ON FISHERY, MORTALITY RATES AND YIELD PER RECRUIT OF RIBBONFISH *TRICHIURUS LEPTURUS* LINNAEUS

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ABSTRACT

The months of abundance for *Trichiurus lepturus*, forming 61.2 to 95.3% of the ribbonfish catches, are October to December with minor peaks in April-May and July-August. Majority of the fish caught belonged to the '0' age group and fish older than 3 years are scarce in the commercial catches.

Based on the data for 1967-71, the instantaneous total mortality coefficient, Z, was estimated at 1.2 from the average catch curve with boatseine as standard gear. Instantaneous coefficient of natural mortality, M, was estimated as 0.9. The yield-in-weight-per-recruit values were computed at various levels of fishing mortality rates and ages of exploitation by the simple Beverton and Holt model, as modified by Jones, at three different levels of natural mortality rates, M = 0.7, 0.9 and 1.1. This study clearly showed that even at the young age of exploitation (Tpl = 0.3 years) the ribbonfish population is underfished and there is considerable scope to increase the yield by stepping up the fishing effort.

INTRODUCTION

Along the Andhra coast the ribbonfishes are an important group of food fishes, and during 1962-74, with an average annual catch of 6090 tonnes, they formed 7.3% of the total marine fish landings (Silas et al 1976). Among them *Trichiurus lepturus* Linnaeus is the most dominant species. In this paper are presented the data on the fishery of this species from the Kakinada area together with estimates of mortality rates and yield per recruit.

MATERIAL AND METHODS

Material was collected from 3 landing centres, Dummulapeta, Uppada, and Kakinada fishing harbour, for varying periods during 1966 to 1973. From the Dummulapeta and Uppada, three types of units, namely, shoreseines, boatseines and gillnets are operated; and the crafts used are non-powered catamaran and the plank-built Kakinada nava. From Kakinada fishing harbour, 3 types of commercial trawlers, namely, Pablo (9.14 m, 20-30 H.P. engine, 11.89 and 12.95 m two-seam cotton trawl), Pomfret|Royya (9.75-10.0 m, 45-60 H.P. engine, 14.94, 16.5 and 18.29 m two-seam cotton trawl), and Sorrah (11.41

m, 60-75 H.P. engine, 14.94, 16.5 and 18.29 m two-seam cotton trawl), conducted daily fishing, going out in the morning and returning to Kakinada base in the evening. Further details of these trawlers and their gear are given by Muthu et al (1977). From January 1967 to March 1968 the catch and effort data of the trawlers were collected, treating them as a single type of unit, as the commercial trawl fishing at Kakinada was in formative stages and the vast majority of the units were pablos. In fact, up to 1972, the pablo units accounted for over 50% of the total trawl units. From April 1968 onwards, the catch and effort data were collected separately for each type of trawler. All the fishing units from the 3 landing centres conducted operations off Kakinada (Latitude 16°-30′ to 17°-25′N and Longitude 82°-20′ to 83°E) in 5-50 m depth range. The non-powered craft usually fished in less than 25 m depth.

Weekly or biweekly observations were made at all the 3 landing centres. On each observation day, data on total fish catch, specieswise ribbonfish catch and the effort expended were recorded for 20 to 100% of the fishing units landed. From these data monthly and annual catch estimates were made. For brevity, these data are given in table 1-3 on annual basis. On each observation day 25-50 numbers of *T. lepturus*, depending upon their availability, were measured for total length, and their weight recorded for each type of unit. These numbers were raised in relation to the catch to get the observation-day's total. By raising the sampling-day's length-frequency distribution, the monthly and annual size composition in numbers were obtained for each type of unit. The effort was standardised on annual basis in terms of 10 boatseine units since the ribbonfishes predominate the catches landed by this gear. The absence of data separately for each type of trawler unit for part of the study period rendered it difficult to standardise the effort of trawlers by a consideration of the efficiency factors of these units. However, it was observed that the standard effort, obtained by dividing the total catch of *T. lepturus* landed by all types of units by the annual average catch per unit effort of boatseines, was the same as calculated by taking the efficiencies of different trawl units for 1969, 70 and 71. For this reason the catch and effort data of different trawlers were pooled on annual basis and showed as a single type of unit.

