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Article

Growth aspect of squid (*Loligo chinensis*) from the Banyuasin Coastal Waters, South Sumatra, Indonesia

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Abstract
Squid (*Loligo chinensis*) played an important role in small scale fisheries in Banyuasin Coastal Waters, however, the information and publications were limited. This study aimed to estimate the length at first capture ($L_{C50\%}$), the length at first maturity (L_m), growth pattern and condition factor of *L. chinensis* from Banyuasin Coastal Waters of South Sumatra. The squids were observed for samples in April 2018 and March 2019 using a stationary lift net. During the observation, the squid measurement was conducted on 1179 individuals. The mantle length ranged was 40-210 mm and their body weight ranged was 2-42 gr. The value of $L_{C50\%}$, L_m and $½L_\infty$ were obtained at 103 mm, 147 mm, and 110.5 mm respectively. The analysis results of the length-weight relationship ($W = 0.0145L^{1.4618}$, $R^2 = 0.9265$ and $P < 0.05$) showed that their growth pattern was negative allometric ($b < 3$). The mean relative condition factor ($K_n = 1.01$) above the critical value limits (K=0.56) confirmed that the environmental condition of Banyuasin Coastal Waters suitable for the *L. chinensis* growth. However, should be careful with their length size of the squid catch were not feasible in the capture.

Key words: allometric, Banyuasin, condition factor, *Loligo chinensis*.

Introduction

Banyuasin coastal waters are strongly influenced by Sungsang estuary and have good fish diversity (Fauziyah et al. 2019b; Fauziyah et al. 2019c; Fauziyah et al. 2019a). This area is essential for the local fishing community (Fauziyah et al. 2018; Fauziyah et al. 2019b) due to not only maritime transport and settlement but as fishing center activities (Sari et al. 2013; Nurhayati et al. 2016).

In Banyuasin Coastal Waters, squid (*L. chinensis*) is the by-catch of fishing operation but it has high economic value (Fauziyah et al. 2012; Fauziyah et al. 2013). The composition of squid catches using the fishing gear of stationary lift net in Banyuasin Coastal Waters ranged from 7-12% (Gustaman et al. 2012). On the other hand, in the Cirebon waters, the squid is the main catch of the "bouke ami" net with an average percentage of catch more than 50% of total fish landed (Puspasari and Triharyuni 2013).

Although as a by-catch, due to its high economic value (Gustaman et al. 2012), squid plays an important role for the small scale fisheries in Banyuasin Coastal Waters and also in other waters in

Indonesia such as Rembang (Puspasari and Triharyuni 2013), Bangka (Oktariza et al. 2015) and Lampung (Yudha 2011). In addition, using the stationary lift net, the squid was also caught by local fishermen in the Java Sea using pure seine and seine net (Puspasari and Triharyuni 2013).

Besides squids play an important role in the small-scale fisheries, they play an important role in the marine food chain due to belong to the third trophic level in the food chain (Emam et al. 2014). However, the information and publications on squid fisheries in Banyuasin are limited therefore, a preliminary study on squid resources is needed. One of them is the study of growth aspects such as size distribution, morphometric, length-weight relationship (LWR), condition factor, growth pattern, age, life cycle, and growth parameters (Arkhipkin et al. 1998; Bat et al. 2009; Guerra and Castro 2012; Nuzapril et al. 2013; Ferreri 2014; Muchlisin et al. 2014; Oktariza et al. 2015; Fauziyah et al. 2016).

Some studies on the squid growth in the Indonesia waters had been conducted by some authors such as biological characteristics of squid in the Java Sea (Puspasari and Triharyuni 2013), the LWR of squid in the Bangka waters (Bangka (Oktariza et al. 2015), morphometric and condition factor of squid in Northern Coast of Central Java (Nuzapril et al. 2013), the LWR and condition factor of squid in Northern Sea of Aceh (Muchlisin et al. 2014). The LWR research can reflect population dynamics, growth patterns, gonadal development and general conditions, and the body shapes comparison from different fish groups (Sarma 2015). The LWR was useful in fisheries management for both basic research and applications (Shingadia 2015) and as an important tool in fisheries biology, ecology, physiology, conservation, and fisheries assessment as well as water management and conservation (Lawson and Olagundoye 2011; Hossain and Sultana 2016).

