



**CMFRI**  
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# **ARTIFICIAL REEFS AND SEAFARMING TECHNOLOGIES**

**CENTRAL MARINE FISHERIES RESEARCH INSTITUTE**

INDIAN COUNCIL OF AGRICULTURAL RESEARCH  
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ERNAKULAM, COCHIN - 682 014, INDIA

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**DR. K. RENGARAJAN**

*Editor*

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## TECHNOLOGY OF MUSSEL CULTURE

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### Introduction

Culture of edible molluscs is now recognised as an effective way of enhancing food production and sea mussels among all the known cultivable organisms, give the highest production rate for two reasons : (1) they feed directly on the primary producers namely the phytoplankton and (2) it is farmed three-dimensionally in the water column at the farm site. The world production of mussels amounted to 13,37,551 tonnes in 1988 (FAO, 1992) of which 10,86,310 t originated from culture. China ranks first in the production of cultured mussels in the world, followed by Spain, Italy, Netherlands, Denmark and France.

### Resources and distribution

The green mussel *Perna viridis* and the brown mussel *P. indica* are the two species occurring along the Indian Coasts. The green mussel enjoys a wider distribution along the east and west coasts of India, including the Andaman Islands, whereas the brown mussel is restricted to the southwest coast of India. Along the east coast, the green mussel is found on small beds in Chilka Lake, Kakinada, Madras, Pondicherry, Cuddalore and Porto Novo and along the west coast it forms on extensive beds around Quilon, Alleppey, Cochin, Calicut to Kasargod, Mangalore, Karwar, Goa, Bhatia Creek, Malvan and the Gulf of Kutch (CMFRI, 1980). Regular fishery for the green mussel exists in the region from Calicut to Kasargod and for brown mussel from Quilon to Kanyakumari along the Kerala Coast. The total annual production for both the species from traditional fisheries has been estimated at 10,000 t. This annual production of 10,000 t from the natural beds can be taken as the maximum sustainable yield from the available stocks. Being sedentary animals, whose distribution is limited to the intertidal and submerged rocks in the shallow waters, further increase in the yield is possible if suitable substratum is provided for the mussels for growth.

### Biology

Mussels are sedentary animals with elongate, equivalved and inequilateral shells. The two valves are hinged at the anterior end with terminal umbo. External colour of the shell is green in *P. viridis* and dark brown in *P. indica*. Interior of the shell is margaritaceous and shining, muscle scar deeply impressed. Foot is finger-shaped, thick and extensible. Byssus threads emanate from the byssus stem and threads are long, thick, strong with a well developed attachment disc at their distal end. The mussels can discard the byssus threads and secrete new ones for enabling it to change its position. Phytoplankton forms the food of mussels and like oysters they are filter feeders.

### Growth

*P. viridis* grows to 63 mm in 6 months, 91.5 mm in one year 117 mm in 2 years, 129 mm in 3 years and 135 mm in 4 years at Kakinada. At Ennore Backwater, green mussels have grown to 64 mm in 8 months. At Kovalam near Madras, mussel seeds of 13.6 mm have grown to 52 mm in 3 months and 25-30 mm to 70-75 mm in 3½ months when grown in ropes suspended from rafts. At Muthukad 26.6 mm green mussels have grown to 52.4 mm in 6 months when grown on poles and 47.9 mm when grown in nylon webbing. At Calicut 23.6 mm mussels have grown to 88.2 mm in 5 months when grown in ropes suspended from rafts and 66.9 mm in the natural bed. In the Binage Bay, Karwar 17.5 mm mussels reached 62.6 mm with an 4½ months in culture rafts. At Ratnagiri 8 mm spat have grown to 61 mm in 7 months. At Goa, in natural bed, mussels have grown to 96 mm, 132 mm and 156 mm in 1-3 years respectively. Cultured mussels reached marketable size of 60-64 mm within 5 months and in 11 months they reached 85 mm.

*P. indica* of 20 mm have reached 55 mm in one year when grown in ropes suspended from

rafts in Vizhinjam Bay. The cultured mussels usually grow faster than those in natural bed and growth is comparatively faster in the open sea when compared to the Vizhinjam Bay.

