STOCK ASSESSMENT OF COASTAL TUNAS ALONG THE EAST COAST OF INDIA

H. Mohamed Kasim[1], and E.M. Abdussamad[2]
Research Centre of Central Marine Fisheries Research Institute, Chennai[1], Tuticorin[2], Tamilnadu

ABSTRACT

All India tuna landing fluctuated from 39,684 t in 1998 to 54,001 t in 2000 with an annual average of 48,042.5 t. The East coast tuna landing varied from 7,248 t in 1998 to 12,218 t in 2000 with an annual average of 9,157.6 t and it formed 19.1% of the total tuna landings of India. The percentage contribution by different maritime states towards the total tuna production along the east coast during 1998-2003 was Tamil Nadu: 67.0%, followed by Andhra Pradesh: 24.5%, Pondicherry: 5.0%, Orissa: 2.5% and West Bengal: 1.0%. They were exploited by drift gillnets and hook and lines of varying specifications. Fishery occurred round the year with peak during June-August. The species composition was *Euthynnus affinis:* 61.3%, followed by *Auxis* spp.: 12.7%, *Katsuwonus pelamis:* 9.9%, *Thunnus tonggol:* 7.0% and other species: 9.1% comprising *Thunnus albacares* and *Sarda orientalis*. Detailed studies on the fishery and biology of tuna resources carried out at Tuticorin, Chennai and Kakinada are presented. Stock assessments of theses species were made. Exploitation rate of the former is 0.82 and Emax, 0.764 indicating over-exploitation of stock whereas, for latter it is 0.67 and 1.0 respectively indicating scope for increased production. Average stock of *E. affinis* is 6,842 t and MSY is 5,648 t and that of *A. thazard* it is 1,830 t and 1,292 t respectively.

Introduction

Tunas are one of the major exploited marine fishery resources of Indian seas having good domestic demand as food fishes. All published reports and observations indicate that a considerable magnitude of untapped tuna resource is available, especially in deeper waters, for exploitation (Sivaprakasam, 1995; Mitra, 1999; Pillai and Ganga, 2002). They further pointed out that there is no organised tuna fishing in the high seas of Indian Ocean except in certain pockets. Many developing countries have expanded their fishing activities in order to intensify the exploitation of tuna resource from their EEZ (Silas, 1985; James and Pillai, 1991). Consequently, fishing industry of our country also require

aimed transformation for exploiting this resources. However, any such measures have to be formulated based on sound knowledge on resource characteristics, their abundance in space and time and inter-relationship of fishery with the sea environment.

Tunas and related fishes dominate the oceanic pelagic resources and support a sustainable fishery all along the coast. Sriaimeetan (1985) provided valuable information on the fishery, species diversity and bionomics of different species along Gulf of Mannar coast. The present study attempts to update scientific information on fishery and population characteristics of coastal tunas. Management issues are also discussed to a limited extent.

Materials and methods

Catch, effort and species composition data of tunas by different gears and size frequency data of *E. affinis* and *A. thazard* for the period 1998-03 are used for the study. Growth parameters, mortality rates and recruitment pattern are estimated from monthly length frequency data. $L\infty$ and K were estimated by surface response analysis of restructured length frequency histogram by ICLARM's FiSAT software (Gayanilo *et. al.*, 1995). Probability of capture and size at first capture (Lc_{50}) are estimated as per Pauly (1984).

Total mortality (Z) was estimated from catch curve (Pauly, 1983) and natural mortality (M) from the empirical formula proposed by Pauly (1980). Exploitation ratio (E) and rate (U) were estimated from the equations; $E = F/Z$ and $U = F/Z \times (1 - e^{-Z})$ as given by Beverton and Holt (1957) and Ricker (1975). Pattern of stock exploitation was studied following virtual population analysis following FiSAT. Total stock and biomass were estimated from the formulae Y/U and Y/F respectively. Maximum sustainable yield was estimated as in Corten (1974).

