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Fishery, reproductive biology and stock status of the largehead hairtail *Trichiurus lepturus* Linnaeus, 1758 off Karnataka, south-west coast of India

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ABSTRACT

Rribbonfish fishery along Karnataka Coast is supported by a single species, the largehead hairtail *Trichiurus lepturus*. The species is exploited mainly by trawls and gillnets and during 2007-2012, production from Karnataka fluctuated between 11090 and 28845 t. The asymptotic length (L_∞), growth coefficient (K) and age at zero length (t_0) for *T. lepturus* were estimated as 116.75, 0.65 yr^{-1} and -0.171 respectively. Recruitment showed a bimodal pattern with peaks during March to June and August to December. Total mortality, fishing mortality and natural mortality were estimated at 3.32 yr^{-1}, 2.41 yr^{-1} and 0.91 yr^{-1} respectively. The length at first capture (L_{50}) and size at first maturity ($Lm_{50\%}$) were estimated at 54.91 cm and 55.4 cm respectively. Mean length in the catch was 67cm indicating that the fishery was sustained by mature fishes. However, the current exploitation rate (E) is 0.73 which is little higher than $E_{0.1}$ (0.70). As ribbonfish is an r selected, tropical species with a very high fecundity, SSB of 20% would help to maintain the fishery at sustainable levels and hence it is advisable to reduce the effort by 20%. Thompson and Bell bioeconomic analysis showed that the present level of exploitation can maintain the revenue from the fishery at economic level.

Keywords: Karnataka, Reproductive behaviour, Ribbonfish, Stock assessment

Introduction

The largehead hairtail *Trichiurus lepturus* is a marine carnivorous fish found worldwide in tropical and subtropical regions and an important fishery resource (FAO, 2005). Though the occurrence of eight well recognised species has been reported from Indian waters (James *et al.,* 1986), a single species *Trichiurus lepturus* supports commercial fishery in Karnataka. This species can switch between estuarine and marine ecosystems, including coastal and oceanic areas, according to its life cycle stages and food demand (Elliot *et al*., 2007). Distribution of the species ranges between the shallow inshore waters to about 350 m depth in the open sea and occurs in dense schools. It feeds on a variety of fishes, squids and crustaceans (Randall, 1995; Rohit *et al.,* 2015). Ribbonfishes are increasingly targeted from Indian waters on account of increased demand for export to China and other South-east Asian countries (Khan, 2006).

Average ribbonfish production from India during 2007-2012 was 177514 t, of which Karnataka contributed 11% (19343 t) (CMFRI, 2012). Initially, exploitation of ribbonfishes was mainly by traditional and motorised gears and was confined to the coastal waters. However, with increased mechanisation, the operation depths increased and trawls alone contribute more than 50% of the ribbonfish catch. Earlier studies revealed that ribbonfish follow a flexible reproductive strategy (Thiagarajan *et al*., 1992; Kwok and Ni, 1999; Martins and Haimovici, 2000). Females often spawn more than once in a reproductive season and have group synchronous spawning behaviour (Kwok and Ni, 1999). Sex ratio often favour females, particularly in larger size classes (Martins and Haimovici, 2000). Size at maturity ranges widely depending on the stock characteristics (James *et al*., 1983; Martins and Haimovici, 2000). Population dynamics of *T. lepturus* from north-west and north-east coasts of India have been studied by several workers (Chakraborty, 1990; Thiagarajan *et al.,* 1992; Chakraborty *et al.,*1997; Abdussamad *et al*., 2006; Ghosh *et al*., 2014). The present study during 2007-2012 investigated the stock characteristics of *T. lepturus* from Karnataka Coast, to assess the current status of the stock aimed at formulating regulatory management measures to maintain the fishery at sustainable levels.

Materials and methods

The study area is located off Mangalore in Karnataka along the south-west coast of India, in the Arabian Sea (Fig. 1). *Trichiurus lepturus* samples landed by the trawlers were collected weekly from the Mangalore Fishing Harbour. A total of 5750 fishes comprising 2652 males and 3098 females were collected between January, 2007 and December, 2012. Total length and body weight were recorded individually to the nearest centimeter (cm) and gram (g).

