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# Abundance and size distribution of female *Scylla olivacea* in Klong Ngao mangrove swamp, Ranong Province, Thailand

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**Abstract**: The abundance and size distribution of female *Scylla olivacea* were investigated in Klong Ngao mangrove swamp, Ranong Province, Thailand using collapsible traps during the period of October 2003 to September 2004. *Scylla olivacea* formed about 99.76% of the mud crab catch. Both mature and immature female crabs were caught throughout the year. The variation in CPUE of immature females was not correlated with either temperature or salinity whereas the CPUE of mature females was positively correlated with temperature but not salinity. The abundance patterns of mature female with respect to monsoon timings at different sites show that the sites located in landward areas were very different from other sites that located near the Andaman Sea which are end route to migration and aggregation locations for mature female crabs. About 75% of the female catches in 2003–04 consisted of individuals with a carapace width less than that of mature individuals (~9.5 cm). The median size of female crabs caught was 8.25 cm, which is smaller than that for female crabs caught in 1988–89 where the median carapace width was 9.50 cm.

***Keywords:*** *Abundance; Size distribution; female Scylla olivacea; Klong Ngao mangrove swamp, Thailand*

## 1. Introduction

Mud crabs of the genus *Scylla* (also known as the mangrove crab) occur from tropical to warm temperate zones in the Pacific and Indian Oceans. They are commonly associated with mangrove swamps and nearby inter–tidal and sub–tidal muddy habitats where they feed predominantly on mollusks and other less mobile invertebrates (KEENAN, 1999; HILL, 1980). Within their inter–tidal habitat mud crabs hide in an extensive burrow system which offers protection from predators (MACINTOSH, 1988). Mud crabs occupy a wide range of habitats ranging from the inter–tidal to the sub–tidal zone. Generally, they prefer to live in the mangroves of estuarine areas. Each stage of the mud crab, especially the juveniles, seeks shelter in mangrove areas where they are to be found in small creeks and channels under stones, in sea grass beds and even between roots or pneumatophores of mangrove trees (HILL *et al.,* 1982).

The mud crab, *Scylla* spp., represents a valuable component of small scale coastal fisheries in many countries in tropical and subtropical Asia. It is likely that the mud crab population is now facing an increased fishing pressure which targets all size class, from juveniles to adults. These crabs are used in either pond culture for production of mature females for a premium Market or in soft shell mud crab culture (PRIPANAPONG, 1995; CHOLIK, 1999). A decline in mud crab landings and a high percentage of small size classes in mud crab catches have been reported over the last two decade due to the tremendous increase in fishing efficiency and effort and the reduction in mangrove forest habitat (JIRAPUNPIPAT and PRADISSAN, 2005). The main reason for mangrove loss has been wood extraction,

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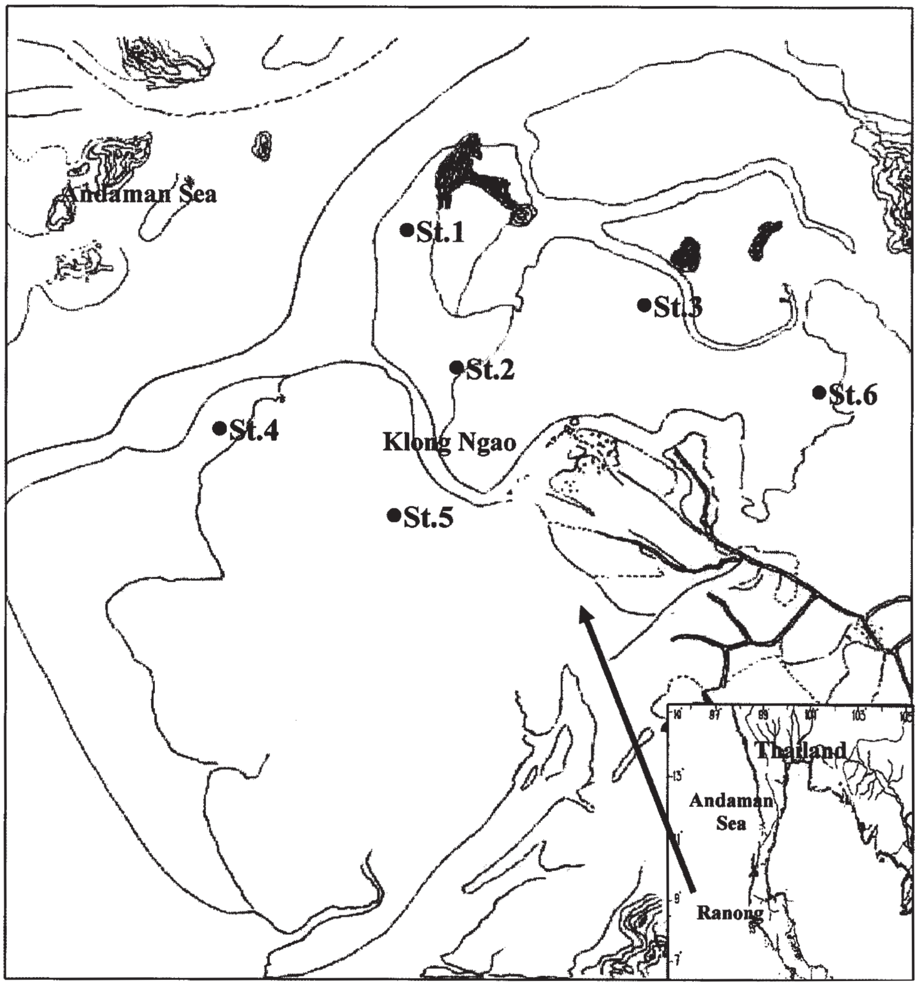



