# Cage culture in Reservoirs

## Introduction:

Cage culture can be defined as a method of rearing or raising fish or any aquatic organisms in an enclosed space while in captivity that maintains the free exchange of water with the surrounding water body.

A cage is enclosed on all sides with mesh netting made from synthetic material that can resist decomposition in water for a long period of time and is sold under the brand name **Netlon**. Cages are generally small, ranging in freshwater reservoirs from 1 $m^2$ to 500 $m^2$. Several small cages combined in a battery are suited for even intensive culture.

## Why cage culture is important for Indian reservoirs?

- The reservoirs of India have a combined surface area of 3.25 million hectares (ha), mostly in the tropical zone, which makes them the country's most important inland water resource, with huge untapped potential.
- Fish yields of 50 kg/ha/year from small reservoirs, 20 kg/ha/year from medium-sized reservoirs and 8 kg/ha/year from large reservoirs have been realized while still leaving scope for enhancing fish yield through capture fisheries, including culture-based fisheries.
- The success rate of auto-stocking is very low in Indian reservoirs, especially in smaller ones. Many of the smaller reservoirs dry up during the summer, partly or completely, with no stock surviving.
- A policy of regular, sound and sustained stocking would greatly augment fisheries in such water bodies. Stocking with the right fish species, using seed of appropriate size and introducing it at the right time are essential to optimizing fish yield from reservoirs.
- Though 22 billion fish fries are produced every year in India, there is an acute shortage of fish fingerlings available for stocking reservoirs. Where fingerings are available, transporting them to reservoirs usually incurs high fingerling mortality.
- In this context, producing fingerlings *in situ* in cages offers opportunity for supplying stocking materials, which are vital inputs towards a programme of enhancing fish production from Indian reservoirs.

## Advantages of cage culture

- Cage culture is suitable to a wide range of open freshwater ecosystems, especially reservoirs.
- It efficiently exploits water bodies, tapping their natural productivity and thereby reducing pressure on other resources.
- It uses simple technology and locally available resources for cage construction and operation, making it economically, socially and environmentally sound.

- As carp feed at a low trophic level, rearing carp fingerlings has minimal impact on the environment.
- Polyculture of carp species with various feeding habits makes wise use of resources, as the different feeding habits of various species and their acceptance of a wide range of supplemental feeds maximizes fingerling uptake of feed while minimizing competition among species, feed waste and the resulting pollution.
- Cage culture eliminates losses to predation and facilitates prophylactic measures to contain any outbreak of disease, allowing very high fingerling survival rates.
- It makes effective use of manpower, as daily maintenance routines and monitoring are relatively simple, and harvesting is rapid, easy, sure and complete.
- As cage culture can be practiced intensively, high yields can be achieved very cost effectively.
- Since most reservoirs in India are designated for multiple uses, including supplying drinking water, cage culture is appropriate because it is minimally polluting and maintains the ecological health of the reservoir.

## Constraints of cage culture

- Cages occupy space on the surface of water bodies and, if poorly positioned, may disrupt navigation or diminish the scenic value of the reservoir.
- Poorly placed cages may alter current flows and worsen sedimentation.
- Inappropriately intensive or poorly managed cage culture may pollute the environment with unconsumed feed and fish fecal waste, causing eutrophication.
- During the summer months, cages may be damaged by strong winds or flooding, but this risk can be avoided by properly anchoring batteries of cages in protected inlets away from strong currents.
- Theft is particular problems exist where intensive cage aquaculture is practiced for producing marketable fish or prawns.

