Brackishwater aquaculture for food employment and property

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Brackishwater cage culture with multi-trophic candidate species in diverse rearing systems for alternate livelihood and societal development in Maharashtra

(Under Mangrove Cell Project)

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4. Site selection techniques to assess the suitability of brackishwater creeks and backwater for cage culture

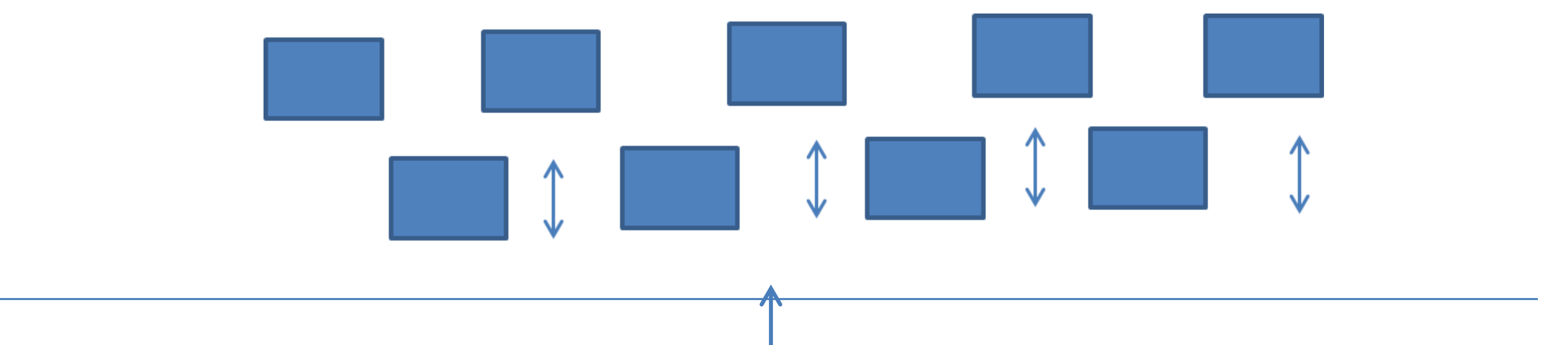
M.Jayanthi, M.Kailasam and Pankaj Patel

Cage aquaculture is culturing aquatic organisms in a mesh enclosure on all sides in the existing waterbodies, supports the developmental livelihood activities of coastal poor for producing healthy and cost-effective fish protein by utilizing natural waters with minimum economic costs. Although cage aquaculture was in practice in India since ancient times, it has not been viewed or planned with a systematic supporting activities. Though open sea cage culture was developed and promoted by CMFRI to a great extent, it is new to the inland aquaculture scenario of the country, brings in new openings for enhancing fish production from the reservoirs, creeks, lagoons, lakes and backwaters, and also developing new skills among fishers to improve their earnings. As India is blessed by virtue of its 8 118 km long coastline, 3.9 million ha of estuaries and 3.5 million ha of brackishwater areas in the country, cage aquaculture can play a significant role in rural developmental supporting activities. As the resources are limited and demand is high, any unplanned expansion can lead to adverse impacts in terms of environmental sustainability and multi user conflicts. The suitable sites for aquaculture may have the minimum environmental stress, full potential for species, reduced production costs, and less potential conflicts with other waterbodies users. Identifying suitable sites, species, culture practices are three important activities in cage aquaculture to ensure a successful crop.

Success and long term sustainability of cage culture depends on site selection, water quality, culture and management practices. The appropriate selection of site in any aquatic farming operation is very much essential as it can greatly influence environmental conditions, economic viability and production capability. Several cage farming operations have experienced high fish mortality due to pollution of waterbodies. It is important to select the waterbodies located in areas not contaminated by sewage, industrial, thermal, agricultural pollutants. Apart from the water quality, physical characteristics of the water body should be able to satisfy the positioning of cages of required capacity. Before installing cages, the suitable areas for cage farming using the three dimensional approach – physical, chemical and biological characteristics of the system need to be taken into consideration. The important factors for deciding the sites for cage aquaculture are described below.

