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Population Dynamics and Fishery of Ribbonfish (*Trichiurus lepturus*) of Saurastra Coast

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Abstract

Ribbonfish fishery in Saurastra coast of Gujarat is majorly supported by *Trichiurus lepturus*. It is exploited by trawls and gillnets throughout the year with peak during September to December. The highest length of *T. lepturus* was found to be 125 cm with a mean length of 76.47 cm. The asymptotic length, growth coefficient, and age at zero length were 131.25 cm, 0.13 and -0.0777 years. The performance index was 3.35. Recruitment pattern was trimodal with peak during May to July. The smallest length of recruitment was 27 cm. The total, natural and fishing mortality was 0.44, 0.13 and 0.31. The exploitation ratio and rate of exploitation was 0.30 and 0.105. The annual total stock, biomass and MSY was 1,91,935 t, 1,55,277 t and 34,161 t, respectively. The yield and yield per recruit at present fishing effort was 23,682.5 t and 65.13 g. The study revealed that currently the ribbonfish at Saurastra coast of Gujarat is underexploited. The fishing pressure has to be increased by 120% from the present condition to get maximum yield and biomass.

Keywords: *Trichiurus lepturus*; Ribbon fish; Fishery; Population dynamics; Saurastra coast; Gujarat

Introduction

Ribbonfishes belong to the family Trichiuridae having long body resembling to that of a snake, but highly compressed and has a ribbon like body with silvery in colour and occurring abundantly in the Indian Ocean. *Trichiurus lepturus* occurs throughout tropical and temperate waters of the world, between latitude 60°N and 45°S [1]. Ribbonfishes are represented in the seas around India by eight well recognized species such as *T. lepturus*, *T. auriga, T. pantului, T. haumela, Lepturacanthus savala, L. gangeticus, Eupleurogrammus muticus, E. intermedius*. One of these, *T. lepturus* appears to be the only dominant species occurring all along the West and East coasts of India.

Ribbonfish (*T. lepturus*) represents an important group of food fish along the Saurashtra Coast. They form one of the major components of exploited marine fishery resources in Gujarat and have good domestic and export demand. The annual average catch of ribbonfish in Gujarat during 2002-2006 was 58,196 t, contributing 14% to the total marine landings. However in 2006 it was the single highest contributor (18%) to the marine fishery of the state. According to CMFRI [2], ribbonfishes accounted for nearly 31% of the pelagic fishery in Gujarat. Earlier fishery was confined to the coastal belt and was in the hands of traditional fishermen using artisanal gears operated from both motorized and non-motorized crafts, but now trawl net contributed 50% of the all India catch of ribbonfish [3], but now the fishery is confined to the depth zone shallower than 70 m. The resource is exploited by a variety of gears but the major contribution comes from multiday trawl-nets in the Saurashtra coast.

The present study aims to provide an insight into the fishery population characteristics and yield estimates of *T. lepturus* caught by trawlers at Saurastra coast. The results of the present study may thus help in devising strategies for managing the fishery of this particular resource at a healthy and sustainable level at Saurastra coast of Gujarat.

Material and Methods

Multi stage stratified random sampling design [4] was followed for estimating the monthly and annual catch of *T. lepturus* landed by trawlers at Saurastra coast of Gujarat. Every fortnight, a total of 50 specimens with minimum to maximum size ranges were collected from Saurastra coast during April 2008 to March 2009. Specimens were placed into insulated box with ice and brought to laboratory for analysis.

The Length – Weight relationships were estimated from the allometric formula proposed by Le Cren [5], separately for both the sexes and significant differences in the slopes of the regression lines for males and females were ascertained by ANACOVA [6].

$W = a L^b$ or $\log W = \log a + b \times \log L$

Where, W is total body weight (g), L is the total length (mm), a and b are the coefficients of the functional regression between W and L.

Von Bertalanffy growth parameters like asymptotic length (L∞) and growth co-efficient (K) was estimated using the ELEFAN I (Electronic Length Frequency Analysis) module of FiSAT software [7].

$$L_t = L\infty\,(1 - e^{-k\,(t-to)})$$

The growth performance index was calculated from final estimates of Asymptotic length (L∞) and Growth coefficient (K) [8] using the formulae:

$\text{Phi}\ (\text{Ø}) = \log K + 2 \log L\infty$

Where Phi (Ø) = growth performance index, L∞ = Asymptotic length,

K= Growth coefficient.

