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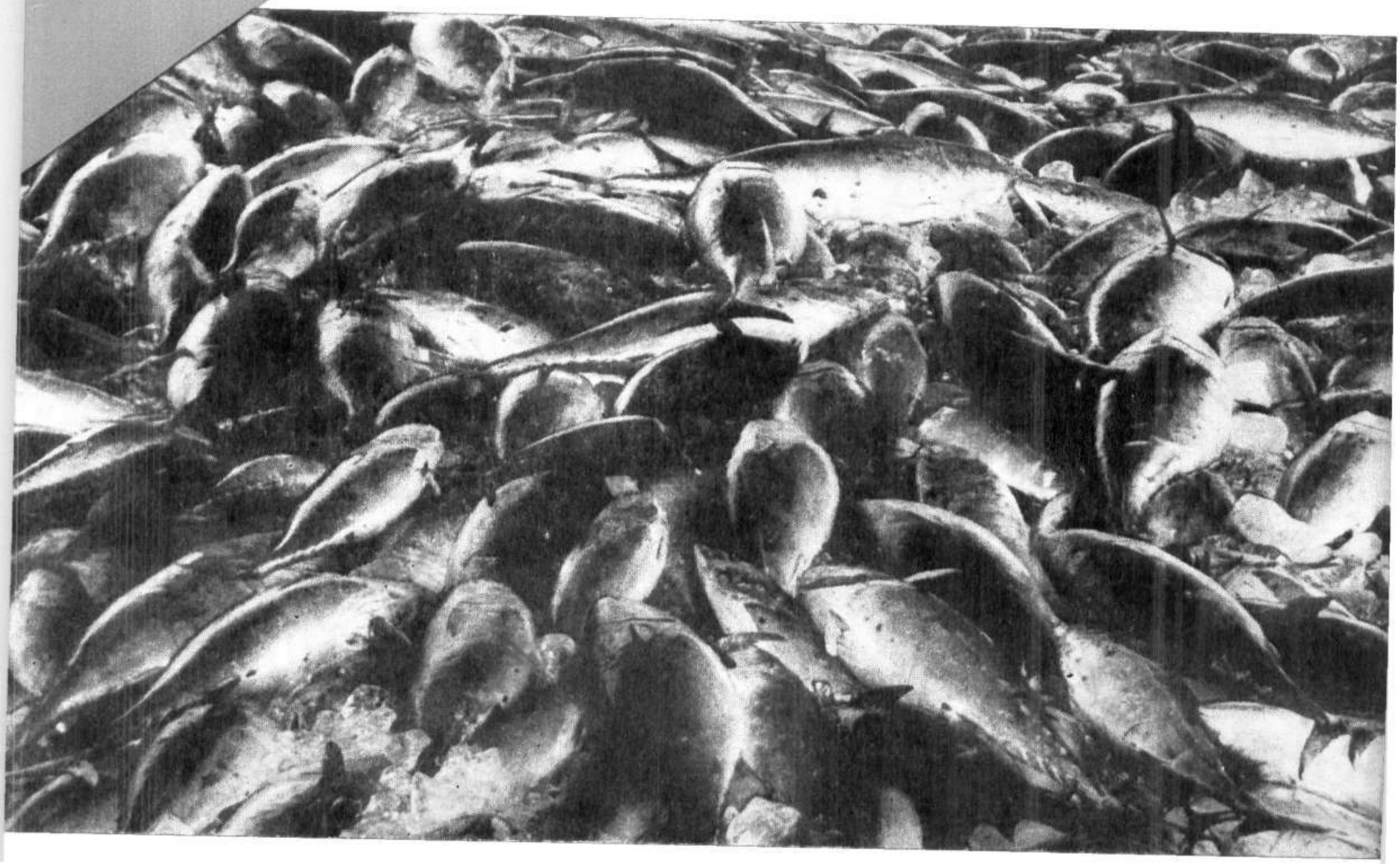
TUNA FISHERIES OF THE EXCLUSIVE ECONOMIC ZONE OF INDIA: Biology and Stock Assessment

Edited by: E. G. SILAS



CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
P.B. No. 2704, Cochin 682 031, India

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POPULATION DYNAMICS OF TUNAS : STOCK ASSESSMENT

E. G. Silas, P. Parameswaran Pillai, 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. Sadasiva Sarma

Central Marine Fisheries Research Institute, Cochin 682 031

1. Data base : Methods of sampling and analysis

Crafts and gears employed in the fishery and the system of collection of data at different centres along the west and east coasts in the mainland of India and from Minicoy Is. were dealt with earlier. In the manner described, the following informations were collected :

- — Numbers landed by fishing gear ;
- — Estimated total tunas landed by weight by fishing gear ;
- — Estimated weight of sampled landings ;
- — Species composition of sampled landings, and
- — length and weight of tunas in sampled landings.

Data collected were summarised at the end of the month by fishing gear and species. Samples of length frequencies obtained during the month by a particular fishing gear and species were summarised to calculate the weighted per cent length frequency distribution of total landings for that month.

