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Growth and Age Structure of Nomei (*Harpadon nehereus*, Ham. 1822) in Juata Laut Waters of Tarakan Island, North Borneo, Indonesian

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Abstract

Nomei (*Harpadon nehereus*) in Juata Laut waters, Tarakan are caught using "pukat hela" (small trawler) that fits the muddy character of the sea, producing nomei with various sizes and biological attributes (such as growth and age structure). This research intends to see the trend of biological condition in order to provide actual data for the management of sustainable nomei resources. The result shows that female nomei have longer body and more weight compared to the males. The length of male nomei grows approximately $L\infty$ = 37,658 cm and maximum age of 951 days with value of K= 0,0146 cm/day and t_0 = -1,082 cm. The female fish can grow up to $L\infty$ = 38,535 cm and maximum age of 813 day with value of K = 0,0159 cm/day and t_0 = -1,039 cm. The male fish grow fast in the day 0-142 up to 32,995cm and grow slow in day 143-277 up to 37.008 cm and constant grow after day of 278-951.7 at $L\infty$. The female fish grow fast in the day 0–170 up to 35.995 cm and grow slow in day 171–365 up to 38.420 cm and constant grow after day 366-813.7 at $L\infty$.

Keywords: infinitive length; growth coefficient; estimated fish-age; nomei fish; small trawler.

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1. Introduction

Nomei fish or Pepija fish [1] are local names for *Harpodon nehereus* found in Juata Laut waters, Tarakan. *Harpodon nehereus* is the family of *Synodontidae* from class *Actinoptergyii* [2]. Nomei fish that are caught in Tarakan morphometric identically to lomek fish found in Dumai [17, 20]. *Harpodon nehereus* is estuarine fish found in Bengal bay, Indian ocean, Bangladesh and Pakistan [12, 15, 5, 2, 9, 11]. *Nomei* fish found in Juata waters, Tarakan, are caught using *pukat hela* is used to fit the characteristics of the sea which has muddy substrate. The use of the tool is legal based on the rule in regulation of the Ministry of Marine and Fishery Republic Indonesia, number 6 year 2008. The trawl is used to catch the Nomei fish as the main target that is done when the sea is lowest tide [21, 17, 6]. The Nomei fish has been an important commodity for various product of salted fish which plays big role to the improvement of the fishers' economy and society [7].

The application of *pukat hela* brings in Nomei fish with various sizes due to the various shapes in its condend. It is also caused by the nature of the multi-species tropical biota and the active towing/dragged of the *pukat hela*. Besides, the variety of length, body circumference, and weight is also identified and being followed by various biological conditions, such as the growth pattern and the structure of age. The parameter growth of *H. nehereus* in India sea, Bangladesh, and Pakistan has been studied [2, 15, 5, 9] which results showed that the infinitive length of the fish ($L\infty$) tended to decrease, while the coefficient of growth (K) was likely to increase. The growth of *H. nehereus* in Dumai, Riau was observed by [20] which result showed that the pattern of growth for lomek fish was negative allometric with sex ratio of 67% male and 33% female. The biological aspects fish found in Tarakan have also been observed including the pattern of growth, age structure and condition factors [8]. Based on the result of this study, it has been figured out that there were changes occurred to the biological aspect of the *H. nehereus* in middle Asia. What about the *lomek* fish or *nomei* fish in Indonesian?

The management of the fishery resources should consider biology of values when using these the resources which should also apply to the fishing of nomei fish in Tarakan. The pattern of growth analysis is beneficial to determine the selectivity of the capture fisheries [16]. The parameter of growth such as K (growth coefficient), $L\infty$ (estimated of the maximum length) and t_0 (estimated of the fish age at the null length theory) are the values that realistically correlated [14]. The research on the biological aspects using the pattern of growth and age structure of the Nomei fish (*Harpadon nehereus*) caught in Juata Laut waters, Tarakan, attempts to find out the trend of biological aspects as an important value to consider in the sustainable utilizations of Nomei fish. The analysis of the growth of the fish is the most frequently used parameter to determine the fish population which also beneficial to the productivity and the supply of the fish resources [10].

