Overview of Mariculture

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Aquaculture, the farming and husbandry of aquatic animals is the promising area for increasing aquatic food production in future years. It is the fastest growing food production sector with an annual average growth of >6% in the last two decades. It increased from <1 million tonne in 1950 to 70.2 million tonnes in 2013. An update of aquaculture production (FAO) revealed that the total world aquaculture production continued to grow in 2013, reaching 97.2 million tonnes (live weight) with an estimated value of USD157 billion. A total of 575 aquatic species and species groups grown in freshwater, seawater and brackish water have been registered in the FAO Global Aquaculture Production Statistics Database. The production of farmed food fish (finfish, crustaceans, molluscs and other aquatic animals) was 70.2 million tonnes in 2013, up by 5.6 percent from 66.5 million tonnes in 2012. The production of 27 million tonnes of farmed aquatic plants was a 13.4 percent jump on the 23.8 million tonnes of 2012. The contribution of aquaculture to the world total fish production reached 43.1 percent, up from 42.1 percent in 2012. It was only 30.6 percent a decade ago in 2003. Meanwhile, world production of aquatic plants, mostly seaweeds, is still overwhelmingly dominated by aquaculture (95.5 percent in 2013). On a global scale, the production of major non-fed species contributed 30.7 percent to world food fish aquaculture production in 2013, including 13.9 million tonnes of bivalves and 7.7 million tonnes of filter-feeding carps.

Mariculture is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in an enclosed section of the sea (cages/pens), or in tanks, ponds or raceways which are filled with saline water. Generally the mariculture production data focuses on commercial data, which is the output of marine and brackish farming activities for profit whose final harvest is used for human consumption.It is a promising sector by which the additional marine fish requirement can be met in the future years. It is also the fastest growing sub-sector of aquaculture. At global level, mariculture produces many high value finfish, crustaceans, and molluscs *viz.* oysters, mussels, clams, cockles and scallops. In 2013 mariculture has contributed around 25.5 million tonnes of foodfish globally which formed about 36.3 % of the foodfish aquaculture production . (World food fish aquaculture production was 70.2 million tonnes in 2013). Molluscs dominated the global mariculture production (59.7%) followed by finfish (22.7%), crustaceans (16.2%) and others (1.4%). In addition about 26.9 million tonnes of macro algae and seaweeds were also produced by mariculture. The total mariculture production including the sea weeds was 52.4 million tonnes in 2013 which constituted 53.9% of the total aquaculture production during the year (The total global aquaculture production including the aquatic plants was 97.2 million tonnes in 2013).

Indian scenario

The dwindling catch rates in capture fisheries and rampant unemployment in the coastal region focus towards the development of mariculture and coastal aquaculture as a remunerative alternate occupation. The Central Marine Fisheries Research Institute (CMFRI) is the pioneering institution in the country which has initiated mariculture research and has been developing appropriate mariculture technologies and Central Institute for Brackishwater Aquaculture (CIBA) is the lead institution for R & D on brackishwater aquaculture in India. In India till date saline water aquaculture activities are confined only to coastal brackish water aquaculture, chiefly shrimp farming. Although about 1.2 million hectares are suitable for land based saline aquaculture in India, currently only 13% is utilized. Farmed shrimp contributes the major share in the total shrimp export. In 2013-14 the estimated farmed shrimp production was about 3,25000 tonnes.The farming of shrimp is largely dependent on small holdings of less than 2 hectares, as these farms account for over 90% of the total area utilized for shrimp culture. Coastal aquaculture is mainly concentrated in the states of Andhra Pradesh, Tamil Nadu, Orissa and West Bengal.

