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Principles of CAGE OPERATION and MANAGEMENT

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INTRODUCTION

Culture of finfishes in cages has been practised for years in countries like Cambodia, Vietnam, Indonesia, Thailand, Malaysia, Singapore and Hongkong. Cage was first used as a holding facility for fish. True cage culture was said to have started in 1243 in China. The early culture species were snakeheads, gobies, catfishes and carps. Use of modern cage materials like synthetic nets, woods and metals started in early 1960's. Norway and Scotland used marine cages in the culture of Atlantic Salmon in 1960 and 1965 respectively.

The Philippines started to adopt cage farming in the late 1970's in freshwater lakes. The primary species cultured was tilapia. In the 1990's, cages were used in the culture of grouper and siganids. At present, milkfish in the province of Pangasinan are cultured intensively in seacages producing about 30 T per cropping using a 20 m diameter cage.

DIFFERENT TYPES AND DESIGNS

Fish Cages are enclosures used as a rearing facility for fishes. It has enclosed bottom and sides. It can be made of wood, net screens or wire mesh. Sizes can range from 1 to 1,000 m^2.

Cages have an enormous diversity of designs. According to Beveridge (1996), there are four basic types of cages: fixed, floating, submersible, and submerged.

Fixed Cages

Fixed cages are very common in the Philippines. They are cheaper and simple. However, they are limited in size and shape. They are used in sheltered shallow sites.

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Grading of Stocks

Fish stocks can be graded when sizes vary significantly during the culture period. However for milkfish, re-grading is not practiced.

Maintenance

Growth of fouling organisms in net bags is the primary problem of cage management. In freshwater cages, excessive growth of algae on the nets may impair water circulation in the culture unit and can affect the health and growth of fish. Nets should be regularly cleaned by brushing off the algae or changed when needed.

In sea cages, fouling organisms include barnacles, oysters, mussels, algae, etc. Net bags are changed every two months to check growth of fouling organisms. Fouling organisms are removed using high-pressure water and brush. Nets are repaired before re-used. Plastic drum floats are regularly rotated to minimize growth of barnacles. Fouling organisms reduce life span and buoyancy of drum floats.

Mooring lines are also regularly checked for abrasions and fouling organisms. GI cage frames are repainted regularly to avoid corrosion.

Harvesting

Harvesting of cultured fish are done easily. Smaller cages are brought close to shore and the fish are scooped. Harvested fish are graded counted and weighed.

In intensive production of milkfish cage harvesting is done using small seines or vacuum machines. Grading, weighing, icing and packing are done in a working platform beside the cage. Boats await the packed harvest for delivery to a waiting truck at nearby port or shoreline.

Marketing

Prior to harvest, market inquiry on the prevailing price of fish can be done. Known fish landing areas and ports can offer better price and services to a cage farmer.

susceptibility to diseases.

For transport, plastic bags, one third filled with water and remaining space with oxygen, is popular in tilapia and smaller milkfish. For mass transport of milkfish, holds of big boats called "pituya" that pumps water continuously into the fingerlings for aeration and water exchange during transport is in practice today.

If the fish are to be moved considerable distances. Transportation at night is recommended. Water and air in plastic bags or transport containers are changed every 6 hours.

Stocking

Prior to stocking, salinity and temperature of fish being transported should approximate that on the new environment. Stocking is done early morning or late evening when temperatures are lower. Handling stress should be kept to a minimum.

Stocking management can be done two ways: fish are stocked according to a desired density which will allow fish to grow up to harvestable size or fish can be stocked at higher density which will be redistributed to other cages as they grow.

Feeding

Fish are fed after 3 to 4 hours when they have recovered after transfer.

Juvenile fish are fed with high protein diet at greater frequency. Tilapia are fed a ratio of 5 - 6 percent body weight daily given 5 times a day. In intensive cage culture of milkfish, juveniles are fed until satiation. Frequency of feeding is higher than tilapia but decreases as the fish grows.

Commercial feeds for fry to adult tilapia and milkfish are available. For juvenile and adult fish, sinking and floating feeds can be used. Floating feeds allow observation of the stocks. Feeding of the fish can be checked thus avoiding excessive feed loss. For sites with stronger winds, waves and current, sinking pellets are preferred.

Floating Cages

Floating cages has a variety of designs. Shapes and sizes can suit the purpose of the farmer. Rigid materials such as GI pipes, bamboos and plastic pipes can be used as frames. Flotation materials such as empty plastic drums and styropor can also be utilized. Floating cages can be towed to other favorable sites , as maybe needed.

Other countries were reported to used rigid bag and solid floor. Various types of rotating floating cages were also noted. Rotation of cages may discourage excessive fouling of the enclosure.

Submersible Cages

Submersible cages were designed to take advantage of prevailing environmental conditions. During bad weather, the cages are submerged to avoid destruction by strong waves.