## Steps of cage culture

- Site selection => Procurement of cage materials => Frame fabrication => Floating the frame => Fitting the catwalk => Installation of cages => Selection of stocking materials => Stocking => Grow-out period => Supplementary Feeding => Cage and stock maintenance => Removal and release/ Harvest => Economics of cage culture => Cost of production of each crop

## Types of cage

Four types of cage are used in cage aquaculture:

a. Fixed b. Floating c. Submersible and d. Submerged

a. The fixed cage is the most basic and widely used in shallow water with a depth of 1-3 metres. It consists of net bag fitted to posts and is normally placed in the flow of streams, canals, rivers,

rivulets, shallow lakes and reservoirs, not touching the bottom. Fixed cages are comparatively inexpensive and simple, but their use is restricted.

b. Floating cages, on the other hand, are supported by a floating frame such that the net bags hang in water without touching the bottom. Floating cages are generally used in water bodies with a depth of more than 5 meters. Enormous diversity in size, shape and design has been developed for floating cages to suit the wide range of conditions of fish culture in open waters.

c. The net bags of submersible cages are suspended from the surface, have adjustable buoyancy, and may be rigid or flexible.

d. Submerged net bags are fitted in a solid and rugged frame and submerged under the water. Their use is very limited.

## Site selection

The selection of site for cage culture is very important, as success often depends largely on proper site selection. Potential sites vary according to the size and shape of the reservoirs where cages are to be installed. The critical issues in selecting sites are the following:

- The depth of the water column should be at least 5 meters.
- Water quality and circulation should be good, free from local and industrial pollution.
- In large and medium-sized reservoirs, sites should be in sheltered bays for protection from strong winds. In small reservoirs, the cage should be anchored in the deeper lentic sector to avoid the current flow through sluice gates and irrigation channel.
- They should be safe from frequent disturbance from local people and grazing animals. • There should be access to land and water transportation.
- They should be devoid of algal blooms to avoid fouling.
- They should be free of aquatic macrophytes and high populations of wild fish, which can cause oxygen stress.
- Cages should be placed where they will not hinder navigation.
- They should be at a distance from bathing and burning Ghats.
- Sites should be secure.

## Procurement of cage materials

Making cage culture economically viable demands the preparation of a comprehensive list of materials available on local markets

**Bamboo**: Bamboo poles should be straight, rigid and light, such as the bhaluka type from Assam, which is commonly available in local markets. Poles should be 7.5 meters long, with an internode circumference of about 26 centimeters (cm) at the base, 25 cm in the middle and 24 cm at the tip. This means a diameter of 8-9 cm and wall thickness of 2.5 cm at the base. Fifty-six bamboo poles are required to make one frame.

**Floats**: Empty 200-liter steel drums with tightened lids make suitable floats 88 cm long, 180 cm in circumference, 58 cm in diameter and weighing 22 kg. Twenty-four drums are required to float a frame 13.75 meters long and 11.05 meters wide, with drums sandwiched between upper and lower frames. Floats are painted with acrylic paint and fastened with the frame with glazed iron (GI) wires.

**Nuts and bolts**: Steel bolts 18 cm long and 3 cm in diameter, with nuts, are used to fix bamboo poles at the corners and at the middle joints on the side. A total of 120 such nuts and bolts are required to ensure a sturdy bamboo frame able to withstand waves even during a cyclone.

**Sinkers**: Sinkers are locally available stones weighing 3-4 kg that are tethered to the bamboo frame with nylon ropes at the corners and along the sides to help cages maintain their rectangular shape. The bottom portion of Netlon cages is tied to the nylon ropes running down to the sinkers such that the Netlon does not bear the weight of the sinker but the ropes maintain the shape of the cage. Eight Netlon cages require 48 sinkers, with eight sinkers maintaining the underwater shape of each cage.

**Anchors**: Large, locally available stones weighing 40-50 kg or more are used as anchors that rest on the reservoir bottom to hold the cages in place. Two anchors are tied with thick nylon rope to every corner of the frame, and another anchor is tied to the center of each long side, thus requiring 10 stones for each cage.

**Netlon**: High-density propylene extract (HDPE) nets with 1.5 mm mesh are used to prepare Netlon cages for rearing fingerlings to >100 mm from fry initially measuring 10-25 mm. A rectangular cage measuring 5x3x3 meters is convenient to operate. The cage is totally enclosed with Netlon on all four sides, the bottom and the top (to prevent predation by birds). Small flap openings at

two top corners allow feeding and harvesting. The Netlon should be well stitched with doubly laced nylon ribbon 3.8 cm in width at the corners and joint, with loops at the corners and sides. The same nylon ribbon stitches together the upper and lower lids at regular intervals to make the cage sturdier. Eight cages are hung from bamboo frame and tied with the sinkers at the bottom corners to keep them straight and hanging vertical. Thus, in a battery of eight net cages has a good functional volume of 360 $m^3$, of which 320 $m^3$ (40 $m^3$ in each cage) is under water. The net cages are tied with silk rope to the frame to keep them straight.

