Journal of Agricultural Technology 2016 Vol. 12(1):75-89
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Population dynamics of the g*reasyback shrimp (Metapenaeus ensis, De Haan,*1844) in the Songkhla Lake, Songkhla Province, Thailand.

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Samphan, P., Sukree, H. and Reunchai, T. (2016) Population dynamics of the *greasyback* shrimp (*Metapenaeus ensis*, De Haan,1844) in the Songkhla Lake, Songkhla Province, Thailand. Journal of Agricultural Technology 12(1):75-89

The dynamic mathematical models (e.g., Beverton and Holt 1957, 1966), useful for predicting future yields and stock biomass at different levels of fishing strategies, are extensively used for defining management strategies. The knowledge about growth and mortality of fish populations is an essential pre-requisite for the derivation of these models. In tropical and sub- tropical waters, despite the difficulty in determining age of fish and shrimps, the dynamic pool models have, unfortunately, been under-utilized for defining management strategies in fisheries. The present study was therefore designed to investigate the population dynamics of *Metapenaeus ensis* in Songkhla Lake. Samples were obtained monthly for (during January 2010 to Janauary, 2011) a period of thirteen month from Songkhla Lake. The samples were collected using trap nets. The population dynamics of *Metapenaeus ensis* from the Songkhla Lake was investigated based on catch/effort and length frequency data, using FiSAT software. Asymptotic size (L∞), growth coefficient (K), total (Z) and natural (M) mortality, exploitation rate (E), recruitment pattern.

The result showed population dynamics of *Metapenaeus ensis* was divided into two group.The result in group C was showed the asymptotic length ($L\infty$) and the growth rate constant (K) were estimated to be 16.74 cm and 1.80 yr^{-1} . The fishing mortality coefficients were 2.50. The natural mortality was estimated at 3.16 yr^{-1}.The instantaneous total mortality (Z) 5.66 yr^{-1}. The exploitation ratio (E) 0.44.The result in group H was showed the asymptotic length ($L\infty$) and the growth rate constant (K) were estimated to be 14.57 cm and 2.30 yr^{-1}. The fishing mortality coefficients were 2.05. The natural mortality was estimated at 3.86 yr^{-1}.The instantaneous total mortality (Z) 5.91 yr^{-1}.The exploitation ratio (E) 0.35.

***Keywords*:** Penaeidae, population dynamics, *Metapenaeus ensis*, SongkhlaLake, Trap nets

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Introduction

Penaeids shrimps include the widespread tropical and subtropical shrimps of the genera Fenneropenaeus, Penaeus and Metapenaeus (Richmond, 2002). Most commercially important shrimps in tropical areas belong to a group known as penaeids. The adults of most commercially important penaeid shrimps live and spawn in deeper water away from the shore. Most species are found naturally in shallow, inshore tropical and subtropical waters and many have been artificially cultured in ponds (Holthuis, 1980). The greasyback shrimp (*M. ensis)* is a commercially important, brackish-water crustacean species (Chu *et al*., 1995), widely distributed in many Asian countries (Chu and So, 1987). It is a bottom-living species and can be found inshore at depths of < 3 m and offshore at depths of > 65 m. It occurs on muddy bottoms in estuaries and coastal waters, including river, canals, and swamps (Holthuis, 1980), at salinities of 5 to 30 ppt (Kungvankij and Chua, 1986). There is high demand for this species in Thailand markets and in many countries throughout the world because of the high quality of its meat (Liao and Chao, 1983).

In Thailand, *M. ensis* is exploited at various life stages, from the post larval to sub-adult and adult stages, in the brackish waters of coastal area (rivers, canals, and shrimp farms in mangroves) with many kinds of small- scale equipment, including barrier nets, cast nets, bag nets, and trap nets. The trap net is commonly used to catch *M. ensis* in the Songkhla Lake. *M. ensis* has been exploited for several generations in this region, but the dynamics and yields of this species are unknown, scientific information is limited by lack of research. The fishing activities of fishermen depend on their experience, but information about this species is not underpinned by scientific data. The results should provide initial information about *M. ensis* for fisheries managers, so that they can establish programs that will protect and develop this species in a large proportion of fisheries in the coastal region of Thailand.

