

RECENT TECHNOLOGICAL ADVANCES IN COASTAL AQUACULTURE IN INDIA

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INTRODUCTION

The importance of coastal aquaculture in the context of augmenting fish production, improving rural economy and productive utilisation of derelict waters was recognised only recently in India. The need for an urgent development of coastal aquaculture received further stress as certain fish stocks in the marine capture fishery indicated optimum level of exploitation, and their catch returns, despite increased efforts, showed declining trend. Following this, several national Institutes concerned with research and development of marine and brackishwater fisheries, initiated a series of investigations on the coastal aquaculture of suitable commercial organisms. The important results of these investigations, and the technological progress made in the field in recent years are presented in this paper.

RESOURCES AVAILABLE FOR COASTAL AQUACULTURE

India possesses the essential basic resources required for immediate development of coastal aquaculture. The potential coastal water area available in the country includes about 8.9 million ha of productive inshore waters for open-sea farming, and 1.7 million ha of estuaries, backwaters, brackishwater lakes and swamps. A variety of suitable fishes, crustaceans molluscs, seaweeds and other marine organisms, possessing high reproductive capacity, short larval development, fast rate of growth, and physiological features to adjust to wide changes in the environment are available in our coastal waters. For immediate establishment of culture fisheries, adequate seed resources of the cultivable species are also available. As the active fishermen engaged in the coastal fisheries form only 21 per cent of the total marine fisher population in the country, there are large number of unemployed and under employed fishermen who could advantageously take up coastal aquaculture.

RECENT ADVANCES IN COASTAL AQUACULTURE TECHNIQUES

As the entire marine fish production and the bulk of the brackishwater fish catch of our country are realised through the capture fisheries, the main emphasis of research and developmental activities has so far been in this field. Except for a few isolated studies and experimental and pilot-scale projects taken up by the Fisheries Departments of certain maritime states, there have been no detailed investigations or concerted efforts to develop coastal aquaculture until recently. However, following the recognition of the potentials in the field, its importance and the high priority assigned to its development, several intensive research programmes have been taken up during the last seven years. Most of these investigations are centred around the culture of prawns, lobsters, crabs, mussels, pearl oyster and pearls, edible oysters, clams, fin fishes and seaweeds because of their commercial importance.

Prawn culture

Researches on the culture of prawns are being mainly carried out at the Central Marine Fisheries Research Institute, the Central Inland Fisheries Research Institute, the National Institute of Oceanography, the Central Institute of Fisheries Education, the Konkan Krishi Vidyapeeth, certain Universities and by the All-India Coordinated Research Project on "Brackish water prawn and fish culture". The investigations are mainly directed towards developing an indigenous technology of large-scale culture of prawns on scientific lines. The techniques of breeding and rearing of larvae of the commercial penaeid prawns, namely, *Penaeus monodon*, *P. indicus*, *P. semisulcatus*, *P. merguensis*, *Metapenaeus dobsoni*, *M. monoceros*, *M. affinis*, *M. brevicornis* and *Parapenaeopsis stylifera* under controlled conditions have been developed. Laboratory experiments on mass production of seed of certain species such as *P. indicus* and *M. dobsoni*, up to stocking size have given encouraging results with a survival rate above

40%. These are accomplished by the knowledge accumulated over the years on the biology of these species and their ecological requirements, and the techniques evolved for the culture of suitable species of diatoms, the brine shrimp *Artemia salina*) and zooplankters, which form the food of larvae and postlarvae. Field experiments on the culture of selected species of fast growing prawns such as, *P. indicus* and *P. monodon*, have shown that they attain marketable size within 3½ to 4 months. Surveys carried out on the prawn seed resource have enabled to locate several grounds in the estuaries, backwaters and surf regions and to know about their availability and seasonal abundance, particularly along Tamil Nadu and Kerala coasts. Suitable gears to capture the prawn seed have also been developed.

