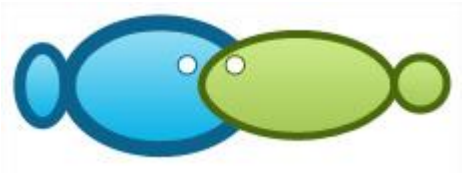

Population dynamics of the climbing perch *Anabas testudineus* in the Semayang Lake, East Kalimantan Province, Indonesia

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Abstract. The study was conducted from February 2017 to January 2018 at Semayang Lake, Kutai Kartanegara Regency, East Kalimantan Province, Indonesia. This study aims to determine growth, mortality, exploitation rate and relative yield per recruit of *Anabas testudineus* at the Semayang Lake. The fish samples were caught from 6 stations by using fishing gear traps. The study was conducted on 1592 fish samples. The result showed average von Bertalanffy growth parameter $L\infty$ = 202.13 and average growth coefficient (K) = 0.7 year^{-1}, t_0 = -0.14 year^{-1} and Rn (Goodness of fit) = 0.204. Length growth equation Lt = 202.13 (1-e$^{-0,7(t+0,14)}$). Based on length distribution analysis showed a total mortality (Z) value of 1.63 year^{-1}, natural mortality (M) 0.87 year^{-1}, catch mortality (F) 0.76 year^{-1} and exploitation rate of 0.47 year^{-1}. Based on the results model yield-per-recruit Beverton and Holt potential of actual *A. testudineus* resource E_{cur} will be raised to the maximum value of sustainable yield (E_{max}) then this time, the value of E_{cur} is 81.03% and still can be increased by 18.97%. The result of analysis shows that the estimated value of Y/R on E_{cur} is 0.05970 g/recruit, meaning that in each recruit of *A. testudineus* contains 0.05970 g which can be taken as the catch result. Sequentially, the value of Y/R on E_{10} is 0.0603 and E_{max} is 0.0610.

Key Word: growth, mortality, *A. testudineus*, exploitation rate, growth coefficient.

Introduction. Semayang Lake is an ecosystem of flooding swamp type, composed of flowing and not flowing water ecosystems, with an area of 9,132 Ha (Fakhrudin et al 2012). Due to its particularity of flowing and not flowing water ecosystem, thus providing a variety of habitats available to aquatic organisms (Welcomme 1985). The diversity of these habitats creates an ecological niche that has a positive correlation to the high diversity and biomass of fish resources. Fish resources utilize this area in various ways to support the process of fish life such as for spawning (Lim et al 1999), and fish juvenile's protection (Ribeiro et al 2004). The high diversity of fish fauna found is a feature of ecological dynamics as a fish response to habitat heterogeneity (Agostinho et al 2000).

In Semayang Lake was found 15 fish species (Haryono 2006), then added by (Wahyudewantoro 2014) that there were 46 species of fish species in the environment of Semayang Lake which were collected from primary and secondary data information, including the type of *Anabas testudineus*. *A. testudineus* is one of the most common freshwater fish species found in swamps, small rivers and lakes (Mustakim et al 2009; Sheenaja et al 2011; Kumary & Raj 2016). *A. testudineus* is one of the fish that is an affordable source of animal protein in Southeast Asian countries such as Bangladesh and Malaysia (Alam et al 2010; Zalina et al 2011). *A. testudineus* can naturally be found in Bangladesh, India, Pakistan, Ceylon, Burma, Sri Lanka, Thailand, Cochin-China, Tongking, southern China, Philippines, Polynesia, and Malaysia (Axelrod et al 1971; Jayaram 1981; Sterba 1983; Sen 1985; Talwar & Jhingran 1991; Kohinoor et al 1991; Tay et al 2006). This species has a high economic value and is favored in East

Kalimantan, Indonesia, because it's appreciated taste (Helmizuryani & Muslimin 2016), as a consequence, the demand of the species is high. However, the efforts to fulfill the market demand in East Kalimantan are still completely dependent on the catch result from nature, because the cultivation activities of *A. testudineus* are still not intensively performed. If this condition continues, it is predicted that the population of *A. testudineus* will decrease drastically, so it is necessary to manage its fishing optimally.

Based on the circumstances, this research is important to be performed in order to highlight the dynamics of *A. testudineus* populations by exploring estimated growth, mortality, exploitation rate, and relative yield per recruit as a reference in the management of *A. testudineus* with the hope that *A. testudineus* populations will be maintained and fishing activities can be done optimally and sustainably.

