History of cage culture, cage culture operations, advantages and disadvantages of cages and current global status of cage farming

Gopakumar, G.

Mandapam Regional Centre of Central Marine Fisheries Research Institute
Mandapam Camp, Tamil Nadu - 623 520
drggopakumar@gmail.com

Introduction

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. Since the 1970, Thailand has developed cage culture techniques for two important marine finfish: the sea bream (*Pagrus major*) and grouper (*Epinephelus* spp.). 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 is currently dominated by production from Norway, Scotland and Chile. Cage culture of fish was adopted in USA in 1964.

Currently many fish species have been cultivated in various designs and sizes of cages in Asia, Europe and other parts of the world. Tilapia and carp predominate in freshwater cage culture in Asia, while salmonids are commonly farmed in Europe and the Americas.

The rapid growth of the industry in most countries may be attributed to the availability of suitable offshore sites for cage culture, well established breeding techniques that yield a sufficient quantity of various marine and freshwater fish juveniles, availability of supporting industries such as feed, net manufactures, fish processors *etc.*, strong research and development initiatives from institutions, governments and universities and the private sector ensuring refinement and improvement of techniques/ culture systems, thereby further development of the industry.

Cage culture operations

Cage culture operation involves:

Stocking: The stocking density of fish depends on the carrying capacity of the cages and feeding habits of the cultured species. For those species which are low in the food chain, stocking will also depend on the primary and secondary productivity of the sites. The optimal stocking density varies with species and size of fish and ensures optimum yield and low disease prevalence.

Feeding: Many biological, climatic, environmental and economic factors affect feeding of fish in the cages. Growth rate is affected by feeding intensity and feeding time. Each species varies in maximum food intake, feeding frequency, digestibility and conversion efficiency. These in turn affect the net yield, survival rates, size of fish and overall production form the cage. Trash fish is the main feed for yellowtail, grouper, bream, snapper and other carnivorous fish species cultured in marine cages. The shortage of trash fish is a major problem in many countries with large scale cage farming.

Farm management: Farm management must optimize production at minimum cost. Efficient management depends heavily on the competence and efficiency of the farm operator with regard to feeding, stocking, minimizing loss due to diseases and predators, monitoring environmental parameters and maintaining efficiency in technical facilities. Maintenance works are also very vital in cage culture.

Advantages and disadvantages of cages compared to land based structures

The advantages and disadvantages of cage culture is adjudged by its comparative performance with other land based culture systems in terms of level of technology required for construction, ease of management, adaptability, quality of the fish reared, resource use, social implications, and economic performance.

Advantages

- Construction of cage is comparatively easy, be it artisanal type or modern sophisticated ones.
- Observation of the stock is easy in cages, therefore feeding and routine management is easy
- Cage reared fish are superior in quality in terms of condition factor, appearance and taste
- Cages make use of existing water bodies and thus it can be given to non-land owned people of the community (fishermen) whose income is affected by many reasons in fishing sector. It therefore acts as an alternative income for such groups.
- Harvesting is typically less labour intensive in cages
- Fish are protected from predators and competitors

Disadvantages

- Pond fish can make use of naturally occurring food, while cage grown fish only have a limited access natural food since they cannot forage on their own. Cage grown fish therefore needs to be fed by the farmer to a much higher extent. The food that is given to the cage grown fish also has to be nutritionally complete, *e.g.* contain proper amounts of all necessary vitamins and minerals.
- When fish grown in cages instead of ponds, most farmers opt for a high stocking density. A high stocking density creates a stressful environment for the fish and stress damages the immune system. The risk of disease is therefore high. The risks will be increased further if the farmer fails to provide the fish with optimal water conditions and a satisfactory diet. Cage culture can introduce or disrupt disease and parasite cycles, change the aquatic flora and fauna and alter the behaviour and distribution of local fauna.
- If proper water exchange is not there, the uneaten feed and metabolic waste released from cages will lead to eutrophication of the site.

- Predators can be attracted to the cages and for that additional protection has to be provided such as predator nets
- Poaching is easy because fish are confined in a small area
- Marine cages face problems like fouling and is more expensive
- Storms can damage the cages.
- When cages are installed indiscriminately, its impact on environment and biodiversity is adverse and it will have influence on current flow and increase local sedimentation
- Since cages occupy open water sources, it may affect navigation in the area, or reduce landscape value of that area and are vulnerable to pollution from any source.

Current global status of sea cage farming

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. In total, 62 countries provided data on cage aquaculture for the year 2005.

The cage aquaculture sector has grown very rapidly during the past 20 years and is presently undergoing rapid changes in response to pressures from globalization and growing demand for aquatic products. Fish consumption in developing countries will increase by 57 percent from 62.7 million metric tons in 1997 to 98.6 million in 2020. By comparison, fish consumption in developed countries will increase by only about 4 percent, from 28.1 million metric tons in 1997 to 29.2 million in 2020. Rapid population growth, increasing affluence and urbanization in developing countries are leading to major changes in supply and demand for animal protein from both livestock and fish.

The move within aquaculture toward the development and use of intensive cage farming systems was driven by a combination of factors, including the increasing competition faced by the sector for available resources, the need for economies of scale and the drive for increased productivity per unit area. Particularly the need for suitable sites resulted in the sector accessing and expanding into new untapped open water culture areas such as lakes, reservoirs, rivers and coastal brackish and marine offshore waters.

