DISTRIBUTION, ABUNDANCE, AND SPAWNING OF BLOOD COCKLE (*ANADARA* SP.) IN CENTRAL THAILAND

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ABSTRACT

Blood cockle populations were investigated in Petchaburi, Chachoengsao, and two areas in Trat from January 1993 to August 1995. Cockle spat occurrence indicated that major spawning varied among study sites from November to January. A smaller secondary spawning occurred from April to June. The average abundance of cockle in Chachoengsao, Ao Ang Krapong Trat, Leam Ngop Trat, and Petchaburi was 3.6, 3.2, 0.8, and 2.7 individuals m^{-2} respectively. Standing stock of blood cockle in the four study sites was estimated at approximately 1,488 metric tons.

INTRODUCTION

Total harvest of blood cockle in Thailand is between 15,000-20,000 metric tons annually. Major harvests come from mariculture in coastal areas of Petchaburi, Surat Thani, and Satun. Cockle seed for culture are obtained locally and/or imported from Malaysia. Shortage of cockle seed for culture has recently occurred because export of seed from Malaysia was prohibited. The cockle culture industry must therefore rely on local seed from natural cockle beds. The Department of Fisheries (DOF) has tried to establish cockle seed beds in various suitable areas but the result has not yet been promising. To remedy the situation, DOF has a programme to investigate cockle resources in order to study population density, distribution and potential seed production. The present study is part of this programme with a view to use the results in management plans for cockle populations and to ensure adequate supply of the seed for coastal culture in the future.

MATERIALS AND METHODS

Study areas

Four study areas in three provinces were selected: Site I in the vicinity of Tambon Klongdan, Samutprakan and Tambon Klongcha Reon-Vai, Chachoengsao (708 ha) from January 1993 through December 1993. Site II in Petchaburi province between Tambon Banleam and Ban Bang-In, Tambon Bangkunsai (675 ha) from February 1993 through January 1994. Site III, Ao Ang Krapong on the west coast of Trat Province (225 ha) from September 1994 through August 1995. Site IV at Amphoe Laem Ngop on the east coast of Trat (775 ha), same period as site III.

Six stations were sampled along each of the contours 10, 500 and 1,000 m from the shoreline at the sites I, II, and IV. Five stations were sampled at site III.

In shallow water at Petchaburi and Ao Ang Krapong (Sites II, III), samples were collected with 33 x 10 cm scoop net. The net was pressed 13 cm into the mud before sweeping it 50 cm in horizontal direction to collect the sample. Thirty samples were taken from each station monthly.

Samples were collected in deeper water with a dredge (90 cm bag net, 5.5 mm mesh size) which was pushed 25 cm down into the mud before dragging by manpower over a distance of 3 m. Nine samples were collected at each station monthly. Each sample was sieved and cockles sized into six groups ranging from 1-7 mm, 8-14 mm, 15-21 mm, 22-28 mm, 29-35 mm, and over 36 mm. Length, weight and number of individual cockles of each group were recorded for further analysis.

RESULTS

Abundance and distribution

Year round densities of cockles in 4 different locations are shown in Figs. 1-4 and Tabs. 1-4.

Site I: In Chachoengsao, overall average density of cockles was 3.6 ind. m^{-2} (Tab. 1). Highest cockle densities were 4.7 to 6.9 ind. m^{-2} during July and December 1993 (Fig. 1). Density increased with distance from shore: 2.8 ind. m^{-2} at 10 m, 3.7 ind. m^{-2} at 500 m, and 4.2 ind. m^{-2} at 1,000 m (Tab. 1).

Site II: In Petchaburi, overall average density of cockles was 2.7 ind. m^{-2} (Tab. 2). Cockle abundance was highest in all 3 zones in April and November 1993: 1.7 ind. m^{-2} in November and 5.5 ind. m^{-2} in April (Fig. 2). Average densities of cockle were 2.9 ind. m^{-2} at 10 m, 3.0 ind. m^{-2} at 500 m, and 2.3 ind. m^{-2} at 1,000 m.

