Training Manual Series No. 10 / 2016

Training Manual on

Cage Culture of Marine Finfishes

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Organised by
Visakhapatnam Regional Centre
ICAR-Central Marine Fisheries Research Institute,
Visakhapatnam -530 003
Andhra Pradesh, India

Financial Assistance
All India Network Project on Mariculture (AINP-M),
Indian Council of Agricultural Research, New Delhi-110 012

Cover page: Designed by
V. Uma Mahesh
M.V. Hanumantha Rao

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7-12 November, 2016

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ICAR-Central Marine Fisheries Research Institute,
Visakhapatnam -530 003
Andhra Pradesh, India

2016

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Introduction

The decline of fish stocks has been a motivating factor for expanding the role of aquaculture in the fishing industry. Nowadays, the trend demonstrates that while wild harvest volume remains stable (or is in decline in several fisheries), aquaculture production has increased. In this situation, cage farming has an important role in meeting the global demand for fish products. It is one the alternative source to increase the aquaculture production. The development of this type of fish production is a long-term solution to meet the global demand for fisheries products and also provides economic opportunities for displaced and landless fishermen.

Cage culture of marine fish has grown rapidly over the last decade in Asia, Europe and Australia, utilizing inshore or offshore net cages. The cage farming industry, particularly in northern Europe, North America, Chile and Japan, expanded dramatically during the 1980s and 1990s, which attracted the interests of a growing number of large multinational companies seeking to diversify into a new and growing market and with resources to carry out research and development. Similarly the cage culture has spread to South East Asian countries and developed well. Of the estimated one million tonnes of marine fish cultured in Asia, probably 80-90 % is from cage farming. The major advantage in these countries is that they have large, calm and protected bays to accommodate the cages safely against natural bad weather conditions. Compared to that, India is endowed with very few such areas and the sea conditions are hostile at least during certain periods making the safety of structures uncertain. In the simplest term a cage is nothing but an enclosure in the water body whereby the juveniles of aquatic animals are stocked, fed and grown to marketable size. However, in practice it is very complicated in its structural, engineering, social and biological aspects.

Fish farming in cages is a lucrative business for poor coastal communities. In some countries and locations, cage farming provides an important source of fish production and income for farmers, other industry stakeholders and investors. In modern times, cage culture is also seen as an alternate livelihood, for the persons displaced by the construction of reservoirs or acquisition of land for other developmental activities. In such a situation, cage aquaculture has emerged as a promising venture and offers the farmer a chance for optimal utilization of the existing water resources which in most cases have only limited use for other purposes.

History

The earliest record of cage culture practices dates back to the late 1800 in Southeast Asia, particularly in the freshwater lakes and river systems of Kampuchea. Marine fish farming in cages traces its beginning to the 1950s in Japan where fish farming research at the Fisheries Laboratory of the Kinki University led to the commercial culture of yellow tail *Seriola quinqueradiata* and developed into a significant industry as early as 1960. Thailand has developed cage culture techniques for two important marine finfish: the sea bream (*Pagrus major*) and grouper (*Epinephelus* spp.) since 1970. Later, large scale cage farming of groupers were established in Malaysia in 1980. Korea started cage culture in the late 1970s and by the end of 1980, cage culture of the olive flounder

(*Paralichthys olivacens*) and black rockfish (*Sebastes schlegeli*) was established, and developed into a successful aquaculture industry in the 1990s. Cage culture of groupers (*Epinephelus* spp.) in the Philippines has been practiced since 1980s. Mariculture of milkfish in the 1990s led to the further growth and development of the industry. In Europe, cage culture of rainbow trout (*Oncorhynchus mykiss*) in freshwater began in the late 1950s and in Norway, Atlantic salmon (*Salmo salar*) followed in the 1960s. More than 40% of its rainbow trout comes from freshwater cages. Salmonid culture in cages is currently dominated by production from Norway, Scotland and Chile. Cage culture of fish was adopted in USA in 1964. In India, open cage culture started recently by CMFRI and it has demonstrated along the Indian coast in different states for culturing different species such as sea bass, lobster, cobia etc.,

