Status, trends, and biological insights of tropical tuna fisheries in Indian waters

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Abstract

Tropical tunas, especially skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*), are vital to India's oceanic and coastal fisheries, supporting thousands of fishers, contributing significantly to seafood exports, and playing an important ecological role in the Indian Ocean. An analysis of tropical tuna landings along the Indian coast from 2007 to 2024 revealed annual landings ranging from 16,125 tonnes in 2007 to 57,191 tonnes in 2019, with an average of 30,329 tonnes. During this period, tropical tunas accounted for 24.2% to 54.8% of total tuna landings in India, with an average contribution of 34.2%. The fishery is primarily supported by mechanized (69.5%) and motorized (29.0%) fishing units, with a negligible contribution from non-mechanized units (1.5%), all operating within India's Exclusive Economic Zone (EEZ). Gillnetters are the dominant gear, responsible for more than half of the tropical tuna landings along the Indian coast. Among the tropical tuna species, *T. albacares* contributed between 44.6% and 78.7% (average 55.2%), while *K. pelamis* accounted for 20.9% to 55.4% (average 44.5%) of the total tropical tuna landings during the 2007–2024 period.

The length of *T. albacares* specimens ranged from 19.0 cm to 186.0 cm, with a mean length of 82.7 cm. In contrast, *K. pelamis* measured between 22.0 cm and 84.0 cm, with a mean length of 48.0 cm. The observed sex ratios were 1:0.93 (male: female) for *T. albacares* and 1:0.94 for *K. pelamis*. The presence of mature females throughout the year in both species indicates year-round spawning activity, with peak spawning observed from March to May and from November for both species. Gut content analysis of *T. albacares* revealed that teleost fishes— *Encrasicholina devisi, Decapterus* spp., *Stolephorus* spp., *Nemipterus* spp., ribbonfish, and partially digested unidentified fishes—were the major prey items. Cephalopods formed the secondary component of the diet. In *K. pelamis*, the dominant prey consisted of teleosts such as *Decaptesus* spp., *Megalaspis cordyla, Stolephorus* spp., *Nemipterus* spp., *Rastrelliger kanagurta, Dussumieria acuta*, along with partially digested unidentified fishes. Crustaceans and cephalopods were also prominent in the diet.

Keywords: Skipjack tuna, Yellowfin tuna, Tropical tuna fishery, Indian EEZ, Tuna biology

Introduction

Skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), and bigeye (*Thunnus obesus*) are important members of the family *Scombridae*, collectively recognized as tropical tunas. These species are broadly distributed across the tropical and subtropical zones of the Atlantic, Indian, and Pacific Oceans (Artetxe-Arrate et al., 2021). They constitute a major component of global tuna fisheries and are vital for food security, livelihoods, and the economies of many coastal nations (FAO, 2016). Widely occurring in tropical and subtropical seas, these species underpin international tuna fisheries and make significant contributions to global seafood availability, trade earnings, and food security (FAO, 2016). Within the Indian Ocean, tropical tunas account for a substantial portion of total catches, with India recognized as a key coastal nation engaged in their exploitation.

In India, tropical tuna fisheries encompass a wide spectrum of operations, from traditional small-scale handline and pole-and-line fishing to modern mechanized fleets deploying gillnets, longlines, and purse seines. This sector serves a dual purpose—providing livelihood security to large numbers of artisanal and mechanized fishers along the coastline, while also generating substantial foreign exchange through the export of frozen, canned, and sashimi-grade tuna.

In 2023–24, India exported more than 50,000 tonnes of tuna, generating revenues in the range of tens of millions of US dollars. Tuna, particularly sashimi-grade yellowfin and value-added skipjack products, commands a higher market price compared to many other marine species. This premium makes tuna a critical contributor to income at coastal landing centres, supports the livelihoods of fishers, and provides significant revenue.

In 2024, India reported a tuna landing of 1.2 lakh tonnes, of which tropical tunas accounted for nearly 37% (0.44 lakh tonnes) (ICAR-CMFRI, 2025; FRAEED CMFRI, 2025). Within this group, yellowfin tuna (*Thunnus albacares*) formed the dominant share, contributing 58.12% of the landings, followed by skipjack tuna (*Katsuwonus pelamis*) at 41.86%. In contrast, bigeye tuna (*Thunnus obesus*) was recorded only in trace quantities (0.02%), reflecting its relatively minor contribution to the Indian tuna fishery (ICAR-CMFRI, 2025). These figures highlight the predominance of yellowfin and skipjack in sustaining India's tropical tuna fisheries, while also pointing to the limited exploitation or availability of bigeye tuna in domestic waters.

Although tropical tunas represent a major component of India's marine fisheries and contribute substantially to coastal livelihoods and export earnings, they have historically received limited scientific attention. This paper presents a detailed review of the current status, temporal trends, and biological characteristics of tropical tuna fisheries in Indian waters, aiming to bridge knowledge gaps and support sustainable management of these valuable resources.

Materials and Methods

Annual estimates of tropical tuna landings for the period 2007–2024 were sourced from the National Marine Fisheries Data Centre (NMFDC), ICAR–Central Marine Fisheries Research Institute. The tropical tuna landing data were from the eastern Arabian Sea, representing the northwest coast (NWCI) and southwest coast (SWCI) of India, and from the western Bay of Bengal, representing the northeast coast (NECI) and southeast coast (SECI) of India. (Fig. 1). Monthly data on length–frequency distribution and biological characteristics of *Thunnus albacares* and *Katsuwonus pelamis* were collected from major fishing gears operating at different landing centres along the southwest (SWCI) and southeast (SECI) coasts of India during 2020–2024. The length–weight relationship of was estimated following the equation $W=aL^b$ (Le Cren, 1951), where W denotes the weight of the fish (g), represents the total length (cm), '*a*' is the regression intercept, and '*b*' the regression slope.

