5. CONCEPT OF CBA, REQUIREMENTS AND PRACTICES

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The importance and popularity of culture of food fishes is increasing rapidly in coastal states of India. The support and expanse of marketing network and advancement of preservation technologies solved long standing problems marketing in domestic as well as international market. In view of its high demand in internal and international market, more and more entrepreneurs are getting interested in the farming of food fishes. Innovations in cage culture technology and its success has drawn the attention of policy makers into giving thrust on food fish culture. Those who have invested huge amount in shrimp culture installations along the coastal areas are also showing interest in switching over to food fish farming following these developments and setback in shrimp culture. In estuaries cage culture is the most viable technique to rear fin fishes. The indigenous technology is developed in cage culture of food fishes in India. There are two general types of cages, floating and stationary. A floating cage is made up of a floating unit from which a single or a series of netcages are suspended. Some of them are mobile and can be easily towed away. A stationary cage, on the other hand, is tied to fixed poles at their corners. In Asia, finfish like grouper (*Epinephelus tauvina*), seabass (*Lates calcarifer*), snapper (*Lutjanus* spp.) and siganid (*Siganus* spp.) are cultured in commercial scales in tropical countries such as Singapore, Thailand, Malaysia, Philippines, Indonesia and Hong Kong.

Fishing and aquaculture are in the past have tended to be treated as distinct and isolated sectors. "capture-based aquaculture" is form of overlap between fisheries and aquaculture which is being propagated in many parts of the world successfully. The fishing is put at the service of aquaculture or aquaculture is practiced to avoid the loss of fishery due to juvenile exploitation. Capture-based aquaculture is the practice of collecting "seed" material – from early life stages to adults - from the wild, and its subsequent on-growing in captivity to marketable size, using aquaculture techniques.

Capture-based aquaculture is a global activity but has specific characteristics that depend on geographical location and the species being cultured. The species groups used in capture-based aquaculture include molluscs (e.g. oysters, mussels, scallops), crustaceans (e.g. shrimps, crabs) and finfish (e.g. eels, grey mullets, milkfish, yellowtails, groupers, rabbitfish, tunas). In worldwide CBA is practiced in many species following are some of the species, with the countries where it is practiced.

- Shrimp (*Penaeidae*) in South America and South-East Asia;

- Milkfish (*Chanos chanos*) in the Philippines, Sri Lanka, Pacific Islands and Indonesia;
- Eels (*Anguilla* spp.) in Asia, Europe, Australia and North America, mainly in China, Japan, Taiwan Province of China, The Netherlands, Denmark and Italy;
- Yellowtails (*Seriola* spp.), mainly in Japan, Taiwan Province of China, Viet Nam, Hong Kong, Italy, Spain, Australia and New Zealand;
- Tunas (*Thunnus* spp.) in Australia, Japan, Canada, Spain, Mexico, Croatia, Italy, Malta, Morocco and Turkey; and
- Groupers (*Epinephelus* spp.), which is now widespread in Indonesia, Malaysia, Philippines, Taiwan Province of China, Thailand, Hong Kong, People's Republic of China, and Vietnam, and in other parts of the tropics, for example in southeastern, USA and Caribbean.
- Grouper culture is also on-going in India, Sri Lanka, Saudi Arabia, Republic of Korea and Australia.

These species are caught and farmed using various techniques and systems, depending on different local cultural, economic and ethnical traditions. In some areas this is typically artisanal, rather than industrial in nature. Economic considerations are the key drivers for capture-based aquaculture. The selection of species for culture reflects their acceptability and demand in local or international markets. Market requirements are determined primarily by people's tastes and customs. As capture-based aquaculture potentially generates higher profits than other aquaculture systems, the market demand for the products and species cultured is high and it is likely that efforts to promote this activity will significantly increase. This development will be capable of causing a number of very important and diverse effects, not all of them beneficial.

Cage based aquaculture is getting adopted rapidly in many parts of the country. When it is being practiced in high intensity some of the scientific factors has to be taken care. Carrying capacity of the water body where cages are is a very important factor. The number of cages should be according to the carrying capacity of the water body and the number of cages exceeds its carrying capacity, it will effect fish growth and survival. There is a strong need for better data on the biology and fisheries of the species. Accumulation of uneaten feed and fish excreta under the cage can become an environmental problem, but this can be avoided by selecting a site with good water exchange to install the cage. capture-based aquaculture provides significant positive returns in areas with depressed and marginal economies, and an alternative livelihood for coastal communities. However, the difficulties of marketing fresh fish and supplying markets that demand live fish (e.g. groupers), and the need to expand markets limit its potential. Skill gaps are evident in the sector, including specific knowledge on economics and management, the suitability of individual (new) species for culture, information on their biology and dietary requirements, and marketing. Capture-based aquaculture is labour intensive in its farming and processing operations, and can contribute to poverty alleviation in developing countries.

