1. Overview of Mariculture in India

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Introduction:

The fish production from capture has registered an increase over the years but the rate of increase has stabilized globally. Aquaculture on the other hand has progressively increased. In India though the capture fish production has steadily increased, production from the present grounds has reached its maximum and several problems such as increase in fishing intensity, declining stocks, conflict between the fishing sectors, decreasing catch rate, decreasing recruitment, inappropriate exploitation pattern, habitat degradation and resource degradation have been identified. Further scope for increased production lies in exploitation of resources from deeper waters which necessitates introduction of bigger vessels, trained manpower, better handling facilities, etc. Aquaculture on the other hand has progressively increased and production through mariculture is the best way to increase overall marine fish production. Mariculture contributes to the production of protein rich food and has been the source of livelihood of millions of coastal villagers. Global production from the marine environment increased from 21.6 million tonnes in 1999 to 27.6 million tonnes in 2003.

Mariculture is defined as the cultivation of marine organisms in their natural environment (Webster's Dictionary). In other words mariculture is the rearing of the aquatic organisms under controlled or semi-controlled conditions in coastal and offshore waters. The mariculture environment thus includes sea, backwaters, estuaries and coastal lagoons. Marine organisms include both migratory species to estuaries/backwaters and non-migratory species confined only to the sea. Mariculture today includes predominantly migratory marine fishes such as seabass, shrimps,lobsters, cobia, snappers, mullets, pearlspot, milkfish etc. Most of these species are capable of tolerating variations in the environment.

Potential areas for mariculture in India:

The near shore coastal waters, creeks and backwaters in all the maritime states are suitable for mariculture adopting different culture practices. The creeks and backwater area have been extensively used for shrimp culture. Some area has also taken up crab fattening. The backwaters too have been used for culture practices and culture of mussels in a large scale is being practiced in Kerala for several years. Mussel culture in the estuarine waters has been taken up in Karnataka, Goa and Maharashtra. The potential sites for open sea mariculture have been identified by CMFRI at Palk Bay and Gulf of Mannar in Tamil Nadu, Lawsons Bay near Visakhapatnam in Andhra Pradesh, Balasore in Odisha, Marine bay's in Karwar, Near shore areas in Goa and off Ratnagiri in Maharashtra. The open seas around the Andaman & Nicobar Islands and Lakshadweep too have high potential to take up mariculture activities.

Mariculture

i. Brackishwater aquaculture

Aquaculture in brackishwaters in India is an age old practice and has been carried out in bheries of West Bengal and *pokkali* fields of Kerala. However, scientific farming in the country is just a decade old. The country possesses huge brackishwater resources of over 1.2 million hectares suitable for farming and presently (2001-02) only 13% of the potential water area available i.e. 157,400 ha in is utilized. Shrimp is the single commodity that contributes almost the total production of the sector. The production levels of shrimp recorded marked increase from 28,000 tonnes in 1988 89 to 127,170 tonnes in 2001-2002. The black tiger prawn, *Penaeus monodon*, is the most abundantly cultivated prawn species followed by other shrimp species such *as P. indicus*, *P. penicillatus*, *P. merguiensis*, *P.semisulcatus* and *Metapenaeus* sp.

Induced breeding of shrimps was initiated by the Central Marine Fisheries Research Institute as early as in the early 70s'; an experimental hatchery was established by the Institute in 1975 at Narakkal, Kerala, MPEDA took the lead for establishment of two large scale hatcheries viz., TASPARC and OSPARC in 80's that gave a boost for the establishment of a number of commercial hatcheries in the private sector. The technology of hatchery production of shrimp seed involving broodstock development, induced maturation and spawning, larval-rearing and post-larval (nursery) rearing has been standardized. At present about 226 shrimp hatcheries are operational with a total production capacity of 10.5 billion PL20/year. Semi-intensive culture practices mainly with black tiger prawn have demonstrated production levels of 4-6 t/ ha in a crop of 4-5 months. The high return coupled with credit facilities from commercial banks and subsidies from MPEDA have helped in the development of shrimp farming in the country to a multi-billion dollar industrial sector. In spite of disease problem that has been plaguing the sector since 1994-1995 the industry has learnt to live with certain modifications in pond management, which has resulted in sustaining the shrimp production of the country during last two years. During the year 2000-2001 the shrimp production of the country from aquaculture has witnessed a record production of 97,100 tonnes valued as Rs. 3,620 crores.

