# Prospects for Open Sea Cage Farming in India

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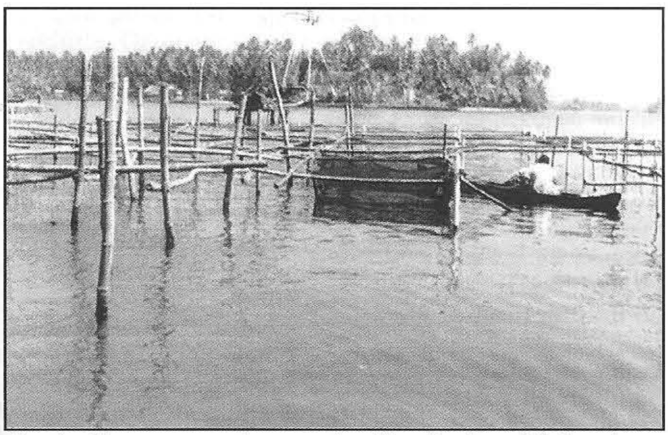
**What is Open Sea Cage Farming ?**

Aquaculture has been recognized as a sunrise industry, registering an average annual growth of about 9.2 % since 1970 in comparison to capture fisheries (1.4 %) and terrestrial farmed meat production ( 2.8%) (FAO, 2004). Globally, the annual value of farmed fish has crossed US $ 50 billion. Surprisingly, the bulk of the aquaculture production comes from the developing low income food deficit countries.

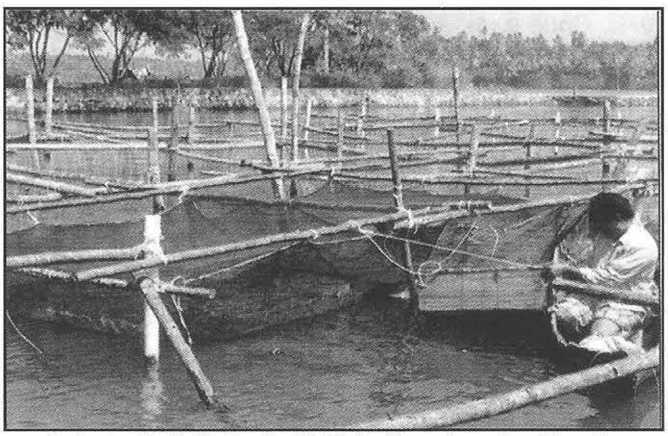
Modern industrialized open sea cage farming is a practice of recent origin. Basically, the method of culturing aquatic organisms in the open sea in enclosed cages made of various materials is known as open sea cage farming. According to Li (1994),case culture in China was established during the Man Dynasty 2200 years ago. Although the practice of traditional cage culture developed independently in a number of southeast Asian countries, this innovative entrepreneurship is developing fast and turning into a highly commercialized business activity in many Asian countries. Modern cage culture is a highly evolved and technically refined activity, using modern materials and technological inputs and practices. There are basically two types of systems: capture based and hatchery based. As the names indicate, the source of stocking material ( seed) decides the type of farming activity. In some countries capture based farming is called 'fattening'. Presently the bulk of sea farmed fish / shellfish comes from seed obtained from the wild / capture fisheries. Capture based aquaculture is defined as the practice of collecting seed material - from very early life stages to adults- from the wild, and its subsequent on-growing in captivity to marketable size, using aquaculture techniques. While traditional cage farming relied greatly on natural construction materials and natural feeds, modern cage farming utilizes synthetic netting materials, reinforcements, high protein formulated feeds, advanced water and dissolved oxygen management including aerators and compressed air, automatic and demand feeders, automatic harvesters and carefully executed husbandry and management practices. Cage farming also can be grouped into extensive, semi-intensive and intensive, depending on the degree of stocking and nature of feeding.

