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Research Article

Population Structure and Life Table of Dog Conch (*Strombus turturella*) in Bangka Belitung Islands, Indonesia

Struktur Populasi dan Tabel Hidup Siput Gonggong (*Strombus turturella*) di Kepulauan Bangka Belitung, Indonesia

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Abstract

Dog Conch *(Strombus turturella)* has an essential economic value in Bangka Belitung Islands. Allegedly, the population of Dog Conch is decreasing due to overexploitation. The purpose of this study is to provide information related to the distribution of long frequency, growth pattern, age group, recruitment time estimation and life table of Dog Conch. This research took place on the coast of *Tukak* Village and *Anak Air* Island, Bangka Belitung Islands. Samples of Dog Conch were taken using 3x3 m^2 square. The shell length of Dog Conch found ranged between 18.18 to 77.49 mm, consisting of three age groups. Asymptotic length value (L_∞), growth coefficient (K) and theoretical age on zero-length (t_0) were 83.94 mm, 0.79/year and -0.152 sequentially. In the first year, Dog Conch grows to 50.18 mm and slows down when it grows older until it is 13 years old. The proportion of high mortality rate was at 1 to 2 years old and 3 to 4 years old or in adult individuals, while the highest life expectancy rate was in the age group of 0-1-year old or young individuals. It indicated that the high mortality rate was in the group in which people use to consume or sell in the markets

Abstrak

Siput gonggong *(Strombus turturella)* memiliki nilai ekonomis penting di Kepulauan Bangka Belitung. Diduga populasi siput gonggong semakin menurun akibat dari eksploitasi berlebihan. Tujuan penelitian ini adalah untuk memberikan informasi terkait distribusi frekuensi panjang, pola pertumbuhan, kelompok umur, estimasi waktu rekruitmen dan tabel hidup siput gonggong. Lokasi penelitian berada di Pesisir Desa Tukak dan Pulau Anak Air, Kepulauan Bangka Belitung.Pengambilan sampel siput gonggong dilakukan dengan menggunakan kuadrat 3x3 m^2. Panjang cangkang siput gonggong yang ditemukan berkisar antara 18.18 s.d 77.49 mm yang terdiri atas 3 kelompok umur. Nilai panjang *asymptotic* (L_∞), koefisien pertumbuhan (K) dan umur teoritis ketika panjang sama dengan nol (t_0) adalah 83.94 mm, 0.79/tahun dan -0.152 secara berurutan. Pada tahun pertama siput gonggong mengalami pertumbuhan, mencapai 50.18 mm dan melambat ketika umur semakin tua hingga umur 13 tahun. Proporsi laju kematian tinggi terdapat pada umur 1 s.d 2 tahun dan 3 s.d 4 tahun atau pada individu dewasa, sedangkan nilai harapan hidup tertinggi terdapat pada kelompok umur 0-1 tahun atau individu muda. Hal ini menunjukkan bahwa kematian tertinggi terdapat pada kelompok umur yang telah diambil oleh masyarakat untuk dikonsumsi dan dijual ke pasaran.

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1. Introduction

Dog Conch (*Strombus turturella*) was a sea organism of gastropod class which generally lived in the coast planted with seagrass as its habitat (Poutiers, 1998; Dody and Marasabessy, 2007; Supratman and Syamsudin, 2018). The distribution of Dog Conch covered the Indo-Pacific area, especially in South East Asia; such as Vietnam, Malaysia, Singapore, and Indonesia (Poutiers, 1998; Tan and Yeo, 2010; Dody, 2011). One of the areas in Indonesia where Dog Conch was found was Bangka Belitung Islands.

Dog Conch in Bangka Belitung Islands was one of the fishery commodities with high economic value (Doddy, 2011). All of the body parts of this type could be utilized, both the meat and the shell. Dog Conch meat was cooked for meals in the restaurants since it contained high protein and was rich in minerals, while its shell was used as accessories (Arularasan *et al*., 2010; Rasyid and Dody, 2018). Nowadays, the demand for Dog Conch is getting higher; however, the need for Dog Conch depends on the fishermen's catches. As a result, there is massive exploitation and has an impact on the decline of its population in nature. According to Dody (2011), there was a decline in the fishermen's catches in 2003 from 25 tons to 15 tons in 2017.

To overcome the decline in population that occurs continuously it is necessary to make an effort to manage Dog Conch sustainably. The efforts could be made through the setting the size of the catch, adding stocks of mother in nature from the cultivation process and making marine protected areas, so that reproductive mother stocks protected (Stoner *et al.*, 2012; Stoner, 1994; Cárdenas and Aranda, 2010). For these activities to succeed, some information related to the biological parameters, including population structure and life table of Dog Conch are in need to be obtained.

