# TUNA RESEARCH IN INDIA

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# FISHERY, BIOLOGY AND STOCK ASSESSMENT OF SMALL TUNAS

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## INTRODUCTION

The status of fisheries in India and their distribution and abundance in the Indian EEZ were reviewed in the recent past (James and Pillai, 1989, 90; James, 1991 and Pillai, 1991 a). The first attempt to estimate the state of the stock of these species and their exploitation rate from Indian seas was made by Silas *et al*. (1986), followed by James *et al*. (1987). Recently, CMFRI has collated the tuna fishery and biological data collected from 9 research centres located along the west and east coasts of India and from Lakshadweep (Minicoy and Agatti Islands) and made an indepth study on the stock assessment of coastal tunas (James *et al*., MS, 1992) and James *et al*. (1992).

Fishery Survey of India has brought out publications on the results of the operations of chartered vessels in the oceanic tuna fishery (Sudarsan *et. al*., 1991; FSI, 1992) and a bibliography of tuna fisheries in Indian seas (John and Bhargava, 1992). These publications have updated our information on the coastal and oceanic tuna fishery resources from the Indian EEZ.

In the present study, the data collected on the catch, effort, C/E, species composition and length frequency distribution of *E. affinis, A. thazard, A. rochei* and *T. tonggol* during the period 1989 to '91 have been synthesised for estimating the stock of the above species from the inshore area along the mainland of India. The status of the stock of skipjack tuna and yellowfin tuna has been dealt with separately (Yohannan *et al*., MS, 1992; Pillai *et al*., MS

1992). For raising the catch and for the purpose of utilising different models, the state wise catch data were taken from the Fishery Resources Assessment Division of CMFRI.

The length frequency data of different species from the following centres collected by different gears were utilised for estimating parameters such as mortality rate and assessing yield and biomass.

| Species | Gear | Centres | Period |
|---|---|---|---|
| **E. affinis** | DGN, HL & PS | Veraval | 1990-91 |
| | | Mangalore | 1989-91 |
| | | Calicut | 1989-91 |
| | | Cochin | 1989-91 |
| | | Vizhinjam | 1989-91 |
| | | Tuticorin | 1989-91 |
| **A. thazard** | DGN, HL & PS | Mangalore | 1989-91 |
| | | Cochin | 1989-91 |
| | | Vizhinjam | 1989-91 |
| | | Tuticorin | 1989-91 |
| **A. rochei** | HL | Vizhinjam | 1989-91 |
| **T. tonggol** | GN | Veraval | 1990-91 |
| | | Cochin | 1989-91 |

(DGN and GN = Drift gillnet, PS = Purse seine, HL = Hooks and lines)

## METHODOLOGY

1. Presentaiton of basic length frequency data, their grouping in space and time and Ponderation.
2. Estimation of growth parameters using ELEFAN I programme of Pauly and David (1981). The VBGF for length takes the form

$$Lt = L\infty \ (1-e^{-k\,(t-t_o)})$$

3. Estimation of length at age based on the estimates of growth parameters.
4. Estimation of total mortality (Z) under the assumption of steady state, using "length converted catch curve" (Pauly and Ingels, 1981). Here the length frequency data pooled over the period 89-91 were used to construct a plot where X axis represents the relative age ($t-t_o$) of the fish, and whose descending limb can be fitted with a straight line of the form

$$\ln \frac{Ni}{ti} = a + b_{ti}$$

where, Ni is the number of fish in the length class i, $t_i$ is the time taken to grow through length class i, and $t_i$ is the relative age of the fish in length class i. Total mortality, $Z$ is then estimated as – b.

5. Estimation of Natural Mortality (M) based on the empirical equation of Pauly (1980) (with correction) and obtain the Fishing Mortality rate $F$ on substraction of $M$ from $Z$ and computation of exploitation rate Ep.

('M' estimation :

$$\ln M = -0.0152 - 0.279 \ln L_\infty + 0.6543 \ln K + 0.463 \ln T)$$
$$(T = 29.3^\circ C \text{ and } 29.5^\circ C)$$

6. Assessment of the state of stock based on the values estimated, complimented as permitted by the available data, by raising the annual length frequencies for different years of study (1989-91) and pooling them. The input parameters used in the analysis such as $L_\infty$, $K$, $M$, terminal $F/Z$, q and b in the length weight relationship ($W = q\,L^b$) are presented in Table 1. Based on these inputs, the mortality rates, $F/Z$ for length groups, $F$ and mean $F$ were estimated by length Cohort Analysis (Sparre, 1987- LFSA package programme was employed to analyse the yield and biomass of different species of tunas).

## DESCRIPTION OF THE FISHERY

Tuna and billfish production in India evinced variation during the period 1981 (31,168 tonnes) - 1991 (37,722 tonnes). The average tuna production has been estimated at 44,720 tonnes (Fig. 1). During 1991, about 67.8% of the total tuna landings has been made from the west coast of India and 15.5% from the east coast. The tuna production from Lakshadweep and Andaman Nicobar islands was 15.8% and 0.9% respectively. A comparison of tuna production indicate that as an average Kerala, Karnataka, Maharashtra, Gujarat, Tamil Nadu and Lakshadweep contributed to more than 70% during the period 1981-91 (Figs. 2, 3, 4, 5).

The overall pattern of tuna fishery in the above years indicate that the premonsoon and postmonsoon are the productive period along the south west coast. The productive periods for tuna fishery along the area Mangalore to Gujarat was the postmonsoon period and along the southwest and southeast coasts was premonsoon and monsoon periods.

The emerging pattern of mechanisation of crafts and operation of more efficient gears has been changing the scenario of tuna fishery along the

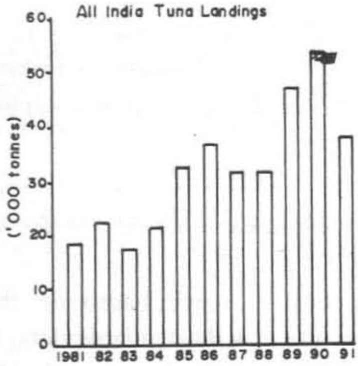


*Fig. 1. All India tuna landings during the period 1981-91*

mainland coast with continued operations during the monsoon period also.

It is evident that the maximum production of tunas is from the state of Kerala where mechanisation/motorisation of the crafts was responsible for the enhancement of the tuna catch.

In the mainland of India, there is no aimed fishery for tunas. The major gear operated along the mainland coasts of India is the multimeshed gillnet meant to catch a variety of larger pelagics among which tunas constitute about 20-30% at different centres. The increased catch of bullet tuna (*A. rochei*) at Vizhinjam was due to the expansion of the area of operation of both the drift gillnetters and Hooks and Liners from the motorised crafts since 1987. At Veraval the increased catch in recent years is due to the employment of the drift gillnets (*Jadajal* and *Jinajal*) from wooden and FRP dug out canoes with OBM and wooden plank built boats with IBM in the area 18-75 m. The purse seine catch of tunas has evinced a declining trend in recent gears. The preference for FRP boats and ring seines is expected to enhance the production of tunas in future years.

