Neritic tuna with special reference to the fishery and biology of *Thunnus tonggol* in the Indian Waters

Abdul Azeez P., Abdussamad E. M., Mohammed Koya K., Rajesh K. M., Surya S., Shoba Joe Kizhakudan, Grinson George

ICAR-Central Marine Fisheries Research Institute, Kochi-682 018, India

Abstract

The neritic tuna fishery of India is supported by five key species: longtail tuna (*Thunnus tonggol*), kawakawa, striped bonito, bullet tuna, and frigate tuna. These species are of high economic value and provide significant livelihood support, especially to the coastal states. They are exploited by mechanized, motorized, and non-mechanized fishing units operating within the Indian Exclusive Economic Zone (EEZ), primarily along the continental shelf. Gillnetters are the primary gear targeting larger individuals of this group. The total tuna catch in Indian waters shows a steady increase between 1995 (37,789 t) and 2024 (120342 t), with neritic tunas consistently dominating over oceanic tunas. Neritic tunas contributed 51–65% to the total tuna catch in India, *Euthynnus affinis* remained the dominant species, accounting for nearly 63.5% of the neritic tuna catches followed by *Auxis spp.* (29.1%), *Thunnus tonggol* (6.4%) and *Sarda orientalis* (0.9%) (563 t). *Thunnus tonggol* (longtail tuna) is widely distributed along the Indian mainland coast and the Andaman and Nicobar Islands. However, its fishery is particularly significant along the northwest coast, accounting for 97.83% of the national longtail tuna catch. During the study period, annual landings of *T. tonggol* varied from 4,195 tonnes (2020) to 6,537 tonnes (2024), averaging 3,909 tonnes. Length measurements of *T. tonggol* specimens ranged from 34.0 cm to 94.5 cm, with a mean length of 58.7 cm. The growth parameters, L_∞ and K were 91.18 cm and 0.2 year^{-1} respectively. The size at first capture (Lc) was 62.27 cm. The growth performance index was 3.22 and t_anchor 0.64. The estimated mortality rates M, F and Z were 0.457, 0.464 and 0.921 respectively. The F/M was 1.015 and exploitation rate was 0.504, indicating fishery is sustainable. The observed sex ratio (male:female) was 1:2.11, indicating a strong dominance of females. The estimated length at which 50% of fishes attained sexual maturity was 67±0.52 cm total length and average fecundity was estimated at 3,11,433 numbers. The diet comprised mainly of fishes (61.92%), shrimps (18.51%), cephalopods (15.67%), partially digested materials (2.44%), squilla (1.37%) and crabs (0.08%), based on Index of Relative Importance (IRI).

Keywords: Longtail tuna, Neritic tuna fishery, Indian EEZ, Tuna biology

Introduction

The neritic tuna fishery of India is supported by five key species: longtail tuna (*Thunnus tonggol*), kawakawa (*Euthynnus affinis*), striped bonito (*Sarda orientails*), bullet tuna (*Auxis rochei*), and frigate tuna (*A. thazard*). These species are of high economic value and provide significant livelihood support, especially to the coastal states. Among them, *Thunnus tonggol*, commonly known as the longtail tuna, is one of the most commercially significant species in the Indian Ocean, particularly in the coastal waters of India. This species contributes substantially to the artisanal and small-scale fisheries along west coasts. Its abundance in nearshore waters, accessibility to small motorized craft, and relatively high market value make *T. tonggol* a target species for several coastal fishing communities.

The fishery of *Thunnus tonggol* is characterized by seasonal abundance, with landings primarily supported by gillnets, drift nets, and other gears. However, due to its fast-swimming nature and migratory behavior, variations in catch trends are observed across regions and seasons. The biological characteristics of *T. tonggol*, such as its growth rate, reproductive cycle, feeding ecology, and mortality, are crucial for understanding its population dynamics and ensuring its sustainable exploitation.

Despite its economic importance, the longtail tuna has received relatively less scientific attention compared to other neritic tuna and its oceanic counterparts like yellowfin (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*). Data on its stock status, spatial distribution, and fishery-dependent parameters remain sparse and fragmented across Indian waters. In the context of increasing fishing pressure, climate-induced oceanographic changes, and a growing demand for tuna products, comprehensive knowledge of the fishery and biology of *T. tonggol* is essential for evidence-based management.

This paper aims to consolidate and analyze existing information on the neritic tuna resources with a specific focus on the fishery and biological aspects of *Thunnus tonggol* in Indian waters, thereby contributing to informed policy decisions and sustainable fishery development.

Materials and methods

The monthly and annualy estimated marine fish landings database created through stratified, multi-stage random sampling programme of ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI, Kochi, India) for all major fishery resources of each region (Fig 1) was used to arrive at a gear aggregated, monthly catches from 1995-2024. The monthly length-frequency data for *T. tonggol* landed by major gears operated at different landing centres along the northwest coast of India (NWCI) were collected for the period 2021-2023. The length-weight relationship was calculated as $W = aL^b$ (LeCren, 1951), where W is the weight of the fish in grams and L is its total length in cm; 'a' being the regression intercept and 'b' the slope.

Fig. Study area indicating India's location in the Indian ocean.