The length-frequency data collected during 1967-71 alone were used in the estimation of mortality rates due to nonavailability of data for different types of fishing units in other years. The annual size compositon of the catches for standard effort was converted into age composition based on the age estimation arrived at by the present author (Narasimham 1978). As the number of fish surviving beyond the third year are few, they were added to the 'III' age group and indicated as III age group. The total instantaneous mortality coefficient Z was estimated from the average catch curve (Ricker 1975).

The mathematical model used

The logarithmic length-weight relationship, obtained from the author's (Narasimham 1972) data for both the sexes combined for *T. lepturus*, is:

$$\text{Log } W = -4.0197 + 3.4637 \text{ Log } L$$

Where W = weight in grams and L = length in cm. The regression coefficient was tested and it was found to be significantly different from 3. Hence, the following Beverton and Holt (1957) equation as modified by Jones (1957) was preferred, as growth in weight in relation to length in *T. lepturus* is not isometric.

$$Y_W = \frac{K}{F} R' W_\infty \; e^{Z(T_{pl}-T_o)} \left[B(X, P, Q) - B(X1, P, Q) \right]$$

Where Y_w = yield in weight; F = instantaneous fishing mortality coefficient; Z = instantaneous total mortality coefficient; K, T_o anb W_∞ are the parameters in von Bertalanffy growth equation; R' = number of recruits entering the fishery; T_{pl} = age at which fish become fully exploitable; X, X1, P, Q are the parameters for the incomplete Beta function, where $X = e^{-K(T_{pl}-T_o)}$, $X_1 = e^{-K\lambda - T_o)}$. $P = \frac{Z}{K}$, Q = one + b, which is the exponent in the length-weight relationship $T\lambda$ = the maximum age attained and B is the symbol of incomplete Beta function.

The Fishery

1966: Data were collected only from Dummulapeta landing centre where an estimated 11.9 t of fish were landed (Table 1). The fishery was poor due to the operation of few boatseines which invariably land high proportion of this fish. The catch of *T. lepturus* was 0.9% in total fish production and 61.2% in ribbonfish landings. The catches were slightly better in May and October (Fig. 1). About 70% of *T. lepturus* landed belonged to 0 age group, 26% to I age group and the rest to II age group.

1967: The fishery was good and the production from the three landing centres (Tables 1-3) was 364.8 t which formed 91.4% of the ribbonfish catch and 10.5% of the total marine fish catch. Intensive boatseine operation, particularly at Uppada, accounted for 301.4 t and this was mainly responsible for the good fishery. The catches were moderate to good throughout the year, except for February-March and June; they were high in November-December, and formed over 28% of the total fish catch in each of these months (Fig. 1). The '0' age group formed 67.3%, I age group 25.6%, II age group 6.8% and the rest III age group (Table 4). While 0 and I age groups were landed throughout the year, II and III age groups were caught in considerable numbers during January-February, April and November-December.

TABLE 1. *Catch, effort and catch-per-net-per-day* (C/E) *of* T. lepturus *from Dummulapeta during* 1968-71. (S = shoreseine; B = boatseine; G = gillnet).

	No. of Units	Total catch (t)	Ribbonfish (Kg) (% in total catch	*T. lepturus* (Kg) (% in ribbonfish)	C/E	Peak month*
1966						
S	4552	496.1	8835 (1.8)	3664 (41.5)	0.8	Oct
B	582	29.1	6754 (23.2)	5169 (76.5)	8.9	Apr May Oct
G	10710	779.6	3897 (0.5)	3086 (79.2)	0.3	Jul
1967						
S	2946	668.8	25627 (3.8)	20654 (80.6)	7.0	Apr
B	2012	374.5	76721 (20.5)	69980 (91.2)	34.8	Apr
G	9406	666.9	7492 (1.1)	7492 (100)	0.8	Nov
1968						
S	1474	325.8	15168 (4.6)	13474 (88.8)	9.1	Jun, Feb
B	1104	14.7	4699 (31.3)	3218 (68.5)	2.9	Apr
G	14640	685.1	917 (0.1)	882 (96.2)	0.06	Apr
1969						
S	1279	205.6	6082 (3.0)	4919 (80.9)	3.8	Feb
B	8	2.4	2400 (100)	2400 (100)	300	Mar
G	12979	1206.6	1118 (0.1)	830 (74.2)	0.06	May
1970						
S	861	173.3	16670 (9.6)	14026 (84.1)	16.3	Mar, Apr
B	128	6.1	4210 (69.0)	3160 (75.0)	24.7	Dec
G	14306	771.0	913 (0.1)	648 (71.0)	0.05	Aug
1971**						
S	1603	164.7	1551 (0.9)	1476 (95.2)	0.9	Dec
B	572	18.5	13886 (75.0)	13080 (94.2)	22.9	Dec
G	8876	323.1	5215 (1.6)	4915 (94.2)	0.6	Dec

