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# Understanding the population parameters for unicorn leatherjacket, *Aluterus monoceros* (Linnaeus, 1758) exploited along the Western Bay of Bengal

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Information on age and growth for monocanthid species globally is limited. *Aluterus monoceros* forms an important fishery in the northern Indian Ocean; however, information on its population dynamics is sparse, as the species has not been explicitly studied. This study elucidates the population parameters from 1031 individuals landed in the multi-day trawl fishery along the western Bay of Bengal from January 2017 to December 2019. Total length ranged from 21.5 to 64.4 cm with a mean of 47.54 cm. Von Bertalanffy growth equation was $L_t = 67.67\ [1 - e^{-0.32\ (t\ +\ 0.0592)}]$. The fishery was dominated by 3 and 4-year-old age classes and the estimated lifespan was 9.32 years. Recruitment was observed throughout the year and was bimodal, with the major pulse from October – February and the minor pulse from April – June producing 52.44 % and 36.24 %, respectively of the annual recruits. Natural mortality, fishing mortality and total mortality per year were 0.66, 0.55 and 1.21, respectively. Exploitation ratio was 0.45 and exploitation rate was 0.32. Though the species is currently underexploited, considering their lower capture sizes and their occurrence as by-catch in the trawl fishery, precautionary approach is suggested with management measures targeted at protecting their early life history stages.

[**Keywords**: *Aluterus monoceros*, Bay of Bengal, Exploitation, Growth, Mortality, Unicorn leatherjacket]

## Introduction

The Bay of Bengal Large Marine Ecosystem is an embayment of the northeastern Indian Ocean bordered by Sri Lanka, India, Bangladesh, Malaysia, Thailand, Myanmar, Indonesia and the Maldives. It is the largest bay in the world, and is influenced by the second-largest hydrologic region, the Ganges-Brahmaputra-Meghna basin. The bay is impacted by monsoons, storm surges and tsunamis leading to strong seasonality in water characteristics and productivity. Fishery in the bay is multi-species in nature and is exploited by a plethora of gears, as a result of which the ecosystem is under intense fishing pressure resulting in habitat destruction and high bycatch levels[1]. Mechanized trawlers with an overall length ranging from 11 m to 15 m and powered by engines ranging in horsepower from 90 to 250 extensively exploit the finfish and shellfish resources in the coastal waters at depths ranging from 30 to 100 m[2]. The cod-end mesh size of the trawl nets varied from 15 to 30 mm. One among the several non-targeted species landed in considerable quantities is the unicorn leatherjacket, *Aluterus monoceros* (Linnaeus, 1758), belonging to the family Monocanthidae. Monocanthids, with 28 genera and 107 species worldwide, are popularly called filefishes in the northern hemisphere and leatherjackets in the southern hemisphere. These fishes are characterised by deep and laterally compressed body and generally inhabit shallow littoral tropical and sub-tropical waters along the continental shelf. They are benthopelagic species, inhabiting the shelf down to 80 m depth, and are associated with either reef or with rocky and sandy bottoms in all the major oceans[3]. The species is either solitary or found in pairs, and only occasionally exists in groups of five or six. Juveniles are pelagic and inhabit areas close to reefs while adults, nests on sand flats adjacent to reefs in relatively deeper waters[4]. Studies on reproductive aspects of monacanthids indicate enormous intra-species variability[5]. In the northern Indian Ocean, encompassing the Arabian Sea in the west and the Bay of Bengal in the east, 13 monocanthid species are known to occur, among which only *Aluterus monoceros* forms a fishery of importance[6]. Upto 2008, sparse landings were observed for the species as by-catch in the trawl fishery. During 2008 – 2011, substantial quantities were landed and a sudden emergence of fishery for *A. monoceros* was observed at most major fish landing centres in the Arabian Sea and Bay of Bengal[7-11] which continued for several years[12,13]. At Veraval fishing harbour in the north-eastern Arabian Sea, from September to December in 2009, 8985 tonnes were landed, of which 7042 tonnes were caught in October alone[7]. Off Tuticorin waters in the south-eastern Arabian Sea, 5313 tonnes and 1360 tonnes were caught by trawlers in 2009 and 2010[(ref.8)], respectively. In the Malaysian waters, during 2008 – 2013, 19570 tonnes were landed[12]. Infact, due to the enormous catch encountered, targeted fishing for this species was carried out[7]. However, of late landings of the *A. monoceros* have decreased but have remained steady and formed part of the trawl catch along with the targeted resources.

Knowledge on population characteristics gained from estimating age and growth is vital for effectively managing the resource. Fish stock assessment is fundamentally aimed to provide advisories on the optimum level of exploitation for each resource. Notwithstanding the diversity and distribution of monocanthids in the northern Indian Ocean, apart from one study on *A. monoceros*[7], no information exists on either the biology or the population of any species of this family. Further, the above study[7], was performed based on a limited number of samples, and hence has not effectively captured the life-history traits of the species. Globally also, monocanthids are relatively less studied with respect to its population biology. Studies on age and growth are limited to *Navodon modestus*[14], *Balistes vetula*[15], *Monacanthus tomentosus*[16], *Stephanolepis hispidus*[17], *Stephanolepis diaspros*[18], *Thamnaconus modestus*[19], *Nelusetta ayraudii*[20,21] and *Meuschenia scaber*[22]. In the above context, the present study was performed to decipher the population dynamics and to estimate the population parameters for *A. monoceros* fished from Western Bay of Bengal. With no insights available for any monocanthid species from the northern Indian Ocean, knowledge gained would be used as baseline information for managing this species and other related monacanthid species. This study would also ensure evolving sustainable management measures for exploiting monocanthids in the region.

