Site Selection, Structural Design, Construction, Management and Production of Floating Cage Culture System in Malaysia

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INTRODUCTION

For any aquaculture practice to suceed, it is important to ensure that the cultured animals in the confinement are provided with:

a) sufficient oxygen in the water
b) plenty of food
c) favourable environmental conditions for the cultured fish to be able to live and grow without necessary expenditure of energy to resist an unfavourable environmental pressure such as strong currents, waves and pollution.

Therefore, success of cage culture system is largely determined by correct selection of favourable sites, suitable cage size and facilities and management of the system. These three elements are of equal importance as site selection ensures a favourable environment for the cultured animals; the cage facilities provide living conditions at which a certain population of cultured animals are confined into, and management of the farm ensures optimal productivity of the culture system.

Cage culture system was developed in Malaysia in late 1973 and its commercial viability has been well illustrated by the mushrooming of such culture practice in various parts of the country.

SITE SELECTION

Selection of suitable sites is one of the important criteria in the establishment of a cage culture system. A good site will help solve much of the management problems in the culture system. The basic principles in selecting sites for floating cage culture are good water quality, adequate water exchange, and freedom from predators and natural hazards.

For coastal cage culture, one should consider current speed of the selected sites, direction and speed of prevailing winds as well as whether the selected sites are likely to be influenced by hurricanes, typhoons and strong tidal waves.

In Malaysia, coastal cage culture facilities are established in protected lagoons such as those located in Kuala Setiu, and in inland seas or straits such as the Straits of Penang and the Straits of Johore. They are also established in protected open coasts such as those in Tanjung Penyabong in Johore. In the state of Kelantan, cage culture systems are established at the mouths of rivers such as in Kuala Semerak. In Sabah, fish are cultured in cages in the Menggatal estuaries.

Bays, lagoons, straits and open coasts are ideal locations for cage culture as long as they are protected from strong monsoonal winds and rough seas. These locations are usually subjected to tidal flushing and the sea is relatively calm. With the exception of lagoons, salinity fluctuation in these culture sites is small and the environmental conditions are stable. While lagoons are ideal sites for fish culture, the problem of sufficient exchange of water from the sea may affect the stability of the environmental condition. In the East Coast of Peninsular Malaysia, there are large lagoons located throughout the coastline such as that of kuala Setiu in Trengganu and Nenasi in Pahang. However, because of heavy northeast monsoonal rains from November to March, the surface water of the lagoons may be diluted considerably causing serious vertical stratification of the water mass. Such condition is not favourable for the culture of stenohaline marine fishes which are less tolerant to wide fluctuation of salinity. Similar problems are faced in selecting river mouths as culture sites as, very often, the salinity pattern of the river mouths changes considerably with the onset of rainy season. Therefore, considerable care should be taken when selecting a coastal site for cage culture. It is important to know the seasonal variation of the main environmental parameters such as salinity, temperature, water current, turbidity and dissolved oxygen content. One should also examine the fertility of the water as too fertile water may encourage the growth of fouling organisms resulting in serious fouling of net-cages.

Fish can also be cultured in cages in lakes and reservoirs. Apart from adhering to the criteria for site selection discussed above, one should pay particular attention to the vertical stratification in deep lakes or reservoirs as it has been shown in the Muda Reservoir where the oxygen content fluctuates considerably at the surface and at a depth of four meters (Lai and Chua, 1976). Variation in pH should also be considered seriously as in freshwater, the pH level is usually low and near acidity.

Floating cage culture system can be used in deep mining pools where stocking of the pools make harvesting extremely difficult. The floating cage system utilizes the surface layer of the water in the mining pools where oxygen content is much higher than in the deeper layers. Disused mining pools have been largely used in the central part of Peninsular Malaysia for the culture of Chinese carps as well as for stocking of the marble goby *(Oxyleotrix marmorata)*. Floating cage can also be utilised for river and canal systems where there is a steady flow of water. However, the problems of sediment loads from the source of the rivers as well as freshwater discharge during monsoonal rain should be taken into serious consideration before the site is chosen.

STRUCTURAL DESIGN AND CONSTRUCTION

Cage Design

The design of cages are determined by the behaviour of the cultured species. For pelagic species such as the threadfin bream (Polynemidae) and the jack (Carangoides) which swim incessantly near the surface, bigger net space is required. Such fishes tend to aggregate in shoal and swim incessantly around in circular motion. Therefore, circular or hexagonal cages may be more suitable than rectangular or square cages. For demersal fish such as groupers (Serranidae) and marble goby (Gobidae) which are less active and territorial in habits and which prefer to hide under any underwater structures, the shape of the cages does not affect fish mobility. Under such circumstances, square or rectangular cages have an advantage over a circular or hexagonal one in view of easy assemblage of cages and management.

The size of the cage depends on the species. An economical size for each species should be worked out separately. For estuary grouper, *Epinephelus salmoides,* the economic size of the net-cages is 3-11 m^2 where the stocking can range from 360-1320 fish at a stocking rate of 60 fish/m^3 for size less than 1 kg.

It is not economical to have a cage size beyond the physical capability of the fish farmers to handle. In tropical waters, the net could be fouled in a relatively short period of time of less than two weeks and the weight of the net would be considerably increased rendering cleaning of the net difficult. This will also reduce the floatation of the framework on which the net are suspended.