The age at zero length (t_0) was calculated from Pauly's empirical equation [9] given below:

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$$\log(-t0) = -0.392 - 0.275 \log L\infty - 1.0381 K$$

Where t_0 = age at zero length, L∞ = Asymptotic length, K = Growth coefficient.

Natural mortality (M) was calculated by Pauly's empirical formula [10], by taking the mean sea surface temperature as 27°C.

$$\ln(M) = -0.0152 - 0.279 \ln(L\infty) + 0.6543 \ln(K) + 0.463 \ln(T)$$

Where L∞ = Asymptotic length, K = Growth coefficient and T = Sea surface temperature

Total mortality (Z) was calculated from length converted catch curve using FiSAT software [11,12]. Fishing mortality (F) was estimated by Pauly [10] as

$$F = Z - M;$$

Where F = Fishing Mortality, Z = Total Mortality, M = Natural Mortality.

Length structured Virtual Population Analysis (VPA) of FiSAT was used to obtain fishing mortalities per length class. Exploitation ratio (E) and exploitation rate (U) were estimated from the equations [13,14]:

$$E = \frac{F}{Z}$$

Where F= Fishing Mortality, Z = Total Mortality, E = Exploitation ratio

$$U = \frac{F}{Z} x(1 - e^{-z})$$

Total stock (P) and biomass (B) were estimated from the ratios Y/U and Y/F respectively; where Y is the annual average yield in tons. Maximum sustainable yield was calculated by the equation for exploited fish stocks given by Gulland [15]:

$$MSY = Z \times 0.5 \times B;$$

Where Z= Total Mortality, B= Biomass.

The relative yield per recruit (Y/R) and biomass per recruit (B/R) at different levels of fishing mortality was estimated using LFSA package [16].

Results

Seasonal abundance

The seasonal abundance of *T. lepturus* revealed that post monsoon season i.e. September to December months were the most productive in terms of catch and catch rate at Saurastra coast. This was due to increase in the average fishing hours of trawlers during this season. The average monthly catch of *T. lepturus* was maximum in September (5228.4 t) and minimum in August (58.3 t). The catch rate was highest in August (29.13 kg/h) and lowest in February (5.61 kg/h). The average monthwise contribution of *T. lepturus* to the trawlers in Saurastra coast (Figure. 1) was higher during April to August (10.91% to 40.76%) and then there was a decreasing trend with the lowest contribution observed in January (5.93%).

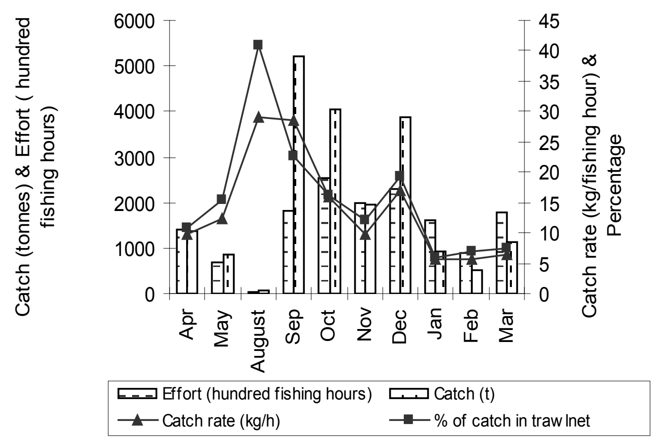

Figure 1: Month wise seasonal abundance of T. lepturus at Saurastra coast

Length composition

The higher mean lengths were recorded in the months of April (80.33 cm), October (85.08 cm) and December, 2008 (88.2 cm), while lower values were seen in November (69.65 cm) and May, 2008 (60.8 cm) (Figure. 2).The highest length of *T. lepturus* was found to be 125 cm during September, 2008.

Length weight relationship

A total of 1058 (464 males and 594 female) specimens in the length range of 52-119.9 cm were used for determining the length weight relationship separately for males and females.

Male: $\log W = -4.1851 + 3.54472 \log L$ (r = 0.94)

Female: $\log W = -4.4895 + 3.69923 \log L$ (r = 0.97)

Since there was no significant difference between the slopes at 5 % level, a combined relationship was obtained for males and females.

