
ROLE OF WATER QUALITY IN SEAFARMING

A.H. Parulekar

National Institute of Oceanography,
Dona Paula 403 004, Goa

Abstract

An attempt is made to review the importance of water quality in the rearing of marine and estuarine organisms, under restricted environments. Though diverse in nature, the success of static and/or, the flowing system of seafarming, depends not only on the species to be farmed and the type of system to be deployed, but principally, on the uniform renewability of water within a small range of environmental variations. Despite the partial environmental control, the incidences of water quality deterioration, resulting, not only in economic losses but also posing potential human health hazard, are not uncommon in seafarming. Type of parameters, conservative and non-conservative, causes of the variability, effects on the organisms reared and the possible remedial measures, are presented and discussed.

Introduction

Seafarming or mariculture, which involves the commercial production of marine and estuarine organisms, under restricted environment, is a water-linked technology. Water being the environment in which the organisms have to be reared, the process of degradation, of metabolic products or chemical substances, is not as fast as in the air or on the land. This, inspite of monitoring, many a times results in the deterioration of water quality and, besides causing heavy financial losses to the fish farmer, it also poses a potential danger to human health, through the consumption of contaminated seafoods.

An important basic principle of seafarming, particularly critical with reference to water quality, is that a healthy population of organisms can be maintained only if they remain free from any stress and strain. Every problem that arises in seafarming is the result of or leads to degradation of water quality (Stickney 1979). A site for aquaculture, therefore, should have conducive environmental conditions, like uniform renewability of water with small range of environmental variations (Qasim 1977).

Mariculture and Water System

Seafarming techniques are very diverse in nature. They depend not only on the species to be reared but mainly on the water system to be deployed. Accordingly, a critical factor in the optimization of production and also the optimum utilization of a mariculture site, is the selection of a

proper type of water system.

In relation to water movement, two systems, namely, static and flowing, are commonly used in commercial production through seafarming.

Static System

This is the commonly used method in which the provisions have to be made for the regular renewal of water. Renewal of water is mainly meant for the removal of biogenic waste products and import of food material through the incoming water. Being an enclosed system, the possibilities of water quality deterioration, inspite of strict monitoring, are always high in such systems. However, implementation of remedial measures are also easily possible in static systems.

Flowing system

A continuous flow of water characterizes this type of seafarming and, accordingly, such system can be in the open sea or in a enclosed place, provided with seawater circulating facility. In such systems, the turnover rate i.e. the time taken for the total renewability of water, varies considerably from site to site. The flowing system can further be classified, depending on whether the water leaving the culture site can fully be recycled (closed type), partly recycled (semi-closed type) and non recycled (open type).

However, unlike static system, the control over water quality in a flowing system is of a very low magnitude, and, therefore, the present day seafarming operations are more confined to static systems than to flowing systems, where the problems of water quality management are rather of acute nature. Though the extensive type of seafarming is undertaken in static waters and intensive farming in flowing water systems, the amount of physical space required for extensive culture systems is much greater than that required for intensive systems capable of the same annual production (Stickney, op. cit.)

The requirements of a species to be reared is also a primary factor in the factor in the selection of a water system. While, for the mobile or nektonic organisms like finfishes and shrimps, a static system ensuring prevention from escape besides the freedom from predators, is ideal, for the immobile and sessile organisms like shellfishes and seaweeds, off-bottom culture in flowing systems is always beneficial.

Besides, the above mentioned mariculture systems, which are commonly practised, there are other systems that have been utilized as commercial or research facilities (Parulekar and Dalal 1978; Chatterji 1983 & 1984). A classic example is that of a modified flowing system where sewage effluent as also the domestic animal waste is used as a nutrient source (Huguenin and Ryther 1974). The logic behind this modified system is, as the food production in the sea is nutrient limited, the artificial supply through treated human waste, can substantially increase the product-

ivity, at least in a small area (Douglas 1974). Domestic wastewater effluent from secondary sewage treatment, mixed with seawater, is used as a source of nutrients for growing unicellular marine algae and the algae, in turn, are fed to filter feeding organisms, like oysters and clams, which through their faecal matter supports polychaete worms, forming food for finfishes. The final effluent from such polyculture system is virtually free of inorganic nitrogen and, thus is incapable of either supporting further growth of any marine life or eutrophication of any water body (Ryther, 1975.) Though such systems considerably help in containing marine pollution due to sewage effluents, they also pose potential hazard to consumers in the form of viral infections, bacterial contaminations and heavy metal toxicity (Goldman and Ryther 1975).