* When over 20% of ribbonfish were landed
** 11 months' data only

TABLE 2. *Catch, effort and* C/E (*Catch in kg per net per day's fishing*) *of* T. lepturus *from Uppada landing centre during* 1967-71. (S = shoreseine; B = boatseine and G = gillnet)

	No. of Units	Total catch (t)	Ribbonfish (Kg) (% in total)	*T. lepturus* (Kg) (% in ribbonfish)	C/E	Peak month*
1967**						
S	375	63.7	3157 (5.0)	1593 (50.6)	42.6	Oct
B	14185	619.9	249214 (40.2)	231423 (92.9)	16.3	Nov
G	11974	286.5	13076 (9.5)	12898 (98.6)	1.1	Oct
1968						
S	456	113.7	30605 (26.9)	16750 (54.7)	36.7	Oct
B	14873	610.6	260275 (42.6)	229678 (88.2)	15.4	Apr, May
G	38733	1183.8	32218 (2.7)	31332 (97.2)	0.8	Oct
1969						
S	304	49.3	4135 (8.4)	2107 (50.9)	6.9	Jan, Mar
B	8182	331.7	139094 (41.9)	109899 (79.0)	13.4	Mar, Jul
G	28965	1212.2	55315 (4.6)	54435 (98.4)	1.9	May
1970						
S	359	96.5	3947 (4.1)	3541 (89.7)	9.9	Oct, Dec
B	3790	110.1	32812 (29.8)	32053 (97.7)	8.5	Dec
G	24242	762.8	14647 (1.9)	14547 (99.3)	0.6	Mar
1971***						
S	242	40.3	1685 (4.2)	1055 (62.6)	4.4	Apr, Aug
B	2881	164.1	86387 (52.6)	84839 (98.2)	29.4	Aug
G	14753	444.5	10644 (2.4)	10294 (96.7)	0.7	Apr, Jul, Aug

* Months when over 20% of *T. lepturus* were landed.
** 10 months data only
*** 8 months data only

TABLE 3. *Catch, effort and* C/E (*Catch in Kg per boat unit*) T. lepturus *from Kakinada Fishing Harbour.*

	No. of Units (Effort)	Trawling hours	Total fish catch in t	Ribbonfish Kg (% in total fish)	*T. lepturus* catch in kg (% in total Ribbonfish catch)	C/E	Peak* months
1967	4517	20484	792.4	23892 (3.0)	20738 (86.8)	4.5	Nov
1968	9858	44517	1679.3	76483 (4.5)	69148 (90.4)	7.0	Sep
1969	7652	34235	1300.2	54457 (4.2)	51041 (93.7)	6.7	Sep
1970	8489	38201	1456.3	59391 (4.1)	57222 (96.3)	6.7	Nov
1971	12412	55854	2308.7	236230 (10.2)	221961 (94.0)	17.9	Oct, Nov
1972	13588	67507	2869.5	116391 (4.1)	110899 (95.3)	8.2	Oct, Nov
1973	20305	134119	3497.3	217514 (6.2)	207267 (95.3)	10.2	

* Months when over 20% of *T. lepturus* were landed.