Types of floating net-cages in Malaysia

Most of the floating net-cages used in the culture of fish in Malaysia are very similar in designs and construction. Essentially, each floating cage unit consists of a floating unit, a framework, a batttery of net-cages and anchorage facilities.

a) The floating unit

The floating unit consists of a number of floats below the framework to provide sufficient floatation. The types of floats used vary from ordinary oil drums to used fibreglass barrels. Fish farmers in Malaysia use various types of floats as long as they are cheap and available. In Penang, the fish farmers employ used empty fibreglass barrels as floats (Fig. 1). For a floating cage unit of size 5.4 m x 8.4 m a total of forty-eight, eight-gallon barrels are used. In Kuala Setiu, some fish farmers use styrofoam blocks to float their cages. At Penyabong open coast, oil drums coated with marine paint are used as floats for net-cages (Fig. 2). In Semerak, fish farmers used bamboo frames in addition to empty plastic barrels for floatation (Fig. 3). Although cement blocks as well as used tyres stuffed with styrofoam materials are satisfactory as floats for cages, they have not been tried in this country.

b) Framework

The framework is used to suspend the net-cages in the water and to provide sufficient weight to maintain stability of the suspended unit in the water against strong tidal waves, currents or monsoonal winds. The stability of the culture unit is important as too much rocking of the cages may frighten the fish which could suffer from mechanical injury while rushing around for hides. In coastal site, sea water resistant wood such as Changai Pasir *Hopea odorata* has been found to be an ideal material for the construction of the framework as the wood is rather heavy and could last more than four years if the wood is regularly maintained and coated at least once a year with anti-fouling paints. The framework must be strong enough to stand the force of tidal waves up to one metre in height and also provides a walkway for easy operation of the cage (Fig. 1). The framework is usually 8.4 metres long and 5.4 metres in width with the walkway measuring approximately 0.3 metre wide.

Simple framework built of *nibong* poles can also be used to suspend the net-cages. However, availability of the materials is limited. *Nibong* is rather salt resistant and itself provides floatation and could last much longer than wood.

Bamboo framework could be used in very calm waters such as in lagoons, reservoirs, rivers, and canals. The cost of bamboo framework is very much less than wood, plastic or steel. However, they have to be replaced once a year.

The framework of the culture unit used in Penang is divided into eight compartments, the sides of which are fixed with hooks sleeved with plastic tubing to prevent rusting (Fig. 1). The framework is so designed as to allow for suspension of eight net-cages 1.83 metres long and 2.13 metres wide or for four larger net-cages of size 2.4 m x 3.66 m, or for two larger net-cages of size 4.8 m x 3.66 m or just one single large net-cage for the whole framework.

c) Net-cages

The net-cage is made of polyethylene netting of thickness varying from 18 ply to 24 ply. Thicker netting is strongly recommended for cage nets so that it could not be easily torn by crabs or puffer fish which are abundant in coastal waters. The size of the net-cages depend on the species cultured. For estuary grouper it was found that net-cage of size 1.83 x 2.13 and 1.42 m deep is suitable while net-cage size of 2.4 x 3.66 x 1.42 m is ideal for threadfin breams and jacks.

Mesh size of the net-cages are determined by the stocking size. The cages are weighted with cement blocks. with cement block (Fig. 1). In areas where the water is strong, the net-cages may be swept to one corner of the framework and, to keep the net well spread, a rectangular metal frame of the same size as the bottom of the net-cage is placed at the bottom of each cage.

Nylon netting for cages is not recommended in tropical conditions because the exposed portion of the netting becomes brittle from long exposure to the sun. Polyethylene netting has a life span of more than four years if properly maintained.

Galvanized wire mesh could also be used to keep the fish in floating cages. However, it may have to be replaced rather frequently and it is rather bulky.

d) Anchorage facilities

The floating cage unit is usually anchored to a fixed locality either by large metal anchors or by wooden pegs driven into the bottom. It can also be anchored from the land if the cage is not too far away from the nearest land. In coastal waters, a unit of floating cages were anchored by means of four 10-kg metel anchors one at each corner of the framework. Other units can then be stationed by the side of the anchored one, and hence a battery of net-cages could be established by the coast.

The fish farmers are generally equipped with marine engineering skill and they usually abandon the use of metal anchors in favour of wooden pegs. Each peg measures approximately 10 feet long with a thick rope passing through a hole 6-8 inches below the cut-end of the peg. With a guide pole and applying simple pulley system, the fish farmers utilize the weight of the boat to drive the peg right into the bottom soil (Fig. 4A & 4B). The rope is then attached to a float as a marker. A schematic diagram showing anchorage of the family unit cages is shown in Figure 5.

Family Unit Net-Cages

The idea of family unit net-cages has been proposed by Chua and Teng (1977, 1978) with the objectives of extending the cage culture technology to fishermen whose economy are badly affected by the dwindling catch of the inshore water, as well as to train future generations of fish farmers through participation in the culture practices by the family members. For such units, a total of four-unit rafts, each with eight-unit net-cages were employed and a total of four-unit rafts, each with eight-unit net-cages were employed and the construction and design of the cage is similar to these described earlier. In addition to the unit-cages and the floating units, a floating house is built to accommodate the family living or working at the farm. The area of the floating house is twice that of a floating unit, i.e. 9.6 x 15.6 m floated on used plastic barrels (Fig. 5). The house will accommodate at least a family of four and would have a working platform for cleaning, drying or mending of nets as well as space for preparation of feeds.

The house is furnished with cooking facilities and a small room for accommodation. A family unit therefore consists of four floating cage units of size 5.4 x 8.4 m each and a floating house. Both the house and floating cage unit are anchored to the sea bed by wooden pegs. The whole family unit could be moved and towed away at will if the environment becomes unfavourable.

PRODUCTION

One of the advantages of cage culture system over traditional pond culture practices in Malaysia is the high production attained through heavy stocking and adequate feeding. Fish production in cages depends on a number of factors which act independently or simultaneously on the cultured fish. Some of these are water quality, diseases, natural hazards, feeds, feeding frequency, stocking density and cannibalism. Optimum poduction could be attained if these factors are controlled and regulated.