Site III: In Ao Ang Krapong, overall average density of cockle was 3.2 ind. m^{-2} (Tab. 3). High density was found from September to December 1994 and during May to August 1995. The density during those periods were from 1.2 ind. m^{-2} in June to 7.9 ind. m^{-2} in August 1995 (Fig. 3). Cockle density was highest offshore. Average densities were 0.2 ind. m^{-2} at 10 m, 4.2 ind. m^{-2} at 500 m, and 5.1 ind. m^{-2} at 1,000 m.

Site IV: In Leam Ngop, overall average density of cockle was 0.8 ind. m^{-2} (Tab. 4). No

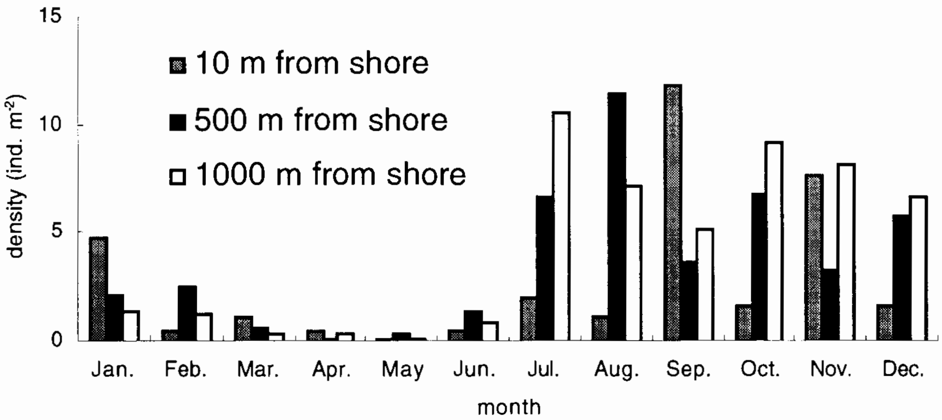

Figure 1. Distribution and density (ind. m^{-2}) in Chachoengsao Province (Site I).

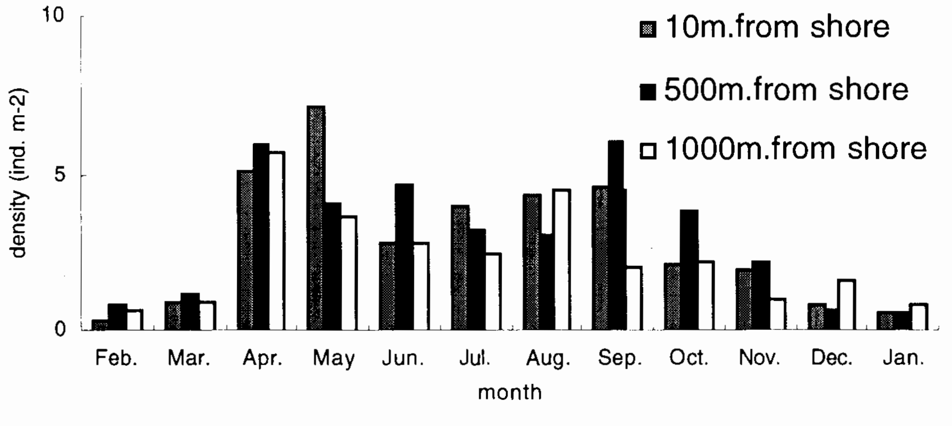

Figure 2. Distribution and density (ind. m^{-2}) in Petchaburi Province (Site II).

peaks were noticed in monthly averages from the 3 zones, but high densities were observed in September 1994 and February 1995 in the 10 m zone (Fig. 4). Average densities were 1.7 ind. m^{-2} at 10 m, 0.4 ind. m^{-2} at 500 m, and 0.4 ind. m^{-2} at 1,000 m.

