# Importance of water quality in marine life cage culture

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Water quality in marine life cage culture is one of the most important factors that determine production and mortality. Choice of site for marine cage culture is of paramount importance since; it not only affects water quality but also greatly influences the economic viability. Once the site is selected for marine cage culture, there is little that can be done to improve the site, if water exchange is poor.

## Criteria for selecting a site for marine cage culture

### *Environmental Criteria*

Depth

Shallow bays with limited depth of water under cages are not favorable for water renewal and generally the settling of wastes. A depth of 10 – 30m at low tide may be considered as ideal condition. Cages should be sited in sufficient depth to maximize the exchange of water, yet keep the cage bottom well above the substrate in order to avoid interaction between the cage bottom and sea floor. Water is drawn into the cage not only through the sides but also through the bottom panel and as the cage bottom approaches the substrate, flows become increasingly impeded. It can cause chemical and bacterial interactions, net damage and predation of the fish by crab and bottom organisms. The cage of sea bass established by CMFRI, Cochin was at a depth of 10 m in inshore area off Cochin.

Wind

The wind can determine the suitability of a particular site or area for cage fish culture through its influence on cage structures and caged stock. Of particular concerns are violent storms. But up to certain level, effects due to moderate winds can be profitable by the mixing of water. Maximum permissible wind limit is 30 – 40 km $hr^{-1}$. The wind velocity limit also emphasis the need of suitable season for marine cage culture when wind velocity is low. The cage culture of sea bass conducted by CMFRI, Cochin was during October – April in the open sea, at Munambam, off Cochin. In the Arabian sea, during June – August, the winds blow at their greatest strength and by September, the wind velocity decreases and by October – November, the wind starts blowing from north westerly to north easterly with comparatively low velocities.

Waves

Wind driven waves are propagated by the frictional drag of wind by the wind blowing across a stretch of water that transfers energy to the fluid. Wave size is determined by wind velocity, wind duration and the distance of open, unobstructed water across which the wind blows; and is also influenced by the waves present when the wind starts to blow. At the windward end, waves are poorly developed with small wave heights and short periods of oscillation.

However, waves develop with distance, reaching maximum size when they attain the same velocity as the wind. Wave height increases with wind velocity and wave energy increases proportionally with square of wave height. The maximum limit of wave height for working on floating cages is 1m.

Currents and tide

Good water exchange through cages is essential both for replenishment of oxygen and removal of waste metabolites. A weak and continuous current stream is favorable to bring oxygen and remove wastes in a cage. However excessive currents impose additional dynamic loadings damaging floating structures or cages, reduce the cage usable volume due to the deformations of the net and may adversely affect fish behavior. The limit for current velocity is with a minimum of 0.05 m $S^{-1}$ to a maximum of 1 m $S^{-1}$.

In all except a few coastal regions of the world, tidal currents are the predominant source of surface water currents. Attractive forces exerted by the moon and sun on the Earth produce tidal waves. The crest and trough of the wave are termed high and low tide respectively, while the wave height is referred to as the tidal range. Associated with the rise and fall of the tide are the horizontal motions of water or tidal currents. Maximum current velocity occur at the middle of the rise (flood) and fall (ebb) ie., during the mid time between highest and lowest tide. For marine cage culture, limited tide amplitude (<1m) is preferred. Based on the tide table for the particular area of the coast, current velocity thus can be predicted in pre-monsoon and post-monsoon season during a cage culture period. But in monsoon, current velocity is unpredictable. Current velocity during monsoon is mainly influenced by littoral current, strong winds, wave effects and increased river discharge. Hence there is every chance that current velocity can exceed its permissible maximum limit prescribed for marine cage culture. Monsoon season is generally avoided for marine cage culture activity.

Substrate

The cage site substrate range from rocky to soft mud. Mud or rock bottom may cause difficulties for a safe and reliable anchorage for cage. A sandy or gravel bottom is generally looked for.

***Water Quality Criteria***

Temperature and salinity

Fish and other farmed organisms have no means of controlling body temperature, which changes with that of environment. A rise in temperature increases metabolic rate and causes a concomitant increase in oxygen consumption and activity as well as production of ammonia and carbon dioxide. Salinity is a measure of the amount of dissolved solids present in water and is usually expressed in parts per thousand. Its relevance to cage culture lies principally in its control of osmotic pressure, which greatly affects the ionic balance of aquatic animals. Rapidly fluctuating conditions of temperature and salinities are harmful for marine life cage culture. Seasonal changes are also to be taken care of during the culture period. For most tropical marine life aquaculture, a temperature of 26 - 28°C in early morning with no abrupt changes is considered as suitable. Similarly preferred salinity range is 25 – 40 ppt, evading abrupt changes.