The von Bertalanffy growth parameters L_∞ and K (annual) were estimated using bootstrapped ELEFAN SA routine with 1000 resample using TropfishR package in R (Mildenberger *et al.,* 2017; Schwamborn et al., 2019). the natural mortality rate (M) was calculated using Pauly's empirical formula (Pauly, 1980) ($\ln(M) = -0.0152-0.279 \ln(L_\infty) +0.6543 \ln(K)+ 0.463 \ln(T)$, where 'T' is the average sea surface temperature assumed as 28°C during the study period. The instantaneous total mortality rate (Z) was estimated from the length converted catch curve (Pauly, 1983) and the fishing mortality rate (F) was estimated as F = Z-M. The relative fishing mortality (F/M) and current exploitation rate (E) as E= F/Z were estimated to considered a proxy for sustainability.

Maturity stages were studied following the standard classification of the stages of maturity, fecundity was estimated by gravimetric method and the relative fecundity was derived by dividing the absolute fecundity by body weight. The size at first maturity (Lmat or Lm_{50}) was estimated using the logistic regression model and confidence intervals were determined by bootstrapping the model for 10,000 runs as described by Haig et al. (2016). Gonadosomatic index (GSI) was calculated using the formula GSI = Gonad weight/Bodyweight *100 (Vladykov, 1956). The sex ratio was estimated based on the number of females and males in the sample and the homogeneity was tested using the Chi-square test. The gastrointestinal tract from each specimen was carefully removed and dissected and the contents were examined. The food items were identified to the lowest possible taxon. Diet analysis based on the Index of Relative Importance (IRI) was calculated as IRI= (%N+% W) *%O (Pinkas *et al.,* 1971) where, the percentage frequency of occurrence (%O), percentage composition of number (%N) and the percentage composition of weight (%W) were taken into account. IRI was expressed as a percentage (% IRI) following % IRI = (IRI/ Σ IRI) *100 to allow for a comparison of values between prey groups (Cortes, 1999). Three groups were made for the ontogenic and seasonal shifts in prey preference based on IRI. Ontogenic groups were juvenile (<57.43 cm TL (<25% of mature), sub-adult (57.43-67 cm TL (25-50% of mature) and adult (>67 cm TL (>50% of mature), and the seasonal groups were monsoon (August-November), winter (December-February) and summer (March-June). All the analysis were carried out in R (R Core Team, 2022)

Result and discussion

1. ***Fishery trends in Indian EEZ***

The total tuna catch in Indian waters shows a steady increase between 1995 (37,789 t) and 2024 (120342 t), with neritic tunas consistently dominating over oceanic tunas (Fig 2). Oceanic tuna catches rose notably after 2010, peaking in 2020. In the last five years (2020-2024), the neritic tuna catch reached its highest levels, averaging around 60,467 tonnes. Species/group-wise composition of neritic tunas during this period revealed that *Euthynnus affinis* remained the dominant species, accounting for nearly 63.5% (38404.4 t) of the neritic tuna catches. *Auxis spp.* contributed approximately 29.1% (17619.6 t), while *Thunnus tonggol* made up around 6.4% (3880 t). *Sarda orientalis* represented 0.9% (563 t) the smallest share among the four (Fig 3).

The catch of *Thunnus tonggol* has remained stable across the years, with a consistent contribution of about 4,052-6,537 tonnes annually in recent years. This indicates its sustained presence in the neritic fishery and emphasizes the importance of monitoring its stock health and habitat to ensure long-term sustainability.

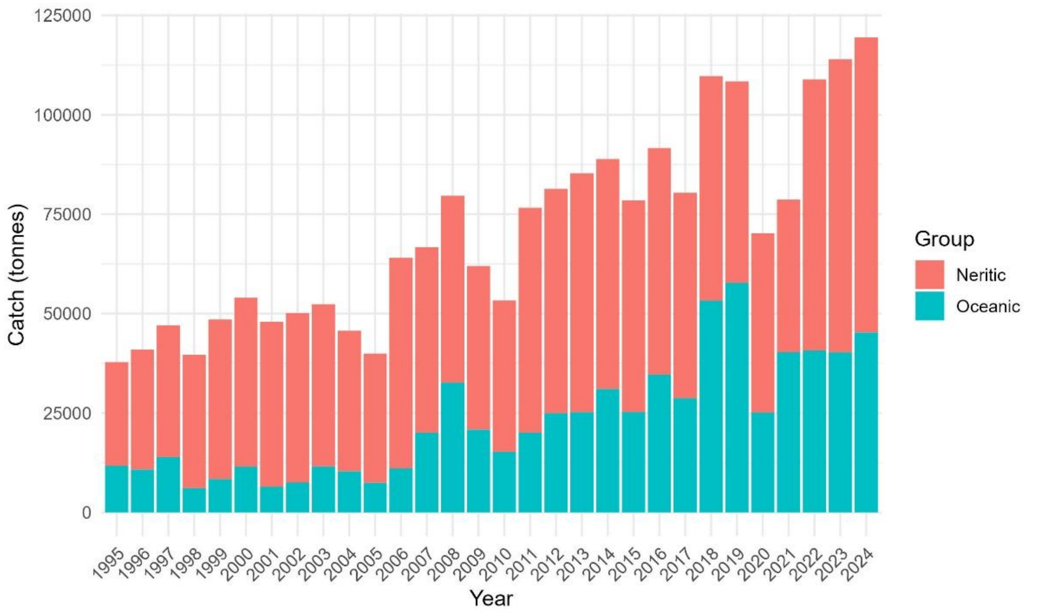

Fig. 2. Tuna catch trends in Indian EEZ from 1995 to 2024.

