1
Introduction

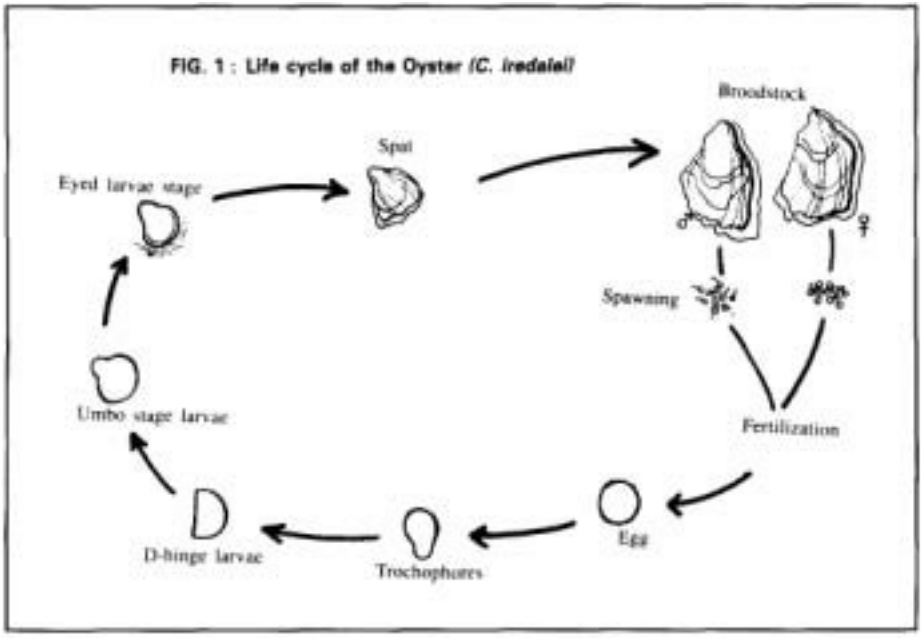
Oysters have traditionally been appreciated as a seafood in Malaysia. They are found on the market in fresh form, or as shucked meat, frozen meat, dried or canned. Fresh, live oysters are usually sold in S-star hotels and luxury seafood restaurants. To meet the demands of the seafood consuming public, the Department of Fisheries in 1990 implemented a project that introduced oyster culture and aimed at increasing production in the country. Research was undertaken under the project to overcome the lack of knowledge of culture technology in Malaysia. The Department of Fisheries received technical and financial assistance from the Bay of Bengal Programme (BOBP) of the FAO in the implementation of the project.

Three genera of commercially important oysters are found in Malaysia, *Crassostrea, Saccostrea,* **and** *Ostrea.* **The** genus *Crassostrea* comprises **of** two species, *C. iredalei* and *C. heicheri.* whereas the genus *Ostrea* has only one species, *0. folium. C. heicheri, C. iredalei* and *Saccostrea* spp. (see **Plate la)** are usually harvested in Malaysia for human consumption. The species most valued for culture is *C. iredalei.*

C. iredalei can be differentiated from *C. heicheri* by its black muscle scar (see Plate lb). **The** flesh of *C. heicheri,* which inhabits mangrove forested estuaries, is brownish, while that **of** *C. ireda/ei* is white or slightly yellowish.

Figure l illustrates the typical life cycle of oysters of the genus *Crassostrea* and *Saccostrea.* Oysters, like other bivalve molluscs, spend the first few weeks of their lives as small, drifting larvae. When the larva is about one-third millimetre long, it attaches to a substrate (sets)

Fig. 1. The life cycle of oysters belonging to the genus *Crassostrea* or *Saccostrea*



undergoes a change in its internal organs. eventually reaches sexual maturity and spawns. thus completing its life cycle. Adult oysters are either male or female, except for *Ostrea folium,* which begins as a male and changes to female after one or two years as an adult.

2
Oyster Culture

Oyster culture can be divided into two stages, spat collection and grow-out. The methods used are discussed in detail in the sections that follow.

