J. mar. biol. Ass. India, **47** (1) : 50 - 56, Jan. - June, 2005

Fishery and population characteristics of coastal tunas at Tuticorin

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Abstract

The coastal tunas, the little tunny *Euthynnus affinis* and the frigate tuna *Auxis thazard*, are exploited round the year by the small and large meshed gillnets, and hooks and line at Tuticorin along the southeast coast of India. Catch and catch rate increased in the recent years mainly due to additional effort input and extension of fishing to deeper waters. Catch trend and stock assessment of the species indicated rich abundance of tunas in deeper waters. Stock of *E.affinis* fluctuated between 281t during 1997-98 and 970t during 2001-02 and that of *A. thazard* between 103t and 417t. Exploitation rate (0.7) and E_{max} (0.95) of *E.affinis* and that of *A. thazard* 0.63 and 0.96 respectively indicated under-exploited status.

Key words: Little tuna and frigate tuna, fishery, stock assessment

Introduction

The tunas constituted a major component among the larger pelagics exploited at Tuticorin along the southeast coast of India. Previous observations and other published reports indicate that considerable magnitude of this resource still remains untapped in the seas around India, especially in deeper waters (Sivaprakasam, 1995; Mitra, 1999; Pillai and Ganga, 2002). However, barring at certain pockets, there is no organised fishing for tunas in the high seas around the country. Many developing countries have expanded and intensified their fishing activities to increase production of tunas from their EEZ (Silas, 1985; James and Pillai, 1991). Therefore, fishing industry of this country also require aimed transformation for exploiting these resource. Such measures have to be formulated based on sound knowledge on resource characteristics, their abundance over space and time and inter-relationship of fishery with environment. Siraimeetan (1985) provided some information on tuna fishery, diversity and bionomics of major species exploited from the Gulf of Mannar and adjacent areas. Present study was aimed to generate more information on the population characteristics of major species, to aid in developing management strategies for their exploitation.

Authors sincerely acknowledge the encouragement given by Dr. N.G.K. Pillai, Head, Pelagic Fisheries Division and Dr. Mohan Joseph, Director, CMFRI, Cochin.

Material and methods

Catch, effort and species composition

data of tunas exploited by different gears for the period 1989-2002 and size frequency data of *E.affinis* and *A.thazard* in gillnet for 1997-2002 were used for the analysis and interpretation. Growth parameters, mortality rates and recruitment pattern were estimated from monthly length frequency data. L_∞ and K were estimated by surface response analysis of restructured length frequency histogram by ICLARM's FiSAT software (Gayanilo and Pauly 1997). Probability of capture and size at first capture (Lc_{50}) were estimated as in Pauly (1984) and age at zero length (t_0) as in von Bertalanffy plot (Bertalanffy, 1934).

Natural mortality (M) was estimated from the empirical formula (Pauly,1980) and total mortality (Z) from catch curve (Pauly, 1983) using FiSAT software (Gayanilo and Pauly 1997). Losses operating in the stock were studied by virtual population analysis following FiSAT. Exploitation rate (E) was estimated from the equation; $E = F/Z$ and exploitation ratio (U) from $U = F/Z * (1-e^{-Z})$ as given by Beverton and Holt (1957) and Ricker (1975); where, F is the fishing mortality rate. Total stock and biomass were estimated from the ratios Y/U and Y/F respectively; where, Y is the yield in tonnes. Maximum sustainable yield was estimated graphically as in Corten (1974).

Results

Fishing methods and area of fishing

Tunas were exploited by small meshed gillnets, locally known as *Podivalai*, large meshed gillnets, *Paruvalai* and hooks and line operated from mechanised boats and motorised *navas.* Small meshed gillnets with 3.0-6.0 cm mesh are operating in shallow waters within 10-15 m depth and land these tunas along with other medium sized pelagics. Large meshed gillnets with 6.0-13.0 cm mesh and hooks and line are operating in 50-150 m depth zone, beyond 10 km from the coast and land large tunas and other pelagics.