Combined: $\log W = -4.3256 + 3.61631 \log L$ (r = 0.96)

This study depicted that the slope of the regression equation for *T. lepturus* was significantly (5%) different from the isometric value of 3 indicating allometric growth for the species.

Growth parameters

The growth parameters, asymptotic length (L∞) and Growth coefficient (K) estimated using the ELEFAN I programme were 131.25 cm and 0.13. The growth performance index (Ø) was found to be 3.35 and t0 was calculated at -0.0777 years. The Von Bertalanffy growth equation was written as:

$$L_t = 131.25[1 - e^{-0.13(t+0.0777)}]$$

Accordingly the fish attained a size of 17.15 cm, 31.06 cm, 43.2 cm, 54 cm and 63.42 cm, respectively by the end of 1, 2, 3, 4 and 5 years. The length at first capture (Lc) was estimated at 32.04 cm (Figure. 3), which corresponds to an age (tc) of 2.07 year.

Recruitment pattern

The recruitment of *T. lepturus* indicated a trimodal pattern with one major peak during May – July and two minor peaks during January – February and October – November (Figure. 4). The major peak pulse on an average produced 40.89% (May – July) of the recruits. The smallest length of recruitment was found to be 27 cm. The highest recruitment was seen in June (16.42%) and lowest in April (5.02%).

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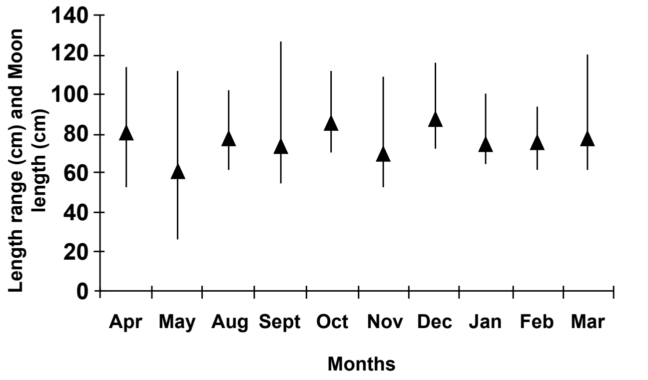
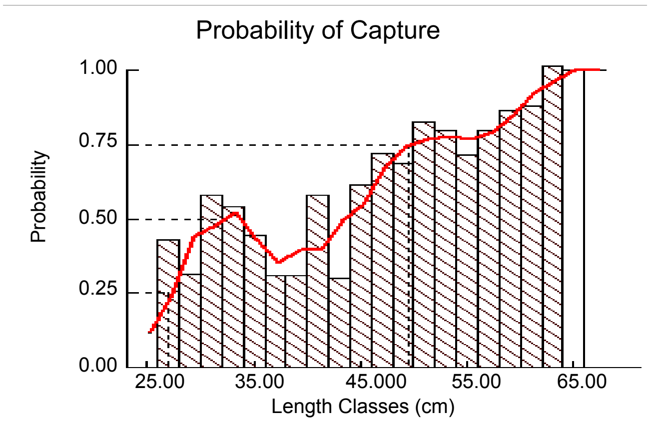
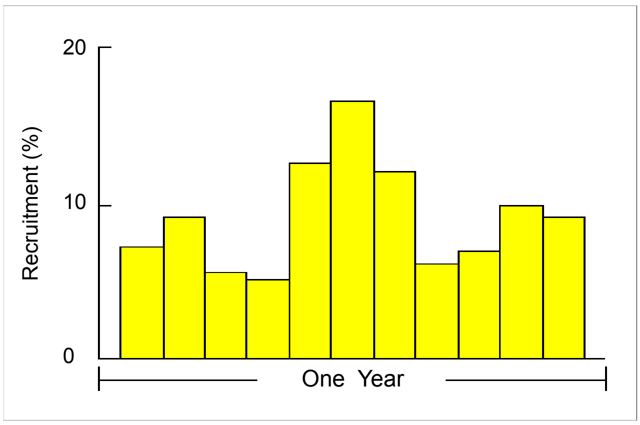


Figure 2: Length range and mean length of T. lepturus landed by trawlers at Saurastra coast



L∞ = 131.39 cm, K = 0.13 and t0 = -0.0777 years

Figure 3: Probability of capture of T. lepturus at Saurastra coast



L∞ = 131.39 cm, K = 0.13 and t0 = -0.0777 years

Figure 4: Annual recruitment pattern of T. lepturus at Saurastra coast

Mortality rates and exploitation

The Natural mortality (M), Fishing mortality (F) and Total mortality (Z) computed were 0.31, 0.13 and 0.44, respectively. The length converted catch curve utilized in the estimation of Z is represented in (Figure. 5).

