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BUREAU OF INDIAN STANDARDS

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भारतीय मानक

समुद्र में पिंजरा मत्स्यपालन के लिए उत्तम मत्स्यपालन व्यवहार रीतियाँ

Draft Indian Standard

Good Aquaculture Practices for Sea Cage Farming

ICS 67.120.30

Fish, Fisheries and Aquaculture Sectional Committee, FAD 12

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FOREWORD

(Formal clause will be added later.)

The requirement of fish for domestic consumption in India is estimated to touch 18 million metric tonnes in coming years. 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, so are the challenges 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 conceptualized in India in 2005 and a demonstration project was successfully performed by ICAR-CMFRI. 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 open-sea cage farming will be a ready reckoner for fish farmers venturing into cage mariculture.

1 SCOPE

This Indian Standard provides Good Aquaculture Practices for cage culture in seawater, cages, site and species selection, seed, feed and health management, safety measures, market and post- harvest facilities.

2 NORMATIVE REFERENCES

No normative references in this Indian standard

3 GOOD AQUACULTURE PRACTICES FOR CAGE CULTURE IN SEAWATER

The procedures carried out for cage culture in seawater are given under this clause.

3.1 Site selection–

Appropriate site selection decides the profitability and sustainability of the cage farm. The sites selected, 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 by 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.

3.1.1. *Topographical Parameters*

a) Cages shall 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

b) 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.

c) A firm substrate, with a combination of fine gravel, sand and clay is an ideal site for cage culture. 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 bottom with more clay

3.1.2. *Physical Criteria*

a) 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.

b) Turbid water affects the visibility of the feed to fishes, and if turbidity remains for longer duration, then it results in reduced feed intake and impaired fish growth.

c) Suitable temperature for their optimum metabolic activities ranges from 27–31°C.

3.1.3. *Chemical criteria*

a) Dissolved oxygen is the most important parameter for keeping the animal healthy. Dissolved oxygen of 5.0 ppm is optimum.

b) Optimum salinity range for important marine the species is 15-35 ppt. Site at the river mouth should be avoided.

c) Optimum value of pH for both the species is 7.5 to 8.5 and usually, seawater pH is within this range.

d) Optimum range for total ammonia: 0-0.05 ppm, nitrate: < 200 mg/lit; nitrite: 4 mg/lit.

e) Organic load in water is measured by Chemical Oxygen Demand (COD), and should be <3mg/lit. Phosphate in seawater should be less than 70 mg/lit.

Recommended water quality criteria for sea cage culture of marine finfishes is given in Table 1.

Table 1: Water Quality Criteria for Sea cage culture of Marine Finfishes

(Clause 3.1.3)

Sl.No	**Water Quality Parameters**	**Optimum Range**
1	Dissolved Oxygen	5– 8 mg/L
2	Water Temperature	28 – 330 C
3	pH	7.9 – 8.3
4	Salinity	15 – 34 ppt
5	Transparency	>40 cm
6	Ammonia	0-0.05 ppm
7	Nitrate	< 200 mg/lit
8	Nitrite	<4 mg/lit
9	COD	<3mg/lit

3.1.4. ***Biological Criteria***

Presence of more biological organisms will directly affect the shelf life of 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.

3.1.5. ***Accessibility***

Cage culture activity involves frequent movement 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 road facilities for transportation of seed, feed and harvested fish.

3.1.6. ***Social problems***

Social issue is non-biological, and is one of the major constraints in cage culture activity. Therefore, selected site should be away from fishing villages, and cage culture areas should be clearly demarcated.

3.2. Types of cage

Floating type cage is commonly used in marine waters. It is basically supported by a floating frame, where from net bags are kept hanging in water without touching the basin. It is generally practiced in water bodies with depth of water more than 6m.

3.3. Cage Design: Size and shape

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

3.4. Cage Accessories

Different cage accessories are being used for complete cage fabrication and deployment. The different accessories are: cage frame, mooring systems, ballast System, cage net.