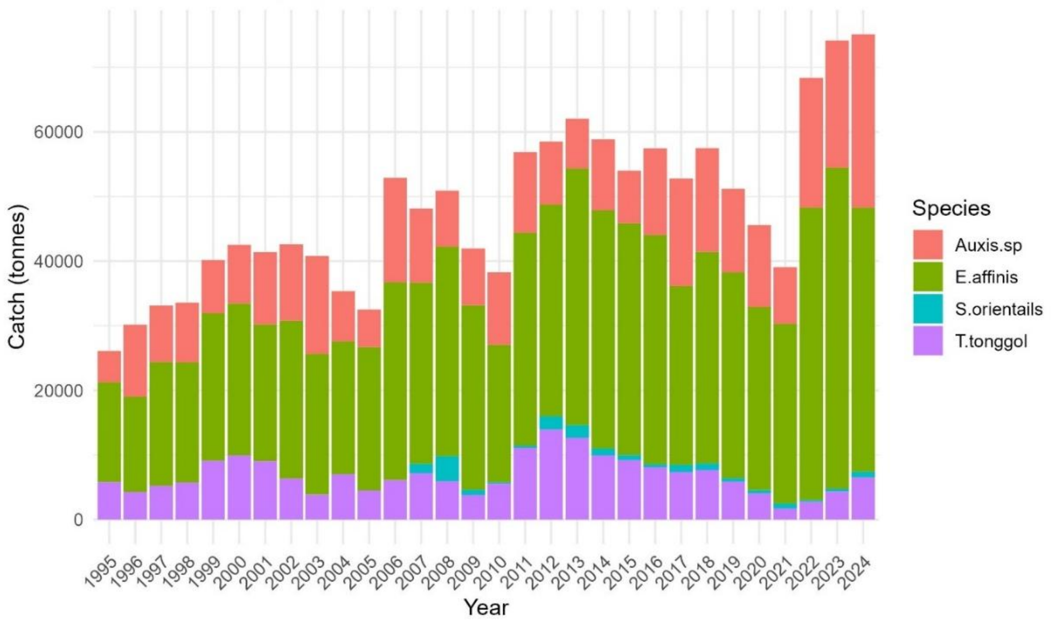

Fig. 3. Neritic tuna catches trends and its species composition in Indian EEZ from 1995 to 2024.

2. *Regional, seasonal and gear wise fishery status*

Regionally, the southwest coast of India (SWCI) contributed the highest to the neritic tuna catch (26,612.47 tonnes) in 2023, followed by the northwest coast (NWCI) with 23185.62 tonnes, southeast coast (SECI), and northeast coast (NECI) (Fig 4). *T. tonggol* was most prominent in NWCI (4,228.03 tonnes, 97.83%), followed by SWCI (93.83 tonnes). Monthly distribution indicates peak landings of neritic tunas from February to March and again from August to October, with highest catches in October exceeding 10,000 tonnes (Fig 5). Specifically, *T. tonggol* showed notable peaks from August to November, with peak catches September reaching up to 1769.4 tonnes. Gear-wise analysis shows that gillnets contributed approximately 25613.94 tonnes to the neritic tuna catch, with *T. tonggol* accounting for around 4210.93 tonnes (16.44% of gillnet neritic tuna catch) in 2023 (Fig 6). Seine nets yielded 44.47% of the catch about 32830.51 tonnes, primarily dominated by *E. affinis* and *Auxis spp.*. Hook-and-line and other gears together contributed around 13,950.93 tonnes, with *T. tonggol* comprising about 115.34 tonnes of this. Trawl nets contributed less than 1,754.91 tonnes in total, with minimal *T. tonggol* presence.

