Coastal Aquaculture in Thailand

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Sahavacharin S. 1995. Coastal aquaculture in Thailand, pp. 149-157. In: Bagarinao TU, Flores EEC (eds) Towards Sustainable Aquaculture in Southeast Asia and Japan. SEAFDEC Aquaculture Department, Iloilo, Philippines.

Abstract

Coastal aquaculture in Thailand has expanded rapidly in both area and production in the last decade. The important cultured species are the shrimps (*Penaeus monodon* and *P. merguiensis*), sea bass *Lates calcarifer,* groupers *Epinephelus malabaricus* and *E. tauvina,* green mussel *Perna viridis,* horse mussel *Modiolus senhausenii,* blood cockles *Anadara granosa* and *A. nodifera* and the oysters *Crassostrea belcheri, C. lugubris* and *Saccostrea commercialis.* The total production from coastal aquaculture in 1991 was 230,444 tons, consisting of 70.3% shrimp, 28.8% mollusks, and 0.9% fishes. The seaweeds *Gracilaria* spp., pearl oysters, scallops, and abalones are cultured on a pilot scale in some places. Hatchery technologies have recently been developed for groupers, oysters, scallops, and abalones. Expanded aquaculture has had some adverse effects on the environment and has also suffered from the environmental changes and conflicts due to other sectors using the same water and other resources.

Introduction

Thailand has about 2,600 km of coastline along the Gulf of Thailand and the Andaman Sea. The total fisheries production slightly increased during the last decade from 2.12 million tons in 1982 to 2.97 million tons in 1991 (Table 1). Capture fisheries made up 88% and aquaculture 12% of the total production.

The development of coastal aquaculture in Thailand focused on the black tiger shrimp, banana shrimp, mudcrab, sea bass, groupers, green mussel, horse mussel, blood cockles, and oysters. Culture techniques for these species have steadily improved. Production from coastal aquaculture grew from 36,900 tons in 1982 to 230,444 tons in 1991 (Table 1). The bulk (70%) of the production was from intensive shrimp culture but over the same period, mollusk and fish production also increased.

Table 1. Fisheries production in Thailand from 1982 to 1991. Data from Department of Fisheries, Ministry of Agriculture and Cooperatives, Thailand.

Year	Total	Production (×1,000 tons) Capture Fisheries		Aquaculture	
		Inland	Marine	Freshwater	Coastal
1982	2,120.1	87.7	1,949.7	45.8	36.9
1983	2,225.4	108.4	2,055.2	47.0	44.8
1984	2,134.8	111.4	1,911.5	50.4	61.5
1985	2,225.2	92.2	1,997.2	75.2	60.6
1986	2,536.3	98.4	2,309.5	89.3	39.1
1987	2,779.1	87.4	2,540.0	89.8	61.9
1988	2,629.7	81.5	2,337.2	102.1	108.9
1989	2,740.0	109.1	2,370.5	91.7	168.7
1990	2,786.4	127.2	2,362.2	103.8	193.2
1991	2,967.7	136.0	2,478.6	122.7	230.4

To further promote fisheries in the country's economic development, the Government formulated a progressive fishery policy under the Seventh National Five-Year Plan (1992-1996). Under this policy, the coastal aquaculture sector was mandated to achieve the following:

- Undertake extensive propagation of brackishwater species
- Increase the production from coastal aquaculture by developing intensive culture techniques
- Use remote sensing and ground surveys in coastal zone development
- Develop effective techniques for sustainable utilization and conservation of coastal living resources

This paper reviews the status of aquaculture of different brackishwater and marine species, including some of the problems that further research may be able to resolve.

Shrimp Culture

The shrimp culture industry in Thailand started to take off in 1986 and soon became the most profitable agribusiness venture. Shrimp production in 1982 was 10,091 tons from a culture area of 30,792 hectares; this increased to 184,884 tons from 72,796 hectares in 1992 (Table 2). The culture techniques and management vary according to the scale of operation (Potaros 1994).

The extensive culture system was in practice when shrimp culture began along the inner Gulf of Thailand. Most of the extensive farms are in mangrove areas. Farming depends on the natural seed supply and tidal water exchange. Ponds have sluice gates on the side to receive seawater, nutrients, and wild postlarvae (mostly *Penaeus merguiensis* and *Metapenaeus* sp.) during high tide. The water in the pond is maintained at a depth of 50-60 cm. After 3-4 months, when the shrimps attain marketable size, the water is drained through the sluice gate during low

tide and the shrimps are trapped in a bag net. Before a new crop starts, the dikes are repaired and the ditch scoured. Farmers can raise two crops a year at yields of 187-375 kg/ha per crop.