Although the fishery and biological data have been collected on species such as *E. affinis*, *A. thazard*, *A. rochei*, *S. orientalis*, *T. tonggol*, *T. albacares* and *K. pelamis* from 1976 till date, time-series data representing all the months are available in the case of *E. affinis* and *A. thazard* in the mainland of India and *K. pelamis* and *T. albacares* in the Minicoy waters during 1976-'82. In the case of the former two species, data collected from five centres along the mainland during the four year period (1979-'82) were pooled, annual averages taken and raised to all India level. Fishery and biological data on skipjack and yellowfin tuna during the period 1976-'82 were pooled and annual averages estimated for computation.

Estimation of growth parameters

In the present study, the growth (in length) of different species was assumed to follow the von Bertalanffy's (1938) growth equation :—

$$L_t = L_\infty \left(1 - e^{-K(t - t_0)}\right), \quad \ldots\ldots\ldots (1)$$

(Where L_t, L_∞, K and t_0 have their usual meanings) an assumption made by several authors for tunas earlier (Josse *et al.*, 1979 ; Cole, 1980 ; Wankowski 1981 ; White and Yesaki, 1982 ; Yesaki, 1983). The parameters L_∞ and K of the equation were estimated using the computer programme developed by Pauly and David (1981) for modal progression (ELEFAN I). In this method, a ' best fit ' growth curve is fitted objectively through the time series of length frequency measurements. The estimated values of L_∞, K and t_0 for the von Bertalanffy's equation for different species of tunas are given in Table 1.

Since the set of estimates at different centres did not show much variation, single set of estimates for each species is obtained and presented in the above Table.

2. Cohort analysis

In the classical stock assessment theory, it is usual to assume that, within any one age group, the decline in number with age follows an exponential curve. For cohort analysis, the exponential curve within any age group is replaced by a ' step function ' by assuming that—

Table 1. *Values of L_∞, K and t_0 computed from different centres*

	L_∞ (cm)	K	t_0**	I	II	III	IV	V+	VI (?)	
				....			(cm)	....		
E. affinis ..	81.00	0.3655	—0.3438	31.43	46.60	57.14	64.44	69.50		
A. thazard ..	63.00	0.4898	—0.2700	29.20	42.20	50.30	55.00			
T. tonggol ..	93.00	0.4898	—0.2400	42.30	61.90	74.00	81.30	85.90		
S. orientalis ..	66.00	1.0005	—0.1300	44.70	58.00	63.00	65.00			
K. pelamis ..	90.00	0.4898	—0.0600	36.00	57.00	69.00				
*T. albacares** ..	145.00	0.3200	—0.3400	50.60	76.40	95.20	108.8	118.30	125.90	131.20

(* *Based on Minicoy data*) ** Computed from Pauly (1979)

PLATE I. Tunas landed by drift gillnets are counted after auction at Cochin Fisheries Harbour.

PLATE II. Tunas landed by drift gillnet stacked at Cochin Fisheries Harbour before transportation.

PLATE III. Tunas are being loaded at Cochin Fisheries Harbour for transportation to distant markets.

