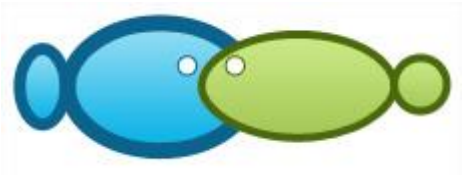

Biological aspects of *Euthynnus affinis* caught with gill net in Rembang Waters, Indonesia

[1]Nur Khasanah, [1]Fitri A. D. Purnama, [1]Abdul K. Mudzakir

[1] Magister Study Program of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang, Indonesia. Corresponding author: N. Khasanah, bundaquinta@gmail.com

Abstract. Gill nets are the fishing gear of choice among Rembang fishermen. One of the targets caught by gill net in Rembang waters is Kawakawa (*Euthynnus affinis*). The conservation of *E. affinis* resources in Rembang waters has not been optimally implemented due to lack of data and information regarding biological aspects and their populations. This research was conducted to examine the biological aspects which include the size distribution of *E. affinis* catches, the length-weight relationship and condition factors of *E. affinis* caught using gill net in Rembang waters, Central Java Indonesia. This research was conducted for 10 days in March 2023 in the waters of Rembang, Central Java. This is used a descriptive research method in which all data were obtained by measuring directly in the field using a gill net on a 3 GT boat. The results showed that the length range of *E. affinis* was 33–58 cm, with the highest distribution of length frequency in the 53–56 cm for a number of 65 individuals or 32.02%, while the lowest distribution was in the length range of 41-44 cm, with only 7 individuals or 4.45%. Based on the proportion of the size of the gill net catch, it can be seen that the majority (69.46%) of the *E. affinis* caught were worth catching, their length value being above 42.78. The results of the analysis of the length and body weight of the fish showed b=3.44 for *E. affinis* caught with gill net in Rembang waters, meaning a pattern of positive allometric (the weight gain is faster than the increase in length).
Key Words: biological aspects, gill net, Rembang, tuna.

Introduction. Kawakawa (*Euthynnus affinis*) is one of the high economic value fish species and is widely exported. The national production value of *E. affinis* was approximately 690,000 USD in 2019 and increased to approximately 716,000 USD in 2020 (MMF 2022). Eastern little tuna habitat is also widely distributed in the coastal and oceanic waters of Indonesia (Ilhamdi et al 2016). Thus, *E. affinis* is the primary target catch of fishermen (Akhlak et al 2015), including Rembang fishermen. The catch of *E. affinis* in Rembang rose 68.94% in 2019 compared to the previous year (Central Statistics Agency Rembang Regency 2020).

The growing demand for *E. affinis* may lead to the possibility of unsustainable exploitation of fish resources. Therefore, it has the potential to affect the stock of *E. affinis* resources in Indonesia. The exploitation rate (E) of *E. affinis* in the Western Waters of South Sulawesi is 0.64, indicating that the potential of this fish has decreased, and it is estimated that overfishing has occurred (Yunus 2020). Overfishing can cause devastation to the *E. affinis* fishery if not managed properly and wisely.

Studying biological aspects is essential for effective fisheries resource management (Ritonga & Khairul 2022; Nuriningtyas et al 2019). For example, Yudha (2022) stated that the utilization of *E. affinis* resources in Teluk Semangka waters is over-exploited, which can be seen from the negative allometric fish growth pattern (b = 2.2251). Meanwhile, Agustina et al (2018) found that the level of utilization of *E. affinis* was not yet maximum in the waters of Tanjung Luar Nusa, which was concluded from the growth pattern data of *E. affinis* — positive allometric, where weight gain was faster than length gain. However, research on the biological aspects of *E. affinis* in Rembang has never been carried out. Updated data and information on the biological aspects of this fish are needed as a primary effort to manage fisheries resources.

This study aimed to assess the biological aspect, specifically allometric growth, of *E. affinis* caught by fisherman gillnet in Rembang using descriptive methods. The resulting data is helpful to be used for further study of management and policies to regulate *E. affinis* fishing.

