E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2024; 12(2): 93-98

www.fisheriesjournal.com
Received: 16-02-2024
Accepted: 18-03-2024

Effarina Mohd Faizal
Fisheries Research Institute Kg. Acheh, Department of Fisheries Malaysia, Kampung Acheh Fisheries Complex, 32000 Sitiawan, Perak, Malaysia

Nur Amalia Salleh
Fisheries Research Institute Kg. Acheh, Department of Fisheries Malaysia, Kampung Acheh Fisheries Complex, 32000 Sitiawan, Perak, Malaysia

Nur Hidayah Asgnari
Fisheries Research Institute Kg. Acheh, Department of Fisheries Malaysia, Kampung Acheh Fisheries Complex, 32000 Sitiawan, Perak, Malaysia

Corresponding Author:
Effarina Mohd Faizal
Fisheries Research Institute Kg. Acheh, Department of Fisheries Malaysia, Kampung Acheh Fisheries Complex, 32000 Sitiawan, Perak, Malaysia

Length-weight relationship and relative condition factor of yellowfin tuna (*Thunnus albacares*: Bonnaterre, 1788) West Sabah Waters

Effarina Mohd Faizal, Nur Amalia Salleh and Nur Hidayah Asgnari

DOI: https://doi.org/10.22271/fish.2024.v12.i2b.2916

Abstract
Yellowfin tuna (*Thunnus albacares*) is one of the important handline catches in Sabah, Malaysia. This study was carried out from January to December 2017 to determine the length-weight relationship and condition factor of yellowfin tuna in West Sabah waters, Malaysia. A total of 11,650 yellowfin tuna were sampled by enumerators at the landing site. The result showed that the length-weight relationship of this species was $W=0.00003FL^{2.8854}$ which exhibits negative allometry growth. Meanwhile, the mean relative condition factor (Kn) was 0.956±0.105 SE which the value is near to 1 indicating the fish is in good growth condition. This species is a commercially important type of tuna that can be found in tropical and subtropical seas across the globe. Therefore, it is crucial to understand the relationship between length and weight, as well as the relative condition factor. This information is essential for effective fishery resource management, ensuring the sustainability the long-term sustainability of fisheries resources.

Keywords: Length-weight relationship, relative condition factor, allometric negative and yellowfin tuna

1. Introduction

The yellowfin tuna, scientifically known as *Thunnus albacares*, is a highly valuable type of tuna found in tropical and subtropical seas across the globe, spanning from 45° N to 45° S of the equator [1]. Yellowfin tuna is an important and widely recognised species in the Southeast Asian region. Known for its vibrant yellow fins and streamlined body, the yellowfin tuna inhabits the tropical and subtropical waters of Southeast Asia. This species holds significant commercial value and is highly sought after by both industrial and artisanal fisheries in countries such as Malaysia, Indonesia, the Philippines, Thailand, and Vietnam. The abundance of yellowfin tuna in Southeast Asian waters has led to targeted fishing efforts specifically aimed at capturing this prized species.

Yellowfin tuna is highly coveted as an oceanic tuna species globally, leading to specific fishing efforts aimed at capturing this species in multiple countries [2]. It plays a crucial role in the fishing industry within its distribution range, comprising nearly 50% of the total catch obtained through industrial and artisanal fishing methods [3]. The yellowfin tuna, with its large population and significant economic impact, plays a vital role in sustaining the livelihoods of coastal communities and bolstering the regional fisheries industry.

Kota Kinabalu, Sabah, is an important tuna landing site in East Malaysia. Fishing for yellowfin tuna in the waters of Kota Kinabalu have been ongoing since the early 2000s, primarily by commercial and traditional fishers. It has gained importance, and the catch contributes significantly to the marine fish landings in East Malaysia. The landing of yellowfin tuna in East Malaysia from 2010 to 2022 ranged between 909.44 and 5783.19 metric tons per year [4]. The highest landing from Kota Kinabalu waters is in 2018 with 896.98 metric.

The length-weight relationship (LWR) is a valuable tool in the fields of fish biology, physiology, ecology, and fisheries assessment. Initially, its purpose was to assess the condition of fish and determine whether somatic growth is isometric or allometric [5, 6]. Furthermore, this information can be used to estimate the average weight of fish based on their known length. This, in turn, can help determine the biomass of the fish population [7].

