

AQUACULTURE DEVELOPMENT IN MALAYSIA

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ABSTRACT

Malaysia is a fish-consuming country with fish representing 60% of a total animal protein intake. At an annual per capita consumption of 32 kg some 560 000 mt of fish is required for the projected of 17.5 million people in year 2000.

Coastal marine capture fisheries, the mainstay of Malaysia's fish supply, has not shown any increase in landings over the last few years. In fact in 1985 there was a decline of 3.7% compared to 1984 fish landings. This declining contribution of marine fisheries is compensated by an increase in aquaculture production. In 1985, aquaculture contributed 51 709 mt to the total fish supply. This represents 10% of the total fish landings of 514 570 mt or 13% of total table (edible) fish landings.

Malaysia does not have a long standing aquaculture tradition unlike its neighbours in the Indo-Pacific. Even then, the industry has seen rapid growth in the last few years. Today there are 19 species of finfishes, crustaceans and shellfish cultured in the country. The main freshwater fish species bred and cultured are bighead carp (*Aristichthys nobilis*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*), Indonesian carp (*Punctius gonionotus*), catfish (*Clarias macrocephalus* and *Pangasius* spp), snakefish gourami (*Trichogaster pectoralis*) and tilapia (mainly *Oreochromis niloticus*). Marine finfishes bred and cultured are sea bass (*Lates calcarifer*), grouper (*Epinephelus* sp.)

and snapper (*Lutjanus johni*). *Penaeus monodon* is the dominant marine prawn species bred and cultured but culture of *P. merguensis* is receiving considerable interest. *Macrobrachium rosenbergii* is the only freshwater prawn cultured commercially. Molluscs cultured are the blood clam (*Anadara granosa*) and the green mussel (*Perna viridis*).

In 1985, blood clam and mussel culture accounted for 87% of all aquaculture production of Malaysia, freshwater fish 12%, floating cage culture of marine fish 0.7% and brackishwater pond culture 0.3%. In terms of value blood clam and mussels represented 30% (M\$15M) of total value (M\$49.5M), freshwater fish 57% (M\$28M), cage culture of marine fin fishes 7% (M\$3.4M), and brackishwater pond production 6% (M\$2.1M).

Aquaculture in Malaysia has considerable growth potential. It is projected that 22 000 ha of mangrove will be opened by the year 2000 for shrimp culture. Some 330 000 m² of protected coastal waters have been identified for cage culture. Some 6500 rafts can considerably expand the present capacity. In freshwater culture about 8000 ha of land and 17 500 ha of mining pools can be developed while 200 000 ha of artificial lakes and impoundments for freshwater fish cage culture are available. Yet such development is not without constraints. Freshwater finfish culture is hampered by lack of good quality broodstock. There is also a limited market for freshwater finfishes. Marine finfish culture is limited by lack of fingerlings and good quality compounded diet to replace trash fish which is deteriorating in quality and quantity. Marine prawn culture is heavily dependent on wild spawners, the supply unpredictable and inadequate. Acid sulfate soil continues to cause the deterioration of brackishwater ponds. Cockles and mussels can be sold to export markets only if they meet specific quality standards.

PRODUCTION AND DEMAND FOR FISH AND FISH PRODUCTS

Malaysia is essentially a fish-consuming country. Fish plays a major role in the average diet of Malaysia, accounting for 60% of total animal protein intake.

Two noteworthy attempts have been made to project the demand for fish. A projection offers a "high" and "low" option. The "high" demand projection starts with a base per capita consumption of 26.8 kg for 1973 increasing to 30.9 kg for 1995. The "low" demand project takes 26.6 kg as constant throughout the period. In 1981 the Fisheries Development Authority published a similar study indicating the capita consumption as 43.4 kg in 1980, 49.0 kg in 1985, and 54.1 kg in

1990. The methodology employed in both these formulations are essentially similar. The only difference lies in the value of the parameters adopted.

A recent survey conducted by the Research Survey Malaysia (RSM) for the Federal Agricultural Marketing Authority has produced empirical data to show that the per capita fish consumption (unweighted) for Malaysia as a whole is approximately 21 kg. This suggests a daily intake of 6.2 g/head which represents about 17.6% of the animal protein intake (of 35.3 g) of an average person. In the light of the RSM findings it may be necessary to revise the earlier demand projections. As a rough approximation, assuming that the per capita consumption is 32 kg, an annual production of 560 000 mt fish is required to meet the requirement of the projected population of 17.5 million people in the year 2000.