Material and Method

Description of the study sites. This research was conducted in March 2023 in the waters of Rembang, Central Java (Figure 1). In this study, the main target of the gill net is *E. affinis.*

Figure 1. Map of research location, Rembang waters.

Sampling method. This study used a descriptive research method in which the whole data was obtained by measuring directly in the water using gill net fishing gear with a 3 GT vessel. Measurement of biological aspects in this study was carried out on resources of *E. affinis* fish, the catch target. Biological aspects include the distribution of *E. affinis* catch size, the relationship between weight and length, and the condition factors of *E. affinis* caught from gill net fishing gear studied. Some of the biological parameters to be collected in the study are presented in Table 1.

Table 1

Measurement of biological parameters for caught fish

No.	*Data type*	*Description*
1.	Length frequency distribution	Fish length data, determining the dominant target by catch
2.	Catch size	Length at first capture (Lc) of fish caught in one operation trip
3.	The length-weight relationship	As an estimator to determine the value of fish weight based on the formula $W=aL^b$ and to determine its growth pattern

Data collection for the length frequency distribution of catches was carried out quantitatively by making direct observations to see the number of fish and data on the body length of both target and non-target fish species (bycatch) from gill net catches. As

a reference in the Marine Stewardship Council (MSC) certification system, it has been determined that the tolerable by-catch limit for fish species in general is 10-15% of the total catch (Musthofa 2011). Biological parameters for fish catch size are data on the length of the target fish at first mature gonads (length at first maturity or Lm) and data on the length of the dominant target fish caught in one fishing operation trip (Lc). The Lm (length at first maturity) value is obtained from research reports or can refer to the Fishbase website (http://fishbase.org). Primary data was obtained from direct sampling measurements of the average length of dominant target fish caught in one fishing operation trip. Data for weight-length analysis was collected to determine the growth pattern of fish caught from gill net. Fish morphometric data was total length (TL) in centimeters and fish weight data in grams. The quantitative method used for data collection was direct sampling: caught fish species were directly measured using meters and scales.

Data analysis. The collected data of fish catch was analyzed with a descriptive comparative method. Calculating the length frequency distribution can be done by specifying the number of interval classes, the width of the interval classes, and the frequency of each class. The frequency distribution of predetermined lengths within intervals of the same class was then depicted in a graph. The estimation of first caught length was done by plotting the relationship between the length distribution of class (x) and the number of fish stated by the estimated cumulative normal distribution (y). According to Sparre & Venema (1996), the value of Lc is given by the curve of the function between the x-axis and the y-axis for a value of 50%. To create such a curve must first calculate the SL value (selectivity) of the estimate with the formula (Le Cren 1951):

$$SL_{obs} = \frac{1}{1 + e^{(S_1 - S_2 + L)}}$$

Where:
SLobs - cumulative frequency of restrained proportions (y);
S1 - intercept value a (intersection between linear line and y-axis);
S2 - slope value b (regression line slope angle);
L - middle length of class in cm (x).

Data on the fish weight-length is stated in the formula (Le Cren 1951):

$$W = aL^b$$

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

The general formula when transformed into logarithms is expressed as follows (Le Cren 1951):

$$\text{Log } W = \log a + b \log L$$

Growth patterns in fish are determined as follows: b=3 suggests an isometric growth pattern, meaning a balanced increase in fish length and weight; b>3 shows a positive allometric growth pattern where weight gain is faster than the increase in length; b<3, the growth pattern is a negative allometric where the increase in length is faster than the increase in weight (Le Cren 1951).

Results and Discussion

Length frequency spread. There were 203 targeted fish caught during the research. Based on the observation, the length range of *E. affinis* was 33-58 cm. The fish samples were grouped into 7 classes of length groups with an interval of 2.7 cm. The distribution

of length frequency of *E. affinis* caught with gill net in the water of Rembang district, Central Java is presented in Table 2.

