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POPULATION DYNAMICS AND EXPLOITATION STATUS OF TWO HIGHLY VALUED SCOMBRIDS (RASTRELLIGER KANAGURTA AND THUNNUS TONGGOL) ALONG THE BALOCHISTAN COAST, PAKISTAN

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ABSTRACT

This study investigates the population dynamics of the Indian mackerel (Rastrelliger kanagurta) and the longtail tuna (Thunnus tonggol), two commercially vital species of the Scombridae family. A total of 207 R. kanagurta (16–30 cm TL; 18–250 g) and 132 T. tonggol (40–133 cm TL; 1600–11200 g) specimens were collected from commercial landings at Gwadar and Pishokan, Balochistan. Growth parameters, length-weight relationships (LWRs), mortality rates, recruitment patterns, and virtual population analysis (VPA) were estimated using FiSAT II software and Excel. High correlation coefficients (R^2) were observed in the LWRs for both species. For R. kanagurta, the estimated parameters were asymptotic length (L_∞) = 27.30 cm, growth coefficient (K) = 0.460 yr^{-1} natural mortality (M) = 0.763, and fishing mortality (F) = 0.768. For T. tonggol, L_∞ was 63 cm, K was 0.540 yr^{-1}, M was 0.936, and F was 0.534. Recruitment patterns for both species indicate continuous, year-round recruitment with distinct cohorts appearing in both summer and winter seasons. In order to sustainably manage and conserve the Scombrid stocks in North Arabian Sea, these findings provide the necessary biological benchmarks.

Keywords:

Rastrelliger kanagurta, Thunnus tonggol, Scombridae, Population dynamics, FiSAT II, Arabian Sea, Stock assessment.

INTRODUCTION

Tuna fishes, from the family Scombridae, are one of the most highly migratory and commercially lucrative species present in oceans ranging from tropical to temperate regions (Collette and Nauen, 1983). Longtail Tuna, Albacore, Bluefin, and Yellowfin are three of the 15 species of this family (Collette and Nauen, 1983). These species are reported to travel distances of more than 1000Km, considering their oceonodromous nature, in search of feeding grounds, mates and perfect environmental conditions. (Block et al., 2011).

The Longtail tuna, *Thunnus tonggol* (Bleeker, 1851), is a commercially noteworthy pelagic fish widely spread across temperate and tropical neritic habitats within the Indo-Pacific region. Being a coastal species, *T. tonggol* typically forms small, fast-moving schools. The fact that its smaller size compared to other *Thunnus* species (not exceeding 142 cm), often poses unique challenges for commercial capture, which thus at times, impacts its perceived commercial value in specific markets. The annual worth of tuna fisheries, globally, is

estimated at approximately $12 billion (World Bank, 2019), providing for the livelihoods of millions of people in coastal communities (FAO, 2020). Concern is, that a significant number of tuna species are classified as overfished or endangered as of now, threatening the sustainability of these stocks. Some populations have plummeted by as much as 90% largely due to habitat loss, climate change and overfishing (IUCN, 2020). Consequently, international cooperation and active management frameworks-employing catch quotas, rigorous monitoring, creating marine protected areas, and eco-labelling programs-are necessary to ensure the long-term viability of tuna ecosystems (World Bank, 2019; FAO, 2020).

For Pakistan, the fisheries industry, which contributes around 25% to the agricultural GDP, thus an important source of foreign exchange is indeed a vital economic pillar, (Ebrahim, 2014). This sector has evolved intensely since 1947, when it was merely a small-scale operations, lacking proper harbours or processing facilities (Qureshi, 1961). Today, the Pakistani coastline has nine significant landing sites which include Karachi, Gwadar, Pasni, Ormara, Keti Bandar, Shah Bandar, Sonmiani, Jiwani, and Badin alongside four major harbours: Karachi, Korangi, Pasni, and Gwadar. The largest one, Karachi Fish Harbour, accommodates 80–90% of the industrial fishing fleet, which primarily consists of large gillnetters and shrimp trawlers (Hornby, 2014).

The economic essentiality of the fisheries sector for Pakistan's growth can be judged by the fact that it, directly employs 400,000 people with an additional 600,000 working in ancillary sectors (Akhtar and Expert, 2010). Supporting the livelihoods of near one million residents along the Sindh and Balochistan coastlines Sheikh, 2004) and plays a critical role in regional food security (Qureshi, 2012). Marine fish production had already reached 278,149 metric tonnes back in 1982, it is rather the diversity of Pakistan's waters, which is prominent; out of 760 documented species, 114 are of high economic significance (Hoda, 1985; Majid and Khan, 1992). Interestingly, while Pakistan's domestic fish consumption remains largely low, approximately 71% of the annual catch is destined for export (SMEDA, 1992).

