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Translated from Thai and edited by Edward W. McCoy

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT

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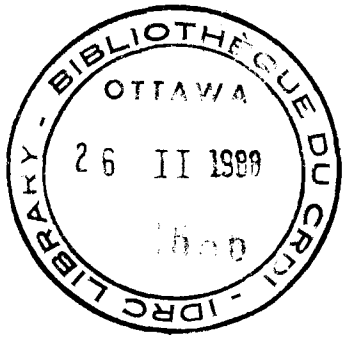

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Abstract

Thailand has cultured cockles or arc shells (*Anadara granosa* Linnaeus) since 1900 at which time the traditional farm area was 1-1.5 ha. Seeds were collected from nearby culture beds. In 1973, seeds were imported from Malaysia for culture in Satun Province in the southern part of Thailand. The culture beds were expanded to 160 ha and the culture method was modified and developed. However, commercial cockle farming is beset with problems which should be solved with further research.

Introduction

Cockles are bivalve molluscs which commonly inhabit muddy seashores. Culture of these molluscs in Thailand began about 75 years ago at Bang Tabun Subdistrict, Baan Laem District, Phetchaburi Province. The cockle seeds were collected and reseeded in a bamboo fenced area (Chomdet and Poocharoen 1979). The fencing was 50 cm high and enclosed an area of 5-10 rai (one rai = 1,600 m^2). The farmers sifted seed from natural beds for sowing in the culture area. The culture period was one to two years. Later, cockle farming spread to other districts in the Province and into Samut Songkhram Province.

Cockle farming was conducted by this method until 1972, when severe water pollution occurred in the inner Gulf of Thailand. The source of pollution was waste water released from the sugar factories on the Mae klong and Phetchaburi Rivers. The waste polluted the freshwater resources of the two rivers and ultimately the brackishwater. The pollution was particularly harmful for cockles because they could not move to nonpolluted areas. The cockle beds in Phetchaburi and Samut Songkhram Provinces eventually became polluted and unsuitable for cockle production. Cockle production decreased and subsequently a shortage of cockles for consumption occurred. Since cockles were a highly favored product in Thailand, some people began to import cockles from Malaysia where production was said to exceed consumption. In 1973, some farmers began production of cockles by sowing cockle spat (approximately 10,000 pieces/kg) at Tam Malang Bay, Muang District, Satun Province (Tookwinas 1981).

The cockle farming in Satun Province was relatively large scale. The culture area for each farm was 200-900 rai (Tookwinas 1981). The culture method was the same as used in Malaysia. Malaysians were involved in all operations on a partnership basis. Malaysians either shared investments or operated the farms. They assisted with site selection, seed purchase, seed sowing, sorting and thinning, harvesting and marketing. Due to the ease of operation of a cockle farm, the labor requirements were limited. Labor was used for seeding, thinning, harvesting and guarding. The cockles were not fed. The farming operation normally could return a cash income about 5-10 times that of input costs (variable cash costs). Cockle farming spread rapidly throughout the southern part of Thailand to the provinces of Trang, Ranong, Nakhon Si Thammarat, and Surat Thani. After five to six years of culture a serious problem developed. The culture beds gradually deteriorated and growth rate decreased while mortality rate increased.

Life History of Cockles

The cockles farmed in Malaysia and Thailand are bivalves of the genus *Anadara*, Family Arcidae. They are not true cockles but more correctly arc shells.

The cockles found in Thailand include:

Anadara granosa Linnaeus, which is commonly called arc shell or bloody clam. This species is commonly found in fine muddy sand along the shallow coastline. The width of mature shell is 4-5 cm. This is the species cultured in Malaysia.

Anadara (Tegellarca) nodifera (E. Von Martens). This species is like *A. granosa* but the width and height relationship differs. The habitat is similar to that of *A. granosa*. This is one of the species cultured at Phetchaburi Province.

Anadara (Scapharca) trocheli (Dunker). This species is heart shaped. The shell width is 6-7.5 cm. The species is found in relatively large quantities along the western coast of Thailand from Phangnga to Satun Province.

Anadara (Scapharca) satowi (Dunker). The shape of this species is rather square. The shell width is 7.5-10 cm.

Only *A. granosa* and *A. nodifera* are cultured or imported for culturing in Thailand.

