Site selection for Mussel Culture

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INTRODUCTION

In India, most of the bivalves produced are fished from the natural stocks. At present green mussels are cultivated mainly in the states of Kerala and Karnataka.. Production of bivalves by mariculture in India is very little compared to the rest of the world. The major source for collection of the seeds of the bivalves is through wild collection or through laying of cultch material as in edible oysters.

The success of mussel mariculture depends largely on the proper selection of culture sites. Considerations should be carefully given to a number of factors, which can be grouped under primary and secondary factors. Physical, ecological and biological factors (primary factors) are of prime importance in the selection of suitable culture sites, while factors such as risk, economics and legal usually follow in terms of importance. It is important to understand that if the primary factors are not fully satisfied, the particular site under consideration should be discarded whether or not all secondary factors are satisfied.

Primary factors

Area Location

The site for mussel cultivation should be well-protected or sheltered coves and bays rather than open un-protected areas. Sites affected by strong wind and big waves must be avoided because this causes damages to stocks and culture materials. The sites must be clear from serving as catchments basins for excessive flood waters. Flood waters would instantly change the temperature and salinity of the seawater, which is detrimental to the mussels. Sites accessible by land or water transportation are preferred so that culture materials and harvests can be transported easily.

Substrate

Substrate composition and stability is a major environmental parameter to be considered during the selection of a culture site suitable for benthic species such as cockles and clams or where bottom culture is intended to be carried out. Of late, bottom culture of mussels is practiced in various parts of Kerala. If bottom culture is the only possibility, substrate nature in terms of firmness needs to be carefully examined in order to carry out a correct cost/benefit analysis.

Water depth

Water depth is not usually a limiting factor in mollusc culture, however it will determine what culture method can be used. Probably the most important aspect with regard to water depth is to avoid long exposure periods during the extreme low water spring tides when benthic molluscs are cultured. The water depth for mussel farming should be at least below 1 m mean tide level. Culture methods vary with different water depths. Bottom culture can be practiced in areas where the mean tide level is less than 1.5 m (Lovatelli, 1988). For off bottom culture, methods such as raft and long line usually need a minimum water column height during low water spring tide. The hanging ropes with mussel seeds of these culture methods should be at least 1 m above the sea floor during extreme low water spring tides (Lovatelli, 1988) to prevent ground predators, seabed high water turbidity and friction with the bottom. Favourable water depth for both seed collection and mussel cultivation is 2 m or more (Aypa 1990). In the backwaters of Calicut where the depth are often about one meter, horizontal seeded ropes of green mussel were used as a practical method.

Exposure

Marine molluscs are unable to function when removed from their water medium and long exposure periods usually lead to death. Exposure is one of the major environmental conditions that influences the growth and mortality of marine molluscs. Both growth and mortality rate vary according to shore elevation. Growth performance of a mollusc located at higher levels is usually lower compared to one located at lower levels, due to prolonged exposure periods and subsequently reduced feeding time.

Exposure to sun is one of the physical parameters, which need to be taken into account when selecting a potential culture ground in shallow coastal areas. In raft or long-line culture, exposure is not a problem as the cultured organisms are always below the water surface. A further example where limited exposure is an advantage can be clearly seen in the mussel culture industry in the Venetian lagoon, Italy. Mussel (*Mytilus edulis*) is extensively cultured by using the rack hanging method. During late spring and summer month, the suspended ropes bearing the mussels (known as "pergolari") become heavily encrusted with fouling organisms, such as sea squirts and seaweeds. The presence of these organisms is undesirable because they compete for food and space and critically increase the weight of each hanging unit.

There is, therefore, a need to remove these fouling organisms. This laborious process, however, is not required in this particular site, as the adequate exposure time of the mussel ropes causes all encrusted organisms to dry up. In other areas such as Taranto, in the south of Italy, mussel aquaculturists have to routinely suspend the mussel ropes and remove the fouling organisms manually. This process is time consuming and labour intensive. Labour effort and growth period are therefore related to exposure.

Water movement

As filter feeders, mussels need water movement or currents for providing adequate food supply as well as dissolved oxygen. However, a very strong current can cause high turbidity and thus difficulties for young mussels to attach to the substrate and drag on ropes or lines. Moderate or suitable current speeds within the range of 0.1 – 0.3 m/sec have been reported to be potential sites for mussel farming (Lovatelli, 1988). Slow water movement usually results in slow growth of the mussels and also promotes the settling of organic and inorganic particulate materials on the cultured organisms. A water current of 0.17–0.25 m/sec during flood tide and 0.25–0.35 m/sec at ebb tide should be observed (Aypa, 1990).

Turbidity

The turbidity level of water determines the presence of suspended, organic and inorganic matters in the culture area. High levels of these materials have ill effects on mussel culture due to failure of filtering activity and reduced penetration of sunlight in the water column, which will result in low primary productivity. . The presence of suspended materials above a certain level hinders the filtering activity of the bivalve, which often remain closed to avoid tissue damage and becoming clogged As a result, the cultured species may face slow growth rates due to limited food availability. Lovatelli (1988) reported that a site having a disc reading of less than 25 cm of the Secchi-disc should be considered unsuitable for mussel culture. . It has been reported that water containing a high suspended load of more than 400 mg/1 have a lethal effect on the grow-out of mussels.

