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Small-scale Oyster Culture on the West Coast of Peninsular Malaysia

BOBP For Fisheries Development

BAY OF BENGAL PROGRAMME

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Small-scale Oyster Culture on the West Coast of Peninsular Malaysia

by

Devakie Nair
Fisheries Research institute
Penang, Malaysia

Robert Hall
Economist (Associate Professional Officer)
Bay of Bengal Programme

Charles L. Angell
Sr. Aquaculturist
Bay of Bengal Programme

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This paper describes small-scale oyster culture trials carried out in the states of Kedah and Perak on the west coast of Peninsular Malaysia. Rafts and longlines were found to be economically viable and the technology was transferred to fishermen. Spat of the slipper oyster, *Crassostrea iredalei*, were transplanted from the east coast of peninsular Malaysia to the west coast sites.

Small-scale depuration units were established at farm sites and a series of market promotions successfully undertaken.

Hatchery seed production and remote setting were done by biologists and staff of the Fisheries Research Institute with assistance from temporarily hired field biologists. Artificial spat production was necessary to supplement short supplies of wild spat.

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CONTENTS


THAILAND
1
P. Langkawi
Kelantan river estuary
KEDAH
Batu Lintang
George Town
P. Pinang
Kuala Setiu
Kuala Terengganu
Merchang
KELANTAN
PERAK
TERENGGANU
ANDAMAN SEA
P. Pangkor
Teluk Dalam
Telaga Nenas
PENINSULAR
MALAYSIA
SOUTH
CHINA
SEA
SELANGOR
PAHANG
Kuala
Lumpur
1. PERLIS
2. MELAKA
NEGRI
SEMBILAN
2
Pasir
Panjang
Muar
JOHOR
STRAITS OF MALACCA
SINGAPORE
Sumatera
INDONESIA

<<

1. INTRODUCTION

Oyster culture is widely practised bysmall-scale producers in Thailand and the Philippines. Simple, low-cost technology has been developed through years of experience and has contributed to improved earnings for artisanal fisherfolk who, in other countries of the Bay of Bengal region, are relatively poor. Given the growth of the industry in Thailand and the Philippines, the Department of Fisheries of the Government of Malaysia targeted oysters for aquaculture development during its 7th Five-year Plan.

Financial and technical assistance was requested from the Bay of Bengal Programme (BOBP) in 1987 and a BOBP subproject entitled ‘Oyster Culture in Malaysia’ was established. Work began in 1988 through the Fisheries Research Institute, Penang. Originally, sites were selected only on the west coast, in the states of Kedah and Perak. When it became obvious that spat supplies from these areas would be insufficient, activities were expanded to the east coast state of Terengganu in 1989 (see Figure 1 facing). However, BOBP’s support here was limited to spat collection.

Coastal inhabitants of Malaysia traditionally consume oysters harvested from wild stocks. While a variety of suitable species can be found along the country’s coasts, oyster farming is a recent innovation, beginning with trials in the 1960s. These initial trials were of short duration, but gave some indication of the potential. However, until 1989 nothing had been published concerning the domestic market. That year, three studies of marketing and consumption in the country (Angel! 1988) were carried out under the subproject.

1.1 *Species and their distribution*

The four main genera of oysters and their respective species that have been identified in Malaysia (Ng 1979) are:

- *Crassostrea (C. beicheri* and *C. iredalei);*
- *Saccostrea (S. echinata and Saccostrea spp);*
- *Ostrea (O. folium);* and
- *Hyotissa (Hyotissa hyotis).*

The *Crassostrea* spp, or the mangrove oysters, are the largest species, often measuring up to 10 cm (marketable size) and are of commercial value. They thrive best in estuarine locations with a salinity range of *15-25* ppt.

C. beicheri are most common in the mangrove systems of the west coast of Peninsular Malaysia (Kedah, Perak and Johor). They have also been reported to occur along the mangrove coast of Sabah (Chin and Lim, 1975).

C. iredalei, on the other hand, is confmed to brackishwater lagoons in the east coast states of Terengganu and Kelantan. Its range is known to extend into southern Thailand and the Philippines, where it is the top commercial species.

common oyster species in Malaysia, left to rignt, crassostrea iredalei, C. belcheri, Saccostrea ***sp. and*** Ostrea folium.

Saccostrea spp, usually chipped off rocks, are the most abundant small species, measuring up to 5 cm. It was reported by Okada (1963) that they form 70 per cent of the oysters found in Malaysia. They are distributed along the estuarine and marine intertidal regions off the east and west coasts of Peninsular Malaysia.

Ostrea folium, the flat oyster, has been described by Ng (1980) as a subtidal marine species inhabiting the outer coasts of Peninsular Malaysia (P. Langkawi), where sahnity is normally over 30 ppt. Experiments done throughout 1988-1990 in P. Langkawi, Kedah (Nair and Lindeblad, 1991), indicated that it is not a significant commercial species due to its low market value and limited distribution.

Hyotissa hyotis is another subtidal species commonly found among coral reefs in Malaysia. Though large specimens, measuring 25 cm have been observed, it is not a species commercially exploited in the country

C. iredalei *(above) and* C. beicheri. *Note dark muscle scar on* C. iredalei.

1.2 *Selections of technologies and the rationale*

Several attempts to culture oyster in Malaysia were carried out in the Sixties by Okada (1963). Chin and Lim (1975) cultured *C. bekheri* in Sabah. Technology for the farming of *Ostrea folium* in P. Langkawi, Kedah, was developed by the Fisheries Research Institute (Ng, 1979 and 1980).

Under the BOBP subproject, several field trials to grow oysters were launched along the west coast of Peninsular Malaysia , embracing sites at Batu Lintang and P. Langkawi in Kedah, Telaga Nenas and Kg. Teluk in Perak and Sg. Muar in Johor. Spat collection was attempted at several east coast sites as well. These included Kuala Setiu and Sg. Merchang in Terengganu (east coast).

The choice of technology for spat collection and grow-out was made on the basis of market surveys which, with the exception of the one in Langkawi, indicated live oysters would be the most profitable product. The culture system used for O.*folium* in Langkawi was based on previous experience using net panels (Ng 1980).

Raft and longline culture are commonly used in the oyster industry in temperate climates. Locally available materials were adapted to these technologies and modifications were made according to local conditions of depth and bottom sediment, whether sandy or muddy.

2. SPAT PRODUCTION

The development of an oyster culture industry depends directly upon the reliable supply of 'seed', which are usually referred to as 'spat'. Two sources of spat are utilized – natural and hatchery. Commercial hatchery production is limited to the northern hemisphere, although pilot operations have been successful in Thailand. Hatchery spat production is reliable and lends itself to genetic manipulation for better growth and disease resistance.

All oyster production in Southeast Asian countries depends on natural spat production. While Filipino farmers are adequately supplied, growers in Thailand are faced with frequent shortages which limit farm production.

2.1 Natural spat

Natural spat production forms the basis of most oyster industries, the exception being the Pacific Northwest of the USA.

Since hatchery spat production is not yet well developed in Malaysia, extensive trials were made to collect natural spat. Methods for predicting spatfall were field-tested concurrently with spat collection trials on both the east and west coasts.

PREDICTING SPATFALL

The most important criterion in spat collection is to know the right time to suspend substrate 'cultch'. If cultching is too early, biofouling and siltation will result in low spat density. Too late, and the spatfall will be missed entirely.

The following methods of predicting spatfall were tested :

- Gonad maturity surveys,
- Eyed larvae counts,
- Test panels, and
- Observations of spatfall on locally occurring substrate.

The methods are described below :

Gonad maturity study : Twenty oysters were examined monthly for maturity. If the gonad was scratched and gametes oozed freely from the wound without pressure, the oyster was classified as 'running ripe'. When 80 per cent reached running ripe condition, cultch was put in the water.

Eyed larvae counts : Plankton hauls of 5-minutes duration were made with a 'Kitahara' plankton net, giving about 100 revolutions of the flowmeter. Eyed larvae of Crassostrea spp. were counted. If they were greater than 100 per haul, this was taken as an indicator of imminent setting.

Test panels : Test panels of asbestos, netlon and oyster shells were hung at different levels to determine the density of larvae. Density was considered to be high at 10 spat/cm^2.

Spat on natural substrate : Observation of spat on naturally occurring substrate can be an effective indicator for suspending cultch. Natural substrate include oyster shells, submerged rocks, fish traps, cage floats and mangrove roots. However, spat size should be less than 2 mm to indicate recent spawning.

CULTCH

'Cultch' refers to substrate material hung by oyster farmers natural or hatchery spat attach themselves to it. The choice of cultch depends on the type of system employed. Cultch in use on the east coast of Peninsular Malaysia included tyres, Netlon, oyster and coconut shells. The ideal cultch should be attractive to eyed larvae, cheap, readily available and durable. Some commonly used cultch are discussed below

Tyres : Discarded motorcycle tyres are readily available, inexpensive and attractive to oyster larvae. The tyres are turned inside out and suspended individually from raft/racks or made into reefs. The reef tyres are placed at the bottom and tied to a rope marked with floats for easy retrieval. Observations have shown that oyster spat tend to settle more on the inner side of the tyre (see picture on right).

Netlon*: Netlon is an extruded HDPE mesh which, although relatively expensive, is extremely durable, lasting many years in seawater. Netlon of 1 cm mesh size cut into panels measuring 62 cm x 67 cm was used in the trials. The panels were formed into cylinders by joining and lacing opposing edges along the 67 cm side. These cylinders were then dipped in a mixture of cement, sand, and lime in the proportion of *5:2:1*. After two days' drying, this cultch could be put out in the water. (see picture below).

Oyster and coconnt shells : Discarded oyster shells were abundant in Merchang, having been discarded after shucking the meat. The shells were punched and strung on HDPE line.

The hard, inner shell of the coconut *(tempurong)* is also easily found in the area, coconut being widely cultivated for home use and as a cash crop. In sandy areas like Merchang and K. Setiu, the shells were scattered on the bottom or hung from culture systems. The shells were strung 2 cm apart on a string adjusted to the water depth (see picture below, right).