The dynamic mathematical models (e.g., Beverton and Holt 1957, 1966), useful for predicting future yields and stock biomass at different levels of fishing strategies, are extensively used for defining management strategies. The knowledge about growth and mortality of fish populations is an essential pre-requisite for the derivation of these models. In tropical and sub- tropical waters, despite the difficulty in determining age of fish and shrimps, the dynamic pool models have, unfortunately, been under-utilized for defining management strategies in fisheries. However, with the development of the length-based stock assessment methodologies, it is possible to investigate population dynamics of fish stocks in tropical waters. (Pauly 1984; Pauly and Morgan 1987)

The fishery in the Songkhla Lake is dominated by several commercially important species of fish and shrimps. Among those ones are *Metapenaeus* *ensis Metapenaeus affinis, Metapenaeus brevicornis, Metapenaeus tenuipes* . Despite their commercial importance, they have been poorly investigated, especially on the dynamics of shrimp populations distributed in the coastal areas of the Songkhla Lake. Against the background of the lack of any biological information on the commercially shrimp species, the present study was carried out to investigate several demographical characteristics of these species in the Songkhla Lake with a view to identifying management schemes needed for the management and rational exploitation of this valuable resource.

Materials and Methods

This study was performed in SongKhla Lake, which is located in southern of Thailand(Fig.2). Monthly samples of shrimp were collected from January 2010 to January 2011. Samples were kept in ice and transported to the laboratory. Then the carapace length (CL, to the nearest 0.1 mm; from the posterior margin of the orbit to the posterior margin of the carapace) as well as the body weight (BW, to the nearest 0.01 g) of these individuals were measured as wet weight in the laboratory.

Study sites

The Songkhlalake is the largest natural lake in Thailand, located on the Malay peninsula in the southern part of the country. Covering an area of 1,040 km^2 it borders the provinces of Songkhla and Phatthalung. Despite being called a lake, this water surface is actually a lagoon complex geologically.

The lake is divided into three distinct parts. The southern part opens by a 380 m wide strait to the Gulf of Thailand at the city of Songkhla, and contains brackish water of about half the salinity of the ocean. Further north after a bottleneck of only 6 km width is the ThaleLuang (782.80 km^2), and finally at the northern end in between a mangrove swamp the 28 km^2 small ThaleNoi in Phatthalung Province. The most striking feature is the long 75 km long spit which separates the lake from the sea. Unlike most spits, it is probably formed when originally existing islands became interconnected by the silting from the lake precursor.

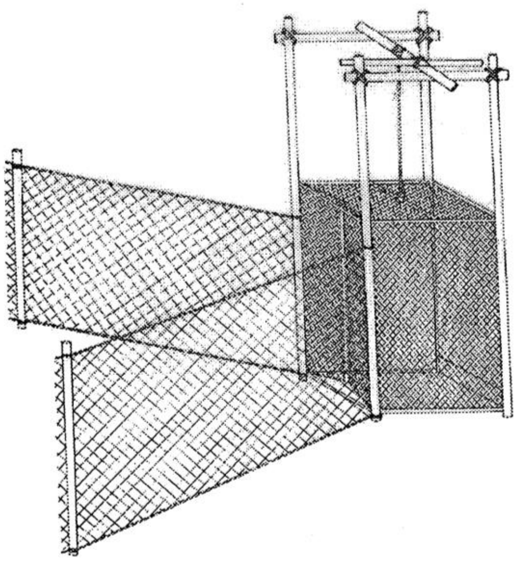


Figure 1. Schematic of a trap net, as used in this study.

