

I. INTRODUCTION TO LVHD CAGE TECHNOLOGY

LOW VOLUME, HIGH DENSITY CAGE FISH CULTURE

Cage fish culture is the raising of fish in containers enclosed on all sides and bottom with mesh material that secures the fish inside while allowing relatively free exchange of water with the surrounding environment. Low volume, high density (LVHD) cage fish culture is the raising of fish in cage volumes of 1 to 4 m³ at optimum densities of 300 to 500 individuals or 150 to 250 kg of fish/m³ of cage. LVHD culture technology is advanced over traditional cage technology commonly practiced in net cages of ≥ 100 m³ at stock densities of about 40 fish/m³ and yields of 20 to 25 kg/m³. Cage cultures are most suited for freshwater lakes and reservoirs, but may be practiced in any environment suitable for fish life.

There are no records of the first use of cages for culturing fish, but cage-type enclosures have been used by fishermen for centuries to hold excess captured fish for later disposal. It is logical to assume fishermen tried to culture these fish to a larger size. The earliest records of fish culture in cages date to the late 19th century. However, only since the early 1980s has cage fish culture been a significant contributor to aquacultural production. Until recently the application of cage fish culture for commercial purposes has been constrained primarily by the limited availability of fish feeds of the required quality.

Cage culture has become a major contributor to freshwater fish production in China. In 1996 China produced 450,000 mt of fish, representing 4.8% of total freshwater aquaculture, in approximately 18 million m³ of cages. LVHD was introduced into China in 1991, and in 1996 production reached 7,000 mt in 50,000 m³ of cages. Cage culture in general and LVHD specifically will continue to expand in China because: 1) China's population is increasing by 17 million people annually while natural fish, land and water resources are decreasing on a per capita basis; 2) per capita demand for fish is increasing at an estimated 10% per year; 3) capture fishery production will soon stabilize and eventually decline; 4) limited opportunities for expansion of land-based aquaculture will accelerate demand for cage culture in open waters; and 5) LVHD permits higher production and profitability than traditional cage culture.

LVHD cage culture will be the future cage technology of choice for many reasons: 1) the technology satisfies fundamental government goals of producing high quality food, creating employment, generating farm income, balancing trade revenues and improving use of natural resources; 2) it is relatively inexpensive and simple and, therefore, adaptable by poor, non-land owners; 3) it is applicable in most existing water environments and does not require conversion of land into new bodies of water; 4) it is technically and economically applicable at any magnitude of

scale; and 5) it will increase fish production and consumption in inland areas where availability of fish is low. A primary driving force behind the expected change from conventional fisheries and aquacultures to cage culture is the increasing magnitude and density of human populations in China and other countries.

HUMAN POPULATIONS AND FISH SUPPLIES

Efforts throughout the world to curb human population growth have produced measured success. Rates of growth are declining in almost all countries of the world, including China and other populous countries where rates are now below 2.0% and declining. Nevertheless, populations continue to expand. Governments are concerned about how to feed, employ and otherwise provide services to so many new persons each year. They realize that as a direct result of human population increase:

1. Arable land area will decrease as competition for land resources increases. Arable land will be required for increased housing, roads, industry and other nonagricultural purposes even with major efforts to protect arable lands.
2. National and international capture fishery yields will stabilize and decrease because of over fishing as a direct result of increased competition for all fisheries resources. Already 65% of the world's fish stocks are considered over fished.
3. Some freshwater and marine fish stocks will disappear from the fishery. This has already occurred in some areas.
4. Capture success and effort in some freshwater and shallow sea fisheries will decline to a principally subsistence level. This has also already become reality in some locations.
5. Employment throughout all the fishery sub-sector will decline primarily because of stabilizing and declining capture fisheries and modernization of capture fishing technology. As a consequence, a socioeconomic shift to other resources for employment will likely be necessary for a large segment of the population.