2. Materials and Methods

Research on the biological aspects using the pattern of growth and age structure approach of Nomei fish in Tarakan sea was conducted for six months. Observations were done specifically in the fishing base of *pukat hela* fishery in Juata Laut sub-district, Tarakan city, in the northern part of the area in which the fishing ground of Nomei fish (Figure 1)

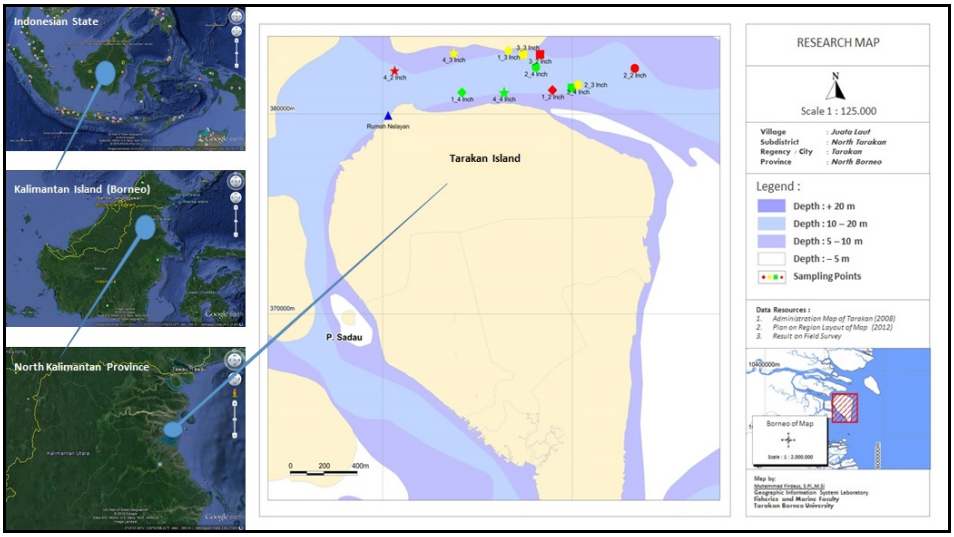

Figure 1: Fishing area of nomei in the *pukat hela* fishery area in Juata Laut waters, Tarakan.

A number of nomei that were caught using *pukat hela* from the Juata Laut waters, Tarakan were used as the sample. The collection of the primary data was conducted using purposive sampling technique for six months. Approximately 80 fish were collected every month by catching the samples once in a two week to collect around 20 fish in two days, involving different fishermen in different area. The sample collection was done by following the fisherman sailing to the sea once a week and observing from the dock fish collection once. Observations were conducted by measuring the total length, weight, body's circumference of each fish.

The collected data were then analyzed using *von Bertalanffy* model and using approach proposed by Gulland and Holt Plot [23]. Parameters to review were the L_∞ (infinitive length), K (coefficient of growth) dan t_o (age estimated at zero length theory) based on the model of growth developed by *von Bertalanffy* as follows.

$$Lt = L_\infty \{1 - e^{-k(t-to)}\}$$

In making assumptions of the coefficient of growth (K) and infinitive length (L_∞), researcher employed the approach proposed by Gulland and Holt Plot [23] as follows

$$\Delta L/\Delta t = a - b\,(L_t + L_{t+1})/2$$

notes:

$\Delta L/\Delta t$ = length growth per age difference.

$(L_t + L_{t+1})/2$ = length average of different ages.

a, b = coefficient in length at t-age and growth velocity

Therefore, the value of coefficient parameter of growth (K) and infinitive length (L_∞) can be estimated using the

equation as follows:

$L_\infty = - a / b$, and $K = - b$

The estimation of t_0 value was done using empirical formula by [19] as follows:

$ln (-t_0) = -0{,}3922 - 0{,}2752\ ln\ L_\infty - 1{,}038\ ln\ k$

L_∞ and k value of were obtained from the data of distribution fish frequency using *Ms. Excel 2013*. The analysis of age structure using shifting of modus class *von Bertalanffy* model [23] is:

$Lt = a + b * \Delta L/\Delta t$

3. Result

The sample of nomei obtained from 12 times sampling in six months for the review of biological aspects (pattern of growth and age structure) were 480 fish. The sample of the nomei consisted of 204 (42.5%) female and 276 (57.5%) male. The result of the measurement showed various kinds, sizes, weight and circumferences of the male and female fish (table 1).