Very little is known about the growth aspect of squid in Banyuasin coastal waters. The study aimed to estimate the length at first capture, the length at first maturity, growths pattern and condition factor for the squid from Banyuasin coastal waters. The study results are expected to be useful for the basis of the squid population management in Banyuasin coastal waters.

Material and methods

The study was conducted in April 2018 and March 2019 in Banyuasin Coastal Waters of South Sumatra, Indonesia (Figure 1).

During the observation, the stationary lift nets (11 samples units in 2018 and 17 samples units in 2019) were used. All measurements were conducted on the stationary lift net included mantle length (L) and body weight (W). The estimation of the length-at first capture ($L_{C50\%}$) using the standard logistic curve method (Saputra et al. 2010; Fauziyah et al. 2016). The feasible fish size for capture was obtained by the ratio of the $L_{C50\%}$ value to the asymptotic length (L_∞). And other opinions used length-at maturity (L_m) as the critical limit value (Hoggarth et al. 2006; Amponsah et al. 2016). The mean length size of the fish capture had been feasible if the ratio ($L_{C50\%}/L_\infty$) > 0.5. The estimation of the L_∞ and L_m value was obtained by the formula (Pauly 1983; Hoggarth et al. 2006; Amponsah et al. 2016) as follows:

$$L_\infty = \frac{L_{max}}{0.95}$$
$$L_m = \frac{2}{3} L_\infty$$

where L_∞ is the asymptotic length, L_{max} is the maximum size of mantle length from the squid catch, and L_m is the length-at first maturity.

The growth pattern was determined through the LWR analysis using the equation (Le Cren 1951; Froese 2006):

$$W = aL^b$$
$$\log W = \log a + b \log L$$

where W is the squid weight in grams, L is the squid mantle length in centimeters, log a is the exponent describing the change rate of weight with length and b is the slope of the regression model or the allometric coefficient.

