Model of growth and mortality of otek fish (*Netuma thalassina* (Rüppell, 1837)) in Tarakan waters, North Kalimantan

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Abstract. Tarakan is rich in marine biological resources, including otek fish (*Netuma thalassina*), in the Juata waters and Mamburungan waters. Despite its abundance, this species is rarely used for consumption, primarily being processed into salted fish. Therefore, this study aimed to analyze the growth and mortality model of otek fish in Tarakan waters, North Kalimantan. Employing field surveys and quantitative descriptive methods, the investigation was conducted in Juata waters and Mamburungan waters. A sampling of otek fish was performed 12 times over 4 months from April to July 2023, with intervals of 2 weeks, in the sea and Mamburungan waters. Data collection comprised parameters such as sex, length, and weight of otek fish. The results showed that both male and female otek fish exhibited negative allometric growth, predominantly characterized by a thin body shape. While males demonstrated faster maximum length growth, females had swifter growth. The natural mortality value was higher among male fish, but total mortality, catch mortality, and exploitation rate were more pronounced in females. Additionally, mortality and exploitation rates were indicative of optimum exploitation.
Key Words: capture, diversity, marine waters, wild population.

Introduction. Tarakan waters, particularly in Juata waters, are rich in marine biological resources (Salim et al 2023). Among these resources, the prominent species include nomei fish (*Harpadon nehereus*) (Firdaus et al 2018; Salim et al 2022b, 2023), gulamah fish (*Johnius* sp.) (Salim 2011), puput fish (*Ilisha elongata*) (Firdaus & Salim 2011; Salim 2011), layur fish (*Lepturacanthus savala*) (Indarjo et al 2020), white shrimp (*Litopenaeus vannamei*) (Salim et al 2020a), tiger shrimp (*Penaeus monodon*) (Salim et al 2020b, 2021), manthis shrimp (*Harpiosquilla raphidea*) (Salim et al 2020c), pakistani lobster (*Panulirus polyphagus*) (Indarjo et al 2023b), pearl lobster (*Panulirus ornatus*) (Indarjo et al 2023a), and otek fish (*Netuma thalassina*), as stated by Dewi (2023). Otek fish, commonly known as the giant catfish (Kailola 1999; Fishbase.org 2023; Kottelat 2013), is prevalent in Indonesian waters. It is important to note that a certain species in genus *Arius* has been designated as endemic and under conservation consideration by the IUCN Red List of Threatened Species in 2021, beating the identifier T196792A2476387, with the scientific name *Arius dispar* (fleshysnout catfish) (Torres et al 2021). However, Arius fish in Juata waters is identified with the species name *N. thalassina*, not in consideration of the conservation of endangered species.

Otek fish is an important commodity for Kalimantan people, spanning North, East, and South Kalimantan. In addition to Indonesia, it is also discovered along the western and eastern coasts of India, Bangladesh, Myanmar, Brunei Darussalam, Malaysia, Singapore, and the Philippines (DKP 2001; Anggawangsa & Faizah 2020).

The fish exhibits a substantial economic value (Anggawangsa & Faizah 2020), particularly in the by-catch category (Dewi 2023), and is used for salted fish production, as indicated by field surveys (Febriyanti et al 2015). There has been a substantial decline in the fishing yield of otek fish in Juata waters. Thus, the otek fish, despite being categorized as a fish in the economic classification of penning, is inadvertently caught as by-catch during regular fishing activities. Besides, it is processed as a dried fish product. The swim bladder is one part of the high-priced body of fish (note: having an essential economic value in the international market) (Kartika et al 2016). Some collectors sold the swim bladder (one of the internal organs of a fish) from otek fish for around IDR 450,000/kg or USD 28.97 (note: based on dollar exchange rate on September 2023). There were also various other types of fish swim bladders, and their prices vary based on size. Collectors stated that fish swim bladders are exported to China, where they are highly regarded as a luxurious culinary ingredient, primarily used in soup due to their high collagen content. Trilaksani et al (2006) reported that dried otek fish swim bladders have been used in China for an extended period as a food additive in vegetable soup, making them a prized edible luxury. Swim bladders can also be used as raw material for the production of isinglass, which has been used on an industrial scale as a fining agent.

Study on the otek fish population model, including the analysis of growth (Chandra et al 2014), condition index (Chandra et al 2015), mortality and exploitation rate of otek, plays an important role in comparing individuals across different populations (Lagler et al 1962). The analysis of otek fish growth in the waters of Juata waters, Tarakan City, employed two main methodologies, namely the length-weight relationship (Chakraborty et al 2017; Sarkar et al 2017; Chirwatkar et al 2021a; Indarjo et al 2021) and the Von Bertalanffy model (Salim 2010; Salim et al 2021, 2022a; Indarjo et al 2023a). Additionally, a model for the maximum growth of the species in their natural environment was determined using the methodology outlined by Gulland (1983). A condition index analysis was performed to establish a physiological model of fish body shape in its natural habitat, with a focus on obtaining comprehensive details regarding fish health during their developmental stages (Bhakta et al 2019a, b, 2020; Dewi 2023). To gain a comprehensive understanding of otek fish population dynamics, particular emphasis was placed on mortality and catch rate investigations. This facilitated the derivation of critical parameters such as natural mortality, catch mortality, and total mortality of otek fish in the Juata waters of Tarakan City. This approach was essential in generating a comprehensive model comprising otek fish fishing rates in this specific region (Masran 2016). It is important to note that while Masran (2016) indicated that otek fish typically inhabits offshore areas, including the Amal Beach area of Tarakan City, field surveys (Dewi 2023) have uncovered a distinct preference for the Juata waters of Tarakan City as their primary habitat.