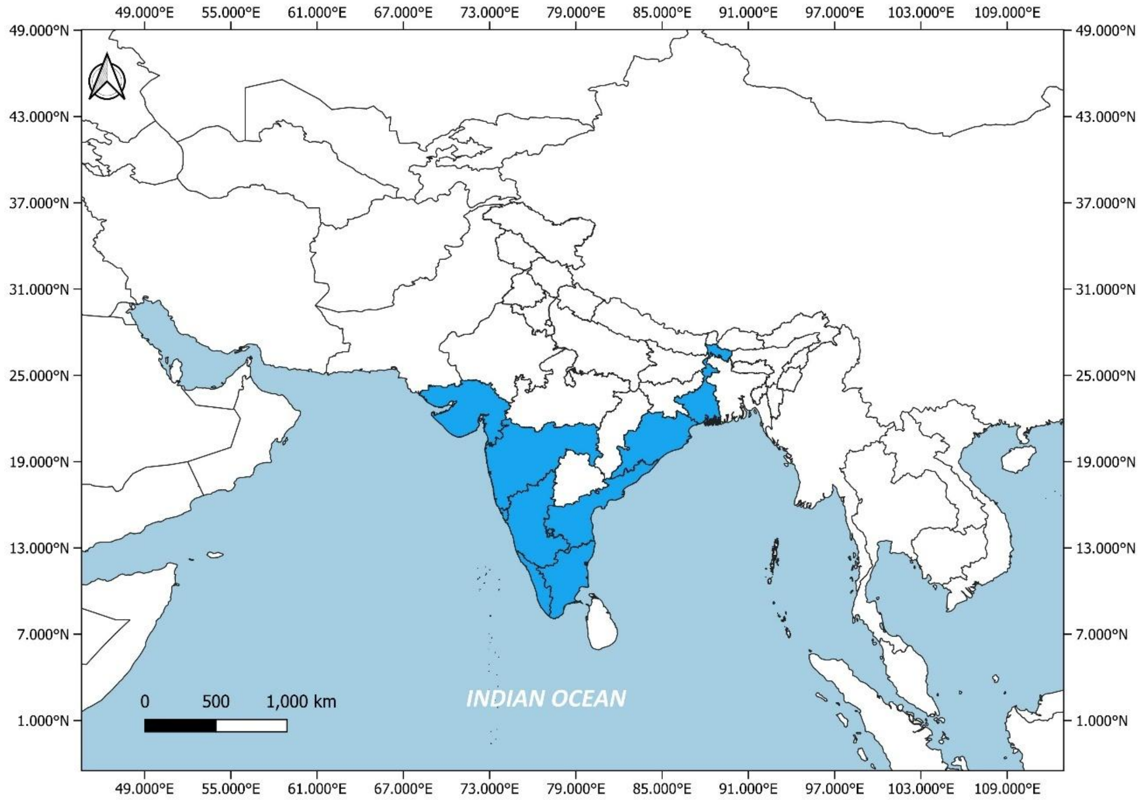


Fig. 1. Sampling locations along eastern Arabian Sea and western Bay of Bengal.

Maturity stages were classified based on gonad size, external appearance, and the space occupied by the testes and ovaries. The gonadosomatic index (GSI) was computed using the formula: GSI = (weight of gonad/weight of fish) * 100. The annual spawning period was inferred from variations in GSI values in conjunction with the frequency distribution of maturity stages. The female-to-male ratio was estimated and tested for deviation from the expected 1:1 ratio using the Chi-square test. The length at which 50% of individuals attained sexual maturity (Lm_{50}) was estimated using the logistic equation described by King (2007).

The stomachs of individual specimens were visually examined to assess fullness based on the quantity of food present in the gut and classified on a six-point scale: empty, trace, quarter full, half full, three-fourths full, and full. Subsequently, the stomachs were carefully dissected, and prey items were separated and identified to the lowest possible taxonomic level following Fischer & Bianchi (1984) and Smith & Heemstra (1986). The number of prey items for each species/genus was recorded, and their respective weights were measured to the nearest 0.01 g. Partially digested and unidentifiable items were pooled under the category 'unidentified prey'. The Index of Relative Importance (IRI) was calculated by combining three indices: frequency of occurrence (%F), gravimetric index (%W), and numerical index (%N), following Pinkas et al. (1971).

Result and discussion

Landing Trends and status

The tropical tuna landings along the Indian coast from 2007 to 2024 revealed annual landings ranging from 16,125 tonnes in 2007 to 57,191 tonnes in 2019, with an average of 30,328 tonnes (Fig. 2). During this period, tropical tunas accounted for 24.2% (2007) to 54.8% (2019) of total tuna landings in India, with an average contribution of 34.2%. Landings showed a steady increase from 2007, peaking in 2019, followed by a sharp decline; thereafter, they gradually recovered, reaching 44,081 t in 2024.

The fishery is primarily supported by mechanized (9.5%) and motorized (29.0%) fishing units, with a negligible contribution from non-mechanized units (1.5%), all operating within India's Exclusive Economic Zone (EEZ). Gillnetters are the dominant gear, responsible for more than half of the tropical tuna landings along the Indian coast (Fig. 3).

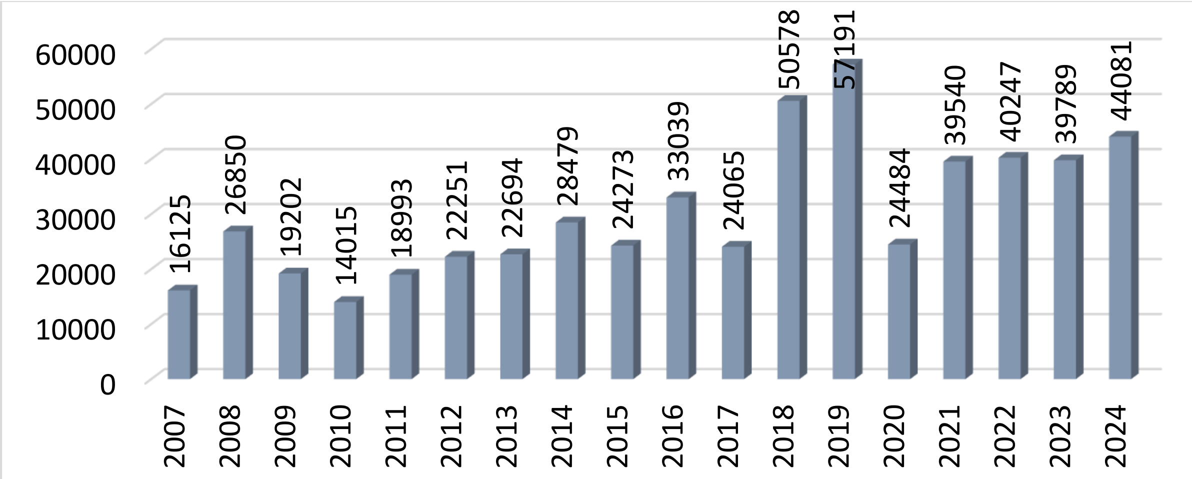


Fig. 2. Landings of Tropical tunas along the Indian coast in tonnes (2007-2024)