Behavior of Cockles

As indicated, cockles generally inhabit the fine muddy shore of the coastline. When cockles are placed in an aquarium with fine mud from the natural beds, they burrow into the mud with the open side up (Fig. 1). In general, the cockles burrow only into the surface of the mud. The shell is then partially opened, one end is used for water and nutrient intake, the other end is the waste outlet. The inlet and outlet can be observed on the mud surface.

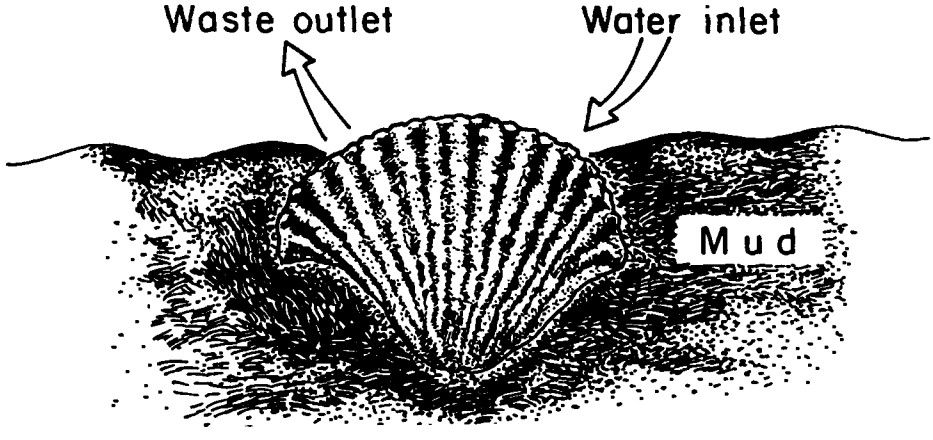

Fig. 1. Position of cockles in mud.

Presumably, when water is suctioned in, small organisms are also taken in, such as phytoplankton, zooplankton and organic matter (detritus). At the same time, the water passed through would carry away the excretionary products. According to a study by Tuaycharoen (1983), the stomach contents of cockles were dominated by phytoplankton. The predominant groups were algae and diatoms, *Chlorella* sp., *Coscinodiscus* sp., *Rhizosolenia* sp. and *Nitzchia* sp.

Cockles are benthic bivalves. The farmers wonder whether migration of the cockles occurs by self or wave action. Some farmers believe cockles can crawl or move by turning the open side down and projecting the foot for movement. This is the primary reason why farmers at Bang Tabun, Phetchaburi Province surround the growing area with bamboo strips. The strips prevent cockles from migrating to surrounding farms. The author also desired to determine if cockles could or would migrate. A trial was conducted by placing cockles in an aquarium. Half of the aquarium bottom was filled with mud and the other half was not filled. After 10 hours, the cockles placed on the unfilled side migrated to the mud filled side. Cockles can move to find more favorable conditions by projecting the foot.

Suitable Culture Area

Suitable areas for cockle culture is near the mouth of canals or coastline with a salinity not lower than 25 ppt (Tookwinas 1983). Experiments indicate mortality will occur when salinity decreases to 23 ppt. The area should be a wind sheltered bay with a river or canal to bring in nutrients. The bottom slope should not exceed 15 degrees so cockles will not be moved by wind or wave action. The bottom should be mud or silty clay without sand (Fig. 2). A simple method for testing the fineness of the mud