The coastal marine capture fisheries, hitherto the mainstay of Malaysia's fish supply, however, has shown no increase in landings over the last few years. The quantity of marine fish landings in 1985, for example, actually declined by 3.7% over the preceding year, while the wholesale and retail value of marine landings decreased by 0.8% and 3.3%, respectively. Exports also declined both in terms of weight as well as value. On the other hand, value imports increased by 4.4% although the quantity imported remained somewhat stable. Aquaculture production was also on the upswing, contributing 51 709 mt to total fish supply.

Most aquaculture products find a ready domestic or export market. Freshwater fish is consumed almost entirely by the domestic market although some are exported to Singapore. The market base is small and variable. Different communities consume different species in different forms and freshwater fish is not staple among any of them. The urban market is dominated by Chinese carps for the fresh fish market while tilapia and cat fishes are consigned to the live fish trade. Outside major urban areas, demand is for fresh tilapia, Indonesian carp and catfish. There is no live fish market. The marine finfish industry also caters largely to the live fish trade. Shellfish, both the blood clams as well as mussels, are sold at wet markets throughout the country. Most cultured shrimps are channeled to the export market. Live shrimp is exported to Singapore but the bulk is frozen and exported to Japan. Some of the small farms do, however, dispose of their produce in local markets.

PRESENT STATUS OF THE AQUACULTURE INDUSTRY

Malaysia does not have a long standing aquaculture tradition unlike its neighbors in the Indo-Pacific Region. In spite of that, the industry has seen rapid growth in the last few years.

Aquaculture began only in the early 1900's with the culture of Chinese carps in mining pools. In the mid-1930's, shrimp trapping ponds developed as a major industry in the southern state of Johore. The culture of blood clams began only as recently as 1948.

While semi-intensive culture of freshwater organisms and extensive culture of blood clams dominated the 1950's and 1960's, things began to change in the last two decades. Cage culture of marine fish and raft culture of mussels began in the early 1970's. More significantly, is the growing corporate involvement in the aquaculture industry, particularly in shrimp farms. Today there are over 19 species of finfish, crustaceans, and shellfish cultured in the country.

In 1985, some 51 709 mt of aquaculture products with a total value of M\$49.5 million (US \$1 = M\$2.50) was landed by the industry. This amounted to about 10% of total fish landings (514 540 mt). However, a comparison of this nature is highly misleading, given the fact that aquaculture deals with table products. Landings from marine capture fisheries consist substantially of trash fish which has no human food value. On the basis of edible fishery landings, the role of aquaculture is much enhanced, accounting for 13% of total table fish landings. The growth rate of productive assets of the industry also indicates how far it has progressed within the last few years. Blood clam culture areas grew by 25% from 4000 ha to 5000 ha in 1980-1985. The freshwater fishpond culture, however, recorded a negative growth of 18% in area (5158 ha to 4226 ha) although there was a positive growth of 25% in the number of ponds operated (14 459 to 18 087). Brackishwater ponds grew rapidly from 100 ponds (30 ha) in 1980 to 481 ponds (455 ha) in 1985, representing a 381% increase in the number of ponds and 1400% increase in area. The growth rate of floating cage culture was similarly impressive. Starting with only about 100 units with an effective culture area of 1204 m² in 1980, the industry grew to 6835 units with a net area of 82 339 m² in 1985. Similarly, mussel culture grew by 1000% over the same period from 20 to 200 rafts.

In terms of production volume, the culture of blood clams and mussels is the most significant rearing activity undertaken. In 1985, these molluscs accounted for 87% of all aquaculture production. The culture of freshwater fish weighed in next at 6362 mt or 12% of total production. The cage culture of marine fish was the third largest, amounting to 408 mt or 0.7%. Brackishwater pond production which landed 180 mt or 0.3%, ranked last.

In terms of value, however, the figures change considerably. Blood clams and mussels, despite their volume, were estimated at M\$15 million or 30% of total value. The freshwater fish production was estimated at M\$28 million or 57% of total value. Cage culture of marine finfish contributed a creditable M\$3.4 million (7%) while brackishwater pond culture production was valued at M\$ 4.1 million or 6%.