## Materials and Methods

Random samples of *Aluterus monoceros* (Fig. 1) were collected on a fortnightly basis for three years from January 2017 to December 2019 from Visakhapatnam (17°41'45.6" N 83°18'03.6" E) and Kakinada (16°59'02.4" N 82°16'44.4" E) fishing harbours, along the Western Bay of Bengal (Fig. 2) and their total length (cm) and weight (g) were recorded. Total length of individual fishes was measured to the nearest millimeter (mm) and total weight to 0.1 g precision. No samples were obtained in May, as a ban on mechanized trawling from mid-April to mid-June exists along this coast. The collected samples were placed in insulated ice boxes and transported to the laboratory of Visakhapatnam Regional Centre of Central Marine Fisheries Research Institute for further analysis. A total of 1031 individuals, 526 females and 505 males ranging in total length and weight from 25.3 to 64.4 cm and 141 to 2250 g for females and 21.5 to 64.1 cm and 98 to 2245 g for males, respectively were analysed during the study period. Pooled length frequencies obtained in each sampling day were grouped into 10 mm class intervals and raised for the day based on the sample weight and the total catch observed for the species on the sampling day. Daily raised length frequencies were summed up for the two observed days in the month and multiplied by the monthly raising factor taking into consideration the total fishing days in that month to arrive at monthly raised numbers[23].

Monthly raised length frequencies were analyzed using the ELEFAN I module of FiSAT software[24] for estimating the von Bertalanffy growth parameters *viz*., asymptotic length ($L_\infty$) and growth co-efficient (K). An additional estimate of $L_\infty$ obtained using Powell – Wetherall plot was compared with that obtained from ELEFAN I before arriving at the final value. The output of the growth curve was obtained and the length-based growth performance index (Ø) was calculated from the final estimates of $L_\infty$ and K[25]. The length at first capture ($L_c$) was estimated as in Pauly[26] and the age at zero length ($t_0$) from Pauly's[27] empirical equation, $\text{Log}(-t_0) = -0.3922 - 0.2752 \text{ Log } L_\infty - 1.038 K$. The growth and age were estimated

Fig. 1 — Photographic depiction of *Aluterus monoceros*

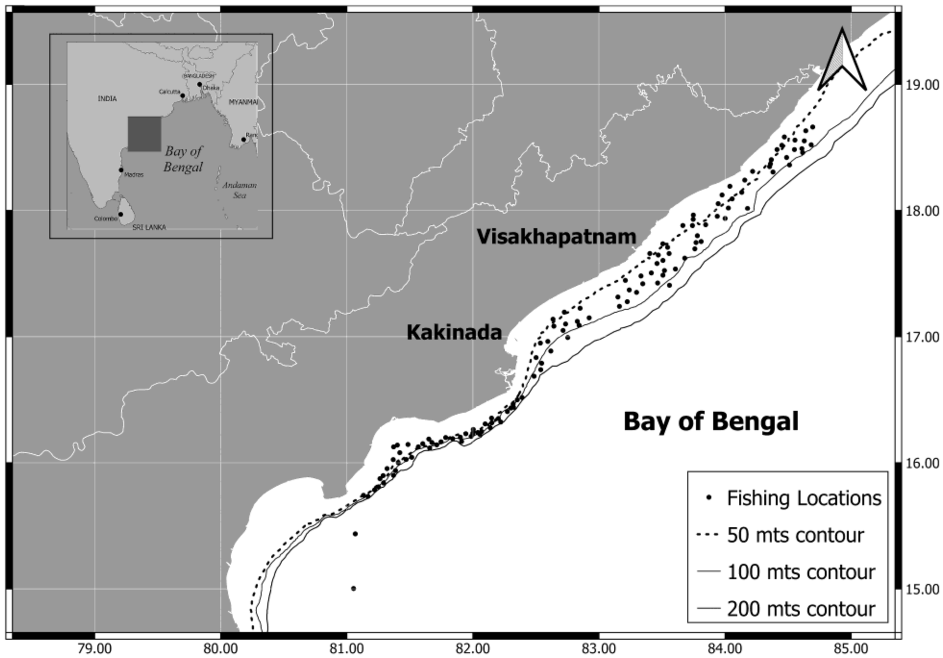


Fig. 2 — Study area showing the sampling sites

using the von Bertalanffy growth equation, $L_t = L_\infty (1 - e^{-k(t - t_0)})$. The mid-point of the smallest length group in the catch was taken as length at recruitment ($L_r$). The recruitment pattern was studied from the recruitment curve using final estimated values of $L_\infty$, K and $t_0$. Lifespan ($t_{max}$) was estimated at $3/K + t_0$[28].