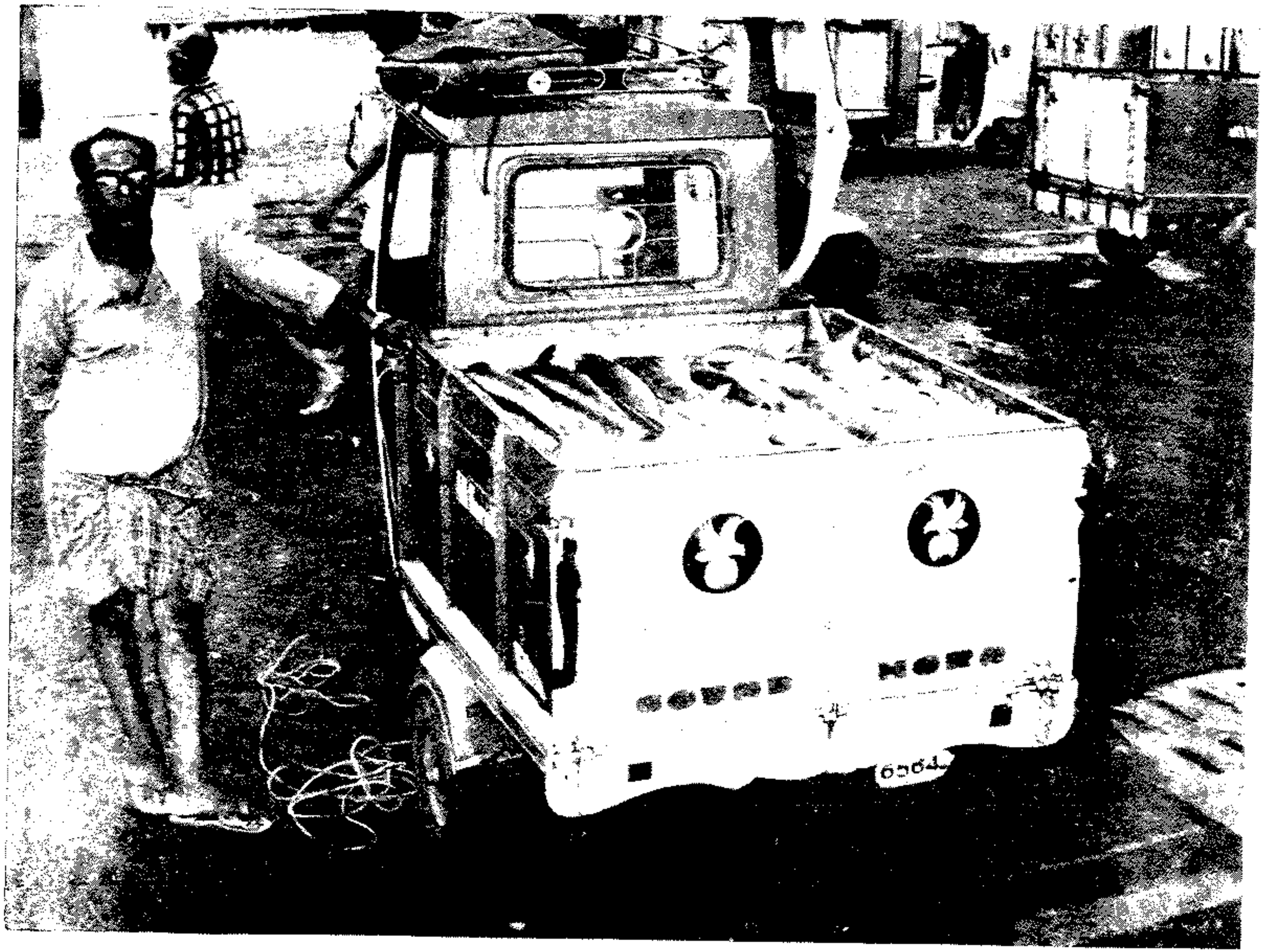

PLATE IV. Tunas and Seerfishes loaded in autocarrier at Cochin Fisheries Harbour for local interior markets.

(1) the whole of the catch for that age group is taken at exactly the middle of the age interval, and

(2) only natural losses occur continuously on an exponential basis.

The analysis of length composition data by adjusting the age-data in order to apply for their length-data, as discussed by Jones (1981) is adopted in the present study.

Further, in this analysis, it is easy to understand what is happening to fish stocks by looking at the numbers of fish caught during successive intervals in their life span. The length of the fish can be used to define the bound areas between successive intervals and each length interval represents a successive interval in the life of the typical year class, though the duration of the interval will vary. In the case of *E. affinis* and *A. thazard*, the length cohort analysis has been applied in order to estimate their numbers in the sea, average numbers and weight in the sea, F, Z and F/Z for each length class under the assumption that the population of these species occurring in the Indian waters represents one unit stock respectively.

3. FORMULATION (Jones, 1981)

The basic equation used in the length cohort analysis was

$$N_t = N_t + \triangle t e^{M \triangle t} + C_t e^{M \triangle t/2} \; \ldots\ldots (2)$$

where $\triangle_t$ = the time required to grow from the beginning to the end of a length interval.

Using von Bertalanffy's (1938) growth equation, the time required to grow from the beginning of a length interval (L_1 cm) to the upper limit of a length interval (L_2 cm) had been determined. In this way,

$$\triangle t = t_2 - t_1 = (1/K) \; [1_n \; (L_\infty - L_1) / \; (L\infty - L_2)] \; \ldots\ldots (3)$$

This equation is a function of L_∞ and K but is independant of t_0.

The equation for $\triangle t$ has been used in conjunction with equation (2) to arrive at a modified equation for analysing length composition :—

$$N_1 = (N_2 X_L + C_{1,2}) X_L \ldots\ldots (4)$$

where, $C_{1,2}$ = the number of fish caught during a year with lengths between L_1 and L_2 cm, and

$$X_L = [(L_\infty - L_1) / (L_\infty - L_2)]^{M/2K} \ldots\ldots (5$$

N_1 and N_2 represent numbers in the sea with length L_1 and L_2 respectively.

According to Jones (1981), this equation is a function of L_∞, M and K. More particularly, since the '*M*' and '*K*' appear as the ratio M/K, the equation is a function of the two variables, L_∞ and M/K.

The procedure followed was the estimation of a value for the fish reaching the length corresponding to the beginning of the largest length group. Successive application of equation then led to the estimation of the number reaching a particular length for successive smaller specimens.

The difference between a lightly fished and heavily fished stock is emphasized by the consideration of the appropriate input values to use for '*F*' and '*M*' for the oldest animals.

If the oldest age group comprises all individuals, older than a certain age, an input value of F/Z is required. The effect of the estimates among younger ages, of adopting different values of F/Z will depend on whether the stock is heavily exploited or not.