Length composition data were raised to monthly catch estimated by the Fishery Resources Assessment Division (FRAD) of ICAR-Central Marine Fisheries Research Institute, Kochi, India. The von Bertalanffy's growth parameters *viz.*, asymptotic length (L_∞) and growth co-efficient (K) were estimated using the ELEFAN 1 module of FiSAT II (Gayanillo *et al.*, 2005). The length based growth performance index was calculated as: $\varphi = \log_{10} K + 2\log_{10} L_\infty$ was calculated as per Pauly and Munro (1984) and the age at zero length (t_0) from $\text{Log}_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$, as per Pauly (1979). Longevity was estimated from the equation: $t_{max} = 3/K + t_0$ (Pauly, 1983a).

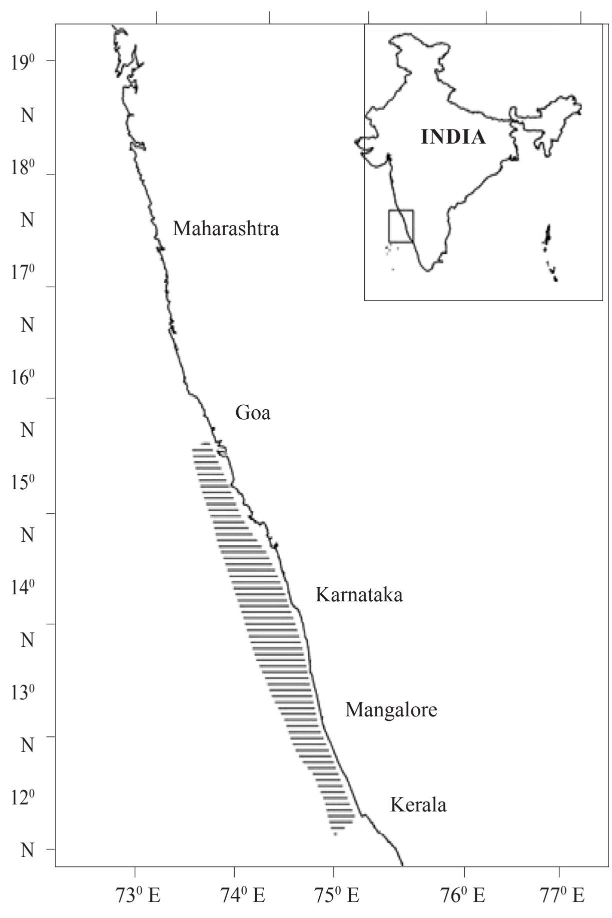

Fig. 1. Map of the study area. Shaded portions indicate fishing area

Mortality rates were estimated using FiSAT II package by the length converted catch curve method (Pauly, 1983b) and fishing mortality rate (F) as F = Z-M. Current exploitation rate (E) was calculated as E = F/Z (Ricker, 1975). Length structured virtual population analysis (VPA) of FiSAT II was used to obtain fishing mortalities of different size groups. Month-wise sex ratio was determined from 5750 specimens and Chi-square test was performed to test the homogeneity of male and female distribution.

Maturity stages of females were recognised based on the macroscopic appearance of the ovary in the body cavity and microscopic structure of ova. In males, only the macroscopic appearance of testes was considered. Seven stages of maturity were fixed for males and females based on ICES scale (Lovern and Wood, 1937) with suitable modifications. The size at first maturity (L_{50}) was determined by fitting the fraction of mature fish (stage III and above) against length interval using the nonlinear least square regression method (King, 1995).

The recruitment pattern was determined using FiSAT II. Temporal spread was deduced using restructured data and normal distribution of the recruitment pattern was determined by maximum likelihood method using NORMSEP (Pauly and Caddy, 1985). Probability of capture was approximated by backward extrapolation of the regression line of descending limb of length converted catch curve (Pauly, 1987). Probability of capture of sequential length classes were regressed using a logistic curve for the estimation of L_{50}. The relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) at different fishing levels were estimated using relative yield per recruit analysis (Beverton and Holt, 1966). The economic yield (Y), total biomass (B) and spawning stock biomass (SSB) at different fishing levels were predicted using length based Thompson and Bell bioeconomic model (Thompson and Bell, 1934).