Fig. 1. Study area at Klong Ngao mangrove swamp, Ranong Province, Thailand showing the sampling station 1–6, Inset shows the location of the study area on the west coast of Thailand.

conversion of mangrove areas to agricultural and coastal aquaculture and tin mining. Meanwhile the demand for mud crabs has increased considerably. To conserve the mud crab stock some countries have imposed minimum landing sizes (ROBERTSON and KRUGER, 1994). Furthermore, restoration of mangrove habitat is now widely practiced in the south East Asia (MACINTOSH *et al.*, 2002) but little is known about the recovery potential of mud crabs

Ranong province in the western coast of Thailand is well known as the main area for orange mud crab (*Scylla olivacea*) or black mud crab collection by local fishermen. Klong Ngao is a mangrove-fringed shallow tidal creek located within the northern part of Ranong where the mud crab fishery is the main income of local fishermen (MOSER, *et al.*, 2005).

The mangrove forests in Ranong Province have been rapidly decreasing in area from 367,900 Ha in 1961 to only 168,682 Ha in 1993, a decrease of 54% (KHEMNARK, 1995), while the total annual catch had declined from 109 tons in 1988–89 to 65 tons in 1994–95 (JIRAPUNPIPAT and PRADISSAN, 2005). Furthermore, feedback from local fishermen that the size and relative abundance (catch per unit of effort) of mud crab have decreased in recent years. Therefore a large area of mangrove forest has been replanted with the aim of bringing the ecosystem back to its original condition. In addition, the Department of Fisheries, Thailand (DOF) has developed a project for mud crab stock enhancement, with Klong Ngao mangrove forest being selected as a pilot project. The project started in 2001 with the release of ~200 million megalopa crab larvae to the mangrove forest. In spite of the comprehensive project, scientific assessment of the recovery project is still insufficient. Thus, little is known about the abundance and size range of mud crab caught after reforestation and stock enhancement in the area. Moreover, it is said that environmental condition of local habitat is important for recovering the mud crab population, while the relationship between the abundance and environmental factors is also unknown. This paper investigates the current state of abundance; include variation in abundance related to the environment factors, size distribution and long-term changes in median size of female mud crabs (*Scylla olivacea*) caught in Klong Ngao mangrove forest. From this quantitative analysis, we will discuss some effectively of the recovery programs for the mud crab stock such as rehabilitation of the mangrove forest and stock enhancement.

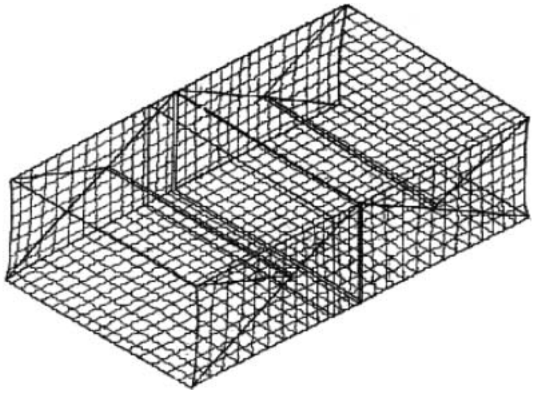


Fig. 2. Collapsible trap for catching the mud crab in Klong Ngao mangrove swamp, Ranong Province, Thailand.