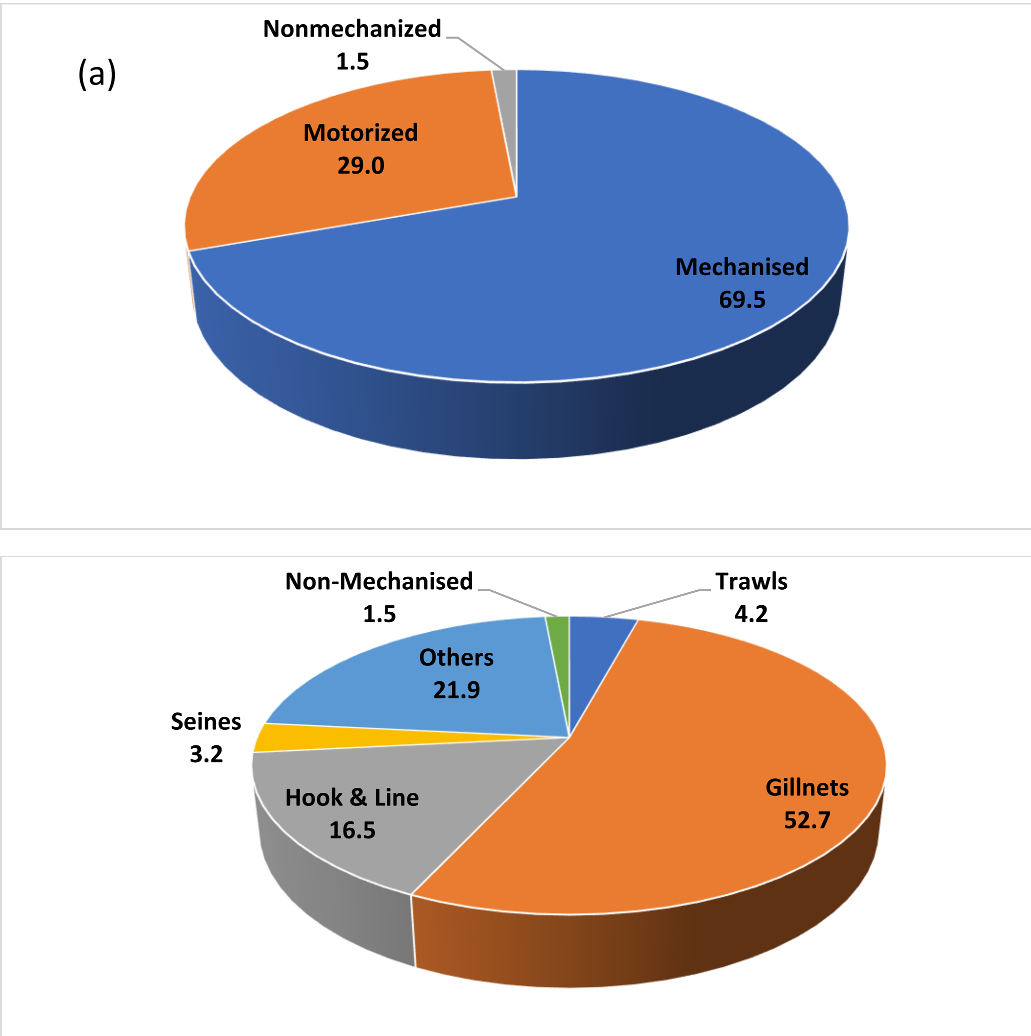
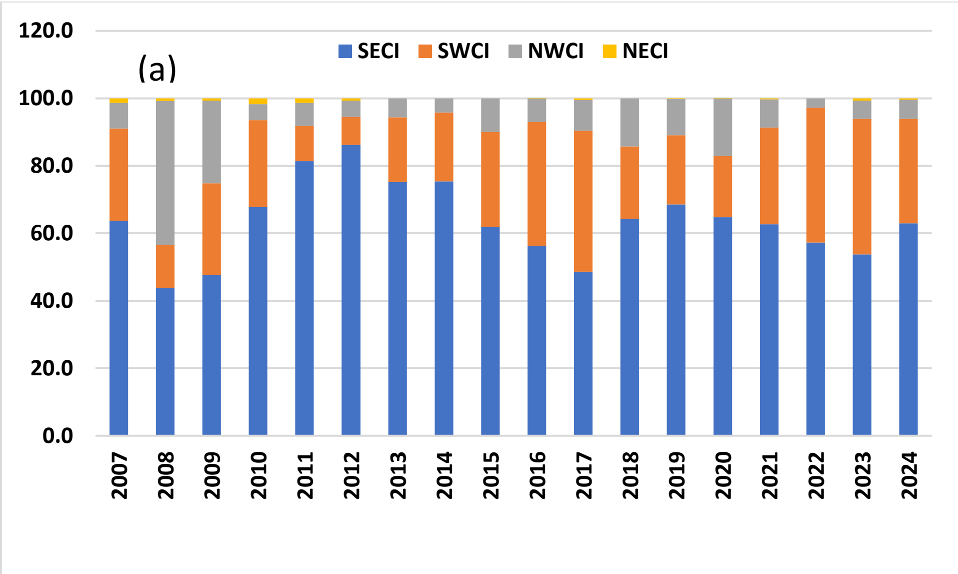


Fig. 3. Landings of Tropical tunas from (a) mechanised, motorised and artisanal non-mechanised sector and (b) various gear types operated along Indian EEZ.

Among the four regions, the southeast coast of India (SECI) accounted for the highest contribution to tropical tuna landings, ranging from 43.8% in 2008 to 86.2% in 2012 (Fig. 4a), with an overall average of 63.0% (Fig. 4b). The southwest coast of India (SWCI) made a moderate contribution, varying between 8.3% in 2012 and 41.8% in 2017, with an average of 26.3%. The northwest coast of India (NWCI) recorded the lowest contribution, ranging from 2.7% in 2022 to 42.6% in 2018, with an average of 10.3%. In contrast, the northeast coast of India (NECI) reported negligible landings during most of the study period, with a maximum of only 1.7% in 2010 (Fig 4a) showing an overall average of 0.4% (Fig. 4b).