Based on interviews with fishermen in Juata waters, Tarakan City (Dewi 2023), many of them express frustration in catching otek fish in the coastal waters. This species is not the primary target for trawl fishermen (FAO 1971), leading to less emphasis on its capture in the fishing community (Firdaus et al 2013). From a scientific perspective, this situation presents the necessity for thorough investigations. The population of a species plays a pivotal role in shaping the environmental ecosystem (Indarjo et al 2023a) in Juata waters, contributing to high biodiversity (Dewi 2023). Various studies have underscored the importance of studying the population growth and mortality models of otek fish in the waters of Juata, Tarakan City (Salim et al 2020a, 2021, 2022a, 2023). This study aims to develop a comprehensive understanding of the otek fish population in Juata waters, facilitating the creation of a population model. This enables the implementation of effective aquatic resource management practices, ensuring sustainability (Indarjo et al 2023a) and long-term viability. The subsequent phase includes the utilization of the domestication model (Indarjo et al 2022, 2023b).

Studies focusing on otek fish, particularly those aiming to derive population and mortality models from the catch of marine fishermen in Tarakan City, are considerably scarce. Consequently, it is imperative to conduct a study to gain insight into the natural population dynamics of otek fish. This knowledge will serve as the foundation for the sustainable and effective management of marine biological resources. Previous reports on otek fish have delved into various aspects, such as the feeding habits in the Charity coastal waters of Tarakan City (Masran 2016), and the characteristics of oil extraction from otek fish using dry extraction and wet rendering methods (Wijaya 2023). Otek fish belong to the important Ariidae family, with specific emphasis on the genus *Arius*. Bhakta et al (2019a, b, 2020) documented several species within this genus, including *A. arius*, *A. gagora*, *A. jella*, *A. maculatus*, *A. malabaricus*, *A. subrostratus*, *A. sumatranus*, and *A. venosus*, in India. Furthermore, Froese & Pauly (2018) identified dominant giant catfish species along the West Bengal coast, including *A. arius*, *A. maculatus*, *A. jella*, *Tachysurus caelatus*, *T. thalassinus*, and *Osteogeneiosus militaris*. This study represents an initial exploration, providing a comprehensive reference regarding the population of otek fish in the Juata waters of Tarakan City. The primary objective was to analyze the population model of this species based on catches made by trawl fishermen (Saputra et al 2016) in Tarakan City waters. The results are anticipated to furnish current information on the status of the otek fish population in Tarakan, with due consideration of its significant economic implications for the national economy. This enables policy makers to effectively determine the stages of sustainable fisheries resource management.

Material and Method. Sampling of otek fish from the sea waters of Tarakan city (Figure 1) was carried out for 4 months (April-July 2023) (Salim et al 2021, 2022a).

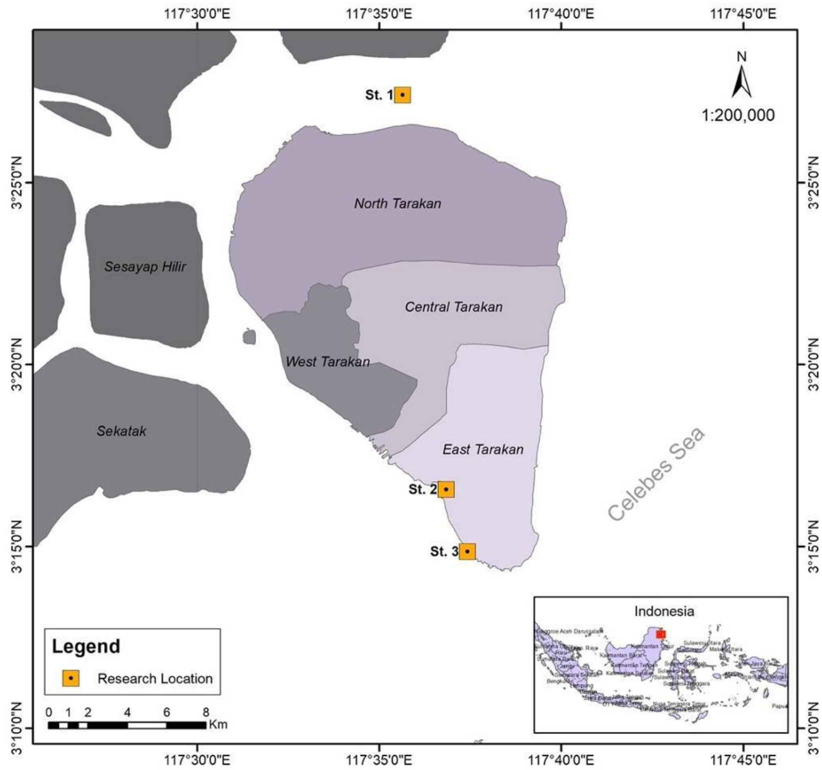


Figure 1. Map of research stations.

Data collection of otek fish samples at the research stations was conducted every two weeks (Dewi 2023). The sampling duration adjusts to the research location's high and low tide pattern. This condition was to maximize the number of samples collected.