Results and discussion

Fishery, seasonal abundance and sex ratio

The annual landings of *T. lepturus* in Karnataka during 2007-2012 (Fig. 2) remained more or less same throughout the period with an average catch of 19343 t. Average monthly catches were higher during September to November followed by moderate landings during February to May. Catch was minimum (Fig. 3) during fishing ban season (June to August).

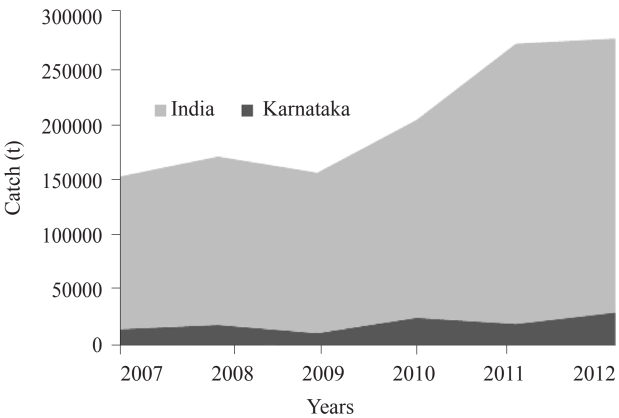

Fig. 2. Production trends of *T. lepturus* along Karnataka and India (2007-2012)

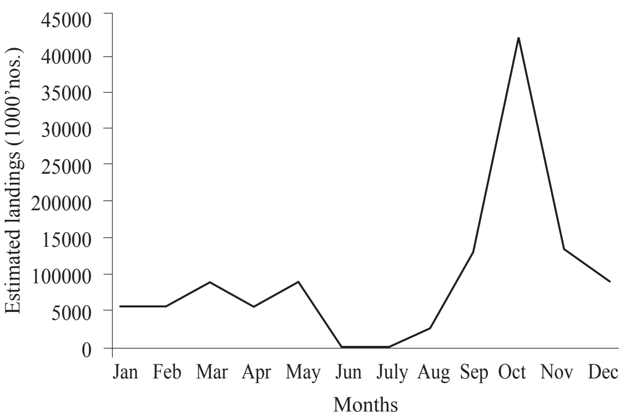

Fig. 3. Month-wise landings of *T. leprurus* along Karnataka

Of the total 5750 specimens studied, males constituted 46.1% (n=2652) and females 53.9% (n=3098). Average sex ratio of male to female during the study period was 1:1.17, indicating a dominance of females in the fishery. Monthly sex distribution also showed a dominance of females throughout the year except during August and September (Table 1). Female dominance was prominent in almost all size and age classes in the Arabian Sea and northern Bay of Bengal (Ghosh *et al*, 2014), Arabian Sea of Oman (Al-nahdi *et al.,* 2009) and in the South China Sea (Kwok and Ni, 1999). Dominance by females in almost all the months and by males only during August/September could be attributed to the differential fishing due to changes in the pattern of migration of sexes to and from the fishing grounds. Chi-square values indicated significant ($p<0.05$) dominance by females (Table 1) during February and March which happens to be the peak breeding season as reported by earlier workers (Narasimham, 1972; Abdussamad *et al.,* 2006). Peak spawning in winter and premonsoon months with a prolonged spawning season throughout the year was observed for *T. lepturus* from northern Arabian Sea and northern Bay of Bengal (Ghosh *et al.*, 2014).