The Indian mackerel, *Rastrelliger kanagurta* (Cuvier, 1816) is also a keystone of Pakistan's coastal fisheries, harvested almost round the year. Surface gillnets with a 5 cm stretched mesh size are usually employed to catch them, though 'Katra' (surrounding) nets are also used for large schools. Traditional fishing vessels, known as 'Hora' in Sindh and 'Rachin' in Balochistan, are the most important craft used for these operations. Along the Balochistan coast, key fishing grounds include Ganz, Gwadar (West and East Bays), Pishukan, Sur Bandan, Kappar, Karwat, Badok, Basul, Rumbra, Ormara, Kund Malir, and Gaddani. In Sindh, fishing is concentrated around Ras Mauri, Paradise Point, Charna Island and the proximity of major creeks.

Large Pelagic fisheries account for more than 20% of Pakistan's total marine catch thus, Tuna species are Pakistan's major pelagic resource. A considerable portion of this catch is transported to Iran via land or sea from Gwadar, while small-sized salted and dried tuna (such as kawakawa, bullet and frigate tuna) are exported to Sri Lanka. Tuna fishing season lasts from November to April , peaking in March, with commercial gillnetting operations centered in Gwadar, Jiwani, Karachi, and Pasni (Khan, 2017; FAO, 2009).

However, declining production statistics indicate towards a grave situation that has resulted from the over-fishing due to the export factor (MFD, 2012), aggravated by lucrative prices in neighbouring markets like Iran, which can incentivize unregulated trade (Undercurrent News, 2014). Unchecked overexploitation could severely deplete Tuna stocks potentially leading to the decline of capture fisheries. Dwindling catches and revenues may also cause overcapitalisation of fishing fleets. (FAO, 2009; Moazzam and Nawaz, 2014).

Historically, the presence of Indian mackerel in Pakistani waters has been well-documented, with early records by Zugmeyer (1932) describing the species as *Scomber microlepidotus* along the Makran coast. This research intends to provide a detailed analysis of the Indian mackerel and Longtail tuna,

examining condition factors, length-weight relationships and reproductive biology—including sex ratios, gonad maturity levels, gonadosomatic index (GSI), fecundity and length at first maturity. As per earlier observations, the spawning of Indian Mackerel is at its height during the summer months (June to October), particularly in September and October, and early developmental stages appearing by November.

Materials and Methods

Study Area and Sampling Period

This study was done along the coastal belt of Balochistan, Pakistan, targeting two main landing sites: Pishukan (a coastal town of Gwadar) and the Gwadar Fish Harbor (Figure 1). Data collection was conducted during two distinct periods in 2024: the summer season (July-August) and the winter season (October-November).

Figure 1. Gwadar Fish Harbor

A total of 248 individuals were firstly examined to form the population dynamics. Specially, for the summer season, sampling included Longtail tuna (*T. tonggol*, n=44) and Indian mackerel (*R. kanagurta*, n=18). For the winter season, the sampling effort for *R. kanagurta* was extended with an additional 186 specimens (Figures 2 and 4). Therefore, the comprehensive analysis for Indian mackerel was based on 204 specimens, with total lengths ranging from 16 to 30 cm and body weights ranging from 140 to 300 g.

Figure 2. T. tonggol

Figure 3. R. kanagurta

Field Procedures and Data Collection

Specimens were acquired from commercial catches made in near-offshore waters, using, pelagic trawls, monofilament gill nets and Katra i.e surrounding nets. Once a school of fish is detected in these artisanal fisheries, nets are arranged to entangle the catch. The fish are typically pulled and stored on-board without ice or chemical preservation after which they are transported to the landing centres for auction.

Primary biological data was recorded "on-the-spot" i.e at the harbours, to ensure morphological integrity. The following measurements were taken:

- Total Length (TL): Measured to the nearest 0.1 cm using a calibrated measuring board (foot scale),

extending from the end of the snout to the end of the caudal fin.

• Body Weight (W): Recorded in grams using a high-precision digital weighing scale.

Data Analysis and Growth Parameters

The length-weight relationship (LWR) was calculated using the power function $W = a\ L^b$

Where: W is the total weight of the fish (g), *L* is the total length (cm), *a* is the intercept (initial growth coefficient), *b* is the slope (growth exponent).

To estimate growth parameters and analyse length-frequency data, the FiSAT II (FAO-ICLARM Stock Assessment Tools) software package was utilized. The degree of association between length and weight was assessed using the coefficient of determination (R^2). The coefficients of determination and regression parameters are further detailed in the subsequent sections.