At present, studies related to the population structure and life table of Dog Conch has not been carried out yet in Bangka Belitung Islands, or even in Indonesia. The previous studies were only limited to the growth parameters, spawning, distribution and habitat condition (Amini and Pralampita, 1987; Dody, 2011; Supratman and Syamsudin, 2018; Muzahar and Hakim, 2019; Ramses *et al*., 2019). Compared to the other strombus genotype, there have been some studies related to the population structure of *S. canarium* carried out in Johor Strait, Malaysia and *S. Gigas* in Carribean waters (Cob *et al*., 2009; Cárdenas and Aranda 2014). However, the previous studies did not discuss in detail about life table. While information about population structure and life table is very needed because it will be related to the harvesting plan in the cultivation and management of Dog Conch. The purpose of this research is to analyze the size class frequency distribution, growth pattern, age groups, estimated recruitment time and life table of Dog Conch.

2. Materials and Methods

2.1 Location and Time of Research

This research was carried out on the coast of *Tukak* Village and *Anak Air* Island, Bangka Belitung Islands, Indonesia in July to December 2014. Samples were taken in the seagrass ecosystem which was the catching area of Dog Conch. Dog Conch sampling was divided into four stations; they were two stations on the coast of *Tukak* Village and two stations in *Anak Air* Island (Figure 1).

2.2 Sampling Procedure on the Site

Dog Conch sampling was done using a square of 3 x 3 m^2. Line transect from the land to the sea was drawn in every station with a distance between transect about 50 meters. Then in every transect, a square of 3 x 3 m^2 was placed 50 meters between squares. Therefore, there were six transects where there were six squares in every transect. So, the number of square in each station was 36 squares (Figure 2). Individuals found in the square were counted, then they were preserved in 70% alcohol and stored in sample plastics to be analyzed in the Ecology Laboratory-SITH, Institut Teknologi Bandung.

2.3 Sample Measurement Procedure in the Laboratory

The collected Dog Conch samples were measured the shell length using a caliper with an accuracy of 0.02 mm. The measurement was performed from the apex on the posterior until the most bottom part of the shell on the anterior (Chiu *et al*., 2002; Poutiers, 1998). The determination of the sex of Dog Conch was based on the genital organ characters in the form of the penis for males which was known when it was separated from its shell (Cob *et al*., 2008b). The result of the separation could determine the sex ratio by comparing the male and the female.

2.4 Length Frequency Distribution

The result of the shell length measurement was then calculated its length-frequency distribution using the following equation (Walpole, 1995).

$$J = X_{max} - X_{min}$$

Where J was a class range, X_{max} was the longest shell, X_{min} was the shortest shell. Then, the number of class (k) was determined using the following equation (Walpole, 1995)

