# 2 OPEN SEA CAGE CULTURE OF MARINE FIN FISH AND SHELL FISHES IN INDIA

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## Introduction

Fishing industry is facing a major crisis with fish stocks declining all over the world. The list of depleting fish stocks is getting longer and longer every year. According to the FAO, about 17% of the world's major species and eleven of the 15 major fishing areas are in the process of disappearing. This decline in the world fish supply is the result of over fishing, indiscriminate fishing methods and degradation of coastal and inland ecosystems due to various reasons (FAO, 2010). Fishing and aquaculture supplied the world-wide market with 148 million tonnes of fish in 2010 which rose to 154 million tonnes in 2011 (Rao *et al*. 2013). Marine fisheries, largely practiced as coastal fisheries, is an open access, multi-species, multi-gear regime. Unrestrained expansion of fishing efforts and extensive use of non-selective fishing gears have led to increasing pressure on several groups of fishes. Fish production from marine resources presents more or less a stagnating trend all over the world. Cage farming is an alternative production sector increasingly contributing to the nutritional security of the coastal fisher folk in particular and mankind in general.

Rearing of finfish and shellfish in cages and pens in water-based confinements is an aquaculture technique which is gaining importance world-wide for intensive exploitation of existing, especially large, fresh or brackish water and marine resources. The confined aquaculture systems such as cages, pens or enclosures consist of growing of young fry of finfish or shellfish to a large size, within netting or screening, which allows free circulation of water. Enclosure is a confined bay, where shoreline is typically closed-off by a net or a screen barrier on all but one side. The rearing facility in pen is almost man-made, the sides being covered by bamboo-matting, netting or screening. The bottom in both, enclosures and pens, however, is bound by lake bed. Cage, on the other hand, is enclosed on all sides leaving a small portion at the top for cage operations. However, the terms 'enclosure', 'pen' and 'cage' are virtually synonymous and therefore, they are often together referred to as enclosures.

**Indian fisheries at a glance**

**Rivers**

Inland waters provide a wide range of services to human population, being a basic element in development of agriculture, transport, industry and power generation. It also provides fundamental ecological services, such as those required to support a healthy ecosystem and demand-derived services, such as fish production for fisheries.

There are large numbers of rivers in the country which run into a total length of 45,000 km. These rivers fall under 13 river basins having a total catchment area of 3.12 million $km^2$. There is a large network of perennial rivers, all of which are characterized by very large seasonal variations in their discharge due to seasonal rainfall and prolonged dry periods. The Indian mainland is drained by 15 major (drainage basin >20,000 $km^2$), 45 medium (2,000 to 20,000 $km^2$) and over 102 minor (<2,000 $km^2$) rivers, besides numerous ephemeral streams in the western arid region. These river systems are traditionally grouped, according to their origin, into Himalayan and peninsular rivers, or according to directions of flow into east-flowing and west-flowing rivers. Therefore rivers can be regarded as most suitable place for cage culture of fresh water species such as *Catla catla, Labeo rohita*, *Cirrhinus mrigala, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Cirrhinus chinensis, Ctenopharyngodon idella, Cyprinus carpio*.

**Estuaries**

Estuaries are the transitional zones between the rivers and sea and have specific ecological properties and biological composition. Estuaries offer immense biological wealth characterized by the diversified rich flora and fauna including fisheries. Estuarine water is extremely variable in its salinity, while marine and freshwater have distinctive stable salinities.

The total estuarine water resources of India are estimated to be 1.44 million ha. The state-wise break up (in lakh ha) is as follows: West Bengal, 2.10; Odisha, 4.17; Andhra Pradesh, 0.79; Tamil Nadu, 0.56; Puducherry, 0.01; Kerala, 2.43; Karnataka, 0.08; Goa, 0.12; Maharashtra, 0.10; Gujarat, 3.76, and Andaman and Nicobar, 0.37. The Odisha, West Bengal, Andhra Pradesh, Gujarat and Kerala have rich estuarine resources. The major estuaries, viz. Hooghly – Matlah, Mahanadi, Godavari, Krishna, Cauvery, Vellar and brackish water lakes of Chilka and Pulicat on east coast and the estuaries of Narmada, Tapi, Mahi, Mandovi – Zuari and back waters of Kerala and Vembanad lake on west coast are important fishery resources.