Tyre cultch with a good set of C. iredalei.

Netlon cylinders coated with cement-lime dip.

Oyster and coconut cultch strings.

* Netlon is a trademark for extruded plastic net material. Use of a trademark does not imply endorsement by BOBP or FAO.

EAST COAST COLLECTION SITES

The two peak seasons for spat collection at Sg. Merchang and Kuala Setiu, Terengganu, are April-June and October-December (Ahmad et al., 1992). C. iredalei and Saccostrea sp. predominate on the east coast. The latter constituted about 15-25 per cent of the spat collected in Merchang and 30-55 per cent in K. Setiu. It was found that spat density at Merchang was evenly distributed throughout the water column, while at K. Setiu density was highest at a depth of 0. l-l .0 m below the water surface.

WEST COAST COLLECTION SITES

The two species of oysters favoured on the west coast were C. belcheri and C. iredalei. The latter was transplanted from the east coast (see Section 2.3). All attempts on the west coast to collect commercial quantities of C. belcheri spat failed.

Field trials were conducted on Langkawi Island during 1988 and 1989 to collect O. folium spat. However, culture trials were abandoned due to marketing problems.

Activities at the west coast sites are summarized below and described on the next page.

Oyster spat collection trials conducted at various locations along the, west coast of Peninsular Malaysia

Areas	*Species*	*Systems*	Cuhlre *materials*	*Redlts*
KEDAH				
Teluk U	Saccostrea *echinata*	**Intertidal** rack	**Oyster shells, Egg crates**	**Failure due to fouling from barnacles.**
Tg. Rhu	*O. folium*	Raft	**Net panels**	**Very few spat collected.**
PERAK				
Teluk Gedung (P. Pangkor)	*Crassostrea* **sp. and** *Saccostrea* **sp.**	*Stakes*	**Oyster shells hung from strings**	**Very few spat collected and hi mortality due to heavy biofouling.**
Telaga Nenas	*C. belcheri*	**Longline**	**Netlon**	**Spatfallvery light, below commercial requirements.**
Teluk Dalam	**do .**	**Raft**	**Oyster shells in Netlon bags**	**. do_**
MELAKA				
Sg. Linggi	**saccostrea sp.**	**Rack**	**Netlon**	**very few spatcollected. Current too swift.**
		Interidal mud flats	**Cement poles and broken flower pots**	
N. SEMBILAN				
Pantai Pasir Panjang, Port Dickson	*Saccostrea* **sp.**	**Interidal mud flat**	**Netlon oyster shells**	**Failed to collect spat due to heavy siltation**
JOHORE				
Sg. **Muar**	**Crassostrea** *belcheri*	**Rocks on intertidal flats**	**Rocks**	**Very few spat collected because of algal and barnacle fouling and also rubbish getting entangled with the cultch materials.**
		Bottom longline	**Strings of oyster shells, Netlon, tyres, flower pots and fibre-glass reefs.**	**Pollution load very heavy, oysters overfished.**

Batu Lintang is located on the Merbok River, about 11 km from the sea. Cultch materials tried here were oyster shells, coconut shells and Netlon. Oyster and coconut shells were good for only one cycle, as they became brittle and tended to break when the spat was separated. Oysters from this kind of cultch material are more suitable for the production of shucked meat; their irregular shapes make them unsuitable for half-shell sales.

Spat collection was carried out with cement-coated Netlon cylinders using bottom longlines for spat distributed in the lower water column and surface longlines for spat in the upper water column. Test panels made of asbestos and measuring 10 cm^2 were placed at a distance of 0.5 m apart to check the availability of spat in the area. Studies showed that the two peaks were in April-June and October-December, when the spat density was 0.01 -2.0/cm^2 (Hasbullah, 1992). It was also observed that the density of eyed larvae was related to the gonad maturity of oysters and the salinity levels in the area.

P. Langkawi was another site for spat collection trials; they were carried out in Kg. Kelibang, on the south coast of the island, using polyethylene net panels of 1 m^2. The panels were suspended from rafts of 6 m^2 and held vertically by stone weights tied at the two bottom corners of each panel. About 128 such panels could be hung from a raft. The main seasons for spat setting of *O. folium* were observed to be April-May and August-October. However, spat was obtained in small quantities throughout the year (Nair and Lindeblad, 1991).

Other areas, several in number, were tested for spat collection, but the results were not satisfactory, either because the spat were available only in small quantities or heavy biofouling caused high mortalities among the collected spat. Table 1 on the previous page shows the areas and results.

2.2 Hatchery spat

Hatcheries play an increasingly important role in bivalve culture in the northern hemisphere, but are still experimental in Thailand and Malaysia. However, these experimental hatcheries have shown their potential as a supplementary source of oyster spat. The basic technology is the same as applied in temperate waters, although minor modifications have had to be made. These changes are principally with the salinity regime and setting systems.

INDUCED SPAWNING

Some preliminary trials on induced spawning of oysters were carried out in the hatchery at FRI (Ng, 1992). Mature oysters cleaned of barnacles and other fouling organisms were randomly selected and given 1.5-2.0 ml serotonin of 0.1 mm concentration. The oysters were then placed in containers to allow them to spawn. Gametes held in separate containers were usually mixed minutes after the injection. The hatching rate was about 30-50 per cent, while the survival rate from hatching till eyed stage was 5-10 per cent.

NATURAL SPAWNING

An alternative method is to spawn oysters naturally.

Matured oysters (50-100) were procured from the wild and cleaned of silt and other sedentary organisms. They were then left to dry for 2-3 hours before being flushed with seawater into 300-litre troughs.

Macerated gonad tissue from a few oysters was sometimes washed into the trough to trigger spawning. The oysters usually began spawning within 30 minutes and took 30 to 60 minutes to complete gamete release. Upon cessation of spawning activity, the broodstock was removed from the spawning tank and the fertilized eggs collected on a 15 micron nylon screen and then rinsed with seawater filtered through a 1 micron material. Usually, about 20-30 oysters from the stock produced 20-25 million eggs. Out of this, some 60-70 per cent fertilized successfully and hatched into D-shape larvae. Survival rate from hatching till eyed stage was reported to be about 80 per cent.

LARVAL REARING

Fertilized eggs were separated by 35 micron mesh screen and transferred at a stocking rate of 2-5 larvae/ml into 2 t tanks where they were raised (Ng, 1992). After reaching the veliger stage in 24 hours, the larvae were fed with Isochrysis galbana at 10,000 cells/ml for the first 10-day period after which they were given a mixture of I. galbana and Chaetoceros calcitrans at 15,000 cells/ml. During the larval rearing period, water was maintained at 20 ppt and flushed out completely on alternate days. Fifty per cent change was done on the other days. The larvae were graded from time to time to separate the fast-growing ones from the rest. The eyed larval stage (220-240 micron) was usually attained by the 16th day, but records show that some would reach this stage by the 10th day of culture. The growth rate is dependent on the supply of food and water temperature. The ideal water temperature is between 28°-30°C.

2.3 Spat transplantation

The slipper oyster, C. iredalei, is preferred by consumers (see Section 5). It does not occur naturally on the west coast, consequently spat had to be transplanted from east coast collection centres to west coast culture sites. Although oyster species have been widely transplanted on a global basis, this was the first experience in Malaysia.

Spat were purchased directly from fisherfolk, or through an agent, in Kota Bharu. FRI and BOBP staff, extension agents or culturists on the west coast placed orders by telephone or paid personal visits to collection centres. Upon confirmation of the order, the spat were shipped by refrigerated truck. Transit time to the west coast culture sites was about 12 hours. Mortality was very low under this system.

Slipper oyster spat have become scarce as oyster culture is developing on the east coast. Some growers in the Kelantan River estuary have, from 1992, even begun to import spat from southern Thailand.

The transplantation was very successful. C. iredalei adapted well to the west coast environment. Survival was high and, although growth was somewhat slower than C. belcheri, the culture was profitable (see Section 7). There has been evidence of spawning by the transplanted oysters, but spatfall is still very sparse. As culture spreads on the west coast, it is possible that sufficient spawning stock will be established to supply commercial quantities of C. iredalei spat.

3. NURSERY CULTURE

Hatchery-produced spat or small natural spat must be carefully tended in an intermediate stage before stocking in grow-out systems. This stage is referred to as ‘nursery culture’.

3.1 Natural spat

The bulk of the oyster supply came from the wild on the east coast. Spat which were collected locally, using coconut or oyster shells and tyres, were allowed to grow on the cultch to marketable size and then harvested. However, those collected on Netlon material were grown to about 2 cm in size before being transferred to grow-out trays. Wild spat measuring 2-5 cm were frequently sold to culturists on the west coast for grow-out.

There was actually not much work involved in nursing natural spat, which took 2-2½ months to attain 2 cm size. The culturists only had to ensure that the collectors were not infested with fouling organisms or covered with silt.

3.2 Hatchery spat

Attempts to set eyed larvae were first initiated at the hatchery itself. Two-tonne fibreglass tanks lined with plastic sheet were used for this purpose. Some setting trials were done using marble chips and Netlon cylinders. Eyed larvae were released into the setting tanks at a rate of 2/ml. Setting occurred in phases, due to differences in the development rate of larvae. Water was completely changed every other day, while 50 per cent was changed on the other days. During water changes, a 200 micron screen was placed at the end of the siphon tube to retain unset larvae. Complete setting took 4-5 days.

Observation showed that setting was better on plastic sheet than on marble chips. A density count showed that setting was 20 per cent (400,000 spat) on plastic compared to about 12.5 per cent (250,000 spat) on marble chips. This could be due to larvae getting buried under the marble chips during water changes or due to aeration. In addition, it was more difficult to siphon dirt out from tanks that contained marble chips than from those with plain plastic. Another problem was to separate spatted chips from unset ones. As for Netlon tubes, it was not possible to do density counts on the Netlon due to the colour of the spat which was almost the same as Netlon. However, they too proved quite effective once spat were large enough to observe (i.e. about two months later).

