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Population dynamics of mantis shrimp (*Miyakea Nepa* Fabricius, 1781) in Siwa, Bone Bay, South Sulawesi, Indonesia

Kaisar[1], Nadiarti Nadiarti[1], Moh. Tauhid Umar[1], Yayu Anugrah La Nafie[2], Dody Priosambodo[3], Irmawati[1], Joeharnani Tresnati[1] and Suwarni[1]

[1]Fisheries Department, Universitas Hasanuddin, Makassar 90245, Indonesia
[2]Marine Science Department, Universitas Hasanuddin, Makassar 90245, Indonesia
[3]Biology Department, Universitas Hasanuddin, Makassar 90245, Indonesia

E-mail: nadiarti@unhas.ac.id

Abstract. *Miyakea nepa* is a mantis shrimp commonly found in the coastal waters of Bone Bay, Indonesia. This study aimed to determine mantis shrimp population dynamics including age groups, growth, mortality, exploitation rate, and relative yield per recruit. The study was conducted in the waters around Siwa in Bone Bay, South Sulawesi from June to July 2019. The age groups, natural mortality, total mortality, fishing mortality, exploitation level, and yield per recruit were calculated and analyzed using equations and methods contained in the FAO-ICLARM Fish stock Assessment Tools II (Fisat II) program. The results imply rapid growth in the mantis shrimp *Miyakea nepa* (Latreille,1828) and indicate that the population studied has been over-exploited.

1. Introduction

Mantis shrimps belong to the ordo Stomatopods are marine tropical predator crustaceans mostly found in the shallow coastal waters [1]. They are usually found in soft sediment [2–4] and are economically important marine resources and can be found in several global markets such as Spanyol, Italy, Egypt, and Marocco [5]. In Indonesia, the price of mantis shrimp relatively higher than other shrimps. A live mantis shrimp about 11 inches in size is sold for about USD 5.5 for local consumption and in the seafood restaurant in Bali, the price is about USD 40 to USD 60 per kg (Pers. Obs). Besides local consumption, the mantis shrimp is also exported and majority to Hong Kong and Taiwan where the demand is increasing every year [4].

Mantis shrimp, *Miyakea nepa*, one of the most popular mantis shrimp species in Southeast Asia [6], but the information of *M. nepa* is still very limited, except for their economic and population dynamics in the Hongkong waters [1]. This mantis shrimp is frequently found in fish traps with the muddy sand substrate at around the Siwa Waters, Bone Bay, South Sulawesi. Very little is known about their population status in Indonesia, including their biological information. Therefore, this study aimed to determine mantis shrimp population dynamics including age groups, growth, mortality, exploitation rate, and relative yield per recruit at around Siwa waters, Bone Bay, South Sulawesi.

2. Methods

The study was carried out in Siwa waters, Bone Bay, Wajo Regency, South Sulawesi from June to July 2019. Mantis shrimp samples were collected from ten different fish traps located in three different fishing spots (Figure 1), where the fish traps belong to the local fishermen. Each mantis shrimp sample was measured for total length following [7], using a digital caliper to the nearest 0.1 mm. Sex determination of each sample followed several authors such as [4,8,9].
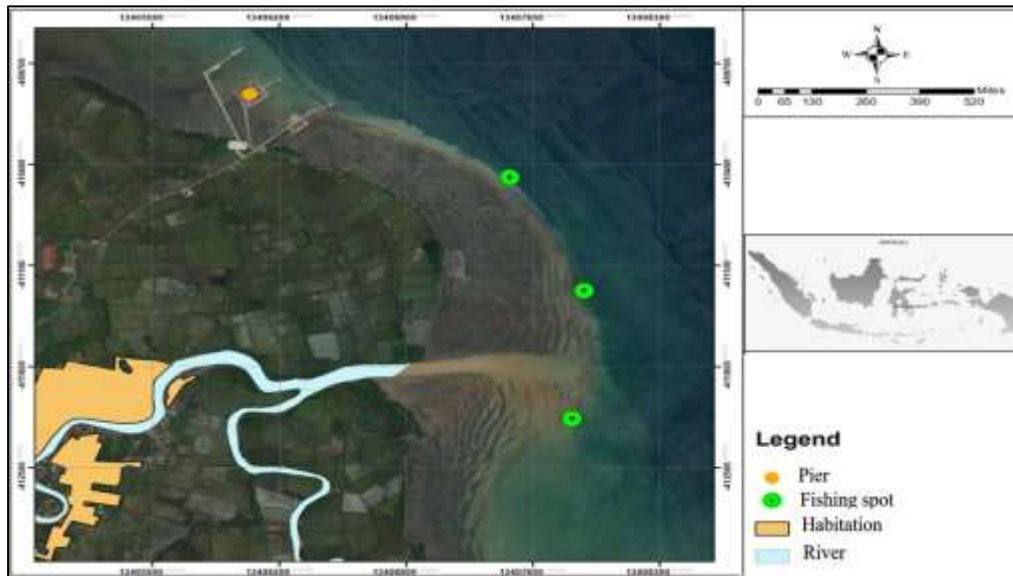

