Good Aquaculture Practices (GAP) in Sea cage farming of Indian pompano and orange spotted grouper

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Indian Council of Agricultural Research
Central Marine Fisheries Research Institute

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Sekar Megarajan, Ritesh Ranjan, Biji Xavier,
Biswajit Dash, Shubhadeep Ghosh, A. Gopalakrishnan

Visakhapatnam Regional Centre
Central Marine Fisheries Research Institute

Indian Council of Agricultural Research

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Dr. A. Gopalakrishnan
Director
ICAR-Central Marine Fisheries Reasearch Institute
P.B. 1603, Ernakulam North P.O.
Kochi- 682 018, Kerala, India

www.cmfri.org.in
E-mail: director@cmfri.org.in, director.cmfri@icar.gov.in
Telephone: +91 484 2394867
Fax: +91 484 2394909

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Preface

By 2030 the requirement of fish for domestic consumption in India is estimated to touch 18 million metric tonnes. With the present annual fish production of 12.60 million metric tonnes, a gap of 5.4 million metric tonnes will need to be bridged to meet the projected domestic fish demand. Given the limitation of marine capture fisheries sector of the country and the modest enhancement that is likely to occur from deep sea resources along with the limited opportunities for expansion of land-based fisheries and aquaculture systems, the focus is mainly on expansion of mariculture. The promises are immense, but it is reasonable to target a production of 3-4 million metric tonnes from mariculture by 2030. India with 8119 km length of coastline encompassing nine coastal states and possessing an Exclusive Economic Zone area of 2.172 million square km offers immense potential for mariculture. Cage farming is widely recognized as the most important technology in mariculture for increasing fish production.

Open-sea cage farming was conceptualised in India in 2005 and a demonstration project was successfully performed by ICAR-CMFRI with funding from Ministry of Agriculture. The first successful open-sea cage harvest was in 2007 from Visakhapatnam. Subsequently, through intensive research efforts and innovations in designing and fabricating cages and mooring systems, improved cages of 6 m diameter and mooring systems were developed and standardized for rough sea conditions in this location. Presently, with expansion of cage farming over the past half a decade, the country boasts of more than 3300 cages, which are technically assisted, either directly or indirectly by ICAR-CMFRI at multiple locations in each maritime state. Cage farmed fishes include mostly cobia, pompano, grouper, Asian seabass and snappers. A quantifiable tonnes of finfishes are produced annually from these cages, adding to the food basket of the country.

The Department of Fisheries, Ministry of Fisheries, Animal Husbandry, and Dairying, Government of India has envisaged large scale expansion of cage farming under the Pradhan Mantri Matsya Sampada Yojana (PMMSY). Prior to embracing open-sea cage farming in a big way by encouraging private entrepreneurs, it is paramount that sufficient knowledge is made available on various aspects of cage farming for ensuring maximum income and returns. However, such practical information suiting to turbulent Indian waters is scanty. This manual on the set of "Good Aquaculture Practices" for sea cage farming with reference to Indian pompano and orange spotted grouper will be a ready reckoner for fish farmers venturing into cage mariculture.

Dr. A. GOPALAKRISHNAN
DIRECTOR, ICAR-CMFRI

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1. Introduction

- Malnutrition and hunger are still predominant in many countries and projections of population by 2050 suggest that the future demand for meat will be more than 500 megatonnes (Mt) per year for human consumption.
- Scaling up the production from land-derived food crops is a big challenge, due to declining yield rates and competition for land and water resources.
- Aquatic food (fish production from fresh-water source) has an important role in food security and global supply, but its expansion is also constrained due to scarcity of land and water.
- The future need of food demand is depending on the sustainable fish production from the sea. Fish from sea through wild capture fisheries and farmed (mariculture) production currently contributes approximately 17% of global edible meat production. An array of hope is remaining on marine fish.
- Sea foods are a major source of protein, essential fatty acids and minerals; which contribute to global nutritional and food security.
- Importance of sea food has increased among different stakeholders for its nutritional value and environment friendly production approach.
- Efforts on improving marine food fish production has been undertaken by many countries and agencies with use of different culture and harvesting methods, and as a result, the marine fish production (both capture and culture) has improved from an average of 86.8 million tonnes in 1995 to 115.2 million tonnes in 2018.
- In India, the population growth is projected to be 1.65 billion by 2050, and it has been estimated that India has to produce nearly 10.5 million tonnes of marine fishes to meet the burgeoning food requirement for increasing population.

- To achieve the huge fish production, significant contribution from mariculture/coastal aquaculture is essential in addition to the stagnated capture marine fisheries production of 3.5-4.0 million tonnes.
- Use of suitable culture technology for effective utilisation of available and underutilised marine environment is the need of the hour for increasing fish production.
- Sea cage farming is the major and widely accepted production technology for marine finfishes without altering the marine environment. The technology is considered the most suitable for increasing marine fish production through landless farming.

2. Cage Culture in India

- Cage culture is one of the aquaculture production systems, where the cultured organisms are held in a floating net structure.
- Cages are used to culture different kinds of finfishes or shellfishes in different water systems such as fresh-water, brackish-water and marine-water. Sea cage culture involves growing marine fishes in sea.
- Cage culture is one of the intensive culture methods available for fish production and is a boon for poor landless farmers.

- This technology helps to reduce mounting pressure on land for producing fish.
- Globally, the cage aquaculture sector has grown very rapidly during the past 20 years and is presently undergoing major changes in response to pressures from globalization and growing demand for aquatic products in both developing and developed countries.
- In India, sea cage farming was initiated as a research and demonstration activity in 2005 by Central Marine Fisheries Research Institute, Indian Council of Agriculture Research.
- The cage culture technology, thereafter underwent several modifications; in-terms of establishment, stability under different climatic conditions and standardisation with different culture methods. Presently, cages manufactured using High Density Poly Ethylene (HDPE) are considered the best suited for cage frame, to withstand the diverse climatic condition across the Indian coast.
- In India, marine cage farming is practiced in selected locations by individual fisherman, fisheries co-operatives, and non-governmental organisations through support of state and central governments. The major fish species used for culture are Asian seabass, cobia, silver pompano, Indian pompano, orange spotted grouper and mangrove red snapper.

3. Good Aquaculture Practices (GAPs) in Cage Farming

- Practices believed to be the most effective and practical in reducing environmental impact levels and those compatible with resource management goals are called GAPs.
- GAPs are adopted in different context for minimising waste and maximising production in a sustained manner with varying guidelines in accordance to the prevailing situations.
- In aquaculture/cage culture, good management practices are defined as a management guideline or approach designed to minimize or prevent any adverse environmental impacts, to

maximize the health and well-being of the organisms being raised and to encourage economical production.

- The objective of GAP is to provide farmers sensible and practical guidelines to follow in the planning, management and operation of their farms.
- Guidelines developed in GAP are based on lessons learned from local and international practices or scientific researches. GAP guidelines are useful to improve the ways of working (knowledge, skills, capacity and practices) for improving production.
- GAP guidelines for different aquaculture activities have been formulated in different countries, and some of the guidelines pertain to specific regions. An effective implementation of the GAP guidelines in most of the aquaculture practices have helped to achieve better successes.
- In India, GAP guidelines were developed by MPEDA and Network of Aquaculture Centres in Asia Pacific (NACA) during 2000-2002 for shrimp culture operations, which has helped the country to be one of the leading global producers of cultured shrimp.
- Cage culture involves; site selection, selection of cage frame and accessories, cage fabrication and installation, and finally fish culture. While culturing fish in cage, optimum selection of all parameters is vital for successful operation. However, mostly, inadequate selection of different essential parameters and unorganised culture operations lead to failure of the culture operation and ultimately creates a negative impact on the culture method.
- Therefore, development of good aquaculture practices and proper implementation of these prescribed culture practices will help farmers to achieve success in culture operation, thereby maximising production.

- Indian pompano and orange spotted grouper are considered us good candidate species for cage culture with their interesting culture traits and demand in both national and Inter national market.
- This manual deals with the good aquaculture practices to be followed for culture of Indian pompano and orange spotted grouper in marine cages.

4. Marine Cage Culture

- Mariculture, or marine aquaculture, is performed in the sea, in a marine water environment. However, for some species that relies on freshwater for hatchery (seed production) and nursery rearing, mariculture represents their grow-out phase in the production cycle.
- Mariculture and coastal aquaculture collectively produced 30.8 million tonnes (USD 106.5 billion) of aquatic animals in 2018; in which the mariculture production was mostly from marine cage culture.
- Marine cage culture involves growing of fishes in the sea while being enclosed in a net cage which allows free flow of water. It is a production system made of a floating frame of varying dimensions and shape, net materials and mooring system, to hold and culture large number of fishes.
- It is one of the super-intensive culture methods with high unit rate of production. The unit production from marine cage culture systems varies from 20-40 kg/m^3 depending on the species cultured.
- Operational expenditure associated with development and maintenance of infrastructure is lower in cage farming as compared to shore-based farming practices.
- Cage farming provides effective and easy way of fish monitoring and harvesting when compared to other culture systems.

- Culturing of fishes in marine cages involves site selection, selection of cage accessories (cage frame and net), cage mooring, species selection, cage management and animal husbandry.
- Appropriate attention on site selection, selection of optimum cage accessories and suitable species will help in profitable and long-time sustainability of the cage culture technology.