Size distribution

The cockle size group of 8-28 mm was most abundant in July and November except in Leam Ngop where high density of the above size group was found in September and February. The abundance of smaller and larger sizes varied with time and locations. In 1993, cockles with a diameter less than 7 mm appeared in samples from June to November, both in Chachoengsao and Petchaburi, except that no cockle spat was observed in November in the latter location. Similar occurrence of cockle spat was found in Ao Ang Krapong. Small cockles were observed from June to November but at Leam Ngop, spat was found only in the months of July, September, and October. Density of each size group of cockle in 4 study sites is shown in Fig. 5.

DISCUSSION

According to Kamal (1986), it takes 4-6 months from the planktonic stage to reach the size of 6-10 mm. Thus, occurrence of this size group may be used as an indicator of

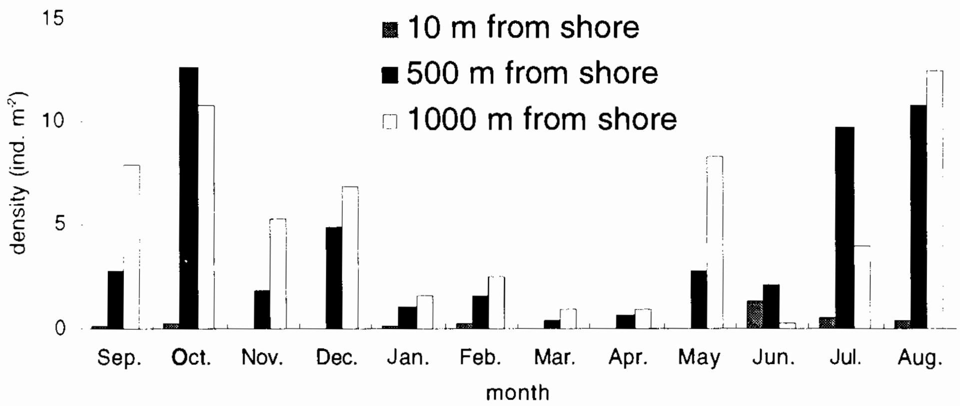

Figure 3. Distribution and density (ind. m^{-2}) in Ao Ang Krapong (Site III).

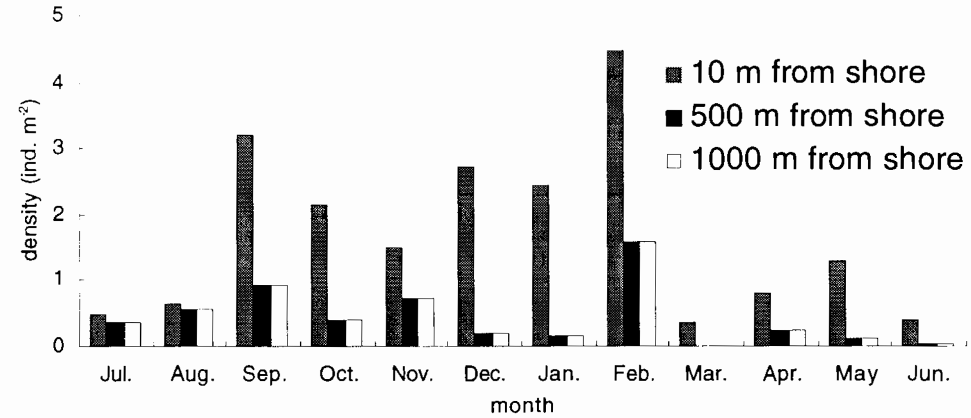

Figure 4. Distribution and density (ind. m^{-2}) in Leam Ngop (Site IV).

Table 1. Distribution and density (ind. m^{-2}) at different stations during January - December 1993. Chachoengsao Province (Site I).