Table 2. Shrimp culture and production in Thailand, 1982-92. Data from the Department of Fisheries, Ministry of Fisheries and Cooperatives, Thailand. US$1 = Baht 25.

Year	Number of farms	Total area (ha)	Production (tons)	Value (million Baht)
1982	3,943	30,792	10,091	766
1983	4,327	35,537	11,550	950
1984	4,519	36,792	13,007	1,024
1985	4,939	40,769	15,841	1,348
1986	5,534	45,368	17,886	1,738
1987	5,899	44,770	23,566	3,449
1988	10,246	54,778	55,633	7,901
1989	12,545	71,166	93,494	11,072
1990	15,072	64,606	118,227	14,365
1991	18,998	75,332	162,070	19,834
1992	19,403	72,796	184,884	25,500

The semi-intensive culture system improves on the extensive by stocking shrimp postlarvae from hatcheries. In 1983, the Department of Fisheries succeeded in mass producing the postlarvae of the banana shrimp *P. merguiensis* and tiger shrimp *P. monodon* in the hatchery and made up for the depleted natural supply. The semi-intensive farm is generally smaller, about 0.5-1.6 hectare, and includes a water reservoir pond from which water is pumped into the grow-out ponds. Pests, predators, and competitors of shrimp are eliminated with teaseed cake or rotenone root powder. Banana shrimps and black tiger shrimps are stocked at a density of 5-20/m^2. Supplemental feeds are given. Yields are 375-625 kg/ha after a 4-month culture period.

The development of hatchery techniques in 1986 enabled the private sector to produce about 3,000 million shrimp postlarvae each year. This stimulated the shift from semi-intensive to Taiwan-style intensive shrimp farming. Intensive shrimp ponds vary from 0.16 to 1 hectare, about 1.5-3 meters deep, and are either rectangular or circular. Stocking densities range 30-60/m^2. Intensive farms require high financial and technical inputs. Artificial diets and artificial aeration are absolutely necessary. Paddlewheels (electric or diesel motor-driven) and and oxygen injectors are used. It is possible to grow 2-3 crops a year with 60-90% survival and yields of 5-10 ton/ha per crop. The national average yield surged from 0.39 ton/ha in 1985 to 2.15 ton/ha in 1991, at which time tiger shrimp made up 95.7% of total production (Csavas 1994).

The fishery census in 1993 showed 12,000 hatcheries producing more than 3,000 million postlarvae. Still, this supply does not meet the demand of the shrimp industry in Thailand. Also, the hatcheries depend on wild spawners, which are now in short supply. Thus, shrimp broodstocks must be developed.

With the rapid development of shrimp culture came various negative effects on the environment (Phillips 1995). In Thailand, 34% of cleared mangrove areas are now shrimp farms. Ponds were built even in unsuitable sites and more intensive culture methods were adopted. Farmers pushed their stocking densities to high levels to maximize the harvest. These profit-oriented practices eventually led to disease outbreaks. The first disease outbreak occurred in the intensive farms along the Inner Gulf of Thailand. More serious outbreaks spelled the end of shrimp culture in the Inner Gulf; many farms were abandoned. The farmers moved to the eastern and southern provinces and are now more aware of proper health management. Still, diseases persist. Antibiotics are widely used in Thailand and residues have been found in shrimp tissues (Saitanu et al. 1994).

Intensive shrimp farms discharge large quantities of effluents. To reduce the adverse impacts of shrimp culture, the Department of Fisheries issued various regulations. The total production ceiling is set at 200,000 tons a year. To control effluents, farms larger than 8 hectares are required to construct a wastewater oxidation pond with an area 10% that of the total water area of the farm. The biochemical oxygen demand of the effluents must not exceed 10 ppm. Legal action is taken by the government against farmers who discharge pond sediments. The government meanwhile has improved water flow in drainage canals and tributaries.

Mudcrab Fattening

In 1986, the production of mudcrabs *Scylla serrata* amounted to 223 tons from 100 small farms, which disappeared when shrimp culture boomed (Csavas 1994). Nowadays, farmers prefer to fatten large but lean mudcrabs rather than culture small ones for a longer period. Mudcrabs are fattened in a pond surrounded by bamboo or netting to prevents the crabs from escaping. Fattening takes 10-20 days during which the mudcrabs are fed with chopped 'trash' fish.

The major constraints in mudcrab fattening are the short supply of mudcrabs and the high mortality in ponds due to cannibalism.

Fish Culture in Cages

Total production of fishes from cages has improved over the years but is still lower than from mollusk culture (Table 3).