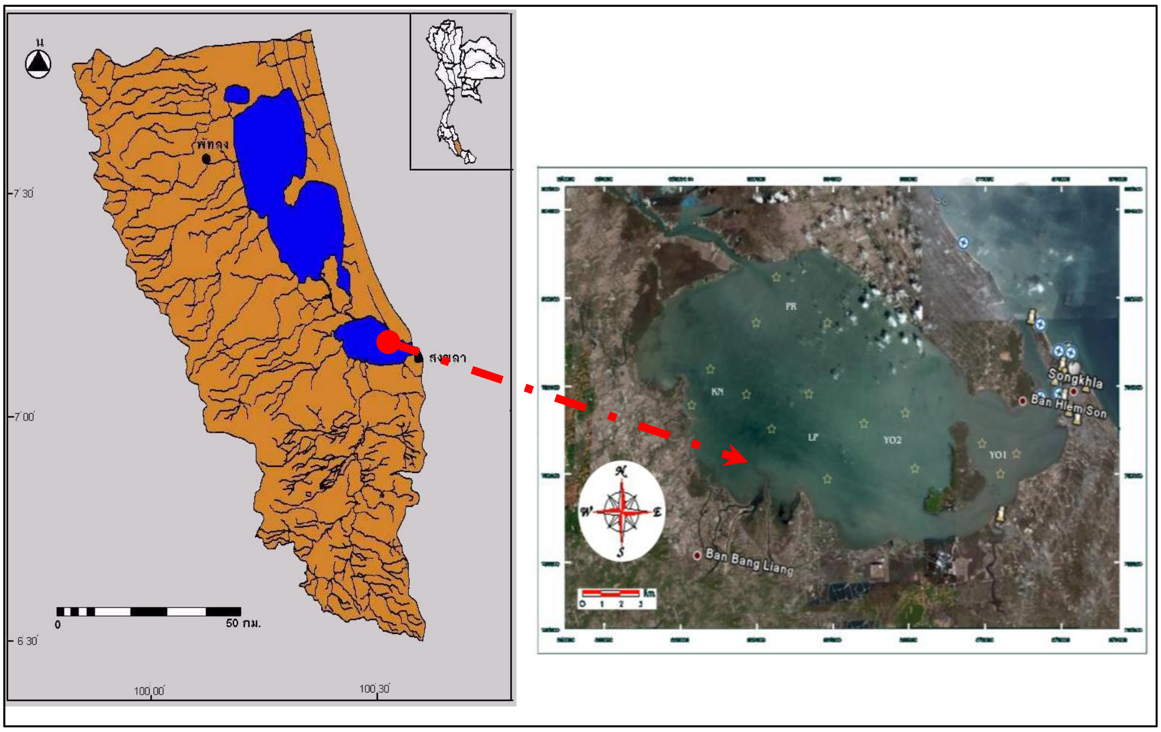


Fig. 2. The map showing sampling sites in the SongKhla Lake.

Fig. 3. The figure showing *Metapenaeus ensis* collected from the SongKhla Lake.

The greasyback shrimp, *Metapenaeus ensis,* (De Haan 1844), is a species of the penaeid family, and is a very important component of estuarine and marine systems in the tropics, with high fecundity and a short lifespan (Garcia, 1998). It is widely distributed in South Asia and Pacific Asia (Chu and So, 1987; King, 2001). The postlarval and adult stages live on the muddy bottoms in estuaries and coastal waters (Holthuis, 1980).(Fig.2) In the Songkhla Lake, *M. ensis* is caught in the brackish waters with artisanal fishing gear, including bag nets, cast nets, and trap nets. The bag net is considered the largest scale of these types of artisanal fishing gear. The commercial value of *M. ensis* is high, not only in Thailand but in many countries of the world, in response to the high market demand, which is based on the quality of its meat (Liao and Chao, 1983; King, 2001). Various aspects of the species have also been studied in Australia (Courtney et al. 1989), China, Hong Kong (Leung, 1997), and Japan (Taguchi et al. 2002).

Sampling methodology

The marine shrimps *Metapenaeus ensis* were collected monthly during January 2010 to January 2011 in the Outer Songkha Lake, Songkhla province, Thailand(Fig.3).The samples were collected using trap nets(Fig.1) and preserved in 10 % formalin. The specimens were identified to species level, sexed, and measured in the laboratory. Total length (TL, to nearest 0.1 mm.) was measured from the tip of the rostrum to the end of the telson, carapace length (CL, to nearest 0.1 mm.), from the posterior margin of the orbit to the posterior margin of the carapace and total weight (TW, to nearest 0.1 g) as wet weight.

