Chapter 15

# Technological advancement in Mariculture in India for production enhancement and sustainability

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Mariculture is the farming and husbandry of marine plants and animals in the marine environment. Mariculture produces many high value finfishes and shellfishes (crustaceans, and molluscs - oysters, mussels and clams). As the production from the capture fisheries reached its sustainable limits, mariculture is the next viable alternative for increasing seafood production of the country. Indian coastline offers immense potential for the expansion of mariculture activities. CMFRI through its research programmes over the years has developed technologies for seed production and farming of bivalves, marine pearl oysters, marine food fishes and ornamental fishes, marine crustaceans and seaweeds.

## Existing major mariculture species and farming technologies

### Mussel farming

Various methods for mussel farming like raft method (in bays, inshore waters), rack method (in brackish water, estuaries) or long line method (open sea) were developed for mussels. Commonly adopted species for mussel farming are *Perna indica and P. viridis*. Commercially important edible oyster species are *Crassostrea madrasensis*, *C. cucullata* and *C. gryphoides*.

Recently CMFRI has perfected spat production and nursery rearing system for green mussel at its Vizhinjam Centre. An average small scale unit can produce 10 million spats/annum. Nursery production of green mussel spat can significantly reduce wild collection of seeds.

**Edible oyster farming**

CMFRI has developed methods for edible oyster (*Crassostrea madrasensis)* culture and has produced a complete package of technology, which is presently being widely adopted by small scale farmers in shallow estuaries, bays and backwaters all along the coast. Technology for production of oyster spat was also perfected by CMFRI.

**Marine pearl culture**

Technology for the production of spherical pearls from *Pinctada fucata and Pinctada margaritifera* was developed by CMFRI. Raft culture and rack culture in nearshore areas are the two methods commonly adopted techniques for rearing pearl oysters. Shell bead nucleus (3-8 mm) implantation along with graft tissue is done in the gonads of the oyster through surgical incision for production of pearls. Implanted oysters were stocked in suitable cages for rearing in the farm. Harvesting of Pearls was carried out after 3-12 months and harvested pearls were graded based on their quality as 'A', 'B' and 'C" grades for marketing.

**Mabe pearls**

Technology for production of image pearls/designer pearls is very simple and can be easily carried out by farmers, unlike the technology for free round pearl production. A Mabe pearl is a dome-shaped or image pearl produced by placing a hemisphere or miniature image against the side of the oyster shell interior. The result is an exquisite pearly nacre-coated miniature image which can be made into pendants, eardrops, rings etc.

**Clam Culture**

Package of clam culture practices has been developed for the blood clam *Anadara granosa* and *Paphia malabarica,* where production of 40 tonnes/ha/6 months and 15-25 tonnes/ha/4-5 months have been achieved in field trials. Induced spawning and larval rearing to setting of spat has been perfected for clams like *P. malabarica, Meretrix meretrix and Marcia opima.*

**Lobster farming and fattening**

Increasing demand for live lobsters in the export market led the farmers and entrepreneurs to collect juvenile lobsters from the wild and grow to marketable size in ponds, cages and tanks by feeding trash fishes and other discards.

**Crab farming / fattening**

Seed production of the blue swimming crab, *Portunus pelagicus,* has also been developed. Protocols for fattening and grow out have been successfully developed.

**Seaweed Culture**

Since 1972 the CMFRI is engaged in the cultivation of important seaweeds such as *Gracilaria edulis*, *Gelidiella acerosa, Sargassum wightii, Acanthophora spicifera* and *Ulva lactuca*. Mariculture of seaweeds in India mostly deals with cultivation of *Gracilaria edulis*. Very recently the cultivation of *Kappaphycus sp*, gained popularity among farmers. There are two methods for cultivation of seaweeds - Vegetative propagation using fragments and also by different kinds of spores.

