



Biological Insights into Length–Weight Relationship and Relative Condition Factor of Frigate Tuna *A. thazard* (Lacepede, 1800) Landed at Veraval Fishing Harbour, Northwest Coast of India

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ID 0009-0008-9529-7447

ABSTRACT

The present study was carried out during March, 2025 and February, 2026 at Veraval Fishing Harbour along the northwest coast of India to evaluate the length–weight relationship (LWR) and relative condition factor (K_n) of frigate tuna, *Auxis thazard*. A total of 300 specimens were collected between March 2025 and February 2026. The sampled fish ranged from 26.5 to 46.5 cm in total length and weighed between 205 and 1353 g. The length–weight relationship was analysed separately for males, females, and pooled samples using the allometric growth equation. The estimated b-values were 3.4737 for males, 3.4951 for females, and 3.4827 for pooled specimens, indicating positive allometric growth, where body weight increased at a faster rate than length. High coefficients of determination ($R^2 > 0.94$) revealed a strong relationship between length and weight. The relative condition factor (K_n) remained close to 1 throughout the study period, suggesting that the fish population was generally in good health and adapted well to its environment. Minor seasonal fluctuations were observed, with slightly lower values in some months, particularly among females during November, which might be associated with reproductive energy expenditure. Overall, the results indicated healthy growth and favourable physiological condition of *A. thazard* in the study area. These findings provided useful baseline information for stock assessment, fisheries management, and the sustainable utilization of this commercially important tuna species.

KEYWORDS: *Auxis thazard*, length–weight relationship, relative condition factor

Citation (VANCOUVER): Kakkad et al., Biological Insights into Length–Weight Relationship and Relative Condition Factor of Frigate Tuna *A. thazard* (Lacepede, 1800) Landed at Veraval Fishing Harbour, Northwest Coast of India. *International Journal of Bio-resource and Stress Management*, 2026; 17(9), 01-07. [HTTPS://DOI.ORG/10.23910/1.2026.7244](https://doi.org/10.23910/1.2026.7244).

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, author have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The author has declared that no conflict of interest exists.

1. INTRODUCTION

Gujarat, situated in India on the Asian continent, is rich in both marine and inland water resources. The state has a 2,340.62 km² coastline, a continental shelf spanning about 164,000 km², and an Exclusive Economic Zone (EEZ) of 214,000 km². With India's total coastline measuring 11,098.81 km², Gujarat accounts for 32% of the nation's continental shelf and 10% of its EEZ. (Anonymous, 2024). Frigate tuna is a widely distributed, highly migratory fish that lives in the upper layers of the ocean. It is commonly found in both coastal and open ocean waters across tropical and temperate regions. Adult fish are usually seen closer to the coast, while younger ones tend to inhabit deeper offshore waters (Recio et al., 2022). In Indian waters, it can grow up to approximately 500 mm in length and has a maximum lifespan of four years (Abdussamad et al., 2005; Lelono and Bintoro, 2019). Due to their abundance, they play a crucial role in the marine food web, serving as an important forage species for commercially valuable predators, including larger tunas (Frimodt et al., 1995). They are commercially marketed in various forms, including fresh and frozen (Collette, 1995) as well as dried, salted, smoked, and canned (Frimodt et al., 1995). In the Maldives, frigate tuna is commonly processed into dried or smoked products, and it is also used to prepare rihaakuru, a traditional fish paste (Ahusan and Adam, 2011). The length-weight relationship (LWR) is a vital parameter for understanding the growth patterns, reproductive biology, and life-history traits of fish populations. It helps determine the maximum body length, which is essential for assessing the productivity and resilience of exploited fish stocks (Bradford et al., 2014; Jessop, 2010; Lowerre-Barbieri et al., 2017; Randall et al., 2013). LWR provides valuable insights into growth patterns, habitat conditions, life history, and the morphological characteristics of fish (Froese, 2006; Schneider et al., 2000). Studying LWR is crucial for fish stock estimation and fisheries biology, as it enables the calculation of the average weight for fish of a given length group through a mathematical relationship between length and weight (Beyer, 1987). Fish size is considered biologically more significant than age, as it is more influenced by ecological and physiological factors (Kalayci et al., 2007). The frigate tuna is characterized by a robust, elongated, and rounded body. It has 10–12 dorsal spines, 10–13 dorsal soft rays, no anal spines, and 10–14 anal soft rays. Its teeth are small, conical, and arranged in a single series, while the first gill arch contains 36–42 total gill rakers. The species possesses two dorsal fins, with the first (D1 X–XII) separated from the second by a large interspace at least equal to the length of the first dorsal-fin base. The second dorsal fin is followed by eight finlets, and the anal fin is followed by seven finlets. The pectoral fins are relatively short. The body is mostly naked, except for a