The rate of exploitation (U) of *T. lepturus* was 0.105. The exploitation ratio (E) was 0.30, which was lower than the Emax of 0.486 obtained from the selection curve, indicating under exploitation of the *T. lepturus*.

Virtual Population Analysis (VPA)

The VPA (Figure. 6) indicated that main loss in the stock up to 61 cm size was due to natural causes. Fishes became more vulnerable to the gear after this size and mortality due to fishing increased eventually. Fishing mortality exceeded natural mortality at sizes of 107 cm and 111 cm. The maximum fishing mortality of 1.07 was recorded at size of 111 cm. The mean value for fishing mortality was 0.132 and the mean value for exploitation ratio was 0.3.

Estimation of stock and Msy

The annual total stock, biomass and MSY of *T. lepturus* estimated were 1,91,935 t, 1,55,277 t and 34,161 t, respectively.

Yield/Recruit

The yield and biomass/recruit and yield and biomass curves showed that the maximum yield and yield/recruit were obtained by increasing the present level of fishing by 120% (Figure 7 and 8). The maximum yield and yield per recruit that was obtained at 220% of the present fishing effort is 23,682.5 t and 65.13 g (Figure 7 and 8). At the present level of fishing, it is 20186 t and 55.52 g. At the increased effort, the increase in relative yield would be 17.32%. So to get optimum yield and yield per recruit, the present fishing effort has to be increase by 120% (Figure 9).

Discussion

Seasonal abundance

The post-monsoon period (September to December) was found to be the most productive in terms of catch and catch rate of *T. lepturus* at Saurastra coast coinciding with increased fishing activity during this period. The target oriented fishing for ribbonfishes coupled with improvement in the operating efficiency of trawl nets resulted in higher catches and catch rates of *T. lepturus*. The multiday trawlers conduct voyage fishing lasting for 4 – 12 days at depth of 30 – 60 m for *T. lepturus*. James et al. [17] reported the availability of this resource in waters at depths between 25 and 75 m. In the recent past, specially designed nets targeted to catch ribbonfishes have been implemented by the local fishermen owning multiday trawlers. The nets possess large meshed cod end (4 cm to 6 cm) and have large mesh openings in the wing sections of the trawl (45 – 60 cm) which helped to reduce the drag resistance and increased the catch rate by decreasing the hours expended in fishing. This target oriented fishing for ribbonfishes also explains the increasing contribution of *T. lepturus* to the trawl landings. Moreover, the injudicious removal of large quantum of fishes, which include competitors of ribbonfish by intensive fishing over the last decade might have created favorable conditions for *T. lepturus* to proliferate. The decrease in effort of trawls over the years is mainly because of switching over to target fishing for ribbonfishes and cephalopods coupled with several other socio-economic factors like labor problem, hike in fuel price, etc.

At Saurastra, protection is provided to the fishery resources during June – August when fishing is suspended for the monsoon, which has contributed to the usually high catch and catch rates in the post monsoon season. The seasonal fluctuations in the catch are an inherent feature of this fishery and are due to several biotic and abiotic factors

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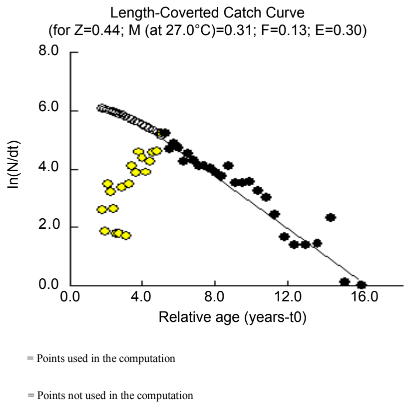

Figure 5: Length converted catch curve of T. lepturus at Saurastra coast

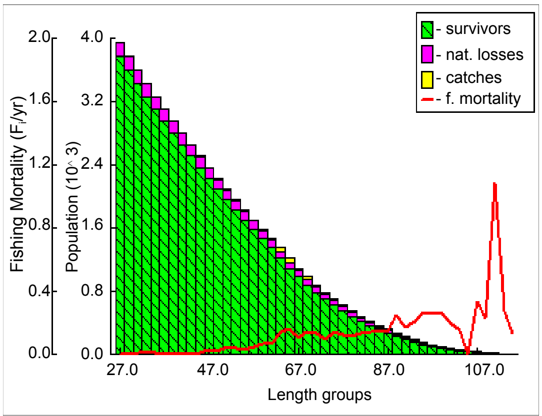

Figure 6: Length structured VPA of T. lepturus at Saurastra coast

viz., environmental parameters, fishing intensity, fishing techniques, changes in the fishing pattern, fishing ground, food availability, spawning success, etc.