**Global Status**

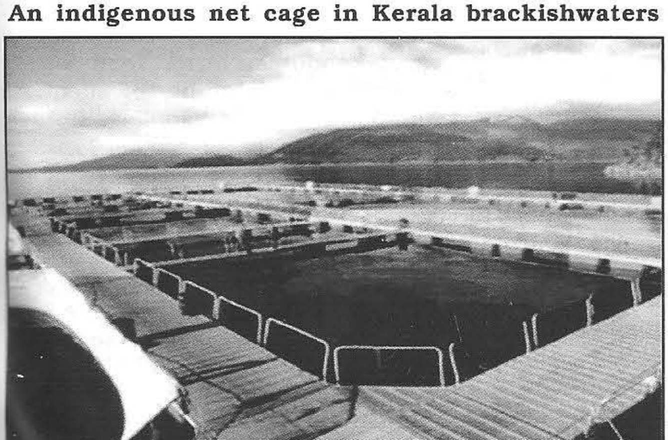
Global aquaculture production of food fish totalled 35.6 million metric tons, of which Asian farmers contributed to 89 % of the production. Production from open sea farming has been growing at a fast rate from 32 %



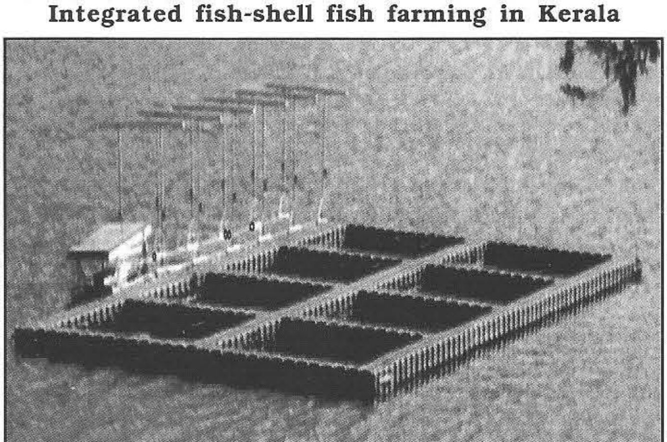
**An indigenous net cage in Kerala brackishwaters**



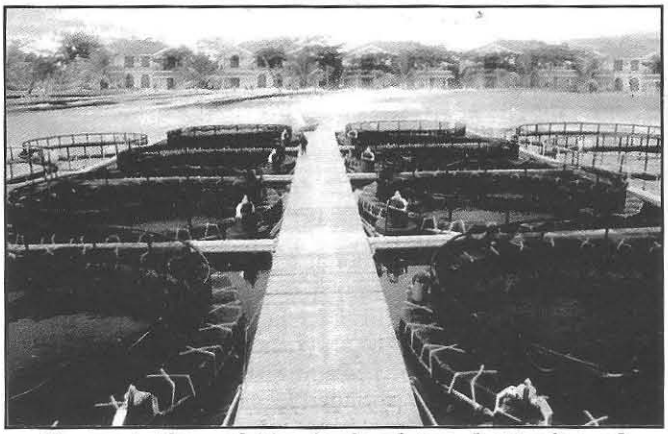
**Integrated fish-shell fish farming in Kerala**