Table 1. Monthly sex ratio of *Trichiurus lepturus* during 2007-2012 along Karnataka

Months	Sex ratio (Female/Male)	Chi-square value
January	1.38	0.29
February	1.44	5.21
March	1.56	11.69
April	1.34	0.22
May	1.22	2.21
June	1.03	1.18
August	0.79	5.43
September	0.69	15.71
October	1.10	1.25
November	1.15	0.84
December	1.21	0.25

*$p_{0.05}$= 3.16

Growth, mortality and exploitation parameters

The growth, mortality and exploitation parameters obtained in the present study and from the northern Arabian Sea and northern Bay of Bengal (Ghosh, *et al.*, 2014) are given in Table 2. The longevity (t_{max}) obtained in the present study was 4.4 years. Reuben *et al.* (1997) estimated longevity of the species as 4.9 years from Vishakhapatnam waters. The estimate of growth performance index was 3.94, representing good growth which is in agreement with earlier reports (Narasimham, 1976; Chakraborty, 1990; Reuben *et al.,* 1997; Ghosh *et al.,* 2009; 2014). Growth performance index is consistent for a particular species and so the values of L_∞ and K will compensate each other to arrive at the index value (Sparre and Venema, 1998).

Total mortality, natural mortality and fishing mortality estimates were 3.32 yr^{-1}, 0.91 yr^{-1} and 2.41 yr^{-1} respectively. The F (2.41 yr^{-1}) observed in the present study, was higher than M (0.91 yr^{-1}). Exploitation rate (E = 0.73) was higher than the optimum exploitation rate (0.5) indicating that there is heavy fishing pressure on the stock. Similar high values for exploitation rate have been reported earlier (Thiagarajan *et al.,* 1992; Reuben *et al.,* 1997; Khan, 2006; Abdussamad *et al.,*2006; Ghosh *et al.,*2009). VPA showed that fishing mortality exceeded natural mortality at 60 cm TL (total length) and maximum fishing mortality was observed at 82 cm TL.

Maturity and recruitment

Length at first maturity (L_m) was estimated at 55.4 cm TL (Fig. 4). Recruitment to the fishery was continuous throughout the year with two peaks, a minor peak in April (8.5%) and a major peak in August (18.1%). More than 50% of the total recruitment occur during June to September. Combinations of trophic enrichment and retention process in the Arabian Sea during monsoon months probably provide a favourable reproductive regime for the spawning and recruitment of ribbonfishes.

Table 2. Growth, mortality and exploitation parameters of *T. lepturus* from Karnataka coast (2007-2012) in comparison with northern Arabian Sea and northern Bay of Bengal (2007-2010).

Parameter	Karnataka	Northern Arabian Sea*	Northern Bay of Bengal*
Asymptotic length (L_∞)	134.0 cm	131.6 cm	114.4 cm
Growth coefficient (K)	0.82	0.15	0.28
Growth performance index (φ)	3.94	3.41	3.56
Age at zero length (t_o)	-0.171	-0.0740 years	-0.0564 years
Annual recruitment (nos.)	1621666	952812519	651795036
Natural mortality (M)	0.91	0.34	0.54
Fishing mortality (F)	2.41	0.18	0.81
Total mortality (Z)	3.32	0.52	1.34
Exploitation rate (E)	0.70	0.35	0.60
Exploitation ratio (U)	0.73	0.14	0.45
Annual average yield	19343 t	42649 t	31944 t
Total biomass	115983 t	236939 t	39437 t
Spawning stock biomass	29196 t	184542 t	18908 t

*Source: Ghosh *et al.* (2014)

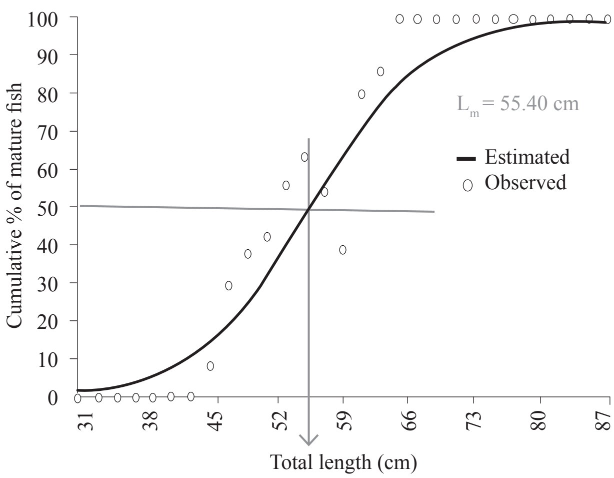

Fig. 4. Maturity curve of *T. lepturus* showing size at first maturity

Monsoon with associated upwelling activities replenish seawater nutrients leading to better productivity offering enough food for the larvae, giving them a better chance to grow faster and pass quickly through critical stages. The length at first capture (L_c) was estimated at 54.91 cm. and is slightly lower than length at first maturity (L_m). This indicates that the species enter the exploitation phase just prior to the attainment of sexual maturity. However, the mean length of the exploited fishes is much higher allowing large proportion of the fishes to mature and breed before they are caught.