5. Cage Culture Practices – Requirements and Components

- Optimum selection of different parameters helps in successful farming of marine finfishes. Major parameters to be considered for culturing marine finfishes in cages are:

  1) Site selection; 2) Cage design and accessories; 3) Cage mooring system; 4) Ballast system; 5) Cage net; 6) Deployment of cage mooring and frame; and 7) Species selection.

5.1. Site Selection

- Appropriate site selection decides the profitability and sustainability of the cage farming. The site selection directly impacts construction costs, operating costs, growth and survival rate of fish, and shelf life of cage accessories.
- Before establishment of cage farming, an extensive knowledge on the site environment (topography and water quality parameters) is required; involving detailed survey, secondary information from existing literature and government sources and first-hand information from local people.
- Major criteria to be followed for site selection are: topographical, physical, chemical, biological, accessibility, social problem and legal aspects.

5.1.a. Topographical Parameters

- Cages should be installed in sheltered areas, protected from strong winds and waves; in general, wind velocity and height of wave should preferably not exceed 10 knots and

1.0 m for floating cage. Cage structure suggested by Indian Council of Agricultural Research – Central Marine Fisheries Research Institute (ICAR-CMFRI) for the east coast can withstand wind speed of up to 50 knots.

- The preferred depth for a floating cage is 8-10 m. Sufficient depth beneath the cage is necessary for avoiding oxygen depletion, accumulation of uneaten food, faeces and debris under cage; avoiding build-up of noxious gases (H_2S) generated by the decomposition of deposited wastes and finally, for enhanced water exchage.
- A firm substrate with a combination of fine gravel, sand and clay is an ideal site for cage culture. The design of the cage is directly influenced by the type of substrate present at any given site. In general, sloping areas from the shore leading to flat bottoms are suitable for cage culture because the waste build-up at the bottom is easily eliminated. The use of anchoring system is dependent on the sea bottom. Concrete cement blocks or gabion boxes are preferred for sea bottom with more sand, whereas toothed anchor is recommended for clayey sea bottom.

5.1.b. Physical Criteria

Some of the physical criteria to be strictly followed for cage culture of Indian pompano and orange spotted grouper are:

- Tidal currents help in keeping the cage site clean, it brings fresh oxygenated water and removes waste from the cage site. The ideal current speed should be 50-100 cm/sec, and should not exceed 100 cm/sec. Selected site with current speed less than 10 cm/sec will result in poor water exchange, especially during neap tide, which may invite issues associated with low oxygen and bacterial infection due to accumulated waste.
- Turbid water affects the visibility of the fish to the feeds,

and if turbidity remains for longer duration, then it results in reduced feed intake and impaired fish growth. Turbidity in seawater is normally caused by freshwater run-off during rainy season. Site with frequent occurrences of turbid water should be avoided.

- Indian pompano and orange spotted grouper are tropical fishes, and the suitable temperature for their optimum metabolic activities ranges from 27–31°C. The selected sites with temperature beyond the optimum range, or sites with frequent temperature fluctuations will negatively influence fish growth. Also, frequent changes in water temperature will affect fish metabolic activity, oxygen consumption, feeding rate, food conversion and ultimately fish growth.

5.1.c. Chemical Criteria

- Chemical parameters of seawater cannot be controlled, but change in values due to seasonal fluctuations follows a similar trend over the years. Thus, thorough knowledge on the chemical parameters of selected locations will certainly help to keep the fishes healthy. The optimum range required for both the species are given below:

- Dissolved oxygen is the most important parameter for keeping the animal healthy. Dissolved oxygen of 5.0 ppm is optimum, but both the species can remain in water without any problem up to 2.5 ppm. However, unlike pond culture systems, DO fluctuations are not catastrophic in sea cage farming due to constant currents. Cages installed in shallow areas are often influnced by benthic organisms and sediment wastes which reduces the oxygen level. Solubility of oxygen in water declines with increasing temperature and salinity.

- Salinity controls the osmotic pressure which affects the ionic balance of the fish. Frequent changes in salinity or water

salinity below optimum range will affect metabolic activity and simultaneously, growth. Optimum salinity range for both the species is 10-35 ppt. Site near the river mouth should not be selected to avoid frequent fluctuation in water salinity.

- Optimum value of pH for both the species is 7.5 to 8.5 and usually, seawater pH is within this range. The extreme variation in pH affects the fish gill, increases the toxicity of ammonia and ultimately kill the fish. pH fluctuations are often associated with freshwater influx.
- Optimum range of total ammonia for both the species is 0-0.05 ppm. Ammonia level in sea water is increased by the decomposition of uneaten food and debris at the bottom. Excess ammonia affects fish metabolism. Cage site with good water movement will always be with low ammonia content.
- Optimum range of nitrate and nitrite is < 200 mg/l and 4 mg/l, respectively. Excess concentrations of nitrate and nitrite cause hypoxia in fish by methemoglobin formation.
- High organic load in seawater reduces oxygen content and increases the bacterial infection to fish. Organic load in water is measured by Chemical Oxygen Demand (COD), and should be <3mg/l. High concentrations of phosphate can cause oxygen depletion through development of algal blooms. Phosphate in seawater should be less than 70 mg/l.

5.1.d. Biological Criteria

- Presence of more biological fouling organisms will directly affect the shelf life of the cage accessories. There are more than 200 species of marine fouling organisms present in sea in different regions, which affects the cage accessories. Attachment of these organisms to the cage net or other cage accessories is dependent on the silt accumulation. The silt

accumulated in the cage net act as substrate for fouling organisms. Therefore, site selected for cage culture should be free from silt accumulations. Density of fouling is high in places with low current velocity, high temperature and high turbidity. Also, the fouling density depends on the material used for cage culture. For minimizing maintenance costs with respect to removal of fouling organisms, cage farms should be selected in areas unfavourable for the growth of fouling organisms. Fouling accumulation varies with seasons and locations. Depending on the load of fouling organisms, the cage accessories should be periodically cleaned.

- Excessive concentration of phytoplankton leads to blooms, which affects fish by clogging gills and creating oxygen depletion, particularly during night. Algal blooms are formed in locations with high light intensity, increased nutrient levels (organic load), elevated temperatures and stagnant hydrological conditions. A number of marine algal groups form blooms; including diatoms, cyanobacteria, prymnesiophytes and dinoflagellates. Fish mortality due to algal blooms depends on the species causing the bloom. Generally, long-term historical records on occurrences of algal blooms are available. Depending on their temporal incidences, fish needs to be harvested.

- Pathogenic bacteria are the major disease-causing agents for the cage cultured species; the major bacteria being *Vibrio parahaemolyticus*, *V. harveyi* and *V. alginolyticus*. Ectoparasites; marine isopods (*Nerocila*) and copepods are also a major aetiological agent. Major routes for disease causing agents are polluted water and runoff from sewage, industry or hatchery.

5.1.e. Accessibility

❖ Cage culture activity involves frequent transport between cage site and shore for feeding, transportation of seed and cage accessories, and for routine cage monitoring. Therefore, cage site should have jetty facilities for ease of voyage. Selected cage site should have access to road for transportation of seed, feed and harvested fish.

Site - Suitable for cage farming

5.1.f. Social Problems

✠ Social issue is non-biological, but one of the major constraints in cage culture activity. Security/poaching and conflicts with traditional fisherman as a result of voyage obstruction are common. Therefore, selected site should be away from fishing villages, and cage culture areas should be clearly demarcated.

Site - Unsuitable for cage farming

Fish mortality due to influx of flood water in cage site

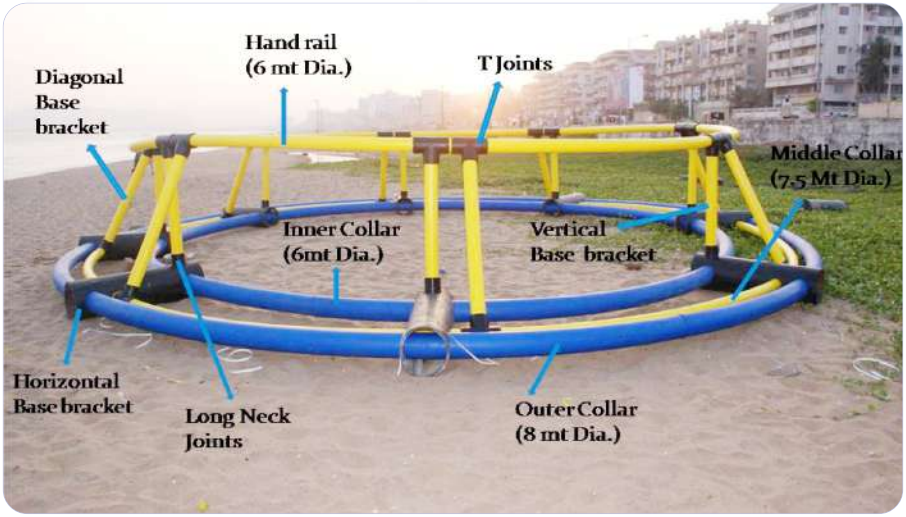
Occurrence of Harmful Algal Bloom in cage site

Points to be considered for cage culture site selection

- Should be away from domestic sewage, industry, hatchery and agricultural run off
- Should be away from shipping channels, harbour area and chemical factories
- Should be away from river mouth to avoid fluctuations in salinity
- Should be in protected areas with optimum water current

5.2. Cage Design and Accessories

- The cage design for fish culture should be able to withstand rough sea conditions, should provide a conducive condition for the fish being reared and should have good manoeuvrability. For farming along the east coast of India, circular shape of cage is suggested.