Results

Fishery

Tunas are exploited by drift gillnets and hook and lines. Gillnets with 6.0-13.0 cm mesh and hook and lines of varying specifications are operating in 10-150 m depth zone and landed tunas along with other pelagic fishes. All India tuna landing fluctuated from 39684 t in 1998 to 54001 t in 2000 with an annual average of 48042.5 t. The East coast tuna landing varied from 7248 t in 1998 to

12218 t in 2000 with an annual average of 9157.6 t and it formed 19.1% of the total tuna landings of India. The percentage contribution of tuna by different maritime states to the total tuna production along the East coast during 1998-2003 was Tamil Nadu: 67.0%, followed by Andhra Pradesh: 24.5%, Pondicherry: 5.0%, Orissa: 2.5% and West Bengal: 1.0%.

Catch composition

The fishery was supported by seven species. The species composition was *Euthynnus affinis:* 61.3%, followed by *Auxis* spp.: 12.7%, *Katsuwonus pelamis:* 9.9%, *Thunnus tonggol:* 7.0% and other species: 9.1% comprising *Thunnus albacares* and *Sarda orientalis.*

Seasonal Pattern of Fishery

Tuna fishery occur round the year, with peak during June-August (Fig.1). Nearly 85% of the total catches were landed during the peak period. Catch rates of major species were also higher during this period. *E. affinis* forms continuous fishery. *A. thazard, T. albacares* and *K. pelamis* also occur almost round the year, except for short periods, whereas occurrence of other species is highly seasonal.

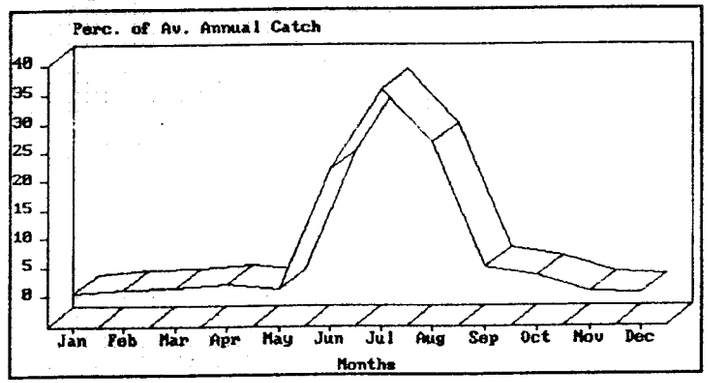

Fig. 1 Seasonal pattern of tuna fishery along East coast

Population Characteristics of the Species

Euthynnus affinis

Fishery was supported by 18-83 cm class fishes with 54-56 cm as modal class (Table 1). Size at first capture (Lc_{50}) was estimated as 50.14 cm .

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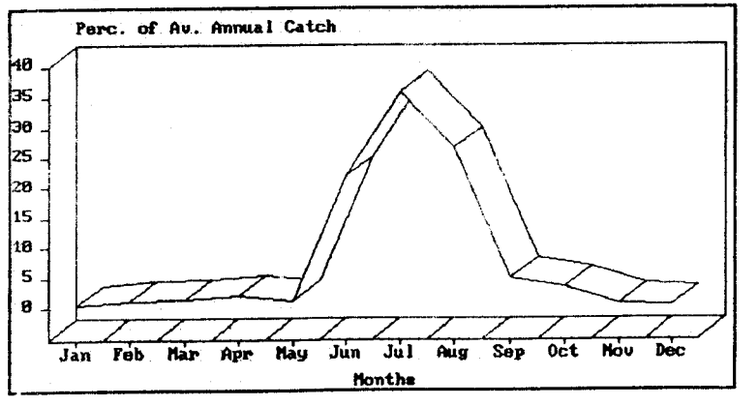

Fig. 1 Seasonal pattern of tuna fishery along East coast

Population Characteristics of the Species

Euthynnus affinis

Fishery was supported by 18-83 cm class fishes with 54-56 cm as mo class (Table 1). Size at first capture (Lc_{50}) was estimated as 50.14 cm.