## Frame Fabrication

The frame of the cage can be made from locally available bamboo, which is a cheaper option than wood, steel or polyvinyl chloride (PVC) and will last for at least 3 years, with 5-10% of the poles replaced as needed. Two frames are required, one above water and the other below, to hold the floats firmly. The useful life of bamboo poles in the underwater frame is much longer than for those on top. Fully grown, cured bamboo poles at least 7.5 meters long and 8-9 cm in diameter at the base are best suited to make the frame. To make a battery holding eight cages, each measuring 15 $m^2$, the battery should be 13.75 meters long and 11.05 meters wide. To make such a frame, 32 bamboo poles are required for the top frame and 24 for the lower frame.

Four poles are used to make one long side of the rectangle. Two poles are placed on the ground with their tip portions overlapping to make their combined length at least 14.5 meters. Six such lengths are made for the two long sides and the central divider. Each long side and the central divider consist of two such 14.5-metre lengths placed parallel 35 cm apart. The short sides of the frame are made using similarly paired poles with a combined length of 11.75 meters. Ten such lengths are required for the two short sides and three partitions, again with two lengths placed parallel 35 cm apart. (The difference between the frame above the surface and the underwater frame is that the latter has only two partitions, instead of three, which is why it requires eight fewer poles.) Where the lengths cross at 90 degrees they are fixed with a bolt and nut, creating the rectangular frame of the battery, with inner partitions from which to hang eight net cages.

## Floating the frame

The battery of eight cages is buoyed by 24 steel drums. The drums are sandwiched between the two frames, one above the surface and the other below, placed mostly in the corners and near joints to provide the frame with balanced buoyancy. The drums are attached to the frame with two types of GI wire. The thicker, 2 mm wire is used at the central portion, and the thinner, 1.5 mm wire is used for encircling the drum with the frame at the end portions to better tolerate wave turbulence, especially during summer and storms. The drums are painted with acrylic paint before being attached to the frame. Only 16 cm of the drums' 58 cm of diameter is under the surface of the water when bearing the frame.

## Fitting the catwalk

Catwalks made of locally available bamboo cross-beamed with wood are wired to the top of the bamboo frame with GI wire for ease of access. Care should be taken while wiring on the catwalks so that the wire ends do not damage the net cages. With the floats and catwalks wired to the frame, the assembly is towed to the selected site and anchored.

## Installation of cages

Once the frame is anchored at the culture site, the next step is to tie on the Netlon cages, eight to a battery. Along the top, silk ropes are used to tie the nets to the bamboo frame firmly to prevent sagging. Sinkers are tied to the bottom corners and the sides of the Netlon cages to hold them vertical. The hanging net cages should remain at least 1-2 meters above the lake bottom to avoid damage caused by crabs and other bottom dwellers. Local fishers should be instructed not to tie their gillnets to the frame, as this may damage it. The net cages should be left in the water for at least a week before stocking to allow algae on grow on the netting. Curing the net thus reduces injury to fry.

## Stocking

For raising fingerlings in cages in Indian reservoirs, healthy carp fry measuring 12-15 mm long, or even up to 25 mm, are best suited. Advanced fry longer than 35 mm should be avoided for cage culture to fingerling

