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on

Cage Culture
of
Marine Finfishes

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Contents

Capture based aquaculture - Alternate method for sustainable fish production

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Introduction

Global aquaculture has grown considerably and contributing significant quantities to the world's supply of fish for human consumption and it has shown to be an attractive option for enhancing the fish production in the world. It is the fastest growing, animal based food production sector with 73.8 million tonnes of production in 2014. Food and Agriculture Organization of the United Nations (FAO) define aquaculture as it is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. It is a diverse sector, which employs different strategies for fish production. There are two major strategies are followed in the sector including hatchery based aquaculture (HBA) and capture based aquaculture (CBA). The HBA allows the commercial and viable production for number of organisms through the management of their entire life cycles. In this system, the seeds are produced from the brood stock fish maintained under the controlled environment, and these produced seeds are used for culture. It involves the development of all aspects of fish husbandry, such as the facilities required for the different life-cycles stages of the fish, feed development, fish handling systems, and disease control. This system is possible for those fishes for which the seed production technology has been standardized, e.g. salmonids, seabass, seabream, different species of grouper, pompanos, and cobia etc.

However, the HBA technology cannot be followed for the species that may not be presently spawned in captivity and also for the species, whose complete life cycle has only been completed at the research and development level. Therefore, enough numbers of seed may not available for commercial farming operations due to controlled breeding techniques have not been perfected. In this contest, farmers have to depend on seeds available from the wild for aquaculture operation and this method is called as capture based aquaculture (CBA). CBA referred as the practice of collecting seed (larvae and juveniles or even large individuals) from the wild, and subsequently growing them in captivity to marketable size, using aquaculture techniques (FAO).

Capture based aquaculture industry has developed long back, but recently has received the interest among the researcher and other stakeholders and thereafter term CBA was first appeared in the literature in 2004 by Ottolenghi *et al.,* (2004). This method practices the growing-out or fattening of wild-caught seeds, using a range of marine and freshwater vertebrate and invertebrate species. The fish production from CBA is estimated to be at least 20 percent of the total annual aquaculture fish production. Although CBA has been practised for decades, recently it has been clearly distinguished from hatchery-based aquaculture (HBA) and also from capture fisheries. In reality, CBA is a hybrid of HBA and capture fisheries but differs from both as a means of food production and in relation to fishing pressure on wild populations, respectively. Capture-based aquaculture has certain advantages and disadvantages compared to aquaculture which controls the full breeding cycle of farmed species. The system does not depend on reproduction and breeding of farmed species. Thus, species of high market value or those that are readily available naturally can be farmed without the necessity to develop hatcheries or breeding program. Importantly, the CBA method has been developed due to the existence of market demand for some

high value species, for which the life cycles cannot currently be closed on a commercial scale.

Species selection for CBA

Species selection is an important criteria for aquaculture practice, the major characters that determine the suitability of a species for aquaculture are its potential marketability, growth rate, easy availability of seeds in the wild and ability to function under culture conditions. While selecting species for CBA, economic considerations should be of more important to an aquaculturist than biological factors. In general, carnivorous species are considered to be a good candidate species for aquaculture operation, because most of the carnivorous species command higher market prices and therefore have greater market potential. The major high value fin fishes including, eels, grey mullets, milkfish, yellowtails, groupers, tunas and other reef fishes, etc. Among the high value fin fish used for CBA, four target species groups, viz. eels, groupers, tunas and yellowtails are of special significance due to their rapid grow-out and high market demand. However, the species selection is also some time depends on the regional specific.

The species like groupers are popular food fish farmed in Southeast Asian countries and have the potential to become an important aquaculture species due to their fast growth, efficient feed conversion, high market prices and reduced availability from wild resources. Groupers are good candidates for aquaculture for its gastronomical reasons and they are valued as one of the highest quality sea-foods in many parts of the world. The amberjack or yellowtail is another good candidate species for the diversification of farmed fish products because of its high growth rate and good performance in captivity especially for easy acceptance

of food and high survival. Yellowtails have a good market especially in Japan, and this market acceptance has been developed over the last 30 years due to capture-based aquaculture production. One of the most interesting characteristics of the fish is that they can be processed and marketed as range of products, e.g. whole, fillets, steaks, etc. This is one of the few species for which the farm-raised fish is unanimously considered superior in quality than the fish caught from the sea, and fetches a much higher price in the market. Eels are another important species that has gone to commercial aquaculture in many countries for their delicacy meat quality. Traditionally, Western Europe and Japan are the areas where demand is highest. Practice of capture-based tuna farming has been rapidly increasing over the past few years; the major focus is on three populations including *Thunnus thynnus thynnus* in the North Atlantic and the Mediterranean, *Thunnus thynnus orientalis* in the North Pacific, and *Thunnus maccoyii* in Australia. These developments have been driven by the market demand for "*sushi*" and "*sashimi*" products in Japan. Capture-based aquaculture practices involve a thorough understanding of the behaviour, habitat and general environmental requirements of each species, as well as knowledge of its reproductive biology, nutritional requirements, larval and juvenile physiology, culture systems, seed availability and susceptibility to disease under culture conditions. Therefore, the selected species need to be studied for all these parameters before it is cultured.

