TOTAL PRODUCTION COSTS OF THE SCALLOP *CHLAMYS SENATORIA* GMELIN CULTURED IN PRACHUAP KHIRI KHAN, THAILAND

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ABSTRACT

Breeding of scallop, *Chlamys senatoria* Gmelin has been successfully conducted in the Prachuap Khiri Khan Mollusc Hatchery since 1994. The hatchery-produced spat were cultured in Prachuap Khiri Khan Bay where good growth and survival rates were obtained. The present study estimates total production costs from rearing of the scallop larvae to settlement of spat and grow-out culture in the sea. It took 12 months of culture in submerged cages to produce scallops between 5 and 7 cm shell height. The total cost of production from broodstock to marketable scallop was 2.5 bath per scallop or 85 bath per kg (35 bath = 1 US dollar).

INTRODUCTION

The scallop *Chlamys senatoria* Gmelin occurs on sea beds off reef flats. Scallops attach to the substrate by byssus, which they can detach if disturbed. They can swim away. *C. senatoria* are distributed both in Gulf of Thailand and the Andaman Sea. They are collected and used for food by local fisherman.

The commercial species of scallop in Thailand is *Amusium pleuronectes*. In 1995, the total catch was 600 ton worth 34 million bath. Most of them were exported. Unfortunately, *A. pleuronectes* is not feasible for aquaculture because of their behaviour in enclosures. Instead *C. senatoria* should be cultured in Thailand for the local market. We have calculated the costs of producing scallops with a view to estimate the feasibility of culture of this species. The information is needed for further development of scallop culture techniques on a commercial scale in Thailand.

MATERIALS AND METHODS

The hatchery of Prachuap Khiri Khan CADC
From an intake located below the surface, sea water is pumped to sedimentation tanks, onwards to sand filters, and finally stocking tanks. Before entering the mollusc hatchery, sea water is again sand filtered and kept in the header tank of the hatchery (Fig. 1).

The algal culture units are divided in two sections: stock culture and mass culture. The stock culture room is air conditioned to temperatures in the range of 25-26 °C. The photoperiod is 8 h light and 16 h darkness.

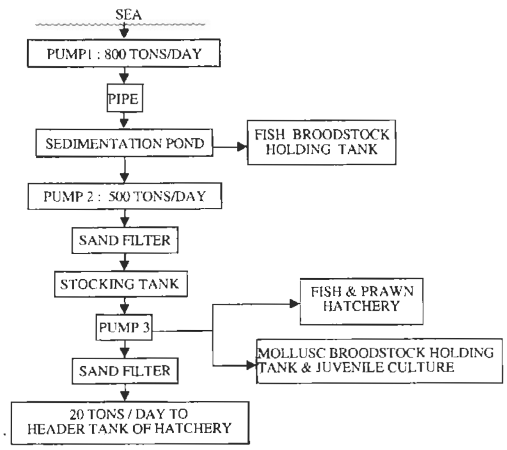

Figure 1. Sea water system at Prachuap Khiri Khan Coastal Aquaculture Center.

The media are Conway and Sato & Serikawa for the stocks up to 20 litres of carboy culture. The main production are unicellular phytoplankton such as *Isochrysis galbana*, *Chaetoceros calcitrans*, *Chlamydomonas* sp. and *Tetraselmis* sp. Phytoplankton from mass culture was harvested by continuous centrifugation. One ton of mass culture was concentrated to 5 litres. The high-density algal were used for feeding the spat.

Scallop culture

Scallops with mature gonads were selected for breeding. Induced spawning and rearing were conducted according to Nugranad & Promjinda (1997). Nylon filaments, nylon rope, plastic shade-cloth were provided as substrata in the rearing tanks when the larvae were competent.

Newly settled juveniles were kept in nursery tanks. After 30 days, the nursery tank was filled with filtered sea water and provided with mass cultured phytoplankton at a concentration of 20,000-30,000 cell ml^{-1}. Water was changed 2 times per week. Spat were nursed in the hatchery around 45–95 days or until they reached a juvenile size of 3–5 mm shell lengths.