The accuracy of the length-weight relationship depends on several factors, including the condition of fish caught in different seasons, sex, length range, sample sizes, stomach fullness, and fitting methods [7, 8].
An additional important biometric tool is the relative condition factor (Kn) that was derived from the LWRs following the formula by Le Cren [10]. Kn measures the deviation of an organism from the average weight in a given sample to assess the suitability of a specific water quality parameter in the sea for the growth of fish [11, 12]. An overall fitness for fish species is assumed when Kn values are equal or close to 1. According to Le Cren [10], the deviation of Kn from 1 reveals information concerning the differences in food availability and the consequence of physicochemical features on the life cycle of fish species. In addition, when the fish gets enough food for its growth, the Kn value will be greater than one due to optimum growth conditions [13].
However, the study of the length-weight relationship of yellowfin tuna in Malaysia is very limited. The importance of determining this relationship was emphasized by many studies. Thus, the objective of this study was to determine the length-weight relationship and relative condition factor of yellowfin tuna (*Thunnus albacares)* in South China Sea Waters, Kota Kinabalu, Sabah, and Borneo of Malaysia. It is essential to comprehend the length-weight relationship and the relative condition factor of this species. This knowledge is pivotal for estimating significant biological information and evaluating the health condition of the population. Subsequently, this information can be utilized for efficient management of fishery resources, thus guaranteeing the sustainability of fisheries resources.

2. Materials and Methods

2.1 Sampling Location

The study was conducted in Kota Kinabalu, Sabah waters from January to December 2017 (Figure 1). A total of 11,650 yellowfin tuna caught by using handline fishing were sampled in this study, Enumerators then measured the fork length (FL) of each fish specimen to the nearest 0.1 cm and individual body weights were taken by using a mechanical weighing scale with a precision of 0.1 kg.

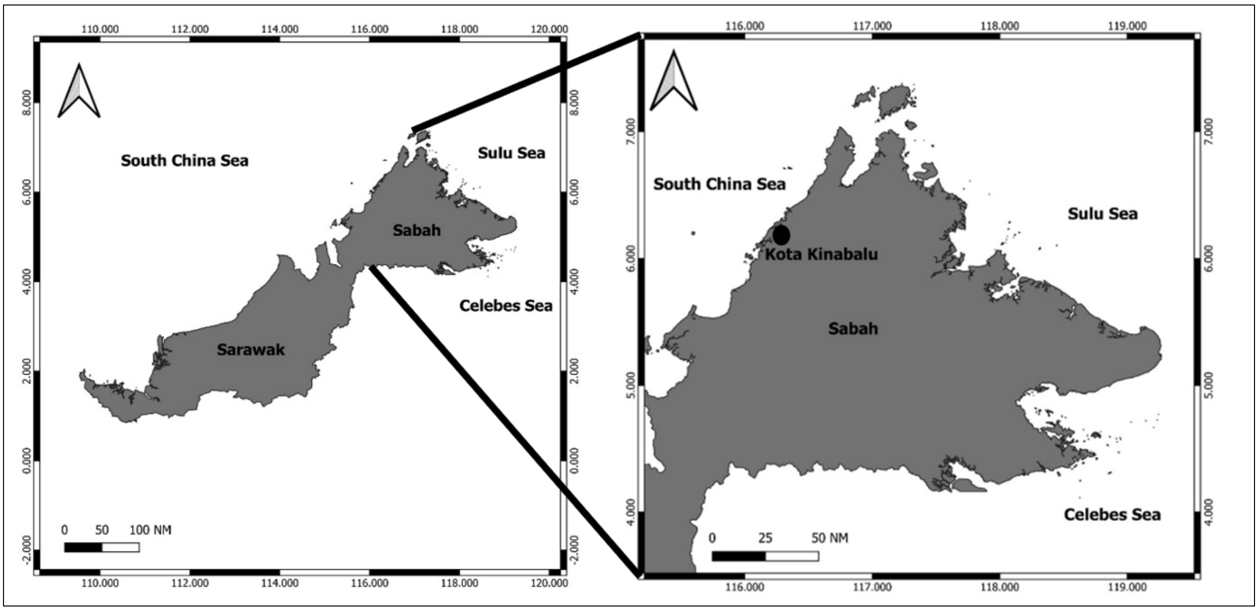

Fig 1: Fishing ground/area of Yellowfin tuna in Kota Kinabalu, Sabah.