## Marine ornamental fish catch and trade

Based on the Global Marine Aquarium Database (GMAD) the annual global trade is between 20 - 24 million numbers for marine ornamental fish, 11-12 million numbers for corals and 9-10 million for other ornamental invertebrates. A total of 848 numbers of reef associated fishes are reported in Indian waters. Out of which about 350 species are reported to be of ornamental value. Some important ornamental fish families are Family Pomacentridae (Clown fishes and damsel fishes), Family Labridae (Wrasses), Family Scaridae (Parrot fishes), Family Chaetodontidae (butterfly fishes and banner fishes) and Family Acanthuridae (Surgeonfishes).

Marine ornamental fishes are caught in India either as a by-catch in gears such as traps or bottom-set gillnets or caught unscientifically in coral reef areas. Indiscriminate collection practices followed at coral reef habitats inflict damage to the ecosystem.

## Hatchery Production of marine ornamental fishes

CMFRI developed package of technologies on bloodstock development, captive breeding and larval rearing of several species of marine ornamental fishes. The methodologies developed can be scaled up for commercial level production and a hatchery produced marine ornamental fish trade could be developed in the country. It is high time that the fisheries developmental agencies should come forward with attractive schemes to popularize the technology.

Hatchery technology for following species marine ornamental fishes was developed at CMFRI and these technologies are being transferred to fishermen/women SHG's at various maritime states of the country.

- Clown fishes: *Amphiprion sebae, A. ocellaris, A. percula, Premnas biaculeatus, A. sandaracinos, A. frenatus, A. clarkii.*
- Damsels: *Dascyllus trimaculatus, D. aruanus, Pomacentrus caeruleus, P. pavo, Neopomacentrus nemurus, N. filamentous, Chrysiptera unimaculata, C. cyanea, Chormis viridis, D. carneus*
- Dottybacks: *Pseudochromis dilectus*
- Marcia'santhias: *Pseudanthias marcia*
- Marine invertebrates: *Rhynchocinetes durbanensis* (Camel shrimp)

## Cage aquaculture

Production of farmed aquatic organisms in caged enclosures has been a relatively recent aquaculture innovation. Cage culture utilizes existing water resources, but encloses the fish in a cage or basket which allows water to pass freely between the fish and pond. Cage and pen culture are viewed as the aquaculture system of the millennium. Cage culture has made possible the large scale production of commercial finfish and will probably the most efficient and economical way of rearing fish. Depletion of ocean and coastal fishery resources has led to the development of marine cage culture.

### Site selection

Choice of site in any fish farming operation is of paramount importance since it greatly influences economic viability by determining capital outlay and affecting running costs, production and mortality.

Important criteria to be considered in site selection are Lakes, bays, lagoons, straits and inland seas are ideal sites for cage-culture which are protected from strong winds and rough weather.

Water current 5-10 cm/s

Depth> 2 m

Dissolved oxygen levels>5ppm

Salinity 34 ppt

Temperature 25-30° C.