Results

Population Dynamics of *R. kanagurta*

A total of 207 specimens of *R. kanagurta* were analysed, with total lengths ranging from 16 to 30 cm and weights from 18 to 250 g. The length-weight relationship (LWR) showed a high degree of correlation (R^2= 0.920), as detailed in Table 1.

Table 1. Summary of statistical estimates for the length-weight relationships of the studied species.

Species name	Length range (cm)	Weight range (g)	Intercept (a) (CI)	Slope (b) (CI)	R^2	SE
T. tonggol	40-133	1600-11200	0.429 (0.265-0.592)	1.687 (1.605-1.770)	0.931	0.050 (a) 0.041 (b)
R. kanagurta	16-30	18-250	0.562 (0.387-0.736)	1.770 (1.534-1.709)	0.920	0.088 (a) 0.044 (b)

Population Dynamics of R. kanagurta

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The growth parameters were estimated using the K-scan routine in FiSAT II, which provided an asymptotic length ($L\infty$) of 27.30 cm and a growth coefficient (K) of 0.460 yr^{-1} (Figure 4). Analysis of the population structure revealed that cohorts are present in both summer and winter seasons (Figure 5).

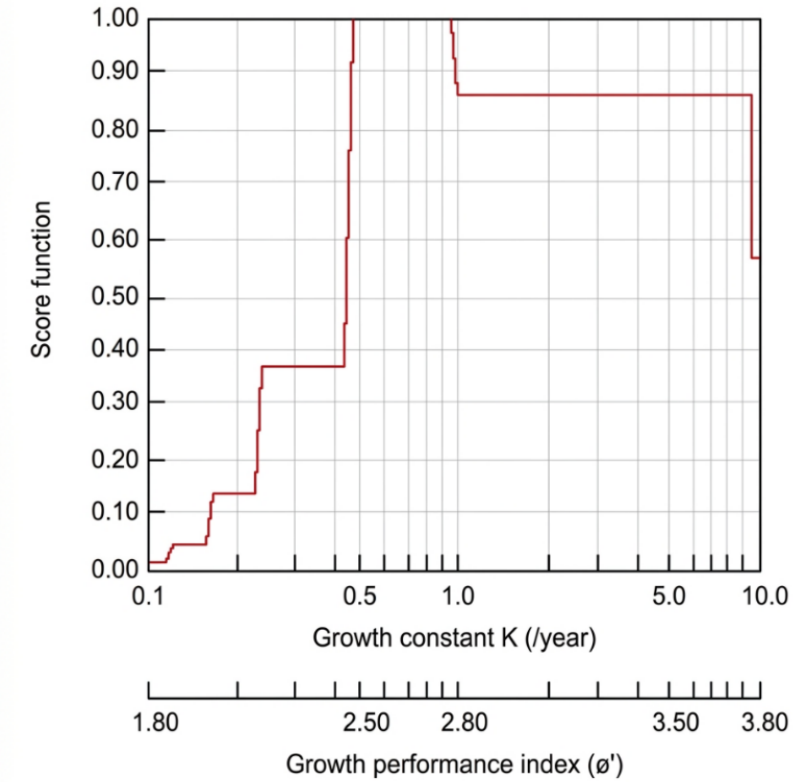

Figure 4. K-scan approach was used to assess growth in R. kanagurta

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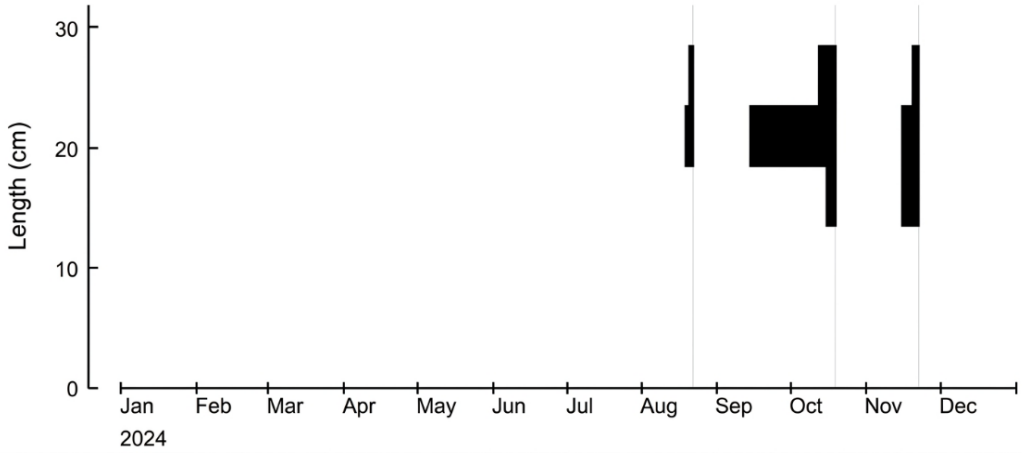

Figure 5. Population size-classes in summer and winter estimated for R. kanagurta

The recruitment analysis showed a continuous, year-round pattern, ensuring the constant addition of new individuals to the stock (Figure 6). Lastly, the Virtual Population Analysis (VPA) was done to assess the interaction between mortality, growth and the number of survivors from different length groups, giving a full overview of the species' status (Figure 7).

