4

CAGE CONSTRUCTION: PRINCIPLE AND DESIGN

Anulekshmi Chellappan, J. D. Sarang and A. D. Sawant

Introduction

The culture of finfishes in cages has been practiced for years in countries like Cambodia, Vietnam, Indonesia, Thailand, Malaysia, Singapore and Hongkong. Cage was first used as a holding facility for fish. True cage culture was said to have started in 1243 in China. Use of modern cage materials like synthetic nets, woods and metals started in early 1960's. The size and shape of the cages are very important for the growth and production of the fishes/ shell fishes living inside it. The design will vary depending on the selected site. The constructed cage must withstand the force of wind and wave while holding the stock safely. The cage must be safe, secure and easy to manage. Circular cage bags make the most efficient use of materials, and thus have the lowest costs per unit volume. Shape is likely to influence effective stocking densities and swimming behaviour, which in turn can influence production. Fish cages can be constructed from a variety of materials. All materials used for the cage should be durable, nontoxic, and rustproof. The netting material used for the body of the cage must allow maximum water circulation through the cage without permitting fish escapes. Some type of flotation is needed to suspend the cage at the water surface. Circular shaped cages appear to work the best; however, square or rectangular shaped cages are widely used. The circular cage has no corners for the fish to bump into and become injured. When constructed properly, they are light enough for one person to pull partially out of the water to crowd the fish. Regardless of the shape, do not lift the entire cage out of the water with the fish inside unless the cage is properly reinforced. The plastic will usually break at the seams.

Different types of cages and designs

Fish Cages are enclosures used as a rearing facility for fishes. It has enclosed bottom and sides. It can be made of wood, net screens or wire mesh. Sizes can range from 1 to 1,000 m^2. Cages have an enormous diversity of designs. According to Beveridge (1996), there are four basic types of cages: fixed, floating, submersible, and submerged.

1. **Fixed Cages**

Fixed cages are cheaper and simple. However, they are limited in size and shape. They are used in sheltered shallow sites.

2. **Floating Cages**

Floating cages has a variety of designs. Shapes and sizes can suit the purpose of the farmer. Rigid materials such as GI pipes, bamboos and plastic pipes can be used as frames. Flotation materials such as empty plastic drums and styropor can also be utilized. Floating cages can be towed to other favorable sites, as maybe needed.

3. **Submersible Cages**

Submersible cages were designed to take advantage of prevailing environmental conditions. During bad weather, the cages are submerged to avoid destruction by strong waves.

4. **Submerged Cages**

Submerged cages are those enclosures that are underwater the whole duration of the culture period. Simple submerged cages were reported to be adopted in Indonesia and in lakes in China (Vass & Sachlon, 1957; Li, 1994). Frameless or flexible cage is suited in shallow sites with less fluctuating water depth. Submerged cages allow the use of site exposed to strong winds. Fewer materials are needed for framing and flotation and may yield better per cubic meter. However, cage size is limited and working area is absent.

Cage design and construction

A good design must consider environmental conditions, cost and species to culture. It must be safe, secure and easy to manage.

The design should satisfy the following criteria:

a) Hold the fish securely while permitting sufficient water exchange.

b) Remove potentially harmful metabolites

c) Cage volume must remain relatively resistant to deformation by external forces.

Traditional designs

Traditional cages were developed from fish traps and fish holding facilities and were fabricated using existing skills from whatever materials were at hand and familiar to the builders. Natural materials, such as grasses or wood, were used not only to form the collar or frame but also to enclose the fish. Bamboo is a much more appropriate material being strong, cheap, widely available, and easily worked with simple tools. A number of trials have compared growth, survival and production of various species of fish in similar-sized bamboo and nylon net cages. All-bamboo constructions are sometimes claimed to be as good as, and in some cases superior to, those fitted with nylon mesh and they cost considerably less. However, other studies have shown they were inferior: they had poor water exchange and caused damage to the caged stock. It can be difficult to find straight bamboos, resulting in a non-uniform mesh that may allow fry to escape. Traditional floating cages utilize a variety of materials such as bundles of bamboos or hardwood logs and oil drums that are lashed to the sides of the structure for supplementary flotation. Simple anchoring systems – ropes and block weights, or posts driven into the substrate – are most commonly used.

Sizes

Size of cages is influenced by site, materials and management/financial capability of the farmer. An advantage of increasing bag size is that it has lower cost per volume. Sizes vary from $1m^3$ to 1,000 m^3. In marine cages, sizes of rearing units are larger compared to freshwater cages. Most freshwater cages use bamboo for framing and flotation. Most sea cages use GI pipes and Styrofoam or plastic drum for framing and flotation, respectively. Very few can afford to use PVC pipes for framing and flotation. Large cages require more sophisticated technology and equipment. Large cages are best suited for species that do not require regular grading or sequential harvesting.