Annual year-wise catch, effort and C/E of tunas landed at different centres, and also the species-wise contribution by different types of nets are indicated in figures 6, 7, 8, 9, 10 and 11. As seen from the figures, *E. affinis* formed the main species landed in all the centres followed by *A. thazard*. At Veraval *T. tonggol* and *T. albacares* contributed to 51.1% and 21.5% of the total tunas respectively.

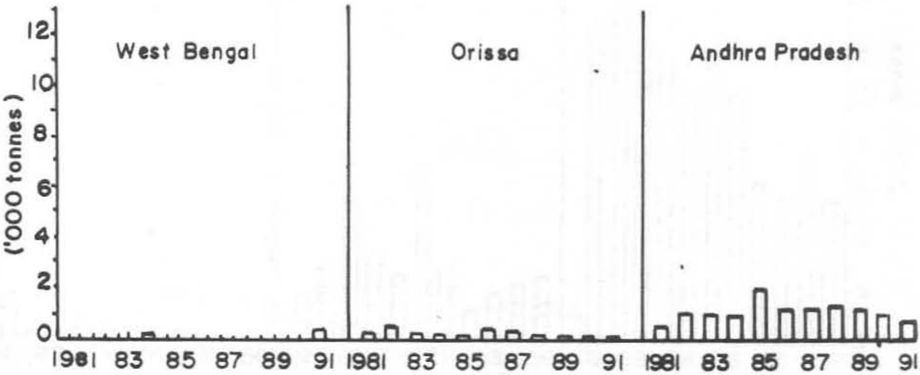


*Fig. 2. State-wise landings of tunas is West Bengal, Orissa and Andhra Pradesh during 1981-91*

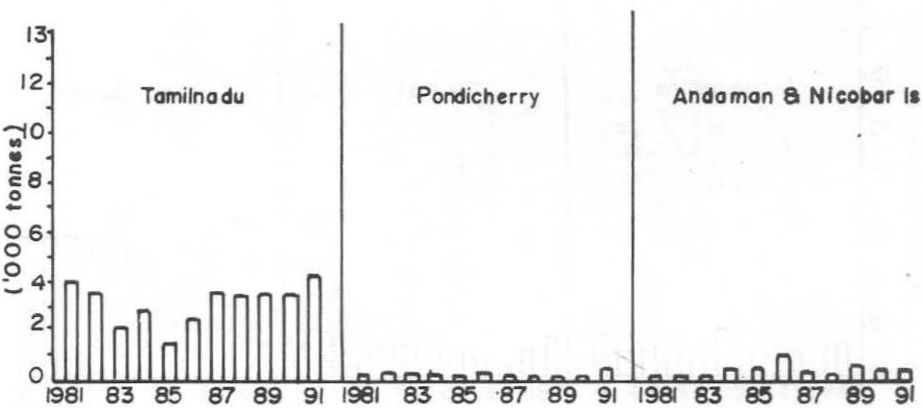


*Fig. 3. State-wise landings of tunas is Tamil Nadu, Pondicherry and Andaman & Nicobar Islands during 1981-91*

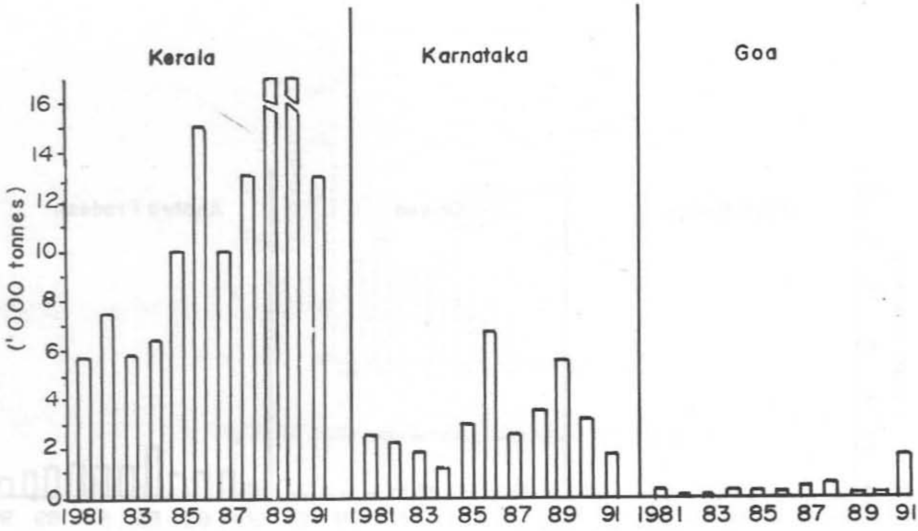


*Fig. 4. State-wise landings of tunas in Kerala, Karnataka and Goa during 1981-91*

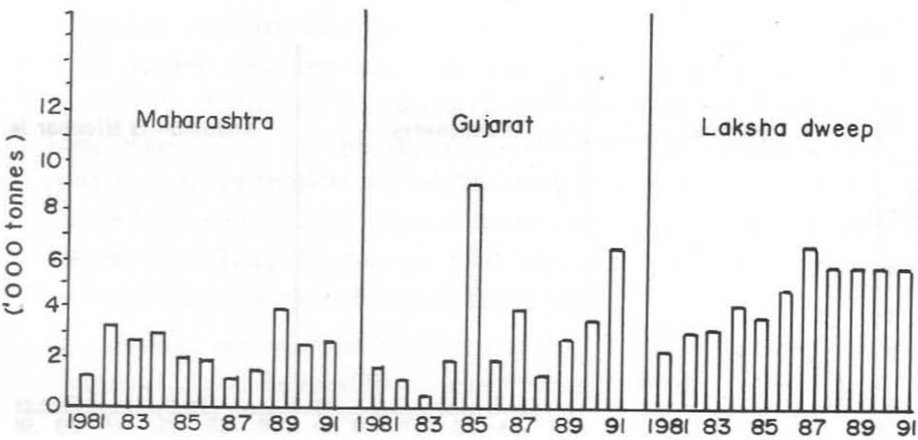


*Fig. 5. State-wise landings of tunas in Maharashtra, Gujarat and Lakshadweep during 1981-91*

