The population dynamics of *Pholas orientalis* (Gmelin, 1791) in the area of Kelang Beach, Serdang Bedagai, North Sumatra, Indonesia

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Abstract. *Pholas orientalis* is categorized as a razor clam. *P. orientalis* can be found in the area of Kelang beach, North Sumatra, Indonesia. Local people collect the clams for more income or for consumption. This study aims to determine the population dynamics of *P. orientalis* in the area of Kelang beach. Exploratory research with purposive sampling was used in this study. The clams were collected from July to September 2019, by hand (hand sorting). Length-weight correlation using the Allometric Linear Model (ALM) was employed. The population dynamics of *P. orientalis* were determined with FAO-ICLARM Stock Assessment Tools-II. The results showed a correlation value (W) of $8.8126L^{-46.119}$ and an R^2 value of 0.8637. Asymptotic length (L_∞) was 18.38 cm, the growth coefficient (K) was 0.450 year^{-1}, growth performance index (Ø) was 4.27 year^{-1}, the time at which length is zero (t_0) was -0.022 year^{-1}. The estimated value of natural mortality was 1.36642 year^{-1}, and the optimal length of catch (L_{opt}) was 89.9 mm. In addition, the total mortality rate (Z) was 2.802 year^{-1}, the natural mortality rate (M) was 0.921 year^{-1}, the catch mortality rate (F) was 1.88 year^{-1}, and the exploitation rate (E) was 0.67 year^{-1}.

Key Words: anglewing clams, growth parameters, recruitment pattern, sustainable fisheries resources.

Introduction. Clams in general are an important source of protein and nutrients for the human body (Yeni 2012). The price of *Pholas orientalis* (Gmelin, 1791) is high in Taiwan and Hong Kong, compared to other clams. These clams are known as "angelwing clams", "diwal" in the Philippines, "mentarang" in Malaysia, "pim" in Thailand (Golez et al 2011), and "tembarang" or "bintarang" in Indonesia.

One of the anglewing clam habitats is in the area of Kelang beach, North Sumatra, Indonesia. Anglewing clams can be found in muddy sandy areas, namely intertidal areas (Laureta & Marasigan 2000; Yap et al 2009). Ronquillo & McKinley (2006) explained that these clams usually immerse themselves in the mud about 5 cm. Local people usually collect them when the tide is receding. They usually sell directly to beach visitors at a price of 0.67–1 USD per kg, a high price, because anglewing clams have important economic value and a very open market opportunity. However, in terms of efforts to obtain them, fishermen still rely on collecting them from the wild. This can threaten the sustainability of *P. orientalis* in their natural habitat.

Very little information about population dynamics of anglewing clams in Indonesia has been found. Therefore, this study has an important meaning in providing information for the resource management of anglewing clams in the future. Efforts are needed to preserve them in nature for future generations. It can be considered that *P. orientalis* is already endangered in the Pacific region; however, they are still commonly found in the Southeast Asian coastal region (Ronquillo & McKinley 2006).

Material and Method

Study location and period. This study was conducted from July to September 2019 in Kelang Beach, Teluk Mengkudu District, Serdang Bedagai Regency, North Sumatra, Indonesia. There were 3 observation stations in this study: Station 1 (99°6'52.94"E and 3°34'38.5"N), Station 2 (99°6'59.68"E and 3°34'34.14"N), and Station 3 (99°6'44.26"E and 3°34'43.84"N). The map of the research location is presented in Figure 1.