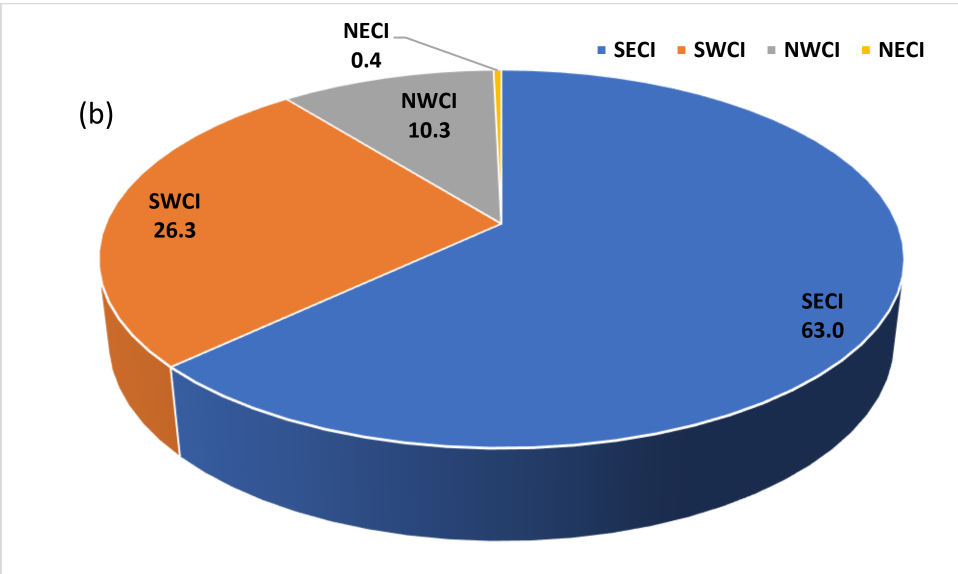


Fig.4. (a) Annual percentage contribution (2007–2024) and (b) average percentage contribution between 2007 and 2014 for tropical tuna landed along the different zones of Indian coast.

Species composition

Among the tropical tuna species, *Thunnus albacares* constituted a major share of landings along the Indian coast, ranging from 44.6% (2022 and 2023) to 78.7% (2007), with an overall average of 55.2% (Fig. 5a & b). *Katsuwonus pelamis* contributed between 20.9% (2007) and 55.4% (2022), averaging 44.5% over the study period. In contrast, the overall contribution of bigeye tuna (*Thunnus obesus*) was negligible, accounting for only 0.2%.

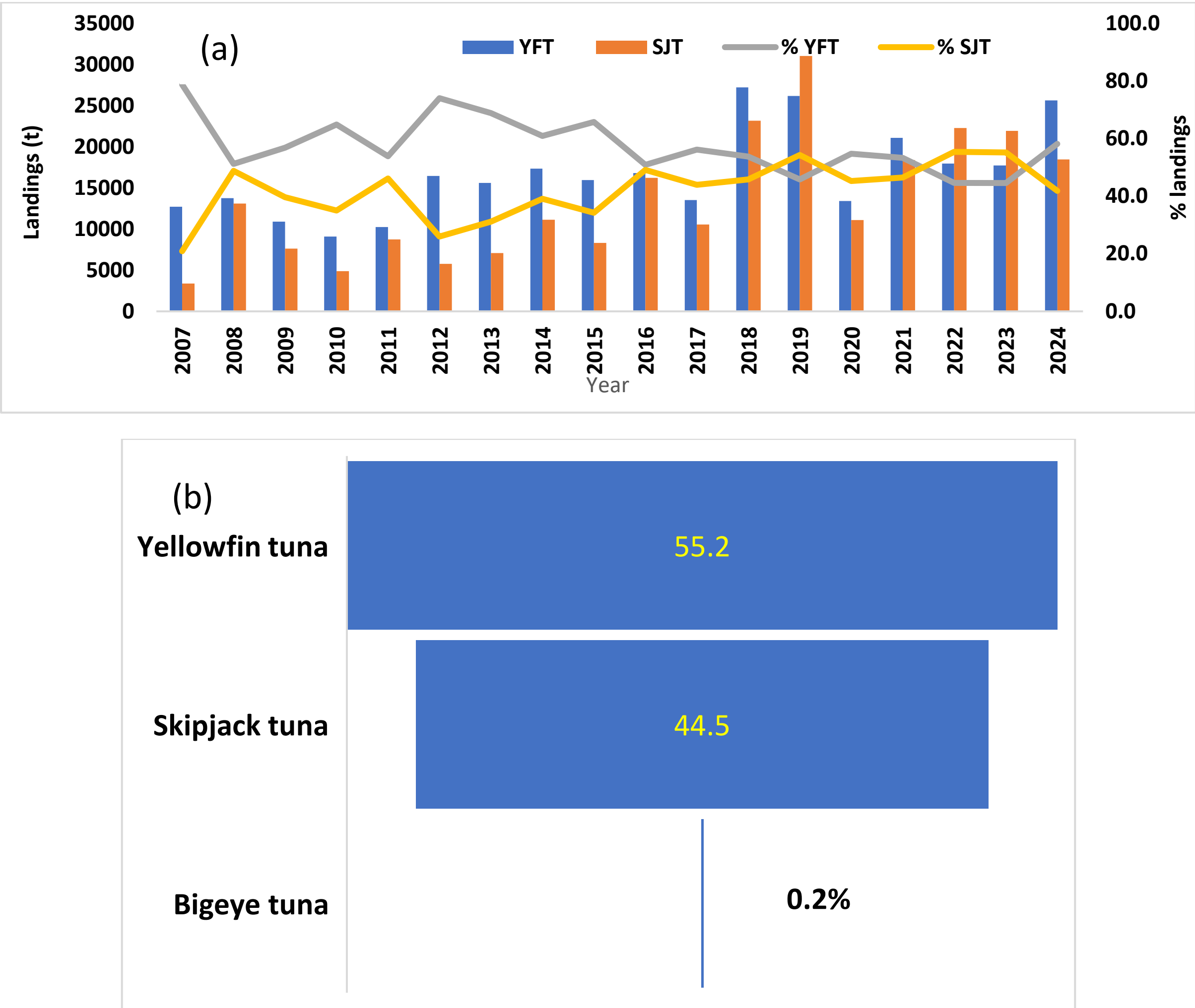


Fig. 5. (a) Annual and (b) overall (2007-2024) species composition of tropical tuna along Indian coast.

Size composition and length-weight relationship (LWRs)

The fork length of *Thunnus albacares* ranged from 19 to 186 cm, with a mean length of 82.7 cm (Fig. 6a). The majority of individuals (76%) were within the 40–120 cm size range, indicating that medium-sized fishes dominate the landings, while very small and exceptionally large individuals were comparatively less. In contrast, *Katsuwonus pelamis* exhibited fork lengths between 22 and 84 cm, with a mean length of 48.3 cm (Fig. 6b). Most specimens

(77.1%) were concentrated in the 40–60 cm size range. These patterns reflect species-specific growth characteristics and selective fishing by the gears employed along the Indian coast.