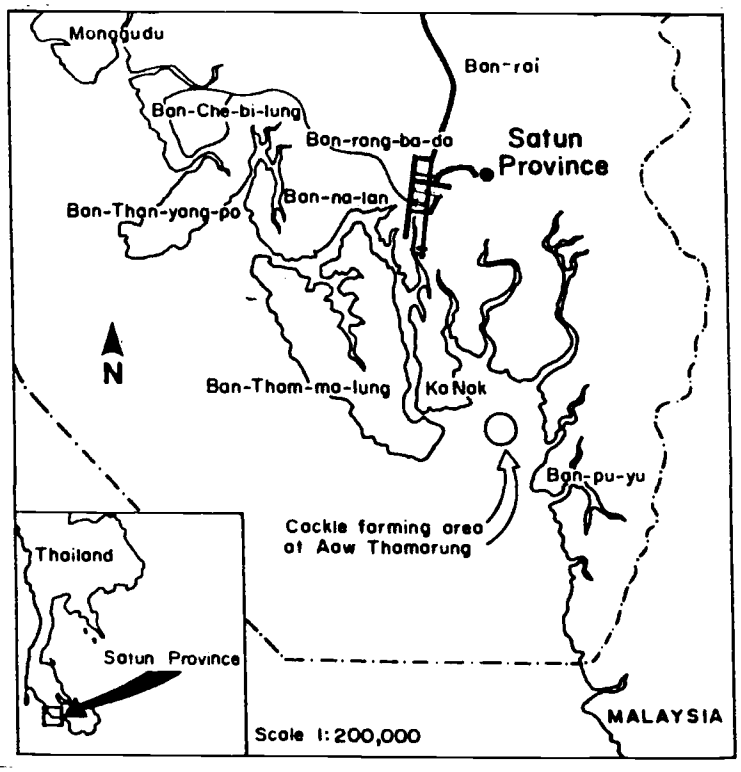

Fig. 2. Cockle farming areas in Satun Province.

is as follows: put a small amount of mud in one hand, then rub with the thumb of the other hand. If sand is present, it can be felt. The mud layer should not be less than 0.5-1.0 m deep. The mud should not have a strong smell. Water depth should be between 0.5 and 1.0 m (mean sea level) and the exposure period should be two to three hours a day (Fig. 3). In addition, the culture area should be secure from predators.

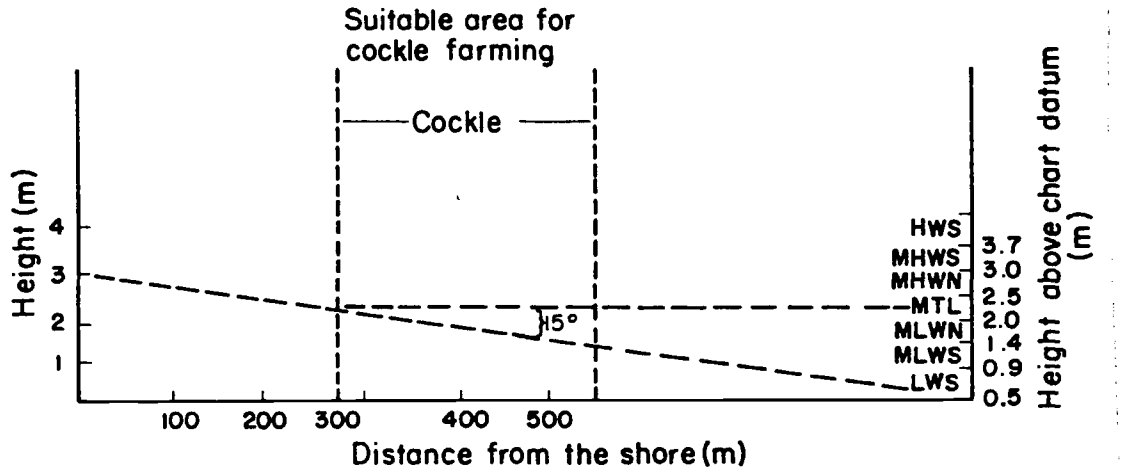

Fig. 3. Distance from the shore and tidal zone suitable for cockle farming (from Boonruang and Janekarn 1983). HWS (high water spring); MHWS (mean high water spring); MHWN (mean high water neap); MTL (mean tide level); MLWN (mean low water neap); MLWS (mean low water spring); LWS (low water spring).

Seed Bed and Spat Collecting Season

SEED BED

As previously mentioned, cockles originally were widely cultured in Phetchaburi and Samut Songkhram Provinces. The area had sufficient seed (size approximately 2,000/kg) to supply the local production. However, in 1972, water pollution destroyed not only cockles but many other aquatic animals in the area. The culture and seed beds deteriorated and were no longer suitable for production. Cockle production virtually ceased for four to five years. During the last few years, production has restarted and seed has been collected. Data are not available to indicate the amount of seed available at Phetchaburi.

In 1979, Satun Province had about 3,800 rai in cockle production but no reported spat settlement has occurred. In January 1983, a report from Nakhon Si Thammarat, where cockle farming also exists, indicated that spatfall had occurred. Many spat, size 170-200 pieces/kg, could be collected. The spat collection area was about 2-3 km from the culture area in Nakhon Si Thammarat Bay. The seed bed at Nakhon is a very hopeful sign for continued cockle culture in Thailand.

