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Original research article.

Growth Pattern of Rabbitfish (*Siganus Guttatus*) in Seagrass Habitat in The Tukak Waters

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ABSTRACT

The Baronang fish (*Siganus guttatus)* is an economically valuable species commonly found in seagrass ecosystems, which serve as critical habitats providing food, spawning, and nursery grounds. This study, conducted from June to August 2024, aimed to examine the length-weight relationship, growth patterns, and the influence of environmental parameters on Baronang fish growth. Fish samples were collected using beach seines of various mesh sizes. The length-weight relationship in June followed the model $W = 0.12L^{2.19}$ ($R^2 = 0.72$), in July $W = 1.07L^{0.34}$ ($R^2 = 0.99$), and in August $W = 2.72L^{0.674}$ ($R^2 = 0.94$), indicating varying degrees of correlation across months. Growth analysis using the von Bertalanffy model showed an asymptotic length ($L\infty$) of 154.00 mm and growth coefficient (K) of 0.51/year. In August, the estimated $L\infty$ was 19.95 cm, K = 1.01/year, and $t_0 = 0.176$. The fish reached a length of 88.97 mm in the first year and 150.95 mm by the sixth year, with growth slowing down after this period. Environmental parameter analysis revealed that temperature had a significant positive effect on fish weight (B = 14.664, $p < 0.001$), while salinity (B = -5.920, $p = 0.005$) and dissolved oxygen (DO) (B = -28.357, $p = 0.001$) had significant negative effects. These findings highlight the importance of environmental conditions in regulating the growth of Siganus guttatus in seagrass ecosystems.

Introduction

The baronang fish (*Siganus guttatus)* is one of the species of fish with high economic value that is ecologically closely associated with seagrass and coral reef ecosystems. The baronang fish is a type of marine biota that has a close relationship with the seagrass ecosystem (Jemi et al.,2022). According to Latuconsina et al., (2016) The Baronang fish prefers to use seagrass beds as a nursery and growing area, and when they are adults they will move to the surrounding ecosystems such as coral reefs to spend part of their adult life in that ecosystem. In the coastal area of Tukak, South Bangka Regency, the seagrass ecosystem has been identified as an important habitat with the presence of

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several seagrass species. There are 4 species of seagrass that have been found on Tukak Beach, namely Enhalus acoroides, Thalassia hemprichii, Halophila minor, Halophila ovalis, and Cymodocea serrulata (Supratman & Adi, 2018).

However, until now, scientific studies on the growth and population dynamics of baronang fish in the area are still very limited. Related research is urgently needed to provide initial information that can support sustainable management of fisheries resources in the area. Fish growth is a complex biological process that lasts throughout its life, known as indeterminate growth. In fisheries studies, fish growth patterns are classified into two main types, namely isometric and allometric, depending on the proportion between the increase in length and body weight. This information is generally obtained through the relationship between length and body weight formulated in the form of a mathematical model and can be used to assess the general growth conditions of fish populations (Pattirane et al., 2022).

In addition, fish growth is influenced by various environmental factors such as temperature, salinity, and dissolved oxygen, as well as internal factors such as genetics, hormones, and metabolic efficiency (Usemahu et al., 2022). Therefore, understanding growth patterns and their relationship to environmental parameters is an important aspect in the study of fish ecology. One approach that is often used to describe fish growth theoretically is the von Bertalanffy growth model, which provides important parameters such as the asymptotic maximum length ($L\infty$) growth rate (K), and theoretical age at zero length (t0). The research objectives include analysis of the relationship between fish length and weight, analysis of fish growth rates and analysis of the relationship between fish growth and environmental parameters.

Materials and Methods

Time and place

This research was conducted in June - August 2024. Field data collection was conducted in the Seagrass area in Tukak Waters, South Bangka Regency. Sample identification was conducted directly at the Tukak research location, South Bangka Regency. The research map is presented in Figure 1.