Physical characteristics of waterbodies influencing the site selection of cage culture

- Water depth **-** The water bodies should have sufficient water depth, preferably more than 3m. Shallow water bodies less than 1.5 m depth should be avoided. Three tier system to grow fry in happas, fingerling in pre grow out culture and fish in grow out cage can be done in small cages (volume 1-2 m^3) of 1m depth, medium cages (around 20m^3) of 2 m depth, and big cages (more > 50 m^3) of >2 m depth for grow out culture respectively.
- Water Current flow: The water current rate for optimum cage culture operations will be 10-20 cm/sec. High water current i.e more than 50 cm/sec or no movement will not give the conducive environment for cage culture operations.
- Wind action: Areas having strong wind action need to be avoided, mild turbulence constantly supports exchange of metabolites and nutrients from the cage to outside environment and vice versa.
- Climate hazards: The site should not be prone to frequent extreme climatic events such as cyclones or floods.
- Transparency: Light diffusion is obstructed by suspended and organic material (detritus), and also the plankton of the pond. If goes beyond certain level, will result in oxygen depletion. Generally, 15 ï24 inches water visibility will be an ideal condition.
- Bar mouth operation ï Site should be situated in a place where bar mouth closure or opening operations occurs systematically based on environmental conditions. If bar mouth is not opened, it may lead to deterioration of the water quality, and lead to mortality of animals.
- Cage location should be placed alternate in adjoining rows to enable the proper water exchange



Water current

Fig. 1. Positioning of cages in adjoining rows

Slope - Site having sloping areas from the shore leading to flat bottoms are appropriate for cage culture because the waste build-up at the bottom is easily eliminated

Due to ecological reasons, cage culture in rivers is not discouraged world over. In India, the riverine ecosystems are already under severe stress resulting in habitat loss/degradation due to a number of reasons such as dams, water abstraction, low flows, river training and pollution from industrial, domestic and agricultural runoff. Cage culture in a water-starved stream will add further stress to the ecosystem. However, backwaters can provide sufficient sites and play a major role in the cage culture development.

Chemical characteristics influencing site selection

It is impossible to attempt to change water quality criteria in cage culture locations, hence, culture should be established in geographical locations ensuring suitable water quality and exchange.

- Water should be unpolluted and without any industrial activities, and also suitable for the species to be cultured. The parameters such as pH, temperature, dissolved oxygen, salinity, nitrate, phosphate, ammonia, biological oxygen demand need to be with in the optimum range for aquaculture.
- Apart from regular water quality characteristics, possible pollutants such as hydrocarbons, heavy metals and pesticides have a strong potential adverse influence and are also of great importance

Fig. 2. Cage culture in the coastal waters of Maharashtra

- As the cage culture actions will increase nutrient and oxygen load in the water bodies, care must be taken to evaluate the water quality of the location before the start of culture activities.
- Excessive nutrient load can create eutrophic situations with devastating consequences to the surrounding ecosystem. Cage culture should not be attempted in any water body having total phosphorous and total nitrogen concentration in exceeding 0.02 mg/l and 1.2 mg/l, respectively

However, the availability of suitable areas for aquaculture is diminishing because of water quality degradation. Therefore, the first prerequisite for sustainable aquaculture is an adequate aquaculture resource allocation system

Biological characteristics influencing site selection

- Excessive phytoplankton and macro algal growth in the water bodies can reduce the transparency in other way light penetration, can lead to loss of submerged aquatic vegetation, toxic algal blooms**.** Sites with high fouling rate and more frequent toxic algal blooms occurrence should be avoided.
- Water bodies known for the presence pathogenic or potentially pathogenic organisms presence need to be avoided.