3.5. HDPE Cage Frame

i. The cage frame has two collar rings with floatation properties and a middle catwalk, and all the three frames assists in routine cage management.
ii. 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 polyurethane foam or thermocole to enhance their floatation efficiency.
iii. 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 pipe outer diameter.
iv. Vertical and diagonal supports help to join the base collar rings to the hand rail. They are made up of HDPE pipes with 90 mm pipe outer diameter.
v. 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.

3.6. Cage Mooring System

i. 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.
ii. 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 suggested.
iii. 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.
iv. 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 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.
v. 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.
vi. 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.
vii. 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 Fiber Reinforced Plastic (FRP) to prevent rusting of clamps.

3.8. Ballast system

i. Ballast pipes help to maintain cage net structure in-tact, in proper shape against the water movement.
ii. 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.
iii. 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 HEPE pipes, they may tear the net.
iv. While mooring cages, the ballast pipes should be shifted along with the cages in order to avoid extra expenditure on separate shifting.

3.9 Cage Net

i. HDPE braided nets is preferred for its strength and light-weight. HDPE nets are durable in seawater for up-to 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.

ii. 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.

iii. Inner net is vertically hanged from the handrails of cage frame. 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 100g 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

iv. 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 birds' predation.

Specification for inner nets mesh size in different grow-out stages for marine finfishes is given in Table 2.

Table 2: Specification for inner nets mesh size in different grow-out stages for Marine Finfishes

(Clause 3.9)

Species	18 mm Mesh (Fish Size (g))	25 mm Mesh (Fish Size (g))	40 mm Mesh (Fish Size (g))	60 mm Mesh (Fish Size (g))
Cobia	10-70	100-1100	1100-4000	4000-7000
Pompano	10-100	100-1000	1000-2000	-
Grouper	15-300	300-1000	1000-2000	
Seabass	15-300	300-1000	1000-2000	

4. Cage structure deployment

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 time gap is required for proper setting of anchoring system in sea bottom.

4.1. Mooring systems deployment

i. 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.
ii. The entire structure is loaded onto 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.
iii. The attached buoys help for floatation and also for identifying the mooring locations.

4.2. Deployment of cage frame

i. 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.
ii. The ballast pipes are also shifted with the cage frame by attaching to the handrails.

5. Species Selection

i. 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.

ii. 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, high nutritional value, consumer acceptance, economic value in local and international market and regional preference.
iii. As per the above criteria, Indian pompano (*Trachinotus mookalee*), Cobia (*Rachycentron canadum*), Silver Pompano (*Trachinotus blochii*), Groupers (*Epinephelus sp*.), Seabass (*Lates calcarifer*), Snappers (*Lutjanus sp*.), are highly suitable for sea cage farming.

5.1. Fish Seed

Quality of fish seed is of vital importance for the success of grow-out culture in cages. Uniform size seeds appropriate for the mesh size of the fish net cage should be stocked to prevent their escape. This will also help in selecting the correct sized feed for fishes, avoid wastage of feed and reduce cannibalism. Seeds should be healthy, free from diseases and deformities. Fish seed specifications for different species of Marine Finfishes is given in Table 3.

Table 3 Fish seed specifications for different species of Marine Finfishes
(Clause 5.1)

Sl.No	Aspects	Specification
1.	Stocking Size	• Marine Fin fishes: ≥ 20 – 25 g (~10-15 cm)
2.	Seed Quality	• Large effective population size of broodstock fishes (Ne): At least 50 brood fish pairs. • Permissible level of inbreeding accumulation: ~1% per generation. • Family Selection based breeding. Use of Factorial Mating design. • A centralized fish seed certification system necessary.
3.	Seed Purity	• Monoculture of preferred/desirable fishes at hatchery level • Community breeding of multiple fish species in the same breeding tank must be stopped. • A centralized fish seed certification system necessary
4.	Seed Price	• Periodic market survey required for determining minimum fish seed prices feasible and adjustment of current fish seed price accordingly. • Seed sale strategy modification: from ‘per piece’ basis to ‘per kg’ basis. • A centralized fish seed certification system necessary.
5.	Stocking Strategy	• Should be transported in open container with dissolved oxygen support and oxygen concentration should be above 5.p ppm • Stocking uniform size is preferred to avoid cannibalism during grow-out culture operation