well-developed corselet that narrows at the posterior end, measuring no more than five scales wide beneath the second dorsal-fin origin. The coloration of *A. thazard* is distinct, with a bluish back those transitions to deep purple or almost black near the head. The scaleless area above the lateral line features a pattern of 15 or more narrow, dark wavy lines that are oblique to nearly horizontal. The belly is white, and the pectoral and pelvic fins appear purple with black inner sides (Collette, 2001). Thus, the present study was carried out to evaluate the length-weight relationship (LWR) and relative condition factor (K_n) of frigate tuna, *Auxis thazard*, landed.

2. MATERIALS AND METHODS

2.1. Location

The study was carried out during March, 2025 and February, 2026 at the Veraval fish landing center (20°54'912"N and 70°21'355"E), located in the Gir-Somnath district of Gujarat, India. Veraval is the largest and most active fish landing center along the Gujarat coast. The center features a well-developed harbour, a substantial fleet of fishing vessels, predominantly trawlers and numerous fish processing facilities, establishing it as a major hub of the regional fishing industry.

2.2. Sampling design

Specimens of frigate tuna, *Auxis thazard*, were collected from gill netter landed at Veraval fishing harbour along the Saurashtra coast, Gujarat. Each month, 30 Samples were randomly obtained in every fortnight from different vessels of different sizes and weights to represent the actual populations. Specimens were brought to College of Fisheries science, Kamdhenu University laboratory for the length weight analysis.

2.3. Methodology

The collected fish were washed and identified using standard taxonomic keys. For each specimen, the total length (TL) was measured from the tip of the snout to the end of the caudal fin using a measuring board to the nearest 0.1 cm. The total body weight (TW) was recorded using a digital balance with an accuracy of 0.1 g.



Figure 1: Specimen for study *Auxis thazard*

2.4. Length–weight relationship (LWR)

The length–weight relationship (LWR) was calculated using the allometric formula proposed by Le Cren (1951), separately for both sexes.

$$W = a L^b \text{ or } \log W = \log a + b \times \log L$$

Where, W=Total body weight (g), L=Total Length (cm), a and b were the coefficients of the functional regression between W and L.

2.5. Relative condition factor (K_n)

The relative condition factor (K_n) of individual fish was estimated following Le Cren (1951) using the equation:

$$K_n = W_o / W_c$$

Where, W_o represented the observed body weight and W_c denoted the calculated (expected) weight derived from the length–weight relationship.

3. RESULTS AND DISCUSSION

3.1. Length and weight composition

During the study period, author obtained a total of 300 specimens of *Auxis thazard* were collected, comprising 162 males and 138 females. The total length of the specimens varied between 26.5 cm and 46.5 cm, while their body weight ranged from 205 g to 1353 g. The highest average length was recorded in February (39.38 cm), whereas the lowest was observed in May (29.3 cm). The smallest individual (26.5 cm) was also recorded in May, while the largest specimen (46.5 cm) was obtained in February. The average body weight was highest in January (941.03 g) and lowest in May (341.93 g). The lightest specimen, weighing 205 g, was recorded in November, whereas the heaviest individual (1353 g) was observed in December (Table 1).

Table 1: Monthly range and mean of total length and total weight of *A. thazard*

Month	No. of fish observed	Body length (cm)		Body weight (g)	
		Range (cm)	Mean (cm)±SD	Range (g)	Mean (g)±SD
Mar-25	30	28–41	37.13±3.26	298.2–1095	777.61±197.89
Apr-25	30	32–41	37.47±2.74	460.2–1101	769.66±205.91
May-25	30	26.5–35	29.3±2.45	245.2–648.1	341.93±108.38
Aug-25	30	28–43.5	33.33±3.85	267.3–1209	509.15±230.01
Sep-25	30	30–44	36.18±4.25	382–1050	656.73±244.30
Oct-25	30	27–40	32.68±3.59	211.3–958.5	476.87±198.80
Nov-25	30	27–40	32.02±3.57	205–935	431.83±188.52
Dec-25	30	30–44	39.18±3.89	342.8–1353	935.38±280.00
Jan-26	30	30–44.5	39.28±4.19	346.3–1307	941.03±293.87
Feb-26	30	28–46.5	39.38±4.51	301–1335	914.33±268.96
Total	300	26.5–46.5	35.60±3.63	205–1353	675.45±221.66