2.1 *Spat collection*

A reliable source offering sufficient quantities of spat of the desired species is critical to successful oyster culture. Spat may be obtained from natural sources or from a hatchery. Natural production is the most important source of spat in Malaysia and will continue to be so until commercial hatcheries are established.

At present, there are only two hatcheries in Malaysia. One is located at the Fisheries Research Institute in Penang and the other at the Muka Head Station of the Science University of Malaysia, Penang.

Efficient spat collection requires that the farmer knows the spat setting season and where to collect sufficient spat for stocking his grow-out operation.

SPAT COLLECTION AREAS

The choice of a spat collection area is based on the presence of stocks of adult oysters of the desired species. The occurrence of spat is further indication that spawning is taking place.

A suitable spat collection site should also be sheltered from strong waves and currents that could damage the materials (cuitch) on which the spat attach themselves. Setting intensity varies with depth, so the depth at which maximum spatfall occurs should be determined by placing cultch at varying depth intervals.

SPAT COLLECTION SEASONS

Although oysters spawn throughout the year, spatfall is significant only during periods referred to as 'peaks'. Spatfall peaks for major collection areas have been determined by experience. Heavy spatfall is usually associated with relatively low salinity. Oysters geherally mature when salinity is high and spawn when it drops – for example, with the onset of the rainy season. The majority of oysters have mature gonads by that time.

Gonad maturity can be divided into three stages, immature, mature and post-spawning.

The gonads of immature oysters are thin and whitish. The gonad will cover only a portion of the flesh, exposing the brownish-coloured gastro-intestinal organs. At the same time, the mantle is relatively thick.

The gonad of a mature oyster completely covers the gastro-intestinal area, is thick and creamy white in colour. When the surface is scratched, gametes readily ooze from the wound. The mantle of mature oysters is thin and transparent.

Post-spawning oysters are flaccid with lean meat. The gastro-intestinal area is clearly visible through the thin mantle.

The spawning season is usually from April to June and October to December. Cultch should only be put out during the spawning season, thereby avoiding fouling. Spat will not set on heavily fouled cultch.

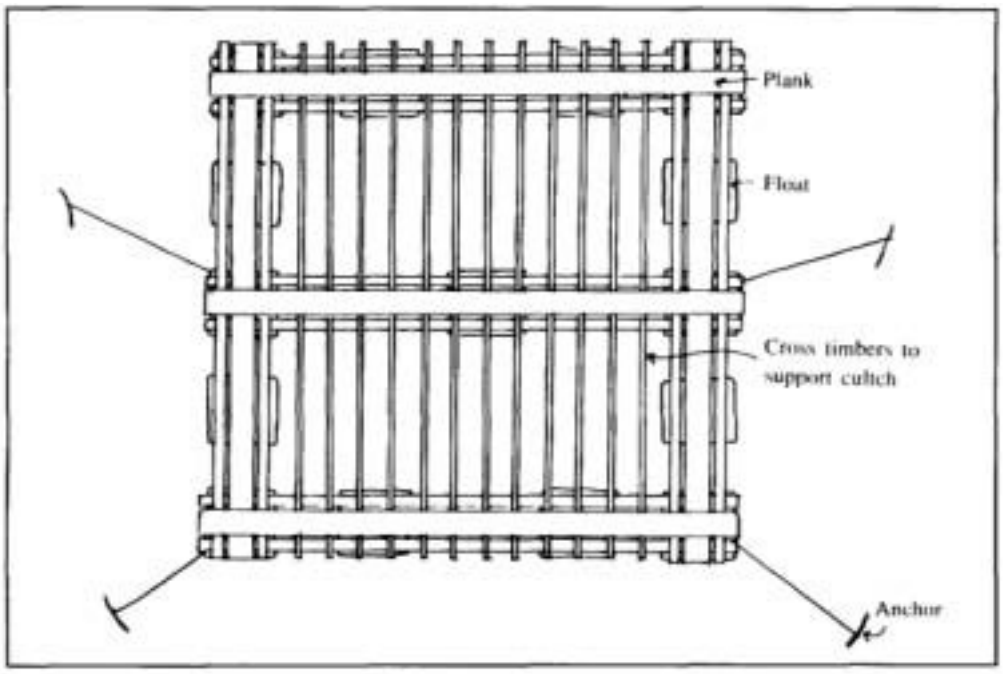
2.2 *Cultching systems*

Rafts, floating longlines and bottom longlines are used to suspend cultch. The choice of method depends upon cost, durability of materials, and environmental conditions such as wave exposure and water depth.