CBA world scenario

Capture Based Aquaculture (CBA) is a global activity but has specific characteristics that depend on geographical location where the species being cultured. Worldwide, CBA is practiced in different countries with many species; the followings are some of the species with the countries where it is practiced.

Table.1. Capture based aquaculture for different fish species

Species	Region / Countries
Milkfish (*Chanos chanos*)	Philippines, Sri Lanka, Pacific Islands, India and Indonesia.
Eels (*Anguilla* spp.)	Asia, Europe, Australia and North America, mainly in China, Japan, Taiwan Province of China, Netherlands, Denmark and Italy.
Yellowtails (*Seriola* spp.)	Japan, Taiwan Province of China, Viet Nam, Hong Kong, Italy, Spain, Australia and New Zealand.
Tunas (*Thunnus* spp.)	Australia, Japan, Canada, Spain, Mexico, Croatia, Italy, Malta, Morocco and Turkey.
Groupers (*Epinephelus* spp.)	Indonesia, Malaysia, Philippines, Taiwan Province of China, Thailand, Hong Kong, Republic of China, and Viet Nam, and in other parts of the tropics, for example in south-eastern USA and Caribbean. Grouper culture is also on-going in India, Sri Lanka, Saudi Arabia, Republic of Korea and Australia.
Seabass (*Lates calcarifer*)	Indonesia, Malaysia, Philippines, Taiwan Province of China, Thailand, Hong Kong, Republic of China, and India.
Shrimp (*Penaeidae*)	South America and South-East Asia.

These species are caught and farmed using various methods and systems depending on local cultural, economic and traditions. In some areas this sort of culture is typically artisanal, rather than industrial. For example, the collection

methods of grouper and seabass seed for CBA systems are local and artisanal in countries like Philippines, Malaysia and India, respectively. However, bluefin tuna culture in Mediterranean is completely industrialized enterprises, which need heavy capital investment, including purse seine boat for catching fish and helicopters to locate fish shoals.

Economic considerations are the key drivers for capture-based aquaculture around the world. The selection of species for culture reflects their acceptability and demand in local or international markets. Compare to other culture methods, the market demand for the species cultured is high in this system and it is likely that the efforts to promote this activity will significantly increase in future. This development will be capable of causing a number of very important and diverse changes on socio economic status particularly in those regions with depressed, marginal low income and characterized by high rates of unemployment.

Advantages of CBA

Higher economic return is the major force for the development of capture based aquaculture technology over the land based aquaculture techniques and capture fisheries. In CBA, mostly the high value fin fishes are produced and therefore the species, size and quality of the produce produced by the farmer is having high demand in international and national markets. The CBA is holding several important revenue enhancing features over the capture fisheries, some of which are similar with land based aquaculture methods and some of the features exclusively for the CBA. In CBA, the producer is holding more control over the production parameters. The important production parameters which help to increase the income in CBA are follows.

1. Increased yield in a cubic meter area, when compared to other culture methods.
2. Improve the quality characteristics of the product through feeding manipulation.
3. Exploit the size related prices for the product by harvesting in appropriate market size.
4. Smooth out supply by doing demand based harvest.
5. Avoid unfavourable natural conditions by ease of harvest in unfavourable conditions.
6. Avoids the unnecessary problems caused by water quality parameters which is prevalent in land based aquaculture methods.

General principles for the development, management and conduct of CBA

Capture based aquaculture depends on both capture fishery and aquaculture activities. It has become an emerging area of fish production and having several socio-economic benefits to the fisher folk compared to original fisheries and aquaculture activities. However, it also has several negative impacts related to environment, ecosystem and social problems. Understanding the problems, the following general principles developed by FAO for the development, management and conduct of CBA in a sustainable manner.

1. Management of the CBA practice is essential and regulatory actions should be undertaken for the area where CBA activity is highly dependent on wild-caught live material.
2. Regional fisheries management organizations (RFMOs) are required in addition to national level organization, and it should ensure that CBA fishery activities are managed and monitored effectively.