Research methods. The research method uses a descriptive quantitative case study approach (Salim et al 2022a, b). Sampling of otek fish was carried out by means of direct surveys in the field with locations in the sea waters of the city of Tarakan (Salim et al 2020a; Indarjo et al 2023a). Otek fish individuals were collected using a purposive sampling method (Indarjo et al 2022; Salim et al 2022a) where the fish taken were already mature fish (Salim et al 2020b, 2021).
The samples obtained were brought to the Fisheries Biology Laboratory of FPIK UBT to collect research data in the form of total length, weight, and sex (Indarjo et al 2022, 2023a) of the otek fish. Total length data was collected by measuring the fish body from the tip of the nose to the posterior part of the caudal fin (Salim et al 2020c; Indarjo et al 2022), weight data were obtained by using an analytical balances, the data from the sex was obtained surgically to take the gonads and determine the sex (Effendie 2002; Indarjo et al 2020) of otek fish. Data testing used growth models, namely the allometric growth model, the condition index growth model, the von Bertalanffy model and the mortality model (Salim et al 2021; Indarjo et al 2023b)

Data analysis. Data analysis of growth variables used Von Bertalanffy model formulas (Wiharyanto et al 2013), while alometric models and condition index models used data on total length, total weight and sex (Salim et al 2022a; Indarjo et al 2023a). Analyses of mortality data processing variables used the natural mortality model formula, catch mortality, total mortality, and the level of exploitation of fish resources used advanced data from the Von Bertalanffy model (Salim et al 2022a; Indarjo et al 2023a).

Fish population. The absolute growth model for the size class of otek fish used the von Bertalanffy formula based on the Gulland & Holt (1959) in Sparre & Venema (1998) as follows:

$$L_t = L_\infty \left(1 - \exp^{-k(t-to)}\right)$$

where: L_t = the length of otek fish at the age of t (cm);
L_∞ = the infinitive length of otek fish (cm);
K = growth coefficient (per day);
t_o = theoretical age of fish at zero length.

Age structure. The age structure analysis uses the class shift mode method with the Von Bertalanffy model as described in Sparre & Venema (1998), namely:

$$(\Delta L/\Delta t) = (L_2 - L_1) / (t_2 - t_1) \text{ and } L_{(t)} = (L_2 + L_1)/2$$

where: $(\Delta L/\Delta t)$ = relative growth;
ΔL = fish length;
Δt = time period;
L(t) = the average length mode.

By plotting the values of $L_{(t)}$ and $(\Delta L/\Delta t)$, a regression linear formula is obtained:

$$y = a + bx$$

where: $a = ((\Sigma y/n) - (b\,(\Sigma x/n)))$;
$b = (n\Sigma(xy) - (\Sigma x) * (\Sigma y)) / (n\Sigma x^2 - (\Sigma x)^2)$;
n = total samples;
x = value $L_{(t)}$;
y = value $(\Delta L/\Delta t)$.

The average value of the length mode of the method was used to calculate the asymptotic length (L_∞) and the growth coefficient (K):

$$K = -b$$

$$L_\infty = -a / b$$

To determine the value of the theoretical age t_0 (the theoretical time at zero fish length) the model of Pauly (1984) and Pauly & David (1980) was used:

$$\text{Log}(-t_0) = 0.3922 - 0.2752 \text{ Log}(L_\infty) - 1.0382 \text{ Log } k$$

To derive the relative age at various lengths from the Von Bertalanffy model the following equations were used, according to Gulland (1983):

$$-\ln(1-Lt/L_\infty) = -K(t_0) + K(t)$$

$$t = t_0 - \ln * (1 - (Lt / L_\infty)$$

Allometry. The length-weight relationship correlation was analyzed to determine the growth pattern, by entering length and weight data converted into logarithmic form and then processing using SPSS 26.0 software with linear regression method (Kurniawan & Yuniarto 2016; Suryono 2018). The length-weight relationship model used the following formulae (Effendie 1979):

$$Y = a X^b \text{ or } \text{Log } Y = \text{Log } a + b \text{ Log } X \text{ or } W = aL^b$$

Condition factor. The value of K_{TI} (condition factor) for an isometric growth was determined by using the formula suggested by Effendie (1979) as follow:

$$K_{(TI)} = 10^5 \times \frac{W}{L}$$

where: $K_{(TI)}$ =condition factor;
W = apparent weight of fish (g);
L = fish length (mm).

According to Weatherley (1972), the condition factor of fish with allometric growth characteristics can be determined by the following formula:

$$Kn = \frac{W}{\hat{W}}$$

where: Kn = condition factor;
W = total fish weight (g) / total weight measurement (g);
$\hat{W}$ = estimated fish weight (g) / ideal weight estimate (g);
$\hat{W} = a L^b$ ($\hat{W}$ is derived from the length-weight regression equation).

The condition index criteria according to Salim et al (2020a) and Indarjo et al (2023b) are as follows:

1. the range the of condition index values is from 0.1 to 1.51 for a skinny body shape;
2. the condition index values range from 0.1 to 0.49 for a thin body;
3. the condition index value is 1 for a proportional body shape;
4. the condition index values range from 1.01 to 1.50 for a fat body shape;
5. the condition index values are > 1.50 for an obese body shape.

Mortality. The total mortality rate (Z) plays a role in population dynamics. It can be estimated following the Von Bertalanffy model (Salim et al 2022a; Indarjo et al 2023b) of the natural fish stock. The total mortality rate was estimated from the average length (L) of the catch of an otek fish population.