5.2. Nursery Rearing

i. 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.
ii. Nursery rearing of marine fin fishes 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 transfer.
iii. 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 and species reared.
iv. For majority of the species, with a proper nursery management, 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 month (75 days).
v. 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.
vi. 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.
vii. 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 fish jumping out of the tank.
viii. Vibriosis is the most common bacterial infection occurring during nursery, because of stress. Minimizing 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.

5.3. Seed Transportation for Grow-out stocking

i. 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.
ii. When fingerlings are stocked at more than 5g in size, they should be transported in a container supported with pure oxygen for achieving maximum survival. Sintex or open container based seed transportation with oxygen supply is preferred mode of transportation for better survival.
iii. Adequate care should be provided while transferring fingerlings. Fingerlings transported in stressed condition (overcrowding and less dissolved oxygen) are more susceptible to

vibriosis after stocking in cages. Thus, adequate care should be given to keep the animals under stress-free conditions.

iv. Use of ice while seed transportation is recommended during summer season in-order to avoid heat shock to the transported larvae.

v. 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.

vi. Based on the current research; the optimum fish size, stocking density and mode of transportation is given in the Table 4.

Table. 4 Transportation of Marine Finfish seeds
(Clause 5.3)

Fish Size (g)	Duration (hr)	Stocking (nos/lit)	Mode of transportation
> 0.25	24-36	50-60	Polythene bag filled with oxygen
1.0 to 2.5	15-30	20-25	Polythene bag filled with oxygen
2.5 to 5.0	12-24	10-15	Sintex tank supported with oxygen
5.0 to 15.0	12-20	4-5	Sintex tank supported with oxygen
25.0 to 30.0	12-20	1-1.5	Sintex tank supported with oxygen

5.4. Stocking

Stocking appropriate size and number of fish seed in cages is very crucial for the success of cage farming. After allowing the hatchery produced spawn to grow for a period ranging from 30 to 60 days, fish seed can be stocked in cages. Nursery rearing of seed is essential for all species and it can be done as a separate activity, in land based nursery ponds or hapas held in ponds or in floating nursery cages, by individuals or groups at different localities to support sea cage farming with ready to stock fingerlings. Healthy, uniform-sized fingerlings should be procured for stocking in cages. The fingerling stocking details are given in Table 5.

Table 5 Optimum stocking size and stocking density for different species of Marine Finfishes
(Clause 5.4)

Species	Stocking Size (Length/Weight)	Stocking Density (No/m^3)
Cobia	15 cm/35 g	8-10
Silver Pompano	10 cm/35 g	30-40
Indian Pompano	11 cm/35 g	25-30

Orange Spotted grouper	12 cm/35 g	20-25
Asian Seabass	15 cm/35 g	30-40

6. Grow-out Culture

i. After reaching the cage site, transported juveniles should be slowly released into the cage for acclimatizing to the cage water environment.
ii. Appropriate stocking density should be followed for achieving optimum growth and economic benefit.
iii. Artificial floating pelleted feed with high nutritional composition (40% Crude Protein and 10% Crude Fat) is recommended for grow out systems.
iv. 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 0.10-0.05 mm mesh size and 1.0 m width, to the inner net helps in controlling the feed wastage. Even, using mosquito net can act as feed mesh for controlling feed wastage.
v. 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 fish deprived from feed will be non-existent.
vi. 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.
vii. Better feed digestion and assimilation ensures better fish growth, thus, a minimum of 3 hours' 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.
viii. In grow out culture, fish growth should be monitored fortnightly and feeding rate to be adjusted based on the weight gain after every sampling.
ix. In a well-managed cage culture grow-out system, fish fingerlings stocked at 20 to 25g 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.
x. Survival rate varies with stocking size; survival rate for fish stocked at 25 g varies from 90 – 95 %, whereas for fish stocked at 100g, survival ranges between 95 – 98 %.
xi. Feed conversion Ratio (FCR) varies from 1.65 to 2.0, and achieving low FCR is dependent on effective feed management.
xii. Fish growth, feeding frequency and rate of feeding for Indian pompano in marine cage culture is given in subsequent clauses.