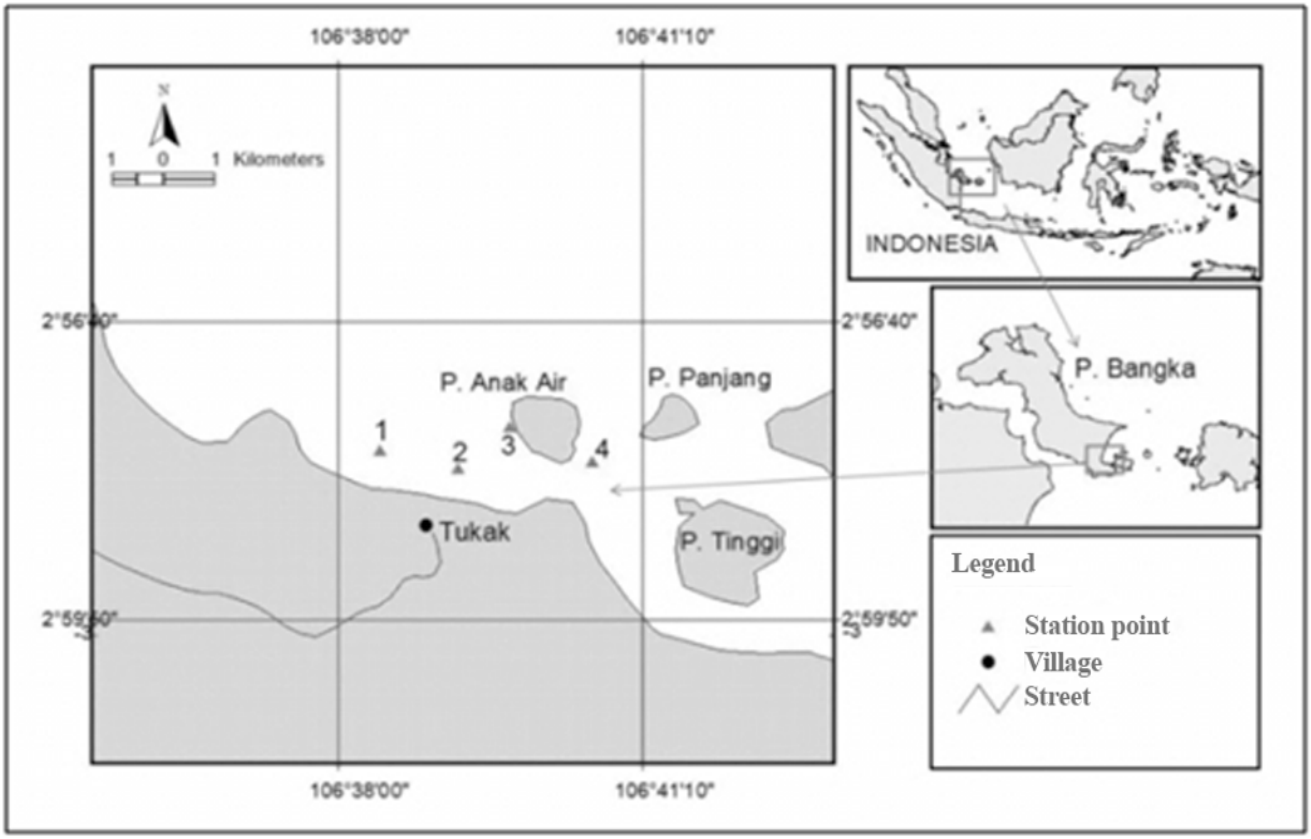

Figure 1. Map of research locations on the Tukak Coast and Anak Air Island, Kepulauan Bangka Belitung

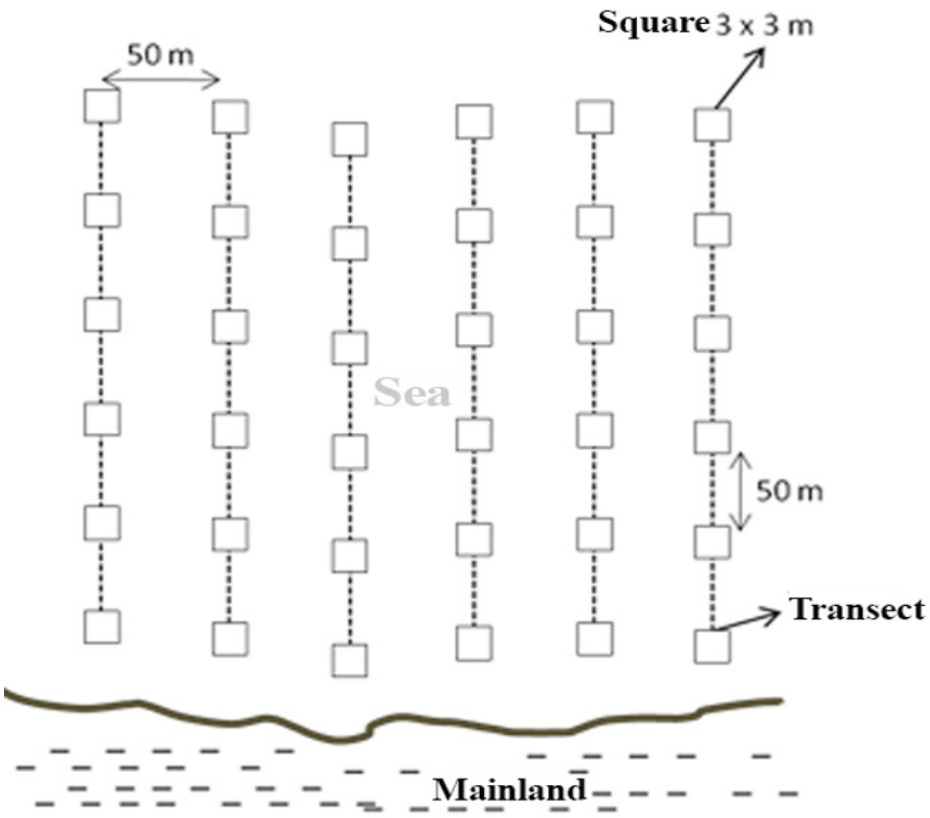

Figure 2. Design sampling in the field

$$k = 1 + 3.3 \log n$$

Where k was the number of classes and n was the number of individuals found. Both of these equations could determine the class size length by dividing class range (J) with the number of classes (k). The data were then grouped based on the number of individual in every class size group