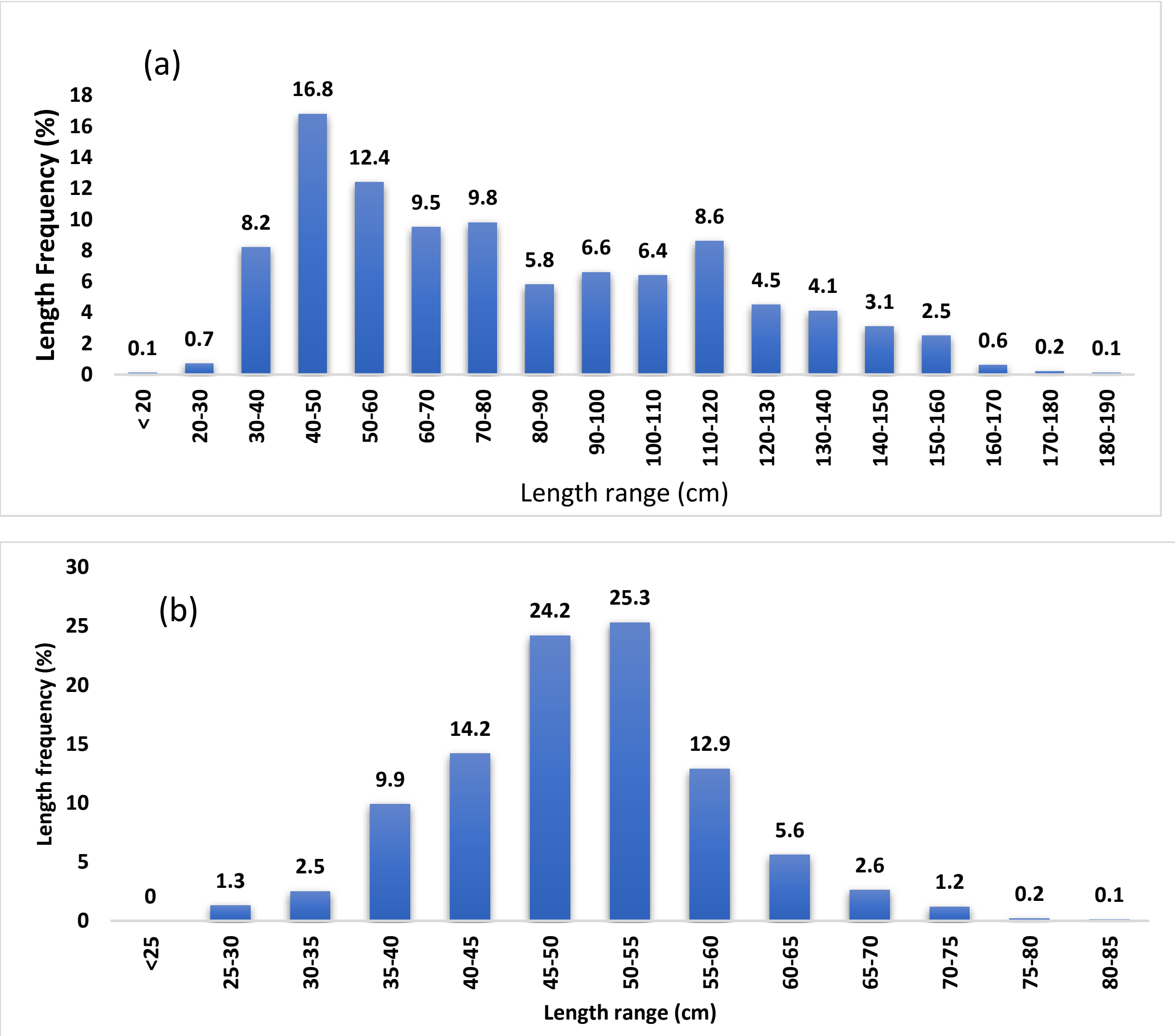


Fig. 6. Size composition of (a) Yellowfin and (b) Skipjack tuna

The length-weight relationships for *Thunnus albacares* and *Katsuwonus pelamis* (Fig. 7 a & b) are as follows:

Thunnus albacares: $W = 0.0172\ L^{2.9837}$ ($r^2 = 0.9895$, n=2537)

Katsuwonus pelamis: $W = 0.008\ L^{3.189}$ ($r^2 = 0.9714$, n=4136)

Thunnus albacares exhibited isometric growth, with a length–weight regression coefficient (*b*) approximately equal to 3, indicating that weight increases proportionally with length. In contrast, *Katsuwonus pelamis* displayed positive allometric growth ($b > 3$), suggesting that individuals gain weight at a faster rate than length as they grow. These differences in growth patterns reflect species-specific biological characteristics, with implications for understanding energy allocation, condition factors, and population dynamics, which are critical for effective stock assessment and fisheries management.