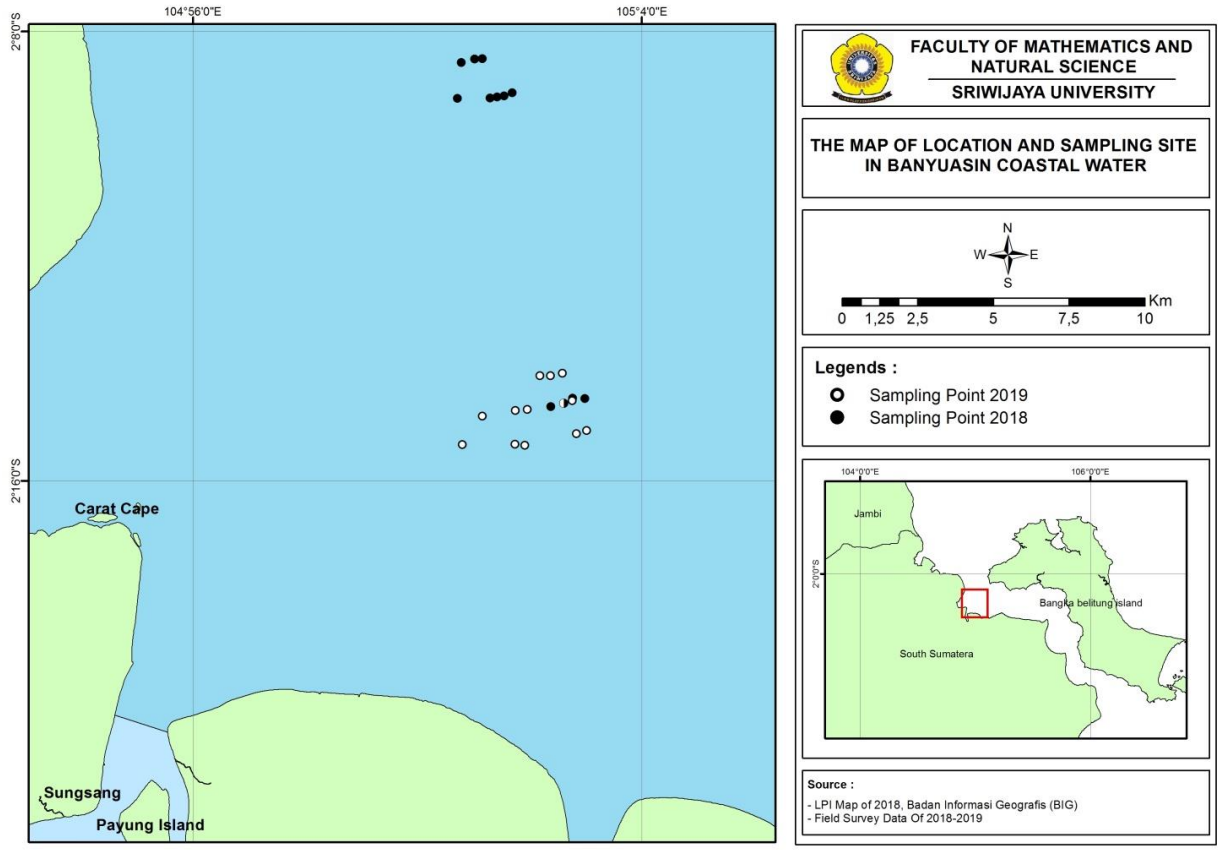


Figure 1. Location and sampling in Banyuasin Coastal Waters. The black circle indicated the sampling position in 2018 while the white circle indicated the sampling position in 2019. Sampling was conducted using a stationary lift net.

In order to determine the growth pattern, Bailey's t-test was needed (Thomas 2013; Nair et al. 2015). The t-test was run to determine significant differences from the isometric value (b = 3) with significant level at 5% ($P < 0.05$). The formula of Bailey's t-test as follows (Fauziyah et al. 2019d):

$$t_s = \left|\frac{3-b}{Sb}\right|$$

where H_0 is b = 3, H_1 is b ≠ 3, t_s is testing value b is regression coefficient of log-transformed data and Sb is the standard error of b. If the t_s value ≤ t_{table} indicated the isometric growth pattern whereas if $t_s > t_{table}$ indicated the allometric growth pattern. When the b value less than 3, their growth pattern was negative allometric. On the contrary, positive allometric if the b value greater than 3 (Sangun et al. 2007; Benchikh et al. 2018).

The relative condition factor (K_n) and Fulton's condition factor (K) were used in this study. Fulton's condition factor was used for the isometric growth pattern whereas the relative condition factor for the allometric growth pattern (Nuzapril et al. 2013). Both condition factors were calculated based on the LWR results using the formula (Le Cren 1951; Ricker 1975; Karnik and Chakraborty 2001; Froese 2006; Nash et al. 2006; Nuzapril et al. 2013; Muchlisin et al. 2014; Ferreri 2014; Emam et al. 2014):

$$K = 10^5 \frac{W}{L^3}$$
$$K_n = \frac{W}{aL^b}$$

where K is Fulton's condition factor, K_n is the relative condition factor, W is the squid weight in grams, and L is the squid mantle length in millimeters and 10^5 is the factor is used to bring K close to unity.