Global Overview

The high tonnage production cage culturing industries has been established in marine environment in some of the temperate countries, and the species include yellowtail (*Seriola quinqueradiata*) and sea bream (*Sparus aurata*) in Japan and salmon/trout in worldwide. Only a small fraction of the world's total aquaculture production comes from cages. However, cage production is nevertheless sizeable, of high monetary value and growing at a very impressive rate. Although no official statistical information exists concerning the total global production of farmed aquatic species within cage culture systems or concerning the overall growth of the sector, there is some information on the number of cage rearing units and production statistics being reported to FAO by some member countries. The total reported cage aquaculture production during 2005 was 3.4 million tonnes. The major cage culture producers in 2005 included China (29%), Norway (19%), Chile (17%), Japan (8%), United Kingdom (4%), Vietnam (4%), Canada (3%), Turkey (2%), Greece (2%), Indonesia (2%), Philippines (2%), Korea (1%), Denmark (1%), Australia (1%), Thailand (1%) and Malaysia (1%). The fish family wise worldwide cage aquaculture production was dominated by salmonidae (66%) followed by sparidae (7%), carangidae (7%), pangasiidae (6%), cichlidae (4%), moronidae (3%), scorpaenidae (1%), cyprinidae (1%) and centropomidae (1%). There are at present 80 species of finfishes currently cultured in cages all over the world. Of these, *Salmo salar* accounted for half (51%) of all cage culture production. The other major contributors were *Oncorhynchus mykiss*, *Seriola quinqueradiata*, *Pangasius* spp. and *Oncorhynchus kisutch* contributing altogether 27% of total cage farmed fish. In addition, *Oreochromis niloticus* contributed 4%, *Sparus aurata* contributed 4%, *Pagrus auratus* contributed 3% and *Dicentrarchus labrax* contributed 2%.

Total European aquaculture production using cage culture technology was estimated at 2.2 million tonnes. Along Northern Europe, the production volume in 2004 was about 0.8 million tonnes of Atlantic salmon and about 80, 000 tonnes of rainbow trout. The European seabass and the gilthead sea bream are currently the most widely caged fish species in the Mediterranean. Production has progressively increased over the last ten years from 34,700 tonnes in 1995 to 137,000 tonnes in 2004, with an average annual growth rate of 17%. In 2004, the cage production of these two species accounted for approximately 85% of the total production. Salmonid production in cages each from North and South of America exceeded more than a few lakh tonnes.

Cage farming in brackish and inshore waters in Asia is relatively recent, started first in Japan. It is estimated that over 95 percent of marine finfish aquaculture is being carried out in cages in these region. Cage farming is most dominant in East and Southeast Asia, but not in South Asian nations. The main species farmed in brackish waters are the barramundi or Asian seabass (*Lates calcarifer*) and the milkfish (*Chanos chanos*). In inshore marine cage farming, apart from traditionally farmed species such as amberjacks (*Seriola* spp.) and snappers (*Lutjanus* spp.), cage farming of groupers (*Epinephelus* spp.) and cobia (*Rachycentron canadum*) is gaining ground in Southeast Asia. Grouper and snappers production from cages in Asia was estimated by FAO in 2004 at around 0.06 and 0.135 million tonnes, respectively.

The Japanese amberjack (*Seriola quinqueradiata*) is the main marine fish species cultured in Asia (mainly in Japan) in cages, comprising 17 percent of total marine finfish production, with just less than 0.16 million tonnes produced in 2003. Most production of cobia currently comes from the cages in China and Taiwan Province of China and totalled around 20,000 tonnes in 2003. Production of barramundi in cages increased during the past ten years, and FAO statistics estimated that 26,000 tonnes were produced in 2004. Milkfish (*Chanos chanos*) production in Asia in cages is significant, with Indonesia and the Philippines contributing the bulk of the 0.515 million tonnes as reported by FAO in 2004.