HDPE Cage Frame Components

- Cage size determines operational expenditures and profit. The optimum cage sizes that suites easy maintenance and provides moderate income is 6.0 m diameter, and circular in shape.
- The materials used in sea cage farming should be strong enough to withstand the rough sea conditions and should also be rust-proof with long durability in seawater. Cage frame made using High Density Poly Ethylene (HDPE) (PE 100) is considered the most suitable for marine cage farming.
- The cage frame has two collar rings with floatation properties and a middle catwalk, and all the three frames assists in routine cage management.
- Inner and outer collar rings,with 6.0 m and 7.0 m diameter respectively, are made up of HDPE pipes of 140 mm pipe outer diameter. The middle catwalk, with 6.5 m diameter, is made up of HDPE pipe with 90 mm pipe outer diameter. The inner and outer collar pipes are filled with

HDPE - T- joints

HDPE - base pipes with T- joints

HDPE welding of T-joints

HDPE welding of circular cages

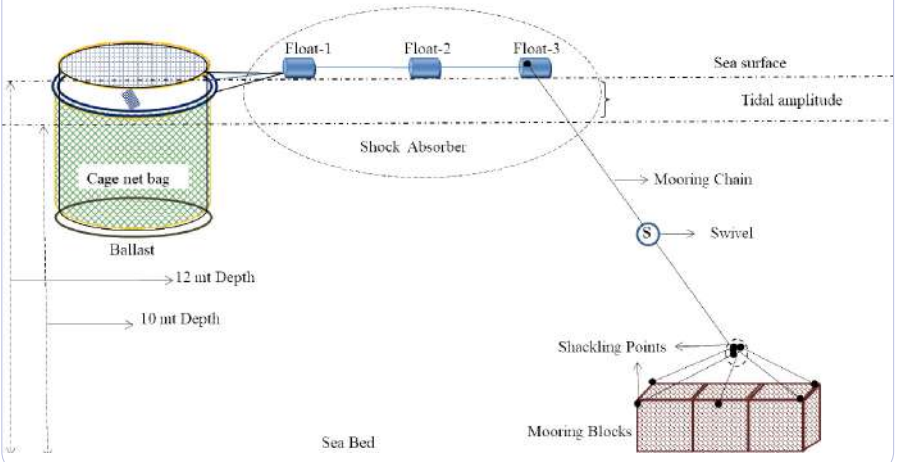
polyurethane foam or thermocole to enhance their floatation efficiency.

- Base pipes help to keep inner and outer collar rings together and provides shape for the cage. Base pipes are connected to hand rail via vertical and diagonal supports. Base pipes are made up of HDPE pipes with 250 mm outer diameter.
- Vertical and diagonal supports help to join the base collar rings to the hand rail. These are made up of HDPE pipes with 90 mm pipe outer diameter.
- Hand rail is used for tying the inner net, and during routine cage management, it functions as support for the workers. The hand rail is made up of HDPE pipes with 90 mm pipe outer diameter.

5.3. Cage Mooring System

- Mooring system holds the cage in the desired position and depth with mooring chains, and anchors. Individual cages are to be moored using single point mooring, and a battery of cages should be moored through grid mooring.
- Use of anchors in mooring system depends on the sea bottom. The preferred anchors along the east coast are concrete blocks or stones. For sites with clayey bottom, especially along northern Odisha and West Bengal, toothed anchors along with concrete blocks are recomended.
- Use of concrete cement blocks is the preferred anchoring system. Concrete block, each weighing approximately 200 kg is used, and 10-12 such blocks, with a total weight of 2.0 to 2.5 tonnes is recommended for effective and efficient anchoring.
- Mooring chain connects the anchoring system to the cage frame via floats (buoy). Long-linked alloy steel chain of 14.0 mm outer diameter and 22 tonnes shearing strength is preferred. If chain thickness is less than 14.0 mm, it gets

SINGLE POINT MOORING (REVOLVING MOORING)



Concrete cement blocks of 200 kg weight

Toothed anchor for clayey bottom

FRP - coated 200 litre buoy with clamps

Mooring chain connected to swivel via D-shackles

Chain - suitable for mooring

Chain - unsuitable for mooring

easily eroded and may not hold the tensions associated with rough sea. Two such mooring chains are used for each cage, and are secured with the help of D-shackles. For a site with 10.0 m water depth, approximately 100 m of mooring chain is required for ease of cage movement.

- D-shackles help in securing the mooring chain to the concrete blocks, swivel, buoy and cage frame. D-shackles, made of stainless steel with 19.0 mm outer diameter, are used to counteract the heavy load. A mooring system with 10-12 numbers of 200 kg cement blocks and 100 meter of mooring chain requires nearly 35-40 D-shackles.
- Swivel is attached to the middle of the mooring chain and helps to rotate the cage frame freely in different directions in tune to the water current.
- Mooring chain is connected to cage frame through buoys. In addition to providing floatation, buoys act as shock absorber in the mooring system. The pressure created on the mooring chain by currents and winds is prevented by the buoys from directly impacting the cage frame. Three buoys of 200 litre capacities are used. Buoys are coated with Fibre Reinforced Plastic (FRP) to prevent rusting of clamps.

5.4. Ballast System

- Ballast pipes help to maintain cage net structure in-tact, in proper shape against the water movement.
- Ballast is prepared using 2.5 cm diameter perforated HDPE pipe. For ensuring maximum net space to allow sufficient fish movement, inner net is tied with two ballast pipes, at the bottom and middle, and this prevents the net from getting distorted due to constant water movement.
- For sites with turbulent sea conditions, steel or irons rods are inserted within perforated HDPE pipes for providing strength to the ballast. However, usage of steel or iron rods should be avoided as far as possible, because if rods come out of HDPE pipes, they may tear the net.
- While mooring cages, the ballast pipes should be shifted along with the cages in order to avoid extra expenditure on separate shifting.

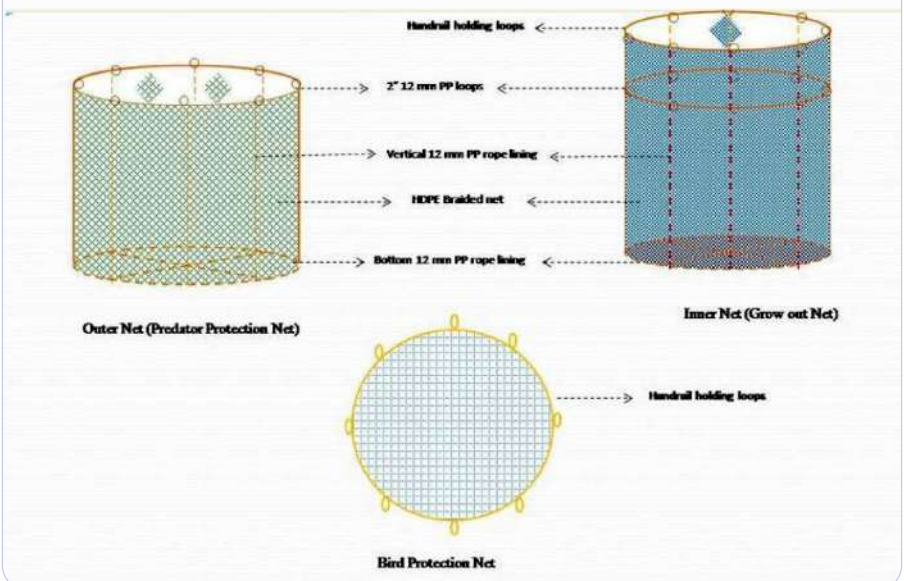
Ballast pipe preparation

Ballast pipes shifted with cage for attaching with fish net

5.5. Cage Net

- HDPE braided nets of 2.5 mm twine thickness is preferred for its strength and light-weight. Also, HDPE nets are durable in seawater for upto 5 years. In cages, three nets are used: outer net, inner net and bird net. Inner and outer net of sapphire blue is the preferred colour.
- Outer net is vertically hanged from the outer collar. It functions to prevent the entry of predators to the inner net. Net with mesh size of 40.0 mm should be used, both for avoiding predator entry and for providing relatively lesser load on the cage frame. Optimum size of outer net is 7.0 m diameter and 4.0 m depth. Mesh sizes less than 40.0 mm burdens the cage frame with additional load, and thus should be avoided. For preparing the specified net size, a raw net weight of 18-20 kg is required.