The other coastal aquaculture activities are green mussel farming which is confined to Malabar Coast in Kerala producing more than 15,000 tonnes and seaweed farming along the coast of Tamil Nadu producing about 17000 tonnes (wet weight) annually. Many mariculture technologies are very simple, eco-friendly and use only locally available infrastructure facilities for construction of farm, feed and seed and hence the entire farming can be practiced by traditional fishermen. Another advantage is that most of our brackish and coastal areas are free from pollution and suited for aquaculture. In recent years, the demand for mussels, clams, edible oysters, crabs, lobsters, sea weeds and marine finfishes is continuously increasing and brings premium price in the national and international markets. The long coastline of 8129 km along with the adjacent landward coastal agro climatic zone and the sea-ward inshore waters with large number of calm bays and lagoons offer good scope to develop mariculture in the country. In addition, a fast growing trade of marine ornamental fishes and other tropical marines has also emerged in the recent years which open up the possibility of culture and trade of these organisms.

Existing major mariculture species and farming technologies

Shrimp seed production and culture

Brackish water shrimp farming started in a big way in India in the early 90s especially in the coastal districts of Andhra Pradesh and Tamil Nadu. So far, shrimp remains as the single largest and maximum value earner among the seafood exported from the country. Shrimp farming in India, till 2008, was synonymous with the monoculture of tiger shrimp, *Penaeus monodon*. Since 1995, culture of *P. monodon* is affected by White Spot Syndrome Virus (WSSV) and the development of shrimp farming has become stagnant. Most of the Southeast Asian countries like Thailand, Vietnam and Indonesia shifted to culture of exotic white leg shrimp, *Litopenaeus vannamei*. The successful development of Specific Pathogen Free (SPF) and Specific Pathogen Resistant (SPR) broodstock of L. *vannamei* also favoured the large scale expansion of its farming. However, in India, pilot-scale introduction of *L. vannamei* was initiated in 2003 and after risk analyses large-scale introduction was permitted in the year 2009. Currently, farming of the white shrimp *Litopenaeus vannamei* has gained momentum in India and is contributing to the bulk of farmed shrimp production. Of late *L. vannamei* farming is being threatened by outbreak of new diseases namely Early Mortality Syndrome (EMS), Acute Pancreatic and Haematopoietic Necrosis Syndrome (APHNS) and many viral diseases.

Shrimps being a highly valued export commodity, its farming are considered a lucrative industry. Depending on the area of the pond, inputs like seed, feed and management measures like predator control, water exchange through tidal effects or pumping, etc., farming systems have been classified into four groups: extensive, modified extensive, semi-intensive and intensive. The farming community has now become more responsive to the concepts of environment-friendliness and sustainable aquaculture. Disease problems are being overcome through adoption of closed system of farming (recirculation system, zero water exchange) in grow outs, application of probiotics, secondary aquaculture of selected fishes like mullets, milkfish, molluscs and seaweeds in reservoirs and drain canals, adoption of indigenous, good quality seed, feed and reduction in stocking density. The recent advances in shrimp farming are directed towards, disease prevention, environment safety and food safety. Bioremediation has assumed a greater importance with the intensification of farming. A number of culture systems have been evolved which incorporates sustainability as the main criteria.

The very fact that diseases are common to many of the shrimp species, the aqua farmers are now desperately looking for an additional species for farming. Hence, species diversification with viable finfish can be one of the best options for a long term solution for sustaining the aquaculture sector. The major constraints for initiating and developing marine finfish farming in the country are the lack of seed production technologies for suitable high value species and the non-availability of commercially viable farming techniques. Now, with the development of indigenous technology for seed production and farming of cobia and silver pompano by CMFRI, and sea bass by CIBA/RGCA there is great scope for the aqua farmers to diversify their aquaculture practices.

