Important management measures in cage culture

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To get the maximum benefit out of the cultured system, given the restrictions imposed by the site, species or type of feed used, the stock must be kept in conditions which minimise losses and promote good growth and finally optimum production. It is to be considered first that the cages must be of a reasonable size that makes management by an individual or small group easy.

The major factors to be taken care in cage management are:

- Stocking the candidate species at optimum density appropriate to the site and rearing conditions
- Feeding the fish in the most cost effective manner aimed at maximum production
- Ensuring the best possible water quality within the cages
- Maintaining cages, moorings, anchors, nets and related accessories
- Regular monitoring of the cultured species by sampling, for details on health conditions, removal of dead fishes, and treatment of infected fish

Stress reduction to the fish

Stress can be defined as any physical, chemical or environmental stimulus which tends to disrupt normal well being of an animal. The processes of capture, handling, loading and transport are highly stressful to fish, resulting not only in physical damage, but also in changes in blood chemistry, increased oxygen consumption, osmoregulatory problems, and increased susceptibility to disease. Under stressful conditions, fish must expend more energy to maintain homeostasis (tendency of an organism or cell to maintain internal equilibrium by adjusting its physiological processes) and less energy to combat disease. Aquatic organisms are fundamentally different from terrestrial animals: they are immersed in their environment and cannot go somewhere else. Some disease agents are almost always present in the water (ubiquitous). These opportunistic pathogens will invade fish when they become stressed. Thus, it is essential to reduce stress factors in cultured fish.

Common measures to reduce stress are:

a) *Starvation before handling of fish:* Handling is a source of stress as it puts fish under extreme conditions like overcrowding. Starving the fish for 24 - 48 h (to clean their gut of food and to reduce O_2 consumption) prior to handling will reduce stress and will avoid the deterioration of water quality when fish are overcrowded. Seabass, *Lates calcarifer*, however, require only 1-2 h starvation prior to packing. Because of rigours of journey fish should be carefully checked and injured or weak fish should be removed.

b) *Sedation during handling and transportation*: In situations such as handling or transportation, fish are overcrowded. Therefore, there is a higher risk of skin injuries (scale removal, abrasion *etc.*). To avoid such damages, sedation using approved fish anaesthetics/ sedatives is recommended as it decreases the level of stress and possible skin injuries.

c) *Grading of fish to give a homogeneous population*: When size variation increases in a cage, it often creates competition between the larger and the smaller fish. This can result in stress, especially for the smaller fish. In addition, when feeding, the bigger fish are stronger and get more feed. As a consequence, the smaller fish get weaker and more susceptible to disease. As they get sick, they will also become a source of infection for bigger fish as size variation is also a source of cannibalism (leading to horizontal disease transmission). For seabass, grading is essential during the initial stage of growth due to its cannibalistic behaviour

d) *Good water quality maintenance*: Water quality should be monitored on a regular basis and be maintained at optimal conditions.

e) *Over-feeding to be avoided*: Since over-feeding can induce stress and unconsumed feed will pollute the water, it should be avoided.

f) *Transportation process*: Plastic bags filled with one third with water and the remaining space filled with oxygen prior to sealing and double bagging for safety is better for less than 4cm fry of seabass. Insulated (with thermocol/ saw dust *etc.*) transport box (1t to 3t) mounted on truck can also be used for fish transportation. The tanks should have smooth (round) corners to minimize damage to the fish, and are often provided with aeration facility during transport. Transport problems may be aggravated by high temperatures and by salinity. Therefore, it is better to transport fish during night or packing containers with ice and saw dust (1:1). If fish have to be transported over considerable distances there is also a risk of a build up of toxic metabolites, such as CO_2 and ammonia and increased bacterial load.

g) *Lowering metabolic rate and thus oxygen consumption and waste production*: Through a combination of light sedation and hypothermia lowering of metabolic rate and thus oxygen consumption and waste production can be achieved. Absorption of ammonia and CO_2 and control of bacterial growth through the addition of natural zeolite, a buffer and an antibiotic to the transport media is also practiced (only after standardization).

Good records of water quality conditions, growth and mortalities should be kept so that management procedures can be properly evaluated and modified as and when necessary.