Water quality in Mariculture

A number of physical, chemical and biotic parameters, either singly or jointly or in a variety of combinations, determine the water quality in the restricted environment of seafarming (Stickney op. cit.1979). As the magnitude of effect of one or more of the factors is widely varying, especially in relation to its or their impact on biota in a seafarming system, they, are divided into, conservative and non-conservative type of factor.

Conservative factors are those which are not affected in any significant way, by the activities of organisms, except at a microscopic level, that too in few cases. Some of the important conservative factors of water quality in seafarming are temperature, salinity, alkalinity, suspended solids etc.

Almost all the organisms, presently grown in seafarming are cold blooded or poikilothermic, and hence their metabolic rates are controlled by the stability of the ambient water temperature. Temperature tolerance and optima vary greatly among the species, however, in tropical marine and estuarine environment, majority of the species reared through mariculture, are eurythermic. However, except in closed recirculating system, seasonal variations in temperature, do affect all the culture systems (Stickney op. cit.). Water slightly warmer than the optimum provides for faster growth and faster food conversion efficiency (Qasim et.al.,1977) Metabolic rate slows down below the optimum temperature for a particular species and increases as the temperature rises above the optimum level (Parulekar et al 1982). Though the metabolic rate continues to increase above the optimum temperature, the growth gets adversely affected, as the energy gets diverted from growth to maintenance of the higher metabolic rate. However, in the tropical seafarming, temperature is not a limiting factor of higher significance (Bardach, Ryther and McLaren 1972).

A dominant evolutionary trend, in all the marine and estuarine organisms, is the development of a mechanism to maintain a salt balance (Kinne 1967). Rhythmic salinity changes, common to coastal and estuarine seafarming, results from diurnal tidal changes and also from temporal variations associated with freshwater run-off during rainy season. Most of the organisms reared in seafarming, especially in tropical environment, though

basically euryhaline, attain optimum rate of growth, survival and food conversion efficiency, within a limited range of salinity (Parulekar et al., 1982). Especially, in invertebrates, a narrow range of preferred salinity, is reported (Lockwood 1976) to prevail. While the oysters can adjust to salinities as low as 3 ppt or as high as 35 ppt (Pearse and Gunter 1957), the green mussels, though can withstand salinities as low as 0.12 ppt, the growth and spawning gets suspended at such low salinity (Parulekar et al., op.cit.) As emphasized by Stickney a saline medium not only introduces new aspects of water quality into the culture system, but it also places a tremendous stress on the facility, as a whole.

Another factor of considerable significance is the amount of suspended solids in a seafarming system. High suspended solids besides drastically cutting the penetration of light in the culture media, also deters the primary production, Clogging of the gills and filtration mechanisms also affect the efficiency of feeding (Loosanoff and Tommers 1948). Similarly, increased particulate matter suspended in water provides a vast amount of surface area for the growth of pathogenic micro-organisms and thus could increase the potential for infections and subsequent mass mortality in a seafarming operation (Cairns 1967).

Any changes in pH of seawater affects the percentage of alkalinity and these relationships are affected, besides, temperature and salinity by the entry of certain chemical substances, especially the nitrogenous ones (Verlencar et al., 1977)

Similarly, the incidence of acute toxicity and mass mortality in seafarming operations, due to the changes in water quality, because of excessive addition of trace metals, pesticides and fertilizer residues, are well documented (Bardach, Ryther and McLaren op. cit.). The classic example is that of "Minamoto" disease, caused in human beings, due to the farmed oysters, contaminated by methyl mercury (Bardach, et al., 1977).

Non-conservative properties of water quality in seafarming operations are related to alterations due to biological activity and some of the important factors are primary production, dissolved oxygen and plant nutrients. Though in a seafarming system, most of the water quality parameters are regularly monitored, sometimes deterioration of water quality, due to biological activity, does occur.

The plant nutrients, especially those of nitrogen, phosphorous and silicon are essential for primary production, through photosynthesis. The natural source of nutrient salts in the marine environment is through land runoff and to a certain extent from the biodegradation of organic matter. However, in a partially controlled or restricted environment like seafarming system, the natural balance of nutrient concentration gets disturbed mainly due to lower bio-degradation rate. This often results in the depletion of dissolved oxygen especially in static systems. As a general rule, if dissolved oxygen is equal to or in excess of 5 mg/l, no stress will be caused to aquaculture animals (Wheaton 1977), and hence of all the problems with water quality that can plague a tropical seafarming system, oxygen depletion is the most frequent. If dissolved oxygen falls to a

concentration that places stress on organisms or threatens their lives, other water quality parameters, both conservative and non-conservative, tend to become insignificant until a safe concentration of dissolved oxygen is re-established (Stickney op cit.). The level at which the dissolved oxygen begins to induce stress, varies with species and is associated, to some extent, with other stress causing factors especially, un-ionized ammonia concentration, nitrite, pH salinity and temperature. However, the synergistic relationship between the set of conservative and non-conservative parameters of water quality in seafarming, still remains to be evaluated, in detail.