Culture of crab species like *Scylla serrata* and *S. tranquebarica* has also been taken up by few entrepreneurs. Crab fattening and demand for soft crabs and berried crabs has induced several aquafarmers to take up culture of these species on a commercial scale. Seed production techniques too are available.

Several finfish species of mullets (*Mugil cephalus*, *Liza parsia, L. macrolepis*, *L. tade),* milkfish *(Chanos chanos),* seabass *(Lates calcarifer),* cobia *(Rachycentron canadum)* pearlspot *(Etroplus suratensis)* and rockcod *(Epinephelus tauvina),* snappers (*Lutjanus* sp), pompano (*Trachinotus blochii*) and rabbitfish (*Siganus* sp.), possess great potential for farming. Commercial production of most of these species on a

small scale has been taken up by some entrepreneurs in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Seed production technology of seabass, cobia, pearlspot, pompano and rockcod is available.

ii. Aquaculture in seawater

The Central Marine Fisheries Research Institute has been the pioneering fisheries organization to initiate research in this area and have developed of several viable technologies with regard to seed production and culture of important marine crustaceans, molluscs, finfishes and seaweeds. Several programmes on sea ranching of exploited stocks such as pearl oysters (*Pinctada* spp.), mussels (*Perna viridis*), sacred chanks (*Xancus pyrum*), topshells (*Trochus* sp.), turbanshells (*Turbo* sp.) and clam (*Paphia* sp., *Meritrix* sp.) have been taken up in the country.

Mussel culture

Green mussel, *Perna viridis* and brown mussel, *Perna indica* are the two important mussel species available in the country. The culture technology of these has been standardized. Mussel farming is carried out either in rafts or by long line methods. While long line system is very flexible and can withstand turbulent sea, raft system is more rigid and suited for more calm seas.

Edible oyster culture

The culture of edible oyster in India was initiated as early as the beginning of this century. However, intensive researches on various aspects of the culture were taken up only during seventies. The technique of oyster farming consists of two items, collection of spat and growing the spat to adult stage. The farming practices for *Crassostrea madrasensis* have been standardized. *Saccostrea cucullata* too is gaining commercial importance and farming of this species too has been proposed. Technology has been developed for hatchery production of seed, which has opened up scope for establishment of large-scale commercial farms.

Pearl culture

The success of marine pearl culture in India was achieved in 1973 by the Central Marine Fisheries Institute at its Tuticorin Research Centre. Raft culture techniques are followed for culture of pearl oysters and the important species being *Pinctada fucata*. Culture practices for the black lip oyster *P.margaretifera*, for the production of black pearls, is also being standardised.

Seaweed culture

Seaweed forms an important component of the marine living resources, available largely in shallow seas, wherever, suitable substratum is available. Agar agar and algin are two principal industrial products of seaweeds. Seaweed is also used as food, fodder, fertilizers and in products. The seaweed resources of the country are mainly confined to the coasts of Tamil Nadu and Gujarat. Since 1972,

CMFRI is involved in experimental culture of different seaweed species and developed technologies for important agarophytes like *Gracilaria edulis, G.corticata and Gelidiella acerosa.* Both net and rope culture technologies have been standardized. In case of *G. acerosa* both coral stone method and net culture method have been standardized. Culture practices of several other species are on experimental scale.

Finfish culture:

Culture of fishes mostly available in the brackish waters (mullets and pearlspot), using traditional/extensive or semi-extensive method has been practiced since several years. Mixed and poly culture too has been going on in most of the suitable areas. However, scientific semi-intensive monoculture of finfishes in open sea cages, smaller cages in creeks and coastal earthen ponds is a very recent development. The concept and techniques of opensea cage farming for rearing fishes and shellfishes in suitable area along the Indian coast was introduced by CMFRI in 2008. Initial experimental open sea cage farming was initiated at Visakhapatnam and has now extended to all maritime states of the country. Cages of different dimensions and shapes depending on the location, species to be cultivated and depth at the site have been installed in different areas. Seabass, *Lates calcarifer* has been cultured in opensea cages at Balasore in Odisha, Viskhapatnam in Andhra Pradesh, Kovalam in Tamil Nadu, Munambam in Kerala, Karwar and Byndoor in Karnataka. Lobster fattening in cages was done in Maharashtra and Gujarat. Snappers *Lutjanus argentimaculatus,* mullet *Mugil cephalous,* pearlspot *Etroplus suratensis has* also been grown in open sea cages. Open sea cage culture has really taken off in a big way and several groups of fishermen are engaged in this activity.