The spat were left to grow in the hatchery until attaining about 5 mm size. This took 1½ - 2 months because of lack of phytoplankton. The spat were then transferred onto plastic trays lined with 2 mm mesh size Netlon before being brought to the culture ground. The trays were also covered to prevent predators from entering. The stocking rate ranged from 3,000-4,000 spat/tray due to their small size. The spat were culled from time to time, depending on the growth and survival rate.

3.3 Remote setting

Remote setting was developed in the Pacific Northwest of the United States and revolutionized the oyster industry there by

- eliminating the cost associated with the transport of cultch from farms to hatcheries, and
- simplifying hatchery operation.

Advanced eyed larvae are collected on 280 micron screens, kept moist and sent to setting tanks at the farm site. The larvae are introduced into the tank to set on cultch of the farmer's choice. Spat are maintained for a short time in the setting tank. They are fed either natural or cultured phytoplankton during this time. Upon reaching a suitable size, the spat are moved to nursery rafts.

Initial trials for the FRI project were done in collaboration with the University of Science, Malaysia (USM). Eyed larvae were sent to FRI from the USM hatchery at Muka Head on Penang

Island and set in the FRI hatchery. Although there was insufficient phytoplankton to rear the spat for long, the trials were successful and led to the development of a field station for remote setting.

FRI began remote setting trials in 1992 using eyed larvae produced in the FRI hatchery. The remote setting facility was established at Bath Lintang. It consisted of a raft bearing a shed within which were three setting tanks. HDPE plastic sheet strips were used as cultch. The tanks were also lined with the same material. Plastic sheet made it very easy to remove spat with minimal damage to the animals. Gently rubbing the reverse side or directing a stream of low pressure water on the film sufficed to remove spat.

Remote setting installation

The aeration system on the raft had to be battery-powered as there was no practical way to provide utility service. Initially, small 'C'-cell-powered aquarium aerators were used, but these proved extremely costly. This system was subsequently replaced with a 12v portable compressor powered by heavy-duty marine storage batteries which were conveniently recharged ashore.

Spat set on plastic film — inside installation (above) and close-up (below).

Three water treatments were used in the first trial in November, 1992. One tank was filled with seawater filtered through 1 micron material, another with seawater filtered through 60 micron material and the third with unfiltered seawater. Approximately 4.5 miffion eyed larvae were equally divided among the three treatments. The best setting was observed in the water filtered through 60 micron material, but growth was most rapid in the unfiltered treatment. It was estimated that 7 per cent of the eyed larvae set.

4. GROW-OUT

Several grow-out methods for oyster culture were field tested: raft, longline and rack. The method tested at each site depended on local environmental factors like the depth of the area and nature of the bottom, whether sandy, rocky or muddy.

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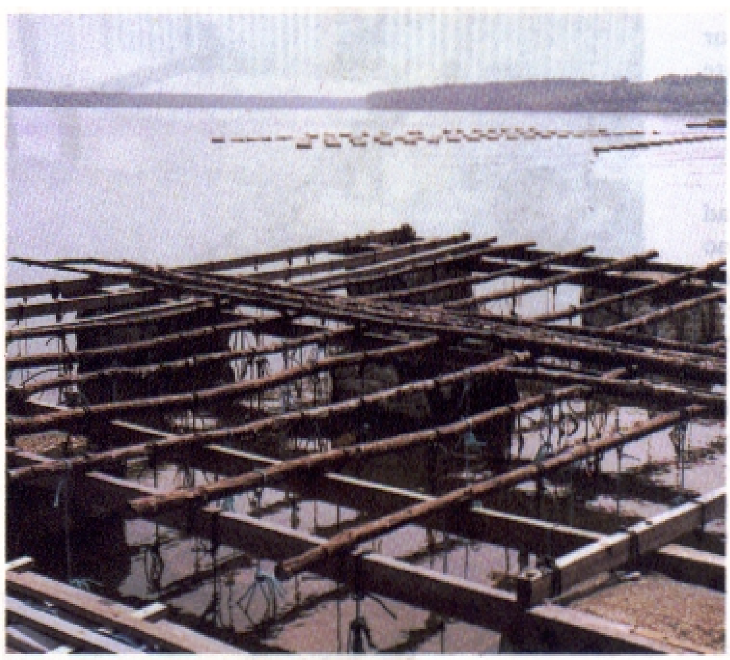
Typical raji installations. Note mangrove cross poles in installation below.



4.1 *Rafts*

The standard raft measured 6.7m x 6.7m and cost RM 3,000-4,000*. The frame was made of hard timber *(Balanocarpus heimii)* and was supported by 15 floats (plastic drums of 60-litre capacity). However, a cheaper version was tested in which only the frame was of hard timber while mangrove poles served for hanging the culture trays, thus reducing the -cost to RM 2,000-2500. (See photographs alongside.)

Rafts are suitable for sites with water depth of at least 3m during low tide. Oyster or coconut shell cuitch and tyre trays were used. One raft accommodated 10,000 shells or 70 trays.

4.2 *Longlines*

Stretching 50m in length, longlines are the most economical culture system, costing RM 1,000. The structure is simple; parallel polyethylene ropes are lashed to 40 l plastic drums which serve as floats (see photograph on facing page). The longline is anchored at either end, with allowance for the depth difference between low and high tide. Longlines are well suited for slightly exposed areas, the advantage being that better water circulation around the oysters promotes faster growth. Culture methods employed are plastic trays, tyres and Netlon trays (see photographs on facing page). One longline can carry about 70 trays in a single tier. Tyre trays can be double tiered.

A slightly modified version of the longline is used on the east coast. Small floats were used here to indicate the longline to which the tyre reefs were tied. The longline in this case served for easy retrieval of the tyres on which the oysters attached (see photograph below).

Modifid longline used at Merchang, Terengganu.

* **US $ I = RM** 2.60 appx. (1990-1993).

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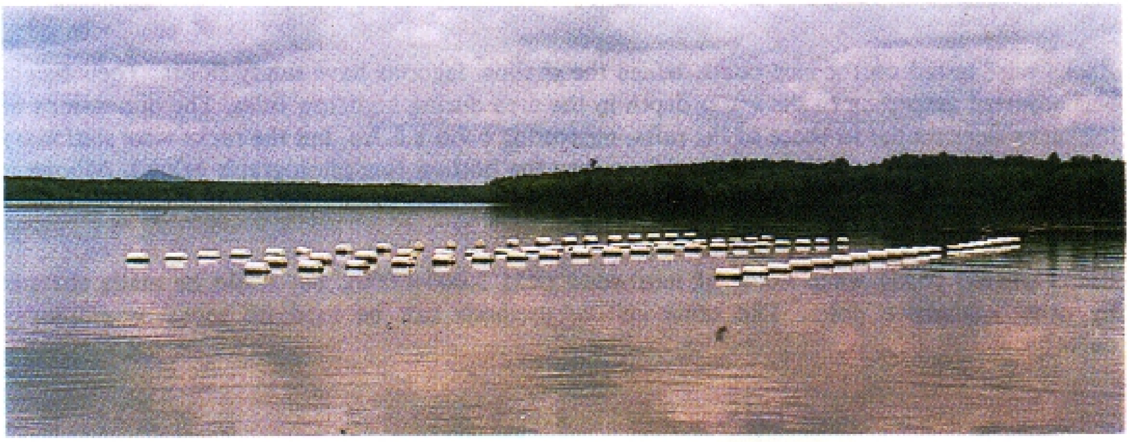
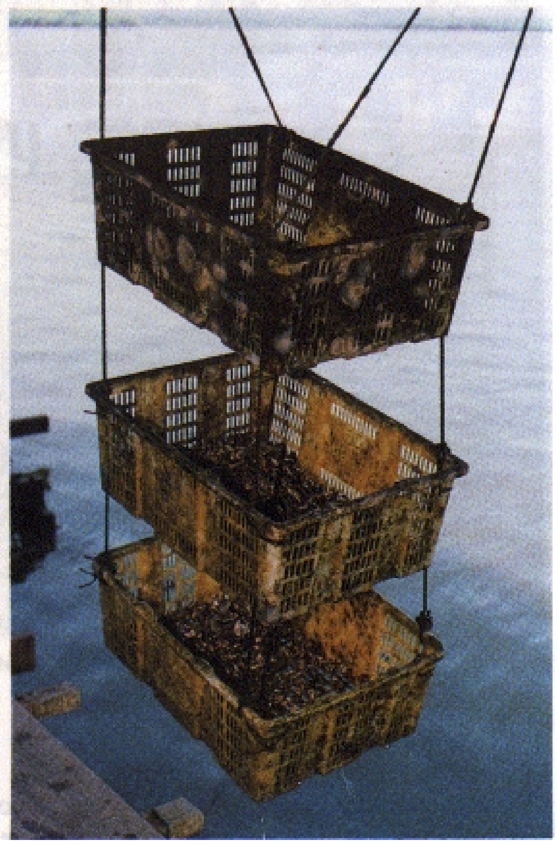


The longlinefarm at Batu Lintang, Kedah.



Tyre trays (left, above) and commercially available plastic baskets (right, above) are usedfor grow-out.

Netlon trays used on longlines.

4.3 *Racks*

Racks were tested on the east coast, where the shallow lagoons have sandy floors. Their height was adjusted according to the water depth in the area during high/low tides. The dimensions of the racks were similar to those of the rafts, measuring 6.7m x 6.7m, but the racks were stationary and were supported by *nibong* poles driven into the bottom (see photograph below). *Nibong* is a local palm whose trunk is highly resistant to seawater and marine borers.

Racks proved costly when made of hardwood (RM 3,000-4,000), but could be made cheaper by using mangrove poles. The same culture methods can be used on racks as employed on rafts.

The rack set up at Merchang, Terengganu.

4.4 *Maintenance*

One of the advantages of oyster culture as an income-generating activity for fisherfolk is its relatively low operating cost. However, a labour input is required to maintain the stock in optimum condition and maximize production. The basic maintenance operations are

- controlling biofouling and siltation,
- culling; and
- controlling predators.

Usually all activities are done concurrently by the culturists. The operations are described below.