size, as they routinely are affected by fungal diseases such as Seprolegniosis if collected from nurseries that have eutrophied. Indian major carps are especially prone to fungal diseases. A stocking density of 250 carp fry measuring 12-18 mm per cubic metre is best for cages installed in Indian reservoirs. Fry should be shifted late in the day or early in the evening to allowing conditioning at the site of procurement and acclimatization at the site of release in cages. Conditioning is required to transport the fry with empty stomachs, as the ammonia and carbon dioxide generated by fish waste may prove lethal to fry during transport. Fry acclimatization is essential at the site of release in cages to ensure a balanced environment, especially in terms of temperature. The oxygen packets transported with the fry (1,000 fry in 4 litres of water in a polythene packet 2/3 filled with oxygen) are kept inside cages for at least an hour before the fry are released. Prior to release, fry are subjected to some prophylactic measures to protect them from diseases and ecoto-parasites. They are dipped in a 5-6% salt solution as well as potassium permanganate (5-8%) for 1 to 2 minutes and then released into the cage water.

## Grow-out period

Raising carp fingerlings in cages generally requires 60 to 120 days, depending on the water body's natural productivity and the quality of supplementary feed.

## Supplementary feeding

Feeding is essential for carp fry in captivity, as the natural food in many Indian reservoirs may not be sufficient for their growth even to fingerling size. Feeds should be available locally and inexpensive to contain production costs. Carp accept a wide variety of feed, providing a range of options for selecting locally available feed ingredients with an eye on cost. In general, rice bran and mustard oil cake blended 1:1 provides a mixture with vitamins, amino acids and minerals available at concentrations of 0.01%. As the cages are installed in reservoirs and subjected to waves, it is not advisable to provide supplementary feed in floating trays, as is the practice in cages installed in wetlands or calm lakes. In general, the fine, flaky powdered form of rice bran and mustard oil cake mixed together is spreading over the water surface inside each cage twice daily at 08:00 and 17:00 hours, at a rate of 3-5% of aggregate fry body weight. Initially, 3-4 kg of feed is applied per cage per day. This is reduced as time passes. Feed floats on the water surface for a time before sinking slowly, thus favouring in succession the feeding habits of surface feeders like C. catla, column feeders like L. rohita and bottom feeders like C. mrigala, as well as common carp. Excessive feeding should be avoided in cages, as it may pollute the environment and hamper the growth rate of stocked fish. Feed usually comes in bulk, requiring proper storage to protect it from excess humidity and heat, insects, rodents, fungi, and contaminants. The spoiled feed can become less palatable and

nutritious to fish, or even toxic. So, due care has to be taken to keep feeds properly and maintain their quality.

## Cage and stock maintenance

**Monitoring water quality**: Water quality parameters that must be monitored in the cages are dissolved oxygen, acidity, free ammonia and phosphate. Indian reservoirs normally maintain water parameters suitable for rearing fingerlings in cages, though very rarely an algal bloom may push some parameters to the point of threatening fish survival.

**Cleaning Netlon cages**: Cages should be cleaned with soft brush fortnightly to remove algae, sponges and other organisms. Floating macrophytes that waves sometimes push against cages should also be removed. Any dead fish should be removed from cages immediately and disposed of in a pit. Covering dead fish with lime helps contain any disease. Deaths should be recorded to facilitate later analysis of disease outbreaks.

**Routine checking**: Loose twine, mesh torn by predators, anchors and sinkers must be checked routinely and immediately mended or replaced as needed. Repair torn mesh with patches to keep fry from escaping. With the onset of bad weather, anchors should be checked and fastened tightly.

**Fish stock monitoring**: Routine checks of fish health help prevent massive fry loss. Fish health can be easily checked by monitoring fry response when feed is applied. Signs of ill health include surfacing, lesions, rashes, spots, lumps, excessive mucus formation, woolly mat formation, bulging eyes, and fin and tail erosion. Appropriate prophylactic measures should be applied as necessary and at least fortnightly. Remove the fry from the cages and soak them for 2 minutes in a 5-6% salt solution followed by 5-8% potassium permanganate solution to eradicate ectoparasites. A 20-30% potassium permanganate solution may be spread on the water surface inside the cages. At times, a lime solution may be spread inside the cages to clear the water.

**Monitoring of growth rate**: Samples should be taken at a regular interval to assess fry length and weight to monitor growth. This information is important for maintaining fish health and optimal feeding, as well as for scheduling the harvest.