Stock assessment

"Selection ogive" was used for the relative yield per recruitment analysis as, "knife edge selection" leads to considerable bias in the analysis for short lived, fast growing tropical species (Pauly and Soriano, 1986; Silvestre *et al*., 1991; Silvestre and Garces, 2004). Maximum Y/R was obtained at an E_{max} of 0.70, suggesting a 32% reduction in effort to achieve MEY (Fig. 5). However, the analysis did not consider spawning stock biomass (SSB) which is essential for maintaining recruitment in the future (Clark, 1991) and E_{max} usually corresponds to very low levels of B/R. *T. lepturus* being a pelagic, fast growing species characterised by higher natural mortality (Gunderson, 1980; Lee and Hsu, 2003) the E_{max} estimates may be unrealistically high (Gulland 1983; Pauly, 1984). Therefore, it is safer to adopt a precautionary approach and reduce the exploitation rate to $E_{0.1}$ (an effort level at which the marginal increase in yield per recruit reaches 1/10 of the marginal increase. E_{max} and $E_{0.1}$ can be used as proxies for the maximum sustainable yield (MSY) and maximum economic yield (MEY), respectively and set as a target reference point (TRP) (Jakubaviciute *et al*., 2011). $E_{0.5}$ represents exploitation rate at which

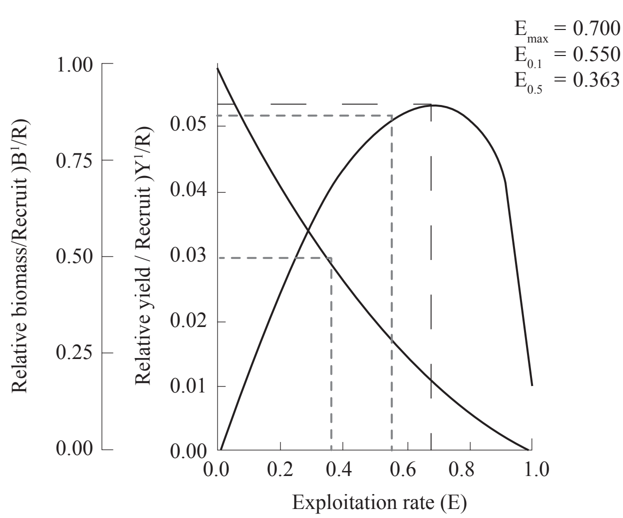

Fig. 5. Relative yield per recruitment analysis of *T. lepturus*

B/R reduces by 50% compared to virgin stock, *i.e.,* to the level which theoretically maximises surplus production (Pauly, 1984) and the same can be used as a proxy for the optimum sustainable yield (OSY) (Dadzie *et al*., 2005). In the present study, the optimum biomass of *T. lepturus* can be maintained at $E_{0.5}$ of 0.363 whereas, E is high and is depleting the B/R considerably. Since B/R and E are proxies for catch rate (CPUE) and effort (F) respectively, it shows that the CPUE decreases with increase in F. But this decrease in CPUE should not be confused with growth overfishing as the latter occurs at a very high fishing effort (usually above F_{msy}) where growth cannot balance the death process (Sparre and Venema, 1998). So, as far as recruitment overfishing is concerned, it is necessary to understand the relationship between spawning stock biomass (SSB) and recruitment.