Length composition

In the present study the mean sizes of *T. lepturus* recorded in the present study were considerably higher than 52.1 cm recorded for the same species from Kakinada [18]. Narasimham [13,14], from the waters of Kakinada stated that for *T. lepturus* the annual length composition ranged from 22 to 94 cm with a dominant mode at 42 cm.

Length weight relationship

The combined length-weight relationship showed that *T. lepturus* exhibited allometric growth. Similar results on length-weight relationship were reported by Narasimham [19-21] from Kakinada. However, higher b values individually for male and female were recorded in the present study as compared to Reuben et al. [22] and Abdurahiman et al. [23], who reported b values of 3.246 (male) and 3.299 (female) and 2.819 (male) and 3.029 (female) from Visakhapatnam and southern coast of Karnataka, respectively. This variation is possibly due to factors related to ecosystem and biological phenomena like maturity stages, feeding behaviour, competition for food, etc. Kwok and Ni [1] reported lower b values of 2.571 for males and 2.549 for females. Narasimham [20] reported b values of *E. muticus* to be 3.556 for males and 3.485 for females. The higher proportion of females among larger ribbonfishes was observed in the growth studies of Martins and Haimovici [24] and Munekiyo and Kuwahara [25].

Growth parameters

The present estimate of L∞ (131.25 cm) is higher than that reported by Misu [26] from East China and Yellow Sea (45.5 cm), Ingles and Pauly [27] from Philippines (78 cm), Somvanshi and Joseph [28] from north-west coast of India (109 cm), Chakraborty [29] from Bombay (129.7 cm), Reuben et al. [22] from Visakhapatnam (106.83 cm) and Thiagarajan et al. [3] from east and west coast (129 cm, 126 cm), Abdussamad et al. [2] from Kakinada (128.2 cm). However, Narasimham [20,13] recorded much higher values of L∞ (145.2 cm, 138.1 cm) from Kakinada waters and Dawson [30] (152.4 cm) from Gulf of Mexico.

The growth coefficient of 0.13 per year in the present study is nearly comparable to Narasimham [20,21]), but much higher values of growth coefficient ranging from 0.5 to 0.72 were reported by other authors [18,22,27-29].

The growth performance index (Ø) was 3.35 in the present study which is less when compared to earlier published reports of Narasimham [20] (3.786); Ingles and Pauly [27] (3.629); Somvanshi and Joseph [28] (3.881); Chakraborty [29] (3.928) and Reuben et al. [22] (3.844), as also the value of t_0. The results showed that the maximum growth rate in length was observed during the 2nd year of life but after which the annual increment decreased with increasing age. The fishery at Saurastra coast was represented mostly by fishes of one to four year classes, as also observed from Visakhapatnam by Reuben et al. [22].

The length at first capture of 32.04 cm was higher than that reported by Narasimham [21] but lower than 40.9 cm and 42 cm reported by Abdussamad et al. [18] from Vishakhapatnam and Narasimham [13,14] from Kakinada waters. The length at first capture was very low indicating that majority of them were caught before they matured and spawned at least once in their life. This indicated stress on spawning stock and could be addressed by enhancing their size and age at

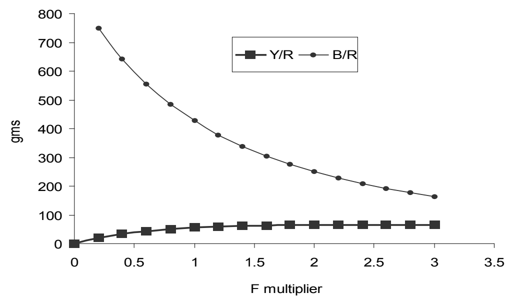

Figure 7: Yield per recruit and biomass per recruit of T. lepturus for different multiples of F