Juveniles were transferred to an open sea nursery in Prachuap Khiri Khan Bay. They were put in 40 x 70 cm nylon mesh bags. The bags were hung from a raft to about 1 m below the sea surface. Juveniles attaining 1 cm shell length were changed to the lantern nets, 30 cm diameter, 90 cm in height, 6 levels, and 0.5 cm mesh size. The juveniles were culture at 2,100 juveniles m^{-2} or 900 juveniles per net. Juveniles attaining 2 cm shell length were changed to lantern nets with 1 cm mesh size. The juveniles were cultured at 420 juveniles m^{-2} or 80 juveniles per net. The bags and the juveniles were cleaned every month to get rid of fouling organisms. The scallops were harvested after culture in the sea for 12 months or at the age of 15 months.

PRODUCTION COST

We divide production costs into fixed costs and variable costs.

The fixed cost is an operating expense that does not vary with the volume of output: depreciation of buildings, machinery and equipment (Halcrow, 1980). Depreciation was calculated according to the straight-line method (Pongphatiroj, 1996) using the formula: Depreciation of assets = (Cost of assets - scrap value)/ estimated useful life. The scrap value was equal to zero in the present calculation.

Variable cost is a production cost that varies in direct proportion to the volume of the output. Thus, by definition a variable cost cannot be incurred when output is at a stand still (Halcrow, 1980). The principal variable costs of any manufacturing enterprise are raw material, labour, repair and maintenance of buildings and equipment, and utilities such as electricity and water. In this study, most buildings, machines, equipment and labour were shared with other activities of the Center.

Sea water system

The pump station of Prachuap Khiri Khan CADC is located in the mouth of a canal. The water turbidity is very high especially during the rainy season. Hence, this Center uses many sedimentation and stocking ponds, which requires many pumps and sand filters.

The cost of preparing one ton of filtered sea water for the hatchery was about 6.75 bath (Table 1). The largest payment was depreciation of stocking tanks, electric pumps and sand filters. The second largest cost was repair and maintenance of equipment. The labour expense was for one worker to clean the sedimentation ponds. If the water were clean all year the production cost could decrease to 0.63 bath/ton or about 10 % of the cost at this Center.

Table 1. The production cost of obtaining 1 t of sea water for the mollusc hatchery at Prachuap Khiri Khan CADC

Item	Unit	Cost	Capacity	Useful life	Fixed cost	Variable cost (bath)		
		bath	tons	yrs	Depreci-ation	Repair etc.	Labor	Electricity
Pump1	2/each	200,000	800	10	0.07	0.07		0.46
Pipe	1/set	160,500	800	15	0.04	0.00		
Sedimentation Pond	1/set	150,000	500	20	0.04	0.00		
Pump2	2/each	133,000	500	10	0.07	0.07		0.33
Sandfilter tank1	2/each	100,000	500	15	0.04	0.05		
Stocking tank	1/set	37,825	500	20	0.01	0.00	0.00	
Pump3	2/each	133,000	500	10	0.07	0.07		0.33
Sand filter2	1/each	300,000	20	15	2.74	2.08		
Labor							0.06	
total expense (bath)					3.08	2.35	0.06	1.13
% of total					46.49	35.48	0.96	17.08

Table 2. The production cost of obtaining 4,000 l phytoplankton in the intermediate culture room

