Population Dynamics of the Indonesian Mantis Shrimp, *Harpiosquilla raphidea* (Fabricius 1798) (Crustacea: Stomatopoda) Collected from a Mud Flat in Kuala Tungkal, Jambi Province, Sumatera Island

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Abstrak

Penelitian ini bertujuan untuk mengungkapkan struktur populasi, pertumbuhan, lama mass hidup, dan laju ekspoitasi dari udang mantis (Harpiosquilla raphidea Fabricius, 1798). Penelitian ini dilakukan secara periodik di Kuala Tungkal, Tanjung Jabung Barat, Jambi dari Juli 2009 hingga Juni 2010. Hasil penelitian memperlihatkan adanya dua kelompok ukuran yang berbeda di daerah intertidal dengan di daerah subtidal. Ukuran panjang udang mantis yang hidup di daerah intertidal berkisar 25-233 mm dengan kelompok dominan berukuran 79-96 mm, sedangkan di daerah subtidal ukuran panjang udang mantis adalah 160-366 mm dengan kelompok dominan berukuran 193-258 mm. Koefisien pertumbuhan (K) adalah 0,14 untuk jantan dan 0,11 untuk betina; sementara L_∞ kedua jenis kelamin adalah sama yakni 381,68 mm. Lamanya masa hidup jenis udang mantis ini diperkirakan antara 6,7 sampai 8,5 tahun. Nilai laju eksploitasi (E) sebesar 0,42 mengindikasikan laju yang belum optimum.

Kata kunci: *Udang mantis, pertumbuhan, laju eksploitasi, masa hidup, Kuala Tungkal*

Abstract

This study aim was to reveal the population structure, growth, life span and exploitation rate of mantis shrimp (*Harpiosquilla raphidea* Fabricius, 1798). This research was conducted in Kuala Tungkal, Tanjung Jabung Barat, Jambi from July 2009 to June 2010 and partially carried out periodically. The results showed the difference in group size distribution between the mantis shrimp caught in the intertidal and those caught in subtidal areas. The length of the mantis shrimps in the intertidal area ranged from 25 to 233 mm with the dominant length was 79-96 mm, while in the subtidal area the length ranged from 160-366 with dominant length between 193-258 mm. Growth coefficient (K) was 0.14 for males and 0.11 for females; while L_∞ was the same for the two sexes, i.e. 381.68 mm. The life-span of the shrimp was estimated to be 6.7 to 8.5 years. The value of exploitation rate (E) was 0.42 indicating a not optimum exploitation rate of the shrimp.

Key words: *mantis shrimp, growth, exploitation rate, life-span, Kuala Tungkal*

Introduction

In the fishery point of view, macrobenthic communities of demersal invertebrates and fish in marine soft-sediment have contributed to the global fishery, especially in Asia (Colloca *et al*., 2003; Garces *et al*., 2006; Lui *et al*., 2007). Of those communities, many species of mantis shrimp is commercially valuable species, such as *Oratosquilla oratoria* (Kodama *et al*., 2004), *Squilla* sp. (Musa & Wei, 2008), and *Harpiosquilla raphidea* (Wardiatno & Mashar, 2010). As fisheries product mantis shrimp can be found regularly in fish markets of several countries, such as Spain, Italy, Egypt and Morocco (Abello & Martin, 1993).

The spearer mantis shrimp, *Harpiosquilla raphidea* lives on muddy bottoms in coastal waters around Indonesia. In a mudflat developed in the mouth of Tungkal river of Province Jambi, the shrimp is exploited commercially, mainly by small bottom-trawlers and gill net due to its economical value. Live caught mantis shrimp by the fishermen costs around USD 3.5 per individual with 7–9 inch size (Personal observations; 2009). The size of the shrimp may attain 335 mm (Manning, 1969; Moosa, 2000). The shrimp is mostly exported to Hong Kong and Taiwan, and the demand increases in years.