#### *Condition index*

Condition index shows seasonal changes and is usually related to reproductive cycle. Index is always high before spawning. In *P. viridis* the meat is 33 to 40% of the total weight at Calicut in farmed mussels and in natural bed population it ranged from 27.2 to 29.2%. At Vizhinjam, the raft grown *P. indica* had 21.3 to 47.8% of meat in total weight.

#### *Reproduction*

In mussels sexes are separate and reproduction and larval development are similar to that of edible oysters. The male gonad is creamy white and in females it is pink or reddish. The mussels attain maturity at very small lengths. The green mussel attains maturity at 15.5 to 28.0 mm. The peak spawning period of the green mussel at Kakinada is from January to May, at Madras and Goa year round, at Calicut August-October and at Ratnagiri June-September and February-March. At Vizhinjam brown mussel spawns from the end of May till September with peak in July-August.

#### *Technology of mussel farming*

##### *Seed collection and seeding*

The major part of the seed required for farming is collected on ropes suspended from the rafts during the peak spawning period. The spat settled on ropes are allowed to grow to a length of 30-40 mm. These half grown mussels are collected and transplanted to fresh ropes to avoid overcrowding and help further rapid growth and fattening. Seed mussels are also collected from the natural mussel beds during low tide. A well experienced farmer collects upto 100 kg seed in one tide. These seeds are wrapped around the ropes with a loosely woven synthetic netting, which is specially manufactured for Spanish mussel farming. The seeded length of the rope is 8-10 m and these ropes are suspended at rafts 60-70 cm apart from the rafts. In the raft culture, the seeds reach harvestable size of 70-100 mm by 18-24 months in the temperate waters.

Mussel seeds are collected from the intertidal and submerged mussel beds after the peak spawning season (September-November). Normally an experienced person can easily collect 20-30 kg of mussel in one hour. The average seed size for farming is 15-25 mm and 600 g seeds are required for seeding 1 m length of the rope. Synthetic and coir ropes of 15-20 mm diameter are suitable for growing mussels from the rafts. The seeds are placed around the rope and securely wrapped with knitted cotton cloth. The seeded ropes are suspended from the rafts, 0.5-1 m apart, with the lower free end of the rope about 2 m above the sea bed. An optimum of 60 ropes, each having 6 m seeded length can be suspended from a raft of 6 x 6 m size. The seed mussels get attached to the ropes by means of freshly secreted byssus threads in two to three days and the cloth disintegrates in seawater within about 10 days. After the suspension of seeded ropes the mussel culture farm needs only minimum attention to see that the rafts are in good shape and the ropes with growing mussels are hung properly.

##### *Hatchery production of spat*

The basic technology for production of spat of *P. viridis* has been developed by CMFRI at Madras and for *P. indica* at Vizhinjam. At Goa, the National Institute of Oceanography also has achieved spat production in the case of green mussel. So far large scale production of mussel spat in hatchery has not been tried in our country.

##### *Culture methods*

Methods currently used for culturing mussels in the tropical and temperate waters fall into four categories : (1) the sea bottom culture, (2) Pole culture, (3) suspended (raft) culture and (4) Long line culture.

##### *Sea bottom culture*

This method is widely practiced in Holland, Netherlands, Denmark and Germany. The principle of sea bottom culture is the transfer of young or seed mussels from areas of great abundance, where growth is often poor owing to overcrowding, to areas of good growth and fattening. Government allows farmers to collect mussel seeds from public seed beds during certain specified periods. The wild seeds are gathered by

special mechanised mussel boats, equipped with three or four powered dredges. Each dredge can be operated separately and one dredge load will bring 500-600 kg of mussel seeds. One boat can carry 5000-6000 kg mussel seeds. Seeds collected thus are transferred to private culture plots, leased to the individual farmers and allowed to grow at the bottom. The half grown mussels are later transferred to plots in deeper areas for further growth and fattening. Normally the seeds reach the harvestable size of 50-70 mm in 20-36 months.

