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Fishery, Growth, Mortality Rates and Stock Assessment of *Auxis thazard* (Lacepede) Along Tuticorin Coast, Gulf of Mannar

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Abstract

Paruvalai, a drift gillnet with mesh size ranging from 90 to 170 mm exploits the tuna resource more effectively (98%) than the *podivalai*, another type of drift gillnet with mesh size 40-70 mm, and hooks and lines. Among the seven species, *Auxis thazard* (Lacepede) was the second dominant species next to *Euthynnus affinis* (Cantor) forming 40.2% of the total tuna production by *paruvalai*. The $L \infty$ and K are estimated to be 49 cm and 1.3/yr, respectively for males and 51.2 cm and 1.3/yr, respectively for females of *A. thazard*. The natural mortality rate (M) is estimated to be 1.85 for males and 1.82 for females. The total mortality coefficient (Z) is estimated to vary from 4.88 in 1992-93 to 7.07 in 1993-94 with an average of 5.55 for males and from 3.53 in 1995-96 to 5.94 in 1992-93 with an average of 4.85 for females. The fishing mortality rate (F) ranged from 3.03 in 1992-93 to 5.22 in 1993-94 with an average of 3.70 for males and from 1.71 in 1995-96 to 4.12 in 1992-93 with an average of 3.03 for females. The exploitation rate (U) ranged from 0.62 in 1992-93 to 0.74 in 1993-94 with an average of 0.66 for males and from 0.47 in 1995-96 to 0.69 in 1992-93 with an average of 0.62 for females. Average annual yield of *A. thazard* is estimated to be 288 t during 1992-97 and the average annual stock (P) is estimated to be 429.9 t.

Key words: Fishery, growth, mortality rate, stock assessment, *Auxis thazard*

Introduction

Exploitation of the coastal species of tuna resource along the coasts of Indian main land and islands is more intensive, and the stocks of the oceanic species in the exclusive economic zone (EEZ) still remain to be one of the least exploited. More information on the occurrence, fishery and biology of the coastal tuna is available from Indian waters. However, very limited accounts are available on the growth, mortality rates and stock assessment of the component species of tunas exploited by the traditional and mechanised sectors in India (Silas *et al.*, 1985; James *et al.*, 1987, 1992, 1993; Yohannan *et al.*, 1993). Further, only a few workers have studied the tuna fishery in the Gulf of Mannar (Silas, 1967; Sivasubramanian, 1969, 1973, 1985, Pon Siraimeetan, 1985a&b) and information on the present level of exploitation of coastal tunas along the Gulf of Mannar coast is lacking. In view of this lacuna, the present study on the fishery, growth, mortality rates and stock assessment of the second dominant species ***Auxis thazard*** (Lacepede) was carried out at Tuticorin during 1992-97.

Material and Methods

The data on the catch, effort, species composition and sexwise length frequency of the dominant species *A. **thazard*** were collected once in a week by observing at least 10% of the boats landed on the observation day. The data were raised to the observation day's catch and then to the month with respective raising factors. The fishing holidays such as the weekly closed holidays, festival days and holidays due to unforeseen eventualities were not taken into consideration for the estimation. The sexwise length-weight relationship of ***A. thazard*** was studied by regression analysis as per the Least Squares Method (Snedecor and Cochran, 1967). The growth parameters such as $L \infty$ and K have been estimated as per ELEFAN I through FISAT programme (Gayanilo *et al.* 1995) and t_0 by Bagenal (1955) method. The natural mortality rate (M) was estimated as per the empirical formula proposed by Pauly (1980). The total mortality rate (Z) was estimated using the catch curve method (Pauly, 1984). The fishing mortality rate (F) was obtained by subtracting the M from Z and exploitation rate (U) from the equation $U = F/Z\ (1 - e^{-Z})$. The total stock (P) was estimated from the relation $P = Y/U$ where Y is the yield in t and U is the exploitation rate. The L_c50 was obtained from the probability of catch from the catch curve. The optimum age of exploitation and potential yield per recruit have been estimated as per Krishnan Kutty and Qasim (1968). The yield per recruit and biomass per recruit were estimated as per Beverton and Holt (1957).