Water bodies not suitable for cage aquaculture

- Places with turbulence and excessive wave/wind action, should be avoided.
- water bodies with obstructions and heavy weed invasion, should be avoided
- Shallow water depth, should be avoided
- Difficult to access the site should be avoided
- No logistical facilities should be avoided
- Nearer to human settlement, tourism, recreations facilities should be avoided
- Nearer to industries, thermal power plants should be avoided
- Areas of fish nursery and breeding grounds should be avoided
- Ecologically sensitive areas like wildlife sanctuary, bird nesting grounds, pilgrimage centres, should be avoided
- Water bodies meant for common use such as drinking water supply, water transport or navigation, should be avoided

In addition to the above environmental factors social factors such as legal disputes or requirements, support personnel and facilities, safety of the animals,

Advanced tools available for large scale site selection

Remote sensing technology had advanced manifolds in recent years and proved to be an appropriate method for aquaculture planning due to its analytical capabilities and able to handle large volume of geographic data. The orderly approach in data capturing through satellites, high resolution of multispectral and temporal satellite images, affordability and high level of accuracy has made the technology as an indispensable tool in earth resource management. Satellite images are increasingly utilized as data sources in conjunction with a geographical information system (GIS) in the decision-making process which involves multiple criteria ranging from local to global level decision making with the past, present and future scenario and also it permits additional spatial data incorporation and advanced analysis to identify the suitable sites from the unused coastal resources without multi-user conflicts. Multiple spatial criteria such as resources availability, water quality, water availability and environmental regulations can be incorporated in GIS as different layers to derive the decision on site suitability. National or state level GIS database of the available water bodies extent, characteristics and usage pattern, will be helpful to draw a policy of frame work to make use of the unused water bodies for the livelihood support programs.

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5. Nursery rearing of Asian Seabass in happas in mangroves coastal water bodies

Pankaj Patil, Tanveer Hussain, Kedar Palav, Shweta Patil, Sushant Sanaye, Shubham Pilankar, M. Kailasam, C.V. Sairam, R. Subburaj, K. Ambasankar, K. K. Vijayan

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Brief background

India is bestowed with number of locally important cultivable brackishwater finfishes for aquaculture such as Asian seabass, Milkfish, Grey mullet, Pearlspot, Scat, Estuarine grouper and Cobia. Diversification assumes significant importance in coastal aquaculture in India as coastal aquaculture is limited to the shrimp aquaculture. The brackishwater aquaculture production from India chiefly originates from small stakeholders owning relatively smaller farming areas. Fish has universally consolidated its position as an affordable health food and increase in its production ensures income, food and nutritional security.

In India, Maharashtra state has huge scope for Brackishwater aquaculture since the state is bestowed with rich resources of bracksihwater areas and especially the mangrove based creeks, canals and backwaters. Maharashtra has a long coastline of 720 km, stretching from Zai River bordering Gujarat in the north to the Terekhol River bordering Goa in the south. As per Forest Survey of India 2017, mangrove cover of state is 304 sq km. Maharashtra State has about 80 thousand hectare of brackish water and the potential brackishwater area in the state of Maharashtra is about 14,450 hectares. The percentage area utilized for brackishwater aquaculture is very low (less than 1%), the figures emphasizes on underutilized potential of brackishwater aquaculture to bring about a significant difference in fish production and livelihood generation at different coastal district, Maharashtra.

In Maharashtra, deforestation of mangroves timber for boat fabrication, fuel wood for human settlements, illegal aqua cultural activities have impacted biodiversity as well as on the nursery and breeding grounds of Marine Fishes, mammals, birds, etc. Conservation of mangroves and coastal & marine habitats has become increasingly important in the last decade as the threats to these habitats have increased at an alarming rate in the last decade. The mangroves and the associated habitats of creeks and estuaries have a great potential for providing alternative livelihood sources to the local people.

The coastal community of this region mainly depends on marine fisheries and agriculture for their livelihood. However, due to depletion of natural fish stocks from unsustainable fishing by trawlers, an expanding tourism sector, and pollution from fishing vessels and other maritime traffic affecting the livelihood security of coastal community. Similarly deforestation of mangroves timber for boat fabrication, fuel-wood, human settlements, illegal aqua cultural activities have also impacted on the nursery and breeding grounds of Marine Fishes, mammals, birds, etc.