Legal and security issues: We will have to envisage some difficulties in future development of capture based aquaculture. Security of the cages is the major issue. For leasing the inland waters and estuaries, the provisions were made in the 73rd and 74th amendments to the Constitution of India empower the panchayats to perform functions mentioned in the eleventh schedule of the Constitution in 29 subjects including fisheries. However, due to lack of legal clarity this has not been implemented in any panchayat. Leases policies should be guided by a set of rules and principles relevant to public trust responsibilities and should specify the size of farm, duration of farming and other terms of lease. Rents thus collected should be used for development of coastal areas.

Food safety issues: The success of cage culture depends on maintaining good water quality around the fish cages and so it is in the farmer's best interests to minimize environmental impacts. Size and intensity of the process should fit to the size of the water body and water exchange rate. It may facilitate to overcome adverse impacts on water and sediment quality. In common with other types of aquaculture, careful choice of aquafeed ingredients and on-growing sites, in addition to good management practices, are necessary to avoid the accumulation of chemical and antibiotic residues, in order to ensure the continued safety of farmed products. Capture-based aquaculture provides other opportunities to reduce the risks associated with food safety.

Site and species selection criteria for cage culture

Cage culture is a popular method of rearing finfish most of Asian countries and it is getting popularised in India also. This new technology utilizes little physical facilities, less space, low initial and is moderately inexpensive to operate. Another advantage is the easy and fast harvesting of live fish which fetch higher price in the market.

There are two general types of cages, floating and stationary. A floating cage is made up of a floating unit from which a single or a series of netcages are suspended. Some of them are mobile and can be easily towed away. A stationary cage, on the other hand, is tied to fixed poles at their corners. In Asia, finfish like grouper (*Epinephelus tauvina*), seabass (*Lates calcarifer*), snapper (*Lutjanus* spp.) and siganid (*Siganus* spp.) are cultured in commercial scales in tropical countries such as Singapore, Thailand, Malaysia, Philippines, Indonesia and Hong Kong. While other finfish like red sea-bream (*Pagrosomus major*), black sea-bream (*Sparus microcephalus*), yellow tail (*Seriola quinqueradiata),* flatfish (*Paralichthys olivaceus*) etc., are cultured in temperate waters, such as in China, DPR Korea, ROKorea and Japan.

Proper site selection for marine netcage culture is of paramount importance as it may considerably affect construction costs, operating costs, growth and survival rate of the fish, and the period of usefulness of the cages. Although floating cages can be usually towed away, sometimes it is not economical to do so.

Site selection criteria also serve as a technical guideline for the production of seafarming resources atlas, rules and regulations, which are necessary for planning seafarming development programme in each country. The guidelines considered in this paper are broad and general, which may have to be modified to suit local conditions and species to be cultured in each area.

1.Topographical criteria

1a.**Exposure**

Cages should be situated in sheltered areas protected from strong wind and wave. Strong winds such as those generated by a typhoon will destroy any structure projecting above the water while waves will bear on any object on and under the water. Normally, storms in tropical countries can be classified into three types: 1) cyclones or typhoons (3–15 m. wave height); 2) tropical storms (1–8 wave height); and 3) depressions (0.75–5 m wave height). Meteorological records in the area will provide an indication of extreme condition of the weather. The information on the long-term frequency, direction and speed of surface wind obtained from meteorological records can be modified for prediction of the height of the wave. Generally, the wind velocity should not exceed 5 knots for stationary cage and 10 knots for floating cage. In relation to the wind speed, the height of the wave in a suitable area should preferably not exceed 0.5 m for stationary cage and 1.0 m for floating cage. Waves are also created from the wake of passing vessels, hence culture site should be at some distance from navigation routes. In case of stationary cages at the mouth of river, creek and canal such as in southern Thailand, the Port Authority has to limit the speed of the vessel instead of removing the cage out of navigation traffic.

1b. **Depth**

The usual depth of a cage is 2–3 m, hence it is necessary to allow sufficient depth under the cage in order to maximize water exchange, avoid oxygen depletion, accumulation of uneaten food, faeces and debris, disease infection, and build up of some noxious gases such as H_2S generated by decomposition of the deposited wastes. In turbid water, silt will tend to accumulate in the cage preventing good water exchange. The clearance for a floating cage should be at least 2–3 m at the lowest low water of spring tide. But a stationary cage is allowed 1–2 m minimal clearance to minimize the costs of fixed poles. Also, because fixed cages are usually placed in the mouth of rivers, creeks and canals where the water flow is stronger than in the open sea. In summary, the selected sites for floating and stationary cages should be at least 5 m and 4 m, respectively at the lowest low water of spring tide.