The most significant result of research recently recorded, is the domestication of two marine penaeid prawns, namely, *M. dobsoni* and *P. monodon* in the brackishwater. In that medium, these prawns have been successfully grown, and they attained maturity and spawned viable eggs. Induced maturation and breeding through ablation technique have been achieved in the case of *P. monodon*.

Considerable progress has also been made on the experimental culture of the commercial palaemonid prawns, *Macrobrachium rosenbergii*, *M. malcolmsonii* and *M. idella*. Studies conducted at the Central Inland Fisheries Research Institute have shown that the berried *M. rosenbergii* could be obtained at any time of an year, and their larvae could be reared on compounded diets, plankton raised in the laboratory, pieces of *Tubifex* worms or egg custard. The young prawn grows well in fresh water ponds and reaches a size of 200 to 250 mm in one year.

The larval development of *M. malcolmsonii* has been studied. Natural seed grounds of the species have been located in the rivers Godavari and Mahanadi. Field culture experiments have indicated a production rate of 285-300 kg/ha/year. Techniques of rearing of larvae of *M. idella* have been developed and perfected, and it has been shown that the species can be maintained over generations under controlled conditions.

The technical feasibility and economic viability of intensive culture of *P. monodon* and

P. indicus have been established. A simple technique which could easily be adopted by the small farmers with advantages of better production and higher income, has been evolved; and it is based essentially on selective stocking, culturing for longer duration and better management of the culture system. The production of prawns by adopting this improved technique could be increased by 3 times over that obtained from the traditional culture practice, and the value by 4.5 times. Besides the congenial estuarine and brackish water areas, fallow ecosystems such as the canals in between the bunds in the coconut grove and the salt pans in the coastal areas could also be utilised for productive prawn culture.

Lobster culture

Although isolated experiments on the breeding of the spiny lobsters (*Panulirus* spp.) and rearing of phyllosoma larvae were conducted earlier in our country, directed research on lobster culture, particularly on *Panulirus homarus* was taken up only an year back at the Field Laboratory of the Central Marine Fisheries Research Institute at Kovalam, near Madras. Techniques of collection of pueruli that migrate into the coastal waters, by special collectors have been developed. The young ones of lobsters thus collected are reared in the laboratory. The results of these experiments have indicated that the young lobsters of 35 mm carapace length grow to a size of 57-58 mm carapace length in about 15 months and that they reach marketable size in 18 months. During this period of growth in the laboratory both males and females attained maturity and mated. Subsequently, the female released the eggs on to their pleopods, where the eggs underwent further development and hatched out into free swimming phyllosoma larvae (Radhakrishnan, MS). Encouraged by this result, intensive studies on the controlled breeding and rearing of phyllosoma larvae are in progress.

Crab culture

Among the edible crabs occurring in our country, the most suitable species for culture is the green crab, *Scylla serrata*. The species grows to a size of 200 mm across carapace and is available in the estuaries and backwaters all along the coast. It can withstand wide ranges of salinity from almost fresh water to that of sea

water. The culture experiments carried out on the species involve collection of seed crabs from the wild and growing them either individually in baskets which are arranged in rows in the field or in cages, each containing a few crabs. They are fed with the easily available trash fish. These experiments have indicated that the young crabs grow at a relatively faster rate of about 12-15 mm carapace length per month.

Mussel culture

Great strides have been made in the technology of culture of both the brown mussel (*Perna indica*) and the green mussel (*P. viridis*) since 1971 when the Central Marine Fisheries Research Institute started researches on the subject. Mussels can be cultured in protected inshore waters either by raft culture method using ropes in 10-20 m depth zone, or on poles in shallow areas. In the raft culture method, the ropes (12-20 mm thick) are suspended from the floating raft during the breeding season (July-November) so as to facilitate settlement of mussel seed on the ropes or collection of spat from the natural source for transplantation to the ropes. Seed mussels (20-30 mm size) are transplanted by arranging them around the ropes and covering with a mosquito netting which gets disintegrated in about a week's time within which mussels get attached to the ropes. Open-sea farming experiments on the brown mussel carried out at Vizhinjam, and on the green mussel at Calicut have shown a production rate of 150 tonnes/ha/year and 235 tonnes/ha in 5 months respectively. Further studies on the economic viability of large-scale culture of mussels and on the problems associated with it are in progress.