CAGE NET



HDPE twisted sapphire blue net

Nylon net - blue colour

- Inner net is vertically hanged from the handrails. It functions to hold the cultured fish within the cage net structure. Inner net of 25.0 mm mesh size is used for rearing fishes above 100 g in size. However, mesh size is also dependent on the shape of the fish. Indian pompano is broad in shape, whereas orange spotted grouper is cylindrical; therefore, the chances of escape for Indian pompano is much less when compared to orange spotted grouper for any specific mesh size. In spite of the above, for fish of 100 g size, inner net with 25.0 mm mesh size is ideal. Fishes whose width is less should initially be stocked in smaller mesh (1.5 or 2.0 mm) net until it reaches the optimum size. Use of 25.0 mm mesh net is recommended for free flow of water and to reduce fouling accumulation. Fouling accumulation is more in small mesh net due to availability of more surface area for attachment. Optimum size of inner net is 6.0 m diameter and 5.0 m depth. For preparing the specified net size, a raw net weight of 25-30 kg is required.
- Bird net is tied to the hand rails and is placed horizontally. It helps to prevent fish predation by birds. Nylon net of 1.25 mm twine thickness and 80 mm mesh size is preferred for preventing bird's predation.

5.6. Deployments of Mooring Systems and Frame

Deployment of mooring systems and cage frame structure should be done one after the other with the help of boats.

Mooring system should be deployed at least one week prior to deployment of cage frame, and this period is considered as setting time for proper setting of anchoring system in sea bottom.

5.6.a. Mooring systems deployment

- Concrete blocks of required numbers are arranged at distances of 1.0 m apart, and are connected via mooring chain with the help of D-shackles. After blocks, the chain is connected to the swivel and finally to the three buoys. The buoys are placed at distances of 2.0–3.0 m apart.
- The entire structure is loaded on the vessel (trawlers) and arranged in an order at the rear end. At the selected location, the entire structure is dropped into the water, and due to the anchor weight, the mooring system settles in the location.

Mooring blocks connected with mooring chain

Buoys connected with mooring chain

Mooring blocks with anchor for clay bottom

Mooring blocks loaded in the vessel for deployment

- The attached buoys help for floatation and also for identifying the mooring locations.

5.6.b. Deployment of cage frame

- The cage frame is deployed with the help of out-board motor vessels. The frame is tied to the boat with the help of 8.0-10.0 mm rope and is dragged to the selected site, where it is attached to the mooring chain after the buoys. The distance between the first buoy and the cage frame should be at least 3.0 m.
- The ballast pipes are also shifted with the cage frame by attaching to the handrails.

Dragging of HDPE cage to the cage site

Attaching dragged cage to the mooring system

5.7. Species Selection Criteria

- Selection of fish species is pivotal for cage culture operation. While selecting the species for culture, certain criteria like biological, economical aspects and consumer preference should be given prime importance for economic sustainability.
- The major criteria to be considered before selecting the species are: sufficient availability of fish seeds, availability of hatchery technology for seed production in confined environment, acceptance to artificial feeds, tolerance to different environmental conditions, compatibility to culture

in various system, resistance to disease and stress, nutritional value, consumer acceptance, economic value in local and international market and regional preference.

- ❄ Considering the different important criteria for culture, a variety of commercially important marine fish species are found suitable for cage farming. The Indian pompano and orange spotted grouper are among the most suitable species for culture along the eastern coast of India.

6. Cage Culture of Indian pompano (*Trachinotus mookalee*)

- ❍ The group pompano includes 20 commercially important species from tropical and subtropical waters. Some of the species has been established in aquaculture and has gained popularity in Asian countries, America and Canada.
- ❍ Commercial aquaculture of a few pompano species commenced in the late 20th century and in 2016, production reached 110,000 tonnes. This is us indicative of a positive trend on the culture potential of pompanos.
- ❍ Indian pompano belonging to the family Carangidae, is a potential candidate finfish species for marine cage aquaculture. This species is mostly available in the Indian sub-continent.

Indian pompano - *Trachinotus mookalee*

- The fish possesses potential culture characters: quick adaptability to different culture conditions, tolerant to wide range of salinities, fast growth rate, quick acceptance to artificial feed, pleasant appearance, good meat quality and high consumer preference. Most importantly, the species readily accepts artificial pelleted feed and completes the culture cycle with artificial pelleted feed alone.
- Hatchery seed production technology for the species was developed in 2016 by Visakhapatnam Regional Centre of ICAR-CMFRI, and the culture technology was subsequently standardised and demonstrated, mostly along the east coast of India.
- Additionally, domestic consumer preference for the species is moderately high in different states of India.
- Marine cage farming of the species includes several important management aspects, and all management measures are to be meticulously performed for achieving maximum production from a unit area. The important management measures are given below.

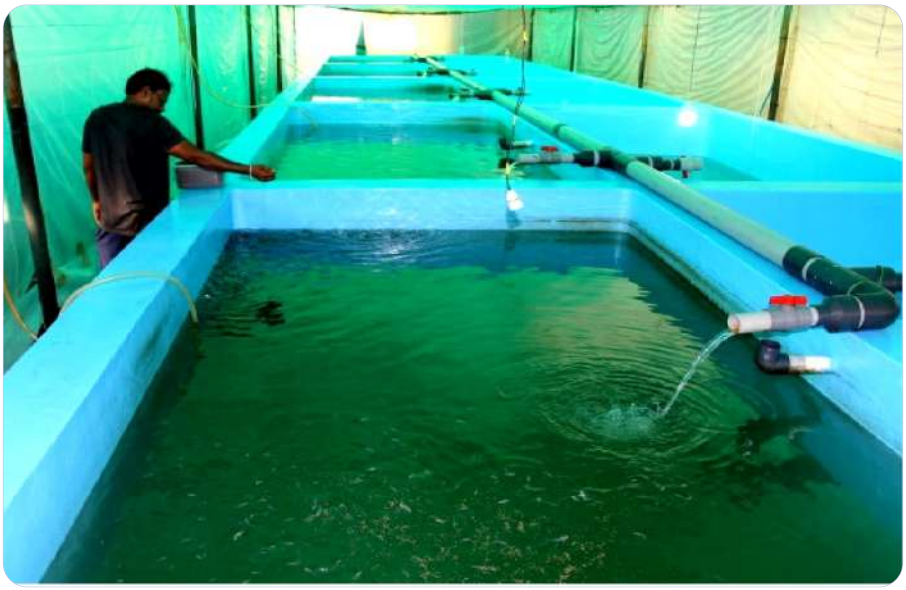
6.1. Nursery Rearing

- Rearing fish larvae through the early life stages is performed in nursery, and this is the phase between hatchery and grow-out. Thus, before stocking for grow-out, culture species needs to be nursed for attaining optimum stocking size.
- Optimum size of Indian pompano for stocking in cage is 25.0 g, and the fish stocked at the optimum size takes nearly 10 months to attain the marketable size of 850.0 g. However, culture duration can further be reduced if the fish stocked is of bigger sizes.
- Nursery rearing of Indian pompano is essential in cage culture for reducing the culture duration during grow-out. Three types of nursery systems are preferably used: hapa-

based nursery in earthen ponds, recirculating aquaculture system (RAS) based nursery and concrete or FRP tank-based flow-through nursery. These nursery facilities should be established near to cage site for ease of fish fingerlings transportation.

- Feed used in nursery should have a high nutrient profile; 45% crude protein and 10% crude fat. Feeding frequency of 4-5 time/day at 8-12% body weight is recommended. The feeding rate varies with size of the fingerlings reared.
- For proper initial nursery, advanced fry of 2.5 cm (0.5 to 0.6 g) stocked at 500 nos/m^3 should reach 6.25 cm (5.0 g) within 45 days. Optimum feed size to avoid size variation should be 0.8 to 1.2 mm, at 12% of body weight. During the later phase of nursery, early fingerlings stocked at 5.0 g size should attain 25.0 g size in 30 days at a stocking density 300/m^3 with a feeding rate of 10% body weight. Therefore, during the entire nursery duration, advanced fry of 2.5 cm size should reach 25.0 g in two and half months (75 days).
- Indian pompano, being a fast-moving pelagic fish, dissolved oxygen requirement is very high; therefore, during nursery, the dissolved oxygen concentration should always be above 4.5 ppm.
- With proper feeding and water quality management, expected survival in RAS and indoor tank-based cultures should be above 96%, whereas in hapa-based earthen ponds, more than 90-95% survival is expected.
- Fishes are very active during nursery rearing; therefore, they tend to jump to at-least 15.0 cm above the water level.Thus, water level should be at least 30.0 cm below the tank surface for avoiding fish fingerlings falling out of water. It is suggested to cover the tank surface with fish net to avoid jumping of fish out of the tank.

Indian pompano nursery rearing in FRP tank-based RAS



Indian pompano nursery rearing in concrete cement tank-based RAS

Indian pompano nursery rearing in FRP tank-based RAS

Indian pompano nursery rearing in hapa based coastal earthen pond

- Vibriosis is the most common bacterial infection occurring during nursery, because of stress. Minimising stress in nursery will help to keep the fishes free from bacterial infection. Possible stressors are: overcrowding, more waste accumulation in tank bottom, rough handling, higher water temperature and lower dissolved oxygen.

