Aquaculture Extension Manual No. 6

Manual on MUSSEL FARMING

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SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER
Tigbauan, Iloilo, Philippines
SEPTEMBER 1979

MANUAL ON MUSSEL FARMING

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ACKNOWLEDGMENT

This manual is the end product of three years of work which was made possible with the generous assistance of the Government of New Zealand in the form of materials, expertise and training.

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I. Biology of the Green Mussel *Perna viridis L. (formerly Mytilus smaragdinus)*

A. Species suitable for farming

The green mussel, or tahong, *Perna viridis* (formerly *Mytilus smaragdinus*) is the species of mussel farmed commercially in some areas in the Philippines. This mussel should not be confused with the brown mussel, or amahong, a more widely distributed species common in many shallow bays throughout the Philippines. The brown mussel belongs to another genus – *Modiolus,* of which there are 2 species: *Modiolus metcalfei* and *Modiolus philippinarum.* It is easily distinguished from the green mussel by its brown color and hairy appearance. Unfortunately, the brown mussel is not suitable for farming because it is not known to attach to rope or bamboo but only on living adults growing in dense mats on the muddy bottom. The brown mussel is widely distributed, occurring in Luzon, most Visayan islands, and Mindanao. In contrast, the popularly cultured green mussel has a more restricted distribution and occurs only in Bacoor and Manila Bays in Luzon; Panay, Negros and Samar Islands in the Visayas, with no confirmed occurrence in Mindanao.

B. Life cycle

Adult mussels live attached to solid substrates by means of byssal threads. When sexually mature, mussels spawn or release their eggs and sperms freely into the water where fertilization takes place. Fertilized eggs develop into larvae within 24 hours and remain free-swimming for 15-20 days before they mature and are ready to settle and attach themselves to solid substrates. This event is called *spatfall* and the attached young mussels are called *spats.*

C. Habit

In the water, mussels live attached to solid objects by means of *byssal threads.* These threads are secreted by the foot and serve to attach the mussel firmly to its substrate. If these byssal threads are damaged or cut, the mussel can secrete new threads within a few hours. Moreover, by using both foot and these byssal threads, the mussel can crawl around and change its position. This ability to move around sets it apart from the oyster (oysters remain cemented to their substrate for life) and allows for thinning and transplanting operations in mussel farming.

D. Growth

Growth rates of green mussels average 1 cm a month, allowing it to reach

marketable size (40-50 mm) in 4-6 months. Growth rates vary, however, with the availability of food in the water. They can reach a size of 150 mm or more but adults generally average 50-60 mm in length. At these sizes the uncooked meat comprises 40-45 percent of the total weight (whole unopened mussel).

E. Reproduction

1. Sexual dimorphism

The sexes in the green mussel are separate. One cannot tell a male from a female just by looking at the shells, although the color of the meat inside may be used to tell the sex of a mature animal. The meat or mantle of a male mussel is generally milky white to creamy white in color, while that of a mature female is orange to red orange. The ratio is generally 1:1.

2. Maturity

Perna viridis is sexually mature at 20-30 mm in length. Mussels of this size range are easily stimulated to release their eggs and sperms and very suitable for use as transplants for increasing natural mussel stocks.

F. Feeding

The green mussel is a filter-feeder (ciliary-mucoid feeder). It has 4 rows of gills which serve as both respiratory organs and the filter-feeding apparatus, deriving both oxygen and food from the water.

The food of the green mussel consists of microscopic plants and animals (phytoplankton and zooplankton) suspended in the water. Feeding activity is affected by temperature, salinity, and the concentration of food particles in the water.

G. Predators, parasites, and associates

Juvenile and adult mussels have one main enemy, the crab. The alimango, *Scylla serrata* is the principal predator, although there are a few other species which also prey on mussels. Crabs are capable of cracking their shells and large adult can easily consume a dozen or more mussels every day.

Next to crabs, starfishes are also a serious enemy of mussels although certain methods (e.g. raft method) of farming make it less easy for them to invade the stocks.

Various other organisms are associated with the green mussel in one way or another. Potentially harmful associates include fouling organisms that attach to the shells (e.g. barnacles, filamentous algae, bryozoans and tunicates), ectoparasites that live on the shell and endoparasites that live within the tissues of the mussel. These fouling organisms and parasites may stunt the growth of the mussel, decrease the weight of the meat or affect its taste.

II. Review of Mussel Farming Techniques in the Philippines

In the Philippines, mussels were originally regarded as "pests" by oyster farmers and bamboo fish-trap operators in Cavite, as they competed with the oysters for space as well as for food. It was only in the 1950's that their value as a primary crop in itself was recognized by the Bureau of Fisheries biologists and technologists at the Binakayan Oyster Experimental Station in Cavite. The earliest recorded commercial mussel farm was a 300-square-meter farm in 1955. It was not till 1959 that another farm was established. From this very slow start, mussel farming suddenly proliferated in the early 1960's.

The method used in Bacoor Bay is very simple. Bamboo poles sharpened at the thick end are simply staked deep into the soft muddy bottom in waters as deep as 10 meters. The bamboo stakes are spaced from one to two meters apart. From observations on the appearance of young mussels during the initial first year of cul-

ture the Cavite mussel farmers generally install their stakes before April and perhaps again before November. The mussels are harvested by divers in six to ten months. Generally the mussels are stripped and the bamboo stakes allowed to rot in place and new stakes are laid alongside the old.

In 1974, a new method was tried successfully in Sapian Bay, Capiz by a U.S. Peace Corps Volunteer through the auspices of the Capiz provincial government. This method consisted of a web of polypropylene rope made up of two 5-meter lengths of rope positioned two meters apart and from which a 40-meter long rope was tied in a zig-zag fashion at 40 cm intervals. The free ends of the ropes at each of the four corners were then fastened to bamboo plots staked into the bottom, Fig. 1.