Natural mortality (M) was estimated as in Pauly[29] by taking the mean sea surface temperature as 27 °C and total mortality (Z) from length converted catch curve[30] using FiSAT software. Fishing mortality (F) was estimated by F = Z - M. Length structured Virtual Population Analysis (VPA) of FiSAT was used to obtain fishing mortalities per length class. Exploitation ratio (E) was estimated from the equation, E = F/Z and exploitation rate (U) from $U = F/Z (1 - e^{-z})$. Optimal fishing length ($L_{opt}$), the length at which unfished cohort provides the maximum biomass and length at sexual maturity ($L_m$), the length at which 50 % of the population becomes sexually mature were estimated from length-frequency using the equation proposed by Froese & Binohlan[31].

## Results

*Aluterus monoceros* was caught around the year, as evident from the length distribution. Mean length ($L_{mean}$) in the landings was 47.54 cm, with the highest of 57.62 cm recorded in April and the lowest of 43.92 cm recorded in July. Fishes below 25.3 cm were males and were landed in October. At 25.3 cm and above, upto 64.4 cm, both males and females were encountered in the landings in all months. In the length-frequency distribution (Fig. 3), several modes were observed. Primary modal peak was at 47.45 cm, followed by secondary peaks at 49.45, 51.45 and 52.45 cm and tertiary peaks at 45.45, 46.45 and 48.45 cm.

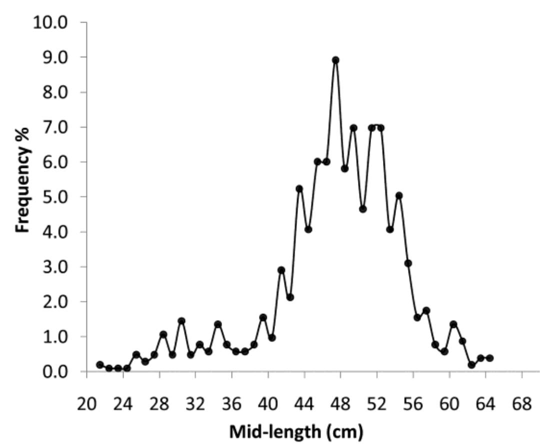


Fig. 3 — Length-frequency distribution of *Aluterus monoceros* from western Bay of Bengal

Population parameters for *A. monoceros* are presented in Table 1. The asymptotic length estimated using ELEFAN I and Powell-Wetherall plot was 67.67 cm and 67.52 cm, respectively. With more or less similar values obtained from different methods, the $L_\infty$ estimate from ELEFAN I was selected for further computation. Von Bertalanffy's growth equation was $L_t = 67.67[1 - e^{-0.32\,(t + 0.0592)}]$ and the output of the monthly pooled growth curve is exhibited in Figure 4. Growth performance index calculated was 3.17. Size at age during its entire lifespan is given in Figure 5. The fishery was dominated by 3 and 4-year-old age classes with individuals measuring between 42.25 – 49.20 cm and 49.21 – 54.25 cm contributing 45.20 and 27.74 %, respectively by number to the landings. The share of 2 (32.66 to 42.24 cm) and 5 (54.26 to 57.93 cm) year old age groups by number to the fishery were 10.86 and 7.18 %, respectively. Length converted catch curve used for estimation of mortality is depicted in Figure 6 and probability of capture in Figure 7. Recruitment was bimodal and occurred throughout the year, with the major pulse from October – February producing 52.44 % of the annual recruits and the minor pulse from April – June yielding 36.24 % of the annual recruits. Corresponding ages, obtained by converting length into age using inverse growth equation, for $L_r$, $L_c$, $L_{mean}$, $L_m$ and $L_{opt}$ were 1.13, 1.55, 3.73, 2.39 and 2.75 years. From virtual

Table 1 — Population parameters of *Aluterus monoceros* from western Bay of Bengal (n = 1031)

| Parameter | Value |
|---|---|
| Asymptotic length ($L_\infty$) in cm | 67.67 |
| Growth co-efficient (K) $yr^{-1}$ | 0.32 |
| Length at first capture ($L_c$) in cm | 27.22 |
| Age at zero length ($t_0$) in years | -0.0592 |
| Length at recruitment ($L_r$) in cm | 21.45 |
| Lifespan ($t_{max}$) in years | 9.32 |
| Optimal fishing length ($L_{opt}$) in cm | 40.1 |
| Length at sexual maturity ($L_m$) in cm | 36.8 |
| Natural mortality (M) $yr^{-1}$ | 0.66 |
| Fishing mortality (F) $yr^{-1}$ | 0.55 |
| Total mortality (Z) $yr^{-1}$ | 1.21 |
| Exploitation ratio (E) | 0.45 |
| Exploitation rate (U) | 0.32 |