2.5 Growth Parameter

The growth model of the Dog Conch size was obtained from the von Bertalanffy equation (Sparre and Venema, 1998; Gayanilo and Pauly, 1997). Before calculating this equation, it was important to know the value of L_∞, K, and t_0. L_∞ value and K were determined using ELEFANI of FiSAT II (Gayanilo *et al*., 2005). While t_0 value was calculated based on the L_∞ and K using Pauly equation (1979).

$$\text{Log } (-t_0) = -0.3922 - 0.2752 \log L_\infty - 1.038 \log k.$$

Once L_∞, K, and t_0 were obtained, the von Bertalanffy growth model could be estimated using Gayanilo and Pauly equation (1997).

$$L_{(t)} = L_\infty (1\text{-exp}^{-K(t-to)})$$

Where: $L_{(t)}$ = the shell length of the individual at t years old, L_∞ = maximum length that could be reached by the individual, K = growth curve parameter, and t_0 = theoretical time when the shell length was zero.

2.6 Age Group and Estimated recruitment time

Age group determination was analyzed using the Bhattacarya method based on the separation of total population distribution into normal distribution in each age group (*cohort*) (Sparre and Venema, 1998). From the result of age group separation, then information about population size, deviation standard, and separation index were obtained (Gayanilo *et al*., 2005). These three values were analyzed using *Model Progression Analysis* (MPA) with the Bhattacarya method in FiSAT II to make the histogram of the age frequency distribution. Information related to the age group could be used to estimate recruitments which were assumed that the number of age groups could describe the number of generations produced from spawning in a particular time (Sparre and Venema, 1998).

2.7 Life Table

The life table was determined based on the age data and the number of individuals in each measurement class. The age in each class was determined based on the calculation using the von Bertalanffy method (Gayanilo and Pauly, 1997). Life table was calculated using sequences in equation (Stilling, 1999)

$$d_x = n_x - n_{x+1}$$

Then, determining the individual proportion value living in the x age group (l_x) was calculated based on the values from the number of population living in the x age group (n_x) using the following equation (Stilling, 1999).

$$l_x = n_x / n_0$$

Based on the number of individuals that died between x age groups (d_x) and the number of population that lived in the x age group (n_x), mortality rate value in each age group (q_x) could be determined using the following equation (Stilling, 1999):

$$q_x = d_x / n_x$$

Before determining live expectancy-value in each age group (e_x), it was important to know in advance the number of individuals living at the age of x (L_x) using the following equation (Stilling, 1999):

$$L_x = (n_x + n_{(x+1)}) / 2$$

After that, determine T_x using the following equation (Stilling, 1999)

$$T_x = \sum L_x$$

Live expectancy in the-x age group (e_x) was calculated using the following equation (Stilling, 1999).

$$e_x = T_x / n_x$$

3. Result and Discussion

3.1 Sex Ratio

There were found 238 Dog Conch individuals, with 139 female individuals, 76 male individuals, and 68 juveniles during the research. The number of female individuals was found more than male individuals with a ratio of 1.82:1. The high number of female individuals was due to the fertilization process of Dog Conch was done internally through copulation (Muzahar and Hakim, 2018). Copulation could be performed by male individuals with some female individuals by approaching the female individual; then it released the air in the

mantel cavity of female individuals. After that, it moved to the other female individuals (Dody, 2012; Supratman, 2015).

3.2 Size Structure of Dog Conch

The result of the shell length measurement of Dog Conch in the research site was between 18.18 to 77.49 mm. Most of the obtained size class distribution was medium-sized around 47.43 mm to 60.43 mm, with the most significant number of individuals were the ones with a size of 53.93 mm (Figure 3). The biggest shell size was found in Kelabat Strait, Bangka Belitung with a size of 61.5 mm and in Stoko Island, Batam with a size of 69.9 mm (Dody and Marasabessy, 2007). The large Dog Conch shell was in the site was due to the natural habitat condition and planted with seagrass bed with high cover and diversity (Supratman and Adi, 2018). Seagrass bed took an important part as a nutrient supplier from the litters which became the source of organic matter for Dog Conch's food. It was because Dog Conch was detritus eater and epiphytic on the seagrass leaves (Cob *et al.*, 2014; Supratman and Syamsudin, 2016).