Distance from shore	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
10 m	1	21.1	1.3	1.1	0.4	0.2	1.1	8.5	1.9	29.7	1.5	15.6	1.7	7.00
	2	3.8	0.2	0	1.5	0	0.2	0.8	4.9	26.1	4.8	28.2	3.8	6.19
	3	1.0	0	0.9	0.4	0.2	0.4	0.2	0	1.5	0.4	0.2	0.4	0.47
	4	0.2	0.4	1.7	0.4	0.4	1.2	0.6	0	1.2	2.3	0.6	0.6	0.80
	5	2.6	0.4	1.0	0	0	0	1.0	0	0.8	0.2	1.1	2.9	0.83
	6	0	0.4	2.5	0.4	0	0.4	1.2	0.2	-	0.4	0.8	0.4	0.61
	Average	4.78	0.45	1.19	0.52	0.13	0.55	2.05	1.17	11.86	1.60	7.75	1.63	2.81
500 m	1	0	1.2	0	0.2	0	5.8	29.1	10.7	5.1	3.6	0.6	0	4.69
	2	0.4	0.2	0	0	0	1.3	0.8	3.6	9.4	35.7	13.2	15.2	6.65
	3	1.5	1.7	0	0.4	0	0.2	0.4	0.2	0	0	0	0.2	0.38
	4	10.4	7.3	1.7	0	1.5	0.2	0.8	0.4	0.4	0.2	0	1.2	2.01
	5	0.4	0.6	1.4	0.2	0.4	0.4	7.1	41.4	3.6	0.9	2.3	16.4	6.26
	6	0	4.1	0.4	0.2	0	0.2	2.1	12.8	-	0.4	3.7	1.9	2.35
	Average	2.12	2.52	0.58	0.17	0.32	1.35	6.72	11.52	3.70	6.80	3.30	5.82	3.74
1000 m	1	0	0	0	0.2	0	0	21.7	28.9	0.2	14.7	2.2	0.2	5.68
	2	0	0.2	0	0	0.4	0.2	0.6	0.8	7.0	4.7	13.9	10.7	3.21
	3	1.9	0.4	0.2	0.6	0	0.6	0.2	0.2	0.2	0	0	2.3	0.55
	4	5.2	4.9	1.3	0.6	0	0	0.6	0.6	0.4	1.7	0.6	0.6	1.38
	5	1.3	0.6	0.6	0.6	0	3.8	40.6	10.9	18.3	0.2	1.3	2.7	6.74
	6	0	1.5	0	0	0	0.4	0	1.9	-	33.7	31.0	23.7	8.38
	Average	1.40	1.27	0.35	0.33	0.07	0.83	10.62	7.22	5.22	9.17	8.17	6.70	4.28
Average		2.77	1.41	0.71	0.34	0.17	0.91	6.46	6.63	6.93	5.86	6.41	4.72	3.61

Table 2. Distribution and density (ind. m^{-2}) at different stations during February 1993 - January 1994. Petchaburi Province (Site II).

