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Training Manual on

Cage Culture of Marine Finfishes

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Cage culture requirements - Site selection and water quality needs

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Introduction

Culture of fish in cage is a popular method of rearing the fish along the coastal areas. Site selection and water quality is one of the most important factors that determine the success and failures of cage culture system. It also determines the cost of production and survival of the system in the long run. Controlling water quality parameters in open water cage culture systems is an impractical; therefore, culture of any species must be established in the sites having adequate water quality and frequent exchange. Before establishing a cage culture site, it is foremost important to conduct a field survey for gaining prior knowledge on the environmental/ hydro-biological parameters of the site so as to ascertain that the water body chosen will support the increased biological demand due to cage culture activities in due course of time.

Topographical criteria

Wind and wave pattern

Cages used in culture activities are susceptible to damage by the strong winds and waves in the water bodies. Therefore, the site selected for the cage culture operation should probably in the site where the velocity of winds and wave action is less. In general, the protected areas in the seas or any other water bodies are the suitable place for the cage culture operation. The information on the prevalence of waves, winds and cyclones could be obtained from meteorological records or literatures. Usually the optimum wind velocity for stationary cage should be < 5 knots and for floating cage < 10 knots. For a stationary cage the area identified should not have a wave height of more than 0.5 m and not more than 1.0 m for floating cage. The selected site should be away from navigational routes, since waves may be created from the wake of passing vessels.

Depth

Areas with limited water depth like shallow bays are not suggested for cage culture since water renewal and settling of wastes may create problems. A depth of 8-10 m during lowest low tide is an ideal condition. A bottom clearance of 3-4 meter is necessary to allow sufficient water exchange. Good water exchange may increase oxygen availability, prevents accumulation of faeces, debris and uneaten feed and thereby prevents the cultured animals from noxious gases such as H_2S generated by decomposition of the deposited wastes. This eventually helps to keep the cultured animals away from stress and prevent the disease. But a stationary cage is allowed 1–2 m minimal clearance to minimize the costs of fixed poles, which are provided to withstand force of strong current if any. On the other hand, the area where the floating cage is positioned should have a maximum depth of less than 10 m, otherwise cost required for initial investment may increase. For a stationary cage the maximum depth should not exceed 8 m since it is difficult to find sufficiently strong supporting posts longer than 8 m for mooring.

Bottom

Sea bottom with a mixture of fine gravel, sand and clay are the ideal site for cage culture. The place with rocky bottom and mud substrates may cause difficulties and require more expensive anchoring system, but have better water exchange rate. Muddy substrates may be suitable for stationary cages as poles can be easily set up. But due to their low water exchange rate they are not suitable for high stocking density. Bottom water exchange is more important to prevent accumulation of wastes and oxygen deficiency. Therefore, the place with flat bottom and adjacent slope may bring in more water exchange and prevents waste accumulation thus forms a suitable area for cage culture.

Physical criteria

Current movement

Favourable tides and current brings fresh oxygenated water and remove waste from the cage. Tidal fluctuations are a primary need for better conditions for high stocking density of fish. But strong currents will generate excessive strain on the fishes as well as on the cage structure leading to damage and less growth of fish. A sound knowledge on tidal fluctuation and current pattern is necessary for positioning of the cage. So a weak but continuous current is most suitable for cage culture operation to bring in the necessary oxygen and to remove accumulated wastes. The ideal current velocity for cage culture operation is 0.5 to 1.0 m/sec. Preferred tidal amplitude of around 1 m is found suitable for marine cage culture.

Turbidity

Turbid water leads to deposition of unwanted wastes and increase organic loads in cage culture site by freshwater run-off from land leading to reduction in salinity. The accumulated waste harbours fouling organisms and microbes /pathogens and thereby prevents proper water circulation and causes health concerns to the fishes. Suspended solids in a suitable site for net cage culture should not exceed 10 mg/l. The turbidity in the water may be due to colloidal clay particles, dissolved organic matter and abundance of plankton. It could be measured with secchi disc visibility readings, and the optimum readings for marine cage culture site should be < 5 m as yearly.