6.2. Seed Transportation for Grow-out Stocking

- It is preferred to establish the nursery unit near to cage culture site for ease of transportation. Advanced fingerlings reared in nursery should be transferred to cage site either in polythene bags filled with oxygen or in sintex or FRP tanks supported with oxygen.
- When fingerlings are stocked at more than 5 g in size, they should be transported in a container supported with pure oxygen for achieving maximum survival.
- Adequate care should be provided while transferring fingerlings. Fingerlings transported in stressed condition (overcrowding and less dissolved oxygen) are more susceptible to vibrios after stocking in cages. Thus, adequate care should be given to keep the animals under stress-free conditions.
- Use of ice while seed transportation is recommended during summer season in-order to avoid heat shock to the transported larve.
- Seeds transported over long distances should be in sintex tanks supported with oxygen, and for short distances of less than an hour, in open FRP tanks supported with oxygen.
- Based on the experience; the optimum fish size, stocking density and mode of transportation is given in the Table below.

Indian pompano seed transportation by sintex tank with pure oxygen for long distance by lorry

Indian pompano seed transportation by sintex tank with ice for avoiding temperature shock

Indian pompano seed transportation by polythene bag filled with pure oxygen

Indian pompano fingerlings transported in polythene bag and stocked in cage

Indian pompano seed transportation by FRP tank supported with pure oxygen to the cage site

Details of fish fingerlings trasportation

Fish Size (g)	Duration (hr)	Stocking (nos/l)	Mode of transportation
> 0.25	24-36	50-60	Polythene bag with oxygen
1.0 to 2.5	15-30	20-25	Polythene bag with oxygen
2.5 to 5.0	12-24	10-15	Sintex tank with oxygen
5.0 to 15.0	12-20	5-6	Sintex tank with oxygen
25.0 to 30.0	12-20	2-2.5	Sintex tank with oxygen

6.3. Grow-out Culture

- After reaching the cage site, transported juveniles should be slowly released into the cage for acclimatising to the cage water environment.
- The stocking density of Indian pompano suggested for achieving optimum growth and economic benefit is 25 nos/ m^3, and thus, a 6.0 m dia cage with 4.0 m net depth having a water volume of nearly 110 m^3, should be stocked with 2750 numbers of fish fingerlings.
- Artificial floating pelleted feed with high nutritional composition (40% crude protein and 10% crude fat) is recommended for grow out systems.
- Feed should be broadcasted in the middle of the cage. While broadcasting the feed, some feed gets wasted by drifting due to wave and wind action. Therefore, attaching a feed mesh, of 0.1-0.5 mm mesh size and 1.0 m width in size, to the inner net helps in controlling the feed wastage. Even using mosquito net also can act as feed mesh for controlling feed wastage.
- It is suggested to broadcast feed slowly and at multiple times during each feeding. This will ensure equal availability of feed for all fish, and make sure that no fish is deprived of feed.
- Recommended feeding rate in grow-out culture varies from 6.0-1.5%, according to the growth of the fish, and this ration should be divided and given 3.0–4.0 times during each day.
- Better feed digestion and assimilation ensures better fish growth, thus, a minimum of 3 h time interval between two feeding schedules should be given, and therefore, the feeding frequency should be decided accordingly. However, feeding should be provided at least twice a day to maintain good fish health. Feeding frequency of 3-4 times/day has been observed to show better growth instead of feeding twice.

Fortnight observation of cage cultured Indian pompano

Growth monitoring of cage cultured Indian pompano

- In grow out culture, fish growth should be monitored fortnightly and feeding rate to be adjusted based on the weight gain after every sampling.
- In a well-managed cage culture grow-out system, fish fingerlings stocked at 20 to 25 g requires nearly 10 months to reach the market size of 800-1000 g, whereas if it is stocked at 100 g size, it takes 5 to 6 months to reach the same size.
- Survival rate varies with stocking size; survival rate for fish stocked at 25 g varies from 90-95%, whereas for fish stocked at 100 g, survival ranges between 95-98%.
- Feed conversion Ratio (FCR) varies from 1.65 to 2.0, and achieving low FCR is dependent on effective feed management.
- Fish growth, feeding frequency and rate of feeding for Indian pompano in marine cage culture is given in the following Table.

Feeding pattern in growout culture of Indian pampano

DOC	Size (g)	Feed Size (mm)	Feeding Rate (%)	Feeding Frequency (times/day)
0-30	25 -50	1.2 to 1.8	8	4-5
30-120	50-100	1.8 to 3.0	6-5	4
120-180	100-300	3.0 to 4.0	5-4	4
180-210	300-500	4.0 to 6.0	4-3	3
210-300	500-750	6.0 to 7.0	2.5	3
300-360	750-1100	7 to 10.0	2	2

Note: DOC - Days of Culture

Pelleted feed preparation

Feeding of Indian pompano in cage with pelleted feed

6.4. Cage Structure Management

- Managing cage frame and other accessories is an important component for marine cage culture. Periodical monitoring of cage frame and accessories helps in avoiding loss of fish stocks due to escape caused by net damage, and because of cage drifting away from mooring. Proper and routine monitoring, will also help improving the durability of the cage.
- Fish fingerlings stocked at 25.0 g size requires culture duration of ten months; therefore, different cage components should be managed efficiently. Various management activities include net exchange, cage frame cleaning and mooring checking.
- The cage net is the structure which holds the fish, and is prone to attachment of barnacles, and algal and silt accumulation. Thus the net, needs to be exchanged periodically, depending on the accumulation rate. The accumulation depends on the season and the location, and based on the experiences from the east coast, the cage net should be exchanged at least once in two months. If the cage nets are not exchanged within the stipulated time, then, they may tear off due to the heavy load. Also, fouling load on cage net will negatively impact the buoyancy of the cage frame.
- Cage frame, being the walkway, is prone for settlement of barnacles, and if the settlement is more, it would adversely impact the durability of the cage. Also, settlement in cage frame, more often than not results in tearing of the net ropes through rubbing. Attachment of micro and macro algae (*Ulva* spp) in cage frame leads to skidding during routine management. Thus, cage frame requires monthly cleaning.

- Cage mooring helps to keep the entire cage structure in position, thus the mooring chain requires continuous monitoring, at least once in a month. The mooring system specified for the cages will remain without much of an issue for a minimum of two years, and then slowly the chain starts eroding, resulting ultimately in chain tear. Thus, mooring checking with the help of underwater diver is recommended once in a month. With prevailing heavy wind and wave along the east coast of India, the chains are mostly damaged in proximity to the anchors, below the swivel; therefore, providing a single additional chain of 10 m length between anchors and swivel will result in an additional 2 years of durability for the mooring chain.

Mooring checking

Cleaning of buoy

Cleaning of dried net after exchange

Minor repairing of old and used net

Net exchange

Cleaning of cage frame

6.5. Fish Health Management

- Cage cultured fish should be checked and critically observed for its feeding and health status by periodic sampling at fortnight intervals.
- Also, daily observations during feeding are essential for understanding the feeding behaviour, which is an excellent indicator on the health status of the fish.
- The major diseases associated with grow-out cage culture of Indian pompano are: Vibriosis caused by selected bacterial species of *Vibrio*, and parasitic infestations caused by ecto-parasites.

Parasite infestation (wound in body)

Parasite infestation (attachment on body)

Vibriosis in cage farmed Indian pompano

Fish mortality after parasitic infestation

- Fish affected by Vibriosis exhibits the symptoms of moving on the water surface, and the eyes and the fins become reddish in colour. Fishes, when infected, do not accept feed and virtually stops feeding. Vibriosis in fish is controlled by the use of medicated feeds and probiotics.
- In parasitic infestation, a visible minor ulceration appears on the entire body and, importantly in the gills. Isopods causes coin-shaped wound, mostly in the dorsal side. Also parasitic attachment can be noticed on the body surface, ultimately killing the fish.
- The parasitic infestation is controlled by a freshwater dip or by using medicated (Praziquntel) feeds. Avoiding high stocking density, helps to get rid of parasitic infestations in cages.

6.6. Fish Harvest and Marketing

- In cages, fishes are reared in a small confinement, so harvesting of cage cultured fish is easier than any other culture methods.
- It is suggested to harvest the fish either in early morning or late evening hours to maintain their freshness.
- While harvesting, the inner cage net is lifted from all sides, and the lifted net is hanged on hand rails and tied to it. The fishes in the inner net are harvested with the help of a hand scoop net.
- Immediately upon harvest, washing in clean water and chill killing is suggested to maintain the freshness and quality of the harvested fish.
- Harvested fishes should be packed in plastic trays or thermocole boxes, by adding layers of ice in equal quantities below and above the fish.
- A well-managed cage of specified size and stocking density can harvest an approximately 2.0 tonnes of Indian pompano/cage/year.

- Cage farmed Indian pompano could be harvested based on demand, and is most preferably harvested either during the lean fishing period or during the trawl-ban season.

Harvesting of Indian pompano from cage

- Market potential in different states has been increasing, with excellent demand in Kerala, Goa, West Bengal, Tamil Nadu and Andhra Pradesh. Demand during trawl-ban season is exceptionally high for the species.

Harvested Indian pompano prior to packing

Packing of harvested Indian pompano

6.7. Economics

❄ The total operational expenditure and profit for culture of Indian pompano in a battery of 10 cages is given in the Table below. Culturing the fish for 10 months at the stocking of 25 nos./m^3 will support the farmer with a net profit of approximately ₹ 17.0 lakhs at price realization of ₹ 325/kg.