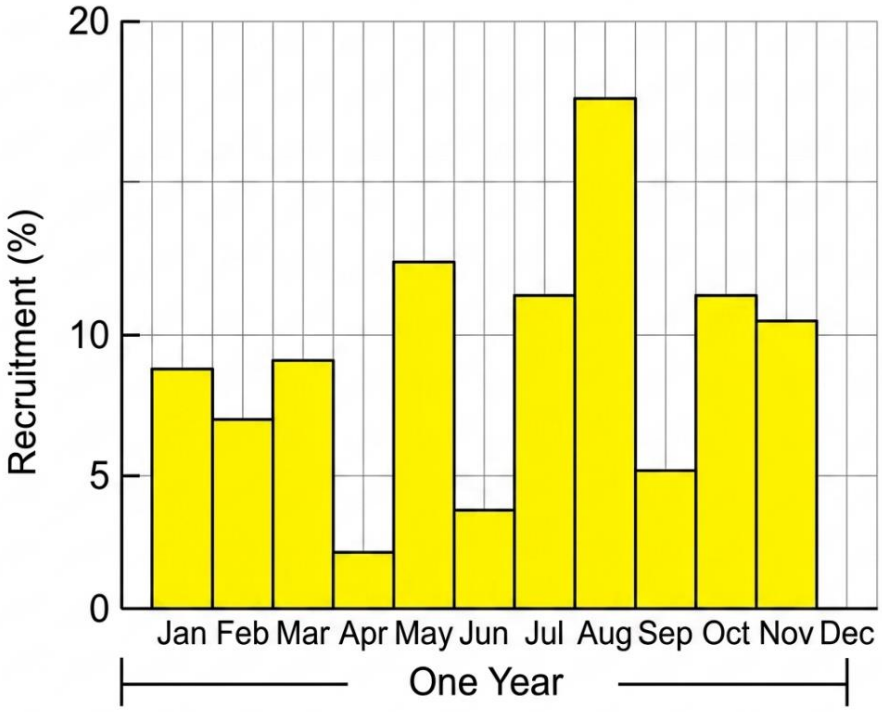

Figure 6. Recruitment outline in R. kanagurta

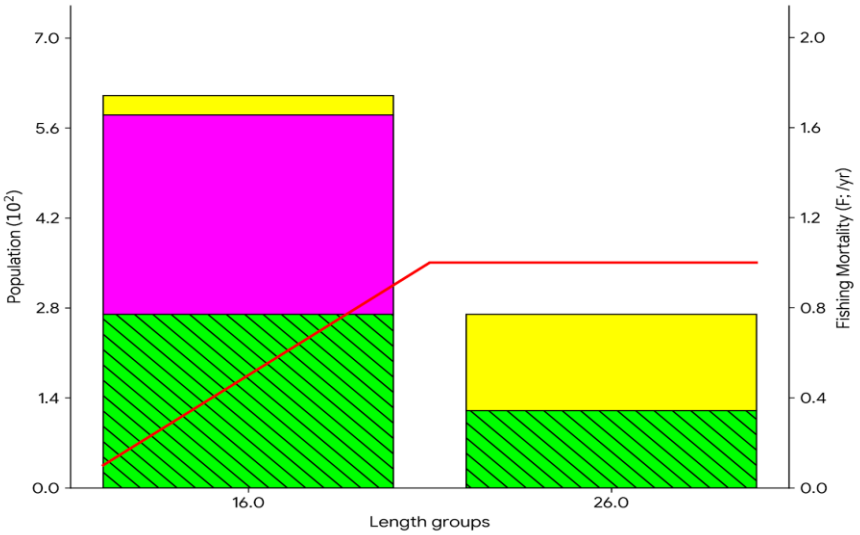

Figure 7. Virtual population analysis assessed for R. kanagurta

Population Dynamics of T. tonggol

132 specimens for *Thunnus tonggol* were studied (TL: 40–133 cm; W: 1600–11200 g). The LWR for this species revealed a very strong linearity with an R^2 value of 0.931 (Table 1).

