

## Marine Cage Farming

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Sea cage culture is the farming of fish in floating net enclosures that permit natural water exchange while providing a controlled rearing environment. Successful production depends on appropriate cage design, durable construction materials, efficient mooring systems, and sound management practices. Recognizing its potential, CMFRI initiated open-sea cage culture research in 2006–07 and developed indigenous HDPE cages suited to Indian conditions. Subsequent refinements led to economically viable 6 m diameter cages. With an estimated production potential of 3.2 million tons from just 1% of India's inshore waters, sea cage farming offers a promising and sustainable livelihood option for coastal communities.

Sea cage farming offers several advantages over conventional pond-based aquaculture. Cage fabrication is relatively simple, rapid, and cost-effective, while the initial investment required is only about 30–40% of that needed for traditional pond farming. By utilizing natural water bodies such as the open sea, lagoons, and sheltered bays, cage farming eliminates the need for valuable land resources and makes productive use of otherwise underutilized coastal areas. Cage size and location can be modified or expanded with ease, providing greater operational flexibility. Fish harvesting is faster and more efficient, enabling a consistent supply of fresh fish to meet market demand. Additionally, sea cage farming creates alternative livelihood opportunities, generates supplementary income for coastal communities, and supports sustainable aquaculture development with appropriate regulatory approvals.

Grow-out technologies are fundamental to the success of marine cage farming, enabling the efficient rearing of juveniles to market size under controlled conditions. Advances in cage design, stocking density, feeding strategies, health management, and environmental monitoring enhance growth performance, survival, and feed utilization while minimizing disease outbreaks and environmental impacts. These technologies improve production efficiency, product quality, and economic returns, making marine cage farming a reliable and sustainable aquaculture practice. Furthermore, optimized

grow-out systems support the diversification of high-value marine finfish species, reduce fishing pressure on wild stocks, strengthen coastal livelihoods, and contribute significantly to food security and the sustainable development of the blue economy.



### **Site selection for marine cage farming**

Site selection is one of the most critical factors determining the success and sustainability of marine cage farming. An ideal site should provide suitable environmental, biological, and logistical conditions that promote fish growth while minimizing operational risks and environmental impacts. Water quality parameters such as temperature, salinity, dissolved oxygen, pH, and low levels of pollutants should remain within the tolerance limits of the cultured species throughout the production cycle. Adequate water depth and moderate currents are essential to ensure continuous water exchange, maintain oxygen levels, and prevent the accumulation of waste beneath the cages. Sites should be protected from strong waves, storms, and cyclones, while still allowing sufficient water circulation.

The seabed should be stable and free from sensitive habitats such as coral reefs and seagrass beds to reduce ecological impacts. Accessibility to hatcheries, feed suppliers, markets, harbours, and emergency services is important for efficient farm management and reduced operational costs. The site should also have secure navigation routes, minimal conflicts with fishing, tourism, and shipping activities, and comply with local environmental regulations and coastal zone management policies. Regular monitoring of environmental conditions and carrying capacity is necessary to prevent overstocking and

maintain ecosystem health. Careful site selection ultimately enhances fish survival, growth performance, production efficiency, environmental sustainability, and the long-term economic viability of marine cage farming.

### **Design of marine cages for grow out farming**

The design and construction of sea cages are critical determinants of the technical efficiency, durability, and economic viability of marine cage farming. Cage design should be based on the biological and behavioural characteristics of the cultured species. Pelagic fishes, which actively swim near the surface in schools, require larger swimming space and perform better in circular or hexagonal cages that facilitate continuous movement. In contrast, demersal species are relatively sedentary, occupy territories near the bottom, and readily adapt to square or rectangular cages, which also offer advantages in cage assembly and farm management. An effective cage design should be simple, cost-effective, easy to fabricate using locally available materials, structurally strong, and capable of ensuring adequate water exchange while securely retaining fish throughout the culture period.

The cage frame forms the primary structural component and is commonly fabricated using galvanized iron (GI), high-density polyethylene (HDPE), mild steel, or PVC. In India, HDPE PE100 and GI pipes are widely preferred because of their durability, strength, and affordability. Circular HDPE cages provide excellent resistance to wave action and are suitable for commercial-scale farming, whereas epoxy-coated GI cages offer an economical alternative for small-scale farmers. A typical low-cost GI cage consists of a 6 m diameter circular frame supported by airtight fibre barrels that provide buoyancy and a stable working platform for routine operations.

Net cages are generally fabricated from HDPE twine because of its resistance to seawater corrosion, chemicals, and biofouling, ensuring long service life with proper maintenance. Mesh size is selected according to the cultured species and production stage to allow efficient water exchange while preventing fish escape. Ballast pipes fitted along the bottom of the net maintain cage shape and stability.

A reliable mooring system is essential to anchor cages securely and minimize the effects of waves, currents, and wind. The design of the mooring system is site-specific and

depends on environmental conditions, cage type, and operational requirements. Strong anchors, durable mooring lines with high breaking strength, and properly designed connections are necessary to maintain cage stability, reduce structural stress, and safeguard fish stocks during adverse weather conditions.