Submerged Cages

Submerged cages are those enclosures that are underwater the whole duration of the culture period. Simple submerged cages were reported to be adopted in Indonesia and in lakes in China (Vass & Sachlon, 1957; Li, 1994). In the Philippines, the design is adopted in Magat Dam and Taal Lake tilapia cages, where bamboo is used for framing and flotation material. Another design has no frame and requires 20 liter plastic containers as float to maintain the shape of the cages. Frameless or flexible cage is suited in shallow sites with less fluctuating water depth.

Submerged cages allow the use of site exposed to strong winds. Less materials are needed for framing and flotation and may yield better per cubic meter. However, cage size is limited and working area is absent.

CLASSIFICATION OF CAGE MANAGEMENT

Cage management can be classified on the basis of feed inputs as extensive, semi- intensive and intensive. (Beveridge, 1996)

Extensive cage culture

Extensive cage culture is restricted to freshwater such as highly productive lakes and reservoirs . The system depends solely on primary production and may be limited to few species, such as tilapia, big head carp, common carp and milkfish. Stocking density maybe limited in this system. Extensive cage culture is practiced in highly euthrophic lake like Laguna de Bay.

Semi - intensive cage culture

In addition to the primary productivity of the body of water where the cage is located, artificial food such as rice bran and commercial feeds are given the fish. Semi - intensive cage culture is widely practiced in tropical freshwaters. Species that feed low in the food chain such as tilapia, milkfish and big head carp are cultured.

To a limited extent of culturing siganids, semi - intensive system is not practiced in marine environment.

Intensive cage culture

Intensive cage culture is practiced in freshwater and marine environment. In the Philippines, tilapia culture in reservoirs, like Magat Dam in Isabela is found to adopt the system . The constant changing and the inherent circulation of dam water lessen the possibility of euthropication, due to waste loadings from the cages.

A recent development is the intensive culture of milkfish in floating sea cages. A stocking density of about 100 fish / m^3 and intensive feeding of commercial feeds are employed . Fish are harvested after 5-6 months with a production capacity of about 24 k / m^3.

ADVANTAGES AND DISADVANTAGES OF CAGE CULTURE

Like other aquaculture systems, raising fish in cages has advantages and disadvantages.

Advantages

The advantages of cage culture are the following :

a) simple to construct and requires smaller financial investment .

turbidity may disrupt feeding of fish and clog or irritate the gills which can lead to bacterial infection.

d) Water depth - Water depth should be 2 - 3 meters for freshwater. In marine environment, deeper sites are preferred for sufficient water circulation and acceptable water quality. In addition, sea cages have deeper net bags.

e) Services and Security - Sufficient land area must be available for office, tool and feed storage and labor / security house. Availability of road, electricity or telephone should also be considered. Proximity to market and production supplies may affect production costs. Cage operation should be located where they can be readily observed. Conflict with traditional fishing activities should also be considered (Escover & Claveria, 1985).

CAGE FARM MANAGEMENT

The goals of cage farm management is to increase profitability by minimizing stock losses, promoting good growth while controlling costs.

Seeds

Sources of fish seeds are land-based hatcheries and from the wild. Post fry which are readily available are brought from hatcheries and nurseries. They are grown in nursery ponds or smaller cages from 1 to 2 months until the desired size is attained. The post fingerlings are graded to group uniform-sized fish in a cage.

Transport

Prior to transport, post fingerlings are pre-conditioned in hapas or tanks with sufficient aeration and water drips for 1 or 2 days. The fish are deprived of food during this stage to clear their digestive tracts. This minimizes fouling of the transport system and reduces oxygen consumption.

Fish are packed and transported in the early morning when travel can be more comfortable to the fish. It is important to avoid physical damage to the fish during capture, handling, counting, loading and transport to lessen occurrence or spread of diseases.

Cages can be linked together using rope, chain and used tires in-between cages. The link should provide enough spacing to facilitate water circulation between cages.

Mooring systems

Mooring system consists of lines and anchors for the purpose of securing the cages in a desired location. Chain, nylon ropes or combination can be used for mooring. The length of mooring in marine waters should not be less than three times the water depth of the site. Embedding anchors can be bought or fabricated. The cheapest, however, is the concrete block anchors with steel rods for strengthening and eyebolt for mooring attachment. Once installed, block anchors are difficult to recover.

Site Selection

Foremost in any aquaculture endeavor is the selection of best site. The practical considerations in site selection for cage farming are the following:

a) **Shelter** - Few structure can withstood the impact of the open sea (Beveridge, 1996) strong winds tear at structures projecting above the water and waves can impair objects on the surface. A suitable area should be protected from strong winds and waves. Sheltered sites are preferred for cage culture.

b) **Currents** - Stagnant waters are used for cage farming. However, sites with sufficient currents can offer good water exchange for replenishment of oxygen and removal of waste metabolites. However, excessive currents may lessen the volume of the cage, add weight to the supporting structures and moorings and may contribute to feed losses.

c) **Water Quality** - The site must be free or far from sources of industrial, agricultural and domestic pollution. Water run-off from rivers will cause high turbidity, abrupt salinity fluctuations and possible destruction of cages caused by run-off debris. Turbidity brought by water run-off can affect 2 to 15 kilometer radius of a coastal area from the mouth of the river and may last for 3 to 6 days. High

b) easily managed e.g. fish stocks are easily observed fed and harvested.
c) transferable to sites with better environmental conditions.
d) can be stocked with fish at higher densities than ponds.
e) offers high production per unit area or volume.
f) greater opportunity for expansion.
g) allows the use for aquaculture of existing water bodies.

