Capture - based Aquaculture : Mariculture Initiatives — By CMFRI

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It is well known that availability of seed in adequate quantities is one of the major constraints in the development and expansion of mariculture. The increasing exploitation pressure on the wild stocks of many major marine fisheries has led to overexploitation and consequent decline in their catch and hence the only sunrise sector to augment seafood production is through marine farming. Eventhough seed production technologies have been developed for many marine finfish and shellfish species, many of these technologies have not been scaled up to commercially viable levels. The hatchery seed production of many high value marine finfishes and shellfishes is complex and expensive due to the high costs involved in the establishment of broodstock and hatchery facilities and also due to the complicated larviculture procedures involving culture of proper live feeds, their nutritional enrichment, feeding protocols, grading, water quality maintenance, nursery rearing and disease management. Eventhough production of seeds of the concerned species by development of commercially viable technologies is essential for development of sustainable mariculture practices, many of these technologies are sti in the emerging state and may tak several years for standardisation o a cost effective level. Since marin food production from the captur sector is not increasing, marin farming has to be developed an expanded urgently and it is no advisable to wait for th standardisation of seed productio technologies for all the concerne species. In this context, the concep of capture based aquaculture can b considered as the mid way betwee fishing and aquaculture an requires to be developed into sustainable commercial activity fo augmenting seafood production.

Fig.1: 6m cage launched off Munambam near Cochin

Fig.2 : Broodstock cages at Mandapam

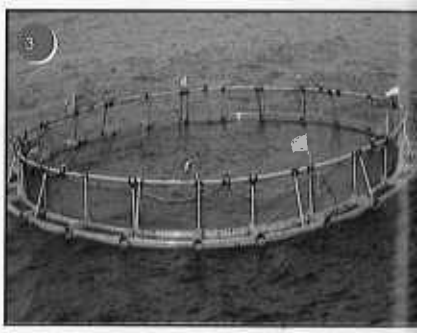

Fig. 3 :15 m cage at Visakhapatnam

Fig. 4 : Penaeus indicus being grown in a cage near Cochin

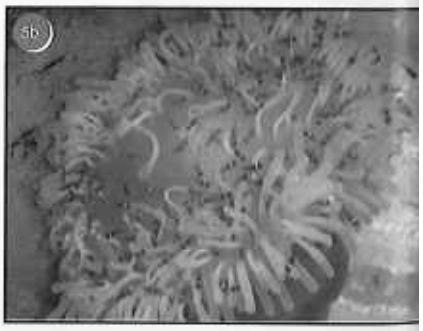

Fig. 5 a,b Ornamental fish production for which complete package is available (c,d&e contd below)

(contd.) 5c,d&e) Ornamental fish production for which complete package in available

Capture based aquaculture (CBA) is the practice of collecting 'seed' material – from early life stages to adults – from the wild, and its subsequent growing in captivity to marketable size, using aquaculture practices (FAO, 2004). As hatchery technologies remain to be perfected for many species, fish farmers have to depend on 'seed' available from the wild. Capture based aquaculture has developed due to the market demand for some high value species whose life cycles cannot currently be closed on a commercial scale. CBA is a world-wide aquaculture practice and has specific and peculiar characteristics for culture, depending on the areas and species. The species/ groups harvested as wild juveniles at the different countries / regions where CBA is practised include shrimps, milkfish, eels, yellowtails, tunas and groupers. Eventhough CBA could be considered as an unsustainable aquaculture practice in the long run due to the successive stock depletion of the wild stock, there are some aspects which highlight the importance and potential of this practice. It is generally considered that further development of marine aquaculture is possible only by the increase in mass production of juveniles in hatcheries. But it remains a fact that much of world's coastal aquaculture can still be expected to come from the supply and availability of capture-based juveniles. Many of the environmental concerns associated with grow out juveniles produced in hatcheries like transfer of diseases and 'genetic pollution' of wild stocks is not encountered in CBA. As capture based aquaculture potentially generates higher profits than other aquaculture systems, the market demand for the products and species cultured is high and it is likely that efforts to promote this activity in future will increase significantly. CMFRI has developed several technologies for the seed production of marine invertebrates such as pearl oysters, edible oysters, clams, green mussel, pelagic crab (*Portunus pelagicus*), shrimps and sand lobster (*Thenus orientalis*), and several species of ornamental fishes, which are technically very advanced with more of complications than edible finfish. Developments of the above technologies were the priority in earlier years when there was no demand for marine finfish culture like in other countries. However, in the current scenario, finfish culture has become a national priority.