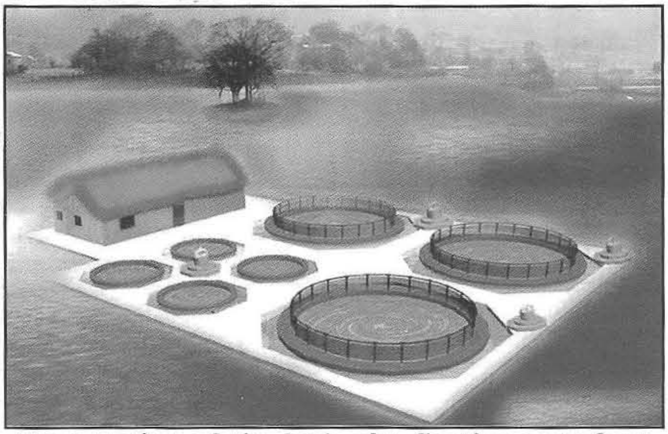
**A modern cage farm with walkway**



**A floating open sea cage farm**



**Presentation of the look of two batteries of Round floating cages**



**Presentation of the look of a floating cage farm complex with overstay shed**

in 1991 to 36% in 2000. Because of their higher values, sea farmed fish have earned a total global value of over 50 % of all farmed fish. In 2000, about 81 % of sea farmed fish came from Asia and 11 % from Europe. This indicates the lead the Asian countries have made in this sector. In marine and brackishwater areas, the most productive continent was Asia producing about 12. 2 million tons. The top ranking country was China, producing over 9.4 million tons through brackishwater and marine farming, followed by Japan (0.7), Norway (0.5), Thailand(0.4), Indonesia 0.4), Chile (0.4), Egypt (0.3), Korea (0.3), Spain (0.3), and the Philippines (0.3). The annual rate of growth of sea farming has been the highest in the marine sector (12.6%) during 1991-2000. Global production by cage farming has shown very rapid increases in some countries, for example, in Norway production of salmon doubled from 47,420 t in 1997 to 80,370 t in 1998. Southeast Asian countries have also made impressive strides in cage farming of a variety of marine food fishes. Beveridge ( 2004) states that production from marine and diadromous fishes from culture is around 1 million tons per annum, of which about 800,000 tons are derived from cages.

### Species Farmed

Around the world about 130 species of finfish and a dozen species of crustaceans are cage farmed presently. There has been a rapid increase in their number in recent years as the practice of cage farming is extending to newer areas as well as fresh candidate species. Mostly high value carnivorous fishes such as Salmon in Norway and Scotland, Snappers, yellowfin bream, black bream and tunas in Australia and Japan, Sea bass, groupers and snappers in Malaysia , Shellfishes like mud crab, lobsters and the black tiger prawn in Philippines are the best examples of cage farming. The yellowtail, tuna and salmon farming industries are almost exclusively cage based. Recent developments include cage farming of some unconventional species like tuna, eels and even shrimps. A few hundred tons of penaeid shrimps are currently produced in Singapore, Thailand and China and lobsters in Vietnam and probably in the near future in Australia.

In India, cage farming has been a recent phenomenon. Maintaining grouper broodstock in net cages in the Gulf of Mannar by CMFRI has been one of the pioneering attempts. Sea bass was experimentally cage farmed in Valinokkam Bay near Tuticorin by CMFRI. In Ashtamudi Lake integrated farming of bivalves with food fish *Etroplus* was tried in fixed net cages by CMFRI . Some trials are going on at NIOT for cage farming of finfishes. Capture based mariculture in India has other dimensions. A good deal of wild seed is used in many shrimp farms along the east coast of India for pond culture of shrimps, although in the strict sense, it does not fall under cage farming. Similarly, wild seed is the only source in mariculture of green mussels and oysters in India, the annual production of which has exceeded 4,000 tons now. Semiculture of Milkfish is another activity where the seed comes entirely from the wild. In recent years, fattening of lobsters and crabs has become a popular activity along the south east and south west coasts of India where cages of various materials are used. In the Andamans, large quantities of finfishes especially the Groupers are collected from the wild and fattened in cages as an activity of the live fish trade. Details of quantities produced by this activity are not available. James (2000) has stated that 200 tons of groupers are farm produced from India, but the author is not aware of any organized cage farming of finfish in India except that some wild caught Groupers are traded live from the Andamans. There is some organized cage fattening of lobsters and crabs along the south east and south west coast of India, although these practices are resource unfriendly and unsustainable.

### Cage Farming : The Future for India

***Potential Sites:*** Site selection for cage farming has to be carried out with a lot of care. Factors to be considered include the type of species to be farmed, the water characteristics, annual variabilities in their physical and chemical properties, type and nature of bottom, sediments, wind and wave action, tidal and ocean current influences, land drainage, sewerage, agricultural and industrial run off including industrial pollution, toxic algal blooms, faecal coliforms in water bodies, other food safety concerns, availability of adequate infrastructure for handling, storage, transport, processing, other logistics, social and community concerns, risks including those from weather, calamities and poaching, local water usages, traditional rights, common property resource utilization patterns, future usages and plans for local areas and several others.