Need for Intervention

The most of coastal fisher folks of Maharashtra daily works as labourers for unsustainable Purse Siene and Trawler Boat fishing while most of women work as an agriculture labour. Their daily income and livelihood depend on the availability of fish catch and agriculture work. Similarly fishing ban period during monsoon also affected their livelihood. Provision of fishery based alternative avocation could provide them the livelihood. Inculcating the skill of fish nursery rearing and providing them an opportunity to adopt it could be a source of alternative livelihood for them. Hence for mangrove protection and regeneration through coastal livelihood and ecotourism activities Mangrove Foundation, Mumbai have formed several conservation and livelihood scheme programmes for selected coastal villages of Maharashtra. Under this schemes different SHG were formed in the selected mangrove coastal villages.

Therefore, from such selected villages Self Help Groups comprising of men and women's were formed for seabass nursery rearing. The theme of the work is to create a satellite hub of seabass culture unit in Maharashtra through production of seabass seeds, stockable fingerlings and table size fish with SHG's active participation.

Features of innovation

ICAR-CIBA and Mangrove Cell of Maharashtra government have initiated the CIBA's three tier model of seabass farming which includes hapa based nursery rearing, cage based pre-grow out and grow out culture in and around the mangrove coastal waters in coastal districts of Maharashtra with the participation of Self Help Groups. Nursery rearing of Asian seabass seed in hapas was taken up. CIBA team provided training and demonstration to SHG's on pond preparation, hapa installation and cleaning, seed stocking, grading, feeding and water quality management. Happas (2 x 1 x1 m, 2 mm mesh size) are installed in a pond with water depth of 1.5 m and salinity 05-35 ppt. A total of 10000 seabass seeds (1.8-2.0 cm) are provided to each SHGs and stocked at a density of 500-750 per happa-1. The fry are fed with CIBA formulated Seabass larval feed (0.2 mm-1.2 mm) @ 8-10% body weight two times a day. Regular grading need to be done at the interval of four days to separate the shooters and to maintain uniform size of the stock. During grading work, men farmers do removal of fishes from hapas for grading and cleaning of hapas while women farmers do the work of grading. The grading results in non-occurrence of cannibalism and improved survival rate. After the nursery rearing of 75-90 days, when the seed reaches to the fingerlings size of 8-10 cm and 10-12 g are sold at rate of Rs. 25-45/- depending on the size.

Seabass nursery rearing unit of mangrove coastal self-help groups at Sindhudurg, Maharashtra

Asian seabass (*Lates calcarifer*)

Asian seabass (*Lates Calcarifer*) known as Bhetki or barramundi in India is one of the commercially important finfish species caught from inshore areas, estuaries, backwaters, lagoons and fresh water ponds. Seabass is a fast growing species with ability to tolerate wide fluctuations in environmental conditions and gaining rapid popularity as a candidate species for diversification in coastal aquaculture in India. Seabass is carnivorous in nature. However, juveniles are omnivores. Seabass is an opportunistic predator, whose diet changes at different ages of various size groups. It feeds mainly on zooplankton in early stages and as they grow changes to feeding on young fishes and shrimps. They show preference for pelagic fish rather than benthic crustaceans as the prey is large. However, juvenile seabass even consume smaller sizes of seabass of the same age group as whole and can cause reduction in the survival rate. It is one of the fastest growing fish, can grow to an average size of 1.5 kg in 10 to 12 months and fetches good price in domestic and international market. It is considered as a potential candidate species for farming in saline or freshwater environments in ponds and cages. The culture of seabass involves nursery rearing in happas, pre growout culture and growout culture in ponds and cages.

Asian Seabass *Lates calcarifer*

Nursery rearing

In aquaculture, seed being one of the major inputs for a sustainable and viable farming. Similarly, the traditional method of collection of seed from natural sources and farming may not be sustainable in the long run.