#### *Pole culture or "Bouchot" culture*

Culturing mussels on poles is mainly carried out in the extensive intertidal mud flats along the Atlantic Coast of France. Initially rows of poles called "bouchots" interwoven with branch-wood are placed in the deeper part of the intertidal zone to allow mussel spat to settle during the spawning season. When the spat grow slightly bigger they are transferred to "bouchots" placed in shallow area in the same zone. Now-a-days "bouchot" used for collection of spat, are obsolete and forbidden since they cause silting. At present seed collection is carried on loosely woven cocoa fiber rope, 13 cm diameter and 3 m long, placed on fixed poles in the intertidal area near the natural mussel beds during spawning season. Spat settlement takes place in 2-3 weeks between rope stands. These ropes are removed and wound around oak poles, 15-20 cm thick, 5 m long and driven 2 m into the tidal flat. The mussels attain marketable size on the poles. Periodical thinning of mussels from the poles is necessary to prevent overcrowding. The mussels attain harvestable size of 50-70 mm in 24-36 months.

#### *Mussel culture on ropes suspended from raft*

This method has shown the greatest development in recent years and appears to offer the best prospects for future expansion. There are two basic types of suspended culture, fixed and floating rafts. Suspended culture from fixed rafts is usually practiced in bays or sheltered areas, where the depth is less than 4 m with very little tidal range. This method is being followed along the European Coasts of Mediterranean and Atlantic, including Spain, southern France, Yugoslavia and Italy. The fixed mussel raft or park is constructed on top of 200 concrete posts of 15 x 15 cm size and 7 m long, piled in 5 rows of 40

each, at a distance of 5 m. 2 m length of the posts are driven into the bottom, 4 m in water and 1 m above the water level. A framework is constructed on top of these posts using wooden beams of 20 x 10 cm size. Eucalyptus poles are nailed over the framework at an interval of 1-1.5 m for suspending the mussel ropes.

#### *Longline culture*

Longline culture of mussel is practised in shallow waters of 10-15 m depth. This method of culture can withstand the severe monsoon conditions in the west coast. A single longline consists of 60 m long horizontal HPD rope of 20-24 mm thickness, anchored at both the ends with 150 kg concrete blocks and a series of 100 lt capacity barrels as floats fixed at 3 m intervals. Vertical lines of 6 m length seeded with mussel spat are hung at a distance of 75 cm between two floats in the main line. A longline unit of 60 x 60 m can accommodate 12 horizontal ropes and 920 to 1,000 vertical seeded ropes. The horizontal lines are interconnected using additional lines.

Mussel farming trials were initiated in the Vizhinjam Bay by following the floating raft culture method in 1973 and later the experiments were shifted to the open sea. In 1975, experiments on culture of green mussel were initiated in the open sea at Calicut and Madras adopting the floating raft culture technique, which continued upto 1980. After successfully developing and demonstrating the technique and production potential at Calicut the programme was shifted to Karwar in 1980 to explore suitable sites for mussel farming, to do further developmental work and demonstrate the production potential along the Karnataka Coast. Concurrent to the above developments, the National Institute of Oceanography developed a research programme on mussel culture in Goa. The Konkan Krishi Vidyapeeth implemented a project on mussel culture at Ratnagiri. Several short term experiments on mussel culture have been carried out by some University departments also.

#### *Production and farming of mussel P. viridis by raft method comprising 10 rafts of 8 x 8 m*

A commercial unit comprising 10 rafts, each measuring 8 x 8 m is considered. Each raft holds 100 ropes and the seeded portion in each rope is