The Indian coast offers many ideal locations for cage farming. Potential sites include bays in Ratnagiri, Goa, Karwar, Palk Bay, Larsons Bay, Gulf of Mannar, Lakshadweep Islands, Andaman & Nicobar Islands. The CMFRI has undertaken a project to identify and characterize potential mariculture sites in a GIS platform in order to prepare a road map for future development on a knowledge based water body utilization plan. The results of this study will be forthcoming by the end of 2005. Since this is a new activity for the Indian fish farmers and entrepreneurs, there is a great need to have a demonstration facility depicting the various technologies, practices and options available to our people so that private investment into this area can be attracted for further growth and development.

***Potential Species:*** Species selection for cage culture must be done with great care. Suitability of the species will depend on several factors which include the biological characteristics, seed availability, robustness, survivability, feeding habits, growth rates, suitability for live fish trade, value addition and niche marketability including live fish export trade, handling ease, and overall market demand and price which could be realized in relation to wild catch.

The potential Indian species include Groupers (of the genus *Epinephelus*), Snappers (of the genus *Lutjanus*), Sea bass (*Lates calcarifer*), Rabbit fish (of the genus *Siganus*), Cobia (*Rachycentron canadum*), Horse mackerel (of the genus *Megalaspis*), skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), Lobsters (of the genus *Panulirus*), Crabs (of the genus *Portunus*), Shrimps (of the genus *Penaeus*), Edible Oysters (*Crassostrea*), Mussels (*Perna*), Pearl oysters (*Pinctada*) and Seaweeds (various species).

***Design of Cages:*** Various types of cages are used for open sea cage farming, the type and size mostly depending on the local conditions, needs, species cultured and investments envisaged. Cages from less than a meter in size (for crabs and lobsters) to hectares in area are used (for example for Tuna). Various types of materials are also used from locally available plant and tree materials to nylon, steel, stylofoam and HDPE. Beveridge (2004) has given a detailed overview of cage farming and readers may consult his book *Cage Aquaculture* (Blackwell Publishing) for details. Under Indian conditions, investment levels, compatibility, environmental concerns, reusability, species used, are all factors which need to be considered especially, as cage farming is a new type of activity and costs and benefits are yet to be demonstrated. Therefore, it is important to keep the investment levels as low as possible at least in the initial stages. Since technical expertise on the entire spectrum of cage farming is not fully available in the country, setting up of demonstration farms (floating cages) with technical expertise from south Asian countries would be an option. There are also leading cage/netting manufacturers in India whose expertise and materials could be utilized in developing locally suitable cages for open sea farming depending on local topography, waves, currents and other parameters. A floating cage supported by a buoyant collar or frame is the most widely used and can be designed in a large variety of shapes and sizes . Square / round net mesh cages with floats attached to rigid collars, and the new HOPE cages developed in Malaysia are also suitable.

A self contained overnight stay facility with solar lighting, storage area, etc. is a must in a large cage farm. The floating watch house will be useful in providing security to the structure and stock. The overall robustness of a cage depends on the properties of the construction material, size and profile of the structural members, strength of joints between structural members, degree and distribution of flexibility in joints and members, design and location of mooring points to distribute resultant stresses, logistics and management. Multi-disciplinary and complex issues are involved in the management of a large cage farm. Ensuring optimum yields and minimum losses are prime concerns. Appropriate stocking densities related to the site, species and methods of rearing are key to success of the venture. There is need for supplementary feeding which must be not only cost effective, but easily accessible and storable. The feed must ensure maintaining the best possible water quality within cages. Maintaining cages, moorings, anchors and ancillary gear and regular checking of the stocks for signs of disease, removal of mortalities and treatment of infected fish are all important in ensuring successful operation.