Species selection

The potential marketability, growth rate, and its ability to function under culture conditions and economic consideration are the main criteria for the species selected for CBA. Eventhough carnivorous species are more expensive to rear; these species command higher market prices and compensate for the high feeding costs. Most species farmed under CBA are carnivorous. The species / groups used in capture based aquaculture include molluscs (oysters, mussels, and scallops), crustaceans (shrimps, crabs and lobsters) and finfish (eels, grey mullets, milkfish, yellowtail, groupers, rabbitfish and tunas) (Pillay, 1995; Hair and Doherty 2002). Among the high value finfishes used for CBA, four groups *viz.* groupers, yellowtails, eels and tunas are of special significance due to their rapid growth and high market demand. Groupers are popular foodfish farmed in Southeast Asia owing to their fast growth, efficient feed conversion, high market prices and reduced catch from wild sources. The demand for groupers has grown markedly over the last two decades in parts of South-East Asia. The value of live groupers depends on the species (ranges from US $ 8-31 / kg). The amberjack or yellowtail (*Seriola* spp) is another good candidate species for the diversification of farmed fish products because of its high growth rate and good performance in captivity. Yellowtails have a good market especially in Japan, which has developed over the last 30 years due to capture based aquaculture production. It can be processed and marketed as a range of products – whole, fillets, steaks etc. The farmed fish is considered superior in quality to wild caught fish and fetches a much higher price in the market. Some of examples are listed below.

Yellowtail: Under the genus *Seriola* of family Carangidae, three species are widely used for CBA – the yellowtail (Japanese amberjack) *S. quinqueradiata*, greater amberjack *S. dumerili*, and goldstriped amberjack *S. lalandi*. Yellowtail aquaculture is mainly based on the availability of capture based seeds in Asian countries and Mediterranean. The seed production methods have not been developed on a commercial scale. Young greater amberjack are captured by using Fish Aggregating Devices (FADs) in the Mediterranean. Traditional FADs are built with vegetal material and before reaching the FAD area, juveniles aggregate under floating objects such as floatsam and vegetal matter. Several hundreds of FADs built with palm leaves or with green canes are employed. These are positioned to float and are anchored with a rope to ballast weighing 30-40 kg. They are set along transects extending perpendicularly to the coast for several kilometers. The transect extends from shallow (<15 m) coastal waters to offshore depths of about 500m. Fishermen use simple purse seines for catching amberjack juveniles.

The juveniles caught are transferred to PVC tanks placed onboard fishing vessels with open water recirculation and oxygenation system and sometimes with temperature regulators. In Japan, wild juveniles are weaned onto prepared feed after capture and weak individuals are removed. They are then sold to producers who rear them in net cages.The minimum market size for Japanese amberjack starts at about 1.2 kg. There is a great demand for live fish, which fetch a higher price. Yellowtail are mainly marketed fresh, chilled or frozen at a price ranging from US $ 5-18/kg depending on the region and season of the year. The key restrictions to increasing production are juvenile supply, the development of successful feeds and the introduction of better management practices to limit losses from 'red tide' events.

Tuna: The species of special interest to capture based aquaculture are the northern bluefin tuna (*Thunnus thynnus*) and the southern bluefin tuna *Thunnus maccoyii*. Specimens that are used in CBA are caught with traditional fishing gears. Individual 'rod fishing' with single fish hook has been adapted for catching juveniles and sub adult specimens. Barbless hooks can be used for capturing specimens weighing several kilograms. The fishing method most physiologically suited to catching bluefin tuna for CBA is the purse seine. The purse seine fishery has become the most important provider of live tunas for CBA. The fish are first caught using a purse seine in the traditional manner, before being transferred to transport cages by 'swimming through'. Another technique employed in bluefin tuna fishing is the use of tuna traps

placed in the course of trophic migration. Mortality rates in grow out cages were high during the first month of adaptation and decreased significantly during subsequent months.