Economics for Seacage farming of Indian pompano

Sl. No	Head of expense	Cost in INR (in lakh)
1	Depreciation value on cage and accessories with an average life of 10 years for cage frame and five years for cage mooring and nets (Cost of cage and accessories including installation: ₹ 300,000/unit): Depreciation is ₹ 43,000/unit/year	4.3
	Operational expenditure	
2	Cost of 32,500 numbers of pompano seeds @ ₹ 20/ seed (including nursery rearing expenses)	6.5
3	Cost of 35.7 t of extruded pelleted feed (Survival 85%; Average Body Weight 750 g at harvest) @ FCR 1:1.70 @ ₹ 100/kg	35.70
4	Labour Charges @ ₹ 30000/ month for 10 months	3.00
5	Boat Hiring and Fuel Charges @ ₹ 6000/ month for 10 months	0.60
6	Charges for net exchange @ 500/person for 3 persons, five times in the production cycle for each cage	0.75
7	Miscellaneous expenditure, feed medicines and probiotics	0.5
8	Expenditure (Sl no: 1-7)	51.35
9	Total income: Production: 21 tonnes @ 85% survival with harvest size of 750 g at selling price @ ₹ 325/kg	68.25
10	Net profit : (8-7)	16.90

7. Cage Culture of Orange spotted grouper (*Epinephelus coioides*)

Orange spotted grouper: Epinephelus coioides

- Groupers are popular carnivorous fish with high market demand in many parts of the world, and form the main stay in the global Live Reef Food Fish (LRFF) trade.
- Aquaculture of groupers (Family Serranidae, Subfamily Epinephelinae) is an important component in the production portfolios of many countries, particularly in Asia.
- Culture of some grouper species is being carried out globally, and they have the potential to become an important aquaculture species because of high market price, high consumer demand, desirable taste, fast growth, efficient feed conversion and hardiness.
- Aquaculture of groupers is being carried out in tropical and subtropical areas of the world, but approximately 90% of the production is from Asia, with major contribution from China, Taiwan Province of China and Indonesia. In 2015, almost 1,55,000 tonnes of grouper were produced through aquaculture, with a total value of USD 630 million (approx. Rs 4,400 crores).
- Orange spotted grouper, *Epinephelus coioides* is one among the many grouper species established for aquaculture. The species has been cultured, both in cages and in coastal ponds.

- Cage farming technology is widely recognized as one of the important culture technology in mariculture for increasing fish production and as, suitable grow–out technology for grouper culture.
- Grouper culture in India using hatchery produced seeds is a recent initiative by ICAR-CMFRI, after success in captive seed production during 2015-2016.
- Visakhapatnam Regional Centre of ICAR-CMFRI has succeeded in breeding and producing seeds for the species. Later, sea cage culture technology was standardised and demonstrated.
- The standard culture protocols and management measures involved in sustainable production are explained below.

7.1. Nursery Rearing

- Nursery is an intermediate phase, and should be undertaken after juvenile groupers (2.5 cm) leave the hatchery, till they attain optimum sizes for stocking in sea cages (20-25 g).
- During nursery, juveniles accepts artificial feed well, and are therefore, can be fed with high nutrient content feed containing 45% crude protein and 10% crude fat. Also, chopped minced meat from trash or low value fish can be given. However, supplementing meat spoils water quality immediately after feeding. Thus, use of minced meat in nursery should be avoided as far as possible.
- The recommended feeding rate in nursery is 8 to 10% when pelleted feed is used, whereas for meat, it is 15 to 13%. The recommended feeding frequency is 4-5 times/day.
- In a well-managed nursery, 2.5 cm size fish fry stocked at 700-750 numbers/m^3 attains 10.0 g after 30 days of rearing. Thereafter, 10.0 g size advanced fry stocked at 350 numbers /m^3 attains 25.0 to 30.0 g in another 30 days of culture. Therefore, fry of 2.5 cm size takes around two months to reach an optimum size for stocking.

Nursery rearing of orange spotted grouper in indoor FRP tanks

Nursery rearing of orange spotted grouper in earthen coastal ponds

- Nursery for orange spotted grouper is on-shore, and the facilities are established near grow-out culture for ease of fish transfer. Two types of nursery systems are ideal: flow-through based FRP or concrete tank nursery and hapa based nursery in earthen ponds. RAS based nursery is not suitable for orange spotted grouper.
- The ideal depth for nursery rearing tank should be a maximum of 1.0 m, and capacity should be less than 5.0 tonnes for ease of management. This facilitates increased feed acceptance, and helps in routine tank management.
- Size variation during nursery is common for the species, thus, weekly grading based on size is necessary for achieving good survival and better growth.
- The commonly available supplier for nursery feeds are: Skretting (Norway), Lucky star (Singapore), Uni-President Enterprises Corporation (Taiwan), and Growel Feeds Pvt Ltd (India).

7.2. Seed Transportation for Grow-out Stocking

- Nursery reared fish seeds are transported to cage site, either in oxygen filled polythene bags or in containers supported with oxygen. On reaching the cage site, the transported juveniles are slowly released for acclimatising to the cage water environment.
- It is suggested to transfer the advanced fry of above 5.0 g size in sintex tank supported with oxygen. Advanced fry of 15.0 - 30.0 g should be transported at density of 1000 nos/ tonne for a maximum duration of 12-20 h.
- Stocking during winter should be avoided, as the species is highly sensitive to low temperatures. Fish stocked at low temperatures are easily stressed, which makes them susceptible to bacterial infection.

Orange spotted grouper seed transportation in sintex tank

Orange spotted grouper seed transportation in open FRP tank

- Adequate care should be provided for controlling temperature rise (>32.0^0 C) in tank water during shifting of fingerlings in open tank for stocking. As increased water temperature may kill the fish; the tank should be covered with wet cloth for controlling temperature rise.
- Transporting fish in water containing residual ozone or bleach used during water treatment, should be avoided. Raw filtered seawater or water treated prior to a week, should be used for shifting fish fingerlings.

7.3. Grow-out Culture

- Grow-out is for rearing fish after nursery till marketing.
- The optimum stocking density, suggested for grow-out is 20-25 nos/m^3 and thus, a 6.0 m dia cage with 4.0 m net depth will have to be stocked with nearly 2500 numbers of fish seed.
- Grouper, being a demersal fish, remain at the bottom; therefore, cage with low net depth (1.5 to 2.0 m) is preferred for better feed visibility to fish. Hence, during initial phases of culture, net depth of 2.0 m is maintained. Once the fish size exceeds 250.0 g, then the net depth is increased to 4.0 m.
- Artificial floating pelleted feed with high protein content is recommended for grow-out systems. Though the fish accepts artificial pelleted feed well, it requires bigger size of pellet during grow-out, in tune to the comparatively bigger mouth sizes for the species. Hence, feed size is important for ensuring efficient feeding.
- Fish fed solely on artificial pelleted feed in grow-out exhibits positive feeding response and moderate growth. However, artificial pelleted feed alone causes size variation in approximately 30% of the stocked individuals. Therefore, mixed feeding is suggested for grow-out systems.

Releasing of orange spotted grouper seed transported using polythene bags filled with oxygen

- Feeding alone with low value fish (preferably sardine, Indian scad and juvenile tilapia) can also be adopted. Mixed feeding, using pelleted feed and low value fish meat, is the most suggested feeding strategy for cage cultured orange spotted grouper.
- When pelleted feeds are provided, a feed mesh of 1.0 m depth is attached in the inner cage net for avoiding feed wastage.
- Feeding ration varies with the type of feed used: 6.0-10.0% for pelleted feed and 5-10% for chopped low value fish meat. As fish grows, feeding ration reduces.
- Proper feed digestion and assimilation in fish body helps for better growth; therefore, a minimum time gap of 3 h should be given between two feeding schedules. Preferred feeding frequency is 2-3 times/day.

- Orange spotted grouper is highly carnivorous and moderatelycannibalistic. Thus, sufficient feeding should be provided for better growth and avoiding cannibalism during the initial stages of grow-out.
- Cannibalism is common till the fish reaches 10.0 g in size. Hence, grading is important for increasing survival during the initial phases for avoiding cannibalism.
- During grow-out, fish growth should be monitored fortnightly and feeding rate to be adjusted based on the weight gain after every sampling. Based on several demonstrations, if fish fingerlings of 20 to 25 g are stocked at 20 nos/m^3, then it takes nearly 12 months to attain the size of 0.8 to 1.0 kg, and 15 months to attain 1.5 kg. Fish in excess of 1.0 kg possess high demand in international market. Fish growth and optimum feeding rate is given in Table below.
- When pelleted feed and low value fish meat are provided together, both should be reduced to 50% of the original quantity.