Results

The values of $L_{C50\%}$, L_∞ and L_m

The length-frequency data for 1,179 specimens of *L. chinensis* were used in this analysis. Mantle length (L) ranged from 40 to 210 mm and their weight ranged from 2 to 42 grams. The mean of the mantle length and their body weight were 105.5 mm and 13.5 gram respectively. The most specimens were found distributed in 101 to 110 mm (Figure 2). The L_∞ and $½L_\infty$ values observed were 221 and 110.5 mm respectively. The critical value for feasible capture was 110.5 mm. Figure 3 showed the length at first capture ($L_{C50\%}$) of *L. chinensis* using the catch curve based on normal cumulative distribution. The $L_{C50\%}$ value was 103 mm which was smaller than the critical value ($½L_\infty$ = 110.5).

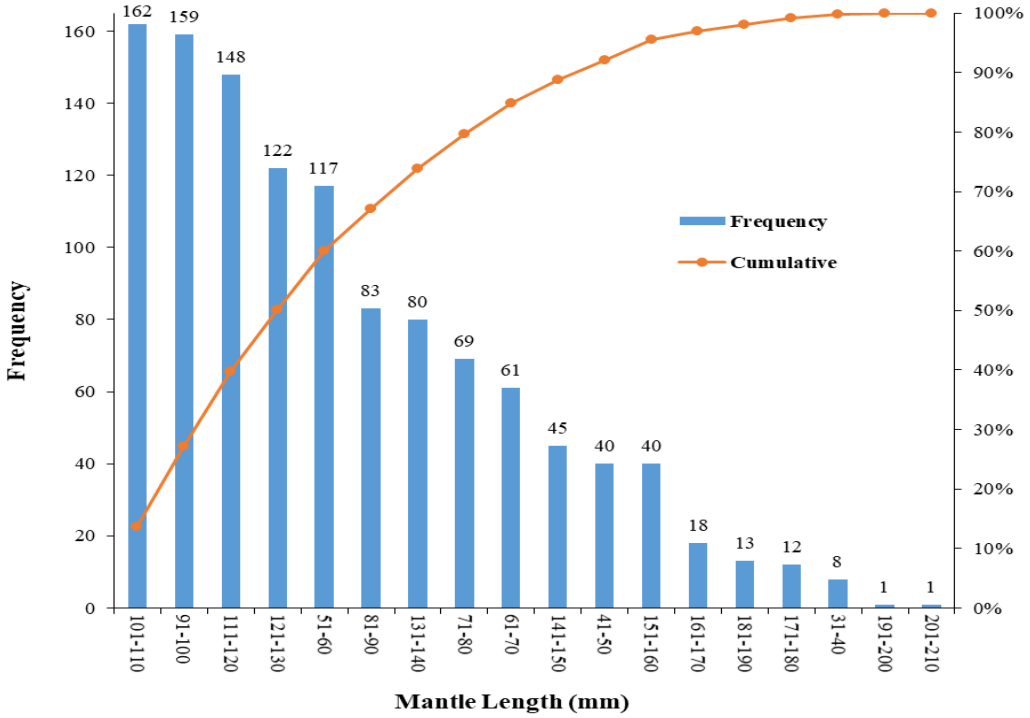


Figure 2. Pareto diagram for *L. chinensis* from Banyuasin Coastal Waters of South Sumatra. This diagram indicated a graphical overview of frequency distribution in ranking order from the most frequent to the least frequent. The first length group at X-axis (101-110 mm) showed the most frequently that the specimen was found.