Table 1 : Size composition of *E. affinis* in the catch along East coast during 1998-2003

Period	Size range (cm)	Major mode	Lc_{50} (cm)
1997-'98	28-81	51	49.5
1998-'99	22-76	55	51
1999-'00	24-81	55	49.3
2000-'01	20-83	57	53.21
2001-'02	18-76	53	46.17
2002-'03	18-78	51	36.87
Average	18-83	55	49.89

Growth

Growth parameters, L_∞ and K were estimated respectively as 87.5 cm and 1.50/year respectively and their growth can be described by von Bertalanffy growth equation as;

$$Lt = 87.5\,[1 - e^{-1.50\,(t-to)}]$$

They grow fast and attain 45.0, 67.6 and 78.2 cm respectively at the end of 6, 12 and 18 months. Their size frequency distribution shows that mainly 1st year group constituted the fishery.

Recruitment pattern

The species spawn and young recruits enter the stock almost round the year with two peaks, major during November-December and minor during April-May (Fig.2).

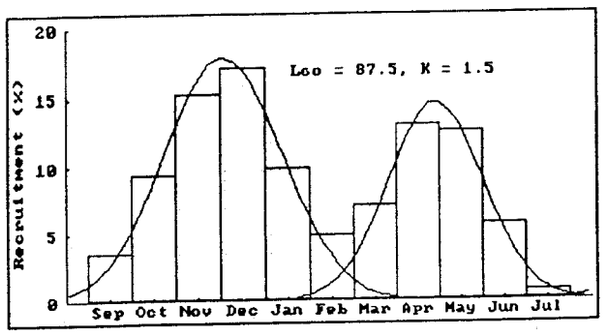

Fig 2 Recruitment pattern of *E. affinis* along the East coast

Mortality

Total mortality varied between 7.7 during 2002-'03 and 13.13 during 1998-'99, with 9.8 as mean (Table 2). Natural mortality rate was 1.76. Fishing mortality was 8.03 during the period and it varied between 0.78 and 11.38. Mortality rate was relatively high for the stock along Tuticorin coast and low along the Chennai coast.

Table 2 : Estimates of mortality rates, exploitation rates, biomass and stock of *E. affinis* along the East coast during 1998-2003 (Natural mortality (M): 1.76)

Years	Total Mortalty (Z)	Fishing Mortality (F)	Exploitation rate (E)	Exploitation ratio (U)	Yield	Biomass (t)	Stock (t)
1998-'99	13.13	11.38	0.87	0.867	5,562	489	6,415
1999-'00	9.32	7.56	0.81	0.811	5,974	790	7,366
2000-'01	12.31	10.56	0.86	0.858	6,118	579	7,131
2001-'02	7.99	6.24	0.78	0.781	4,903	786	6,278
2002-'03	7.7	5.95	0.77	770	5,501	925	7,144
Mean	9.79	8.03	0.82	0.82	5,612	699	6,842
Mean for Tuticorin	10.63	87	0.83	0.821	-	-	-
Mean for Chennai	7.6	5.84	0.77	0.774	-	-	-

Exploitation rate

Exploitation rate varied between 0.77 and 0.87 over the years with 0.82 as mean (Table 2), whereas E(max) is 0.7641, indicating over-exploitation of the stock (Fig 3). Exploitation rate of the species along Tuticorin coast is relatively large, whereas it is small along the Chennai coast.