Fishing effort

Effort by different gears fluctuated widely during 1989-2002 (Table 1). Effort by small meshed gillnet was 2,950 units during 1989-90 and it increased to 8,849 units during 1993-94. It declined sharply thereafter and increased again to 8,277 units by 2000-01. Effort by large meshed gillnets was 13,738 units during 1990-91, which declined sharply to 4,440 units by 1994-95 and increased again to 12,070 units by 2000-01. Information on hooks and line fishery is available only from 1992-93 onward. Effort was 2,875 units during 1992-93 and it increased sharply to 28,593 units during 1997-98. Effort declined thereafter to 6,729 units by 2001-02.

Fishery

On an average, gillnets and hooks and line together landed 774 t tunas annually during 1989-02 (Table 1). Total catch was 1,767 t during 1992-93 and it declined sharply to 317 t in 1997-98. Catch and catch rate in all gears fluctuated widely over the years and it followed similar pattern over the period. Small meshed

Table 1. *Annual catch (ton), effort (units) and catch rate (kg/unit effort) of tunas in major gears during 1989-02.*

	Small meshed gillnet			Large meshed gillnet			Hook and lines			Total
Year	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Catch
1989-90	2,950	3	0.9	11,950	683	57	-	-	-	686
1990-91	5,855	5	0.8	13,738	556	40	-	-	-	561
1991-92	8,218	1	0.1	7,825	421	54	-	-	-	422
1992-93	7,114	13	1.8	6,925	1749	253	2875	6	1.9	1768
1993-94	8,849	3	0.3	5,876	732	125	3364	5	1.6	740
1994-95	4,852	2	0.3	4,440	326	73	8980	5	0.5	333
1995-96	4,867	7	1.4	5,887	431	73	5761	12	2.1	450
1996-97	5,995	12	2.1	4,893	293	60	5313	15	2.8	320
1997-98	5,809	4	0.7	5,496	274	50	28593	39	1.4	317
1998-99	6,396	14	2.3	8,449	963	114	12184	8	0.7	985
1999-00	7,803	3	0.4	10,201	925	91	8084	23	2.9	951
2000-01	8,277	23	2.8	12,070	1313	109	7344	26	3.5	1362
2001-02	7,963	10	1.3	9,332	1097	118	6729	14	2.1	1121
Average	6534	8	1.2	8237	751	91	8293	15	1.7	774

gillnets landed 8 t tunas annually at a catch rate of 1.2 kg/unit effort. Large meshed gillnets contributed 96% of the total tunas caught by landing 751 t at an average catch rate of 91kg/unit. Hooks and line landed 15 t annually at a catch rate of 2 kg/unit effort.

Catch composition

Fishery, though supported by seven species, is dominated by *Euthynnus affinis* in all gears. The species formed 53% of the total catch of the region. Other species representing the fishery were *Thunnus albacares* (22%), *Auxis thazard* (17%), *Katsuwonus pelamis* (6%), *A.rochei*, *T. tonggol* and *Sarda orientalis*.

In small meshed gillnets, 93% of the tuna catch was constituted by *E.affinis*, *A.thazard* (4%), *A.rochei* (2%) and *S. orientalis* (1%). Seven species supported the fishery in large meshed gillnets. *E. affinis* dominated (52%) the catch followed by *T. albacares* (23 %), *A. thazard* (17%), *K. pelamis* (6%), *S. orientalis*, *T.tonggol* (1%) and *A. rochei* (0.6%). In hooks and line *E. affinis* (96%), *A. thazard* (1%), *T. albacares* (3%) and *S. orientalis* formed the catch.

Seasonal pattern of fishery

Tunas are exploited round the year. Nearly 85% landing was during June-August (Table 2). Catch rate were also high during peak season. Large meshed gillnets landed tunas round the year, whereas in other gears it was seasonal. *E. affinis* supported a fishery round the year. *A. thazard*, *T.albacares* and *K. pelamis* also have been found to occur almost round the year, but in lesser magnitude. The occurrence of other species was highly seasonal.