Salinity

Although most species of molluscs tolerate a certain range of salinity levels, some species tend to be more euryhaline than others. When the salinity value falls below or above the range of a certain species for prolonged periods, high mortalities generally occur. Decrease in salinity levels is usually the major and frequent problem, mainly caused by the influx of large volumes of fresh water from rivers or land runoff during the rainy season. *P.viridis* is reported to tolerate a high range of salinity. (Sivalingam, 1977) observed that the species has 50% survival salinity tolerance at 24 ppt and 80 ppt for a period of 2 weeks in a laboratory experiment. The green mussel shows a good growth performance in estuarine habitats with salinities ranging from 18 ppt to 33 ppt and temperature from 1°C to 32°C as reported in and this species shows a broad salinity and temperature tolerance in experimental testing. Salinity of 27 ppt to 35 ppt is ideal for mussel farming (Aypa, 1990). *P.viridis* can grow in water salinity ranging from 5.2 ppt to 39.8 ppt (Rajagopal *et al.* 1998).

Food organisms

All bivalves are filter feeders, mainly feeding on a wide range of phytoplankton species. The presence of suitable micro algae species is usually not a problem, however, problems do arise when the availability of food is limited. . It has been estimated that when bivalves are grown under similar conditions at different sites, up to 85% of any difference in growth observed between sites can be attributed to water temperature and primary productivity. As filter feeders, green mussels mainly feed on a wide range of phytoplankton species, small zooplankton and other suspended fine organic materials. High primary productivity areas lead to high productivity and biomass of mussels. The carrying capacity of a body of water, (i.e. the biomass of animals that the algae food it contains can support) can be exceeded by overstocking; leading to reduced growth. Bivalve intensively cultured in rafts may be affected by the length of the culture period when food is scarce. In the above example, poor growth is usually the result of poor water movement (i.e. low current) rather than food availability.

Another problem related to food organisms are the sudden blooms of certain phytoplankton organisms, usually in coastal waters. This phenomenon is known as red tide as the organisms become so dense that the seawater takes on a brown, red or yellow coloration. Unfortunately, it is often difficult to predict if any area is prone to be affected by these toxic blooms, however, during the site selection process, one should ask about the history of the area. Bivalves affected with red tides are not usually killed, but tend to accumulate toxic substances in their flesh. Depuration studies have shown that those bivalves can be depurated, however the longer depuration time required would make it very uneconomical. Another problem which arises from food organisms are shellfish which are harvested or cultured in estuaries or coastal areas which are used as repositories for untreated domestic sewage. Shellfish from such areas are known to accumulate bacteria and viruses which are pathogenic to man. Major diseases are typhoid and paratyphoid fever, salmonellosis, *Vibrio parahaemolyticus* infection, cholera, viral Hepatitis type A and viral gastroenteritis. Contaminated bivalves can be made edible by re-laying or transferring the shellfish to pollution free waters or by depuration. These processes are time, labour and cost intensive. Therefore, during site selection it is important to bear in mind that being filter-feeders, they can accumulate pathogenic organisms, toxins as well as heavy metals at levels which can be lethal to humans.

Source of seed

Bivalve culture needs a regular supply of spat or seed is one factor which may affect site selection decisions. However, if it has to be transported from elsewhere, it should be transported to the farm site within a reasonable time and cost. This factor has to be considered as it will affect the cost and returns analysis. Transportation itself is not only costly, but usually negatively affects the bivalve seed due to abnormal and stressful conditions. *P.viridis* seed can remain without water for about 24 hrs and seeds are transported to areas where there is short supply. At Padanna, the mussel farmers get seeds of mussel from Calicut, Malpe and Karwar. The region of abundant seed availability need not be the ideal areas for grow out.

Pests

At Vizhinjam, in the raft culture of *Perna indica*, predation by the fish *Rhabdosargus* and lobsters were reported. At Parappanangadi, the green crab *Scylla serrata*, destroyed the seeded mussel ropes in the rack culture.

Secondary factors

Pollution

Waters with heavy industrial contamination such as trace metals and organic compounds are unsuitable for bivalve cultivation. The development of intensive agriculture, heavy industries along the coastal areas and increasing number of urban settlements have increased the pollution load into the biologically productive coastal waters. Domestic wastes carry detergents, solids and various toxic substances. Agriculture pollution involves animal waste, solids, insecticides, herbicides etc. Bivalves are known to accumulate trace metals and pollutants. This renders it unpalatable due to the unpleasant flavour they impart like the copper and oil tainting. In the 1980's the biocide tributyl tin (TBT) was highly toxic to bivalves. Banning of TBT in July 1987 helped in reviving the oyster industry. In areas with untreated effluents discharges as is done in many developing countries, the location of these sites could affect the production as well as the product quality. In Jakarta Bay and Manila Bay, due to pollution and numerous heath incidences related to consumption of molluscs reared in these areas, the molluscan culture enterprise have suffered severe losses as the market demand was reduced. The EU standards to be met for export of mussel products are given in Table 1 and the criteria for classifying shellfish harvesting areas are given in Table 2.