MALAYSIA SEED BED

Cockle seed has been imported from Malaysia (Pathansali 1977). In 1977, about 200 t were imported. Cockle seed beds in Malaysia are primarily in Bagan Fermal and Balik Pulau of Penang State, and Kuala Selensing, Kuala Jarum Mas and Bagan Sungei Jelukang of Perak State (Fig. 4).

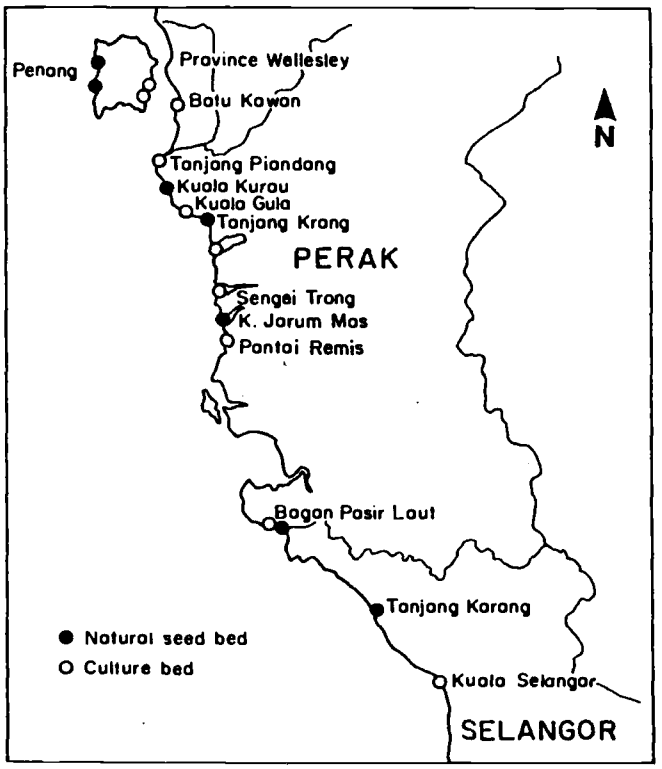

Fig. 4. Cockle culture areas in Malaysia (from Pathansali 1961).

SPAT COLLECTING SEASON

According to farmers in Nakhon Si Thammarat Bay, spat (approximately 170-200/kg) were collected in January 1983. Cockles of this size are five to six months in age. The spat survey at Sapum Bay, Phuket Province (Boonruang and Janekarn 1983) indicated that spat were 18 mm in size in December, almost the same as the Nakhon seed. These data indicate the spawning season in both areas must occur around June-August.

Pathansali (1977) reported the spawning season in Malaysia was in May-September and spat (1 mm) collection was in June-November. Spawning and collection periods varied due to the environmental effects such as salinity and tide. In Malaysia (Pathansali 1977), spat settlement was on fine muddy bottoms with a low slope, around the mouth of rivers or the mangrove coastline. Settlement period was at the beginning of high or low tide during neap tide (about the 8th-10th day of waxing or waning). The spat settlement occurred at 28 to 30 ppt salinity.

Purchasing Cockle Seed for Culture

Cockle farmers in the south of Thailand import seed from Malaysia; therefore, the quantity available and price in Malaysia strongly influence cockle farming in Thailand. Cockle farmers in the south of Thailand thus join with Malaysians who provide the seed by buying in Malaysia. An interview in

1980 by the author disclosed that the Malaysian government required farmers to form a cooperative for seed collection in the village area. Sale was by bidding thus price was dependent on quantity collected and demand by producers. The price, in 1961, was about M$0.12/kg. In 1982, the price of cockle seed (1,300/kg) was M$1.6/kg* and in 1983, M$5.5/kg* (2,500/kg). The farmers in Thailand have to purchase seed through competitive bidding. In addition, seed exported to Thailand was subject to an 8% tax on the selling price.

Predators, Disease and Parasites

Predators, disease and parasites are significant problems for all types of aquaculture. Shellfish, because of external anatomy, have fewer problems than other types. Some of the major problems are as follows.

HUMAN PREDATORS

Humans are the most significant predators in the culture area. The culture area is large and near shore, thus theft is a constant problem. Theft is accomplished by use of hand dredges or even boat dredges even though watchmen are employed to guard the production area.

FISHING IN THE CULTURE AREA

Bottom trawling in the culture area using push nets can press the cockles into the mud or disturb the growing area. Cockles may be killed by siltation or burial. The push nets can also destroy the cockle larvae suspended in the water. Other small-scale fishing equipment such as fish traps, gill nets, and hand lines are not a direct problem but the users of the gear can easily steal cockles.