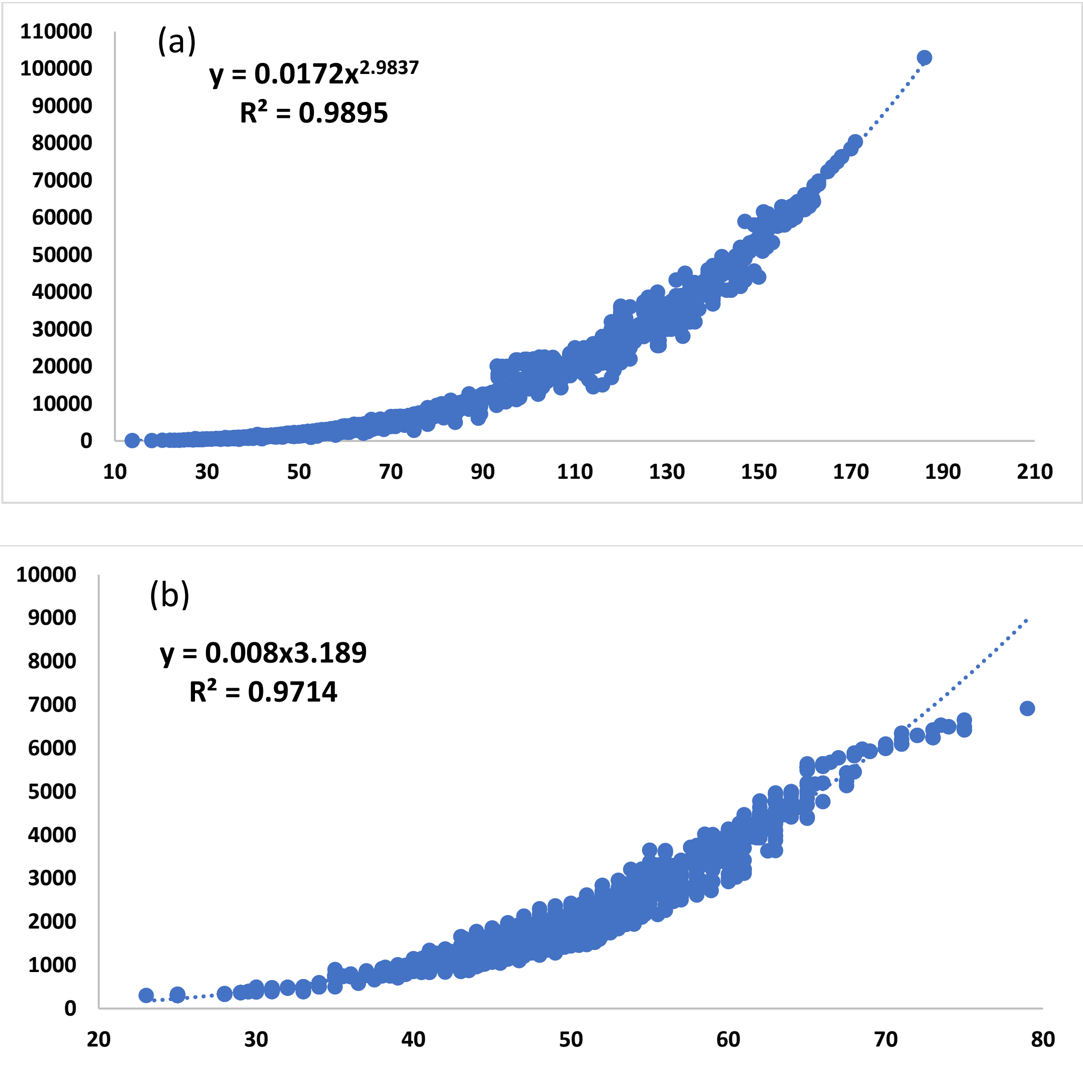


Fig. 7. Length weight relationship (LWRs) of (a) *Thunnus albacares* and (b) *Katsuwonus pelamis*

Sex ratio

The overall sex ratio (male: female) of *Thunnus albacares* (1:0.93) and *Katsuwonus pelamis* (1:0.94) indicated a slight predominance of males in both species, though the differences were not statistically significant ($P > 0.05$). In *T. albacares*, males dominated in most months, except in February, May, September, and December, when females were more numerous. Similarly, in *K. pelamis*, females outnumbered males in September, October, November, and December. Significant deviations from the expected 1:1 ratio ($P < 0.05$) were observed during April, May, June, August, and September for *T. albacares*, and in April and December for *K. pelamis* (Table

1). Such temporal fluctuations in sex ratio may be attributed to sex-specific differences in feeding, breeding behavior, pre-spawning migrations, or responses to ecological factors.

Table 1. Sex ratio of *Thunnus albacares* and *Katsuwonus pelamis* from Indian waters

Months	***Thunnus albacares***		***Katsuwonus pelamis***	
	Sex ratio (Male: Female)	Chi square (χ^2) value	Sex ratio (Male: Female)	Chi square (χ^2) value
January	0.7	0.01	0.6	0.01
February	1.6	11.9	0.8	0.4
March	1.03	0.001	0.8	0.7
April	0.8	1.3*	0.5	3.4*
May	1.6	1.2*	0.9	0.01
June	0.7	1.1*	0.7	0.3
July	0.9	0.01	0.9	0.01
August	0.6	19.3*	0.8	0.1
September	1.4	4.1*	1.2	0.01
October	0.8	0.8	1.1	0.03
November	0.9	0.1	1.1	0.01
December	1.1	0.01	1.7	8.3*

* Significantly different at $p > 0.05$

Length at first maturity

Knowledge of the length at first maturity (Lm_{50}) is a critical parameter in fisheries science, as it provides insight into the reproductive potential of a population and serves as a key input for stock assessment and management. It helps determine the proportion of mature individuals in the catch and thereby reflects the status of the spawning stock biomass, which plays a vital role in sustaining recruitment and ensuring long-term fishery productivity.

In the present study, the length at which 50% of individuals attain sexual maturity (Lm_{50}) was estimated at 97.5 cm for *Thunnus albacares* (Fig. 8a) and 44.5 cm for *Katsuwonus pelamis* (Fig. 8b). These estimates are largely consistent with values reported from other regions of the Indian Ocean and adjacent waters, though slight deviations were observed. Such variations may arise from environmental differences, genetic factors, or sampling-related biases.