Table 1: Various sizes of the fish.

Sample of Fish		Variables		
		Length (mm)	*Weight (gram)*	*Circumference (cm)*
Male	*Max.*	310	150	18,4
	Min.	146	13,5	4,4
	Average	220,9	65,2	9,3
Female	*Max.*	330	233	16,5
	Min.	170	20	4,5
	Average	250,2	89,4	9,4

The parameters of growth that were being analyzed included the infinitive length (L_∞) or the maximum length at t-age and zero growth velocity; growth coefficient (K) or growth velocity as long as growth times; and estimated of fish age (t_o) or age estimated at zero length theory. Based on the analysis of the growth using *von Bertalanffy* model [23], the pattern of growth was formulated as follows:

$Lt = 37{,}658\ \{1 - 2{,}71828^{\ 0{,}0146\ (t - 1{,}080)}\}$

The equation describes that the sample of the male fish had L_∞ (infinitive length) of 37.658 and K (coefficient of growth) of 0.0146 and t_o (assumed age) of -1.080 with a (intercept) 0.498 and b (slope) 0.0146 (Table 2 and

Figure 2).

Table 2: Parameter value of the nomei growth based on the pattern suggested by *von Bertalanffy*

Parameter	Result of Analysis					
	Male			*Female*		
	Value	*Unit*	*Log*	*Value*	*Unit*	*Log*
Intercept (a)	0,5498			0,6127		
Slope (b)	-0,0146			-0,0159		
Infinitive length (L∞)	37,658	cm	1,5758	38,535	cm	1,5858
Coefficient of growth (K)	0,0146	cm/day	1,8356	0,0159	cm/day	1,7998
Assumed age (t_o)	-1,080	day		-1,039	day	

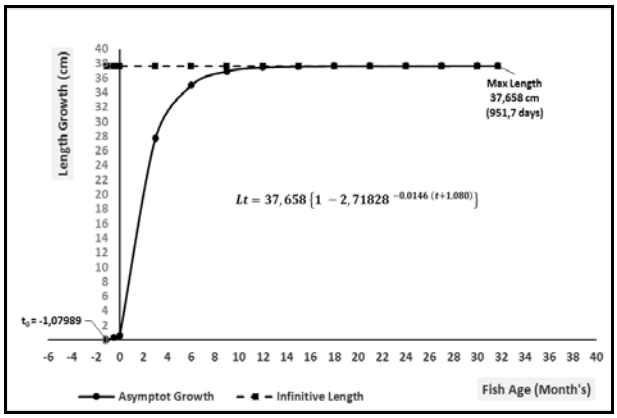

Figure 2: *Von Bertalanfy's* curve of growth of the male fish.

The data analysis using the *von Bertalanffy* model [23] approach also resulted to the pattern of growth of the female fish using this equations:

$$Lt = 38,535 \{1 - 2,71828^{\,0,0159\,(t\,-\,1,039)}\}$$

Using this equaton, it was found that the female fish had infinitive length (L_∞) of 38.535, coefficient of growth (K) of 0.0159, assumed age (t_o) of -1.039. The other result from the measurement on the pattern of growth of the female fish showed that a value (intercept) was found at 0.6127 and b (slope) -0.0159 (table 2 and figure 3).

To find out the age structure of the male fish, the researcher employed the shifting method of modus classes under the pattern of growth proposed by *von Bertalanffy* model [23] which resulted this following equation.

$$\Delta L/\Delta t = 0,5498 - 0,0146\ Lt$$

The infinitive length of the male fish when reaching the zero point was at 37.658cm (Figure 4).