The trap nets is a small sized stationary fishing gear, combined with seine wing-like barriers used for re-directing and then trapping crab, shrimp and fish as shown in Figure 1. Trap selectivity relies on the shrimp moving actively into the trap and catches depend on the duration of the soak, i.e. the time the trap is left on the fishing ground.

The study areas were divide in five stations and three replicates in each station. The station one (front of KoYo), near channel of water flow pass from Songkhla Lake. Station two (KoYo), the habitat lied adjacent to the station one, the habitat was a sediment of fine sand Station three at the middle of Outer Songkhla Lake (Ban Laeam Po), the habitat was mudflat. The station four was at the lower of Outer Songkhla Lake (Ban Ao Thing), the habitat was a sediment of coarse sand. The station five at the end of Outer Songkhla Lake (Ban Pak Rua) the habitat was characterized by sediment and water turbulence. In general the bottom of Outer Songkhla Lake were mudflat habitat. Additional characteristics of the sample area were different in water salinity and other environmental parameters. (Figure. 1)

Analyses

The total length (TL, cm) of each sample were recorded. For the stock assessment study, however, only total lengths were considered, using the FAO-ICLARM Stock Assessment Tools II (FiSAT II) (Gayanilo and Pauly 1997). The length data were grouped into 1-cm size classes in order to have about 10 to 20 length-classes, as suggested by Gayanilo et al. (2002), for a proper implementation of the FiSAT analysis.

Estimation of growth parameters

From the length-frequency distribution of the samples, ELEFAN I was used to obtain preliminary estimates of asymptotic length ($L\infty$) and growth constant (K) of the von Bertalanffy Growth Function (VBGF) following Gayanilo et al. (2002). Based on these preliminary estimates, a length-converted catch curve was constructed. Through the detailed analysis of the left (ascending) part of the length-converted catch curve, the mean selection curve of the fishing gear was estimated. This selection curve was used to correct the length- frequency data for gear selection toward small fish (Pauly 1980, 1984). New estimates of $L\infty$ and K were obtained using the FiSAT II software from the analysis of the corrected length-frequency data. The best growth curve was then fitted on the basis of a non-parametric scoring from the goodness of a fit index, the so-called "Rn value" (Gayanilo et al. 2002). The Phi-Prime index, Φ' (Munro and Pauly 1983, Moreau et al. 1986), was used to compare the growth performance of species studied with other previous estimates available in the literature or other previous estimates available in the literature.

Estimation of mortality rates

The length-converted catch curve method (Gayanilo et al. 2002) was used for the estimation of the instantaneous total mortality (Z). For obtaining an independent estimate of the natural mortality (M), Pauly's equation (Pauly 1980) was employed. The mean annual environmental temperature was taken as 29.49 C^0 as it is the average of the monthly water temperature. Fishing mortality (F) was derived as the difference between Z and M. Following the estimations of Z, M and F, the routine was also used to obtain the exploitation rate (E).

Results

Growth Parameters

A total of 4653 shrimps were collected from January 2010 to January 2011. Total length of shrimp (from tip of rostrum to tip of telson) was taken to the nearest mm for length-frequency data. The original length- frequency distributions of shrimp were obtained and each set of the length-frequency data was analysed by using the FiSAT II software (Gayanilo *et al.*, 2002) for determination the parameters of shrimp population such as growth parameters, mortality, gear selectivity and exploitation rates. Growth parameters of *M. ensis* were estimated and presented in Figure 4 and Table 1. The original, length-frequency distributions for *M. ensis* are presented in Fig.4.