OTHER PREDATORS

Fig. 5 shows predators which damage or drill cockles. These are drilling gastropods—*Natica maculosa* (moon snail) and *Thais carinifera.* These gastropods can consume cockles. Also, starfish and catfish *(Plotosus anguillaris)* can eat small cockles. At times also a small crab is found within cockles between the shell and meat. The crab has a carapace with width of about 0.25 cm. Generally there is only one crab in a cockle. No references, Thai or English, have been found to classify this crab. In addition, no references have been found reporting the relationship, symbiotic or parasitic, of the cockles and crab.

WATER POLLUTION

Cockles are benthic animals that migrate very slowly, thus pollution can have a major effect on the production area. Red tide, caused by blooms of phytoplankton, can create oxygen and nutrient depletion in the water. If red tide occurs in the culture area, the sediment can accumulate on the mud surface and create an oxygen depletion and nutrient deficiency that will cause mortality in the cockles. The red tide phenomena is caused by blooming of two phytoplankton species—*Trichodesmium* sp. and *Noctiluca* sp.

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*M$2.32 = US$1 as of December 1982.

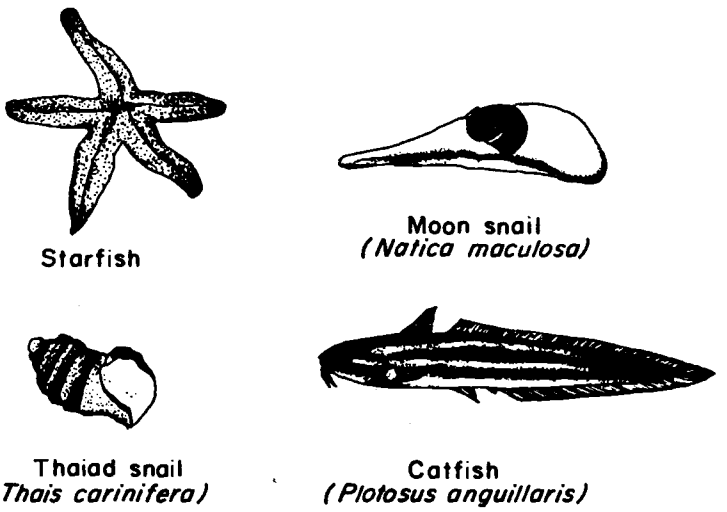

Fig. 5. Cockle predators.

Management and Farm Operation

SEED TRANSPORT AND STOCKING DENSITY

Size of cockle seed for culture varies from 1,000-10,000 pieces/kg. Handling during transport is very important. In general, farmers importing seed from Malaysia transport at night. The seed are packed in sacks weighing 60-80 kg. The sacks are sprayed with seawater at varying times during transport. Sowing of seed is done in the early morning or late evening for a better survival rate. Seeding is always done at neap tide (the 7th-11th day of the waxing moon) when the entire culture area is covered with water. According to farmers who import from Malaysia, the mortality was not greater than 15% (by weight). The farmers use a metal dinner plate for sowing the seed and attempt to spread them evenly over the area. Stocking is dense for the first three months for convenience in determining growth rate. Only a portion of the growing area is stocked. Interviews with producers indicate 540 kg (30 tins) to 1,080 kg (60 tins) per rai are stocked (Tookwinas 1981). After three to six months, the cockle will be redistributed over the entire growing area.

GROWTH RATE

In the cockle farm operation, the farmer checks growth rate and density on a monthly basis. The check is to insure that crowding does not occur that could decrease growth rate or cause mortality.

The farmer uses a mud ski, a plank about 0.9 m wide and 1-1.5 m long with the front portion angled up to check cockle density. The farmer propels the plank across the mud at low water spring. The farmer sits on the heel of the left leg and propels the plank with the right leg (Fig. 6). Efficiency in movement depends on the skill of the farmer. When a crowded area is discovered, the farmer will dip up cockles with a wire sieve, screen size 0.5 cm (Fig. 7), and distribute the cockles to a less crowded area.

A survey to determine proper stocking density was done in Satun Province. The proper density for small cockles during the first six months was 400-450/m^2. After one year, the density should be

Fig. 6. Farmer propelling mud ski for harvesting or distributing cockles.