Earlier studies have indicated that spawning stock biomass per recruit (SSBR) can be used as TRP and should be maintained at 20% for stocks having average resilience and at 30% for the little known stocks (Mace and Sissenwine, 1993). However, when relation between SSB and recruitment cannot be statistically established, it is safer to adopt a precautionary management approach and ensure that the SSBR is maintained between 20-30% of virgin stock to prevent recruitment overfishing (Rosenberg and Repestro, 1996). Thompson and Bell bioeconomic analysis (Fig. 6) reveals that exploitation of the resource has already reached the maximum sustainable yield (18291t) at the current effort level. As ribbonfish is an r selected, tropical species with a very high fecundity, SSB of 20% would help to maintain the fishery at sustainable levels. It is advisable to reduce the effort by 20% to maintain the SSB at 20%.

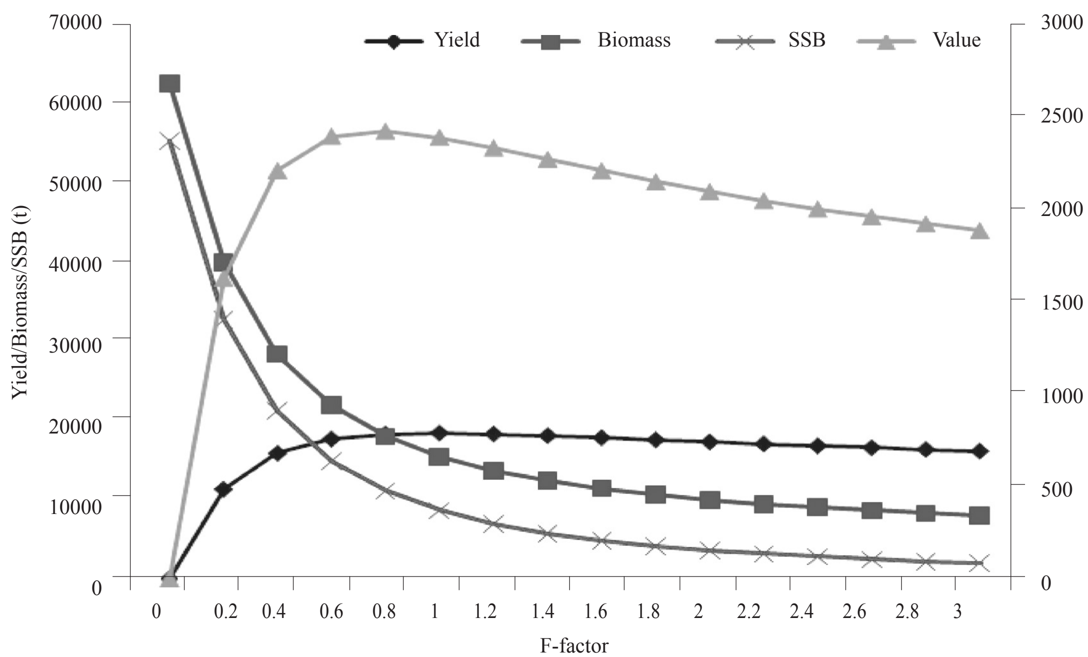

Fig. 6. Thompson and Bell analysis of *T. lepturus*

References

Abdussamad, E. M., Nair, P. N. R. and Achayya, P. 2006. The ribbonfish fishery and stock assessment of *Trichiurus lepturus* Linnaeus off Kakinada, east coast of India. *J. Mar. Biol. Assoc. India*, 48(1): 41-45.

Al-Nahdi, A., Al-Marzouqi, A., Al-Rasadi, E. and Groeneveld, J. C. 2009. The size composition, reproductive biology, age and growth of large head cutlass fish *Trichiurus lepturus* Linnaeus from the Arabian Sea coast of Oman. *Indian J. Fish.,* 56(2): 73-79.

CMFRI 2012. *Annual Report 2011-12*. Central Marine Fisheries Research Institute, Kochi, India, 186 pp.

Beverton, R. J. H. and Holt, S. J. 1966. Manuals of methods for fish stock assessment: Part II, Tables of yield function, *FAO Fish. Biol. Tech. Pap*., *Version 1,* Rome, Italy, 38 (4): 67 pp.