3. The ecosystem approach to fisheries and aquaculture needs to be considered and applied. This includes impacts of feeding, seed captured for grow-out, fishing methods and culture operations on the environment and on non-target species, and genetic issues.
4. In CBA activities, due consideration paid to other fishing sectors targeting the same stock to ensures that the sum of fishing does not exceed the natural mortality of the exploited stock.
5. The place where natural-mortality-curve information is unavailable for a new CBA fishery, then no CBA activities should be undertaken for that species, except for controlled collection of live material to produce a natural mortality curve for the species and other relevant biological and socio economic information. Alternatively, exploratory fishing could be conducted at low and controlled levels of fishing intensity, and the CBA fishery should only proceed under a set of guidelines that integrate the adaptive management concept. In all cases, new CBA activities should apply the precautionary principle and consider potential risks.
6. Brood-stock capture should be kept to a minimum and carefully monitored, especially in the case of threatened species. Appropriate handling methods should be applied to seeds or brood-stock to minimize mortalities during transfer or grow-out.
7. Migration routes, spawning sites and important nursery and settlement sites of CBA species should be identified, protected and managed by appropriate spatial, temporal and technical means.
8. Holistic management is required for additional controls beyond fishery management measures, such as controls on the aquaculture component of the operation. These might include licensing of hatcheries or culture operations, requirements for reporting and monitoring, regulations on quantities and size of wild seed or brood-stock used.

9. Monitoring and reporting of CBA fisheries should include information on the transfer of seed into aquaculture operations (i.e. including mortalities from capture and during transfer) and, where possible, data from the aquaculture operation, such as mortality levels during the culture period.
10. Place in which the wild capture live material or brood-stock fishery is not under management and overexploitation of the wild stock and adult fishery is likely, so the fishery should be halted or restricted until sustainability can be demonstrated. The material or brood-stock fisheries should not come from illegal, unreported and unregulated (IUU) fishing.
11. When management measures are proposed, the social and economic impacts of the management should be identified, along with mitigation measures and appropriate agencies such as non-governmental organizations, international non-governmental organizations, RFMOs, etc. All stakeholders, inclusive of fishers from all fishing sectors, fishery managers and aquaculture operators, should communicate to ensure that the linkage between the sum of capture pressure and supply and demand for seed is appropriately measured and controlled, and to ensure consultation across fishing sectors and interests.
12. Countries which performing CBA activities should collect separate statistics on CBA with data clearly disaggregated between wild fisheries capture for CBA and aquaculture production.

CBA - Indian scenario

India has the vast area of suitable coastal waters, lagoons and bays which can be utilized for mariculture through capture based aquaculture (CBA). India is bestowed with vast potential area for mariculture activities, but production is restricted to around 1 lakh tonnes annually and it is mainly contributed by marine

shrimps. The mariculture activity through capture based aquaculture in India was mainly confined to shrimp, mussel and edible oyster farming. Till recent years CBA for marine fin fishes were not practiced or initiated due to unavailability of confined culture system and difficulties in rearing of marine fin fishes in tank/pond. But, in the last few years, initiative has been taken up by Central Marine Fisheries Research Institutes (CMFRI) for development and popularizing of marine cage culture for mariculture activities. Thus, CBA has become reality in India with help of cage culture and now CBA could be possible for high value marine fin fishes. A large number of juveniles of high value finfish and shellfish are caught as by-catch in many of the non selective bag type gears that are commercially operated in India. The catches of fish juveniles are either discarded or sold in the market at very low price. If these juveniles can be brought in live condition, these can be used for capture based aquaculture practice by which the resource can be conserved and utilized for increasing production.

In India CBA started with shrimp/prawn culture in several decades back in traditional water bodies like pokkali paddy field. The culture was practiced by trapping the young-ones of prawns brought in by the tide and growing out in the field till they attain market size. Thereafter, move on mussel and oyster farming was initiated by CMFRI. The mussel farming is mainly consisting of green and brown mussels and oyster farming is mainly of giant oyster. Culture of these species is mainly practised in the west coast of India especially in Kerala. For culture, the wild seed are collected and grown until attaining the market size using raft and rack culture methods. The technology of raft and rack culture was developed by CMFRI and it has been demonstrated and disseminated successfully among the villagers for taking forward. Lobster culture is recent initiative by CMFRI, where the coastal spiny lobsters *Panulirus homarus, P. polyphagus, P. ornatus, P. penicillatus and P. longiceps* are the good candidate species for

farming. Spiny lobster farming/fattening was demonstrated by Veraval regional centre of CMFRI by rising under sized or juvenile lobsters of wild origin in suitable enclosure to marketable size through appropriate feed and water quality management. Marine finfish culture through CBA has got popularized and becoming an emerging area after advent of cage culture in India. The most common cultivable candidate species of marine fin fishes include seabass, rabbit fish, pearl spot, groupers, snappers, sea bream, mullet, etc. Culture of some of these fishes has been demonstrated in cages in different places using wild collected seeds by CMFRI. Added to several other factors, identifying the available seed resources of the marine finfishes plays major role in the development the culture method in India. Therefore, recently, CMFRI has taken initiative to prepare the seed calendar of marine finfishes all over the India, pertaining to information on species availability, location and seasonality under the All India Network Project (AINP) on Mariculture. Certainly, it would bring correct picture on the available seed resources in India and may help for the CBA culture programme.