From the calculation result of the growth parameter of Dog Conch, obtained the value of asymptotic length value (L_∞) was 83.93 mm, growth curve coefficient (K) was 0.79 per year and theoretical time when the shell length was zero (t_0) was -0.153. Asymptotic length (L_∞) was 83.94. The L_∞ was the maximum length of the shell reached by a Dog Conch individual or the length of the shell on the very old individuals (Sparre and Venema, 1998). L_∞ value of *Strombus turturella* was higher than the other species of Dog Conch, such as *Strombus canarium*. L_∞ was higher in the Riau Islands, which was 82.5 mm, and was 69.91 mm in Johor Strait (Malaysia) (Amini and Pralampita, 1987; Cob *et al.*, 2008a). The growth curve coefficient value (K) described the higher the value, the faster the growth size to reach asymptotic length (L_∞), and vice versa. Compared to the species *S. canarium*, K value was 1.3 per year, and *S. gigas* was 0.71 per year (Cob *et al*, 2009; Peel and Aranda, 2013).

The growth calculation result could be determined by the von Bertalanffy growth model. Based on the data, the shell length of Dog Conch in the first year reached 50.18 mm, while the time needed to reach asymptotic length (L_∞) was about 13 years (Table 1). One-year-old individuals were adult individuals that people consumed and sold. These results could be used as a reference for cultivation activities with optimum harvesting at one-year-old because after they were one year old, the growth of Dog Conch was getting slower.

3.3 Age Group and Estimated Recruitment Time

The age group estimation model using the Bhattarcarya method resulted in three age groups (Figure 4). The median value for the shell length of the first group was 40.93 mm, while the estimation result using the von Bertalanffy growth was 0.83 years old. The median value for shell length of the second group was 60.43 and an estimated 1.58 years old. The median value for shell length of the third group was 60.43 and an estimated 1.58 years old. The median value for shell length of the third group was 76.68.43 and an estimated 3.08 years old. These three groups were categorized into young (0.83 years old), adult (1.58 years old) and old (3.08 years old). The number of individuals found in the research site was 116 individuals from the young group, 161 individuals from the adult group, and six individuals from the old group (Figure 5). The low number of Dog Conch found from the old group was due to the high mortality rate of the previous age group. Therefore their life expectancy was low.

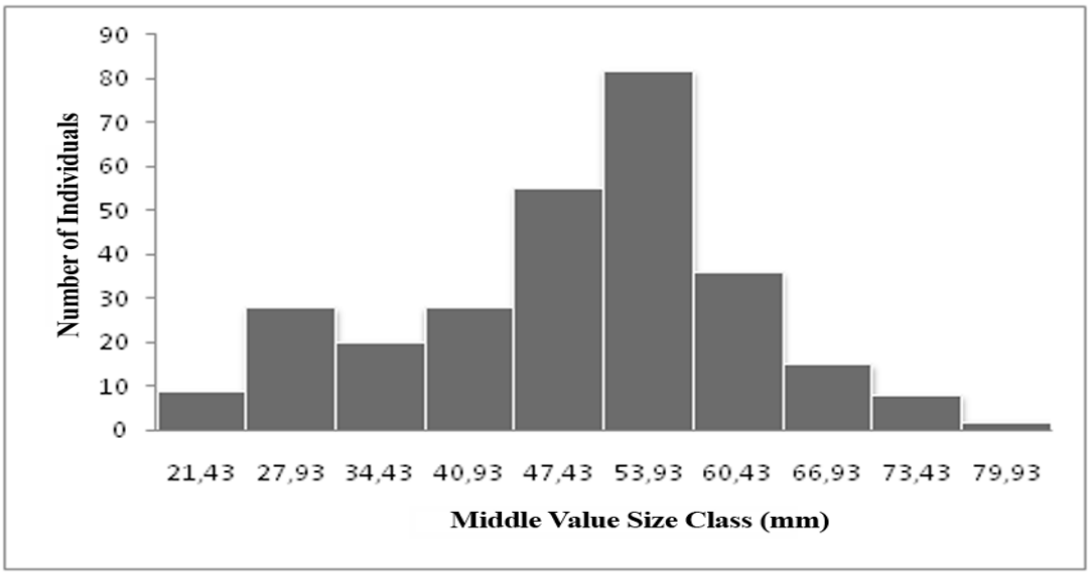

Figure 3. The frequency distribution of lenght of Dog Conch *(S. turturella)* shells