Research on orders stomatopoda has been done a lot for a long time, including on the ecology of economically important stomatopoda (Lui, 2005), the behavior of mantis shrimp (Manfrin & Piccinetti, 1970; Schiff, 1989; Heitler *et al*., 2000), population dynamics

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of *Squilla mantis* (Griffiths & Blaine, 1988 ; Abelló & Martin, 1993), food habit (Froglia & Gianinni, 1989), the ecological function of the retina of the eye (Cronin *et al*., 1994; Cronin *et al*., 2000), the influence of environment on the distribution of the mantis shrimp (Abelló & Macpherson, 1990), and genetic population (Barber *et al*., 2002). However, research on *Harpiosquilla raphidea* has not been much done, if any. Data and information about *H. raphidea* were limited to the taxonomy and morphology (Manning, 1969; Moosa, 2000; Azmarina, 2007; Ahyong *et al*., 2008), or reproductive biology (Wardiatno & Mashar, 2010). This paper presents the information on the biology of *Harpiosquilla raphidea* with a highlight to its population dynamics.

Materials and Methods

Study area

The present study was carried out on an intertidal mudflat developed at the mouth of Tungkal River, Tanjung Jabung Barat District, Province Jambi (Figure 1). At extreme low spring tides the mudflat is exposed for about 1 km seaward. *Harpiosquilla raphidea* occurs over almost the entire mudflat. The depth of the sediment column was at least 50 cm, and could probably reach more than 2.0 meter. The water characteristics are as follows: temperature ranged from 28.2 to 30.5 °C, salinity ranged from 15 to 19 psu, and oxygen concentration ranged from 6.7–7.6 ppm.

Sampling of Harpiosquilla raphidea

Mantis shrimp samples were taken from two sites, i.e. intertidal and sub-tidal areas. Mantis shrimps of subtidal area were obtained from the mantis shrimp catch of fishermen using gill nets. While the mantis shrimp samples from the intertidal areas were caught by the sweeping area method using sondong and mini trawl.

The total number of mantis shrimp are caught during the study was 2109 individuals, comprising 1294 individuals caught by gillnet and 815 individuals caught with sondong and mini-trawlers. Collected shrimps were measured to obtain the Kubo's body length [abbreviated as BL: from the base of the rostrum to the anterior edge of the median notch of the telson (Ohtomi *et al*., 1992; Kubo *et al*., 1959)]. Measurements were made to the nearest 0.1 cm using caliper. The weight was measured as well using a balance to the nearest 0.1 g. Sex was determined by the presence or absence of penis located at the base of a pair of third pereiopods on the eighth thoracic segment (Kubo *et al*., 1959), unless evident by the conspicuous presence of ovaries in females.

Data analysis

Length frequency distribution analysis is used to determine the distribution of the mantis shrimp is based on group size. Frequency distribution analysis was conducted with Battacharya method (Sparre & Venema, 1999) using the program FISAT II.

Analysis of the length-weight relationship is used to determine growth patterns of mantis shrimp using regression tests following Effendie (1997). To further strengthen the testing in determining the closeness of relations between the two parameters (b value), t-test may be performed with the following formula by Walpole (1992).

Ford-Walford plot was used for estimating growth parameters L_∞ and K from the von Bertalanffy

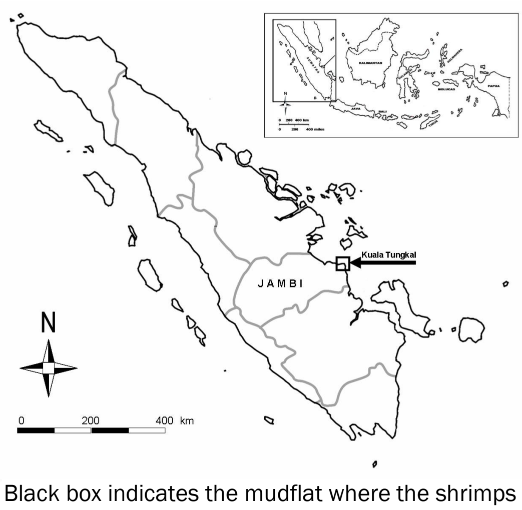

Figure 1. Research location. Black box indicates the mudflat where the shrimps were collected (Adopted from Wardiatno & Mashar, 2010).

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Ford-Walford plot was used for estimating growth parameters L_∞ and K from the von Bertalanffy equation with the same sampling time interval (King, 1995). While the theoretical age at length zero was estimated separately using an empirical equation as described in Pauly (1984). The results of measurements of growth parameters were used as a basis to estimate the time required by the mantis shrimp to achieve maximum growth.

