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ABSTRACT

Mud crab production in Sri Lanka grew from 1422t in 1980 to 1973t in 1984, reaching a peak of 2309 t in 1983. Production has declined in recent years due to civil strife and overfishing. The average size and catch/unit effort of mud crab have declined in Negombo Lagoon, the principal fishing area. Sri Lanka mud crab are well known in the export trade and are considered a quality product. Singapore receives 90 per cent of Sri Lanka's exports. Recommended management measures include the prohibition of capturing immature crab, educating fisherfolk and developing aquaculture of the mud crab.

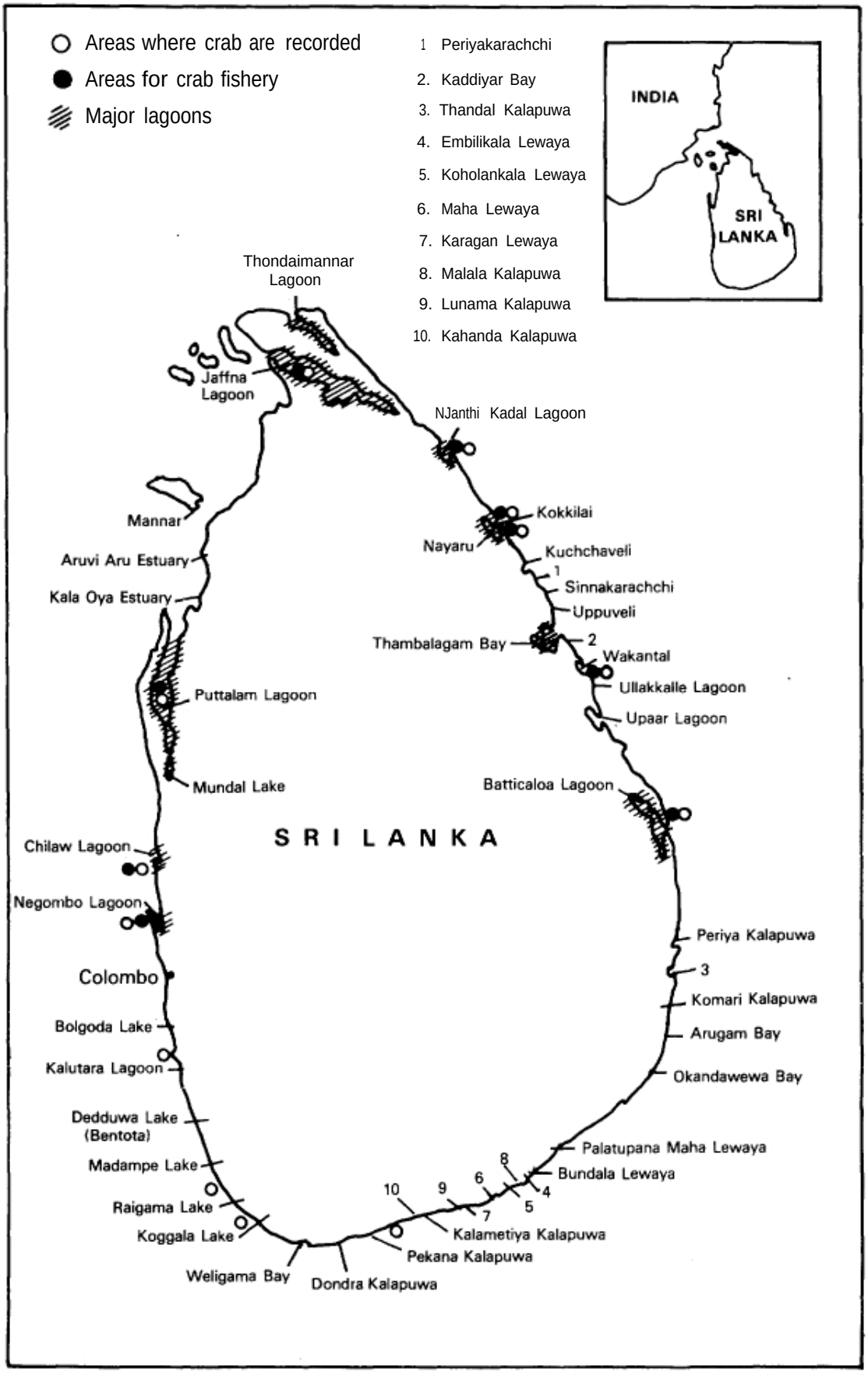
1NTRODUCTION

The mud crab Scylla serrata (Forskal) is widely distributed in the Indo-West Pacific region. It is a member of a group of swimming crab, portunid, characterized by a flattened hind pair of legs. Mud crab are predominantly estuarine, but depend on the marine environment for spawning and early larval life (Arriola, 1940). Scylla serrata is locally known as the kalapu kakuluwu (lagoon crab) or ala man kakuluwa (crab which lives in channels). It is one of the six species of crab which has a good world market. Alverson, 1971, emphasizes its importance to developing countries as a good foreign exchange earner. Only two preliminary investigations have been carried out on Scyalla serrata in Sri Lanka (Raphael 1970; Arudpragasam 1976). These related to the aquaculture potential of the mud crab and the host-parasite relationship of Scylfa serrata and Octalmis cor. Jayamanne (1991) has studied the biology and economics of the mud crab fishery in the Negombo Lagoon.

HABITAT

Mud crab mainly inhabit lagoons, but move into offshore areas to spawn. Early larval stages are marine and they begin their lagoon life only at the final larval stage, the megalopa, which is a benthic form. Megalopa, after living some time in shallow comers of the lagoon, moults into the crab.

Small crab, those measuring about 2-7 cm carapace width (CW), inhabit sea grass beds and the root props of mangroves. They usually stay hidden in sheltered areas in the subtidal zone of the lagoon. Subadults of Scylla serrata, those of about 7-13 cm CW, move more freely in the lagoon and inhabit open areas. They too are benthic in nature and occupy subtidal areas but frequently move into intertidal areas in search of food. The larger crab, measuring 13.0 cm or more CW, usually occupy deeper subtidal areas of the lagoon.


Areas where crab are recorded
Areas for crab fishery
Major lagoons
1 Periyakarachchi
2. Kaddiyar Bay
3. Thandal Kalapuwa
4. Embilikala Lewaya
5. Koholankala Lewaya
6. Maha Lewaya
7. Karagan Lewaya
8. Malala Kalapuwa
9. Lunama Kalapuwa
10. Kahanda Kalapuwa
INDIA
SRI LANKA
Thondaimannar Lagoon
Jaffna Lagoon
NJanthi Kadal Lagoon
Mannar
Aruvi Aru Estuary
Kala Oya Estuary
Kokkilai
Nayaru
Kuchchaveli
Sinnakarachchi
Uppuveli
Thambalagam Bay
Wakantal
Ullakkalle Lagoon
Upaar Lagoon
Puttalam Lagoon
Mundal Lake
Batticaloa Lagoon
SRI LANKA
Chilaw Lagoon
Negombo Lagoon
Colombo
Bolgoda Lake
Kalutara Lagoon
Dedduwa Lake (Bentota)
Madampe Lake
Raigama Lake
Koggala Lake
Weligama Bay
Dondra Kalapuwa
Pekana Kalapuwa
Kalametiya Kalapuwa
Periya Kalapuwa
Komari Kalapuwa
Arugam Bay
Okandawewa Bay
Palatupana Maha Lewaya
Bundala Lewaya

Distribution and areas of fishing

Scvlla serrata occur in almost all the lagoons and estuaries of Sri Lanka. hut are abundant in the lagoons of the west, north and east coasts. Their presence along the south coast has been reported (Maitipe and De Silva 1986), hut they are not exploited commercially in the south to the extent they are in the Jaffna. Kokilai and Nayaru (north). Batticaloa. Trincomalee and Valaichchenai (east) and Puttalam. Mannar. Chilaw and Negombo (west) areas (see Figure 1