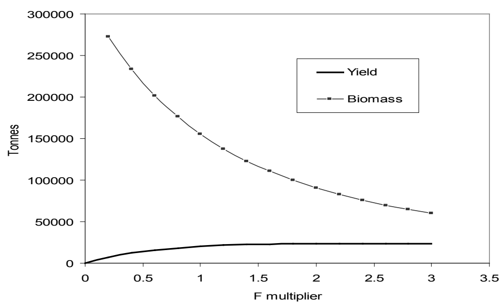

Figure 8: Yield and biomass of T. lepturus for different multiples of F

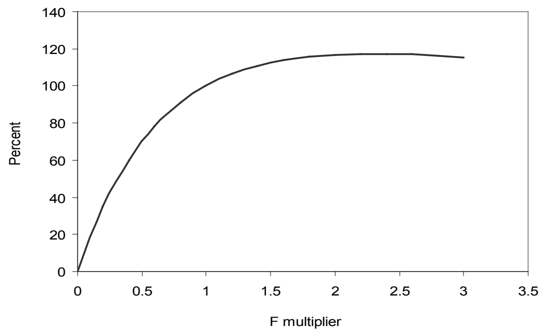

Figure 9: Relative yield percentage of T. lepturus for different multiples of F

exploitation, which meant that increase in mesh size of gears is required to avoid the young fishes.

Mortality rates and exploitation

Beverton and Holt [31] pointed out that the natural mortality coefficient of a fish is directly related to the growth coefficient (K) and inversely related to the asymptotic length (L∞). The natural mortality was 0.31 per year in the present study. Various authors have reported natural mortality as 0.9 [21], 1.08 [27], 0.8 [28], 1.05 [29], 1.0 [3], 0.89 [22], 0.7 [32] and 0.98 [18] for *T. lepturus*.

The fishing mortality was 0.13 for *T. lepturus* in the present study which was too low when compared to that of Reuben et al. [22] (1.524), Abdussamad et al. [18] (3.34), Chakraborty [29] (0.91) and Somvanshi and Joseph [28] (0.99). The exploitation ratio observed was 0.3 which was an indication of low intensive fishing of this species. However, Chakraborty [29] recorded an exploitation ratio of 0.46 for the species from Bombay and Abdussamad et al. [18] recorded an exploitation ratio of 0.77 from Kakinada while Reuben et al. [22] recorded an exploitation ratio of 0.63 from Visakhapatnam which was higher when compared to the present study. It is evident from the results that since the value of E were lower than the E_{max} and MSY higher than the annual catch, the stock is under less fishing pressure than the sustainable level warranting immediate increase in fishing effort.

In the present study, the rate of exploitation (U) of *T. lepturus* was 0.105 which is near to the rate of Narasimham, [21] from Kakinada waters (0.17). However, higher values of exploitation rate were reported by Chakraborty [5] (0.39) and Mohite [32] (0.66) from Mumbai waters, Narasimham [13,14] (0.82) from Kakinada waters, Reuben et al. [22] (0.5741) from Visakhapatnam.

Growth and mortality parameters of ribbonfish by various Indian and foreign authors from different study areas of the world are given in (1 and 2).

Virtual Population Analysis (VPA)

Khan [33] reported that the biomass and yield of *T. lepturus* from Mumbai waters was 46,000 t and 60,000 t. In the present study the annual total stock, biomass and MSY of *T. lepturus* estimated were 1,91,935 t, 1,55,277 t and 34,161 t, respectively. This shows lower yield and higher biomass compared to Khan [33].

The yield per recruit of 55.52 g obtained in the present study for *T. lepturus* was lower than 74.6 g reported by Abdussamad et al. [18] but higher than 23 g reported by Narasimham [21] from Kakinada waters.

The yield/recruit and yield curves depicted that the stock was subjected to under fishing with respect to its optimum fishing effort. Hence to get maximum yield and biomass, the fishing pressure has to be increased by 120% from the present condition.