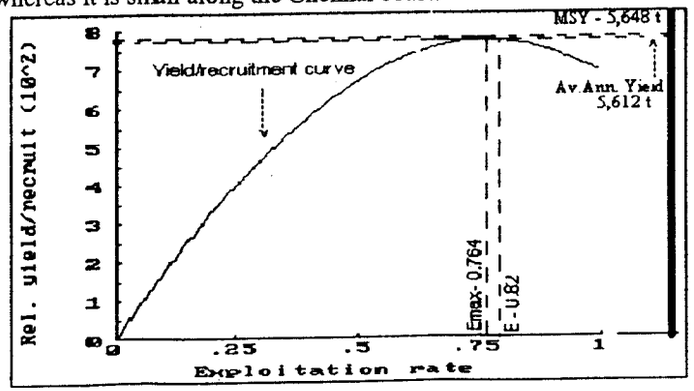

Fig.3 Relative yield/recruit of *E. affinis* at different levels of exploitation

Virtual population analysis

Population studies indicated that up to 35 cm size the main loss in the stock was due to natural causes (Fig 4). Thereafter loss due to fishing increased and outnumbered natural losses. Fishing mortality increased sharply for fishes above 50 cm size and it declined sharply beyond 63 cm size.

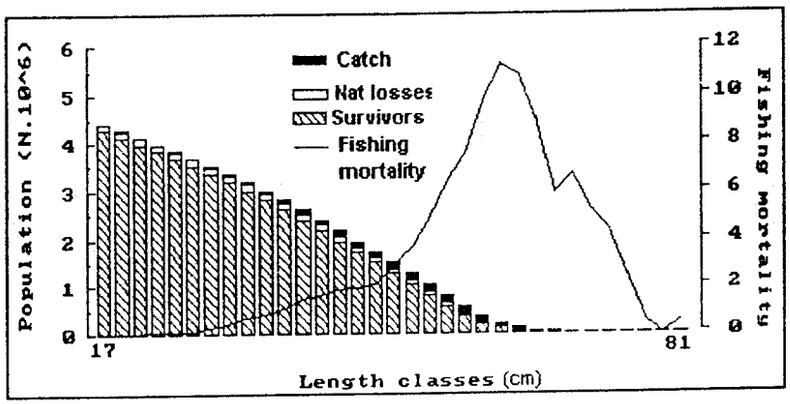

Fig. 4 Survival and losses due to natural causes and fishing operation in different size groups of *E. affinis* stock along East coast during 1998-2003

Yield and stock

Stock fluctuated between 6,278 and 7,366 t and yield between 4,903 and 6,118 t during the period (Table 2). Biomass during the period was between 489 and 925 t. Maximum sustainable yield from the present fishing grounds of the coast is 5,648 t (Fig 3).

Auxis thazard

Size composition

Fishery was supported by 20-48 cm class fishes with 37.7 cm as mean (Table 3). 32-44 cm size groups represented major share of the catch. The size at first capture (Lc50) was 35.14 cm.

Table 3 : Size composition of *A. thazard* in the catches along the East coast during 1998-2003

Period	Size Range (cm)	Major mode	Mean size (cm)	Lc50 (cm)
1998-'99	30-46	35	38.2	37.66
1999-'00	22-46	39	37.9	35.78
2000-'01	28-48	39	39.3	34.04
2001-'02	20-48	37	36.2	35.18
2002-'03	24-48	39	37.8	36.39
Mean	20-48	39	37.8	35.14

Growth

Growth parameters, $L\infty$ and K were estimated respectively as 53.8 cm and 1.04/year and growth can be described by von Bertalanffy growth equation as;

$$Lt = 53.8\,[1 - e^{-1.04\,(t-to)}]$$

This equation shows that they attain 33.52 and 46.63 cm respectively at the end of 1st and 2nd year. This shows that fishes landed were mainly 1+ year group.

Recruitment pattern

Recruitment indicated that the spawn and young recruits enter the stock almost round the year with peak during May-June (Fig 5).