## 2. Materials and methods

### 2.1. Study area and collection of samples

The study was carried out in a mangrove forest called Ngao located in Ranong province. It lies between latitude 9°21' to 10°42' north and longitude 98°24' to 98°56' east, and covers an area of approximately 30 square kilometers (Fig. 1). Ngao canal or Klong Ngao as it is called locally, runs from east to west and divides the mangrove forest into two parts. The

Table 1. CPUE (number of crabs per trap) of mature and immature females *Scylla olivacea* by station and month

| Site | Month | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sep. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| St.1 | No. of traps | 75 | 80 | 85 | 85 | 80 | 85 | 85 | 70 | 73 | 81 | 80 | 72 |
| | Mature | 0.040 | 0.025 | 0.024 | 0.012 | 0.025 | 0.059 | 0.071 | 0.086 | 0.151 | 0.037 | 0.013 | 0.000 |
| | Immature | 0.213 | 0.025 | 0.200 | 0.094 | 0.150 | 0.247 | 0.141 | 0.671 | 0.493 | 0.247 | 0.038 | 0.042 |
| St.2 | No. of traps | 95 | 105 | 105 | 105 | 76 | 90 | 105 | 105 | 98 | 98 | 98 | 91 |
| | Mature | 0.042 | 0.019 | 0.000 | 0.010 | 0.000 | 0.144 | 0.057 | 0.105 | 0.020 | 0.112 | 0.041 | 0.077 |
| | Immature | 0.179 | 0.029 | 0.038 | 0.067 | 0.118 | 0.122 | 0.133 | 0.305 | 0.316 | 0.235 | 0.082 | 0.099 |
| St.3 | No. of traps | 75 | 70 | 80 | 80 | 80 | 80 | 80 | 70 | 70 | 85 | 80 | 80 |
| | Mature | 0.080 | 0.000 | 0.000 | 0.025 | 0.038 | 0.025 | 0.050 | 0.029 | 0.100 | 0.071 | 0.063 | 0.038 |
| | Immature | 0.120 | 0.100 | 0.038 | 0.100 | 0.125 | 0.113 | 0.138 | 0.429 | 0.386 | 0.212 | 0.025 | 0.225 |
| St.4 | No. of traps | 80 | 83 | 85 | 71 | 85 | 85 | 75 | 86 | 86 | 87 | 89 | 88 |
| | Mature | 0.075 | 0.012 | 0.012 | 0.014 | 0.024 | 0.141 | 0.107 | 0.023 | 0.023 | 0.126 | 0.034 | 0.023 |
| | Immature | 0.275 | 0.120 | 0.082 | 0.225 | 0.306 | 0.235 | 0.187 | 0.523 | 0.547 | 0.322 | 0.124 | 0.239 |
| St.5 | No. of traps | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 75 |
| | Mature | 0.024 | 0.012 | 0.000 | 0.012 | 0.024 | 0.082 | 0.118 | 0.071 | 0.059 | 0.071 | 0.035 | 0.027 |
| | Immature | 0.153 | 0.012 | 0.047 | 0.059 | 0.212 | 0.094 | 0.106 | 0.306 | 0.282 | 0.153 | 0.212 | 0.080 |
| St.6 | No. of traps | 60 | 60 | 50 | 50 | 60 | 60 | 60 | 60 | 50 | 50 | 50 | 40 |
| | Mature | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.050 | 0.050 | 0.017 | 0.020 | 0.040 | 0.040 | 0.000 |
| | Immature | 0.233 | 0.250 | 0.180 | 0.280 | 0.400 | 0.217 | 0.317 | 0.167 | 0.280 | 0.160 | 0.060 | 0.100 |

local climate is strongly influenced by two monsoon seasons: the southwest monsoon from May to September and the northeast monsoon from November to February.