Dissolved Oxygen

Dissolved oxygen is required by all higher marine organisms for the production of energy for essential functions such as digestion and assimilation of food, maintenance of osmotic balance and activity. Oxygen requirements vary with species, stage of development, size and are also influenced by environmental factors such as temperature. If the supply of oxygen deviates from the ideal feeding, food conversion, growth and health can be adversely affected. It is therefore important that good oxygen conditions prevail at a site.

During the day, there is a net production of oxygen, but at night, when photosynthesis stops, the algal community in water becomes a net oxygen consumer. Where there are large algal communities, super saturation of DO may occur during the day and sub saturation condition prevail at night, with late afternoon maxima and pre-dawn minima, stressing fish. The environmental conditions conducive to blooms usually occur during the warmer months in areas subject to high nutrient influxes. External sources such as sewage discharges and agricultural run off may be important contributors. However, a sudden upwelling of nutrient rich water from deeper layers of the water body during the break down of stratification may also stimulate blooms. Problems can occur when algal blooms die. During decomposition, microbial respiration may remove much or even the entire DO resulting in fish kills.

Benthic oxygen demand can cause de-oxygenation of the hypolimnion. Good mixing, water exchange and flushing by proper currents, tides and winds is a must in order to shun this situation. Marine sites which have good bottom current which disperse settling wastes are desirable. Preferred DO level for marine life culture is >6 mg $l^{-1}$.

*pH*

pH is a measure of hydrogen ion concentration of a solution. pH is important to aquatic life because extreme values of it can damage gill surfaces, leading to death and because it affects the toxicity of several common pollutants like ammonia and heavy metals.

The pH of sea water usually lies in the range 7.5 – 8.5. Sea water is also well buffered ie., comparatively resistant to changes in pH through the addition of alkaline or acidic compounds. Preferred pH for marine life culture is 7.8 – 8.4.

Turbidity

Total suspended solids

Turbidity refers to the decreased ability of water to transmit light caused by suspended particulate matter ranging in size from colloidal to coarse dispersions. Turbid conditions arise from organic or inorganic solids suspended in the water column as a result of soil erosion, mining wastes and other industrial effluents. Cage fish farms are themselves a source of suspended solids.

The quantity and quality of material suspended in water column at any particular moment is largely determined by water movement, which transports, fractionates and modifies solids. Large, dense particles are more easily settled than small, less dense particles. Water currents can also prevent particles from settling and re-suspend settled materials. Water chemistry and salinity in particular influences turbidity through its effect on flocculation and settling and is important in the transport of sediments.

High levels of suspended solids cause gill damage, inducing the gill epithelial tissues to proliferate and thicken. If damage is sufficiently severe, the fish will die. Turbidity levels less than 100 mg $l^{-1}$ have little effect on most species. However, duration of exposure is important. Preferred range of dry suspended matter for marine life cage culture is <2 mg $l^{-1}$.

Color / Transparency

Part of the light (solar radiation) striking water does not penetrate the surface. A portion is reflected depending on the roughness of the water surface and the angle of radiation. As light passes through water, scattering and differential absorption by the water takes place. Turbidity and color in water may result from colloidal clay particles, from colloidal or dissolved organic matter or from an abundance of plankton. Secchi disk visibility can be taken as a measure of colour / transparency of the water in marine life cage culture. The Secchi disk is a weighted disk, 20 cm in diameter and painted in alternate black and white quadrants. The average of depths at which the disk disappears and reappears is the Secchi disk visibility. Optimum transparency expressed as Secchi disk visibility for marine culture is <5 m as yearly mean. Transparency is an important factor deciding light penetration and euphotic zone (the stratum of water receiving 1% or more of incident radiation, where, photosynthesis proceeds at rates exceeding respiration), affecting the primary productivity and oxygenation of the culture water.

Total inorganic nitrogen

Ammonia N

Ammonia is the most toxic form of inorganic N produced in water. The major source of ammonia in water is the direct excretion of ammonia by fish. It also originates from the mineralization of organic matter by heterotrophic bacteria and as a by product of nitrogen metabolism by most aquatic animals. Both ammonia ($NH_3$) and ammonium ($NH_4^+$) are toxic, but $NH_3$ is much more toxic than $NH_4^+$. Ammonia toxicity increases with the increase in pH and temperature.

The ammoniacal N content of water is an index of the degree of pllution. Its concentration in unpolluted water should never be more than 0.1 mg $l^{-1}$ and below this level, healthy growth of fish is expected. Aquatic autotrophs rapidly utilize ammonium ions, thus naturally preventing it from reducing to toxic levels.

