

Development of Sea Cage Farming in India: ICAR-CMFRI Research Initiative Towards Mariculture Sustainability



**ICAR-Central Marine Fisheries Research Institute
Visakhapatnam Regional Centre**
Ocean View Layout, Pandurangapuram
Andhra University P.O., Visakhapatnam – 530003
Andhra Pradesh

Research-Driven Cage Farming for Sustainable Mariculture in India

Introduction

Globally, the cage aquaculture sector has grown very rapidly during the past few decades and presently undergoing rapid changes in response to pressures from globalization and growing demand for aquatic products in both developing and developed countries. Sea cage farming is an important aquaculture technology that enables fish production in coastal and offshore waters using floating cages. It addresses several challenges faced by traditional inland and coastal aquaculture systems. Understanding the importance, sea cage farming research in India began as a research and demonstration project in 2005, spearheaded by the ICAR-Central Marine Fisheries Research Institute (CMFRI). Initial open sea cage farming project was initiated for four locations (Diu, Ratnagiri, Mandapam and Visakhapatnam) and was funded by Ministry of Agriculture, Government of India to the ICAR- Central Marine Fisheries Research Institute (CMFRI). The first successful open-sea cage culture in 2007 was from Visakhapatnam, wherein seabass was successfully harvested from HDPE cages of 15 m diameter. The successful deployment of the first open-sea fish cage in the Bay of Bengal off the Visakhapatnam coast marked a significant milestone in Indian mariculture. The development of this technology has been a progressive journey, with continuous refinements to adapt cage systems to India's diverse and often challenging coastal environments.

Key milestones in the evolution of open-sea cage farming in India

Initiation of open-sea cage research: (Year – 2005)

Recognizing the need to enhance marine fish production and create alternative livelihood opportunities for coastal communities, the Government of India, through the Ministry of Agriculture, initiated research and development programmes on open-sea cage farming.

First successful open-sea cage deployment and harvest: (Year –2007)

Owing to the challenging sea conditions, the initial cage design deployed at Visakhapatnam coast had remained operational for only 45 days. Based on the lessons learned, a second-generation cage was developed in collaboration with marine engineering and naval diving experts and deployed in December 2007. A robust 15-metre High-Density Polyethylene (HDPE) cage was redesigned and deployed in the Bay of Bengal. This improved design successfully completed a culture cycle by April 2008 under low stocking density conditions, achieving a recovery rate of 75%, with harvested fish weighing between 300 and 1,200 g. The improved cage successfully withstood the prevailing sea conditions and resulted in India's first successful harvest of cage-farmed marine fish, laying the foundation for the country's open-sea mariculture sector. However, the structure could not be stabilised for long time, and observed with operational difficulties. The experience led for development of next version of cage model. The experience of large dia cage including operation cost, and operation difficulties and end user necessitated for need of smaller size cage for Indian condition.

Evolution of present sea cage designs: (Year - 2008-2015)

To address the challenges posed by harsh and unpredictable monsoon conditions in Indian coastal waters, CMFRI, in collaboration with IIT Kharagpur, undertook a series

of engineering improvements to design better mooring systems. Thereafter, several generations of cage designs were developed and tested during this period, resulting in the standardization of smaller, robust 6-m dia cages. These designs were more resilient to rough sea conditions, cost-effective, and better suited for adoption by individual farmers and self-help groups. Specifications of cage designed suitable for Indian conditions includes: Circular floating cages of 6.0 m inner diameter and 8.0 m outer diameter with 4.0 m net depth (water holding depth) were used for the experiment. The estimated volume of each floating cage unit was 100 m³. The high-density polyethylene (HDPE) pipes of Pressure Nominal (PN)-10 and Polyethylene (PE) 100-grade quality are used for the fabrication of the floating cages. HDPE nets are used for better strength; inner fish-holding vertical hanging net, outer predator-protection vertical hanging net and a horizontal surface bird-protection net. A 40 mm mesh size is used in the outer net for the complete culture period, whereas two different mesh sizes were used in the inner net at different growth periods. A mesh size of 15 mm can be used for initial two months of culture, and then a 25 mm mesh can be until the fish harvest. The individual floating cage structure is stabilized in the sea with the help of a single-point mooring system, which is supported by 1.5-tonne capacity concrete cement blocks and a mooring chain (long linked alloy steel of 13 mm diameter with 22 tonnes shearing strength). The cage can be deployed up to 15 m water depth, and chain length of double the water depth recommended for better stability.