Table 2

Length frequency distribution of *Euthynnus affinis*

Length class (cm)	*Frequency*	
	Number	*%*
33-36	22	10.84
37-40	36	17.73
41-44	7	3.45
45-48	20	9.85
49-52	43	21.18
53-56	65	32.02
57-60	10	4.93

The distribution of *E. affinis* length can be seen in Figure 2. The length range of *E. affinis* caught by gill net is 33-58 cm with the highest distribution of length frequency in the 53-56 cm length group which comprised 65 fish specimens or 32.02%, while the lowest is in the length range of 41-44 cm, with only 7 fish or 4.45%.

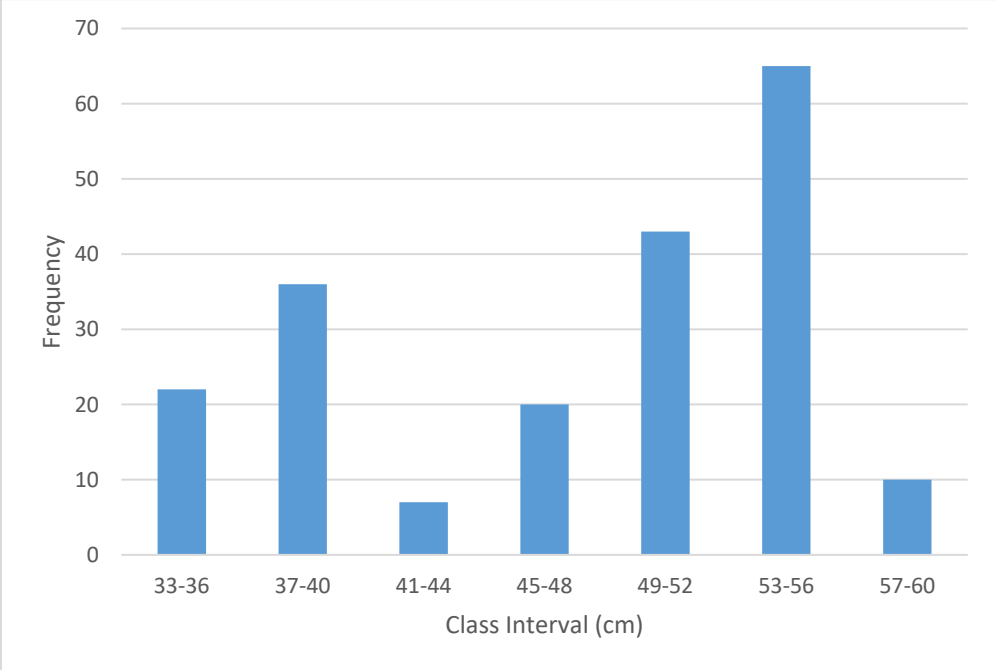

Figure 2. Distribution of *Euthynnus affinis* length.

According to the results of Jamal (2022), the length of specimens caught by gill net in Pekalongan waters Indonesia ranged from 26 to 49 cm. The length of the majority of specimens was in the size class of 32-34 cm. Meanwhile, in a study conducted by Saputra (2021), the total length of *E. affinis* caught on gill net with a mesh size of 3 inches was in the range of 34–37 cm. The length of the majority of *E. affinis* caught was in the range of 34-34.5 cm with a total of 32 fish (equivalent to 30% of the total catch), whereas the least specimens captured had a length in the range between 36–36.5 cm: as much as 3 heads) (equivalent to 3%. The difference in the length range of fish caught by gill net is caused by the use of fishing gear that is different in size and specifications. These differences concern the mesh size, hanging ratio, buoyancy force and sinking force of gill net used during the study.

Length at First Capture (LC). Based on length distribution of the fish body, a size calculation of the first caught fish was carried out. The estimation size of the first *E. affinis* caught in gill net was used to determine the proportion of fish worth catching. Fish biologically worth catching was determined based on the fork length (FL) of fish with first maturity gonads or Length at First Maturity (Lm). The proportion of biologically catchable fish was known by measuring the length of captured fish and comparing to Lm in the literature or reference library. The results showed that the Lc value of *E. affinis* caught with gill net in Rembang water was 42.78 cm (Figure 3). This value was then compared with the Lm value of the literature reference. According to data from NWG EAFM (2014), the mature gonad size of *E. affinis* is 35 cm. According to data from Fishbase (2023), the maturity size of the gonads of *E. affinis* is 42.3 cm.