RAFTS

Grow-out rafts can be used, for spat collection. Cultch can be hung from the raft frame. Rafts usually measure (7 m x 7 m) and are used in sheltered locations (see Figure 2).

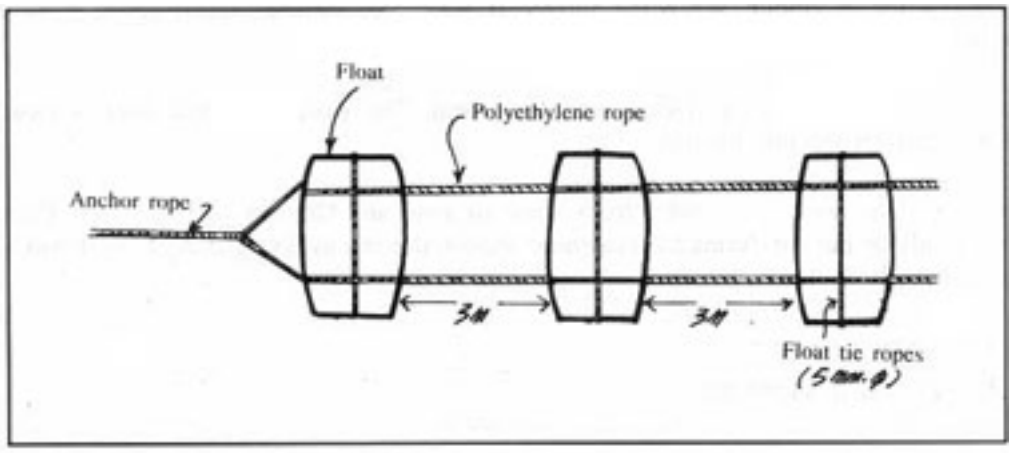
Fig. 2. Raft used for spat collection



FLOATING LONGLINES

Cultch is also just hung from longlines suspended from floats. The same longlines can be used for suspending grow-out trays. Longlines are suitable for use in more exposed locations, such as river mouths (see Figure 3).

Fig. 3. Longline used for spat collection



2.3 *Cuitch materials*

Oyster larvae **will set on a wide variety of materials, but prefer old oyster shells. Cuitch has to be free of fouling organisms and non-toxic. Cuitch should be inexpensive, durable and easy to handle. Some examples are given in the paragraphs that follow.**

TYRES

Discarded motorcycle tyres are good cultch material if the oysters are to be grown to market size on the tyre itself. Usually the tyres are turned inside out, bundled into a pyramid shape and placed directly on the bottom or suspended from racks, rafts or longlines (see Plate 2). Tyres are very cost-effective for collecting spat of *C. iredalei.*

Plate 2 *Tyres used for cuitch.*

NETLON

Netlon is a trademark for extruded HDPE plastic mesh. Mesh with 5mm opening is cut into 60 cm x 15 cm pieces which are then formed into cylinders. The cylinders are dipped into a mixture of cement, sand and lime (in the ratio 5:2:1). The mixture attracts setting larvae because of the lime content and facilitates removal of spat (see Plate 3).

Netlon collectors were originally used at Sunggai Merbok and Telaga Nenas to collect spat of *C. heicheri.* As this species has relatively low commercial value, spat collection using Netlon was shifted to the east coast. Netlon has also been used to set hatchery-produced larvae at the FRI.

Plate 3 : *Netlon cultch material.*

OYSTER SHELLS

Old oyster shells are attractive to setting larvae. A hole is punched or drilled in the centre of each shell and the shells are strung one on top of the other. Shell strings are about 1 m long (see Plate 4).