Marine Finfish

In recent years at a global level a rapid growth in marine finfish culture is noted which has shown an average annual growth rate of 9.3% from 1990 onwards. The major finfish groups which are maricultured include salmonids, amberjacks, sea breams, sea basses, croakers, groupers, drums, mullets, turbot, other flatfishes, snappers, cobia, pompano, cods, puffers and tunas. The expansion of sea cage farming on a global basis can be attributed as a shot in the arm for the increased farming of marine finfish. Cage culture has made possible the large-scale production of commercial finfish in many parts of the world and can be considered as the most efficient and economical way of rising fish. The most vital prerequisite for the development of sea cage farming is the technology for breeding and seed production and the reliable supply of good quality hatchery produced seeds of suitable high value marine finfishes. In India, much research attention was not given for developing seed production methods for high value finfishes suited for sea farming. Till recently we had commercial level seed production technology of only one marine finfish – the Asian sea bass (*Lates calcarifer*). Here also private entrepreneurship for seed production has not yet been developed. Unless an intensified research on the development of commercial level seed production technologies is taken up, sea farming cannot emerge as a significant seafood production sector in the country. In the recent past, the Central Marine Fisheries Research Institute (CMFRI) has been intensifying its research activities on the breeding and seed production of high value marine finfish and success was achieved in the breeding and seed production of cobia (*Rachycentron canadum*) and silver pompano (*Trachinotus blochii*) for the first time in the country at Mandapam Regional Centre of CMFRI.

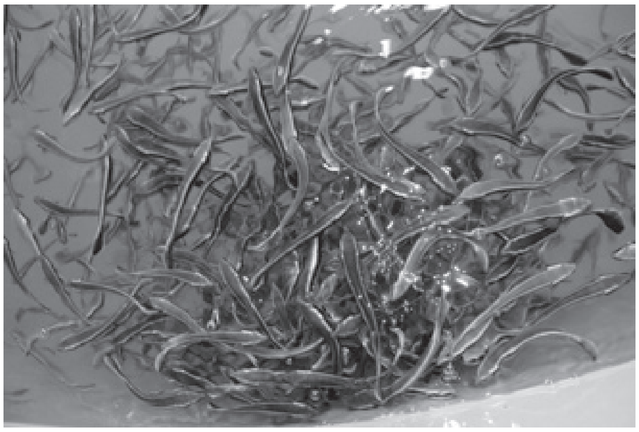
Asian seabass

Comprehensive technology for controlled breeding of seabass was developed in 1997 and sincethen the technology has been further refined andvalidated. The technology includes captive broodstock development, acceleration ofmaturation, providing optimum conditions like water quality management, health management and feed management, induction of spawning through hormonal administration and facilitating natural spawning in the Recirculating Aquaculture System (RAS). Larvae are reared feeding with live feeds like rotifers up to 9th day followed by *Artemia* nauplii up to 20 days and afterwards weaned to formulated diet or shrimp/fish meat. The fry arefurther reared in nurseries. Several pond farming and cage farming demonstrations were successfully carried out.

Cobia

Fast growth rate, adaptability for captive breeding, low cost of production, good meat quality and high market demand are some of the attributes that makes cobia an excellent species for aquaculture. In recent years the seed production and farming of cobia is rapidly gaining momentum in many Asian countries. Envisaging the prospects of cobia farming in India, CMFRI has developed for the first time in the country the broodstock development, breeding and seed production of cobia and several successful seed production trials were conducted and the technology is now standardised at its Mandapam Regional Centre.

The farming protocols for the hatchery produced cobia fingerlings in sea cages with different feeding strategies were developed, tested and validated. Based on the trials, an economically viable farming model has been evolved. Several front line demonstrations and participatory farming were successfully carried out.



Silver pompano

Among the many high value marine tropical finfish that could be farmed in India, the silver pompano, *Trachinotus blochii* is one of the topmost, mainly due to its fast growth rate, good meat quality and high market demand. The silver pompano is caught only sporadically in the commercial fishery and hence its availability is rather scarce. It is a much sought after species and hence the demand can only be met through aquaculture.The farming can be successfully carried out in ponds, tanks and floating sea cages. The species is pelagic, very active and is able to acclimatize and grow well even at a lower salinity of about 10 ppt and hence is suitable for farming in the vast low saline waters of our country besides its potential for sea cage farming.