Estimates of the exploitation rate, designated by the ratio F/Z, has been determined for each length interval from the relationship :—

F/Z = Number caught/Number dying

Values of 'F' (instantaneous fishing mortality) corresponding to fishing mortality over a particular time interval was derived at from the relationship :—

$$F \triangle t = (F/Z)(Z \triangle t) \; \ldots\ldots (6)$$

For the calculation of the annual mortality rates, '*Z*' and '*F*', it was necessary to take into account the actual time interval $\triangle t$ for length interval. This required input information equivalent to separating the ratio M/K into two separate compartments M and K. Assuming for a given value of M instantaneous mortality rate (Z) was calculated from the relationship

$$Z = M/(1\text{-}F/Z) \; \ldots\ldots (7)$$

The basic input parameters for carrying out cohort analysis are the terminal *F/Z* (the exploitation rate for the largest group) and *M/K*. In the accompanying work sheets the exploitation rate (*F/Z*), total mortality (*Z*) and fishing mortality rate (*F*) their No. in the sea, Average Number and weight in the sea with respect to *E. affinis* for F/Z (0.70 and 0.50) and $M/K = 1.0$ and *A. thazard* for $F/Z = 0.50$ and 0.80 and $M/K = 1.0$ is presented (Tables 2-5) (Fig. 1).

As presented in the work sheets attached for *E. affinis* applying $F/Z = 0.7$, the total stock was 2.17 lakh tonnes and the average stock 32,000 tonnes. Applying $F/Z = 0.5$ also the average stock was 31,775 tonnes. In the case of *A. thazard*, for $F/Z = 0.5$, the total stock estimated was 7,745 tonnes and the average stock was 925 tonnes.

From the present data it appears that any further increase in the fishing effort in the presently exploited grounds will not lead to increase in the production of these species. The indications are that there will be a steep decline in the catch per Unit of effort. The solution is the expansion of the areas of operations both in the continental shelf waters and in the Lakshadweep and Andaman Sea.

With regard to the stock status of skipjack and yellowfin tuna (young ones), yield per recruit analysis following Beverton and Holt Yield Model was carried out. The instantaneous rate of mortality is estimated following Alagaraja's (1984) method. The data had been collected from the investigations conducted at Minicoy during the period 1976-'82.

The estimation of the growth parameters and the techniques used has been described earlier. Further the corresponding estimates for W∞ were calculated as follows :

Skipjack – W∞ 16.372 kg and for yellowfin tuna it is 49.478 kg.

Estimates of 'Z'

Following the methods presented by Alagaraja (1984) and Srinath (1986 : MS) that portion of the length frequency distribution which resembled the right limb of the catch curve was only considered for estimation of 'Z'. The procedure followed in the estimation of 'Z' was as follows :

Derivations

$$\log(N_t + \Delta t/N_t) =$$

$$\frac{Z}{K} = \log_e\left[\frac{L_\infty - l_{t+\Delta t}}{L_\infty - l_t}\right] \quad \ldots\ldots(8)$$

Estimates of $L\infty$ and K were taken from Table 1. l_t and $l_t + \Delta_t$ were the successive mid values of the length classes, whose frequencies are N_t and $N_t + \Delta_t$. It was considered that 'Z' is constant for the entire size range of the catches in numbers at successive age, Ct and $Ct + \Delta t$ are proportional to Nt and $N_t + \Delta_t$.

Equation (8) can be re-written as :

$$Y_i = \left(\frac{Z}{K} - 1\right) X_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(9)$$

$$\text{Where } Y_i = \log\left(\frac{Nl_t + \Delta t}{Nl_t}\right)$$

$$X_i = \log\left(\frac{L_\infty - l_{t+\Delta t}}{L_\infty - l_t}\right)$$

From this, $\frac{Z}{K} - 1$ is given by Y/X. If there are n + 1 length groups considered for estimating Z/K then there will be 'n' ratios of type (9), each one an estimate of $\frac{Z}{K} - 1$. The mean of such ratios gives an average value of $\frac{Z}{K} - 1$ for the length range considered ie., if the first estimate is e_1, the second e_2 .... the last one e_n.

Then,

$$\left(\frac{\bar{Z}}{K} - 1\right) = \frac{1}{n} \sum_{i=1}^{n} e_i \quad \ldots\ldots\ldots\ldots\ldots(10)$$

and

$$S^2_{Z/K-1} = \frac{1}{n-1} \sum e_i^2 - \frac{(\sum e_i)^2}{n} \quad \ldots\ldots\ldots(11)$$

from this the standard error of (Z/K) is given by :

$$SE\left(\frac{Z}{K} - 1\right) = \frac{1}{\sqrt{n}} \quad S_{Z/K-1} \quad \ldots\ldots\ldots(12)$$

where, $S_{Z/K-1}$ is the root of (11)

Multiplying $\bar{Z}/K$ by the value of 'K' alredy calculated, the estimates of $\bar{Z}$ and standard error can be estimated. The estimates thus obtained are given in Tables 6 & 7 along with l_c, and l_r where l_c indicates the size at the first capture of the