Pearl oyster and pearl culture

One of the remarkable contributions made to promote mariculture in our country, is the successful development of an expertise on the techniques of production of pearls under controlled conditions. Researches leading to this achievement were started in 1972 at the Field Laboratory of the Central Marine Fisheries Research Institute at Veppalodai, near Tuticorin. Pearl oysters (*Pinctada fucata*) collected from the natural beds are cultured by the raft culture method. The techniques of pearl culture involve conditioning of the pearl oyster in the labora-

tory, careful operation for grafting a piece of mantle in the gonad or hepatopancreas region of the oyster, implantation of suitable nuclei, transfer of the operated oysters to the rafts in the inshore sea for post-operative culture, and regular monitoring of the growth of the pearl.

Average production of pearls in the experiments conducted so far is found to be 60-70%. The time required to obtain pearls of 3 mm to 8 mm size, varies from 3 to 18 months. Multiple pearls in individual oysters have also been obtained. Tools required for the surgery have been fabricated indigenously. The nuclei developed locally from the conch-shell wastes have been successfully employed to produce pearls of good quality. The current research programmes on the project mainly relate to the investigations on the problems of commercial-scale culture of pearls and pearl oysters and the economics of pearl culture.

Edible oyster and clam culture

Hornell, in 1910, made some efforts to culture edible oysters at Pulicat in Tamil Nadu. Subsequently, experiments on transplantation and rearing of *Crassostrea gryphoides* were also carried out in Maharashtra. However, directed research on the culture of edible oysters, particularly *C. madrasensis*, was initiated only recently at Tuticorin. Techniques of collection of spat from the wild on different kinds of material such as lime coated tiles, oyster shells and empty coconut shells and growing them by rack and long line culture methods, on poles as well as in trays are being developed. Investigations on the abundance of spat in space and time and on the breeding of oysters under controlled conditions are progressing.

Very little information is available at present on the culture aspects of clams occurring in our waters. As they form an important group that can advantageously be cultured in the estuaries and backwaters, pre-farming studies on the biology and ecology of the commercial backwater clams, and preliminary experiments on their transplantation and field culture have been taken up by the Central Marine Fisheries Research Institute at Kakinada and Mangalore.

Fin fish culture

Although several fin fishes such as mullets, milkfish, pearl spot and perches suitable for

culture in the coastal waters are available, there is no organised farming practise for these fishes in India. The existing salt-water fish culture forms only a part of the traditional brackishwater fish culture prevalent in Kerala, West Bengal, Karnataka and Goa. In the commercial culture of mullets in West Bengal and the mixed culture of milkfish, mullet and pearl spot in Kerala, the production has been found to be very low due to poor management of the culture operation. However, considerable progress has been made abroad on the marine and brackishwater fish farming by adopting the modern techniques of pond management, feeding and monitoring of stocked fishes. A production of over 4 tonnes/ha/year has been obtained in the commercial mullet culture in Taiwan and Hong Kong and in the milkfish farms in Indonesia, Philippines and Taiwan. Realising the great scope for salt-water fish farming, a series of experiments are now being carried out in different parts of the country. Surveys are being carried out on the seed resources of cultivable fishes to locate seed grounds and to understand their seasonal abundance. Field experiments have shown that the milkfish fry (4.5 cm size) grow to marketable size of 45 cm in about 4½ to 5 months.

Since 1971, studies on the culture of the eel, *Anguilla bicolor*, are being carried out at Mandapam Camp. The eels breed in the sea and their larvae (Leptocephali) after metamorphosis into elvers immigrate into the rivers. During this process, they are caught by dip nets, scoop nets and by the specially designed net called the 'elver net'. The elvers can be cultured in running water tanks. Several collection grounds of elvers in the river mouths along the south-east coast have been located. Elvers grow very fast under controlled conditions and attain marketable size of about 35 cm (106 g) at the end of an year. They feed on fish and clam meat. A pilot project covering survey of elver resource, collection of elvers and transportation, export of live elvers and culture of elvers to eels, is being implemented by the Central Marine Fisheries Research Institute at Mandapam Camp with the financial assistance of the Marine Products Export Development Authority.

