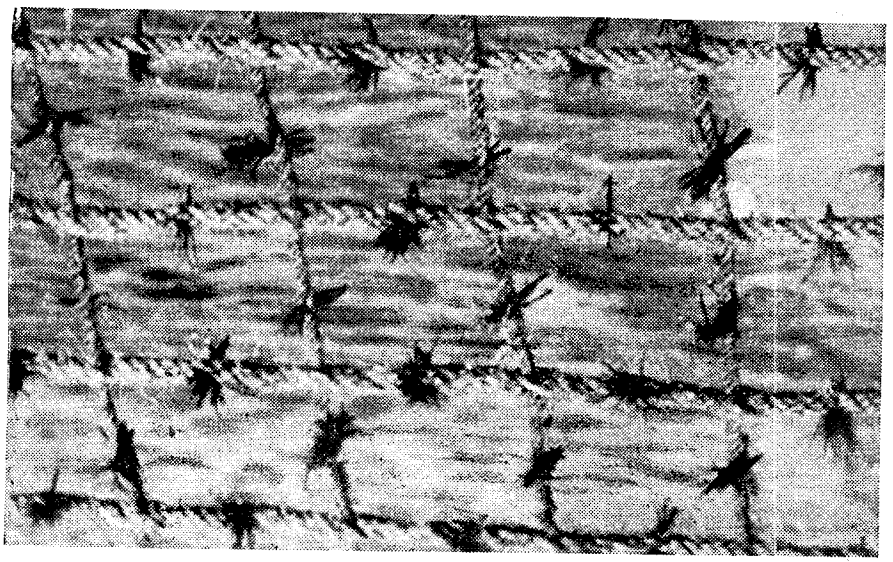

Fig. 13. A close up of the same showing pieces of *Gracilaria edulis* inserted in the coir ropes.

Fig. 14. A view of the frame after 30 days of growth

Salt water fish or prawn culture requires careful selection of the farm site and designing of the farm, preparation of the farm by addition of compost and fertilizers, stocking of fish (larvae in the case of prawns) in optimum density, maintenance of farm and harvesting at proper time. Favourable ecological conditions in the farms, availability of proper type of food which results in fast growth of the species cultured and elimination of pests and predators influence the yield from farming and hence are very important. For profitable culture of edible oysters and mussels, spats have to be collected in huge numbers and have to be reared in shallow inshore waters, backwaters and adjoining areas where the shellfish grow rapidly.

Another aspect which is receiving the

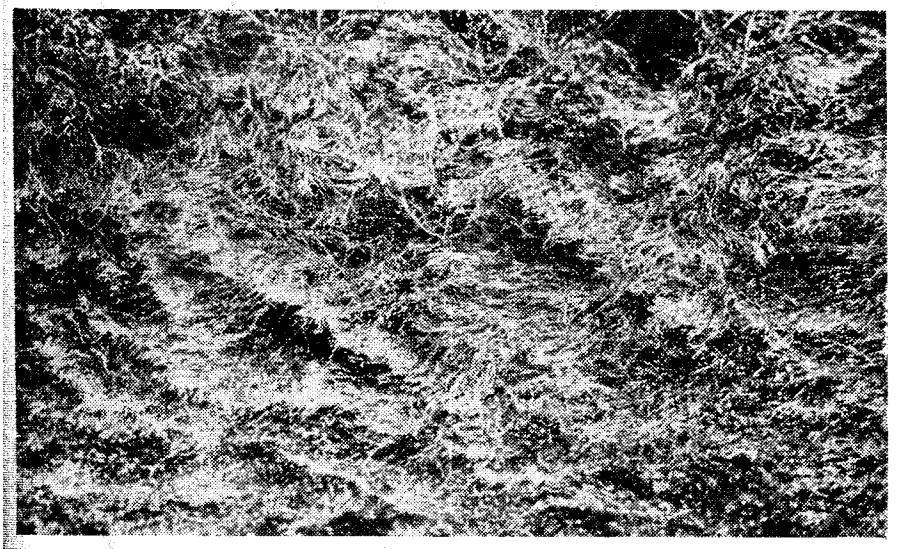

Fig. 15
The same frame after 80 days showing luxuriant growth. This photograph was taken prior to harvesting.

attention of Central Marine Fisheries Research Institute is the artificial fertilization and rearing of larval stages of culturable species as it will enable supply of larvae for culture purposes as and when required. In this field the success achieved in other countries like Japan and U.S.A. in closely related species will be useful for evolving techniques suitable for the different culturable species and environment found in our country.

The successful production of spherical cultured pearls by Central Marine Fisheries Research Institute will help in the establishment of pearl culture industry in our country and will greatly benefit the nation as we import annually pearls worth more than 8 million rupees. There are very good prospects for conducting seaweed culture in our coastal waters. Seaweed cultivation should prove very popular as it does not require much investment and there is good demand from the seaweed industries manufacturing agar-agar and alginates.

Adoption of mariculture practices on a large scale in the maritime states of our country will not only increase the marine fish production potential of the nation but also lead to regular supplies of high quality cultured fishes, prawns and molluscan shellfish. Further, mariculture will also provide employment to thousands of persons in coastal areas and help in earning valuable foreign exchange through export of cultured eels and other fishes, prawns, oysters and mussels, cultured pearls and seaweed products for which there is great demand in other countries.