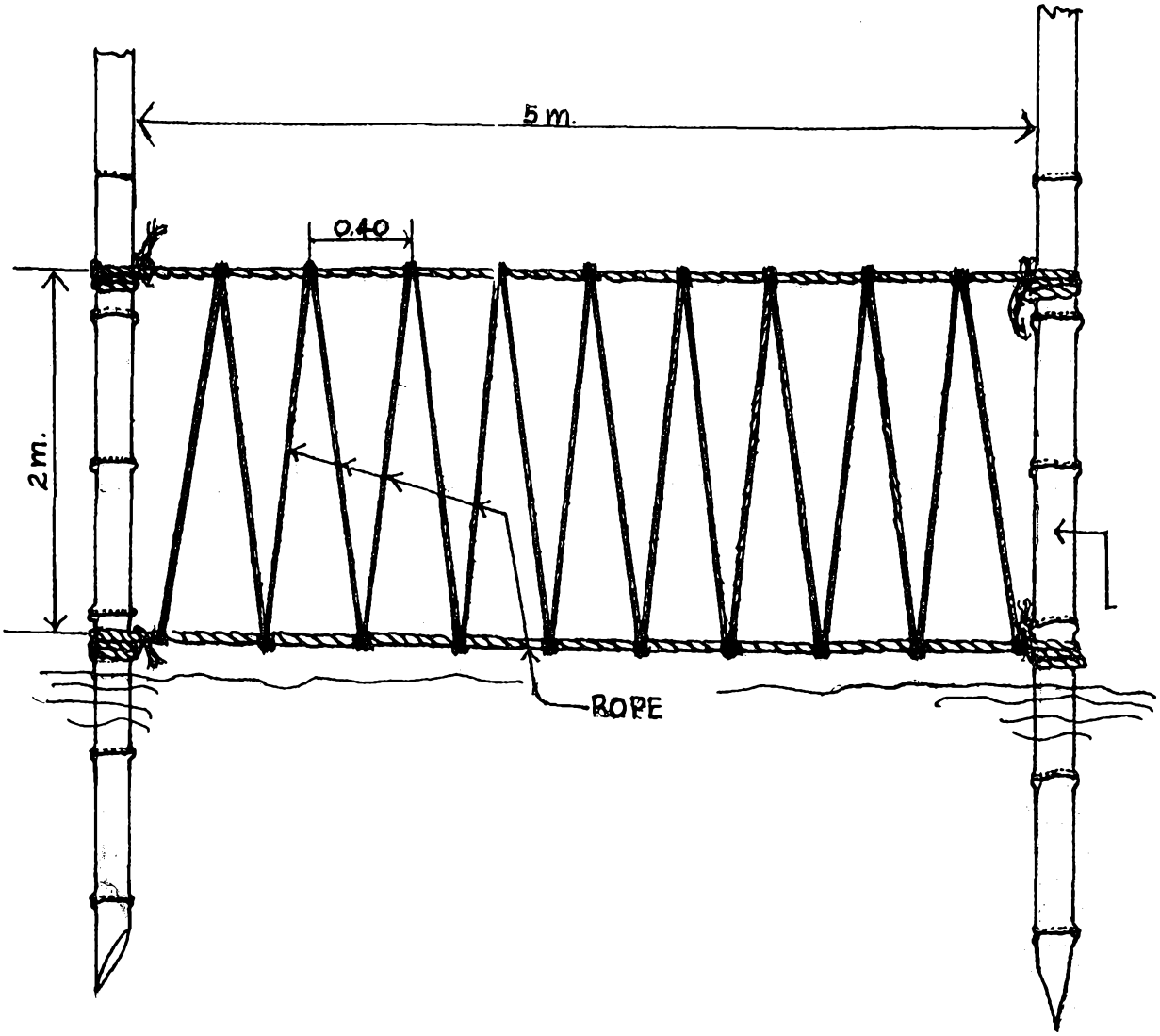

Figure 1. The rope-web method employed in Sapian Bay, Capiz.

Other methods used are basically modifications of the stake method in terms of providing the stakes with horizontally structured support or staking eight bamboo poles around a circle slanted towards the center so that the top ends meet and are fastened in a "wigwam" fashion.

All the above methods of farming mussels have one common drawback: – the heavy dependence on bamboo poles or stakes, and this has many disadvantages. Firstly, the cost of bamboo poles has become quite prohibitive, and this is accentuated by the fact that the poles are driven into the mud, the parts in the mud (approximately 10-20 percent), near the mud (another 10 percent), and the water surface (exposed at low tide) respectively are wasted. Also, mussels growing on bamboo stakes are preyed upon by all types of crawling organisms such as drills, and other harmful gastropods, starfishes, crabs and sea urchins. The xanthid crabs which nest inside submerged bamboo poles have also been observed to be capable of toppling bamboo stakes when the stakes have been in the water beyond six months. Managing a stake-method mussel farm is difficult due to the fact that regular maintenance and inspection can be carried out only when the tide is sufficiently low to permit easy diving. Other drawbacks in using bamboo poles include the crowding of mussels over certain portions only, and the difficulty in timing staking operations to coincide with spatfall.

Perhaps the greatest objection to the use of bamboo stakes is the increased rate of siltation of areas occupied by such stake-farms. This is brought about by the fact that bamboo stakes, especially when they are quite close to each other, hinder the flow of the water allowing suspended organic and inorganic matter to settle. Such increased siltation not only makes the farming area too shallow, but also adversely affects the ecology of the river due to the build-up of organic matter. As a result, growth of the mussels is retarded. Furthermore they may develop very thin shells which make them easy prey for crabs and fishes.

In France, a country with a long history of mussel culture, commercial farming of mussels also started with the stake method, with branches interwoven between the stakes. This method promoted so much siltation and degradation that they are now banned. Today, while the "bouchots" still consist of tree-trunks (oak or pine) 4-6 m long, horizontal branches are no longer interwoven in between the poles, and the poles are spaced 15-20 m apart to lower the rate of siltation in the area.

In Spain, the biggest producer of farmed mussels, the culture system uses ropes suspended from rafts moored in fairly deep waters of more than five meters. In order to prevent the build-up of silt beneath the farm the rafts are transferred from one area to another after each harvest. In New Zealand a system of buoys and long lines adopted from the Japanese system of oyster culture has been successfully applied.

Mussel farming using floating structures has several advantages: 1) faster growth of mussels; 2) possibilities for regular thinning; 3) ease in harvesting independent of tidal conditions; 4) rafts can be moved around, thus preventing silt accumulation; 5) rafts can be constructed out of durable materials capable of lasting several years; 6) predation by crawling bottom organisms is minimized; 7) greater production per unit area.

III. Basic Principles of Mussel Farming

A. Spatfall

Mussel farming depends entirely on one natural phenomenon: spatfall. This is the period when mussel larvae are developed enough to cease their floating existence, settle, and attach themselves to solid surfaces. Successful collection of these spats is essential for mussel farming.