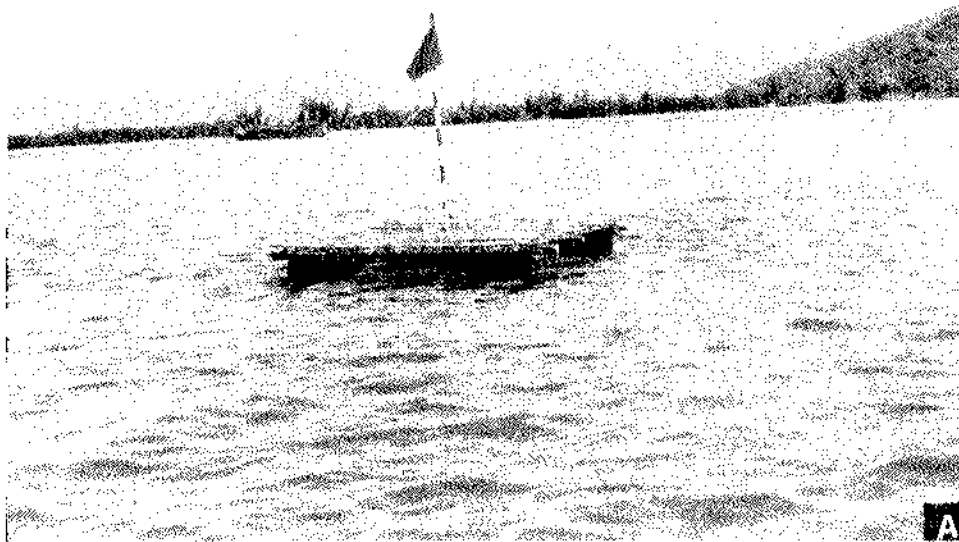


PLATE I A. Mussel raft in the open sea and B. Seed collection from the wild.