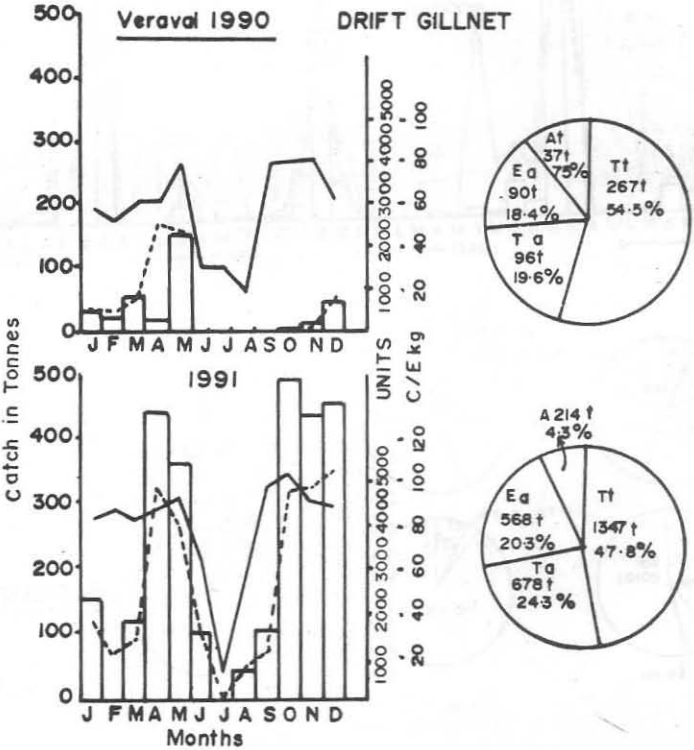


*Fig. 6. Catch, effort, c/f and species composition of tunas at Veraval taken by drift gillnets, 1990-91*

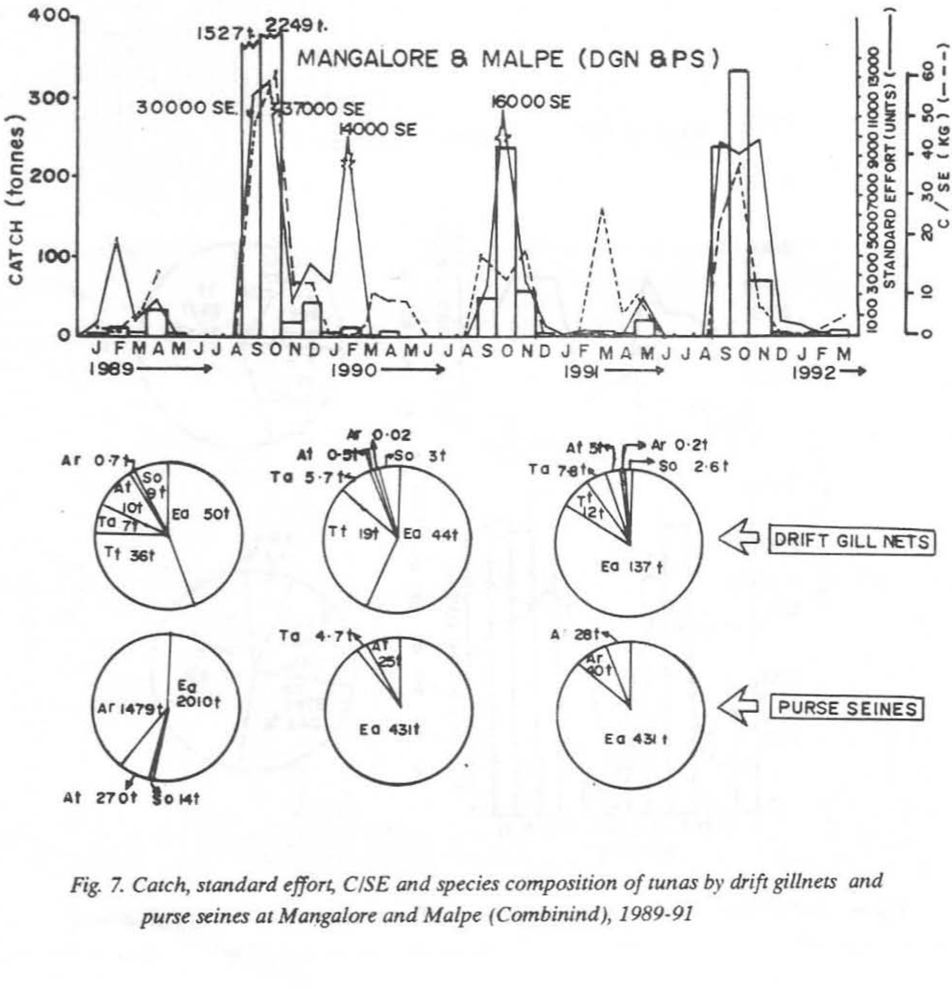


*Fig. 7. Catch, standard effort, C/SE and species composition of tunas by drift gillnets and purse seines at Mangalore and Malpe (Combinind), 1989-91*

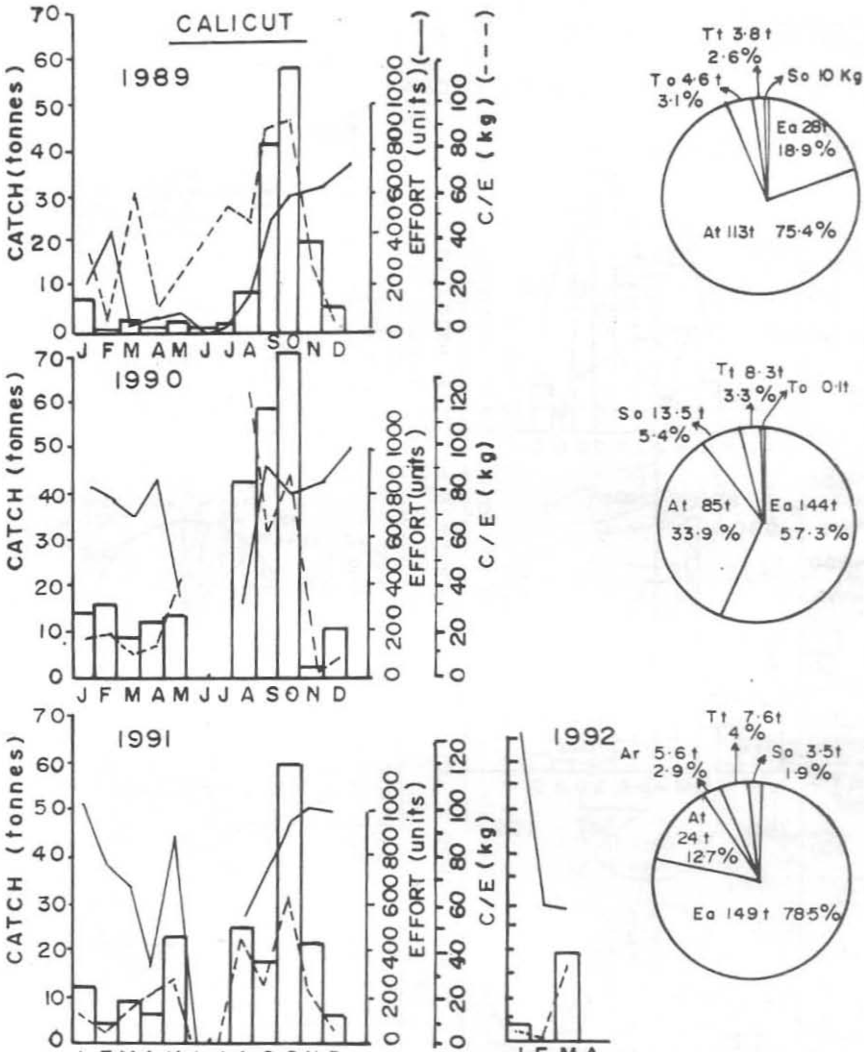


*Fig. 8. Catch, effort, c/f and species composition of tunas taken by drift gillnets at Calicut, 1989-91*