Disadvantages

The disadvantages of cage culture are the following :

a) crowded condition of fish may lead to incidence of diseases.
b) high feeding cost
c) vulnerability to adverse weather condition.
d) vulnerability to the effects of pollution.
e) attractive to poachers and vandals.
f) wastes have pronounced negative impact on the aquatic environment
g) disrupt navigation and reduce landscape value of a site.
h) wastes may stimulate primary production adversely affecting water quality of site and surrounding environment.

CAGE DESIGN AND CONSTRUCTION

Designs of cages must have evolved empirically due to lack of studies regarding interaction between environmental forces and cage structures. A good design must consider environmental conditions, cost and species to culture. It must be safe, secure and easy to manage.

The design should satisfy the following criteria:

a) hold the fish securely while permitting sufficient water exchange.
b) remove potentially harmful metabolites
c) cage volume must remain relatively resistant to deformation by external forces.

Shape

The behavior of the species may be considered in selecting a shape for a cage. Experience shows that any shapes can do well with tilapia. However, in growing bighead carp and milkfish which swim in circular pattern, circular shape maybe more appropriate. Circular cages make the most efficient use of materials, but may have higher construction cost than square cages. In marine environment, circular cages are found to be more stable during bad weather conditions as experienced during typhoon Gading this year.

Shape is likely to influence effective stocking densities and swimming behavior (Beveridge 1996). Stocking densities of tilapia, which is a less active species, is about 20 to 40 pcs / m^3 in square or rectangular cages while milkfish can be stocked at $100/m^3$ or higher in circular seacages.

Sizes

Size of cages is influenced by site, materials and management/financial capability of the farmer. An advantage of increasing bag size is that it has lower cost per volume.

Sizes vary from $1m^3$ to 1,000 m^3. In marine cages, size of rearing units are larger compared to freshwater cages. Most freshwater cages use bamboo for framing and flotation. The length of available bamboo may dictate the size of the cages. Most sea cages use GI pipes and styropor or plastic drum for framing and flotation, respectively. Very few who can afford to use PVC pipes for framing and flotation. GI sea cages can have a dimension of 15 x 15 m or 10 m diameter surface area. Sea cages made of PVC are about 20 m in diameter with depth of about 6 m.

Large cages require more sophisticated technology and equipment. Large cages are best suited for species that does not require regular grading or sequential harvesting.

Cage bag

Netting materials can be flexible or rigid. Flexible materials are natural or synthetic fibers like cotton and nylon. Rigid or semi rigid materials are plastics and metals.

Natural fibers are seldom used because they are susceptible to rotting. Synthetic fibers are preferred which are manufactured from coal or oil based raw materials. Nylon nets are of two types: knotless and knotted.

Knotless nets are usually used in cage culture of tilapia because it is cheaper and less abrasive. In sea cages, it is used in rearing post fry to fingerlings. Sea cages usually prefer the bigger mesh knotted nets which are easier to repair and more resistant to bending deformation. Knotted nylon nets are less affected by fouling organisms. Removal of barnacles from knotless but weaved nets may adversely affect the durability and maintenance requirements of the cage.

Modern rigid mesh cages use plastics and metals. They are usually square or diamond mesh. The durability and appropriateness of using rigid nets are not fully evaluated.

Cage collars

The function of cage collars is to support the bag securely in the water column and help maintain shape. They may also serve as work platforms. Bamboos and GI pipes are the most common materials used as collars in the Philippines. Bamboos are light and resistant to bending. However, it has short useful working life. Especially when cut immature, they crack, susceptible to destruction by borrowing insects, rots quickly and lose flotation properties early. According to IDRC/SEAFDEC (1979) bamboo tends to have a useful working life of 18 - 24 months in freshwater and 12 - 18 months in seawater.

GI pipes are expensive but excellent materials for collars. Size of cages can be increased and designed to desired shape. With empty plastic drums as flotation a sufficient work platform can be incorporated in the design. This type of collar can last for 8 - 12 years and widely used in marine environment.

Groupings and Linkages

Grouping of cages is influenced by the nature of the site, mooring constrains, environmental considerations and disease prevention. Cage groupings must not impede navigation. In tilapia culture, arranging the cage to face the prevailing wind results to a higher harvest. The system takes advantage of plankton drift and better water circulation and aeration.

Separating the cages with enough space in between will improve water circulation, prevent concentrated waste loadings in the environment and