While the technology to artificially produce the spats in controlled conditions is available, it is not yet economically viable and is probably not necessary considering the abundance of natural spats. The mussels need not be grown in the same area where the spats are collected, and in some cases it is actually more desirable to have a separate growing area. Here in the Philippines, however, all successful mussel farming ventures have been conducted in the spatfall areas. Thus, at the moment, the presence of natural mussel spatfall should be considered a primary criterion in determining the viability of a potential mussel farming project. Other parameters for the site selection are given below.

B. Site selection

The following must be considered when selecting a site for the mussel farm:

1. There should be sufficient breeding stock and spatfall in the area to produce enough young mussels for the farm.

2. The site should be protected from strong winds and waves.

3. The tidal range of the site should be enough to change the water completely and frequently. The greater the tidal exchange, the faster the growth as more food is brought to the suspended mussels and wastes are more easily flushed away.

4. The water should contain enough food for the mussels. (Generally, "clean" or "clear" waters do not contain enough food to sustain optimum growth of mussels. A greenish color in the water is one indication of food availability).

5. The tidal currents should be strong (no less than 2 cm/sec). Weak or slow water movements result in poor growth of mussels due to the slow replenishment of food. Furthermore, weak currents promote the settling of organic and inorganic particulate materials in the water.

6. The site should be sufficiently enclosed to effectively retain the larvae. (Offshore areas and exposed areas are usually poor areas for collecting young mussels because the mussels are carried out to sea before they have a chance to settle on collectors).

7. The site should be relatively deep. (At least 2 meters at low tide.

8. The site should not be too far upriver as to be subject to salinity drop during rainy season. Generally salinity decreases with increasing distance from the sea.

9. The site should be near the market or at least, should be near the road so that the mussels can easily be transported to market.

10. The site should be free from pollution and sewage. Pollution constitutes a double threat to the mussel industry for even if the mussels are not harmed by pollutants, they may concentrate and accumulate pollutants in their flesh and become unfit for human consumption. Discharges from fishponds using pesticides specially molluscicides, are particularly deadly to mussels.

C. Selection of suitable collector materials

Mussel farming depends largely on placing the right type of collector surface in the right place at the right time or season to collect young mussels or spats. In this regard, the choice of the collector materials is very important. Therefore, the following must be considered in choosing the type of collector to be used:

1. It should be "attractive" to mussel larvae. At the end of their larval period, mussel larvae all settle on filamentous objects, later moving on to more solid substrates are effective in "attracting" mussel larvae.

2. It should be easily available locally.

3. It should be easy and inexpensive to prepare.

4. It should be durable (should last till harvest at least).

So far, the only material which satisfies almost all of the above four criteria is coconut husk. Due to its hairy, fibrous nature coconut husk is a very attractive substrate for mussel larvae to settle on. Furthermore, coconut husks are readily available in the Philippines and are easy to prepare. The husk is stripped from the coconut shell and shredded. The only difficulty with coconut husk, however, is that it does not last long in the water, so that usually the mussels will have to be "re-laid" or transplanted.

In accordance with the above guidelines for the choice of collector materials, other suitable materials are cabo negro, old frayed ropes, etc.

IV. Farm Construction and Operation

A. Basic considerations

1. Cultures are always under water even at low tide. This is because green mussels have a natural preference for living below the lowest tidal level. Those mussels which manage to attach and survive above the lowest tide level are generally stunted or deformed.

2. Cultures should always be in an off-bottom position. This is to prevent potential predators such as starfish, crabs, snails and other organisms from crawling up the culture ropes.

3. Materials used should be durable enough to last at least until the mussels are harvestable. Durable materials, while generally more expensive initially, will pay off in terms of number of crops they can be used for.

4. Clusters of mussels on a rope should be adequately spaced so as to avoid any possible contact with each other especially through wave action.

5. Structures must always be so positioned as not to obstruct navigation and should be properly marked.

6. The cultures should be laid perpendicular to wave action and parallel to current flow, (i.e. lined up in the direction of current flow).

7. The environment of a mussel farm degrades with continued use. It is advisable to have an area two or three times larger than the actual culture site. This would allow the farm to be moved from one section of the area to another from year to year.

B. Raft or suspension culture: Materials and Design

Suspension culture of mussels consists of growing mussels on ropes hung from rafts or other similar floating structures. "Collectors" (coconut husk) are inserted into the lay of ropes to collect mussel spats. These spats are allowed to grow for 4-5 months and are harvested when they reach 37-60 mm in length.

The raft consists of 2 compartments:

a rigid framework (or lattice structure) from which the ropes are hung. This framework should be kept above water.

buoyant objects to keep the rigid framework floating.

1. The framework

Materials used for the rigid framework should be strong enough to support the weight of the mussels, but should not be so heavy as to require a great number of buoys to keep it afloat. In this regard, there are 2 choices: bamboo and lumber. Although bamboo breaks easily, it does

have the advantage of being cheap and widely available. Lumber, on the other hand, unless of the hardwood variety (those used for bridges and piers), generally will not last long in the sea. If wood or lumber is used, it should be treated with marine anti-fouling paints. A basic raft design is sketched in Figure 2.