Smaller cages of rectangular size were installed in shallower saline waters *in* creeks nearshore waters. Such culture activity in smaller cages was initiated in line with the concept of capture based aquaculture a participatory approach for fish culture. It was proposed to collect juvenile fishes caught during fishing in live condition and stock them in such cages. The idea was to use the seeds of potential cultivable fishes available in the wild and grow them to marketable size. Though stocking of such cages still continue to use seed sources form the wild many of them stock hatchery grown fish seeds for culture.

Monoculture of marine fish using scientific method was initiated in 2011. Ponds having facility to draw seawater (>15ppt) are being used to stock seed and grow them to marketable size. Pompano, sand whiting, pearlspot and mullets are being cultured now in such farms.

Governmental support and assistance from public financing institutions with an element of risk coverage in the initial stages are necessary for establishment of commercial mariculture farms. Ownership or leasing right with protection against navigation, traditional fishing and encroachment are other pre-requisites for development of farming, which must be addressed by the Governmental interventions. Taking into account the potentials of production of fish and shellfish from different

areas of the fisheries sector, following strategies for enhancing production through coastal aquaculture have been evolved.

Brackishwater area available	1.2 million ha.
Presently under utilization	0.1 million ha.
Present Production	0.9 lakh tonnes
Projected potential production	0.5 million tonnes

Strategies

- Increasing water area under aquaculture practices
- Increasing productivity of existing water bodies
- Diversification of candidate species
- Research support for sustainable, eco-friendly and techno-economically viable hatchery & culture systems
- Fish health management and disease diagnostics
- Fish nutrition and feed formulation
- Fish genetics and selective breeding
- Utilization of inland saline soils for aquaculture

Several State Government departments have envisaged interest in installation of cages in openwaters. Mariculture activities is thus on an expansion trail and this is will ultimately result in increased production from the marine sector.

2. TECHNOLOGIES FOR FISHERIES ENHANCEMENT

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By 2050, Global human population is projected to reach more than 9.2 billion, which is within estimates of the maximum carrying capacity of the planet. A fundamental question for science is whether it is possible to increase food production enough to feed a human population of that magnitude and will fisheries be sustainable as human population pressures and accompanying coastal development pressures continue. Capacity of multiplication of fish and fishery resources is considered far higher than from other sources and fisheries is considered to the majour source in meeting the future protein requirement of the human population. Marine fisheries enhancement is possible through three methods, harvest management, production enhancement and habitat management

Harvest Management: We can control fishing catch & effort – seasonal closures, size and catch limitations, area closures, incentives (catch shares), number of angler licenses (limited entry), spatial planning.

Production Enhancement: Mariculture, hatchery technology, sea ranching.

Habitat Management: We can identify, protect and restore essential habitat – EFH, MPAs, spatial planning, habitat preservation and restoration, artificial habitats

Mariculture:

Among these three measures product enhancement methods, mariculture provide direct results of production enhancement in quantifiable terms and rest are the indirect means to enhance the production. Mariculture is identified as a prime industry to tap the enormous sources of and very good potential for India. According to Food and Agriculture Organization (FAO), the projected global aquaculture production in 1995 was 19.29 million tonnes and it is expected to increase to 26.90 million tonnes by 2000 AD. Currently in India, there is a growing interest in aquaculture in order to meet the protein demand of the fast growing population. Marine finfish culture has been an established practice is now undergoing rapid development. Information on the relative abundance of cultivable fin fish seed together with physico-chemical conditions of the environment is a essential prerequisite for aquaculture. At present, in marine finfish culture practices only a part of seed requirement is met from the hatchery and most of the culture practices in India are supported by the supply of seed collected from the natural environment. The technology for the mass production of marine finfish seed by induced breeding are being carried out in various Institutions which started providing very promising results which will lead to adoption of finfish culture in India in large scale. India have developed technologies for mass scale seed production of seabass, cobia, pompano, prawns, crabs, Ornamental marine fishes etc.