Exploitation rate analysis is used to determine the rate of capture mantis shrimp in the study sites. Exploitation rate analysis is performed only on mantis shrimp catches by gillnet in subtidal areas. The rate of exploitation is determined by comparing the catch mortality (F) on total mortality (Z) (Beverton & Holt, 1957; Pauly, 1984; Pauly, 1980 *in* Sparre & Venema, 1999). The exploitation rate is then compared to the optimum rate according to Gulland (1971) *in* Pauly (1984) which is 0.5.

Results and Discussion

Length frequency distribution of Harpiosquilla raphidea

Number of mantis shrimp are caught during the study was 2109 individuals consisting of 1294 individuals (549 males and 745 females) that were captured in the subtidal area and 815 individuals (331 males and 484 females) that were captured in the intertidal area (see Figure 2). By sex, number of female mantis shrimp are caught at the study site, both in intertidal and subtidal areas, is higher than the male. This condition is consistent with the results of Abello & Martin (1993) and Hamano et al. (1987) who conducted a research on the mantis shrimp, *Squilla mantis*.

Based on Figure 2 it seems that there are two groups due to size distribution of the mantis shrimp *Harpiosquilla raphidea* with relatively similar pattern in both males and females. The two groups showed differences in the size distribution of group size mantis shrimp is caught in the intertidal and subtidal areas. Group size of the left, both in males and females, showed the group the size of the mantis shrimp intertidal areas, while the right shows the size of the mantis shrimp size groups subtidal areas. It is obvious that there are differences between the distribution of group size mantis shrimp caught in the intertidal with those caught in subtidal areas. In intertidal areas, mantis shrimp were caught in the range of length of 25 mm to 233 mm and were dominated by the mantis shrimp the size of 79-96 mm, both males and females. While in the subtidal area, mantis shrimp caught ranged from 160 mm to 366 mm which were dominated by the mantis shrimp size 193-258 mm, both males and females. The results of t-test on difference of two regression analysis (Fowler & Cohen, 1992) between the regression of the size distribution of the mantis shrimp intertidal areas with subtidal areas indicate a significant difference (at 95% confidence interval) at both the regression. T-test results showed that the population size of the mantis shrimp in the intertidal area is different from the size of the mantis shrimp populations in subtidal areas.

In general, the length of the mantis shrimp in the study sites varies greatly and have a fairly wide range of length between 25 mm to 366 mm. This may

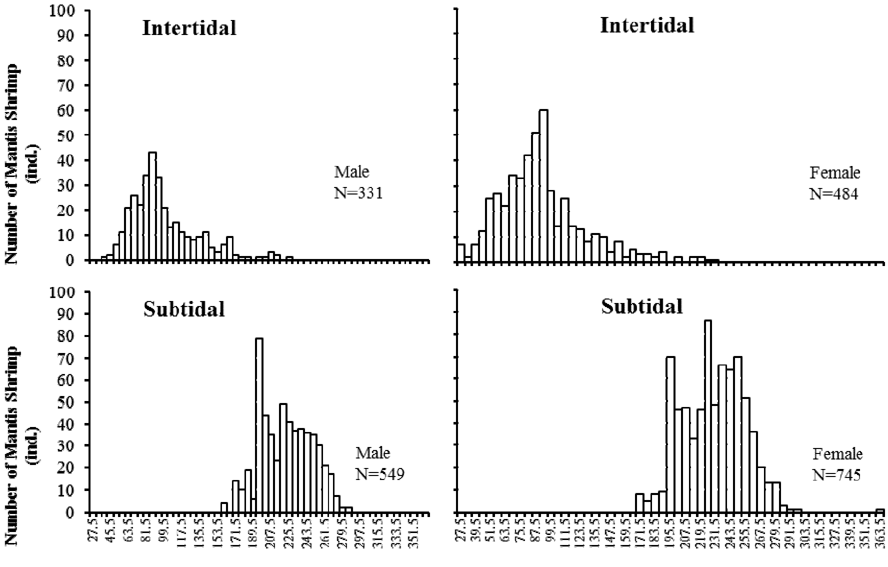

Figure 2. Length distribution of males and felames *Harpiosquilla raphidea* caught in the intertidal and subtidal area.