In terms of the number of people gainfully employed in the industry, again the freshwater aquaculture industry takes the lead. In 1985, a total of 13 047 culturists were employed in the production of a variety of freshwater fish in ponds or cages. This represented 93% of the total workforce of the aquaculture industry. However, there were few employed full-time. Most were farmers involved in agriculture, animal husbandry, or both, who undertook fish culture part-time. The blood clam culture sector employed only 199 full-time culturists or 1.4%. Cage culture of marine finfish employed 503 (3.6%) while mussel culture, 60 (0.4%). The brackishwater pond culture employed only 1.6% of the workforce underscoring its essentially capital intensive nature.

Malaysia has considerable growth potential for aquaculture. The government, in fact, has identified aquaculture as a priority industry and efforts are being made to actively promote investment. Among the major growth sectors, the following stand out:

1. *Shrimp culture in ponds.* Malaysia has over 570 000 ha of mangroves that can be developed for shrimp culture. Given the vital role that mangroves play in coastal ecosystems, development will be limited to a maximum of 20% of the existing area. This means that over 110 000 ha can be made available for shrimp culture purposes. It is anticipated that by the year 2000, about 22 000 ha of mangroves will have been developed for shrimp culture.

2. *Cage culture of marine finfish.* A total of 330 000 m² of protected coastal waters have been identified for cage culture of marine finfish.
3. *Mussel culture.* The growth of this sector is limited to areas of mussel spatfall. Studies indicate that present capacity may be extended by another 6500 rafts.
4. *Freshwater fish culture in ponds and mining pools.* The resource potential for this sector is good. It has been estimated that there are over 8000 ha of land and 17 200 ha of mining pools that can be developed for freshwater fish culture.
5. *Freshwater fish culture in floating cages.* The prospects for this sector is even more encouraging. By the year 2000, it is expected that there will be over 200 000 ha of artificial lakes and impoundments in which cage culture may be developed.

In short, the resource base for aquaculture is very large and the prospects for development are excellent. The government has instituted numerous fiscal policies ranging from credit with subsidized interest rates, tax exemption, pioneer status, and other factors to encourage investment. Steps are being taken to facilitate land and resource alienation to ensure low-entry costs.

PRESENT STATUS OF PRODUCTION TECHNIQUES

Freshwater Finfish Culture

Broodstock production. The main species commercially bred are the Chinese and Indonesian carps followed by the snakeskin gourami, tilapia, and the catfishes. Fry supply for the culture of these species is mainly from government hatcheries but a small number of private hatcheries also carry out the natural breeding of selected species such as the common carp (*Cyprinus carpio*) and the tilapia (*Oreochromis* spp.)

Government hatcheries undertake artificial propagation of some Chinese carps, specifically the big head carp (*Aristichthys nobilis*) and grass carp (*Ctenopharyngodon idella*). Other species similarly bred include the Indonesian carp (*Puntius gonionotus*) and the catfishes (*Cla-*

Clarias macrocephalus and *Pangasius* spp.). Natural propagation of the snakeskin gourami (*Trichogaster pectoralis*), common carp (*Cyprinus carpio*) and tilapia (mainly *Oreochromis niloticus*) is also undertaken by these hatcheries.

The size of broodstock ponds depend on the species cultured. For carps, pond size of about 0.2 ha are common and for snakeskin gourami and tilapia, much smaller ponds of 0.1 ha or less are used. Broodstock of *Clarias* spp. are also kept in 100 mt tanks. Depending on the species of broodstock both monoculture and polyculture are practised. In polyculture, the common combinations are the common carp/bighead carp and grass carp/bighead carp. Generally, broodstock are kept at low densities of 1500 kg-2500 kg/ha.

In most establishments static water conditions with regular water exchange of 5-10% a day is common management practice. To ensure optimal conditions, water quality is monitored regularly. The desired fecundity of broodstock is achieved by using formulated pellet feed with a protein content of 32-40% containing mainly fish meal, rice bran, and maize, fed at 3 to 5% of body weight. Freshly prepared ground nut meal and grass are also used. Wet feeds consisting of trash fish and boiled rice as well as pelleted feeds, are fed to *Clarias* spp. The broodstock are checked weekly for gonadal development. Spawning is induced by HCG (Human Chorionic Gonadotropin) and Carp Pituitary Extract.