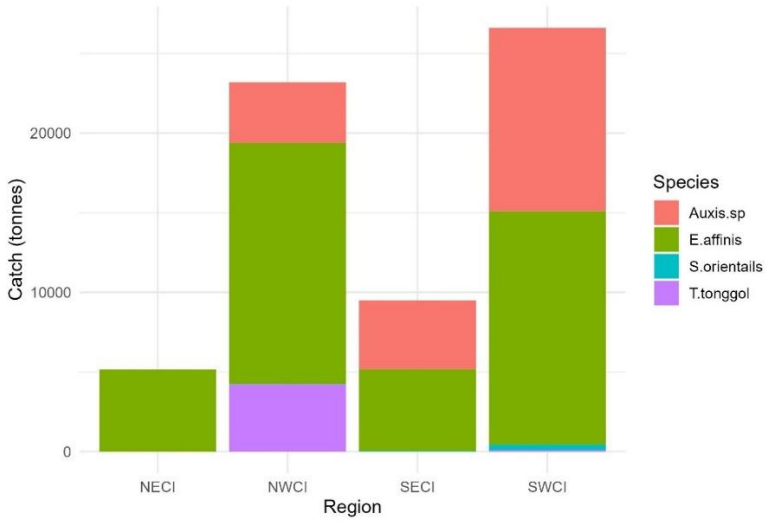

Fig 4. Region-wise contribution neritic tuna catches in Indian EEZ

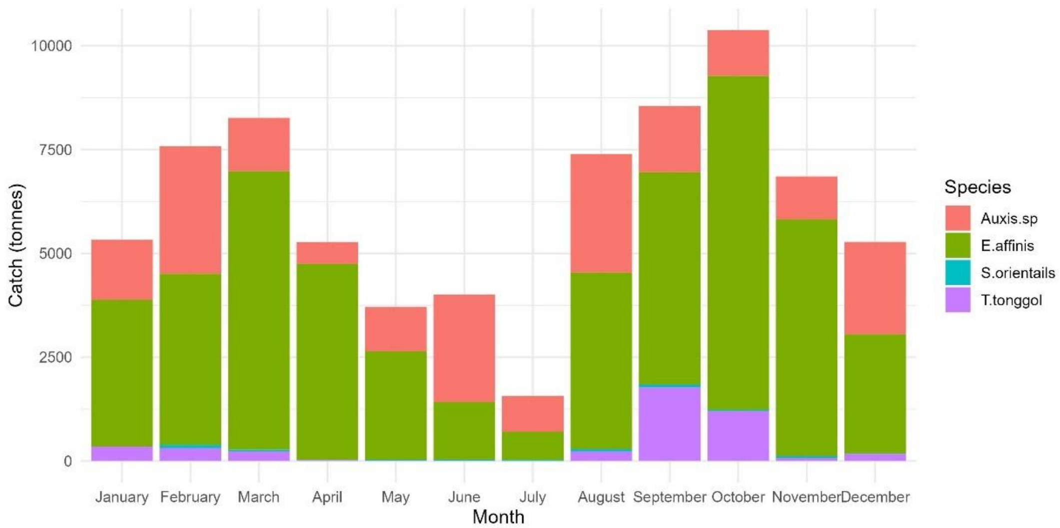

Fig 5. Monthly contribution neritic tuna catches in Indian EEZ

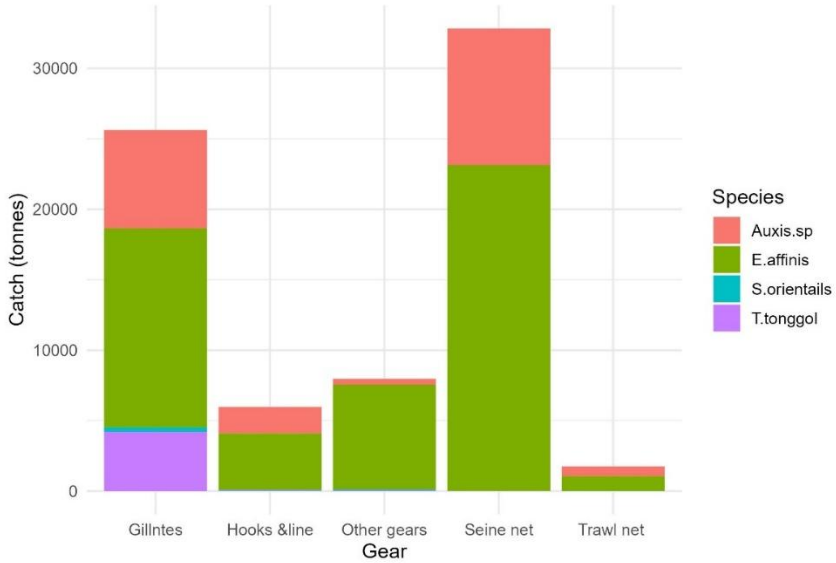

Fig 6. Gear-wise contribution neritic tuna catches in Indian EEZ

3. Length composition

The Total length of sampled *T. tonggol* ranged from a minimum of 34 cm to a maximum of 94.5 cm recorded during 2021-23. The estimated combined length-weight relationship for the species is (Fig 7):

log W = 0.0353 + 2.70 log L (r2= 0.93; 95% C. I.)

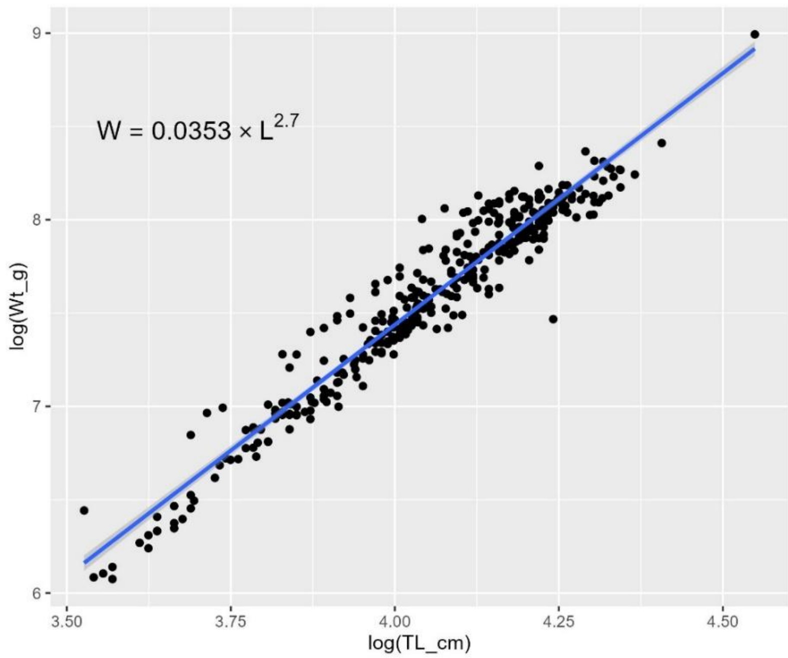

Fig 7. Length-weight relationship of *T. tonggol* in Indian EEZ.