1968: A total 364.5 t were landed (Tables 1-3) which accounted for 86.7% of ribbonfish catch and 7.9% of total fish production. Though there was a decrease in the boatseine effort, compared to 1967, their catch of 232.9 t is considerable. The otter trawl catch of 69.1 t was more than 3 times the catch of 1967 and the effort was more than double. The catches were poor in February-March and June-September (Fig. 1). They were moderate in other months with peak catches (over 20% of fish catches) in October-November. The 0 age group accounted for 62.2%, I age group 25.4%, II age group 11.9% and the rest by III$^+$ age group (Table 4). Large numbers of 0 and I age group fish were landed in July-September. The II and III$^+$ age groups dominated in February and were reasonably represented in the catches in January, April and August-November.

1969: The fishery was moderate with a catch of 225.6 t, which (Tables 1-3) formed 85.9% and 5.2% of ribbonfish and total fish catches, respectively. The decline in the boatseine operations both at Uppada and Dummulapeta resulted in decreased catches, compared to 1967 and 1968. Also there was a decrease both in the effort and the catch landed by trawlers, compared to 1968. Only in May and July the catches exceeded 10% of the total fish landing (Fig. 1). The 0 age group contributed 53.3%, 1 age group 26.6%, II$^+$ age group 17.2% and the III$^+$ age groups were mainly landed in March.

1970: The fishery was poor with a catch of 125.2 t, which formed 94.4% of ribbonfish catch and 3.7% of total fish catch (Table 1-3). The catch was about

TABLE 4. *The annual age and size composition of* T. lepturus

Age	Modal length mm	Numbers per 10 boatseine units				
		1967	1968	1969	1970	1971
'0'	165	14.0	3.8	—	—	—
	195	139.6	88.5	27.4	40.9	105.2
	225	223.4	98.7	70.0	95.0	259.4
	255	650.4	134.4	178.0	110.2	206.7
	285	526.2	186.3	148.1	25.1	550.6
	315	379.1	246.2	115.2	177.6	345.5
	345	184.1	205.7	125.0	132.7	200.0
	375	116.1	174.9	131.5	90.3	167.3
	405	165.4	103.5	85.2	67.6	184.6
'I'	435	207.5	113.3	67.8	56.0	201.9
	465	154.6	68.6	60.4	62.5	211.0
	495	128.0	39.4	43.1	50.5	68.8
	525	87.2	37.4	60.7	64.4	58.3
	555	79.4	27.2	39.3	51.1	45.1
	585	66.1	43.3	72.9	62.1	26.9
	615	63.1	82.8	21.0	85.9	49.3
	645	66.9	41.7	18.2	54.1	58.2
	675	61.8	53.1	56.8	17.0	52.7
'II'	705	76.0	80.4	87.0	33.1	61.2
	735	74.7	71.2	73.6	21.6	71.9
	765	25.2	33.7	45.2	3.2	74.2
	795	38.2	32.8	18.6	0.1	42.1
	825	16.2	12.5	32.5	0.6	29.4
	855	11.3	6.4	27.7	—	33.9
'III+'	885	2.2	7.4	22.2	—	39.5
	915	5.7	0.8	10.6	—	40.0
	945	0.2	1.2	6.9	—	30.3
	975	0.2	0.5	3.6	—	—
	1005	2.8	0.2	2.9	—	—
	1035	0.1	0.2	1.9	—	—

a third of 1967 and 1968 and a little more than half of 1969. The sharp fall was due to the decline in boatseine effort, and these units accounted for only 35.2 t. The contribution by trawlers was steady at 57.2 t. The catches were generally poor most of the year, except November and December, when they formed about 12% of the total fish catch in each of these months (Fig. 1). The age

composition showed that the 0 age group formed 56.8%, I age group 38.7% and the rest by II age group (Table 4). The 0 and I age groups were most dominant during August-December period while II age group were available in considerable quantities during January and August.