The Length-Weight relationships equation was estimated from the allometric formula by Le Cren [10]:

$$W = aL^b$$

Then, the logarithm transformation of the equation Le Cren [10] was expressed as:

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

Where W = Weight of fish in kilogram (kg), L = Fork length of fish in centimetres (cm), a = Intercept or constant, b = Slope. The student's t-test was performed to verify whether the parameter b was significantly different from the expected or theoretical value of 3 (Lawson [14]). Thus,
Ts = (*b*-3)/*sb*

$$sb = \sqrt{([(sW/sL) - b^2])/(n-2)}$$

Where: Ts=student's t-test, *b*=slope, sb=standard error of the slope, sW=variance of body weight, sL= variance of total length, n=sample size. While for the relative condition factor, Kn [10] as follows:

$$Kn = \frac{W}{L^b}$$

Where, W = Observed weight and L^b = Estimated weight.

3. Results and Discussions

3.1 Length-weight frequency distribution of yellowfin tuna in Kota Kinabalu, Sabah Waters.

Table 1 shows the length-weight frequency distribution of 11,650 samples of yellowfin tuna in Kota Kinabalu, Sabah (January to December 2017). The length frequency distribution of yellowfin was 20-170 cm with a weight range of 0.2-82 kg. Meanwhile, a study from Molluca Sea, Indonesia showed a length range of yellowfin from 85-174 cm and a weight range of 10-75 kg [15], length range of yellowfin in West Java, Indonesia from 23-168 cm [16].

Table 1: Length-weight frequency distribution of yellowfin tuna in Kota Kinabalu, Sabah Waters.

Year	Sample size (N)	Fork length (cm)			Body weight (kg)		
		Min	Max	Mean ± SD	Min	Max	Mean ± SD
2017	11,650	20	170	73.3±27.0	0.2	82	9.74±9.73

***Notes:** SD: Standard Deviation

3.2 Length frequency distribution of yellowfin tuna in Kota Kinabalu, Sabah Waters.

The length frequency distribution of yellowfin tuna is illustrated in Figure 2. The histogram shows a relatively normal distribution with two peaks with size range from 20 cm to 170 cm. The class mode of yellowfin tuna was 50-59 cm (2,851 samples) thus, the dominant size of this species caught in Kota Kinabalu waters ranged between 50 cm to 59 cm. The mode size of yellowfin tuna in this study was close to the study in West Java (46.7-54.4 cm), however, it is shorter than yellowfin tuna in Andhra Coast, India with the mode of 90-130 cm as shown by Pratibha and Rammohan [17].

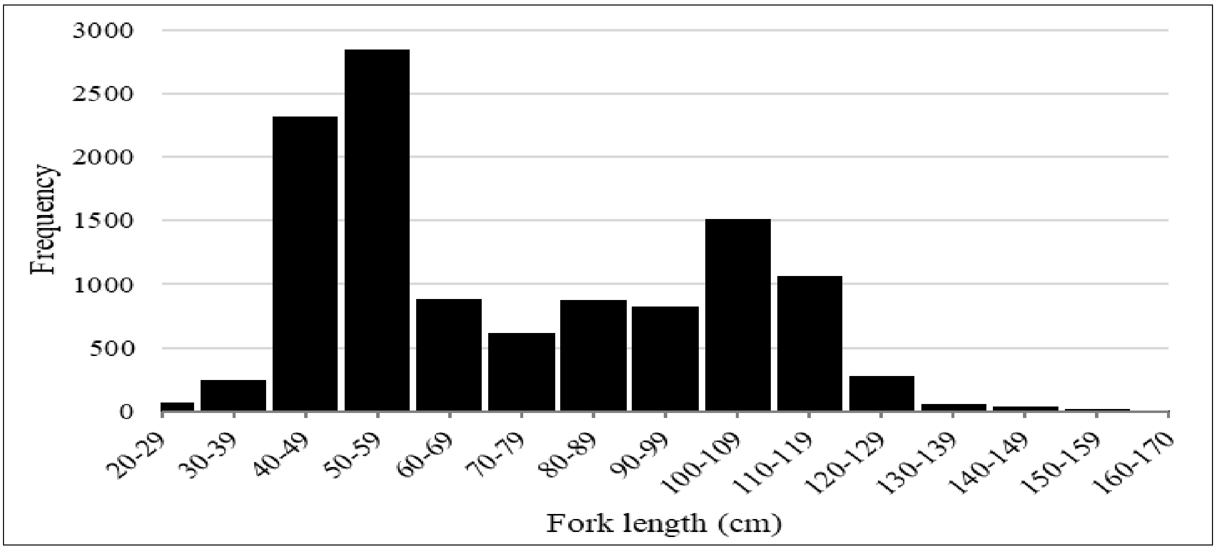

Fig 2: Length frequency distribution of Yellowfin tuna in Kota Kinabalu, Sabah Waters.