FISHING METHODS

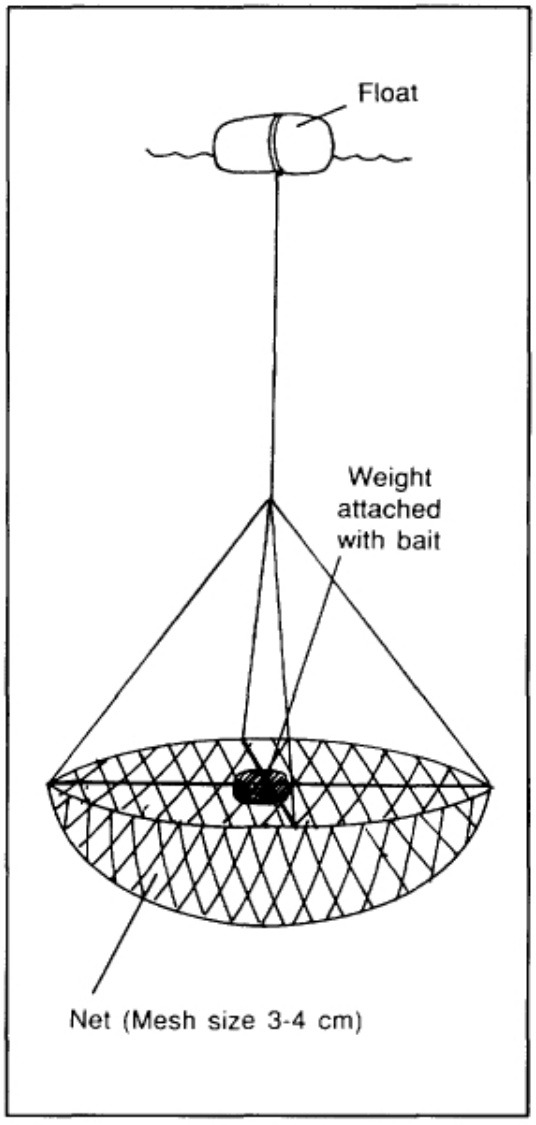
The gear used vary to some extent in the different lagoons of the country. Baited trap. the most common gear. is widely used by fishermen in Negombo. Chilaw. Puttalam. Batticaloa. Jaffna, Nayaru. Kokilai and Valaichchenai. Those in Trincomalee and Mannar seem to prefer gillnets.

The trap is a low cost device, designed specifically for trapping crab (Figure 2). The size of the trap and mesh size of the net used in the trap vary from lagoon to lagoon. hut the method used is similar everywhere.

Gear used for catching crab in some important lagoons of Sri Lanka are listed below:

Lagoon	*Fishing gear*
Negombo	Baited trap. Gillnet. Brushpi le
Chilaw	Baited trap. Gilinet. Brushpile
Putialam	Baited trap. Gilinet
Mannar	Gillnet
Nayaru	Baited trap. Gillnet
Kokilai	Baited trap, Gillnet
Jaffna	Baited trap. Gillnet
Trincomalee	Baited trap, Gilinet
Batticaloa	Baited trap, Gillnet
Valaichchenai	Baited trap. Gillnet

Fig 2. The baited trap used for catching crab



PRODUCTION

The data on annual production of mud crab in Sri Lanka, according to the Ministry of Fisheries, is given in Table 1.

Table 1: Annual production of mud crab in Sri Lanka from 1980-1984

Year	*Production (1)*
1980	1422
1981	1405
1982	1592
1983	2309
1984	1973

Production data from Negombo Lagoon (1985 - 1987) are available from a study carried out by the author (Table 2).

Table 2: Production of mud crab in Negombo Lagoon, 1985 - 1987

Year	*Production (t)*	*Export (t)*	*Local* (t)
1985	35	18	17
1986	43	16	27
1987	40	16	24

Besides this information, very little data are available on mud crab production in any other part of the country.

Fifty per cent of the crab produced in Negombo Lagoon during 1985 were exported to Singapore, Japan and Malaysia. This has gradually declined to 40 per cent over the last few years (Jayamanne, 1991). Table 3 shows the exports of mud crab from the Mannar Lagoon during six months in 1991. The data indicate that more than 40 per cent of the production is not suitable for the export market although they are exported at a lower price. Exports were high in March and low in January. The low exports in January may probably have been due to the prevailing civil unrest in the region, which affected transport into Colombo. Mortality rate during transport was 8.0-28.2 per cent.

Table 3: Export of mud crab (in kg) from Mannar Lagoon, 1991

Quality	*JAN*	*FE6*	MAR	*APR*	*MAY*	*JUN*
Large	160	1786	4314	1123	I510	2361
Medium	I55	240	1048	311	753	936
Soft	431	711	2155	1497	2321	1745
Hard	116	210	1094	4471	785	962
Dead	339	608	831	303	560	641
Total	1201	3555	9442	7705	5929	6645

Source: J S Enterprises

CURRENT STATUS OF THE FISHERY

Production of mud crab in Sri Lanka has been showing a declining trend in recent years. The production data from the Ministry of Fisheries, from 1980 to 1984, show an increase, but since then a decline is reflected in the export figures provided by the Department of Customs (Table 4).

Table 4: Mud crab exports from Sri Lanka, 1985 - 1990

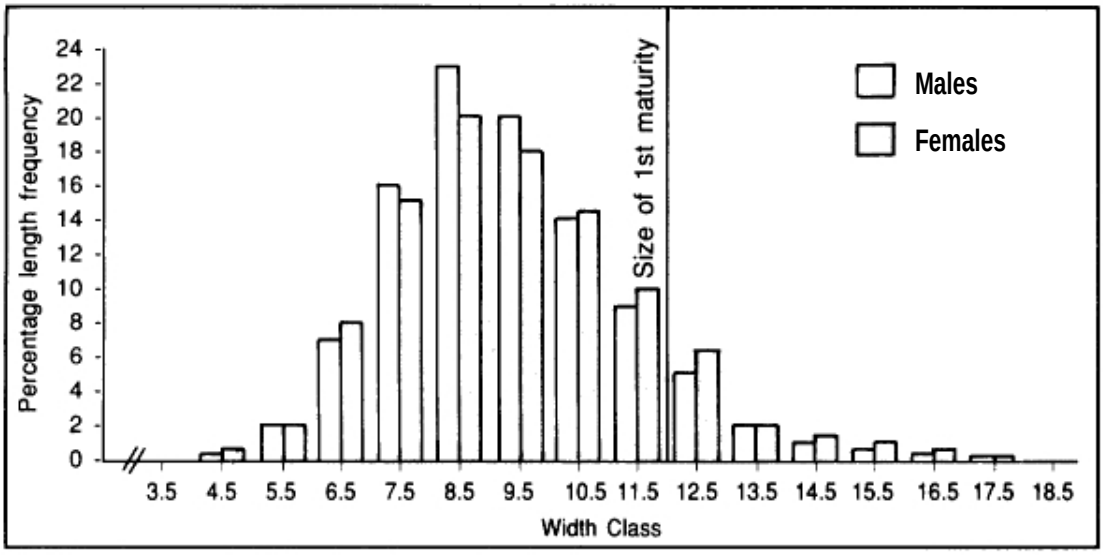
Year	*Quantity exported (t)*	*Earnings SL Rs (millions)*	*Price (SL Rs/kg)**
1985	913.75	33.38	34.28
1986	105.71	37.13	53.46
1987	337.53	26.93	79.78
1988	391.42	35.96	90.48
1989	443.11	31.50	84.64
1990	45.02	43.51	96.67

Source: Sri Lanka Customs

* 1 US $ = SL Rs. 35 Appx. (1985-1990)

The quality of exported crab has also decreased since 1985, probably due to a lack of resource management in lagoons. For instance, over 80 per cent of the total catch from Negombo Lagoon consists of immature crab (Figure 3). A declining trend is also evident in the annual mean catch/unit effort (CPUE), calculated in terms of the number of crab caught/trap/hour. The CPUE estimate was 0.0022, *0.0015,* and 0.0014 in 1985, 1986 and 1987 respectively. The CPUE was highest in May 1986 and lowest in March 1987.