Feeding pattern in growout culture of orange spotted grouper

DOC	Fish size (g)	Feed size (mm)	Feeding rate for pelleted feed	Feeding rate for low value fish	Feeding frequency (times/day)
0-60	20-75	1.8-3.0	8%	10-12%	4
60-120	75-150	3.0-5.0	6%	8-10%	4
120-180	150-275	5.0-6.0	4%	6-8%	3
180-240	275-450	6.0-10.0	3%	4-6%	3
240-300	450-650	10.0-15.0	2%	4-5%	2
300-360	650-900	10.0-18.0	1.5%	3-4%	2
360-420	900-1300	15.0-20.0	1.25%	3-4%	2
420-480	1300-1500	15.0-20.0	1.25%	3-4%	2

Weighing of required quantity of low value fish (sardine) for feeding orange spotted grouper

Feeding of orange spotted grouper in cage with low value feed

Orange spotted grouper grow-out in cages

7.4. Cage Structure Management

- Grow-out culture for orange spotted grouper need to be maintained at-least for a year; therefore, different cage components should be managed efficiently. Different management activities include net exchange, cage frame cleaning and mooring checking.
- The cage net is the structure which holds the fish, and is prone to attachment of barnacles, and algal and silt accumulation. Thus the net, needs to be exchanged periodically, depending on the accumulation rate. The accumulation depends on the season and the location, and based on the experiences from the east coast, the cage net should be exchanged at least once in two months. If the cage nets are not exchanged within the stipulated time, then, they may tear off due to the heavy load. Also, fouling load on cage net will negatively impact the buoyancy of the cage frame. The fish being elongated in shape, even a small cut in the cage net will lead to escapement of the fish.
- Cage frame, being the walkway, is prone for settlement of barnacles, and if the settlement is more, it would adversely impact the shelf life of the cage. Also, settlement in cage frame, more often than not results in tearing of the net ropes through rubbing. Attachment of micro and macro algae (*Ulva* spp) in cage frame leads to skidding during routine management. Thus, cage frame requires monthly cleaning.
- Cage mooring helps to keep the entire cage structure in position, thus the mooring chain requires continuous monitoring at least once in a month. The mooring system specified for the cages will remain without much of an issue for a minimum of two years, and then slowly the chain starts eroding, resulting ultimately in chain tear. Thus, mooring checking with the help of underwater diver is recommended once in a month. With prevailing heavy wind and wave along the east coast of India, the chains are mostly damaged

in proximity to the anchors, below the swivel; therefore,providing a single additional chain of 10.0-15.0 m length between anchors and swivel will provide extra strength to the mooring chain.

7.5. Fish Health Management

- Cage cultured fish should be checked and critically observed for its feeding and health status by periodic sampling at fortnight intervals. Also, daily observations during feeding are essential for understanding the feeding behaviour, which is an excellent indicator on the health status of the fish.
- Three pathogens: parasite, bacteria and virus are responsible for diseases in orange spotted grouper. Details of disease causing agents, symptoms and preventive measures are provided in the attached Table.

Major Diseases of orange spotted grouper in Cages

Group	Major group	Symptoms	Control measure
Parasite	Protozoa, Monogenea and Digenea	Skin irritation and rubbing against the hard surface, skin ulceration and reduced appetite	Freshwater dip and use of Praziquintel in feed
Bacteria	*Vibrio parahaemolyticus, V. alginolyticus, Streptococcus* and *Flexibacteria*	Haemorrhage, weakness, surface swimming, fin rot and reduced appetite	Use of probiotics
Virus	Nodavirus and Iridovirus	Dark colouration, loss of equilibrium, and mass mortality	Selection of disease-free juveniles

- All diseases are associated with stress, and the stressed fishes are opportunistically affected by the pathogens. Therefore, stress during culture should be minimised by maintaining optimum water quality, feeding and stocking density. Rough handling leads to stress; thus, fish should be handled carefully while sampling and net exchange.
- As viral infection can occur from hatchery produced larvae itself, selecting active and nodavirus free seed is paramount for controlling the infection.

Orange spotted grouper infested with isopod infestation

Orange spotted grouper affected by Vibrio bacteria

7.6. Fish Harvest and Marketing

- In cages, fishes are reared in a small confinement, so harvesting of cage cultured fish is easier than any other culture methods. Orange spotted grouper, being relatively calm and residing at the bottom, harvesting from cage is simple.
- It is suggested to harvest the fish either in early morning or late evening hours to maintain their freshness.
- While harvesting, the inner cage net is lifted from all sides, and the lifted net is hanged on hand rails andtied to it. The fishes in the inner net are harvested with the help of a hand scoop net.

Orange spotted grouper harvested from sea cage

Orange spotted grouper kept in ice prior to packaging

- The colour of orange spotted grouper plays a pivotal role in marketing, fetching a premium price. Fishes with bright colouration and prominent orange spots are having higher demand. With cage cultured fish looking relatively darker, colour can be enhanced by employing appropriate harvesting methods by maintaining cold chains.
- Immediately upon harvest, washing in clean water and chill killing is suggested to maintain the freshness and quality of the harvested fish. Later, the dead fish is kept in ice water till packaging, to regain the colour.
- Harvested fishes should be packed in plastic trays or thermocole boxes, by adding layers of ice in equal quantities below and above the fish.
- The species is highly popular in international trade for export in live and chilled conditions. South-East Asian countries and United Arab Emirates (UAE) are the major buyers. Groupers, with their popularity in live fish trade in South-East Asian countries, fetches premium price of 3-4 times higher than the price of dead fish. Apart from live fish trade, chilled fish is another major mode of export to the UAE countries.
- The market demand is dependent on the fish size. South-East Asian countries demand for fish sizes ranging from 1.0 to 1.5 kg size per fish, whereas, the UAE countries demand 2.0 to 4.0 kg size per fish.
- Domestic market potential for the species in India is comparatively less.

7.7. Economics

❄ The total operational expenditure and profit for culture of the fish in a battery of 10 cages is given in the Table. Culturing the fish for 10 months at the stocking of 20/m^3 will support the farmer with net profit of approximately ₹ 11.0 lakhs with price realization of ₹ 300/kg in chill fish trade. However, in live fish trade, the profit may be still higher.

Economics for Seacage Farming of orange spotted grouper

Sl. No	Head of expense	Cost in INR (in lakh)
1	Depreciation value on cage and accessories with an average life of 10 years for cage frame and five years for cage mooring and nets (Cost of cage and accessories including installation: ₹ 300,000/unit): Depreciation is ₹ 43,000/unit/year	4.3
	Operational expenditure	
2	Cost of 25000 numbers of grouper seeds @ INR 20/ seed (including nursery rearing expenses)	5.0
3	Cost of 35.0 t of extruded pelleted feed (Survival 80%; Average Body Weight 1000 g at harvest) @ FCR 1:1.75 @ ₹ 100/kg	35.00
4	Labour Charges @ ₹ 30000/month for 10 months	3.00
5	Boat Hiring and Fuel Charges @ ₹ 6000/ month for 10 months	0.60
6	Charges for net exchange @ 500/person for 3 persons, five times in the production cycle for each cage	0.75
7	Miscellaneous expenditure, feed medicines and probiotics	0.5
8	Expenditure (Sl no: 1-7)	49.15
9	Total income: Production: 20 tonnes @ 80% survival with harvest size of 1.0 kg at selling price @ ₹ 300/kg	60.00
10	Net profit : (8-7)	10.85

8. Site Selected for Cage Culture Activities along North-East Coast of India

❍ Based on the survey conducted by ICAR-CMFRI, under the All India Network Project on Mariculture, following sites have been selected as suitable for performing cage culture operations. The factors considered for selection were physical, chemical, biological and social. However, still, many more locations would be suitable for cage culture in all the three states, and they should be selected by following different site selection parameters discussed earlier.

Sl. No	District	Village/Location	Latitude (° N)	Longitude(° E)
		ANDHRA PRADESH		
01	Srikakulam	Baruva	18.527	84.358
02	Srikakulam	Kocherla	18.089	83.476
03	Srikakulam	Koyyam	18.165	83.557
04.	Srikakulam	D. Machilesam	18.109	83.523
05	Srikakulam	Dibbalapalem	18.125	83.559
06	Vizianagaram	Chintapalli	18.040	83.399
07	Vizianagaram	Mukkam	17.595	83.339
08	Visakhapatnam	Jalaripeta	17.416	83.190
09	Visakhapatnam	Mangamaripeta	17.527	83.273
10	Visakhapatnam	Bheemili	17.497	83.253
11	East Godavari	Pampodipeta	17.141	82.320
12	East Godavari	Uppada	17.041	82.206
13	East Godavari	Konapapapeta	17.074	82.241
14	East Godavari	Danaiahpeta	17.125	82.297
15	East Godavari	Perumallapuram	17.141	82.320
16	East Godavari	Chodipallipeta	17.088	82.257
17	West Godavari	Vemuladeevi	16.195	81.355
18	West Godavari	Perupalem	16.202	81.355
19	Krishna	Etimoga	15.525	80.536
20	Krishna	Nagayalanka	15.569	80.547
21	Krishna	Kruthivennu	16.220	81.226
22	Krishna	Urlagondadibba	16.205	81.255
23	Krishna	Chinnagollapalem	16.213	81.405
24	Guntur	Nizampatnam	15.491	80.381