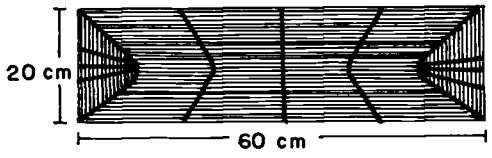

Fig. 7. Wire sieve for sorting young cockles.

reduced to 100-200/m^2. The farmers start to harvest after 18 months when cockles reach about 4 cm and 24 g in weight, 40-50/kg.

In addition to the detection method listed above, an Ekman grab can be used to collect cockles from a boat. In measuring cockles, Vernier calipers were used. Fig. 8 shows dimensions for technical measurement of cockles.

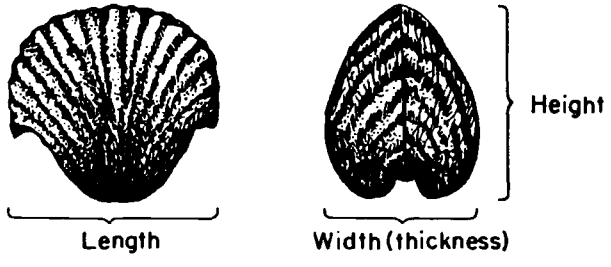

Fig. 8. Dimensions for technical measurement of cockles.

FARM MANAGEMENT

Good management is necessary for any culture of aquatic animals. Detection of disease is much more difficult in aquaculture than for terrestrial animals. Cockle farming is somewhat easier than other aquaculture because it requires less management but gives high returns per unit of capital. Farmers must build a guardhouse in the production area and employ full-time guards to prevent theft of cockles. Provision of a guard is one of the most important management tools. In addition, the farmer has to check for and irradicate predators, such as starfish, from the culture area. Starfish can swiftly reduce the cockle population.

HARVESTING

After 18 months the farmer begins to harvest cockles. At this point, cockles are about 50-60/kg. The farmer employs workers to dredge cockles every day. Daily production will average 6-10 t for an

area of 500 rai. After harvest, cockles are transported to Bangkok or Samut Prakan. Equipment used in harvest is an iron frame with strong wire connected along the frame and thin wire across the strong wire making a 2.6-cm mesh size (Fig. 9). The frame is attached to a pole. In dredging, the pole is attached by rope to the front of the boat. One man tilts the pole upright and the forward motion of the boat pulls the dredge. When the dredge is full, the man lifts it into the boat and dumps out the cockles. The boat normally has a central engine and is 6 m long and 2 m wide. The operator holds the pole with his hands and guides it with his legs. The boat circles in an area until harvesting is complete. Boat harvesting continues until density is reduced to 1-3 cockles/m^2.

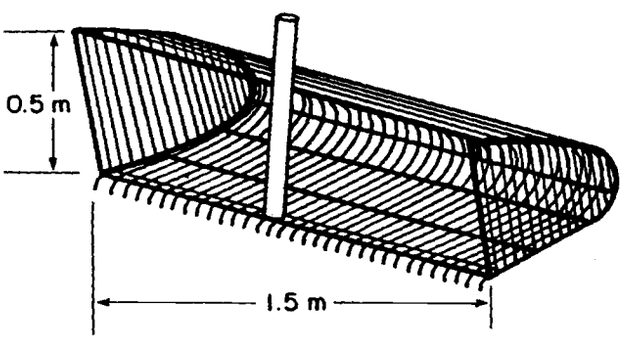

Fig. 9. Rake for harvesting cockles.

MARKETING AND BENEFITS

Intensive cockle farmers in Thailand always arrange forward contracts with wholesalers in Bangkok or in the local area. Since the harvest period is short and the quantity produced is high, the contracts avoid market gluts and consequent low prices. Occasionally when production is not sufficient, the farmer must purchase cockles from Malaysia to fulfill the contract. The wholesalers distribute the cockles to other middlemen. The other middlemen redistribute to dealers who deliver cockles to all sections of Thailand (Fig. 10).