Recently, bluefin tuna culture is expanding in the Mediterranean and the production accounts for more than half of the global total. Here, tuna farming is based on catches taken from wild populations which are moved alive to floating cages in offshore areas. The fish are then kept in large cages for variable periods, ranging from a few months to years, depending on the farming location and fish size.

The products from the capture based aquaculture of tuna are nearly all destined for the Japanese market, where they will be used mostly for *'sushi'* and *'sashimi'*. To achieve the best prices in this specialised market, producers must harvest high quality tuna. The criteria for high quality tuna are – a high level of freshness, signs of fast bleeding of tuna after kill, the absence of fresh burns due to lactic acid formation, the absence of, or a very low level of histamine, and a high fat content.

Groupers:Groupers are highly priced for the quality of their flesh and most species fetch high market prices. The most commonly abundant species that are captured for culture purposes and are also reared in hatcheries are *Epinephelus coioides* and *E. malabaricus*. Grouper seed is mainly caught in coastal areas, particularly around sea grass beds, mangroves, shallow brackish water areas, river mouths of estuaries as well as in tidal pools and around reefs. The peak grouper seed season is associated with monsoon months.

The Indian scenario

Taking advantage of fast growth and high market value of marine finfish, CMFRI has initiated programmes on breeding of finfish such as the cobia (*Rachycentron canadum*), pompano (*Trachynotus* spp), redsnapper (*Lutjanus* spp) and groupers (*Epinephelus* spp) in the newly constructed modern finfish hatchery complex at CMFRI's Mandapam Camp.

India has vast areas of suitable coastal waters, lagoons and bays which can be utilised for mariculture. Irrespective of India's vast potential, mariculture production is only about 80,000 to 1,00,000 tonnes annually, almost entirely from shrimp culture. It is high time that India should focus much attention on mariculture to ensure food and nutritional security to its growing populations. Several Asian countries are leading in marine finfish farming and artisanal cage culture, but we have yet to make an impact in these areas. The capture based aquaculture in India is mainly confined to mussel and edible oyster farming. Commercial level seed production technologies are yet to be standardised for high value marine finfishes except the sea bass. Seeds of finfish are available abundantly in the wild at different locations. A large number of juveniles of high value finfish and shellfish are caught as by catch in many of the non-selective bag type gears which are commercially operated in India. Considerable growth over fishing occurs and the catches of these juveniles are either discarded or sold at a very low price. If proper training and equipments are provided to the fishermen employing these gears, these juveniles can be brought in live condition and can be used for capture based aquaculture and the resources can be conserved and utilised for increasing production. In this context, it is high time that at least an artisanal level of capture based aquaculture should be promoted in India with sustainable management practices.

R & D initiatives of CMFRI on Capture based aquaculture in India

Shrimp farming:During the first half of the 20th century, the paddy field prawn filtration was only a subsistence fishery of trapping the young ones of prawn brought in by the tide, holding it for a few days in the embanked and sluiced paddy fields and then fishing it by filtration of the out-going water during the neap tide. CMFRI has given elaborate guidelines for site selection and construction of shrimp farms and suggested utilising a variety of wet lands, in addition to the traditional prawn filtration areas, such as backwaters and estuaries, brackishwater canals in coconut grooves, derelict salt pans and brackish/salt water impoundments.

Lobster fattening/farming: The cultivable lobsters of India can be grouped under two major categories- the spiny lobsters or rock lobsters belonging to the family Palinuridae and the sand lobsters or squat nose lobsters belonging to the family Scyllaridae . The coastal spiny lobsters *Panulirus homarus, P. polyphagus, P. ornatus, P. versicolor, P. penicillatus and P. longipes* and the sand lobster *Thenus orientalis* are excellent candidate species for farming. Spiny lobster farming / fattening, though demonstrated as technologically feasible by CMFRI, it has not yet developed commercially in India. Raising under-sized or juvenile lobsters of wild origin in suitable enclosures to marketable size through appropriate feed and water quality management is all that is done in spiny lobster culture at present. Some enterprising aquaculturists of Bhavnagar District of Gujarat have been practising it on a limited scale by fattening the undersised juveniles of *Panulirus polyphagus* in pits dug in the intertidal zone.