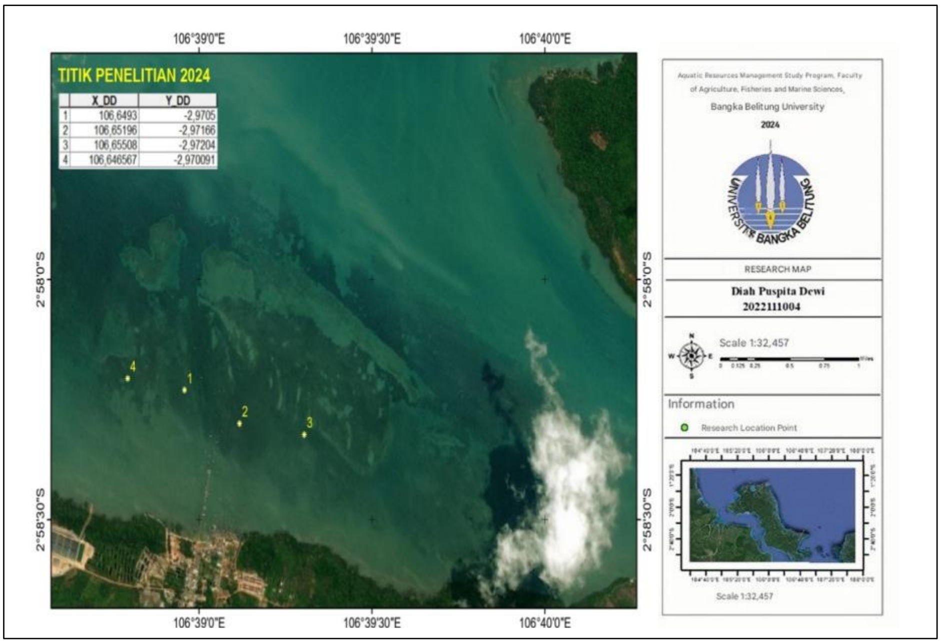

Figure 1. Research Location

Research Materials

The tools and materials used in this research can be seen in Table 1 below.

Working Procedure

Determination of sampling locations was carried out using the purposive sampling method, which is a method based on the selection of points that are considered to represent the entire research area based on previous observation results. Determination of points using a GPS device consisting of 4 location points, namely on Tukak Beach. Information about the research location can be seen in Table 2 below.

Table 1. Tools and material

No	Tools and materials	Utility
1.	GPS	Determining the research position
2.	Stationery	Untuk menulis data yang didapat dari lapangan
4.	*Tissue*	To write data obtained from the field
5.	*Cool box*	Cleaning fish samples obtained,
		As a storage
6.	Gill net or beach net	container for tools,
		Fishing tools used in taking fish samples
7.	Vernier calipers	to measure the length of the fish
8.	Digital scales	to measure the weight of fish
9.	Camera	To photograph the conditions around the station and fish samples.
10.	Boties	Foot protective equipment
11.	*Thermometer*	Measuring water temperature
12.	DO meters	Measuring dissolved oxygen in water
13.	*Refractometer*	Measuring salinity levels
14.	*Roll* meters	Measuring the length of transect lines
15.	Formalin 4%	Materials for preserving fish
16.	Flashing Plastic	As a container for fish
17.	Gloves	To protect hands and keep them sterile

Table 2. Description of the research location

Station	Research location	Latitude (Y)	Longtitude (X)	Condition
1	Tukak beach	-2,971828	106,665873	There is a fish farming area
2	Tukak beach	-2,969739	106,656936	There is a dock area, close to residential areas and fishing activies
3	Tukak beach	-2,967579	106,645097	The existence of tourism activities and fishing activities
4	Tukak beach	-2,965649	106,632168	Fishing Activities

Seagrass data collection was carried out using the 100-meter square transect method perpendicular to the coastline and the distance between one transect and another was 50 meters. The square frames were placed on each right side of the transect with a distance between one square and another of 10 meters, placing 50 x 50 cm2 squares from the beginning of point 0 to point 100 on each line, in one station consisting of 3 lines. The next stage is to determine the percentage value of seagrass cover in each small box in the square frame (Rahmawati et al, 2017).