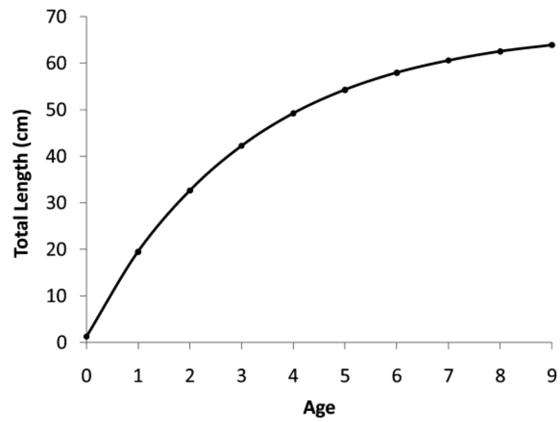

Fig. 5 — Length-at-age for *Aluterus monoceros* from western Bay of Bengal

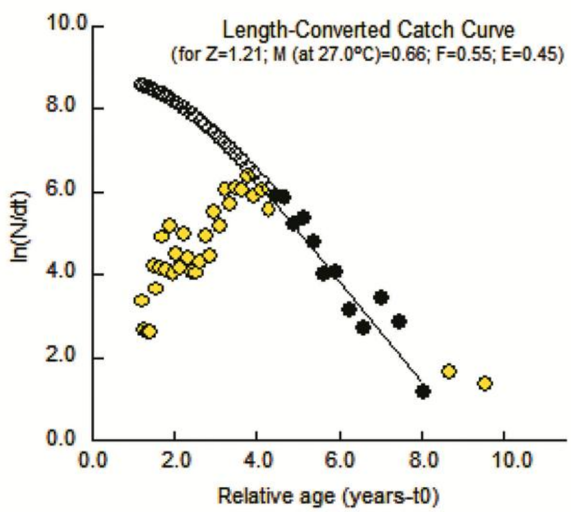

Fig. 6 — Length converted catch curve for mortality estimation in *Aluterus monoceros*

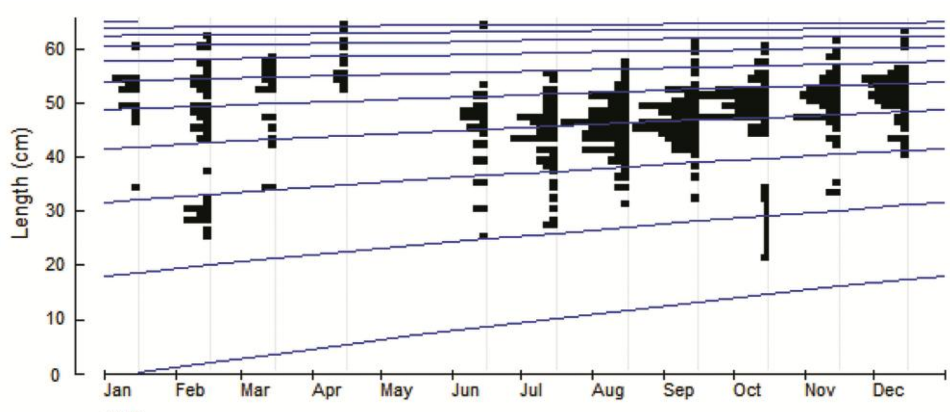

Fig. 4 — Growth curve of *Aluterus monoceros* from western Bay of Bengal

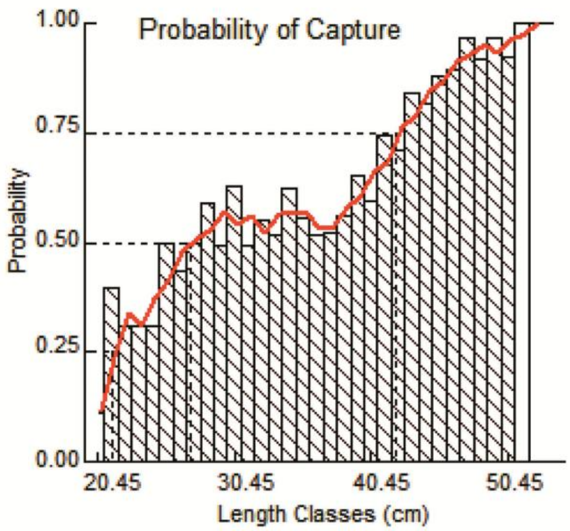


Fig. 7 — Probability of capture for *Aluterus monoceros*

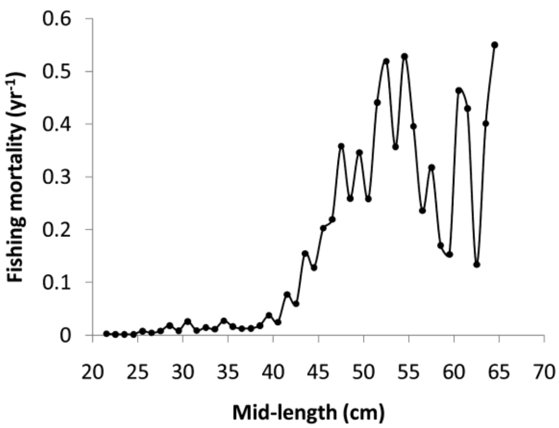


Fig. 8 — Fishing mortality in different lengths for *Aluterus monoceros*

population analysis, it is evident that upto 42.45 cm, the main loss in the stock was due to natural causes. With fishes becoming more vulnerable, fishing mortality increased from 43.45 cm, but never exceeded the natural mortality (Fig. 8). Present exploitation ratio (0.45) is less than the exploitation ratio providing maximum yield ($E_{max}$) (0.65), indicating the species to be currently underexploited.