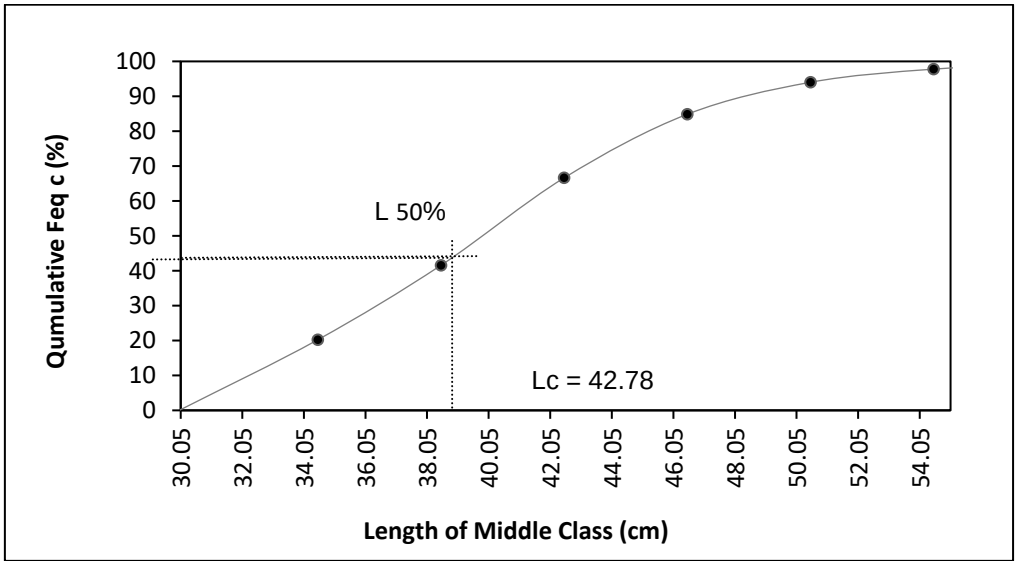

Figure 3. The size of the first *Euthynnus affinis* capture (Lc) with gill net.

Based on NWG EAFM (2014) and Fishbase (2023) regarding the mature size of the *E. affinis* gonads, it can be seen that the Lc value (42.78 cm) is greater than the Lm value (35 and 42.3 cm). These results show that the average fish caught is already in an adult state (mature gonads). The gill net fishing gear used can be said to be selective because it catches adult fish. Based on the Lc value obtained, the proportion of fish worth catching was calculated. Worth catching fish were *E. affinis* with mature gonads, at a length above 42.78. The proportion of fish worth catching is presented in Table 3.

Table 3

The proportion of fish worth catching

Criteria	*Number*	*%*
< Lm	62	30.54
> Lm	141	69.46
Total	203	100

Based on the proportion of gill net catch size, it can be seen that most of the *E. affinis* caught is worth catching. This can illustrate that gill net fishing gear used to catch *E. affinis* is selective, thus reducing unwanted catch (incidental catch) or catch that does not fit the size (unwanted catch).

Length relationship of fish weight. The weight-length relationship is one of the important information used to determine growth. Data on the length of the weight of the *E. affinis* was obtained from the measurement performed during March 2023. The number of fish measured was 203, both female and male. The relationship between the length of fish weight obtained during the study is shown in Table 4 and Figure 4.

Table 4

Results of calculation of *Euthynnus affinis* length and weight

n	*a*	*b*	R^2	$W=aL^b$	*Growth pattern*
203	0.002101	3.44	0.9028	$0.002101L^{3.44}$	positive allometric