Figure 1. Map of study area. Green dots indicate the sampling sites of *Myakea nepa*

Size frequency distributions by sex were obtained from the survey data collected from June to July 2019. Determination of cohorts in the *Miyakea nepa* population followed the Bhattacharya method [10]. The number of cohorts and their corresponding mean carapace lengths (CL) obtained were then grouped into several length interval classes. These data were then analyzed using the FISAT II software [11].

Determination of growth parameters (the growth coefficient K and the asymptotic length L∞) was performed using the von Bertalanffy's growth model (Sparre and Venema 1999): $Lt = L_\infty [1 - e^{-K(t-t_0)}]$, where Lt is the length at time t (mm), L∞ is the asymptotic length of mantis shrimp (mm), K is the von Bertalanffy growth constant (mm month^{-1}), and t_0 is the age at zero length, t is the age of mantis shrimp (month). The K and L∞ were estimated using ELEFAN Program in FISAT II [11].

The mortality rates of mantis shrimp were calculated using Pauly's empirical equation [12]: Log M = -0,0066 − 0,279 Log L∞ + 0,6543 Log K - 0,4634 Log T, where M is natural mortality, L∞ is the asymptotic length, K is the growth coefficient, and T is the mean annual water temperature. Total mortality (Z) was calculated using the formula of Beverton and Holt [13]: $Z = K \frac{L_\infty - \bar{L}}{\bar{L} - L'}$, where $\bar{L}$ is average length of the collected mantis shrimp (mm), L' is the smallest size limit for the length class of collected mantis shrimp. Fishing mortality (F) was obtained by substracting the natural mortality rate (M) from the total mortality rate (Z): F = Z - M. The exploitation level (E) was estimated using the formula of Gulland (1971) [14] $E = \frac{F}{Z}$. In the end, the relative yield-per-recruit (*Y*/R') was calculated using the Beverton and Holt equation [13]: $Y/R' = E.U^{\frac{M}{K}}\left(1 - \frac{3U}{1+m} + \frac{3U^2}{1+2m} - \frac{U^3}{1+3m}\right) \rightarrow U = 1 - \frac{L'}{L_\infty}; \ m = \frac{1-E}{M/K}$.