Spawners are handled carefully to prevent injury and subsequent bacterial infections. Prior to capture, spawners are pre-stressed. Parasitic diseases such as *Oodinium* sp., *Lernaea* and *Ichthyophthirius* sp. are common. *Oodinium* is treated with methylene blue, *Lernaea* with salt and Abate, and *Ichthyophthirius* sp. using biological methods such as flushing.

One of the major constraints delimiting the hatcheries is the lack of good quality broodstock. Aside from the Chinese carps which are imported from Taiwan, breeding of other species rely on a limited broodstock that owes its origins to stock imported during the late 1950's. The Department of Fisheries is currently working to broaden the genetic pool by importing brood fish from other countries. In particular, Indonesian carp (*Puntius gonionotus*) and common carp (*Cyprinus carpio*) have been imported from Indonesia and crossed with local strains. Tilapia (*Oreochromis niloticus*) stock has also been imported from Thailand. Efforts are underway to similarly

import brood fish of different species from diverse sources to prevent inbreeding from existing stock.

Seed production and nursery operations. In the seed production of freshwater finfish, simple facilities such as earthen ponds and to a limited extent concrete, high density polyethylene and fiberglass tanks are used for spawning and nursery rearing. These facilities are normally small to accommodate 4-6 breeders. Larval rearing is usually carried out partly *in vitro* and partly in well prepared and fertilized ponds, about 0.1 ha in size. Outside of micro-encapsulated egg, no formulated larval feeds are used. The pond-rearing phase depends entirely on natural pond productivity. The average size of fry harvested is 2.5 cm. Fry are transported in oxygenated plastic bags.

The breeding of grass carp has posed problems particularly in obtaining gonadal maturation. Nevertheless, attempts to breed this species is still going on because of the demand for fry. Culture of local cyprinids has a good potential but fry production is hampered by lack of knowledge of the biology and larval grow-out. Even for currently cultured species, fry production (nursery stage) is still dependent on natural food. To intensify production, development of formulated feeds for larvae is necessary.

Production of table fish. The total production of freshwater finfish in 1985 was 6362 mt valued at M\$28 million. This figure is, in fact, thought to be somewhat pessimistic, since collection of accurate production data from many semi-commercial farms is somewhat problematic. Production of freshwater fish is probably closer to 15 000 mt. Production is mainly from excavated ponds (17 424 ponds; 2962 ha) followed by culture in mining pools (663 pools; 1236 ha), floating cages (862 units; 14 321 m²). Pond culture is carried out generally in small ponds, 0.2 ha-1 ha, and managed on extensive and semi-intensive system, or even on a subsistence level. In pond systems, polyculture and stocking densities of 1000-5000 fish/ha in various combinations is a common practice. The stocking density can increase to 15 750 fish/prawn/ha in the polyculture of the freshwater prawn (*Macrobrachium rosenbergii*) and finfish.

Mining pools are irregularly shaped bodies of water, 0.4-10 ha, a consequence of Malaysia's huge tin-mining industry. Serving as water resource ponds to active mines, they are, however, left abandoned after the mine is exhausted. These pools have been, for decades, used for fish culture. The commodities cultured have been limited to species

such as grass carp, bighead carp, and tilapia. Demersal species such as the common carp and freshwater prawn are not generally cultured given the extremes of depth (20-40 m) mining pools are likely to have. Stocking densities of cultured fish is about 1500-2000 grass carp in about 500-600 ha. Both ponds as well as mining pool culture are undertaken in consonance with complementary agriculture and animal husbandry activities. Tri-commodity integrated farming consisting of crops (vegetable, tapioca, bananas, etc.), livestock (pigs, cows, goats, chickens, ducks) and freshwater fish, is, in fact a major feature of Malaysian freshwater aquaculture.

Floating cage culture of freshwater fish is also undertaken particularly in the Cenderoh hydroelectric impoundment and the Durian Tunggal reservoir. Both water bodies are huge, man-made impoundments enough to sustain this system of culture. The culture is intensive and centers around monoculture of grass carp and catfish (*Pangasius* spp.), both about 12 pieces/m² Indonesian carp and tilapia, both about 36 pieces/m².