Seed supply and stocking

Any species for which seed is readily available is ideal for cage aquaculture. Those fro which hatchery technology is standardized is ideally suited for cage culture. Wild collected seed can also be used for cage culture if adequate number is available in healthy condition. Nursery rearing is very crucial for all species and specially seabass, with frequent grading and adequate feeding. For seabass, if grading is not done periodically, cannibalism will considerably reduce the stock volume. However, a 30 percent loss in stock is anticipated in normal case during nursery rearing of fry to cage stocking size (20-30 g).

Before stocking the fish to cages, care should be taken to ensure that the temperature of the fish is adjusted to approximately that of their new environment. It is better if transfer is done during evening or early morning hours. When transported using tanks, the volume of water is reduced prior to the fish being transferred by hand or net.

If nets are used, these should be of fine knotless mesh to minimize damage. Feeding of fish on transfer to the cage can commence 3-4 h after transfer.

Feed management

Feed and the feeding regimes need proper management for better health and growth of the cultured stock. However, the quality and safety of feed and the use of fish medicines and chemicals must be controlled by concerned agencies so that it will integrate aquatic product security examination, environmental monitoring and fish disease prophylactic systems at different levels.

Feeds and feeding

Feeding is essential in cage farming especially if stocking rate is towards the higher side or to the maximum carrying capacity. As in other aquaculture operations, the feeding cost accounts for an estimated 40-60% in cage farms also. Formulated feed meeting with the complete nutritional requirement of carnivorous fish is used in many parts of the world for such species. However, the cost is high for such feeds. Fresh or frozen minced and chopped trash fish still forms the main stay feed for a number of carnivore groups cultured. Economic factors and problems with diet formulation, feed storage and distribution are the principle reasons why this type of feed remains popular in some quarters.

The advantages of using trash fish are:

- Cost effective
- Availability (of the 3mt in India @ 40 % is trash and used in chicken and swine feed. Why not fish feed to fish rather than to poultry and livestock?)

The problems in using trash fish are:

- Seasonal Fluctuation in flesh quality
- High moisture content and expensive to transport (best for farming operations sited close to fish landing or processing centres).
- High wastage, which affects water quality
- Increased bacterial load in raw diet which may lead to bacterial infection.

Dry diet are less polluting, stable in water, nutritionally complete, easy to transport and store, available in floating and sinking forms, *etc.* however, they are expensive and formulation not known and cost escalates from one operation to the next depending on demand.

Storage of feeds

Storage facilities are essential for cage fish farming operations. Feed bags should be stored without open access to moisture and thus to prevent fungal attack. Trash fish may arrive at the farm in either frozen or unfrozen state and since fish spoils rapidly it should be checked for freshness before being stored. Smell and appearance should be sufficient indicators of quality. Cold storage is ideal for trash fish.

Shelf life of various feeds

Feed type	Storage and duration
Dry feeds (Rice bran, wheat middling)	With < 10% moisture content and stored in cool , dry and pest free environment; can be stored for several months
Trash fish frozen	feed with high fat content up to three months at – 20°C; low fat content more than one year a t– 20°C
Pellet feeds	2-3 months

Feeding

Feeding should be done throughout the culture period at varying levels depending on the growth rate and natural feed availability. Hand feeding is done in most cases and is recommended for small scale farmers. However, mechanical feeders are used in large scale cage farms – demand feeders and automatic feeders are the two types of feeders used.

Feeding rings can be used if floating pellets are used. Feed trays set inside the cage at different positions can also be used for feed distribution. By hand feeding, the feeding of fish can be watched and can be fed till satisfaction. While doing so, the stocks health status can also be monitored (stressed or sick fish stops feeding first). Frozen trash fish is thawed first, chopped and minced and broadcasted over the surface using a shovel or scoop.

Water quality management

Water quality management is a key ingredient in a successful fish culture practice. Most periods of poor growth, disease and parasite outbreaks, and fish kills can be traced to water quality problems. Water quality management is undoubtedly one of the most difficult problems facing the fish farmer. Water quality problems are even more difficult to predict and to manage

Oxygen

In cage culture situations, if proper water exchange is not there, low dissolved oxygen is particularly acute because the fish are crowded into such small areas. Most fish kills, disease outbreaks, and poor growth in cage situations are directly or indirectly due to low dissolved oxygen. Dissolved oxygen management is one of the most critical management techniques that must be learned by a fish farmer. The cage net mesh should be kept open always to have maximum flow of water and no drifting objects or plants should obstruct water flow in the cage system.