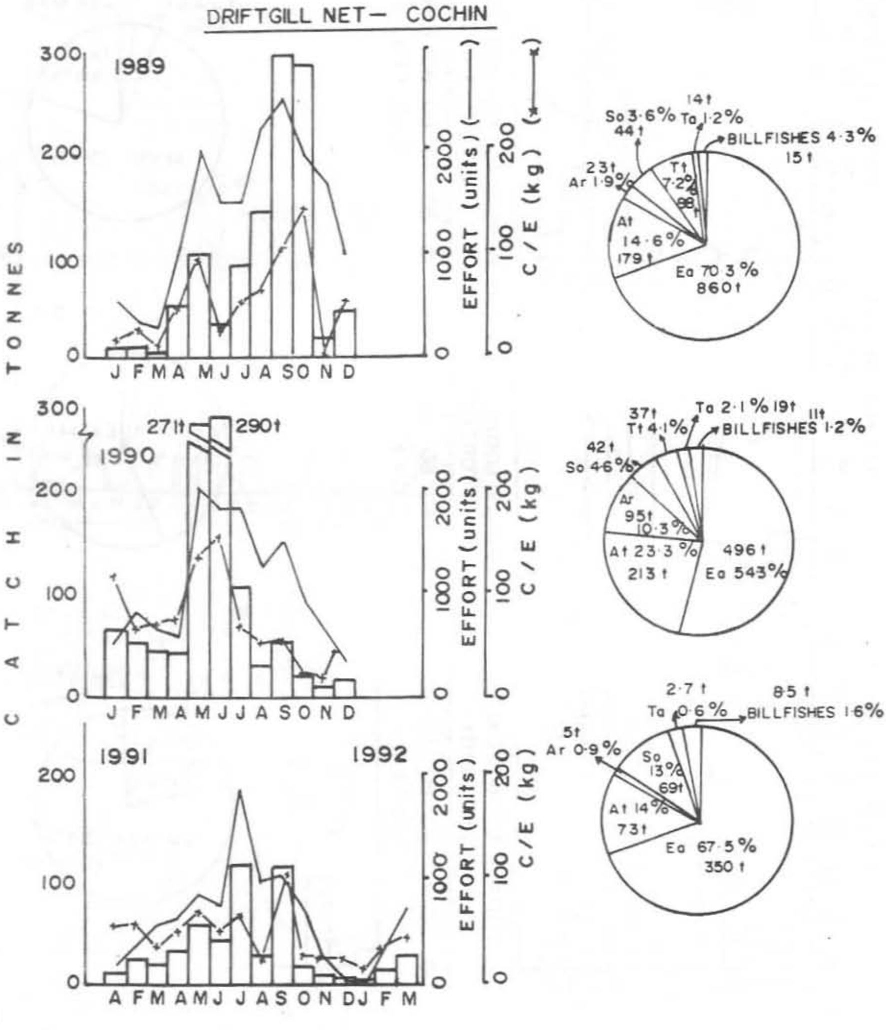


*Fig. 9. Catch, effort, c/f and species composition of tunas taken by drift gillnets at Cochin, 1989-91*

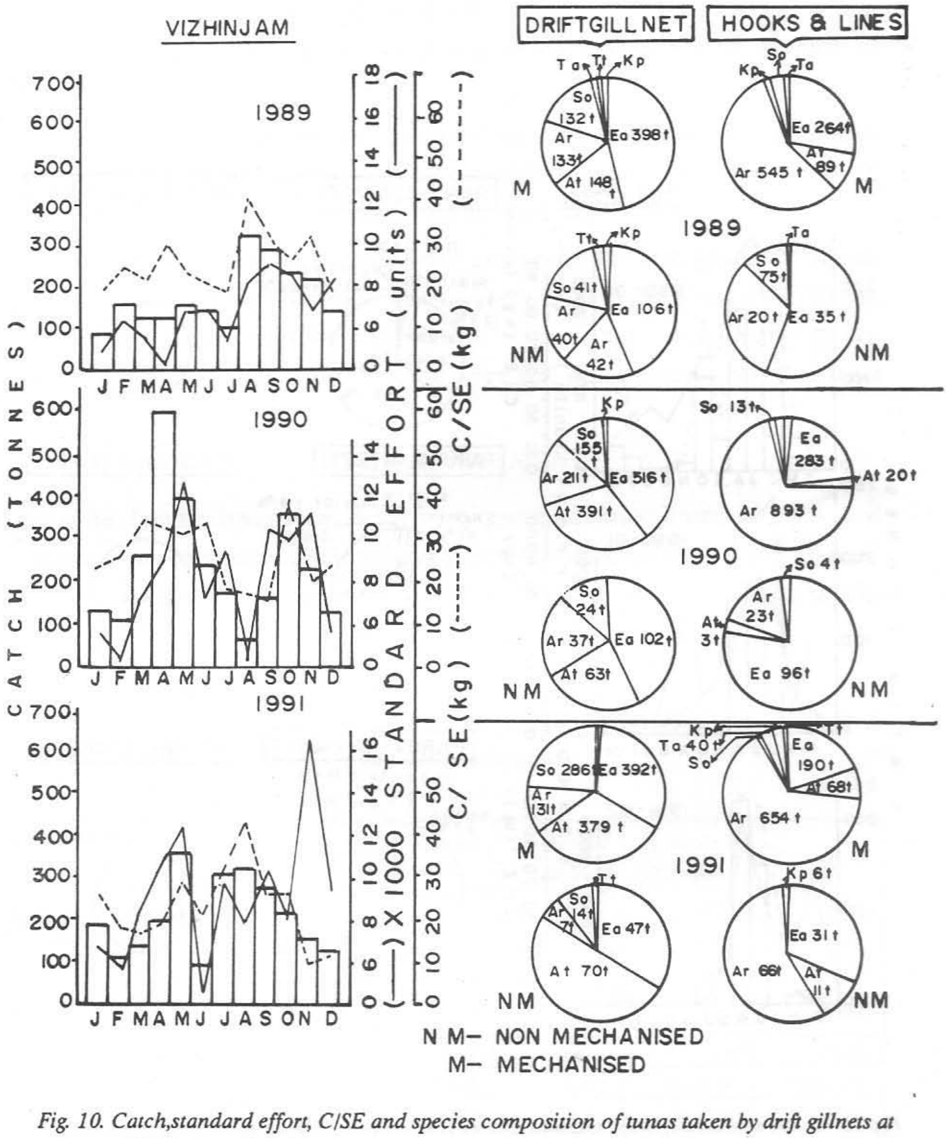


*Fig. 10. Catch,standard effort, C/SE and species composition of tunas taken by drift gillnets at Vizhinjam, 1989-90*