For any aquaculture system to be successful commercially, the production cost must be sufficiently low so that the products are within reach of the ordinary consumers. The existing floating cage system of producing marine finfish is a labour intensive farming practice and the production cost is quite high. Chua and Teng (1977) indicated that the cost of producing one kilogram of estuary grouper *(Epinephelus salmoides)* was M$4.80 or US$2.20. This is rather high and is not within reach of most of the lower income group. The present and popularly used method of farming is by stocking cages at 60 fish/m^3 and reared over a period of eight months feeding exclusively on trash fish.

Economic production of the estuary grouper could be attained through provision of suitable (unpolluted) sites, optimal stocking density, proper feeds, optimal feeding frequency, reduction of predation, prevention of diseases as well as proper and effective management. It was shown recently that the stocking density for estuary grouper in floating net-cages could be increased by 260 percent from the optimal stocking of 60 fish/m^3 to 156 fish/m^3 just by providing artificial hides using used car tyres (Teng and Chua, 1979). Net production was found to increase by 260 percent. Similarly, by feeding the fish adequately and at the right frequency and time of the day, the wastage of feeds could be avoided and best conversion efficiency could be attained. In estuary grouper, the digestive time of food was found to be 36 hours and feeding the cultured fish once every other day has been found to yield the same growth rate and production as those fed once or more than once a day (Chua and Teng, 1978b). Hence the cost of feeds could be reduced considerably by at lest onefold. Feeds account for approximately 22.4 percent of the total operational costs and any attempt to reduce the cost of feeds through optimal feeding frequency without lowering the net production should be a great contribution to the lowering of production cost. By incorporating growth promoters in the feeds of estuary grouper, the growth rate of the fish is greatly enhanced by 43.4 percent and 62.8 percent, respectively (Chua and Teng, 1978c). Through proper manipulation of feeds, feeding frequency, feeding time, stocking, artificial hides and effective management (Chua and Teng, 1978d; Teng and Chua, 1978; Teng et al., 1978; Chua and Teng in press), it has been shown that the production time for estuary grouper could be reduced from the usual 6-8 months of culture from an initial size of 50 grams to a marketable size of 500 grams. The cost of production was also lowered from US$1.28. The production was found to increase from 23.76 kg/m^3 to 136.75 kg/m^3 (Table 1). Therefore the various culture techniques can be standardized and is shown in Table 2 for estuary grouper.

Compared with other marine fishes cultured in floating cages, the production rate of 0.17 kg/m^3/day obtained for estuary grouper is higher than species such as yellowtail, *Seriola quinqueradiata,* (Fujiya, 1976) the pompano, *Trachinotus carolinus* (Smith, 1973) and *Polydactylus sexfilis* (May, 1976) (Table 3). The production in terms of kilogram per cubic metre is also comparable with that of the pompano but much higher than that of the yellowtail or threadfin breams.

In freshwater environment, the stocking rate of freshwater fishes in cages could be higher if the dissolved oxygen content could be continuously maintained at a sufficiently high level. Thus, a production of 60.8 kg/m^3 was obtained for common carps, *Cyprinus carpio* cultured in Germany (Steffens et al., 1969), and 61.2-173 kg/m^3 for channel catfish culture in cages (Schmittou, 1970; C.M. Collins, 1972 and R.A. Collins, 1972). For other freshwater species cultured in net-cages, the production attained were fairly high. In general, the production is much higher than those of the marine cage culture system. This is because of the lower dissolved oxygen content in sea water than in freshwater as a result of the higher salt content of sea water.

Table 1. Comparison of net production, production time, production cost and net income over total cost (including capital and operational cost) using different culture techniques for culturing estuary grouper in floating net-cages.

Culture techniques	Net Production kg/m^3	Production Time	Production Cost (US$)	Net income/total cost (percent)
A (Trash fish only)	23.76	6	2.00	33.3
B (Formulated feeds only)	31.05	4.6	2.06	32.5
C (Trash fish and artificial hides)	61.78	6	1.68	63.2
D (Formulated feeds and hides)	80.73	4.6	1.80	55.1
E-a (Formulated feeds and 17^{d}-methyl-testosterone)	45.95	3.1	1.61	64.3
E-b (Formulated feeds and Payzone$^{(R)}$)	52.60	2.7	1.44	82.0
F-a (Formulated feeds and artificial hides and 17L-methyltestosterone)	119.48	3.1	1.44	93.3
F-b (Formulated feeds and artificial hides and Payzone$^{(R)}$	136.75	2.7	1.28	115.5

Stocking size 54 g and the fish are fed once in 2 days till satiation. The value is based on a culture period of 6 months.

Table2. Standardisation of culture techniques for optimizing production of estuary grouper in floating net-cages.

Culture Site	Dissolved Oxygen: 3 cc/1 Water Current: 0.2 - 0.5 m/sec pH: 7.5-8.6 Wave Height- 1 metre Salinity: 15-32^{0}/oo Coliform bacteria: 500/100 ml Temperature: 27 - 32^{o}C
Cage design and size	Rectangular or square; 4 m^2-10 m^2 and 2 m deep
Mesh size	0.64 cm (Fish below 5 cm) 1.27 cm (Fish between 15 - 20 cm) 2.5 - 3.8 cm (Fish above 21 cm)
Optimal Stocking density	60 fish/m^3 (without artificial hides) 156 fish/m^3 (with artificial hides)
Feeds	Trash fish or formulated feeds
Feeding time	6 - 7 a.m. 5 - 7 p.m.
Feeding Frequency	Once daily for fish below 15 cm and every alternate day above 15 cm
Grading	Once fortnightly
Growth promoter	Nitrovin
Pre-stocking Treatment	0.1 percent sulfamonomethoxine 10 - 20 minutes
Net change	At least once fortnightly

Table 3. Comparison of production of cage cultured marine finfishes.