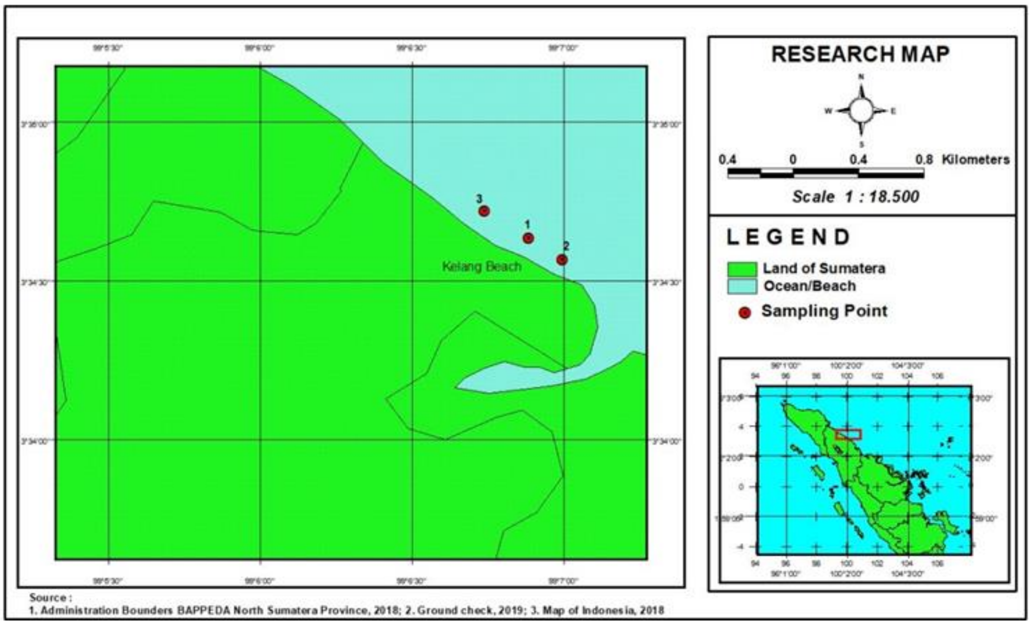

Figure 1**.** Research location.

Sample collection. The research stations were positioned to observe the population dynamics of *P. orientalis*. The sampling was conducted using a purposive sampling method in which the clam location was determined based on information gained from the local community that usually collect *P. orientalis*. The clams were collected directly by hand (hand sorting), by digging.

Data analysis. According to Albuquerque et al (2009), length-weight correlation is generally used in research in fisheries to explain changes in individual size, to determine the growth pattern of an organism, to acquire the index of physical condition of the population, and to evaluate the quality of the habitat. Length-Weight correlation of *P. orientalis* was conducted using the Allometric Linear Model (ALM) with Le Cren's formula (Le Cren 1951), as follows:

$$W=aL^b$$

Where: W - total weight (g); L - total length (cm); a and b - constants.

The asymptotic length (L_∞), growth coefficient (K), mortality, and recruitment (reconstructs the recruitment pulses from a time series of length – frequency data) were estimated using FAO-ICLARM stock assessment tool (FISAT) (Gayanilo et al 2005). Growth was defined by the following von Bertalanffy growth function (Sparre & Venema 1998) was used:

$$L_t=L_\infty\ [1-e^{-K(t-t0)}]$$

Where: L_t - length at age t; L_∞ - asymptotic length; K - growth coefficient; t_0 - the hypothetical age at which the length is zero. Asymptotic length (L_∞) and growth coefficient (K) of the von Bertalanffy growth equation were estimated by means of ELEFAN-1 routine in the FISAT 2 software.

The catch mortality rate (F) was calculated based on Pauly (1980):

$$F=Z-M$$

Where: Z - total mortality rate; M - natural mortality rate.

The exploitation rate (E) was calculated based on the formula suggested by Sparred & Venema (1992):

E=F/Z

Where: E is the exploitation rate, F is the catch mortality rate, and Z is the total mortality rate.

The optimum length of collected clams (Lopt) was calculated based on the formula suggested by Froese & Binohlan (2000):

$L_{opt}=3xL_{\infty}/(3+M/K)$

Where: L_{opt} - the optimum length of clams collected; M - the natural mortality rate; L_{∞} - infinity or asymptotic length; K - the growth coefficient. The recruitment pattern was carried out by using FISAT II by inputting the values of L_{∞}, K, and t_0.

Results and Discussion

Size distribution and length-weight relationship. The monthly length and weight data are presented in Table 1.