Line from shore	Station	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Average
10 m	1	0.2	1.4	4.2	9.9	0.8	10.1	4.0	10.0	1.0	1.6	1.0	0.2	3.70
	2	0.0	0.2	1.2	1.2	2.8	4.4	5.0	4.2	0.6	1.4	1.2	0.6	1.90
	3	0.4	0.6	5.6	5.4	4.0	1.8	9.4	3.8	0.6	1.8	1.6	0.8	2.98
	4	0.2	1.0	4.6	7.2	3.2	3.0	3.2	4.0	2.8	3.4	1.2	0.6	2.87
	5	0.8	0.8	8.8	16.3	4.6	1.8	2.4	5.0	3.2	2.0	0.2	1.4	3.94
	6	0.6	1.6	6.2	3.0	1.6	3.0	2.0	0.8	4.4	1.6	0.0	0.0	2.07
	Average	0.37	0.93	5.10	7.17	2.83	4.02	4.33	4.63	2.10	1.97	0.87	0.60	2.91
500 m	1	0.4	0.2	1.2	5.2	1.4	5.4	6.0	9.6	1.4	1.6	0.6	0.0	2.75
	2	0.6	0.8	3.8	2.2	2.6	1.2	6.0	6.4	6.2	4.6	2.0	0.4	3.07
	3	0.8	1.0	12.9	7.4	9.0	4.6	3.2	7.8	2.6	2.8	0.8	0.6	4.46
	4	2.6	0.6	6.6	5.2	6.2	3.4	1.6	6.4	5.8	2.2	0.0	0.8	3.45
	5	0.0	2.8	6.8	2.8	8.7	4.0	1.6	2.2	5.2	1.8	0.4	1.4	3.14
	6	0.6	1.6	4.8	1.6	0.4	1.0	0.0	4.0	2.0	0.2	0.2	0.2	1.38
	Average	0.83	1.17	6.02	4.07	4.72	3.27	3.07	6.07	3.87	2.20	0.67	0.57	3.04
1000 m	1	0.4	0.8	0.6	5.0	1.2	2.0	7.8	7.0	1.8	0.6	1.8	0.2	2.43
	2	0.4	1.2	4.0	2.4	1.2	2.8	2.8	1.8	4.2	2.2	4.6	0.4	2.33
	3	0.4	2.2	13.0	3.2	5.0	4.6	6.4	0.6	3.2	3.0	1.0	1.6	3.68
	4	0.4	0.8	4.6	8.3	7.5	3.6	8.4	1.8	3.0	0.6	2.2	1.8	3.58
	5	0.6	0.6	9.5	2.4	1.8	1.6	1.2	1.0	1.0	0.0	0.0	1.0	1.73
	6	2.0	0.2	2.6	0.8	0.2	0.2	0.4	0.2	0.0	0.0	0.0	0.0	0.55
	Average	0.70	0.97	5.72	3.68	2.82	2.47	4.50	2.07	2.20	1.07	1.60	0.83	2.38
Average		0.63	1.02	5.61	4.97	3.46	3.25	3.97	4.26	2.72	1.74	1.04	0.67	2.78

Table 3. Distribution and density (ind. m^{-2}) at different stations during September 1994 - August 1995. Ao Ang Krapong (Site III).

Line from shore	Station	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Average
10 m	1	0	0	0	0	0.20	1.01	0	0	0	0	0	0	0.10
	2	0.20	0	0	0	0	0	0	0	0	1.41	0.20	0	0.15
	3	0	0	0	0	0	0	0	0.20	0	0	0	0	0.02
	4	0	0.61	0	0	0	0	0	0	0	2.02	1.01	0.20	0.32
	5	0.61	0.40	0	0	0.20	0.20	0	0	0.20	3.03	1.41	2.02	0.67
	Average	0.16	0.20	0	0	0.08	0.24	0	0.04	0.04	1.29	0.52	0.44	0.25
500 m	1	0	0.20	0	0	0.20	0	0	0	0.20	0	0	0	0.05
	2	1.01	1.41	0.81	0.40	1.82	1.41	0.81	0.20	0	0	0	0	0.66
	3	0.81	2.63	1.41	8.08	0.61	1.82	0.40	0.81	0	2.02	0.20	2.63	1.79
	4	0.81	0.81	3.84	8.28	1.41	3.43	0.81	1.21	1.21	0.00	5.45	4.85	2.68
	5	10.90	57.98	2.83	7.68	1.01	1.01	0.20	1.21	12.32	8.28	43.03	46.26	16.06
	Average	2.71	12.61	1.78	4.89	1.01	1.53	0.44	0.69	2.75	2.06	9.74	10.75	4.25
1000 m	1	0	0.20	0	0.20	0	0	0	0	0	0	0	0	0.03
	2	0	4.65	0.40	0.40	0.40	0.40	1.01	1.01	0	0	0.40	0	0.72
	3	2.42	5.05	5.86	1.81	3.23	3.43	2.63	2.63	1.01	0	0	0.40	2.37
	4	1.21	13.13	6.06	20.00	3.43	6.67	0.81	0.81	1.21	0.40	17.17	22.22	7.76
	5	35.76	30.71	13.94	12.12	0.61	1.82	0.40	0.40	38.99	0.60	2.02	40.20	14.80
	Average	7.88	10.75	5.25	6.91	1.53	2.46	0.97	0.97	8.24	0.20	3.92	12.56	5.14
Average		3.58	7.85	2.34	3.93	0.87	1.41	0.47	0.57	3.68	1.18	4.73	7.92	3.21