On the other hand, the maximum depth of the floating cage should preferably be less than 20 m, otherwise investment and maintenance costs will be higher as longer anchoring ropes and heavier anchor blocks are required. The maximum depth of a stationary cage should also not exceed 8 m since it is difficult to find sufficiently strong supporting posts longer than 8 m.

1.c **Bottom condition**

A firm substrate, with a combination of fine gravel, sand and clay presents an ideal site for cage culture. The design of the cage is directly influenced by the type of substrate present at any given site. For example, floating netcages over rocky substrates require more expensive anchoring blocks, but have better water exchange rate. On the other hand, stationary cages easily set up in a muddy substrate with the use of cheaper poles are not suitable for high stocking density due to their low water exchange rate. In general, sloping areas from the shore leading to flat bottoms are suitable for cage culture because the waste build-up at the bottom is easily eliminated.

2. Physical criteria

2a. **Current movement**

Tidal currents bring fresh oxygenated water to and remove waste from the cage. A large tidal range generally indicates better conditions for high stocking density of fish. On the other hand, strong currents will generate excessive strain on the raft anchoring system or fixed poles, distortion of the nets and cage structures, slow growth of fish caused by too much expense of energy in swimming against the current, and food losses. If the fish is unable to swim against the current, the stress will occur, from their being impacted on one side of the net. It would be therefore necessary to reduce the stocking density of fish. The direction of current is also a major criteria for positioning a raft. To minimize the strain on the anchoring system resulting from strong currents, the rectangular raft should be in a direction parallel to the current. This is opposite to the weak current areas where a cage needs to be positioned against the current for a better water flow.

The most appropriate time for measuring the maximal current velocity is at 1–2 hrs after the peak of high water during spring tide. Current velocity is generally stronger at falling tide than at rising tide except that there are other factors involve such as storms, etc. The maximal current should be ideally less than 50 cm/sec and should not exceeding 100 cm/sec. If the maximum current is less than 10 cm/sec, it will cause poor water exchange, especially during neap tide, for intensive culture of fish.

2b. **Turbidity**

Turbid water which is normally caused by freshwater run-off during rainy season is not suitable for cage culture. Organic and inorganic solids are suspended in the water column as a result of soil erosion. Run-off also brings some heavy metals leached from the catchment area as well as other industrial effluents. It also reduces salinity at the site. Suspended solids in turbid waters with strong current from freshwater run-off will also stir up already sedimented material from the usually soft muddy bottom of estuarine areas causing more solids to deposit on the nets. These sediments act as a substrate for the growth of fouling organisms, which prevent proper water circulation. In addition, suspended sediments tend to clog fish gills which may lead to mortality from asphyxiation or cause gill epithelial tissues to proliferate and thicken. The presence of suspended solids also relates to some disease such as “fin-rot” caused by Mycobacteria (Herbert and Merkens, 1961; Herbert and Richards, 1963). The visibility of fish to the feeds will also be reduced which may lead to feed loss and impair fish growth.

Suspended solids in a suitable site for netcage culture should not exceed 10 mg/l. But its effects also depends on the exposure time and current speed. In estuarine site during flood periods, the turbidity can be higher than 100 mg/l but the exposure time is only at low tide and the current is also rapid enough to prevent the sedimentation of solid matters.

3. Biological criteria

3a. **Fouling organisms**

There are about 200 species of marine fouling organisms in the world (Lovegrove 1979). More than 34 species of algae (cyanophytes, rhodophytes, chlorophytes) coelenterates, polyzoans, annelids, arthropods, molluscs and simple chordates have been observed clinging to netcages after immersion for only two months (Cheah and Chua 1979). Colonization of fouling organism is primarily caused by silt particles deposited at the net which serve as substrate for fouling organisms. Silt particles can be more than 50% of total fouling weight. Clogging of the net by fouling organism restricts the water flow thus lowering the dissolved oxygen and waste removal in the netcage. It also increases surface area of the net which causes deformation of the cage in strong current and also increases the stress on both cage structure and anchoring system.

Rate of fouling varies with the environmental conditions and materials used. Fouling is generally more rapid in areas with low current velocities, high temperature, high turbidity (enriched water) and high salinity. It was found that the rate of fouling of galvanized mesh and netting panels was much less than that of synthetic fibre netting panels. In an area of high fouling growth, netcages would have to be cleaned and washed more often to facilitate water exchange. The additional weight of fouling will make net changing difficult and time consuming.

To minimize maintenance cost, netcage farms should be sited in areas unfavorable for the growth of fouling organisms.