As ammonia concentration increases in water, ammonia excretion by fish decreases and levels of ammonia in blood and other tissues increase. This results in an elevation of blood pH and adverse effects on enzyme catalyzed reactions and membrane stability. High ammonia concentrations in water also affect the permeability of fish by water and reduce internal ion concentrations. Ammonia also increases oxygen consumption by tissues, damages gills and reduces the ability of blood to transport oxygen. Histological changes occur in kidneys, spleen, thyroid and blood of fish exposed to sub-lethal concentrations of ammonia. Chronic exposure to ammonia increases susceptibility to diseases and reduces growth. Preferred range of Ammonia N as ($NH_4$ + $NH_3$) for marine culture is < 0.1 mg $l^{-1}$.

Nitrite N

Nitrite originates as an intermediary product of nitrification of ammoniacal N by aerobic bacteria. Marine water has high concentration of calcium and chloride which tend to reduce nitrite toxicity.

Nitrate N

Nitrate is the end product of nitrification of ammoniacal nitrogen by aerobic autotrophs. Its presence can also be due to land drainage.

The total inorganic nitrogen for marine life culture is < 0.1 mg $l^{-1}$.

Total inorganic phosphorus

Phosphorus (P) is found in the form of inorganic and organic phosphates ($PO_4$) in natural waters. Inorganic phosphates include orthophosphate and polyphosphate while organic forms are those organically-bound phosphates. Phosphorous is a limiting nutrient needed for the growth of all plants - aquatic plants and algae alike. However, excess concentrations of P can result to algal blooms. The total inorganic phosphorus for marine life culture is < 0.015 mg $l^{-1}$.

COD (Chemical Oxygen Demand)

The COD of water represents the amount of oxygen required to oxidize all the organic matter, both biodegradable and non biodegradable by a strong chemical oxidant. Preferred Chemical Oxygen Demand for marine life culture is < 1 mg $l^{-1}$.

Chlorine

Both free and combined, residual available chlorine are extremely toxic to fish. The measurable concentrations of chlorine in water for marine life culture is <0.02 mg $l^{-1}$.

Heavy metals

They originate mainly from anthropogenic industrial pollution. The toxicity of heavy metals is related to the dissolved ionic form of the metal rather than total concentration of the metal.

*Mercury*

Mercury (Hg) is toxic to both aquatic life and humans. Inorganic form occurs naturally in rocks and soils. It is being transported to the surface water through erosion and weathering. However, higher concentrations can be found in areas near the industries. The most common sources are caustic soda, fossil fuel combustion, paint, pulp and paper, batteries, dental amalgam and bactericides.

Mercury remains in its inorganic form (which is less toxic) until the environment becomes favorable, *i.e.* low pH, low dissolved oxygen, and high organic matter where some of them are converted into methylmercury (the more toxic organic form). Methylmercury tends to accumulate in the fish tissue, thus making the fishes unsafe to eat.

The total mercury in water for marine life culture should be <0.05 mg $l^{-1}$.

*Lead*

Lead (Pb) comes from deposition of exhaust from vehicles in the atmosphere, batteries, waste from lead ore mines, lead smelters and sewage discharge. Its toxicity is dependent on pH level, hardness and alkalinity of the water. The toxic effect on fish is increased at lower pH level, low alkalinity and low solubility in hard water.

The lead in water for marine life culture should be <0.1 mg $l^{-1}$.

*Copper*

Copper enters the environment naturally through the weathering and solution of copper minerals and from anthropogenic sources. Anthropogenic sources of copper in the environment include corrosion of brass and copper pipes by acidic waters, industrial effluents and fallout, sewage effluents, and the use of copper compounds such as copper sulphate as aquatic algicides. Major industrial sources of copper include smelting and refining industries, copper wire mills, electroplating, metal finishing, coal burning, and iron and steel producing industries. Large quantities of copper can enter surface waters, particularly acidic mine drainage waters, as a result of metallurgical processes and mining operations.

The toxicity of copper to marine organisms in marine and estuarine environments is influenced by physical factors and chemical characteristics of the marine environment:

The copper in water for marine life culture should be <0.02 mg $l^{-1}$.

*Pesticides*

Pesticide refers to any chemical used to control unwanted non-pathogenic organisms, including insecticides, acaricides, herbicides, fungicides, algicides and rotenone (used in killing unwanted fish) (Svobodova, 1993). These chemicals are designed to be toxic and persistent, thus it is also of concern in aquaculture. It can affect the quality of the aquaculture product as well as the health of the fish and humans.

Pesticide can be split into seven main categories namely, inorganic, organophosphorous, carbamates, derivatives of phenoxyacetic acid, urea, pyridinium, and derivatives of triazine (Dojlido and Best, 1993). Among these, the chlorinated form is of particular concern due to its persistence and tendency to bioaccumulate in fish and shellfish. Some examples are dichloro-diphenyl-trichloro-ethane (DDT), aldrin, dieldrin, heptachlor, and chlordane. The most common sources are agricultural run-offs, effluents from pesticide industries and aquaculture farms.

The safe level of DDT group in water for marine life culture should be < 0.025 ←g $l^{-1}$.

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