Being an innovative method of seafood production, the location of mariculture activity needs to be set up taking into consideration not only the commonly known environmental factors but also the economic and social deferminants. Some of the important criteria relevant to this are condusive environmental conditions like uniform renewability of water with small range of environmental variations, high biological productivity potentials for ensuring the sustained abundance of natural feed and free from any environmental stress due to pollution. In fact, the ultimate aim of seafarming technology is to achieve control over the organisms during the whole period of rearing and therefore the strict monitoring of water quality, which form the habit and habitat of the cultured organisms, will always be a matter of utmost importance.

References

- Bardach, J.E., J.H.Ryther and W.O. Mclarney 1972 : Aquaculture. PP.868 (Wiley-Inter-Science, New York).
- Cairns, J. Jr. 1967 : Suspended solids standards for the protection of aquatic organisms. Purdue University Engineering Bulletin, No. 129 : 16-27.
- Chatterji, A., B.S. Ingole and A.H. Parulekar 1983 : Seawater circulation system in an aquaculture laboratory. Mahasagar Bull. natn. Inst. Oceanogr. 16:81-86.
- Chatterji A., Z.A. Ansari, B.S. Ingole and A.H. Parulekar 1984 : Growth of the green mussel, *Perna viridis* L., in a seawater circulating system. Aquaculture, 40:47-55.
- Douglas, J.H. 1974 : Oysters, algae & sewage. Science News, 106 : 170-171.
- Goldman, J.C. and J.H. Ryther 1975 : Nutrient transformations in mass culture of marine algae. J.Env.Engr. Div. ASCE, 101, EE3, Proc. Paper 11358 : 351-364.

-
- Huguenin, J.E. and J.H. Ryther 1974 : Experiences with a marine aquaculture tertiary sewage treatment complex. Proc. Conf. Waste Water Use In The Production Of Food And Fiber, U.S. Environmental Protection Agency, EPA-660/2-74-041.
- Kinne, O. 1967 : Physiology of estuarine organisms with special reference to salinity and temperature. In Estuaries, G.H. Lauff ed. No. 83 : 525 - 540 (AAAS Publication, Washington D.C.).
- Lockwood, A.P.M. 1976 : Physiological adaptations to life in estuaries. In Adaptations to environment, R.C. Newell ed.:315-393 (Butterworths, London).
- Page, J.W. and J.W. Andrews 1975: Effects of light intensity and photoperiod on growth of normally pigmented and albino channel catfish. Proc. Fish cult., 37:121-125.
- Parulekar, A.H. and S.G. Dalal 1979 : Prospects for aquaculture in India. Research & Industry, 9:1-6.
- Parulekar, A.H., S.G. Dalal, Z.A. Ansari & S.N.Harkantra 1982: Environmental physiology of raft grown mussels in Goa, India. Aquaculture, 29:83-93.
- Qasim, S.Z. 1977. : Role of aquaculture in rural development. Invention Intelligence, 12:107-112.
- Qasim, S.Z., A.H. Parulekar, S.N. Harkantra, Z.A. Ansari and A Nair 1977 : Aquaculture of green mussel, *Mytilus viridis* L. : Cultivation on ropes from floating rafts. Indian J. mar. Sci., 6:15-25.
- Ryther, J.H., J.C. Goldman, Gifford, J.E. Huguenin, A.S. Wing, J.P. Clarner, L.B. Williams and B.E. Lapointe 1975 : Physical models of integrate waste recycling - marine polyculture systems. Aquaculture, 5:163-177.
- Stickney, R.R. 1979 : Principles Of Warmwater Aquaculture, ed : R.R. Stickney pp. 373 (Wiley Inter-Science, New York).

Verlencar, X.N., N.B. Bhosle
and A.H. Parulekar 1977

: Toxicity tests of oil dispersants
on some marine animals. Mahasagar -
Bull. natn. Inst. Oceanogr., 10:109-115.

Warren, R. 1971

: Biology And Water Pollution Control
ed. : R. Warren, pp. 434 (W.B. Saunders
& Co., Philadelphia).

Wheaton, E.W. 1977

: Aquaculture Engineering, ed. :
E.W. Wheaton, pp. 708 (Wiley Inter-
Science, New York).