Modern designs

Materials

Ideally, the materials used to construct the cage bag should be:

- strong
- light
- rot, corrosion and weather resistant
- fouling resistant
- easily worked and repairable
- drag free
- smooth textured and thus non-abrasive to fish
- inexpensive

The materials should be rigid and thus resistant to deformation in strong currents. The materials used to fabricate the cage frame and collar should have similar properties.

Shape

The behavior of the species may be considered in selecting a shape for a cage. Circular cages (Fig. 1&2) make the most efficient use of materials, but may have higher construction cost than square cages. In marine environment, circular cages are found to be more stable during bad weather conditions. Shape is likely to influence effective stocking densities and swimming behavior.

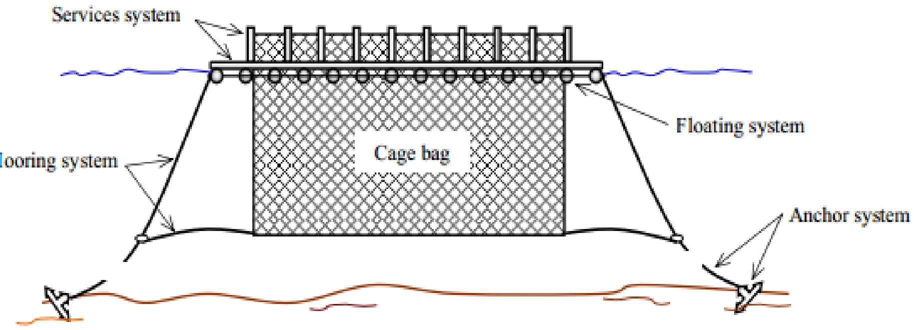


Fig.1: **Modern circular cage**

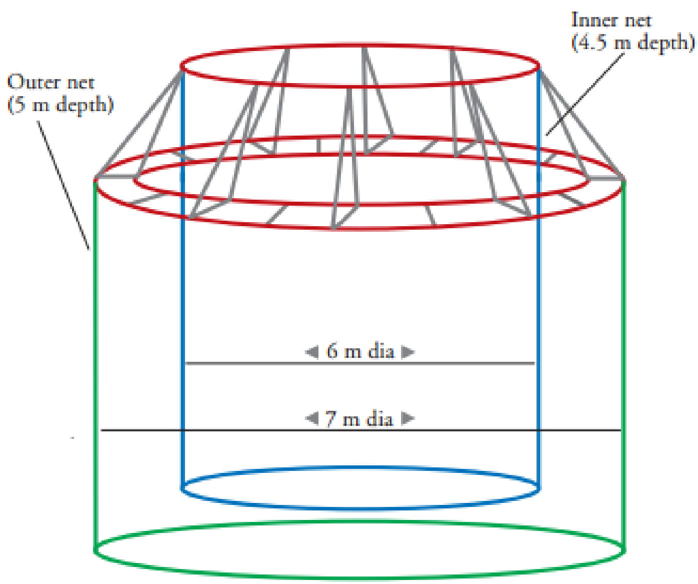


Fig. 2: **Schematic diagram of circular cage**

Cage bag

Netting materials can be flexible or rigid. Natural fibers are seldom used because they are susceptible to rotting. Synthetic fibers are preferred which are manufactured from coal or oil based raw materials. Modern netting is composed of synthetic fibres, the most common are polyamide (PA), polyester (PES), polyethylene (PE) and polypropylene (PP). These vary not only from country to country but also within a country from manufacturer to manufacturer. They are of two types: knotless and knotted. Knotless nets are usually used in cage culture of tilapia because it is cheaper and less abrasive. In sea cages, it is used in rearing post fry to fingerlings. Sea cages usually prefer the bigger mesh, knotted nets (Fig. 3) which are easier to repair and more resistant to bending deformation. Knotted nets are less affected by fouling organisms. Removal of barnacles from knotless but weaved nets may adversely affect the durability and maintenance requirements of the cage. Modern rigid mesh cages use plastics and metals. They are usually square or diamond mesh. The durability and appropriateness of using rigid nets are not fully evaluated.

Fig.3:**Knotted nets used in open sea cage culture**

Before stocking lobster in the cage, the bottom of the cage bag should be stitched with velon screen to provide extra surface area for scrolling (Fig. 4). Bottom of the cage bag should be tied with ballast pipe to retain the circular structure (Fig. 5)

Fig.4: **Velon screen for lobster**

Fig. 5: **Cage tied with ballast pipe**

Cage collars

The function of cage collars is to support the bag securely in the water column and help maintain shape. They may also serve as work platforms. HDPE and GI pipes are the most common materials used as collar. HDPE are light and easy to bend. However, it has short useful working life. GI pipes are expensive but excellent materials for collars. Size of cages can be increased and designed to desired shape (Fig. 6). This type of collar can last for 8 - 12 years and widely used in marine environment. Synthetic net bags are usually designed with an area of freeboard (an area which protrudes above the water surface) to prevent fish jumping out. The height of freeboard is determined by the species, fishes such as cobia, being able to jump considerable heights.