Fig 3. Annual width frequency distribution of male and female S. *serrata* from Negombo Lagoon



Length and weight relationship

The maximum size and weights of crab caught from different lagoons are given below:

Lagoon	*Maximum size (CW) (cm)*	*Maximum weight (kg)*
Negombo	19.0	1.0 - 1.5
Chilaw	19.0	1.0 - 1.5
Puttalam	22.0	1.5 - 2.0
Nayaru	26.0	1.5 - 2.2
Kokilai	28.0	2.0 - 3.0
Mannar	28.0	2.0 - 3.0
Jaffna	28.0	2.0 - 3.0
Trincomalee	28.0	2.0 3.0
Batticaloa	27.0	2.0 - 3.0
Valaichchenai	26.0	2.0 - 3.0

The maximum size of *Scylla serrata* ranged from 19.0 cm CW (Negombo and Chilaw Lagoons) to 28.0 cm CW (Mannar, Jaffna, Trincomalee and Kokila Lagoons). However, the average maximum size of the crab observed in the market is 22 cm CW.

Feeding habits

The feeding habits of *Scylla serrata* change with age. Juvenile crab, measuring about 2-7 cm CW, feed mainly on crustaceans, while subadults of about 7-13 cm CW feed chiefly on bivalves and gastropods. Larger crab consume smaller crab and fish.

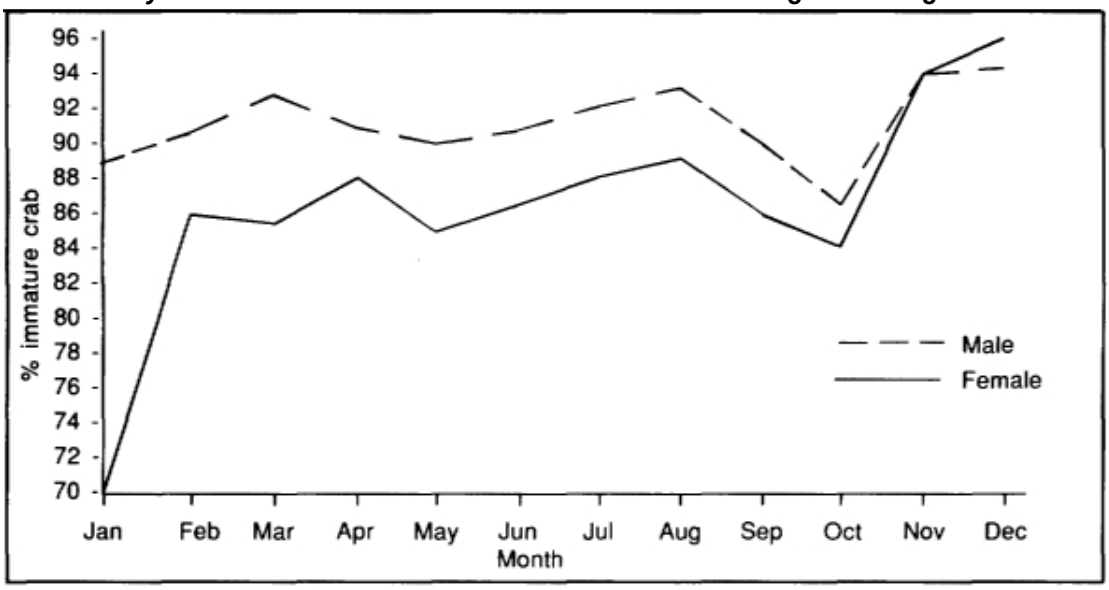
Growth and maturity

Scylla serrata in the Negombo Lagoon reaches its first maturity at 12 cm CW. Two recruitment periods occur in a year: The first is April-May, the second August-September. The pre-spawning fecundity of *Sevila serrata* is about 1.76-3.5 million, while the post spawning fecundity was around 1.28-1.84 million. Asymptotic length for both male and female *Scylla serrata* is nearly the same (22.3 cm male; 22.2 females) although the rate at which they reach that size are different. Males grow at a faster rate than females (growth co-efficient (k) = 0.72 males and 0.56 for females).

Relatively high values of mortality and exploitation rates were obtained for the crab population in the Negombo Lagoon. The present exploitation rate of 0.66 males and 0.60 for females is much higher than the optimum level of exploitation (0.50). The high value of the total mortality, which is 4.68 for males and 2.29 for females, is due to the high fishing mortality, which is 3.10 for males and 1.96 for females. The fishing intensity for crab is known to be very high in the Negombo Lagoon due to the export market demand. Year-round exploitation of immature crab by various gear is still continuing.

The percentage frequency of male and female mud crab of different sizes are shown in Figure 4. The proportion of immature crab exploited was more than 80 per cent for both males and females around the year. Highest exploitation of immature crab was in December and lowest in January and October. Exploitation of immature males is higher than that of females. This can be regarded as a veryharmful practice for mud crab in Sri Lanka.

Fig 4. Seasonal variation in the percentage distribution of immature *Scylla serrata* in the commercial catches in the Negombo Lagoon.



MARKETING

Local market

Crab are consumed locally in hotels, restaurants and households. They are purchased through intermediate vendors for hotels and restaurants. But households usually buy directly from fishermen. The crab sold locally are ones with low meat content or weighing less than 300 g/crab. There is very little availability of large, meaty crab in the local market due to high prices offered by exporters.

Export market

Crab, rich in meat content and weighing more than 300 g, are considered export quality. Meaty crab are identified by pressing the branchial region with the fingers to determine the hardness. Worn claws and a hard carapace carrying barnacles are also good indicators of meaty crab.

Crab exported from Sri Lanka come from several lagoons in the northeast and west. The majority of the export quality crab come from the Nayaru. Nanthikadal, Kokilai and Jaffna Lagoons of the Northern Province and Valaichchenai and Batticaloa Lagoons of the Eastern Province. Crab are also collected from Mannar, Puttalam, Chilaw and Negomho Lagoons. In Negombo Lagoon, only 30-50 per cent of the crab catch is exportable; most crab caught here are of small size and low meat content. Mannar and Kalpitiya Lagoons are the main sources of supply for export quality crab from the west coast.

Recent exports (1991 -end) from the country comprise 45 per cent from the Mannar Lagoon, 38 per cent from the Jaffna Lagoon, 25 per cent from the Kalpitiya Lagoon and 2 per cent from the Trincomalee Lagoon. Catches from Kokilai and Batticaloa Lagoons are not considered suitable for the export market, as the animals are too weak.

Export quality crab are purchased and transported daily through the intermediate agents of various exporters. Cane baskets moistened with brackish water are used for packing and transport of crab.

Crab exports became a foreign exchange earner in 1985. The quantity of crab exported in 1985 was 973 t. The average foreign exchange earned per annum is around SL Rs. 30 million during the period 19X5-1990 (see Table 3). The average price of a kilogram of crab increased from Rs 34 in 1985 to Rs 97 in 1990 (see Table 4), but appears very low compared to the current prices for high grade crab both in local and foreign markets. A large proportion of crab dying during transport would bring the average price down. Crab must arrive live at the point of export; dead crab fetch very low prices.

Crab are now exported to many countries in Asia and Europe. Singapore receives more than 90 per cent of the export. Malaysia, Hong Kong, Japan, Taiwan, U.S.A, U.K, Pakistan, Syria, Saudia Arabia, South Korea, Switzerland, Australia and the Maldives take the balance (see Table 3).

Prices

The current prices offered to the fishermen by the exporters and the prices offered to the exporters by Singapore and Japan are given below.

Quality of the crab	*Purchase cost (SLRs/kg)*	*Selling* price *(SLRs/kg)*	
		Japan	*Singapore*
Large crab (weighing>600g)	I x0.00	300.00	250.00
Medium crab (300 g-600 ¦	125.00	184.00	
Hard. low meat crab	90.00		
Soft shell crab	50.00	103.00	

Average purchase cost = 2 10.00 SLRs/kg
Freight cost for 250 kg or more to Singapore = 39.40 SLRs/kg
Freight cost for 250 kg or more to Japan = 92.00 SLRs/kg.