3b. **Phytoplankton**

Excessive blooms of phytoplankton can happen whenever the suitable condition prevails such as high light intensity, high nutrient level (organic load), warm water temperature, stagnant hydrological conditions. These conditions should be avoided when selecting cage farming. Algal blooms can affect fish, not only by damaging fish gills by clogging, but also by competing for dissolved oxygen at night. Some species of phytoplankton can produce toxins which can kill fish or accumulate in fish up to the level that becomes toxic to human. A number of marine algae groups form blooms, including diatoms, Cyanobacteria, prymnesiophytes and dinoflagellates. In estuarine area, blooms of some freshwater species which can produce toxin, will become dominant due to the influx from river.

The most important group of toxin-producing algae is dinoflagellates (the cause of red tides). Red tides commonly occur in warm water, especially during summer months. Fish farm wastes and effluents from fertilizer plants can also generate red tide blooms due to nutrient loading. Before selecting the site for cage culture, it is necessary to inquire with the local people or concerned authorities about the occurrence of red tides in the past in that area.

3c. **Diseases and predators**

Most pathogenic or potentially pathogenic organisms spread to the cage farm with the polluted water from sewage (domestic, industrial and agricultural) and the nearby cages. For example, 'red-boil disease' in estuarine grouper (*Ephinephelus salmoides*) is produced by the bacterium, *Vibrio parahaemolyticus*, and is contracted following skin damage caused by handling (Wong et al., 1979). This organism is commonly found in excessive amount in sewage-polluted water. Ectoparasitic marine isopod, *Nerocilia,* which attacks the rabbit fish (*Siganus* spp.) is also more prevalent in organically enriched marine water (Chua, 1979). E. coli number in water is used as an indicator to determine the degree of pollution as well as the possibilities of disease infection in fish. A good site for cage culture should have an *E. coli* count of not more than 3,000 cell/ml.

The setting up of a large number of cage culture units in the same area, will cause the outbreak of diseases, especially when they spread from long-established cages. Wild fish as well as some intermediate hosts of parasites can also carry some disease and transmit them to the caged fish. Fish predators include sea birds, puffer fish and some small fish which compete in feeding. Some of these predators can also carry diseases. Hence the above problems should be considered for site selection.

4. <u>Accessibility</u>

The culture site should be near a shore preferably with a jetty for boat connection with farms and near a good road for land transportation. Good accessibility facilitates distribution of farm products, (especially live fish), transport of feed, fingerlings, fuel, farm equipment, supplies and other necessities. The owner can visit the farm site more often to ensure proper management if it is easily accessible. There are many evidences that the production in the farm is poor because the owner leaves only one or two labourers staying at the farm in an isolated area. Fresh water is needed for daily living and washing of farm equipment. The suitable site should have above facilities close by.

In most of the developed or large scale-intensive cage farms, there are housing facilities on the floating rafts (such as in Singapore) or on the shore close to the cages which always include an office, feed store, laboratory, hatchery and dormitory. Housing facilities on the rafts or close to the cages would increase the possibility of the sewage and toilet waste being released to the water which is not hygienic. It would also minimize production costs if other facilities like power source, telephone, market and food supplies are close to cage culture sites.

5. <u>Social problem</u>

Security is an important consideration anywhere, and probably more so in the region. Since cage culture units are sited in public waters, few countries in the region have laws and regulations to protect the products of cage farmers. Hence the farmers have to keep a careful watch on them to prevent poaching, or select a site far away from the village. These will also increase the production costs in terms of guarding, transportation, and management costs. In some areas such as in Thailand, the owners will site the cages in front of their houses but this also bring in other problems like sewage discharge from village, low water exchanges due to blocking of water currents by boats, jetties and fish traps. In many countries like Philippines, Thailand, etc., a prime consideration in site selection is security.

There are many large scale farms which may have conflicts with villagers. For example, they may have to hire the labour from outside the village. This always brings conflict with villagers and finally lead to poaching problem. If the site cannot be avoided from such villages, it might be a good idea to have a leader of the village be one of the partners. The conflicts may occur from the other common users of the sea, such as waves or oil leak from boats, pollution from industries, waste from other farms and oil spilt from tankers or shipyards.

6. Legal Aspects

Most of the countries in the region have a standard law on lease of public water for any construction and for fisheries. The land below the low water tide level is owned by the government. In some countries in the region cage farmers have to obtain licence to culture fish in cages with restrictions concerning site, species, size structure and type of developments. The government should identify the site for cage culture so as to avoid competing with the other common users of the sea and interference with local navigation regulations. This site identification should also follow the above technical criteria. Size of the farm is also important to avoid or minimize disease outbreak. Lay out plan and strength of cage structures should be approved by the government. Fish species and culture methods should also be regulated with the public interest in mind such as having the proper outputs and avoiding environmental degradation, pollution and other adverse effects

Existing regulations should be carefully studied to avoid any obstacle. Lease and licence (if any) should be applied for early enough due to the lengthy processing involved in obtaining permission in some countries caused by many government departments involved. The operations of cage culture should strictly follow the conditions required by the government such as lighting at night, pollution avoidance, etc.