Chakraborty, S. K. 1990. Fishery, age, growth and mortality estimates of *Trichiurus lepturus* Linnaeus, from Bombay waters. *Indian J. Fish.,* 37(1):1-7.`

Chakraborty, S. K., Deshmukh, V. D., Khan, M. Z., Kuber, V. D. and Raje, S. G. 1997. Estimation of growth, mortality, recruitment pattern and maximum sustainable yield of important fishery resources of Maharastra coast. *Indian J. Mar. Sci.,* 26: 53-56.

Clark, W. G. 1991. Groundfish exploitation rates based on life history parameters. *Can. J. Fish. Aquat. Sci.,* 48: 734-750.

Dadzie, S., Manyala, J. O. and Abou-Seedo, F. 2005. Aspects of the population dynamics of *Liza klunzingeri* in the Kuwait Bay. *Cybium*, 29(1): 13-20.

Elliot, M., Whitfield, A. K., Potter, I. C., Blaber, S. J. M., Cyrus, D. P., Nordlie, F. G. and Harrison, T. D. 2007. The guild approach to categorising estuarine fish assemblages: a global review. *Fish Fish.,* 8: 241-268.

FAO 2005. Available from: http://www.fao.org/figis/servlet/FiRefServlet?ds=species&fid=2468. (10 May, 2005 and 13 June, 2009).

Gayanillo, Jr., F. C., Sparre, P. and Pauly, D. 2005. *FAO-ICLARM stock assessment tools II (FiSAT II). User's guide. FAO Computerized information Series (Fisheries). No. 8, Revised version*, FAO, Rome, 126 pp.

Ghosh, S., Pillai, N. G. K. and Dhokia, H. K. 2009. Fishery and population dynamics of *Trichiurus lepturus* (Linnaeus) off Veraval, north-west coast of India. *Indian J. Fish.,* 56: 241-247.

Ghosh, S., Hanumantha Rao, M. V., Rohit, P., Rammohan, K. and Maheshwarudu, G. 2014. Reproductive biology, trophodynamics and stock structure of ribbonfish *Trichiurus lepturus* from northern Arabian Sea and northern Bay of Bengal, *Indian J. Geo-Mar. Sci.,* 43(5): 755-771.

Gulland, J. A. 1983. Fish stock assessment: A manual of basic methods., *FAO Wiley series on food and agriculture*, *vol. 1*, Chichester, U. K. Wiley Interscience, 223 pp.

Gunderson, D. R. 1980. Using r-k selection theory to predict natural mortality. *Can. J. Fish. Aquat. Sci.,* 37(12): 2266-2271.

Jakubaviciute, E., Putys, Z., Dainys, J. and Lozys, L. 2011. Perch (*Perca fluviatilis*) growth, mortality and stock exploitation by 40-45 mm mesh-sized gillnet fishery in the Curonian Lagoon. *Acta Zool. Lituan*., 21(3): 215-220.

James, P. S. B. R., Chandrasekhara Gupta, T. R. and Shanbhogue, S. L. 1983. Some aspects of the biology of the ribbonfish *Trichiurus lepturus* Linnaeus. *J. Mar. Biol. Assoc. India*, 20(1&2): 120-137.

James, P. S. B. R., Narasimham, K. A., Meenakshi Sundaram, P. T. and Appanna Sastry, Y. 1986. Present status of ribbonfishes of India. *CMFRI Special Publication,* 24: 49 pp.

Khan, M. Z. 2006. Fishery resource characteristic and stock assessment of ribbonfish, *Trichiurus lepturus* (Linnaeus). *Indian J. Fish*., 53(1): 1-12.

King, M. 1995. *Fishery biology, assessment and management.* Oxford University Press, Oxford, U. K., 342 pp.

Kwok, K. Y. and Ni, I. H. 1999. Reproduction of cutlassfishes *Trichiurus* spp. from the south China Sea. *Mar. Ecol. Prog. Ser.,* 176: 39-47.

Lee, H. H. and Hsu, C. C. 2003. Population biology of the swimming crab, *Portunus sanguinolentus* in the waters off northern Taiwan. *J. Crust. Biol.,* 23 (3): 691-699.

Lovern, J. A. and Wood, H. 1937. Variations in the biochemical compositon of herring. *J. Mar. Biol. Assoc. U.K.*, 22: 281-293.