## Discussion

A perusal of length composition revealed that fishes of all sizes were sampled from Western Bay of Bengal, with lengths ranging from 21.5 to 64.4 cm. Previous length ranges reported globally for *A. monoceros* varied from 20.0 to 70.0 cm[7-11,33,34]. Thus, it is surmised that the sampling in the present study represented the gamut of population in the nature. $L_{mean}$ was 47.54 cm and varied in months between 43.92 and 57.62 cm. An earlier study[7] had reported mean lengths to vary in individual months from 46.19 to 52.93 cm; however, their sample size was only 222, much lower than 1031 in the present study. The highest mean length recorded in April is because, before the commencement of monsoon, due to favourable weather conditions and sea state, fishermen ventured into the deeper offshore waters for trawling and therefore large individuals, which are found at considerable depths, were caught. Lower mean lengths, ranging from 43.92 to 45.73 cm were observed during the months of June – August, due to inclement weather conditions and sea state during these months, trawling was confined to nearshore coastal waters, and as a result, small individuals dwelling in shallower waters were abundantly captured. In *Nelusetta ayruadii*, significant migrations between inshore and offshore waters have been reported with larger fish captured in the deeper waters[32].

Information on population parameters is used to assess fish stocks for optimum management of the resource and also for predicting the response of stocks to current and future management measures. In tropical finfish species, unlike temperate waters, markings on scales, vertebrae and other hard parts for direct determination of age is unreliable due to the absence of a marked seasonality in environmental parameters, particularly temperature. Therefore, analysing length frequency and converting length to age and growth is most commonly preferred. According to Pauly[35], age and growth estimates are reliable only if the size of the population sampled is 1500 or more, and in the present study, 1031 fishes were sampled over 33 months, which is close to the minimum numbers proposed. It is in this context that the earlier study on the population dynamics of *A. monoceros* by Ghosh *et al*.[7], wherein only 222 individuals ranging in length from 41.0 to 60.9 cm were studied, loses its relevance. Growth and mortality estimate for monacanthid species reported globally are presented in Tables 2 and 3. Most monocanthid species (*Navodon modestus*, *Balistes vetula*, *Monacanthus tomentosus*, *Stephanolepis hispidus*, *Stephanolepis diaspros*, *Meuschenia scaber* and *Thamnaconus modestus*), except *Nelusetta ayruadii* are small, with lower values of asymptotic length. Their lifespan, barring for *Meuschenia scaber*, is reported to vary from 3 to 9 years[21]. *Meuschenia*

Table 2 — Growth estimates for monocanthid species

| Species | $L_\infty$ (cm) | K ($yr^{-1}$) | $t_0$ (years) | Ø | Area |
|---|---|---|---|---|---|
| *Navodon modestus*[14] | 37.8 | 0.168 | -2.262 | 2.38 | Pacific Ocean |
| *Balistes vetula*[15] | 41.5 | 0.30 | -0.600 | - | Pacific Ocean |
| *Monacanthus tomentosus*[16] | 11.79 | 0.86 | | 2.08 | Pacific Ocean |
| *Stephanolepis hispidus*[17] | 25.7 (fem)<br>27.4 (male) | 0.40 | | 2.42 (fem)<br>2.48 (male) | Atlantic Ocean |
| *Nelusetta ayruadii*[32] | 88.6 | 0.163 | -0.565 | - | Pacific Ocean |
| *Stephanolepis diaspros*[18] | 27.83 | 0.35 | -0.499 | 2.43 | Atlantic Ocean |
| *Nelusetta ayruadii*[21] | 59.1 | 0.377 | -0.247 | 3.11 | Pacific Ocean |
| *Aluterus monoceros*[7] | 63.53 | 0.22 | -0.077 | 2.95 | Indian Ocean |
| *Thamnaconus modestus*[19] | 46.19 (fem)<br>41.20 (male) | 0.21 (fem)<br>0.19 (male) | -1.560 (fem)<br>-2.363 (male) | 2.57 (fem)<br>2.51 (male) | Pacific Ocean |
| *Meuschenia scaber*[22] | 27.97 (fem)<br>28.22 (male) | 0.74 (fem)<br>0.9 (male) | -0.24 (fem)<br>-0.1 (male) | - | Pacific Ocean |

Table 3 — Mortality estimates for monocanthid species

| Species | M ($yr^{-1}$) | F ($yr^{-1}$) | Z ($yr^{-1}$) | Area |
|---|---|---|---|---|
| *Monacanthus tomentosus*[16] | | | 2.03 | Pacific Ocean |
| *Stephanolepis diaspros*[18] | 0.70 | 1.18 | 1.88 | Atlantic Ocean |
| *Nelusetta ayruadii*[39] | 0.5 | 0.6 | 1.1 | Pacific Ocean |
| *Aluterus monoceros*[7] | 0.53 | 0.58 | 1.11 | Indian Ocean |
| *Meuschenia scaber*[22] | | | 0.37 (fem) 0.75 (males) | Pacific Ocean |