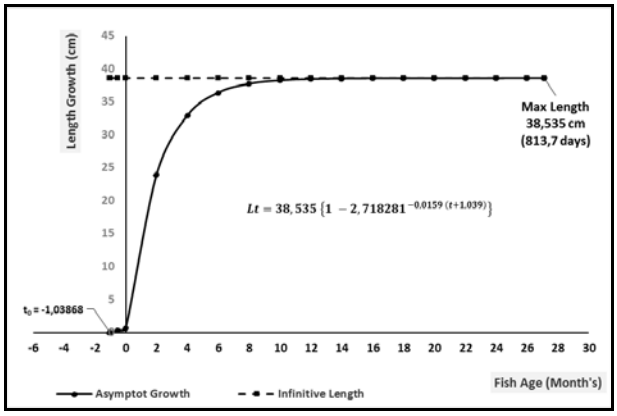

Figure 3: *Von Bertalanfy's* curve of growth of the female fish.

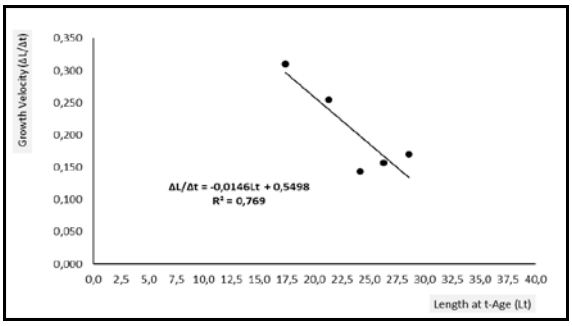

Figure 4: Age structure curve of the male fish

To find out the age structure of the female fish, the researcher employed the shifting method of modus classes under the pattern of growth proposed by *von Bertalanffy* model [23] which resulted this following equation.:

$\Delta L/\Delta t = 0,6127 - 0,0159\ Lt$

The infinitive length of the female fish when reaching the null point was at 37.658 cm (Figure 5).

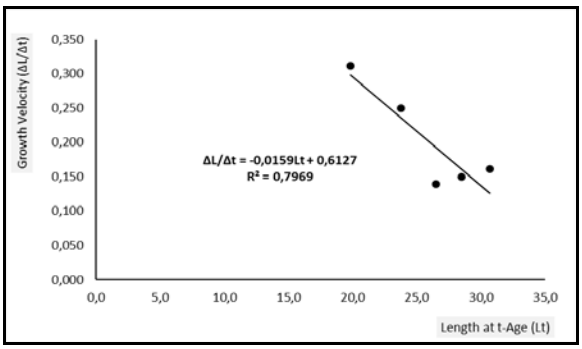

Figure 5: Age structure curve of the female fish

4. Discussions

Overall, there were 480 Nomei fish collected and used as the sample from the Juata Laut, Tarakan. The sex ratio of the sample was 1.3:1. There were 276 male fish with the total length of 22,09±8,0 cm and average weight of 65,2±68,3 gram with average circumference of 9,4±6 cm. Based on the date, it was found that the female fish were lengthier and weightier compared to the male fish. Compared to the Nomei fish found in the Dumai, Riau, [20] the Nomei fish from Tarakan, the male and female fish were lengthier, yet the female fish were weightier and the male fish were lighter. Different results were found from the research on the fish in Dumai, Riau which the percentage of the fish's sex of the sample was 67% male and 33% female [20]. Similar to it, out of the 720 fish as the sample, the sex ratio of the fish in Tarakan was 1: 0.95, which was also similar to the *H. nehereus* found in Indian sea [5, 2, 9], which can be concluded that there are slightly more male fish than female fish.

Based on the equation, it can be assumed that the pattern of growth of male nomei (*H. nehereus*) in Tarakan can reach up to the maximum length of 37.658 cm and assumed age of 951.7 days. Whilst, assumption of pattern of growth of female nomei can reach up to the maximum length of 38.535 cm and assumed age of 813.7 days. The assumed infinitive length found in this study is shorter than the finding of [12] 40.0 cm and by [5] 48.8cm. Yet, the it is lenghtier than the result of study conducted by [9] for the fish in Saurashtra India. In addition, it is also lengthier than the length of the fish were 33.85 cm (male) and 35.74 cm as written by [8] of 2012 year data caught in Tarakan.