The sea bass *Lates calcarifer* is the most popular brackishwater fish cultured in Thailand. In 1973, the Department of Fisheries succeeded in artificial propagation of sea bass (NICA 1986) and now hatcheries produce about 30 million juveniles a year. Sea bass can be grown in earthen ponds, net cages, and pens (Kungvankij et al. 1986). The stocking rate is usually 20-40/m^2. Net cages, usually 5x5x2 m, can be floating or stationary. The floating net cages are hung from wooden or bamboo frames kept afloat by styrofoam blocks or polypropylene tubs. Stationary net cages are fastened to wooden poles at the four corners and set in shallow waters with small tidal fluctuations. Farmers usually use chopped fresh 'trash' fish as feed. In 1991, about 1,461 cages were in operation and 1,650 tons of sea bass were produced.

The groupers *Epinephelus coioides* and *E. malabaricus* are the most popular marine fishes cultured in Thailand. At present, the culture sites are mostly in the east and southwest provinces. Groupers are cultured in net cages similar to those used for sea bass. Juveniles for stocking are collected from the wild. In 1991, about 355 tons of groupers were produced from 1,045 farms at yields of 300-400 kg/cage. In the near future, government and private hatcheries may be able to provide juveniles for stocking; larval rearing techniques are now being developed (Ruangpanit 1993).

Table 3. Production from coastal aquaculture of fishes and mollusks in Thailand from 1982 to 1991. Data from Department of Fisheries, Ministry of Agriculture and Cooperatives, Thailand.

Year	Production (x 1,000 tons)				
	Fishes	Blood cockle	Green mussel	Oyster	Horse mussel
1982	0.1	3.7	16.1	3.5	0.6
1983	1.2	7.1	18.7	3.4	0.6
1984	0.8	12.5	26.2	4.9	1.6
1985	0.7	12.4	25.9	3.5	0.4
1986	0.9	6.9	11.1	0.6	0.3
1987	1.5	9.6	23.9	1.5	0.8
1988	1.4	4.7	44.2	1.9	0.6
1989	1.8	12.8	58.7	1.4	0.0
1990	1.6	12.3	58.4	1.4	0.9
1991	2.0	26.4	35.5	3.3	1.1

Mussel Culture

The green mussel *Perna viridis* is the most important mollusk cultured in Thailand the past 60 years (McCoy et al. 1988). The culture method developed from a stationary fishing gear, the bamboo stake trap. To collect mussel spats, bamboo poles or coconut palms are staked into the muddy bottom 4-8 meters deep. Another adaptation is to extend the wings of fish traps to collect mussel spat. The spats are left to grow on the stakes for 6-10 months until the mussels are marketable. The mussel culture areas are near the mouths of large rivers such as Bang Pakong, Chao Phraya, Mae Klong, and Tha Chin in the inner Gulf of Thailand. The culture area was expanded in 1979 by transplanting mussel spats to Pattani Bay in southern Thailand (Brohmanonda et al. 1988b). In 1991, mussel farms covered 300 hectares and produced 35,455 tons, less than during the previous three years (Table 3).

The horse mussel *Modiolus senhausenii* is also widely distributed throughout Thailand, in intertidal zones with water less than 3 meters deep and bottoms of mixed silt, sand and mud. The farmers collect 5-10 mm spats and transfer them to selected mudflats. After 8-12 months, the 2-3 cm mussels are harvested by dredging. The production of horse mussel in 1991 was

1,092 tons from 34 farms covering 80 hectares (Table 3). Horse mussels are sold for human consumption and as animal feed.

Green mussel culture in Thailand can be further developed. Basic scientific knowledge and information is needed regarding the biology of green mussel, how to fatten it, and when best to harvest it. Spat collection techniques using ropes or other material should be introduced. New culture methods such as the hanging-line method proven most efficient in Europe should be investigated for biological and economic feasibility in Thailand. Also, packaging techniques must be improved given that about 51% of the harvest is marketed fresh shell-on and the rest is processed into various forms (McCoy et al. 1988).

Cockle Culture

The blood cockles farmed in Thailand generally inhabit nearshore or estuarine bottoms with fine mud. Suitable areas for cockle culture are sheltered bays with a river or canal to bring in plankton and other particulate food. The bottom slope must not exceed 15 degrees so that cockles are not moved by wind and wave action. Water depth must be 0.5-1 meter below mean sea level and the exposure period must not exceed 2-3 hours a day.

Culture of a local species of cockle, *Anadara nodifera,* began about 90 years ago in Phetchaburi Province (Tookwinas 1988). Cockle spats each 0.3-0.5 grams are still collected from natural settling grounds and stocked in selected areas 0.8-1.6 hectares wide at rates of 12-19 million spats per hectare. These 'farms' are fenced with bamboo poles 50 cm high to prevent the spats from being washed away. It takes about two years to reach the marketable size of 14-17 grams.