*scaber* is the longest-lived monacanthid with a maximum lifespan of 17 years[36]. Growth coefficient, as reported (Table 2), fluctuated widely between genera, and these variations in growth and age are attributed to the phylogenetic distances between different genera under this family[37]. *A. monoceros* with $L_\infty$, K and $t_{max}$ of 67.67 cm, 0.32 $yr^{-1}$ and 9.32 years formed the link between smaller and larger and short-lived and long-lived monocanthids. Generally, fishes of relatively larger sizes exhibit slow growth and live longer and are, therefore, vulnerable to overfishing and need careful monitoring and management. According to Sparre & Venema[38], substantial differences in growth are observed at individual, population and cohort levels; which are usually genetic but are also highly dependent on physical (temperature, salinity, levels of dissolved oxygen, photoperiod), biotic (food availability and quality, competition and age and maturity) and general environmental conditions. Compared to other monocanthids (Table 2), growth performance index was high for *A. monoceros,* indicating better growth in the species. This is in tune to the observations of Visconti *et al*.[36], who in *Meuschenia scaber* have reported faster growth in warmer lower latitudes than in cooler mid and higher latitudes. Similarly, as *A. monoceros* inhabit the warm tropical waters of the Bay of Bengal, growth was faster in comparison to other monocanthids, which were studied from cooler temperate waters.

The fishery for *A. monoceros* exploited in the bay was dominated by 3 and 4-year-old age classes, contributing to around 73 % of the landings by number. In other monocanthids, 1 year old age class dominated the fishery for *Balistes vetula*[15] and *Stephanolepis diaspros*[18] and 2 and 3 year old age classes contributed the most to the fishery for *Navodon modestus*[14] and *Nelusetta ayraudii*[39]. Growth rate in terms of length increment was maximum during the 1st year of life, after which the annual increment decreased with increasing age. Similar, fast growth in first two years of life was reported for *Meuschenia scaber*[22]. Length at first capture, as observed for *A. monoceros* was higher than 8.5 cm reported for *Stephanolepis diaspros*[18] and 6.2 cm for *Monacanthus tomentosus*[16]. *A. monoceros* was recruited to the fishery at an age of 1.13 years, lower than the 2 years observed for *Nelusetta ayraudii*[39]. Again, contrary to *Meuschenia scaber*[22] which attains maturity between 1 and 2 years, *A. monoceros* attained maturity at a higher age of 2.39 years. The lower capture size in the bay in comparison to $L_{opt}$ and $L_m$ implies that substantial numbers are removed by fishing before they grow large enough to mature and spawn and contribute significantly to the stock biomass. However, with $L_{mean}$ higher than both $L_{opt}$

and $L_m$, the species is experiencing minimal stress with respect to its growth and recruitment at present. If $L_{mean}$ in the future, due to excessive fishing pressure, falls below $L_{opt}$ and $L_m$, then with lower sizes at capture, the species could be under severe spawning stress.

*Aluterus monoceros* was recruited to the fishery throughout the year, with a major peak from October – February and a minor peak from April – June. Recruitment pulses coupled with recruitment age indicate the species to breed throughout the year in the Bay of Bengal with the major spawning peak from September to January and the minor spawning peak from March to May. Sudden fluctuations in water temperature, a sharp decrease during September and October and a sharp increase in March creates favourable thermal conditions which triggers gonadal development and spawning by stimulating the physiological mechanisms. Pauly[29] had earlier stated that tropical fish species exhibit double recruitment pulses, in line with the present findings.

Natural mortality coefficient varies with the age of the species, and also with predator abundance in the respective environment[29]. According to Beverton & Holt[40], natural mortality coefficient is directly related to the growth coefficient and inversely related to the asymptotic length and the life span. The same was true for *A. monoceros*, with low natural mortality. According to Beverton & Holt[41], M/K ratio, which explains the relationship between natural mortality and physiological factors, should range from 1 – 2.5, and for *A. monoceros*, the value was 2.06. The predominance of growth on mortality is estimated from the Z/K ratio[42], and a ratio of 3.78 observed for *A. monoceros* indicates the population to be mortality dominated. Exploitation ratio, either using $E_{opt}$ equal to 0.5 or using estimated $E_{max}$ is used to assess the status of stocks[43,44]. Present ratio for *A. monoceros* along Western Bay of Bengal was lower than both $E_{opt}$ and $E_{max}$, indicating the underexploited nature of the stocks. Fishing mortality increased with fish size. *A. monoceros*, with a deep laterally compressed body has very low probability of escaping an active gear like trawl and invariably large sized individuals inhabiting the trawled area are caught.

## Conclusion

Present study estimates the population parameters for unicorn leatherjacket, *Aluterus monoceros* from the Western Bay of Bengal. The population of *A. monoceros* is characterised by slow growth and low natural mortality and high asymptotic length and lifespan. *A. monoceros*, though presently underexploited, is highly vulnerable to fishing pressure. A precautionary approach needs to be followed in the context of multi-species multi-gear fishery in the Bay of Bengal and that the resource is not targeted and is landed as by-catch in non-selective fishing gear like trawl. Discard mortality for species that are caught as by-catch are unaccounted and are generally high. With lower capture sizes and ages, growth and recruitment overfishing are a possibility in the future, and this needs to be addressed by increasing their sizes and ages of capture, probably by increasing the mesh sizes in the cod-end of trawl nets and by imposing restrictions on harvest size coupled with spatio-temporal protection of nursery grounds. Enforcing a minimum legal capture size and inhibiting trawling in nearshore coastal waters would protect the fish during the early stages of its life history.