Species	*Seriola quinqueradiata*	*Trachinotus carolinus*	*Polydactylus sexfilis*	*Epinephelus salmoides* *
Country of culture	Japan	Florida, U.S.A.	Hawaii, U.S.A.	Penang, Malaysia
Initial stocking density				
fish/m^3	10	250	50	60
kg/m^3	0.15-0.55	1.75	0.4	3.4
Rearing period (days)	225	273	300	240
Production (kg/m^3)	0.85-14.45	44.7	–	41.4
Average production rate (kg/m^3/day)	0.004-0.06	0.16	–	0.17
Mean size of fish				
Initial (gm)	10-50	7	9	55.7
At harvest (gm)	1000-2000	213.6	300	795.9
Average growth rate (gm/fish/day)	4.40-8.67	0.76	0.97	3.08
Reference	Fujiya (1976)	Smith (1973)	May (1976)	Chua & Teng (1978c)

*Based on existing commercial culture.

MANAGEMENT

The objective of management in a commercial farm is to ensure optimisation of fish production at minimum cost. This objective can be achieved if the farm manager understands fully the whole concept of the culture system and is able to effectively control the various stages of operation of the farm from the establishment of the cages to the harvesting stage.

Once a site has been selected, the physical facilities established and the cages stocked, the farm manager has to ensure that:

a) the fish grows at expected growth rate
b) loss of fish is minimized due to disease, damage of nets by predators or foulers;
c) nets are regularly maintained by cleaning of the fouling organisms;
d) there is maximum uptake of feeds through provision of feeds at the right time of the day, suitable feeds for different sized fish and the right frequency of feeding; and
e) regular grading of the stocked fish and routine checking of the water quality throughout the operating periods are carried out.

Cage Maintenance

In tropical coastal waters, where temperature is relatively high (26-33^{o}C) and the annual fluctuation is small (Tham, Khoo and Chua 1970, Chua et al. 1977), a great diversity of animals and plants could be found. Submerged cages in this coastal belt can be fouled very easily and rapidly. If they are not removed regularly, the fouling organisms might block the passage of water through the net thereby reducing the dissolved oxygen content inside the cage which may impose respiratory stress on the cultured fish. The net could sink from immense weight of the foulers or tear due to the sharp edges of bivalves or barnacles.

The main fouling organisms found on the floating cages in Penang Straits are compound tunicates *(Botryllus, Botrylloides, Trididemnum* and *Symplegma),* green mussels *(Perna viridis),* oysters *(Pinctada* and *Crassostrea),* algae *(Gracillaria* and *Enteromorpha),* barnacles *(Balanus),* amphipods, nereids, serpulids, gastropods and *Bowerbankia.* The wooden framework was found to be fouled by a wood borer, *Martesia striata.* Cheah and Chua (MS) reported that there were at least thirty-four species of micro and macro-foulers on the floating net-cages in Penang Straits.

The nets are changed once a week for smaller mesh size of 0.635 cm (1/4 inch), once a fortnight for mesh size between 1.27-2.54 cm (1/2-1 inch) and once a month for mesh size above 3.81 cm (1 1/2 inches). The fouled nets are dried under the sun for 1-3 days and are removed by hand using a rattan or a piece of wood, after which it is soaked in the sea water for a day. Although a pressure pump could be used to flush the foulers, it is not convenient and it becomes less effective if the nets have been fouled for too long.

Regular checking of the conditions of the nets for wear and tear is most important as very often the netting might be torn by predators such as the puffer fish or by the sharp edges of barnacles or bivalves.

Cages located in the east coast of Peninsular Malaysia are not fouled as rapidly as those located in the coastal waters of the west coast. The nets are usually cleaned once a month for smaller mesh nets.

Fouling in cages located in freshwater bodies is less serious rendering maintenance of cages relatively easy.

Change of nets

The nets have to be changed according to the fouling situation. In changing nets, the following steps are followed so that there will be no direct handling of the fish.

1. A new piece of wood with hooks along both sides are fastened across the middle of the old cage (Fig. 6a).

2. The rimline (the polyethylene rope that is seamed along the upper edge of any side of the net) of the old net is removed from the sleeved hooks and rehooked onto the hooks of the new wood in the middle (Fig. 6b).

3. A new net is then placed at the empty space vacated by the removal of the old net. Cement weight is attached to the corners of the new net so that one side of the new net is suspended into the water with the rimline hooked to the sleeved hooks of the framework and the opposite sides to the hooks on the wood at the middle (Fig. 6c).

4. The weights attached to the corner of the nets are then removed and the old nets gradually lifted from the bottom and pulled over the sides of the framework (Fig. 6d).

5. At this stage the fish are concentrated at the surface of the old net by gradual lifting of the bottom of the old net. By this time, a portion of the old net is placed over the wood between the old and new net cages, thus making it fish proof and the fish is easily herded into the new net. Sometimes when there are too many foulers on the net, the fish are first concentrated and scooped into the new net.

6. The old net is then removed and the side of the new net attached to the wood is detached and hooked onto the sleeved hooks of the framework of the floating unit.

Disease prevention and treatment

The most common disease sustained by estuary groupers in Malaysia is the red boil disease or vibriosis, caused by the infection of *Vibrio parahaemolyticus* in polluted waters. Fish usually suffer from initial mechanical injury while being caught by collectors using beach seine. Such fish generally developed redness on the body and head especially the snout. They may recover in 3-4 days time if kept in clean water but usually the redness spreads and the fish may die.

The cultured fish can also be infected with vibriosis if they were first infested with gill flukes. In estuary grouper, it was noted that fish do get infected with a datylogyroid, *Diplectanum sp.* (Monopisthocotylea) which multiplies rapidly.