***Seed Supply:*** Providing the right type of seed in adequate quantities is a challenge in open sea cage farming. When large quantities of uniform sized seed of the same species is required for simultaneous stocking, hatchery is the best source. However, technologies for hatchery production of seed are still in the development stage in the case of many species of finfishes, particularly the marine ones. However, technologies for hatchery seed production of seed in the case of Milk fish, Barramundi (*Lates calcarifer*), grouper, and rabbit fish are presently commercialized in many Asian countries and it is possible to supply the required quantities for cage farming. In India, hatchery reared seed of *Lates calcarifer*, swimming crab, marine shrimps, edible and pearl oysters are available for cage farming. Capture based stocking is another option in the initial stages when the requirements are not high. Large seed sources of mullets, milk fish, mud crabs, groupers, etc could be utilized for the present for stocking coastal farms. There are certain apprehensions on dependence on wild seed for stocking as this could lead to depletion of natural recruitment. While these concerns are true in certain cases, it is not so in the case of all stocks. In those species where the natural mortality is high after settlement as juveniles, removal of some quantities for stocking in cages will not result in setbacks in natural recruitment as many of these juveniles if left in the wild will any way die. But in those fishes where the mortality after settlement is low, removal of young fish for stocking in cages will have an adverse impact on the adult stock. Thus there is need to understand basic biology of some of the potential species before advocating capture-based stocking. However, heavy targeting of larval collection of species with specific habitat requirements or seasonally in respect of breeding may also adversely affect the natural stock and therefore should be discouraged.

***Stocking:*** Stocking with seed of appropriate high value species is vital for ensuring profitability. Initial stocking density of many species are fairly high; thinning occurs as the size increases. For example, Grouper fry (2.5 to 7.5 cm) or fingerlings (7.5 to 12 cm) are held in net cages at densities ranging from 100 to 150 individuals / $m^2$. A net cage of 2 x 2 x 2 m would

**Economic analysis of a Grouper Cage Farm with year round operation**

| | | |
|---|---|---|
| I | **Capital investment (cages,boats, cottage, floats,materials etc)** | 26,00,000 |
| II | **Fixed costs (annual)** | |
| | 1. Depreciation @ 20 % | 5,20,000 |
| | 2.Interest @ 10 % | 2,60,000 |
| | **Subtotal** | **7,80,000** |
| III | **Variable costs (annual)** | |
| | 1.wages | 3,50,000 |
| | 2.Fuel | 3,00,000 |
| | 3.Seed | 2,00,000 |
| | 4.Feed | 3,00,000 |
| | 5.Miscellaneous | 1,50,000 |
| | **Subtotal** | **13,00,000** |
| IV | **Total Costs** | **20,80,000** |
| V | **Yield and Revenue** | |
| | 1.Production/annual | 18 tons |
| | 2.Revenue @ Rs.200/kg | 36,00,000 |
| VI | Net Profit (V2 - IV) | 15, 20,000 |
| VII | Rate of return | 68.5 % |
| VIII | Pay back period | 1.3 years |
| IX | Break even Price | Rs. 115.16 |

*(Note: Economics vary widely depending on species grown and market price of farmed live fish. Cages are expected to last for 5 years under normal sea conditions)*

hold 500 to 600 fingerlings. Sorting takes place every week and when the size is about 16 cm, they are transferred to net cages of 5 x 5 x 5 m size at the rate of 1100 fish per cage. In the grow out cage the optimum stocking density is 120 fish per m$^2$. Marketable size is about 600 to 800 g although the fish can grow to 1 kg in 18 months and 2 kg in 24 months. In a normal culture system, the stocking density in the grow out net is about 120 / m$^3$ and the grow out period is about 8 months.

***Feeding and Feed Management:*** The kind of feed to be used for feeding of cage farmed fish mostly depends on the species as well as local availability of feed materials. For example, fry and fingerlings of Groupers are mostly fed with mysids, shrimps etc while trash fish forms the main feed in the nursery and grow out systems. In recent times, this type of feed is being replaced by moist pelleted feed.

Feeding is also related to the type of farming system. Extensive farming systems depend on natural feed such as plankton, seston while in semi intensive farming a mixture of natural feeding and formulated semi intensive feeds are used. These feeds are made from low cost locally available materials (See reviews by De Silva and Anderson, 1995; Jauncey, 2000) . Intensive farming system use intensive feeds such as trash fish, moist feeds and dry feeds. Amongst these, the dry feeds have great advantages as they are more stable in water, less polluting, readily eaten and have better storage qualities and longer shelf life. Floating, semi floating and sinking pelleted feeds are now available for various types of fishes.