Six stations were established in different areas as shown in Fig.1. Sampling was conducted monthly for 12 months during October 2003 to September 2004 using collapsible traps (Fig. 2). Measurements of surface temperature and salinity were also taken at these times. The number of traps used at each station varied between 40–105 traps (Table 1) depending on the weather condition. Fresh trash fish was used as bait in the traps. The standard size of the collapsible traps was 27 cm width; 40 cm length and 12 cm height with two funnel entrances at opposite side. The metal frame of the trap was covered with a strong fishing net of stretched mesh diameter 4 cm. Crabs were collected during spring tides when the water level was high enough to cover the mangrove habitat. Traps were set in the morning at low tide and then collected during the subsequent high tide. At each station the size (external carapace width) and weight of crabs were recorded. Sexes were identified and female crabs from each station were grouped into immature and mature females according to the shape of abdomen, mature crabs as determine by a larger, more rounded abdomen than the immature crab.

## 2.2 Data analysis

2.2.1 *Abundance and assemblage pattern*

At each station, the relative abundance (catch per unit of effort; CPUE) of mature and immature female crabs was estimated in term of number of crabs caught per trap. Pearson correlation was used to identify the relationship between CPUE of immature and mature female crab and salinity and temperature.

The CPUE of mature and immature females during the inter-monsoon period between the southwest and northeast monsoon (October); the north east monsoon (November to February); the inter-monsoon period between northeast and southwest monsoon (March to April) and southwest monsoon (May to September) were estimated. Assemblage patterns of abundance at different sites were analyzed by cluster analysis. Square Euclidian distances among sampling stations were calculated and UPGMA (Unweighted Pair-Group Method Using Arithmetic Average) were used to determine clusters.

2.2.2 *Size distribution and long term change of median size*

The recent size distribution of both immature and mature females *S. olivacea* was analyzed using catch data during October 2003–September 2004. In addition, the long–term changes in size distribution and median size were compared by female *S. olivacea* caught in Klong Ngao mangrove swamp for the period of 15 years. The size of female *S. olivacea* data during April 1988 – March 1989 and July 1994 – June 1995 were previously available from Cheewasedtham and Sudthongkong pers. comm. and the data during October 2003–September 2004 was from the present sampling. The crab data during 1988–1989 was collected by crab lift net while the data during 1994–95 and 2003–2004 were collected by collapsible pot. There was no difference in the size of mud crabs caught by the two forms of fishing gear (Jirapunpipat and Pradissan, 2005). The SPSS version 10 (Statistical Package for the Social Sciences) was used in all analyses.

## 3. Results

*Abundance and assemblage patterns*

The dominant species of mud crab was *Scylla olivacea* which accounted for 99.76% of the total annual mud crab caught by collapsible trap. The female catch of *S. olivacea* was made up of 19% mature and 81% immature crabs (Table 1). Relative abundance was defined as the mean number of *S. olivacea* caught per trap (CPUE). Mean surface water temperature varied from 23 to 32℃ while salinity varied from between 23 to 34 ppt. The variation in CPUE of immature females was not correlated with either temperature or salinity whereas the CPUE of mature females was positively correlated with temperature but not salinity (Spearman, $P$= 0.03). The CPUE of immature female crabs caught throughout the year was greater than that of mature females. The maximum CPUE of immature crabs was found in May at station 1 with a value of 0.67 crabs per trap but the highest average CPUE for immature crabs was

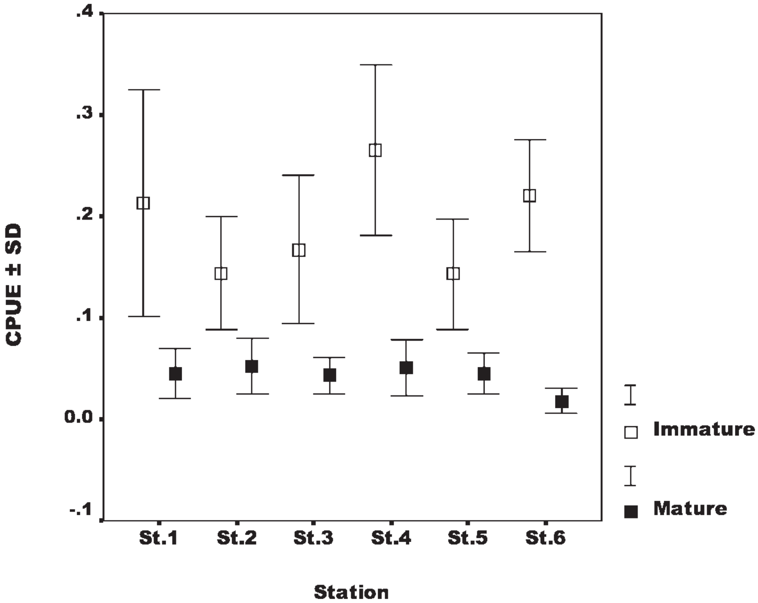



Fig .3. Mean CPUE (number of crabs per trap) and standard deviation for immature and mature females *Scylla olivacea* by station.

at station 4 (Fig. 3 and Table 1).

