Indian J. Fish., 61(2) : 14-18, 2014

Population dynamics of *Trichiurus lepturus* (Linnaeus, 1758) off Veraval

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ABSTRACT

Population dynamics of the ribbonfish, *Trichiurus lepturus*, was studied from April 2008 to March 2009 along Veraval coast (lat. N 20°54'912'' and long. E 70°21'355''). Ribbonfishes are exploited mostly by trawls throughout the year with peak catch from September to December. The mean length of *T. lepturus* in trawls was 76.47 cm. The asymptotic length, growth coefficient and age at zero length were 131.25 cm, 0.13 and -0.0777 years, respectively. The growth performance index was 3.35. Recruitment pattern was trimodal with peak during May to July. The length of recruitment was 27 cm. Total, natural and fishing mortalities were 0.44, 0.13 and 0.31. The exploitation rate and ratio of exploitation were 0.30 and 0.105. The annual total stock, biomass and MSY were 1,91,935 t, 1, 55,277 t and 34,161 t, respectively. Yield and yield per recruit at present fishing effort were 23,682.5 t and 65.13 g, indicating the ribbonfish stock along Veraval coast is underexploited. The fishing pressure can be increased by 120% to obtain maximum yield and biomass.

Keywords: Fishery, Population dynamics, Ribbonfish, *Trichiurus lepturus*, Veraval

Introduction

Ribbonfish, *Trichiurus lepturus* (Linnaeus, 1758) represents an important group of commercially important fish along the Saurashtra coast and forms one of the major components of exploited marine fishery resources in Gujarat, having good domestic and export demand. The contribution of *T. lepturus* in Gujarat increased from 55,500 t in 2003 to 90,000 t in 2006 (Mohanraj *et al*., 2009). Annual average catch during 2002-2006 was 58,196 t, contributing 14% to the total marine fish landings (Mohanraj *et al*., 2009). In 2006, it was the single highest contributor (18%) to the marine fishery of the state. At Veraval during the same period, the annual average catch was 18,813 t forming 27.6% of the trawl catches (Ghosh *et al*., 2009). The fishery was earlier confined to the coastal belts and was in the hands of traditional fishermen using artisanal gears operated from both motorised and non-motorised crafts, but now the fishery has spread to deeper zones. The resource is exploited by a variety of gears but the major contribution comes from multiday trawl nets operated along the Saurashtra coast. Although there is published information available on the yield and mortality parameters, length-weight relationship and population dynamics of *T. lepturus* from Veraval waters (Ghosh *et al*., 2009), the extension in each season in the vertical and horizontal fishing grounds of trawlers targeting ribbonfishes will have an impact on their population parameters. This necessitated the present study to be conducted on the population dynamics of *T. lepturus* from Veraval.

Materials and methods

Data on catch and effort were collected weekly from the landings of commercial trawlers at Veraval from April 2008 to March 2009. The monthly and annual estimates of catches were made following the methodology adopted by the Fishery Resources Assessment Division of Central Marine Fisheries Research Institute, India (Srinath *et al*., 2005). A total of 1008 specimens (464 males and 544 females in the length range of 52-119.9 cm were used for recording total length (cm) and body weight (g). The length – weight relationship was estimated using the formula $W=aL^b$ (Le Cren, 1951), separately for both the sexes and significant differences in the slopes of the regression lines for males and females were ascertained by ANCOVA (Snedecor and Cochran, 1967). Asymptotic length (L_∞) and growth co-efficient (K) were estimated using the ELEFAN I (Electronic Length Frequency Analysis) module of

FiSAT software (Gayanilo *et al*., 1996). Growth and age were estimated using the von Bertalanffy growth equation, $L_t = L_\infty (1–e^{–k(t-to)})$. Growth performance index was calculated using the formulae given by Pauly and Munro (1984). The age at zero length (t_0) was calculated from Pauly's empirical equation (Pauly, 1979). Natural mortality (M) was calculated by Pauly's empirical formula (Pauly, 1980), taking the mean sea surface temperature as 27 ^{0}C. Total mortality (Z) was calculated from length converted catch curve using FiSAT software (Pauly, 1983). Fishing mortality (F) was estimated as: F = Z – M (Pauly, 1980). Length structured virtual population analysis (VPA) of FiSAT was used to obtain fishing mortalities per length class. Exploitation rate (E) and exploitation ratio (U) were estimated using the equations E = F/Z and U = F/Z (1-e^{-z}) (Narasimham, 1994).

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 as MSY = Z x 0.5 x B (Gulland, 1979), The relative yield per recruit (Y/R) and biomass per recruit (B/R) at different levels of fishing mortality was estimated using LFSA package (Sparre, 1987).