CMFRI has successfully developed and standardised the broodstock development, induction of spawning, larviculture and fingerling production of silver pompano for the first time in India. The first farming demonstration from the hatchery produced seed was carried out in a coastal aquaculture pond at Antharvedi Village, East Godavari District, Andhra Pradesh. The growth performance, survival and productive capacity of silver pompano, *Trachinotus blochii*, were evaluated in a brackishwater pond. Based on the experience gained from the above demonstration, farming protocols were evolved. Several pond and cage farming front line demonstrations and participatory farming were successfully carried out.

Ornamental Fish Culture

On a global basis a lucrative marine ornamental fish trade has emerged in recent years which area low volume high value industry. There are a wide variety of ornamental fishes in the coral reef ecosystems along the Indian coast, which if judiciously used, can earn a sizeable foreign exchange. However, a long term sustainable trade of marine ornamental fishes could be developed only through hatchery produced fish. The Central Marine Fisheries Research Institute has pioneered in the development of techniques for breeding, seed production and culture of more than a dozen species of marine ornamental fishes which are in heavy demand in the national and international trade. They include *Amphiprion percula, A.ocellaris, A. perideraion, A. ephippium, Dascyllus aruanus,* *Pomacentrus caeruleus* and *Chrysiptera cyanea.* Hatchery production and culture of marine tropical ornamental fish is very lucrative due to the high price per unit of ornamental fish. The clown fishes and damselfishes of the family Pomacentridae offer immediate scope for hatchery production due to the availability of seed production methodologies.

Recirculating Aquaculture System (RAS)

Closed-system aquaculture presents a new and expanding commercial opportunity. Recirculating aquaculture systems (RAS) are tank-based systems in which fish can be grown at high density under controlled environmental conditions. They are closed-loop facilities that retain and treat the water within the system. In a RAS, water flows from a fish tank through a treatment process and is then returned to the tank, hence the term recirculating aquaculture systems. Recirculation systems use land based units to pump water in a closed loop through fish rearing tanks and consist of a series of sub-systems for water treatment which include equipments for solids removal, biological filtration, heating or cooling, dissolved gas control, water sterilization and photo-thermal control. Sustainable production of bio-secure cobia seed all through the year employing photo-thermal conditioning is possible only by recirculating systems.

At Mandapam Regional Centre two recirculation aquaculture systems are installed for controlled broodstock development and breeding. The first successful off-season spawning of cobia through thermal regulation has been achieved in the RAS. Breeding experiment was conducted in the RAS through thermal regulation by installing titanium water heaters. During this season the temperature in source seawater was 25.1 to 26.0°C and it was raised in the RAS to 29.7 to 30.3 °C, by titanium heaters. The cobia brooders were healthy and broodstock development was continued in the RAS by regulating the temperature. Intra-ovarian cannulation biopsy revealed the maturation of ova in the altered temperature. The female cobia was weighing 9.29 kg and males were 9.89 kg & 10.34 kg. Successful hormonal induction with hCG was carried out and spawning was achieved. The fertilized eggs were collected and stocked in the incubation tanks for hatching. It is felt that the present success is a major breakthrough which can pave way for the successful spawning and seed production of cobia all through the year. The same infrastructure can be utilized for seed production of other species also.

Sea cage farming

The sea cage farming has been expanding in recent years on a global basis and it is viewed by many stakeholders in the industry as the aquaculture system of the millennium. Cage culture has made possible the large-scale production of commercial finfish in many parts of the world and can be considered as the most efficient and economical way of rising fish. The rapid growth of the industry in most countries can be attributed to (i) availability of suitable sites for cage culture (ii) well established breeding techniques that yield a sufficient quantity of various marine and freshwater fish juveniles (iii) availability of supporting industries such and feed, net manufactures, fish processors etc. (iv) strong research and development initiatives from institutions, governments and universities and (v) the private sector ensuring refinement and improvement of techniques/ culture systems, thereby further developing the industry. Total reported cage aquaculture production from 62 countries and provinces/regions from where data is available amounted to 2412167 tonnes (excluding China) On the basis of the reported information, the major cage culture producers in 2005 included - Norway (652306 tonnes), Chile (588 060 tonnes), Japan (272 821 tonnes), United Kingdom (135 253 tonnes), Vietnam (126 000 tonnes), Greece (76 577 tonnes), Turkey (78 924 tonnes), and the Philippines (66 249 tonnes). Currently on a global basis commercial cage culture has been restricted to the culture of high value, compound feed fed finfish species, including salmon, Japanese amberjack, red sea bream, yellow croaker, European sea bass, gilthead sea bream, cobia and groupers. Cage culture systems employed by farmers vary from traditional family owned cage farms (Asian countries) to modern commercial large scale salmon and trout cage farms in Northern Europe and Americas.