CONCLUSION

Mud crab resources are an asset to the country and can be developed to the status of a major foreign exchange earner if proper management measures are implemented. Legal prohibition of capturing of immature crab is essential to maintain the resource. This could be achieved by restricting the mesh size of nets (as in Australia) and by educating the fishing community on the gainful aspects of resource management of which they are the immediate beneficiaries. This warrants in-depth investigations on the mud crab resource in all parts of the country in order to achieve maximum utilization while sustaining the resource.

Techniques for mass breeding, culture and fattening are also important areas which should be developed and strengthened. Transportation techniques will have to be developed to get maximum earnings from the exports.

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BIOLOGICAL STUDIES OF THE MUD CRAB *Scylla serrata* (Forskal) OF THE MANGROVE ECOSYSTEM IN THE ANDAMAN SEA

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ABSTRACT

Biological studies of *the crab* Scylla serrata *were conducted during 1986-1 989. The results are expressed in percentage of catch by size groups and show 53 per cent in size group 9-1 I cm. 22 per cent in size group 11· 13 cm. 23 per cent in size group of less than 9 cm and 2 per cent in size groups larger than 13 cm. The proportion of males tofemales varies in each season. More male crab were caught in October-January and more females in February-April. Female crab attain sexual maturity when their maturity index (FMI) value is at least 0.88, or their carapace width is about 11 cm. Reproduction occurs continuously throughout rhe year in* S. serrata *population However Gonad Somatic Index (GSI) values* show *peaks from October-December. Consequently, it is predicted that the migration of* mature female crab *to* spawn *occurs mostly during October-February. Possible* conservation *measures might include a ban on fishing during the spawning season and restrictions on capture of immature crab.*

INTRODUCTION

Mud crab are an economic species of the mangrove ecosystem. information on the biology of mud crab in Thailand is meagre, except for reports on crab fattening and the mud crab fishery in the Bangla mangrove area of Phuket (Poovachiranon 1987). Total catches and monthly production of mud crab were investigated in 1986. The female maturity index (FMI) was determined to classify the developing gonad stages.

This study includes biological data on mud crab generated during 19861989 in Phang Nga Bay, Andaman Sea. The monthly production by size frequency is shown. The FM1 was measured and compared with the developing stages of female gonads. The Gonad Somatic Index (GSI) of mature female crab was studied to determine the peak spawning season. Carapace width (CW) to weight **(W)** relationships for male and female crab were also estimated.

MATERIAL AND METHODS

Study area

Crab samples were collected in the Bangla mangrove forest in Phuket Province. They were also provided by a middleman in the mud crab business. Monthly crab samples were received from Phang Nga Bay, covering Phuket, Phang Nga and Krabi Provinces. Sampling size was 100-200 crab of both sexes.

Female Maturity Index (FMI)

Crab were separated into males and females based on the shape of the abdomen (wider and globular in the female and narrow in the male). In younger females, the abdomens were invariably triangular. Female Maturity Index (FMI) is calculated as follows:

$$\text{FMI} = \frac{\text{width of the widest part of the 5th abdominal segment}}{\text{the width of the widest part of the thoracic sternum between the base of the 5th pair of legs}}$$

Gonad maturation

Crab carapaces were dissected and examined. Ovaries of Scylla serrata are H-shaped organs lying in pairs below the carapace (Shanmugam and Bensam 1950). The developing gonads are divided into three major stages. ***Scylla*** ovaries begin to enlarge and change colour when crab attain sexual maturity (Quin and Kojis 1987). Immature ovaries are translucent. When they become sexually mature, the ovaries initially become white, then tan. The immature oocytes of these ovaries have a reticulate cytoplasm with little yolk. As oocytes enlarge and mature, yolk globules form in the cytoplasm and the ovaries become yellow, orange or red and orange, the latter being the most common colour.

In the present study, based on the area covering the body-cavity and coloration, four major stages of maturity could be distinguished for female crab:

Maturity Stage	***Definition***
Stage 1	Gonad immature; thin and transparent. Abdomen somewhat triangular in shape and not quite globular in younger females.
Stage 11	Represents developing gonad condition. Creamy white or yellowish gonads occupying about a fourth of the area of both digestive glands.
Stage III	Maturing condition. Ovarian lobes enlarged, occupying about half to three-fourths of the digestive gland area. Gonad yellow-orange.
Stage IV	Prominent seminal receptacles. Gonads orange or orange-red.

Gonad maturity condition related to FM1

About twenty female crab were obtained during the monthly sampling (1987-1989). A total of 605 crab were examined and carapace widths and flesh weight were measured to estimate the Female Maturity Index (FMI). Different ranges of FMI were grouped while the gonad maturity condition of the individual crab was identified and grouped accordingly into Stage 1 to Stage IV.

Carapace width to weight relationship

Mud crab from the capture fishery were measured for weight and carapace width twice a month. The CW was measured to the nearest 0.01 cm using vernier calipers. The number in each size group was counted monthly from 1986 to 1989, making a total of 6070 crab. Carapace width and weight relationships were calculated separately for 3402 males and 2668 females.

The monthly size-frequency distributions of ***Scylla serrata*** caught by crab traps in mangrove forests were also computed for both sexes. A one centimetre interval was used.

Gonadosomatic index (GSI)

The mean index was calculated for sexually mature crab over 12 months, from March 1987 to March 1988. Twenty female crab, which represented different gonad stages from II to IV, were randomly sampled. The crab were examined by placing them in a freezer for 3-5 hours, weighing

to the nearest gram, then dissecting the carapace and removing gonads into tared plastic containers and weighing to the nearest 0.01 g. A total of 437 crab were examined. The GSI was calculated as follows:

$$GSI = \frac{\text{drained ovary weight x } 100(\%)}{\text{total live weight}}$$

The Gonad Somatic Index values were grouped according to carapace width.

RESULTS

Gonad maturity condition related to FMI

Table I shows the grouping of the FMI relating to stages of gonad development. FMI values ranging from 0.650 to 0.850 represent the first stage of gonadal development. The ovaries of ALL female crab that were not sexually mature were translucent. When the FMI ranged from 0.850 to 0.875, all stage of gonadal development were present. The gonad developing stages constituted 54.2 per cent, 20.8 per cent, 8.4 per cent and 16.6 per cent for the first to the fourth stages, respectively. This range of FMI values shows that about half the female crab become sexually mature.

Table 1: Female maturity index (FMI) reflecting the different stages of gonadal development

Range of FMI	Number of samples	Percentage of gonad developing				Total
		(immature)	(mature)			
		Stage I	II	III	IV	
0.650-0.750	50	100	0	0	0	100
0.751-0.850	64	100	0	0	0	100
0.851-0.879	48	52.2	20.8	8.4	16.6	100
0.880-0.950	269	0	29.0	35.3	35.7	100
0.951-1.000	154	0	31.1	37.0	31.9	100
>1.00	20	0	41.7	41.7	16.6	100

All crab are sexually mature when either the abdomen is enlarged or the FMI values reach 0.88-1.00, respresenting Stages 11, III, and IV. Some female crab had enlarged abdomens entirely covering the width of the thoracic sternum, with FMI value slightly more than 1.00. Most of them were quite large crab. The percentage of Stage II, Stage 111, and Stage IV was 41.7, 41.7 and 16.6 per cent, respectively.

Results from Table I indicate that female crab are not sexually mature when FMI values are less than 0.85. They include various stages of gonadal development, depending on the duration of ocyte development after mating. Thus, an FMI equal to 0.88 is a critical point to assess sexual maturity.

Poovachiranon (1987) demonstrated a significant relationship between FMI and carapace width ($r=0.8277$, $P<0.001$). From this equation, the size of mature *S. serrata* females can be estimated in the Andamans population. When females reach 10.8 cm, or about 11 cm CW, they become mature. The smallest sexually mature female crab was 8.94 cm CW. Large crab generally had a high GSI.