Table 1

Monthly length and weight of *Pholas orientalis* in Kelang Beach, Indonesia

No	*Sampling period*	*N*	*Location*	*Total length (cm)*				*Weight (g)*			
				Min	*Max*	*Mean*	*SD*	*Min*	*Max*	*Mean*	*SD*
1	July	32	St. 1	6.5	10.7	9.17	0.92	11.4	54.8	33.85	10.07
2	August	26	St. 1	6.1	10.5	8.79	1.35	10	54.9	31.74	12.19
3	September	55	St. 1	7.1	12.5	9.11	1.25	16.5	57.3	34.50	11.68
4	July	11	St. 2	6.5	10.7	9.04	1.47	11.4	50	32.9	13.86
5	August	20	St. 2	6.1	10,4	8.71	1.30	10	46,8	31.03	11.37
6	September	18	St. 2	7.2	10.6	9,10	1.23	18.6	55.2	34.95	11.55
7	July	10	St. 3	6.1	10.4	1.54	8.86	10	46.8	33.35	13.72
8	August	8	St. 3	7.1	10	1.05	8.31	17.3	42.9	26.73	8.36
9	September	7	St. 3	7.2	10.5	8,71	1.32	18.6	54.9	31.24	13.14

Note: St. - station; SD - standard deviation.

Analysis of the angelwing clams length and weight indicated a correlation value (R^2) of 0.885, close to 1. This indicates a strong linear relationship. Data on the relationship between length and weight can be seen in Figure 2, while data on the growth constant curve of P. orientalis can be seen in Figure 3.

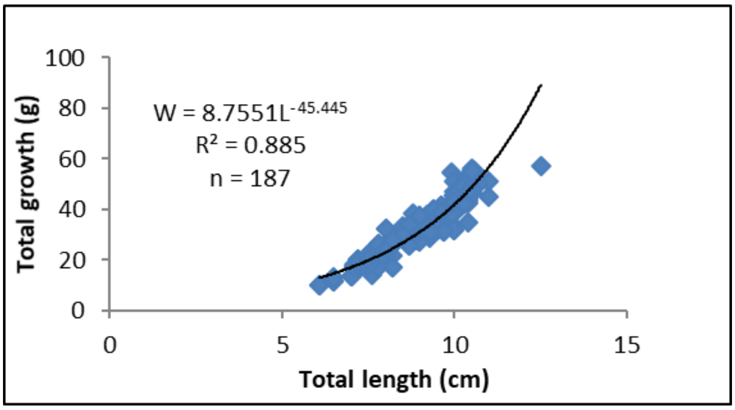

Figure 2. Length-weight relationship of angelwing clams (*Pholas orientalis*).

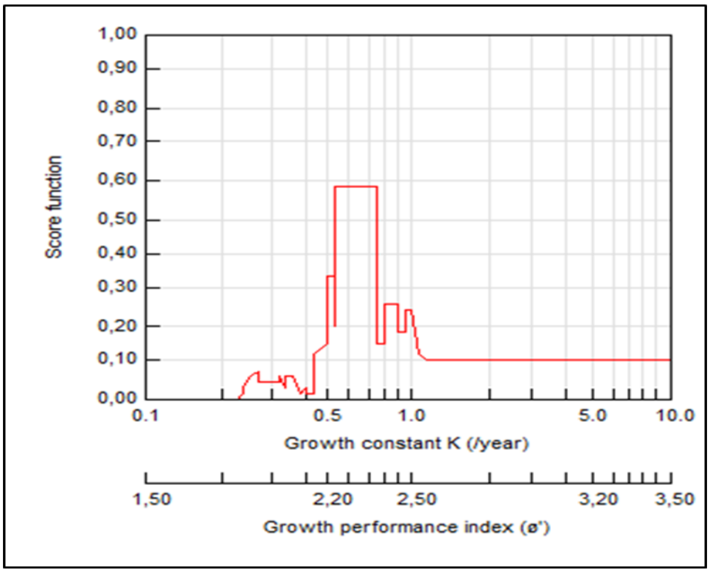

Figure 3. The growth constant curve of angelwing clams (*Pholas orientalis*).

Growth parameters. Based on von Bertalanffy's growth model, the obtained growth coefficient (K) was 0.91 year^{-1}. The asymptotic length (L∞) value was 18.38 cm. Furthermore, the estimated value of the theoretical age when the angelwing clam length is zero (t0) was 0.540 years^{-1}. Therefore, the growth equation of *P. orientalis* in Kelang beach was L_t = 32.34 [1-e$^{-0.91\ (t-\ +0.14)}$] (Figure 4).