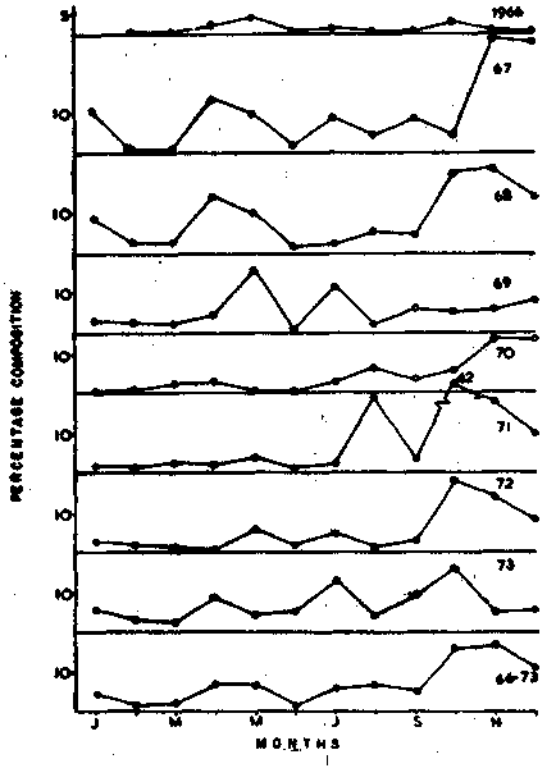

FIG. 1. Monthly percentage composition of *T. lepturus* in total fish catch during 1966-73.

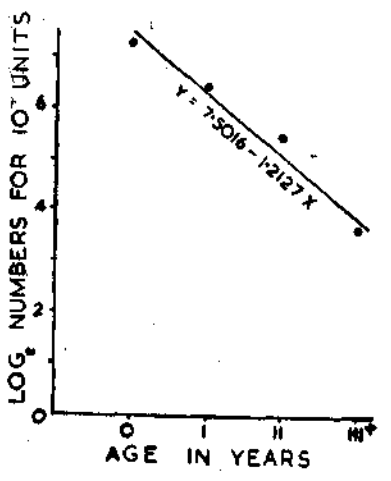

FIG. 2. Catch curve of *T. lepturus*

1971: The fishery was fairly good with a catch of 337.6 t and this formed 94.9% of ribbonfish catch and 9.7% of total fish landings. This compared favourably with the 1967 and 1968 landings. The main reason for the success of the fishery was the increased landings by trawlers (table 3) which accounted for 222 t. Coupled with increased effort, the percentage of *T. lepturus* in trawler catches was high (9.6%) which was not surpassed in any year during this study. Over 15% of *T. lepturus* landings were in August and November, while in October they touched 42% (Fig. 1). The catches were mostly made up of the 0 age group (62.8%), followed by I age group (24%), II age group (9.7%) and the rest by III+ age group (Table 4). The 0 age group was most dominant in May and August, the I age group was considerable in May-July and October. The II age group was most conspicuous in October.

1972: Data were collected only from Kakinada fishing harbour. The fishery was moderate with a catch of 110.9 t which formed 95.3% of ribbonfish catch and 3.9% in total fish landings (Table 3). In spite of increased effort by the trawlers, the catches have come down to half of 1971. The peak catches (over 14%) were landed in October-November (Fig. 1). The 0 and I age groups formed 79.8% and 20.2% respectively. The 0 group were particularly abundant in October, when the peak catches were landed.

1973: Data were collected from Kakinada fishing harbour and the fishery was good with a catch of 207.3 t which formed 95.3% of ribbonfish catch and 5.9% of total fish catch (Table 3). The steep increase in the trawler effort was partly responsible for these increased catches. Peak months of abundance were July and October when the ribbonfish formed 12 and 16%, respectively, in the catches (Fig. 1). The 0 age group accounted for 87.1%, I age group 12.6% and the rest by II age group fish. Except July the 0 age group dominated the catches in all the months.

1966-73: The pooled data for the 8-year period show that *T. lepturus* formed 90.8 and 6.5%, respectively, of the ribbonfish and total fish catches in the Kakinada area. It is evident that the last quarter of the year was most productive for this species with minor peaks of abundance in April-May and July-August (Fig. 1). Usually, during these periods of abundance, it was observed that large shoals of *T. lepturus* measuring 50-90 cm in length move into the fishing grounds and contribute to a considerable extent for the success of the ribbonfish fishery. In all the years the 0 age group dominated and it formed from 53.3 to 87.1% of the catches. The oldest fish available in the catches measured 114 cm and it was considered as 5 years old (Narasimham 1978). As the catch rates show, boatseine is the most efficient gear for the ribbonfish. Apart from the abundance of the fish in the fishing grounds, the success of the fishery from Dummulapeta and Uppada landing centres is mainly dependent upon the intensity of effort put in by boatseines.