6.1 Feeding

Any material used for feeding should contain the following five principle constituents: (i) Protein, (ii) Carbohydrate, (iii) Fat, (iv) Minerals and (v) Vitamins. Proteins are essential for growth of the animal and a deficiency can lead to growth retardation. The nutrient requirements of marine carnivorous fishes (as percent) are given in Table 6.

Table. 6: Optimum nutritional requirements for different species of Marine Finfishes
(Clause 6.1)

Size of the fish	**Moisture**	**Crude Protein**	**Crude Fat**	**Crude Fibre**
Fry to Fingerlings (1-20g)	<12	>45	~10	<4
Juvenile (20-50 g)	<12	40-45	~10	<4
Grower (50-500 g)	<12	38-40	8-10	<4
Marketable size (>500 g)	<12	38-40	8-10	<4

Marine fishes require higher protein (38 – 40 %) feed for their optimal growth. Based on growth of the fish, size of the feed pellet should be adjusted. Normal feeding rate is 10% of the body weight for juvenile fishes which can be reduced to 3% body weight as farming progresses. A feed with an FCR of 1.5 is advisable. Only recommended ration should be given to fishes since overfeeding leads to wastage and environment pollution.

6.2 Feed Storage

During storage, feeds undergo deteriorative changes which not only lower their nutritive value but also affect their palatability and appearance. Feeds should be stored in dry ventilated warehouses away from direct sunlight at more or less constant temperature. All feeds should be used within the prescribed time (preferably within two months of manufacture) and inspected regularly. During long storage there may be changes such as fungal growth, degradation of vitamin potency and fat rancidity. Unnecessary handling may damage feed bags and reduce pellets to powder that is usually not consumed by fish and wasted. Pests like rats, cockroaches, etc., must be strictly controlled in the storage, to avoid contamination. Proper storage of feed is simple, but it is important to keep its quality high.

6.3 Feeding Schedule

Feeding rates, frequency of feeding and time of feeding are important factors to be considered in cage farming. Feeding rates and frequencies are related to age and size of the fish. Fish larvae and fry need to be fed on a high protein diet more frequently. When fishes grow bigger, feeding rates and frequencies can be reduced. Feeding fish is a labour-intensive activity and the frequency has to be adjusted in such a way that it is economically viable. Generally, growth and feed conversion increase with increase in feeding frequency. Feed consumption is also influenced by time of day, season, water temperature, dissolved oxygen levels and other water quality parameters. Even though several feeding charts are available, it is better to construct one of your own with information on: Days of Culture (DOC), Fish Weight, Protein in Feed, Meal/Day, Feed Consumed as % of body weight, Average Daily Gain (ADG) and

Feed Conversion Ratio (FCR). Indicative feeding charts for Indian pompano, orange spotted grouper, Silver Pompano and Cobia are given in Table 7, Table 8, Table 9 and Table 10 respectively.