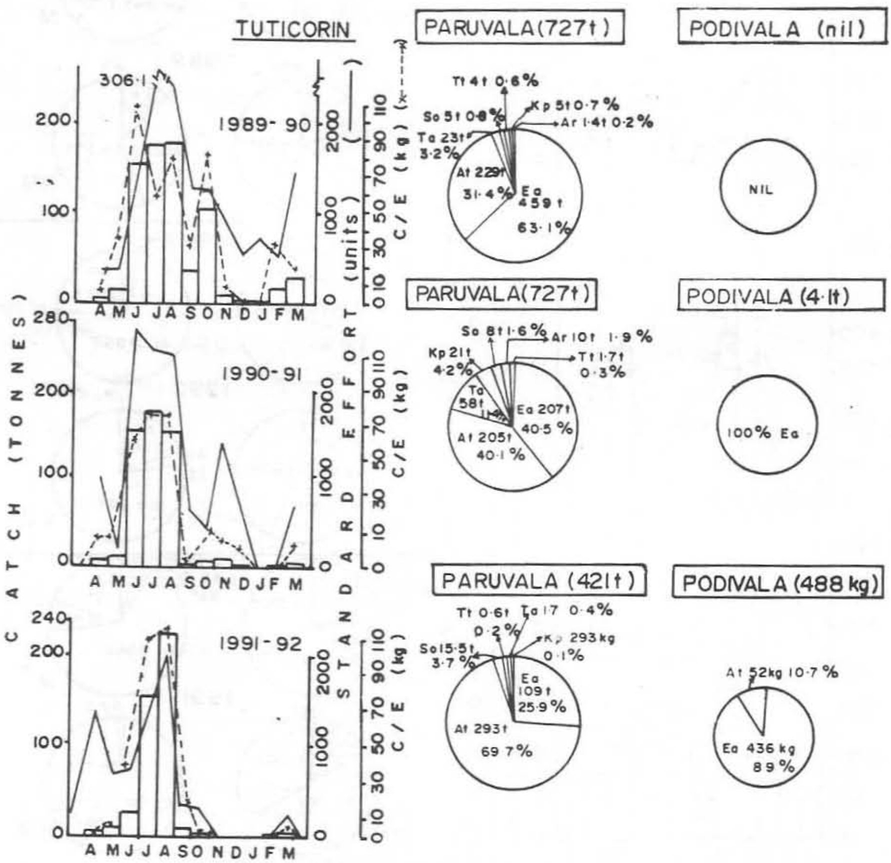


*Fig. 11. Catch, standard effort, C/SE and species composition of tunas taken by drift gillnets (Paruvala and Podivala) at Tuticorin, 1989-90*

*E. affinis* occurred in the fishery during 1989-91 in the size range 12-75 cm. The size group 48-50 cm was well represented in the fishery. The size at first maturity has been observed to be at 44 cm. Spawning season appears to be during October-November and April-May.

*A. thazard* was obtained chiefly in the size range 16-50 cm and the dominant size in the fishery was 38-40 cm. The length at first maturity was at 32 cm. Spawning season was observed to be mainly during August to November.

Only limited data on the biological aspects of *A. rochei* is available. They occurred in the size range 16-32 cm. with dominant size group at 24-26 cm. The size at first maturity was observed to be at 23 cm.

*T. tonggol*, chiefly at Veraval were present in the size group 16-92 cm. Two size groups were dominant, one at 44-46 cm and the other at 68-70 cm. The smaller size groups were dominant in the fishery along the southern sector of the mainland of India, while large size groups were recorded from the northwest coast.

## STOCK ASSESSMENT

The length frequency data were grouped into 2 cm interval and estimates of the asymptotic length and growth coefficients ($L\infty$ and $K$) were made using ELFFAN I programme for fitting the growth curve. The results obtained on the four species are presented in Table 1.

*Table 1. Input parameters for Length converted Cohort Analysis (Tunas) (Mean F and Z values are also indicated)*

| | *E. affinis* | *A. thazard* (Kerala) | *A. thazard* (Tamil Nadu) | *A. rochei* (Kerala) | *T. tonggol* |
|---|---|---|---|---|---|
| 1. L infinite (cm) | 83.5 | 56.0 | 56.0 | 37.0 | 94.0 |
| 2. K( annual) | 0.42 | 0.77 | 0.77 | 0.60 | 0.48 |
| 3. M (annual) | 0.76 | 1.26 | 1.26 | 1.2 | 0.80 |
| 4. Terminal exploitation rate | 0.45 | 0.62 | 0.7242 | 0.72 | 0.289 |
| 5. M/2 K | 0.904 | 0.82 | 0.818 | 1.0 | 0.836 |
| 6. q in $W = q^b$ (gm, cm) | 0.0190906 | 1.5012 | 1.5012 | 5.18749 | 0.000083 |
| 7. b in $W = q^b$ | 2.95 | 3.04 | 3.04 | 3.1711 | 2.7046 |
| 8. Mean 'F' | 1.4032 | 1.79 | 2.85 | 1.77 | 0.3538 |
| 9. Z | 2.565966 | 3.28 | 4.05 | 3.04 | 1.22 |

**E. affinis**

The length weight relationship estimated for this species was :

$$q \text{ in } W = qL^b \quad (\text{gm, cm}) = 0.0190906$$
$$b \text{ in } W = qL^b \quad = 2.95$$

The length converted catch curve gave an estimate of $Z$ as 2.57. The length groups used for the analysis are 48-50 cm to 66-68 cm and growth parameter estimates used are $L\infty = 83.5$ cm and $K = 0.42$.

Based on the length Cohort Analysis using the parameters $L\infty = 83.5$ cm, $K = 0.42$, $M = 0.76$, and terminal exploitation rate 0.45, the mean $F$ ($L >= 48$ cm) was 1.40 which has been weighed by stock number. The Thompson and Bell long term forecast model gave a MSY of 25,896 tonnes with a Biomass MSY 28,917 tonnes and the optimum exploitation as 1.4 times of the present exploitation level (Table 2). The average yield and biomass in the period 1989-91 are 25,595 tonnes and 35,952 tonnes respectively. If the present exploitation rate is increased by 40%, the MSY level will be reached. But the increase in yield due to this will be only about 310 tonnes which may not be economical. Hence it is considered that the present exploitation level is more or less optimal (Fig. 16).

*Table 2. E. affinis, all India 89-91 avg.*

THOMPSON AND BELL LONG TERM FORECAST

| X | Yield | Mean Biomass |
|---|---|---|
| 0.0000 | 0.00 | 108381.93 |
| 0.2000 | 13302.73 | 77798.45 |
| 0.4000 | 19894.04 | 59791.70 |
| 0.6000 | 23202.00 | 48540.02 |
| 0.8000 | 24837.74 | 41111.87 |
| 1.0000 | 25594.75 | 35951.64 |
| 1.2000 | 25878.98 | 32196.09 |
| 1.4000 | 25904.95 | 29347.14 |
| 1.6000 | 25789.06 | 27106.70 |
| 1.8000 | 25596.00 | 25290.23 |
| 2.0000 | 25362.36 | 23779.70 |

**A. thazard** (Kerala)

The length weight relationship of *A. thazard* estimated was

q in $W = q L^b$ (gm cm) = 0.000015012
b in $W = q L^b$ = 3.04329

The length converted catch curve gave an estimate of $Z$ as 3.28 (Fig. 12). The natural mortality M was estimated as 1.26. These estimates were arrived at by using the estimates of growth parameters as $L\infty = 56$ cm and $K = 0.77$ and the length groups used for this is 36-54 cm. Using the estimates of the above parameters, the length cohort analysis gave an estimate of mean $F$ ($L >= 36$) as 1.79 at terminal exploitation rate 0.62. The average catch in Kerala during 1989-91 is 3792 tonnes. The Thompson and Bell long term forecast model estimated the MSY as 3945 tonnes at an exploitation level of 3 times of the present exploitation level (Table 3). The Biomass MSY estimated is 2254 tonnes and mean biomass estimated for 1989-91 period is 3768 tonnes. Since the difference between present yield and MSY is only 153 tonnes increase in effort will not result in significant increase in catch (Fig. 17).