Production

Total reported cage aquaculture production from 62 countries and provinces/regions from where data is available amounted to 2412167 tonnes (excluding China) On the basis of the reported information, the major cage culture producers in 2005 included - Norway (652306 tonnes), Chile (588 060 tonnes), Japan (272 821 tonnes), United Kingdom (135 253 tonnes), Vietnam (126 000 tonnes), Greece (76 577 tonnes), Turkey (78 924 tonnes), and the Philippines (66 249 tonnes).

Major cultured species, cage culture systems and culture environments

To date commercial cage culture has been mainly restricted to the culture of higher value (in marketing terms) compound-feed-fed finfish species, including salmon (Atlantic salmon, coho salmon and Chinook salmon), most major marine and freshwater carnivorous fish species (including Japanese amberjack, red sea bream, yellow croaker, European seabass, gilthead sea bream, cobia, sea raised rainbow trout, Mandarin fish, snakehead) and an ever increasing proportion of omnivorous freshwater fish species (including Chinese carps, tilapia,

Colossoma and catfish). However, cage culture systems employed by farmers are currently as diverse as the number of species currently being raised, varying from traditional family –owned and operated cage farming operations (typical of most Asian countries; to commercial cages used in Europe and the America).

In terms of diversity, altogether an estimated 40 families of fish are cultured in cages, but only five families (Salmonidae, Sparidae, Carangidae, Pangasiidae and Cichlidae) make up 90 percent of the total production ad one family (Salmonidae is responsible for 66 percent of the total production. At the species level, there are around 80 species presently cultured in cages. Of those, one species (*Salmo salar*) accounts for about half (51 percent) of all cage culture production and another four species (*Oncorhynchus mykiss, Seriola quinqueradiata, Pangasius spp* and *Onchorhynchus kisutch)* account for about another one fourth (27 percent). Ninety percent of total production is from only eight species (in addition to the ones mentioned above: *Oreochromis niloticus, Sparus aurata, Pagrus auratus* and *Dicentrarchus labrax*) the remaining 10 percent are from the other 70+ species.

On the basis of the information gathered from the regional reviews, Atlantic salmon is currently the most widely cage-reared fish species by volume and value; reported aquaculture production of this coldwater fish species increased over 4000-fold from only 294 tonnes in 1970 to 12 35 972 tonnes in 2005 (Valued at US$4 767 000 million), with significant production of more than 10 000 tonnes currently being restricted to a handful of countries, including Norway, Chile, the United Kingdom, Canada, and the Faroe Islands.

Most of the top marine and brackish cage aquaculture producers are found in temperate regions (Table 1), while the top species include salmonids, yellowtails, perch-like fishes and rockfishes (Table 2).

Table 1 Production of the top ten marine and brackish water cage aquaculture countries

Country	Quantity (Tonnes)	in percent of total
Norway	652 306	27.5
Chile	588 060	24.8
China	287 301	12.1
Japan	268 921	11.3
United Kingdom	131 481	5.5
Canada	98 441	4.2
Greece	76 212	3.2
Turkey	68 173	2.9
Republic of Korea	31 192	1.3

Table 2 Production (tonnes) of the top ten species / taxa in marine and brackish water cage aquaculture (excluding PR China)

Species	Quantity (tonnes)	in percent of total
Salmo salar	219 362	58.9
Oncorhynchus mykiss	195 035	9.4
Seriola quinqueradiata	159 798	7.4
Oncorhynchus kisutch	116 737	5.6
Sparus aurata	85 043	4.1
Pagrus aurata	82 083	4.0
Dicentrarchus labrax	44 282	2.1
Dicentrarchus spp	37 290	1.8
Oncorhynchus tshawytscha	23 747	1.2
Scorpaenidae	21 297	1.0

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.

Prospects

Cage culture has great development potential. For example, intermediate family-scale cage culture is highly successful in many parts of Asia and one of the key issues for its continued growth and further development will not be how to promote but rather how to manage it. However, there is also an urgent need to reduce the current dependence of some forms of cage culture systems in Asia upon the use of low value/ trash fish feed inputs, including those for Pangasid catfish and high value species such as Mandarine fish, snakehead, crabs and marine finfish.

However, the intensive cage culture of high value finfish is growing fastest and there are important social and environmental consequences of this growth and transformation of the sub-sector. Similar to global tends in livestock production, there is a risk that the fast growth of intensive operations can marginalize small-scale producers and high production at different levels of intensity can lead to environmental degradation if not properly planned and managed. Considering that most of the cage aquaculture takes place in the fragile yet already much pressured coastal environments, there is increasing agreement that particular emphasis has to be given to the environmental sustainability of the sub-sector. 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 installation of cages far from the coast.

Even though the sea cage farming has been advancing in many Asia-Pacific countries such as China, Indonesia, Japan, Philippines, Taiwan, Vietnam and Korea in recent years, it still remains to be commercialised in India. The Central Marine Fisheries Research Institute has been taking pioneering and massive steps towards this direction currently. The major constraint for popularization of cage farming in India is the less availability of sheltered areas which are ideally suited for sea cage farming. In this context, the development of advanced types of mooring, anchor and floating systems which can withstand the impact of adverse weather and currents will help us to venture into more unsheltered open sea areas. Hence, it is felt that more technological and engineering interventions in cage farming coupled with large-scale hatchery production of high value and fast growing finfishes can pave the way for the development of sea cage farming industry in our country in near future.