The result of the data analysis using the pattern of growth proposed by *von Bertalanffy* to measure the growth of *H. nehereus* in Tarakan showed that the value of growth velocity was 0.0146 cm/day and initial length estimated at zero age theoritic of 1.08 cm for the male fish. Whereas, for the female fish, the value of growth velocity was 0.0159 cm/day with initial length estimated at zero age theoritic of 1.039 cm and the determinant value of (R^2) 0,99. Those values are lesser than the ones found by [8] showing that the K value was at 0.018 and the t_0 = -1,79.

Differences of values in growth parameters, be possible by some factor such as enviroment, food and feeding habits, prey and predators, fishing exploitation and research method [9]. Factors of environment includes the temperature, salinity, and the clearness of the water. While the factors related to the foods are the supply of the food, the eating habit, and the competition to get the food. Factors related to the preying are the existence of other predators and preys. Meanwhile, the exploitation (fishing technique) is related to the how to use the tool to catch fish for sampling and the research method employed by the researcher in collecting and analyzing the sample. Those factors were not directly measured in this research due to the inability of this study to represent specific seasons throughout a year, yet those factors were used as considerations to make annual estimation. Reference stated [13] that the increasing values of the pattern of growth parameter indicates the improvement on the nutrition consumed by the fish. The Nomei fish in Tarakan mostly consume tiny white shrimp with IBT value 78.10% [3]. White shrimp are also widely found in estuarine sea and coasts which mangroves are in the good condition. The Nomei fish in Tarakan were caught using *pukat hela* which is best operated in the muddy sea and in estuarine sea [21, 6].

Based on the use of the model by *von Bertalanffy* to analyze the data of the Nomei fish in Tarakan, the

determinant coefficient (R^2) was shown at 0,9996 which means that the parameter of the growth ($L\infty$, K and t_0) successfully explained 99.96% of the realistic correlation between the length of the fish and the age of the fish. The correlation coefficient (r) fr the male fish was 0.876 which can predict the growth parameters ($L\infty$, K and t_0) at 87.6%. Whilst. The correlation coefficient (r) for the female fish was found at 0.893 which means that the growth parameters ($L\infty$, K and t_0) can be predicted from the length and the age of the fish with good regression *goodness of fit the model* [18, 11].

The analysis of the age structure of the male nomei using the shifting pattern of growth by *von Bertalanffy* resulted the regression equation for the male fish:

$\Delta L/\Delta t = 0{,}5498 - 0{,}0146\ Lt$ ($r^2 = 0{,}769$; r =0,876)

The equation of the age structure describes the linear line down to the zero point (x axis). The line is the increase of the age gap ($\Delta L/\Delta t$) or the growth velocity of the fish which reversedly linear to the age t (Lt) or the length of the fish in a certain age. The result also means that every accretion of 1 length unit, the growth velocity will decrease at 0.0146 cm/day.

When the regression line touches the x axis, then the value of $\Delta L/\Delta t$ or the growing speed reaches the zero point which means that the growth has reached its maximum length. The estimated maximum length is 37.658 cm and maximum age of 951.7 days or the longetivity value of the male fish is 2.6 year. The analysis of the equation is being strengthened by the determination coefficient (R^2) at 0.769 which means that the accretion per age gap ($\Delta L/\Delta t$) is described at 76.9% by the correlation between the length and the age of the fish with good regression/ *goodness of fit the model* [18, 11]. Another value is the correlation coefficient (r) at 0.876 which means that there is strong correlation between the accretion per age gap ($\Delta L/\Delta t$) and the age longetivity t (Lt) as stated by [22] that when the correlation coefficient is around 0.5 to 0.75 shows strong correlation between the variables, and very strongly correlated when it the coefficient is around 0.75 to 0.99.