Author obtained most frequently observed length range was 38–40 cm, whereas the 47–49 cm group was the least represented. Among males, the highest number of individuals (39 individuals) were recorded in the 41–43 cm size class, while only a single individual was observed in the 47–49 cm range. In contrast, females were most abundant in the 32–34 cm group (33 individuals), and least represented in the 44–46 cm range, with only two individuals recorded. In terms of weight distribution, the 351–500 g range showed the highest frequency, while the 1251–1400 g range was the least represented. Among males, the majority of individuals (31 individuals) were recorded in the 351–500 g weight group, whereas only 4 individuals were observed in the 1251–1400 g range. Similarly, females were most abundant in the 351–500 g group (32 individuals), while the lowest representation (1 individual) was noted in the 1251–1400

g weight class (Table 2).

Mariyasingarayan et al., (2018) analysed 618 specimens of *A. thazard* from Parangipettai, southeast coast of India, he got fish with total length range from 18–49 cm and total weight range from 70–2000 g. Azeez et al., (2024) analysed 832 specimens of *A. thazard* from Indian waters got forked length in range from 22.8–68 cm. Herath et al. (2019) worked on total number of 405 frigate tuna samples during his research in Sri Lankan coast. He got standard length of the collected samples varied from 19.4 to 40.7 cm and the weight of the samples varied from 118.9 to 1430.9 g.

3.2. Length–weight relationship (LWR)

In author's study, a total of 300 specimens were analysed, comprising 168 males and 132 females. The total length of the specimens ranged from 26.5 to 46.5 cm, while their body

Table 2: Length-weight frequency distribution in *A. thazard*

Length intervals (cm)	Frequency (count)			Weight intervals (g)	Frequency (count)		
	Male	Female	Pooled		Male	Female	Pooled
26–28	20	9	29	201–350	30	28	58
29–31	21	24	45	351–500	31	32	63
32–34	26	33	59	501–650	19	18	37
35–37	16	21	37	651–800	10	16	26
38–40	33	30	63	801–950	17	23	40
41–43	39	19	58	951–1100	30	17	47
44–46	6	2	8	1101–1250	21	3	24
47–49	1	0	1	1251–1400	4	1	5

weight varied between 205 and 1353 g. The length–weight relationship was assessed separately for males, females, and the combined sample.

For Males, the relationship was:

Parabolic equation: $W=0.0025 \times L^{3.4737}$ ($R^2=0.9512$)

Logarithmic equation: $\log W=-2.60206+3.4737 \log L$

For Females, the relationship was:

Parabolic equation: $W=0.0023 \times L^{3.4951}$ ($R^2 = 0.9496$)

Logarithmic equation: $\log W=-2.63827+3.4951 \log L$

Since there was no significant difference between the male and female relationships, the data were combined (pooled), resulting in:

Pooled data (both sexes):

Parabolic equation: $W=0.0025 \times L^{3.4827}$ ($R^2=0.9514$)

Logarithmic equation: $\log W=-2.60206+3.4827 \log L$

In author's study, the regression coefficient (b) and coefficient of determination (R^2) were estimated as 3.4737 and 0.9512 for males (Figure 1), 3.4951 and 0.9496 for females (Figure 2), and 3.4827 and 0.9514 for the combined sexes (Figure 3). The relationships were found to be statistically significant ($p<0.05$). Since all b values exceeded 3, the species exhibited

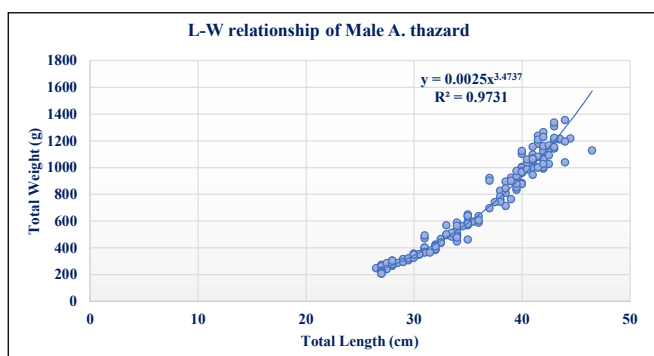


Figure 1: Length-weight relationship of Male *A. thazard*
Source: Author's analysis