Material and Method. The research location was located at Semayang Lake. Sample collection had been done in 6 locations (Figure 1). These locations were identified as fishing spots which are always visited by fisherman. Sample collection was helped by local fisherman. Data collection of catch result was done once a month starting from February 2017 until January 2018 by using fishing gear in the form of *A. testudineus* trap. The recorded data were the total fish number and total display (mm) with measurement accuracy of 1 mm.

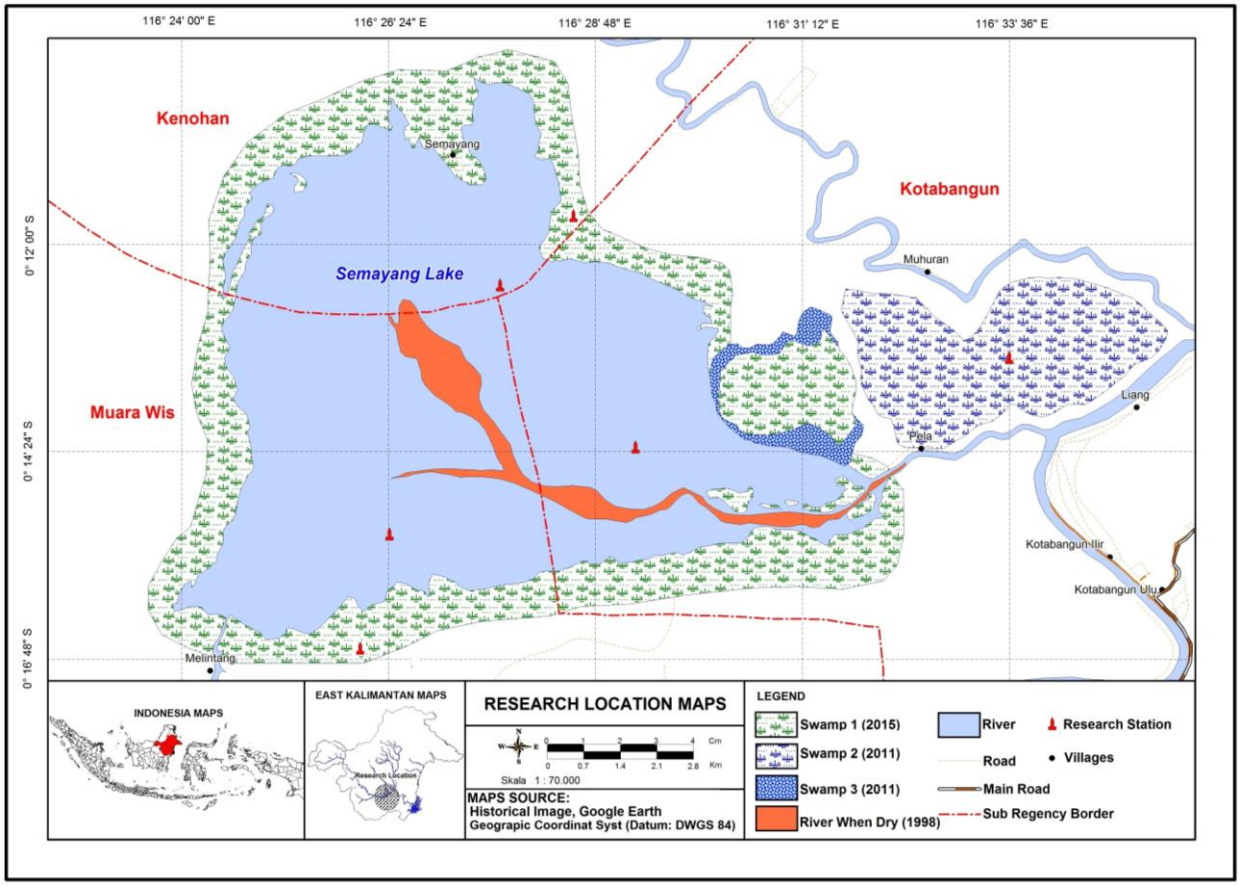

Figure1. Research location at Semayang Lake, East Kalimantan, Indonesia.