Generally, feeding levels are about 5 % of body weight. Many fishes have distinct feeding habits and these should be well understood so as to reduce wastage and improve effective utilization of feed. In modern cage farms, both automatic and demand feeders are used. Feeding behaviour of fish also must be well understood. For example, Groupers will not feed on anything which has fallen to the bottom of the cages. Therefore, in order to fully utilize such leftovers, sea breams are grown along with those which act as scavengers. In cage farming feed costs are very high and it is important to reduce the costs to the minimum to ensure better returns, especially in carnivorous varieties.

***Husbandry and Management:*** Intensive cage farming calls for adequate and careful husbandry and management. Monitoring of water quality is of prime importance as it helps in avoiding losses due to mortality, maintaining optimum stocking and feeding, evaluating the stress of farmed fish for planning activities such as grading as well as long term site suitability evaluation. Husbandry and management practices include weight / size increment monitoring, feed input quantifications, grading, disease monitoring, removal and disposal of dead fish and overall stress assessment. Preventing disease outbreak by careful monitoring is of utmost importance in intensive cage farming. Modern technology and gadgets are used in advanced cage farming practices.

***Harvesting:*** In intensive cage farms, harvesting is carried out either in batches or continually depending on the production cycles. Fish are starved prior to harvest, duration of which depends on the species and water temperature. Harvesting is carried out *in situ* or by towing the cages to more convenient sites for mechanical harvesting. In some countries in the east, the cages are towed to the market. When the product is expected to be a live fish for trade in the live fish market as is the case with Grouper, Snapper, Sea Bream, the harvested fish is transferred to the holding tanks where they are kept alive and transported to wholesalers. Since the prices realized for live fish are much higher, present day practice in the Indo-China region is to keep the fish alive till final consumption .

**Economics**

A question often asked about open sea cage farming is on its economic feasibility. No doubt, intensive open sea cage farming is a capital intensive activity. But then, the species selection, feeding and value addition and marketing are important to realize the best returns from the business. All the species that are cage farmed are targeted at export or niche markets. Live fish and shellfish command very high prices in the international market and these must be realized from the cage farmed fish. A rough cost analysis for a cage farm for Groupers indicates an investment of Rs. 26 lakhs as capital investment in the form of 20 cages of 4m x 4m x 3m size along with overnight hut, boats and equipments, a working capital of Rs.13 lakhs per annum as variable costs, which include wages of Rs.3.5 lakhs, fuel *etc.* of Rs. 3 lakhs, fish seed of Rs. 2 lakhs, feed of Rs. 3 lakhs, and others (including lease charges) 1.5 lakhs. The projected annual production is about 18,000 kg with an average farm gate price of Rs. 36,000,00. (@ Rs. 200 ( US$ 4.00 per kg of live fish). Seed of some high value items like lobsters command higher prices, with a potential to realize a high farm gate price of over Rs.500 per kg. International farm gate prices of some of the commonly farmed fish / shellfish are: Groupers US $ 14 to 18 per kg, Coral trout US $ 25 to 29 per kg, Snappers, US $ 6 to 10 per kg, Pompano US $ 4 to 7 per kg, Rabbit fish US $ 6 to 11 per kg, Mud Crab US $ 6 to 7 per kg, Spiny lobster US $ 23 to 26 per kg, and Banana shrimp US $ 14 to 16 per kg. From the foregoing it is clear that under WTO regime, Indian entrepreneurs have

***(Contd... at page 46)***

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tremendous potential opportunity for realizing the full advantage in the international trading of farmed finfish and shellfish through open sea farming in our seas. It is pertinent to point out here that the price realization is calculated at the rate of US$ 4.00 per kg while the international price is several folds higher. Therefore, the level of profitability depends on the ability to realize a high market price for the produce.