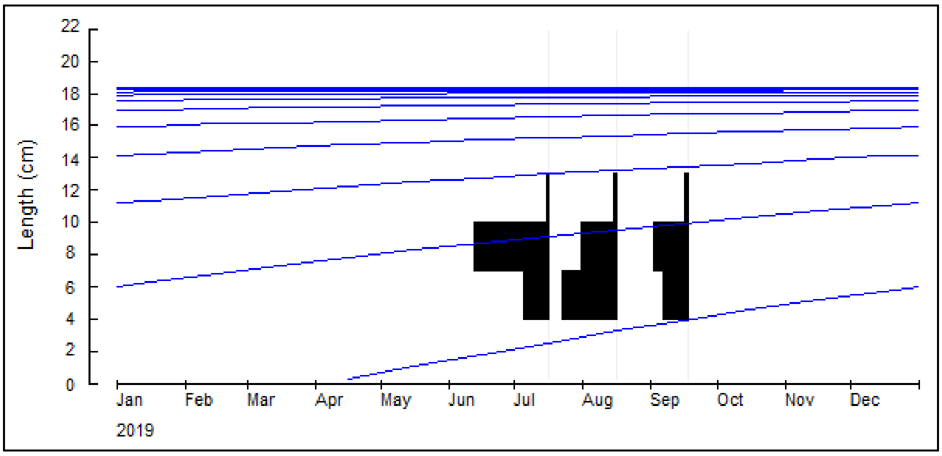

Figure 4. Von Bertalanffy's growth curve for *Pholas orientalis*.

Growth parameters indicated that *P. orientalis* consists of 3 size groups which were dominated by the small size group. The small value of L∞ and K is assumed to be due to over exploitation rates. This is argued by the large number of fishing operations carried out by fishermen in the area.

Length converted catch curve and Recruitment pattern. Further data can be seen in Figure 5.

The estimated value of natural mortality was 1.36642 year^{-1}. The total mortality rate was 2.802 years^{-1}. The average normal mortality is 2.05 year^{-1}, which indicates that deaths occur regularly in the research location. Pauly (1980) states that such number is higher than the maximum accepted mortality rate of 1.5 year^{-1}. The growth constant (K) of 0.54 year^{-1} is a parameter that describes how quickly angelwing clams reach their maximum width.

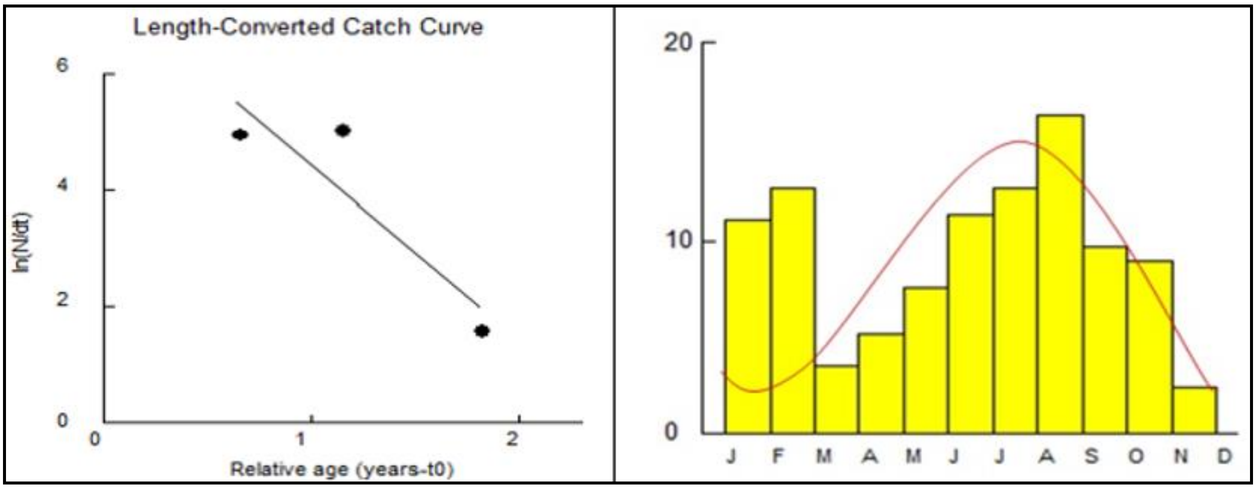

Figure 5. Length converted catch curve (left) and recruitment pattern of *Pholas orientalis* in Kelang Beach, North Sumatra, Indonesia (right).