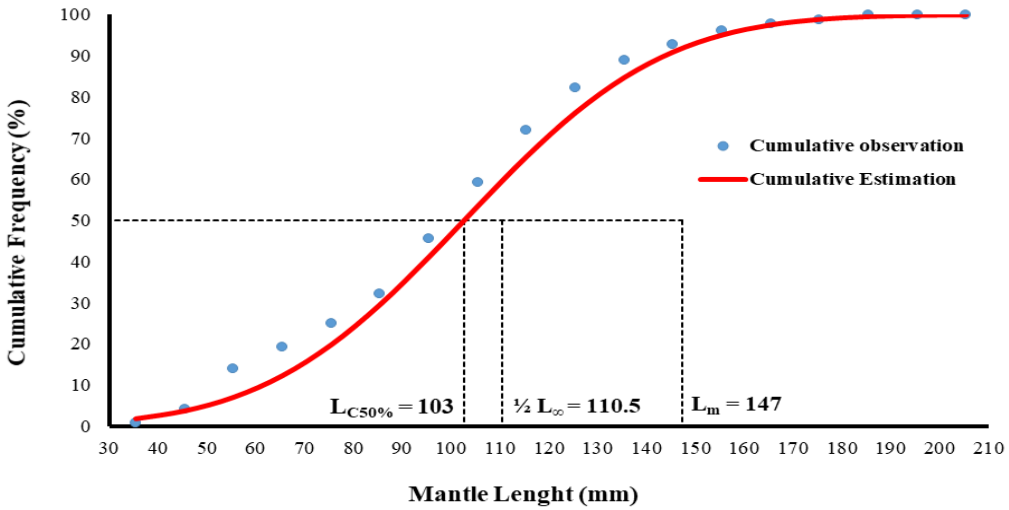


Figure 3. The length at first capture ($L_{C50\%}$), critical value ($½L\infty$) and length at maturity (Lm) for *L. chinensis* from Banyuasin Coastal Waters of South Sumatra. The blue dot indicates the cumulative observation and the red line indicates the cumulative prediction.

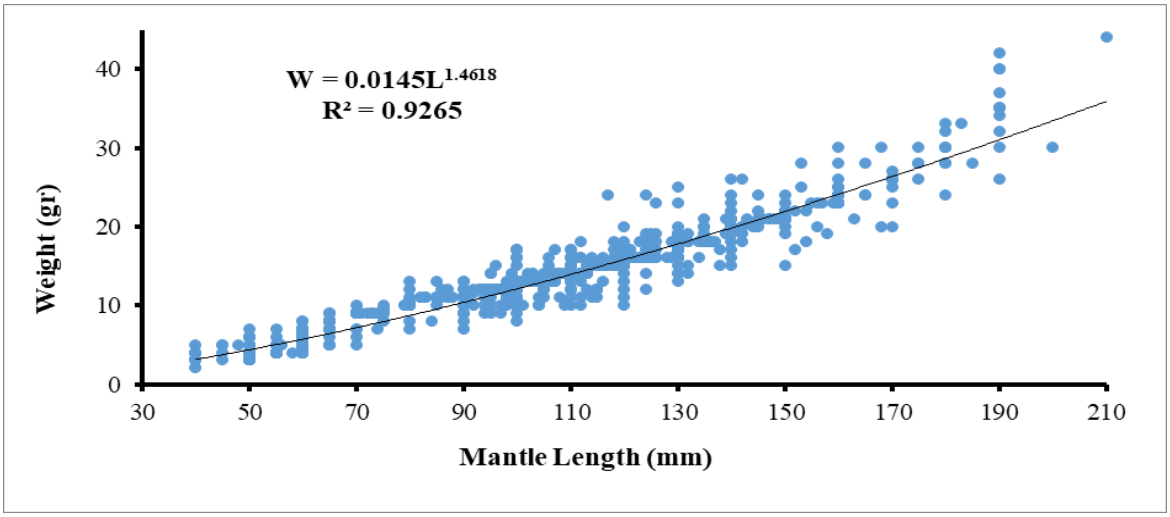
Length-weight relationship

The results of the LWR analysis were given di Table 1 and illustrated in Figure 4. F test showed that the mantle length diversity of *L. chinensis* can explain the bodyweight diversity simultaneously. Highly significant correlation coefficients values ($R^2 > 0.9$; $p < 0.05$) were obtained for this squid indicated that a very strong correlation between mantle length and body weight. The LWR analysis obtained was $W = 1.4618L^{1.4618}$ and the logarithmic formula could be written as Log W = 1.4618 Log L - 1.8391. The t_s value greater than t_{table} indicated that the b value significantly differs ($p < 0.05$) from the isometric value (b = 3). And the b value < 3 exhibited the growth pattern of *L. chinensis* was negative allometric growth.