The natural mortality (M) of the otek fish was estimated using the empirical formula of Pauly (1984), as follows:

$$\text{Log } M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$$

The total mortality (Z) of the otek fish was then estimated using the Beverton and Holt formula (Sparre et al 1998) as follows:

$$Z = K \cdot \left[\frac{L_\infty - \bar{L}}{\bar{L} - L'} \right]$$

The fishing mortality (F) of the otek fish was estimated according to the following equation:

$$F = Z - M$$

where: F = fishing mortality;
Z = total mortality;
M = natural mortality.

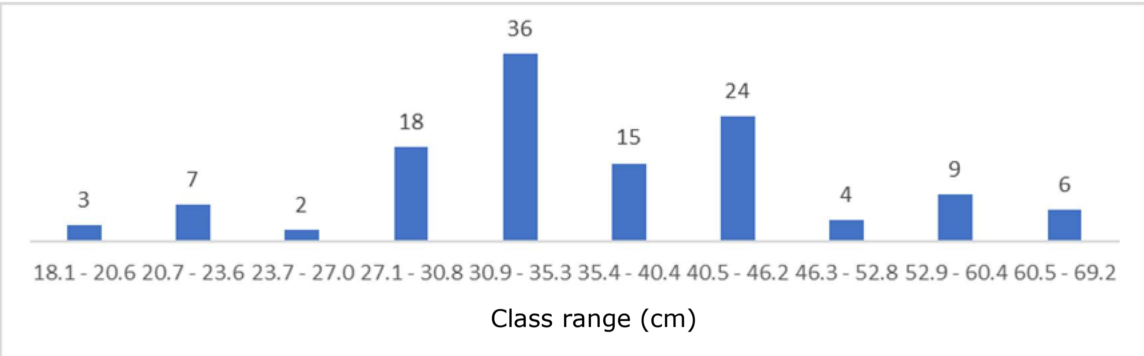
Finally, the exploitation rate (E) of the otek fish in the study area was estimated following Pauly (1984) as follows:

$$E = F / (F+M)$$

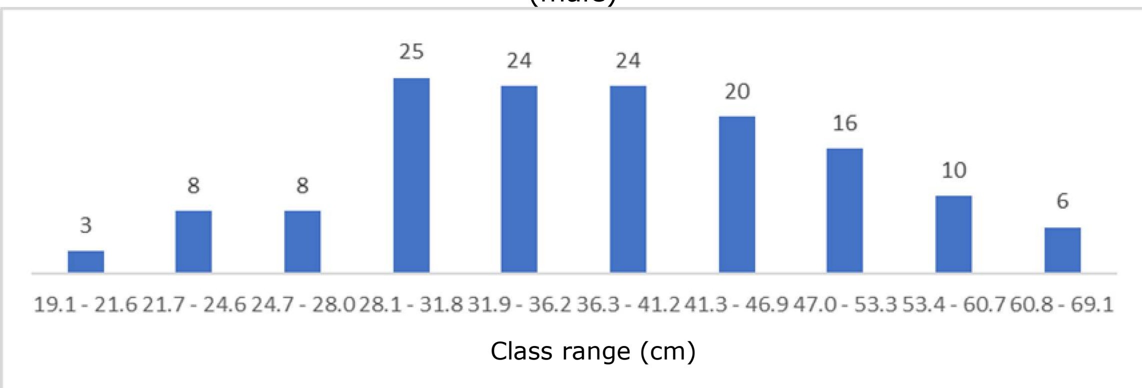
where: E = exploitation rate;
F = fishing mortality;
M = natural mortality.

Results. Based on the study results from the waters of Juata Laut, Tarakan City, and Mamburungan waters, Tarakan City, a total of 268 fish samples were collected, comprising 124 males and 144 females. Among the male fish, total lengths ranged from 18.1 to 69.2 cm, with an average of 37.7 cm. Additionally, the total weight varied from 42 to 2581 grams, averaging 590.2 grams. Female fish exhibited total lengths spanning from 19.1 to 69.1 cm, averaging at 38.75 cm. Their total weight ranged from 72 to 2703 grams, with an average of 634.6 grams. The results indicated that otek fish demonstrated a sex ratio of males to females at 1:1.16. The number of female samples exceeded the number of male fish samples.

The von Bertalanffy model. The Von Bertalanffy model was employed in the study of male otek fish, utilizing a sample size of 124 males and 144 females. The size structure formula model, which comprised 10 length classes for male fish, demonstrated a size range of 18.1-69.2 cm. Female fish exhibited a slightly wider range of 19.1-69.1 cm, as shown in Figure 2. Within Tarakan City waters, the largest male fish measured between 30.9-35.3 cm, comprising 36 individuals. In contrast, only 2 were observed at the smallest size range of 23.7-27.0 cm. Among female otek fish in Tarakan City waters, the most prevalent size category was 28.1-41.2 cm, comprising 24-25 individuals. The smallest category, with sizes of 19.1-21.6 cm, had the lowest frequency of sightings, totaling 3 individuals, as presented in Figure 2.