Cockles are highly favored in Thailand and the production of A. *nodifera* was not enough to meet the local demand. Thus, cockle farmers imported the spats of *A. granosa* from Malaysia beginning in 1973. About 20,000 tons are imported annually and cockle farming has developed considerably in places such as Satun, Nakhon Sri Thammarat and Surat Thani, where single farms may range 32-144 hectares in size. The culture method is similar to that in Malaysia (Tookwinas 1988). Production has varied during the past decade; in 1991, 260 farms covering 1,566 hectares produced 26,442 tons of blood cockles (Table 3).

Oyster Culture

Oyster culture in Thailand dates back about 50 years (Brohmanonda et al. 1988a). The three species of oysters that are cultured are widely distributed along the coasts of Thailand. The east coast is the culture area for *Saccostrea commercialis* and the south coast mainly for *Crassostrea lugubris* and *C. belcheri.* The production has been low and variable during 1982-1992 (Table 3). In 1991, about 1,500 oyster farms occupied 768 hectares and produced 3,311 tons.

Oysters require hard substrates for attachment — wood, stones or rocks. Farmers use stones and branches to collect spats, which are then grown in shallow waters. The most suitable areas for oyster culture are river mouths that are protected by natural or artificial barriers against strong winds and waves. The salinity must not fall below 10-15 ppt for long periods and the water

must contain adequate nutrients for plankton production. Water depth must be 1-2 meters and the bottom must not be exposed for more than 2-3 hours a day during spring tides.

The traditional culture method is to use rocks as substrates for oyster spat settlement and let the spats remain on the rocks until they reach marketable size. The rocks are piled in groups of 5-10 and spaced in rows 50-80 cm apart. This method is extensively used in Chonburi and Chantaburi provinces. Some farmers now use concrete poles or tubes 15 cm in diameter and 40 cm high that are fitted on bamboo stakes driven into the bottom of the culture area. The poles or tubes are placed in rows about one meter apart. This method is widely used in Surat Thani province.

In another method, bamboo poles and wooden stakes 2-3 meters long are driven into the bottom to serve as spat collectors then culture structures. Stakes usually number 10,000-12,500 per hectare. This method is very similar to that for mussel culture; the only difference is that the oyster culture grounds are usually nearer shore. The hanging-line and tray methods are also used in mussel culture in some localities, depending on the substrate and the availability of materials. The culture period from spat to marketable oyster is 1.5-2 years.

The culture of the large oyster *C. belcheri* in Thailand has good potential, but the quantity of oyster spats from the wild is not sufficient for the needs of the oyster growers. The spat collection and culture techniques need to be improved and new ones developed. To improve the spat supply, the government established a mollusk hatchery in Prachuab Khirikhan in 1986. This hatchery can produce 500,000 oyster spats a year (Sahavacharin et al. 1988).

Mollusk culture in general is limited by the shortage of spats and suitable culture areas (McCoy and Chongpeepien 1988). Improved or new culture techniques are needed by the industry for oysters, pearl oysters, scallops, giant clams, and abalones. The demand for mollusks in both the domestic and the world markets must be expanded for the industry to grow further.

Pollution is a big problem. Water quality in the mollusk culture grounds has deteriorated due to sewage discharge, industrial effluents, and agricultural run-off. At present, no system exists for ensuring sanitation of mollusk products. At present, handling during harvest causes serious contamination. To solve this problem, farmers should decluster and clean the mollusks at the culture site where seawater is clean rather than at the landing sites where the water is generally polluted. The levels of heavy metals and bacteria must be kept within the international limits of acceptability (Phillips and Mutarasin 1985, Saitanu 1988).

Seaweed Culture

Gracilaria and *Polycavernosa* are collected from natural beds or sea bass and grouper cages, dried, and sold to middlemen in Trat, Chantaburi, Songkhla, Pattani, and Trang (Csavas 1994). Most of the 60-200 tons collected each year is exported. At present, *Gracilaria* sp. is experimentally cultured in ponds or on net cages. The Department of Fisheries is examining the feasibility of mass propagating *Gracilaria* and other seaweed species. Experiments to grow *Gracilaria* in effluents from intensive shrimp ponds has shown initial success.

The main constraints in the expansion of seaweed culture in Thailand are the lack of domestic processing facilities and the low export prices.