4. Growth, Mortality and exploitation

The growth parameters, L_∞ and K were 91.18 cm and 0.2 $year^{-1}$ respectively (Table 1). The size at first capture (Lc) was 62.27 cm. The growth performance index was 3.22 and t_anchor 0.64. The estimated mortality rates M, F and Z were 0.457, 0.464 and 0.921 respectively. The F/M was 1.015 and exploitation rate was 0.504, indicating fishery is sustainable and further scope for sustainable exploitation of this species.

Table 1. Growth and mortality parameters of *T. tonggol* from Indian EEZ

Parameters	L_∞	K	Lc	t_anchor	ϕ	M	F	Z	F/M	E
Value	91.18	0.2	62.27	0.64	3.22	0.457	0.464	0.921	1.015	0.504

5. Reproductive biology

The estimated length at which 50% of fishes attained sexual maturity was 67±0.52 cm total length, whereas 95% of the fish attained sexual maturity at 92.7±0.83 cm (Fig. 8). Matured fish was were recorded in all the months except April and June and with peak occurrence during August-September followed by December-February. Similarly, monthly gonadosomatic index (GSI) revealed that its peak occurrence during August-October followed by January-February. These suggested that the third quarter of the year is the peak spawning time and followed by first quarter for *T. tonggol* in the region (Fig. 9). The overall sex ratio (Male: Female) was 1:2.11 with a bias towards females, a *Chi*-square test indicated significant ($p < 0.5$) dominance of females throughout the year, except in August, October and November (Fig. 10). The number of eggs released generally increased with the weight and size of the fish. The total fecundity ranged between 1,46,538 and 5,62,333 with an average of 3,11,433 numbers.

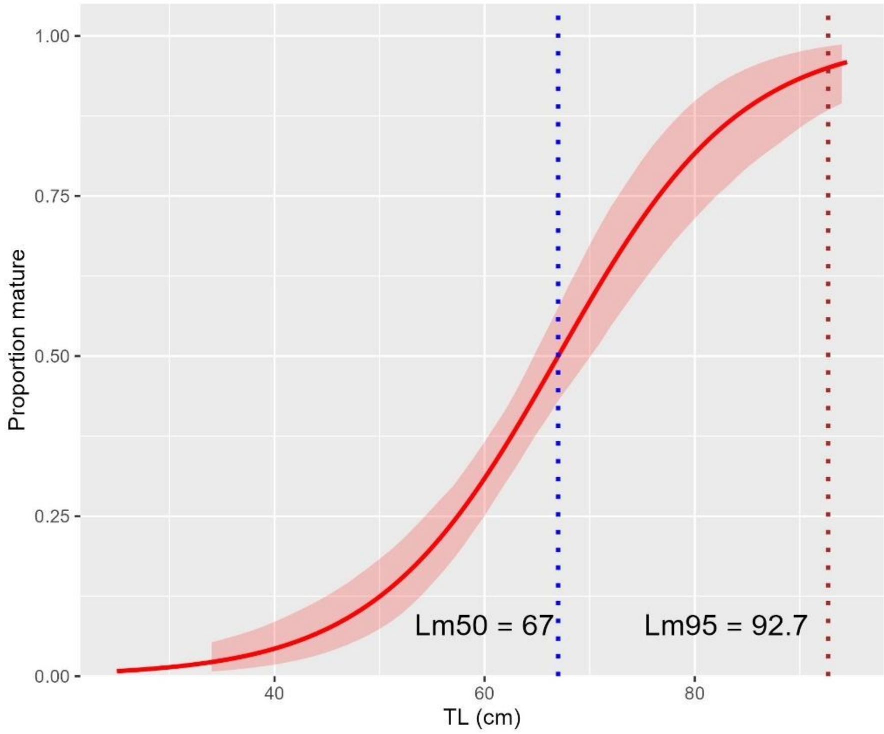

Fig 8. Percentage of matured specimens showing length at maturity of *T. tonggol* in Indian EEZ.