*Table 3. A. thazard, Kerala 1989-91 avg.*

THOMPSON AND BELL LONG TERM FORECAST

| X | Yield | Mean Biomass |
|---|---|---|
| 0.0000 | 0.00 | 9259.48 |
| 0.2000 | 2090.89 | 6741.08 |
| 0.4000 | 2982.76 | 5446.24 |
| 0.6000 | 3416.56 | 4669.48 |
| 0.8000 | 3649.24 | 4147.84 |
| 1.0000 | 3783.21 | 3768.11 |
| 1.2000 | 3863.93 | 3475.63 |
| 1.4000 | 3913.50 | 3241.27 |
| 1.6000 | 3943.62 | 3048.10 |
| 1.8000 | 3960.94 | 2885.50 |
| 2.0000 | 3969.52 | 2746.41 |

MSY = 3946.797 X = 3.015665 Biom. MSY = 2254.305

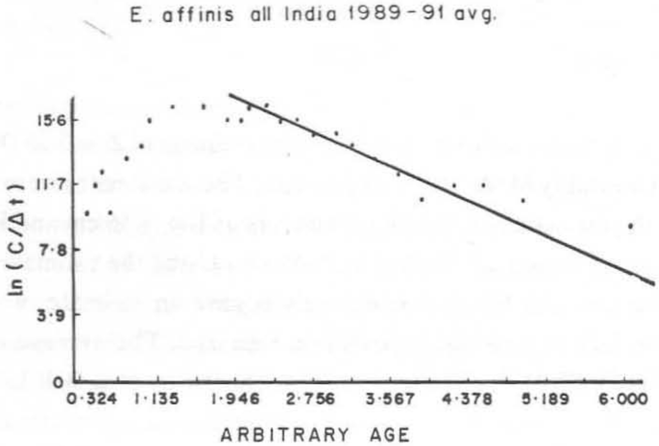


*Fig. 12. 'Z' of E. affinis estimated by "Length converted catch curve method"*

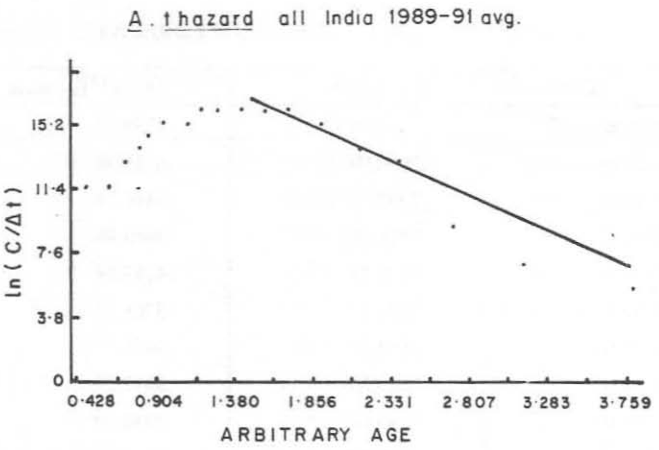


*Fig. 13. 'Z' of A. thazard estimated by "Length converted catch curve method"*

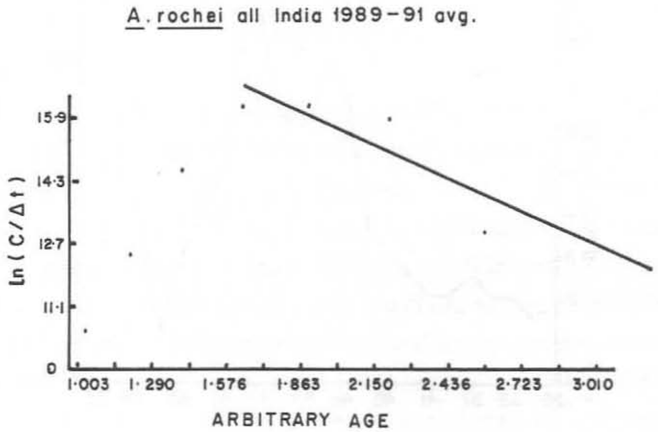


*Fig. 14. 'Z' of A. rochei estimated by "Length converted catch curve method"*

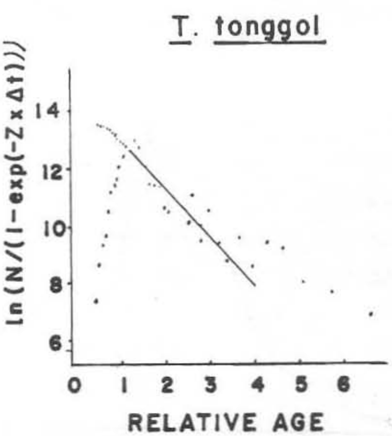


*Fig. 15. 'Z' of T. tonggol estimated by ELEFAN I (VPA model)*

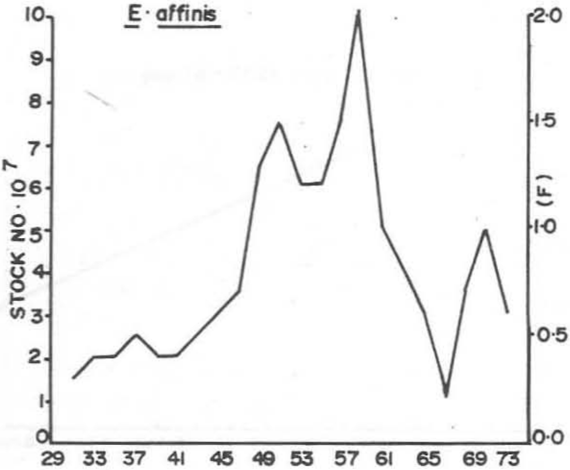


*Fig. 16. 'F' of E. affinis estimated by Thompson and Bell model analysis*

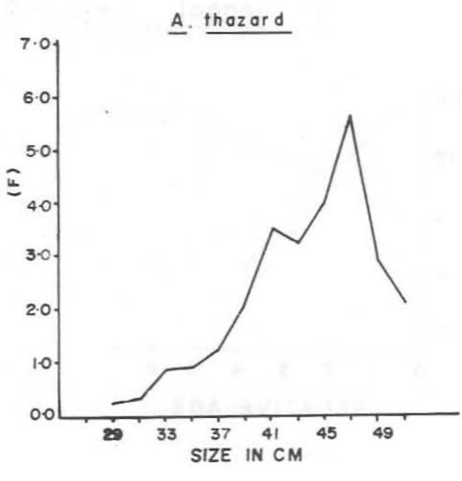


*Fig. 17. 'F' of A. thazard estimated by Thompson and Bell model analysis*

**A. thazard** (Tamil Nadu)

The length weight relationship parameters estimated for this species are

$q$ in $W = q L^b$ (gm, cm) = 0.000015012
$b$ in $W = q L^b$ = 3.04329

With the estimates of growth parameters as $L\infty = 56$ cm and $K = 0.77$ and by using length groups in the range 38-48 cm the length converted catch curve gave an estimate of Z as 4.05 (Fig. 13). The natural mortality estimated is 1.26. Using these estimates of $L\infty$, K, M, q and b, the length cohort analysis gave an estimate of mean F ($L >= 38$) as 2.85 at a terminal exploitation rate of 0.72. The average catch of this species in Tamil Nadu during 1989-91 is 472 tonnes. The Thompson and Bell long term forecast model gave estimates of MSY and Biomass MSY as 518 tonnes and 314 tonnes respectively (Table 4). The MSY is at an exploitation level which is 9 times of the present exploitation level. But the additional catch expected by increasing the effort 9 times is only 46 tonnes and hence is not economical. The average biomass estimated for the period 1989-91 is 496 tonnes.

*Table 4. A. thazard, Tamil Nadu 1989-91 avg.*

THOMPSON AND BELL LONG TERM FORECAST

| X | Yield | Mean Biomass |
|---|---|---|
| 0.0000 | 0.00 | 1022.46 |
| 0.2000 | 270.14 | 757.48 |
| 0.4000 | 376.10 | 636.64 |
| 0.6000 | 426.89 | 568.79 |