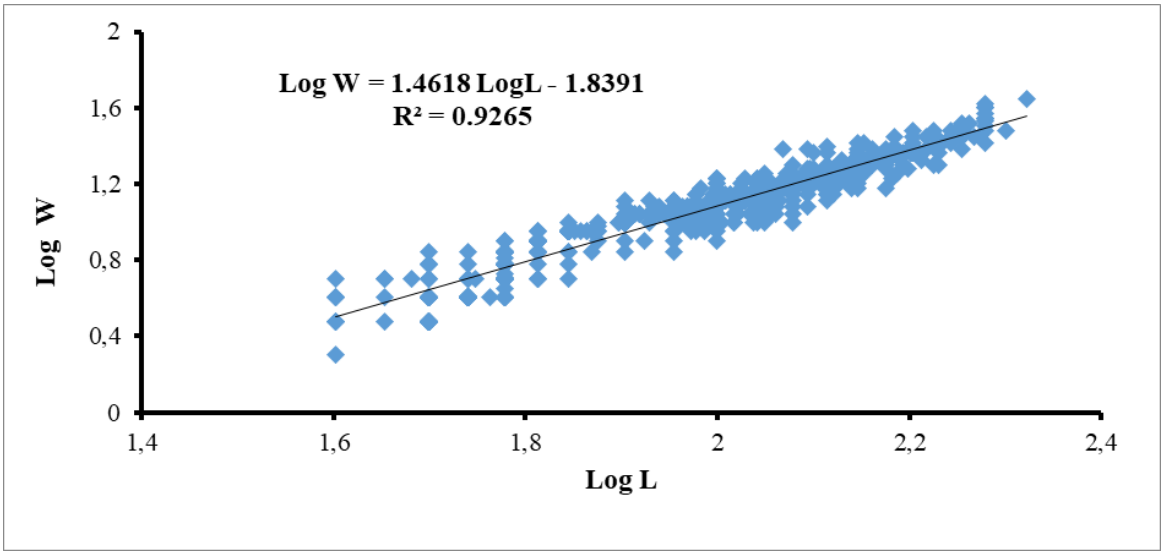
Table 1. Parameters of Length-Weight Relationships (LWRs) for *L. chinensis* in Banyuasin Coastal Waters of South Sumatra. The R^2 value > 0.86 indicates the model performance was very good.

Parameters of the relationship					Bailey's t-test		Growth pattern
W-L equation	S_b	Sig. F	R^2	t_{test} of b	t_{table}	$t_s=(3-b)/S_b$	
$W=0.4195L^{1.4618}$	0.012	0.00 [a]	0.926	121.8 [a]	2.244	128.14 [a]	Allometric (+)

[a]: significant at 5% level ($p<0.05$); S_b : standard error of b; b : regression coefficients



A. The power equation



B. The logarithmic equation

Figure 4. Length-weight relationship (LWR) for *L. chinensis* in Banyuasin Coastal Waters of South Sumatra. The LWR graphs can be expressed in terms of the power (A) and logarithmic (B) equations. Both of these equations produce the same values of R^2 (model performance parameter) and b (growth pattern parameter).

Condition factor

The result of Bailey's t-test had been indicated the allometric growth pattern for *L. chinensis* in Banyuasin Coastal Waters. Therefore, the condition factor analysis calculated by the formula of relative condition factor (K_n). The fluctuations of Kn values were represented in Fig. 5. The K_n value ranged from 0.63 to 1.59 with the mean value was 1.01±0.13. All of the K_n values were greater than the critical value (K=0.56) indicated that the environmental condition of Banyuasin Coastal Waters suitable for the growth of *L. chinensis*.