Wet feeds such as chicken intestines and broiler mash combined with ground nut meal and grass are commonly used in all three systems. Some commercial culturists use formulated pelleted feeds. The common parasites encountered include *Trichodina* spp., *Piscinoodinium* sp., *Lernaea* sp., bacterial infections caused by *Aeromonas hydrophila* and *Pseudomonas* sp. are also prevalent. Among the commonly cultured species, the Indonesian carp is the most susceptible to parasitic and bacterial infection. Other species such as grass carp and tilapia are also susceptible but to a lesser degree. For the treatment of *Piscinoodinium* sp. in the Indonesian carp, copper sulphate at 1.0 ppm is effective on adult fish.

Harvesting of marketable fish is commonly carried out by the fish buyer who supplies nets and manpower for harvest. Harvested fish are transported live in aerated fiberglass containers.

Finfish production on a commercial basis is being encouraged by the government to ensure self-sufficiency in fish production. The strategy involves more comprehensive use of existing water such as impoundments and reservoirs and the application of intensive production technologies. The biggest constraint holding back the industry is market. At present the market is limited to specific communities with small volume. Thus, to expand the industry there is a need to develop new markets through campaign as well as product develop-

ment to diversify the existing market base.

Marine Finfish Culture

Broodstock production. A substantial amount of fry for marine finfish farming is imported. Of late, however, the government hatchery at Tanjung Demong, Trengganu has started production of sea bass, *Lates calcarifer* seed. Preliminary runs for the production of grouper (*Epinephelus* sp., fry have also been started. There are, at present, no commercial hatcheries producing marine finfish fry.

Broodstock for the Tanjung Demong facility is obtained from the center's own cages and/or purchased from fishermen. This combination of cultured and wild broodstock will obviate any inbreeding in fry produced. Each brood fish weigh about 4-7 kg. They are maintained in 100-t circular concrete tanks. Feeding is entirely with trash fish at 1-2% body weight.

Neither maturation nor spawning is induced artificially. Spawning occurs naturally during full moon and eggs are collected and hatched. There is minimal handling of spawners, and fish are treated only if injury is observed after spawning.

There is a need, however, as in the case of freshwater fish, to maintain a broad genetic base by constantly supplementing the existing broodstock pool with individuals from diverse population. While, at this point in time, no genetic aberration due to inbreeding of existing stock has been observed, nonetheless, given the fecundity of sea bass, that kind of scenario is probable in the near future.

Seed production and nursery operation. Eggs collected from spawning tanks are transferred to the hatchery and stocked in 500-l fiberglass containers. Hatching occurs within 12-16 hr. The day-old fry are fed with rotifers grown on *Chlorella* and *Tetraselmis* cultures. Around the 8th-9th day, the fry is fed with *Artemia* nauplii. This continues for about 30 days when the fry are about 1.5 cm. Weaning to trash fish then begins. The fry is reared to 2.5 cm and sold to farmers. There are a number of nursery operators who purchase yolk-sac or 8 days old and rear them to commercial size.

No disease of any consequence has yet been reported. However, given the rapidly growing demand for sea bass fry, the existing capacity

of the Tanjung Demong hatchery is stretched to the maximum. The growth of a viable nursery industry would, in fact, substantially reduce the load of the hatchery and free its facilities for spawning. However, the nursery operators are still beginners and have yet to attain the production level of the station for them to effectively take over its seed production function.

Production of table fish. Cultured fish include mainly sea bass (*Lates calcarifer*), grouper (*Epinephelus* sp.), and snapper (*Lutjanus johni*).

Farming of marine finfish is normally carried out in cages (5973 units, 68 018 m²) and, to a limited extent, in ponds (30 ponds, 20 ha). The latter is confined mainly to the East coast of Peninsular Malaysia where suitable sites for cages are limited by rough seas particularly during the monsoon seasons.

Cage culture sites are limited to protected coastal waters with appropriate water quality. Each floating cage system consists of the net-cage and the frame supporting it. The frame is kept afloat usually by plastic drums or styrofoam blocks coated with fiberglass. The system is held in position by anchors, usually of concrete blocks, or wooden pegs.

Depending on their use, net-cages can be of different dimensions and meshes and can usually be classified into 3 classes (Table 1). Each cage system can be from 1 unit (4 cages) to a maximum of 15 units (60 cages).

Both tidal as well as levee ponds are used for finfish culture. Pond sizes are small, about 0.4 ha each.

In cage culture, rearing is divided into 3 phases; the hapa stage, nursery, and the grow-out stages. The technique reduces cannibalism in culturing fish.