3.3 Length-weight relationship of yellowfin tuna in Kota Kinabalu, Sabah Waters

The study of the length-weight relationship (LWR) is a crucial tool for fisheries management [18]. It provides valuable information by estimating the average weight of fish based on their known length, subsequently facilitating the determination of fish population biomass [7]. Particularly valuable in scenarios where only length measurements are available, the LWR offers insights into population health and facilitates cross-regional comparisons of species growth. [19]. Additionally, the utilization of LWRs and condition factor analysis has been instrumental in assessing the stock of the population [20]. Moreover, these methods are invaluable for gaining insights into the species' life history, including the reproduction aspect and general health of the species [21]. LWR of yellowfin tuna showed the equation, $W=0.00003FL^{2.8893}$ (Figure 3). The value of b for yellowfin tuna is less than 3 (b=2.8893). Therefore, it is demonstrated that the growth of yellowfin tuna is negative allometric which means that the body weight of fish grows slower in weight than in length [22].

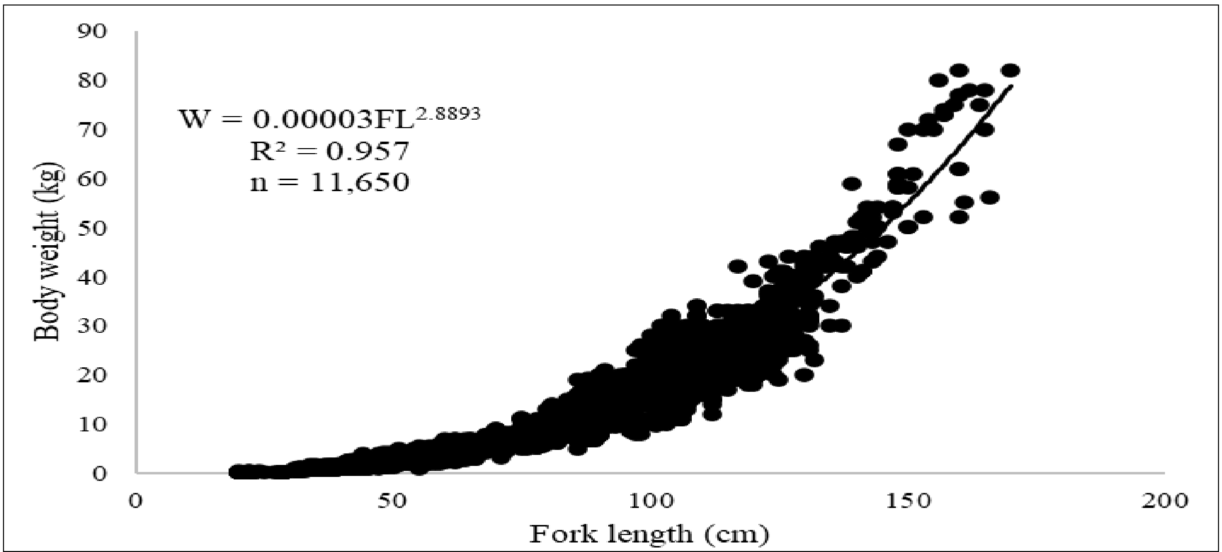

Fig 3: Length-weight relationship of yellowfin tuna in Kota Kinabalu, Sabah waters.

The next analysis used a student's t-test on the *b* value of the whole monthly samples of yellowfin tuna (Table 2). The result showed that the *b* value (*b*=2.765-2.9733; Sb=0.007-0.111; T-Test: T=-3.737--20.436; $p<0.05$) was significantly lower than the theoretical value of 3 which indicated negative allometric growth.

Table 2: Monthly length-weight parameters of yellowfin tuna in Kota Kinabalu, Sabah waters.