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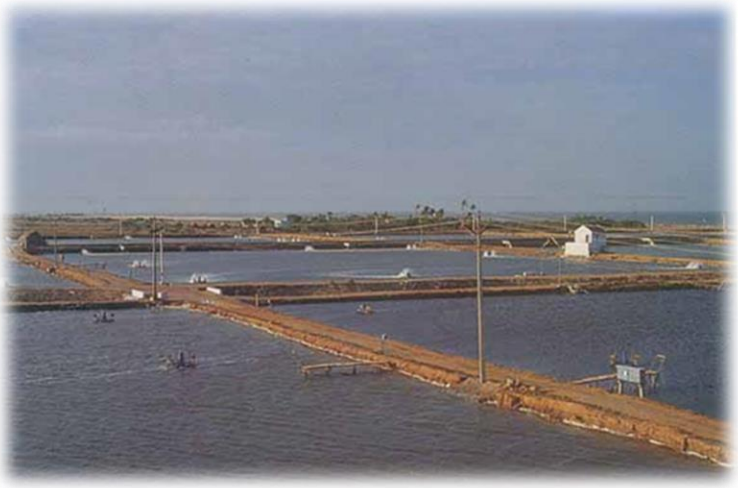
Mariculture development in India:

India is having a long coast line of 8129 Km with many estuaries, creeks, coastal lagoons, mudflat and swamps. In Many parts of India fish/shrimp culture are being carries out traditionally in natural and constructed ponds. Recently pen culture an cagve culture are also being practiced in various states.

(i) Pond Culture



Shrimps are the major groups being cultured in saline ponds along Indian coast. *Penaeus indicus, P.monodon* were the majour species cultured. Recently *Penaus vannamei*, exotic shrimp species is also introduced to tide over the white spot disease prevalent in *P. monodon* stock.

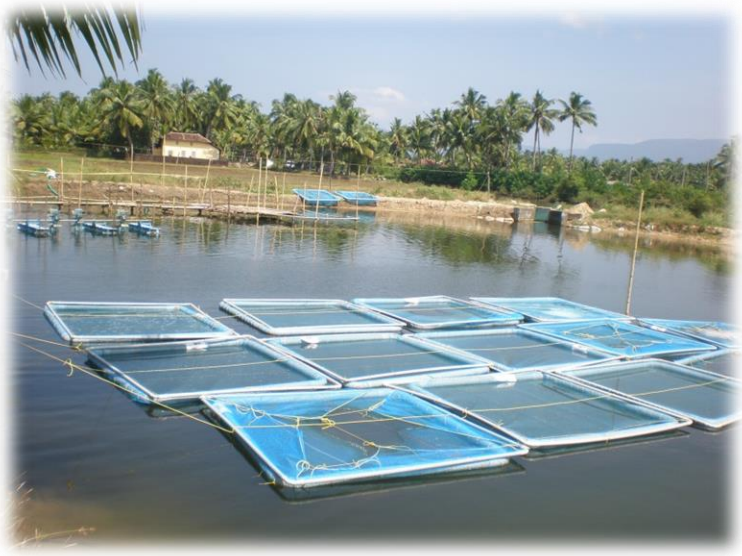
In pond culture method fin fishes and shrimps are the majour groups cultured. Among finfishes, milk fish and mullets, pearlspot were cultured as monoculture as well as in polyculture with shrimps and other fishes. Monoculture of seabass, is being practiced in saline ponds all along Indian coast. Recently pompano also identified for a candidate species for pond culture in saline ponds.

Crabs *Scylla* spp are being cultured in south west coast of India as culture practice or as a fattening method.

(ii) Pen Culture

Pen culture method is found to be one of the better cuture method for Milkfish and Grey mullets. Recently seabass and pompano also are being cultured by pen culture method

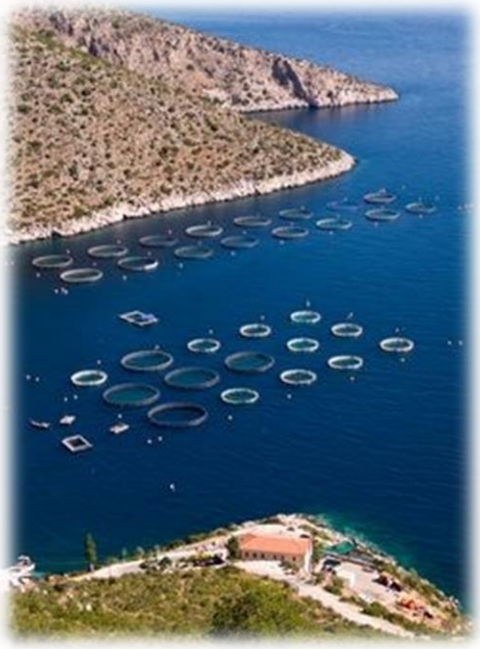
(iii) Cage culture



Cage culture of fish was originated in the Far East and later adopted in several countries.