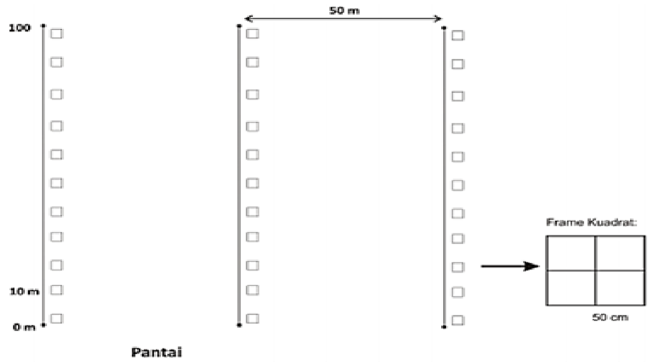

Figure 2. Illustration of seagrass data collection
Source: (Rahmawati et al., 2017)

Fish data collection is carried out every June to August in Tukak in the afternoon using a beach net with a net length of 10 m, a width of 1 m, and a mesh size of 2 mm which is used to catch small fish, while to catch large fish using a beach net measuring 125 m long and 1.3 m wide and a mesh size of 1.5 inches (Figure 3). The net is equipped with a buoy at the top and a weight at the bottom. Each fish sampling is carried out with three repetitions when the tide is moving ebb and flow (Munira & Sulistiono 2010). Examples of rabbitfish that have been caught are separated from other types of fish, then stored in separate plastic containers. Then the samples are taken directly to be measured at the research location. To measure the total length of the fish, a fish measuring board is used with an accuracy of 1 mm. The type of measurement used is the total length, while the measurement of fish body weight uses a digital scale with an accuracy of 0.1 grams. Identification of fish caught using online devices, namely WORMS and Fishbase.

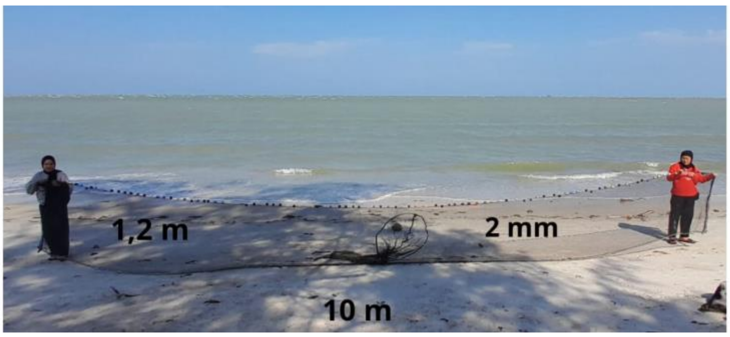

Figure 3. Fishing gear illustration

Data Analysis

The length-weight relationship was analyzed based on the analysis procedure for the relationship between length and weight of fish (Effendie, 1997; Fachrul, 2012) expressed by the formula.

$$W = aL^b$$

Information :

W = Fish weight (grams)
L = Fish length (mm)
a,b = Growth constant

Analysis of fish age groups based on length data, as well as estimation of growth parameters, was carried out by applying the Von Bertalanffy growth model using FiSAT II software.

$$L_t = L_\infty (1 - \exp^{-k\,(t-t_o)})$$

Information :

L_t	: Length of fish at age
L_∞	: Infinitive length
K	: Growth coefficient (per day)
t_o	: Age when theoretical fish length = 0
t	: Age of fish at L_t

The estimated theoretical age of the fish when its length is assumed to be zero can be calculated separately using the empirical formula developed by Pauly (1983).

$$\log(-t_0) = -\,0{,}3922 - 0{,}2752 \log(L\infty) - 1{,}0382 \log(K)$$

The relationship between rabbitfish and environmental parameters was analyzed through multiple linear regression, a statistical method involving one dependent variable (Y) and two or more independent variables (X), using the following formula:

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + e$$

Information

Y	: Dependent variable
a	: Constant (intercept)
X1	: Temperature (°C)
X2	: DO
X3	: Salinity
e	: Eror or residual error

Results and Discussions

Analysis of the length-weight relationship of the Baronang fish (Siganus guttatus) during three months of observation (June–August) in the Tukak seagrass waters showed variations in growth patterns. In June, the length-weight relationship model was $W = 0{,}12L^{2.19}$ ($R^2 = 0{,}72$), with value b = 2,19 which shows a negative allometric growth pattern, where length growth is more dominant than weight. In July, the model was obtained $W = 1{,}07L^{0.34}$ ($R^2 = 0{,}99$) with b = 0,34, also reflects negative allometric growth. August shows the model $W = 2{,}72L^{0.674}$ ($R^2 = 0{,}94$), with value b = 0,674, again indicates a negative allometric pattern. The correlation between length and weight during the three consecutive months also shows a high strength of relationship, with the correlation coefficient value (r) each 0,72 (strong), 0,99 (very strong), and 0,94 (very strong). According to Fadilla et al., (2023) This is in accordance with the correlation category which states that the value r between 0,70 – 0,89 shows a strong correlation, whereas 0,90 – 1,00 shows a very strong correlation.