Shell cultch is not suitable for single oyster production because spat density cannot be controlled. Adult oysters get misshapen and are difficult to remove from the substrate. However, old oyster shells are suitable if shucked meat is the end product.

Plate 4 : *Oyster shell cultch.*

2.4 *Nursing spat*

If single oysters are desired, spat must be removed from the cuitch and nursed in trays until they reach 3 cm. If spat are separated from their cultch, market-sized oysters produced from them will have the proper cup shape. Such oysters can be sold on the half-shell market and are much more valuable. Irregular specimens are used for shucked meat production. Half-shell oysters are sold by the piece, whereas shucked meat is sold by weight.

Oysters may be grown to market size on their original cuitch. However, their growth rate is usually slower than that of individual oysters because no thinning is done.

The choice of nursing system will depend on local conditions. The farmer should give particular attention to the depth differences between low and high tide, water depth and bottom condition (whether muddy, sandy etc.). The site should be protected from strong waves and wind and should be in the salinity range of 15 to 20 ppt to avoid fouling problems. Polluted waters must also be avoided. Good water exchange is essential for fast growth.

RAFTS

Rafts can be used in sheltered locations (see Plate *5).* The 'standard' raft of 7 m x 7 m can support about 120 trays. Trays can be hung from the raft frame in tiers, thus greatly increasing the carrying capacity of the raft.

The number of oysters to be placed in a tray depends on the size. In the case of a motorcycle tyre tray, no more than 100 oysters should be stocked. If there is any mortality, or growth is not satisfactory, the oysters should be thinned out by transferring a portion to new trays.

Oyster-bearing cuitch can also be suspended from the raft if the oysters are to be grown to market size, of if a sufficient number of trays is not available.

Plate 5 *Grow-out raft.*

LONGLINES

Longlines of 50 m length have been found to be profitable. Plastic barrels of 60 l capacity are used as floats and spaced 3 m apart (see Plate 6). Netlon trays as well as cheaper tyre trays may be suspended from the longline. Longlines are cheaper than rafts and easier to construct.

Some farmers use a raft for their nursery and longlines for grow-out.

Plate 6 : *Longlines used for grow-out.*

RACKS

Racks are suitable for. sites with a small tidal range. The bottom should be solid enough for firm emplacement of posts. Any size rack can be used, but 7 m x 7 m is convenient and would hold the same number of trays as a raft of the same measurements (see Plate 7). The trunk of *nihong,* a type of palm tree, is very suitable, because it is durable and economical. Lagoons on the east coast of Peninsular Malaysia are appropriate for rack installation.

Plate 7 : *A rack being used for culture at Merchang, Terengganu.*

2.5 Culture trays

A variety of culture trays have been developed for grow-out. The choice of tray is based on cost, durability and stocking capacity. Tyres, Netlon and plastic baskets have all been found to be effective.

Plate 8 : *Tyre trays used for grow-out.*

TYRE TRAYS

Discarded motorcycle tyres, readily available from factories, make durable and cheap trays. The tyres are turned inside out to form the frame for the tray. A leather punch is used to make holes along the bottom edge of the inverted tyre. The spacing of the holes depends on the mesh size of Netlon to be used. The Netlon is cut to the diameter of the inverted tyre and tied in place with HDPE twine. If the tray is to be used for nursing small spat, 5 mm mesh may be used. A cover should be used to keep predators out. The cover may be made of the same mesh size as the bottom. Mesh of 1 cm is sufficient for grow-out and no cover is required. Four equally spaced holes are punched along the top to accommodate 5 mm HDPE lines used for hanging the trays (see Plate 8). One tyre tray can carry about 100 oysters to market size. Such trays are very durable, lasting five years or more.