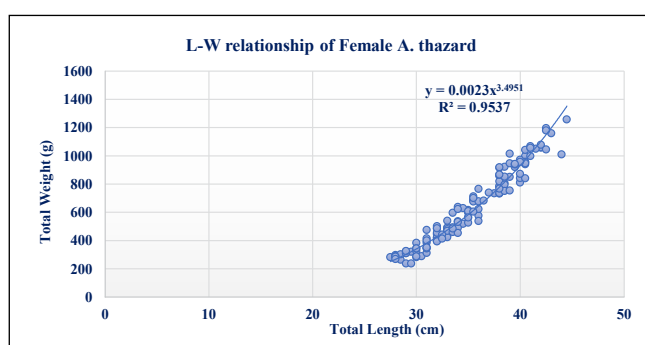


Figure 2: Length-weight relationship of female *A. thazard*,
Source: Author's analysis

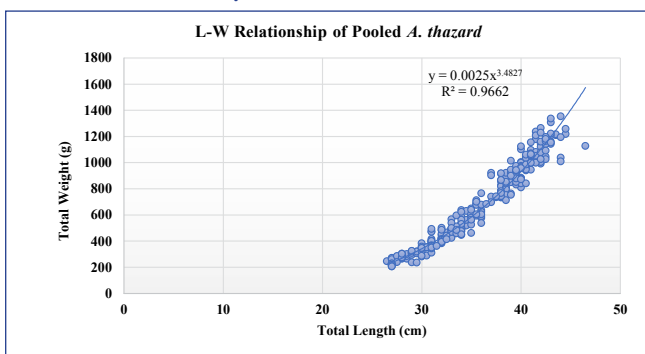


Figure 3: Length-weight relationship of pooled (both sexes) *A. thazard*; Source: Author's analysis

a positive allometric growth pattern, indicating that weight increases at a faster rate than length. Furthermore, the high R^2 values observed for both males and females indicated a strong and positive correlation between length and weight. Similar to my study Mariyasingarayan et al. (2018) studied *A. thazard* from Parangipettai along the southeast coast of India, reported $W=0.0028 \times L^{3.4679}$ and coefficient of determination (R^2) value 0.906. Azeez et al. (2024) reported the length–weight relationship as $\log W=0.000049+3.1740 \log L$ and coefficient of determination (R^2) value 0.93 from Indian waters. Ghosh et al. (2012) studied *A. thazard* from Indian waters, reported $\log W=-2.082723+3.171805 \log L$

and coefficient of determination (R^2) value 0.92. Herath et al. (2019), while studying frigate tuna in Sri Lankan waters, reported $W = 0.1091L^{3.3385}$ and coefficient of determination (R^2) value 0.979. In contrast, Moghadam et al. (2025), while analysing 399 specimens of frigate tuna from the Persian Gulf and the Sea of Oman, reported a negative allometric growth pattern. The length-weight relationship was estimated as $W = 0.00004 FL^{2.75}$ for males and $W = 0.00005 FL^{2.68}$ for females. Here FL means fork length of fish and b value obtained for both males and females is less than 3.0 which describes negative allometric growth. The variations in b values among different studies might be attributed to differences in environmental conditions, food availability, maturity stage, fishing season, sampling size, and geographical location.

3.3. Relative condition factor (K_n)

In the study, author obtained the monthly mean values of the relative condition factor (K_n) for both males and females were calculated and are presented in Table 3 and Table 4 (mean $\pm$ SD). Among males, the highest K_n value was recorded in April (1.009 ± 0.082), while the lowest was observed in November (0.972 ± 0.054). In females, the maximum K_n value occurred in August (1.011 ± 0.042), whereas the minimum was noted in November (0.864 ± 0.073). Overall, although slight fluctuations were observed across months, the weighted average of K_n values did not show any significant variation, indicating a relatively stable condition of the fish throughout the study period. The relative condition factor (K_n) remained close to 1.00 throughout all months, indicating that the fish were generally in good health. The lowest value was recorded in January (0.983 ± 0.097), while the highest was observed in November (1.047 ± 0.090). Overall, only slight seasonal fluctuations were noted around