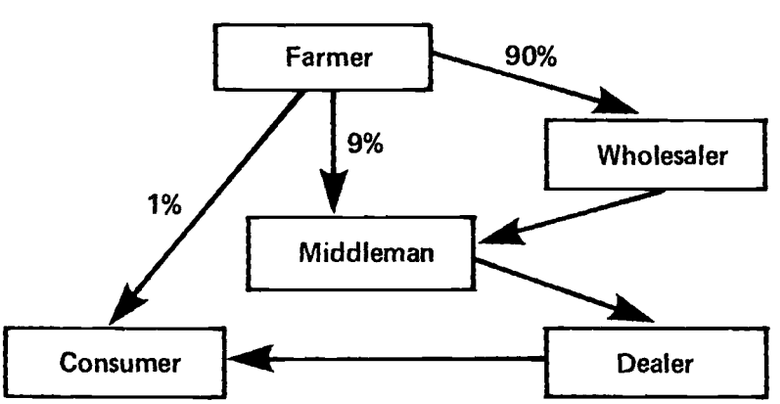

Fig. 10. Cockle marketing system.

The capital requirements and benefits from cockle farming in 1978 are shown in Table 1 (Rabanal et al. 1977).

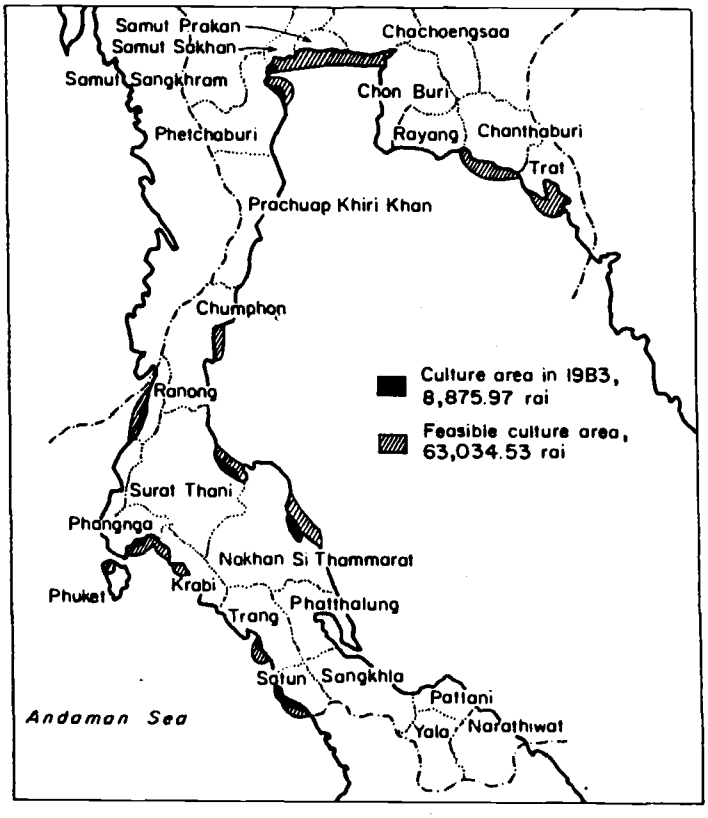

Fig. 11. Present cockle culture areas and feasible areas for expansion.

Table 1. Capital and benefits from cockle farming, 1978.

Item	Cost (Baht*)
Fixed capital	
Equipment, dredge, boats, etc.	55,000
Regular expenses	
Seed (40,000 kg)	93,750
Labor, harvest and transport	2,187
Total	95,937
Income	
Production (109.87 t/6.26 rai @ 1.5 baht/kg)	164,062
Benefits	
Net benefit	68,125
Benefit percentage	17

*15 Baht = US$1 in January-June 1978.

Cockle Farming Area of Thailand

In 1980, cockle farming was conducted in four provinces in Thailand: Samut Sakhon, Phetchaburi, Nakhon Si Thammarat and Satun (Hongskul 1980). Culture area was 4,818 rai. From personal interviews of fisheries officials of many provinces, it appears that the culture area expanded to nine provinces. with an area of 8,876 rai (Table 2 and Fig. 11). A feasibility survey, as well as the author's survey, indicated cockle could be expanded to 21 provinces with a culture area of 71,911 rai (Rabanal et al. 1977; Chomdes and Poocharoen 1979; Hongskul 1980). The feasibility of this expansion requires more study on the technical aspects. Cockle production for 1971-1978 is shown in Table 3; production in 1978 was 16,326 t.