Mace, P. M. and Sissenwine, M. P. 1993. How much spawning per recruit is enough? In: Smith, S. J., Hunt, J. J. and Revered, D. (Eds.), Risk evaluation and biological reference points for fisheries management. *Canadian Special Publication of Fisheries and Aquatic Sciences,* National Research Council of Canada, p. 101-118.

Martins, A. S. and Haimovici, M. 2000. Reproduction of the cutlass fish, *Trichiurus lepturus* in the southern Brazil subtropical convergence ecosystem. *Scientia Marina*, 64: 97-105.

Narasimham, K. A. 1972. Occurrence of early juveniles of ribbonfish *Trichiurus lepturus* Linnaeus in the Kakinada area with notes on their food. *Indian J. Fish*., 19: 210-214.

Narasimham, K. A. 1976. Age and growth of ribbonfish *Trichiurus lepturus* Linnaeus. *Indian J. Fish*., 23: 174-182

Pauly, D. 1979. Theory and management of tropical multispecies stocks. A review with emphasis on the south-east Asian demersal fisheries. *ICLARM Stud. Rev.,* 1: 35 pp.

Pauly, D.1983a. Some simple methods for the assessment of tropical fish stocks. *FAO Fisheries Technical Paper,* 243: 52 pp.

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

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

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

Pauly, D. and Caddy, J. F. 1985. A modification of Bhattacharya's method for the analysis of mixtures of normal distributions, *FAO Fisheries Circular,* 781, Rome, Italy, 16 pp.

Pauly, D. and Soriano, M. L. 1986. Some practical extensions to Beverton and Holt's Relative Yield-Per-Recruit Model. In: Maclean, J. L., Dizon, L. B. and Hosillo, L. V. (Eds.), Proceedings of the first Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines, p. 491 - 495.

Pauly, D. 1987. A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic invertebrates. *ICLARM Conference Procedings,* 13: 7-34.

Randall, J. E. 1995. Coastal fishes of Oman. Crawford House Publishing Pty Ltd., Bathurst, New South Wales, Australia, 439 pp.

Reuben, S., Vijayakumaran, K., Achayya, P. and Prabhakar, R. V. D. 1997. Biology and exploitation of *Trichiurus lepturus* (Linnaeus) from Vishakhapatnam waters, *Indian J. Fish.*, 44: 101-110.

Ricker, W. E. 1975.Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board Can.,* 191: 382 pp.

Rohit, P., Rajesh, K. M., Sampathkumar, G. and Karamathulla Sahib, P. 2015. Food and feeding of ribbonfish *Trichiurus lepturus* Linnaeus off Karnataka, south-west coast of India. *Indian J. Fish.*, 62(1): 58-63.

Rosenberg, A. A. and Repestro, V. R. 1996. Precautionary management reference points and management strategies, Precautionary approach to fisheries - Part 2. *FAO Fisheries Technical Paper,* 350 (2): 129-140.

Silvestre, G. T. and Garces, L. R. 2004. Population parameters and exploitation rate of demersal fishes in Brunei Darussalam (1989-1990). *Fish. Res.,* 69 (1): 73-90.

Silvestre, G. T., Soriano, M. and Pauly, D. 1991. Sigmoid selection and the Beverton and Holt yield equation. *Asian Fish. Sci*., 4 (1): 85-98.

Sparre, P. and Venema, S. C. 1998. *Introduction to tropical fish stock assessment (Part-1 manual),* 306 (1), Rev. 2, 407 pp.

Thiagarajan, R., Lazaras, S., Sastry, Y. A., Khan, M. Z. and Kasim, H. M.1992. Stock assessment of the ribbonfish, *Trichiurus lepturus* (Linnaeus), from the Indian waters. *Indian J. Fish.,* 39: 82-94.

Thompson, W. F. and Bell, F. H. 1934. Biological statistics of the Pacific halibut fishery. Effect of changes in intensity upon total yield and yield per unit of gear. *Rep. Int. Fish. (Pacific halibut) Comm.,* 8: 49 pp.

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