NETLON TRAYS

A frame is made of 1½ Pvc pipe cut to the desired length. Netlon is cut to fit the frame and tied in place. A tray measuring 60 m x 100 cm is a convenient size. Large trays are too heavy and difficult to handle. Suspension ropes are attached to the corners (see Plate 9). Netlon trays can be suspndedin a single layer or in tiers. A tray of the above dimensions can be easily handled by one person. The tray can carry 100 oysters. Although more expensive than a tyre tray, Netlon trays are longer lasting. Growth of stocked oysters is also faster due to good water circulation.

PLASTIC BASKETS

Plastic baskets suitable for nursing spat and grow-out are available in the marketplace. The farmer should take care to choose only the best quality baskets. Cheap material lasts only a few months and will split at the corners. Holes are drilled in the upper corners for tying the suspension ropes (see Plate 10). These trays are suitable for nursing small spat, but must be lined with plastic mesh. A cover, often Sold with the basket, should also be used in this case.

Plate 9 : Netlon trays.

Plate 10 *Commercially available baskets used for grow-out.*

3
Culture Management

Cultured oysters require a level of care to ensure their continued survival and growth to marketable size. Farm management includes cleaning, thinning, sorting or grading, pest control and predator protection.

3.1 *Cleaning*

Silt and other dirt is removed by washing the oysters, either with a pump or swishing the trays up and down in the water (see Plate 11) If affordable, a pump is preferable, since it can also remove newly attached fouling organisms and is fast, saving labour. Should fouling be heavy, brushing may be required.

The frequency of cleaning depends on local conditions. If siltation is heavy, monthly washing may be necessary. Normally, siltation is not much of a problem during the dry season.

3.2 *Thinning*

Oyster spat may be nursed at high density, but upon reaching around 3 cm length, they should be thinned out to the final grow-out density. If the oysters are overcrowded, growth is very slow and mortality increases rapidly.

Oysters should be sorted so that each tray contains more or less the same sizes (see Plate 12). The sorting process continues until oysters are marketed. Sorting also reduces labour at harvest time, as only those trays with marketable oysters need be selected for harvest.

As has been mentioned earlier, tyre and Netlon trays hold a maximum of 100 oysters each. The carrying capacity depends very much on local conditions. In some places, 60-70 oysters a tray will give the best results.

Plate 11 ***Cleaning oyster trays.***

Plate 12 ***Thinning oysters.***

3.3 *Pest removal*

Pests are animals (like sponges, ascidians and barnacles) which compete with oysters for food, space and oxygen. The problem is usually more severe during the dry season when the salinity increases. Sites too close to the sea also experience severe pest problems. That is why the optimal salinity for oyster culture is between 15 and 25 ppt.

Some of the more common pests are mussels, barnacles, *Isognomon* (the flat tree oyster) and horse mussels.

GREEN MUSSELS

Green mussels grow faster than oysters and compete with them for space, food and oxygen (see Plate 13). Mussels are filter feeders like oysters. Green mussels can be controlled by air-drying if they are less than 5 cm. Larger specimens are removed by hand picking.

BARNACLES

Barnacles spawn about the same time as oysters and are particularly troublesome when they set on oyster cuitch. Oyster larvae will not set on cultch covered with barnacles. Cultch should be put out after the barnacle setting season is over (see Plate 14).

Barnacle fouling is worse in higher salinity areas. If barnacles foul market-size oysters, they have to be scraped off before the oysters are sold.

ISOGNOMON

isognomon is a competitor for food and space (see Plate *15).* Heavy fouling by this shell-fish hinders growth. It is controlled by hand picking.

HORSE MUSSELS *(Siput rantai)*

Horse mussels *(Modiolus* spp.) compete for space and food with oysters. They quickly form thick blankets which can smother the oysters (see Plate 16). Horse mussels are easily killed by air-drying the oysters. They can also be removed by hand.

Plate 13: *Fouling by green mussels.*

Plate 14 : *Oysters fouled with barnacles.*

Plate 15 Isognomon *attached to oyster shells.*

Plate 16 : *Horse mussels fouling cultch.*

3.4 *Predators*

Predators must be controlled to avoid high mortality, particularly of spat. The most common and dangerous predators are crabs, oyster drills and blister worms.