The calculation of the length and weight of angelwing clams from Kelang Beach and their coefficient value indicated a very close correlation. This can be seen from the correlation value that is close to 1 (0.8637), meaning that it has a negative allometric growth pattern, in which the growth of the clam length is faster than the growth of its total weight. According to Trisyani et al (2016), the length-weight correlation of *Solen regularisc* was $W= 0.038L^{2.798}$, with a correlation coefficient of 0.95. The b value shows negative allometric growth (b<3). According to Effendie (2002), a negative allometric growth pattern indicates that food supply in the area is low, so that the length is more dominant than the weight. Ricker (1995) explained that the growth process is influenced by internal factors (heredity, sex, age, parasites, and disease) and external factors (food and hydrological conditions of the area). Furthermore, according to Abida et al (2014), the difference between the constant value and the determination coefficient in the regression test is influenced by the large number of catches carried out by fishermen.

The asymptotic width (L_{∞}) is the width average value for old clams, or, in other words, clams that can no longer increase in width. The value of the growth coefficient (K) is a determinant of how quickly the clams reach asymptotic width or a maximum width (Sparre & Venema 1999). The applied asymptotic length is the width of the angelwing clams. According to King (1995) and Spare & Venema (1999), for clams that have greater width than length, the length is replaced by the width. Setyobudiandi (2004) stated that, in sub-tropical waters, the rate of growth of aquatic animals tends to slow down when the water temperature is low. Efriyeldi et al (2012) state that the growth coefficient (K) is an important parameter, because it can describe the growth rate of clams in reaching their maximum size. This value can be used to compare the growth rate of clams with other different clams or the same species of clams, but in different habitats.

Mortality can be defined as the number of individuals that died over a certain time interval (Ricker 1995). Mortality of aquatic biota in nature can be caused by natural death or death due to catch. Natural deaths caused by, among others, inappropriate aquatic environment, food shortages, predation, illness, and aging, are known as natural mortality (M). Meanwhile, deaths due to catch are known as catch mortality (F). The combination of the natural mortality and the catch mortality is known as total mortality (Z), and is analyzed using Beverton and Holt's method (Sparre et al 1999). In fisheries, mortality is generally divided in two causes, namely the natural mortality and the catch mortality. Natural mortality is a mortality that occurs due to various reasons, besides capture by fishermen, such as predation, illness, spawning stress, hunger, and age (Sparre & Venema 1998).

According to Fadly (2014), the exploitation rate of clam resources in a watershed is a comparison between production and the amount of potential for sustainability. In other words, it is a result of a comparison between the number of mortality due to catch and the number of total natural mortality. The evaluation of the exploitation rate of the resources is highly necessary, so that the management of these resources can be rational or sustainable. Furthermore, Bahtiar (2005) explained that if the number of catches carried out by fishermen remains large, approaching the availability of *P. orientalis* populations, this population will decline continuously and, ultimately, it will approach extinction.

Conclusions. *P. orientalis* in the area of Kelang beach is experiencing overfishing. Based on the observations of this study, length-weight relationships are allometric negative ($W=8.8126L^{-46.119}$ and $R^2=0.8637$). The asymptotic length ($L_\infty=18.38$ cm), estimated value of natural mortality (M=36642 year^{-1}), and growth constant (K=0.54 year^{-1}) indicate that the population of *P. orientalis* in the study area is overfished.

References

Abida I. W., Wahyuni E. A., Efendy M., 2014 [Relationship of length and weight of lorjuk (*Solen* spp.) in coastal waters of the south coast of Madura Island]. Jurnal Kelautan 7(1):26-32. [In Indonesian].

Albuquerque F. S., Peso-Aguiar M. C., Assuncao-Albuquerque M. J. T., Galvez L., 2009 [Do climate variables and human density affect *Achatina fulica* (Bowditch) (Gastropoda: Pulmonata) shell length, total weight and condition factor]. Brazilian Journal of Biology 69:879-885.