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## Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Ethical Statement

This manuscript does not contain any experimental studies performed with live animals.

## Author Contributions

SG: Conceptualization, investigation, methodology, and writing - original draft; MSK & MHM: Data curation, and formal analysis; PR: Conceptualization, writing – review and editing; and AG: Funding acquisition, and supervision.

## References


1 Heileman S, Bianchi G & Funge-Smith S, VII-10 Bay of Bengal: LME #34, In: *The UNEP large marine ecosystems: A perspective on changing conditions in LMEs of the world's regional seas*, edited by K Sherman & G Hempel, (United Nations Environement Programme), Nairobi, Kenya, 82, 2009, pp. 237-251.

2 Vivekanandan E, *The trawl fisheries of the western Bay of Bengal*, *APFIC Regional Expert Workshop on Tropical Trawl Fishery Management*, (Food and Agriculture Organisation, Phuket, Thailand), 2013, pp. 39.

3 Froese R & Pauly D, (eds.), *FishBase*, World Wide Web electronic publication, www.fishbase.org version (12/2019).

4 Kuiter R H & Tonozuka T, *Pictorial guide to Indonesian reef fishes*, *Part 3*, *Jawfishes - Sunfishes*, *Opistognathidae – Molidae*, *Zoonetics*, *Australia*, 2001, pp. 623-893.

5 Kawase H & Nakazono A, Two alternative female tactics in the polygynous mating system of the threadsail filefish, *Stephanolepis cirrhifer* (Monacanthidae), *Ichthyol Res*, 43 (3) (1996) 315-323.

6 Nelson J S, Grande T C & Wilson M V, *Fishes of the World*, 5th edn, (John Wiley and Sons, New York), 2016, pp. 752.

7 Ghosh S, Thangavelu R, Mohamed G, Dhokia H K, Zala M S, *et al*., *Sudden emergence of fishery and some aspects of biology and population dynamics of Aluterus monoceros (Linnaeus, 1758) at Veraval*, *Indian J Fish*, 58 (1) (2011) 31-34.

8 Kanthan K P & Zacharia P U, Heavy landing of unicorn leatherjacket *Aluterus monoceros* by trawlers at Tuticorin Fishing Harbour of the Gulf of Mannar, *Mar Fish Inf Serv T & E Ser*, 209 (2011) 5-6.

9 Varghese M, Thomas V J, Gandhi A & Sreekumar K M, *Heavy landings of the filefish Aluterus monoceros from the Gulf of Mannar*, *Mar Fish Inf Serv T & E Ser*, 210 (2011) 18-19.

10 Saleela K N, Anil M K, Jasmine S & Raju B, Unusual landings of *Aluterus monoceros* (Linnaeus, 1758) along Vizhinjam coast, *Mar Fish Inf Serv T & E Ser*, 207 (2011) 30-31.

11 Sethi S N, Rajapackiam S, Mohan S, Rudramurthy N & Vasu R, *Emerging fishery of unicorn leather jacket, Aluterus monoceros at Chennai*, *Mar Fish Inf Serv T & E Ser*, 211 (2012) 17-18.

12 Saleh M F M, Upholding local knowledge for sustainable fishery of the unicorn leatherjacket filefish *Aluterus monoceros*: A case in Malaysia, *Fish for the People*, 12 (3) (2014) 38-43.

13 Lingappa C M, Naik A R, Rajesh K M & Rohit P, Large scale exploitation of the Unicorn leatherjacket by multiday trawlers, *Mar Fish Inf Serv T & E Ser*, 223 (2015) 25.

14 Park B H, *Studies on the fishery biology of the filefish Navodon modestus (Gunther) in the Korean waters*, Ph.D. Thesis, (Pukyong National University, South Korea), 1985, pp. 66.

15 Manooch C S & Drennon C L, Age and growth of yellowtail snapper and queen triggerfish collected from the U.S. Virgin Islands and Puerto Rico, *Fish Res*, 6 (1987) 53-68.

16 Peristiwady T & Geistdoerfer P, Biological aspects of *Monacanthus tomentosus* (Monacanthidae) in the seagrass beds of Kotania Bay, West Seram, Moluccas, Indonesia, *Mar Biol*, 109 (1991) 135–139.

17 Mancera-Rodriguez N J & Castro-Hernandez J J, Age and growth of *Stephanolepis hispidus* (Linnaeus, 1766) (Pisces: Monacanthidae), in the Canary Islands area, *Fish Res*, 66 (2004) 381–386.

18 El-Ganainy A A & Sabra M M M, Age, growth, mortality and yield per recruit of the filefish *Stephanolepis diaspros* (Fraser-Brunner, 1940) (Pisces: Monacanthidae), in the Gulf of Suez, Egypt, *J Fish Aquat Sci*, 3 (4) (2008) 252–560.

19 Kim A, Bae H, Kim H & Oh C, Age and growth of filefish, *Thamnaconus modestus* (Günther, 1877) off the Jeju Island of Korea, *Ocean Sci J*, 51 (2016) 355–362.