Results

Fishery

Two types of drift gillnets, *paruvalai* with mesh size 90-170 mm and *podivalai* with mesh size 40-70 mm, and hooks and lines are deployed for the exploitation of tuna resource along Tuticorin Coast. *Paruvalai* landed on an average 717.6 t of tuna at the catch rate of 128.8 kg/unit, which formed 46.9% of the total catch

by this gear. *Podivalai* landed only 7.2 t at the catch rate of 1.1 kg/unit, which constituted 1.3% of the total catch by *podivalai* and hooks and lines landed 9.3 t at the catch rate of 1.5 kg/unit which formed 5.2% of the total catch by hooks and lines. *Paruvalai* landed 97.7%, hooks and lines 1.3%, and *podivalai* 1.0% of the total tuna catch. Estimated average annual tuna catch, effort and catch per unit effort (CPUE) by *paruvalai* during 1992-97 are given in Table 1.

Table 1. Estimated average annual tuna catch, effort and CPUE by paruvalai (drift gillnet) during 1992-97

Year	Efforts (units)	Tuna catch (t)	Total catch (t)	CPUE (kg/unit)	Percentage of tuna
1992-93	7063	1769.7	2783.0	250.6	63.6
1993-94	5362	711.9	1368.2	132.8	52.0
1994-95	4585	329.0	9.9.2	71.8	36.2
1995-96	6045	483.5	1355.2	80.0	35.7
1996-97	4810	293.8	1235.9	61.1	23.8
Average	5573	717.6	1530.3	128.8	46.9

The effort input varied from 4585 units in 1994-95 to 7063 units in 1992-93. Whereas the catch varied from 293.8 t in 1996-97 to 1769.7 t in 1992-93 and the catch rate also exhibited similar trend. In general, tuna production decreased in subsequent years due to a continued decline in the abundance of tuna in the fishing grounds of drift gillnet. The month-wise average tuna catch, effort and CPUE by *paruvalai* are given in Table 2. Tuna were landed throughout the year by *paruvalai* and the peak period of abundance was recorded to be from June to August and the abundance of tuna was moderate in the rest of the month except in May and November when it was very poor.

Table 2. Estimated average monthly catch, effort and CPUE by paruvalai (drift gillnet) during 1992-97

Month	Efforts (units)	Tuna catch (t)	Total catch (t)	CPUE (kg/unit)	Percentage of tuna
April	213	9.9	29.0	46.6	34.2
May	303	1.9	26.5	6.2	7.1
June	1069	183.7	326.2	171.9	56.3
July	1686	302.4	562.1	179.4	53.8
August	1354	186.9	437.0	138.1	42.8
September	450	22.3	96.1	49.4	23.2
October	218	3.5	30.6	16.1	11.5
November	60	0.2	2.7	3.2	7.0
December	55	0.7	2.6	12.2	26.1
January	30	0.5	1.5	17.3	35.1
February	32	0.6	2.3	18.1	25.0
March	103	5.0	13.9	48.5	35.9
Total	5573	717.6	1530.5	128.8	46.9

Species composition

Percentage composition of different component species of tunas landed by *paruvalai* is given in Table 3. *Euthynnus affinis* (Cantor) was the dominant specie (44.9%) followed by *A. thazard* (40.2%), *Thunnus albacares* (Temminck and Schlegel) (11.3%), *A. rochei* (Risso) (1.7%), *Sarda orientalis* (Temminck and Schlegel) (0.8%), *Katsuwonus pelamis* (Linnaeus) (0.6%) and *T. tonggol* (Bleeker) (0.5%). *E. affinis* was the only species which occurred throughout the year. *A. thazard* occurred from March to October and it was totally absent during November-February. Similarly other five species also occurred only during the peak period of the tuna season, mostly from March to October and *A. rochei* occurred only for a short period during June-August.

Length-weight relationship

The length-weight relationship of both male and female *A. thazard* is described by the following regression equation:

Male : Log wt = - 2.2807 + 3.3034 Log lt
Female: Log wt = - 1.8570 + 3.0251 Log lt

Age and growth

The growth parameters L_{∞} and K have been estimated to be 49.0 cm and 1.3/yr, respectively for the males of *A. thazard* and for the females, the estimates are 51.2 cm and 1.3/yr, respectively. The age at 0 length has been estimated to be -0.0029 yr for males and -0.0043 yr for females. The growth of this species may be described by the following von Bertalanffy growth equation.