reflect that the coastal waters of Kuala Tungkal Jambi is a very suitable habitat and preferred by the mantis shrimp, especially *Harpiosquilla raphidea*. In addition, the facts show that the mantis shrimp *H. raphidea* been exploited more than 30 years in Kuala Tungkal and until recently, quantitatively, the mantis shrimp catches are still quite high, between 1.8 million to 2.4 million individuals per year in the last seven years (DPK Kabupaten Tanjabar, 2010). Furthermore, the maximum length of the mantis shrimp caught during the study, i.e. 366 mm in the subtidal area, was the longest ever found. The length is greater than the mantis shrimp *H. raphidea* ever reported by Manning (1969) with a length of 335 mm and Moosa (1991, 2000) with a length of 266 mm and 335 mm, or Halomoan (1999) of 245 mm for *H. harpax*; and also Ahyong (2001) of 262 mm for *H. harpax* and 257 mm for *H. japonica.*

Related to its distributon, based on these results it is known that the mantis shrimp species *H. raphidea* have sufficiently broad distribution, ranging from the intertidal to the subtidal area. It is in accordance with the Manning (1969) and Moosa (1991; 2000) that the mantis shrimp (especially genus *Harpiosquilla*) has a wide distribution ranging from a depth of 2 meters to a depth of 43 meters, even some species can reach a depth of 92 meters. The results indicate that the intertidal area is a habitat for young mantis shrimp (nursery ground). This may be related to the availability of much-needed source of food during its growth. When nearly mature, mantis shrimp migrate to the subtidal area to mate and spawn, then a young mantis shrimp migrate into the intertidal area to continue the growth process, and so on. Mantis shrimp's behavior is the same as the behavior of crustaceans in general: that when a young age, they inhabit the intertidal area, then when nearly mature, they migrate to deeper waters for mating and spawning (Anggraeni, 2001).

Growth

The results of the analysis of length-weight relationship showed that the growth pattern of the mantis shrimp, both males and females, are negative allometric (b <3), i.e. weight gain is not as fast as the length (see Table 1). In statistical point of view, the length-weight relationship equation mantis shrimp in general have a very close correlation. It is based on the value of the correlation coefficient (r) which approaches the value 1 at all observation stations, both in intertidal and subtidal. The magnitude of this correlation coefficient indicates that the length of the mantis shrimp followed by increments of body weight. It is also a common trait of the crustaceans that usually experience changes in body shape during growth (Hartnoll, 1982).

Based on the t-test against the value of growth coefficient (b) at 95% confidence interval was found that the value of b significantly different at each site. The discrepancy of b-value indicates that the habitat and sex may affect the growth of the mantis shrimp.

Growth patterns of aquatic biota that are allometric negative, in general can be caused by over-fishing, biological competition, and/or predator-prey

Tabel 1. Length-weigh relationship in the mantis shrimp *Harpiosquilla raphidea.*

Site	Sex	Length-weight equation	b-valuae range (α=0,05)	Growth pattern (After t-test at α=0,05)
Intertidal N=815	Male	$W = 3E\text{-}05L^{2,743}$ R^2=0,876; r=0,936	2,686-2,800	Negative Allometric
	Female	$W = 4E\text{-}05L^{2,687}$ R^2=0,885; r=0,941	2,643-2,731	
Subtidal N=1294	Male	$W = 0,0003L^{2,356}$ R^2=0,896; r=0,947	2,322-2,390	
	Female	$W = 0,0002L^{2,413}$ R^2=0,779; r=0,883	2,366-2,460	

Tabel 2. Growth parameter K, L_∞, dan t_0 of male and female *Harpiosquilla raphidea*

Parameter	Male	Female
K (per month)	0,14	0,11
L_∞ (mm)	381,68	381,68
t_0 (month)	-0,5533	-0,3802

relationships. In the mantis shrimp, regarding the condition of the study area, the growth pattern of negative allometric, was more due to the high level of competition both between mantis shrimp populations competition and the competition between mantis shrimp population and the fish/other crustacean species. Study site was inhabited by various species of fish/crustacean with a fairly high abundance. This was seen during the study that the number of mantis shrimp caught, either by sondong or mini trawlers, the percentage was relatively small or even very small compared to total catches, both iterms of species and abundance (Ali Mashar 2007; personal observation). Thus, the mantis shrimp can actually be said to be a by-catch of sondong and mini trawlers. This condition is in line with several other studies showing that the mantis shrimp is a bycatch of fishing gear using a bottom net, such as trawling (Dell & Sumpton 1999; Zynudheen *et al*. 2004; Lui *et al*. 2007).