Both antibiotic and sulfa drugs have been found to be equally effective in treating vibriosis. For estuary groupers, incorporation of terramycin, tetracycline or sulfamonomethoxine and sulfisoxazole in the feeds helps decrease the frequency of vibriosis outbreak. For new stocks, the fish are usually given a 0.1 percent sulfamonomethoxine bath for 10-20 minutes before returning them to the cage. This has been found to be effective as the outbreak of vibriosis has been rather rare at the Jelutong farm in the past two years.

In severe cases, oral or intramascular treatment of vibramycin had been found to be very effective for vibriosis; the fish recover in 4-7 days.

Work on vaccination of the fish from local vaccine preparation is in progress and initial experiments to immune the fish with the prepared antigens are being conducted. Initial results indicate that fish injected with antigens are more tolerant to vibrio infection than those not treated with antigens (Wong See Yong, pc).

In site rich in organic matter, cultured fish can be easily infested with octoparasites such as the marine isopod, *Nerocilia spp.* which, when occurring in large quantity, may infest almost all the fish population in the cage. The isopod does not kill the fish immediately but weakens and irritates the fish considerably, rendering it more prone to pathogens. Rabbitfish *(Siganids)* and white breams *(Pomadasys)* are prone to such parasitic infestation.

Stocking and grading

The optimal stocking density of the cage for each species in mono or polyculture should be carefully worked out and maintained in commercial practices. Earlier experiments have shown that the optimal stocking for estuary grouper is 60 fish/m^3 at initial size of approximately 50 grams. When artificial hides are provided the stocking density could be increased to 156 fish/m^3. In order to reduce the effect of the dominant fish in the culture population, grading is necessary. This would not only hasten the growth rate but also ensure uniform sizes. Gradings are usually done fortnightly by hand.

Predators and poaching

In sites where otters abound, specific measures to prevent such predators should be established. The hairy-nosed otter, *Lutra sumatrana,* is the most common predator that may attack the cultured fish in the cage. They have sharp teeth and strong claws which can easily tear the polyethylene netting and can kill the cultured fish in a relatively short period of time. Fencing the culture site with galvanized wire mesh is one solution to prevent otters from entering the farm (Fig. 3). In Penang Straits, otters could be prevented by keeping watch dogs at the floating cage. This has also been found to be rather effective as very often, the dogs have been seen chasing the otters away. In the Gertak Sanggul farm, an otter trap net made of nylon was used to fence the farm.

Poaching remains a social problem in this part of the world. Due to easy harvesting technique, the fish can be poached easily and rapidly. Keeping of fierce watch dogs and night guards is the best measure to combat such problem.

CONCLUSION

The cage culture system of rearing finfish in Malaysia has been shown to be technically and commercially viable. There is already an increasing number of cage culture enterprises in this country established by both private and semi-governmental sectors. The culture techniques need to be improved especially with respect to cheaper floating facilities, more lasting netting materials, suitable and cheaper feeds, more effective means to reduce fouling and ensuring continuous supply of seeds.

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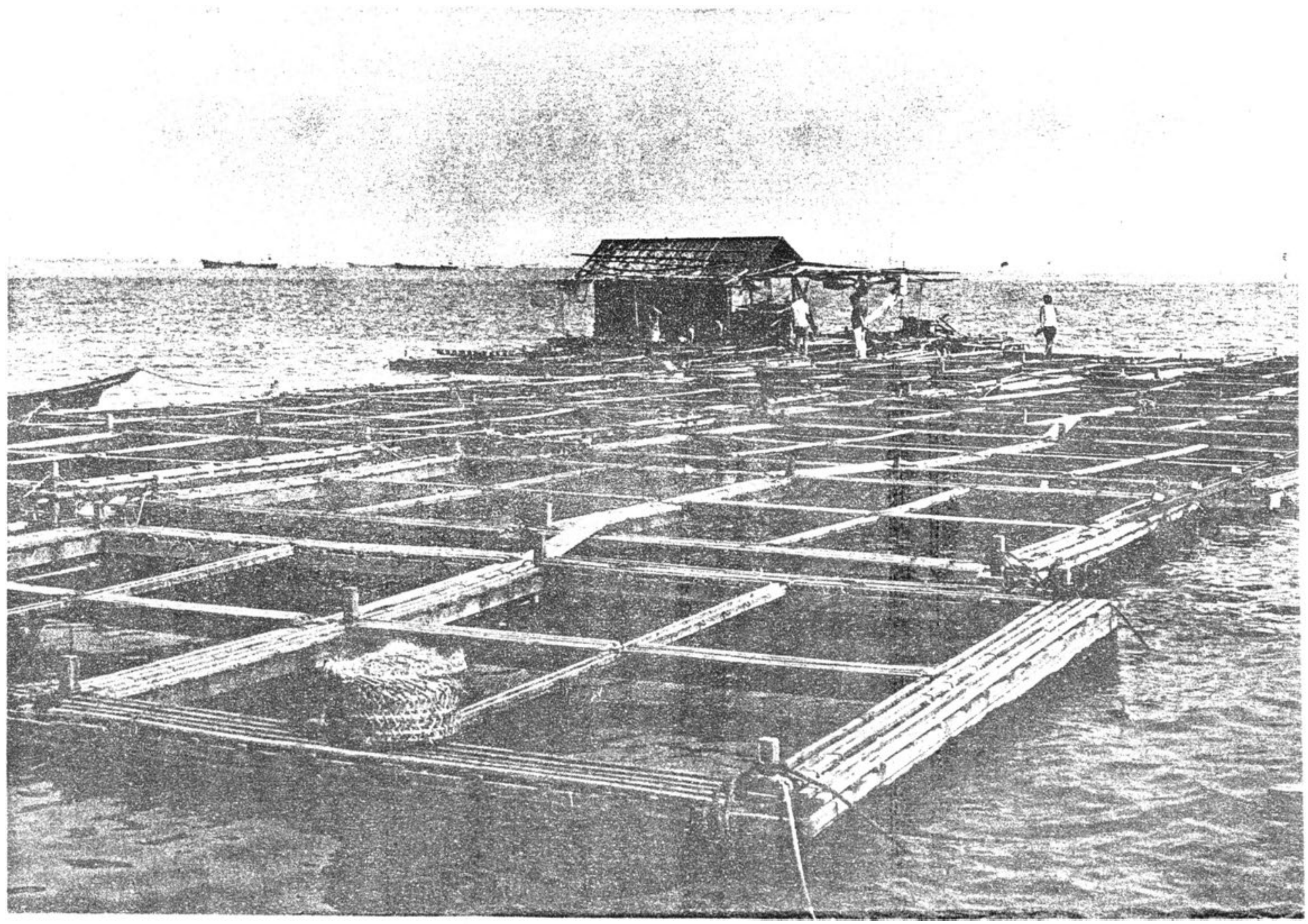