Experiments on Other Species

Experiments are underway to develop culture techniques for the red snapper *Lutjanus argentimaculatus,* starting with hatchery production of larvae (Doi and Singhagraiwan 1993). Cage culture techniques for the local spiny lobsters (*Panulirus* spp.) were tested and found promising (Csavas 1994). The pearl oysters *Pinctada fucata, P. margaritifera, P. maxima,* and *Pteria penguin* are cultured in some places. Efforts are also underway to develop commercial culture of scallops (*Amusium pleuronectes* and *Chlamys senatoria*) and abalones (*Haliotis* spp.). Other species of interest are the cuttlefish *Sepia pharaonis,* the razor clam *Solen strictus,* and the grey mullet *Mugil cephalus.*

Acknowledgements

I wish to thank Pedro Bueno of the Network of Aquaculture Centers in Asia-Pacific and Prof. Prawit Suraniranat, Faculty of Fisheries, Kasetsart University for reviewing and improving the manuscript.

References

Brohmanonda P, Mutarasint K, Chongpeepien T, Amornjaruchit S. 1988a. Oyster culture in Thailand, pp. 31-39. In: McCoy and Chongpeepien (1988) below.

Brohmanonda P. Mutarasint K, Sukwongse S, Thanakumcheep N. 1988b. Transplantation of green mussels (*Perna viridis*) in Thailand, 1979-1981, pp. 80-87. In: McCoy and Chongpeepien (1988) below.

Csavas I. 1994. Coastal aquaculture in Thailand. FAO Aquaculture Newsletter 7: 2-5.

Doi M. Singhagraiwan T. 1993. Biology and Culture of the Red Snapper, *Lutjanus argentimaculatus.* The Research Project of the Fishery Resource Development in the Kingdom of Thailand. Eastern Marine Fisheries Development Center, Rayong, Thailand, 51 pp.

Kungvankij P. Tiro LB Jr. Pudadera BJ Jr, Potestas IO. 1986. Biology and Culture of Sea Bass (*Lates calcarifer*). NACA Training Manual Series No. 3. Network of Aquaculture Centres in Asia, Regional Lead Centre in the Philippines. Reprinted in 1989 as Aquaculture Extension Manual No. 11. 70 pp. SEAFDEC Aquaculture Department, Iloilo, Philippines.

McCoy FW, Chongpeepien T (eds). 1988. Bivalve Mollusc Culture Research in Thailand. ICLARM Technical Reports 19. 170 pp. Department of Fisheries Thailand, Bangkok; International Center for Living Aquatic Resources Management, Manila; Deutsche Gessellschaft fur Technische Zusammenarbeit (GTZ) GmbH, Eschborn.

McCoy EW. Tuaycharoen S, Vakily JM, Boonchuwong P. 1988. A bioeconomic longitudinal processing and marketing study of green mussel in Thailand, pp. 40-69. In: McCoy and Chongpeepien (1988) above.

NICA. 1986. Technical Manual for Seed Production of Sea Bass. National Institute of Coastal Aquaculture, Department of Fisheries, Songkhla, Thailand, 49 pp.

Phillips DJH. Muttarasin K. 1985. Trace metals in bivalve molluscs from Thailand. Mar. Environ. Res. 15: 215-234.

Phillips MJ. 1995. Shrimp culture and the environment, pp. 37-62. In: Bagarinao TU, Flores EEC (eds). Towards Sustainable Aquaculture in Southeast Asia and Japan. SEAFDEC Aquaculture Department, Iloilo, Philippines.

Potaros M. 1994. The Environmental Assessment and Management of Aquaculture Development: Shrimp Culture in Brackishwater Ponds in the Gulf of Thailand. Department of Fisheries, Bangkok, Thailand, 27 pp.

Ruangpanit N. 1993. Technical Manual for Seed Production of Grouper (*Epinephelus malabaricus*). Department of Fisheries, Bangkok, Thailand, 46 pp.

Sahavacharin S, Chindanond A, Amornjaruchit S,]Nugranad J, Silapajarn K, Chawivanskorn V, Limsurat S, Angell CL, McCoy EW, Mutarasint K, Potaros M. 1988. Hatchery techniques for tropical bivalve molluscs, pp. 19-30. In: McCoy and Chongpeepien (1988) above.

Saitanu K. 1988. Bacteriological Quality of Molluscs in Thailand. Technical Paper, Chulalongkorn University, Bangkok, Thailand, 8 pp.

Saitanu K, Amornsin A, Kondo F, Tsai CE. 1994. Antibiotic residues in tiger shrimp (*Penaeus monodon*). Asian Fish. Sci. 7: 47-72.

Tookwinas S. 1988. Commercial cockle farming in Southern Thailand, pp. 158-170. In: McCoy and Chongpeepien (1988) above.