Male: $lt = 49.0\ [1 - e^{-1.3\ (t + 0.0029)}]$
Female: $lt = 51.2\ [1 - e^{-1.3\ (t + 0.0043)}]$

According to the above equations, the males have been estimated to attain a length of 35.7, 45.4 and 48.0 cm in the 1st, 2nd and 3rd years, respectively, and the females attain a length of 37.3, 47.4 and 50.2 cm in the 1st, 2nd and 3rd years, respectively. It is observed that the females grow to a larger size than the males of same age.

Mortality rates

The estimates of total and fishing mortality rates, and the exploitation rates obtained for both the sexes and the pooled estimates for both the sexes are given in Table 4. The M is estimated to be 1.85 for males and 1.82 for females. The total mortality rate varied from 4.88 in 1992-93 to 7.07 in 1993-94 for males with an average of 5.55 and from 3.53 in 1995-96 to 5.94 in 1992-93 for females with an average of 4.85. Similarly the F varied from 3.03 to 5.22, with an average of 3.7 for males and from 1.71 to 4.12 with an average of 3.03 for females in the same years. The mortality rates of males were marginally higher than those of females in all the years except in 1992-93.

Exploitation rate

The exploitation rate (U) ranged from 0.62 in 1992-93 to 0.74 in 1993-94 with an average of 0.66 for males and from 0.47 in 1995-96 to 0.69 in 1992-93 with an

average of 0.62 for females. The exploitation rates of males were marginally higher than the females in all the years except in 1992-93, when it was lower than the females (Table 4).

Table 3. Estimated average month-wise species composition of tuna landings in t by paruvalai (drift gillnet) along Tuticorin coast during 1992-97

Month	*Euthynnus affinis*	*Auxis thazard*	*Auxis rochei*	*Thunnus albacares*	*Thunnus tonggol*	*Katsuwonus pelamis*	*Sarda orientalis*	Total
April	7570	341	0	2002	0	10	3	9927
May	1587	220	0	62	0	0	7	1876
June	99874	79379	1768	1934	164	14	590	183723
July	106109	125182	5282	47123	2817	2384	2905	301801
August	81080	82129	5370	14177	350	1212	2476	186794
September	16537	441	0	4744	55	451	19	22248
October	2857	368	0	269	21	0	0	3516
November	194	0	0	0	0	0	0	194
December	665	0	0	0	0	0	0	665
January	522	0	0	0	0	0	0	522
February	578	0	0	0	0	0	0	578
March	4596	30	0	361	8	0	0	4995
Total	322171	288091	12419	80673	3414	4072	6001	716840
Percent	44.9	40.2	1.7	11.3	0.5	0.6	0.8	

Table 4. Estimates of total mortality rate (Z), fishing mortality rate (F), exploitation rate (U) for male, female and both the sexes pooled for *Auxis thazard* during 1992-97

Year	Male			Female			Pooled		
	Z	F	U	Z	F	U	Z	F	U
1992-93	4.88	3.03	0.62	5.94	4.12	0.69	5.41	3.58	0.66
1993-94	7.07	5.22	0.74	5.60	3.78	0.67	6.34	4.51	0.71
1994-95	5.07	3.22	0.63	4.31	2.49	0.57	4.69	2.86	0.60
1995-96	5.19	3.34	0.64	3.53	1.71	0.47	4.36	2.53	0.57
1996-97	-	-	-	-	-	-	6.48	4.65	0.72
Average	5.55	3.70	0.66	4.85	3.03	0.62	5.53	3.70	0.67

Stock assessment

The estimates of total stock (P) from the annual yield of *A. thazard* by *paruvalai* are given in Table 5. The yield varied from 64.3 t in 1996-97 to 894.8 t in 1992-93 with an average annual production of 288 t during 1992-97 and the estimates of total stock varied from 89.3 t in 1996-97 to 1355.8 t in 1992-93. Based on the average annual yield of 288 t and average exploitation rate of 0.67, the average total stock is estimated to be 429.9 t during 1992-97.

Table 5. Estimated yield (Y), exploitation rate (U) and total stock (P) in t for *Auxis thazard* during 1992-'97

Year	Yield (t)	Exploitation rate	Stock
1992-93	894.8	0.66	1355.8
1993-94	264.9	0.71	373.1
1994-95	107.1	0.60	178.5
1995-96	109.3	0.57	191.8
1996-97	64.3	0.72	89.3
Average	288.0	0.67	429.9

Optimum age of exploitation & potential yield per recruit

The optimum age of exploitation (t_y) is estimated to be 0.9205 year for males and the corresponding optimum length is 34.25 cm. The t_y for females is estimated to be 0.8810 year and the optimum length is 35.0 cm. The potential yield per recruit (Y') is estimated to be 429 g for males and 447 g for females.