Estuarine cages were experimented in the country for many groups like Red snapper Rabbit fishes, Groupers, and sandwhiting and seabass. But lack of seed production techniques limited the progress of estuarine cages in seabasss alone. However new development s in seed production in finfishes will be helpful in augmenting fish production from estuarine cages.

Marine cages:



Finfish seed production from hatcheries lead to the popularization of Marine cages are during last decade. Technology for marine cages, location testing of marine cages , Successful demonstration of the culture of different fishes like, seabass, lobsters, cobia, seabreams, snappers and groupers were demonstrated by CMFRI and in production terms it holds great future.

(iii) Molluscan farming:

Mussel farming is one of the most popular mariculture operations in the temperate countries. In India *Perna viridis* is the species extensively used for rope culture in south west coast of India. Mussels have anti-inflammatory, anti-histamine, prophylactic and therapeutic properties. Oysters are one of the most valued seafoods and are farmed extensively. In India, *Crassostrea madrasensis,* commonly known as the Indian backwater oyster is the most preferred species for farming. A number of clam species occur in the coastal regions of India. Experiments conducted to farm these species, indicated the feasibility of clam farming in pen and on bottom methods

Present status of mariculture in Karnataka

Karnataka state has 3 coastal districts and fisheries sector plays an important role in socio-economic development of the state. The State has 300 km coastline and most importantly. It has a pristine unpolluted brackishwater/estuarine area of about 8000 ha. in these three districts. Dakshina Kannada has 5 estuaries with a total area of 1140 ha, Udupi has 8 estuaries of 1885 ha and in Uttar Kannada there are 13 estuaries with about 4200 ha. The bivalve culture has been adopted by fishermen of Karnataka for last 10 years and small scale fish culture cages are also becoming a practice in many parts of Karnataka. Recent success in Open sea cage culture attracted many fishermen to venture into mariculture.

CMFRI has developed adaptable technologies in bivalve culture in Karnataka. Green mussel (*Perna viridis*) and edible oyster (*Crassostrea madrasensis*) farming practice holds good potential in coastal and estuarine areas of Karnataka. Breakthrough in extraction of GME will increase the demand for bulk quantities and for meeting the demands of the market Standardization of clam farming protocols are being carried out for advising on ideal relaying densities in suitable substratum this may boost the sustainable production of bivalves along Karnataka coast.

Crab fattening is a relatively non-intensive form of mariculture technology. 'Soft crabs' collected from creeks and inshore waters can be maintained in prepared ponds for fattening. The advantage of the

crab farming activity for small-scale fishers of the coastal areas relies on the fact that it can ideally be carried out in smaller areas (<0.25 ha) as short-duration crops. By virtue of its meat quality and large size, the mud crab, *Scylla tranquebarica* has gained prominence in live crab export trade from India. At present, live water crabs are not exported from Karnataka and it is sold in local markets at comparatively low prices. These natural seed resources can be harnessed optimally and used for farming activity as small-scale grow-out operations in suitable coastal areas of Karnataka. Up-scaling of these techniques have to be tried and the techno-economic viability confirmed and transferred to farmers. Hatchery in East coast of India developed seed production technologies and oit holds good potential for carb culture in Karnataka

By Designing and propagating integrated aquaculture units in estuaries and backwaters to rear fishes will boost the aquaculture production of the state and also empower the fishermen to increase the production and provide alternate livelihood in lean fishing period. In all estuaries and coastal waters, where fishery is prevalent a large quantity of juvenile fishes are caught and being discarded due to its smaller size. Out of the discarded fishes there are large numbers of fast growing fishes, if they are identified well and its culture technologies are propagated this will go long way in boosting fish production. Standardization of small-scale capture based farming units for red snapper and seabass has been developed and practiced in Kundapur district and there is a great demand for seeds for small scale culture in the state. Marine cages for rearing Seabass, redsnapper, seabreams, cobia and pompano has been demonstrated in mariner cages in Karwar and there is a good potential for increase in marine fisheries production through marine cages.