Author	L∞ (cm)	K (annual)	t_o (years)	Z	M	F	U	E
Narasimham [13,14]	138.1			3.16	0.4	2.7	0.82	
Chakraborty et al. [34]	148	0.4						
Reuben et al. [22]	106.83	0.6117	-0.1399	2.417	0.8934	1.5236	0.5741	0.6304
Mohite & Biradar [32]	128	0.5	-0.009	2.66	0.77	1.89	0.66	0.71
Rizvi et al., [35]								
L. savala	68.6	0.87	0.000251	4.15	1.3	2.86	0.73	0.68
E. muticus	81.1	0.78	0.00544	2.66	0.77	1.89	0.66	0.71
Khan [33]	127.3	0.67		3.47		3.232		0.756
Abdussamad et al., [18]	128.2	0.72	-0.003					
Present study	131.25	0.13	0.215	0.44	0.31	0.13	0.105	0.3

L∞ (cm) = Asymptotic Length, K (annual) = Growth coefficient, t_o (years) = Age at Zero length, Z = Total Mortality, M = Natural Mortality, F = Fishing Mortality, E = Exploitation ratio, U = Exploitation rate

Table 1: Growth and Mortality parameters of ribbonfish by various Indian Authors

Author	Study Area	L∞ (cm)	K(annual)	t_o (years)
Chen & Lee [36]	Taiwan			
Males		50.2	0.271	-0.22
Females		55	0.289	-0.76
Ingles & Pauly [27]	Philippines	78	0.7	
Wu et al. [37,38]	East China Sea	53.32	0.2928	-0.6806
Du et al. [39]	China	47.74	0.292	-0.634
El-Haweet & Ozawa [40]	Japan			
Males		48.1	0.216	-1.975
Females		62	0.167	-1.791
Kwok and Ni [1]	South China Sea	58.9	0.168	-2.682
Present study		131.25	0.13	0.215

L∞ (cm) = Asymptotic Length, K (annual) = Growth coefficient, to (years) = Age at Zero length

Table 2: Growth parameters of ribbonfish from different study areas of the world

References

1. Kwok KY, Ni IH (2000) Age and growth of cutlassfishes, Trichiurus spp., from South China Sea. Fish Bull (Wash D C) 98: 748-758.
2. CMFRI (2007-2008) Annual Report. Central Marine Fisheries Research Institute, Kochi, India.
3. Thiagrajan R, Lazaras S, Sastry YA, Khan MZ, Kasim HM, et al. (1992) Stock assessment of the ribbonfish, Trichiurus lepturus (Linnaeus), from the Indian waters. Indian J Fish 39: 182-194.
4. Srinath M, Kuriakose S, Mini KG (2005) Methodology for estimation of marine fish landings in India. Fishery Resources Assessment Division, Central Marine Fisheries Research Institute, India.
5. Le Cren ED (1951) The length weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). J Anim Ecol 20: 201-219.
6. Snedecor GW, Cochran WG (1967) Statistical Methods. Iowa State University Press, UK.
7. Gayanilo FC, Sparre P, Pauly D (1996) The FAO-ICLARM Stock Assessment Tools (FiSAT) User's Guide. FAO computerized information series (Fisheries).
8. Pauly D, Munro JL (1984) Once more, on the composition of growth in fish and invertebrates. Fish byte.
9. Pauly D (1979) Theory and management of tropical multi-species stocks. A

review with emphasis on the South-east Asian demersal fisheries. ICLARM Studies.