Age at first capture and age at recruitment

The length at first capture L_c50 is estimated to be 36.3 and 35.8 cm, respectively, for males and females of this species, and the corresponding age at first capture (t_c) is estimated to be 1.0337 year for males and 0.9198 year for females. The size at recruitment is 30.0 cm for both the sexes and the age at recruitment is 0.7259 year for males and 0.674 year for females. The size at first capture is higher than the optimum size of exploitation for both the sexes of this species.

Yield and biomass per recruitment

The yield per recruit increases with the increase in E to attain a peak at the E_{max} and then, it tends to decline in higher exploitation ratio, whereas the biomass per recruit continues to decline with the increase in E indicating the

continued decay of the biomass as the fishing effort increases.

For the prevailing M/K ratio of 1.42 for males of *A. thazard*, the E_{max} is estimated to be 0.689 and the M/K ratio of 1.40 for females of this species the E_{max} is estimated to be 0.6697. The average exploitation rates for males and females of this species during 1992-97 are estimated to be 0.66 and 0.62, respectively, which are lower than the above mentioned E_{max}.

Discussion

Silas (1967) had given a vivid account on the influence of the water current pattern prevailing during different seasons on the tuna fishery of Tinnevelly Coast along the Gulf of Mannar. Later, Pon Siraimeetan (1985a&b) reported on the fishery and bionomics of tuna at Tuticorin. In the present study, a continued decline in the catch and catch rate has been observed with minor fluctuations during 1992-97. Similarly, Pon Siraimeetan (1985a&b) had also observed a decline in the tuna catch from 2,797 t in 1980 to a mere 135 t in 1982. There has been a gradual decline in the effort input. The effort expended increased from 4002 units in 1979 to as high as 9348 units in 1981 (Pon Siraimeetan, 1985a&b) and then it declined to 4585 units in 1994-95. This may be mainly due to the operational difficulties faced by the fishermen due to the inter-operational rivalry between different types of fishing fleet, which operate along the Tuticorin Coast. The *paruvalai* fishing units migrate from the northern Tamil Nadu coast to Tuticorin coast during the beginning of the peak fishing season in May. As seen from the catch rate there seems to be a cyclic fluctuation in the abundance of tuna, the peak period of abundance being followed by a lean period with gradual decline in abundance. This may be attributed to the prevailing current pattern of the water masses influenced by the changes in the environmental factors, which in turn may greatly affect the inward migration of the tuna resource into the Gulf of Mannar from the open Indian Ocean (Silas, 1967).

Silas *et al.* (1985) reported the $L\infty$ and K to be 63.0 cm and 0.4898/yr and James *et al.* (1993) 56.0 cm and 0.77/yr, respectively, for this species. The latter estimates appear to have little faster growth rate than that of the former. However, both the above estimates seem to exhibit a lower growth rate than the estimates reported in the present study. Higher growth rate is common among scombroid fishes, as the kingseer *Scomberomorus commerson* is reported to attain 80.0 cm in the first year (Dayaratne, 1989; McPherson, 1992; Dudley *et al.* 1992). Therefore, the higher K reported in the present study appears to be reliable as the coastal tuna in tropical region like India is likely to have faster growth rate than its counterparts in temperate waters.

A. thazard being a coastal tuna, is exposed to considerable fishing pressure by the traditional and mortorised sectors along the Indian Coast. The exploitation rate was higher than the E_{max} during 1993-94 and 1996-97 indicating that both the sexes were exposed to higher fishing pressure during these years and during the other years of study this species was exposed to near-optimum fishing pressure. However, the age at first capture of both the sexes of this species is higher than the optimum age of exploitation indicating that the prevailing mesh size of *paruvalai* is ideal for the exploitation of this species along the Tuticorin coast. *E. affinis* has been reported to be exposed to higher fishing pressure along the Tuticorin Coast during the same period by Kasim (1999). He has suggested that since *paruvalai* is a mixture of different pieces of nets with mesh size varying from 100 to 170 mm, it is possible to increase the size at first capture of *E. affinis* by increasing the number of large-meshed net pieces in place of small-meshed net pieces and this may help in easing the higher fishing pressure exerted on *E. affinis*. This suggestion will be useful for *A. thazard* also, as this species is also observed to be exposed to higher fishing pressure during certain years in this study.

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