Table 4. Distribution and density (ind. m^{-2}) at different stations during July 1994 - June 1995. Leam Ngop (Site IV).

Line from shore	Station	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Average
10 m	1	0	0	16.88	0.64	5.98	0.21	0	0	0.64	0	3.85	0.85	2.42
	2	1.5	1.5	0.85	1.07	0.64	0	0.43	0.21	0	0.21	0.21	0.21	0.57
	3	1.28	1.07	0.85	4.49	1.5	0.43	13.89	0.21	0.85	1.28	1.5	0	2.28
	4	0	1.28	0	5.77	0.85	11.97	0.43	25.43	0	3.42	0.85	1.07	4.26
	5	0	0	0.64	0.85	0	3.63	0	1.07	0.64	0	1.28	0.21	0.69
	6	0.21	0	0	0.21	0	0	0	0	0	0	0	0.21	0.05
	Average	0.50	0.64	3.20	2.17	1.50	2.71	2.46	4.49	0.36	0.82	1.28	0.43	1.71
500 m	1	0	1.5	1.92	0.21	0	0.85	0.43	8.76	0	0.85	0.43	0.21	1.26
	2	1.5	1.5	0	0.85	0.43	0	0.64	0.43	0	0	0	0	0.45
	3	0	0	1.07	0.21	0	0	0	0.21	0	0	0.21	0	0.14
	4	0	0	1.92	1.07	3.85	0	0	0	0	0	0	0	0.57
	5	0.64	0.21	0.21	0	0	0	0	0	0	0.64	0.21	0	0.16
	6	0	0.21	0.43	0.21	0	0.43	0	0	0	0	0	0	0.11
	Average	0.36	0.57	0.93	0.43	0.71	0.21	0.18	1.57	0.00	0.25	0.14	0.04	0.45
1000 m	1	0.21	0.21	4.91	1.07	0	0.43	0	2.14	0.64	5.56	0.21	0	1.28
	2	1.92	0	0.64	1.92	0	0	0	1.28	0	0.43	0.21	0	0.53
	3	0	0	1.5	0	0	0	0	0	0	0	0.21	0	0.14
	4	0.21	0	0.43	0.21	0	0	0.43	0.21	0	0	0	0	0.12
	5	0	0.85	0	0	0	0.21	0	0	0	0	0	0	0.09
	6	0	0	2.35	0	0	0	0	0	0	0	0.21	1.07	0.30
	Average	0.39	0.18	1.64	0.53	0.00	0.11	0.07	0.61	0.11	1.00	0.14	0.18	0.41
Average		0.44	0.46	1.92	1.04	0.74	1.01	0.90	2.22	0.15	0.73	0.52	0.21	0.86