Fish Species Selection for aquaculture

Species selection needs to be a well thought-out decision. Fishes, with possibly 25,000+ species are in diversity. A study in 2003, conducted for World Aquaculture Society, Salvador 2003, revealed that potentially 60 species had aquaculture potential. For any commercial aquaculture there has to be a market for the fish. The fish species should be suited to the local climate extremes and/or should be native to the area. It is essential that established and reliable rearing techniques are known and readily accessible for the intended species or can be obtained by professional consulting and advice. The natural life cycle of the intended fish should be considered so that its basic biological needs can be met *e.g.* some species can tolerate varying degrees of salinity; some tolerate crowding; some wean onto artificial diets more easily than others do. Here are some criteria which can be followed for selecting species for aquaculture

Criteria for selection of species for culture

- Objectives of culture
- Geographic and climatic considerations
- Culture qualities of the organisms
- Consumer acceptance and marketability
- Cost of production
- Domestic consumption versus export.
- Availability of complete production technology

Desirable biological characteristics of aquaculture organisms

a) Fast growth and higher yields in different types of culture;
b) Efficient conversion of food,
c) Tolerance limits of salinity, temperature and oxygen tension;
d) Ready acceptance of compounded feeds,
e) Good table quality,
f) Disease resistance breeding habits; feeding habits and geographic distribution,
g) Ease of breeding in captivity, early maturation, high fecundity,

Out of 120 families of fishes only two families, sciaenidae and serranidae have good aquaculture potential with 300+ and 500+ species, respectively. There are also special cases such as the cobia, a single member of a fish family, with excellent candidate criteria for production in warm temperate to tropical marine waters. There are some already well established markets available for certain members of the family Carangidae (several species of Yellowtail Jacks, Pompanos and some possible baitfish species) and Sparidae (Breams in EU an US, Snapper in Australia). Grouper culture is well established in Southeast Asia, but has still to catch on in other parts of the world. True snappers, family Lutjanidae, are species rich as well, and routine culture has been established in some species of the genus *Lutjanus* sp., with many more species to be explored. Several species from different genera are in culture for some families of fatfishes (turbot, Atlantic halibut, Japanese flounder), and also the Snooks and two important aquaculture species of the family Latidae in Australlasia. and East-Africa, namely the Asian Seabass or Barramundi and the Nile Perch or Lake Victoria Perch, respectively.

Seabass (*Lates calcarifer*), Grouper (*Epinephelus* sp.), Rabbit fish(*Siganus* sp.) Snapper (*Lutjanus* sp.) are the major fin species found suitable for open sea finfish cage culture in India. Apart from finfishes lobsters are also identified as potential group for rearing in opensea cages.

Cage construction and cage mooring

First generation cages

Cages of 2.5 m x 2.5 m x 2m was fabricated using netlon material as outer net and nylon net as inner net. PVC pipes were used as floats for suspending the cage in the water. The netlon structure serve as a solid frame and protect inner net from predators and big fishes. This will help to maintain the shape of the cage. The net frame was originally fabricated with bamboo poles and PVC pipes were used as floats for suspending the cage in the water. Additional flotation was given by empty oil cans. Sufficient length for the cages leg (2 to 3 feet) are given so that the cage will rest on this legs in the bottom in the case of lowest low tide. This will avoid the damages to nets by avoiding hitting and abrasion with hard and sharp substances in the bottom. For successful installation of long lasting cages, the site selection should be done judiciously. The mooring of the cages is the most important step in successful cage culture.. Mooring should give sufficient anchorage to cage structure throughout the fish rearing period. Filled sand bags packed together in a net material can act as a low coast mooring material. As per the speed of the current the weight of the sand bags are adjusted. The water column at lowest low tide should be more than the height of the cage (more than 3m). The rope attached to the Mooring structure should have enough length to allow the cage float in the water during high tide. To avoid land ward movement of the cage, an additional mooring towards opposite side of the shore should be provided.

Modification of cage fabrication(Second generation cages)

Now with experience the fishermen are finding it feasible to fabricate the cage with frames of GI pipes of 1 inch and the dimension of 4mX 2.5mX 2.5m (with 20 t. of water) with used plastic cans as floats. This cage can last at least for three years only inner net has to be replaced every year.