Fig. 1. A commercial floating cage culture farm in Jelutong, Penang.

Fig. 2. Floating net-cages at Penyebong, Johore using oil drums as floats. The cages are fastened to fixed poles.

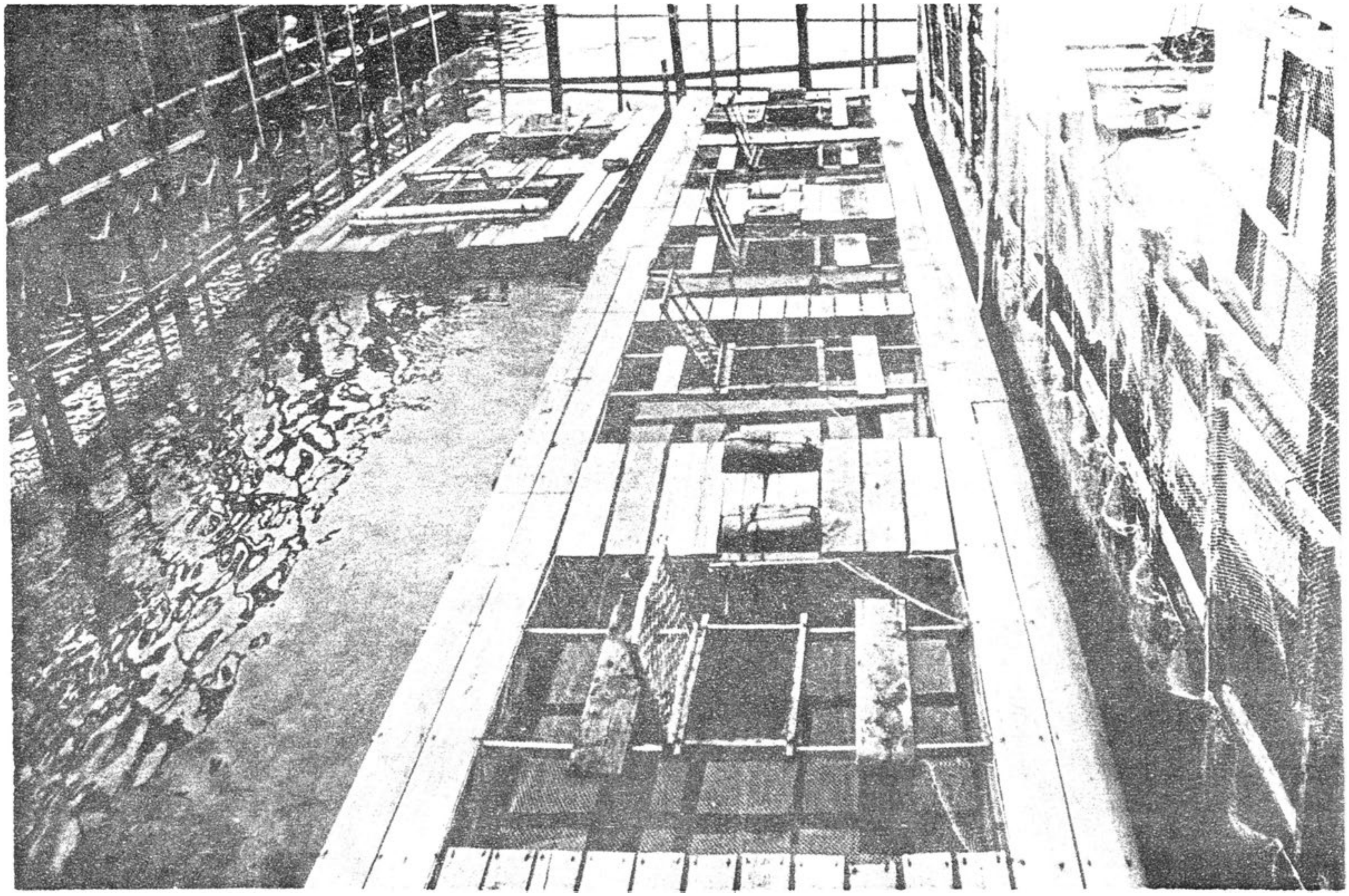

Fig. 3. Floating net-cages at Semerak River, Kelantan. Bamboo are fastened together into bundles which serve as floats. Wooden planks are used as 'walkway'. The farm is completely surrounded with galvanized wire mesh to keep out of predators.