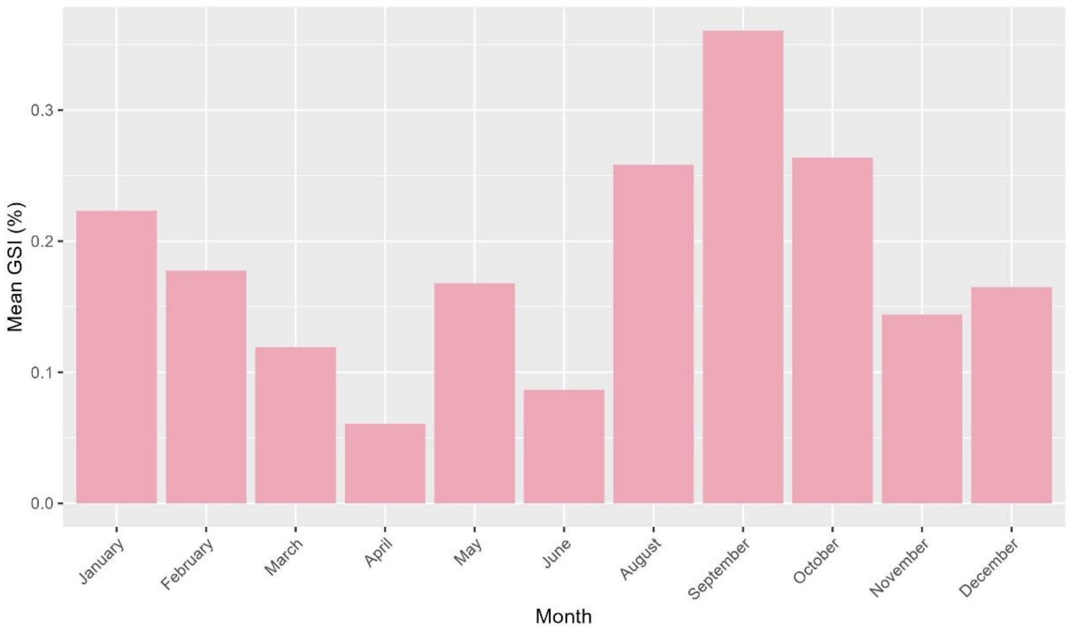

Fig 9. Monthly variations in mean GSI of *T. tonggol* in Indian EEZ.

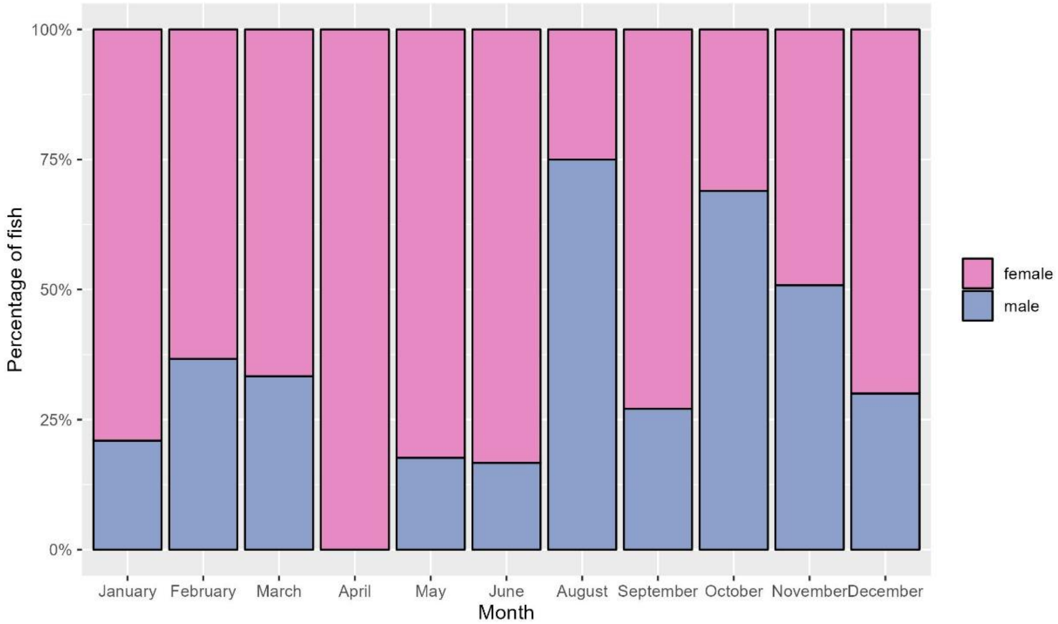

Fig 10. Monthly variations in sex ratio of *T. tonggol* in Indian EEZ.

6. *Prey Preference and Diversity*

The diet comprised mainly of fishes (61.92%), shrimps (18.51%), cephalopods (15.67%), partially digested materials (2.44%), squilla (1.37%) and crabs (0.08%), based on Index of Relative Importance (IRI) (Table 2). Fishes in the diet consisted of sardine, myctophid, ribbonfish, croaker, scads, trevallies, horse mackerel and tuna. Crustaceans included *Solenocera* spp., deepsea shrimps, *Squilla* sp., paste shrimps. Squids, cuttlefish and argonauts were the cephalopod component present in the stomach. Few other prey items found in the stomach could not be identified, as they were in advanced stages of digestion.

Table 2. Index of Relative Importance (IRI) of different dietary components of longtail tuna in Indian EEZ. 'N' is composition of number, 'W' is composition of weight and 'O' is frequency of occurrence.