| 0.8000 | 454.58 | 525.57 |
| 1.0000 | 471.20 | 495.53 |
| 1.2000 | 481.95 | 473.30 |
| 1.4000 | 489.36 | 456.03 |
| 1.6000 | 494.72 | 442.13 |
| 1.8000 | 498.75 | 430.60 |
| 2.0000 | 501.88 | 420.81 |

MSY = 517.8781 X = 9.015625 Biom. MSY = 313.8143

**A. rochei** (Kerala)

The length weight relationship parameters of this species estimated are

$q$ in $W = q L^b$ (gm, cm) $= 5.18749 \times 10^{-6}$

$b$ in $W = q L^b$ $= 3.1711$

The length converted catch curve gave an estimate of Z as 3.04 (Fig. 14). The length groups used for this analysis were 22-32 cm and growth parameter estimates used were $L\infty = 37$ cm and $K = 0.60$.

Based on the length cohort analysis by using the parameter estimates $L\infty = 37$ cm, $K = 0.60$, $M = 1.2$ and terminal exploitation rate as 0.72, the mean *F* ($L > 22$ cm) estimated was 1.77. The Thompson and Bell long term forecast model gave an estimate of MSY as 1457 tonnes at an exploitation level of 19 times of the present level, and Biomass MSY as 695 tonnes (Table 5). The average yield and biomass in the period 1989 and 91 were 1323 tonnes and 1385 tonnes respectively. Since the difference between MSY and present yield is only 134 tonnes present exploitation level is economically optimum (Fig. 18).

**T. tonggol**

The estimates of length-weight relationship parameters for *T. tonggol* are as follows :

$q$ in $W = q L^b$ (gm, cm) $= 0.000083$

$b$ in $W = q L^b$ $= 2.7046$

The estimates of growth parameters used for the analysis are $L\infty = 94.0$ cm and $K = 0.48$. The length converted catch curve gave an estimate of Z as 1.22 (Fig. 15) and the length groups used to estimate this is 44-92 cm. The length cohort analysis with the above estimates of $L\infty$ and K and an estimate of $M = 0.803$, gave an estimate of mean F ($L >= 44$) as 0.35 at a terminal exploitation rate of 0.29. The average catch in the period 1989-91 is 1951 tonnes. The Thompson and Bell long term forecast model gave an estimate of MSY as 3069 tonnes which can be attained at an exploitation level of 4.7 times of the present level (Table 6). By just doubling the present effort an increase of 737 tonnes of yield can be expected. The Biomass MSY estimated by this method is 2683 tonnes and the average biomass in the period 1989-91 is 7965 tonnes (Fig. 19).

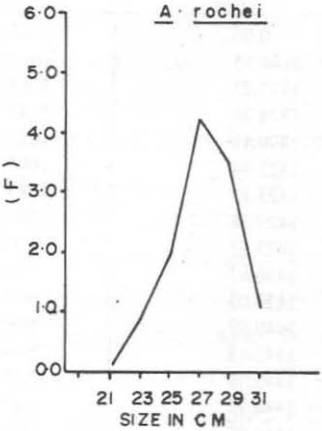


*Fig. 18. 'F' of A. rochei estimated by Thompson and Bell model analysis*

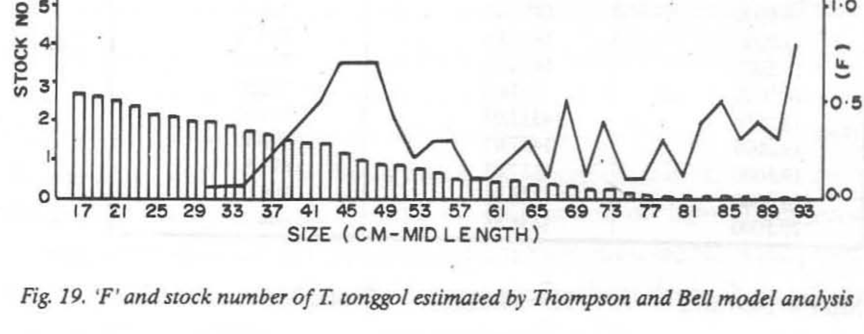


*Fig. 19. 'F' and stock number of T. tonggol estimated by Thompson and Bell model analysis*