Population characteristics of little tunny

In the small meshed gillnets, *E.affinis* of

Table 2. *Species composition (%) of tunas during 1997-02.*

	Species							
Months	*E.a.*	*A.t.*	*A.r.*	*T.a.*	*T.t.*	*S.o*	*K.p.*	Tota
Jan.	0.5	0.1	0.0	0.8	0.1	0.1	2.3	0.4
Feb.	1.7	0.2	0.0	1.3	0.0	0.0	3.4	1.1
Mar.	2.5	0.1	0.0	0.4	0.8	0.0	0.0	1.3
Apr.	3.5	0.6	0.1	1.2	0.0	0.1	0.2	2.0
May.	2.0	0.8	0.1	0.1	0.0	0.3	0.1	1.2
Jun.	23.7	26.0	9.5	11.1	3.0	14.9	3.3	21.9
Jul.	27.9	42.2	39.7	44.8	32.1	33.9	48.9	35.9
Aug.	25.5	28.3	47.6	27.7	6.7	44.4	11.7	26.7
Sep.	5.1	1.4	2.6	8.2	54.8	1.2	20.8	4.9
Oct.	5.4	0.3	0.4	4.2	2.1	5.1	9.3	3.5
Nov.	1.4	0.0	0.0	0.0	0.5	0.0	0.0	0.7
Dec.	0.9	0.0	0.0	0.3	0.0	0.0	0.0	0.4

E.a.: *E.affinis*, A.t: *A.thazard*, A.r.: *A.rochei*, T.a.: *T.albacares*, T.t: *T.tonggol*, S.o.:*S.orientalis*, K.p.: *K.pelamis*.

18-30 cm having a mean size of 23 cm were found compared to 18-76 cm (mean 51 cm) in the large meshed gillnets. Minimum size of the fish in the catch was 28 cm during 1997-98 and it decreased to 18 cm by 2001-02. However, their mean size in the catch remained between 50 and 52 cm. But 42-64 cm fishes constituted the commercial catch. The size at first capture (Lc_{50}) was estimated as 51 cm.

Growth parameters, L_∞ and K were estimated respectively as 82.6 cm and 0.052/month and 't_0' as 0.171. Growth of the fish can be described by von-Bertallanffy equation as;

$$Lt = 82.6 \, [1 - e^{-0.052 \, (t-0.1708)}]$$

This relation showed that the species attained 38, 59, 70 and 76 cm respectively at the end of 1st, 2nd, 3rd and 4th years. The size composition showed that 1+ and 2+ year fishes constituted fishery.

Recruitment pattern indicated that young recruits enter the stock during most part of the year with peak during August-December. Mortality varied widely over the years. Natural mortality (M) was 1.03. Mean total mortality (Z) and fishing mortality (F) was 3.4 and 2.4 respectively. Virtual population analysis indicated that main loss in the stock up to 43 cm size was due to natural causes (Fig 1). Fishes become more vulnerable to gears after this size and mortality due to fishing increased and outnumbered natural losses. The mean exploitation rate was 0.7 and E_{max} 0.9. This indicated scope for increased production. Stock fluctuated between 281 and 970 t and yield between 214 and 711 t during 1997-02. Biomass during the period varied between 65 and 365 t. Both stock and biomass showed steady increase during the period. Maximum sustainable yield from the present fishing grounds is 543 t (Fig 2).