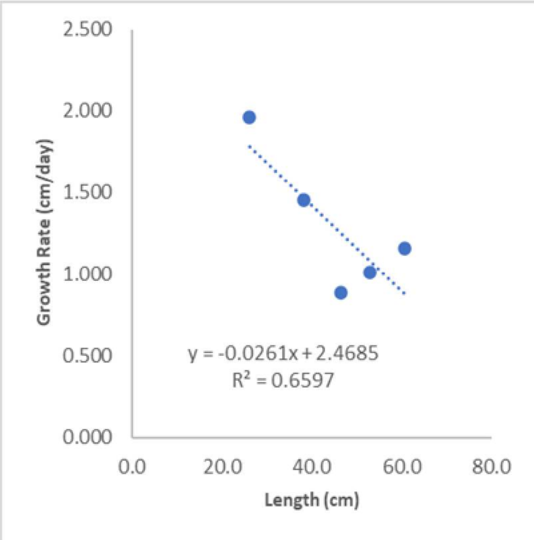
(male)

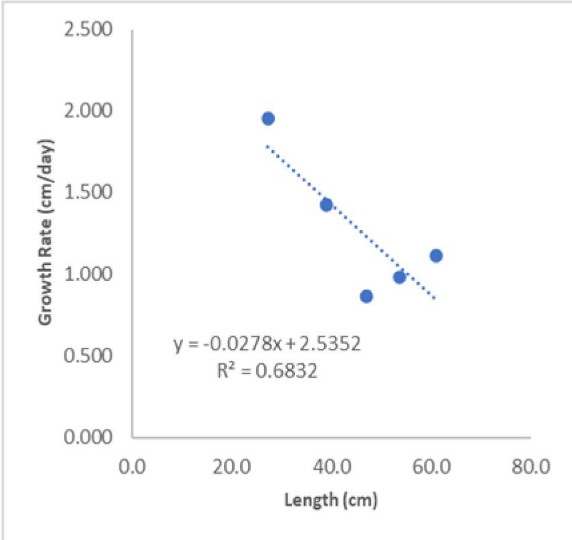


(female)

Figure 2. Class range of male and female otek fish based on fish length (cm).

Based on the results of the size structure model analysis of male and female otek fish obtained from Tarakan City waters, a linear regression equation analysis was derived using a comparison between fish length and growth rate (Figure 3). This produced an equation with the direction of the regression line oriented towards the x-axis. Considering the equation along the x-axis, the maximum length of otek fish with zero growth rate is obtained. The model both for male and female otek fish yielded equations of $y = -0.0261x+2.4685$ with an R^2 value of 65.97% as well as correlation of 81.22%, and $y = -0.0278x+2.5352$ with an R^2 value of 68.32% as well as correlation of 82.66%, respectively. The age structure model obtained a regression equation to produce the Von Bertalanffy model, employing an orthogonal polynomial type 6 model which used 2 different variables, namely the time (day) and the total length variable (cm) of male and female otek fish.

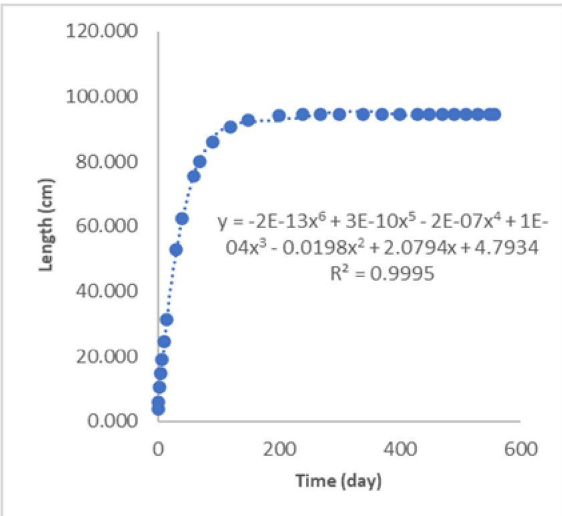


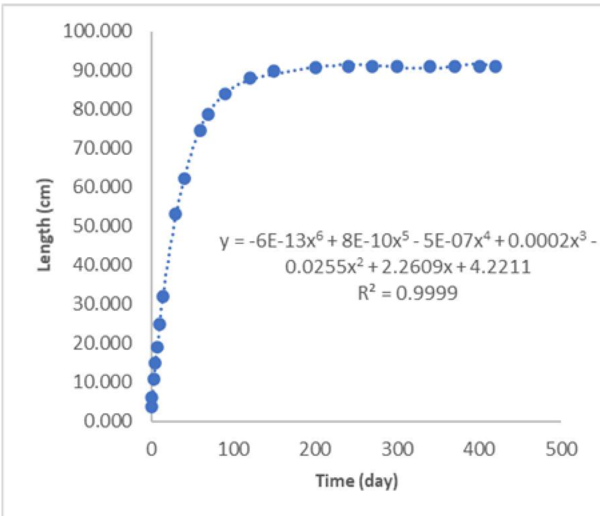


Male Female

Figure 3. Age structure in male and female of otek fish.

The results of data processing using an age structure model obtained a regression equation to produce a Von Bertalanffy model with an orthogonal polynomial type 6 model using two different variables, namely the time variable (day) and the total length variable (cm) of male and female otek fish. Based on Figure 4, the Von Bertalanffy equation model for male otek fish is obtained, namely $y = -2E\text{-}13x^6+3E\text{-}10x^5-2E\text{-}07x^4+1E\text{-}04x^3-0.0198x^2+2.0794x+4.7934$ with R^2 of 0.9995 and female otek fish is $-6E\text{-}13x^6+8E\text{-}10x^5-5E\text{-}07x^4+0.0002x^3-0.0255x^2+2.2609x+4.2211$ with an R^2 value of 0.9999.