Month	N	Fork Length (cm)	Body Weight (kg)	A	B	R^2	SB	T-test	Growth
		Min-Max	Min-Max						
January	1118	36-165	1.0-70	0.00004	2.8356	0.9467	0.013	-12.53	-A
February	1095	37-166	1.0-56	0.00002	2.9287	0.9520	0.012	-5.77	-A
Mac	1228	34-161	1.1-61	0.00003	2.8814	0.9472	0.012	-9.28	-A
April	780	38-156	1.0-80	0.00002	2.9528	0.9403	0.111	-4.25	-A
May	600	39-160	1.2-77	0.00003	2.8993	0.9652	0.012	-5.10	-A
June	952	20-164	0.2-75	0.00004	2.8128	0.9577	0.018	-10.30	-A
July	1002	20-160	0.3-62	0.00005	2.765	0.9495	0.017	-13.88	-A
August	1080	40-160	1.1-82	0.00002	2.9528	0.9455	0.011	-4.13	-A
September	1185	41-136	1.4-46	0.00003	2.9066	0.9465	0.010	-9.60	-A
October	709	35-155	0.8-70	0.00003	2.8355	0.9675	0.010	-16.01	-A
November	1155	25-170	0.4-82	0.00003	2.8908	0.9766	0.008	-20.44	-A
December	746	34-162	0.7-78	0.00002	2.9733	0.9843	0.007	-3.74	-A

***Notes:** N: Sample Size, A: Negative allometric

The allometric coefficient b values obtained in our study fall within the expected range, 2.5-3.5 [7]. Moreover, we observed strong coefficients of determinations (R^2) indicating the robustness of the length-weight relationships. Although the parameters *a* derived from our study were consistent with studies conducted in other areas, *b* values were slightly lower compared to the estimates from Pratibha and Rammohan [17] and Jamitko *et al.* [18]. Nevertheless, the linear regressions values (*b*) for yellowfin tuna caught in our study align with those reported in other areas, such as the Southeast coast of India [23] and West Java, Indonesia [16, 24, 25].

The exponential coefficient (*b*) in the length-weight relationship varies among species due to environmental factors. These factors include temperature, food availability, spawning conditions, and biological variables such as dissolved oxygen levels in the water, fish sex, and age [26]. Consequently, the variations in b values can be attributed to either a single factor or a combination of multiple factors [8, 9].

Table 3: Values of *a*, and *b* from previous study.

Area	A Value	B Value	R^2	Number of samples	Reference
Andhra coast, India	0.0086	3.12	NA	NA	Pratibha & Rammohan [2]
West Java, Indonesia	0.00002	3.029	0.964	NA	Jamitko *et al.* [18]
West Java, Indonesia	0.00004	2.842	0.957	7,550	Nugroho *et al.* [24]
Southeast coast of India	0.0403 (male)	2.78 (male)	0.953	495	Mariasingarayan *et al.* [23]
	0.0647 (female)	2.82 (female)	0.975	659	
West Java, Indonesia	0.0191	2.9991	0.97	3,456	Agustina *et al.* [16]
West Java, Indonesia	0.0001	2.7003	0.95	200	Patanda *et al.* [25]
West Sabah waters, South China Sea	0.00003	2.8893	0.957	11,650	Present study

3.4 Relative condition factor, Kn of Yellowfin tuna

The mean relative condition factor value with standard error for yellowfin tuna was 0.956±0.105. The monthly relative condition factor of this species is displayed in Figure 4. The result indicated that the minimum Kn value was 0.88 which was observed in October. On the other hand, the maximum Kn value was 1.00 in April and June. Additionally, the were two instances when the Kn values of yellowfin tuna increased which is from January to April and from October to December. Conversely, there was a decrease in Kn values from April to October. It is worth noting that the relative condition factor (Kn) exhibits variability in fish condition throughout the months. This variability is possibly influenced by seasonal fluctuations, which in turn could be affected by the availability of food and dietary habits [27, 28] and swimming activity of the fish [29].