**Cage design and construction**

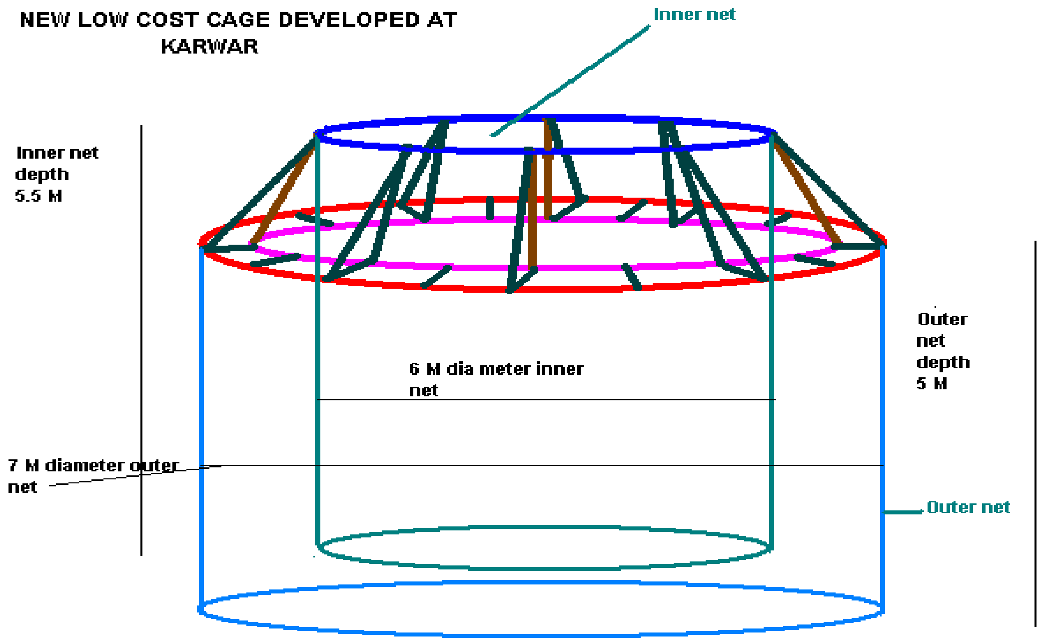
A good and practical design of a cage will meet the requirements of the species farmed and the staff who will operate the system. The structure must be strong to withstand the forces of winds, waves and water currents while holding the stock securely. They must be durable and resistant to corrosion since they are exposed to highly corrosive effects of seawater. The net bags must be strong enough to hold the stock securely and must be weather resistant. The floatation system must support the combined weights of the walkways and framing, the people working on the raft, net full of fish during harvest and fouling organisms of the net. The structure must be securely anchored to avoid being carried away by strong currents.

**Shape:** Shapes of the cages are likely influenced by the swimming behaviour of the fishes. Circular shape cage bag offers the most economical cost of netting materials of the same area and deep than the other shapes such as squares, rectangular, octagon etc. Rectangular cages have a greatest water exchange to volume ratio when the broader side is exposed to current.

**Size:** With the increase in bag size the cost per unit volume of the cage will reduce. This is one reason for using large rearing units in intensive marine fish culture. The common sizes used for floating net cages are 6 m and 10 m diameter and 4x4 m and 4x5 m and 5x5 m floating cages with a net deep of 3.5-5.0 m including freeboard. Larger size floating cages will require equipment and manpower for its management.

**Materials:** The main criteria for selecting the materials for the construction of cages are light weight, strong, weather and corrosion resistant, fouling resistant, drag free, smooth textured, easy to construct and repair, cheap and locally available. Netting materials must not be harmful or stressful to the cultured species.

**Mooring systems:** Most of the mooring systems consist of lines and anchors that secure cages in a particular location. Mooring lines must withstand forces acting on the floating cage system and transmit this to anchors. The total length of mooring lines must be at least 3 times the maximum depth of the water. Depending on the set up of floating cages, mooring system can be single or multiple point. Anchors must be strong enough to resist the forces acting and to secure the floating cages system in place. Components of a cage include cage bag, floats, frame, service system, mooring system and anchor system.




### Cage nets

Net bags fabricated with synthetic nylon or polythene netting reinforced with polythene ropes are used for farming. Recently new stronger materials from different manufactures are available in the market. Netting material is twisted, braided or even knotless.

## Types of net bags are used in cage culture

**Outer net or predator net for protection from competitors and predators in open waters:** Braided HDPE net 3 mm/80 mm mesh (square) of required size with 14 mm PP vertical rope lining

**Inner net for holding the fish:** For fish Nylon / Sapphire/ HDPE net with 15 -40 mm mesh, for periodic change are used.

**Bird net**: Birds should be particularly prevented from cages because they prey on fish and are in many cases are carriers of disease agents and parasites. Bird nets are made with 1.25 mm/80 mm twisted HDPE, provided with rings to connect to the inner cage net, prevent birds from picking caged fish.

**Service system**

Service system helps the farmers for feeding, cleaning, monitoring, grading etc during cage farming. Max height of handrail should be about 100 cm.

**Mooring system**

Two functions of mooring line are to withstand and transmit forces. This must be powerful enough to resist the worst possible combination of forces. There are two types of mooring system exist single point & multi point mooring systems in open sea cages. Fixed mooring system is more commonly used in backwaters/ rivers etc. Different types of anchor systems are using in cage culture practices. Some common types of anchors are dead weight anchors, block of concrete stones, gabion bags filled with stones, scrap metal etc.