TABLE 6. K. pelamis : *Yield per recruit*

W∞=16,372 M=0.75
lc=54 M/K=1.54
lr=30 cm
$e^{M(t_r - t_o)} = 1.861$ $\bar{Z}=2.555$

E	Y/R (g)	
0.05	179.1	
0.10	349.4	
0.15	510.6	E_p=0.71
0.20	662.1	
0.25	803.8	
0.30	934.9	
0.35	1,055.3	
0.40	1,164.4	
0.45	1,261.8	
0·50	1,347.1	
0.55	1,419.9	
0.60	1,480.0	
0.65	1,526.9	
0.70	1,560.6	
0.75	1,581.0	
0.80	1,588.2	
0.85	1,582.6	
0.90	1,565.0	
0.95	1,536.0	
1.00	1,498.5	

* Ep=Present exploitation rate.

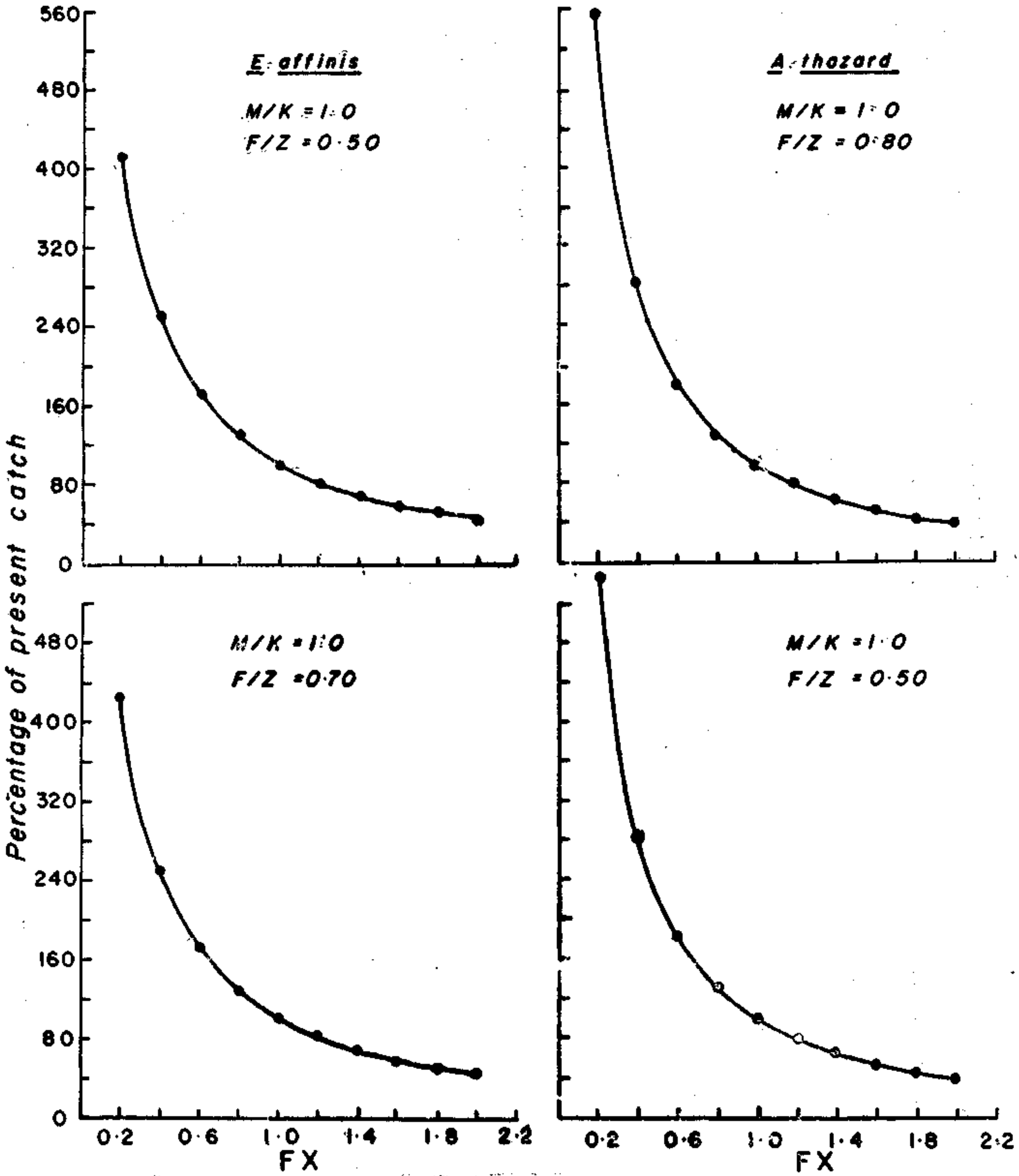

Fig. 1. Effect upon yield of *E. affinis* and *A. thazard* of altering the present level of effort.