Table 7 Growth, feed and feeding for Indian pompano
(Clause 6.3)

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	4-5
120-180	100-300	3.0 to 4.0	5-4	4
180-210	300-500	4.0 to 6.0	4-3	4
210-300	500-750	6.0 to 7.0	3-2.5	4-3
300-360	750-1100	7 to 10.0	2	3

Table 8 Growth, feed and feeding for Orange spotted grouper
(Clause 6.3)

DOC	**Size (g)**	**Feed Size (mm)**	**Feeding Rate**		**Feeding Frequency (times/day)**
			Artificial feed (A.F)	A.F + Trash fish	
0-60	20-75	1.8 to 3.0	8%	4% + 5%	4
60-120	75-150	3.0 to 5.0	6-5%	3% + 5%	4
120-180	150-275	5.0 to 6.0	5-4%	2% + 5%	2
180-240	275-450	6.0 to 1.0	4%	2% + 5%	2
240-300	450-650	1.0 to 1.5	3-2.5%	1% + 5%	2
300-360	650-900	1.0 to 1.5	2%	1% + 5%	2

Table 9 Growth, feed and feeding for silver pompano
(Clause 6.3)

DOC	**Size (g)**	**Feed Size (mm)**	**Feeding Rate (%)**	**Feeding Frequency**

				(times/day)
0-30	15-35	1.2 to 1.8	8	4-5
30-120	35-172	1.8 to 3.0	6-5	4-5
120-180	172-375	1.8 to 3.0	5-4	4
180-210	375-465	3.0 to 4.0	4-3	4

Table 10 Growth, feed and feeding for Cobia
(Clause 6.3)

DOC	Size (g)	Feed Size (mm)	Feeding Rate (%)	Feeding Frequency (times/day)
0-30	35-70	1.5 to 1.8	15	4-5
30-120	70-460	1.8 to 2.5	15-10	4-5
120-180	460-1900	2.5 to 5.0	10-8.0	4
180-210	1900-3300	5.0 to 8.0	8.0-5.0	4
210-300	3300-5600	12.0 to 15.0	8.0-5.0	4-3
300-360	5600-7200	15 to 18.0	5.0-3.0	3

6.4 Cage Structure Management

i. 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 shelf life of the cage.

ii. Fish fingerlings stocked at 25g 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.

iii. 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.

iv. 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.

v. 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 shelf life for the mooring chain.

6.5. Fish Health Management

Disease outbreaks can occur as a result of intensive farming in cages. Infectious diseases are mainly due to waste accumulation, crowding, handling, variations in water quality parameters and bio-fouling. The most common disease that occurs in cages is Vibriosis caused by Vibrio a bacterial species and parasite infestations. Cage abrasion can cause fin and skin damage to farmed fish. Occurrence of infections/ diseases can be minimized by selecting good site, optimal stocking density and careful handling of fish stock. Fish farmers should maintain a record of weather, water quality parameters, feeding rate, length and weight of fish sampled, fish behavioral changes, net cage exchange details, etc. These records provide useful information for analysis of health status. The important aspects should be followed for disease control in cage culture systems are as follows.

i. Cage cultured fish should be checked and critically observed for its feeding and health status by periodic sampling at fortnight intervals.
ii. Also, daily observations during feeding are essential for understanding the feeding behaviour, which is an excellent indicator on the health status of the fish.
iii. The major diseases associated with grow-out cage culture of pompano are: Vibriosis caused by selected species of Vibrio bacteria, and parasitic infestations caused by ecto-parasites. 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 prescribed medicated feeds and probiotics.
iv. 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.
v. The parasitic infestation is controlled by a freshwater dip or by using medicated feeds. Avoiding high stocking density, helps to get rid of parasitic infestations in cages.

6.6 Fish Harvest and Marketing

i. In cages, fishes are reared in a small confinement, so harvesting of cage cultured fish is easier than any other culture methods.

ii. It is suggested to harvest the fish either in early morning or late evening hours to maintain their freshness.
iii. 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.
iv. Immediately upon harvest, washing in clean water and chill killing is suggested to maintain the freshness and quality of the harvested fish.
v. Harvested fishes should be packed in plastic trays or thermocole boxes, by adding layers of ice in equal quantities below and above the fish.
vi. A well-managed cage can harvest an average of 2.0 tonnes of marine fishes /cage/year.
vii. Cage farmed fishes could be harvested based on demand, and is most preferably harvested either during the lean fishing period or during the trawl-ban season. The demand during trawl-ban season is exceptionally high for the species.