Temperature

Temperature is critical in growth, reproduction and sometimes survival. Each species of fish has an optimum temperature range for growth, as well as upper and lower lethal temperatures. Below the optimum temperature feed consumption and feed conversion decline until a temperature is reached at which growth ceases and feed consumption is limited to a maintenance ration. Below this temperature is a lower lethal temperature at which death occurs. Above the optimum temperature feed consumption increases while feed conversion declines

pH, ammonia and turbidity

The desirable range of early morning pH for fish production is from 6.5 to 9. Both ammonia and nitrite are toxic to fish. The level of ammonia toxicity depends on the species of fish, water temperature, and pH. A healthy phytoplankton bloom (green water) is one with a Secchi disc visibility of 15 to 24 inches and clarity above 24 inches indicates poor phytoplankton productivity. Visibility of less than 12 inches indicates a plankton bloom which is too dense and may cause low dissolved oxygen problems. Visibility of less than 6 inches is critical for fish.

Routine Management

Water quality monitoring

Monitoring of water quality is essential

- To avoid losses caused by lethal changes in water quality
- To evaluate site and configuration of cage
- To maintain optimum stocking and feeding requirements
- To evaluate the general condition of stock, so that if stressed, can avoid handling.
- To gain information of long term changes in water quality at a site so that variation in production may be properly evaluated.

Data on dissolved oxygen and temperature are essentially collected. Measurements to be taken preferably at early morning hours and mid-day, and readings of both inside and outside cages and at cage surface and bottom should be made.

Data on nitrogen (ammonia, nitrite and nitrate) and dissolved phosphorus, pH, turbidity *etc.* will give a clean idea about the cage environment.

Waste control and effluent management

Cage-farm wastes are usually in the form of uneaten feed and fish faeces. Feed is usually the major input to the cage-farm operations. Feeding should be scheduled in such a way to ensure that feed wastage is kept to a minimum. Many operators now use extruded fish feed of improved digestibility to maximize assimilation and minimise loss to the environment. Use of floating feed is vital for cage-farm operations. Mooring cages in deep waters, leaving 3-5 m bottom space and where good current flow results in cage wastes being easily flushed away, thereby avoiding organic build up under the cages.

Health management practices

The objective of health management is to maintain a good health status, assuring optimum productivity and the avoidance of diseases. In aquaculture, the economic risk associated with diseases is high. It represents a potential loss in production through mortality and morbidity, and might decrease investor confidence. Moreover, the cost to treat diseases when they are already well established is high and treatments are often initiated too late and are therefore rarely effective. Thus, aquatic animal health management must be a global strategy that aims to prevent diseases before they occur.

Aspects of health management practices – to improve fish health and survival

Responsible transportation of live aquatic animals: Increased trade of live aquatic animals and the introduction of new species for farming, without proper quarantine and risk analysis in place, result in the further spread of diseases. A scientific process should be undertaken to assist decision making regarding the risks versus the benefits for the species intended to be imported.

Hygiene, disinfection and biosecurity: Hygiene and biosecurity aims at preventing the introduction of any disease agent into the farm and should limit the spread of disease. Good sanitation practices in cage-farming systems are difficult to implement as there are no filters or barrier between the cage environment and its surroundings (where pathogens can be found). However, it is necessary to reduce the risk of contamination by simple management practices aimed at reducing the pathogen pressure in the environment. Such practices include proper system maintenance by removing excess suspended particles and uneaten food which is a potential substrate for pathogens. Moreover, their presence reduces water flow and therefore the available dissolved oxygen for the fish. The frequency of net cleaning depends on the severity of the fouling. The removal of dead or moribund fish on a daily basis is an important sanitary measure, as well as important for record keeping. Dead fish, especially in tropical water, decay quickly and can be a critical source of horizontal disease transmission as the remaining live fish will tend to eat the dead fish.

Selection of hatchery-raised fingerlings: The overall health status of fry and fingerlings is a critical factor for a successful production cycle. When choosing a species to be farmed, preference should be given to species that are already available from hatcheries. The attention given to fish in the hatchery, and the availability of specific larval diets required to obtain strong juveniles, will allow for a constant supply of good quality fingerlings. Presently, the availability of hatchery-raised fingerlings is limited. The availability of hatchery-raised fingerlings should certainly increase in the near future.