Much more could be predicted regarding future human populations and fish supplies. However, the point is made that every nation's fishery resource is finite and cannot keep up with inevitable human population growth. There are no solutions to this specific problem. However, aquacultural production is perhaps the most promising short term as well as long term means of increasing fish supply, thereby supplementing and replacing components of the natural fishery.

INCREASING FISH PRODUCTION WITH CAGE CULTURE

World aquaculture production is increasing at an average annual rate of over 10%, while world capture production appears to have stabilized. Aquaculture production could increase at a greater rate by accelerating production intensity, increasing the area of conventional aquacultures, and by expanding into the vast natural waters of inland, coastal and inshore marine environments. Conventional aquacultures in inland and coastal ponds are becoming more intensive, but increasing pond area is capital intensive and highly competitive with other land uses. The raising of fishes in cages is an alternative means of fish production. It has increasing technical, ecological, social and economic advantages over capture fisheries and conventional aquacultures. Cage fish culture technology is:

1. Compatible and not competitive with other fish production systems, and complementary to some;
2. Applicable to almost all aquaculture species;
3. Ideally applicable in open waters where low fish yield and other fishery development is impractical, such as inland reservoirs, large rivers and open waters of coastal estuaries, tidal streams and related environments of marine lagoons, bays and other waters relatively protected from turbulent waves and periodic storms;
4. Basically developed and ready for practical application in freshwater environments and limited application in coastal and marine environments;
5. Technologically simple;
6. Not capital intensive;
7. Economically and technologically available to all sectors of society including uneducated and poor, small-holder farmers;
8. More adaptable than conventional aquacultures to matching production to market demand.

Comparisons of technical differences between traditional and low volume, high density cage fish culture are presented in Table I-1. A visual comparison of physical differences may be made from Figure I-1.

Table I-1. Comparison of some fundamental technological differences between typical traditional and low volume, high density (LVHD) cage fish culture technologies (numbers in parenthesis represent ranges).

Item	Cage culture Technology	
	Traditional	LVHD
Cage volume (m ³)	98(<30 to >250)	1 (1 to 4)
Cage dimensions (m)	7 x 7 x 2	1 x 1 x 1
Cage cover	None or net	Opaque
Feed enclosure (in cage)	None	For float or sink feed
Fish stock density (no./m ³)		
Channel catfish	-----	400 (300 to 500)
Common carp	40 (5 to 45)	400 (300 to 500)
Tilapia	40 (5 to 45)	500 (400 to 700)
Fish optimum yield (kg/m ³)	20 (2 to 28)	200 (150 to >250)

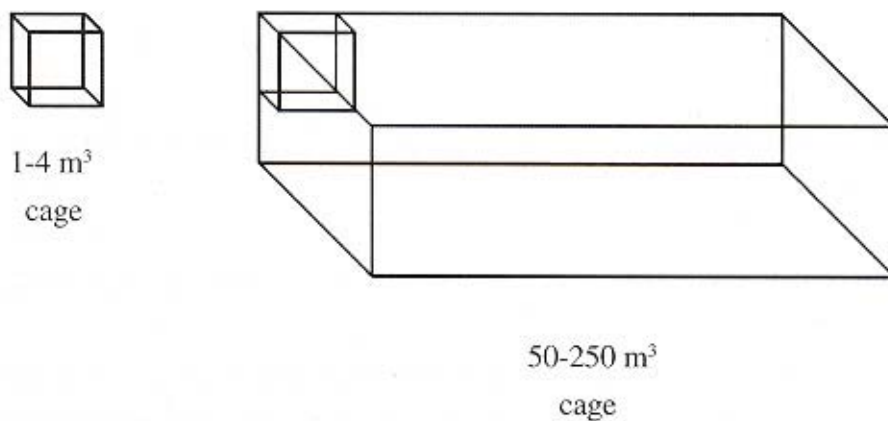


Figure I-1. Relative size comparison between low volume, high density fish culture cages of 1- to 4-m³ volume and traditional fish cages of 50- to 250-m³ volume.