The carapace width-weight relationship

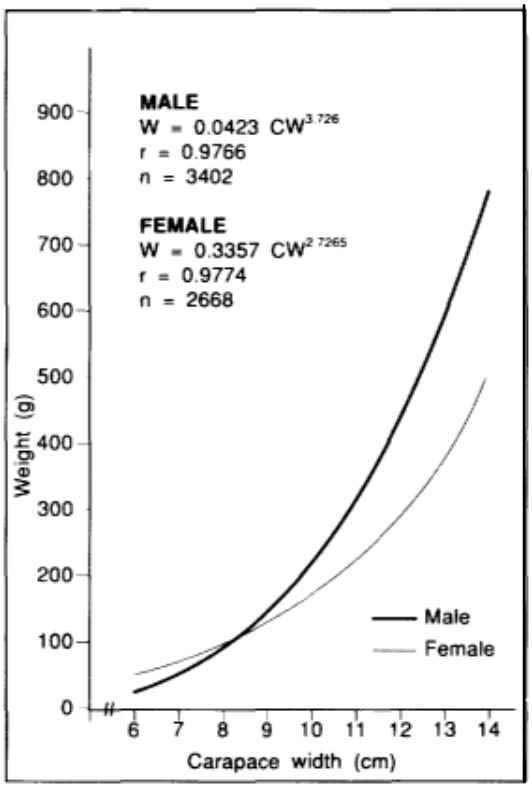
Carapace width (CW) to weight (W) relationship for males and females was estimated as follows (Figure 1):

Male log W = 3.7260
log CW = 1.3751 r = 0.9768

Female log W = 2.7285
log CW = 0.4740 r = 0.9774

The rate of increase in the weight of male crab is usually more than that of female crab. Crab of size 9-il cm constituted the largest group caught by traps. This group had a weight of 150-320 g for males and a weight of 135-235 g for females. Some of the crab examined had moulted not long before or were 'empty'. These could be fattened in ponds. Some premoult crab were also found.

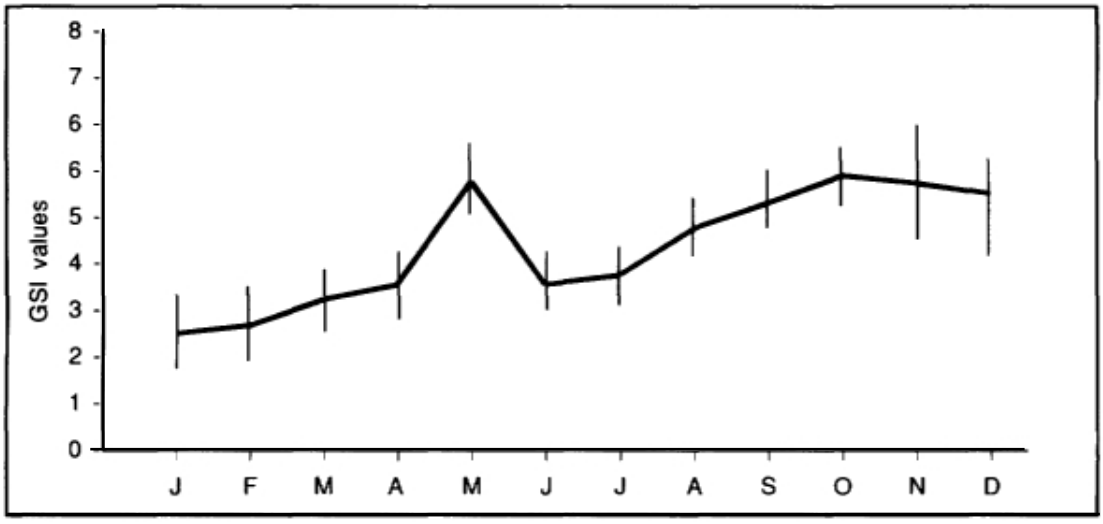
Fig. 1. Carapace width and weight relationship for male and female S. *serrata*



Annual periodicity of female reproduction

The GSI values varied throughout the year as shown in Figure 2. A portion of the population was reproductive throughout the year, but with a seasonal pattern observed from two dominant peaks of GSI values that appeared in May and October-November. The mean values of GSI varied significantly by month (Table 2). The period of least reproductive activity was January, when the GSI was less than half the maximum values of May and October-December.

Fig 2. Monthly mean Gonad Somatic Index (GSI) for female S. *serrata*, 1988-1989



Note: Vertical lines show the standard deviation values.

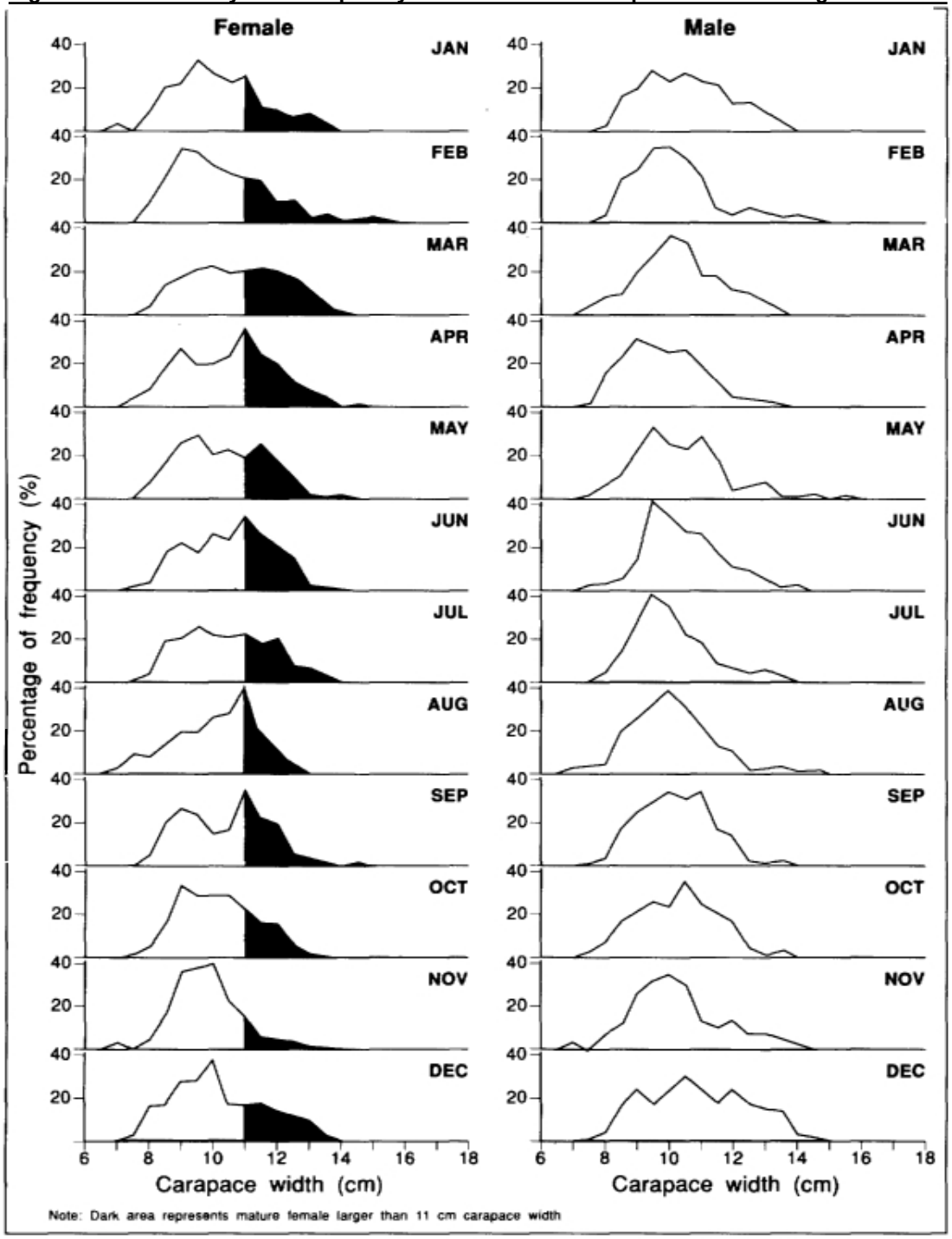
Table 2: One-way ANOVA of monthly GSI values

Source of variation	*SS*	*df*	*MS*	*F-ratio*	*Sig-Level*
Between groups (month)	675.9467	11	6 1.4497	3.721	0.0005
Within groups	7002.6591	424	16.5157		
Total (corrected)	7678.6058	435			

THE MONTHLY **SIZE** DISTRIBUTION OF S. *serrata*

The monthly size-frequency distribution of S.*serrata* caught by crab traps is illustrated in Figure 3. It shows that the distribution pattern of male and female crab exhibit some differences.