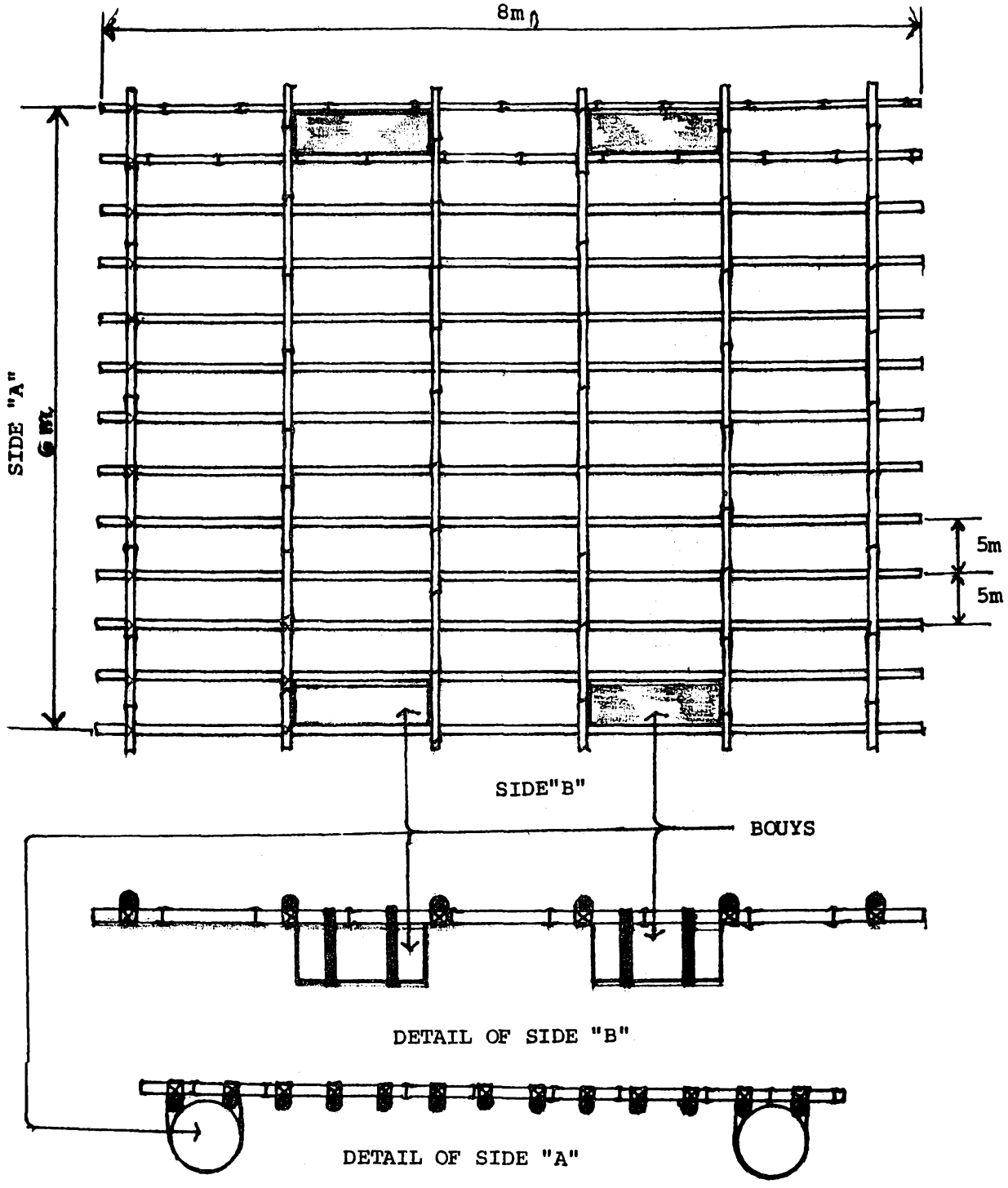

Figure 2. Construction detail of a mussel raft using bamboo framework and floats.

2. Floats or buoys to keep the rigid framework above water

Buoys made of various materials may be used to keep the rigid framework above water. Bamboo, metal drums, plastic drums, styrofoam blocks, and ferro-concrete buoys are some of the materials that may be used as buoys. The final choice should be based on availability, durability and cost.

Type	Durability	Cost	Availability
Bamboo	2 years at most	Low	Generally available
Metal Drum	1 - 3 years	Medium	Generally available
Plastic Drum	2 - 4 years	Medium	Limited availability
Styrofoam blocks	2 - 5 years	High	Needs special order
Ferro-concrete	at least 10 years	High	Materials for construction widely available

3. Ropes for collection and growing of spats

Ropes made of polypropylene or polyethylene, cabo negro, and abaca may be used. Although they are quite expensive the first two materials can last as long as ten years or even longer. Cabo negro and abaca are not as expensive as ropes made of synthetic materials and will last longer if treated with coal tar (coal tar should be thinned by adding one part kerosene to four parts coal tar). Ropes dipped in thinned coal tar should be allowed to drip dry for 3-4 days before use.

4. Construction of collector ropes and growing ropes

In the suspension culture of mussels, spats may be collected with collector ropes and later re-laid or transplanted to growing ropes or spats may be collected and grown on the same rope, without transplanting.

Collector ropes are usually shorter and thinner in diameter than growing ropes. Polypropylene and polyethylene ropes of 5 mm diameter may be used for collector ropes. Coconut husk pieces should be inserted into the lay of the rope at 50-60 mm intervals. Since both the rope and the husk are quite buoyant, it is necessary to tie a heavy object to the end of each rope to keep it weighted down. Stones wrapped in pieces of old netting or simple weights made of cement may be used for this purpose (Fig. 3).

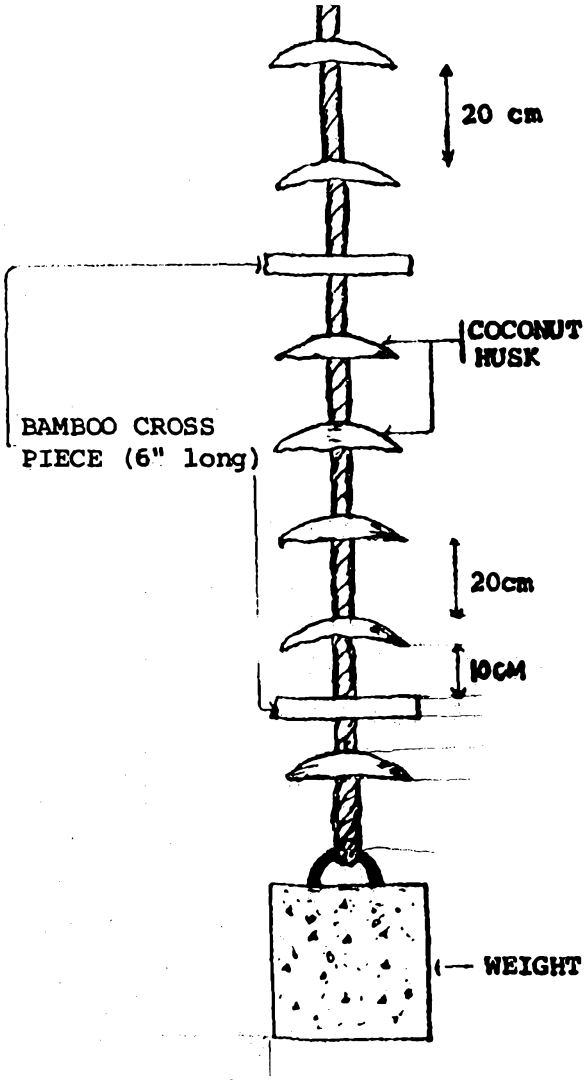

Figure 3. Detail of one (1) growing rope (2.0 m long)

Collector ropes should be hung approximately half a meter apart. Spats or young mussels collected on collector ropes to prevent over-crowding once they have grown to a length of 10-15 mm.