CRABS

Crabs are the most dangerous predators of spat. Even relatively small crabs are able to break the fragile shells of spat to get at the flesh (see Plate 17). Crabs are frequently abundant in the immediate vicinity of spat trays, particularly if the trays are at the water surface. The most effective control measure is by screening. Screens should be fine enough to exclude even small crabs. The screen material should be thick enough to prevent crabs from cutting through it.

STARFISH

Starfish are a major predator of bottom-cultured oysters (see Figure 4). They attack oysters of all sizes. The starfish grasps the oyster with its five arms and pries open the shell using its sucker 'feet'. The stomach is extruded into the oyster to digest its flesh. Starfish are not a problem for any type of off-bottom culture (raft, longline etc.).

OYSTER DRILLS

Oyster drills are snails which drill a small hole through the oyster shell using a rasping device *(radula)* (see Plate 18). The snail's proboscis is inserted through the hole into the oyster's flesh and the meat digested and sucked into the drill's stomach. Drills are not a serious danger to oysters grown by hanging culture methods, but they can seriously affect bottom-cultured animals.

BLISTER WORMS

Blister worms bore through the shell. They do not prey on the oyster and a low rate of infestation is not harmful. However, in cases of heavy infestation, the shell becomes thin and easy to break. If the worm penetrates to the inside of the shell, the oyster tries to cover up the hole by depositing shell, hence the term 'blister' worm (see Plate 19). Growth is slowed and, in extreme cases, mortality will result. The easiest way to control blister worms is by air-drying the oysters for 24-48 hours. Blister worms are normally a problem only in areas of high salinity.

Plate 17 : *One of the crab species which attacks spat.*

Fig. 4. Starfish

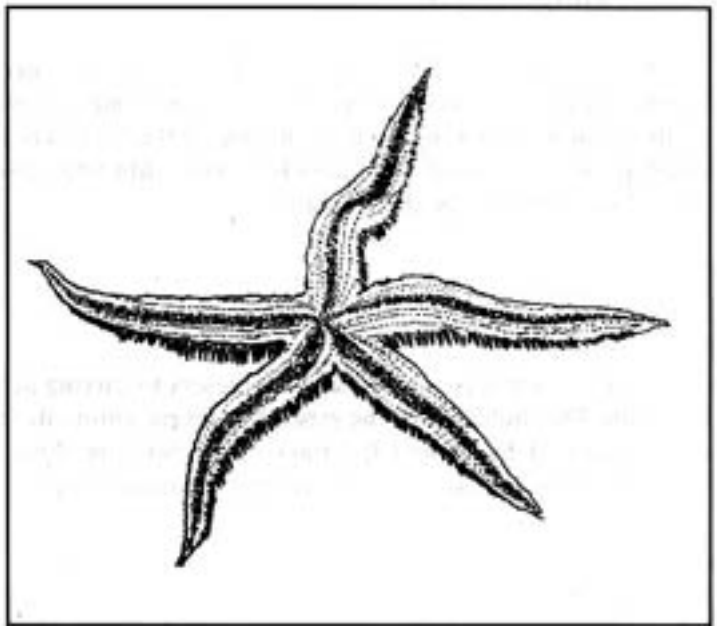


Plate 18 : *An oyster drill.*

Plate 19 : *Oyster infected with blister worms.*

3.5 Fouling control

'Fouling' includes mud, ascidians, coral, sponges and other encrusting organisms. These agents attach themselves to trays and oysters and interfere with the feeding and respiration of the oysters. If not attended to in time, a thick blanket of fouling organisms and silt develops and the growth of oysters is reduced. Mortality also increases due to the restriction of water flow over the animals.

MUD

Mud and silt cannot be avoided and are present to varying degrees at most culture sites (see Plate 20). The problem may be especially severe during the rainy season. Mud and silt are easily removed by rinsing the trays or by washing them with a pump. Mud must he removed continuously, especially during the rainy season.