Fig. 3. Mean monthly size frequency distribution of carapace width during 1986-1989



The dominant modal size in both sexes was in the 9-11 cm group. Shifting modal sizes may be due to growth. Most size frequency patterns were normally distributed, indicating that the population was not over-exploited. Therefore, recruitment of smaller crab is sufficient to replace those harvested from the stock.

It was clearly demonstrated that female crab belonging to the size group over 11 cm decreased from October - February. There was a highly significant difference (P>0.0005) between the percentage of mature females, comparing different periods (see Table 3).

Table 3: One-way ANOVA of mean percentages of mature female caught in traps during first period (October - February), second period (March - May) and third period (June - July, 1986-1989)

Source of variation	*SS*	*d.f*	*MS*	*F-ratio*	*Sig-Level*
Between groups (month)	2043.6755	2	1021.8377	9.420	0.0005
With in groups	4013.5376	37	108.4739		
Total (corrected)	6057.2090	39			

Table 4 shows the size group distribution of crab during 1986-1989. The production of males of 9-11 cm was a little over 56 per cent. Larger crab of 11-13 cm made up 18 per cent and those larger than 13 cm were less than 5 per cent. Twentythree per cent of the male crab represented a group of small crab less than 9 cm CW.

Table 4: Mean percentages of monthly catches of S. *serrata* divided into size groups, 1986-1989

Range of size class (CW in cm)		*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*	*Mean*
Male	7-9	18.42	23.84	21.45	35.14	22.71	15.75	23.93	26.11	21.37	23.24	23.20	21.79	23.08
	9-11	50.66	60.93	*55.81*	51.74	56.27	68.90	60.33	59.11	61.07	54.41	55.60	41.63	56.37
	11.13	28.62	11.92	20.93	11.97	19.66	14.57	14.43	11.33	16.03	19.41	18.00	30.74	18.13
	>13	2.30	3.32	1.81	1.16	1.36	0.79	1.31	3.45	1.53	2.94	3.20	5.84	2.42
Female	7.9	28.31	32.10	*15.85*	25.10	28.09	21.23	23.74	23.03	19.07	29.50	31.40	31.03	25.70
	9-II	50.60	48.15	44.06	45.10	42.98	50.00	49.42	57.58	45.76	53.24	60.47	48.28	49.64
	11-13	18.67	17.90	36.36	28.24	28.09	28.30	24.90	19.39	33.47	17.27	8.14	20.00	23.39
	>13	2.41	1.85	3.73	1.57	0.85	0.47	1.95	0.00	1.69	0.00	0.00	0.69	1.27

The size group 7-9 cm, that is, immature crab, was approximately 23-25 per cent for both the male and female catch. The crab trap is quite an efficient fishing gear to catch small crab in the mangroves. There was a range of *15.75-35.14* per cent for male crab and 15.85-32.10 per cent for female crab.

Approximately 50 per cent of female crab of 9-11 cm were caught using crab traps. Mature females of over 11 cm comprised about 25 per cent of the female catch. Table 4 also shows that small females (< 9 cm) too were exploited. The crab which were smaller than 11 cm CW made up to 70 per cent of the exploited population. The percentage of 9-11 cm animals fluctuated between 42-69 per cent, with the maximum catch of males being in June and females in November. The minimum catch was in December for males and May for females. Only a small amount of crab over 13 cm CW were caught in the mangrove area along the Andaman Sea. The catches of this size did not fluctuate for both males and females.

The percentage of male and female crab caught and their mean carapace widths are indicated in Table 5.

Table 5. Monthly mean carapace width and percentage of catch for male and female mud crab (S. *Serrata)* during 1986-1989

	Sex	*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*
Mean CW (in cm)	Male	10.32	9.94	10.03	9.66	10.07	9.94	9.87	9.86	9.99	10.03	10.00	10.51
	Female	9.91	9.82	10.57	10.23	10.02	10.24	10.12	9.99	10.25	9.81	9.55	9.80
Percentage	Female	64.00	48.00	47.00	50.00	56.00	56.00	54.00	55.00	60.00	71.00	59.00	64.00
	Male	36.00	52.00	53.00	50.00	54.00	44.00	46.00	45.00	40.00	29.00	41.00	36.00

DISCUSSiON

Bundukul (1957) identified sexually mature crab by the abdomen size. He also found that the ovaries become red-orange in colour when the abdomen is fully enlarged or the crab reaches 10.69 cm and 200 g.

FMI values in this study can be used to predict the sexually mature stage of female crab from external measurement of their abdomens. The female crab population in the Andaman Sea matures at 11 cm CW, with a minimum size at 8.94 cm. Ong (1977) reported that male crab reared from the 16th or 17th instar and of approximately 10 cm CW appeared to mate with female crab when the latter reached approximately 10-11.4 cm. Robertson (1987) found that spermatophores were found in the genital tracts of male crab as small as 8 to 9 cm CW. Premoult females clasped by males prior to copulation measured between 10 to 13.9 cm CW. The geographical pattern suggests that S. *serrata* matures at a larger size in higher latitudes. Quinn and Kojis (1987) reported that the minimum carapace width at sexual maturity varied over a range of 5.3 cm in various countries (8.5 cm in the Philippines to 13.8 cm in Queensland, Australia). In the tropics, S. *serrata* becomes sexually mature at a smaller size compared with crab from subtropical areas, particularly those from Africa and Queensland, where they measure 13.8 cm and 13.7 cm, respectively.