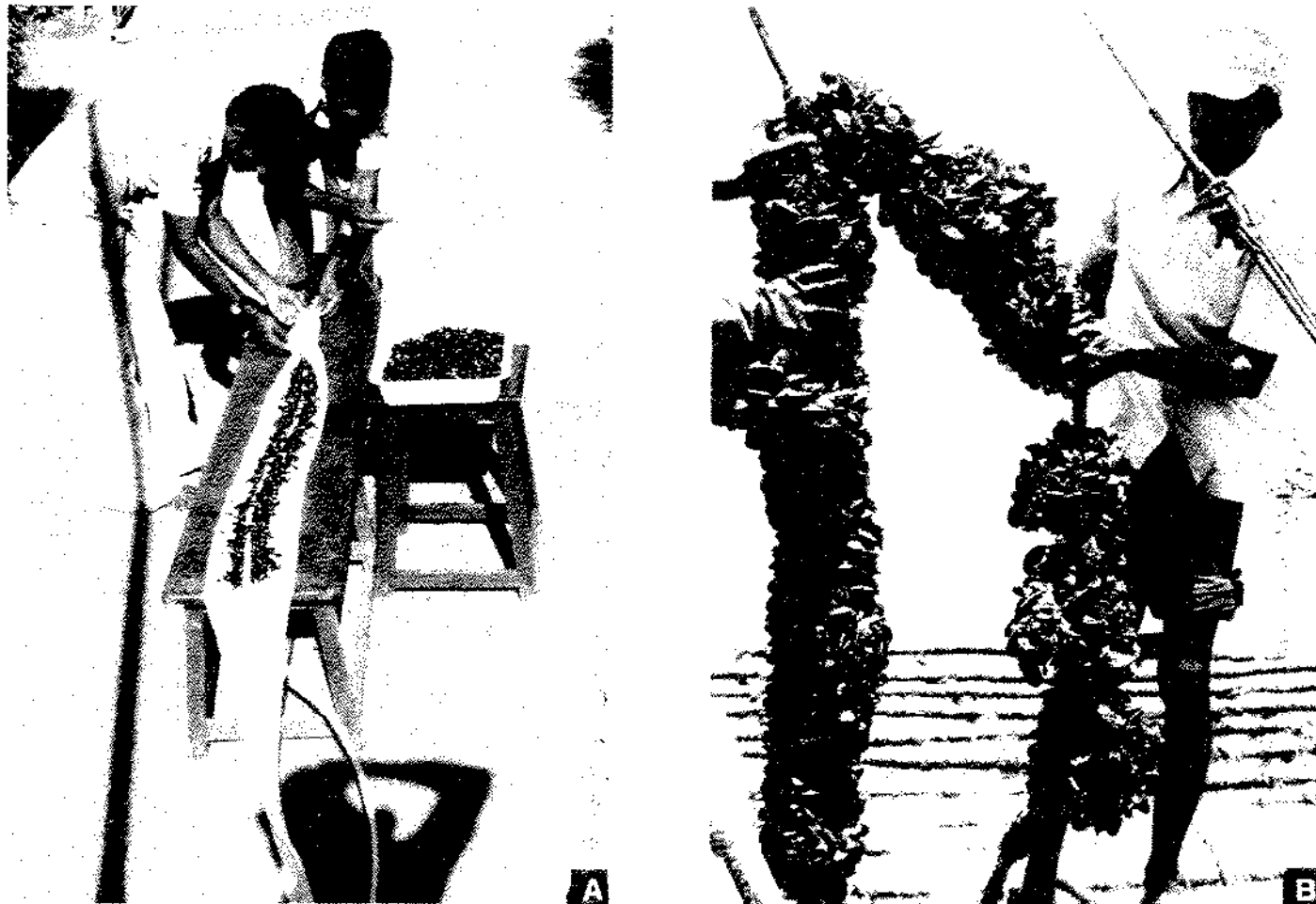


PLATE II A. Seeding of rope and B. Fully grown mussels ready for harvest.



6 m. The duration of the culture is taken as six months and a single crop is envisaged during the course of a year since the sea conditions are not generally favourable for a second crop. Depreciation was calculated on annual basis and the recurring expenditure for the duration of the crop.

In a three year period, the raft is operational for one-and-half years only; cheaper materials like bamboo/eucalyptus poles, and empty oil barrels instead of specially fabricated MS barrels as floats, would meet the requirement.

The production per raft is 6.18 t. The current market price of the mussel at Calicut is Rs. 4,500/t whole weight.

A. Capital expenditure	Rs.
FRP boat with outboard motor	80,000
Cost of 10 rafts	1,00,000
<b>Total</b>	<b>1,80,000</b>
B. Recurring expenditure	
Cost of seed	9,000
Ropes	28,000
Labour cost	28,000
Knitted cloth	8,000
Running cost of boat	9,000
Salary for manager @ Rs. 2000	12,000
Watch and Ward @ Rs. 2000	12,000
Rent for office	6,000
Contingencies	10,000
Unforeseen	5,000
<b>Total</b>	<b>1,27,000</b>
C. Total investment (A+B)	3,07,000
D. Interest at 15% for 12 months on A and 7 months for B	38,112
E. Production cost	
Depreciation on FRP boat @ 12.5%	10,000
Depreciation on rafts @ 33.3%	33,333
Recurring expenditure (B)	1,27,000
Interest (D)	38,112
<b>Total</b>	<b>2,08,445</b>

#### F. Income

Total mussels harvested from 10 rafts (10 x 6.18 = 61.8 t)	
Sale proceeds @ 4,500/tonne	2,78,000

G. Net profit	69,555
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#### *Production and economics of mussel farming by longline method in 0.36 ha area*

Duration of mussel farming is 5-6 months and in the longline method, in an year, two crops can be taken. The growth of mussels in the open sea culture is very rapid. Each mussel gains 11.6 to 12.9 mm in length and 5.9 to 7.3 g in weight per month. A production of 10-12.5 kg marketable size mussels can be obtained from one metre of rope. From a longline unit of 360 m<sup>2</sup> a total production of 54,720 kg shell-on mussels can be obtained of which 40% will be the meat.

The initial investment required for the establishment of a longline unit in an area of 0.36 ha (60 m x 60 m) in open sea works out at Rs. 2.5 lakhs. An entrepreneur has to spend about Rs. 2 lakhs towards operating expenses for a crop. Since it is a labour-intensive technique, about 66.5% of the operating cost is incurred towards wages to the labourers. The net profit to an entrepreneur, venturing into open sea mussel culture, works out to Rs. 2.2 lakhs per crop. At the existing price of Rs. 10 per kg, the break-even production required to cover all the costs works out to 33 t of mussels as against the expected production of 55 t per crop. The cost of production of one kg of mussel in open sea culture works out to Rs. 6/- at the current level of input cost. Besides generating alternative employment to fishermen, the entrepreneur earns substantial profit by adopting this technique of mussel farming.