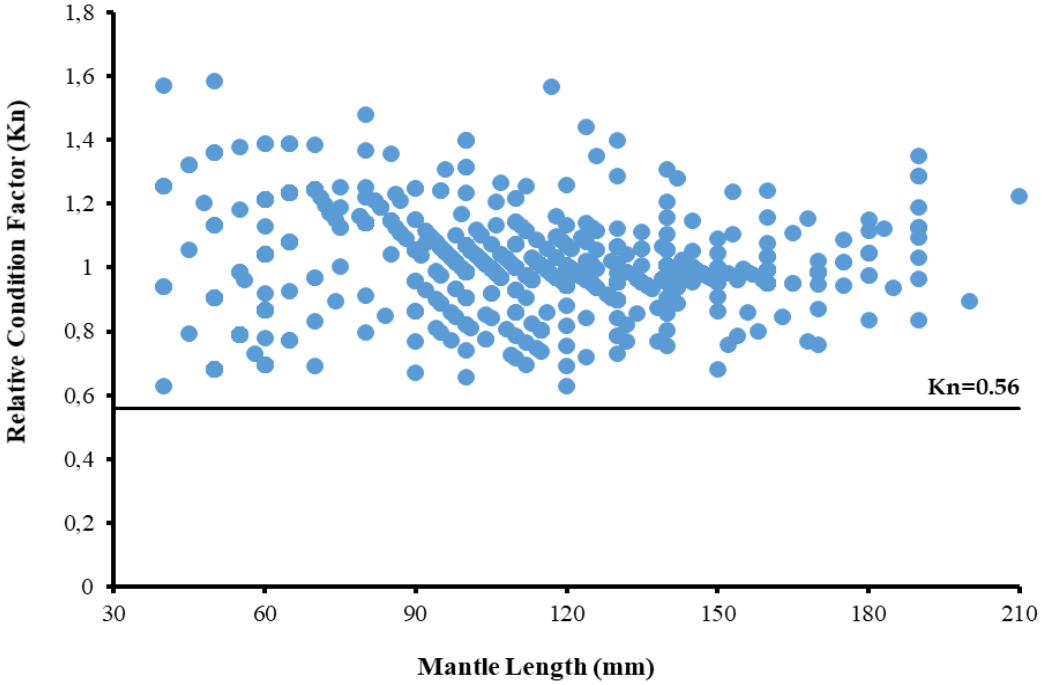


Figure 5. Variation in relative condition factor (K_n) of *L. chinensis* in Banyuasin Coastal Waters of South Sumatra. The Kn value for each specimen is greater than the critical point value (K_n = 0.56) indicating good conditions of well-being.

Discussion

Besides being important as a fishery resource, squid is also an indicator of large-scale oceanographic changes (Chen et al. 2007) and an important ecological species (Jackson 1998). There were at least 19 species of fish, 8 species of marine animals and 13 species of birds that were predators of squid (Jackson 1998).

The squid *L. chinensis* is an Indo-Pacific species (Jereb and Roper 2007) and one of the cephalopods that are fast-growing mollusks (Aneesh et al. 2014). Cephalopods are typically short-lived invertebrates and the lifespan of squid was estimated to average about 1 year (Jackson et al. 1997; Jackson and Moltschaniwsky 2001; Fang et al. 2016). Some tropical loliginids, including *L. chinensis* and *Loliolus noctiluca*, have been reported to have a life cycle of fewer than 200 days (Jackson et al. 1997). Variation in food availability, geographic and ecology condition can affect the variation of growth patterns (Chen and Chiu 2003).