Estimation of Mortality Rates

A regression line was fitted (Fig. 2) to the natural logarithms of the average annual numbers of *T. lepturus* against different ages. From the slope of the line the total instantaneous mortality coefficient Z was estimated as 1.2. Earlier it was stated that the age of oldest fish in the catches was 5 years and this may be taken as the life span of the fish. Assuming that the mortality is at least 99% by the time this age is completed in the unexploited state a value of M = 0.9 is obtained; then F becomes 0.3.

Yield per Recruit

The estimated values of various parameters are:

F = 0.3	$W\infty$ = 2957 g	T_{pl} = 0.3 years
M = 0.9	K = 0.29	T_λ = 5 years
Z = 1.2	T_o = -0.2 years	
	b = 3.4637	

It was observed that at 20 cm length (4 months) the fish first become vulnerable and also fully exploitable. Hence T_{p1} is taken as 0.3 years. In fitting the yield equation, b was taken as 3.5 so that it can be read directly from the incomplete beta function tables (Pearson 1984).

In Figure 3 are given the yield-per-recruit curves at different levels of M and T_{p1}. At present, as stated earlier, M = 0·9, F = 0.3 and T_{p1} = 0.3 years and the yield per recruit is about 23 g (Fig. 3 B). The maximum Y_w/R value of 26 g is obtainable at F = 0.6. This suggets that even at the very young age of exploitation, there is considerable scope to step up the production of *T. lepturus* until F reaches a level of 0.6, under the steady-state conditions. However, at the present level of M and F there is only a marginal increase in the Y_w/R values at different ages of exploitation (up to 1 year); consequently it is not remunerative to increase the age at exploitation without increasing the rate of fishing. A maximum of about 37 g per recruit can be obtained if F is increased to 1, concurrent with an increase in age at exploitation to one year.

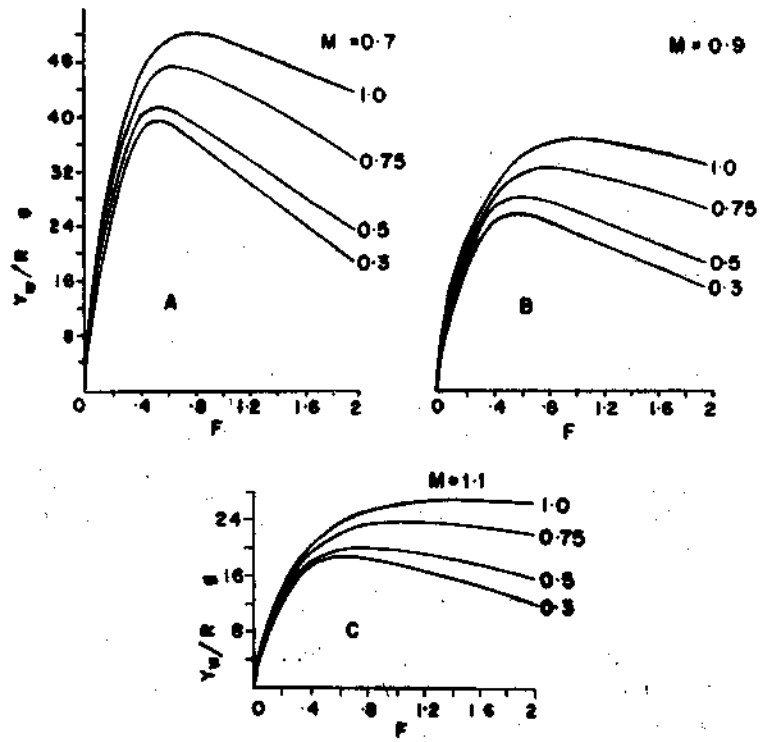

FIG. 3. Yield per recruit in *T. lepturus*. For each curve the right hand side values indicate the age in years when the fish are fully exploitable.

Theoretically, at M = 0.7 and T_{pl} = 1 year (Fig. 3 A) maximum yield of 52 g per recruit is possible at F = 0.8. Similarly, if M = 1.1 (Fig. 3 C) for a given age of exploitation the maximum yield per recruit is relatively low and the curves are considerably flat suggesting a slower rate of decrease in yield at higher levels of F.

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