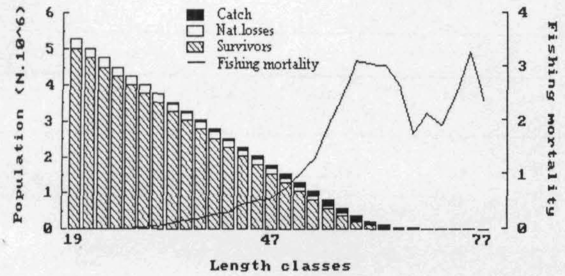

Fig. 1. *Survival and losses in* E. affinis *stock due to natural causes and fishing.*

and 't_o' as 0.288/months. The growth can be described by von-Bertallanffy growth equation as:

$$L_t = 52.9 \ [1- e^{-0.0683 \ (t-0.288)}]$$

The length attained by the fish was estimated as 29, 42 and 48 cm respectively at the end of 1st, 2nd and 3rd years. This and their size composition showed that mainly 1+year fishes constituted the fishery.

Recruitment pattern showed that these fishes spawn and young recruits enter the fishing grounds during most part of the year with peak during November-February. Natural mortality was 1.4. The mean total mortality and fishing mortality were 3.3 and 2.4 respectively. Virtual population analysis indicated that main loss in

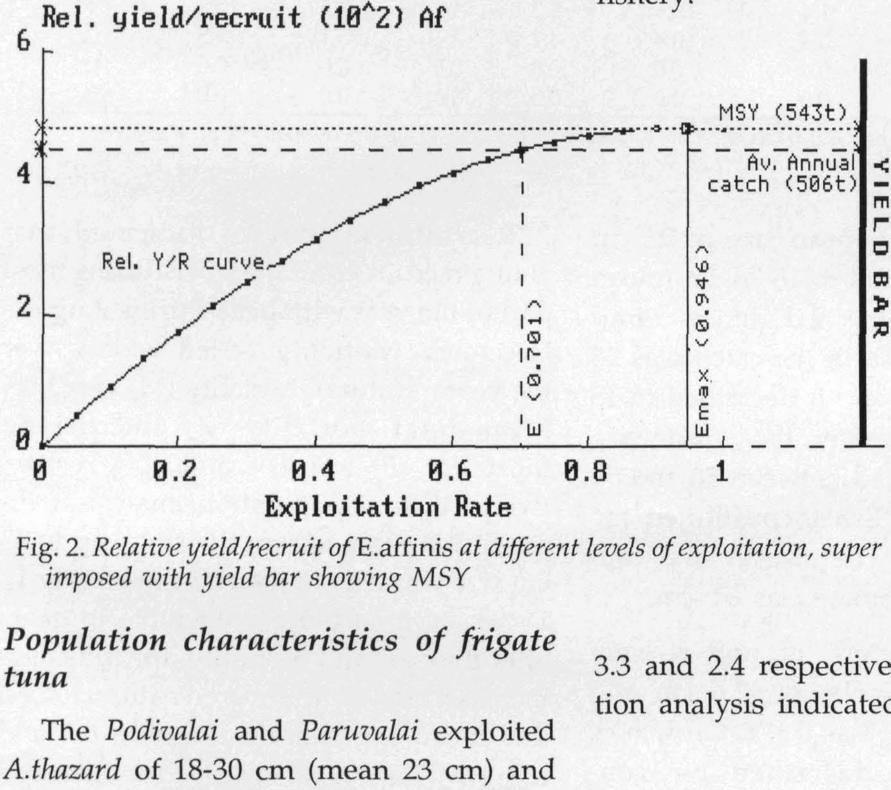

Fig. 2. *Relative yield/recruit of* E.affinis *at different levels of exploitation, super imposed with yield bar showing MSY*

Population characteristics of frigate tuna

The *Podivalai* and *Paruvalai* exploited *A.thazard* of 18-30 cm (mean 23 cm) and 20-48 cm (mean 38cm) respectively. Minimum size of the fish in the catch was 30 cm during 1997-98. It decreased to 20 cm by 2000-01. Fishes of 32-44 cm formed the major share of the catch. The size at first capture was estimated as 33 cm. Growth parameters, L_∞ and K were estimated respectively as 52.9 cm and 0.0683/month