Compared with observation in the Java Sea (Puspasari and Triharyuni 2013; Nuzapril et al. 2013), the mantle length of *L. chinensis* in this study tended to attain larger sizes but smaller than Bangka waters (Oktariza et al. 2015). The difference in the mantle length will affect the L_m and $L_{C50\%}$ values. This present study showed that the $L_{C50\%}$ value was smaller than both critical value (L_m and $½L_\infty$). It illustrated that the majority of the catch constituted juvenile squid. This L_m value was almost similar to the research in the Indian Ocean (Jereb and Roper 2007). If L_m has occurred earlier and $L_{50\%}$ was smaller, it showed evidence of squid population induced outgrowth to earlier maturation at smaller sizes. Maturity at length was positively related to the fishery abundance of squid and it was affected by the environmental condition (Pierce et al. 2005).

The b value from the present study (b = 1.4618) was statistically significant from the isometric value (b = 3, $p < 0.05$). The value was smaller than the other studies in the Bangka Waters with the b value of 1.632 (Oktariza et al. 2015) and the Lamongan waters (Mulyono et al. 2017) with the b value of 1.803. This result showed that the weight of the squid populations in this study increased more slowly. It indicated that squid populations in this study to allocate growth for reproductive tissue also more slowly. This condition was not good in order to maintain their sustainable stock from their high fishing pressure.

Based on the b value and Bailey's t-test for this study showed a negative allometric growth and it was similar to study on *L. chinensis* from Bangka waters (Oktariza et al. 2015), Lamongan waters (Mulyono et al. 2017), Central Java Waters (Nuzapril et al. 2013; Perangin-angin et al. 2015), Java Sea (Puspasari and Triharyuni 2013). The negative allometric growth also reported for *Sepioteuths lessoniana* from Jaffna Lagoon, Sri Lanka (Sivashanthini et al. 2009), *S. lessoniana* and *Uroteuthis* sp. from the northern sea of Aceh (Muchlisin et al. 2014) as well as *Loligo duvauceli* from Mumbai waters, west coast of India (Karnik and Chakraborty 2001). In contrast, *L. vulgaris* from the Cadiz Gulf (Spain) showed positive allometric growth (Vila et al. 2010). In general, cephalopods especially *Loligo* follows the allometric growth pattern (Karnik and Chakraborty 2001). The negative allometric growth (b < 3) showed that the squid became lighter (Nair et al. 2015). The negative allometric growth may be due to the unfavorable condition (Nair et al. 2015).

Variation in growth patterns reflected the change in body squid that can be analyzed by the condition factor (Le Cren 1951). If the growth pattern was the negative allometric, the 'K' value will tend to be decreased with increasing the mantle length (Emam et al. 2014) but it is not identical to the increase in size body (Zubia et al. 2014). The K value is the parameter of feeding condition (Le Cren 1951) or the fitness/wellbeing (Anene 2005), and also useful for monitoring of feeding intensity, age and growth rates of fish (Sinha et al. 2018). The high the 'K' values indicated favorable environmental conditions otherwise low values indicated the unfavorable environmental condition (Blackwell et al. 2000). Opinion for the critical limit of the 'K' value differs between researchers. One opinion said that the fish condition was considered as wellbeing or good condition if the 'K' value ≥ 1 (Le Cren 1951; Sachidanandamurthy and Yajurvedi 2008; Sinha et al. 2018) and other opinions said that the fishes with the 'K' value > 0.56 were considered as in good condition (Bennet 1970). The 'K' value in this study (K > 0.56) indicated that *L. chinensis* was in good condition of well-being. The 'K' value was strongly correlated to LWR, therefore, the b value was essential to assess the wellbeing of fish (Hamid et al. 2015). Therefore higher K indicated good feeding conditions for squid and it depends on seasonal changes and geographical differences.

Conclusion

This research provided basic information about the length-at first capture, length-at first maturity, asymptotic length, growths pattern and factor condition of squid *L chinensis* in Banyuasin Coastal Waters. The length average of this squid catch was not feasible due to the most catch constituted juvenile. The growth pattern of negative allometric had been observed in this study. The condition factor showed evidence this squid was in good condition of well-being but should be careful with the high fishing pressure and their length size of the squid catch was not feasible in the capture.

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