TABLE 7. T. albacares : *Yield per recruit*

Woc=49,478 g. M=0.49
lc=45 M/K=1.54
lr=30 cm $\bar{Z}$=3.488
$e^{M(tr-to)}$=1.426

E	Y/R (g)	
0.05	485.9	
0.10	927.2	
0.15	1,323.0	
0.20	1,671.9	$\bar{E}_p$=0.85*
0.25	1,972.7	
0.30	2,224.0	
0.35	2,425.9	
0.40	2,577.3	
0.45	2,678.2	
0.50	2,728.7	
0.55	2,729.7	
0.60	2,683.2	
0.65	2,590.7	
0.70	2,456.6	
0.75	2,285.9	
0.80	2,085.0	
0.85	1,863.3	
0.90	1,631.3	
0.95	1,401.7	
1.00	1,188.9	

* E_p=Present exploitation rate

fully recruited phase and l_r the size at entry to the fishery.

Yield/Recruit of both these species has been calculated following the Beverton and Holt Yield model (1953). For skipjack tuna, calculating 'Z' as 2.555, $M = 0.75$, M/K as 1.54, $l_c = 54$ cm and $l_r = 30$ cm, the present exploitation ratio calculated was 0.71 based on the equation :—

$$F/Z = \frac{Z - M}{Z} = \frac{2.555 - 0.75}{2.555}$$

This picture represents that the present level of exploitation is not affecting the stock and the capture of this species has not reached the maximum sustainable yield (Fig. 2).

As far as yellowfin tuna (young ones) taken by the pole and line fishery, calculating $\bar{Z}$ as 3.488, $M = 0.49$, $M/K = 1.54$, $l_c = 45$ cm and $l_r = 30$ cm, it was observed that the present exploitation ratio is 0.85 (Fig. 2). However, the pole and line (live-bait) fishery is taking the young yellowfin tunas, and in view of the highly migratory nature of the adults it is emphasized that further expansion of the fishery is possible with regard to these two species by employing efforts in deep longlining, purse seining and by putting in major thrusts on constant supply of bait fishes through mariculture for pole and line (live-bait) fishery as well as use of FADs.

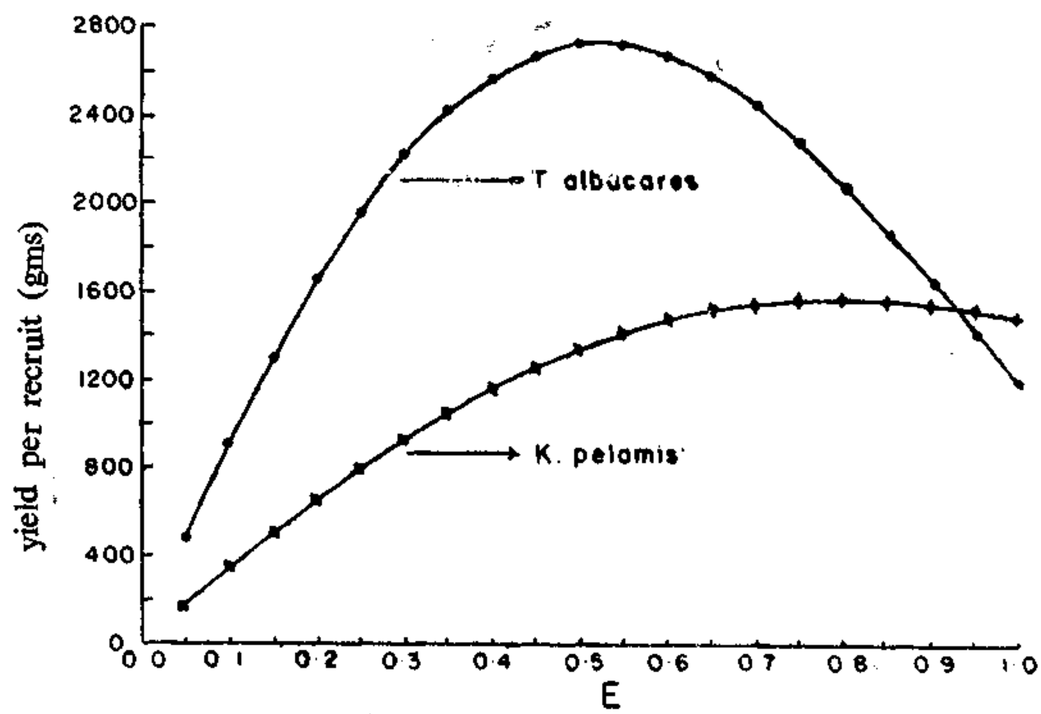

Fig. 2. Yield per recruit of *K. pelamis* and *T. albacares*

TABLE 2. *Exploitation rate, total mortality, instantaneous mortality rate, number in the sea, average number and weight in the sea with respect to* E. affinis

