**Cage mooring:**

Successful mooring of the cages in water is an important aspect in the cage culture. The mooring process takes into account the depth, substrate, and the current speed at the culture site. The fabricated cages which are to be moored can be gently slipped into water with a simple lever mechanism using iron rods, pipes, or wooden logs (Fig. 8). This process avoids any damage to the shape and structure of the cage which could be caused due to abrasion and also reduces the number of manpower required to launch the cage into water. Nylon/polyethylene ropes of 18 mm dia. are tied to sand-filled bags which act as anchors. This keeps the cage stable and secure in coastal waters with strong currents (Fig. 9).
Cages for small scale fish farmers
Karnataka State possesses coast line of 300 km and has pristine unpolluted saline creeks and estuaries of about 8000 ha. These coastal water bodies have high potential for aquaculture, especially cage culture of finfishes. The water current speed in these water bodies is high and ranges from 30 to 42 cm/sec. Therefore, the cages deployed for finfish culture has to be sturdy and firm to withstand the hydromorphic conditions prevailing here. Taking into consideration the dynamic seasonal hydrographic conditions in the creeks and estuaries of coastal Karnataka as well as with an aim to provide the coastal fish farmers an alternate year round profitable livelihood option, research on cage designs for culturing finfishes was initiated by ICAR-CMFRI, Mangalore Research Centre in 2008. The important criteria considered while planning and designing the cages were its stability in fast moving waters, ease of operation, capacity to sustain high hydrodynamic pressure, ease of locally available fabrication materials, skill of local fishers in handling objects and mooring it in water, affordability and ease of accessibility to all family members. Customized all weather cages were designed and fabricated with locally available material for coastal waters of Karnataka. Technically under “Harro cage concept” in Auburn University, Alabama, USA were followed with suitable modifications to design customized indigenous cages for Karnataka. This design can be adopted in other coastal areas and the current study of the cage design was done to consider all the water body is more than 20 cm/sec. The basic caging model was tested and modified to improve its stability, durability and optimize the use of locally available fabrication material. Basically the cage consists of a rectangular frame, an inner net to hold the fish, an outer protective net and bird net on the top.

Initial Cage Designs - Cage prototype-1 and II
Prototype I cages were developed in 2008. It had a dimension of 2.5 m x 2.5 m x 2 m and the frames were made with bamboo poles. Netcon, which were commonly used as fencing material in farm land was selected for making the outer protective net for the cages and nylon nets for inner as well as bird net (Fig. 1). PVC pipes were used for keeping the cages afloat. Protoype-I cages were 12.5 l and 16 t respectively and there commended stocking rate was 50 nos./m³. Seabass/red snapper fingerlings stocked in these cages reached a weight of 800g at the end of 6 months season. With a survival of 90%, the production from these two prototype cages in one season was around 0.4 and 0.5 t respectively. The GI frame cages were sturdy and could withstand the high current prevailing in the estuaries. Sturdy, stable and easy to handle cage model making GI frames with a durability of three years was found to be the best suited cage for installation in estuaries with heavy tidal influx.

Cage prototype-III, final design.
Cage prototype-III was developed in 2011. This cage was designed to optimally use the standard length of GI pipes (6m) and Netcon roll available in the market. The cage dimension is 6 m x 6 m x 2 m with a water holding capacity of approximately 24 l. The basic cage design was tested and modified to improve its stability, durability and optimize the use of locally available fabrication materials. Basically the cage consists of a rectangular frame, an inner net to hold the fish, an outer protective net and bird net on the top. The frame width of the cage is 2 m while the height is 2 m. The cage is made of GI pipes of 4 inch diameter and 6 mm wall thickness. The GI pipes are connected using GI couplings. The cage is fixed using GI rods and GI brackets. The cage is moored using four 4 inch GI pipes. The cage is lifted out of the water using a crane.

Features of the recommended (Prototype – III) cage model
- Corners and joints of the GI frames are secured with ropes oroid net pieces rather than welding as it provided flexibility and reduced pressure caused by currents at joints and the frame continued to maintain shape and support to the cage.
- The Netcon roll marketed has a length and width of 26 m and 2 m respectively. The entire roll can be optimally utilized to fabricate one Prototype-III cage (6 m x 2 m x 2 m). One Netcon roll can cut into three equal pieces (Fig. 4) and wrapped around the GI frame and secured tightly with ropes oroid net pieces.
- The inner cage made of nylon net material with a mesh size of 18-23 mm. If the seeds stocked are very small (<2 cm) then hapas made of mosquito net are kept afloat within the main cage till they attain stockable size (>3 cm) (Fig. 5).
- The PVC pipe used at the top of the cages provides ample floatation and designed in such a way that the cage moves vertically up and down along with the tide, ensuring enough water in the cage even during lowest low-tide. However, the PVC pipes are prone to damage due to fouling and result in seeping of water into the pipe. This reduces floatation ability. This can be solved by providing alternate, additional easily available items like used empty plastic c-cans.
- The cage becomes heavier as the culture period progresses and hence to keep the cages afloat, additional floats (Plastic c-cans) are attached (Fig. 7).
- The prototype-III cage is expected to yield 0.6 to 1.0 l fish at the end of 6-8 months with a stocking rate of 50 nos./m³ and 80% survival.
- The noticeable advantage of Prototype-III cage made of GI pipe frame is that it can be retained for over three seasons in coastal waters. The fish attained 3-5 kg in 18-20 months when the culture period is extended for 2 years ending with an average production of 0.2 t per cages.
- The 6 m x 2 m x 2 m prototype-III cage model is most suitable for culture of finfishes in coastal open-waters of Karnataka as it is cost effective, durable and easy to handle with a production of 1 t of fish at the end of a culture period of 8-12 months and 3.2 t at the end of 20 months. Further, this is the only model developed which can be used in shallow areas (where the water depth is around 1.5 m).