Table 3: Monthly relative condition factor for both sexes (pooled)

Months	Relative condition factor (K_n) $\pm$ Standard deviation (SD)
Mar-25	1.004 $\pm$ 0.064
Apr-25	0.988 $\pm$ 0.079
May-25	0.991 $\pm$ 0.062
Aug-25	1.006 $\pm$ 0.039
Sep-25	1.001 $\pm$ 0.089
Oct-25	0.988 $\pm$ 0.094
Nov-25	1.047 $\pm$ 0.090
Dec-25	1.019 $\pm$ 0.110
Jan-26	0.983 $\pm$ 0.097
Feb-26	1.001 $\pm$ 0.089
Mean	1.003 $\pm$ 0.081

Table 4: Monthly relative condition factor for separate male and female

Month	Male		Female	
	No. of fish	$K_n \pm SD$	No. of fish	$K_n \pm SD$
Mar-25	14	1.001 $\pm$ 0.052	16	1.004 $\pm$ 0.065
Apr-25	13	1.009 $\pm$ 0.082	17	0.986 $\pm$ 0.080
May-25	16	1.001 $\pm$ 0.064	14	1.005 $\pm$ 0.060
Aug-25	14	1.000 $\pm$ 0.036	16	1.011 $\pm$ 0.042
Sep-25	16	1.003 $\pm$ 0.107	14	1.001 $\pm$ 0.056
Oct-25	16	0.995 $\pm$ 0.050	14	0.954 $\pm$ 0.121
Nov-25	17	0.972 $\pm$ 0.054	13	0.864 $\pm$ 0.073
Dec-25	21	0.987 $\pm$ 0.096	9	1.037 $\pm$ 0.138
Jan-26	20	0.993 $\pm$ 0.089	10	1.010 $\pm$ 0.121
Feb-26	15	1.005 $\pm$ 0.093	15	0.998 $\pm$ 0.085
Mean	162	1.020 $\pm$ 0.091	138	1.023 $\pm$ 0.097

the mean value of 1.003 ± 0.081 .

The relative condition factor (K_n) of *Auxis thazard* remained close to 1 throughout the study period, with an overall mean of 1.003 ± 0.081 for pooled samples, indicating that the fish were generally in good and stable condition. Monthly variations were minor, with slightly higher values observed in November (1.047 ± 0.090) and December (1.019 ± 0.110). Lower values in April and October (0.988) indicated slight fluctuations but not a major decline in condition. When analysed separately, both males (1.020 ± 0.091) and females (1.023 ± 0.097) showed very similar K_n values, suggesting that both sexes maintained comparable health and growth patterns. However, a noticeable drop in female K_n during November (0.864 ± 0.073) may indicate energy utilization for gonadal development. Agustina and Ririk (2022) reported that the relative condition factor (K_n) of *Euthynnus affinis* in West Sumatra, Indonesia varied between 1.08 and 1.27 over the year. The highest value was recorded in December, while the lowest occurred in April. However, despite these slight variations, the study indicated that the condition factor remained fairly stable throughout the months. Jatmiko et al. (2016) observed noticeable seasonal changes in the relative condition factor (K_n) of *Thunnus albacares* at Benoa Port, Indonesia. The values were generally higher between September and April, reaching a peak in March (0.89) and dropping to the lowest level in August (0.82).

4. CONCLUSION

Frigate tuna (*Auxis thazard*) showed a strong relationship between length and weight. The b-values greater than 3 indicated positive allometric growth, meaning the fish became relatively heavier as they increased in size. High

R^2 values further confirmed this relationship. The relative condition factor (K_n) remained close to 1 throughout the study, suggesting that the fish were generally healthy and growing under favourable environmental conditions. These findings provided valuable baseline information for future stock assessment and sustainable management of frigate tuna fisheries.