Initiation of commercial sea cage farming dissemination: (Year –2011)

The technology standardised at ICAR-CMFRI, Visakhapatnam led for technology demonstration of open-sea cage farming, which gained momentum with large-scale demonstrations in different coastal states like, Tamil Nadu, Kerala, Karnataka, and Odisha. All the cage farm demonstration was undertaken with the support of the National Fisheries Development Board. Also, at the beginning of the demonstration, the Rajiv Gandhi Centre for Aquaculture (RGCA) played a key role in promoting commercial cage farming by focusing on high-value marine finfish species, particularly cobia and Asian seabass. These initiatives demonstrated the economic viability of sea cage aquaculture and encouraged wider adoption among coastal farming communities.

The first substantial seabass harvest from cages was achieved in 2009 from Balasore in Odisha & from Kovalam, Chennai, Tamil Nadu during August, 2010. Both the trials were successfully yielded over two tonnes Asian seabass (*Lates calcarifer*), and there after cage culture demonstrations for both finfishes (seabass, snappers, pearl spot and mullets) and shellfishes (lobsters) were carried out, mostly with wild caught seeds at multiple locations across most maritime states of the country (Srikakulam and Kakinada in Andhra Pradesh; Chennai, Kanyakumari and Rameswaram in Tamil Nadu; Vizhinjam and Kochi in Kerala; Karwar and Mangalore in Karnataka; Mumbai in Maharashtra and Veraval in Gujarat). However, subsequently for few years, cage farming failed to achieve its true potential because of several issues, most important of which was non-availability of adequate number of quality seed for stocking.

Cage farming technology development demonstration with candidate species of CMFRI: (Year - 2015-2025)

Understanding importance of marine finfish seed requirement for increasing mariculture production, different ICAR institutions-initiated research on marine finfish breeding and seed production. Central Marine Fisheries Research Institute (CMFRI) and Central Brackish Water Aquaculture (CIBA) under Indian Council of Agricultural Research (ICAR) have together achieved breeding for more than a dozen of marine and brackish water finfish species. Among which, at present half a dozen of finfish namely Asian seabass (*Lates calcarifer*), pearl spot (*Etroplus suratensis*), Cobia(*Rachycentron canadum*), Orange-spotted grouper (*Epinephelus coioides*), Silver pompano(*Trachinotus blochii*), Indian pompano(*T. mookalee*) have been introduced for farming in different farming systems due to their culture suitability, and ease of dissemination and operations with the available developed technologies.

Successful development of seed production technology on orange spotted grouper, and Indian pompano by Visakhapatnam regional Centre of CMFRI, led for cage farming technology development for the species. Captive breeding, and large-scale seed production technology for the species were standardized under All India Network Project on Mariculture by ICAR, during the period 2015-18. Thereafter, marine cage culture technology for the species was subsequently developed and standardized. Later, the cage culture technology of the species was demonstrated among different stakeholders including, fishermen, fisheries societies and small entrepreneurs with financial support from National Fisheries Development Board (NFDB), Government of India under Blue Revolution scheme (BRS) and Pradhan Mantri Matsya sampada Yojana (PMMSY) in different states.