Item	Unit	Cost	Useful life	% used	Fixed cost	Variable cost			
		Bath	Year		Deprecia-tion	Materials	Repair	Labor	Electricity
Hatchery	1/set	3,000,000	30	10	833.33		41.67		
Blower	1/each	8,000	20	25	8.33		0.83		167.85
Air condition	3/each	49,500	15	100	275.00		27.50		1,672.00
Scientific equipments	1/set	425,910	15-30	25	409.84		20.49		123.75
Glasswares	1/set	266,100	20	50	554.38		110.88		
Fluoresent lamp	85/set	11,900	10	50	49.58		49.58		1,836
labor: technicial	1/month	6,800		30				2,400	
wroker	1/month	4,100		100				4,100	
Seawater	3.8 ton	25.05				25.05			
Fresh water	0.75 ton	7.5				7.5			
Gas	315 kg	3,850				3,850			
Media	4 l	760				760			
Miscellaneous		983				983			
Total expense					2,130	5,625	250	6,140	3,799
% of total expense					11.87	31.35	1.40	34.21	21.17

Algal food production

The capacities were 4000 l per month for the production of intermediate phytoplankton (Table 2), and 5 l per day for high-density phytoplankton (Table 3). Scientific equipment used in this step were autoclave, hot-air oven, laminar flow, balance, hot plate and shaker.

The mean cost of phytoplankton in the laboratory culture was 4.5 bath per litre. The major cost was labour. The second largest cost was materials, mainly propane gas, which was used to boiled the sea water for culturing. The use of cold sterilisation could reduce the cost of algae culture (Sahavacharin *et al.* 1988). The cost of UV-sterilised sea water was 10,50 bath/ton. The major expense for glassware was purchase of 20 l carboy bottles, which were used to culture phytoplankton in the intermediate room. The use of bag culture (Trotta, 1981), could reduce that cost.

Table 3. The production cost of 5 l high-density phytoplankton from mass culture.

Item	Unit	Cost	Useful life (year)	% used	Fixed cost	Variable cost (Bath)			
					Depreci-ation	Materials	Repair	Labor	Electricity
Hatchery	1/set	3,000,000	30	10	27.78		1.39		
Blower	1/each	8,000	20	25	0.28		0.03		5.60
Pump1	1/each	20,000	10	25	1.39		0.14		0.37
Submersible Pump	2/each	3,600	2	75	3.75				1.41
GlassAquarium	2/each	8,000	10	50	1.11				
Fiberglass tank : 500 l	6/each	13,200	20	50	0.92				
Fiberglass tank : 1000 l	12/each	90,000	20	30	3.75				
Continuous centrifugure1		200,000	10	50	27.78		27.78		8.39
Continuous centrifugure2		395,900	10	50	54.99		54.99		16.79
Labor : wroker								75	
Stocking plankton						45			
Seawater						5.75			
Fresh water						3.48			
Media						8.52			
Miscellaneous						4.5			
Total expense					121.74	67.25	84.32	75.00	32.56
% of total					31.96	17.66	22.14	19.69	8.55

Table 4. The production cost of obtaining 78 million eyed-larvae in the Prachuap Khiri Khan Hatchery.

Item	Unit	Cost	Useful life	% used	Fixed cost	Variable cost (Bath)			
		(Bath)	(year)		Depreci-ation	Materials	Repair	Labor	Electricity
Hatchery	1/set	3,000,0-00	30	10	410.96		20.85		
Blower	1/each	8,000	20	25	4.11		0.41		396.75
Pump	1/each	20,000	10	30	24.66		2.47		111.90
Filter & Uv	1/set	474,000	20	30	292.19		254.03		83.93
Fiberglass tank : 500 l	2/each	4,400	20	100	9.04				
Fiberglass tank : 1000 l	5/each	37,500	20	100	77.05				
Microscope	1/each	56,000	20	10	11.51		11.51		
Plastic pipe		600	5	50	2.47				
Glasswere		4,069	10	50	8.36				
Settling		1,728	3	100	11.05				
Seawater		400.80				400.80			
Phytoplankton		1,287				1,287.00			
Antibiotic		960				960.00			
Labor : biologist								1,590	
Labor : technicial								1,175	
Labor : worker								2,050	
Miscellaneous		983				450			
Total expense					851.39	3,097.80	289.26	4,815	592.58
% of total					8.83	32.11	3.00	49.92	6.14

The cost of producing high-density phytoplankton for feeding the spat was 76,25 bath per litre. The cost was largely for depreciation of building and equipment, i.e., the continuous centrifuge. It was necessary to concentrate the cells of phytoplankton

Table 5. The production cost of 780,000 spat in the Prachuap Khiri Khan Hatchery.