Results

Seasonal abundance

Monthly catch of *T. lepturus* at Veraval revealed post-monsoon season *viz*., September to December, to be the most productive in terms of catch and catch rate. 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^{-1}) and lowest in February (5.61 kg h^{-1}). The average month-wise contribution of *T. lepturus* to the trawl landings in Veraval (Fig. 1) was higher during April to August (10.91% to 40.76%), followed by a decreasing trend with the lowest contribution observed in January (5.93%).

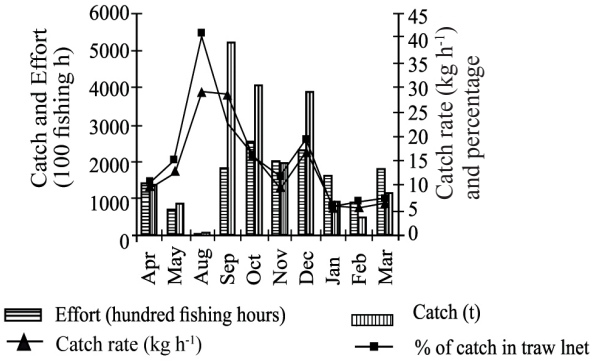

Fig. 1. Seasonal abundance of *T. lepturus* at Veraval

Length composition

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). Maximum length recorded was 125 cm during September, 2008.

The length weight relationship estimated separately for males and females were:

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 ($p>0.05$), a common relationship was obtained for males and females:

log W = -4.3256 + 3.61631 log L (r = 0.96)

The slope of the regression equation was significantly different from the isometric value of 3 ($p<0.05$) indicating allometric growth for the species.

Growth

Growth parameters, L_∞ and K estimated were 131.25 cm and 0.13. The growth performance index (Ø) was found to be 3.35 and t_0 was calculated at -0.0777 years. The von Bertalanffy growth equation was written as:

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

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

Recruitment

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. The major peak pulse on an average produced 40.89% (May-July) of the recruits. The length of recruitment was found to be 27 cm. Maximum recruitment was seen in June (16.42%) and minimum in April (5.02%).

Mortality

Natural mortality (M), fishing mortality (F) and total mortality (Z) computed were 0.31, 0.13 and 0.44, respectively. The ratio of exploitation (U) was 0.105. The exploitation rate (E) was 0.30, which was lower than the E_{max} of 0.486 obtained from the selection curve, indicating under exploitation. The VPA (Fig. 2.) indicated that major 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 and 111 cm. Maximum fishing mortality of 1.07 was recorded at size of 111 cm.

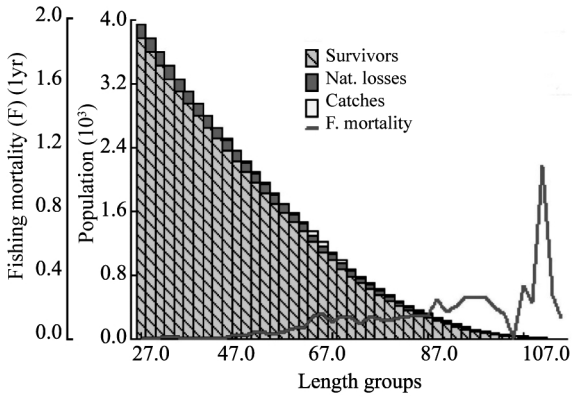

Fig. 2. Length structured VPA of *T. lepturus* at Veraval

Stock, MSY and Yield

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. The yield and biomass per recruit (Fig. 3) and yield and biomass curves (Fig. 4) showed that the maximum yield (23,682.5 t) and yield/recruit (65.13 g) could be obtained by increasing the present level of fishing by 120%. and at the present level of fishing, Y and Y/R were 20,186 t and 55.52 g. With increased effort, the increase in relative yield would be 17.32%.

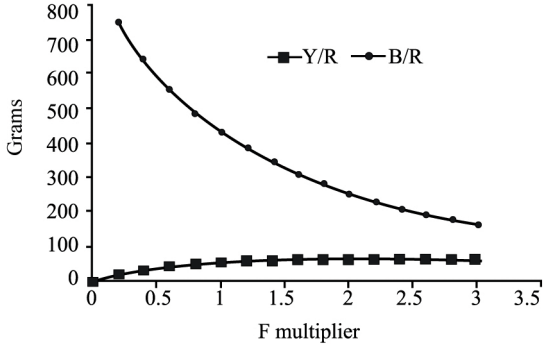

Fig. 3. Yield per recruit and biomass per recruit of *T. lepturus* for different multiples of F