Growth presumption. The growth in fish length was calculated by von Bertalanffy model (Sparre & Venema 1998) as follow:

$$L_t = L_\infty (1 - e^{-K(t-t_0)})$$

where L_t is the length of the fish at the age of -t (mm), L_∞ is the asymptotic length (mm), K is the growth coefficient (t^{-1}) and t_0 = the fish hypothesis age at a zero length (year), the L_∞ and K values were obtained from the results of the calculation by Elefan 1 method contained in the FISAT II program. The value of t_0 could be presumed by the following equation (Pauly 1980):

$$Log -(t_0) = -0.3922 - 0.2752 \, Log \, L_\infty - 1.038 \, Log \, K$$

The long-frequency distribution of fish to determine the cohort was analyzed by Bhattachharya method (Sparre & Venema 1998) with the help of the FISAT II program.

Mortality and exploitation rate. Determination of total mortality by using the Z/K quotient technique and its modification were developed by Beverton & Holt (1957). This method was based on the assumption that fish samples were obtained from stable populations with new additions and constant mortality rates, and follow the von Bertalanffy growth model. The value of Z/K could be expected if the values of L∞, Lc and L known by the equation:

$$\frac{Z}{K} = \frac{L\infty - L}{L - L\sigma}$$

Or if L' was known could be used the formula:

$$Z = K \frac{(L\infty - L)}{(L - L')}$$

Where: K is the growth coefficient of the von Bertalanffy equation, L_∞ is the asymptotic length on the von Bertalanffy growth equation, L is the average of fish length in a certain age group, Lc is the length of the first fish caught by means, L' is the length of the smallest fish in the sample with the amount already taken into account.

The natural mortality rate (M) presumed to use the empiric Pauly (1980) formula referred in Sparre & Venema (1998):

$$\ln M = -0.0152 - 0.279 \ln L_\infty + 0.6543 \ln K + 0.463 \ln T$$

Where M is e (lnM), M is natural mortality, L∞ is asymptotic length on the von Bertalanffy growth equation, T is average of water surface temperature (°C). The rate of mortality of capture (F) was determined by:

$$F = Z - M$$

The rate of exploitation was determined by comparing the mortality of capture (F) towards the total mortality (Z) (Pauly 1984):

$$E = \frac{F}{F + M} = \frac{F}{Z}$$

The rate of mortality of capture (F) or optimum exploitation rate of Pauly (1984) was:

$$F_{optimum} = M \;\; \& \;\; E_{optimum} = 0.5$$

Estimation of yield model per relative recruit (Y/R). Estimation of yield model per relative recruit was determined by the Beverton & Holt equation (Sparre & Venema 1999):

$$(Y/R\ ) = E.U^{m}\left[1 - \frac{3u}{1+m} + \frac{3u^{2}}{1+2m} + \frac{u^{2}}{1+3m}\ \right]$$

Where: $U = 1 - \frac{Lc}{L\infty}$ and $m = \frac{1-E}{M/K}$

Where: E is the rate of exploitation, Lc is the size of the smallest class of captured fish (mm), M is the natural mortality rate (yr^{-1}), K is the growth rate coefficient (yr^{-1}), L_∞ is the asimptot length of fish (mm).

Results and Discussion

Estimation of growth parameters. Estimation of growth parameters from the extraction of collected fish sample data amounted 1,592 individuals, growth analysis result by Elefan 1 method showed a growth coefficient value of k = 0.7 yr^{-1}, assumption of asymptotic length of L_∞ = 202.13 mm, with RN value (Goodness of fit) = 0.204 and the value obtained by the Pauly (1980) equation was – 0.14 yr^{-1}, then we obtained the growth curve of *A. testudineus* (Figure 2).

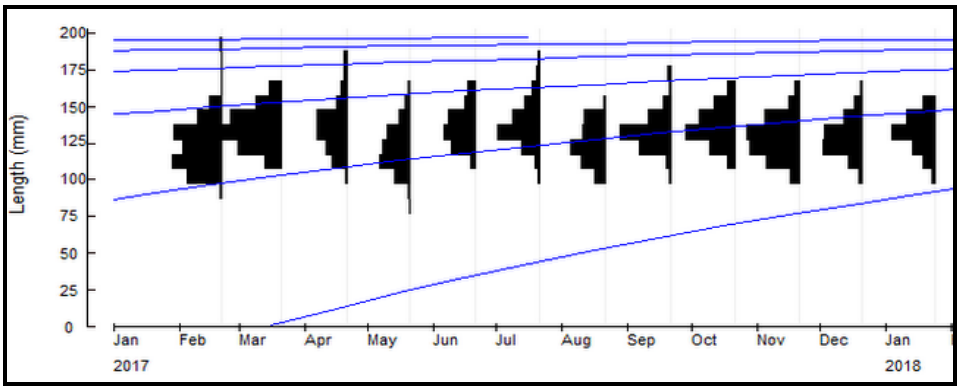

Figure 2. Growth model VBGF (*Anabas testudineus*).