Growth performance of finfishes in cages

Observation has been made in different place showed that the fishes cultured in the cages are performing equally or even better than the fishes are in the wild. In addition, cage culture system provides scope for the growth enhancement for the fishes cultured through feed manipulation. The growth potential of the Asian seabass in floating sea cage was assessed in different locations all along the Indian coast by CMFRI. The juveniles of 28 g stocked in cage @ 60 no/m^{-3} have grown to 540 g in 112 days period at Vizhinjam Bay, south-west coast of India. Asian seabass fingerlings of 3.5±1.5 g stocked in cage has attained an average weight of 315.5 g in 120 days at Munambam, Cochin. At Karwar, Karnataka with survival rate of 68.8%, after 150 days of rearing, seabass reached 1.02 kg in weight and 412.05 mm in length. Sea bass attained an average of 29.45 cm body length and 996.62 g in body weight after 180 days of culture at Balasore, Odisha. At Rajulalanka, Andhra Pradesh, fingerlings with length and weight of 8.36±0.32 cm and 8.10±0.61 g were stocked in six cages at three different stocking densities, 15 m^{-3}, 30 m^{-3} and 45 m^{-3}, and after 150 days of grow-out, seabass fingerlings reached 36.0±6.0 cm and 690.7±41.3 g at density of 15 m^{-3}, 33.9±0.4 cm and 633.2±17.9 g at density of 30 m^{-3} and 30.2±0.4 cm and then 465.0±21.2 g at density of 45 m^{-3}.

Aquaculture of southern bluefin tuna in Southern Australia is based on fattening fish in offshore cages. Juveniles weighing 5 to 10 kg are caught offshore with purse seines and stocked into a cage. Growth rate of southern bluefin tuna in cages is estimated at 2 to 5% of body weight per day with a grow out period ranges from three to ten months. Cage culture of tilapia (*Oreochromis niloticus*) having mean initial individual body weight of 2.78 g in Brahmaputra river in varying stocking densities (100, 150 and 200 fish/m^3) revealed average daily body weight gains of 0.58±0.07 g, 0.67±0.06 g and 0.35±0.02 g, respectively. The net production rates were 7772±950 g/m^3/135 days, 13608±1261.70 g/m^3/135 days and 9444±600 g/m^3/135 days, respectively.

Spotted rose snapper stocked at body weight sizes of 24.5 ± 3.7 g, 55.4 ± 3.5 g, and 110.2 ± 4.6 g in three replicated marine floating cages of 100 m^3 and reared for 153 days at Mexico recorded growth increment of 0.93 g d^{-1}, 1.21 g d^{-1} and 1.83 g d^{-1}. Mean survival ranged from 67.5 to 74.7%. Mutton Snapper (*Lutjanus analis*) grew from an average weight of 12.25 g to over 300 g in nine months, indicating that the commercial size of 0.5 kg was achieved within a 1-year grow-out period. In nursery and grow-out offshore cages in Taiwan, 100–600 g cobia was cultured for 1–1.5 years and they reached 6–8 kg.

Integrated cage farming

Cage culture systems need to evolve further, either by going further offshore into deeper waters and more extreme operating conditions and by so doing minimizing environmental impacts through greater dilution and possible visual pollution or through integration with lower-trophic-level species such as seaweeds, molluscs and other benthic invertebrates. The rationale behind the co-culture of lower-trophic- level species is that the waste outputs of one or more species groups (such a cage reared finfish) can be utilized as inputs by one or more other species groups, including seaweeds, filter feeding molluscs and /or benthic invertebrates such as sea cucumbers, annelids or echinoderms. However, while there has been some research undertaken using land based systems considerably further research is required on open or offshore mariculture systems. Cage aquaculture will play an important role in the overall process of providing enough (and acceptable) fish for all, particularly because of the opportunities for the integration of species and production systems in near shore areas as well as the possibilities for expansion with sitting of cages far from the coast.