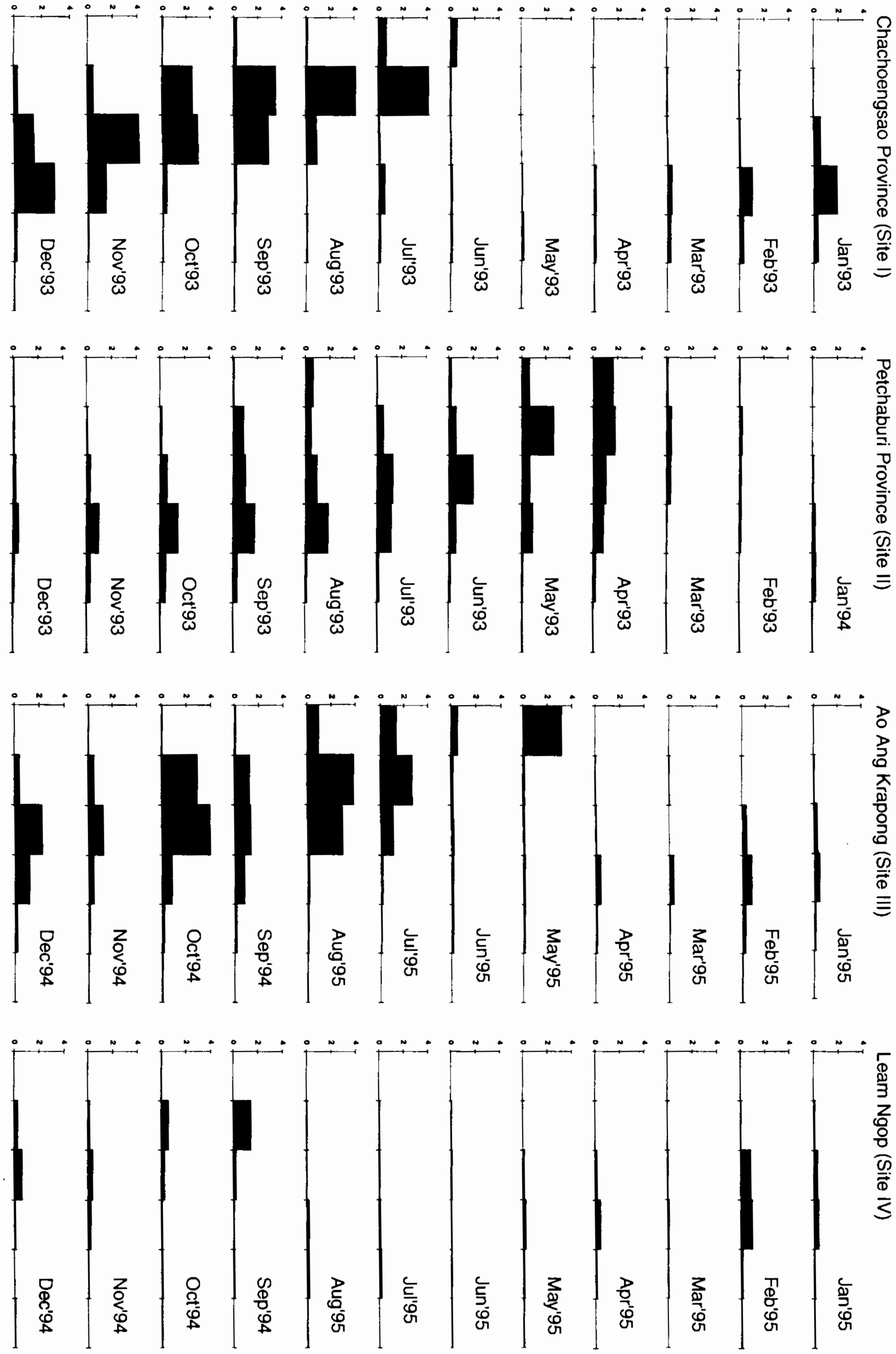

Figure 5. Abundance (ind. m^{-2}) of six different size groups (1-7 mm, 8-14 mm, 15-21 mm, 22-28 mm, 29-35 mm, and 36-42 mm) at 4 different sites. Arranged according to months albeit samples were obtained in different years.