Item	Unit	Cost	Useful life (year)	% used	Fixed cost Depreciation	Variable cost (Bath) Materials	Repair	Labor	Electricity
Hatchery	1/set	30,000	30	20	52.05		20.85		
Blower	1/each	8,000	20	5	5.21		0.52		112.10
Fiberglass tank : 250 l	20/each	40,000	20	100	109.59				
Fiberglass tank : 500 l	6/each	29,800	20	50	153.08				
Settling	1/set	1,728	3	100	78.90				
Sea water						801.60			
Phytoplankton						9,968			
Mass Plk						11,056			
Eyed larvae						9,600			
Labor : worker								3,895	
Miscellaneous		983				143			
Total expense					398.84	31,568.85	21.37	3,895	112.10
% of total					1.11	87.70	0.06	10.82	0.31

Table 6. The production cost of 410 kg scallop cultured in cages in the Prachuap Khiri Khan Bay.

Item	Unit	Cost	Useful life (year)	% used	Fixed cost Depreciation	Variable cost (Bath) Materials	Repair	Labor	Electricity
Raft		80,000	15	25	1,333.33		666.67		
Boat		80,000	10	10	800.00	1,550	400		1,550
Nursery cages	37/each	555	3	100	46.88				
Culture cages	90/each	4,500	5	100	675.00				
spat		10,710				10,707			
labor : worker		18,000						18,000	
Miscellaneous		983				150			
Total expense					2,855.21	10,857	1,066.67	18,000	1,550
% of total					8.32	31.63	3.11	52.43	4.52

because ammonia in the water was dangerous to the spat. The cost of this culture is close to the cost of intermediate culture when calculated for the same concentration.

Spawning and larvae culture

The broodstock (116 ind.) spawned 44.68 x 10^6 eggs. The hatching rate from fertilization to the D-shaped larval stage was 76.6 %. The survival rate from D-shaped larvae to pediveliger was 28.1 %. The cost was 1000 bath per one million eyed larvae (Table 4).

The major expense was labour (fisheries biologist, technician and workers). Materials, mainly phytoplankton, was the second highest cost. The cost of broodstock was included in the miscellaneous. The present production cost could be reduced if the survival rate of larvae from the D-shaped stage to the pediveliger stage could be increased. In the commercial hatchery of pacific oyster (*Crassostrea gigas*), the survival rate from D-shaped larvae to pediveliger averaged 70% (Lipovsky, 1984).

Settling and nursery

The survival rate from pediveliger to spat of 2 mm shell height was 8.1 %. The cost from metamorphosis to spat was 460 bath per 10,000 spat (Table 5). The major expense was phytoplankton for feeding. In this study, the spat were nursed for 45-90 days (Nugranad & Promjinda 1997). For mass production of the scallop, spat should be moved. to the open sea as soon as possible. That would decrease the rather high cost of nursing.

Sea nursery and culture

A stock of 233,000 spat of 2-5 mm shell height were nursed in the sea. At a size of 5-7 cm shell height, or 34 scallops per kg, the final production cost was 2.5 bath per scallop or 85 bath per kg (Table 6)

The major cost was labour. The second largest was the cost of spat (materials). Walker & Gates (1981) reported that labour cost amounted to 58 % of the operating cost of oyster culture in Narragansett Bay, USA. Labour may be provided by the owner and his family.

This study showed that the development of scallop cultured is a realistic possibility in Thailand. However, the production cost of this scallop was quite expensive for the local market. A suitable price should be 50-65 bath per kg, which could be obtained by improving the production technique.

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