The prospect of developing commercial interest in lobster farming in India seems bright due to the substantial increase in price consequent upon heavy demand from export market. To support and sustain this situation, research on conservation, seed production and sustainable capture based lobster farming in India needs to be further strengthened.

Formulated feed of Lobsters

CMFR Institute has developed feed for the maintenance of lobsters without affecting the hygiene during fattening. The feed has been tested and found suitable. This will go a long way in the lobster fattening in open sea cages.

Total package of marine ornamental fish culture

CMFRI has developed a full package of broodstock, seed production, grow out, feed (#Rs 200/kg) and artificial sea water for rearing them in any place. Technology transfer will be undertaken at Mandapam and Kochi. Interested persons may contact CMFRI, Cochin, Scientist-in-Charge, ATIC, CMFRI, Cochin (phone: 0484-2394798)

Mussel farming: Mussels have formed a part of the daily diet of several people especially along the Kerala, Karnataka, Goa and Maharashtra coasts. When the CMFRI launched mariculture development programme in the country, mussel farming practices

were implemented at Vizhinjam, Calicut and Madras. Both the species of mussels, *Perna indica* and *Perna viridis* were given equal importance and grow-out structures suitable for open sea mussel farming, seeding method and farm management measures were developed. The first commercial mussel farm in the country was set up at Padanna, Kasaragod, Kerala and every year the number of farm units is increasing. The significance of group farming activity was brought out through the activities of Women Self Help Groups. Availability of seed in the natural beds in various coastal regions has been assessed .

Oyster farming :The soft and subtle meat of the oyster is a delicacy in most temperate countries and this is the most extensively farmed mollusc globally. In most countries oyster farming has a history of two to three centuries. One of the first reports on oyster farming in India is that of Hornell (1910) who has attempted collection of oyster spat by placing lime-coated tiles in Pulicat Lake. Subsequent to this, oyster spats were produced in the hatchery and methods for cultch-less spat production were also developed by CMFRI. Recently attempts were made to develop the technique of remote setting of oyster. Based on the preliminary success achieved, attempts are now made at CMFRI to develop a protocol for this technique suitable for Indian conditions. Another significant development is the production of triploid oyster.

Clam culture:Clams are a favourite food in several parts of the country. However, commercial clam farming, as practised in temperate countries, is not in vogue in India, basically because the limited domestic consumer demand is met from the wild harvests.

Marine Finfish Culture

Seed production and culture of marine finfishes has been expanding in the recent past at many parts of the world, but in India it is only an emerging sector. The most common cultivable candidate species of marine finfishes include the rabbitfish (*Siganus* spp.), sea bass (*Lates calcarifer*), groupers (*Epinephelus* spp.), pompano (*Trachynotus* spp.), snappers (*Lutjanus* spp.) and sea breams (*Lethrinus* spp., *Sparus* spp.) and cobia. Currently mariculture of finfishes is almost entirely supported from the seed collected from the wild, except for sea bass.

.Marine cage farming

For the first time in India a marine cage was successfully launched and operated off Visakhapatnam, in the east coast of India by the Central Marine Fisheries Research Institute in 2007. This was totally designed and fabricated at the Regional Centre of CMFRI, Visakhapatnam with the help of IIT, Kharagpur, a local Diving Company and HDPE fabricator and Visakhapatnam Port Trust. The cage was found very sturdy and was able to withstand water currents, waves and winds. The inner diameter of the floating cage was 15m. It was provided with an outer catwalk structure for free working, and stabilisation. The cage net was about 15m in diameter and about 6m deep. It was protected by an outer predator net to prevent damage to the cage net by large fish/mammals. On the top of the cage railing, a net was provided to prevent attacks by birds. The entire net was kept in position by ballast and ropes tied to the mooring chains. The cage was provided with a shock absorber on the mooring chain to withstand and absorb the pressure of winds, currents etc. The total volume of net in the water was about 850 cubic meters. It could hold up to 25 to 30 tonnes of live fish at a given time without any congestion. The cage was moored at a depth of 11m, about 300m from the shore. In spite of being under the influence of high underwater currents, strong waves, and winds and generally rough sea, the cage was found intact. Since the stabilisation and standardisation of several parameters of the cage in its natural condition required time, only limited number of seed of Asian seabass (*Lates calcarifer*) was stocked during the first stocking as a trial. Successful harvesting was done after four months.