Based on Figure 4, the resulting model is Mark b < 3 indicating that length growth is more dominant than weight, which generally occurs in young fish or in environments with limited food. Fish growth patterns are greatly influenced by environmental factors, such as season and food availability, which affect energy intake and its distribution in the body. (Zhulfahmi et al., 2018). In addition, habitat conditions, water quality, and gonad maturity levels also play an important role in determining the growth rate of fish. (Sudarno *et al.,* 2018). According to Sartika *et al.,* (2021), The availability and type of feed given also affects the growth rate and survival rate of fish.

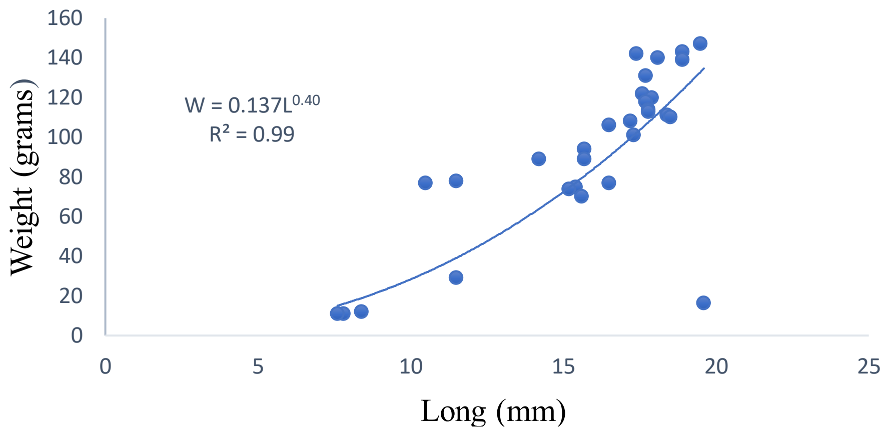

Figure 4. Combined length-weight relationship of baronang fish for 3 months (June, July, Augst 2024)

Table 3. Results of length-weight calculations of rabbitfish (*Siganus guttatus*)

Month	a	b	R^2	Growth pattern
June	0,12	2,19	0,72	Negative allometric
July	1,07	0,34	0,99	Negative allometric
August	2,27	0,67	0,94	Negative allometric

Based on the results of the analysis using the Von Bertalanffy growth model on the body length data of the Baronang fish (Siganus guttatus) in the Tukak seagrass waters, the asymptotic length was obtained ($L\infty$) of 154.00 mm and the growth coefficient (K) of 0.51 per year. According to Sparre and Venema (1999), the growth coefficient (K) describes the rate at which fish reach their asymptotic length, so that a higher (K) value indicates acceleration in growth towards maximum size. Compared with previous studies in Ambon Bay by Ramadhani et al. (2018), which reported a K value of 0.39 per year and $L\infty$ of 167.4 mm, the results of this study indicate that the Baronang fish in Tukak waters grow faster even though with a slightly lower maximum length potential. This variation can be caused by environmental differences such as temperature, salinity, feed availability, and the physiological condition of the fish (Rahman et al., 2021). Based on the growth graph (Figure 5), growth was rapid in the early stages of life. In the first year, the length of the fish had reached 88.97 mm, and increased to 150.95 mm in the sixth year. After that, the growth rate began to slow down, with a maximum length recorded at 153.34 mm in the 10th month, approaching the value $L\infty$. This is supported by Desriani et al., (2020) who stated that fish growth occurs rapidly in the early stages of life, then slows down after approaching the maximum size. This pattern reflects the adaptive growth strategy of tropical fish, where more energy is allocated to body growth in early life. Even though they have reached adult size, the Baronang fish still returns to the seagrass habitat because this area provides the main food source in the form of seagrass and algae, and functions as a shelter. This is in line with the findings of Haptari et al., (2024) which stated that seagrass beds have a strong relationship with the biomass of herbivorous fish such as the Baronang, indicating the importance of this ecosystem as a primary habitat.