M/K=1.0, F/Z=0.5

Length Class (cm)	Numbers landed (lakhs)	Weight landed (mt)	Numbers in sea (lakhs)	Weight in sea (mt)	Average numbers in sea (lakhs)	Average weight in sea (mt)	*F*	*Z*	*F/Z*
12-14 ..	0.001	0.006	196.884	815.101	15.613	64.639	0.0001	0.3656	0.0030
14-16 ..	0.016	0.010	191.176	1208.233	15.615	98.685	0.0010	0.3665	0.0028
16-18 ..	0.009	0.086	185.453	1696.898	15.612	142.847	0.0006	0.3661	0.0019
18-20 ..	0.012	0.161	179.738	2282.671	15.611	198.265	0.0008	0.3663	0.0022
20-22 ..	0.017	0.288	174.019	2970.511	15.609	266.440	0.0011	0.3666	0.0029
22-24 ..	0.063	1.403	168.297	3753.029	15.607	348.038	0.0040	0.3695	0.0109
24-26 ..	0.407	11.598	162.530	4632.118	15.585	444.136	0.0261	0.3916	0.0667
26-28 ..	0.628	22.499	156.428	5600.118	15.530	555.976	0.0405	0.4060	0.0997
28-30 ..	0.728	32.239	150.123	6650.434	15.460	684.890	0.0471	0.4126	0.1141
30-32 ..	1.565	84.359	143.744	7747.789	15.339	826.787	0.1020	0.4675	0.2183
32-34 ..	1.482	96.474	136.573	8890.880	15.168	987.430	0.0977	0.4632	0.2109
34-36 ..	6.245	481.556	129.547	9988.065	14.714	1134.459	0.4245	0.7000	0.5373
36-38 ..	5.546	503.544	117.923	10707.383	13.998	1270.986	0.3962	0.7617	0.5201
38-40 ..	2.859	303.086	107.261	11369.640	13.466	1427.437	0.2123	0.5778	0.3675
40-42 ..	1.817	223.524	99.480	12236.020	13.153	1617.796	0.1382	0.5037	0.2743
42-44 ..	2.163	304.963	92.855	13092.522	12.874	1815.282	0.1680	0.5335	0.3149
44-46 ..	2.952	478.158	85.986	13929.782	12.496	2024.290	0.2362	0.6017	0.3926
46-48 ..	3.808	700.595	78.468	14438.056	12.001	2208.178	0.3182	0.6817	0.4654
48-50 ..	4.460	927.682	70.287	14619.621	11.279	2346.132	0.3954	0.7609	0.5197
50-52 ..	6.056	1417.074	61.704	14438.757	10.346	2421.004	0.5852	0.9509	0.6155
52-54 ..	6.276	1650.712	51.866	13640.736	9.184	2415.399	0.6834	1.0489	0.6516
54-56 ..	6.988	2040.356	42.233	12331.974	7.837	2288.454	0.8916	1.2571	0.7096
56-58 ..	8.066	2621.359	32.381	10523.724	6.186	2010.554	1.0038	1.6693	0.7810
58-60 ..	7.402	2664.716	22.054	7939.393	4.346	1564.715	1.7030	2.0685	0.8233
60-62 ..	5.722	2271.626	13.063	5186.126	2.639	1047.993	2.1676	2.5331	0.8557
62-64 ..	2.514	1098.631	6.376	2786.522	1.464	639.929	1.7168	2.0823	0.8245
64-66 ..	1.444	691.978	3.327	1593.747	0.831	398.145	1.7380	21.035	0.8262
66-68 ..	0.505	264.615	1.579	827.296	0.481	251.803	1.0509	1.4164	0.7419
68-70 ..	0.430	246.177	0.898	513.758	0.284	162.282	1.5170	1.8825	0.8058
70-72 ..	0.245	152.378	0.364	226.470	0.117	72.861	2.0914	2.4569	0.8512
72-74 ..	0.053	35.539	0.763	51.509	0.209	19.838	1.7916	2.1571	0.8306
74-76 ..	0.006	4.722	0.013	9.444	..	..	0.0000	0.0000	0.5000
Total ..	80.485	19332.114	2863.393	205698.327	318.473	31755.670			

TABLE 3. *Exploitation rate, total mortality, instantaneous mortality rate, number in the sea, average number and weight in the sea with respect to* E. affinis