Considering these problems, Central Institute of Brackishwater Aquaculture has developed a comprehensive technology for sustainable and viable farming of seabass, which can be adopted by farmers. Technologies on production of fry under controlled conditions in hatcheries, rearing of fry to fingerlings in hatcheries and farm sites (Nursery phase), rearing the fingerlings to juveniles (pre grow out phase) and culturing juveniles to marketable size (grow out phase) have been developed by CIBA, Chennai. The most important part in the culture technology of seabass is the nursery rearing because it reduces the culture period and increases the survival. Nursery rearing is the intermediate phase between hatchery and grow out system. Nursery rearing can be done in hatchery using FRP or cement tanks, fixing hapas in ponds and stocking in small nursery ponds. However, nursery rearing in hapa is a low venture setup which can be adopted in closed pond or open water bodies. The nursery rearing phase is of 60-75 days depending upon the environmental conditions of the culture system. This type of nursery rearing is gaining importance amongst the small farmers, Self Help Groups, tribal communities as livelihood options in Andhra Pradesh, Tamil Nadu, Maharashtra, Kerala, etc

One unit of seabass nursery rearin

Steps to be followed during seabass hapa nursery in pond

Pond preparation

Small pond with size range of 500-2000 m2 is used for nursery rearing with provision of water to retain atleast 1.0-1.2 m. Suitable sized mesh screen nets (normally 1 mm) should be provided in the inlet side and outlet side to avoid entry of unwanted fishes, crabs and escape of the stocked fish respectively. Prior to stocking of the seed, the pond can disinfected by using organic or inorganic chemicals for removal of unwanted predatory fishes, crabs, etc.

Cleaning and fixing of water screen of pond inlet system

Water quality management

After pond preparation, water can fertilized with organic fertilizers for maintaining the natural food in abundant. The water quality of the pond plays an important role in culture and survival of seabass nursery as seabass growth is affected by acidic and turbid water. If the pond water or bottom is acidic, neutralization is done with lime application. The optimum water quality required for seabass nursery culture in pond is Salinity: 5-35 ppt, pH: 7.5-8.5, Temperature: 28-32 0c, Dissolved oxygen (DO) : > 5 mg/l; Ammonia: 0.25 ppm, Nitrite: 0.05 ppm and Nitrate: < 1 ppm. Daily water parameters like ph, temperature, DO and salinity needs to be monitored for good survival and production of seabass fingerlings.

Pond fertilization

Monitoring of water salinity and dissolved oxygen

Hapa size and design

The HDPE knotless net hapa of 2 x 1 x 1 m with the mesh size of 2, 3 and 5 mm respectively are used over the seabass nursery culture. The hapa net is stitched from all the sides and loops are provided at each corner of hapa for tying to the bamboo poles installed in the ponds. The hapa has provision for opening with the zip from the top. This would facilitate handling and feeding. The hapa need to be installed in pond in such way that the metabolites and the excess uneaten feed will be washed away by the flow of water.

Happa Installation:

Hapa is fixed in earthen pond or open water bodies with the help of bamboo or casurina pole (6 feet height). Between the hapa minimum distance of 3 m is maintained for easy feeding, hapa cleaning and other maintenance work.

Bamboo cutting for hapa installation

Bamboo and happas installation in pond seed accumulation and stocking

Acclimatization and stocking

Hatchery produced seabass fry (1.5-2.0 cm) can be procured and transported under optimal oxygen packing by air lifting or train up to 14-15 hrs without any mortality. On arrival, acclimatization has to be done to the prevailing local conditions. This is done by slowly adding the rearing pond water by sprinkling in order to bring to the prevailing temperature/salinity. The uniform size fry can be stocked @ 500-750 nos./m2

Seed assimilation before stocking in happas

Stocked seabass seed (1.5-2.0 cm)

Preparation of farm made feed

CIBA have developed farm made feed in powder and pellet form for feeding during nursery period. The powder feed is mixed with boiled deboned fish meat and the feed is made into semisolid dough. Dough is steam cooked for 30 min and cooled. Vitamin & mineral mixture along with cod liver oil is added to dough after cooling. Small balls are made from dough and used for feeding. This can be prepared fresh daily for feeding Seabass larvae until it grows to size of 4-5 cm. After this, seabass fry can feed with slow sinking pellet feed of size ranging from 0.6-1.2 mm @ 8-10 % body weight daily in two rations.