Tabel 1. Lenght of shells Dog Conch (*S. turturella*) on the Tukak Village and Anak Air Island, Kepulauan Bangka Belitung

Age	Shells Lenght (mm)
1	50.18
2	68.61
3	76.98
4	80.77
5	82.5
6	83.28
7	83.64
8	83.8
9	83.87
10	83.9
11	83.92
12	83.92
13	83.93

Table 2. Life table of Dog Conch (*S. turturella*) on the Tukak Village and Anak Air Island, Bangka Belitung Islands Kepulauan Bangka Belitung

Age (Year)	Size (mm)	nx	dx	lx	qx	Lx	Tx	ex
0 - 1	18.18 - 50.18	134	1	1	0.007	133.5	216	1.612
1-2	50.19 - 68.61	133	118	0.993	0.887	74	82.5	0.62
2-3	68.62 - 76.98	15	14	0.112	0.933	8	8.5	0.567
3-4	76 .99 - 80.77	1	-	0.007	-	0.5	0.5	0.5

Age group calculation could be used to estimate recruitment time, based on the assumption that the number of age group could describe the number of generations produced from the spawning at a particular time (Sparre and Venema, 1998). Recruitment time or birth population could be determined based on the age in each group. Individuals in the first group were about 0.38 years old or about 10 months old. It is estimated that this population was born 10 months before or during the sampling time or in December 2013. Individuals in the second group were estimated born in March 2013 and individuals in the third group were born in September 2011 (Figure 6). Based on these data, Dog Conch recruitment was done in December, March, and September. Dog Conch peak recruitment was in March since the populations that were born in this month had the highest number among other months. Factors affected the high number of recruitment in March were the high numbers of individuals that were ready to reproduce and spawning season. Information from the fishermen on the coast of *Tukak* Village and *Anak Air* that the catching season of Dog Conch occurred in February to July. In those months, many adult reproductive individuals were found; therefore it affected the high recruitment from the spawning process. According to Effendie (2002), the recruitments came from the adult individuals who were ready to reproduce. Therefore, there was a relationship between the number of adult individuals and the number of recruitments. Another factor that determined the recruitments was spawning season since there were not every organism could spawn throughout the year. The result of the research by Supratman (2015) based on the spawning experiment in the laboratory scale showed that Dog Conch did not spawn throughout the year. However, the spawning occurred in particular months; they were March to April. Compared to *S. canarium* based on the estimation using FiSAT II, recruitment peak occurred in June to August during the research in Johor Strait, Malaysia (Cob *et al.*, 2008a).

3.4 Life Table

Analysis result based on von Bertalanffy was showed in Table 1. One-year-old Dog Conch had a 50.18 mm shell length. The number of individuals found with the length of shell-less than 50.18 mm was

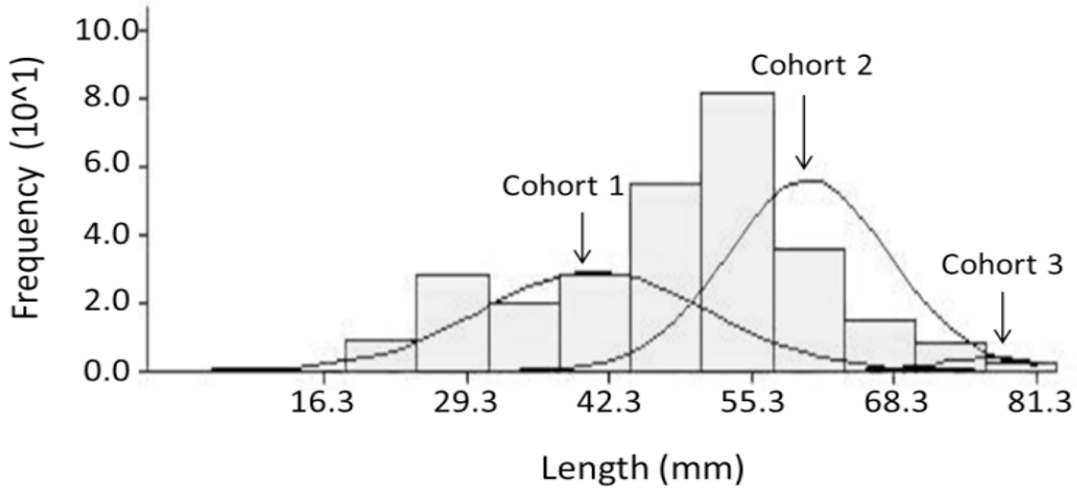

Figure 4. Frequency distribution of Lenght of shells Dog Conch (*S. turturella*) using the Batthacarya method, lines showing cohorts or age groups