Figure 5 shows the relative condition factor (Kn) of yellowfin tuna was determined with a 10 cm interval of fork length (FL). The lowest values of Kn were 0.89 (120-129 cm) and the highest was 1.34 (20-29 cm). The lowest value of Kn in this present study demonstrated a quite similar pattern to the study conducted by Jatmiko *et al.* [18] which the Kn value of yellowfin tuna in East Nusa Tenggara, Indonesia showed a significant decrease up to 0.83 at length group of 110 cm. According to the trendline pattern in Figure 5, it is presented that the Kn values of yellowfin tuna decreased as the fish size increased which indicates to recognise of the condition of fish as stated by Mariasingarayan *et al.* [23]. An overall fitness for fish species is assumed when Kn values are equal or close to 1. Kn value of 1 indicates good health condition, whereas values below 1 indicate an unhealthy condition [10]. In addition, if the fish receives enough food for growth, the Kn value will be greater than one, indicating optimum growth condition [13]. According to Collette and Nauen [1], yellowfin tuna is a species that is a commercially important tuna species inhabits tropical and subtropical seas worldwide The relative condition factor of this species can be affected by migration, feeding intensity and sexual cycle [23]. The findings of this study are essential for estimating the biological information and population health condition, which can be used to assess the stock, age and growth of yellowfin tuna. Therefore, comprehensive research is warranted, particularly focusing on aspects such as spawning season, maturity, and the extent of exploitation over multiple years. Such information will provide valuable insights for documenting fishery resources for management purposes.

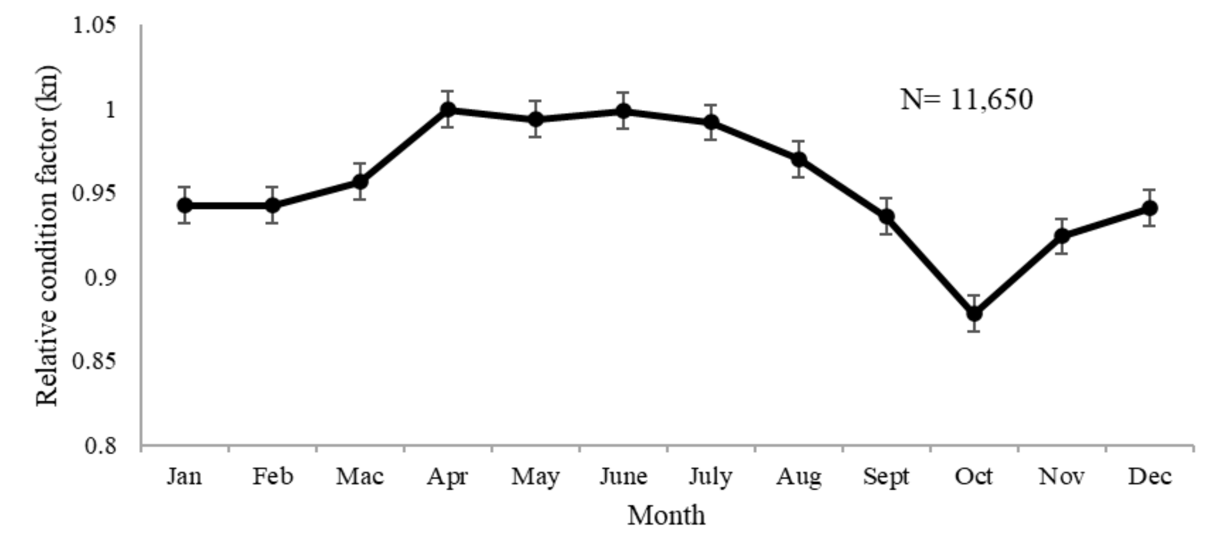

Fig 4: Monthly relative condition factor of yellowfin tuna in Kota Kinabalu, Sabah waters.