In pond culture, the nursery stage is normally carried out in smaller ponds; the fish are transferred later to another pond for grow-out. Size grading is thus carried out only once. Since this method is ineffective in substantially reducing cannibalism, stocking densities are relatively low.

Table 1. Types of nets commonly found in cage system

Net Type	Dimensions	Mesh Size	Uses
Hapa net	2 × 2 × 2 m	8 mm	for nursing fingerlings of 10 cm or less
Nursery net	2 × 2 × 2 m	25 mm	for nursing fingerlings up to 15 cm
Grow-out	5 × 5 × 3 m	20-50 mm	for grow-out to marketable size

After each culture cycle the net-cages are cleaned of biofoulants by using strong water jets. Torn nets are replaced and repaired during this period.

Before the next culture cycle is carried out, ponds are flushed daily to remove excess sediments and waste from the last culture. Upon starting the next culture, the pond is drained and teaseed cake is applied to water left undrained to ensure effective eradication of potential predators or competitors. After application of lime and rice bran, the pond is filled with water again to about 50 cm and fertilized with triple superphosphate and urea to induce plankton bloom. A day or two before stocking the fry, the water depth in the pond is increased up to a meter.

Stocking is normally done early in the morning after the fry have received prophylactic treatment against diseases. Stocking density varies with the type of culture system practised. The fry, which normally are transported from quite a distance, are first conditioned to the local conditions before stocking. The stocking density in nursery cages is 300-350/m² initially. Stock is gradually thinned out, both to reduce its density and to size-grade the fry to reduce cannibalism. The fish, each weighing about 300 g, are transferred to the rearing or grow-out cages normally in about 3 months. The stocking density is thus reduced from 300-350/m² to about 100/m².

In pond culture the fish fry are stocked at a much lower density. In nursery, the stocking density is normally only about 25 fish/ m² and

reduced further to 1-3 pieces/m² when they are transferred to the grow-out pond after about 2 months. Grading is carried out only during transfer from nursery to grow-out pond.

At present the feed given to cultured species is trash fish. A newly formulated feed meant for sea bass is still being tested with encouraging results. Feeding to satiation is done once or twice daily at 3-10% depending on fish weight.

High mortality normally occurs during early stages, especially in the first few days after stocking. This is mainly due to stress from transport and handling.

Diseases encountered in fish culture are bacterial fin rot, vibriosis, streptococcosis, saprolegniasis, and ichthyosporidiosis. Some of the major parasites found in cultured fish with substantial frequency are crustaceans and flatworms. Cultured fish reach market size of about 500 g in 6-8 mo. Average survival per stocking is about 50-60% in cages and 30-70% (at lower stocking) in ponds. The greater range in survival rate in pond culture is due mainly to cannibalism which occurs at higher stocking. The expected harvest from cage culture is about 600 kg/cage compared to an average of 500 kg/ha of pond.

The main constraint setting back finfish culture at the moment is the supply of fingerlings. Even though the hatchery technology for sea bass has progressed so much so that it can ensure adequate supply of hatchlings, the nursery technology, for the production of juveniles having the right size for stocking in ponds and cages, still lags behind. Aside from sea bass seed, the supply for other species such as grouper and snapper still depends on the natural source. Disease is the other factor that needs to be looked into to increase production in finfish culture. The use of trash fish in finfish culture is a problem since supply is deteriorating both in quantity and quality. There is a need therefore to formulate a suitable fish feed. The production of finfish per hectare in pond culture is still very low compared to that of cage culture. The main problem in finfish pond culture is the inability to conduct feeding and grading of fish and other activities that require close supervision and efficient management.

Prawn Culture

Broodstock production. Among the marine prawns, *Penaeus monodon* is extensively cultured with *P. merguensis* also receiving

considerable interest. The giant Malaysian freshwater prawn *Macrobrachium rosenbergii* is the only freshwater prawn cultured on a commercial scale. The marine prawn industry is still heavily dependent on spawners caught from the wild by trawlers. To ensure better survival, the trawling duration is considerably reduced. Spawners are usually collected from the sea by middlemen who rush the spawners to landing points by speed boats. They are then sent to hatchery operators in plastic bags at reduced water temperature by road or air depending on the distance involved. A significant number of small hatcheries are still completely dependent on wild gravid females and have no maturation facilities. The bigger hatcheries generally carry out eyestalk ablation and are, therefore, willing to accept non-gravid spawners from the wild. Hence, there is no rearing of broodstock in the real sense. Wild non-gravid females of adequate size are kept in maturation tanks with more or less equal number of males. The maturation diet consists mainly of squid, mussel, chicken liver, oyster, and maturation pellet. The prawns are fed twice a day; the feed adjusted regularly depending on the left-over from previous feeding. Eyestalk ablated females may spawn up to five times, although the average number of spawning per female is two. The first spawning may occur on the third day after ablation.