### **Fish seed selection and stocking**

Stocking healthy fish seed of appropriate size and density is essential for achieving high survival, uniform growth, and optimum production in marine cage farming. Hatchery-produced larvae are generally reared for 30–60 days before being stocked in grow-out cages. Nursery rearing, either in land-based ponds, hapas, or floating nursery cages, is recommended to produce robust and acclimatized fingerlings suitable for sea cage culture. Only healthy, disease-free, and uniform-sized fingerlings should be selected to minimize size variation, reduce competition and cannibalism, and improve overall production performance. Proper stocking practices contribute significantly to efficient feed utilization, better growth, and higher economic returns.

Species selection is a key factor influencing the success and profitability of marine cage farming. The ideal candidate species should be well adapted to marine conditions, exhibit rapid growth, efficient feed conversion, short culture duration, high survival, and resistance to common diseases. In addition, a species should have consistent seed and feed availability and command a high market price to ensure economic viability. In India, several high-value marine species are successfully cultured in sea cages, including cobia, silver pompano, Indian pompano, orange-spotted grouper, Asian seabass, red snapper, and spiny lobster. Selection of suitable species based on local environmental conditions and market demand enhances production efficiency and farm profitability.



### **Food and feeding**

Feed management is one of the most important aspects of marine cage farming, as feed accounts for nearly 60% of the total production cost. Marine finfish require a high-protein diet (35–40%) to achieve optimal growth and efficient feed conversion. Feed pellet size should be adjusted according to fish size, while feeding rates generally decrease from about 10% of body weight in juveniles to around 3% as fish grow. A feed conversion ratio (FCR) of approximately 1:1.2 is considered desirable for efficient production. Feeding should follow recommended rations, as overfeeding results in feed wastage, increased production costs, and deterioration of water quality. Feeding frequency depends on the age and size of the fish, with larvae and fry requiring more frequent feeding than larger

fish. Feed intake is also influenced by water temperature, dissolved oxygen, season, and other environmental conditions. Proper feed management, using either moist or pelleted feeds, enhances growth, improves feed utilization, and minimizes environmental impacts.

Feeding management plays a crucial role in achieving optimum growth, feed efficiency, and profitability in marine cage farming. Feeding rates generally decrease with increasing fish size, from about 10% of body weight in juveniles to 2.5–3% in larger fish. Feeding schedules should be adjusted according to fish size, water quality, temperature, dissolved oxygen, and feeding behaviour. Proper feeding frequency and fixed feeding times improve feed utilization and reduce wastage.

Cobia is a fast-growing species with excellent meat quality and requires a high-protein diet. During nursery rearing, juveniles are fed at 5–10% of body weight using protein-rich diets (about 45% protein and 5% lipid). During cage culture, chopped oil sardine is commonly fed at 6% of biomass per day initially, with the ration reduced by 2% every three months. Feeding is usually carried out twice daily (06:00 and 18:00 h), and an FCR of 1.4–1.8 is commonly achieved.

Asian seabass requires careful feeding during nursery rearing because of cannibalistic

behaviour. Fry are initially fed chopped trash fish several times daily and gradually weaned to formulated feeds containing about 45% protein. During grow-out, fish are fed chopped fish or



sinking pellets twice daily at 10% biomass initially, later reduced to 5% once daily, achieving an FCR of approximately 1.8:1.

Silver pompano, a fast-swimming species, readily accepts floating, sinking, or chopped feeds. Nursery fish are fed 3–4 times daily with high-protein diets (up to 50% protein), while larger fish require lower protein levels (about 30%). Proper feeding management results in an FCR of around 1.8:1.

### Harvesting and marketing

Harvesting is one of the major advantages of marine cage farming, as it is simple, efficient, and less labour-intensive than conventional aquaculture systems. Fish can be harvested

either partially or completely depending on market demand, allowing farmers to maximize returns by supplying



fresh fish continuously. Harvesting is generally initiated when most fish attain marketable size. During harvest, the total number of fish and their combined weight should be recorded to evaluate production performance. Cage-farmed fish are usually marketed through local fish markets or sold directly at the farm gate, where they command premium prices due to their freshness and superior quality.

### Good management practices

Successful marine cage farming requires regular monitoring and effective management to ensure high productivity and environmental sustainability. Cage nets should be inspected frequently to prevent fish escapes, repaired promptly when damaged, and cleaned or replaced periodically to minimize biofouling. Appropriate stocking densities,

high-quality feeds, and optimized feeding practices help reduce stress and improve growth and feed efficiency. Fish growth, health status, and water quality parameters such as temperature, dissolved oxygen, and pH should be monitored regularly. Mooring systems must be inspected to maintain cage stability. Sustainable practices, including cage rotation or fallowing, careful site selection in areas with adequate water flow, environmental monitoring, and the adoption of Integrated Multi-Trophic Aquaculture (IMTA), further enhance production while minimizing ecological impacts.

### **Further reading**

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