Table 2. Cockle farm areas in Thailand.[1]

Province	Culture area (1980)	Culture area (1981-1982)	Feasible area	Total
Trat	–	–	3,000	3,000
Chanthaburi	–	–	12,000	12,000
Chachoengsao	–	–	1,200	1,200
Samut Prakan	–	–	3,000	3,000
Samut Sakhon	–	–	6,000	6,000
Samut Songkhram	954	250	2,504	2,754
Phetchaburi	672	200	472	672
Chumphon	–	–	1,200	1,200
Surat Thani	–	2,725	11,377	14,102[4]
Nakhon Si Thammarat	–	800	2,200	3,000
Pattani	–	10	?	10[3]
Ranong	44	1,398	10,602	12,000
Phuket	–	–	150	150
Phangnga	–	–	6,500	6,500
Krabi	–	–	1,000	1,000
Trang	–	100	900	1,000
Satun	3,148	2,943[2]	1,380	4,323[5]
Total	4,818	8,876	63,035	71,911

[1] Modified from Hongskul (1980), Table 4.
[2] Includes the permitted area and groups of farmers in the rural poor development project.
[3] Not surveyed for feasible area.
[4] Areas notified by the Department of Fisheries as permitted areas for cockle farming.
[5] Does not include the permitted areas which require improvement.

Problems and Obstacles

Seed shortage is one of the main obstacles to increases in production. Currently, producers must import seed from Malaysia. The imported seed is expensive and sometimes sufficient quantity is not available. The news regarding the seed bed at Nakhon Si Thammarat thus attains greater importance. In addition, cockle seed could be collected from Bang Tabun in Phetchaburi or Khlongton in Samut Songkhram. Thailand seed, if properly utilized and conserved, would be sufficient for cockle farming in Thailand.

Table 3. Cockle production (tonnes) in Thailand, 1971-1978 (from Hongskul 1980).

Province	1971	1972	1973	1974	1975	1976	1977	1978
Phetchaburi	7,332	1,324	2,030	776	1,328	2,448	2,112	1,823
Samut Sakhon	2,802	122	–	–	–	–	–	–
Samut Songkhram	285	1,260	1,890	718	638	745	681	479
Chachoengsao	42	276	–	–	–	–	–	–
Phuket	–	423	390	–	–	17	42	86
Surat Thani	–	288	–	–	–	–	–	–
Chumphon	–	414	545	468	538	–	–	–
Pattani	–	26	–	36	–	94	156	–
Trang	–	4	–	14	24	50	99	165
Satun	–	–	–	1,000	3,600	8,900	13,200	13,467
Songkhla	–	–	–	–	43	–	–	–
Phangnga	–	–	–	–	30	538	267	44
Krabi	–	–	–	–	–	–	89	33
Others	2,121	533	330	110	–	–	–	–
Total	12,581	4,690	5,185	3,131	6,201	12,792	16,646	16,326

DETERIORATION OF CULTURE AREA

Following five to six years of continuous culture, the production area at Che-bi-lung Bay, Muang District, Satun Province had changed. The bottom surface is hard with an accumulation of material including shell of dead cockles. Interview of producers indicated the continuous harvest with the small mesh screen removed only the larger shell. The empty shell remained on the bottom. Additional factors cause the deterioration in culture areas suggesting further research should be performed.

PROBLEMS WITH PERMITS FOR COCKLE FARMING

According to Section 7 of the Fisheries Legislation issued in 1974, a farmer who wishes to engage in cockle farming must follow a certain procedure. First, submit a request to the District Fisheries Officer who passes the request to the Provincial Fisheries Officer who, in turn, submits the request to the Department of Fisheries. The Department of Fisheries will dispatch a Fisheries Biologist to determine the biological feasibility of the area for cockle culture. If the area is feasible, the Provincial and/or District Fisheries Officer will arrange for assembly of the local people to gain approval for the request. After a request is approved for cockle farming, no fishing activity is allowed in the area. In actuality, prospective cockle farmers first seek to gain approval of the local people. Seldom will such approval be granted since the people do not want to give up fishing rights in an area.

LIVE TRANSPORT

As indicated in Fig. 10, farmers transport cockle to wholesalers. The wholesalers in turn sell to other middlemen who distribute throughout the country. These marketing steps require time and cockle may require a few days to reach the consumer. For consumers in the north or northeast it requires an even longer time period. During this transport period the cockles may die. The death loss reduces the quantity available for consumption and price is higher. Transportation needs improvement. At present,

cockles are packed in sacks, about 60-70 kg/sack, and sprinkled with seawater before transport. Ten wheel trucks are used and transportation is done in late afternoon or evening. The cockles arrive in Bangkok early in the morning for distribution the next day.

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