In general, estuaries are the most productive natural ecosystems in the world. In estuaries, cage culture is the most viable technique to rear fin fishes. The indigenous technology is developed in cage culture of food fishes in India. There are two general types of cages, floating and stationary. A floating cage is made up of a floating unit from which a single or a series of net cages are suspended. Some of them are mobile and can be easily towed away. A stationary cage on the other hand, is fixed to the poles at their corners. The candidate species for cage culture in estuaries are Mangrove red snapper (*L. argentimaculatus),* Pearl spot *(E. suratensis),* Milk fish *(Chanos chanos),* Seabass *(Lates calcarifer)* and Groupers (*Epinephelus* spp.).

**Marine resource**

Oceans and seas represent over 70% of the earth's surface, and living aquatic resources can provide a significant contribution to food, energy and bio-based products. India is endowed with 8,120 km long coast line including islands, 0.53 million $km^2$ of continental shelf and 2.02 million $km^2$ of Exclusive Economic Zone, which is roughly 60% of India's land area. To harness the marine resource in India, open sea cage culture has been playing a pivotal role in meeting the demands of fish in near future.

| **1. Indian Fisheries** | | |
|---|---|---|
| Global position | : | 3rd in Fisheries, 2nd in Aquaculture |
| Contribution of Fisheries to GDP (%) | : | 1.07 |
| Contribution to Agril. GDP (%) | : | 5.30 |
| Per capita fish availability (Kg.) | : | 9.0 |
| Employment in sector (million) | : | 14.0 |

| **2. Resources** | | |
|---|---|---|
| Coastline | : | 8129 kms |
| Exclusive Economic Zone | : | 2.02 million sq. km |
| Continental Shelf | : | 0.506 million sq. km |
| Rivers and Canals | : | 1,97,024 km |
| Reservoirs | : | 3.15 million ha |
| Ponds and Tanks | : | 2.35 million ha |
| Oxbow lakes and derelict waters | : | 1.3 million ha |
| Brackishwaters | : | 1.24 million ha |
| Estuaries | : | 0.29 million ha |

| **3. Production** | | |
|---|---|---|
| Potential fish production | : | 8.4 mmt |
| Fish seed production (2007-08) | : | 21,000 million fry (24,143 million fry) |
| Hatcheries | : | 1,070 |
| FFDA | : | 422 |
| BFDA | : | 39 |
| No. of landing centres | : | 1522 |

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|---|---|---|
| (CMFRI: Marine Fisheries Cenus, 2010) | | |
| No.of fishing villages | : | 3299 |
| (CMFRI: Marine Fisheries Cenus, 2010) | | |
| Export of marine products from India (2012-13) | : | 928215 (Quantity MT) |
| | | 18,856 ( Value in Rs. Crores ) |

**History of Cage culture**

Cage culture possibly first originated nearly 200 years (1800) ago in Southeast Asia, particularly in the freshwater lakes and river systems of Kampuchea (Cambodia), where fishermen used to keep *Clarias* sp. and some other fishes in bamboo-made cages in the basements of floating dwellings, primarily for holding and marketing them later. Brackishwater and marine cage farming is relatively new in Asia, having first been developed in Japan for marine cage culture for species such as the Japanese amberjack or yellowtail (*Seriola quinqueradiata*) and red seabream (*Pagrus major*) and developed into a significant industry as early as 1960. Since 1970, Thailand has developed cage culture techniques for sea bream (*Pagrus major)*, and grouper (*Epinephelus* spp.) (Rao *et al.* 2013). Large scale cage farming of groupers were established in Malaysia in 1980. Korea started cage culture in the late 1970s and by the end of 1980, cage culture of the olive flounder (*Paralichthys olivaceus)* and black rockfish (*Sebastes schlegeli)* was established and developed into a successful industry in the 1990s. Cage culture of groupers (*Epinephelus* spp.) in the Philippines has been practiced since 1980s and mariculture of milkfish (*Chanos chanos)* in the late 1990s led to further growth and development of the industry. China is also a leading country in cage culture. In Europe, cage culture of rainbow trout (*Oncorhynchus mykiss)* in freshwater began in the late 1950s and in Norway, culture of Atlantic salmon *Salmo solar* followed in the 1960s.

CMFRI initiated open sea cage farming as an R & D programme during 2006-07 with support from the Ministry of Agriculture, Govt. of India. Further impetus was given by the participation of National Fisheries Development Board (NFDB), Hyderabad in the demonstration of open sea cage farming at different places along Indian coastline.

**Selection of species for cage culture**

Fish culture in enclosures is practiced by 62 countries all over the world and currently 80 species of finfish are being cultured in cages. The dominant being Salmonids followed by Japanese amberjack, Red sea bream, Yellow croaker, European seabass, Chinese carps, Perches, Tilapia etc..