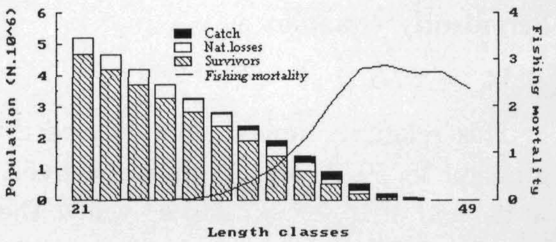

Fig. 3. *Survival and losses in* A. thazard *stock due to natural causes and fishing*

the stock up to 35 cm size was due to natural causes (Fig 3). Vulnerability of fishes to gears increased sharply after this size and loss due to fishing outnumbered natural losses. Mean exploitation rate was 0.634 against an E_{max} of 0.961. This suggested scope for increasing production. Stock of the species ranged between 103 - 417 t and yield between 79-254 t. Biomass during the period varied between 17-116 t. Stock, yield and biomass showed wide annual fluctuation during the period. Maximum sustainable yield from the present fishing grounds is 182 t (Fig. 4).

Discussion

In the recent past fishing effort registered gradual increase and the area of fishing also extended to distant deeper waters. As a result, fishery and catch rate of tuna increased gradually. Contribution of oceanic species also increased considerably during the period. Increase in catch and catch rate indicated that resource abundance was more in deeper waters. Estimates of exploitation rate, E_{max}, MSY and stock of coastal species, *E.affinis* and *A.thazard* indicated that these resources remain under-exploited and showed scope for increased production.

Estimate of growth parameters showed that growth of *E. affinis* is much faster along the coast, whereas that of the *A.thazard* is slow compared to similar estimates from other areas (Silas *et al.*, 1985; Pillai *et al.*, 2002). Estimates of length at first capture of the species are relatively larger than their size at first maturity (44 and 32 cm respectively) as reported by James *et al.* (1993). This indicated that large number of them might mature and spawn atleast once before being caught.

Tunas were reported to be abundant in deeper waters (Sivaprakasam, 1995; Mitra, 1999; Pillai and Ganga, 2002). Increased effort in these areas with continuous monitoring and timely implementation of appropriate measures to maintain stock and production is advocated. Diversification of surplus effort in the present fishing grounds, for exploiting tuna from deeper waters would be ideal. Such an attempt by few mechanized trawlers of the area is yielding encouraging results. Large factory vessels should not be permitted in our EEZ, as it may over-exploit the stock and also obstruct their migration into the present fishing grounds. Tunas being highly migratory and distributed

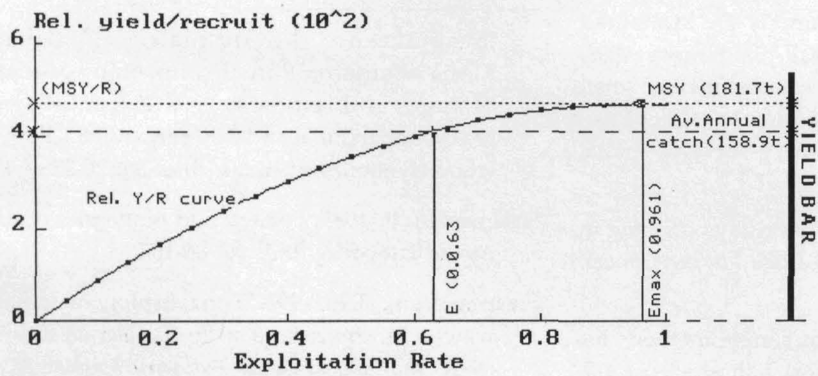

Fig. 4. *Relative yield/recruit of* A. thazard *at different levels of exploitation, super imposed with yield bar showing MSY.*

widely over several oceans, stock abundance depends on the conditions prevailing else where also. So information gained from stock assessment studies may have its own limitations. But it will provide valid clue necessary for formulating management guidelines.