Prey taxa	Group	N	N%	W	W%	O	O%	IRI	IRI%
Sardine	Fish	60.00	7.98	329.01	13.39	8.00	8.89	189.91	11.52
Myctophid	Fish	70.00	9.31	52.38	2.13	1.00	1.11	12.71	0.77
Ribbonfish	Fish	7.00	0.93	82.02	3.34	3.00	3.33	14.23	0.86
Croaker	Fish	2.00	0.27	14.99	0.61	1.00	1.11	0.97	0.06
Scads	Fish	3.00	0.40	165.77	6.74	1.00	1.11	7.94	0.48
Trevallies	Fish	2.00	0.27	51.21	2.08	2.00	2.22	5.22	0.32

Horse mackerel	Fish	1.00	0.13	160.00	6.51	1.00	1.11	7.38	0.45
Tuna	Fish	2.00	0.27	252.58	10.28	2.00	2.22	23.43	1.42
Digest fish	Fish	32.00	4.26	594.95	24.21	24.00	26.67	758.98	46.04
Paste shrimp	Shrimps	438.00	58.24	52.97	2.16	3.00	3.33	201.33	12.21
Deep-sea shrimp	Shrimps	71.00	9.44	81.74	3.33	7.00	7.78	99.30	6.02
Other shrimps	Shrimps	7.00	0.93	10.63	0.43	3.00	3.33	4.54	0.28
Crab	Crab	4.00	0.53	0.95	0.04	2.00	2.22	1.27	0.08
Squilla	Squilla	13.00	1.73	82.59	3.36	4.00	4.44	22.62	1.37
Squid	Cephalopods	30.00	3.98	225.05	8.44	18.00	20.00	248.40	15.07
Cuttlefish	Cephalopods	2.00	0.27	19.66	0.80	2.00	2.22	2.37	0.14
Argonaut	Cephalopods	3.00	0.40	45.21	1.84	3.00	3.33	7.46	0.45
Digest material	Other	4.00	0.53	209.15	8.51	4.00	4.44	40.18	2.44
Total		**752**	**100**	**2457.82**	**100**	**90**	**100**	**1648.40**	**100**

The feeding ecology of *T. tonggol* revealed ontogenic and seasonal shifts in prey preference based on IRI (Fig 11). Ontogenetically, juveniles primarily consumed fish (69.31% IRI) and shrimps (16.48%), while subadults showed increased intake of shrimps (58.46%) and cephalopods (20.83%) with a reduced proportion of fish (19.77%). Adults exhibited a more diverse diet dominated by fish (72.39%), shrimps (12.12%), squilla (8.14%) and cephalopods (7.16%), indicating dietary expansion with growth.

Seasonally, during the post-monsoon period, shrimps constituted the major diet (45.40% IRI), followed fish by (26.41%) and cephalopods (21.91%) (Fig 12). In winter, fish dominant (84.47%) with notable contributions from shrimps (8.69%) and cephalopods (3.54%). During summer, the proportion of fish remain dominant (86.29%). Minor groups like squilla, crabs, and other partially digested collectively contributed less than 5% across all seasons and size groups.

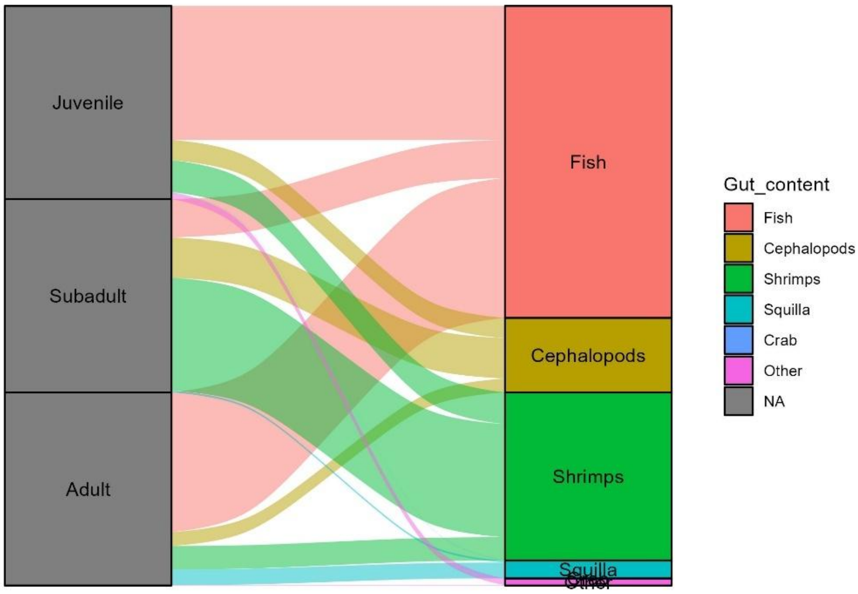

Fig 11. Ontogenic shifts in prey preference based on IRI in *T. tonggol* in Indian EEZ.