From the calculation result of length growth assumption (K, L_∞ dan t_0), it was obtained growth equation von Bertalanffy $L_t = 202.13\ (1\text{-}e^{-0.7(t+0.14)})$ (Figure 3). The growth equation of von Bertalanffy in Figure 3 shows that there is a relatively rapid growth in the age of fish of 0-2 years, and when compared with the size interval of fish caught then at the age of 0-2 years the fish caught has an interval of 108-117 mm size, 118-127 mm, 128-137 mm, 138-147 mm, and 148-157 mm with the number of collected fish data amounts 1,453 or 91% of the total catch. Estimated age of asymptotic length (L_∞) of *A. testudineus* is 6 year.

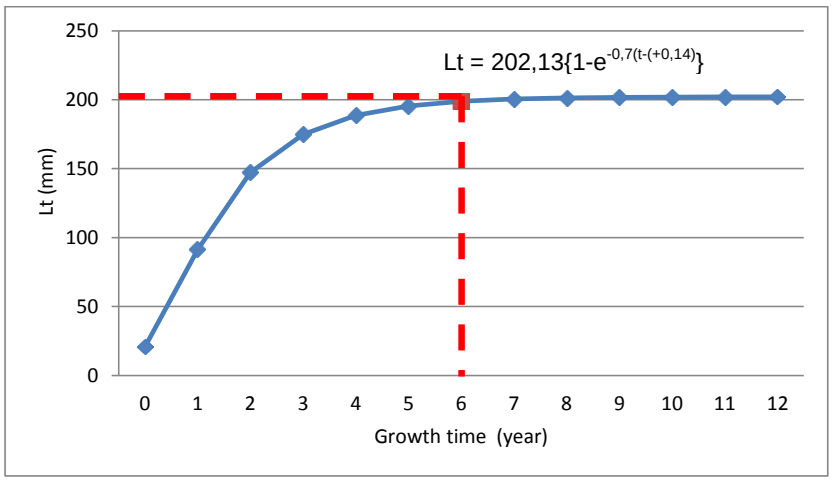

Figure 3. Curve of *Anabas testudineus* growth at Semayang Lake, Indonesia.

Variable in determining estimation of *A. testudineus* growth had differences in each location. The range records the growth coefficient (K) of *A. testudineus* that ranges from 0.7 to 1.4 yr^{-1}, the asymptotic length (L∞) ranges from 63 to 202 mm and the age of fish hypothesis at zero year (t_0) ranges from 0.072 to 0.14 yr^{-1} (Table 1).

Table 1

Presumption of *Anabas testudineus* growth parameter at Semayang Lake and other locations

Location	*Measurement method*	*K yr^{-1}*	*L_∞ (mm)*	*T_0 (yr^{-1})*	*Source and the year of publication/research*
Semayang Lake, Indonesia	Total length	0.7	202.13	0.14	Present research February 2017 – January 2018**
Melintang Lake, Indonesia	Total length	1.3	200.55	0.072	Mustakim et al 2009*
Shapla *beel* Bangladesh	Total length	1.4	171	-	Mustafa & De Graaf 2008*
Sri Lanka *Mahawewa reservoir*	Total length l	-	63	-	Wijeyaratne & Perera 1992-1993** (1999*)
Sri Lanka *Boralasgamuwa Reservoir*	Total length l	1.02	94	-	Wijeyaratne & Perera 1992 - 1993** (1999*)

* - year of publication, ** - year of research.

Growth is a good indicator to see the health condition of individuals, populations, and of the environment. Definition of growth in terms of energy is useful for understanding the factors affecting the growth of fish namely the energy intake from food, energy output for metabolism, energy output for growth, and energy output in excretion (Moyle & Cech 2004). The value of (K) on *A. testudineus* in different locations indicates unequal values. This is influenced by several factors, such as food, environment conditions and temperature (Weatherley 1972). In addition to environmental factors, it is suspected that different food sources at different locations have an impact on the growth rate (Sulistiono et al 2001). Amir & Achmar (2015) added that the differences of growth coefficient can be due to differences in the maximum length of obtained fish samples, the location of the catch, the number of samples taken, and also due to different stock and recruitment.