Marine cage farming is relatively new in Asia and was developed initially in Japan for species such as yellowtail (*Seriola quinqueradiata*) and red sea bream *Pagrus major.* Over the last twenty years the cage farming practice has spread almost throughout Asia. The major cage farming countries are China, Indonesia, Taiwan Province of China and Vietnam. A large number of finfish species are farmed in cages in Asia *viz*. groupers, snappers, carangids, seabass and cobia. In most countries individual operations are not large, and often a clustering of farming activities, which is due to limited site availability in coastal waters, is seen.

When compared to many countries in the Asia-Pacific Region, India is still in its infancy in sea cage farming. For the first time in India as part of R & D a marine cage of 15 m diameter with HDPE frame was successfully launched in 2007 and operated at Visakhapatnam, in the east coast of India by the Central Marine Fisheries Research Institute. Since then, a lot of innovations on designing and fabrication of cages and mooring systems were made which led to the development of better designs of cages of 6m diameter with improved mooring systems that can withstand rough sea conditions. Subsequently demonstrations of cage farming were undertaken along different parts of the Indian coast under a participatory mode with the local coastal fishermen. Successful sea cage farming demonstrations were conducted at Kanyakumari, Vizhinjam, Kochi, Mangalore, Karwar, Veraval, Mandapam, Chennai and Balasore. Cobia, Sea bass and spiny lobsters were the major groups employed for farming. These demonstrations have created an awareness regarding the prospects of sea cage farming in India. Many entrepreneurs, fishermen and farmers are coming forward to take up this venture.

The commercial cage farming of cobia undertaken by Cobia Fisherman Welfare Association, a self help group from Rameswaram under the technical support of Mandapam Regional Centre of CMFRI is a step forward in the popularization of sea cage farming in India. Ten cages of 6m diameter and 3.5m depth were fabricated and floated by them. All the investments in the fabrication of the cages, the cost of seeds, feeds and managing the sea cage farm were borne by the association. A total of 6400 fingerlings of hatchery produced cobia were supplied from Mandapam Regional Centre. The farming was initiated during the middle of November 2013. The harvest of cobia was conducted on 8th May 2014. The length of fish harvest ranged from 48 to 62 cm and weight from 1.0 to 2.3 kg. The farm gate price was Rs. 270 / kg. A total of 10 tonnes of fish was harvested during the fishing ban period and yielded a good farm gate price. This has created wide spread interest among fishermen communities for taking up sea cage farming in the area. Several successful participatory cage farming demonstrations taken up at different parts of Indian coast is paving the way for the spreading of cage farming and in the immediate future it can contribute to additional sea food production.

Mussel Farming

In the wild, mussels are mostly found in the littoral and sublittoral zone in clusters on various substrates. The two mussel species found along Indian seas are *Perna virdis* and *Perna indica*. *Perna viridis* is distributed along the north and south of east coast and the south west coast of India. The brown mussel *Perna indica* species is found along the south west coast. The Institute has developed technologies for culture of bivalves *viz.*raft method (in bays, inshore waters), rack method (in brackishwater, estuaries) or long line method (open sea). These methods are commonly adopted for mussel farming (*Perna indica* and *P. viridis*). Mussel seeds of 15-25 mm size collected from intertidal and sub tidal beds are attached to coir/nylon ropes of 1-6 m length and enveloped by mosquito or cotton netting. Seeds get attached to rope within a few days while the netting disintegrates. The seeded ropes are hung from rafts, racks or longlines. A harvestable size of 70-80 mm is reached in 5-7 months and production of 12-14 kg mussel (shell on) per metre of rope can be obtained. Innovations such as automatic seeding machines and depuration protocols were also evolved. The farming of mussels is currently being practised commercially at brackishwater areas of Malabar Coast, Kerala.