Bahtiar, 2005 [Population study of Pokea shellfish (*Batissa violacea celebensis* Martens, 1897) in the Pohara Kendari River, Southeast Sulawesi]. Thesis, Postgraduate School, Bogor Agricultural University, Bogor, Indonesia, 76 p. [In Indonesian].

Effendie M. I., 2002 [Fisheries biology]. Yayasan Pustaka Nusatama, Yogyakarta, 163 p. [In Indonesian].

Efriyeldi, Bengen D. G., Affandi R., Prartono T., 2012 [Biological characteristics of a population of Sepetang shells (*Pharella acutidens*) in Dumai mangrove ecosystem, Riau]. Jurnal Perikanan Terubuk 40(1):36-44. [In Indonesian].

Fadly F., 2014 [Exploitation level and growth performance of blood shells (Anadara granosa) in Kuala Penet waters, Labuhan Maringgai, East Lampung]. Essay, Faculty of Fisheries and Marine Sciences, Bogor Agricultural University, Bogor, Indonesia, 29 p. [In Indonesian].

Froese R., Binohlan C., 2000 Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. Journal of Fish Biology 56:758-773.

Gayanilo F. C. Jr., Sparre P., Pauly D., 2005 FAO-ICLARM stock assessment tools II (FiSAT II). Revised version. User's guide. FAO Computerized Information Series (Fisheries), No. 8, revised version, FAO, Rome, 168 p.

Golez M. S. M., Laureta L. V., Apines-Amar M. J. S., Caipang C. M. A., 2011 Growth and survival of endangered angelwing clam, *Pholas orientalis* fed different algal diets. AES Bioflux 3(3):237-242.

King M., 1995 Fisheries biology: Assessment and management. Wiley, 341 p.

Laureta L. V., Marasigan E. T., 2000 Habitat and reproductive biology of angelwings, *Pholas orientalis* (Gmelin). Journal of Shellfish Research 19(1):19-22.

Le Cren E. D., 1951 The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology 20(2):201-219.

Pauly D., 1980 A selection of simple methods for the assessment of tropical fish stocks. FAO Fisheries Circular No 729, 54 p.

Ricker W. E., 1995 Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, Bulletin 191, 401 p.

Ronquillo J. D., McKinley R. S., 2006 Developmental stages and potential mariculture for coastal rehabilitation of endangered Pacific angelwing clam, *Pholas orientalis*. Aquaculture 256(1-4):180-191.
Setyobudiandi I., 2004 [Several biological aspects of shellfish reproduction in different water conditions]. Dissertation, Postgraduate School, Bogor Agricultural Institute, Bogor, Indonesia, 169 p. [In Indonesian].
Sparre P. E, Venema S. C., 1999 Introduction to tropical fish stock assessment - Part 2: Excercises. FAO Fisheries Technical Paper, Rome, 376 p.
Sparre P. E., Venema S. C., 1998 Introduction to tropical fish stock assessment - Part 1: Manual. FAO Fisheries Technical Paper 306/1 Rev.2, Rome, 407 p.
Sparre P., Venema S. C., 1992 Introduction to tropical fish stock assessment. Part 1: Manual. FAO Technical Paper T306/1Rev.1, Rome, 376 p.
Trisyani N., Herawati E. Y., Widodo M. S., Setyohadi D., 2016 [The length-weight correlation and population dynamics of razor clams (*Solen regularis*) in Surabaya east coast, Indonesia. Biodiversitas 17(2):808-813.
Yap C. K., Kamarul A. R., Edward F. B., 2009 Heavy metal concentrations (Cd, Cu, Ni, Pb, Fe and Zn) in different soft tissues and shells of Pholas orientalis collected from Sekinchan and Pantai Remis, Selangor. Malaysian Applied Biology Journal 38(1):21-27.
Yeni, 2012 [Antioxidant activity and the effect of processing on the nutritional content of pokea shellfish (*Batissa violacea celebensis*, Martens 1897) in the Pohara River, Southeast Sulawesi]. Thesis, Bogor Agricultural Institute. Bogor, 91 p. [In Indonesian].

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