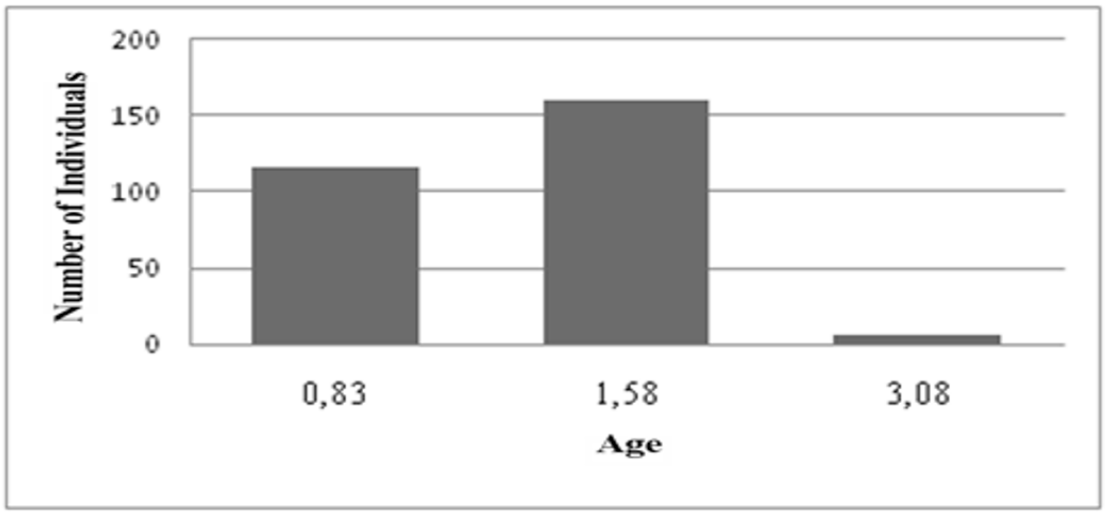

Figure 5. Estimated age and number of individuals in each age group (cohort)

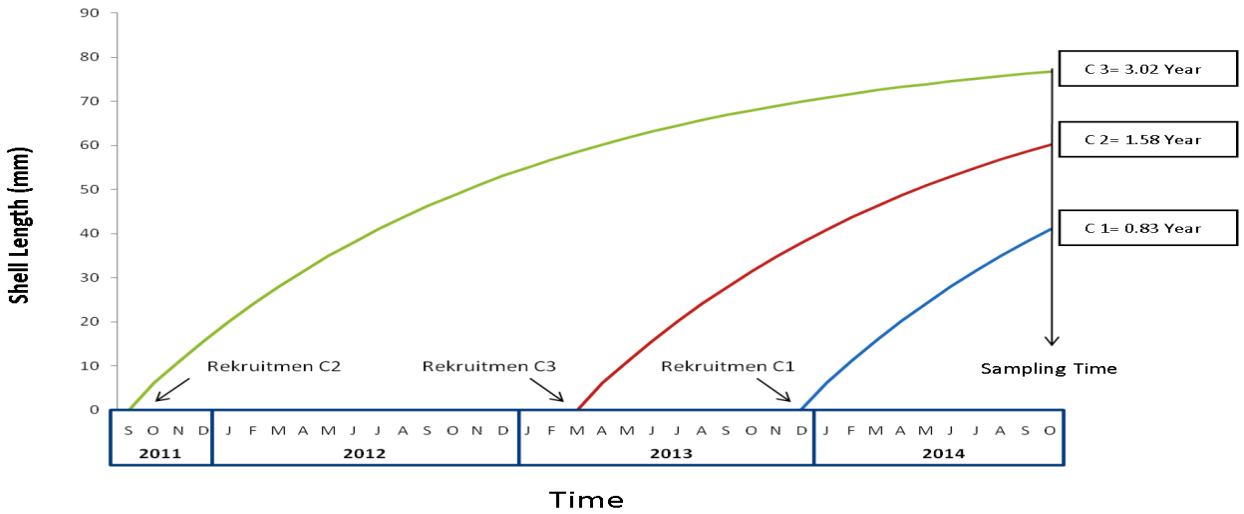

Figure 6. Estimated time for recruitment of sDog Conch (*S. turturella*) in each age group (C1 = 1st age group, C2 = 2nd age group and C3 = 3rd age group).