REMOVAL OF FOULING/SEDENTARY ORGANISMS

Fouling organisms that pose serious problems to oysters are sponges, ascidians, barnacles and blister worms Heavy siltation can also foul the culture trays These problems were overcome by using a water jet to clean the oysters and culture trays. Culturists who cannot afford the pump could vigorously shake the cuitch or trays, or remove the fouling organisms manually.

CULLING SPAT

Oyster spat are culled monthly to reduce density and to separate the fast-growers from the rest. This encourages a better growth rate.

Field experience suggests that tyre trays can hold a maximum of 70-100 market-size oysters. The optimum stocking rate depends on the water quality at the ‘particular site.

PREDATORS

When oyster spat range from 2-5 cm in size, they are prone to predation by crabs. This can be prevented by providing a cover for the trays.

5. MARKETING

Several marketing studies were conducted before embarking on the full-scale field trials in Malaysia. BOBP commissioned a study by INFOFISH (INFOFISH 1988). The study provided an overview of the domestic and potential export markets and identified some of the constraints. A more in-depth study was subsequently undertaken by BOBP itself (Angel1 1988) and is the most comprehensive survey of the industry made to date.

It was estimated that west coast production was 154 t, the bulk of it originating from Langkawi Island. The entire production consisted of shucked meat. A small quantity of live oysters were imported from Thailand, New Zealand, Australia and France for five-star hotels and restaurants. While Langkawi production was marketed through a monopolistic system, direct sales by oyster collectors to consumers and retail outlets were common at most other centres. Retail prices varied markedly between consumption centres, with little exchange of pricing information between the retail and producer levels.

There were indications of over-exploitation of intertidal oyster populations, as seen in increasing prices and occasional scarcities. As a result, oysters were perceived by consumers as a luxury seafood. Declining interest in oyster harvesting as an income source was reflected in the advanced average age of collectors.

The half-shell, or ‘live’, market was identified as potentially the most lucrative outlet for small-scale farmers. Specific buyers of this product were identified by Pacific Marketing Associates as customers for the oysters produced by participants in the project. As a consequence, the culture system was designed to produce products for the half-shell market.

C. iredalei is preferred by consumers because of its sweet flavour and white flesh colour. The flesh of C. belcheri takes on a brownish tint which increases in intensity with age. It is thought that this colouring originates from mangrove detritus upon which the oyster feeds.

5.1 Depuration

Research by USM has shown that all growing waters of peninsular Malaysia are contaminated with enteric bacteria (Wong, T.M., personal communication). Furthermore, their concentration in both the water and the oysters exceeds WHO standards. It therefore became essential to assure the public that oysters produced by the project were safe to consume.

Reports of diseases are the major factor that have affected consumption and the market trend of shellfish. Thus, in order to create public awareness that oyster consumption is safe, concerted efforts were made to introduce commercial depuration. Units were installed by BOBP/DOF at the oyster culture sites and were operated by farmers.

FRI developed a small-scale depuration unit (see picture) with assistance from the Australian Government through ASEAN (Ismail 1988). Three similar units were distributed to participants in Perak and Kedah. Depuration units were prominently displayed during promotions and demonstrations and were featured in newspaper articles about the project.

Small-scale depuration unit used by farmers.

The unit operated on a closed water recirculation system. It consisted of five levels of plastic trays (64 cm x 42 cm x 16 cm) stacked in a nest arrangement totalling 15 trays in all. The water-holding tank (180 cm x 90 cm x 60 cm) was made of fibreglass. Two units of sterilizing ultra-violet lamps, each of 30 W, were used. The lamps were in a box (110 cm x 47 cm x 30 cm) made of fibreglass-lined plywood and positioned on top of the depuration unit. A 0.4 hp 300W pump was used to circulate water through the system. This unit operated on simple technology and cost 3,200 RM/unit. The depuration cost worked out to 0.02 RM/oyster.

The bacterial content found in oysters at the three sites where depuration units were located was as follows

Site	*Species*	*Condition*	*FC*3*	*MPN**/g*
Batu Lintang (Kedah)	*C. iredalei*	Undepurated	2.3	436
		Depurated	0.2	1.0
Telaga Nenas	-do-	Undepurated	2.3	17.2
Kg. Teluk	-do-	Undepurated	26.0	1000

* Faecal coliform
** Most probable number

5.2 *Promotions*

Consumer awareness was stimulated through public demonstrations or 'promotions' at fairs and in collaboration with hotels and restaurants.

The main promotions in 1991 were as follows:

Date	*Days*	*Activity*
5/5	1	Eden Seafood Restaurant. One of the premier seafood restaurants, it has since become a regular customer of the Kedah farmer.
29/5	1	Langkawi Island Resort and Pelangi Beach Resort on Langkawi Island, Kedah. A total of 400 pcs were sold.
5/6	1	Eden Seafood Restaurant. Eight hundred pieces were sold.
30/7	5	Farmers and fishermen's field day at Medan Gopeng, Perak. A total of 4500 oysters were sold and inquiries were received from Penang, Perak and Kuala Lumpur.
8/8	7	National Science and Technology Week.
8/8	5	Casuarina Hotel, Ipoh, Perak. Altogether 5500 oysters were sold.
20/8	7	Agriculture Exhibition, Shah Alam, Selangor. Including giveaways and sales, 3500 oysters were disposed of.
14/9	7	Atria Shopping Complex, Damansara Jaya, Kuala Lumpur. 8000 oysters were sold at a price of RM 1 each.

An oyster promotion demonstrating preparation of oyster dishes.

Interest in oysters among seafood buyers, the consumer and the news media continued throughout the subproject. Newspaper articles were published in major national newspapers, such as the *Straits Times* and *Star* several times a year (see picture). There was also occasional television coverage by national commercial channels.

5.3 Direct market assistance to fisherfolk

The culturist in Kedah proved to be very adept at marketing his production after subproject staff had made initial contact with buyers. In addition, he used his personal contacts and acquaintances to promote sales in the town of Sungai Petani. The culturist carefully balanced sales with stocking rates and growth to ensure a reliable and constant supply to his customers. He was also skilled and diligent in the operation and maintenance of the depuratioñ unit supplied by the project. Consequently, after the initial input by subproject staff, no further assistance was required.

The Straits *Times promotes oysters as a delicacy.*

The situation among the 13 culturists in Kg. Teluk and Telaga Nenas, Perak, was quite the contrary. Both these villages are relatively remote? being located about 10 km from the main highway to Setiawan and Lumut. They are about one hour by motor launch from Lumut. A local middleman buys fish, crab and, occasionally, oysters from the fisherfolk of these villages. It was reported that competition was restricted through pressure tactics employed by this lone middleman. While the Kedah farmer sold oysters at 0.70-1.00 RM/piece, the Perak farmers were offered only 0.35 RM/piece, which they refused, knowing that large spat cost up to 0.30 RM/piece. An attempt was made to overcome the situation by employing a marketing specialist from January through July 1993. The specialist made direct contact with customers in Ipoh, Melaka and resorts on Pangkor Island, not far from the two villages. It was clearly established that a good potential market could be found in these places. The main constraint was the difficulty of finding a progressive middleman willing to pay a good price to the farmers with a view to increasing his supply and building up his customer base.

In July, 1993, the marketing specialist managed to set up a system for marketing oysters from Telaga Nenas. The farmers selected one among them to act as their marketing representative and he has been functioning at the time of writing. As soon as orders are received by telephone, the oysters are depurated and then taken by the market representative to a transport agency in Pantai Remis. Upon arrival in Melaka, a local seafood middleman takes delivery. The farmers sell to thejr market representative at 0.60 RM/piece and he sells to the Melaka middleman at 0.70-0.80 RM/piece, covering transport and depuration costs. The Melaka middleman effects payment by depositing a cheque in the marketing representative’s bank account. The system has yet to be rigorously tested at the time of publication of this report, but it seems to present a viable option to overcome the main constraint in Telaga Nenas. It was encouraging to note that the farmers were beginning to act as a group in their own interest.

Marketing shucked meat and live oysters from the east coast was well established by mid-1993. Several brokers were active in Kelantan and Tefengganu. Oysters from Kuala Setiu, Terengganu, were marketed by a cooperative of employees of the Ministry of Agriculture (KOTANI). Sales were about 300 a day at 0.50 RM/piece.

Marketing problems on Langkawi Island were the primary reason for the failure of oyster culture there. Flat oysters could be sold only as shucked meat, which had a short shelf-life. The local price of 4.50-5.00 RM/kg was not sufficient to cover costs. Off-island marketing was difficult because of the small quantities of shucked meat produced by the participant. Attempting to overcome this, shucked meat was frozen in 1 kg packets in a standard home freezer. Quality deteriorated during storage (perhaps due to freezing temperature being high and freezing time too long) and, eventually, after just a few shipments, the Penang buyer stopped buying. Langkawi Island is a duty-free port and formalities added considerably to the cost of air shipments. All off-island air shipments must go through an agent, which added RM 50 to the cost of each shipment, irregardless of its size or weight.

An attempt was made to smoke shucked oyster meat, but this proved technically difficult and was abandoned.

6. TECHNOLOGY TRANSFER TO FISHERFOLK

The subproject passed through two phases. In the first phase, field trials were made of various technical options at several west coast sites. The second phase consisted of transferring the most successful technologies to fisherfolk and evaluating the economics of oyster culture. On-the-job training, dialogue and training courses were employed in the technology transfer process.

6.1 On-the-job training

The launching of oyster culture projects began with the recruitment of four biologists stationed at Penang, P. Langkawi (Kedah), Muar (Johor) and Terengganu. They were given basic training at FRI, then, under close supervision from DOF and BOBP staff, they identified commercial oyster species, selected suitable sites for oyster culture, designed appropriate culture systems and cultch materials for spat collection. The biologists also evaluated practical methods for establishing spat-setting seasons.

Being directly responsible for launching the projects in the respective areas, the biologists enlisted help of local artisanal fisherfolk on a daily wage basis. These fishermen relied primarily on fishing, but were also involved on a part-time basis in cage fish culture. Employment in field activities indirectly provided training for the participants in all aspects of the culture operation. In the process, they were supplied necessary materials and paid to construct and launch the various culture systems and cultch materials.