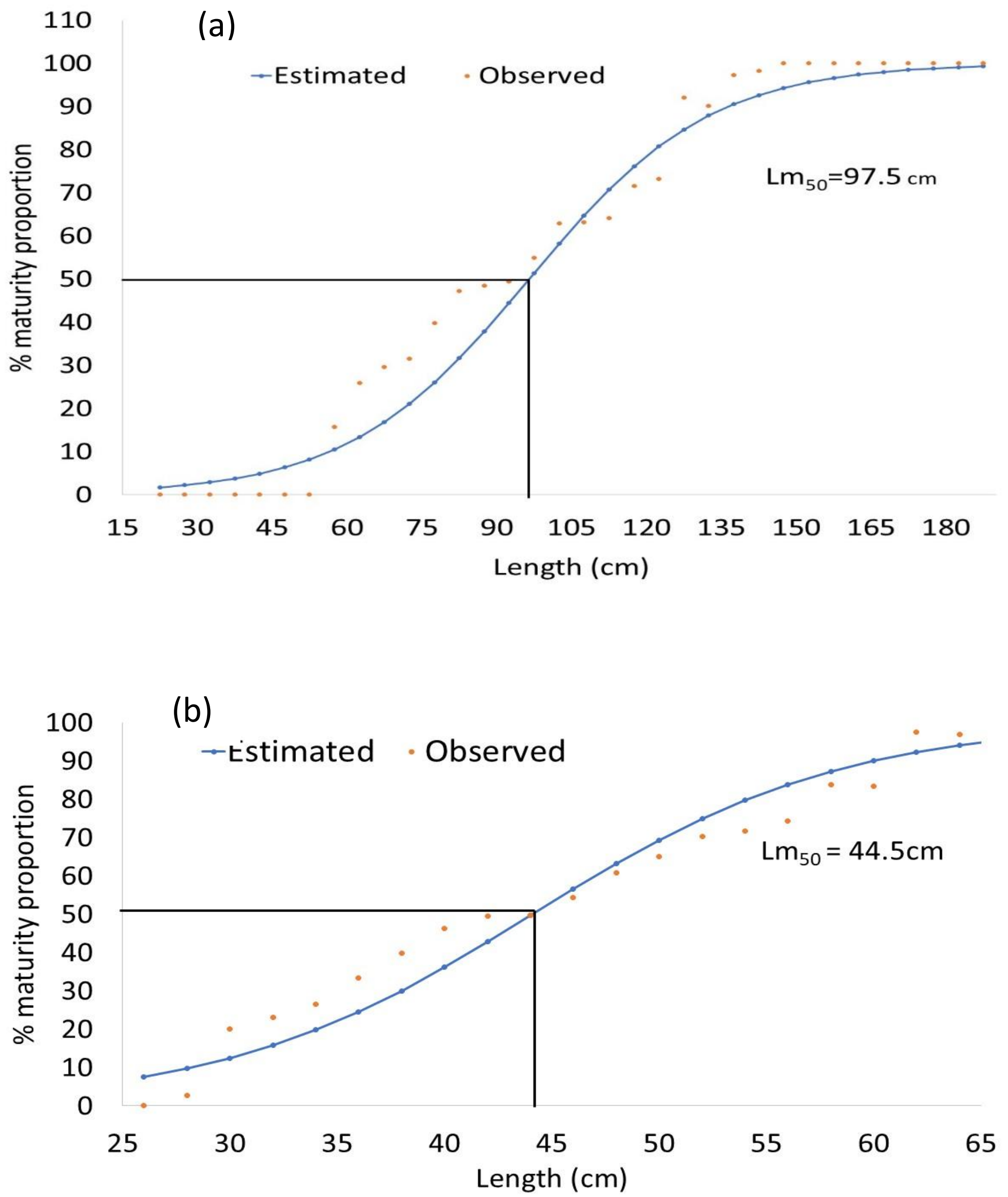


Fig. 8. Length at first maturity (Lm50) of (a) *Thunnus albacares* and (b) *Katsuwonus pelamis*

Gonadosomatic index

The gonadosomatic index (GSI) exhibited clear temporal variations in both *Thunnus albacares* and *Katsuwonus pelamis*, reflecting fluctuations in their reproductive activity throughout the year. In *T. albacares*, the GSI values for females ranged from 1.54 in December to a peak of 3.50 in May, while in males, values varied between 0.40 in December and 1.59 in November. Monthly trends indicated two distinct peaks in gonadal activity — a major peak in May and a secondary peak in November for both sexes (Fig. 9a), suggesting periods of enhanced spawning readiness.

Similarly, *K. pelamis* exhibited pronounced seasonal variations in GSI. In females, GSI values fluctuated from 0.87 in September to a maximum of 4.20 in May, while in males, the index ranged between 0.24 in October and 3.20 in April (Fig. 9 b). The species displayed two prominent spawning peaks, with a major peak during March–May and a minor one in November, indicating extended reproductive activity.

The occurrence of mature and spawning-capable individuals in both species across several months supports the inference that *T. albacares* and *K. pelamis* are multiple or batch spawners, capable of releasing eggs over an extended period rather than during a single spawning event. This pattern of year-round spawning with seasonal peaks is characteristic of tropical tunas inhabiting warm, productive waters, where environmental conditions such as temperature, food availability, and oceanographic features favour continuous reproductive activity with periods of intensified spawning effort.

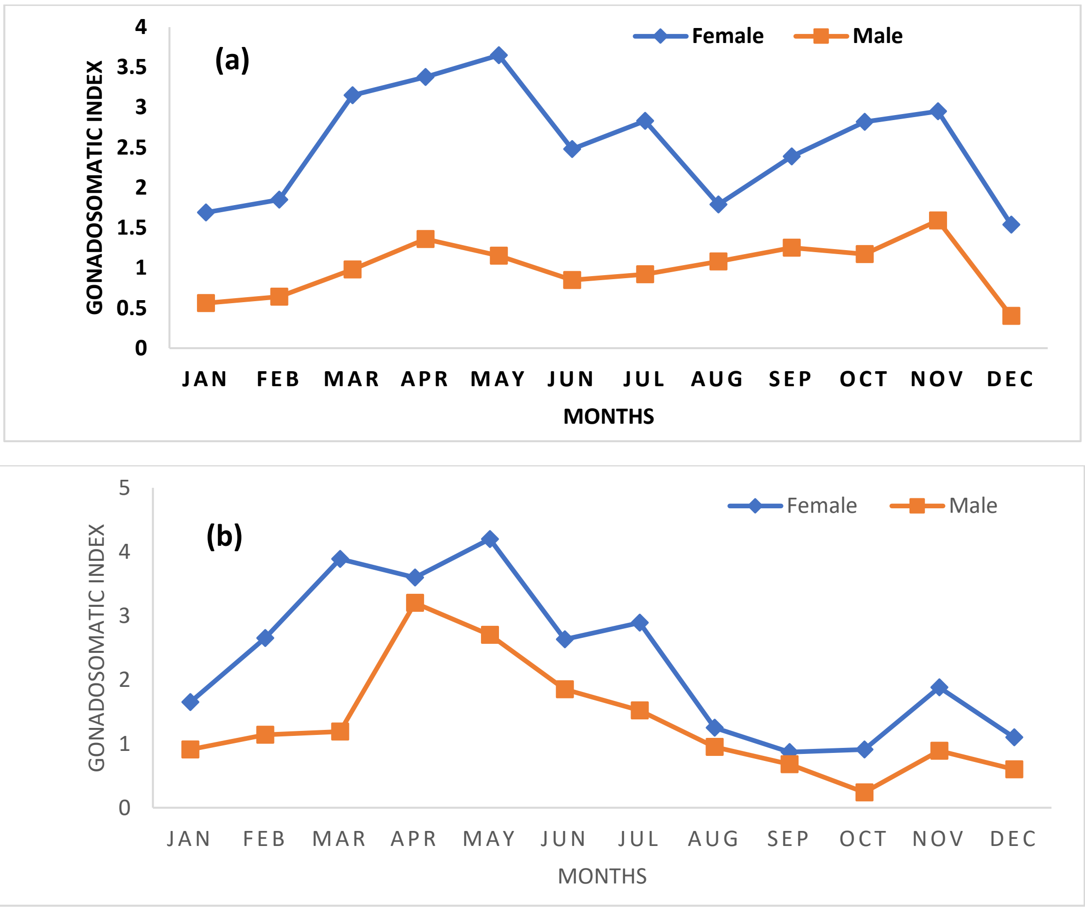


Fig. 9. Gonadosomatic index of (a) *Thunnus albacares* and (b) *Katsuwonus pelamis*

Diet composition

Thunnus albacares

A total of 2,342 specimens of *Thunnus albacares* were examined for stomach contents. Among these, 1,714 individuals (73.2%) contained food in varying quantities. Of the stomachs with food, 10.6% contained only traces, 28.8% were one-fourth full, 18.0% were half full, 7.8% were three-fourths full, and 7.7% were completely full. The dominant and preferred food item of *T. albacares* was teleosts (% IRI = 88.6), followed by molluscs (% IRI = 9.2) and crustaceans (% IRI = 2.2). The main constituents of teleosts based on their dominance were *Encrasicholina devisi, Decapterus* spp., *Stolephorus* spp., *Nemipterus* spp., ribbonfish, *Bregmoceros* spp., *Sardinella longiceps*, *mullets*, *Auxis rocheii Saurida* spp *Cynoglossus* spp., lesser sardines, *Apagon* spp., *Rastrelliger kanagurta* and *Lagocephalus inermis* (Table 2). Among the molluscan components, partially digested squids constituted the major portion, followed by *Loligo* spp. and octopus. The crustacean fraction of the diet comprised partially digested prawns and crabs.