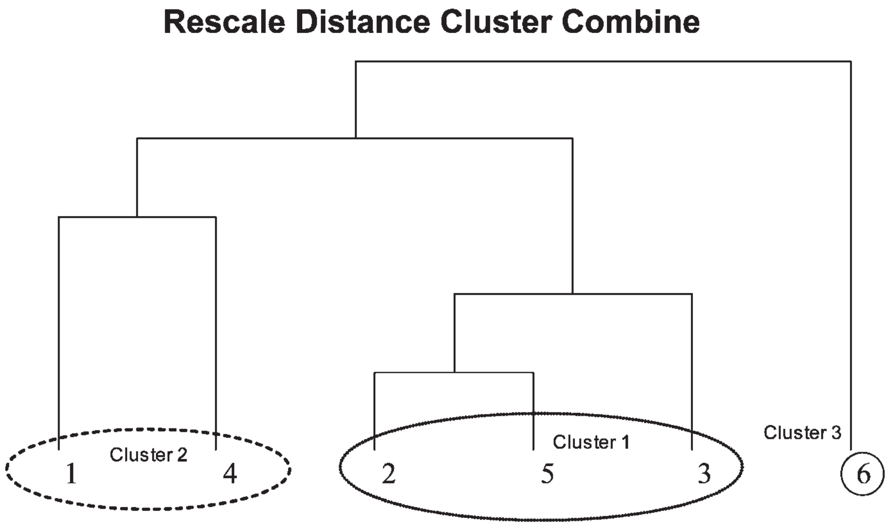
Fig. 4A shows the abundance pattern of immature female crabs. The dendrogram reveals three distinct clusters: stations 2, 5, which are near to Klong Ngao and station 3 which was located more landward, appeared in the first cluster while the second cluster comprised stations 1 and 4, (sites close to Andaman Sea). The third cluster included only station 6 which was located in a more landward position that was not connected to the sea. The first two clusters follow the same seasonal pattern with different magnitudes while the third cluster shows a different pattern from the first two clusters (Fig.4B).

The CPUE of mature female crabs varied from 0.01 to 0.15 crabs per trap (Table 1). The monthly CPUE of mature female crabs from each station showed similar trends with slight differences in the duration of maximal values. High CPUE levels were found in June at station 1 and in March at station 2 and 4 with values of 0.15 and 0.14 crabs per trap respectively. The lowest CPUE values were found between September and February for all stations especially station 6 where mature females were not caught during the period October to February and during September. The average CPUE values for mature female crabs at stations 1 to 5 were greater than that for station 6 (Fig. 3).

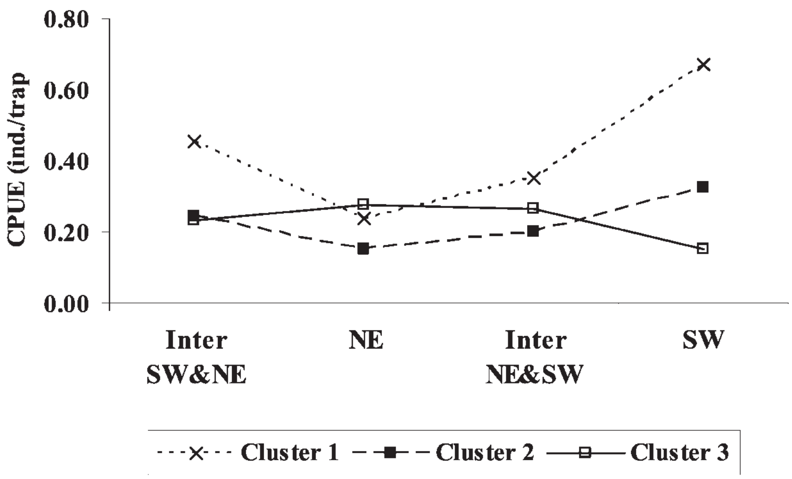
The abundance pattern of mature female crab at each site revealed two obvious distinct clusters and another loosely cluster as shown in Fig. 5A. Station 6 which located in the most landward position appeared in the first cluster; station 3 which was intermediate between inner and outer landward positions appeared in the second cluster and the other stations (1, 2, 4 and 5) (located near the Andaman Sea and close to Klong Ngao) are included in the third loosely cluster. Although three clusters are unclear on the dendrogram, seasonal trend of CPUE among these clusters is obviously different (Fig. 5B). The CPUE values of mature female crabs during different monsoon periods showed varying patterns with quite different magnitudes apart from the northeast monsoon period when CPUE values were of similar magnitude.