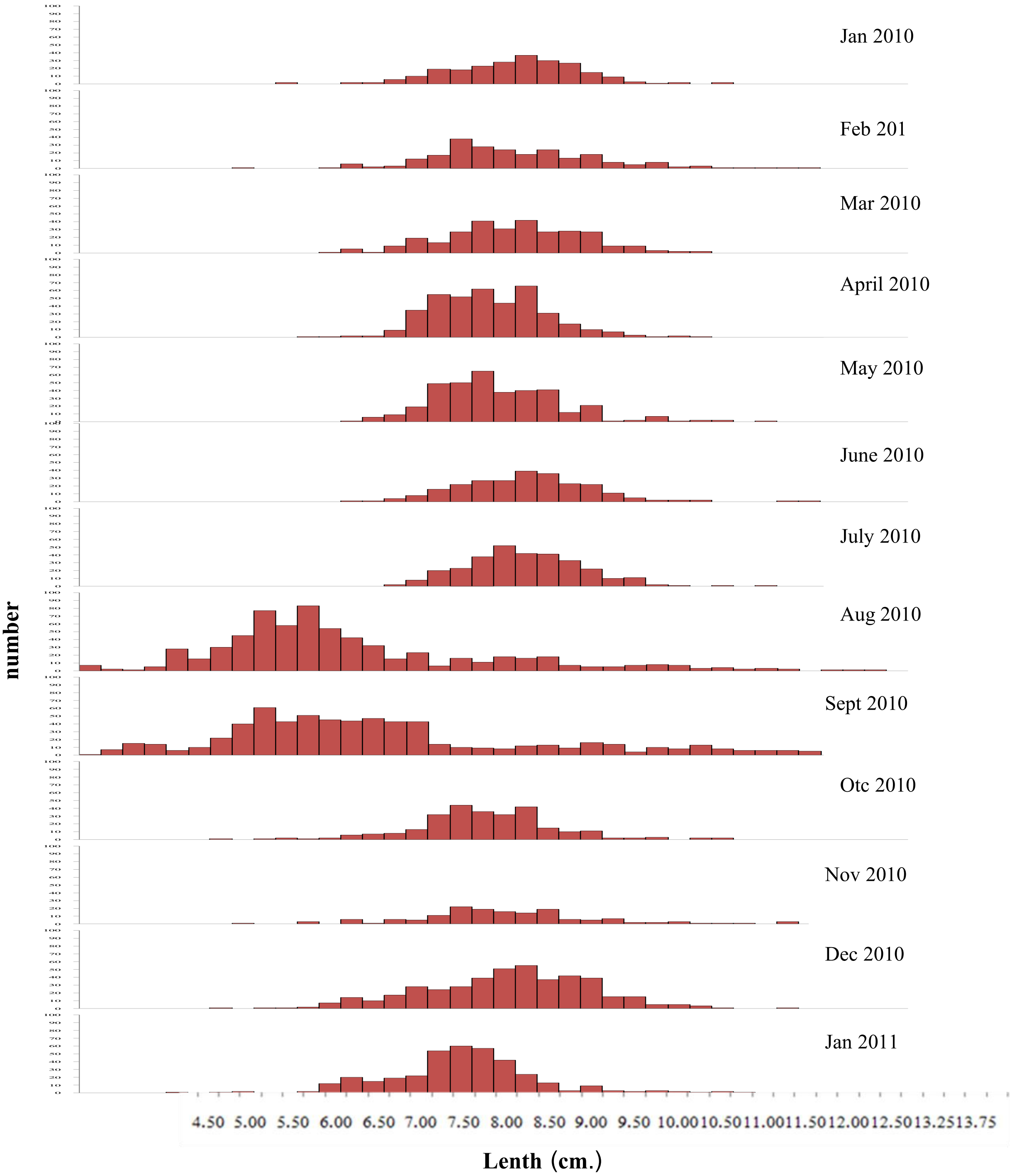


Fig.4 Monthly the length-frequency distribution for total of *M. ensis*

Estimation of growth parameters

From the length- frequency distribution of the samples, ELEFAN I was used to obtain preliminary estimates of asymptotic length($L\infty$) and growth constant (K) of the von Bertalanffy Growth Function (VBGF) following Gayanilo *et al.* (2002). Based on these preliminary estimates, a length-converted catch curve was constructed.