Sea cage farming technology for Orange spotted grouper: (Year - 2017-2020)

The orange-spotted grouper is an economically important marine finfish species with significant potential for cage aquaculture. Owing to its adaptability and high market demand, a standardized marine cage farming technology was developed to facilitate its adoption among fish farmers and other stakeholders. The culture protocol was developed using circular High-Density Polyethylene (HDPE) cages measuring 6 m in diameter with a water depth of 4 m. Suitable farming sites are characterized by water temperatures ranging from 26–33°C, water depths of 6–10 m, and current velocities between 0.5 and 1.0 m/s. Fingerlings of approximately 20–25 g body weight (about 10 cm in length) are considered the optimum size for stocking, as they provide better survival and growth performance. A stocking density of 25 fish/m³ is

recommended, corresponding to approximately 2,750 fish per cage. As a demersal species, orange-spotted grouper generally occupies the bottom region of the cage. Therefore, a net depth of 2 m is maintained during the initial culture phase to improve feed visibility and acceptance. Once the fish attain a body weight of around 250 g, the net depth is increased to 4 m to provide additional rearing space. Feeding is based on a combination of nutritionally balanced floating pelleted feed (containing approximately 40% crude protein and 10% crude fat) and chopped low-value fish. Mixed feeding helps improve growth performance and minimizes size variation within the stock. Under this regime, low-value fish are supplied at 5–7% of fish body weight, while the quantity of artificial feed is reduced by about 50%, resulting in an effective feeding rate of 1–3% of body weight. Feeding is carried out twice daily. Under the recommended culture conditions, fish stocked at 25 fish/m³ can attain an average harvest weight of approximately 1.0 kg (around 40 cm in length) within 12 months, with an expected survival rate of about 80%.

The technology is capable of producing nearly 2.0 tonnes of marketable fish per cage, with feed conversion ratios (FCR) of approximately 1.6 when using artificial feed and 1.5 when using low-value fish-based feeding. Economic analysis indicates that marine cage farming of orange-spotted grouper can generate a profit of about 70 per kilogram of fish produced, with an estimated production cost of 210/kg and a market price of around 280/kg. When implemented as a cluster of 10 cages, the technology has the potential to generate a net profit of approximately 1.4 lakh per cage per production cycle, making it a commercially viable option for coastal aquaculture enterprises.



Sea cage farming technology for Indian pompano: (Year - 2017-2025)

Indian pompano (*Trachinotus mookalee*) is considered an ideal candidate for marine cage farming because of its excellent culture characteristics, including tolerance to a wide range of salinities, rapid growth, attractive appearance, superior flesh quality, and high consumer demand. To promote its adoption among stakeholders, a standardized marine cage farming technology was developed and validated. The technology utilizes circular High-Density Polyethylene (HDPE) cages of 6 m diameter with a water depth of 4 m. Suitable farming sites should have water temperatures ranging from 26–30°C, water depths of 6–10 m, and current velocities between 0.5 and 1.0 m/s. Fingerlings of 12–13 cm length (20–50 g body weight) are recommended for stocking, as this size ensures better survival and growth performance. Seed transportation can be carried out in either open or closed containers with adequate oxygen support. An optimum stocking density of 25 fish per cubic metre is recommended, corresponding to approximately 2,750 fish per cage. Indian pompano readily accepts formulated feeds. During the nursery and early grow-out phase, fish should be fed a diet containing 45% crude protein and 10% crude fat at 5–8% of body weight, divided into four feedings per day, until they attain a weight of 60–75 g. Thereafter, a feed containing 40% crude protein and 10% crude fat may be provided

2–3 times daily at 1.5–5% of body weight until harvest. To maintain adequate cage volume and swimming space for this fast-swimming species, the inner net should be fitted with ballast pipes at both the middle and bottom sections. This prevents net deformation caused by water currents and ensures sufficient space for fish movement. Under these optimized culture conditions, fingerlings weighing about 25 g (10 cm) stocked at 25 fish/m³ can attain an average harvest weight of approximately 0.8 kg (40 cm) within 10 months, with a survival rate of around 80%.

The established system is capable of producing an average yield of 2 tonnes of fish per cage, with a feed conversion ratio (FCR) of approximately 2:1. Economic analysis indicates that the technology is highly profitable. With an estimated production cost of about 260 per kg and a market price of approximately 350 per kg, farmers can realize a profit margin of around 90 per kg of fish produced. When implemented as a cluster of ten cages, the technology can generate a net profit of nearly 1.8 lakh per cage per production cycle, demonstrating its potential as a viable and sustainable mariculture enterprise.