When mussel farming is taken up on a larger scale, depending on the wild seed may not be practicable because it may affect the wild mussel fisheries. Hence low value high volume seed production technologies are needed for hatchery production of mussel seeds for farming. CMFRI has already succeeded in the low cost production of mussel seeds in hatchery and standardisation of the protocols for large-scale productionis needed.

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. In the adopted rack and ren method, a series of vertical poles are driven into the bottom in rows, on top of which horizontal bars are placed. Spat collection is done mainly from the wild on suitable cultch materials. Spat collectors consist of clean oyster shells (5-6 Nos.) suspended on a 3 mm nylon rope at spaced intervals of 15-20 cm and suspended from racks, close to natural oyster beds. Spat collection and further rearing is carried out at the same farm site and harvestable size of 80 mm is reached in 8-10 months. Harvesting is done manually with a production rate of 8-10 tonnes/ha. Oyster shells are also in demand by local cement and lime industry. Hatchery production techniquefor edible oyster seeds is also developed by CMFRI.

Molluscan shellfish (mussels, oysters and clams) are much sought after and widely consumed throughout the world as gourmet food. But in India this nutritious seafood have not found much acceptance. Currently farmed mussel and oyster production in India is between 10,000 and 15,000 tonnes. In order to create awareness on the general public on molluscan shellfish as a highly nutritious food, ShellCon 2014 was organised by CMFRI in which shellfish food festival and programmes for the popularisation of the consumption of molluscan shellfish were conducted.

Mabe Pearl Production

CMFRI successfully developed and standardised a simple technique for value added marine pearls, called mabe pearls. A mabe pearl is a dome shaped or image pearl produced by placing a miniature image against the side of the oyster shell interior. The result is an exquisite pearly nacre coated image. The main advantage is the very short gestation period (2 months) and the superior quality of the nacre of Indian pearl oyster *Pinctada fucata*. There are two ways to make pearl oyster spat available for pearl oyster farming, (1) hatchery production of seed and (2) wild collection of seed by setting up artificial spat collectors in the sea at subsurface during oyster spawning season. The hatchery technology developed by CMFRI is helpful in overcoming the problem of insufficient supply of oysters for cultured pearl production.

Seaweed Culture

Around 60 species of commercially important seaweeds with a standing crop of one lakh tonne occur along the Indian coast. Seaweed products like agar, algin, carrageenan and liquid fertilizer are in demand in global markets and some economically viable seaweed cultivation technologies have been developed in India. CMFRI has developed technology to culture seaweeds by either vegetative propagation using fragments of seaweeds collected from natural beds or spores (tetraspores/carpospores). It has the potential to develop in our large productive coastal belts. The rate of production of *Gelidiella acerosa* from culture amounts to 5 tonnes dry weight per hectare, while *Gracilaria edulis* and *Hypnea* production is about 15 tonnes dry weight per hectare. Recently the culture of the carageenan yielding sea weed *Kappaphycus alvarezii* has become very popular due to its fast growth and less susceptibility to grazing by fishes and is being cultivated extensively along the Ramanathapuram, Pudukkottai, Tanjore, Tuticorin and Kanyakumari districts of Tamil Nadu producing about 17000 t wet weight annually.