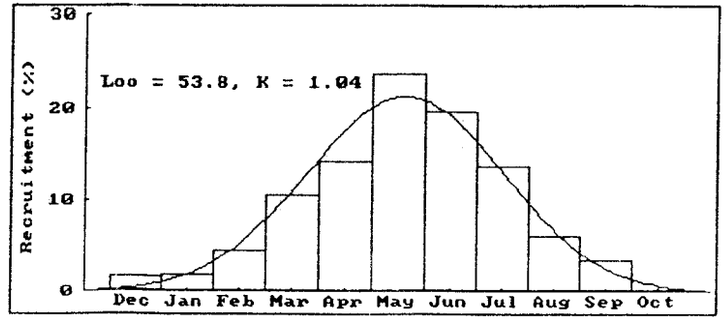

Fig. 5 Recruitment pattern of *A. thazard* along the East coast

Mortality

Total mortality rate ranged between 4.24 and 8.18 with 4.87 as mean during 1998-2003 (Table 4). Natural mortality rate was 1.58. Fishing mortality was 3.19 for the period and it varied between 2.66 and 6.60.

Table 4 : Estimates of mortalities, exploitation rates, biomass and stock of *A. thazard* along the East coast during 1998-2003

Years	Total Mortality (Z)	Natural Mortality (M)	Fishing Mortality (F)	Exploitation rate (E)	Exploitation ratio (U)	Yield	Biomass (t)	Stock (t)
1998-'99	7.71	1.58	6.13	0.79	0.795	1,340	219	1,686
1999-'00	8.18	1.58	6.6	0.81	0.807	916	138	1,135
2000-'01	4.73	1.58	3.14	0.67	0.658	1,098	350	1,669
2001-'02	4.42	1.58	2.84	0.64	0.655	697	245	1,098
2002-'03	4.24	1.58	2.66	0.63	0.618	1,748	657	2,828
Mean	4.87	1.58	3.19	0.67	0.664	1,160	364	1,830

Exploitation rate

Exploitation rate varied between 0.63 and 0.81 during 1998-2002 with 0.67 as mean (Table 4). Emax is large (1.0), indicating that stock is under-exploited and have scope for increased production (Fig 6).

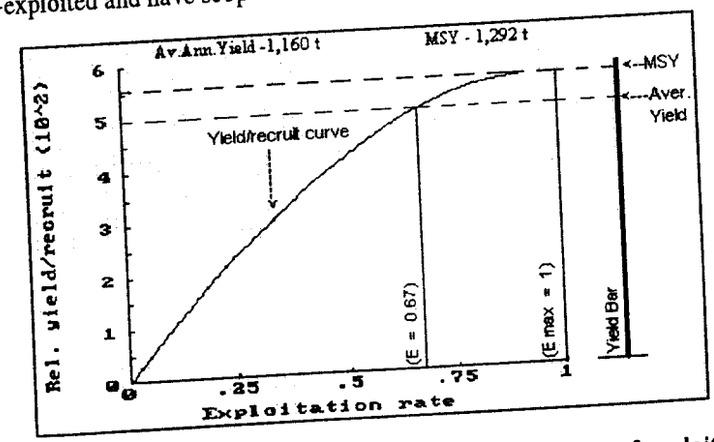

Fig.6 Relative yield/recruit of *A. thazard* at different levels of exploitation

Virtual population analysis

Population analysis indicate that up to 31 cm size, the main loss in the stock was due to natural causes (Fig 7.). Thereafter the loss due to fishing increased and outnumbered natural losses from 37 cm. Mortality due to fishing increased sharply for fishes above 35 cm size and it declined sharply for fishes above 45 cm size.