Using the K-scan approach, growth parameter estimation resulted in an $L\infty$ of 63 cm and a K value of 0.540 yr^{-1} (Figure 8). To assess the impact of fishing on the stock, a length-converted catch curve was established, which estimated a total mortality (Z) of 0.50, natural mortality (M) of 0.936, and fishing mortality (F) of 0.534 (Figure 9).

The recruitment pattern for *T. tonggol*, similar to that of the Indian Mackerel, showed year-round activity, supporting the resilience of the population in waters of Balochistan (Figure 10). The results of the Virtual Population Analysis (VPA) for *T. tonggol* further demonstrate the distribution of fishing pressure and survivor rates across the captured size classes (Figure 11).

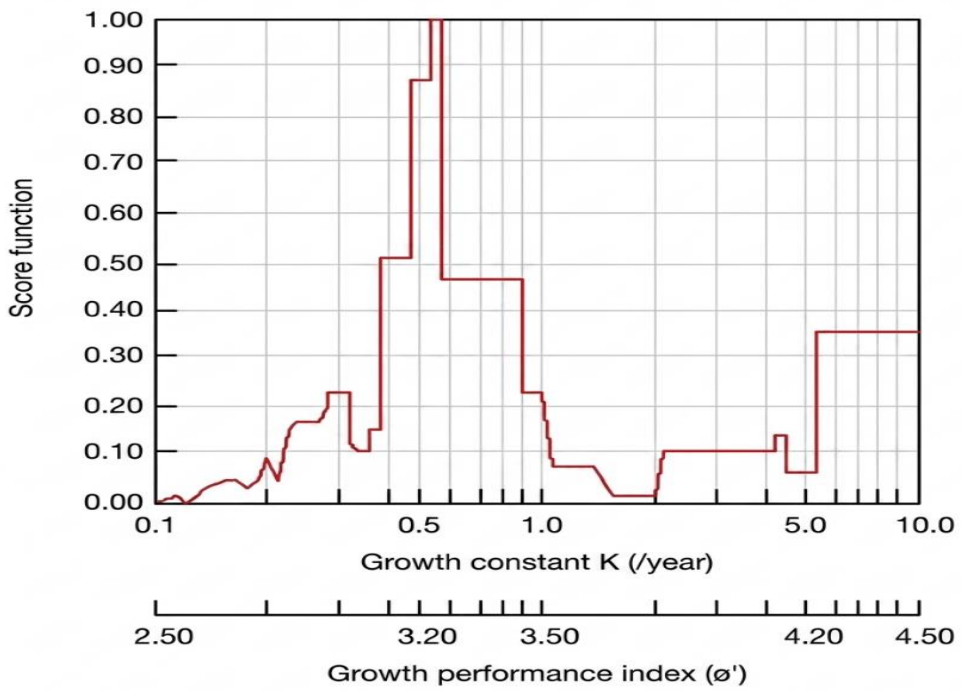

Figure 8. K-scan used to assess growth in T. tonggol