5. REFERENCES

- Anonymous, 2024. Length of coastline of India. Available from: <https://surveyofindia.gov.in/UserFiles/files/Length%20of%20Coastline%20of%20India.pdf>. Retrieved on: February 20, 2025.
- Azeez, P.A., Abdussamad, E.M., Rajesh, K.M., Chellappan, A., Nakhawa, A.D., Surya, S., Koya, M., Ghosh, S., Manas, H.M., Rohit, P., 2024. Fishery, biology and population characteristics of frigate tuna *Auxis thazard* (Lacepede, 1800) from Indian waters. Indian Journal of Fisheries 71(1), 64–69. Available from: <https://epubs.icar.org.in/index.php/IJF/article/view/131132>.
- Abdussamad, E.M., Pillai, P.P., Mohamad Kasim, H., Balasubramanian, T.S., 2005. Fishery and population characteristics of coastal tunas at Tuticorin. Journal of the Marine Biological Association of India 47(1), 50–57. Available from: <https://mbai.org.in/jmbai-details/MTkzMg==/ODg=>.
- Agustina, M., Sulistyaningsih, R.K., 2022. Cpue, Biological and Condition Factor of Kawakawa (*Euthynnus affinis*) Caught By Purse Seine in West Sumatra. Indonesian Fisheries Research Journal 28(1), 15–22. Available from: <https://ejournal-balitbang.kkp.go.id/index.php/ifrj/article/view/9709>.
- Ahusan, M., Adam, M.S., 2011. Status of frigate tuna (*Auxis thazard*) fishery in the Maldives. In: Meeting report of the Indian Ocean Tuna Commission (IOTC-2011-WPNT01-26, p. 9). Indian Ocean Tuna Commission. Available from: <https://openknowledge.fao.org/server/api/core/bitstreams/5e2e9fc6-52c4-4c4f-8c61-451783ef0e3b/content>.
- Beyer, J.E., 1987. On length–weight relationship. Computing the mean weight of the fish of a given length class. Fishbyte 5, 11–13. Available from: <https://www.sid.ir/paper/572108/en>.
- Bradford, M.J., Randall, R.G., Smokorowski, K.S., Keatley, B.E., Clarke, K.D., 2014. A framework for assessing fisheries productivity for the Fisheries Protection Program. Canadian Science Advisory Secretariat. Available from: <https://csas-scas.dfo-mpo.gc.ca/publications-publications/13436192-6516-489b-88a6-5f0c9322ca65?lang=en>.
- Collette, B.B., 1995. Scombridae. Atunes, bacoretas, bonitos, caballas, estorninos, melva, etc. In: Fischer, W., Krupp, F., Schneider, W., Sommer, C., Carpenter, K.E., Niem, V. (Eds.), Guía FAO para identificación de especies para los fines de la pesca. Pacífico Centro-Oriental, 3, 1521–1543. FAO. Available from: <https://www.fishbase.se/references/FBRefSummary.php?ID=9340>.
- Collette, B.B., 2001. Scombridae. Tunas (also, albacore, bonitos, mackerels, seerfishes, and wahoo). In: Carpenter, K.E., Niem, V. (Eds.), FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific, Vol. 6, Bony fishes part 4: Labridae to Latimeriidae, estuarine crocodiles, pp. 3721–3756. FAO. Available from: <https://www.fao.org/4/y0870e/y0870e36.pdf>.
- Frimodt, C., 1995. Multilingual illustrated guide to the world's commercial warmwater fish. Fishing News Books. Available from: <https://www.cabidigitallibrary.org/doi/full/10.5555/19962200577>.
- Froese, R., 2006. Cube law, condition factor, and weight–length relationships: History, meta-analysis, and recommendations. Journal of Applied Ichthyology 22(4), 241–253. DOI: <https://doi.org/10.1111/j.1439-0426.2006.00805.x>.
- Ghosh, S., Sivadas, M., Abdussamad, E.M., Rohit, P., Koya, K.P., Joshi, K.K., Chellappan, A., Rathinam, A., Prakasan, Sebastine, M., 2012. Fishery, population dynamics, and stock structure of frigate tuna *Auxis thazard* (Lacepede, 1800) exploited from Indian waters. Indian Journal of Fisheries 59(2), 95–100. Available from: https://eprints.cmfri.org.in/8993/1/Shubhadeep_Ghosh_95-100.pdf.
- Herath, D.R., Perera, H.A.C.C., Hettiarachchi, G.H. C. M., 2019. Some biological aspects and molecular variations in frigate tuna, *Auxis thazard* of the coastal waters around Sri Lanka. Journal of the National Science Foundation of Sri Lanka 47(3), 333–340. Available from: <https://jnsfsl.sljol.info/articles/10.4038/jnsfsv47i3.9427>.
- Jatmiko, I., Hartaty, H., Nugraha, B., 2016. Estimation of yellowfin tuna production landed in Benoa Port with weight-weight, length-weight relationships and condition factor approaches. Indonesian Fisheries Research Journal 22(2), 77–84. Available from: <https://ejournal-balitbang.kkp.go.id/index.php/ifrj/article/view/1620>.
- Jessop, B.M., 2010. Geographic effects on American eel (*Anguilla rostrata*) life history characteristics and strategies. Canadian Journal of Fisheries and Aquatic Sciences 67(2), 326–346. Available from: <https://cdnsciencepub.com/doi/abs/10.1139/F09-189>.
- Kalayci, F., Samsun, N., Bilgin, S., Samsun, O., 2007. Length-weight relationship of 10 fish species caught by bottom trawl and midwater trawl from the Middle