3. Results and Discussion

A total 1000 individuals of mantis shrimp (*Miyakea nepa*) were analyzed during study of which 53.3% were males and 46.7% were females. Total length for male ranged 70 mm – 148 mm with the highest length frequency was found in the range of 100-104 mm for 90 individuals, whereas the length range for female was 77 mm – 158 mm with the highest length frequency was found in the range of 107 - 111 mm for 59 individuals. The length of male mantis shrimp was grouped into 17 classes and the female length was grouped into 18 classes with 5 intervals for each male and female mantis shrimp. The cohort analysis confirmed the general presence of two cohorts along the study period (Figure 2A & 2B). The size of female mantis shrimps (Figure 2A) was generally larger than that of males (Figure 2B), but number of female populations was smaller than that of male population. This indicates a fishing pressure on the mantis shrimp *(M. nepa)*. Even though the *M nepa* is only as bycatch and not as the main fishing target for the fishermen in the study area, but once the shrimp was trapped in the fish trap, they were not returned back to their habitat but was thrown on the land when the fishermen back from fishing and sorted their catches in the land.
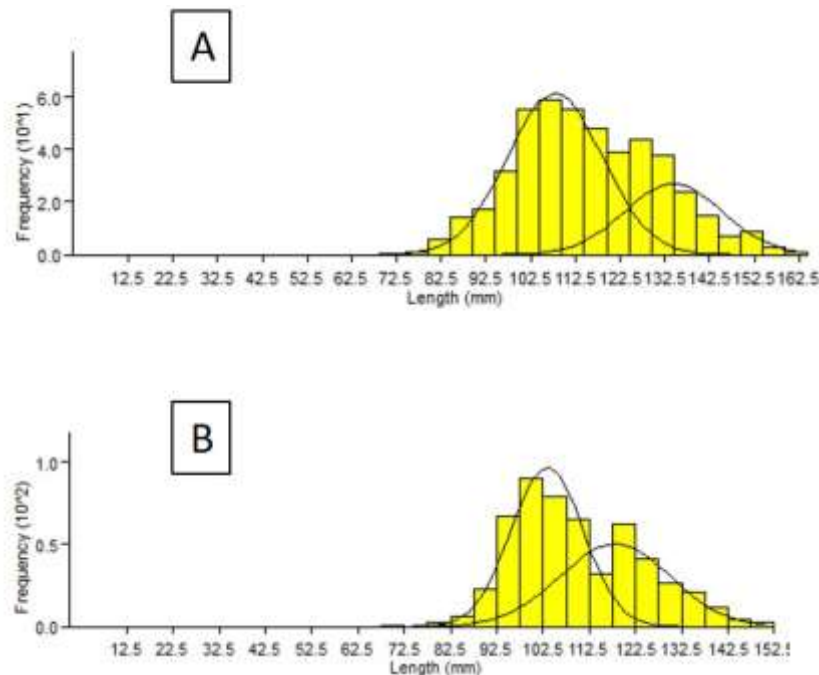

Figure 2. Size frequency distribution of Miyakea nepa from the Herlang waters, Bone Bay, South Sulawesi. Monthly cohorts are represented by normal distribution curves

   A cohort describes the existence of a group of individuals of the same age or size occupying the same space, growing, and developing within the same certain period [13]. In this study, two cohorts indicating there were two generation groups during the study (June to July 2019) in the Siwa waters, Bone Bay, South Sulawesi.

   The *M nepa* females reach their asymptotic length (L∞) shorter than the males, where the females having a higher growth coefficient (K = 0.55) than the males (K = 0.37) (Table 1). Resulting in the females reaching their L∞ faster than the males. This is supported by [13] that fish with a slow growth rate coefficient will spend more time to achieve their asymptote length and vice versa fish with a high growth rate coefficient will reach their asymptote length rapidly.

Table 1. Growth parameters estimation of mantis shrimp (*Miyakea nepa)* based on Von Bertalanffy model in Siwa waters, Bone Bay, South Sulawesi

Parameters	Value	
	Male	Female
L_∞ (mm)	161.00	173.10
K	0.37	0.55
t_o	-0.2810	-0.1825

Table 2 shows that natural mortality rate was smaller than that of fishing mortality rate. This suggests that the mortality of mantis shrimp in Siwa waters, mostly caused by the high fishing effort by the local fishermen, especially fishermen that used fish trap, while the natural mortality might be caused by other factor such as disease, stress, spawning period, hunger and old, environmental condition [13]. Further detailed study that includes environmental parameters is required.

Based on the exploitation value (E) (Table 2) shows that the E values for the male and female mantis shrimp were above the optimum E value (0.5), indicating that the mantis shrimp M. nepa in Siwa waters, Bone Bay have overfished. This supported by [15] that if the optimal rate of exploitation (E) of fishery resources is equivalent to 0.5, it is signifying that the natural mortality rate must be comparable with the fishing mortality.

Table 2. Mortality dan exploitation rates of caught mantis shrimp (*Miyakea nepa*) in Siwa waters, Bone Bay, South Sulawesi

Mortality rate	Estimation value per year	
	Jantan	Betina
Z	0.38	2.43
M	0.60	0.77
F	0.78	1.67
E	0.56	0.69

4. Conclusion

The mantis shrimp *Miyakea nepa* in Siwa waters, Bone Bay, South Sulawesi, Indonesia are overexploited and their mortality mostly caused by fishing.

Acknowledgement

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