Table 5. Estimated stock (ind. m^{-2}) and weight (g per rai) at 4 different sites (1 rai= 1568 m^2).

size(mm)	Density (ind. m^{-2})				Stock weight (g per rai)			
	Site I	Site II	Site III	Site IV	Site I	Site II	Site III	Site IV
1-7	1.54	3.36	6.15	0.04	69	151	291	1
8-14	17.6	7.81	12.05	2.63	10,031	4,451	11,304	1,758
15-21	13.32	8.6	13.66	3.16	31,081	20,018	48,822	9,626
22-28	8.9	10.52	5.83	2.87	52,865	62,487	44,241	22,858
29-35	1.97	2.59	1.57	1.14	22,096	29,049	24,329	15,560
36-42	0.12	0.37	0.18	0.22	1,862	5,742	3,340	4,973
				Total	118,004	121,899	132,327	54,776

Table 6. Total weight of cockle stock (kg) at 4 different sites.

	Site I	Site II	Site III	Site IV
size (mm)	4,430 rai	4,220 rai	1,406 rai	4,843 rai
1-7	306	635	410	5
8-14	44,436	18,784	15,893	8,514
15-21	137,691	84,476	68,644	46,619
22-28	234,190	263,696	62,203	110,702
29-35	97,883	122,589	34,206	75,355
36-42	8,250	24,233	4,697	24,083
Total	522,756	514,412	186,052	265,279
Total weight in 4 sites (tonnes) 1,488				

the spawning period. Fig. 5 shows spawning of cockle in Chachoengsao during January and March, in Petchaburi during November and January, in Ao Ang Krapong during December and February, and in Leam Ngop during April and June. Pathansali (1966) reported that seasonality in breeding cycle appeared to be closely related to salinity. Broom (1982, 1983) has shown that in 1977 there was a distinct depression of surface salinity at Kuala Selangor. It occurred in October/November and coincided with a major spawning. The salinity in Petchaburi and Chachoengsao dropped to 15 and 14 ‰. in October and September respectively (Thanomkiat 1994 a,b). Salinity was low in Trat in August, 16.8 ‰. (Thanomkiat & Pawaputanon 1996). Broom (1982, 1983) argued that the depression of salinity in itself is not the only factor that serves as a spawning cue. A period of high rainfall may also depress temperatures on the intertidal mudflat and this could be another possible environmental cue.

Substratum is also important. *A. granosa* can be found in sandy mud but the highest population densities are found in the soft intertidal mud bordering mangrove swamp forests. Pathansali (1966) found that the silt/clay fraction of the substrate (in this case particles less than 31 μm in diameter) dominated in areas occupied by natural populations of *A. granosa* in Perak. Broom (1982) reported organic matter content to be in the range of 6 to 11 % in cockle beds. Boonruang & Janekarn (1983) reported 10.7-12.9 % organic matter in sediment populated by cockles in Phuket.

In Petchaburi, the substratum was silt with an average of 5.2 % organic matter, while the substrate in Chachoengsao was clay with 6.6 % organic matter (Thanomkiat 1994 a,b). The sediment in Trat, (Ao Ang Krapong and Leam Ngop) had 10.8 % and 8.6 % organic matter respectively (Thanomkiat & Pawaputanon 1996). In the present study, the highest organic content was correlated with the highest stock of cockles (Ao Ang Krapong, Tab. 5). The total cockle stock was estimated at 1,488 metric tons (Tab. 6) which can be utilised commercially. Few cockles larger than 29 mm were observed. This condition is suspected to be a result of daily harvesting of marketable size cockle by local small scale fishermen.

Cockle populations in the present study areas may ensure adequate supply of marketable cockle and seed to supply at least 60 %

of the aquaculture industry, except at Leam Ngop, where the cockle stock may not be sufficient for commercial utilisation. Establishment of a seed bed at Leam Ngop may be required to increase the standing stock of cockle in this area. However, further information on water circulation, water quality, and substratum is needed before action can be recommended.

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