**Selection of species for farming**

The species selected should have a ready market for local consumption or for export. The farmer should decide whether he would culture high volume, low priced species or low volume, high priced species.

**Attributes for an ideal candidate species for cage culture**

- Hardy species that tolerates crowding and wide physiological tolerances.
- High fecundity of female fish with plenty of material for hatchery production of seed.
- Hatchery production of seed to be relatively simple.

- Those feed well on pellet diets, and juveniles easy to wean to pellets.
- Those which grow rapidly, reaching a harvestable size (350 g – 3 kg) in six to eight months.

**Potential species for India**

- Marine: Cobia, Sea bass, Groupers, Snappers, Mullets, Lobsters etc.
- Inland: Carps, Pangasius, Tilapia etc.

The stocking densities for cage culture generally range from 15 to 40 no/$m^3$, although densities can be as high as 60 no/$m^3$. Cannibalistic fish should be graded into several size groups and stocked in separate cages. The stocking should be done in the early hours (06 00–08 00 hours) or late in the evening (20 00–22 00 hours) when the temperature is lower.

Two to three months thereafter, when the fish have attained a weight between 150–200 g, the stocking density can be reduced to 10–20 fish per cubic meter. Higher stocking densities require more frequent monitoring of water quality and more feeds.

Table 1. Farming details of food fishes in cages

| Sl. No. | Species | Length (cm) | weight (g) | Stocking density (nos/ $m^3$) | Culture period (months) | Weight (Kg) |
|---|---|---|---|---|---|---|
| 1 | Sea bass | 12 | 10 | 35 | 8-10 | 1-1.5 |
| 2 | Cobia | 15 | 15 | 12 | 6-8 | 3 |
| 3 | Snapper | 5 | 4 | 30 | 10-12 | 1.5 |
| 4 | Mullet | 8 | 5 | 35 | 8-10 | 1 |

## Feed and feed management in cages

Main components of fish feeds are Protein, Carbohydrate, Fat, Minerals, and Vitamins etc. Deficiency of a nutritious feed leads to growth retardation and subsequent disease outbreak. Marine fish require high protein (35-40 %) for their optimal growth. Overfeeding leads to wastage and pollution. Feeding rate, frequency of feeding and time of feeding are important factors to be considered in cage farming. Feeding rate and frequencies are related to age and size of fish. Larval fish and fry need to be fed on high protein diet more frequently. As fishes grow bigger, feeding rate and frequencies can be reduced. Feeding is labour intensive, so frequency has to be adjusted to become economically viable. Growth and feed conversion increases with increase in feeding frequency. Feeding of fish also influenced by the time of the day, season, water temperature, dissolved oxygen level and other water quality parameters

### Mapping of suitable cage culture sites

The primary requirement for development of sea cage farming is the selection of suitable sites with required depth, current and water quality parameters. Suitable locations all along the East and West Coast of India for sea cage farming of high value marine finfishes were mapped in GIS platform. Satellite data were also used in identification of satiable sites for cage farming. The available physico-chemical and oceanographic parameter data obtained from Landsat 8 and MODIS satellite data were pooled and used on GIS based platform. The maps were layered, and were combined to generate a final output showing the "most suitable, suitable, moderately suitable and unsuitable", locations for open sea mariculture development along the Gujarat coast. Such maps were developing almost all coastal districts for the easy execution of sea cage farming.

### Integrated Multi-Trophic Aquaculture (IMTA)

On a global basis the current mariculture practices are dominated by intensive monocultures which have led to sustainability problems, environmental degradation and consequent disease outbreaks. Integrated  Multi Trophic Aquaculture (IMTA) is the practice which combines in appropriate proportions, the cultivation of fed aquaculture species (e.g. finfish/shrimp) with organic extractive aquaculture species (e.g. shellfish/herbivorous fish) and inorganic extractive aquaculture species (e.g. seaweed) to create balanced systems for environmental stability (bio-mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices). The IMTA can also increase the production capacity of a particular site. It is well understood that the increasing use of coastal waters worldwide, coupled with rapid growth and expansion in mariculture, demand for more sustainable farming practices and hence integrated mariculture has much relevance and scope.