References

Bertalanffy, L. von. 1934. Unter suchungen uberdie Gesetzlichkeiten des wasdestums I. Allgemeine Grundlagen der Theorie. *Roux. Arch. Entwicklungsmech. Org.*, **131**: 613-653.

Beverton, R.J.H. and S.J. Holt. 1957. On the dynamics of exploited fish populations. *Fish. Inves. Minist. Agric. Fish Food.* G.G. (2 Sea Fish), **19**: 533pp.

Corten, A. 1974. Recent changes in the stock of Celtisea herring (*Clupea harengus* L*). J. Cons. Perm. Int. Explor. Mer.*, **35**: 194-201.

Gayanilo, F.C. Jr. and D. Pauly. 1997. FAO-ICLARM stock assessment tools (FiSAT) Reference manual, *FAO computerised information series (Fisheries).* No.8, Rome, FAO. 1997. 262pp.

James, P.S.B.R. and P.P. Pillai. 1991. Strategies for tuna fisheries development and management in the Indian Exclusive Economic Zone. *Bull. Cent. Mar. Fish. Res. Inst.*, **44** (Part II): 619-642.

————, ————, N.G.K.Pillai, A.A. Jayaprakash, G.Gopakumar, H. Mohamed Kasim, M.Sivadas and K.P. Said Koya. 1993. Fishery, biology and stock assessment of small tunas. *In*: Sudarsan D. and John M.E. (Eds.) *Tuna Research in India,* Fishery Survey of India, Bombay: p. 123-148.

Mitra, G.N. 1999. Tuna is the mainstay of fishing in deep-sea zone of Indian EEZ. *Fishing Chimes,* **19** (1): 77-79.

Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. *FAO. Fish. Circular No.* **729**, *FIRM/129:* 54 *pp.*

———— 1983. Some simple methods for the assessment of tropical fish stocks. *FAO. Fish. Tech. Paper* (No. **234**), Rome: p.1-52.

———— 1984. Length-converted catch curves: A powerful tool for fisheries research in the tropics (Part II). *FISHBYTE*, **2** (1): 17-19.

Pillai, N.G.K. and U. Ganga. 2002. Scombroid fishery of the Indian Ocean-an overview. *In*: Pillai N.G.K., Menon N.G, Pillai P.P. and Ganga U. (Eds.) *Management of Scombroid Fishes.* CMFRI, Kochi, India: p. 14-23.

Pillai, P.P., N.G.K.Pillai, C. Muthiah, T.M. Yohannan, H. Mohamed Kasim, G.Gopakumar, K.P. Said Koya, B.Manojkumar, M.Sivadas, A.K.V.Nasser, U.Ganga, H.K.Dhokia, S. Kemparaju, M.M. Bhaskaran, M.N.K.Elayathu, T.S. Balsubramanian, C.Manimaran, V.A. Kunhikoya. and T.T. Ajith Kumar. 2002. Status of exploitation of coastal tunas in Indian waters. ibid. p. 56-61.

Ricker,W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd. Canada,* **191:** 382 pp.

Silas, E.G. 1985. Tuna fishery of the EEZ of India. An introductory statement *Bull. Cent. Mar. Fish. Res. Inst.*, **36**: 1-5.

———— and P.P. Pillai. 1985. A critiquie on national tuna fishery. ibid. **36**: 11-19.

————, ————, M.Srinath, A.A. Jayaprakash, C.Muthiah, V.Balan, T.M.Yohannan, Pon Siraimeetan, Madan Mohan, P.Livingston, K.K.Kunhikoya, M.Ayyappan Pillai and P. S. Sarma. 1985. Population dynamics of tunas. ibid. **36**: 20-27.

Siraimeetan, P. 1985. Fishery and bionomics of tunas at Tuticorin. ibid. **36**: 86-103.

Sivaprakasam, T.E. 1995. Tuna fishing in Indian waters. In: *Proceedings of the Seminar on Fisheries-A Multibillion Dollar Industry,* August 17 – 19, 1985, Madras: 1-6.