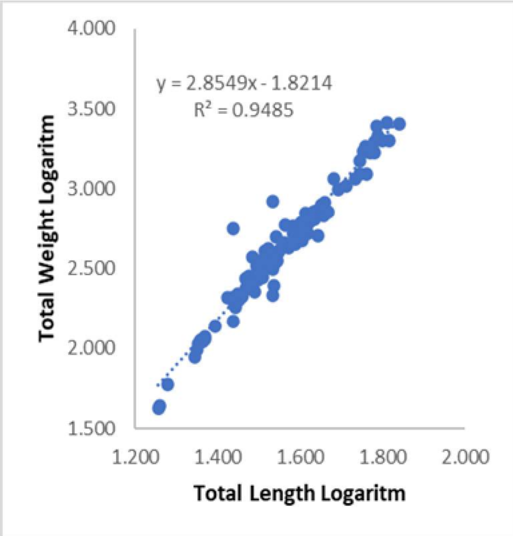


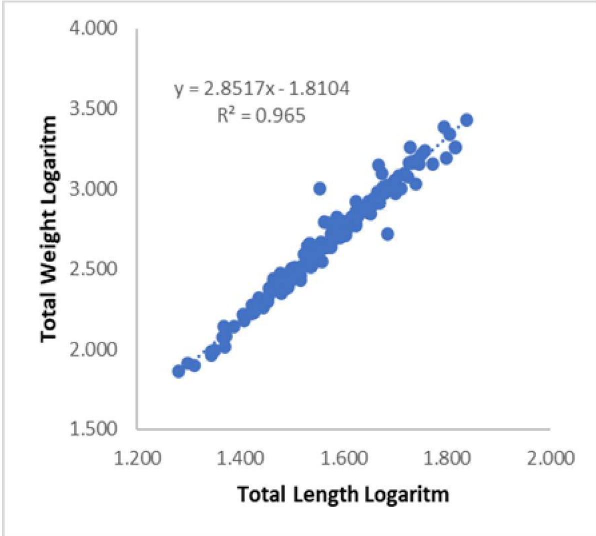


Male Female

Figure 4. Von Bertalanffy model on male and female of otek fish.

Length-weight correlation. Based on the processed data comprising 124 male otek fish, a regression equation of y = 2.8549x - 1.8214 was derived using the logarithms of total length and weight. The corresponding R^2 value was 0.9485 (94.85%), indicating a strong correlation of 0.974 (97.4%). Furthermore, an analysis was conducted on 144 female otek fish using the logarithms of total length and total weight as variables. This yielded a regression equation of y = 2.8517x - 1.8104, along with ratings, total (96.5%), and a correlation value of 0.982 (98.2%), as shown in Figure 5.





Male Female

Figure 5. Length-weight relationship model allometry for male and female otek fish.

Condition index. Based on the study results derived from data processing employing a length-weight relationship model for both male and female otek fish, the parameters "a" and "b" were obtained. These values were utilized in processing the condition index model, using a sample comprising 124 male fish and 144 female fish. According to the outcomes, there are distinct condition index criteria for male and female otek fish. Among these, the thin body shape category, with a condition index ranging from 0.5 to 0.99, yielded 67 male fish, accounting for 54% of the sample, and 76 female fish, constituting 52.8% of the sample. Additionally, the condition index criteria corresponding to a value of 1, indicative of a proportional body shape, were observed in 3 male fish, constituting 2.4% of the sample, and 4 female fish, representing 2.8% of the sample. The condition index criteria comprising a range of 1.01 to 1.50, associated with a fat body shape, yielded 52 male fish, making up 41.9% of the sample, and 62 female fish, comprising 43.1% of the sample. Furthermore, condition index criteria with values surpassing 1.51, signifying a very fat body shape, were identified in 2 individual male and 2 individual female fish, with percentages of 1.6% and 1.4%, respectively, as presented in Table 1.

Table 1

Criteria for condition index of male and female otek fish

No.	*Criteria condition index**	*Body shape*	*Male*	*Female*	*Percentage (%)*	
					Male	*Female*
1.	0	There isn't any	0	0	0.0	0.0
2.	0.1 to 0.49	Very thin	0	0	0.0	0.0
3.	0.50 to 0.99	Thin	67	76	54.0	52.8
4.	1	Proportional	3	4	2.4	2.8
5.	1.01 to 1.50	Fat	52	62	41.9	43.1
6.	> 1.51	Very fat	2	2	1.6	1.4

*The value of the Criteria Condition Index follows Salim et al (2021a, 2022a, 2023); Indaarjo et al (2020a; 2020b; 2020c; 2021; 2022; 2023a; 2023b).

Mortality. The total mortality (Z) rate was observed to be lower in males (1.133) compared to females (1.139), constituting percentages of 113.3% and 113.9%, respectively. Furthermore, the catch mortality (F) rate for male fish was determined to be 0.498 (or 49.8%), while for females, it was slightly higher at 0.522 (or 52.2%). In terms of natural mortality (M), the values for males and females were calculated to be 0.636 (or 63.6%) and 0.616 (or 61.6%), respectively. Examining the exploitation rate (E), it was found to be 0.439 (or 43.9%) for male fish and 0.459 (or 45.9%) for female fish, as presented in Table 2.