The rate of mortality and exploitation. The rate of mortality and exploitation of the total mortality rate (Z) *A. testudineus* was obtained from the calculation of length and the $year^{-1}$ growth coefficient, presumed by using the methods of Beverton & Holt (1957), based on the calculations we obtained the value of total mortality (Z) of 1.63 yr^{-1}. While the natural mortality rate (M) of 0.87 yr^{-1} was obtained from the equation of Pauly (1980) in Sparre & Venema (1998) at an average year temperature of 30.9°C, and the estimation of mortality rate due to capture (F) of 0.76 yr^{-1}. Based on the calculation of total mortality rate value (Z) and death due to capture (F), it is obtained estimation of exploitation rate (E) of 0.47 $yr^{-1.}$ (Figure 4).

Natural death (M) of *A. testudineus* at Semayang Lake when compared to natural death (M) at Shapla beel is relatively lower, so are the total mortality (Z) and death by capture (F) (Table 2). Based on Table 2 it can be stated that *A. testudineus* has a relatively good status of exploitation with unexploited status because its value is still below 0.5 (Gulland 1983 in Bawol et al 2018).

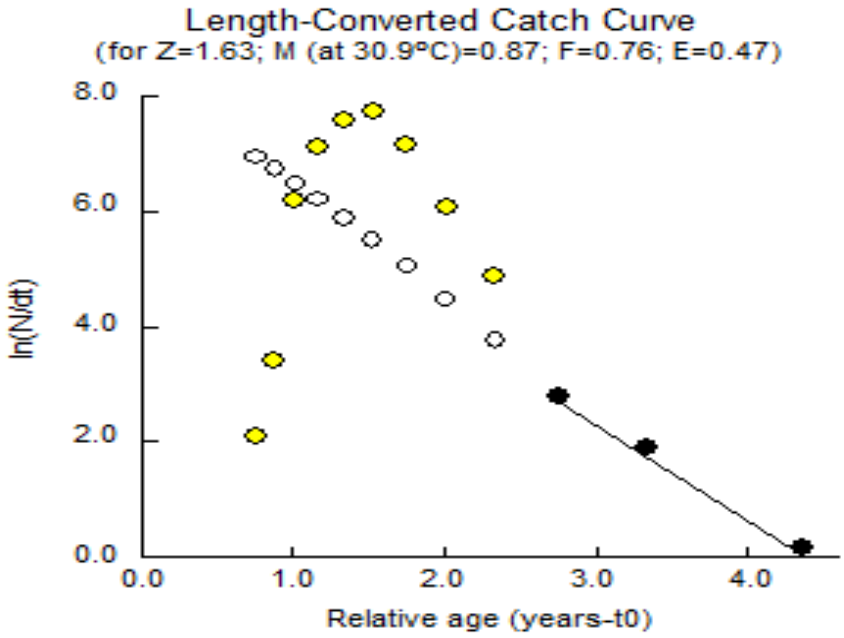

Figure 4. Length converted catch curve of *Anabas testudineus* at Semayang Lake, Indonesia. Yellow dots are fish caught with an estimated age range >0 - <3 years and black dots are fish caught with an estimated age range of >2.5 - >4 years.

Table 2

Mortality estimation and exploitation rate of *Anabas testudineus* at Semayang Lake, Indonesia and Shapla Beel, Bangladesh

Location	*Total mortality (Z)*	*Fishing mortality (F)*	*Natural mortality (M)*	*Exploitation rate (E)*	*Source and the year of publication/research*
Semayang Lake, Indonesia	1.63	0.76	0.87	0.47	Present research February 2017 – January 2018**
Shapla Beel Bangladesh	3.79	1.27	2.52	0.34	Mustafa & De Graaf 2008*

* - year of publication, ** - year of research.

The natural mortality rate (M) is not always analogous or opposite to total mortality value (Z), this is due to the strong influence of the monthly water temperature. According to Mamangkey & Nasution (2014), there was a close relationship between the natural mortality of fish and the water temperature namely higher is the temperature of the water area, higher is the natural mortality. Sparre & Venema (1998) in Jabbar et al (2017) added factors causing natural mortality in fish caused by disease, environmental conditions, stress and predation. This is reinforced by the existing condition of Semayang Lake which has a fluctuate type of water dynamics where in the rainy season, the water is very abundant while in the dry season, Semayang Lake has a drastic quantity of water decreases which causes relatively extreme water condition on quality.