Table 2. Diet composition of *Thunnus albacares* as percentage of occurrence (%O), percentage of number (%N), percentage by weight (%W) and Index of relative importance (IRI).

Diet component	% O	%N	%W	IRI	%IRI
Teleosts	**79.3**	**86.4**	**66.8**	**1502.1**	**88.6**
Partially digested unidentified fish	27.2	17.4	8.6	704.1	41.6
Encrasicholina devisi	10.3	24.6	9.7	353.8	20.9
Decapterus spp.	9.8	6.6	19.6	256.8	15.2
Stolephorus spp.	12.0	16.1	2.0	108.0	6.4
Nemipterus spp.	3.8	2.5	2.9	20.5	1.2
Ribbonfish	3.3	1.9	2.8	15.4	0.9
Bregmoceros spp.	3.3	3.2	1.1	13.8	0.8
Sardinella longiceps	1.1	2.8	1.6	4.8	0.3
Mullets	1.1	2.5	1.5	4.3	0.3
Auxis rocheii	0.5	0.3	7.2	4.1	0.24
Saurida spp.	1.63	1.26	0.6	3.01	0.18
Cynoglossus spp.	0.5	1.3	3.7	2.7	0.16
Lesser sardines	1.6	0.9	0.5	2.4	0.1
Apagon spp.	0.5	0.9	1.7	1.4	0.1
Rastrelliger kanagurta	0.5	0.6	1.6	1.2	0.1
Lagocephalus inermis	1.1	0.6	0.3	1.0	0.1
Molluscs	**8.7**	**10.7**	**32.3**	**149.6**	**9.2**
Partially digested unidentified squids	4.9	3.5	13.5	83.2	4.9
Loligo spp.	4.9	7.9	15.5	69.0	4.1
Octopus	0.5	1.9	4.9	3.7	0.2
Crustaceans	**11.4**	**3.5**	**0.9**	**37.8**	**2.2**

Partially digested unidentified prawns	10.9	3.2	0.3	37.3	2.2
Partially digested unidentified crabs	0.5	0.3	0.6	0.5	0.03

Katsuwonus pelamis

A total of 475 specimens of *Katsuwonus pelamis* were examined for stomach content analysis. Among them, 270 individuals (56.8%) had food material in varying quantities. Of these, 18.7% contained only traces of food, 14.5% were one-fourth full, 12.2% were half full, 5.3% were three-fourths full, and 6.1% were completely full, indicating moderate feeding intensity and variability feeding activity. The dominant and preferred food item of *Katsuwonus pelamis* was teleosts (% IRI = 67.6), followed by crustaceans (% IRI = 29.1) and molluscs (% IRI = 3.5). Partially digested unidentified fish forms the main constituents of teleosts followed by *Decaptesus* spp., *Megalaspis cordyla, Stolephorus* spp., *Nemipterus* spp., *Rastrelliger kanagurta, Dussumieria acuta,* Sardinella *longiceps, Exocetus* spp., *Chirocentrus* spp., Euthynnus *affinis,* lesser sardines, *Bregmoceros* spp., *Priacanthus* spp., *Atul mate,* Selar *crumenophthalmus* and *Encrasicholina devisi* (Table 3). Crustaceans constituted the second most important dietary component after teleosts, being predominantly represented by *Acetes* spp. Among the molluscan group, partially digested and unidentified squids formed the major portion.

Table 3. Diet composition of *Katsuwonus pelamis* as percentage of occurrence (%O), percentage of number (%N), percentage by weight (%W) and Index of relative importance (IRI).

Diet component	**% O**	**%N**	**%W**	**IRI**	**%IRI**
Teleosts	**76.72**	**30.30**	**81.20**	**1712.01**	**67.6**
Partially digested unidentified fish	34.75	9.21	30.97	1396.32	55.08
Decaptesus spp.	10.16	2.94	14.76	179.90	7.10
Megalaspis cordyla	4.59	1.68	6.25	36.39	1.44
Stolephorus spp.	4.92	2.61	3.26	28.85	1.14
Nemipterus spp.	2.30	0.93	4.55	12.58	0.50
Rastrelliger kanagurta	2.30	1.45	3.43	11.20	0.44
Dussumieria acuta	1.97	0.67	4.37	9.91	0.39
Sardinella longiceps	4.59	0.86	0.87	7.92	0.31
Exocetus spp.	3.28	0.93	4.34	8.03	0.32
Chirocentrus spp.	1.31	5.14	1.53	8.76	0.35
Euthynnus affinis	0.98	0.56	2.77	3.28	0.13
Lesser sardines	1.31	0.67	1.33	2.63	0.10
Bregmoceros spp.	1.31	1.38	0.98	3.10	0.12
Priacanthus spp.	1.31	0.63	1.24	2.45	0.10
Atul mate	0.98	0.26	0.19	0.44	0.10

Selar crumenophthalmus	0.33	0.11	0.21	0.11	0.01
Encrasicholina devisi	0.33	0.26	0.16	0.14	0.01
Crustaceans	**11.15**	**65.23**	**14.36**	**736.85**	**29.1**
Acetus spp	9.51	63.36	13.70	732.70	28.90
Partially digested unidentified prawns	1.64	1.86	0.67	4.15	0.16
Mollusc	**12.13**	**4.47**	**4.43**	**86.19**	**3.5**
Loligo spp.	1.64	0.37	0.44	1.34	0.10
Partially digested unidentified squids	10.49	4.10	3.99	84.85	3.35

Although tropical tunas constitute a significant component of India's marine fisheries and contribute greatly to coastal livelihoods and export revenues, they have historically received limited scientific attention. A comprehensive understanding of their biology, particularly aspects such as feeding behaviour, growth, and reproductive dynamics, which remain inadequately studied in Indian waters, which is essential for accurate stock assessments. Such assessments form the scientific foundation for developing effective and sustainable fisheries management strategies. In this context, the present study on yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) tuna provides crucial baseline information that will aid in formulating sound management programmes to ensure the long-term sustainability of these valuable resources.

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