Encouraged by the initial results the work was carried forward with help of MOA and NFDB. The diameter of cage was reduced to 6m and depth of net to about 6m. Further improvements were incorporated in to the cage design and now sixth generation of cage is under preparation with all the modifications in design and mooring. The production capacity is about 4-5 t with a volume of 175 cu.m. These cages are moored off Veraval, Mumbai, Karwar, Mangalore, Cochin, Trivandrum, Mandapam, Chennai, Nellore, Visakhapatnam, Srikakulam and Balasore. Most of the cages are functional; some are in advanced stages with stocking and others are at initial stages. The animals stocked include seabass (*Lates calcarifer*), prawns (*Penaeus indicus*), lobsters (*Palinurus polyphagus, P. homarus*), and few numbers of koth, pomfrets, groupers, pompano etc. Some of these species require evaluation and the process of refinement continues as this is only a beginning. This All India programme is being implemented with the active participation of local fisheremen / fishermen co operatives in most of the places. This gives the fishers immediate experience, understanding of intricacies of cage culture and also financial benefits, thus paving the way for achieving the smooth transfer of technology.

Capture - based Aquaculture (CBA): Seed Resources

Several studies and observations by CMFRI indicated that dol nets of Gujarat and Maharashtra, shore seines of east coast, Thalluvalai of southeast coast, which are mostly operated between 5-10m depth, land juveniles/seed of high value species. These mostly fetch very low price and are dried. The species include seerfish, pomfrets, mackerel, koth, prawns etc. Also, there exists a good fishery for live juveniles of different species of lobsters but very little are used for fattening. It is estimated conservatively that about one million of seerfish juveniles of 7-10 cm and two millions of mackerel juveniles of 5-8 cm are landed by shore seines in the month of April alone along the stretch of Visakhapatnam – Kalingapatnam. This is only an example and similar studies are initiated by CMFRI. If only a small fraction of this seed / juveniles are induced to be brought in live condition, they will form very good source of CBA without affecting the ecosystem and livelihood of fishermen. It will be more lucrative for the fishermen, at the same time contributing to several - fold increase in the mariculture production. Juvenile yellow fin tuna are available aplenty in and around Lakshadweep waters which can be used for farming in cages, for which reasonably viable cage technology is available with CMFRI.

Environmental impacts

The practice of CBA involves the removal of seed from the wild stocks and hence an impact on the environment and ecosystem can be expected. Although these impacts may be negligible, and the benefits to the local communities are considerable, it is necessary to understand and evaluate the potential effect on the overall ecosystem. Finding the balance between rational use, conservation and preservation is the logical way to optimise the use of wild caught seeds for aquaculture. CMFRI has initiated studies on the biodiversity changes, if any, around cage ecosystem and the environmental impacts. Studies are also in progress to quantify the fish resources around the cages as cages act as FADs and its economic impact is also being investigated.

Social and Economic Impacts

Markets have been the driving force behind the development of capture based aquaculture industry. High profitability coupled with high market demand can ensure the development of this activity. The selection of species should be based on their acceptability in local, national or international markets.

Management of Capture Based Aquaculture

Rapid expansion of CBA sector coupled with poor regulatory measures can lead to the collapse of the industry. The examples of capture based aquaculture of southern bluefin tuna and groupers can be taken as models in this regard. Following the explosion of capture based tuna aquaculture, the quota of one member (Australia) was year by year completely utilised by the farming industry until the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) imposed a cap on the maximum amount of juvenile catch to be taken for this purpose.

Food Safety Issues

The expanding trade in capture based farmed species of various ages and life stages for the seafood industry without appropriate health considerations may increase the risk of spreading pathogens that are associated with human illnesses. Food safety issues associated with CBA affect all levels of this activity. Such problems may seriously affect small-scale farmers, who represent the backbone of many rural communities in Asian aquaculture.