Table 2

Mortality between males and females of *N. thalassina*

Variable	*Value*		*Percentage (%)*	
	Male	*Female*	*Male*	*Female*
Total mortality (Z)	1.133	1.139	113.3	113.9
Catch mortality (F)	0.498	0.522	49.8	52.2
Natural mortality (M)	0.636	0.616	63.6	61.6
Exploitation rate (E)	0.439	0.459	43.9	45.9

Discussion. Salim et al (2023) reported that the Von Bertalanffy model stands as a foundational natural growth model, proficient in predicting a spectrum of vital population parameter models. These comprise the maximum growth model, the age structure model specific to aquatic biota, as well as the total mortality, natural mortality, fishing mortality, and exploitation rate models, as stated by Ricker (1975). Von Bertalanffy model is used in the management of aquatic biota stock resources which can be used in conservation and sustainable management processes, including the domestication model (Indarjo et al 2022, 2023b; Salim et al 2023). Determining the growth age of fish plays an important role in estimating population stock, including factors such as the length-weight relationship model (Taherimirghaed et al 2013), the size model for first maturity of the gonads and the size/age structure growth model (Salim 2010) all of which can be applied without the domestication model (Salim et al 2023). The analysis of the Von Bertalanffy growth model serves the purpose of determining the asymptotic length ($L\infty$), a crucial parameter enabling the prediction of the maximum length achievable by aquatic biota. This represents the point at which growth ceases, indicated by a growth rate of zero (Salim et al 2023). According to Beverton & Holt (1959), the asymptotic length represents the theoretical length beyond which no further growth occurs, indicating maximum growth potential. The study results presented in Figure 2 were derived from a size-age structure model, showing that male otek fish exhibit sizes ranging from 30.9 to 35.3 cm, while their female counterparts range from 28.1 to 41.2 cm. Utilizing the Von Bertalanffy model, it was determined that these fish demonstrate rapid growth. Specifically, male fish achieve sizes of 30.9 to 35.3 cm within a span of 14 to 16 days, while female fish attain sizes of 28.1 to 41.2 cm in a range of 12 to 21 days. This observation underscores that the growth of otek fish is in line with their ecological preferences. It was in line with the assertion made by Salim et al (2023) that fish exhibiting rapid growth tend to inhabit ecological niches following their preferences, particularly within the mangrove ecosystem, where a rich food supply including crabs, *Harpiosquilla raphidea* shrimp, various fish species, and mollusks is available (Anggawangsa & Faizah 2020). This is substantiated by the recorded weights of otek fish in the study results. Male fish exhibit an average weight of 590.2 grams, with a maximum recorded weight of 2,581 grams. Meanwhile, female fish display an average weight of 634.6 grams, with a maximum recorded weight of 2,703 g.

Figure 3 presents the regression equations for male otek fish: y = -0.0261x + 2.4685, yielding an R^2 value of 65.97% and a correlation of 81.22%. Similarly, for female otek fish, the regression equation obtained was y = -0.0278x + 2.5352, with an R^2 value of 68.32% and a correlation of 82.66%. It is explained that when the R^2 value exceeds 0.5 (50%), both male and female regressions are deemed to be in the 'good' category. This is in line with Ghozali's (2016) perspective, which asserts that the multiple linear regression model is considered suitable for use when the R^2 value surpasses 0.5 (50%). In this case, Ghozali (2016) states that the growth speed variable influences 65.97% of males and 68.32% of females, while the total length variable of otek fish influences 34.03% of males and 31.68% of females. This interpretation differs from Hair et al (2011) classification, where R^2 values fall into three categories: strong (0.75-0.99), moderate (0.50-0.74), and weak (0.25-0.49).

In Figure 3, the maximum length growth model (L∞) for male fish is projected to reach 94.57 cm, estimating an age of approximately 558 days, with a growth rate of 0.0261 cm day^{-1}. For female fish, the L∞ is estimated to be 91.19 cm, suggesting an age of around 420 days, with a growth rate of 0.0278 cm day^{-1}. This illustrates the robust growth of otek fish in Tarakan waters. This observation is in line with Sawant et al (2013) assertion that *Arius* catfish exhibit voracious and carnivorous feeding habits, contributing to their rapid growth. Balamurugan et al (2013) further emphasize that L∞ and 'K' values for *Arius arius* from the East coast of Tamil Nadu are comparatively lower, owing to variations in environmental conditions, study duration, sample size, and collection techniques. In Figure 4, the Von Bertalanffy model equations are derived for males ($y = -2E-13x^6+3E-10x^5-2E-07x^4+1E-04x^3-0.0198x^2+2.0794x+4.7934$) and females ($y = -6E-13x^6+8E-10x^5-5E-07X^4+0.0002x^3-0.0255x^2+2.2609x+4.2211$). These models exhibit exceptionally high R^2 values of 0.9995 for males and 0.9999 for females. According to Ghozali (2016), a coefficient of determination value equal to 1 signifies a perfect fit of the regression line to the data.

The information and knowledge regarding the length-weight relationship of otek fish play a crucial role in fisheries. This data is instrumental in making individual comparisons across different population locations (Lagler et al 1962). Length-weight relationship establish a mathematical relationship between various variables in otek fish, providing practical indices to comprehend aspects such as survival, growth, maturity, and reproduction within a population (Jennings et al 2001). Indarjo et al (2023a) and Salim et al (2022a) elucidate that the length-weight relationship include the total length and weight, allowing for an isometric or allometric analysis of growth. This analytical approach aids in understanding the natural growth patterns of aquatic biota within a species population.