Live Transportation of Fish Juveniles and Fingerlings

Juveniles and fingerlings procured from the wild and the hatchery has to be transported to the culture site with great care. There are two methods of transportation *viz*., closed system and the open system of transportation. The closed system is a sealed container in which all the requirements for survival are self-contained. The simplest of these is a sealed plastic bag partly filled with water and oxygen. The open system consists of water-filled containers in which the requirements for survival are supplied continuously from outside sources. The simplest of these is a small tank with an aerator stone.

Factors influencing transport

The survival of the fishes during transportation is influenced by number of factor or a combination of factors. The first and foremost of all the factor is the quality of the fish. The fish that is to be transported should be healthy and in good condition. Weakened fishes should be avoided during transportation. Even if the density of the fish is reduced, it is observed that the mortality is high when the weakened fishes are transported.

Reducing the temperature and acclimatizing the fishes to the reduced temperature is another method adopted to reduce the mortality during transportation. Ice could be used for lowering temperature. Direct contact of fish with ice should be prevented and the temperature should not drop drastically. Usually ice packs in plastic bags are kept in between the bags containing fishes to lower the temperature during transportation. A ratio of 25 kg of ice will cool 1,000 litres of water by 2°C. The total temperature difference should not be greater than 12–15°C, with respect to the species and age of the fish (FRG recommendation, 1979).

The fishes except the larval stages has to be starved for a day before the transportation. A fish with gorged stomach would require more oxygen, is susceptible to stress and the excretion would take up much of the oxygen from the water. When fish larvae are transported, their time of survival without food should be taken into consideration. Orloy (1971) has observed that transportation of herbivorous fishes should not last longer than 20 hours.

One single factor which influences the survival during the transportation is the level of dissolved oxygen. Continuous supply of oxygen does not indicate that the fishes are in good condition. The consumption of oxygen by the fish depends on water temperature pH, their tolerance to stress, and concentrations of carbon dioxide and metabolic products such as ammonia. Oxygen consumption in relation to metabolism by the fish is directly related to the body weight and temperature. Heavier fishes transported in warmer water requires more oxygen. In view of fish transport, for each 0.5°C rise in temperature, the fish load should be reduced by about 5.6%; conversely, for each 0.5°C decrease in temperature, the load can be increased by about 5.6% (Piper *et al.*, 1982). The fish at rest would consume minimum oxygen, but during transportation the fishes are disturbed and excited which would result in consumption of more oxygen. Hence during transportation anesthetic agents like Aqueous or Chilaldine or MS 222 or Phenoxy ethanol may be used at lower concentration to keep the fishes on rest. For warm water fish an oxygen level above 5 mg/l during transportation would prevent oxygen from becoming a major stress factor. In closed system of transport, oxygen content in water is not a limiting factor because there is enough pressurized oxygen in a closed bag. In exceptional cases when the density of the fish is high or duration of transport is long which the fish could not stand, oxygen deficit may occur. The dead fishes also compete with the live fishes for oxygen as they increase bacterial multiplication which requires much oxygen, which may further produce toxic metabolites. The slime produced by fish is also another substrate for bacterial growth resulting in decrease of oxygen content. Increase in temperature also intensifies this process.

Water quality is a function of density of the fish and the duration of the transportation. The pH level of the water is an important factor as it is directly related to the CO_2 and toxic ammonia produced. Water pH levels about 7–8 are considered as optimum. With increase in transportation time, the CO_2 level increases which shifts the pH level to acidity which could stress the fishes. Organic buffers which is highly soluble, stable like tris (hydroxyl) methylaminomethane is found to be effective to stabilize the water pH in fresh and salt water. Levels of 1.3–2.6 g/litre are recommended for routine transport of fish (Piper *et al.*, 1982).

Increased carbon dioxide concentrations are detrimental to fish and can be a limiting factor in fish transport. Unless aeration is adequate, the CO_2 level may exceed the oxygen fish consumes. However increased concentration of CO_2 can be tolerated by the fish if the rate of buildup is slow. Tight cover or lids on transportation unit can result in the build up of CO_2 which would stress the fish. Hence adequate ventilation is a necessity for transport units. Aeration of the water will reduce concentrations of dissolved CO_2, if there is adequate ventilation

Chlorine concentration in water is also another factor which is detrimental, although it is also removed from water by aeration. The concentration of 0.5 mg/litre is considered as dangerous, though even lower chlorine levels, e.g., 0.2 mg/litre disturb the fish respiration mechanism considerably (Shevchenko, 1978).

Ammonia (NH_3), which builds up during transportation could be reduced by lowering the water temperature and decreasing the fish activity and by not feeding the fish for day before the transportation.