Predator-prey might also play important role for the shrimp population. Although the shrimp typically inhabits deep burrows, they are susceptible to predation by other animals because they sometimes venture outside their burrow entrances. Posey (1985) did an experiment with callianassid shrimps, and he found that under test conditions, the callianassid shrimp spent over 25% of the time within 2 cm of the burrow entrance. The shrimp were also observed to move from one burrow to another and were often found with part of an appendage exposed above the surface. Potential predator for the mantis shrimp in the study site is crabs, predatory fishes or shark and rays. However, the last two animals are rarely found in the area.

Based on the Ford-Walford plot analysis, the growth parameters (K and L_∞) and t0, both males and females, can be seen in Table 2. The maximum length of the alleged value of (L_∞) equal to the male mantis shrimp mantis shrimp females, which is 381.68 mm. Then, the values of growth parameters are used as basis to get the mantis shrimp von Bertalanffy equation, i.e. $L_t=381,68*(1-e^{[-0,14(t+0,5533)]})])$ for males and $L_t=381,68*(1-e^{[-0,11(t+0,3802)]})$ for females. Based on the von Bertalanffy equations, the mantis shrimp growth curve shown in Figure 3.

Growth coefficient (K) of *Harpiosquilla raphidea* was almost the same or not much different when compared to other mantis shrimp in Order Stomatopoda. K value of *H. raphidea* almost equal to the value K of *Squilla mantis*, namely 1.6 and 1.3 per year (0:13 and 0:11 per month) for males and females (Abello & Martin, 1993) and the mean value of K in *Oratosquilla stephensoni*, namely 1.52 per year (0.13 per month) (Dell & Sumpton, 1999), but slightly higher than the K value of *Oratosquilla oratory*, namely 0.898 and 1.102 per year (0.07 and 0.09 per month) for males and females (Ohtomi & Shimizu, 1994).

When compared with non-group crustaceans stomatopoda orders, the K value of *Harpiosquilla raphidea* was generally lower. Shrimp *Aristeus antennatus* in the western Mediterranean Sea had a K value of 0.25 and 0.3 per month for males and females (Cartes & Demestre, 2003); shrimp *Pandalus borealis* in the Gulf Skjalfandi, North Iceland had a mean K value of 0.46 per month (Mamie, 2008), and the shrimp *Penaeus indicus* in the Bay of Maputo, southern Mozambique with an average value of K 0.39 per month (Jorgensen *et al*. 1991 *in* Franco *et al*. 2006). Differences in rates of growth of the mantis shrimp *H. raphidea* and group of shrimp from stomatopoda with groups other than crustaceans stomatopoda orders can be caused by genetic factors and body size of each