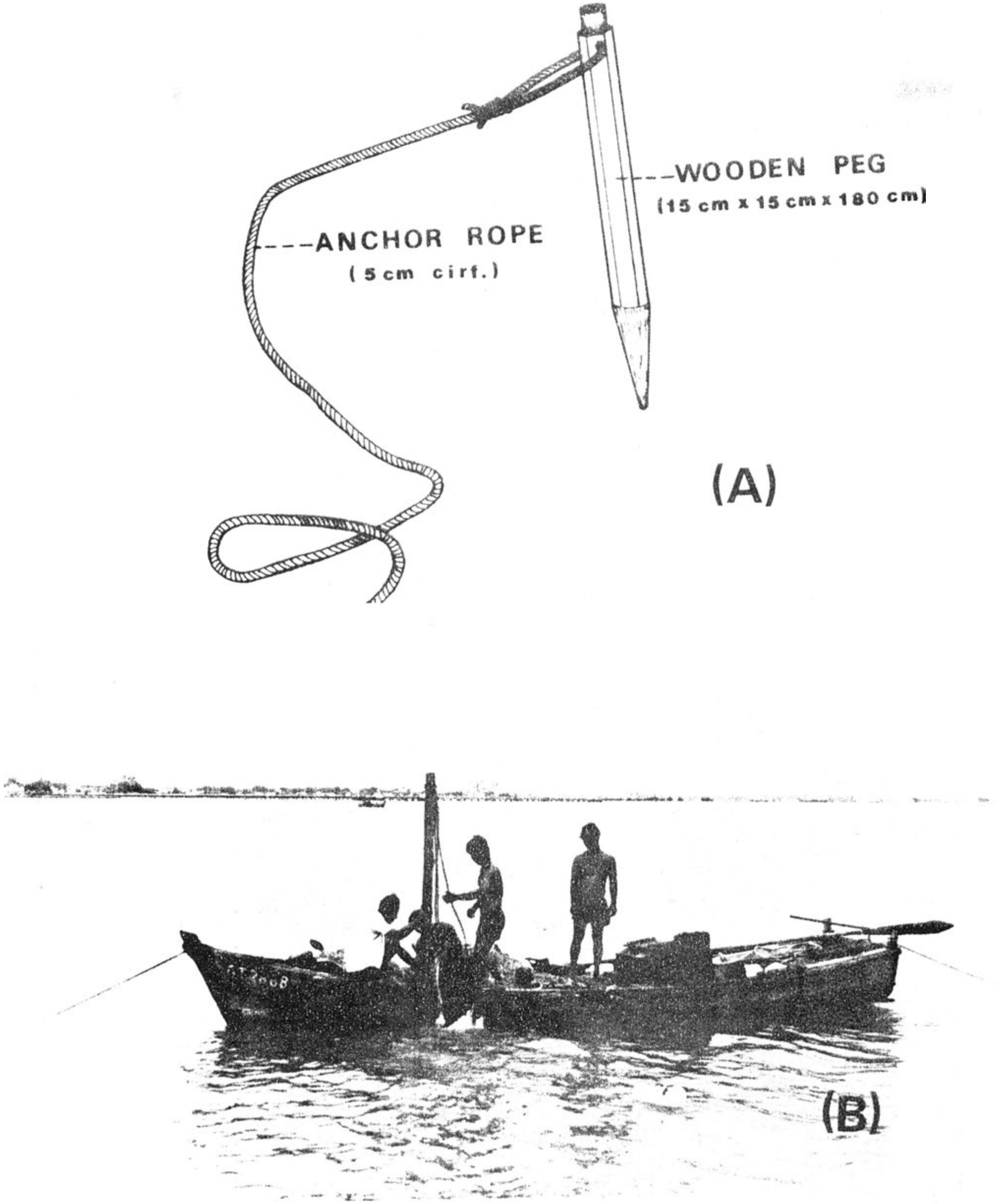

Fig. 4. (A) A wooden peg used to anchor the floating net-cages in Penang.
(B) The fishermen use the weight of the boat to drive the peg into the bottom soil. The metal chain is attached to a pulley system.