Poaching

The problem of pilfering and damage is common in aquaculture. Constant supervision of the culture is the only effective answer. Living near the culture site is obviously the most advantageous situation for keeping constant watch over the stock and facilities. When located away from these grounds, a small guardhouse in the culture site is constructed. However, this adds to the production cost.

Resource competition

Conflicting activities of the common users of the sea may pose problems for stocking suitable culture sites .The proximity of the culture sites to navigation channels, recreational activities and industrial activities may expose the farm to a series of problems generated by the normal activities of the common users. The wave action created by vessels, which may have a disturbing or destructive effect on both the cultured organisms and rearing facilities.

Economic consideration

While considering the different options of culturing (eg. bottom, raft, rack, long-line, etc.) the species, a cost benefit analysis is to be done when the site is selected. Culturists interested in commercially growing oysters, as the selected bivalve species, will be confronted with the initial capital investment required to set up the operation. The various culture systems, which may be set up to culture the oysters, require different levels of investments depending on the complexity of the system itself.

Potential culturists with adequate financial resources may well consider investing in a more capital intensive system such as the raft culture or the long-line method. If the financial needs do not pose any major problem, the investor will direct his efforts in selecting sites suitable for establishing long-line facilities, therefore excluding all other sites unsuitable for this culture method.

Conclusion

The prospective cultivator may be looking for a site on which to cultivate particular types of bivalve mollusc. Or he may already have a site in mind, and needs to decide which species would perform best and be most profitable for that site. Careful consideration of the criteria discussed above will help him to arrive at the most suitable choice. It is wise to approach site selection with caution, since once committed; any errors in judgement may prove expensive. Environmental data and other information on sites may be obtained from various organisations. When looking at environmental data, it is well to remember that there will be a certain amount of variation within and between years for the same site. Very few sites, if any, are likely have the perfect blend of qualities for the cultivation of the chosen bivalve species. Choice of site will also be restricted by availability. Growers should avoid sites where several environmental factors provide less than optimum conditions, as each may impose a small stress on the bivalves, which together result in poor growth and possible mortality. Where circumstances permit, the cultivator should evaluate the suitability of a number of sites in a pilot study with trial plantings of the chosen bivalve species. Growth differences between sites usually reflect differences in conditions, which may be specific to the sites. These conditions may vary widely between and within years, requiring long-term studies of at least one year and preferably longer, to get an accurate picture of the suitability of the site for cultivation. Finally, it should be remembered that a successful and profitable bivalve cultivation operation requires good husbandry and management of the stock as well as the selection of a suitable site.

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Table 1. European Union (EU) standards to be met for export of mussel products.

	Parameters in farm site	Mandatory level
1.	Colour	> 1mg Pt/l
2.	Temperature	± 2 °C from normal sea temperature
3.	pH	7 – 9
4.	Salinity	2 – 48 ppt
5.	Dissolved oxygen (Saturation)	>80 %
6.	Suspended solids (mg/l)	30 %
7.	Petroleum hydrocarbons	Should not be deposited in the flesh.
8.	Organo-halogenated substances	Should not exceed harmful levels in shellfish and larvae

Bacteriological parameters: Maximum permissible limit (Nos./100ml)		
1.	Faecal coliforms	<300 in the shellfish & intervalvular liquid
Heavy Metals in tissue: Maximum permissible residual level (ppm)		
1.	Mercury	1.0
2.	Cadmium	3.0
3.	Arsenic	75
4.	Lead	1.5
5.	Tin	250
6.	Nickel	80
7.	Chromium	12
Pesticides in tissue: Maximum permissible residual level (ppm)		
1.	BHC	0.3
2.	Aldrin	0.3
3.	Dieldrin	0.3
4.	Endrin	0.3
5.	DDT	5.0
Antibiotics and other Pharmacologically active substances in tissue: Maximum permissible residual level (ppm)		
1.	Tetracycline	0.1
2.	Oxytetracycline	0.1
3.	Trimethoprim	0.05
4.	Oxolinic acid	0.3

Table 2. Criteria for classifying shellfish harvesting areas.

Classification category	Faecal coliform bacteria (*E.coli*) per 100 g shellfish flesh	Comment
A	All samples less than 300 (230)	Suitable for consumption. Can be marketed.
B	Less than 6,000 (4,600) in 90% of samples.	Depuration needed (or relaying in catergory A area or cooking by an approved method).
C	All samples less than 60,000 (46,000)	Relaying (minimum of two months in approved relaying area or cooking by an approved method).
Prohibited	Above 60,000 (46,000)	Cannot be taken for placing n the market.