As mentioned earlier the industry is heavily dependent on wild spawners, the supply of which cannot be assured at all times. While the pond-grown males mature spontaneously in captivity, the pond-grown females do not respond even with eyestalk ablation so that further work is needed to ensure adequate supply of spawners for the industry.

On the other hand, *Macrobrachium rosenbergii* broodstock supply is not a problem as the pond-grown prawn mates and spawns readily in tanks or ponds throughout the year. To reduce inbreeding, however, wild prawns are also used as broodstock whenever available. Overfishing and water pollution have resulted in the decline of the natural prawn resource. To overcome the problem, the government has initiated an open water stocking program and released large numbers of fry in the riverine system. As a result, even spawners caught from the wild may in fact, really come from the stocked prawn. The intention of using 'wild spawners' to increase the genetic pool and to reduce inbreeding may not be achieved. Aside from this consideration there is no major constraint to broodstock production of the freshwater prawn.

Seed production and nursery operation. Rearing facilities for seed production of the marine prawn vary from hatchery to hatchery depending both on the scale of operation and the culture system adopted. Generally, either rectangular or cylindrical tanks are used. The tanks are either of concrete or fiberglass. The size of tanks varies considerably for extensive system where spawning, hatching, and larval rearing all take place in the same tank. The tanks are large and may be in excess of 50 t. For hatcheries adopting the intensive culture system, where stocking density may be over 100/1, smaller tanks (2 t) are used. Larval feed consists of live phytoplankton initially followed by brine shrimp nauplii toward the later stages. Depending on the system adopted, the phytoplankton may be cultured in pure form in separate tanks under controlled conditions or in outdoor tanks where mixed endemic species of diatoms are maintained. The larval rearing tanks may also be fertilized to maintain a healthy phytoplankton population. While Baker's yeast is used to some extent, artificial larval feeds are still costly and thus not widely accepted. Formulated feeds are generally introduced only at PL₅ to supplement brine shrimp nauplii.

Bacterial contamination which result in necrosis of the larvae and often heavy mortality is common. Chloramphenicol and furazolidone are used for both prevention and control. Contamination of larvae by fungi (*Lagenidium* sp., *Sirolopidium* sp., and *Fusarium* sp.) is common and Treflan is generally used as a preventive measure.

Besides the supply of wild spawners, the major constraint to hatchery production of marine prawn fry appears to be the heavy dependence on phytoplankton as the early larval feed. Intensive culture of phytoplankton under controlled conditions is laborious and costly and not readily adopted by commercial hatcheries. On the other hand, extensive culture which utilizes endemic species is weather-dependent and hence the required phytoplankton may not be available when needed. There is thus a need to develop reliable formulated larval feed to overcome such problem and to reduce production cost.

Most *Macrobrachium rosenbergii* hatcheries are still small. The tanks used are generally not bigger than 10 tons and may either be cylindrical or rectangular. Stocking density is 30-100/1 depending on the culture system. Water management varies from practically no change of water in the static green water system to near daily complete renewal of water in other systems.

There is heavy dependence on brine shrimp nauplii as larval

food although fish flesh, cockle meat, egg custard, and formulated feed are also given as supplement. The culture of *M. rosenbergii* has not really taken off compared to that of the marine prawn. There is no great demand for fry; hence, hatchery production is still limited. However, should there be an increased demand, it is foreseen that such demand could be met by increased production from both public and private hatcheries.

Production of table shrimp prawn. Shrimp pond culture in Malaysia originated from the traditional trapping ponds which were subsequently phased out and replaced by the present culture pond system. This was mainly due to the declining supply of natural shrimp seeds or fry.

As in marine finfish culture, both tidal and levee ponds are employed. Pond sizes vary from the very small to as big as 5 ha each, although the majority are 0.25-10 ha and are usually rectangular. In 1985, there were 451 ponds with a total area of 445 ha.