*Size distribution and long term change in median size*

The size distribution of immature females ranged from 4.0 to 11.0 cm while mature females ranged from 8.5 to 14.0 cm. Fig.6 shows



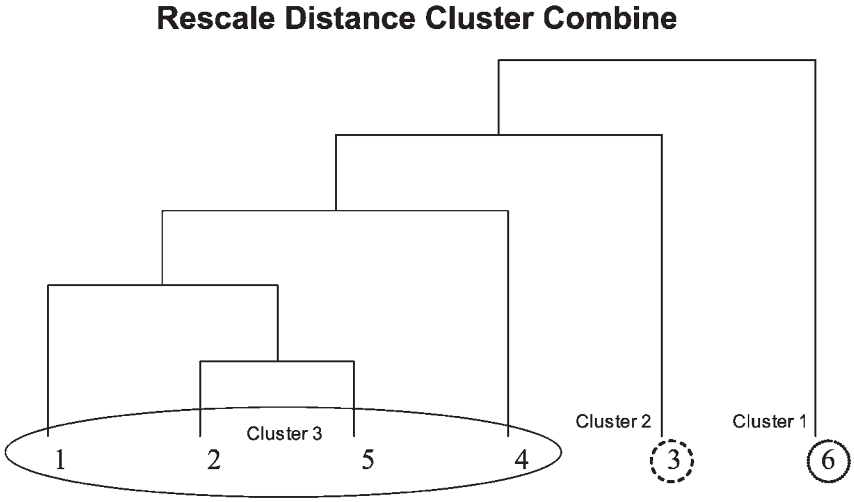

(A)



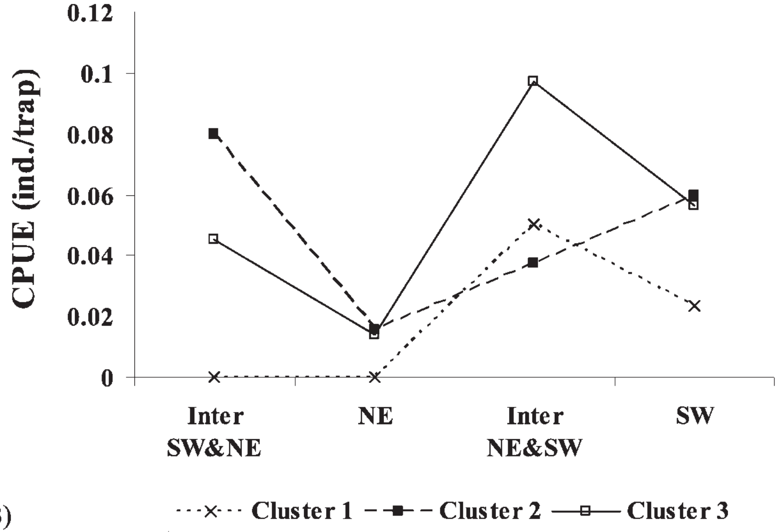

(B)

Fig. 4. (A) Dendrogram obtained from cluster analysis on abundance of immature female at 6 stations. (B) The abundance of immature female; cluster 1 include station 2, 3 and 5; cluster 2 include station 1 and 4 and cluster 3 include station 6 versus monsoon season (inter SW&NE; inter-monsoon period between southwest and northeast monsoon in October, NE; north east monsoon during November to February, Inter NE&SW; inter-monsoon period between northeast and southwest monsoon during March to April and SW; southwest monsoon during May to September) as derived from cluster analysis.

the size distribution of *Scylla olivacea* over a 15y period during 1988–1989, 1994–1995 and 2003–2004. The size distribution of female crabs caught during 2003–2004 ranged from 4.0 to 14.0 cm with a median size of 8.25 cm. The size distribution of female crabs caught during 1994–95 varied from 3.5 to 13.0 cm with a median size of 8.0 cm. The sizes of female mud crabs caught during 2003–04 were a little larger when compared to those of female crabs caught in 1994–95. The box plot showed that about 75% of the crabs caught during 1994–95 and 2003–04