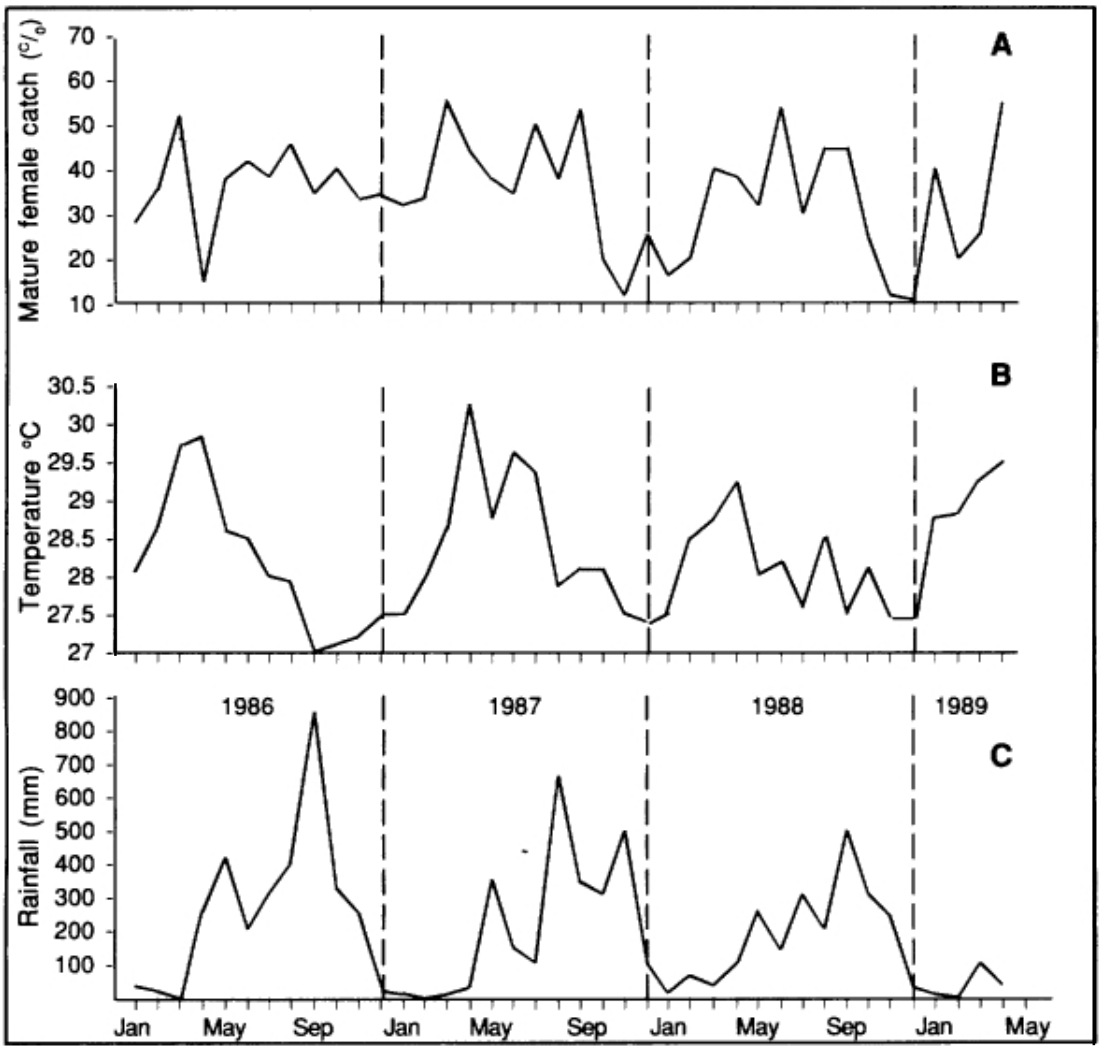
A portion of the population is reproductive throughout the year (Figure 2). There are two dominant peaks of GSI values. During the later period of this peak, a portion of the mature females disappeared from the mangrove area (Table 4). This period is the late rainy season and the beginning of the dry season (Chansang 1984). Hill (1975) suggests that adult females are forced to migrate out of the estuaries to the sea to release their eggs due to the environmental requirements of first stage zoeae. Larvae hatching in these estuaries are probably not viable. The female crab, however, do not move more than 10 km offshore along the southeast coast of Africa. Table 4 also shows another high peak of GSI value in May, but the migration of female crab is unlikely at this time since the peak only lasts one month.

Some majOr factors influencing the spawning migration

Figures 4A, 4B and 4C show that the incidence of mature females (>11 cm CW) decreased during the late rainy season and prior to the beginning of the dry season, when they were supposed to be migrating offshore. This would appear to indicate that the females move out of the estuaries when the mangrove area is influenced by fresh water. Temperature and salinity of sea water varied considerably during this period, particularly in Phang Nga (P. Limsaichol; pers. comn.). Viseshom and Poreeyanond (1990) reported oceanographical data such as air temperature, 27.6 - 30.8°C and salinity from 32 - 32.8 ppt during December-April. Both are within the range of the requirements of the zoeae of S. *serrata.* In tropical estuaries, the period of peak spawning generally coincides with high nutrient inputs associated with monsoonal or cyclonic rainfall. With the beginning of the dry season, phytoplankton develops in the offshore waters of the Andaman Sea (V.Jenakarn pers. comn.). However, nutrient availability and optimal salinity may be the most important factors for the larval stages of this crab.

Hill (1974) indicated that the first stage zoeae of S. *serrata* are not tolerant of high temperature (above *25°C)* or low salinity (below 17.5 ppt). He suggested that zoeae of S. *serrara* from tropical areas may be more tolerant of high temperatures than those from the southeast African coast.

Fig 4. Percentage of mature female *Scylla serrata* (>11cm carapace width) caught in traps 1986-1989 compared with air temperature and monthly rainfall in the same period.



Crab specimens, caught while tuna purse-seining during March-May 1989 in the Andaman Sea, were received from (V. Pokapunt, pers. communication) the Fisheries Department Research Vessel MV4. They included 15 S. serrata caught in offshore waters approximately 15-84 n miles away from the mainland and at a depth of 97-200 m on the shelf slope. This supports the hypothesis that mature female crab in the Andaman Sea migrate offshore to spawn.

The present heavy exploitation of immature crab may affect the sustainable yield. Some guidelines for the conservation of the mud crab resource should therefore be considered. In Thailand, berried crab are prohibited from being caught between October and December, but few berried females are found inshore at this time. In the near future, control of the catching of immature crab should be considered. Crab fishing should be prohibited during the major spawning season of mud crab in the Andaman Sea. Mangrove forests are very important habitats for *S. serrata.* This ecosystem, the living and feeding grounds of the crab, needs to be conserved and protected.

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MUD CRAB PRODUCTION IN THAILAND

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ABSTRACT

Thailand has a relatively long coastline which the Thai people use efficient/v to harvest fish and other marine organisms for domestic consumption and export. Of this harvest, mud crab production is a small portion. This paper describes briefly the socio-economic condition of the people involved in mud crab fishing, the gear they use and the ways mud crab are marketed.

INTRODUCTION

Thailand has a coastline of approximately 2,600 km along the Gulf of Thailand in the east and the Andaman Sea in the west. Marine fish is the major protein food of the Thai people. Surplus production is exported, earning a considerable income for the country. Thailand is one of the top ten countries in the world in fish production and leads in export of canned tuna and marine shrimp.

MUD CRAB RESOURCES

Marine fish production has increased since 1977. However, landings have fluctuated from year to year. In 1988, the marine fish production was 2,377,200 t valued at 19,823 million baht*. Of the total marine fish production, mud crab forms only a small portion. However, crab production has been gradually increasing since 1984 (Table 1).

Table 1: Quantity **and value of crab fisheries in Thailand**

Quantity : 1.000
Value : million baht

	1984		1985		1986		1987		/988		1989	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Swimming crab	22.4	425.6	22.2	452.8	30.4	685.1	34.7	744.7	37.1	922.8	35.5	884.1
Mud crab	4.3	185.1	4.5	221.7	4,6	217.0	5.0	242.8	4.5	230.4	5.0	249.3
Other crab	0.3	2.0	0.1	0.8	0.6	4.3	0.7	8.4	0.3	4.2	1.9	24.0
Total	27.0	612.7	26.8	675.3	35.6	906.4	40.4	995.9	41.9	1157.4	42.4	1,157.4

Source: Fisheries Statistics of Thailand, 1988

The primary species of crab is the swimming crab, *Portunus pelagicus* (Linnaeus). Mud crab, *Scylla serrata*, (Forskal), comes next. However, the mud crab is more valuable than the swimming and other marine crab. In 1989, the production of marine crab was 42,400 t, valued at 1,157.4 million baht. This production was from capture fisheries only. Mud crab fattening is practised in some parts of the country.

* US $ = 25 Baht appx

MUD CRAB MARKETING

Crab products are exported in various processed forms. Frozen crab is the most exported product, followed by salted, dried and smoked meat in airtight containers (Table 2). The species of crab exported are not officially listed, but export companies say the most exported species is the swimming crab. The export of all crab products in 1991 was about 3,179 t. However, the highest export was in 1988, when 12,453 t at a value of 1,567,785 baht was exported.

Mud crab are exported either alive or frozen. The countries that import crab products from Thailand are also shown in Tables 3, 4 and 5.