10. Pauly D (1980) On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J Cons Int Explor Mer 39: 175-192.
11. Pauly D (1983) Some simple methods for the assessment of tropical fish stocks. Food & Agriculture Org, Italy.
12. Pauly D (1983) Length converted catch curves. A powerful tool for fisheries research in tropics (Part-1). ICLARM Fishbyte.
13. Narasimham KA (1994) Fishery and population dynamics of the ribbon fish Trichiurus lepturus Linnaeus off Kakinada. J Mar Biol Ass India 36: 23-27.
14. Narasimham KA (1994) Maturity, spawning and sex ratio of the ribbonfish Trichiurus lepturus Linnaeus off Kakinada. J Mar Biol Ass India 36: 199-204.
15. Gulland JA (1979) Report of the FAO/UNDP workshop on the fishery resources of the Western Indian Ocean - South Equator.
16. Sparre P (1987) Computer programming for fish stock assessment: Length based fish stock assessment (LFSA) for Apple II computers. Food and Agriculture Organization of the United Nations, Italy.
17. James PSBR, Narasimham KA, Meenakshi Sundaram PT, Appanna Sastry Y (1986) The present status of ribbonfish fishery in India. CMFRI Special Publication, india.
18. Abdussamad EM, Nair PNR, Achayya P (2006) The ribbonfish fishery and stock assessment of Trichiurus lepturus Linnaeus off Kakinada, east coast of India. J Mar Biol Ass India 48: 41-45.
19. Narasimham KA (1972) Occurrence of early juveniles of ribbonfish Trichiurus lepturus Linn. in the Kakinada area with notes on their food. Indian J Fish 19: 210-214.
20. Narasimham KA (1976) Age and growth of ribbonfish Trichiurus lepturus Linnaeus. Indian J Fish 23: 174-182.
21. Narasimham KA (1983) On fishery, mortality rates and yield per recruit of ribbonfish Trichiurus lepturus Linnaeus. Indian J Fish 30: 99-109.
22. Reuben S, Vijayakumaran K, Achayya P, Prabhakar RVD (1997) Biology and exploitation of Trichiurus lepturus Linnaeus from Visakhapatnam waters. Indian J Fish 44: 101-110.
23. Abdurahiman KP, Harishnayak T, Zacharia PU, Mohamed KS (2004) Length-weight relationship of commercially important marine fishes and shellfishes of the southern coast of Karnataka, India. NAGA, World Fish Center Quarterly 27: 9-14.
24. Martins AS, Haimovici M (2000) Reproduction of the cutlassfish Trichiurus lepturus in the southern Brazil subtropical convergence ecosystem. Sci Mar 64: 97-105.
25. Munekiyo M, Kuwahara A (1988) Maturity and spawning of ribbon fish in the western Wakasa Bay. Bull Jpn Soc Sci Fish 54: 1315-1320.
26. Misu H (1958) Studies on the fisheries biology of the ribbon fish Trichiurus lepturus in the East China and Yellow Seas. 1. On the age and the growth. Bull. Seikai Reg.
27. Ingles J, Pauly D (1984) An atlas of the growth, mortality and recruitment of Philippine fishes. The WorldFish Center, Malaysia.
28. Somavanshi VS, Joseph A (1989) Population dynamics and assessment of Trichiurus lepturus (Linnaeus) stock in north-west coast of India. In: Studies on fish stock assessment in Indian waters: Special Publication No. 2. Fishery Survey of India, India.
29. Chakraborty SK (1990) Fishery, age, growth and mortality estimates of Trichiurus lepturus Linnaeus from Bombay waters. Indian J Fish 37: 1-7.
30. Dawson CE (1967) Contribution to the biology of cutlassfish (Trichiurus lepturus) in the northern Gulf of Mexico. Trans Am Fish Soc 26: 117-121.
31. Beverton RJH, Holt SJ (1959) 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, Wolsenholmy GEW and O'Connor M (Eds). Little Brown, London.
32. Mohite A, Biradar RS (2001) Mortality estimation of Indian ribbonfish Trichiurus lepturus (Linnaeus) off Maharashtra coast. Indian J Fish Assoc 28: 23-29.
33. Khan MZ (2006) Fishery resource characteristics and stock assessment of ribbonfish, Trichiurus lepturus (Linnaeus). Indian J Fish 53: 1-12.
34. Chakraborty SK, Deshmukh VD, Khan MZ, Kuber VD, Raje SG (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.
35. Rizvi AF, Biradar RS, Chakraborty SK, Deshmukh VD (2005) Estimation of mortality rates, exploitation rates and ratios of Lepturacanthus savala (Cuvier) and Eupleulogrammus muticus (Gray). Indian J Fish 52: 93-98.
36. Chen W, Lee S (1982) Age and growth of the ribbonfishes Trichiurus (Perciformes: Trichiuridae) of Taiwan. Bull Inst Zool, Academia Sinica 21: 9–20.
37. Wu H, Cheng G, Wang J (1985) A study of the ageing of hairtails, Trichiurus haumela (Forskal). Oceanol Et Limnol Sinica 16: 408–416.
38. Wu H, Cheng G, Zhou J, Wang J (1985) Study of the growth of the hairtails, Trichiurus haumela (Forskal). Oceanol Et Limnol Sinica 16: 156–167.
39. Du JR, Li FZ, Lin SD, Zhang QD (1988) On age and growth of hairtail, Trichiurus haumela (Forskal) in western Taiwan Strait. J Oceanogr Taiwan Strait 7: 339–346.
40. El-Haweet AE, Ozawa T (1996) Age, growth of ribbon fish Trichiurus japonicus in Kagoshima Bay, Japan. Fish Sci 62: 529–533.