Water temperature

Fishes are cold blooded aquatic organisms. It cannot control its body temperature with changes in the environment. The rise in the water temperature will affect metabolic rate, activity, carbon dioxide production, ammonia and oxygen consumption. This will in turn affect the feeding rate, food conversion, as well as fish growth. The optimum water temperature needed for cage culture of different species differs: 27–31°C for most tropical species and 20–28 °C for most temperate species. In tropical countries the annual temperature range fluctuates between 20–35°C and 2–29 °C in temperate countries. Some fishes can thrive in wide temperature range by compensating its growth. Therefore, it is essential to select the suitable site that may have the suitable temperature for the fish aimed for culture in order to do the culture with good economic benefits.

Chemical criteria

Dissolved oxygen

Dissolved oxygen requirements vary with species, its size and other environmental factors like temperature and salinity. The problem of dissolved oxygen occurs in any culture system which has direct contact with atmosphere and happens mainly during night hours. Benthic organisms and sediment wastes may also reduce the oxygen level in the case of cage culture. Increasing temperature and salinity will decrease the solubility of oxygen in water. Hence depletion of DO always occurs during night times. Grouper and other demersal species consume lesser oxygen when compared to fishes like rabbit fish, snapper and seabass of pelagic origin requires more oxygen. In general, pelagic fishes require dissolved oxygen level of 5 ppm or more and demersal fish species require 3 ppm level.

Salinity

Importance of salinity in cage culture lies over control of osmotic pressure which greatly affects the ionic balance of fish. Rapidly fluctuating conditions of salinity is not suitable for cage culture. Changes in salinity in coastal area are often caused by fresh water runoff from land. In areas where there is no proper mixing, the surface salinity is usually lower than bottom salinity. This prevents vertical transfer of dissolved oxygen and leads to oxygen depletion. The optimum salinity for better growth of different fish species are given below:

Species	**Salinity range (ppt)**	**Optimal Salinity (ppt)**
Seabass(*Lates calcarifer*)	0–33	15
Grouper(*Epinephelus* sp.)	10–33	15
Rabbit fish (*Siganus* sp.)	15–33	25
Snapper (*Lutjanus* sp.)	15–33	25

A normal strength of seawater (salinity) may be optimal for most tropical fishes; they cannot tolerate low salinities such as 10–15 ppt. Thus, the site selected for cage culture should have salinity range between 15–30 ppt for altering the species cultured according to market demands.

Ammonia

In cage culture system, the ammonia level in water is caused by the debris at the bottom and decomposition of uneaten food. Apart from this, sewage disposal and industrial pollution are also the source for ammonia in seawater. Ammonia is the most toxic form of inorganic nitrogen in water which can affect the fish. Ammonia toxicity increases with the increase in pH and temperature. The level of ammonia-nitrogen in the water should be less than 0.1 ppm.

Hydrogen ion index (pH)

Normally, seawater is alkaline with pH values of 7.5– 8.5. Hydrogen ion concentration or pH level at this range makes the water act as buffer to prevent changes caused by other factors. Extreme changes in the pH level of water may affect fishes directly by damaging its gills and leading to death. Estuarine areas where seawater is mixed by freshwater influx during heavy rain are prone for huge variation in pH. Increase in pH values will also affect the fish indirectly by increasing the toxicity of ammonia, heavy metals and several other common pollutants. The optimum range of pH for most marine species is from 7.0 to 8.5.

Nitrate (NO_3-N) and nitrite (NO_2-N)

Nitrite originates as an intermediary product of nitrification of ammoniacal N by aerobic bacteria. Higher amount of nitrite in water becomes toxic to fish due to oxidation of iron in haemoglobin. Marine water has high concentration of calcium and chloride which tend to reduce nitrite toxicity. Nitrate is the end product of nitrification of ammoniacal nitrogen by aerobic autotrophs. Nitrate serves as fertilizer for phytoplankton, so the increase the nitrate level in the water leads to increase the concentration of unwanted phytoplankton bloom.

Land drainage is also another source for the presence of nitrate in the water. Nitrate (NO_3-N) and nitrite (NO_2-N) also contribute to the level of inorganic nitrogen in seawater. The total inorganic nitrogen for marine animal culture is < 0.1 ppm.

Phosphate

Phosphorous is a limiting nutrient needed for the growth of micro algae and aquatic plants. In natural water the total phosphate content may range from 0.01 to more than 200 mg/litre. However, excess concentrations of phosphate can result in algal bloom which causes the sudden depletion in the level of oxygen in seawater. The optimum level of phosphate for a cage culture site should not be higher than 0.015 ppm.