General Conclusions and Future Prospects

Capture based aquaculture can be considered as the midway between fishing and aquaculture.Yet, as a commercial activity, it constitutes a distinct sector. A very significant proportion (millions of metric tonnes) of the total foodfish (finfish, crustaceans and molluscs) aquaculture production reported by FAO is obtained through growing of wild caught juveniles (eels, grouper, yellowtail, tunas, milk fish, mullets, most molluscs and some marine shrimp are derived from CBA).Most of the production from CBA is from molluscs. Among finfishes eels, tunas, groupers and yellowtail represent a large proportion of the total volume and an even larger proportion by value. The total value of these four groups exceeded US$ 1.7 billion in 2000 (FAO, 2002a). It qualifies to be considered as a separate and distinct entity within the aquaculture sector because it has its own special culture characteristics. CBA is an economic activity that is likely to continue to expand in the short term, both for those species currently under exploitation and possibly with others that may be selected for aquaculture in the near future. In the case of shellfishes like mussels the activity will certainly continue in view of the large scale availability of natural seeds. It is felt that with effective regulations and management practices, the capture based aquaculture offers good scope and potential for the artisanal and industrial sectors in the years to come.

Fish farming as a major job provider in Himachal

The concerned efforts made by Himachal government to tap the fisheries resources have started paying dividends. The State has made remarkable achievements in the fisheries of reservoirs and in commercial farming of rainbow trout.The State reservoirs have made a mark by recording highest fish production as compared to other reservoirs in the country and commercial trout production touched 14.98 tonnes in public sector and 52.3 tonnes in private sector during 2007-08.

The reservoirs in the state also made a mark by achieving higher per hectare fish production and in spite of harsh ecoclimatic conditions, fish seed production and fish production in the State attained high annual levels of 29 million and 7337 tonnes respectively. While the upper zones of rivers were abode of exotic trouts and snow trouts, the lower areas were bestowed with precious fish like Golden Mahseer (*Tor putitora*) *Mystus seenghala, Wallago attu* etc.

The government are extending premium free insurance cover of Rs.50,000 to the licenced fishermen operating in the State riverine sector benefiting about 11,000 fisher families in the State. In case of permanent disability the fishermen would be entitled to get Rs.25,000/-.

Fisheries are one of the sectors where large avenues for self-employment exist and efforts are afoot to encourage enterprises to adopt fisheries as a full time avocation and to generate self-employment opportunities in abundance. Providing insurance cover is one of the steps initiated by the State Government for the welfare of the fishermen.

There are a number of welfare schemes for fishermen which included schemes for reservoir fishermen, fishermen accident insurance scheme, close season assistance scheme and risk fund scheme to protect the interest of the fishermen while working in adverse circumstance and conditions. There are 19 registered cooperative fishermen's societies in the State and Himachal is the only State in the country, promoting cooperative fish-farming,It is learnnt.

The reservoirs of Himachal have the distinction of achieving the highest per hectare fish production in Gobind Sagar and the highest sale price value of fish from Pong Dam.

From the commercial point of view, fish species in Gobind Sagar and Pong Dam reservoirs have emerged as a major resource of economic uplift of local population. Himachal is the first State in the country to introduce and popularise trout farming in the private sector, which is contributing over 50 tonnes of trout. The state is producing 7,337 tonnes of fish valued at about Rs.37 crore towards providing quality fish to the consumers. The Department of Fisheries with its multipronged strategy had been able to arrest the downfall in fish catches during the year 2007-08 when an increase of 350 tonnes was registered. Efforts are afoot to develop the first Mahseer fish farm at Badon in tehsil Jogindernagar in Mandi at a cost of over Rs.5 crore, in the State sector, while a new farm on the bank of river Tirthan at Hamini (Kullu) is also coming up at a cost of about 2.5 crore.

The total riverine length, rich in fish fauna, is over 300 km and there are three reservoirs i.e., Gobind Sagar, Pond Dam and Chamera with an area of over 42,000 hectares where Rainbow, Brown trout species etc. are grown. Besides, the rural people are also being encouraged to construct fish ponds in their villages so as to adopt them as an income generation activity.