**Research**

The concept of cage farming is an entirely new initiative for India and therefore there is need for quite a bit of R & D in this area. Research is possible only under *in situ* conditions and therefore, the demo farm will provide an opportunity to field test many of the technologies developed as well as to understand issues in operation, husbandry, management, scaling up and commercialization. Site selection, stocking, feeding, grow out, management, disease control, sizing, and harvesting are all to be standardized under commercial scale operations so as to evolve packages of best practices for Indian conditions for various candidate species. Integrated cage farming involving molluscs and seaweeds need also be developed in order to mitigate possible negative impacts and ensure sustainability. Such technologies also must be subsequently field tested. There is also need to understand the basic biology of candidate species and their ecology. The need for research on the early life of these species and population dynamics of the juveniles will help us to make decisions on the capture based stocking of cages without adversely affecting the natural stock. Research to develop techniques for capture and captive rearing of late larval stages of marine fish where the natural mortalities of larvae are high is a potential research opportunity.

"The European Union has proposed to support research in the field of sustainable aquaculture, including technical constraints to it and also economic viability of offshore aquaculture, waste water treatment techniques, alternative protein sources to fish meal and oils, and development of polyculture options" (see Mac Allister *et al*, 1999). Research will focus on all these issues as well as issues emerging during operation including environmental concerns and consumer safety.

**Environmental Impacts**

Sea cage farming presents many concerns in terms of mass escapes, Genetically Modified (GM) fish, spread of diseases, parasite infestation, use of chemicals, contamination of sea bed, bioaccumulation of organochlorine pesticides, conflicts between waterbody users, traditional rights and access and other impacts on environment and sustainability of operations. On the other hand, all cage farming activities are not environmentally unfriendly. The important five flaws of cage farming are wastes, escapes, diseases and parasites, chemicals, feed/food. If adequate care and precautions are taken, these issues could be effectively addressed to a great extent. Issues related to consumer safety also must be effectively addressed. There are also concerns about increased demand for fish meal in the feed industry which is putting pressure on wild fish stock by generating increased demand for (and increased capture of) bycatch. Especially in developing countries, large scale marginalization of small fishers could be a fall out of this phenomenon. Therefore, both environmental sustainability and social / livelihood sustainability should be adequately addressed while promoting cage farming in India.

**Policy**

As of now, India has no policy for open sea cage farming. It is vital that India brings out a national policy guideline for open sea cage farming along with the initiation of farming trials. The policy must cover areas such as water body leasing / ownership rights, protection from poaching, crop insurance, preventing stock escapes and mixing of populations with wild, notification of culture sites and development of a knowledge based master plan for open sea cage farming in coordination with other nodal ministries( Shipping &Surface Transport, Ocean Development, MoEF, MoA etc).

**Future**

The future for cage farming in India offers both opportunities and threats. Entrepreneurship development, commercialization, developing a viable trade for live farmed marine fish, value addition, exports etc. offer great opportunities for development agenda. On the other hand, indiscriminate and unregulated and unscientific proliferation of large cages in the open seas and bays and lagoons could pose many threats from the environmental and common property utilization angles. The increased demand for low value fish and fish meal based formulated feed could be a threat to the dwindling marine capture fisheries. Marginalization of poor fishers could be a fallout of the situation resulting from lack of small pelagics and low value fish for the small-scale fish processing sector. There are many research needs to be addressed on alternate feeds, environmental impacts and consumer food safety.

The CMFRI is in the process of developing a model cage farm for the purpose of demonstrating the technical, environmental, social and economic feasibility to those entrepreneurs who are interested in cage farming. The focus will be high value products suitable for niche markets. The long term objective is to increase nation's mariculture production for export and internal consumption. The lessons learnt from the demonstration project are expected to dovetail into future R&D process in CMFRI and help in preparing project proposals for bankable schemes for entrepreneurs and fish farmers. The project is also looking at policy outputs for the government and field testing of several other indigenous technologies and innovations. Past experience is that unregulated and unscientific development of shrimp farming in India ultimately led to its set back and even collapse in certain areas. The lessons learnt from this should be an eye opener for both development workers and policy advisors. Knowledge based and regulated development based on scientific and technical advice could result in not only sustainability and safety, but also social and economic gains. There is a school of thought that "far from being a panacea for the decline in wild fisheries and the need for healthy food, sea cage farming serves only to compound the current crisis" (Staniford, 2002). India should not face this situation on account of unscientific and unregulated sea cage farming. It is hoped that the nation will be able to fully realize the vast potential available in this untapped sector in the days to come through a carefully planned and scientifically managed regulated sea cage farming activity.