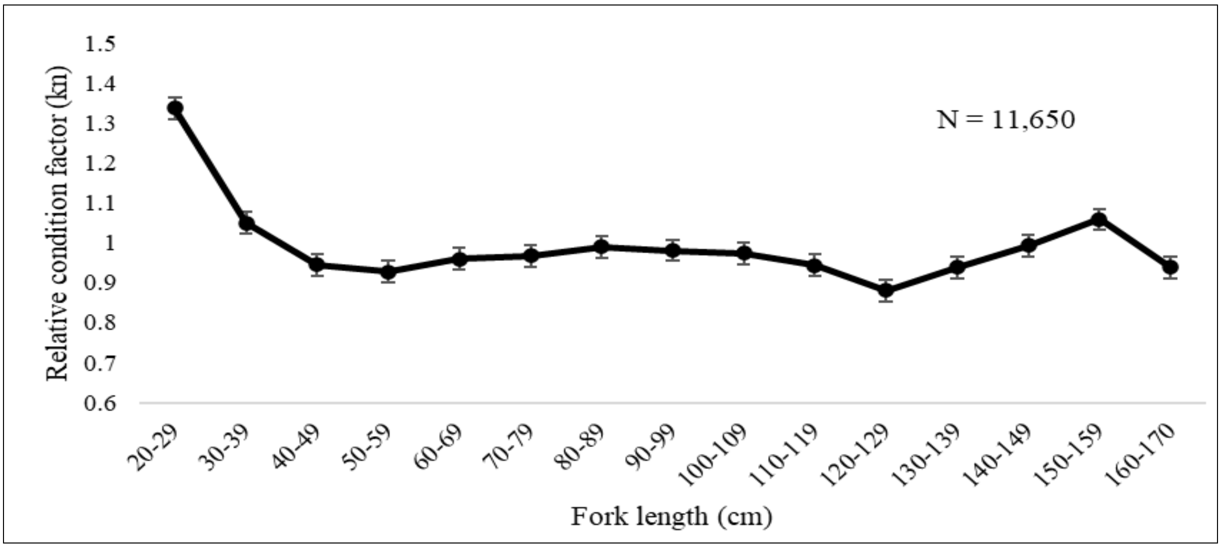

Fig 5: Relative condition factor by class length of Yellowfin tuna in Kota Kinabalu, Sabah waters.

4. Conclusion

In conclusion, this study presents significant insights into the length-weight relationship of yellowfin tuna in the waters of West Sabah. The observed negative allometric growth pattern, coupled with the assessment of the relative condition factor, suggests that the yellowfin tuna population in this region is thriving in a healthy condition. The biological data obtained from this study are invaluable for informing fisheries resources management strategies aimed at ensuring the long-term sustainability of yellowfin tuna resources. Furthermore, the findings highlight the importance of continued monitoring and research efforts to better understand the dynamics of this species' population and to implement effective conservation measures.

5. Acknowledgment

The authors are grateful to the staff of FRI Kg. Acheh for their kind assistance throughout the study. This study was supported by the Department of Fisheries Malaysia Development Fund.

6. References

1. Collette BB, Nauen CE. Scombrids of the World: An Annotated and Illustrated Catalogue of Tunas, Mackerels, Bonitos and Related Species Known to Date. FAO Fisheries Synopsis. Rome: FAO; 1983;2(125):137.
2. Pratibha R, Rammohan K. Fishery and biological aspects of yellowfin tuna *Thunnus albacares* along Andra Coast, India. Asian Fisheries Science. 2009;22:235-244.
3. Zagaglia CR, Lorenzzetti JA, Stech JL. Remote Sensing Data and Longline Catches of Yellowfin tuna (*Thunnus albacares*) in the Equatorial Atlantic. Remote Sensing of Environment. 2004;93:267-281.
4. Department of Fisheries Malaysia. Annual Fisheries Statistics 2020-2022. DOF Executive Information System (EIS-COGNOS). Ministry of Agriculture and Food Security, Malaysia; c2022.
5. Ricker WE. Computation and interpretation of biological statistics of fish population. Bull Fish Res Board Can. 1975;191:1-382.
6. Oscoz J, Campos F, Escala MC. Weight-length relationships of some fish species of the Iberian Peninsula. J Appl Ichthyol. 2005;21:73-74.
7. Froese R. Cube law, condition factor and weight-length relationships: History, meta-analysis and recom-mendations. J Appl Ichthyol. 2006;22:241-253.
8. Cort JL, Estruch VD, Santos DMN, Natale DA, Abid N, Serna DLJM. On the variability of the length-weight