To popularise the capture based aquaculture activities for marine finfish in India, initial attempts were made by CMFRI in different maritime states like Karnataka (Karwar & Mangalore), Kerala (Cochin), Tamil Nadu (Chennai), Andhra Pradesh (Visakhapatnam) and Odisha (Balasore). In the beginning different marine finfish species collected from the wild including seabass, mullet, pearl spot, etc in cages. From the several studies, the culture of Asian seabass was highly encouraging at the Karwar, Balasore, and Chennai. In Cochin, cage culture of fishes like mullet, seabass and pearl spot performed in open sea and back water showed promising result. Recently, as a part of the CBA programme, CMFRI attempted culture of the carangid species, *Alepes djedaba* (shrimp scad) along with the mangrove snapper, *Lutjanus argentimaculatus* in 13 cages at Uppunda

village, Byndoor, Karnataka. The demand for the species is good and it sold for Rs. 250-300/kg in that region. The results of the demonstration showed that the shrimp scad, *Alepes djedaba* is also one of the promising carangid species for capture based aquaculture.

Success story on capture based aquaculture of Asian seabass at Nagayalanka

Visakhapatnam Regional Centre of CMFRI (VRC of CMFRI) has been striving hard to disseminate the cage culture technology since 2007 in different districts of Andhra Pradesh state. Cage farming of seabass was demonstrated in back waters of Krishna river at Nagayalanka, Krishna District in collaboration with Mr. T. Ragu Sekhar. A total numbers of 13 cages were used, of which 11 were wooden cages (square shaped; 4 x 4 x 2 m size) and 2 were HDPE cages (circular with 6 m dia). The cages were installed with help of barrels for floatation and anchor (iron and stones) for mooring. All the cages were stocked with 6 inch sized sea bass in the month of August to November, 2015 and were fed with trash fishes. The seabass seed source was from wild and were collected from sea shore and back water areas in Krishna districts. Total of 500 numbers of fish seeds were stocked in each cage. Fishes has grown to 0.5 kg to 1 kg in 5-8 months of culture period. The grown fishes were harvested on 15.5.2016 and Hon. Shri. Mandali Buddha Prasad, Deputy Speaker, Govt. of Andhra Pradesh flagged off the fish harvest. A total of 3 ton of sea bass was harvested from cages and sold in live at the rate of Rs. 340 per kg, instead of Rs. 270/kg for dead fish, in local market. While addressing the gathering, Mr. Mandali Buddha Prasad, Deputy Speaker, promised to take the initiative for helping the fisher folk to involve in the cultivation of high-valued fish species through the floating cage technology. Mr. Ragu Sekhar, farmer, Nagayalanka mentioned that selling live fish has helped him to earn Rs 70/kg extra. He also mentioned that demand/need based fish harvest,

will fetch higher returns. This demonstration programme was carried out as part of All India Network Project on Mariculture through Visakhapatnam Regional Centre of CMFRI.

Cage farming site at Nagayalanka

Seabass harvested from cage

Hon. Shri. Mandali Buddha Prasad, Deputy Speaker, Govt. of Andhra Pradesh with the harvest

The chief guest addressing the audience

Fig.1. Capture based aquaculture of Asian Seabass at Nagayalanka

Conclusion

Capture based aquaculture is becoming an emerging area, increasingly contribute to world aquaculture production and having many advantages. But still it is considered as an unsustainable aquaculture practice, due to the increasing pressure on fish stocks that could cause successive stock depletion; low recruitment; stock collapse; reductions in genetic biodiversity; and subsequent impact on the ecological dynamics and processes in the wider aquatic

environment. Recently, several initiatives have taken place to make it as sustainable practice with help of recent advances in the knowledge of breeding technology and larval biology. In addition, several management practices have developed to mitigate the effects of CBA on the environment, which include used of proper modelling and assessment methods, proper selection, and control of stocking densities, good feeding regimes, good health management and accurate environmental impact assessments. If these management measures are acknowledged and adopted, CBA will become a sustainable practice and may bring several changes in fisher folk community by providing alternative source of income generation for the traditional fisherman during the lean fishing season, particularly in fishing ban season in India.

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