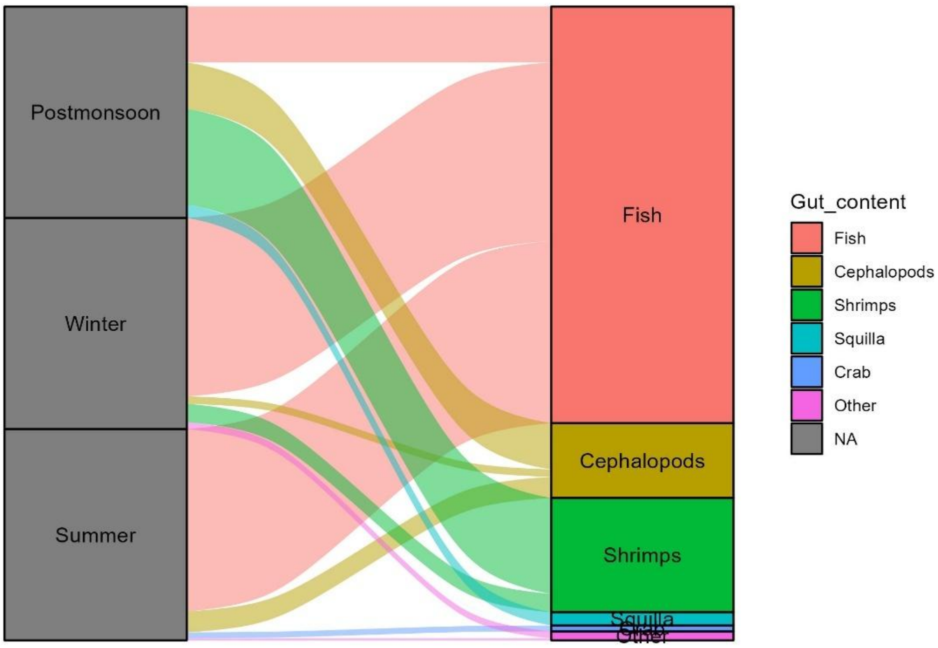

Fig 12. Seasonal shifts in prey preference based on IRI in *T. tonggol* in Indian EEZ.

This variation in diet highlights the opportunistic and adaptable feeding behavior of *T. tonggol*, reflecting prey availability in different seasons and ontogenetic stages. Understanding these feeding dynamics is essential for ecosystem-based fishery management and predicting species response to environmental changes.

Conclusion

The present assessment of the *Thunnus tonggol* fishery in Indian waters reveals a stable and regionally significant exploitation pattern, particularly along the northwest coast, which contributes nearly 98% of the national catch. Biological and fishery indicators such as the estimated growth parameters, exploitation rate (E = 0.504), and F/M ratio (~1.0) collectively suggest that the longtail tuna stock is currently being fished at a sustainable level. The balanced sex ratio skewed towards females, high fecundity, and a predominance of mature individuals in the catch further support the species' reproductive resilience under present exploitation levels. Additionally, the diet analysis indicating a diverse and opportunistic feeding habit reflects ecological adaptability. Overall, the fishery is well-supported by scientific evidence and does not currently show signs of overfishing. However, continuous monitoring and region-specific management strategies are essential to ensure long-term sustainability, particularly in the face of increasing fishing pressure and environmental variability.

Acknowledgements

The authors are grateful to the Director, ICAR-Central Marine Fisheries Research Institute, Cochin for providing necessary facilities for carry out the research work. Authors are thankful to the Scientist-in Charge, Veraval Regional Station of ICAR-CMFRI for providing arrangements for data collection and the Department of Fisheries, Government of India for all the necessary arrangements.

References

Cortes, E. 1999. Standardized diet compositions and trophic levels of sharks. *ICES J. Mar. Sci.*, 56: 707-717. https://doi.org/10.1006/jmsc.1999.0489.

Haig, J.A., Bakke, S., Bell, M.C., Bloor, I.S.M., Cohen, M., Coleman, M., Dignan, S., Kaiser, M.J., Pantin, J.R., Roach, M., Salomonsen, H., Tully, O., 2016. Reproductive traits and factors affecting the size at maturity of *Cancer pagurus* across Northern Europe. *ICES J. Mar. Sci.,* 73: 2572–2585.

Le Cren, E. D. 1951. The length-weight and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol*., 20: 201-219. https://doi.org/10.2307/1540.

Mildenberger, T. K., Taylor, M. H. and Wolff, M. 2017. TropFishR: an R package for fisheries analysis with length-frequency data. *Methods Ecol. Evol.,* 8: 1520-1527. doi:10.1111/2041-210X.12791.

Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *L. Cons. Ciem.,* 39: 175–192.

Pauly, D., 1983. Length converted catch curves. A powerful tool for fisheries research in tropics (Part-1). *ICLARM Fishbyte,* 1: 9–13.

Pinkas, L., Oliphant, M. S. and Inverson, I. L. K. 1971. Food habits of albacore, bluefin tuna, and bonito in Californian waters. *Fish. Bull.*, 152: 11-105.

R Core Team, 2022. R: A language and environment for statistical computing. *R Foundation for Statistical Computing,* Vienna, Austria.

Schwamborna, R., Mildenbergerb, T.K., Taylorc, M.H. 2019. Assessing sources of uncertainty in length-based estimates of body growth in populations of fishes and macroinvertebrates with bootstrapped ELEFAN. Ecological Modelling, 393: 37-51.

Vladykov, V. D. 1956. Fecundity of wild speckled trout (*Salvelinus fontinalis*) in Quebec Lakes. *J. Fish. Res. Board Can.*, 13(6). https://doi. org/10.1139/f56-046.