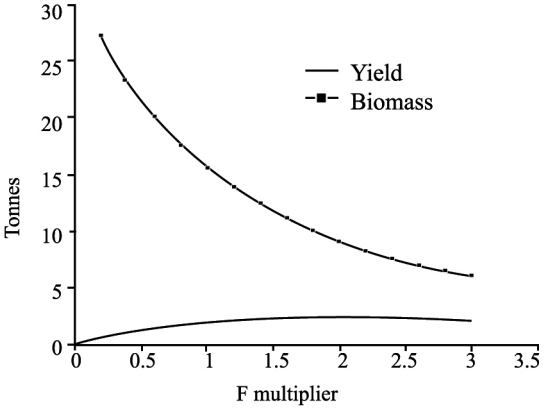

Fig. 4. Yield and biomass of *T. lepturus* for different multiples of F

Discussion

Targeted fishing for ribbonfishes coupled with improvement in the operating efficiency of trawl nets has resulted in higher catches and catch rates of *T. lepturus* in recent years. 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 Veraval coinciding with increased fishing activity during this period. Suspension of trawl fishing along the coast during June-August (monsoon trawl ban) also probably contributes to the high catch and catch rates during the post-monsoon season. Multiday trawlers conduct fishing voyages for 4-12 days at depths of 30-60 m for *T. lepturus*. James *et al*. (1986) 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 ribbon fishes have been implemented by the local fishermen owning multiday trawlers. The nets possess large meshed cod end (4 to 6 cm) and have large mesh openings in the wing sections of the trawl (45-60 cm) which help to reduce drag resistance and increase the catch rate by decreasing the hours expended in fishing. This target oriented fishing for ribbon fishes also explains the increasing contribution of *T. lepturus* to the trawl landings.

The mean size of *T. lepturus* recorded in the present study was higher than that reported earlier for the same species from the same waters (Ghosh *et al*., 2009). The combined length-weight relationship showed that *T. lepturus* exhibited allometric growth. This correlates well with the results of Ghosh *et al*. (2009) and Narasimham (1972; 1976; 1983) from Veraval and Kakinada waters. However, higher b values individually for male and female were recorded in the present study as compared to Reuben *et al*. (1997) and Abdurahiman *et al*. (2004), 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 may be due to factors related to ecosystem and biological phenomena like maturity stages, feeding behaviour and competition for food. The higher proportion of females among larger ribbon fishes was observed in the growth studies of Martins and Haimovici (2000) and Munekiyo and Kuwahara (1988).

The present estimate of L_∞ (131.25 cm) is similar to 134.1 cm reported by Ghosh *et al*. (2009) from Veraval, 128.2 cm reported by Abdussamad *et al*. (2006) from

Kakinada, 129.7 cm reported by Chakraborty (1990) from Bombay and 129 cm and 126 cm reported by Thiagarajan *et al*. (1992) from east and west coasts. However, lower values of 109 cm and 106.83 cm were reported by Somvanshi and Joseph (1989) from north-west coast of India and Reuben *et al*. (1997) from Visakhapatnam and higher values of 145.2 cm and 138.1 cm were recorded by Narasimham (1976, 1994) from Kakinada waters. The growth coefficient of 0.13 per year is nearly comparable to Narasimham (1976, 1983), but much higher values of growth coefficient ranging from 0.29 to 0.72 were reported by others (Somvanshi and Joseph, 1989; Chakraborty, 1990; Reuben *et al*., 1997; Abdussamad *et al*., 2006; Ghosh *et al*., 2009). The growth performance index was less when compared to the reports of Narasimham, 1976 (3.786); Somvanshi and Joseph, 1989 (3.881); Chakraborty, 1990 (3.928); Reuben *et al*., 1997 (3.844) and Ghosh *et al*., 2009 (3.717), as also the value of t_0. The results showed that the maximum growth rate in length was observed during the 1st year of life after which the annual increment decreased with increasing age.

Beverton and Holt (1956) 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 same appeared to be true for *T. lepturus* which had low growth coefficient of 0.13 per year, high asymptotic length of 134.1 cm and relatively low natural mortality co-efficient of 0.31 per year. The M/K ratio (2.38) obtained in the present study was well within the normal range of 1-2.5, as suggested by Beverton and Holt (1959). The present exploitation rate of 0.3 indicates that *T. lepturus* is underexploited and can be subjected to judicious increase in fishing pressure to obtain maximum sustainable yield.

Acknowledgements

The authors express their gratitude to Indian Council of Agriculture Research for financing this study and to Junagadh Agricultural University for facilitating the same.

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Date of Receipt : 26-03-2013

Date of Acceptance : 03-12-2013