There are three main types of culture systems: extensive, semi-intensive, and intensive. The main differences among these systems are their stocking densities, management techniques, and expected harvest (Table 2).

Pond preparation is broadly similar to that of finfish except that minimal water exchange is done within the first month to retain the natural productivity of the pond and to avoid injury to the still fragile post-larvae. In the later stages, after about one month culture period, water is changed practically everyday especially with the semi-intensive and intensive systems.

In extensive culture, food supply comes from the natural food enhanced through periodic pond fertilization throughout the culture. In intensive and semi-intensive operations, feeding is with pellets made especially for shrimps which are already manufactured locally. At the moment research is being conducted to substitute as much as possible the raw ingredients used in these pellets with local feedstuffs.

Usually after one month, the amount of supplementary feed is increased and further increments in feed is carried out at a 10-day interval as the body weight increases. Feeding frequency is 3-4 times daily depending on the stocking density and the amount of feed given daily.

Table 2. Systems of shrimp culture

Culture Systems	Stocking Density (no/m ²)	Management Technique	Expected Harvest (tons/ha/culture)
Extensive	5	Fertilization with minimal water change and no supplementary feeding	0.3-0.5
Semi-intensive	10-15	Fertilization only for the 1st months, minimal water change in the 1st month; 30% water change almost everyday and supplementary feeding needed; mechanical aeration required during later stages.	1.0-2.5
Intensive	20	Fertilization in the 1st month; water change minimal in the 1st month; 30% water change everyday and compulsory pellet feed even at start of culture.	3.0-6.0

Some of the common diseases and factors of economic importance in shrimp culture are bacterial black spot, vibriosis, yellow gills, and viral diseases. Factors that can also contribute to heavy losses of cultured shrimp include algal bloom, e.g., *Hornellia*, *Anabaena*, *Gonyaulax* (Dinoflagellate), and the protozoans *Epistylis*, *Vorticella*, *Zoothamnium*.

Culture periods vary from one culture system to another. At lower stocking densities shrimps grow faster and reach marketable size within 60 days. In semi-intensive and intensive culture, shrimps are harvested after 3-4 months. Where partial harvest is practised, the first harvest can be done from the second month onwards. Shrimps harvested are normally graded to appropriate market size either manually or by grading machines.

One of the main challenges shrimp farmers face is the problem of acid sulfate soils especially in excavated ponds. Correction of acidity may take several years at which time farmers are likely to face

acute cash flow problems. Another significant problem is the non-availability of credit and financing for investors. Being capital intensive, a large fund base is required for a start in the industry. However, financiers and venture capitalists are hesitant in committing funds because of high risks. Even though the technology exists there is still a lack of skilled and experienced manpower since a number of newly set up farms still have to train their workers. Disease is one of the greatest threats in shrimp farming and to date very little information about this is available. Market outlets are also constraints at this stage of transition when total production already exceeds the local market demand but has yet to meet the export market.

Mollusc Culture

The culture of the blood clam *Anadara granosa* and the green mussel *Perna viridis* depend on natural spats for its seed stocks. In the case of the cockle, the spatfall areas are located in the 4000-5000 ha of mudflats along the West Coast of Peninsular Malaysia. Although there is a high degree of unpredictability as to where spats will settle, the spats settle in large quantities and is sufficient to meet the demand of culturists. Seed collection is done by fishermen who sell them to buyers who in turn transport them to culture areas. Cockle spats are spread over the nursery areas of cockle farms at varying densities depending on seed size. Farmers regularly cull and harvest the cockle about 6-7 months after initial stocking.

Culture of the green mussel requires rafts with hanging ropes of jute or polyethylene as a substrate for spat settlement. Culling is also carried out to ensure even growth. A raft area of 1 ha can produce 3 150 000 kg of green mussel in one year. In 1985, 44 561 mt of blood clams and 200 mt of mussel were produced.

Current legislation pertaining to seed collection, production and marketing can ensure the development of the blood clam industry. However, a constraint to its further development is the marketability of fresh cockles in the export market which demand that cockles and mussels meet specific quality standards through depuration. To expand the domestic and export market for the green mussel, some secondary processing of the product is essential as the demand of the mussel in its fresh form is very limited. Pollution in the Johore Straits where the culture of the green mussel is dominant and along the West Coast of Peninsular Malaysia for cockle culture could be a future constraint.