Cabo negro, abaca, polypropylene and polyethylene ropes 12-20 mm diameter may be used as growing ropes. A very important feature of growing ropes are the "pegs" – thin bamboo pieces about 25 cm long and 1.5 cm wide inserted into the lay of the rope at 30 cm intervals. These pegs prevent the heavy load of rapidly growing mussels from slipping off by taking the weight of the mussels in the section of the rope immediately above. This is likely to occur during bad weather, during the lifting of the ropes for regular inspection, or during harvest. If growing ropes are to be treated with coal tar, the pegs must be inserted into the lay of the rope before treatment.

Collector ropes laden with young mussels can be thinned by hand. As much as possible, the clump of mussel spats attached to each coconut husk collector should be broken gently into smaller clusters. In order to attach these small clusters (10-20 mussels per cluster) to the growing rope, the rope should be stretched between 2 persons while a third person fixes or binds the cluster to the rope by means of a thin cotton string or abaca twine. Alternatively, strips of cotton gauze may be used in place of string especially when the clusters are small or the spats are loose. To avoid crowding, a maximum of 300 mussels should be allowed per meter of growing rope. Since mussels are capable of crawling and secreting new byssal attachments, the young mussels will attach themselves to the growing rope a few days.

Growing ropes – in contrast to collector ropes – should be hung at least one meter apart. Length of growing ropes depends on the depth at low tide. Hanging growing ropes too close to each other results in slower growth of the mussels and promotes siltation. In deep waters (3-5 m) the ropes may be suspended individually from the bamboo frame. In shallower waters, however, ropes may be suspended as in Figure 4.

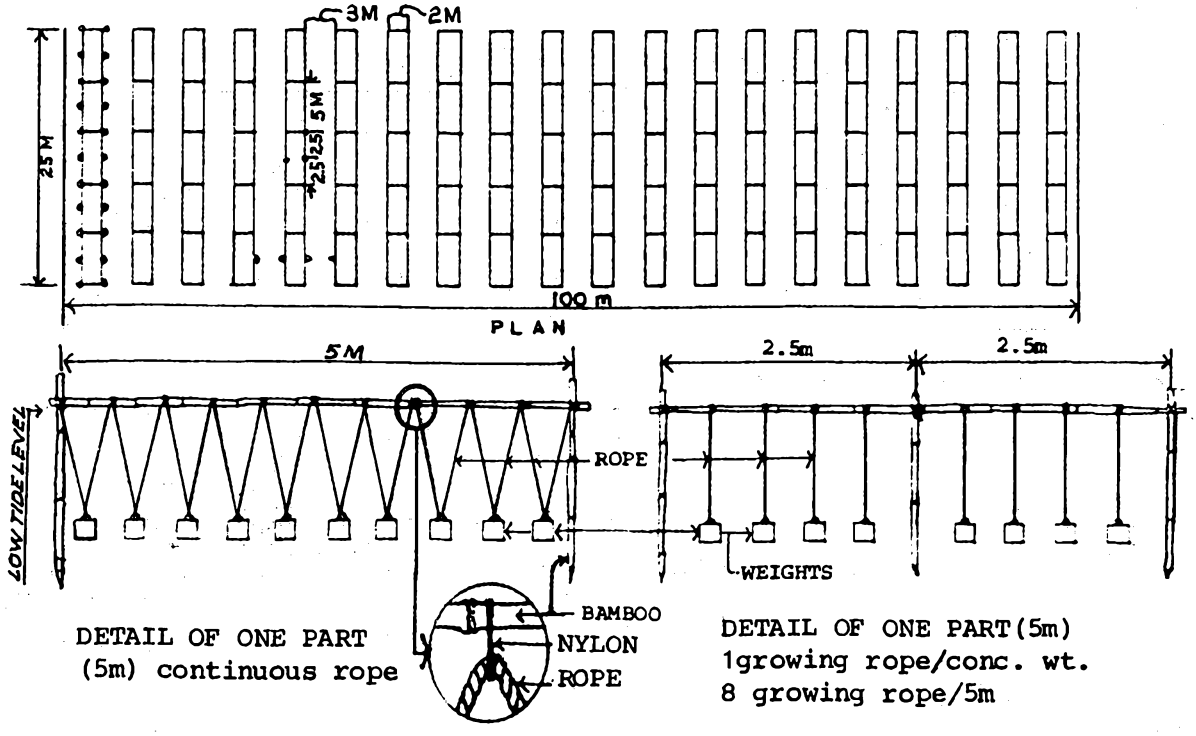

Figure 4. Fixed structure mussel farm using bamboo plots.

If it is desired to collect and grow mussels on the same rope (without any transplanting) the ropes may be prepared as for growing ropes. Additionally, however, coconut husk pieces should be provided as in collector ropes. The coconut husk pieces should be inserted into the lay of the rope about 15 cm apart. The ropes should be spaced as for growing ropes (at least a meter apart).

5. Pointers for raft-farm construction

Bamboo poles may be lashed together with either monofilament nylon or galvanized wire to form the lattice or framework of the raft. Buoys should be lashed securely to the bamboo framework and distributed evenly. Enough buoys should be used to keep the bamboo framework above the water at all times.

Rafts may be tied together then laid out in a series 3-4 meters apart with an anchor at each end of the line (Fig. 5).