The CMFRI has successfully conducted the demonstration of IMTA under participatory mode with fishermen groups by integrating seaweed with cage farming of cobia. A total of 16 bamboo rafts (12× 12 feet) with 75 Kg of seaweed per raft can be integrated with one cobia (*Rachycentron canadum*) cage of 6 meter diameter. It has been proved that in one crop of 45 days the seaweed rafts integrated with cobia cage will give an average yield of 260 Kg per raft while the same was 150 Kg per raft for the rafts which were not integrated. The technology is being adopted by 100 farmers of Palk Bay, Ramanathapuram, Tamil Nadu. In addition to the revenue generated from cobia farming, an additional income of Rs.32 lakhs could be realized due to additional seaweed yield (11 tons) from IMTA. The IMTA adopted by 100 farmers would generate additional 1200 mandays per crop of 45 days.

## Recirculating Aquaculture system

Recirculation aquaculture is essentially a technology for farming fish or other aquatic organisms by re-using the water in the production. The technology is based on the use of mechanical and biological filters, and the method can in principle be used for any species grown in aquaculture such as fish, shrimps, clams, etc. Recirculation technology is however primarily used in fish farming,

In a recirculation system it is necessary to treat the water continuously to remove the waste products excreted by the fish, and to add oxygen to keep the fish alive and well. A recirculation system is in fact quite simple. From the outlet of the fish tanks the water flows to a mechanical filter and further on to a biological filter before it is aerated and stripped of carbon dioxide and returned to the fish tanks. This is the basic principle of recirculation. Several other facilities can be added, such as oxygenation with pure oxygen, ultraviolet light or ozone disinfection, automatic pH regulation, heat exchanging, denitrification, etc. depending on the exact requirements.

## Breeding technology of fin fishes standardized in CMFRI

It has long been recognized that a good source of juveniles is the most important prerequisite for fish farming. Non availability of the seed for stocking in quantity and quality at the right time, will affect the production plans. Most of the world's fish aquaculture still depend on the fry almost comes exclusively from wild. Seed supply from the wild is often unpredictable and seasonal. Hatchery production of seeds of economically important finfish ensures a steady supply of quality seeds for aquaculture operations.

The successful hatchery production of marine finfishes depends on various factors like proper maintenance of broodstock, efficient live feed production systems, larval rearing protocols including water quality management, feed management and nursery rearing systems. CMFRI has developed hatchery production technologies for marine food fishes like Cobia (*Rachycentron canadum*), Silver Pompano (*Trachinotus blochii),* Indian Pompano *(Trachinotus mookalee),* Orange spotted grouper (*Epinephelus coioides)* and Pink ear emperor *(Lethrinus lentjan)*.

Efforts are being taken by various government agencies for improving the availability of marine fish seed for farming by supporting the hatcheries to take up the production of marine finfish seed production. The increased availability of seed for farming in the coming will contribute to increased production through the mariculture in the country.

## Conclusion

Even though the capture fisheries will continue to be the mainstay of the Indian marine fisheries, it is evident that further increase in fishing pressure will not yield the required quantity of seafood to meet the increasing per capita requirement in the future years. In India till date mariculture activities are confined only to coastal brackish water aquaculture, chiefly shrimp farming. Other coastal aquaculture activities like green mussel farming which is confined to Malabar Coast in Kerala and seaweed farming along Ramanathapuram and Tuticorin coasts of Tamil Nadu producing about 5000 tonnes annually.

India is still in infancy in mariculture production in comparison with the global scenario. When we compare the situation in the Asia-Pacific region also, we can find that a lot of advances have been made in the development and expansion of mariculture. Since, mariculture is the only sunrise sector for increasing seafood production in the coming years, the research and development in this sector is of paramount importance to develop mariculture as a substantial contributor of seafood production in the country.