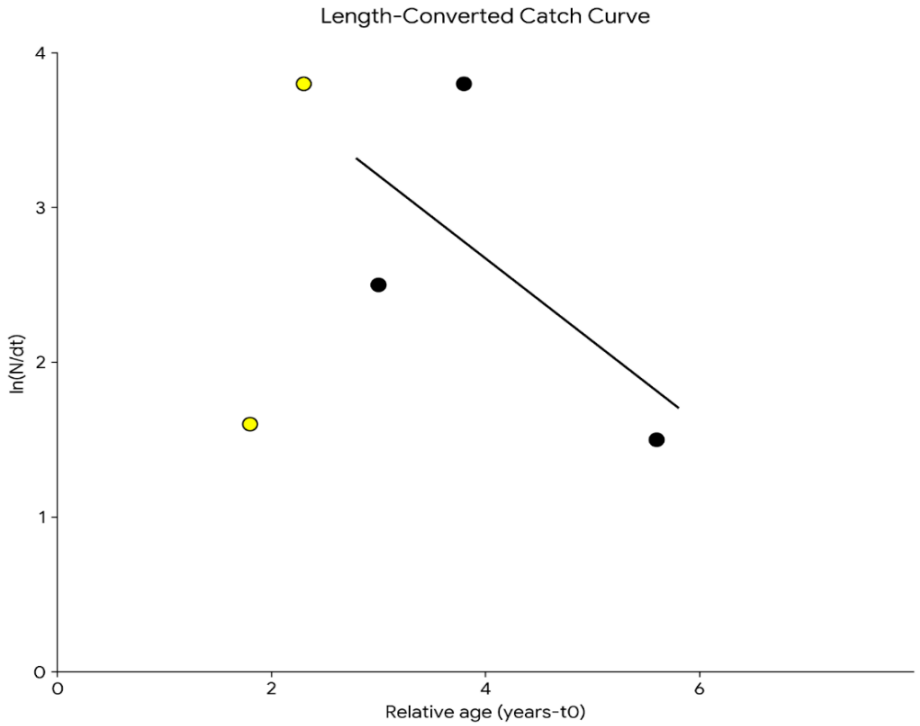

Figure 9. Length converted catch curve made for T. tonggol

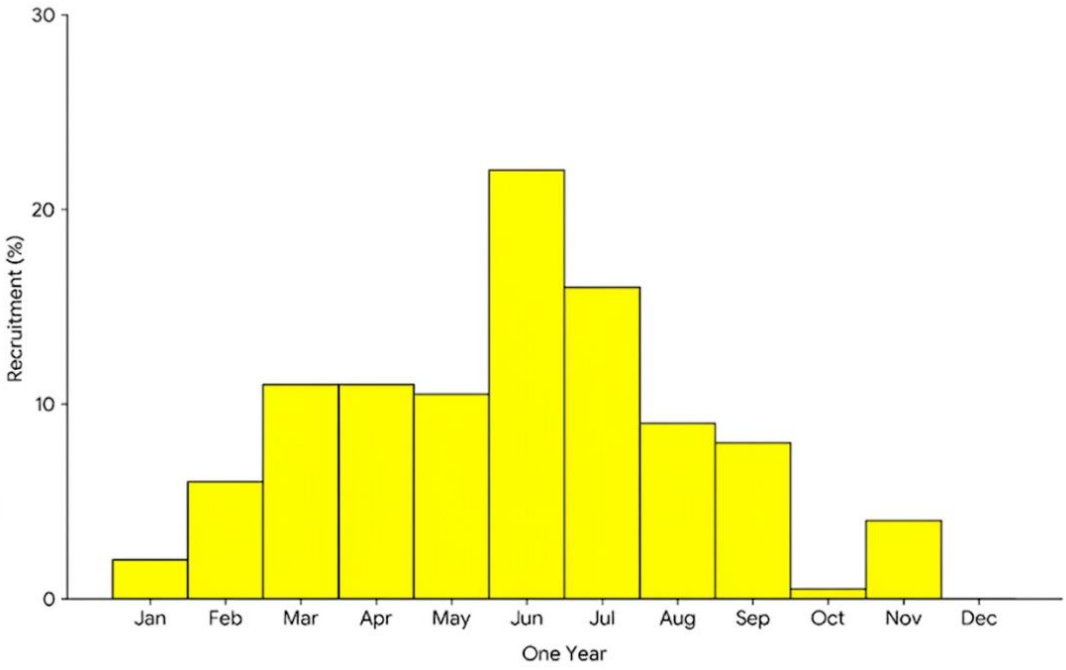

Figure 10. Recruitment pattern in T. tonggol

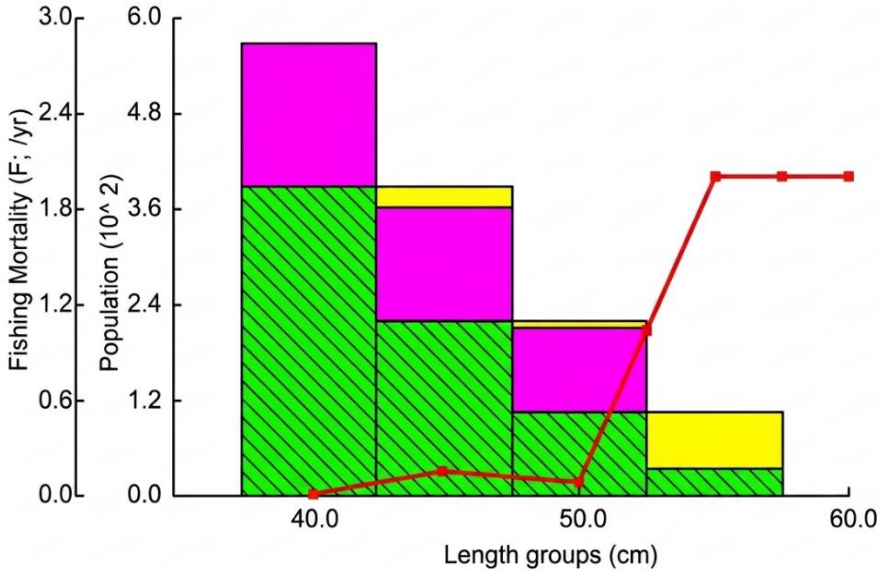

Figure 11. Virtual population analysis for T. tonggol

Discussion

This study provides a detailed assessment of the population dynamics of two economically crucial scombrid species, namely, *R. kanagurta* and *T. tonggol*, along the Balochistan coast. Uniformities in general biological trends and significant regional variations in key parameters such as growth coefficients (K), asymptotic length (L_∞), and mortality rates (M and F) can be observed while doing a comparative analysis of this study with the previous research, specifically the studies by Rehman et al. (2019) and Darvishi et al. (2018)