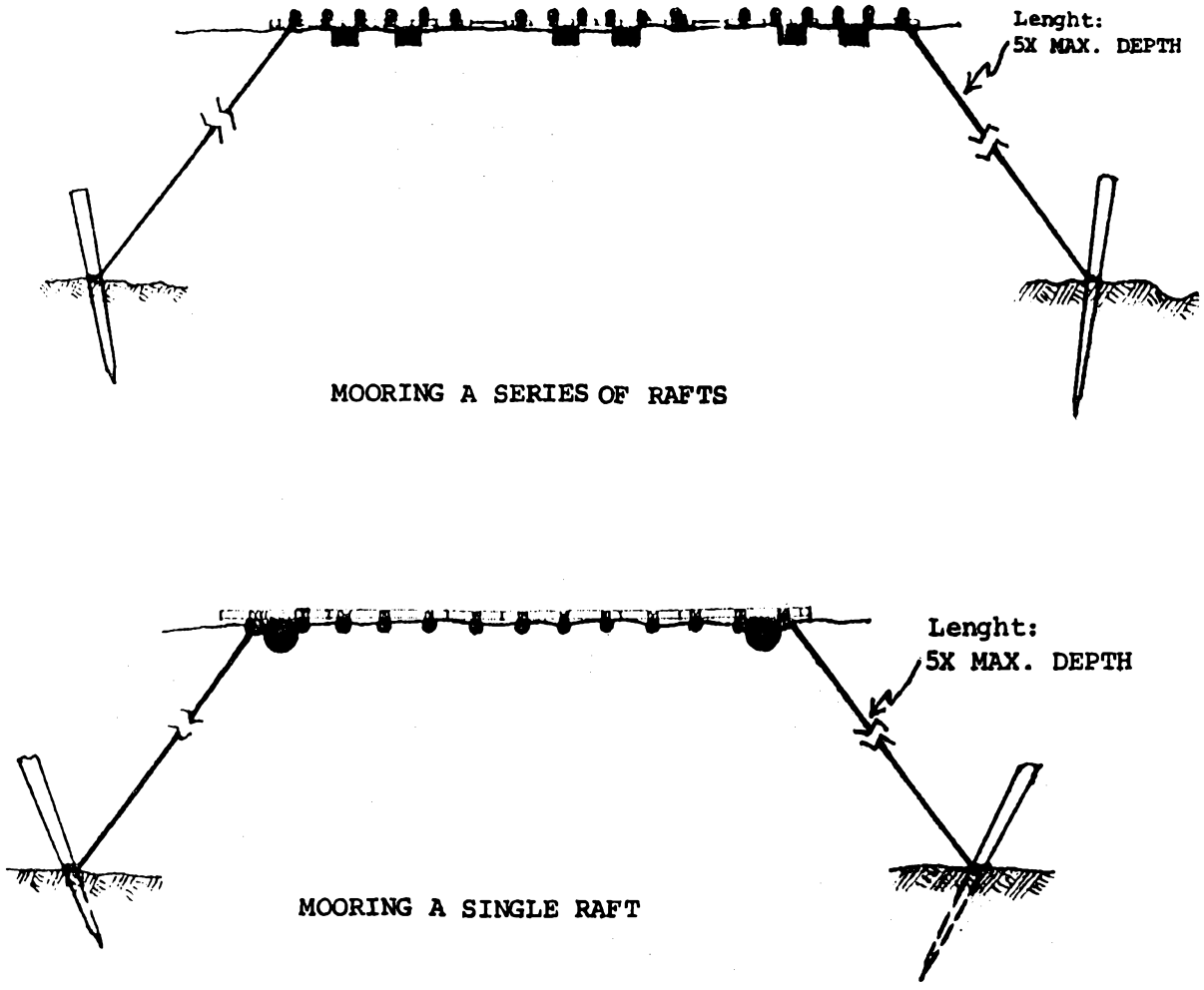

Figure 5. Methods of mooring a single raft or a series of rafts.

In shallow areas the rafts may be moored to stakes. The whole series of raft should be laid out parallel to the direction of the current, taking care not to obstruct navigation or fishing. Markers set conspicously around the farm will minimize the possibility of damage to the raftswhen bumped by vessels.

6. When to hang collector ropes

Settlement of mussels on collector ropes depends on the spawning habits of local adult population. Random spawning occurs throughout the year with peak seasons during which a greater proportion of mussels spawn. The precise time of peak seasons varies greatly with locality, water temperature, salinity, weather, tide, etc. If the collector ropes are set out too much in advance of spawning, large numbers of barnacles and other undesirable organisms will attach to the collectors and make the collectors unattractive to mussels. On the other hand, if the collector ropes are set out too late, only very few spats will be collected.

As stated earlier, spatfall period can be predicted with a fair degree of accuracy after a few years of observation. Thus in Bacoor Bay, farmers generally lay their stakes before April and in November. In Sapian Bay, the periods of highest spatfall intensity have been observed to occur from February to March and again from September to October. In Himamaylan River the spatfall period has been observed to occur during the month of March with a lower intensity spatting on October. Generally, for greater chances of spat settlement, the collectors or ropes should then be installed not earlier than February but not later than March to catch the first spatfall which is usually the heavier one. For the secondary spatfall, ropes should be laid not earlier than September but not later than November.

The most precise way of forecasting spatfall period is by monitoring mussel larval abundance in the water daily. This type of activity can be conducted only by trained technicians using special equipment. In many other countries, this type of service is provided by a government agency or a fishing industry board. In the Philippines a spatfall forecast system or network has not been established. However, a pilot project in mussel and oyster spatfall forecast has been started this year (1979) in Himamaylan, Negros Occidental under the auspices of the SEAFDEC Aquaculture Department.

7. General Farm Management

A raft-farm is easy to maintain due to its independence from the tide. The most important thing to watch for is timely laying of collectors. Once the mussel spats have settled on the collector ropes, maintenance of the farm consists of the following procedures:

a. Thinning out collector ropes and transplanting the young mussels to growing ropes.

The thinning and transplanting operations should be carried out before the coconut husk collectors start to decay. During transplanting operations, the young mussels must be protected from the heat of the sun and from the wind, while they are out of the water. For this purpose, a small hut may be constructed on the raft.

b. Adding additional buoys whenever necessary.

As the mussels grow, the ropes become heavier so that additional buoys must be provided to keep the bamboo framework above water and to prevent the ropes from sinking to the bottom mud. The weight of mussel submerged in water is only 20 percent of its weight in air. This is because the internal water becomes part of the external water when submerged. Thus when weighed under water only the shell and flesh weight are weighed. Once taken out of the water, however, the water trapped inside the mussel becomes part of its total weight.

c. Protecting the mussels from predators/ridding them of parasites, pests, and silt.