(A)




(B)

Fig. 5. (A) Dendrogram obtained from cluster analysis on abundance of mature female at 6 stations. (B) The abundance of mature female (cluster 1 include station 6; cluster 2 include station 3 and cluster 3 include station 1, 2, 4 and 5 versus monsoon season (inter SW&NE; inter-monsoon period between southwest and northeast monsoon in October, NE; north east monsoon during November to February, Inter NE&SW; inter-monsoon period between northeast and southwest monsoon during March to April and SW; southwest monsoon during May to September) as derived from cluster analysis.

were small sized with carapace width less than the mean size at 50% first maturity ($CW_{50}$=9.55 cm, JIRAPUNPIPAT 2008). Few female crabs were observed with a carapace width size greater than 12.0 cm. The size distribution of female crabs caught during 1988–89 ranged from 6.0–14.5 cm with a median size of 9.5 cm; about half of the female catch over this period was larger in size than the 50% mature individuals (9.55 cm).

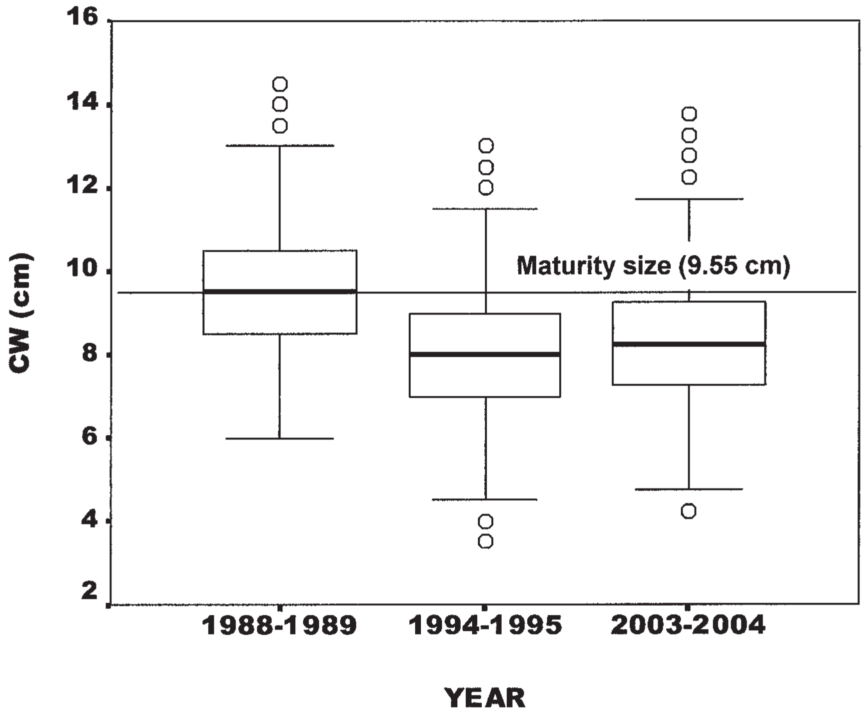



Fig. 6. Box plot of the size distribution of female crabs caught in Klong Ngao (the box lower and upper limits represent the 25th and 75th percentile, the black horizontal line inside the box represents the median and the lower and upper limits of the T-bars represent the 10th and 90th percentile respectively, with values beyond the range represented by open circles). Maturity size is referred from JIRAPUNPIPAT (2008) .

**4. Discussion**

Since there was no information on abundance of female mud crab in Klong Ngao mangrove swamp before this study, the CPUE value was used as an index of abundance even though it is not representative of the entire population. In this study the collapsible traps were thought to provide the best estimation of CPUE as they are the main fishing gear for catching mud crab in Klong Ngao mangrove swamp. Although size distributions of samples caught by collapsible pots were skewed in other crabs (ARCHDALE and KUWAHARA 2005; ARCHDALE *et al.* 2006a, b), there was no difference in the size of the mud crabs sampled between the traps and another fishing gear (JIRAPUNPIPAT and PRADISSAN, 2005). Moreover, the CPUE by the traps demonstrated seasonal distributions of both immature and mature females are correlated with two environmental factors; monsoon timing and temperature.