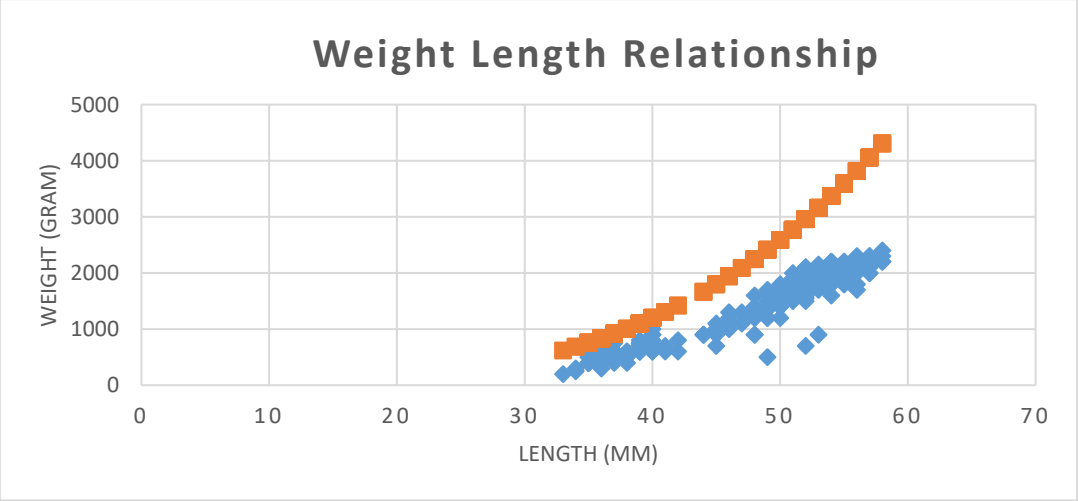

Figure 4. *Euthynnus affinis* weight length relationship.

Based on the calculation of the length and body weight of the fish, the result was b=3.44 for *E. affinis* caught with gill net in Rembang water. A value of b above 3 means that the growth pattern of fish has a positive allometric: the weight gain is faster than length gain. These results are similar to those reported by Wagiyo et al (2018): eastern little tunas caught in Malacca water have a weight-length relationship value of R^2=0.946 and b value=3.2402, indicating a positive allometric. In Agustina et al (2018), in the waters of Tanjung Luar West Nusa Tenggara, the weight length analysis showed a value of b=3.114 which meant that the growth pattern of *E. affinis* in this water had also a positive allometric. Contrarily, Guna et al (2021), in Karangasem water, obtained a value of b=2.95, indicating that the growth of *E. affinis* in these waters has a negative allometric. According to Dwirastina & Makri (2013), differences in growth patterns in fish can be caused by three factors, namely age, type of fish and environmental conditions. In this study, the value of the coefficient of determination (R^2) for *E. affinis* caught by gill net, R^2=0.9028, shows that the fish length factor strongly affects fish body weight by 90.28% while the remaining 9.72% is influenced by other factors. Differences in growth rates can be influenced by internal as well as external factors (Brett 1979). Hartaty et al (2014) further stated that environmental factors influence differences in growth values of the same fish species at different locations. These environmental factors include food availability, water temperature, dissolved oxygen, fish size and gonad maturity. In addition, changing environmental conditions can also cause fish conditions to change so that the weight-length relationship will deviate from the cubic law (Merta 1993). King (2007) stated that the length-weight relationship of fish can be used to determine possible differences between the same species in different stocks.

Conclusions. The length range of *E. affinis* caught by gill net in Rembang water is 33-58 cm with the highest distribution of length frequency in the 53-56 cm length group, with 65 fish specimens or 32.02% of the sample, while the shortest length ranged 41-44 cm, with only 7 fish or 4.45% of the sample. Based on the proportion of gill net catch size, it can be seen that most of the *E. affinis* caught (69.46%) is worth catching, having the length value above 42.78. The result of the analysis of the fish body length and weight relationship indicated that b=3.44. A value of b above 3 means that the growth pattern of fish is positive allometric: the weight gain is faster than length gain.

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Conflict of interest. The authors declare no conflicts of interest.

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Authors:
Nur Khasanah, Magister Study Program of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang, Indonesia, e-mail: bundaquinta@gmail.com
Aristi Dian Purnama Fitri, Magister Study Program of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang, Indonesia, e-mail: aristidian.undip@gmail.com
Abdul Kohar Mudzakir, Magister Study Program of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang, Indonesia, e-mail: akohmud@gmail.com

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