Consideration should also be given to the factor of space and the density of the fish packed. As to fry, the ratio of the volume of the fish transported and the transport water should not exceed 1:3. Heavier individuals, e.g., parent fish can be transported in a fish: water weight ratio of 1:2 to 1:3, but with smaller organisms this ratio decreases to 1:100 to 1:200 (Pecha, Berka and Kouril, 1983). When fish are transported for acclimation, or when endangered species are transported, the stock density should be lower: in such cases the economic aspects are not of primary importance and 100% survival is required. Nevertheless, the economic side of transport can never be neglected; hence, when the transport costs are high and the value of fish of transported comparatively low, the stock density in the transport units can be increased though losses of fish may be expected to be higher.

Types of transportation of fishes.

The closed systems are represented by polyethylene bags and other sealed transport units. They are used mainly for the transport of the early fry, but also brood fish. The transport of fry in polyethylene bags with oxygen is particularly widespread in the world, being used as a very effective method. It substantially reduces the total volume and weight of transport water, enables public transport to be used for fish-transport purposes, makes it possible to prolong the transport time, and is economically advantageous.

The polythene bags used are of 60- 80 x 40-45 cm dimensions. The upper end is usually open and the bottom has a seam or sometimes the bags are in the form of sleeves and the sleeves are cut into required length and one end is tightened using rubber band or strings. For safety reasons usually the bags are duplicated (one bag inserted into another). When the fingerlings of the fishes are transported, usually papers are inserted in between the bags. This would avoid reflection of the water which could agitate the fishes. During transportation the plastic bags are kept in cases or cardboard boxes protecting it from mechanical damage during transportation. The case keeps the bags in the desired position, enables easier handling and/or providing thermal insulation of the bags.


To cool the temperature, bags of ice could be placed between and under the bags. The desirable amount of ice to be kept is 10-20% of the transport water. This method of packing enables transport by public transport. The water to be used for fry transport in a bag should comply with all requirements. It is best to use water of the same quality as that in which the fish were kept before transport, but there should be no organic pollutants and no dispersed mud of mineral origin. If 50 litres volume bag is used about 20 litres of water is poured and the rest is filled with oxygen , the upper end is twisted to prevent oxygen leak and tied .

Open Systems of fish transport

The open systems of transport have many technical modification ranging from small transport fish-cans, containers for fish transport within the territory of a fish farm, up to special fish transport trucks and tank wagons. In case of short time (10-30 min) open transport, plastic containers or metal tanks could be used with constant oxygen supply. Transport longer than half an hour should be in completely filled and closed tanks to prevent splashing and injuries to young fish bumping into each other in the well of the tank. The weight of fish that can be safely transported in a tank depends on the efficiency of the aeration system, duration of the transport, water temperature, fish size and fish species.

Tanks made of fiberglass connected to oxygen cylinder is commonly used for open transport system worldwide. It is light weight and easy to clean and the commonest and simplest design is the round, flat bottom tank with open top.

After transport, or during control on a longer journey, the condition of the fry should be checked before release. The fry are examined for position, i.e., swimming, lying on the bottom, staying in physiological position or turning to one side, for motility, readiness of reaction to light, touch, and/or number (proportion) of dead individuals. The fish are released only when the temperature of the water in the bag reaches the same level as that of the receiving water.

General points to be considered for transportation.

Emphasis should be laid on the requirements to transport the fry after the absorption of food: when the fry are freshly fed the amount to be transported should be reduced by at least 50%. The water in which sac fry are transported should be kept as still as possible (the fry could be damaged in the bags). On the other hand, advanced fry and fingerlings are not affected by increased movement of the transport water. Anesthetics could be used in mild doses to reduce the activity of the fish. The quality of water should be ensured before the transportation. In short the fish transport is a vast area comprising the problems of purely technical design on the one hand, and the chemistry of water, biological reactions of fish and the like, on the other.

Demonstration experiments by Central marine Fisheries Research Institute in Karnataka

Central Marine Fisheries Research Institute is one of the pioneer Research Centres in transferring mariculture technologies in the State of Karnataka. The participatory approach gave exposure to the local fishers on the finfish rearing aspects besides creating awareness on this lucrative farming technique. Encouraged by this success many fishermen group evinced interest in rearing finfish in suitable farming areas near their backyard.

The Karnataka State has 8,000 hectares of unpolluted brackish waters and estuarine areas, which are highly suitable for capture based aquaculture. The local fishermen use dragnets, castnets and gillnets in estuarine and coastal waters, which harvest juveniles of commercially important cultivable finfishes. These juveniles fishes though live at harvest are invariably discarded due to low market demand. The juvenile of commercially important species such as redsnapper, pearlspot, mullets, seabass etc are available in the inshore waters of Karnataka for Capture Based Aquaculture.