Furthermore, Salim et al (2022b) emphasize that analyzing the length-weight relationship enables the prediction of fish density based on fish length, contributing to the estimation of population biomass. According to Indarjo et al (2023b), length-weight relationship can serve as a predictive tool for identifying fish populations in both spatial and temporal dimensions. Salim et al (2023) expand on this by reporting that testing the length-weight relationship can be integrated with age group data for comprehensive analyses. This integration allows for insights into stock composition, age at first gonad maturity or spawning, mortality rates, growth patterns according to the von Bertalanffy model, and condition indices. De la Vega et al (2022) further underscores its capability to differentiate taxonomic units by tracking changes in fish growth throughout the metamorphosis process, offering predictions on fish population numbers. In accordance with Salim et al (2023) and Effendi (2002), the method for establishing the length-weight relationship equation can be expressed in linear form through logarithmic equations. This approach provides a systematic framework for accurately characterizing this crucial relationship.

Salim et al (2023) and Indarjo et al (2023a) clarify that the derived length-weight relationship represents two distinct variables. Specifically, the x-axis corresponds to the logarithm of the total length, while the y-axis represents the logarithm of the total weight. It aligns with Salim et al (2023) graph interpretation, which elucidates the correlation between the logarithmic length and weight values in empirical fish data and theoretical expectations. It is important to note that these results are presented in logarithmic form and should be converted back into their actual numerical values using antilogarithmic transformation for practical application (Indarjo et al 2022, 2023a; Salim et al 2022a, 2023). The results indicate that both male and female fish exhibit negative allometric growth, characterized by a very strong correlation level and a strong category R^2. The analysis shows that 94.85% and 96.5% of R^2 values are attributed to dependent variables for males and females, respectively, while the remaining 5.15% and 3.5% represent independent variables or error components (Indra & Cahyaningrum 2019). The negative allometric growth of male and female otek fish suggests that factors influencing length growth outpace weight growth. This discrepancy is attributed to the quality of food obtained from the natural environment (Salim et al 2023). Furthermore, natural feed may sometimes be of insufficient quality, potentially leading to stunted growth. Conversely, when fish have access to high-quality natural food sources, their growth tends to progress normally (Indarjo et al 2022). Additionally, growth may be hindered by environmental factors, including water conditions such as salinity, temperature, pH levels, and the availability of DO. Effendie (2002) added that growth factors were influenced by internal factors, namely genetics and hormones. According to Salim et al (2023) when organisms acquire food, the majority of the energy is allocated for metabolic processes (maintenance), while the remaining energy is used for growth, reproduction, and various activities such as foraging and evading predators. According to Abujam & Biswas (2014, 2016), factors that influence fish body shape are environmental factors, sex, fish physiology, gonad development, and fish environmental nutrition.

According to Salim et al (2023), the condition index serves as a numerical representation of the body shape of aquatic organisms. This index comprises 5 distinct criteria for body shape classification: very thin, thin, proportional, fat, and very fat (Indarjo et al 2023a). According to Salim et al (2020c), the condition index was obtained based on the results of the length-weight relationship equation by combining the results obtained in the form of allometric growth or isometric growth (Indarjo et al 2022). Based on this study, it is clear that the condition index value for males and females has a thin body shape with a condition index value of less than 1 and a fat body shape with a condition index value of more than 1.5. According to Blackwell et al (2000), a high condition factor value suggests favorable environmental conditions for *Arius* sp. fish in Tarakan City waters. These conditions are influenced by various factors, including the abundance of prey. Meanwhile, low condition index values indicate less suitable environmental conditions, which may not be in line with the ecological preferences of the fish (Salim et al 2023). Le Cren (1951) further emphasized that the size of the condition index in fish was influenced by various factors, with food availability being one of the key determinants.

This study explained that the mortality rate for both male and female otek fish was higher in terms of natural mortality value (M = 0.636 and F = 0.61.6) when compared to the catch mortality value (M = 0.498 and F = 0.522). Additionally, the exploitation rate (M = 0.439 and F = 0.459) is lower than the total catch (M = 1.133 and F = 1.139). These results indicate that the exploitation rate, which is below 0.5, falls within the range of optimal exploitation conditions. This was in line with the opinion of Patterson (1992) which explained that the optimum conditions for exploiting fish resources were below 0.5. This study showed that fishing mortality was below 0.5 in the optimum exploitation category. This was in line with the opinion of Gulland (1983) who explained that fish stocks were in optimum exploitation conditions if the catch mortality rate was at 0.5. Based on the results, Chirwatkar et al (2021b) explained that fishing mortality is higher than natural mortality with an exploitation rate above 0.5. This clarifies that the exploitation rate of *A. arius* is under conditions of overexploitation. This study presents a deviation from the previously mentioned report, proposing that both male and female otek fish offer potential for optimal exploitation, particularly as by-catch, given their current underutilization. This underutilization is identified as a contributing factor to the heightened natural mortality rates of otek fish in the waters of Tarakan.

Conclusions. This study examined otek fish obtained from fishermen's catches. The results showed that both male and female otek fish exhibited negative allometric growth, characterized by a predominantly slender body shape. The male fish displayed a faster maximum growth rate compared to their female counterparts. However, it was observed that female fish exhibited a higher growth rate overall. In terms of mortality rates, the study found that male fish experienced a higher rate, particularly due to natural causes.

Conversely, when considering total mortality, catch mortality, and exploitation rate, females surpassed males in dominance.

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Conflict of interest. The authors declare that there is no conflict of interest.

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