Seabass feed ball

Feeding

For small seed (1.5 - 4.0 cm) the feed ball can be kept in feeding tray which is tied inside the hapa while for fry size seed slow sinking pellet feed is sprayed slowly in hapa. Feeding is done twice a day (morning and evening). Feed requirement is calculated based on the biomass. Feeding rate vary from 8-10 % of total biomass. Over feeding need to be avoided which leads to poor water quality of the culture system.

Seabass Feeding by Women SHGS

Grading

Seabass is highly cannibalistic fish and if proper timely feeding, cleaning and management care is not taken then it affects the survival as well as sustainability of the culture. Hence, seed grading is one of the important steps in nursery rearing of seabass. This is very much essential to reduces the cannibalism and improve the percentage survival during the nursery rearing. Size grading is done at 4-5 days intervals. During the grading, all seed is removed from each hapa and taken in grading containers where shooters are separated from the small size sed group and kept separately according to their sizes as smaller one, medium one and larger one (shooter) in different hapas.

Seabass seed collection for grading

Seabass seed grading by mangrove coastal women SHGs of Maharashtra

Resizing and counting of graded seed

Hapa cleaning and maintenance

Hapa cleaning is done after the grading and hapa is checked for damage if any. After repairing and cleaning they are re-fixed with the pole. Daily cleaning of happa with soft hand brush is viable to avoid the clogging of hapa. This would ensure good health due to free circulation of water in the hapa.

Hapa cleaning by mangrove coastal women SHGs of Maharashtra

Harvesting and marketing

Generally seabass fry reaches the size of fingerlings (3 - 4 inch) in 75-90 days of nursery rearing depending upon the environmental conditions of the culture system, water quality parameters and management. The fingerlings can be harvested and sold for grow out culture in cages @ Rs. 35-40 per piece. On an average four-five cycles of seabass nursery can be undertaken in one year.

Harvested seabass fingerlings **Happy fisherwomen**

Benefits of nursery rearing of seabass

- Seabass nursery rearing in hapa can be cultured in brackishwater canal, cage and aquaculture ponds.
- This method has advantages over other methods since the management is easier and installation of rearing facility requires less space and capital investment.
- It is a potential alternative livelihood options for aqua and tribal farmers of coastal communities of India. Always demand will be available for seabass fingerlings for grow out and polyculture. No marketing problem in coastal region of India.
- Seabass fingerlings price will be fixed as per the size. So farmers will get economic benefit.Seabass is best alternative option for the species diversification and hence always demand will be available for seabass fish because people prefer white flesh fish compared to red meat.

Conclusion

The coastal fisher communities required an alternative option for livelihood and income generation. Brackishwater areas like creeks, laggons, estuaries, small natural ponds, etc can be well utilized for taking up for nursery rearing of different candidate brackishwater finfishes. If such type of nursery rearing technologies is adopted up by coastal fisher communities of Maharashtra then it can be very effectively become a sustainable enterprise for their livelihood.In Maharashtra, this is one of the first kinds of activity which motivated the SHG's especially to women fishermen's to participate in seabass production and to generate the additional income through conservation of the ecosystem. The present on-going demonstrations of seabass nursery culture and training in different district of Maharashtra is emerging as successful livelihood model since it provide the income generation for the unemployed coastal fisher communities through participatory approach of Self Help Group with the technological support by the ICAR-CIBA, Chennai and funding supporting from the Mangrove Foundation , Government of Maharashtra.

Income cheque distribution to mangrove coastal women self help groups of Maharashtra towards production and sale of seabass fingerlings