134 individuals. At the age of 1-2 years old, the length ranged between 50.19-60.51 mm and was found about 133 individuals. At the age of 2-3 years old, the length ranged between 60.52-76.98 mm and was found about 15 individuals. There was one individual at the age of 3-4 years old with a size of 76.98-80.77 mm. More than four years old Dog Conch with a length of more than 80.77 mm was not found.

The life table could be arranged based on the shell length for each age (L_t) and the number of individuals in every size range. The life table of the Dog Conch population at the age of 0-1-year-old had a mortality rate proportion (*qx*) of 0.007. The mortality rate proportion increased sharply in the age group of 1-2 years old, which was 0.887, and it increased in the age group of 2-3 years old, which was 0.993. It indicated that the high mortality rate occurred at the age of more than one-year-old or adult individuals with a size of more than 50.18 mm. The highest life expectancy was on the first age; therefore this age group had a longer life expectancy than the other age group (Table 2)

The low proportion of mortality rate on the first group of young individuals was because individuals from this group were not taken by people, while individuals at the age of more than one year old were adult individuals that have been for sale. It became one of the causes of the high proportion of mortality rate in the age group of 1-2 years old and 2-3 years old. Based on the research result by Dody (2012), it took 10-12 months for Dog Conch to grow from larva until it was ready to harvest. Life table analysis on the high mortality rate in the age group of more than one year old was more caused by over-exploitation by people rather than by natural death, such as diseases, predators, parasites, and others. These phenomena also happened to the other Strombus genus, such as *S. canarium*, *S. gibberulus* and *S. gigas* (Cob *et al.,* 2009; Giovas *et al.,* 2010; Stoner, 1994). It happened because Dog Conch was one of the fishery commodities with high economic value that people often used (Viruly *et al.,* 2019).

People of *Tukak* and *Anak Air* Island took Dog Conch by walking along the beach and diving to collect individuals they found. It caused the younger individuals had the chance to be caught than adult individuals. Different from *Kelabat* Strait, most people in Bangka Island collected Dog Conch directly, and some other people used trawl to collect the Dog Conch. The Dog Conch catching in the research site was environmentally friendly. However, the Dog Conch taken was reproductive adult individuals. Reproductive Dog Conch catching would affect the population size in nature since there was no chance for the population to recruit. The right size and age for a Dog Conch to catch were 68.61 mm and 2 years old since the individuals at that age and size were assumed to reproduce at least once so that there was a population regeneration in the future.

The research result recommended the Dog Conch management to manage catching time, the minimum size for the individuals that were allowed to be caught, and adult reproductive individual protection. The right time to catch Dog Conch was in March because spawning peak happened after March; therefore there was an offspring produced although the mother was caught. The minimum size of a Dog Conch shell that allowed to be caught was 68.61 mm at the age of 2 years old. The size and age of the individuals were assumed as post reproduction individuals that had reproduced once. Other than that, to protect adult reproductive individuals, a protection area of Dog Conch was needed. Therefore, adult individuals had the chance to reproduce, then they became the seed donor around that area. This kind of management had been carried out to protect *Strombus gigas* in the Carribean Islands by managing the shell size, minimum shell clam could be caught, restricting individual adult catch and making marine protection areas (Béné and Tewfik, 2003; Peel and Mandujano, 2014; Stoner *et al.,* 2012).

4. Conclusion

The shell length of Dog Conch (*S. turturella*) was between 18.18 -77.49 mm with *asymptotic* length (L_∞) of 83.94 mm, the growth coefficient (K) was 0.79/year and theoretical age when the length was zero (t_0) was -0.152. Von Bertalanffy growth of Dog Conch in the first year developed very quickly, it could reach 50.18 mm, then it slowed down when the Dog Conch was getting older with asymptotic length (L_∞) found at the age of 13. The population of *S. turturella* had three age groups; they were young (0.83 years old), adult (1.58 years old) and old (3.08 years old). The high mortality proportion rate was at the age of 1-2 years old and 3-4 years old or adult individuals. Therefore, high expectancy-value was in the age group of 0-1 year old or young individuals. It indicated that the high mortality rate was in the age group in which people took them to consume and to sell. Based on the research result, sustainable management could be carried out by managing the time of catch, which was in March or after the spawning peak, the minimum size that was allowed to be caught was 68.61 mm at the age of 2, and making protection on adult reproductive individuals.

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Authors' Contributions

All authors discussed the results and contributed to from the start to final manuscript; Okto; Data collection in the field, data collection in the laboratory, analysis data, and journal drafting, and Tati; Data analysis and manuscript drafting

Conflict of Interest

The authors declare that they have no competing interests

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