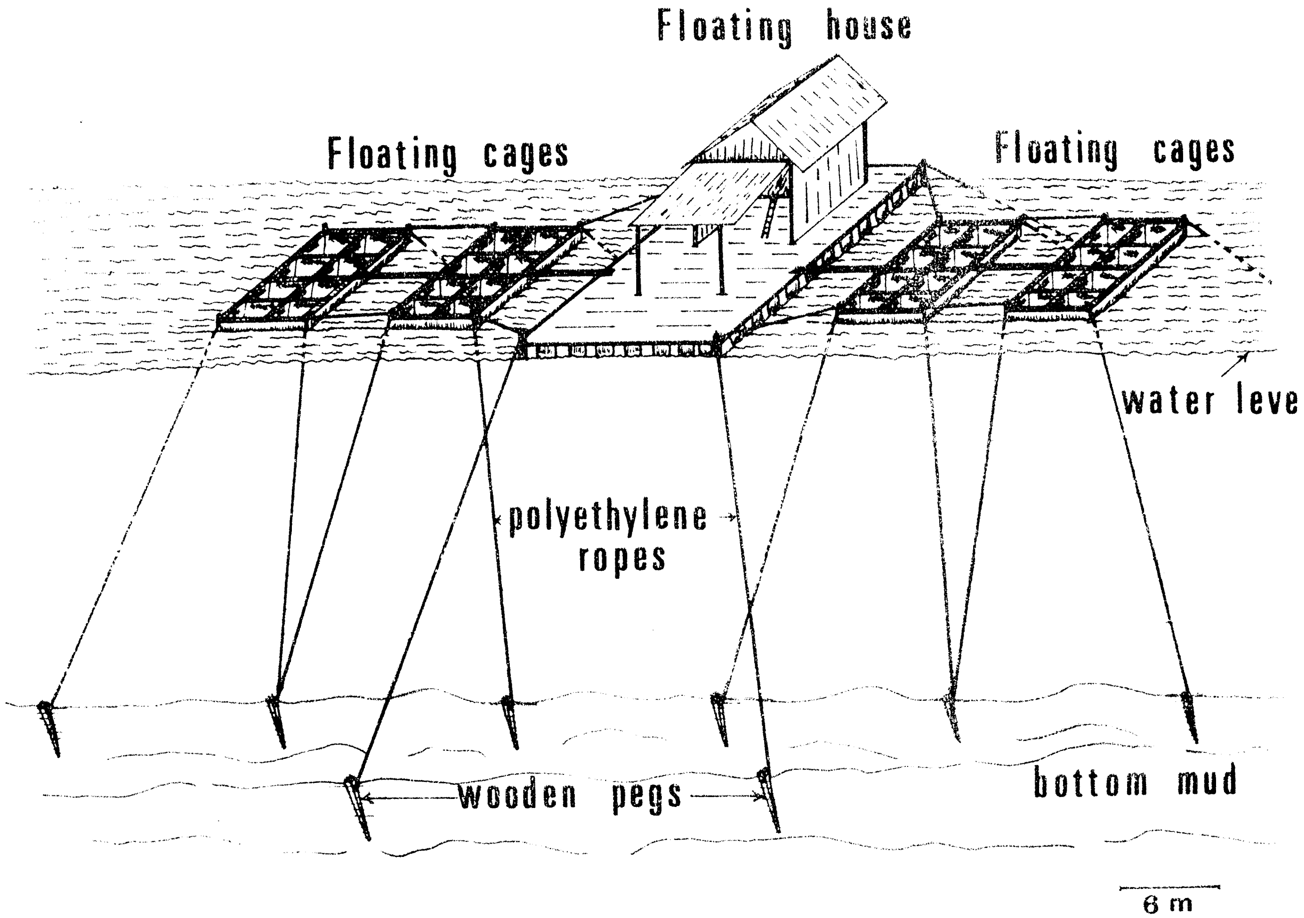

Fig. 5. A schematic diagram of a family unit cage system showing the anchoring facilities.

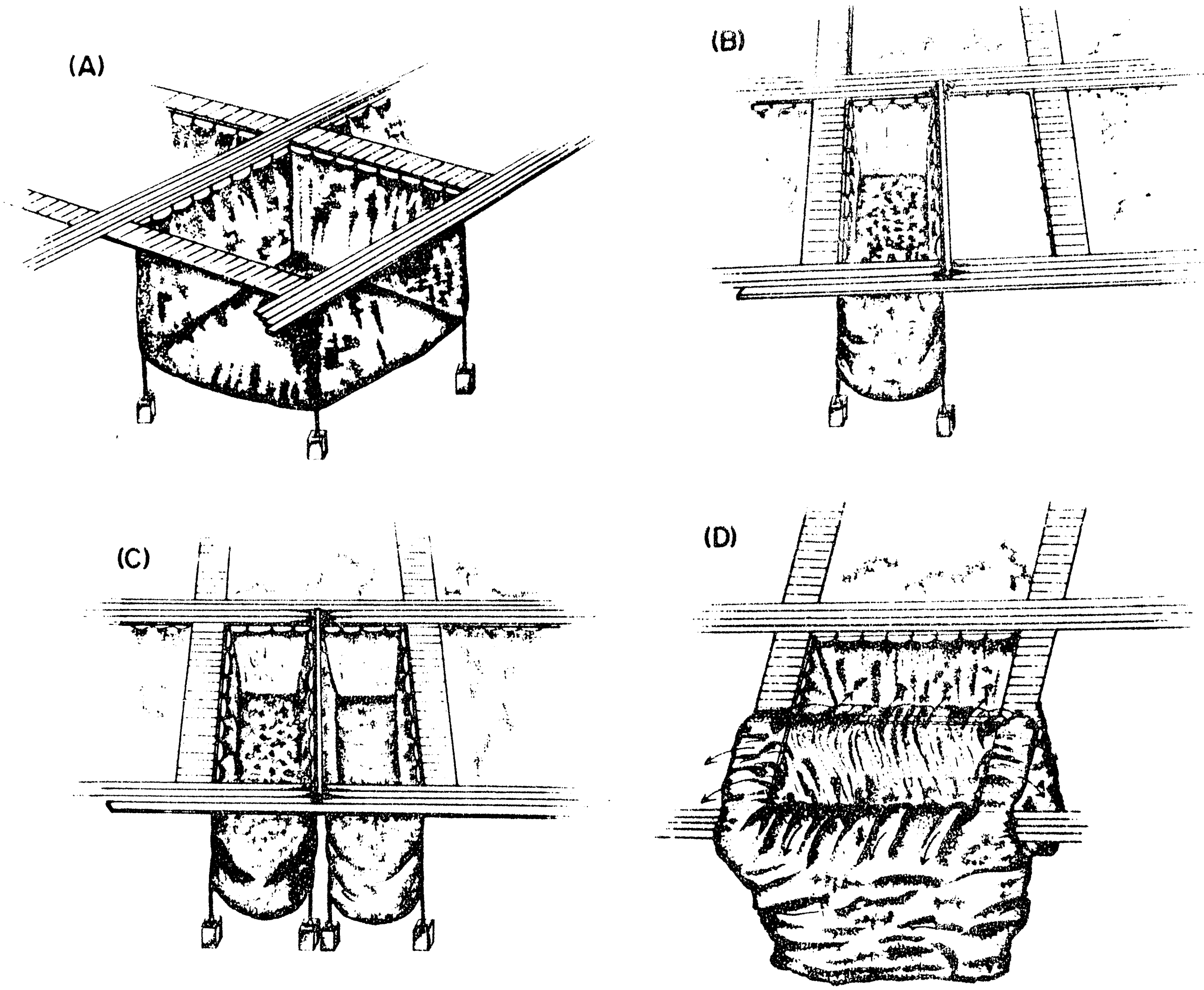

Fig. 6. Changing of the net-cages. (a) A single net-cage suspended from a wooden framework. (b) A wooden pole placed in the middle of the cage to facilitate changing for a new net-cage. (c) Setting of a new net-cage. (d) Removal of old net-cage and herding of fish into the new cage.