Integrated Multitrophic Aquaculture (IMTA)

On a global basis, the mariculture practices are dominated by intensive monocultures which have led to sustainability problems, environmental degradation and consequent disease problems. In this context, the idea of bio-mitigation of the environment along with increased biomass production integrating commercially important species of different trophic levels is emerging as an innovation in aquaculture. Integrated Multi trophic aquaculture (IMTA) is the practice which combines in appropriate proportions the cultivation of fed aquaculture species (E.g. fin fish / shrimp) with organic extractive aquaculture species (e.g. shell / 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). IMTA is well recognized as a mitigation approach against the excess nutrients / organic matter generated by intensive aquaculture activities especially in marine waters, since it incorporates species from different trophic levels in the same system. In addition, it is also relevant in the implementation of ecosystem approach to aquaculture (EAA) propagated by FAO. IMTA can also increase the production capacity of a particular site. It is well understood that the increasing use of coastal waters world wide coupled with rapid growth and expansion of mariculture demand for more sustainable practices and hence the concept of IMTA has much relevance and scope.

Way Forward

Seed availability is the major constraint for the initiation of commercial level farming of marine finfishes and shellfishes. The huge demand for cobia and pompano seeds received at CMFRI from fish farmers and entrepreneurs is indicative of the need of the sector. Hence there is an urgent need to establish marine finfish hatcheries by fisheries development agencies /private sector to ensure the seed availability. In addition, it is required to intensify research programmes for the development of seed production techniques for at least one dozen species of high value marine fishes. In this context, CMFRI has already taken up broodstock development and seed production of orange spotted Grouper *Epinephelus coioides*, Indian Pompano *Trachinotus mookalee* and Malabar Red Snapper *Lutjanus argentimaculatus*. Initial success has already been obtained in the broodstock development and seed production of *E. coioides* and *T. mookalee* at the Vishakapatnam Research Centre of CMFRI. Broodstock development of *L. argentimaculatus* is being pursued. If seed production technologies of more species are available, the farmers will be able to select the species as per the need of the locality.

The commercial level farming of lucrative shellfish species like the sand lobster, *Thenus unimaculatus* and the blue swimmer crab *Portunus pelagicus* can also be practiced if hatchery produced seeds are available. CMFRI is able to succeed in the seed production of both the species and now research is being focused on the standardization of these techniques for consistent production. Similarly seed production techniques are already developed by the Institute for edible oyster, pearl oyster and green mussel. The methods can be scaled to commercial level production as per the requirement of the sector.

The development of farming systems especially the sea cage farming deserves prime attention. To promote sea cage farming in the country, identification of suitable sites with proper depth, water quality and water current are required. Site selection survey and identification of at least a dozen sites suitable for cage farming by the entrepreneurs and farmers deserves urgent attention. Availability of logistic support for cage farming should be given careful consideration if a profitable business is to be established. Cage farming has to be promoted away from the human settlements, discharge points of industrial and municipal waste, so as to maintain ideal water quality for sea farming. Further, policy for leasing the suitable sites, bank finance, and governmental support through subsidy assistance are the needs of the hour.

The bivalve farming which is already being practiced at a few locations can be further expanded. The carrying capacity assessment, low value availability of hatchery produced seed and the feasibility of open sea farming of bivalves require attention by the R&D sector. Similarly the expansion of sea weed farming offers immense scope. A concerted effort by the developmental agencies for popularization of sea weed farming is warranted.

On a global basis, the mariculture practices are dominated by intensive monocultures which have led to sustainability problems, environmental degradation and consequent disease problems. In this regard, the biomitigation impact of IMTA is away forward in sustainable aquaculture. In addition, it is also relevant in the implementation of ecosystem approach to aquaculture (EAA) propagated by FAO. The development of IMTA in marine and coastal environments, has not been demonstrated as a viable enterprise in India and hence there is an urgent need to impart front line demonstrations on this potential sector of mariculture to different stake holders.

The development of commercial level seed production technologies for a few species of high market value finfish and shellfish, establishment of hatcheries by fisheries development agencies, identification of appropriate cage/coastal farming sites, development of economically viable farming protocols, formulation of suitable grow-out feeds, health management protocols, development of mariculture policies and appropriate marketing strategies can go a long way to promote mariculture as a substantial contributor of sea food production in India.