Table 4. Fish growth parameters based on analysis

No	Parameter	Mark
1.	L∞	154,00
2.	K	0,51

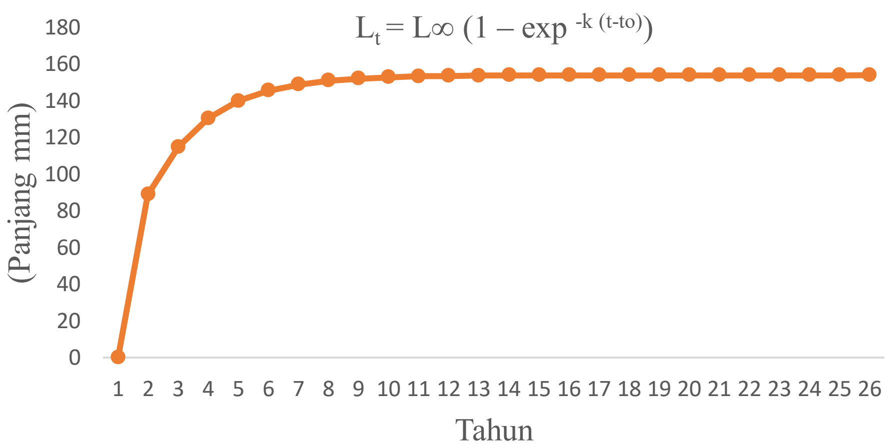

Figure 5. Rabbitfish growth chart

Multiple linear regression analysis was used to evaluate the effect of temperature (X_1), DO (X_2), salinity (X_3), and pH (X_4) on the weight of the Baronang fish (Siganus guttatus). The results of the analysis showed that temperature had a positive and significant effect on fish weight (regression coefficient = 14.664, p = 0.000), while DO and salinity had a significant negative effect with coefficients of -28.357 (p = 0.001) and -5.920 (p = 0.005), respectively. The pH variable did not show a significant effect (coefficient = -0.1457, p = 0.253), so it was eliminated from the model. The final regression model obtained is formulated as follows:

$$Y=1,175+14,664X1-28,357X2-5,920X3$$

Where Y is the weight of the fish, X_1 is the temperature, X_2 is the DO, and X_3 is the salinity. This model shows that temperature is a factor that increases the weight of the fish, while the increase in DO and salinity tends to decrease the weight of the fish in the Tukak seagrass waters. The results of the regression analysis showed that temperature, DO, and salinity had a significant effect on the weight of the Baronang fish (Siganus guttatus), while pH had no significant effect. Physiologically, temperature is the main environmental factor that affects the metabolic rate of fish. At the optimal temperature range, fish metabolism runs efficiently, which increases the ability to digest and absorb nutrients from feed and supports growth (Rahman et al., 2019). Increasing temperature within the tolerance limit can accelerate the rate of feed consumption and protein synthesis, so that the body weight of the fish increases. However, if the temperature exceeds the tolerance threshold, physiological stress can occur, increased basal energy requirements, and decreased feed conversion efficiency which actually inhibits growth. (Ridwantara et al., 2019).

Conclusion

1) Analysis of the length-weight relationship of rabbitfish (Siganus guttatus) in the seagrass ecosystem of Tukak Waters shows variations every month, with b values in June (2.19), July (0.34), and August (0.67). These values indicate a negative allometric growth pattern because all are below the value of 3.
2) Analysis of the estimated growth parameters of the values obtained are the growth coefficient (K) 0.51, infinitive length ($L\infty$) 154.00. The growth graph of the Baronang fish shows that the growth rate is very fast in the first 6 years and slows down after approaching the asymptotic length of 153.34 mm.
3) The multiple linear regression model shows that fish weight (Y) is significantly affected by temperature ($+14.66X1$), DO ($-28.36X2$) and salinity ($-5.92X3$). This relationship significantly shows that increasing temperature will increase fish weight, while increasing DO and salinity will actually decrease fish weight.

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