Table 2: Export statistics of crab from Thailand

Quantity
Value : baht

	1985		1986		1987		1988	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Fresh and frozen	159	9,348	279	10,313	658	34,064	1,032	59,413
Salted and smoked	62	8,193	7	1,074	9	1.211	167	23,348
In airtight containers	6.378	700,194	8,173	867,473	11,590	1,434,226	11,254	1,485,024
Cooked by steaming or by boiling in water	-	-	-	-	-			
Prepared or preserved	-	-						
Total	6.599	717,735	8,459	878,860	12,257	1,469,501	12,453	1,567,785

	1989		1990		1991	
	Quantity	*Value*	*Quantity*	Value	Quantity	Value
Fresh and frozen	623	38,368	290	20.909	114	9,236
Salted and smoked	124	14,493	22	1,228	19	1,027
In airtight containers	8,600	1,123,612	-	-	-	-
Cooked by steaming or by boiling in water	-	-	114	15,388	66	9,047
Prepared or preserved	-	-	10,001	1,313,414	2,980	355,681
Total	9,347	1,176,473	10,427	1,350,939	3.179	374,991

Source: Customs Department

Table 3: Export statistics of fresh and frozen crab from Thailand

Quantity: t: Value: bahi

	1985		1986		1987		1988	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
France	N	12	3	280	N	12	N	23
West Germany	N	15	N	35	N	12	14	904
Hong Kong	35	713	27	739	108	5.086	246	5.037
Italy	—	—	4	197	—		N	29
Japan	5	210	21	1.135	39	2.103	4	273
Malaysia	27	1.220	20	562	10	226	I	46
Singapore	5	182	3	34	4	254	4	251
Taiwan	26	874	52	5.123	475	24,781	754	42.315
USA	61	6.032	39	2.036	18	1,455	7	396
Others	—	90	—	72	4	135	I	139
Total	159	9.348	279	10.313	658	34.064	1,031	59.413

Table 4: Export statistics for crab products (salted, dried and smoked) from Thailand

Quantity: t; Value: baht

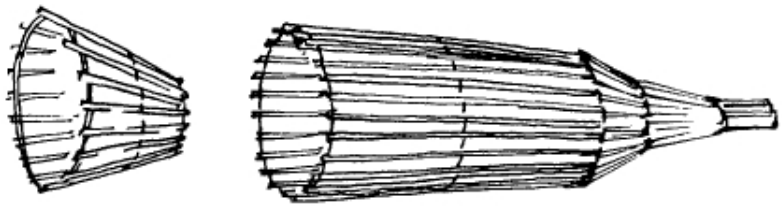
	1985		1986		1987		1988	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantities	Value
Australia	7	1,184	2	177	I	54	19	1,685
Belgium	48	5.300	—	—	—	—	0	I
Hongkong	—	—	0	18	0	20	10	1,396
Japan	7	1,692	3	705	4	876	103	17,366
Singapore	—	—	I	104	0	63	11	1,189
England	—	—	0	1	1	—	9	1,056
America	0	17	1	42	2	24	14	581
Others	0	0	N	2	I +	174	I +	74
Total	62	8,193	7	1,049	9	1.211	167	23.348

Table 5: Export statistics for crab products (in airtight containers) from Thailand

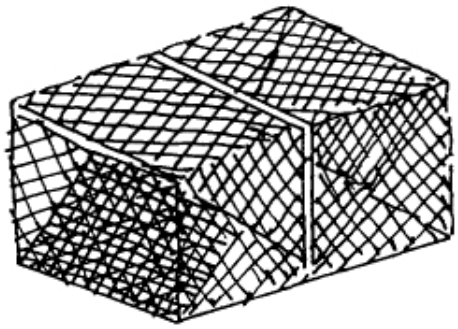
Quantity: t; Value: baht

	1985		1986		1987		1988	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	279	26,228	357	32,857	379	44,819	346	38,617
Belgium	302	38.986	380	34,645	474	48,175	504	60,389
Canada	328	45,930	465	57,339	483	75,298	314	49,776
Denmark	180	16,524	188	6,437	181	18,879	184	21,161
France	2,408	241,503	3,074	285,184	4,481	484,155	3,951	426,258
West Germany	49	4,497	36	3,499	30	3,365	18	2.332
Italy	I	115	154	19,691	506	80,556	359	58,380
Japan	49	5,760	21	3,632	839	136,985	1,202	215,679
Malaysia	610	32,011	734	61.640	611	69,314	566	77,037
Netherlands	173	20,692	365	40,786	610	73,873	481	62,554
Sweden	334	32.150	385	37,739	452	48,784	495	57,810
Singapore	10	909	17	1.931	13	1,389	25	2,889
Saudia Arabia	I	246	4	442	2	203	17	2,112
England	377	52,601	723	105,262	815	124,795	1,008	163,031
USA	1,245	178,730	1,170	157,993	1.492	197,526	1.460	200,894
Others	32	3,312	100	11,396	222	26.110	324	46,105
Total	6,378	700,194	8,173	867,473	11,590	1,434,226	11,254	1,485,024

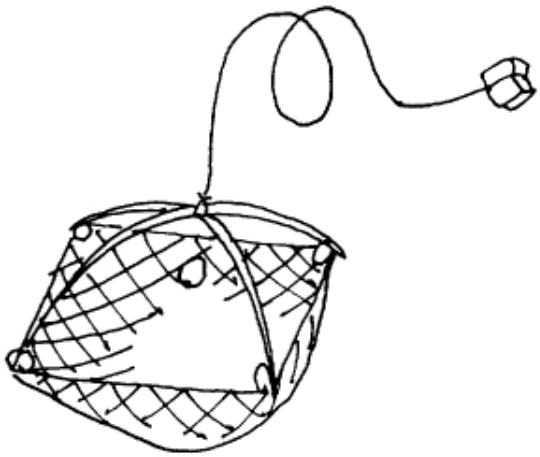
Fig **1. Gear used in the crab fishery**



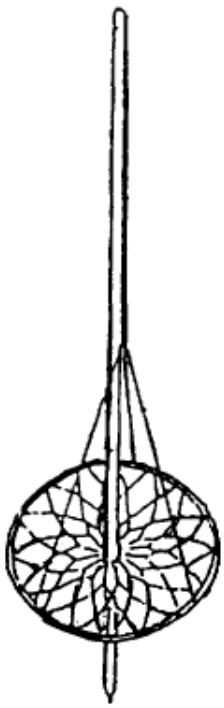
Cone-shaped bamboo trap set on line



Collapsible crab trap



Crab liftnet



Crab liftnet

CRAFT AND GEAR USED IN THE MUD CRAB FISHERY

The mud crab fishery takes place mainly in mangrove and coastal areas. Crab traps. crab gillnets and set bagnets are used, out the crab trap is the main fishing gear. The crab gillnet is mainly used for swimming crab, while the set bagnet is chiefly used for shrimp and other fish.

The mud crab trap is a cone shaped bamboo device. Several of them are set one behind the other in a line. A collapsible crab trap, which can be very easily transported, has recently been developed by the Department of Fisheries (see Figure I facing page.) Fishermen can carry many more of these traps than other types when they go fishing. The efficiency is also higher than other gear. The catch per unit of effort (CPUE) is about 0.5 kg/day, while the crab liftnet is about 0.2 kg/day.

The craft used for the crab fishery is a small wooden boat, with or without a motor. Small wooden boats without motors are popularly used for crab fishing in the mangrove areas.

GENERAL SOCIO-ECONOMIC CONDITION OF MUD CRAB FISHERFOLK

Mud crab fisherfolk usually live in small fishing villages along the coast of the country. These fishermen have about 20-100 traps per family. They earn about 3,000 baht/month/family. Fishermen use other gear, such as gillnets or set bagnets, to earn additional income for their family.

Inter-moulted and post-moulted mud crab are also fattened by these fisherfolk. These crab are reared in enclosures and fed until they reach the pre-moulted or pre-spawning stage. Trash fish is fed them. Crab fattening is a profitable business because, with one crop, a farm would make a profit of about 9,200 baht (or 40 baht/kg), with a net profit of about 4,300 baht or 18 baht/kg.