Initially, one person was recruited per site, while in Terengganu and P. Langkawi family members participated in culture activities. The participants were trained for at least one complete culture cycle before the culture units were handed over to them. Continued technical advice was provided by the biologists and field officers after the hand-over to the participants. In some cases, BOBP also provided financial assistance in the form of soft loans to repair culture systems, procure spat for grow-out and pay labour to shuck the meat. The loans were to be recovered from oyster sales.

6.2 Dialogue with fisherfolk

A one-day dialogue with fisherfolk was conducted in July 1989 in P. Langkawi to discuss the objectives and prospects of the oyster project. In return, feedback from the fisherfolk was expected on the possible problems associated with the project. About 36 fisherfolk from six villages participated. The main problems identified were :

- Initial assets for investment;
- Lack of technical know-how on the culture of the various species; and
- Marketing.

6.3 Training courses

Five three-day courses were held at the National Prawn Fry Production and Research Centre in Pulau Sayak, Kedah, between 1990 and 1992. Trainees from all the states of Malaysia participated in the courses. Of the 62 trainees, 31 were government officers, 28 from the private sector and two university staff. The government officers were mostly extension agents. Private sector participants were primarily fisherfolk, but there were a few small businessmen. Only a few women attended.

The course curriculum covered all aspects of oyster culture and the course was divided between classroom lectures and practical work in the field. Lecturers were BOBP and FRI staff and bank officers from the Agriculture Bank.

A follow-up survey of course participants was conducted in 1992 to assess the impact of the courses. Questionnaires and, in a few cases, field visits were used. In summary, 80 per cent of those answering thought the course was too short, but 90 per cent said such courses should be continued. About 80 per cent of the respondents said they had discussed the course with friends and provided information to interested people in their villages. Some 30 per cent had been culturing oysters before attending the course. These fisherfolk were from Kelantan and Terengganu on the east coast of Peninsular Malaysia. Most of the trainees (90 per cent) faced problems in financing oyster culture.

Visits to the field during the past couple of years seem to indicate that the courses have had more impact in Kelantan and Terengganu on the east coast. The 17 trainees from these states have been very effective in spreading information on oyster culture.

6.4 Impact

Fisher-folk were able to adapt to the technology of oyster culture; this was demonstrated by profitable operations on both the east and west coasts. However, the ability to manage oyster farming as an enterprise varied greatly among the direct participants in the project. Marketing and managerial skills are required, apart from technical ability. By this measure, only one of 14 participants on the west coast demonstrated the abilities necessary to be successful. Perak participants showed little initiative in overcoming marketing problems, depending heavily on project staff. It may also be difficult for full-time fishermen to find sufficient time for marketing, unless other family members become involved.

East coast farmers were much more adept at making money from oyster farming. They used their own resources to obtain culture equipment and spat, often taking advantage of existing fish cage installations for suspending cultch and grow-out trays. There was also more family involvement on the east coast, where wives were often very active in oyster culture activities. However, the growing culture industry on the east coast has to be considered a ‘spin off’, since fisherfolk there were not directly targeted by the project.

6.5 Constraints

Detailed field studies to identify constraints to the expansion of oyster culture have yet to be made. However, several areas were identified which might bear further investigation.

IDENTIFYING PARTICIPANTS

Finding suitable culturists to run the operation was the main problem. It was difficult. to locate people who could maintain their enthusiasm throughout the culture period. There were many who expressed initial interest to get involved, only to later leave due to reasons unknown.

SOCIOPOLITICAL CONSTRAINTS

Partisan political affiliation led to conflict in one of the villages and severely restricted fisherfolk participation. Conflicts arose between various interests and, as a result, village leaders decided against oyster culture development.

The original participant selection was done by fisheries extension agents. There was no organized approach which would have identified political and structural problems in the targeted villages.

In other words, selection was highly individualized and without participation in the process by village leadership. If there was any participation, it appeared to be perfunctory and superficial.

WEAK MARKET STRUCTURE

Marketing was another constraint that affected the motivation of participants, especially in Perak. Sales promotions by the project's marketing staff demonstrated potential in Perak and Melaka. The key constraint was the poorly developed market structure in the two villages, Kg. Teluk and Telaga Nenas. Rather than building a market by encouraging fisherfolk to produce oysters, the middlemen offered unacceptable purchase prices to the oyster culturists. Experience in Kedah, Terengganu and Kelantan has shown that if a reasonably efficient brokerage system is in place, culturists are motivated.

BIOFOULING

The rate of biofouling in most areas was moderate to heavy. Problems from sedentary organisms, like barnacles, sponges, ascidians etc., were quite bad, but not all culturists took the trouble to clean their culture systems. It certainly needed a lot of encouragement and effort from the DOF staff/biologists to make them realize the importance of cleaning their culture systems.

CREDIT

Very few culturists were willing to take the risk of investing the initial capital cost of oyster culture. To solve this problem, the subproject provided the materials needed – such as rafts, longlines or other structures, as well as, in some cases, spat for grow-out purposes, since this consumes the bulk of the capital. Thus, the culturists were very dependent on the subsidized supply of materials. As mentioned earlier, the east coast is the exception; culturists there use readily available, low-cost materials and set up small farms on their own initiative.

7. ECONOMICS

The economics of oyster farming can be looked at as a supplemental income-generating activity to a family's main source of income or as a full-time occupation for a fisherfolk family or small-scale entrepreneur. The latter has been chosen in this analysis, a farm requiring the full-time services of one individual being the basic unit examined. The economics of part-time oyster farming are assumed to be quite similar, as the economics of scale lie only in spat and half-shell transportation and premarketing depuration, the labour component being easily integrated into the regular household work of family members.

7.1 Methodology

The production and costing data were collected from the three culture sites in Kedah and Perak during field visits in 1991 and 1992. The data have been compared with other data from culture sites in Kelantan and Terengganu as well as from material suppliers in Penang, confirming the accuracy. The size of the farm in the model basically reflects the farm established at Batu Lintang, Kedah, which has nine longlines and nine small rafts. The nine small rafts have been replaced in the model with five larger rafts, which are now the preferred suspension system. The size of farm in the model should not be interpreted as a recommended or optimum farm size, but just an example.

The 1991 capital costs and 1992 spat costs, sale prices and sale composition are reflected in the model. The Malaysian inflation rate is quite low, therefore not demanding any inflationary adjustment in the data collected during different visits. The model assumes a higher utilization of farm capacity than yet demonstrated, as difficulties in the spat supply at the Batu Lintang site have resulted in understocking.

The main indicators extracted from the model are the Net Present Value (NPV) and the Internal Rate of Return (IRR) as described by Gittinger (1982). For the cash flow analysis, an abstract, undiscounted Year 0 is used to separate the initial investment period from the first year (Year 1) of culture operations. Using the same data, the Gross and the Net Benefit/Cost Ratios (B/CR) have been calculated as specified by Shang (1990). The former is the ratio of the sum of discounted gross benefits to the sum of discounted total costs: the latter is the ratio of the sum of discounted net benefits to the initial capital outlay.

Another indicator, Payback Period (PBP), which does not encompass the time value of money (discounting), is given for comparison. It, unlike the other methods, includes financing costs. Thus, it is assumed that 80 per cent of the investment costs shall be acquired in the form of a 7.2 per cent loan to be repaid in the project's six-year life span. The calculations have not included taxation. The Payback Period (PBP), the time it takes before net returns (before depreciation) 'pay back' the initial investment costs, is calculated from the point of commencing operations (Shang, 1990).

In the economic analysis, the "simplest form of a Social Cost/Benefit Analysis" is performed as suggested in Little and Mirrlees (1974). Social values are used in the discounted cash flow where appropriate, replacing market values, while other costs and benefits remain unchanged. The discount rate is changed to reflect what is considered a more accurate Accounting Rate of Interest (ARI).

7.2 Investment

The investment costs have been partitioned into initial costs (see below) and replacement costs (see below). Refer to Appendix I for castings of longlines, rafts and depuration unit.

Schedule of initial investment costs

Rem	Units (no)	unit Cost (RM)	Total (RM)	Avg. life (Yr.)	Yearly depreciation (RM)
Longlinc	9	578	5198	2	2126
Raft	5	1024	5118	4	1333
Trays ,	630	15	9167	3	3056
Tyres	2000	5	10,340	6	1723
Depuration unit	1	1490	2490	5	522
Working capital	1	29,016	29,016		
Total			61,329		8760

Schedule of replacement investment costs (in RM)

Item	Year 1	Year2	Year3	Year4	Year5	Year6
Longlinc	0	900	900	3960	900	900
Raft	0	400	400	400	1375	400
Trays	0	0	0	9167	0	0
Tyres	0	0	0	0	0	0
Depuration unit	0	0	0	640	0	0
Working capital	0	0	0	0	0	0
Total	0	1300	1300	14,167	2275	1300

The model incorporated the use of locally manufactured bales of used Styrofoam sheets covered with used fishing net. These floats had not been in use long enough to get an estimate of their longevity, but their cost is a fraction of comparable floats on the market and buoyancy is said to be higher. Mangrove poles used on the rafts were cut from stands adjacent to the participants' villages and, hence, were not costed in the model.

It is assumed that the farmer coming from a fishing community has cost-free access to a small boat.

A depuration unit would be required if a farm of the size in the model were to produce at near capacity. The farm at Batu Lintang has such a unit, but has excess depuration capacity at present. Smaller farms, as those in Perak, could share depuration units.

7.3 Operating costs

Operating costs are tabulated below. These include a Temporary Occupation Licence (TOL) that is required for the area of water occupied by the farm. The fee is a flat annual rate for a one acre area, unrelated to type or level of production.

Spat purchases are the main recurring costs and are directly related to production. The spat supply, and its price as well, remains extremely uncertain at this point in time; however, an average price of 10 sen/spat has been used in the model.