Sea cage farming technology disseminations

Following the successful large-scale seed production of Indian pompano (*Trachinotus mookalee*) and orange-spotted grouper (*Epinephelus coioides*), sea cage farming technologies for these species were disseminated under the Blue Revolution Scheme across various coastal districts of Andhra Pradesh. A total of 30 sea cages were established for Indian pompano farming in the Visakhapatnam and East Godavari districts. Similarly, the technology was extended to Odisha through the demonstration of 30 sea cages in the Balasore district. These demonstrations generated considerable interest among beneficiaries and encouraged their participation in marine cage farming activities. However, the adoption and expansion of cage farming have not progressed as anticipated due to several constraints, including the non-availability of quality seed at the required time, inadequate jetty and landing infrastructure in many coastal locations, difficulties in accessing offshore farming sites, adverse climatic conditions, and policy-related challenges. These factors have collectively limited the wider uptake and commercialization of the technology among stakeholders.

Large diameter cage – Research initiatives : (Year - 2022-2026)

The Indian marine cage farming programme led by the ICAR-Central Marine Fisheries Research Institute initially focused on 6 m and 3 m HDPE cages suitable for artisanal and small-scale farmers. However, with the expansion of marine aquaculture, larger-volume cages are increasingly being explored for commercial-scale farming of species such as Indian pompano and Cobia in offshore waters, where greater carrying capacity and improved production efficiency can be achieved. To address this need, a study was initiated to develop a robust, large-diameter sea cage capable of enhancing fish production. A low-cost 15 m diameter cage was designed using HDPE frame components similar to those employed in the standard 6 m diameter cages, with specific modifications to improve performance under open-sea conditions. Several design refinements were evaluated on a trial basis, including optimization of the mooring system and modifications to the diameter of the base pipes to enhance cage stability. Further improvements in the ballast pipe configuration significantly reduced fish mortality and improved survival during grow-out operations. Following a series of iterative modifications, the optimized cage structure, equipped with a single-point mooring system, demonstrated excellent suitability for farming in rough sea environments and remained stable under wind speeds of up to 70 km/h. Farming trials with Indian pompano in the large-diameter cages indicated substantial potential for increasing fish production and farm productivity. The adoption of such larger cages is expected to improve production efficiency and generate higher economic returns for marine fish farmers.

Way forward

Open sea cage farming has emerged as one of the most promising avenues for increasing India's marine fish production, reducing pressure on capture fisheries, and enhancing coastal livelihoods. With proven technologies developed by the ICAR-Central Marine Fisheries Research Institute and support under government schemes such as PMMSY, the sector is poised for significant expansion. India has the potential to transform open sea cage farming into a major pillar of the Blue Economy. By combining scientific site selection, quality seed supply, advanced cage technologies, digital monitoring, and strong market support, marine cage farming can evolve from a supplementary livelihood activity into a large-scale, sustainable seafood production sector capable of generating employment, exports, and nutritional security.





ADDRESS FOR COMMUNICATION

The Director

ICAR- Central Marine Fisheries Research Institute
Post Box No. 1603; Ernakulam North P.O.
Cochin - 682018; Kerala
Phone : 0484 2394357, 2391407, 2394867,
Fax: 0091 - 0484-2394909
E-mail: director.cmfri@icar.gov.in

Published by:

Dr. Grinson George

Director

ICAR- Central Marine Fisheries Research Institute
Post Box No. 1603; Ernakulam North P.O.
Kochi - 682018; Kerala
Phone: 0484 2394357, 2391407, 2394867,
Fax: 0091 - 0484-2394909
E-mail: director.cmfri@icar.gov.in

Prepared by:

**Sekar Megarajan, Ritesh Ranjan, Biji Xavier,
Joe K. Kizhakudan, Jayasree Loka,
Raju Baitha, R D Suresh**

Visakhapatnam Regional Centre of ICAR-CMFRI, Visakhapatnam,
Andhra Pradesh - 530003

Telugu Translation:

Jayasree Loka & Ravi K Avadhanula

Publication of Institute Technology Management Unit of CMFRI

Publication Production & Co-ordination, Library

CMFRI Pamphlet Series No: 50/2026