The CPUE of mature females was positively correlated with temperature but not salinity. This probably because crabs were captured by means of traps bait with fish which relies on a feeding response by the crabs. Feeding by decapod crustaceans is affected both by environment factors such as temperature and physiological factors such as molt condition (WILLIAMS and HILL, 1980). MILLER (1990) also reported that the catchability of crustaceans often increases with temperature. In contrast, the CPUE of *S. serrata* in Australia was negatively correlated with salinity (24–35 ppt) but positively correlated with temperature (WILLIAMS and HILL 1982). However this is not the case in all examples as MARK *et al.* (2006) found that there was no correlation between CPUE of *S. olivacea* and salinity and temperature in Buswan mangrove, Philippines.

Both immature and mature female crabs were observed throughout the year though no berried females were caught by collapsible traps. However, the berried female crabs were frequently caught by trawl and push net during October to December at offshore sites from the Klong Ngao mangrove swamp (CHEEWASEDTHAM, pers. obs. and POOVACHIRANON, 1987). Furthermore, HEASMAN *et al.*, (1985) reported that the berried females are less susceptible to conventional fishing methods, e.g., baited trap, as they stop feeding when they migrate offshore. Our data support the conclusion that berried female *S. olivacea* migrates offshore for spawning.

It is notable that few mature females were found during October to February and September in landward areas. This is likely due to the fact that during the period September to December when *S. olivacea* is spawning mature females move from landward sites to areas close to the sea in order to migrate offshore for spawning. This behavior is consistent with the abundance patterns of mature female with respect to monsoon timings at different sites e.g. results from station 6 (Fig. 5. B) were very different from other sites. Stations 1 and 4, located near the Andaman Sea, are end route to migration and aggregation locations for mature female crabs.

The largest size of immature crabs was 11.0 cm while a mature female was 14.0 cm. Similarly, the largest size of immature *S. olivacea* in Ban Don Bay, Thailand was found to be 11.8 cm while the largest size of mature measured 17.1 cm in Ban Don Bay (OVERTON and MACINTOSH, 2002). The size distribution of female *S. olivacea* caught during 2003–2004 ranged from 4.0 to 14.0 cm with the median size being 8.25 cm. The size distributions of female crabs caught during 1994–95 and 2003–2004 were similar although the size range of female crabs caught in 2003–04 was a little larger than those of female crab caught in 1994–95. About 75% of the crabs caught during 1994–95 and 2003–04 were small sized with a carapace width less than the mean size at 50% first maturity ($CW_{50}$=9.55 cm, JIRAPUNPIPAT, 2008); a few female crabs were observed with a carapace width > 12.0 cm. In contrast, the size distribution of female crabs caught during 1988–89 was much larger than those caught during the two subsequent periods. The median size of female crab caught in 1988–89 was 9.5 cm which is close to $CW_{50}$ while the median size of female crabs caught during 1995–96 and 2003–04 were 8.00 and 8.25 cm, respectively. Such results suggest an increase in the percentage of small crabs and a decrease in the annual median carapace width of crab landings with few female crabs being caught which are larger than 12.0 cm. The data may indicate a decline in the abundance of larger sized mud crabs. The increase in number of smaller crabs may be a consequence of good recruitment, but traps are selective and smaller crabs tend to avoid entering traps when bigger crab are already inside (ARCHDALE *et al.*, 2007). The increase in number of smaller crab may be the result of there being fewer large crabs on the ground, allowing the smaller crabs to enter the traps. Alternatively market conditions may be responsible for this result since there has been a tremendous increase in demand for soft shell mud crab with the fishermen catching smaller sized crabs. However the size of mud crabs caught in 2003–04 was little different from that of crabs caught in 1995–96. This indicates that both rehabilitation of the mangrove forest and stock enhancement may be effective in enhancing the mud crab stock in Klong Ngao mangrove swamp. However, if heavy fishing pressure and the utilization of all size class mud crab still continue then it is inevitable that the mud crab stock will decline. To be effective in restoring fisheries, both habitat rehabilitation and some form of fishery control such as limiting effort or imposing a minimum landing size of mud crab are necessary. One specific recommendation for the recovery is that the minimum size for *Scylla olivacea* capture in Klong Ngao mangrove swamp Ranong province should be 9.5 cm external carapace width (ECW), which was proposed by JIRAPUNPIPAT (2008).

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