The choice of species depends, to a large extent, on availability of fish seed and market demand. However, the main desirable characteristics of the candidate species for enclosure/cage aquaculture are their potential for fast growth in fingerlings and grow out phases, high survival, capacity to withstand overcrowding, rapid adaptation to artificial feeds, high-feed conversion rate, quality flesh and resistance to diseases and bacterial infections. The Indian and Chinese carps (*Catla catla, Labeo rohita, L. calbasu, L. bata, Cirrihinus mrigala, Cyprinus carpio, Hypophthalmichthys molitrix and Ctenopharyngodon idella*), air-breathing catfishes, (*Clarias batrachus* and *Heteropneustes fossilis*), climbing perch (*Anabas testudineus),* tilapia (*Oreochromis mossambicus)*, Snakeheads *(Channa striatus* and *Channa marulius*) and freshwater prawns (*Macrobrachium rosenbergii* and *M. malcomsonii*) are cultured in freshwaters in India. However, there are many other cultivable species, the most important being, other catfishes (*Ompok* spp. *Mystus* spp., and *Pangasius* sp.), perches, and feather backs. Certain brackish water fishes like *Etroplus suratensis, Lates calcarifer, Mugil cephalus,* and *Chanos chanos* and marine species, viz. cobia (*Rachycentron canadum),* Pompano, *Trachinotus blochi,* Mud crab (*Scylla tranquebarica)* and Lobster (*Panulirus homarus, Panulirus polyphagus),* are being cultured in marine ecosystem currently. However, other fishes like groupers (*Epinephelus malabaricus, E. tauvina*, and *Cephalopholis* spp.); rabbit fishes like *Siganus* spp., Mangrove red snapper, viz. *Lutjanus argentimaculatus* and *L. lutjanus,* could be acclimatized and adopted for their culture in enclosures.

***Etroplus suratensis***

***Trachinotus blochi***

***Lates calcarifer***

***Rachycentron canadum***

***Acanthopagrus latus***

***Mugil cephalus***

*Panilurus polyphagus*

**Stocking density**

Although stocking densities should be determined by species requirements and operational considerations, the influence of stocking densities on growth and production has been determined empirically. The number of fishes that can be stocked in cage or pen is variable and depends on carrying capacity of the water (water-spread area, depth and water quality), water exchange, species of fishes and quantity and quality of supplemental feed input. To get optimum fish production from cages and pens, the stock needs to be provided with conditions which minimize losses and promote growth. This involves (i) stocking at densities appropriate to the site/size of the fish and methods of rearing, (ii) feeding fish in the most cost effective manner, (ii) ensuring best possible water quality within cages, (iv) maintaining cages, anchors and auxiliary gear in proper condition, and (v) regular checking of stock for disease, removal of dead fish and treatment of infected fishes. Samples of fish should be taken at regular intervals and weighed so that growth of stocks can be monitored.

**Food and feeding requirements**

The feed should contain a full complement of proteins (including essential amino acids), fats and carbohydrates as energy sources as well as non-energy sources, like vitamins,

minerals, etc. Compounded diets may be prepared by balancing feed ingredients so that they would yield desired level of proteins, carbohydrates, and fats. About 70% of the energy is used for metabolism and 30% is converted to fish flesh. Protein is the costly factor in feed formulations. The requirement of protein may vary from 24 to 50% of diet according to species and stage of its life-cycle. Excessive amount of protein supplied to fish is used more as energy source than growth. Adequate supply of digestible carbohydrates and liquid fats (with long chain fatty acid-poly unsaturated fatty acids-PUFA) would reduce cost of feed and at the same time carbohydrates would supply up to 20% of the available calories in the ration and fat up to 30%. This will spare protein since less protein would be used for energy and would be converted into fish flesh. Fats may be added at 5to 10% and carbohydrates at 15-25% to diet.

Feed is supplied to grow-out fishes at 5% body weight, at which highest growth rates have been observed in many of the cultured species. Feeding more than twice a day and supplying food in excess of 5% of body weight results in wastage of feed and proves uneconomical. Feed is best supplied *ad lib*. based on quantity of feed consumed by fish within 10 min. of itssupply. Feed formulations are fortified with adequate quantities of vitamins, minerals and growth-promoting substances, together to an extent of 0.1%.

**Harvest**

Harvest of fish or lobsters in cages is made very easy compared to that in ponds. Cages can be towed to a convenient place and harvest can be carried out. Also based on demand, partial or full harvest can be done.

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