Organic load

Dead phytoplankton, sewage discharge, industrial effluents, uneaten food and fish waste in the cage, becomes the source for organic load in water. This high organic load not only causes bacterial infection in fish but also lowers level of dissolved oxygen in water. The organic load in water can be measured by Chemical Oxygen Demand (COD) which should be less than 1 ppm for a suitable site.

Heavy metals

Industrial effluents and other anthropogenic activities are the main source for most heavy metals which are found in seawater. So the site selected should be free from high level of heavy metals or it may become a source for toxicant to humans who are ingesting the cultured fish. Therefore, it is always better to select an area which is away from industrial activities and sewage discharge site. Heavy metals of importance to human and cage culture and their acceptable / safe limits are given below

Heavy metals	Acceptable limits (ppm)
Manganese (Mn)	< 1.0
Iron (Fe)	< 1.0
Chromium (Cr)	< 1.0
Tin (Sn)	< 1.0
Lead (Pb)	< 0.1
Nickel (Ni)	< 0.1
Zinc (Zn)	< 0.1
Aluminium (Al)	< 0.1
Copper (Cu)	< 0.01
Cadmium (Cd)	< 0.03
Mercury (Hg)	< 0.004

Other pollutants

Domestic sewage contains pollutants, detergents, toxic substances including several organic matters which affect cage fish farming. Several products used in agriculture also makes an entry in to the cage farming systems such as herbicides, insecticides and animal wastes, which might be engulfed by fish and leads to its death. For examination of above toxins, it needs regular sampling and high end equipments in the laboratory. Selecting a site for cage culture away from such contaminations may avoid risk of such happenings in the culture period. The acceptable level of Biological Oxygen Demand (BOD) should not exceed 5 mg/l at 5 days period.

Biological criteria

Fouling organisms

Fouling organism comes along with the silt particles which gets colonized at the cage net and frames as substrate. Out of the fouling materials, more than 50% will be of silt origin. Fouling leads to clogging of net mesh, which restricts the water flow, lowers the dissolved oxygen and prevents waste removal from the cage. Fouling rate depends on the surrounding environment and materials used for cage and net fabrication. Marine waters are more prone for fouling than in brackish water as per the earlier reports on cage and pen culture. Frequent cleaning and washing is required in areas of high fouling growth, to facilitate water exchange and to reduce the additional weight on cage frame. This makes net changing troublesome, tedious and time consuming. To optimize the running cost, cages should be located in places unfavourable for the growth of fouling organisms.

Phytoplankton

Favourable conditions including physical and chemical parameters may promote sudden burst of algal growth leading to its bloom. A site which is prone for sudden bloom may be avoided while selecting for cage farming. Algal blooms create problems to fish, directly by clogging its gills, and indirectly by depleting dissolved oxygen at night. Toxin producing blooms not only kill the fish but also pose high danger for human consumption. Algal blooms might also occur if the source water contains fish farm wastes and effluents from fertilizer plants. Thus, care should be taken and proper enquiries should be made along the nearby areas for such occurrences before selecting a site for cage farming

Accessibility

The cage culture site should have access to both water based and land based mode of transportation. Hassle free transportation leads to availability of culture needs (seed, feed, fuel) and other supplies which are necessary. A floating raft with cabin for labourers close to the cages would increase their productivity. It would enormously optimize production costs if other supplies which are necessary are nearer to cage culture sites.

Social problem

Security is a big concern while selecting a suitable site for cage culture. Since cage culture units are located in natural water bodies, laws and regulations are necessary to safe guard the cage reared animals from theft. There is a risk of probable pollution and conflicts which may occur with common users of the sea such as harbours and other marine related industries. This always leads to conflicts and finally leads to poaching problem. One should be cautious to prevent poaching, and wise to select a site away from villages and common users to prevent such future problems.

Legal aspects

Most nations have a rules and regulations for leasing open water bodies for fisheries and aquaculture use. Government has the full rights over the land below the low tide level. Several nations instruct farmers to take prior permission or license before starting a cage culture venture with restrictions over area, species, size and type of culture practised. To avoid future conflicts with end users, prior identification of suitable sites for cage culture may be carried by the licensing authority. Lease, license and regulation rules and procedures have to be formulated in advance to avoid any obstacle and lengthy processing involved in obtaining permission. Cage culture operations should strictly follow the norms required by the government to avoid future problems and to sustain cage aquaculture as a profitable venture.

Suggested readings:

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