#### *Economics of open sea mussel farming (0.36 ha area)*

I. Initial investment	Rs.
Cost of construction of a longline unit (floats, anchors, anchroline, horizontal & vertical lines)	1,28,000
Floating platform for watch & ward	25,000

FRP dinghi & OB engine	75,000
Spat collectors	10,000
Others	12,000
Total	<u>2,50,000</u>
II. Fixed cost (Annual/crop)	
Depreciation @ 33.3%	83,250
Interest @ 18%	45,000
III. Operational cost (per crop)	
Seed	30,000
Materials (cotton cloth, cement block, etc.)	15,000
Labour	1,33,000
Miscellaneous	22,000
Sub Total	<u>2,00,000</u>
IV. Total cost (annual) (II + III)	3.3 lakhs
V. Expected production	55 tonnes
VI. Gross revenue at Rs. 10/kg	5.5 lakhs
VII. Net profit (VI - IV)	2.2 lakhs

The social climate along our country's coast line is very congenial for promoting sea farming of mussel and the fishermen communities can participate in the production programme. If open sea mussel culture is carried out in an area of 0.36 ha by a group of ten fishermen, each one would receive about Rs. 13,300 as wages for the maintenance of installations and obtain a profit share of about Rs. 22,700 per head per annum. The social and economic benefits are very high as the annual per capita earning of a fishermen works out to Rs. 36,000/- including wages. The dwindling catch rates in the capture fisheries and the declining employment opportunities have resulted in diminishing annual and per capita income to traditional fishermen. At this juncture mussel farming offers a sustainable and viable economic activity to the coastal rural communities.

#### *Purification of mussels*

Mussel is a sedentary bivalve growing attached to rocks or any other hard substratum in coastal waters by means of self secreted byssus

threads. They are filter feeders and therefore at any given time their stomachs are likely to be loaded with mud/sand particles and bacteria. Hence depuration of mussels is very important. Legislation regarding sanitary requirements in marketing mussels can be classified into two groups. In most countries mussels can be marketed only when originating from clean waters, where regular analysis ensures that quality is maintained. However, in southern Europe (Spain and Italy) all mussels must be depurated, wherever they originate from. As a result there is less stringent enforcement as to water quality, where the mussels are grown.

It is rather easy to purify mussels of bacterial pollution, because they cleanse themselves of this type of pollution bacteria if kept in clean filtered sea water for 24-48 hours. This treatment can also clean the mussels of mud and sand particles in the stomach. The depuration process consists of three aspects: (1) pumping clear sea water into large storage tanks (2) sterilization of water using 2-3 ppm chlorine or 1-2 mg ozone/litre and (3) keeping mussels in sterilized water for 24-48 hours. Recently ozone is widely used for sterilization of water, as it is a powerful oxidising agent capable of killing bacteria and viruses rapidly.

#### *Prospects*

The advantage of mussel culture in our waters when compared to the temperate region is that the rate of production here is very high. In European waters the seeds attain marketable size in a period of 12-36 months. Here it takes only 5-6 months, because of the high productivity of the tropical waters.

The peak spawning season of green mussel along the west coast of India is from August to October and along the east coast it is May-July. Seed collection and seeding can be made during this period. The crop will be ready within 5-6 months and subsequently due to the monsoon the culture operations cannot be continued. If suitable modifications are made in the floating raft culture system to keep the farm structures in position even in monsoon conditions or by adopting the latest method of long line culture developed for open sea rough conditions, theoretically two crops are

possible. The mussel in the farm spawns continuously 2-3 months after their initial seeding and seeds for further farming will be available from the farm itself.

During the peak spawning season profuse settlement of spat takes place in the presently heavily exploited area. While exploiting the larger mussels, these seed mussels which form clusters with the grown-up mussels are also removed. The catches along with the seed are normally brought to the shore, where they are sorted and the seeds are discarded. The seeds thus destroyed will be 20-30 times the number of the marketable mussels. During one season the number of seed thus destroyed can be staggering. If these seeds are utilized for suspended culture there will be multifold increase in the production of mussels.

The immediate need is for a perspective planning for the development of mussel culture as

an industry with the full realisation of its potential. Government support and assistance from public financing institutions with an element of risk coverage in the initial stage would help the establishment and growth of the industry. Mussel culture, should at least, to begin with be viewed as social necessity with a bias on nutritional improvement of the people and employment potential. Later, if necessary, it can be oriented for export market.

*Suggested reading*

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