Capture based aquaculture

It is well known that the ready availability of seed in commercial quantities is one of the major limiting factors in the development and expansion of mariculture. The increasing exploitation pressure on the wild stocks of many major marine fisheries has led to overexploitation and consequent decline in their catch and hence the only sunrise sector to augment seafood production is through marine cage farming. Even-though the seed production technologies have been developed for many marine finfish and shellfish species, but still remains a fact that many of these technologies have not been scaled up to commercially viable levels. The hatchery seed production of many high value marine finfishes and shellfishes are complex and expensive due to the high costs involved in the establishment of broodstock and hatchery facilities and also to the complicated larviculture procedures involving culture of proper live feeds, their nutritional enrichment, feeding protocols, grading, water quality maintenance, nursery rearing and disease management. Even-though the production of seeds of the concerned species by development of commercially viable technologies is the ultimate answer for development of sustainable mariculture practices, it still remains a fact that many of these technologies are still in the emerging state and may take many more years for standardization on a cost effective level. Since the marine food production from the capture sector is declining, marine farming has to be developed and expanded urgently and it is not advisable to wait for the standardization of seed production technologies for all the concerned species. In this context, the concept of capture based aquaculture can be considered as a mid way point between fishing and aquaculture and requires to be developed into a sustainable commercial activity for augmenting the seafood production.

Capture Based Aquaculture (CBA) is the practice of collecting seed materials from early life stages to adults from the wild, and its subsequent on-growing in captivity to marketable size, using aquaculture practices. It is well understood that even-though the hatchery technologies have been developed for many high value species, the technologies still remain to be perfected and hence fish farmers have to depend on ‘seed’ available from the wild. Capture based aquaculture has developed due to the market demand for some high value species whose life cycles cannot currently be closed on a commercial scale. CBA is a world-wide aquaculture practice and has specific and peculiar characteristics for culture, depending on areas and species. The species/ groups harvested as wild juveniles at the different countries / regions where CBA is practiced include shrimps, milkfish, eels, yellowtails, tunas and groupers. Even though CBA could be considered as an unsustainable aquaculture practice in the long run due to the successive stock depletion to the wild stock, there are some aspects which highlight the importance and potential of this practice. It is generally considered that further development of marine aquaculture is possible only by the increase in mass production of juveniles in hatcheries. But it remains a fat that much of world's coastal aquaculture can still be expected to come from the supply and availability of capture-based juveniles. Many of the environmental concerns associated with the grow-out of juveniles produced in hatcheries like transfer of diseases and genetic pollution of wild stocks are not encountered in CBA. 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 in future will increase significantly.

Capture based aquaculture can be considered the midway point between fishing and aquaculture, yet as a commercial activity it constitutes a distinct sector. A very significant proportion (millions of metric tonnes) of the total food fish (finfish, crustaceans and molluscs) aquaculture production reported by FAO is obtained through the on growing of wild caught juveniles (eels, grouper, yellowtail, tunas, milk fish, mullets, most molluscs and some marine shrimp is derived from CBA). Most of the production in CBA is from molluscs. Among finfishes eels, tunas, groupers and yellowtail represent a large proportion of the total volume and an even larger proportion by value. The total value of these four groups exceeded US$ 1.7 billion in 2000. It qualifies to be considered as a separate and distinct entity within the aquaculture sector because it has its own special culture characteristics. CBA is an economic activity that is likely to continue to expand in the short term, both for those species currently under exploitation and possibly with others that may be selected for aquaculture in the near future. In the case of shellfishes like mussels the activity will certainly continue in view of the large scale availability of natural seeds. It is felt that with effective regulations and management practices, the capture based aquaculture offers good scope and potential for the artisanal and industrial sectors in the years to come.

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