Rastrelliger kanagurta

In this t study, the estimated asymptotic length (L_∞) for *R. kanagurta* was 27.30 cm, with a growth coefficient (K) of 0.460 yr^{-1}. The natural mortality (M) 0.763 and fishing mortality (F) 0.768 were nearly balanced. These results indicate towards a stock that is being harvested at a rate approximately equal to its natural replacement capacity and thus a moderate growth strategy.

In contrast Rehman et al. (2019) reported a lower L_∞ (24.57 cm) but a significantly higher K value (0.84 yr^{-1}), indicating a faster growth rate towards a smaller maximum size. Apart from that, their mortality estimates (M = 1.682; F= 2.208) were considerably higher than those found in this study. The higher K and M values in their research may reflect separate environmental stressors or ecological settings, such as higher predation pressure or higher water temperatures which often usher "fast" life-history traits. Furthermore, the high fishing mortality (F = 2.208) reported by Rehman et al. (2019) suggests intense exploitation in their study area, possibly due to less regulated fishing effort compared to the landing sites sampled in this study.

Thunnus tonggol

For *T. tonggol*, this study estimated an L_∞ of 63 cm and a K of 0.540 yr^{-1}, with mortality rates of M = 0.936 and F = 0.534. Upon comparing these findings with Darvishi et al. 2018 a clear contrast in asymptotic length is observed; they reported a much larger L_∞ of 129.6 cm. This variation suggests that *T. tonggol* populations in different regions of the Indo-Pacific may reach very different maximum sizes, likely swayed by prey density, habitat quality and oceanographic conditions.

Contrastingly, the growth coefficient K = 0.540, in our study, was higher than the 0.39 reported by Darvishi et al Year 2018, indicating that the population present in Balochistan coasts, grows relatively faster during its early life stages, but, the higher natural mortality (M= 0.936 vs. 0.49) suggests more intense ecological pressures, such as predation, in our study area. Conversely, our documented fishing mortality (F = 0.534) was significantly lower than their estimate of 1.09, implying that the Longtail tuna stocks along the Balochistan coast may currently be under less intense fishing pressure or subject to more localized community-based fisheries management.

Regional Variations and Environmental Influence

The observed differences in L_∞, K, and mortality rates (M and F) between these studies highlight the ecological flexibility of scombrid life-history parameters. Variations in nutrient availability (primary productivity), water temperature and the selective nature of different fishing gears (gillnets vs. trawls) pose a significant influence for these parameters. For instance, higher temperatures in certain neritic habitats can boost metabolic rates, leading to higher K and M values. On the other hand, the illegal and unregulated trade of tuna across borders, as mentioned in recent reports, may obstruct in understanding the true extent of fishing mortality in certain regions.

Conclusion

The findings of this study provide critical understanding into the population dynamics and life-history traits of two commercially important scombrid species, *R. kanagurta* and *T. tonggol*, along the Balochistan coast. The analysis of length-weight relationships (LWRs) established strong linearity for both species, with high coefficients of determination (R^2) confirming the strength of the sampled data.

Comparative growth analysis revealed that *T. tonggol* shows a slightly faster growth rate (K= 0.540 yr^{-1}) compared to *R. kanagurta* (K = 0.460 yr^{-1}). Moreover, the recruitment patterns indicate that both species benefit from year-round recruitment in the North Arabian Sea, although the recruitment intensity was considerably higher in *T. tonggol*.

From a fisheries management viewpoint, the proximity of fishing mortality (F) to natural mortality (M) for *R. kanagurta* suggests that the stock is being harvested at its maximum sustainable limit, while the current exploitation level of *T. tonggol* appears more moderate, though its larger size and migratory nature makes continued monitoring necessary. These results serve as a crucial biological reference data for local authorities to implement size-selective harvesting and seasonal management strategies, which would ensure the long-term ecological and economic sustainability of these highly valued marine resources.

REFERENCES

Akhtar, N., and Expert, F. S. (2010). Enterprises based fisheries sector study and strategic plan for interventions at enterprise's level to enhance quality production (Final Report). United Nations Industrial Development Organization, Trade Related Technical Assistance (TRTA II) Programme.