20 Grove-Jones R P & Burnell A F, *Fisheries biology of the ocean jacket (Monacanthidae: Nelusetta Ayraudi) in the Eastern Waters of the Great Australian Bight, South Australia: Final Report to the Fishing Industry Research and Development Council*, Grant No. DFS01Z: South Australian Department of Fisheries, 1991.

21 Miller M E, Stewart J & West R J, Using otoliths to estimate age and growth of a large Australian endemic monocanthid, *Nelusetta ayraudi* (Quoy and Gaimard, 1824), *Environ Biol Fish*, 88 (2010) 263–271.

22 Visconti V, Trip E D, Griffiths M H & Clements K D, Life-history traits of the leatherjacket *Meuschenia scaber*, a long-lived monacanthid, *J Fish Biol*, 92 (2) (2018) 470–486.

23 Sekharan K V, On oil sardine fishery of the Calicut area during the year 1955-56 to 1958-59, *Indian J Fish*, 9A (2) (1962) 679–700.

24 Gayanilo Jr F C, Sparre P & Pauly D, FAO-ICLARM Stock Assessment Tools (FiSAT) Users Guide, In: *FAO Computerized Information Series (Fisheries)*, Vol 8, (FAO, Rome), 1996, pp. 180.

25 Pauly D & Munro J L, Once more on the comparison of growth in fish and invertebrates, *Fishbyte*, 2 (1) (1984) 1–21.

26 Pauly D, Fish population dynamics in tropical waters: a manual for use with programmable calculators, *ICLARM Stud Rev*, 8 (1984) pp. 325.

27 Pauly D, Theory and management of tropical multispecies stocks: a review, with emphasis on the Southeast Asian demersal fisheries, *ICLARM Stud Rev*, 1 (1979) pp. 35.

28 Pauly D, Some Simple Methods for the Assessment of Tropical Fish Stocks, *FAO Fish Tech Pap*, 234 (1983a) pp. 52.

29 Pauly D, A Selection of Simple Methods for the Assessment of Tropical Fish Stocks, *FAO Fish Circ No 729* (1980) pp. 54.

30 Pauly D, Length converted catch curves: A powerful tool for fisheries research in tropics (Part-1), *ICLARM Fishbyte*, 1 (2) (1983b) 9-13.

31 Froese R & Binohlan C, Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data, *J Fish Biol*, 56 (4) (2000) 758-773.

32 Miller M E, *Key biological parameters and commercial fishery for ocean leatherjackets Nelusetta ayraudii (Monacanthidae) off the coast of New South Wales, Australia*, MD Thesis, (University of Wollongong), 2007, pp. 150.

33 Wang X H, Qiu Y S, Zhu G P, Du F Y, Sun D R, *et al*., Length-weight relationships of 69 fish species in the Beibu Gulf, northern South China Sea, *J Appl Ichthyol*, 27 (2011) 959–961.

34 Ul-Hassan H, Ali Q M, Rahman M A, Kamal M, Tanjin S, *et al*., Growth pattern, condition and prey-predator status of 9 fish species from the Arabian Sea (Baluchistan and Sindh), Pakistan, *Egypt J Aquat Biol*, 24 (4) (2020) 281-292.

35 Pauly D, A Review of ELEFAN System for Analysis of Length Frequency Data in Fish and Aquatic Invertebrates, *ICLARM Conf Proc*, 13 (1987) 7–34.

36 Visconti V, Trip E D, Griffiths M H & Clements K D, Geographic variation in life-history traits of the long-lived monacanthid *Meuschenia scaber* (Monacanthidae), *Mar Biol*, 167 (2020) 1-13.

37 Santini F, Sorenson L & Alfaro M E, A new multi-locus timescale reveals the evolutionary basis of diversity patterns in triggerfishes and filefishes (Balistidae, Monacanthidae; Tetraodontiformes), *Mol Phylogenet Evol*, 69 (2013) 165–176.

38 Sparre P & Venema S C, Introduction to tropical fish stock assessment, Part 1: Manual, *FAO Fish Tech Paper*, 306 (1) (1998) Rev. 2, (FAO, Rome).

39 Miller M E & Stewart J, The commercial fishery for oceanleatherjackets (*Nelusetta ayraudi*, Monacanthidae) in New South Wales, Australia, *Asian Fish Sci*, 22 (2009) 257–264.

40 Beverton R J H & Holt S J, A review of method for estimating mortality rates in exploited fish population, with special reference to source of bias in catch sampling, *Rapp P – V Reun CIEM*, 140 (1956) 67-83.

41 Beverton R J H & Holt S J, A review of the lifespans and mortality rates of fish in nature and their relation to growth and other physiological characteristics, In: *Ciba Foundation Colloquia on Ageing*, edited by G E W Wolsenholmy & M O'Connor, 5 (1959) pp. 142-180.

42 Barry J & Jegner M, Inferring Demographic Processes from Size Frequency Distributions: Simple Models Indicate Specific Patterns of Growth and Mortality, *US Fish Bull*, 88 (1989) 13–19.

43 Gulland J A, Manual of methods for fish stock assessment, Part I: Fish population analysis, *FAO Man Fisheries Science*, 4 (1969) p. 154.

44 Gulland J A, The Fish Resources of the Ocean West Poly Fleet, Survey Fishing News (Books) Ltd, *FAO Tech Paper*, 97 (1971) p. 428.