Fig 6: **Cage collar made up of HDPE and GI pipes**

Birds net, usually fabricated from large mesh knotted PE or nylon monofilament, are cut to size and fitted to deter predators. The flotation system is an integral part of the cage collar. Ideal materials are plastic or steel drums filled with air and coated with antifouling agents (Fig 7).

Fig 7:**Air filled plastic drums as floatation system**

With empty plastic drums as flotation, a sufficient work platform can be incorporated in the design. The entire cage collar can be coated with anti rusting and anti fouling agents toprevent damage. Fibre coating can also be used to protect the cage from rusting (Fig 8).

Fig 8**: Fibre paint coating**

For the easy transport of cage collars from the manufacture's site to cage culture site, it can be constructed in such a way that it can be dismantled and can carry easily (Fig 9).

Fig 9: **Dismantle type cages**

Groupings and Linkages

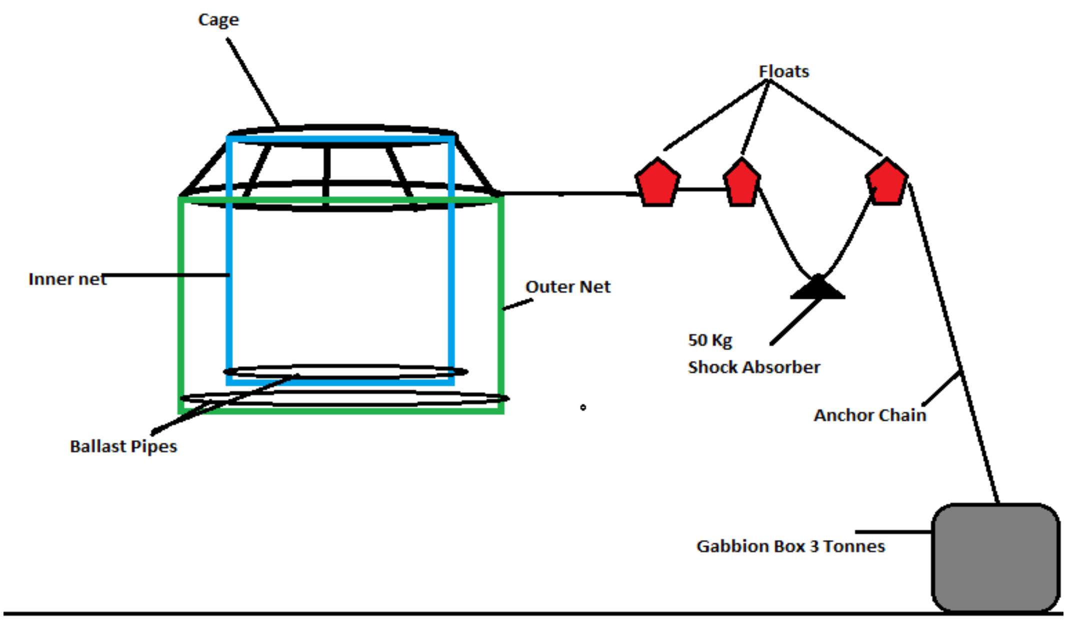
Grouping of cages is influenced by the nature of the site, mooring constraints, environmental considerations and disease prevention. Arranging the cage to face the prevailing winds results in a higher harvest. The system takes advantage of better water circulation and aeration. Separating the cages with enough space in between will improve water circulation, prevent concentrated waste loadings in the environment and occurrence or spread of diseases. Cages can be linked together using rope, chain and used tires in between cages (Fig 10). The link should provide enough spacing to facilitate water circulation between cages.

Fig 10: **Group of linked square cages**

Mooring systems

Mooring system consists of lines and anchors for the purpose of securing the cages in a desired location. Chain, nylon ropes or combination can be used for mooring. The length of mooring in marine waters should not be less than three times the water depth of the site. Embedding anchors can be bought or fabricated. The cheapest, however, is the concrete block anchors or sand filled sacs with steel rods for strengthening and eyebolt for mooring attachment (Fig 11). Once installed, block anchors are difficult to recover.

Fig 11: **Mooring of cage with anchors and sand filled sacs**



Present single point mooring diagram of the sea cage

References

1. Beveridge, M.C.M. 2004. Cage Aquaculture. Third Edition. Fishing News Books. pp.32-110
2. Das A.K., Vass K.K., Shrivastava N.P and P.K. Katiha (2009). Cage Culture in Reservoirs in India (A Handbook). WorldFish Center Technical Manual No. 1948. The WorldFish Center, Penang, Malaysia. Pp. 24.
3. Philipose, K.K and Loka, Jayasree and Krupesha Sharma, S. R and Damodaran, Divu (2012). Handbook on Opensea Cage Culture. Central Marine Fisheries Research Institute. Pp. 77-83

*****