ASCIDIANS

Ascidians grow quickly and cover the oysters' shells (see Plate 21). Remedial measures must be taken before the oysters become completely covered and their growth affected. Brushing or drying can control ascidians, which normally flourish in high salinity water found at sites near the sea.

CORAL

Coral form thicker layers than ascidians and can quickly smother oysters in trays or baskets (see Plate 22). Brushing is effective in removing coral, if they are still thin. If the corals have formed a thick layer, they must be stripped off by hand before brushing. Corals break down the oyster's shell and may even penetrate to the interiorof the shell. If the oyster is heavily infected, it becomes fragile and is easily broken.

4
Harvesting and Handling

Cultured oysters reach marketable size 9-12 months after stocking. Grow-out time depends on initial stocking size. The usual market size is 9-12 cm.

Harvesting raft-cultured oysters is easily done by one person. Two persons are required to work the longline, one to remove the oysters from trays and the other to control the boat.

Plate 20 : *Mud eovering* ***oysters.***

Plate 21 : *Ascidians growing on oyster shells*

Plate 22 : *Coral which has grown over cultured oysters.*

After landing, the harvested oysters should be brushed and any fouling organisms removed. Oysters should be depurated to ensure they are free of bacterial contamination (see Plate 23). Depuration should be carried out for 36 hours. Undepurated oysters are unsafe for consumption and may cause gastroenteritis and related diseases. Reservoir water in the depuration unit should be replaced for each run. Oysters are ready for marketing after depuration.

Some oysters may be sold as shucked meat. A special 'shucking' knife should be used to open the oysters and remove the meat. Care must be taken not to damage the oyster meat during shucking (see Plate 24). The meat should be weighed and then kept on ice until sale.

5
Promotion and Sales

The Department of Fisheries, Malaysia, frequently organizes sales promotions at fairs, hotels and seafood restaurants. Most Malaysians are still unfamiliar with the nutritional benefits and flavour of fresh oysters. Promotion increases demand and improves sales prospects for farmers.

Fresh oysters sold in hotels and restaurants are chosen for their attractive cup shape. They are eaten raw, with a dash of lemon juice and/or tabasco sauce. Farmers should keep this in mind when selecting oysters for harvest.

Plate 23 : *A small-scale depztration unit.*

Plate 24 : *Shucking an oyster.*

The selling price of live *C. iredalei* depends on the size, shape and appearance. Kedah culturists have developed a system of four grades, A, B, C, and D, according to size and shape:

Grade A more than 13 cm; Grade B = 11-13. cm; Grade C = 9-11 cm; Grade D = less than 9 cm (see Plate *25).*

Plate *25* : *Graded oysters, with A on the far left, D on the far right.*

The price of fresh oysters varied from place to place in 1992 as follows: Sungai Petani, 90 cents; Sitiawan, 60 cents; east coast, 50 cents. Oysters found in the market are usually Gtades C and D. The larger grades are seldom seen because their grow-out time is too long and they are, thus, less profitable to grow. For shucked meat, prices (in RM/kg) were as follows at various centres in 1992:

Sungal Petani,	*C. belcheri*	12
Sitiawan,	*C. beicheri*	8
East coast,	*C. iredalei*	10
Muar,	*Crassostrea* sp.	12

Farmers in Muar sell only shucked meat. They do not market live oysters because their stocks comprise of two species of *Crassostrea.* These species do not have the preferred flavour of *C. iredalei* and are, hence, less marketable in the live form. Farmers sell the meat according to weight after the shell has been removed.

Appendix I

Cost of raft construction in 1992

The following estimates for raft construction include materials and labour costs as prevalent during 1992.