Table 1. The asymptotic length ($L\infty$) and the growth rate constant (K) of *Metapenaeus ensis* in eight group

Group	n	r	a	b	K (/month)	K (/year)	L_∞	K
A	4	0.8681	2.8241	-0.1768	0.1768	2.1216	15.97	2.12
B	3	0.8181	1.9565	-0.0976	0.0976	1.1708	20.05	1.17
C	3	0.9718	2.5185	-0.1504	0.1504	1.8050	16.74	1.80
D	3	0.8822	2.8131	-0.1937	0.1937	2.3243	14.52	2.32
E	3	0.4691	1.6881	-0.0882	0.0882	1.0581	19.14	1.06
F	3	0.9876	7.0003	-0.5927	0.5927	7.1123	11.81	7.11
G	3	0.8560	2.580797	-0.19379	0.1937	2.3254	13.32	2.33
H	3	0.9902	2.7971	-0.1920	0.1920	2.3044	14.57	2.30

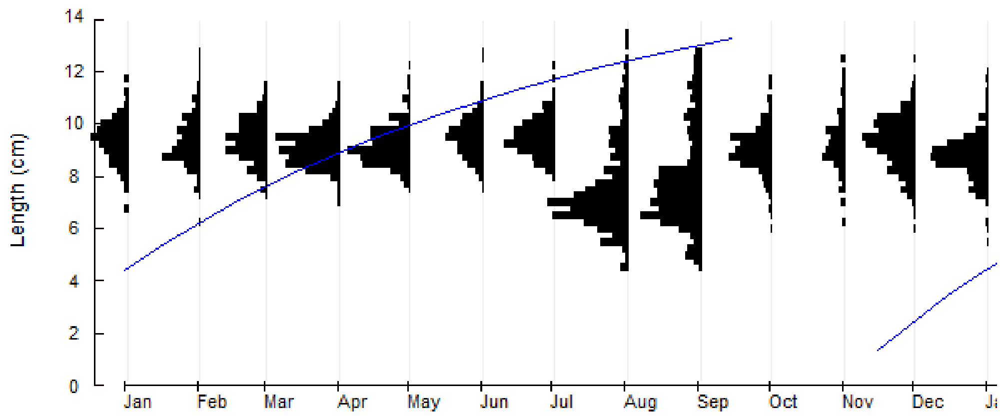


Fig.5 The length-frequency distribution and von Bertalanffy's length growth curves of *M. ensis* group C

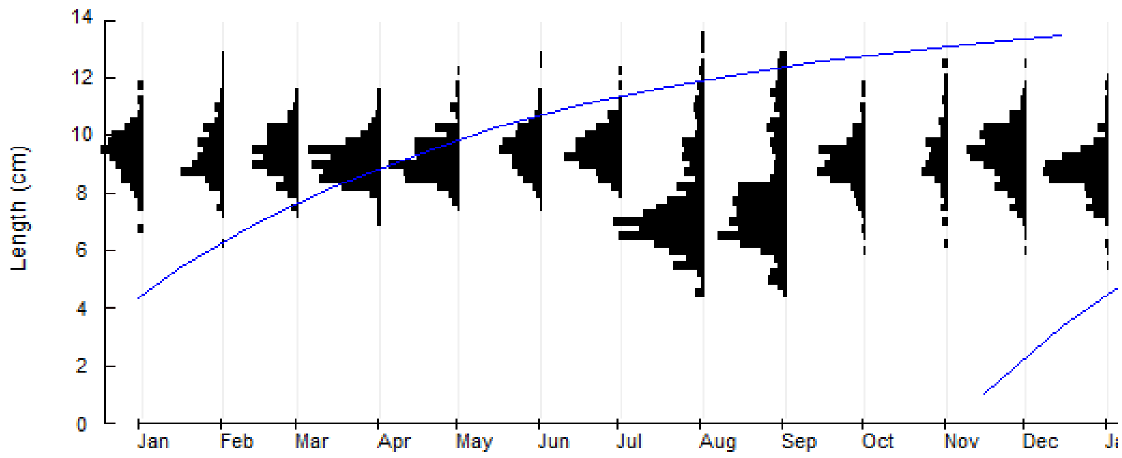
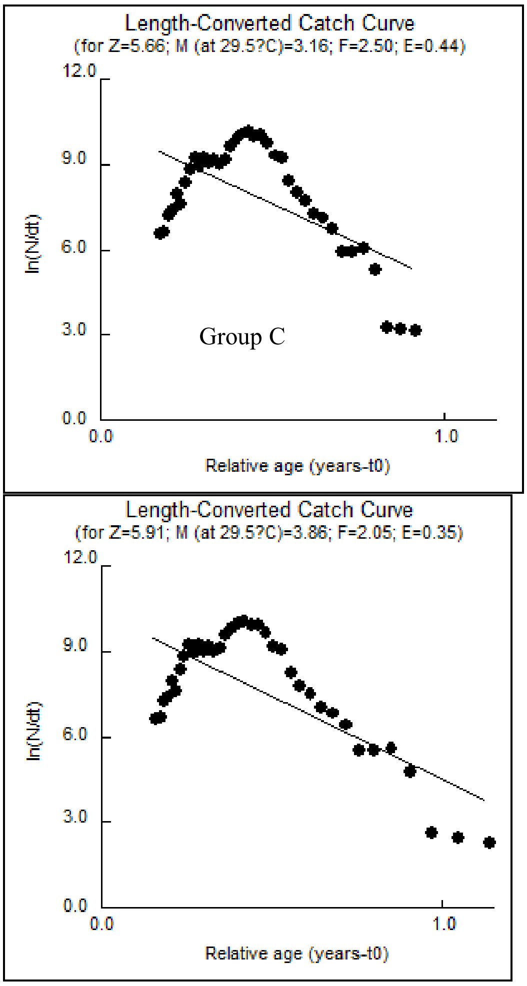