relationship for Atlantic bluefin tuna, *Thunnus thynnus* (L.). Rev Fish Sci Aquac. 2015;23:23-38.
9. Zhu G, Xu L, Zhou Y, Song L, Dai X. Length-weight relationships for bigeye tuna (Thunnus obesus), yellowfin tuna (*Thunnus albacares*) and albacore (Thunnus alalunga), (Perciformes: Scombrinae) in the Atlantic, Indian and Eastern Pacific Oceans. Collect Vol Sci Pap ICCAT. 2009;65:717-724.
10. Cren LED. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J Anim Ecol. 1951;20:201-19.
11. Yilmaz S, Yazıcıoglu O, Erbasaran M, Esen S, Zengin M, Polat N. Length weight relationship and relative condition factor of white bream, *Blicca bjoerkna* L., 1758, from Lake Ladik, Turkey. J Black Sea/Mediterr Environ. 2012;18:380-387.
12. Mensah SA. Weight-length models and relative condition factors of nine freshwater fish species from the Yapei Stretch of the White Volta, Ghana. Elixir Appl Zool. 2015;79:30427-30431.
13. Jisr N, Younes G, Sukhn C, El-Dakdouki MH. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. Egypt J Aquat Res. 2018;44:299-305.
14. Lawson EO, Akintola SL, Awe FA. Length-weight relationships and morphometry for eleven (11) fish species from Ogudu Creek, Lagos, Nigeria. Biol Res. 2013;7(4):122-128.
15. Wahono B, Lumingas LJL. Size frequency and allometric growth of the yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788) caught in the Molucca Sea, Indonesia. Aquat Sci Manage. 2013;2:124-132.
16. Agustina M, Setyadji B, Tampubolon PARP. Perikanan tuna sirip kuning (*Thunnus albacares*, Bonnaterre, 1788) pada armada tonda di Samudera Hindia Selatan Jawa. Bawal. 2019;11:161-173.
17. Pratibha R, Rammohan K. Fishery and biological aspects of yellowfin tuna *Thunnus albacares* along Andra Coast, India. Asian Fish Sci. 2009;22:235-244.
18. Jatmiko I, Hartaty H, Nugraha B. Estimation of yellowfin tuna production landed in Benoa port with weight-weight, length-weight relationships. Indones Fish Res J. 2016;22(2):77-84.
19. Koutrakis ET, Tsikliras AC. Length-weight relationships of fishes from three northern Aegean estuarine systems (Greece). J Appl Ichthyol. 2003;19:258-260.
20. Ricker WE. Growth rate and models. In: Hoar WS, Randall DJ, Brett JR, Ed. Fish Physiology. Vol. III. Bioenergetics and Growth. Academic Press; c1979. p. 195-248.
21. Pauly D. Fishbyte Section Editorial. Naga. Manila, Philippines: The ICLARM Quarterly; c1993, p. 16-22.
22. Karachle PK, Stergiou KI. Morphometrics and Allometry in Fishes. In: Wahl C, Ed. Agricultural and Biological Sciences; c2012, p. 65-86.
23. Mariasingarayan Y, Danaraj J, Vajravelu M, Mayakrishnan M, Ayyappan S. Length-weight relationship and relative condition factor of yellowfin tuna (*Thunnus albacares*) from Parangipettai coast, southeast coast of India. Zool Ecol. 2018;28(19):1-6.
24. Nugroho SC, Jatmiko I, Wujdi A. Pola pertumbuhan dan factor kondisi madidihang, *Thunnus albacares* (Bonnaterre, 1788) di Samudra Hindia Bagian Timur. J Iktiol Indones. 2018;18(1):13-21.
25. Patanda M, Sala R, Manuputty A. Pola pertumbuhan tuna sirip kuning (*Thunnus albacares*) yang didaratkan di PPN Palabuhanratu, Sukabumi. J Pengelolaan Perikanan Tropis. 2022;6(1):27-34.
26. Zakeyudin MS, Isa MM, Rawi CS Md, Shah AS Md. Assessment of Suitability of Kerian River Tributaries Using Length-Weight Relationship and Relative Condition Factor of Six Freshwater Fish Species. J Environ Earth Sci. 2012;2:52-60.
27. King M. Fisheries biology, assessment and management. 2nd Ed. Oxford: Blackwell Publishing Ltd; 2007. 381 p.
28. Saha SN, Vijayanand P, Rajagopal S. Length-weight relationship and relative condition factor in *Thenus orientalis* (Lund, 1793) along East Coast of India. Curr Res J Biol Sci. 2009;1(2):11-14.
29. Muchlisin ZA, Musman M, Azizah MNS. Length-weight relationships and condition factors of two threatened fishes, Rasbora tawarensis and Poropuntius tawarensis, endemic to Lake Laut Tawar Aceh Province, Indonesia. J Appl Ichthyol. 2010;26(6):949-953.