*Table 5. A. rochei*

THOMPSON AND BELL LONG TERM FORECAST

| X | Yield | Mean Biomass |
|---|---|---|
| 0.0000 | 0.00 | 3085.86 |
| 0.5000 | 1164.15 | 1693.67 |
| 1.0000 | 1323.73 | 1384.63 |
| 1.5000 | 1374.75 | 1243.91 |
| 2.0000 | 1399.49 | 1157.16 |
| 2.5000 | 1413.94 | 1095.34 |
| 3.0000 | 1423.13 | 1047.75 |
| 3.5000 | 1429.28 | 1009.39 |
| 4.0000 | 1433.57 | 977.52 |
| 4.5000 | 1436.67 | 950.46 |
| 5.0000 | 1439.03 | 927.09 |
| 5.5000 | 1440.89 | 906.64 |
| 6.0000 | 1442.43 | 888.54 |
| 6.5000 | 1443.76 | 872.37 |
| 7.0000 | 1444.95 | 857.81 |
| 7.5000 | 1446.03 | 844.61 |
| 8.0000 | 1447.03 | 832.56 |
| 8.5000 | 1447.97 | 821.50 |
| 9.0000 | 1448.85 | 811.29 |
| 9.5000 | 1449.69 | 801.84 |
| 10.0000 | 1450.48 | 793.05 |
| 10.5000 | 1451.23 | 784.83 |
| 11.0000 | 1451.93 | 777.13 |
| 11.5000 | 1452.59 | 769.90 |
| 12.0000 | 1453.21 | 763.08 |
| 12.5000 | 1453.78 | 756.63 |
| 13.0000 | 1454.30 | 750.52 |
| 13.5000 | 1454.77 | 744.71 |
| 14.0000 | 1455.20 | 739.18 |
| 14.5000 | 1455.58 | 733.91 |
| 15.0000 | 1455.92 | 728.87 |
| 15.5000 | 1456.21 | 724.05 |
| 16.0000 | 1456.46 | 719.43 |
| 16.5000 | 1456.67 | 714.99 |
| 17.0000 | 1456.83 | 710.72 |
| 17.5000 | 1456.95 | 706.61 |
| 18.0000 | 1457.03 | 702.65 |
| 18.5000 | 14557.07 | 698.82 |
| 19.0000 | 1457.07 | 695.12 |
| 19.5000 | 1457.03 | 691.54 |
| 20.0000 | 1456.96 | 688.08 |
| 20.5000 | 1456.86 | 684.72 |

MSY = 1457.071 X = 19.01563 Biom. MSY = 694.8264

## DISCUSSION

During the past, several accounts were written on the unique nature of tuna fishery in India which is still largely confined to the small scale sector. As opined by Sudarsan (1991) excessively cautious approach has deterred the pace of development of tuna fishery from the oceanic sector although information on the resource availability had been furnished by R & D agencies. One of the areas generally accepted as a commercial possibility for tapping the oceanic resources from the EEZ and beyond by using similar type of vessels and by replacement through conversions of the out rigger trawlers for exploitation of deep sea finfish resources of India upto 300 m depth zone especially tunas and pelagic sharks, needs serious consideration.

Sudarsan *et al.* (1991) and John *et al.* (1991) have discussed the result of chartered vessels operations in the Indian EEZ, and the spurt in the increase of yellowfin and bigeye tunas.

Augmenting tuna production by modification of the crafts and gears presently employed in the small scale sector, enhancing the operational efficiency of the vessels such as drift gillnetters and purse seiners to cover continental shelf area and beyond to tap the tuna resources, especially *Thunnus tonggol* and *Auxis rochei* and highly migratory yellowfin tunas were proposed by James and Pillai (1989, *MS*). Pillai (1991 *b*) analysed the changing pattern of fishery in the small scale sector such as

1) Introduction and careful management of the improved variety of gears such as ring seines
2) Mechanisation/motorisation of the fishing crafts enabling fishing operation beyond the present fishing grounds and
3) Increasing the demand for tunas in the domestic and external markets.

The major options for enhancing the tuna production appears to be deployment of fish aggregating devices utilising low cost materials and their effective utilisation, management and diversification of fishing operations by the introduction of multiday boats with catch storage facilities, expansion of the area of the drift gillnet operations, introduction of 'light luring purse seining', intensification of trolling operations by harnessing the wind power in the tuna fishery, and also exploitation of live-baits from the northern islands of Lakshadweep and their economic utilisation.

*Table 6. T. tonggol*

THOMPSON AND BELL LONG TERM FORECAST

| X | Yield | Mean Biomass |
|---|---|---|
| 0.0000 | 0.00 | 12867.32 |
| 0.2000 | 558.52 | 11589.28 |
| 0.4000 | 1013.81 | 10486.09 |
| 0.6000 | 1386.39 | 9529.13 |
| 0.8000 | 1692.33 | 8695.15 |
| 1.0000 | 1944.25 | 7965.19 |
| 1.2000 | 2152.18 | 7323.67 |
| 1.4000 | 2324.06 | 6757.73 |
| 1.6000 | 2466.30 | 6256.66 |
| 1.8000 | 2584.03 | 5811.55 |
| 2.0000 | 2681.42 | 5414.89 |
| 2.2000 | 2761.88 | 5060.35 |
| 2.4000 | 2828.17 | 4742.58 |
| 2.6000 | 2882.58 | 4457.01 |
| 2.8000 | 2927.02 | 4199.72 |
| 3.0000 | 2963.04 | 3967.36 |
| 3.2000 | 2991.95 | 3757.03 |
| 3.4000 | 3014.85 | 3566.23 |
| 3.6000 | 3032.65 | 2292.77 |
| 3.8000 | 3046.13 | 3234.78 |
| 4.0000 | 3055.94 | 3090.58 |
| 4.2000 | 3062.64 | 2958.73 |
| 4.4000 | 3066.69 | 2837.94 |
| 4.6000 | 3068.50 | 2727.10 |
| 4.8000 | 3068.41 | 2625.20 |
| 5.0000 | 3066.70 | 2531.38 |
| 5.2000 | 3063.62 | 2444.84 |
| 5.4000 | 3059.40 | 2364.90 |
| 5.8000 | 3054.21 | 2290.93 |
| 6.0000 | 3048.21 | 2222.38 |
| 6.2000 | 3041.53 | 2158.75 |
|  | 3034.30 | 2099.62 |

MSY = 3068.675 X = 4.6875 Biom. MSY = 2682.757

The present study indicates that most of the tuna stocks in the traditional fishing grounds are exploited more on less to the maximum level and hence enhanced input of effort may not fetch desired returns.

The medium sized *Thunnus tonggol* (longtail tuna) is being seasonally fished from the south-east coast and south-west coast of India and large sized specimens are taken from the north-west coast by drift gillnets more or less throughout the year except during the monsoon period. *T. tonggol* holds high demand in the export market for far eastern countries as fresh/frozen and chilled form. It is suggested that expansion of the area of fishing and modification and multi-day operation of drift gillnetters would considerably enhance the production of this species, as well as yellowfin tuna. Demand for tuna meat is on the increase and proper extension technology for further awareness of the fishermen, processing technology and introduction of low cost fishing technology should be encouraged. However, expansion programme for drift gillnetting for tunas should also take into consideration proper conservation measures for marine mammals.

Tunas are highly migratory scombroid fish group and the development of tuna fishery in the inshore and oceanic waters of the EEZ of India need priority attention. The estaimated potential yield of coastal tunas from the depth zone 50-200 m of the north-west coast, south-west coast, south-east coast, upper east coast, Lakshadweep and Andaman Nicobar Islands has been estimated as 263,000 tonnes (Sudarsan, 1991) against a catch of 37,722 tonnes of tunas and billfishes in 1991. This, coupled with the fast expanding tuna fishery by the neighbouring countries of India and the western sector of the Indian Ocean explain the imperative necessity of expanding tuna fishery in the Indian EEZ.

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