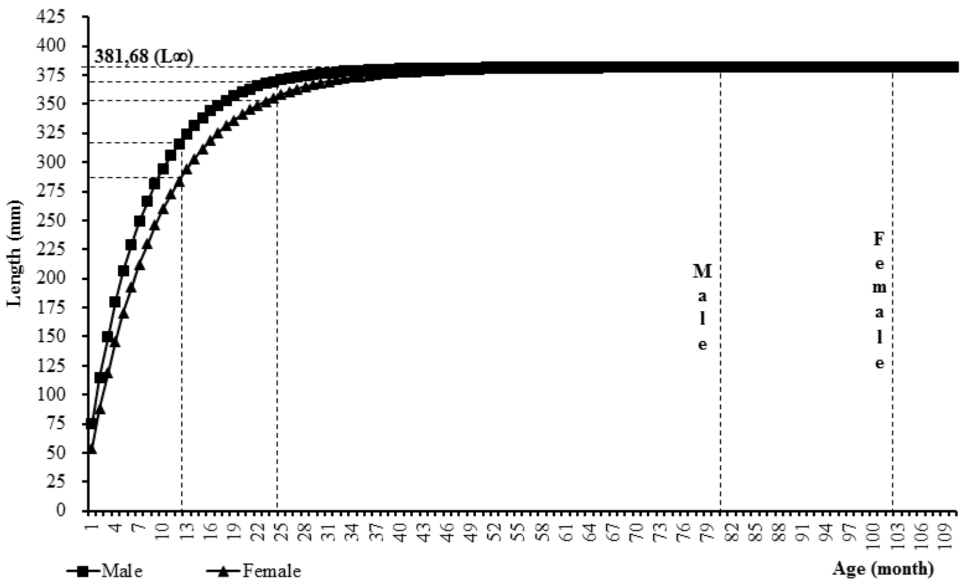

Figure 3. Growth curve of mantis shrimp, *Harpiosquilla raphidea*

species. This fact, in tune with the opinion of Pauly (1994) *in* Welcomme (2001), which states that the difference in rate of growth of aquatic biota can be caused by internal factors, including genetic factors that directly limit the maximum age and body size of these biota.

Figure 3 shows that in the first phase of its life, the mantis shrimp had an extremely fast growth rates, and was able to reach a large size with a length of more than 275 mm. Then enter the second year, the mantis shrimp growth began to decline, but not too slow. After that, in the third phase of its life, the mantis shrimp growth was very slow and stagnant until it reaches maximum size. In terms of sex, mantis shrimp growth between males and females are relatively similar and showed no difference. It is also expressed by t-test on regression analysis of the growth of male and female mantis shrimp that showed no significant difference between the growth patterns of the female mantis shrimp with the growth pattern of the male mantis shrimp.

Based on the mantis shrimp growth curve in Figure 3 above, it can be explained that the female mantis shrimp reach the asymptotic length is longer (102 months) than males (80 months). That is because the female mantis shrimp has a smaller coefficient of growth so that growth in achieving the L_∞ is slower than males. In addition, the energy source of the food consumed by female shrimp at a particular phase, will be prioritized for the formation and maturation of the gonads rather than to growth. Thus, *Harpiosquilla raphidea* have a life span of between 80 months to 102 months (6.7 to 8.5 years) and relatively long-lived biota with a slow growth.

Life-span of *Harpiosquilla raphidea* was higher than that of some other types of mantis shrimps; such as *Squilla mantis* with the life-span of 1.5 years (Abello & Martin, 1993), *Oratosquilla oratory* with a life-span from 3 to 3.5 years (Hamano *et al*., 1987), and *Oratosquilla stephensoni* with life-span of 2.5 years (Dell & Sumpton, 1999). Life-span *H. raphidea* was higher than that of other mantis shrimps, although other species of mantis shrimps have almost the same K value. This can be caused by L_∞ of *H. raphidea* which was higher than those of other mantis shrimps, such as *Squilla mantis*: L_∞ = 200 mm (Abello & Martin, 1993); *Oratosquilla oratory*: L_∞ = 139.9 mm (Ohtomi & Shimizu, 1994); and *O. stephensoni*: L_∞ = 163 mm (Dell & Sumpton 1999)).

Exploitation rate

In mantis shrimp populations that have been exploited, mortality is a combination of natural mortality and mortality due to fishing. The rate of total mortality (Z) of the mantis shrimp, *Harpiosquilla raphidea* is 0.820; with the rate of natural mortality (M) 0.473, and fishing mortality rate (F) 0.347 at the rate of exploitation (E) 0.42. For the rate of exploitation, when compared with the optimum exploitation rate proposed by Gulland (1971) *in* Pauly (1984), namely 0.5, then the rate of exploitation of mantis shrimp in Kuala Tungkal, Jambi was still below the optimum value. Thus, there are still opportunities to elevate the efforts to capture mantis shrimp in Kuala Tungkal. However, study on stock assessment is also needed to ensure the sustainability use of the mantis shrimp resource in Kuala Tungkal.

Conclusion

Mantis shrimp, Harpiosquilla raphidea in Kuala Tungkal have quite broad distribution, ranging from the intertidal to the subtidal area. Intertidal area is a nursery ground for juveniles. H. raphidea mantis shrimp belonging to the age of relatively long, but growth is slow to reach maximum size. In general, the growth rate of the mantis shrimp H. raphidea almost the same or not much different from other mantis shrimp species of the order stomatopoda, but has a longer life span, ie 6.7 years to 8.5 years. By seeing the exploitation rate, there is still opportunity to enhance the efforts in mantis shrimp fisheries in Kuala Tungkal.

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