The concept of CBA was introduced in this village by collection of *Lutjanus argentimaculatus, Etroplus suratensis* and *Lates calcarifer* fingerlings and stocking in floating cages of 2.5 m x 2.5 m x 2 m, made of Netlon (mesh of 30 mm) lined with nylon net. It was envisaged to use local seeds for culture, in addition to assure good production seeds for *Lates calcarifer* was supplemented by CMFRI. The netlon cages was designed and fabricated by CMFRI with the participation of local fishermen. Five cages were provided to the fishermen for stocking the fingerlings.

The technology envisages the utilization of juveniles which were other wise discarded due to small size, but if thesre is a high demand for the seeds for cage culture, this exploitation may lead to stock reduction in estuaries and also lead to social conflict between capture fisheries and culture fisheries. The development of seed production in hatcheries on an economically viable commercial scale, and the refinement of grow-out technology to ensure that the fattening phase is environmentally acceptable are the critical issues for the future. Failure to address these matters successfully would have severe consequences for both aquaculture and capture fisheries. So attempts are being made to complement the CBA cages with hatchery reared finfishes which may be a viable option in the future.

Cage in estuaries

Husbandry: The red snapper and pearlspot fingerlings were continuously stocked by fishermen and the fishermen community was engaged in the cage setting, cage cleaning, feed sourcing, feed preparation and feeding. Feeding was done with locally available trash fish and also fish waste from fish processing areas/plants.

Production and Harvest: Altogether five cages were installed and three of the cages were partially harvested as and when the fishes were grown to marketable size, to meet day to day needs of the fishermen. Two cages were spared for final harvest to demonstrate total production possible from these cages.

Theses cages were harvested during July, 2011, when the mechanized fishing is banned. The *Lutjanus* sps attained an average weight of 755 ± 415 g ranging from 105 to 1,914 g. The pearlspot ranged from 37-222 g (96 ± 35g). About 255 numbers of seabass of average weight 1819 ± 540 g was harvested. The total production from the cages including seabass, red snapper and pearlspot was around ~400 kg realizing a farm gate price of ~ Rs 75,000 per cage.

The fishermen view this as an alternative source of fish when adverse climatic conditions prevent them from venturing into the sea. This concept could be popularized along the coast of Karnataka and sustainable use of the finfish resources to augment the fish production could be done. Demonstration of this methodology encouraged the fishermen to install cages of similar type in the estuary and at present many cages stocked with fingerlings of *L. argentimaculatus*, *E. suratensis* and *L. calcarifer* are found in the village. Thus this concept of CBA was adopted by the fishermen and the diffusion of the technology in this village has been phenomenal. This concept could be popularized along the coastal Karnataka and sustainable use of the finfish resources to augment the fish production could be done. The popularization and adoption of the concept of CBA by the fishermen would generate alternate livelihood, income and contribute to fish production of the region.

PRODUCTION ECONOMICS

Redsnapper: *Lutjanus argentimaculatus*

4X2.5X2.5 m cages

- Stocking density : 1000/cage
- Seed cost: : Rs.20,000 per1000
- Rearing period : 10 months
- Weight attained in 10 months : 800 to 1.2 Kg (Average 900gm)
- Survival : 95%
- Total Harvest : 850 Kg
- Fish price/kg : Rs.300
- Income from one cage : 2,55,000.
- Cage construction coast :20,000 (last for three seasons)
- Feed cost: @Rs.5 (1500kg) :Rs. 75,000
  (Fish cutting waste from cutting plants and trashfishes including transportation)

  - Total expenditure (Rs.) : 1,15,000
  - Total income(Rs.) : 2,55,000
  - PROFIT (Rs.) : 1,40,000

  (Considering no labor charges, since it is a family activity)

Sea bass: *Lates calcarifer*
4X2.5X2.5 m cages

- Stocking density : 1000/cage
- Seed cost: : Rs.40,000 per1000
- Rearing period : 10 months
- Weight attained in 10 months : 700 to 1.0 Kg (Average 800gm)
- Survival : 80%
- Total Harvest : 640 Kg
- Fish price/kg : Rs.350
- Income from one cage : 2,24,000.
- Cage construction cost : 20,000 (last for three seasons)
- Feed cost: @Rs.5 (1500kg) :Rs. 75,000
  (Fish cutting waste from cutting plants and trashfishes including transportation)

  - Total expenditure(Rs.) :1,70,000
  - Total income(Rs.) :2,24,000
  - PROFIT(Rs.) :89,000
    (considering no labor charges, since it is a family activity)

Since the seed availability of the Seabass is assured the fishermen prefer Seabass culture over Redsnapper