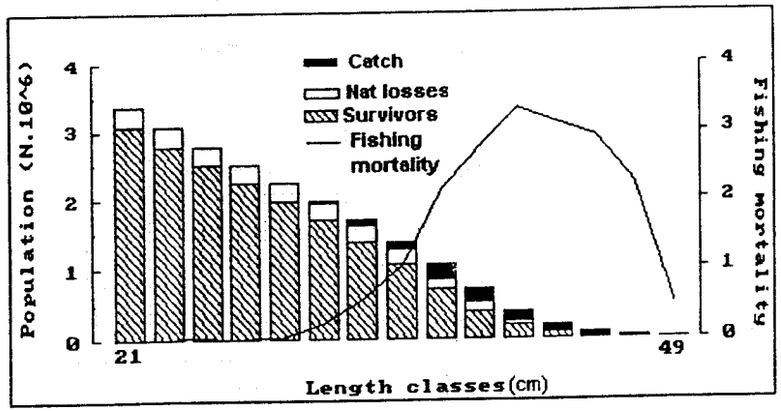

Fig.7 Survival and losses due to natural causes and fishing operating in different size groups of *A. thazard* stock along East coast during 1998-2003

Yield and stock

Stock fluctuated between 1,098 and 2,828 t and yield between 697 and 1,748 t during the period (Table 4). Biomass during the period varied between 138 and 657 t. Maximum sustainable yield from the present fishing grounds of East coast is 1,292 t (Fig 6).

Discussion

Tuna fishery along the East coast remained steady during the period, but with wide annual fluctuation. The exploitation rate, Emax and MSY of *E. affinis* suggested that the resource is slightly over-exploited, whereas *A. thazard* remain under-exploited.

James *et.al.* (1993) estimated size at first maturity of *E. affinis* and *A. thazard* as 44 and 32 cm respectively. Present estimate of their length at first

capture (Lc_{50}) is 50.1 and 35.14 cm respectively which is larger than size at first maturity. This suggested that large proportion of them might get at-least one chance to mature and spawn before being caught.

Field observations showed that, catch of *E. affinis* was constituted by large proportion of matured fishes with fully ripe gonads. Since they are caught by gillnets and hook and lines, chances of getting live fishes onboard is very high. This provide ample opportunity for stripping them onboard and sea ranching fertilized eggs, if adequate training is imparted to fishermen. This also provides scope for raising young ones to study their mariculture feasibility. As pointed out by Silas (1985), Bluefin tuna (*Thunnus thynnus*) is being cultured and harvested in Japan.

Being protected by Srilanka and other Islands, Gulf of Mannar along the coast is suitable for establishing fish aggregating devises (FAD's). But, as opined by Silas and Pillai (1985), this may eventually result in size over-fishing, not only of tunas but also other fishes. So deployment of such systems necessitate strict monitoring and enforcement of regulation on the size of fishes to be caught.

Tunas being highly migratory and distributed widely over several oceans, stock abundance depends on the conditions prevailed else where also. So information gained from stock assessment studies may have its own limitations. But, it may give basic information necessary for formulating management guidelines.

Tunas and related groups have very distinct behaviour pattern and they congregate in areas, where favourable conditions prevail. Information on their ecology and influence of various oceanographic parameters on the resource is essential to predict abundance and to locate productive fishing grounds and season. There is an urgent need to look into such information collected by earlier researchers. With global warming phenomenon there are chances for considerable changes in the profile of several meteorological and oceanographic parameters. Hence, depending entirely on earlier data may not provide the realistic picture. However it will be useful for interpreting changes occurred in the fishery over the period. Therefore continuous and detailed studies on the pelagic food supply, surface and sub-surface temperature, illumination, current pattern *etc.* of tuna fishing grounds round the year need to be undertaken. Such information can be acquired through advanced technologies like remote sensing using satellites or by training and entrusting young dynamic and enthusiastic fishermen with adequate remuneration.

Tunas are reported to be abundant in deeper waters. Increased effort in these areas with continuous monitoring and timely implementation of appropriate measures to maintain stock and production is advocated. Diverting large surplus trawlers after due modification, for exploiting this resource from the present fishing grounds and from deeper waters seems to be promising. Such an attempt at Tuticorin and Visakhapatnam is yielding encouraging results, as it enables year round operation and better catches. By considering the socio-economic implications large factory vessels should not be permitted in our EEZ, as it may over-exploit the stock and also obstruct their immigration to the present fishing grounds.

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