Record keeping and disease monitoring: Often, in small scale operations, recording of farming parameters such as daily mortality, feed consumption, growth rate and water quality parameters is not standard. Record keeping is crucial in understanding the epidemiology of diseases and can also allow us to identify critical management points in the production cycle. The collection of this historical data will help us take early action in the case of disease outbreaks.

Proper disease diagnosis – a prerequisite for effective health management

As aquatic animal health management is about implementation of control measures to prevent the incidence of diseases, it is a prerequisite to have a good understanding of diseases that might occur in a particular fish species. Therefore, adequate attention should be given to disease diagnosis and epidemiology studies.

Fish husbandry and management

Choosing the optimal fish density is important in cage culture. Depending on the fish species and water quality conditions (especially the oxygen saturation of the water), there is a certain fish density that should not be exceeded. A common mistake is to increase the stocking density to compensate for a decrease in survival rate. This is a source of stress for the fish that can lead to skin injuries, low performance and a higher susceptibility to disease. In contrast, stocking fish optimally will allow fish to grow to their best potential and decrease the risk of disease outbreaks.

Regular monitoring of fish from disease point of view is also essential. Often the first signs that something is wrong can be surmised from changes in behaviour. Farmers should therefore be used to observing their fish without unduly disturbing them, and form a general picture of how they are disturbed and behave under normal cycle of environmental conditions which occur at the site, *i.e.*, dawn/mid day/dusk, high tide/ low tide, feeding/non-feeding *etc.* changes in feeding behaviour is an indication of poor health.

If something wrong is observed , then some fish should be sampled and examined further, for changes in general physical appearance (deformed spine), skin (colour, presence of lesions, rashes, spots or lumps, excessive mucus), eyes (bulging eyes, cloudy lens), fin and tail (erosion) are all signs that something is wrong.

Fish sampling should be done regularly so that the growth of stock is monitored. This information with records of mortalities is necessary for making a number of management decisions, such as determination of stocking and feeding policies and timing of harvesting. Recording of mortalities is essential, as a change in incidence of mortalities can help warn of the onset of disease outbreak and gives the farmer valuable information in the progress of the stock and management strategies (stocking densities, feeding rates *etc.*)

Harvesting of fish is done continually or in batches, depending on how the production cycle is managed. Before harvesting the fish may be starved for a day to have empty gut, which will help in shelf life of the produce. Fish can be harvested *in situ* or the cages towed to a convenient place where the netting operation may be carried out more smoothly. The process of harvesting is simple, where the net is lifted up and fishes are concentrated to a small volume and scooped out.

Maintenance of cages and gear

Irrespective of the damage that can be caused by storms, predators, drifting objects, poachers, all materials used in construction of cages have a definitive life span and will eventually wear out. Cages, nets and moorings therefore must be checked at intervals for signs of damage and wear and tear and repaired or replaced if necessary, as not only cages and stock be put at risk, through neglect, but human life may also be endangered. Mooring must be checked regularly by divers, particularly after heavy wind/storms. Mooring level should be kept free from fouling and worn shackles replaced.

Cage nets may be checked during cleaning, which is done more frequently during cage culture. Divers may have to go down and observe the net every week or so, during favourable weather conditions. Small tears may be repaired at the site itself, while major repairs should be done on shore only.

In marine environment fouling is a major issue and in rotating design (single point mooring system) it is reduced. Therefore, the nets have to be frequently changed. In any case, nets of any particular mesh size should be exchanged quite often for ones with larger size as the fish grow. Mesh size should be carefully selected at each stage of growth too. If too small mesh size is selected, then matter exchange is restricted and if too large, escape is possible. The frequency of net charge varies from once in a week to once in a year depending upon the site location, materials used, season and management and design of cage.

Net cleaning can be done physically or by chemical treatment. Physical cleaning involves removing and scrubbing the net and drying. For chemical cleaning bleaching powder or formic acid (3%) can be used. The rate of bio-fouling on cage frame is much slower than on net cages, and doesn't need more frequent cleaning. Cage frames are usually cleaned *in situ* using a hand brush both above and below the water line to dislodge weed and accumulated debris.