Fig. 6 The length-frequency distribution and von Bertalanffy's length growth curves of *M. ensis* group H

Mortality and exploitation rate

The total mortality coefficients from length-converted catch curves indicate an annual estimate, for 1 year to the maximum observed theoretical age. The result showed population dynamics of *M.ensis* was divided into two group. The result in group C was showed the asymptotic length ($L\infty$) and the growth rate constant (K) were estimated to be 16.74 cm and 1.80 yr^{-1}. The fishing mortality coefficients were 2.50. The natural mortality was estimated at 3.16 yr^{-1}.The instantaneous total mortality (Z) 5.66 yr^{-1}. The exploitation ratio (E) 0.44.The result in group H was showed the asymptotic length ($L\infty$) and the growth rate constant (K) were estimated to be 14.57 cm and 2.30 yr^{-1}. The fishing mortality coefficients were 2.05. The natural mortality was estimated at 3.86 yr^{-1}.The instantaneous total mortality (Z) 5.91 yr^{-1}.The exploitation ratio (E) 0.35.



Group H

Fig.7 Length-converted catch curve for *Metapenaeus ensis* in group C and group H

Discussion

Uncertainty does exist when using Fisat for growth performance estimates. It comes from the fact that several combinations of values of L_{oo} and K might give the same value of Rn, keeping in mind that Loo and K are negatively correlated (Moreau *et al*., 1986; Pauly and Morgan, 1987). A routine of FiSAT called the response surface analysis enables the user to identify such combinations. This routine has been used to assess this uncertainty. Any estimation of the total mortality is associated with uncertainty which is displayed by the software. The fishing activities of fishermen were carried out throughout the year, and the frequencies of the different *CL* classes differed in various months, which supports the concept of several recruitments per year. The *CL* of *M. ensis* fluctuated greatly between the rainy and dry seasons. However, it was not clear in which months *CL* peaked in each season, confirming that this species can spawn throughout the whole year. However, the seasonal reproduction of the penaeid shrimp is a very complex issue, because it is affected by varying environmental factors, including rainfall, temperature, and water depth (Dall et al. 1990). Therefore, its seasonal reproduction can differ across different regions. A study in Australia also found that *M. ensis* spawns throughout the year, with the highest peak from September to November and the lowest peak between January and February (Crocos et al. 2001).The recruitment pattern of *M. ensis* is also a complex issue, because recruitment occurs in different months in various regions. The recruitment of the penaeid shrimps is also related to the lunar cycle (Garcia, 1998). A study in Hong Kong found that new recruits began to enter the catch region in April–May, where they grew during June–August, and that this was followed by another smaller recruitment in October (Cheung, 1964). However, the peak recruitment of *M. ensis* occurred in April–June and September–October in Hong Kong (Leung, 1997). A study in the Gulf of Mexico found that the spawning peaks for Penaeidae shrimp occurred in May–June and August–September (Neal and Maris, 1985). The recruitment of postlarvae tended to follow a 28 day cycle, with increased immigration on alternate spring tides (Staples and Vance, 1987). New recruits (2–3 mm *CL*) migrated into the estuaries of southwestern Australia between December and April (Potter and Manning, 1991. Habitat is also a factor that affects the migration of postlarval shrimp during the recruitment of *M. ensis*, influencing shrimp abundance in coastal regions (Neal and Maris, 1985; King, 2001). Negative impacts on the shrimp habitats have been recorded in the study region, where mangrove areas are being reduced and coastline pollution is increasing, and these problems have affected shrimp recruitment and the development of local natural resources (Johnston et al. 2000).In practice, the trap net can catch small and weak individuals that move beneath the current, resulting in a waste of aquatic