- Black Sea, Turkey. Turkish Journal of Fisheries and Aquatic Sciences 7(1), 33–36. Available from: <https://dergipark.org.tr/en/pub/trjfas-ayrildi/article/160565>.
- Le Cren, E.D., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). The Journal of Animal Ecology 20(2), 201–219. Available from: <https://www.scrip.org/reference/referencespapers?referenceid=1822732>.
- Lelono, T.D., Bintoro, G., 2019. Population dynamics and feeding habits of *Euthynnus affinis*, *Auxis thazard*, and *Auxis rochei* in South Coast of East Java waters. In: IOP Conference Series: Earth and Environmental Science 370(1), p. 012054. IOP Publishing. Available from: <https://www.researchgate.net/publication/337709612>.
- Lowerre-Barbieri, S., DeCelles, G., Pepin, P., Catalán, I.A., Muhling, B., Erisman, B., Cadrin, S., Alos, J., Ospina-Alvarez, A., Stachura, M.M., Tringali, M.D., Burnsed, S.W., Paris, C.B., 2017. Reproductive resilience: A paradigm shifts in understanding spawner-recruit systems in exploited marine fish. Fish and Fisheries 18(2), 285–312. Available from: <https://scholarship.miami.edu/esploro/outputs/journalArticle/Reproductive-resilience-a-paradigm-shift-in/991031575601002976>.
- Mariyasingarayan, Y., Danaraj, J., Vajravelu, M., Ayyappan, S., 2018. Length-weight relationship and diet composition of frigate tuna (*Auxis thazard*) from Parangipettai, southeast coast of India. International Journal of Science Inventions Today 7(1), 9–16. Available from: http://ijsit.com/admin/ijsit_files/length-weight%20relationship%20and%20diet%20composition%20of%20frigate%20tuna%20auxis%20thazard%20from%20parangipettai%20southeast%20coast%20of%20india ijsit 7.1.2.pdf.
- Moghadam, R.R., Safaie, M., Darvishi, M., 2025. Some biological aspects of *Auxis thazard* (Lacepède, 1800) in the Persian Gulf and Oman Sea (Hormozgan Province). Journal of Animal Environment 17(2), 87–94. Available from: <https://aejournals.org/index.php/AEJ/article/view/1992>.
- Randall, R.G., Bradford, M.J., Rice, J.C., Clarke, K.D., 2013. A science-based interpretation of ongoing productivity of commercial, recreational, or Aboriginal fisheries. (Canadian Science Advisory Secretariat Document 2012/112) Fisheries and Oceans Canada. Available from: <https://publications.aws.tpsgc-pwgsc.cloud-nuage.canada.ca/site/eng/445753/publication.html>.
- Recio, L., Murua, H., Restrepo, V., 2022. Biology and stock status of minor commercial tunas: Summary of current knowledge and gaps. International Seafood Sustainability Foundation. Available from: <https://www.iss-foundation.org/about-issf/what-we-publish/issf-documents/issf-2022-01-biology-and-stock-status-of-minor-commercial-tunas-summary-of-current-knowledge-and-gaps/>.
- Schneider, S., Roessli, D., Excoffier, L., 2000. Arlequin: A software for population genetics data analysis. User Manual Version 2, 2496–2497. Available from: <https://cmpg.unibe.ch/software/arlequin/archive/website/software/2.000/manual/Arlequin.pdf>.