Schedule of operating costs (in RM)

Item	Unit (no)	Unit Cost	Year 1 Total	Years 2-5 Total	Year 6 Total
Licence [TOL]	1	50	50	50	50
Spat	150,560	0.1	15,056	15,056	0
spat transport	4	300	1204	1204	0
Depuration	1	1402	0	1402	1402
Marketing costs	1	500	0	500	500
Oyster transport	602	2	0	1204	1204
Labour/support. cost	12	800	9600	9600	9600
Total			25,910	29,016	12,756

The running of a depuration unit involves relatively large operating costs as the fluorescent ultra-violet tubelights need regular replacement every 1000 hours. Electricity to power the pump and lights is the second main cost in depuration. Both these costs are indirectly related to total sales but are, more importantly, directly related to the frequency of sales, as depuration costs are fixed per hour, not per oyster. One depuration cycle takes a minimum of 24 hours, though longer may be advisable. As no Malaysian regulation yet exists on oyster depuration, we have assumed that the farmer will depurate at the minimum level.

Marketing costs include diverse items such as telephone calls, postage, business visits, oyster cleaning help and gunny sacks which are necessary expenditures at the time of sale.

Finally, farm labour must be paid, or, at least, an opportunity cost recognized. A sum of RM 800 has been used as the farmer's monthly salary; this may, however, be high for many fisherfolk.

7 .4 Revenue

While oysters can be sold as live half-shell, to be served raw, or as shucked meat to be'served in omelettes, half-shell is the more profitable product. Shucked meat has traditionally been taken from a number of oyster species found in the wild in Malaysia, while all half-shell oyster used to be imported (see Section 7.8). Thus, half-shell oysters cultured in Malaysia would save foreign exchange.

In the model, all sales are half-shell slipper oysters (C. iredalei) As different markets do, and will continue to, exist, it is assumed that 40 per cent are sold as depurated oysters to retailers and 60 per cent are sold undepurated to middlemen who depurate before wholesale distribution (see table below). Logically there will be a price differential, in which sales directly to retailers will prove more attractive to the farmer.

Schedule of revenue

Item	Price/ Oyster RM	%	Type	Year 1 Qty. RM	Year 2-5 RM	Year 6 RM
Oyster A	0.90	40	Depurated	0	43,361	43,361
Oyster B	0.70	60	Undcpuratcd	0	50,588	50,588
salvage						29,016
Total		100		0*	93,949	1,22,965

* Equals 0% of Years 25

** Equals sales plus working capital.

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One of the more difficult assumptions made for the model is the length of time required for an oyster spat to reach marketable size. Three variables complicate the assumption : Initial spat size; Growth rate; and How big marketable size is.

While marketable size is normally considered to be around 9 cm, initial 'spat' size from east coast collection can range from 2-3 cm to 6 cm. Culturists interviewed stated that their spat reached market size in 4-5 months in Kedah and 6-7 months in Perak. This opinion may be based on time required for larger spat. Field experience suggests that 9-12 months is required. To be conservative, 12 months has been chosen for use in the model, but it should be noted that the environmental conditions at each location and the method of cultivation at the farm will affect growth rates. Furthermore, there are individual differences between animals genetically, as well as in the stocking density of trays, which allow for irregular spat stocking but regular harvesting. Farmers can, and do, control growth by relocating animals within the farm.

What economic importance should be placed on the grow-out time? Unlike most other variables which can be individually tested in the sensitivity analysis with all other factors unchanged, grow-out time forces numerous changes throughout the model. Obviously the initial period prior to revenue must be considered. This will also alter the demand for working capital to run the project until revenues are generated. Growth rate effects total flow of oyster throughout the farm which, in turn, effects spat stocking requirements as well as marketing costs (depuration, marketing, oyster transport). Again, with a differing level of operating costs, the working capital must once again be adjusted, accordingly effecting initial investment.

7.5 Financial analysis

The Cash Flow Analysis is done for a 6-year model of the project (see table below), assuming 80 per cent capacity and 20 per cent mortality during a conservative 12-month grow-out period. Capital investments are made annually after the first year of operation to replace worn-out equipment. No salvage value is assumed, though the entire working capital is encashed as revenue at the close of the project. Constant operating costs are assumed throughout the first five years, while in Year 6 operating costs fall as the project begins to close. Revenues are anticipated to begin only after Year 1, due to the initial one-year grow-out period, and stay constant thereafter.

Cash flow analysis of oyster farm model (in RM)

Item	*Year 0*	*I*	2	3	4	5	6
Capital costs	61,329	0	1300	1300	14,557	2275	1300
Operating costs		25,910	29,016	29,016	29,016	29,019	12,756
Total cost	61,329	25,910	30,316	30,316	43,513	31,291	14,056
Sales		0	3949	93,949	93,949	93,949	93,949
Salvage							29016
Total revenue		0	93,949	93,949	93,949	93,949	122,965
NET CASH FLOW	– 61,329	– 25,910	63,633	63,633	50,376	62,658	108,909

The results are a Net Present Value (NPV) at the standard Malaysian Government discount rate of 10 per cent of RM 150,305, while the Internal Rate of Return (IRR) is 48 per cent. The discounted Gross Benefit/Cost Ratio (Gross B/CR) is 1.79. The Net Benefit/Cost Ratio (Net B/CR) would, however, produce a figure of 3.68, as the low investment and high returns are emphasized by this calculation. Another value obtainable from the data above is the Payback Period of 2 years and 6 months.

All these values point to the fact that oyster culture in peninsular Malaysia appears to be attractive as an investment. There is no doubt about the viability of oyster culture, but while some of the values emphasize the low initial investment, it should be noted that working capital is the single largest capital cost. Operating costs are also relatively high. In other words, oyster farming may have low initial investment costs in physical plant, but it has a high amount of capital tied up in the crops themselves. The healthy rating given oyster culture, it will be further seen, is qualified in the Sensitivity and Risk Analyses that follow.

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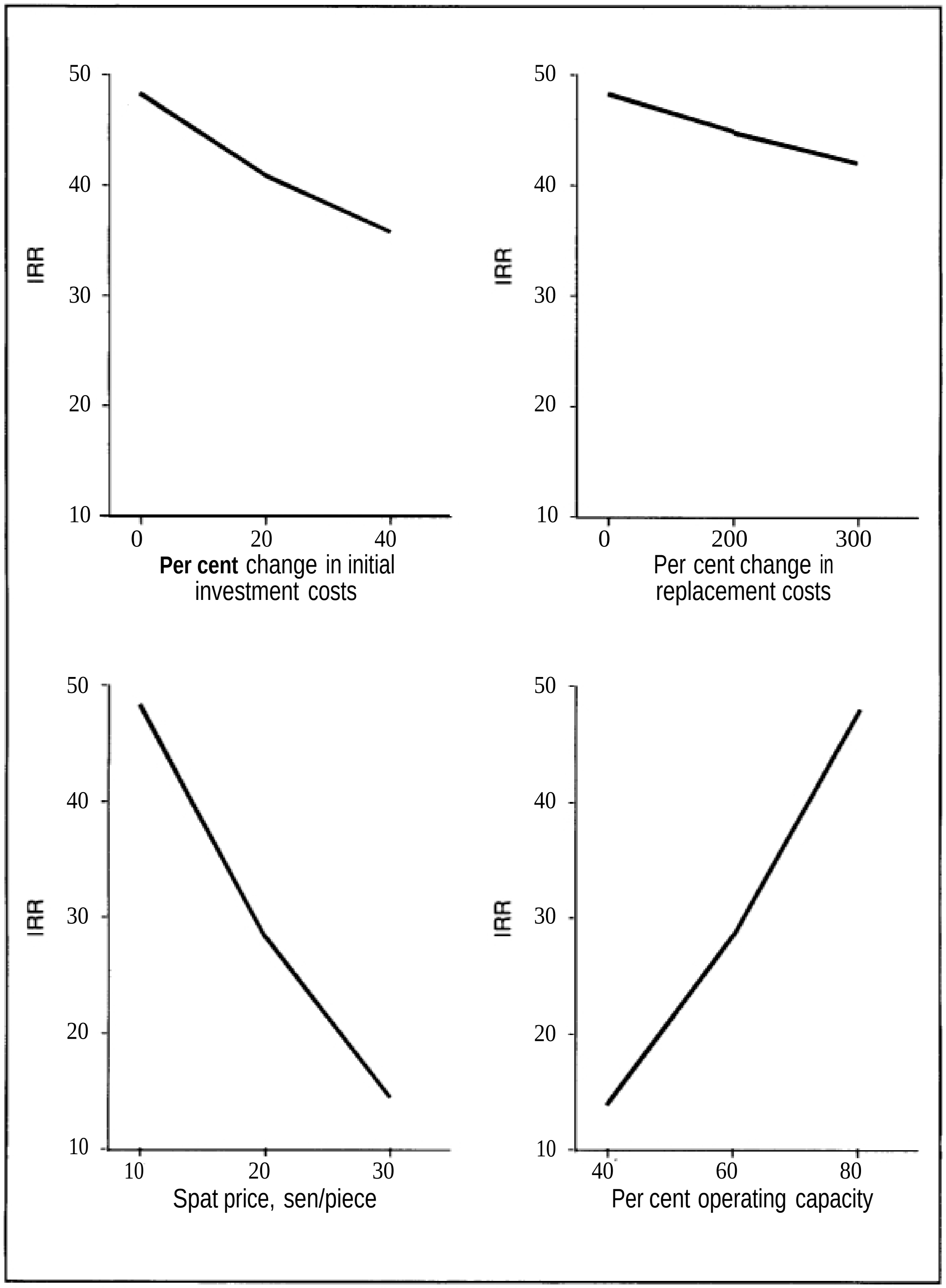
7.6 Sensitivity analysis

As expected, capital cost increases have only a slight effect on the profitability of the farm, as capital costs themselves are relatively small in this low-cost investment. Operating costs are, however, relatively high. A small rise of 20 sen in spat prices, not an unthinkable scenario, would radically reduce the IRR to the break-even point (Figure 2a). Likewise, a lack of spat, causing underutilization of the farm, would also cause a rapid drop in profitability (Figure 2a).