Another fish which has great potentials of culture in the Karnataka State is the sand-whiting, *Sillago sihama*. The species grows to about 200 mm in seven months. Its seed occur

abundantly in the estuaries of all the major rivers of Karnataka.

The ongoing experiments in fin fish culture are mainly directed to induced breeding and pond culture of mullets, milkfish, pearl spot and *Sillago sihama*.

Seaweed culture

The seaweeds such as the species of *Gracilaria*, *Gelidiella* (which yield 'Agar'), *Sargassum* and *Turbinaria* (which produce 'Algin') can easily be cultivated in the near shore waters. The techniques of seaweed culture are simple. A mat or a frame of coir ropes is fabricated and it is tied to wooden poles in the coastal waters. Fragments of seaweed *G. edulis* are planted in the twists of the coir ropes. The growth of the seaweed is carefully monitored, particularly by preventing their grazing by the herbivorous fishes and other animals.

Recent experiments on the field culture of *G. edulis* and *G. acerosa* have shown an yield of about 3-5 kg fresh harvest from an initial seed material of 1 kg within 80 days and that about three harvests could be taken in an year. In *Sargassum*, a growth of 37-52 cm from an initial plant height of 10 cm has been recorded within forty days of culture. Studies on the economic viability of largescale culture of seaweed are carried out from Mandapam Camp.

Polyculture

Combined culture of compatible species of prawns and fishes is gaining considerable importance in the context of augmenting yield from the field and effective utilisation of the available ecological niches of the pond system. Polyculture techniques involve selection of suitable species for combined culture on the basis of their feeding and behaviour characteristics, determination of the proper stocking rate of different species, pond management with correct manuring and fertilisation and monitoring of the growth of the stocked animals. Recent experiments on polyculture of the mullet, milkfish and *P. monodon*, and the milkfish and *P. indicus* at Kakdwip have shown a total production of 1463 kg/ha/7 months and 2196 kg/ha/6 months respectively. But relatively low production has been recorded in similar experiments conducted from the other centres along

the coast. Intensive studies are, therefore, essential to perfect the techniques of polyculture, especially in the dynamic environment of the coastal waters.

Integrated farming of crop livestock-fish and prawn

A synergic system of farming of crop-live-stock-fish/prawn in an integrated manner is another field which is gaining a great deal of attention in the recent years. In India, there is already a well-established traditional practice of paddy-cum-fish/prawn culture in the seasonal fields of Kerala, Karnataka and Goa. Further, it has recently been established that the prawns and the salt-water fishes can be cultivated in the canals of the coconut groves. However, coordinated research on this system of farming which requires knowledge of different subjects, is necessary to establish it on scientific lines and to tackle the problems involved in it.

REMARKS

From the foregoing brief review, it is evident that valuable data/information on the culture of several organisms are now available or are being gathered rapidly. Basic technologies have also

been developed to start immediately intensive commercial culture fisheries for prawns, mussels, pearls and seaweeds. These techniques can easily be adopted by the fish farmers as they are simple and neither require huge investment nor great skill.

Having the basic information and the technology, the time is opportune now to take the results of research to the field. In order to transfer the technology developed in the laboratories and to demonstrate the technology and economic feasibility of culture operation, operational research projects / demonstration programmes are being taken up on prawn, mussel, pearl, edible oyster and seaweed culture from different centres. Further, training of fish farmers as well as the developmental and managerial personnel on the above culture systems is also offered. Although, these measures would considerably help to promote the coastal aquaculture of our country, an integrated approach involving the R & D programmes as well as the active participation of the planners, administrators, financial agencies, and the fish farmers is essential for its rational development.