Growing ropes should be inspected regularly for crabs, sea urchins and other predators. These may be removed by hand. Other parts growing on the shells of the mussels or on the ropes may be removed by scraping them off with a knife or by exposing the ropes for a short period during the early morning or late afternoon when the heat of the sun is not too intense.

Pests and other foulers growing on the mussels or on the ropes reduce yield through crowding or smothering newly settled spats, or by reducing movement of water and food for the mussels. Furthermore, these organisms add to the weight of the mussels and represent extra expense in terms of additional buoys or floats. Likewise, the ropes may have to be shaken periodically to dislodge silt settled on the shells of the mussels.

Perhaps the greatest harm that can be done to a mussel farm is caused by human poachers. As the raft method of culture allows for easy harvest, by the same token it is also easily poached. To discourage poaching, the farm must be guarded at all times, especially when the mussels have grown to marketable size. In this regard, the raft-hut used for transplanting operations may serve as a floating guardhouse.

d. Replacement of pegs

The growing ropes should be inspected regularly to see if the pegs are still doing the job of supporting the mussel clumps. Decayed pegs should be replaced. If necessary, additional pegs may be provided to support exceptionally large mussel clusters.

8. Harvesting

The mussels should be harvested before they grow too big to be acceptable in the market (consumers actually prefer medium or "bite-size" mussels). Also, the mussels should not be harvested when they are too thin. "Thinness" or "fatness" of mussels is indicated by the degree to which the meat shrinks after cooking. A "fat" mussel is full-bodied and attractive in appearance; males have a rich, creamy appearance while females are filled with bright-orange eggs in almost every part of its body. The flesh of fat mussels shrinks only slightly after cooking.

In contrast, the flesh of thin mussels is "watery" and transparent. There is very little distinction between males and females and the flesh shrinks to less than half its original size after cooking. Mussels cultured on ropes grow very rapidly due to the abundance of food and the absence of crawling predators. These off-bottom mussels generally taste better because they do not contain mud.

Transplanted mussels grow faster than mussels which settled and grew on the same surface. They may be harvested 4-6 months after spatfall. Mussels ideally measure 40-60 mm at harvest.

When detaching mussels from the rope, care must be taken not to injure them by pulling out their byssus threads. These threads are very important part of their bodies and they die within a few hours if these threads are so violently pulled out as to include the muscular supports. For this reason, the mussels should be scraped with a sharp knife or bolo and should never be pulled off the ropes. Alternatively, the mussels may be taken off the ropes by grasping their byssal attachment rather than the mussels themselves when pulling them off the rope. If possible, the mussels should be harvested and transported to market in clusters as clustered mussels effectively conserve moisture and thereby live longer. Removing clustered mussels from the rope is relatively easy as the cluster readily slips off. During transport to market, the mussels should be kept in moistened jute sacks protected from the heat of the sun. The mussel clusters should be broken up just before they are displayed for sale, again with a sharp knife or a pair of scissors.

At least 10-15 percent of the mussels should remain after harvest to serve as breeding stock to produce spats for the following season.

C. Fixed structures

In shallow water, the cost of floating structures like rafts may be economically undesirable. A cheaper alternative is to use fixed structures — bamboo poles staked to the bottom to serve as the framework for hanging the culture ropes (Figure 3). As mentioned earlier, in as much as the mussel farm environment deteriorates with continuous culture on account of silt accumulation and therefore has to be transferred to a new site every now and then, transferring a fixed structure farm would mean starting from scratch every time. This is one of the disadvantages of using fixed structures. General management and harvesting practices are similar to those employed in the suspension method of mussel culture.

V. Economic aspects of mussel farming

A mussel farm need not be large. Unlike other forms of aquaculture such as pond culture of milkfish or prawns, one need not think in terms of hectares. The size can be scaled down to fit the economic capability of a prospective farmer.

With all its disadvantages mentioned earlier, stake culture of mussels has the distinct advantage of being the cheapest to set up. A 100 sq m area using 50 stakes will cost only a few hundred pesos depending on the cost of bamboo within a locality. Harvest will be around 20-30 kg mussels per meter of growing surface when fully settled. Generally however not all the bamboos will be settled fully so that at the most only 1000 kg can be expected from the entire 100 sq m area after 6-8 months.

A mussel raft will cost more to put up but has all the advantages mentioned earlier. The cost in constructing one unit of mussel raft is detailed in the following table:

Cost Estimate for one unit mussel raft (6 m x 8 m)

18	Bamboo	₱ 7.00/pc	₱ 126.00
4 pcs	Styrofoam buoys	200.00/pc	800.00
2 kgs	Nylon monofilament No. 150	26.00/kg	52.00
4 rolls	Polypropylene rope, 12 mm 0, 200 m/roll	500.00/roll	2,000.00
3 sacks	Coconut husk	5.00/sack	15.00
1 bag	Cement	28.00/bag	28.00
1 cu m	Sand	20.00/cu m	20.00
	Labor (1 laborer at P15/day for 2 man days to help construct the raft)		30.00
	Municipal Permit (variable from town to town, very minimal)		
		Total	₱ 3,071.00

While the inital investment is high, this cost is non-recurring due to the durability of the materials used. Over a five year period the following cash flow can be attained:

Five-Year Cash Flow Projection for One Unit Mussel Culture Raft (8 m x 6 m)

	1	2	3	4	5
Initial Investment	₱3,071	----	----	----	----
Maintenance*	----	300	300	300	300
Gross Ernings (Min.)	8,000	8,000	8,000	8,000	8,000
Net Earnings	4,929	7,700	7,700	7,700	7,700

*10 percent of initial investment on the assumption that only portions of the bamboo raft will be replaced.

Assumptions:

1. The farm shall be constructed and operated by fisherman-owner who already owns a boat.
2. One meter of rope can hold at least 5 kg of mussels and possibly 15 kg thus 800 meters of rope will yield 4,000 kg - 12,000 kg of mussels.
3. The gross earnings of P8,000 is based on a medium production level at a market price of P1.00 per kg.