Results per relative recruit. From the result of Beverton & Holt analysis Y/R by using Fisat II, was obtained value (E_{50}) of 0.334, (E_{10}) of 0.504, (E_{max}) of 0.580 and exploitation rate value (E_{cur}) of 0.47. Value of E_{cur} if it is compared to E_{OPT} (Gulland 1983 in Bawole et al 2018), the existing exploitation is only 94% and still has the potential to increase by 6%. E_{cur} value is expected to be increased to the value of economic exploitation (E_{10}) so the position of E_{cur} is at 93.3% so that the utilization effort can be increased by 6.7%, but if E_{cur} will be raised to the maximum value of sustainable yield

(E_{max}) then this time, the value of E_{cur} is 81.03% and still can be increased by 18.97% (Figure 5).

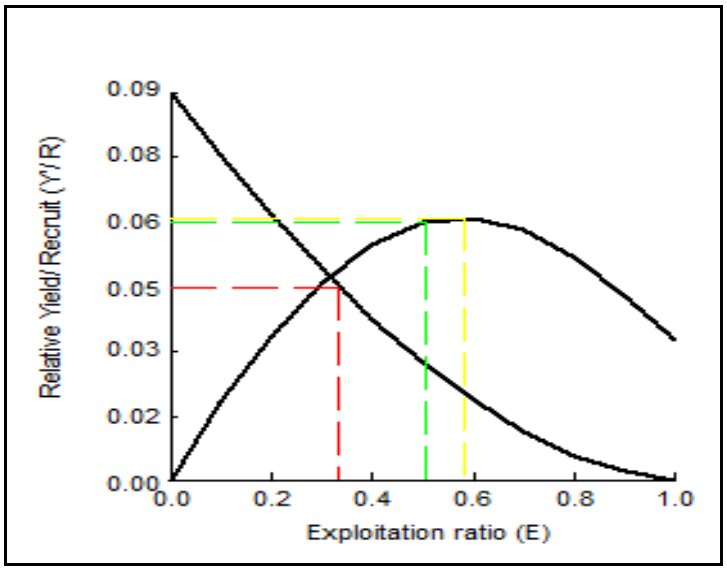

Figure 5. Value of E and Y/R of *Anabas testudineus* at Semayang Lake, Indonesia. Red line (E_{50}), Green Line (E_{10}) and Yellow Line (E_{max}).

The function of Lc/L_∞ and M/K on the analysis Y/R Beverton & Holt determine Y/R value. The result of analysis shows that the estimated value of Y/R on E_{cur} is 0.05970 g/recruit, meaning that in each recruit of *A. testudineus* contains 0.05970 g which can be taken as the catch result. Sequentially, the value of Y/R on E_{10} is 0.0603 and E_{max} is 0.0610. Based on the value of Y/R, then the value of E_{cur} is still classified on safe and sustainable utilization of *A. testudineus* resources. The estimation of results per recruit is one of the models that can be used as the basis of fisheries management strategy. This analysis is required in the management of fishery resources, as it provides an overview of the short- and long-term effects of different actions (Sparre et al 1989).

Conclusions. *A. testudineus* at Lake Semayang in a study conducted during February 2017 - January 2018 had growth coefficient k = 0.7 yr^{-1}, assumption of asymptotics length $L\infty$ = 202.13 mm with RN goodness of fit = 0.204 and the t_0 value of -0.14 yr^{-1} growth equation von Bertalanffy Lt = 202.13 $(1\text{-}e^{-0.7\ (t\ +\ 0.14}$). *A. testudineus* will reach the estimated asymptotic length in 6 years. Based on the length-converted catch curve we obtained total mortality (Z) of 1.63 yr^{-1}, natural mortality rate (M) of 0.87 yr^{-1} at an average temperature year of 30.9°C, and the estimation of mortality rate due to capture (F) of 0.76 $yr^{-1.}$, and also estimation of exploitation rate data (E) of 0.47 yr^{-1} was obtained. Model yield-per-recruit Beverton & Holt potential of actual *A. testudineus* resource E_{cur} will be raised to the maximum value of sustainable yield (E_{max}) then this time, the value of E_{cur} is 81.03% and still can be increased by 18.97%. The result of analysis shows that the estimated value of Y/R on E_{cur} is 0.05970 g/recruit, meaning that each recruit of *A. testudineus* contains 0.05970 g which can be taken as the catch result. Sequentially, the value of Y/R on E_{10} is 0.0603 and E_{max} is 0.0610.

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