1. Cost of constructing culture trays

a. TYRE. TRAYS

i. Tyres	RM 0.20
ii. Netlon	RM 3.62
iii. Rope	RM 0.50
iv. Labour	RM 1.14

b. BASKETS

i. Basket	RM 2.50
ii. Rope	RM 0.50

c. NETLON TRAYS

i. Netlon	RM 9.86
ii. PVC pipe	RM 2.14
iii. Labour	RM 0.81

2. Cost of cultch fabrication

a. TYRES (4)

i. Tyres	RM 0.80
ii. Rope	RM 0.50

b. OYSTER SHELL

i. Oyster shell	
ii. Rope	RM 0.50

c. NETLON

i. Netlon	RM 4.50
ii. Rope	RM 0.50

3. Construction costs for culture systems

a. LONGLINE

i. Rope, 14 mm	2 *x* 50 m	RM	90.00
ii. Anchor rope, 14 mm	20 m	RM	16.50
iii. Plastic drum floats, 60-litre	26 nos.	RM	442.00
iv. Anchor	2 nos.	RM	40.00
v. Line for securing floats to longlines	80 m	**RM**	21.60
vi. Labour		RM	50.00
	Total	RM	660.10

b. RAFT

i. Plastic drum floats, 200-litre	9 nos.	RM	270.00
ii. Hardwood frame members, *chengal*, 2" x 3" x 23"	18 nos.	RM	450.00 *
iii. Planks	6 pcs.	**RM**	150.00
iv. Nails	1 kg	RM	3.00
v. Anchor	4 nos.	RM	80.00
vi. Anchor rope, 14 mm	40m	RM	'33.00
vii. Bolts	24 pcs.	RM	36.00
viii. Labour		RM	80.00
	Total	**RM**	1102.00

* Price varies according to season, species and size used.

c. RACK

i. *Nibong* poles	12	nos.	RM	240.00 *
ii. Timber for support frame, *chengal,* 2" x 4" x 23'	8	pcs.	RM	240.00 *
iii. Cross-members, *chengal,* 2" x 3" x 23'	14	pcs.	RM	350.00 *
iv. Nails	1	kg	RM	3.00
v. Bolts	24	pcs.	RM	120.00
		Total	RM	953.00

4. Cleaning pump cost

a. Pump with petrol engine, 5 hp	1	unit	RM	880.00
b. Suction hose	1	unit	RM	48.00
c. Discharge hose	1	unit	RM	37.50
d. Foot valve	1	unit	RM	10.50
e. Coupling	2	unit	RM	17.00
f. Hose clip	3	unit	RM	2.40
		Total	RM	995.40

5. Depuration unit construction costs

a. Pump, 0.4 hp	1	unit	RM	640.00
b. UV tube lights	2	units	RM	140.00
c. UV lamp mounting	2	units	RM	20.00
d. Plastic trays, 64 x 42 x 16 cm	15	units	RM	330.00
e. PVC pipe, 1"	1	length	RM	10.00
f. One way valve, 1"	1	unit	RM	14.00
g. Ball valve, 1"	3	units	RM	40.50
h. PVC "T", 1"	3	units	RM	2.40
i. PVC cap, 1"	6	units	RM	2.50
j. PVC elbow, 1"	3	units	RM	1.70
k. Valve socket, 1"	12	units	RM	5.05
l. PVC solvent cement	1	tin	RM	2.00
m. Teflon tape	1	roll	RM	0.40
n. Tank, reservoir, fibreglass, 1 t	1	unit	RM	185.00
o. UV light box	1	unit	RM	200.00
p. Wooden rack	1	unit	RM	500.00 *
		Total	RM	2093.55

* Price varies according to season. species and size used.

References

AUMAD ALl, DEWAKIE, N. and ZAIN, Y.M. (1992). *Oyster culture* (Crassostreairedalei and *Saccostrea* spp.) *in Terengganu, Malaysia.* Fisheries Department, Ministry of Agriculture. Malaysia (in Malay).

CHOO, P.S. (1991). *Oyster culture.* Fisheries Department, Ministry of Agriculture, Malaysia (in Malay).

DEWAKIE, N. (1992). *Methods of oyster seed nursing* (Crassostrea iredalei). Fisheries Research Institute, Dept. of Fisheries, Ministry of Agriculture, Malaysia (in Malay).

QUAYLE, P.B. and NEWKIRK. G.F. (1989). *Farming bivalve molluscs: Methods for study and development.* The World Aquaculture Society in association with the International Research Development Centre.