Sl. No	District	Village/Location	Latitude (° N)	Longitude(° E)
25	Guntur	Suryalanka	15.502	80.303
26	Prakasam	Vaadarevu	15.483	80.244
27	Prakasam	Peddaganjam	15.381	80.151
28	Prakasam	Ammanabrolu	15.328	80.125
29	Prakasam	Kothapalem	15.261	80.104
30	Prakasam	Pakala	15.167	80.581
31	Prakasam	Karedu	15.105	80.496
32	SPSR Nellore	Mypadu	14.302	80.104
33	SPSR Nellore	Krishnapatnam	14.175	80.834
		ODISHA		
1	Puri	Chandrabhaga	19° 51.940 N	86° 06.711 E
2	Puri	Pentakota	19° 48.185 N	85° 51.200 E
3	Balasore	Dagra	21° 33.182 N	87° 16.843 E
4	Balasore	Chawmukh	21° 33.200 N	87° 18.167 E
5	Balasore	Thalasari	21° 36.123 N	87° 27.921 E
6	Ganjam	Sonepur	19° 06.630 N	84° 46.675 E
7	Ganjam	Ramayyapatnam	19° 08.204 N	84° 47.896 E
8	Ganjam	Gopalpur	19° 15.408 N	84° 54.550 E
9	Ganjam	Argipalli	19° 18.295 N	84° 58.518 E
		WEST BENGAL		
1	Purba Medinipur	Digha	21° 37.365 N	87° 31.581 E

List of Marine Finfish Hatcheries

Marine Finfish Hatchery	Marine Finfish Species
ICAR-Central Marine Fisheries Research Institute, Regional Centre, Mandapam, Marine Fisheries Post, Mandapam camp, Ramanathapuram Dt, Tamil Nadu - 623520, India Tel: 04573-241973 E-mail: mandapamcmfri@gmail.com;	Silver Pompano and Cobia
ICAR-Central Marine Fisheries Research Institute, Regional Centre, Visakhapatnam Andhra University Post, Visakhapatnam, Andhra Pradesh-530003 Tel: 0891 - 2543154 E-mail: cmfrivsp@gmail.com	Indian Pompano, Orange spotted Grouper & John's snapper
ICAR-Central Marine Fisheries Research Institute, Post Bag No.9, Vizhinjam Post, Thiruvananthapuram - 695521, Kerala Tel: 0471-2480224 E-mail: vrcofcmfrivzm@gmail.com	Silver Pompano and Indian Pompano
Multi species marine finfish hatchery ICAR-Central Institute of Brackish-water Aquaculture #75, Santhome High Road, MRC Nagar, Chennai, Tamil Nadu - 600028. Tel: +91-44-24618817, 24616948 E-mail: director.ciba@icar.gov.in	Asian seabass
Rajiv Gandhi Centre for Aquaculture (MPEDA, Ministry of Commerce & Industry, Govt. of India) 3/197, Poompuhar Road, Karaimedu	Asian seabass

Marine Finfish Hatchery	Marine Finfish Species
Village, Sattanathpuram P.O., Sirkali Taluk, Mayiladuthurai district - 609 109, Tamil Nadu, INDIA Tel : +91 4364 265200 to 265217 Fax : +91 4364 265218 Email :rgcaho@gmail.com .	
M/s MSR Aqua Pvt. Ltd. Marine Fin Fish Hatchery, Konapapapeta East Godavari, Andhra Pradesh E-mail: msraquapvtltd@gmail.com Mob: 9848011451, 9441575757	Silver pompano & Asian seabass
Pompano Hatchery, Regional Shrimp Hatchery Complex, Kerala Fisheries Department, Azhikode, Kodungallur, Thrissur District - 680666 , Kerala	Silver Pompano and Indian Pompano

10. List of Cage Fabricators and Cage Net Producers

Manufacturer	Product
M/s. Poorvi Fabrication, D.No. 50-80-22, Flat No.11, Anjana Residency, Seethammapeta, Visakhapatnam - 530016, Andhra Pradesh Mr. Y.V. Satyanarayana, Tel:9849829264 Phone: 0891-2752926 Email: poorvif@yahoo.co	HDPE/GI (Galvanised Iron) Cages
M/s. Roopak Plastics Pvt. Ltd. Plot No. 51, AIE Pedagantyada, Visakhapatnam - 530 044, Andhra Pradesh Tel: 0891-2750517	HDPE/GI (Galvanised Iron) Cages
M/s. TTK Fiber Glass Works Plot No. 32, F- Block, 3rd Lane, APIIC, Industrial Park, Auto Nagar, Visakapatnam - 530 012, Andhra Pradesh.	HDPE/GI (Galvanised Iron) Cages

Manufacturer	Product
Mr. K.V.N. Raju, Tel: 94403 19197 Email: ttkfibreglass@gmail.com	
Mr. SeeniMohideen, 2/8, Marakayarpatnam, Ramanathapuram - 623 520, Tamil Nadu, Mr. SeeniMohideen, Tel: 8344927487	HDPE/GI (Galvanised Iron) Cages
M/s. Catamaran Cage Fabrications, 5-3592, Raja Nagar, Thangachimadam, Ramanathapuram District - 623 529, Tamil Nadu Mr. S. Ebi Tel: 9600436334 Email: ebipachek90@gmail.com	HDPE/GI (Galvanised Iron) Cages
M/s. RVR & Co Residency Plaza, 5th Floor, No. 41/42, Residency Road, Bengaluru - 560 025, Karnataka Mr. R V Ramana V. Reddivari, Tel: 91 98861 34567	HDPE/GI (Galvanised Iron) Cages
Mr. Sreekumar Vasudevan Theruvilparambil House, Pizhala, Kadamakudy, Ernakulam - 682 018, Kerala. Mr. Sreekumar Vasudevan Tel: 918943909469	HDPE/GI (Galvanised Iron) Cages
Turfropes Pvt Ltd 25, Maker Chambers III, Nariman Point, Mumbai 400021 Tel: +91-22 40502700 E-mai: Contactus@turfropes.com	Nets & Ropes

Manufacturer	Product
Garware Technical Fibres Ltd Plot No 11, Block D1,M.I.D.C, Chinchwad, Pune - 411019, Maharashtra, India Tel: +91-20-27990301, 27990306 E-mail: sales@garwarefibres.com	Nets & Ropes
Kerala State Co-Operative Federation for Fisheries Development Ltd. MATSYAFED, Kamaleswaram, Manacaud, Post, Thiruvananthapuram -695009. Kerala Tel: 0471- 2458606, 2457756, 2457172 Fax: 0471 2457752 Email: matsyafed@matsyafed.in	Nets & Ropes

List of Marine Finfish Feed Manufacturing Companies

Manufacturer	Product (Feed)
Growel Feeds Pvt LTD R.S. No.57 & 58, Chevuru Village, Sriharipuram Panchayat, Mudinapallimandal,Krishna District - 521329, Andhra Pradesh Tel: +91-9618763322, +91-9989453322 E-mail: customercare@growelfeeds.com	Marine Finfish Feed
Ananda Enterprises (India) Pvt Ltd Kothapusalamuru Village, Gollavanithippa Road,BhimavaramMandal, West Godavari District- 534239, Andhra Pradesh Tel: +8816 - 279114, 279115 E-mail :sales.aeiplkpm@gmail.com; anandaenterprises@gmail.com	Marine Finfish Feed
M/s. Uni-President Enterprises Corp. UPES (India) Foods Pvt. Ltd., 83/A, G.N.T. Road	Marine Finfish Feed

Manufacturer	Product (Feed)
(NH-5) PonniyammanMedu, Madhavaram, Chennai - 600 110, Tamil Nadu	
M/s Skretting India Private Limited 12th Floor, B Wing, Embassy 247, Lal Bahadur Shastri Marg, Vikhroli West, Mumbai - 400079, Maharashtra, Tel: +91 70451 12255	Marine Finfish Feed

List of Fish Marketing Agencies

Tamil Nadu Fisheries Development Corporation Limited (TNFDC) 4th Floor, Integrated Animal Husbandry and Fisheries Building, Nandanam, Chennai - 600 035 Tel: 044-24364901 E-mail: tnfdcho@gmail.com
Karnataka Fisheries Development Corporation Limited Hoige Bazaar, Mangalore - 575001. Tel: (0824) 2421281 / 82, Fax - (0824) 2424560 E - mail: kfdcixe@yahoo.com
State Fisheries Development Corporation Limited Bikas Bhavan, North Block, First Floor, Sector-1, Bidhan Nagar Road, BF Block, Sector 1, Salt Lake City, Kolkata-700091 West Bengal Tel: 033-23583123 E-mail: headoffice@wbsfdcltd.com
Kerala State Co-Operative Federation for Fisheries Development Ltd. MATSYAFED, Kamaleswaram, Manacaud, Post, Thiruvananthapuram -695009. Kerala Tel: 0471- 2458606, 2457756, 2457172 Fax: 0471 2457752 Email: matsyafed@matsyafed.in

List of Government Developmental Agencies

Marine Fisheries, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying Room No 479, Krishi Bhavan New Delhi 110001 Tel.: 011-23097014
National Fisheries Development Board Department of Fisheries Ministry of Fisheries, Animal Husbandry & Dairying, Government of India Pillar No: 235, PVNR Expressway, SVPNPA Post, Hyderabad - 500 052 Phone No. 040- 24000177/201, Fax No: 040-2401 5568 info.nfdb@nic.in

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Indian Council of Agricultural Research
CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
Post Box No. 1603; Ernakulam North P.O. Kochi - 682018; Kerala, India
Phone: +91 484 2394357, 2394867,
Fax: +91 484 2394909
Email: director@cmfri.org.in
www.cmfri.org.in