Block, B. A., Jonsen, I. D., Jorgensen, S. J., Winship, A. J., Shaffer, S. A., Bograd, S. J., Hazen, E. L., Foley, D. G., Breed, G. A., Harrison, A., Ganong, J. E., Swithenbank, A., Castleton, M., Dewar, H., Mate, B. R., Shillinger, G. L., Schaefer, K. M., Benson, S. R., Weise, M. J., . . . Costa, D. P. (2011). Tracking apex marine predator movements in a dynamic ocean. *Nature*, *475*(7354), 86–90. https://doi.org/10.1038/nature10082

Collette, B. B., & Nauen, C. E. (1983). FAO species catalogue: Vol. 2. Scombrids of the world: An annotated and illustrated catalogue of tunas, mackerels, bonitos, and related species known to date (FAO Fisheries Synopsis No. 125, Vol. 2). Food and Agriculture Organization of the United Nations. https://www.fao.org/4/ac478e/ac478e00.htm

Darvishi, M., Paighambari, S. Y., Ghorbani, A. R., & Kaymaram, F. (2018). Population assessment and yield per recruit of longtail tuna (Thunnus tonggol) in Northern of the Persian Gulf and Oman Sea (Iran, Hormozgan Province). Iranian Journal of Fisheries Sciences, 17(4), 776–789. doi.org

Ebrahim, Z. (2014, November 4). Inside Pakistan's untapped fishing industry. Inter Press Service. https://www.ipsnews.net/2014/11/inside-pakistans-untapped-fishing-in dustry/

Food and Agriculture Organization. (2009). Fishery and aquaculture country profile: The Islamic Republic of Pakistan. https://www.fao.org/fishery/facp/pak/en

Food and Agriculture Organization. (2020). The state of world fisheries and aquaculture 2020: Sustainability in action. https://doi.org/10.4060/ca9229en

Gondal, M. A., Saher, N. U., & Qureshi, N. A. (2012). Diversity and biomass distribution of intertidal fauna in Sonmiani Bay (Miani Hor), Balochistan (Pakistan). Egyptian Academic Journal of Biological Sciences. B, Zoology, 4(1), 219–234. doi.org

Hoda, S. M. S. (1985). Identification of coastal fish varieties of Pakistan. Pakistan Agriculture, 7, 38–44.

Hornby, C., Moazzam, M., Zylich, K., & Zeller, D. (2014). Reconstruction of Pakistan's marine fisheries catches (1950–2010) (Fisheries Centre Working Paper #2014-28). University of British Columbia. seaaroundus.or

International Union for Conservation of Nature. (2020). The IUCN Red List of Threatened Species. https://www.iucnredlist.org

Khan, M. W. (2017). Tuna fishery in Pakistan: Pakistan's national report to the scientific committee of the Indian Ocean Tuna Commission. Marine Fisheries Department, Government of Pakistan. https://www.iotc.org/sites/default/files/documents/ 2017/11/ IOTC-2017-SC20-NR20_-_Pakistan_Rev_1

Majid, A., Khan, M. W., & Khaliluddin, M. (1992). Commercially important marine fishes of Pakistan. Department of Composition, Compilation and Translation, Federal Government Urdu Science College.

Marine Fisheries Department. (2012). Handbook of fisheries statistics of Pakistan. Government of Pakistan. https://mfd.gov.pk/

Moazzam, M., & Nawaz, R. (2014). By-catch of tuna gillnet fisheries of Pakistan: A serious threat to non-target, endangered and threatened species. Journal of the Marine Biological Association of India, 56(1), 85–90

Qureshi, M. R. (1961). Pakistan fisheries. Central Fisheries Department.

Sheikh, B. A., & Sheikh, S. A. (2004). Aquaculture and integrated farming system. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences, 20, 52–58.

Small and Medium Enterprises Development Authority. (n.d.). About SMEDA. Government of Pakistan, Ministry of Industries and Production. https:// smeda.org/

Undercurrent News. (2014, May 13). Smuggled tuna costing Iran $50m per year. https://www. undercurrentnews.com/2014/05/13/

World Bank. (2017). Tuna fisheries. World Bank Open Knowledge Repository. https://open knowledge.worldbank.org/entities/publication/7b4c453c-ee00-523d-a62b-9866f2f12941

Yesaki, M. (1993). A review of the biology and fisheries for longtail tuna (Thunnus tonggol) in the Indo-Pacific region. In R. S. Shomura, J. Majkowski, & S. Langi (Eds.), Interactions of Pacific tuna fisheries: Vol. 2. Papers on biology and fisheries (FAO Fisheries Technical Paper No. 336/2, pp. 370–454). Food and Agriculture Organization. https://www.fao.org/4/t1817e/t1817e18.htm

Zugmeyer, E. (1913). Die Fische von Baluchistan. Abhandlungen der Königlich Bayerischen Akademie der Wissenschaften, 26: 1–35

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