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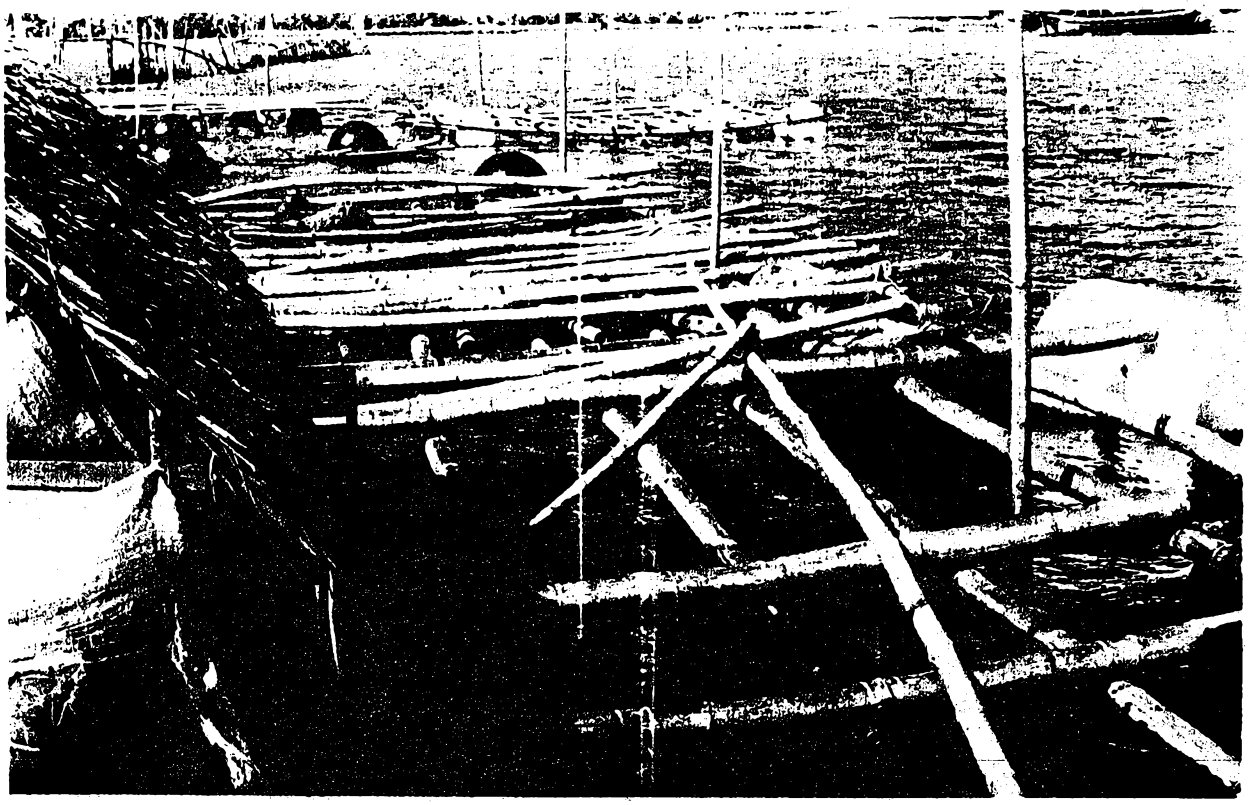
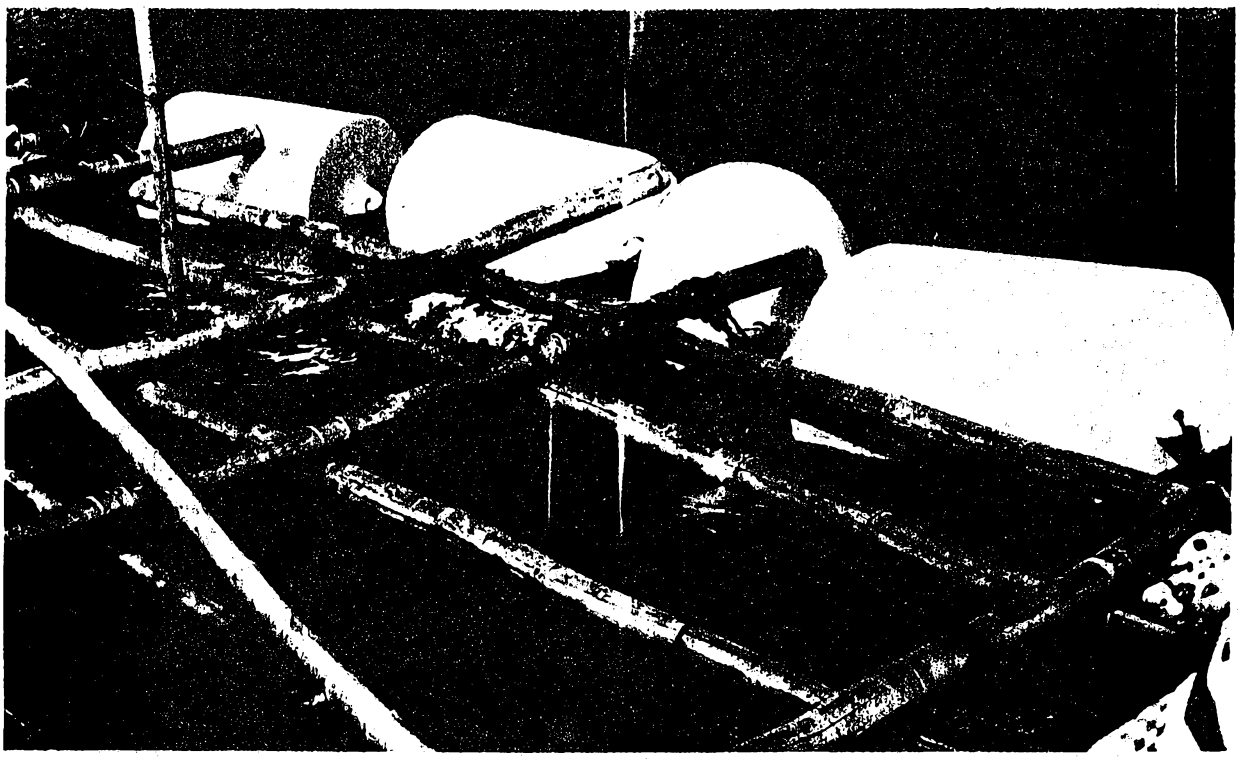
Freshly harvested green mussels (*Tahong)* ready for market.

Brown mussels, *Modiolus metcalfei*



Bamboo rafts for mussel culture. These were set up by the SEAFDEC Aquaculture Department in Himamaylan, Negros, Occidental.



A close up of the floating structure. Note the ferrocement buoys used as floats.

The traditional stake method of culturing green mussels.