Fig. **2a. Sensitivity analysis. Effect of changesin initial investment costs, replacement costs, spat prices and operating costs on IRR.**



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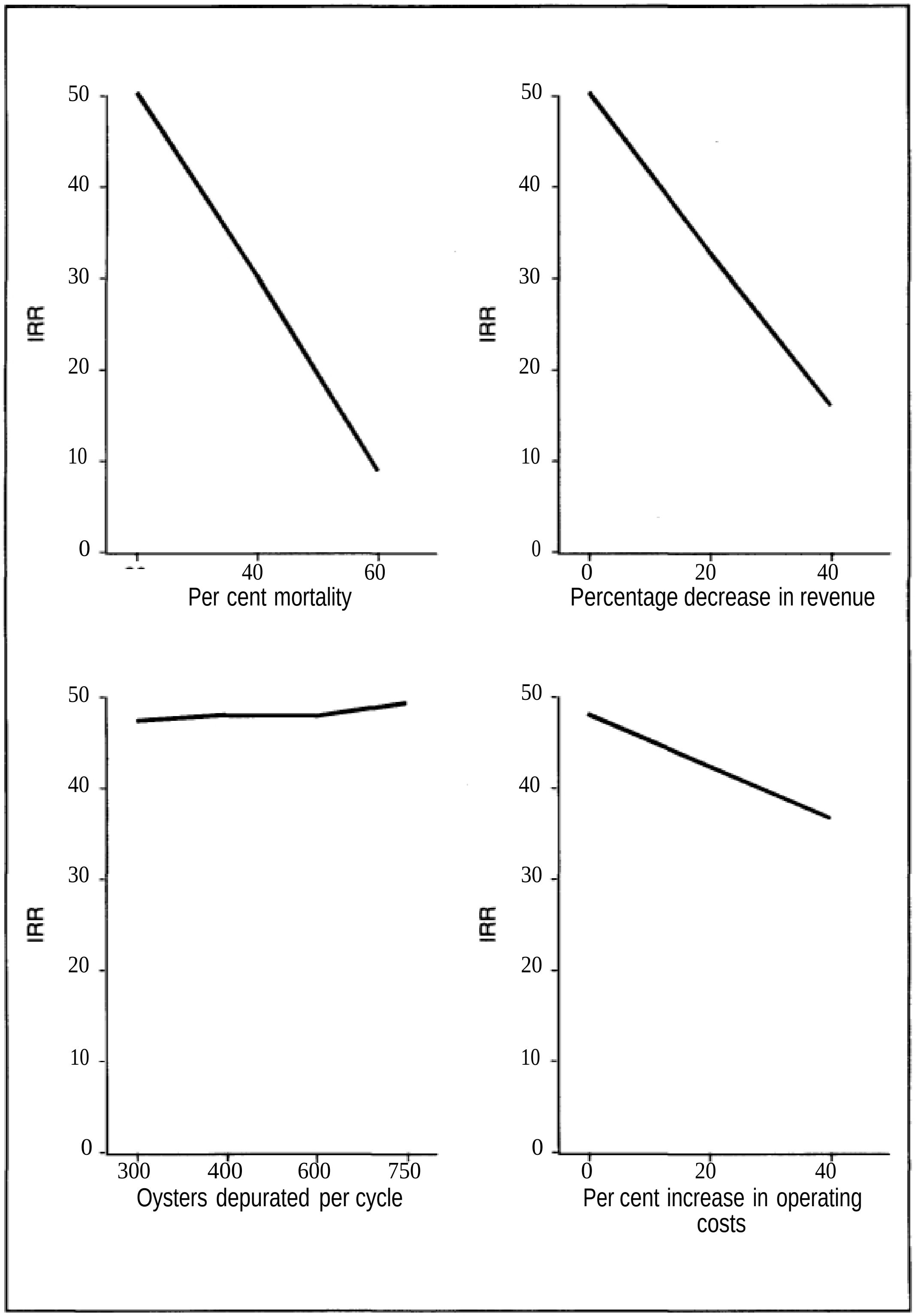
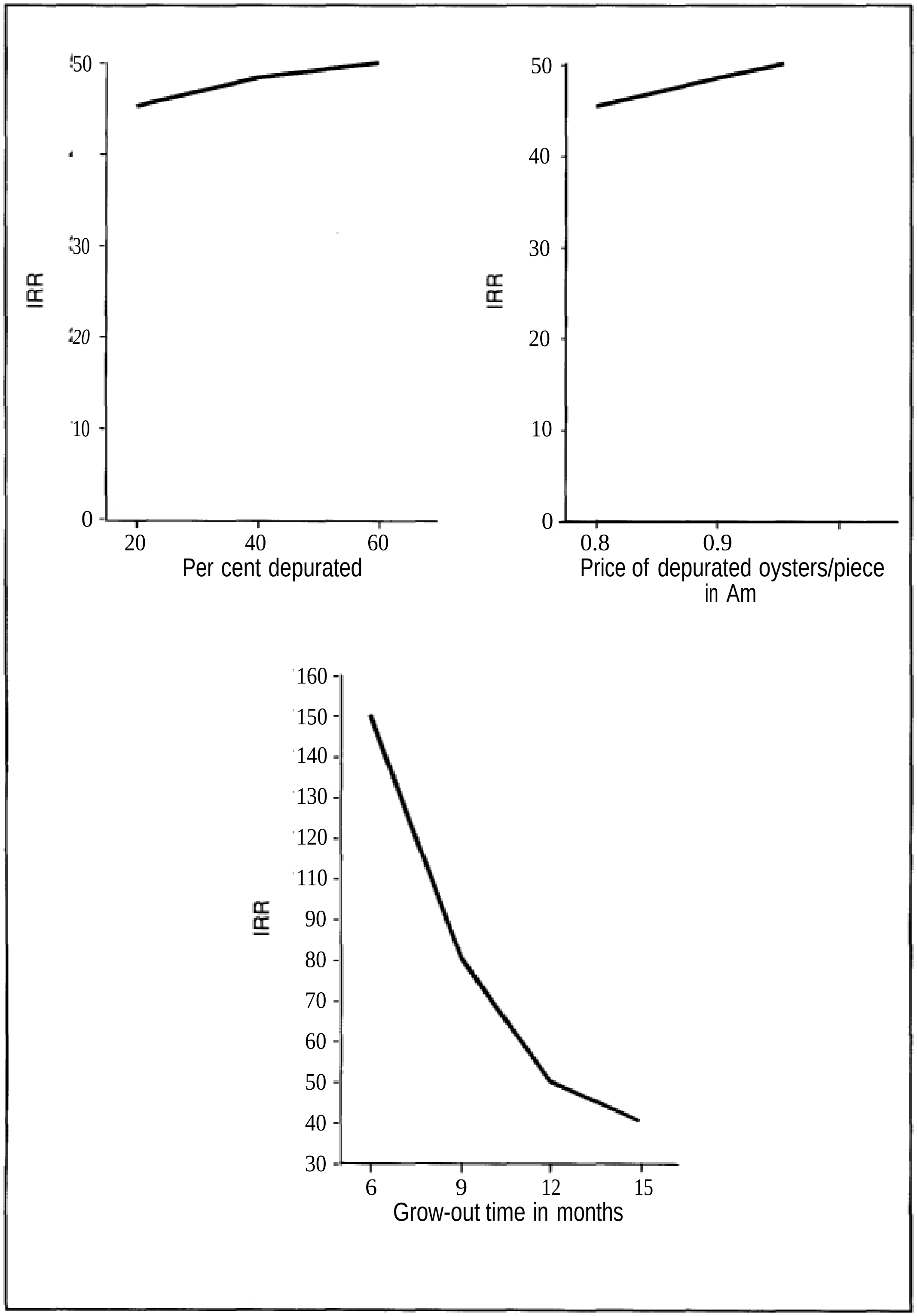
Mortality, often a result of bad maintenance, has also a considerable negative effect on the rate of return, as the investment in spat is made but no revenue is later recovered (Figure 2b). The grow-out time could triple the **IRR if** it were just half of what is assumed. Even nine months, a plausible grow-out time, would almost double the return to a very attractive level (Figure 2c).

Fig. 2b. Sensitivity analysis. Effect of changes in mortality, revenue, and oysters depurated per cycle and operating costs on IRR.



The cost of depuration has a less dramatic effect on returns (Figure 2c). The composition of depurated and undepurated oysters as well as the sale price fluctuation has little effect on long-run viability (Figure 2c). A revenue drop of 40 per cent would, however, cut the IRR to a near break-even level (Figure 2b).

Fig. 2c. Sensitivity analysis. Effect of changes in the percent of oysters depurated, price of depurated oysters and grow-out time on IRR.



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It should be noted that of all the various scenarios suggested, few brought the overall viability into question. It would seem that the project's viability would be endangered **only** through the compound affect of several factors being encountered simultaneously.

DEPURATION

Depuration may be considered as an independent business activity. Using the same unit as in the previous model and with the working capital of RM 250 (equal to one month's operating costs), a 6-year model was created in which 400 oysters were depurated five times a week, charging five sen per oyster. The result was an NPV at 10 per cent of RM 6821 and an IRR of 78 per cent. In a sensitivity analysis, the depuration of 750 oysters at five cycles a week drastically increased the viability. Depurating 400 oysters per cycle every day of the week did not have the same effect, but did put the IRR well over 100 per cent.

The price of five sen per oyster as the depuration charge is considered reasonable. Four sen would not be viable, while any increase would not only result in substantial increase in profits, but also cut into the profits of the culturists, middlemen or retailers if the cost is not passed on to the consumers, all depending on who is the weakest market actor.

7.7 Risk analysis

Risk due to climatic disturbances appears to be low in oyster farms in the west coast estuaries. During the years of the pilot project, there was only one storm that did any damage, several longlines being affected in Telaga Nenas, Perak. As capital investment is relatively low, loss of spat may be of greater value than damaged suspension systems.