resources, which will negatively affect the aquatic resources. Mature individuals were not collected during the study for two main reasons. First, large individuals are more able avoid the gear (trap net) by a rapid swimming reaction, which may ensure that that larger *M. ensis* are caught less often in the trapn net than small shrimp. Second, the environmental conditions in the region are not sufficiently consistent to ensure a homogeneous distribution of mature individuals, because the salinity is low (Leung, 1997). Therefore, mature individuals could not be found in the study area. The longevity of the penaeid shrimp is often affected by different types of fishing gear and environmental factors. In this study, shrimp longevity was 1.8 years for males and 2 years for females, whereas the lifespan of this species is 15–20 months in Hong Kong (Cheung, 1964), However, the total lifespan of the Penaeidae shrimp is usually less than 2 years (Dall *et al*. 1990). Predators and environmental factors are important factors affecting the longevity of these shrimps (Niamaimandiet al. 2007).Increasing the fishing pressure can affect the marketable size of the shrimp, and when a high proportion of small shrimp are caught, it is clear that the species is being exploited at various stages of its life cycle (Garcia, 1998). Although *M. ensis* is now underfished, fisheries managers must establish new regulations for the mesh size of the nets, not only to ensure that fishermen can catch larger individual of greater value, but also to enhance the development of the aquatic resource in a large area of the region. This will form part of the long-term strategy for the sustainable development of aquatic fisheries in the region in the future. In dealing with mortality rates, it is usually important to take into consideration the growth pattern as obtained from growth parameter after correcting for gear selection since more of the larger species are removed by fishing and less of the smaller ones appear in the catches. Downward bias in the estimate could be introduced through sampling individuals that are not fully recruited in the fishery, but there is also a danger of upward bias by not sampling the lower length classes when they are already fully recruited (Dadzie et al. 2005). However, the research areas have managed under traditional ownership by an adjacent community group and the shrimp stocks are regarded as a common resource. Therefore, increase in mesh size of the fishing gears and reduction in fishing effort may be difficult to implement, and can probably only be considered if management of the fishery is devolved to the local communities. Furthermore, the difficulties involved in managing shrimp resource are also related to the number and types of user groups. Hence, the community-based co- management approach should be applied to the fishery for sustainable development of the habitats and shrimp stock; because this approach focuses not only on resource management, but also on community and economic development.

Conclusion

The greasyback shrimp, *M. ensis* was widely distributed and tolerated high fluctuation of environment, it was caught year around, the yield in rainy was higher than in dry season, this problem caused by waste natural resources and effect to sustainable development. The greasyback shrimp, *M. ensis*, in the Songkhla Lake are underexploited. However, there is a high risk of overfishing *M. ensis* is captured as by-catch, with a high proportion of small shrimp. Although *M. ensis* is now underfished, fisheries managers must establish new regulations for the mesh size of the nets, not only to ensure that fishermen can catch larger individuals of greater value, but also to enhance the development of the aquatic resource in a large area of the region.

Acknowledgements

The authors would like to thank the fishermen who cooperated in this study. Authors are also greatly indebted to the Graduated school, Prince of Songkhla University, Hat Yai, Songkhla for providing financial assistance.

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(Received: 14 November 2015, accepted: 5 January 2016)