The analysis of the age structure of the female nomei using the shifting pattern of growth by *von Bertalanffy* resulted the regression equation for the male fish:

$\Delta L/\Delta t = 0{,}6127 - 0{,}0159\ Lt$ ($r^2 = 0{,}7$; r =0,893)

The result for the female fish was similar to the result of the male fish which shows that every accretion 1 point to the age t (Lt), the growing speed decreased 0.0519 cm/day. When the regression line touches the x axis, then the value of $\Delta L/\Delta t$ or the growing speed reaches the zero point which means that the growth has reached its maximum length. The estimated maximum length is 38.353 cm and maximum age of 813.7 days or the longetivity value of the female fish is 2.2 year. The analysis of the equation is being strengthened by the determination coefficient (r^2) at 0.7 which means that the accretion per age gap ($\Delta L/\Delta t$) is described at 70% by the correlation between the length and the age of the fish with good regression/ *goodness of fit the model* [18, 11]. Another value is the correlation coefficient (r) at 0.893 which means that there is strong correlation between the accretion per age gap ($\Delta L/\Delta t$) and the age longetivity t (Lt) as stated by [22] that when the correlation coefficient is around 0.5 to 0.75 it shows strong correlation between the variables, and very strongly correlated

when it the coefficient is around 0.75 to 0.99.

The simulation table of *von Bertalanffy* pattern of growth of the fish showed that the male ones grow very quickly in day 0-60 up to the length of 22.221 cm; grow quick in day 61-142 up to 32.995 cm; grow slow in day 143-277 up to 37.008 then grow very slow or constantly in the day 278 up to the maximum length of 37.658 cm. Statement [23] that the accretion of the length is linear to the time, yet the speed declines as the fish get older and close to the lowest line to the zero. The female fish grow very quickly in day 0-80 up to the length of 27.991 cm; grow quick in day 81-170 up to 35.995 cm; grow slow in day 171-365 up to 38.420 then grow very slow or constantly in the day 278 until reaching the maximum age of 813.7 day and estimated maximum length of 38.535 cm. The pattern of growth of fish is autocatalytic, as mentioned by [4] that fish grow slow, and then grow fast, and then going slow again until reaching certain size, and eventually growing constantly or even stagnant.

To create sustainable capture fisheries, the fishing gear used (as effort) should be having high selectivity. It has to be selective to the kinds of fish, the sizes, and it should support the breeding of the fish. The analysis on the pattern of growth is benefit in determine selectivity to the sustainable capture fisheries [16]. The basic concept of the sustainable capture fisheries is to provide at least one chance for the fish to pass the maturity phase and to do spawning.

The result of the data analysis on the sample of male Nomei fish showed that the actual mean length (L) and the length at first maturity (Lm) could be compared to the value of growth of *von Bertalanffy* to estimate the value of the sustainability of the Nomei fish resources. The male fish with actual average length (L) of 22,110 could have caught in the age of 59,5 days. Length at the first maturity (Lm) is 23.785 cm and caught in the estimated age of 67.32 day. For the female fish, with the actual average length (L) of 25.007 cm would have been caught in the age of 64.80 day, while the estimated first time gonad maturity (Lm) of 25.017 cm which estimated age is 64.85 day. Therefore, carefully action should be taken related to the fishing of the male and female fish to consider the size of the fish to determine the estimated age of the fish, appropriate size of fish net in order to let the fish go through their maturity and spawning phase in the estimated age of above 67 day and size longer than 23.8 cm (male) and estimated age of 65 day and size longer than 25.1 cm (female).

5. Conclusion

Female nomei (*H. nehereus*) in Tarakan have longer body and more weight than the male fish. The nomei (*H. nehereus*) in Tarakan are estimated to reach the infinitive length of 37.658 cm (male), 38.535 cm (female) and estimated age 951.7 days (male) and 813.7 days (female) with the growth velocity 0.0146 cm/day (male), 0.0159 cm/day (female) and the age estimated at zero length theory of -1.08 day (male) and -1.039 day (female). The male nomei (*H. nehereus*) grow very rapidly in the day 0-60 reaching up to length of 22.221 cm; grow fast in day 61-142 reaching up tp 32.995 cm, grow slow in day 143-277 reaching 37.008 cm and grow constantly slow/constant in the day 278-951.7 (maximum age) until reaching the maximum length of 37.658 cm. The female nomei (*H. nehereus*) grow very rapidly in the day 0-80 reaching up to length of 27.991 cm; grow fast in day 81-170 reaching up tp 35.995 cm, grow slow in day 171-365 reaching 38.420 cm and grow constantly

slow/constant in the day 366-813.7 (maximum age) until reaching the maximum length of 38.535 cm.

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