Mortality of oysters is a major risk. While neither predation by aquatic animals nor disease has become a problem, east coast culture sites have had high mortality among spat due to salinity drops during the monsoon rains. This is a predictable risk and can be avoided by harvesting spat for sale to the west coast farmers before the end of October. West coast estuaries are deeper, thus leaving little chance of rapid salinity drops. The only clear cause of oyster mortality at present is poor maintenance.

Current risks to oyster farming in general are spat supply and marketing. As the slipper oyster is not indigenous to the west coast, where it is farmed, the farmers here are vulnerable to a drop in spat supplies. Spat have been obtained from natural sources and these sources could become depleted or diverted at any time. Hatchery production on the west coast is currently only on a laboratory basis and it will be several years before spat can be supplied by commercial hatcheries.

Revenues are the most important and most uncertain factor in assessing project viability. Revenues are dependent, in turn, on market demand and competing suppliers, domestic and foreign. Marketing is initially problematic, as production is not large enough to seriously contend with imported half-shell oysters. The competitive pricing of locally grown oysters should increase demand and promote trade in the Malaysian product.

The lack of government food quality control for oysters is also disadvantageous for a market breakthrough by Malaysian oysters.

While these 'infant' marketing problems will eventually be solved, there will always remain a risk of a market scare, whereby the government or the mass media might warn the public against raw oyster consumption. Such a scare can stop all farm revenues for several years or force a switch to less profitable shucked meat sales.

7 .8 Economic analysis

While the financial assessment of the model oyster farm is unquestionably positive, the value of such a farm to society as a whole should be ascertained to justify further Government promotion. By replacing the individual's market-rate costs and benefits in the cash flow analysis with the estimated social costs and benefits, the external effects brought about by the presence of such a farm can be weighed against the strictly business aspects. Thus, we can establish the social value or profit of the oyster farm.

CAPITAL COSTS TO SOCIETY

The construction of a farm's physical assets utilizes surplus rural labour in the fishing community and, thus, from a national perspective, distributes the benefits of employment to the economic periphery and to lower income earners. There are few such opportunities available to isolated fisherfolk in Malaysia and the labour costs can, therefore, be reduced to reflect a lower shadow wage rate.

Several capital inputs among the physical assets, such as used plastic drums, tyres and Styrofoam, are products previously manufactured for another purpose and discarded after use, resulting in a social cost, as they have to be got rid of by society and there is a consequent cost of disposal. This cost may not be significant for plastic drums, as they have alternative second-hand uses. The tyre trays, on the other hand, are mainly made from used motorcycle tyres, which have little other use and would create a social cost as solid waste in Malaysia. The social cost here is assumed to be half the actual cost paid by the farmer. More extreme are the floats of waste Styrofoam and used fishing nets. While there is nominal market cost, there can be no social cost for utilizing society's discarded waste.

On the contrary, timber purchased in the free market for use in raft and depuration unit construction has a slightly higher long-term social cost than the market price reflects, because the market price does not include the cost of unsound forest management or other socio-environmental concerns. Also, the poles used to suspend the oyster tyre-trays are generally felled in the forest without payment. Nevertheless, there is a social cost, albeit small, in taking the young trees from the nearby forests.

OPERATING COSTS TO SOCIETY

The main operating cost is, by far, spat. While east coast spat collection creates rural employment for some poorer sections of society, the main issue is the social cost of removing the spat from where it naturally occurs. The removal causes loss in future income for these same individuals, as the spat collectors are often also harvesting for shucked meat and, more recently, for half-shell.

As previously mentioned, employment generated by the farm is a positive effect and, thus, once again the social cost is less than the actual wages paid. Finally, the TOL fee paid to the Government is more an intra-society transfer and involves no social cost as there is no real scarcity of farming locations.

SOCIAL BENEFIT

The most important differentiation between market and social accounting prices is in revenue. The benefit of oysters is both to the consumer, demonstrated in the price paid, to the environment and the national economy. The effect of oyster culture on the environment can only be said to be a nontangible positive value as it is nonpolluting (rather, it improves water quality), provides fish with shelter and does not hamper fishing or transport in the waterways.

From an economic viewpoint, oysters produced can either expand oyster consumption or substitute currently imported half-shell. The Batu Lintang farm has actually sold to traditional consumers of imported oyster in Penang, thereby saving foreign exchange to the extent of the difference between the CIF price of the imported oyster and the retailer's cost (wholesale price) of the domestic oyster. Though it is not the farmer who gains, the savings benefit the country, no matter in how small a way.

To better reflect actual opportunity cost of capital in the stable but expanding Malaysian economy, a more realistic discount rate, or Accounting Rate of Interest (ARI), of 8 per cent is used for the NPSV calculation. The result is an NPSV more than triple that of the NPV and an ERR more than double the IRR. Thus, oyster culture is clearly of greater benefit to society than revealed in the Financial Analysis, justifying governmental promotion of the industry.

8. CONCLUSIONS

The live, or half-shell, market is the most lucrative market for oyster farmers in Malaysia. However, the market is discriminating on colour, flavour and quality. The slipper oyster, C. iredalei, has been identified as the species of choice in the market place. Although C. belcheri is abundant on the west coast, it is less suitable for the half-shell market because of its off-colour and flavour. The slipper oyster does not occur naturally on the west coast of Peninsular Malaysia, but has been successfully transplanted from Kelantan and Terengganu.

The model of a 9-longline, 5-raft oyster farm, based on actual pilot farms on Malaysia's west coast, has shown oyster culture to be profitable if run at a moderately full capacity. The benefit to society as a whole is seen as even greater than to the individuals, as rural employment is created and imports are reduced, while only small amounts of capital and numerous post-consumer inputs are used in this nonpolluting enterprise.

Small-scale depuration units were introduced at the farmer level and were successfully operated by participants in the subproject. However, an effective monitoring programme needs to be implemented to assure consumers of the safety of the product.

Depuration must develop hand-in-hand with oyster culture. Full capacity use per cycle is the key to low depuration costs. As a small, part-time business, the depuration unit modelled proved to have a moderately high profitability while at a reasonable level of utilization.

The most significant constraint to the expansion of oyster farming is the growing scarcity of spat of C. iredalei. The expansion of farming on the east coast will further limit the supply of spat to the west coast. Pilot-scale hatchery production of spat of all commercial oyster species in Malaysia has proven technically viable. The two pilot hatcheries operated by FRI and USM will have to expand their production to meet growing spat demand until such time as commercial hatcheries are developed.

Remote setting has been successful experimentally, but needs to be expanded to a pilot-scale which would enable economic evaluation of the technology. The most critical stage will be the nursery phase. The results to date have been poor, the main problem being low survival of newly-set spat.

Fisherfolk demonstrated their ability to manage oyster culture technology at the grow-out stage. However, serious problems were encountered in the areas of marketing and enterprise management. Only one out of 14 participants demonstrated the required entrepreneurial skills. It was evident that the main problem in Perak was poor access to the market, mainly because of the lack of an effective brokering agent, or 'middleman', in the project area. Considerable effort will have to be invested in overcoming this major weakness.

The project had a very important 'spin off' effect on the east coast. It appears that Kelantan and Terengganu will become the major oyster production centres of the country. Local spat are available, the brokerage system appears reasonably fair and efficient and there are alternative sources of spat in nearby southern Thailand. The Kelantan River -estuary offers particular potential due to the large area available for culture.

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APPENDIX I

Capital Inputs

1. Costing of a standard double longline

Materials	Units (RM)	Unit (RM)	Total cost	Avg. life (yrs.)	Yearly depreciation (RM)
Floats, 60-litre plastic	20	17.00	340.00	3	113.33
Main line. PE 14mm	10.8	7.50	81.00	6	13.50
Line, PP twist Imm	5	8.00	40.00	6	6.61
Anchor poles, 8m	4	5.00	20.00	1	20.00
Anchor line, PE 14mm	2.2	7.50	16.50	6	2.75
Labour, constr/m & r/y	4	20.00	80.00	1	80.00
Initial investment cost			577.50		236.25

2. Costing of large raft (7m x 14m)

Materials	Units (RM)	Unit (RM)	Total cost	Avg. life (yrs.)	Yearly depreciation (RM)
Floats, styrobales	15	13.00	195.00	4	48.75
Planks,7m,50*75mm	6	10.00	60.00	6	10.00
Planks,7m,50*100mm	13	12.20	158.60	6	26.43
Bolts/nuts,1/2"*10	36	1.50	54.00	3	18.00
Tree trunk poles,7	14	0.00	0.00	1	0.00
Nails,] mm galvan,	4	3.00	12.00	6	2.00
Nuts/bolts 3/8"*4 .	24	1.00	24.00	3	8.00
Anchor poles	4	20.00	80.00	1	80.00
Ropes	24	10.00	240.00	6	40.00
Labour, constr/m & I		200.00	200.00	6	33.33
Initial investment cost			1023.60		266.51

3. Costing of depuration unit

Materials	Units (RM)	Unit (RM)	Total cost	Avg. life (Yrs)	Yearly depreciation (RM)
Frame wood t bolts	1	800.00	800.00	6	133.33
Main tank	1	280.00	280.00	6	46.67
UV tank	1	200.00	200.00	6	33.33
UV fixture	2	15.00	30.00	6	5.00
Trays	15	26.00	390.00	6	65.M)
Pump, 0.5hp	1	640.00	640.00	3	213.33
PVC pipe	2	15.00	30.00	6	5.00
Plastic tube, 20cm*50	1	1.00	1.00	6	0.17
Metal bank support	4	0.80	3.20	6	0.53
One-way valve	1	7.00	7.00	6	1.17
T-joint	3	1.50	4.50	6	0.75
Elbow joint	4	0.80	3.20	6	0.53
Cap	5	0.50	2.50	6	0.42
PVC valve		5.00	20.00	6	3.33
Threaded adaptor	4	1.20	4.80	6	0.80
Teflon tape	2	0.70	1.40	6	0.23
PVC adhesive		4.50	4.50	6	0.75
Extension outlet		17.50	17.50	6	2.92
Labour, construct.	1	50.00	50.00	6	8.331
Initial investment cost			2489.60		521.59

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