M/K=1.0, F/Z=0.70

Length class (cm)	Numbers landed (lakhs)	Weight landed (mt)	Numbers in sea (lakhs)	Weight in the sea (mt)	Average numbers in sea (lakhs)	Average weight in sea (mt)	*F*	*Z*	*F/Z*
12-14 ..	0.001	0.006	196.848	814.950	15.610	64.627	0.0001	0.3656	0.0003
14-16 ..	0.016	0.103	191.141	1208.010	15.612	98.667	0.0010	0.3665	0.0029
16-18 ..	0.009	0.086	185.419	1696.584	15.609	142.821	0.0006	0.3661	0.0016
18-20 ..	0.012	0.161	179.705	2282.249	15.608	198.227	0.0008	0.3663	0.0022
20-22 ..	0.017	0.288	173.987	2969.962	15.483	264.301	0.0011	0.3666	0.0030
22-24 ..	0.063	1.403	168.266	3752.335	15.604	347.974	0.0040	0.3695	0.0109
24-26 ..	0.407	11.598	162.500	4631.261	15.581	444.058	0.0261	0.3916	0.0667
26-28 ..	0.628	22.498	156.399	5599.079	15.527	555.883	0.0405	0.4060	0.0997
28-30 ..	0.728	32.240	150.095	6649.196	15.458	684.776	0.0471	0.4126	0.1141
30-32 ..	1.565	84.359	143.717	7746.339	15.334	826.488	0.1021	0.4676	0.2183
32-34 ..	1.482	96.473	136.547	8889.198	15.166	987.281	0.0977	0.4632	0.2114
34-36 ..	6.245	481.555	129.522	9986.154	14.713	1134.356	0.4245	0.7900	0.537
36-38 ..	5.546	503.544	117.899	10705.229	13.996	1270.861	0.3962	0.7617	0.5200
38-40 ..	2.859	303.086	107.238	11367.232	13.462	1426.995	0.2124	0.5779	0.3675
40-42 ..	1.817	223.524	99.458	12233.361	13.151	1617.539	0.1382	0.5037	0.2743
42-44 ..	2,163	304.963	92.834	13089.622	12.872	1815.001	0.1680	0.5335	0.3149
44-46 ..	2.952	478.158	85.967	13926.622	12.492	2023.670	0.2363	0.6018	0.3922
46-48 ..	3.808	700.595	78.449	14434.660	11.963	2201.114	0.3183	0.6838	0.4656
48-50 ..	4.460	927.682	70.269	14615.999	11.277	2345.529	0.3955	0.7610	0.5196
50-52 ..	6.056	1417.074	61.688	14434.934	10.345	2420.744	0.5854	0.9509	0.6157
52-54 ..	6.276	1650.712	51.851	13636.715	9.181	2414.676	0.6836	1.0491	0.6516
54-56 ..	6.988	2040.356	42.219	12327.817	7.834	2287.660	0.8919	1.2574	0.7096
56-58 ..	8.066	2621.359	32.368	10519.441	6.183	2009.626	1.3044	1.6699	0.7811
58-60 ..	7.402	2664.716	22.042	7935.026	4.343	1563.621	1.7042	2.0697	0.8234
60-62 ..	5.722	2271.626	13.052	5181.731	2.637	1046.833	2.1700	2.5355	0.8558
62-64 ..	2.514	1098.631	6.366	2782.143	1.461	638.662	1.7202	2.0857	0.8248
64-66 ..	1.444	691.978	3.318	1589.451	0.828	396.755	1.7441	2.1096	0.7431
66-68 ..	0.505	264.615	1.571	823.146	0.478	250.295	1.0572	1.4227	0.7431
68-70 ..	0.430	246.177	0.891	509.835	0.281	160.627	1.5326	1.8981	0.8074
70-72 ..	0.245	152.378	0.358	222.862	0.114	71.065	2.1442	2.5097	0.8544
72-74 ..	0.053	35.539	0.072	48.303	0.026	17.886	1.9867	2.3522	0.8446
74-76 ..	0.006	4.722	0.009	6.747	..	..	0.0000	0.0000	0.7000
Total ..	80.485	19332.205	2862.065	216616.193	318.468	31728.618			

TABLE 4. *Exploitation rate, total mortality, instantaneous mortality rate, number in the sea, average number and weight in the sea with respect to* A. thazard

M/K=1.0, F/Z=0.50

Length class (cm)	Numbers landed (lakhs)	Weight landed (mt)	Numbers in sea (lakhs)	Weight in sea (mt)	Average numbers in sea (lakhs)	Average weight in sea (mt)	*F*	*Z*	*F/Z*
12-14 ..	0.011	0.413	23.036	84.773	1.843	6.784	0.006	0.496	0.0123
14-16 ..	0.019	0.106	22.122	125.873	1.842	10.482	0.010	0.500	0.0202
16-18 ..	0.058	0.483	21.201	176.602	1.841	15.332	0.032	0.521	0.0605
18-20 ..	0.122	1.423	20.242	236.626	1.832	21.417	0.066	0.556	0.1195
20-22 ..	0.057	0.899	19.223	304.686	1.822	28.886	0.031	0.521	0.0595
22-24 ..	0.022	0.457	18.274	381.918	1.818	37.999	0.012	0.502	0.0240
24-26 ..	0.223	5.992	17.361	467.008	1.806	48.589	0.123	0.613	0.2010
26-28 ..	0.450	15.349	16.254	554.249	1.769	60.334	0.255	0.744	0.3419
28-30 ..	0.254	10.744	14.937	632.145	1.727	73.085	0.147	0.637	0.2308
30-32 ..	0.388	20.092	13.837	717.319	1.689	87.549	0.230	0.719	0.3192
32-34 ..	0.386	24.181	12.623	791.583	1.638	102.700	0.236	0.725	0.3248
34-36 ..	0.957	71.756	11.436	857.817	1.542	115.673	0.621	1.110	0.5589
36-38 ..	1.197	106.275	9.724	863.483	1.378	122.404	0.868	1.358	0.6393
38-40 ..	3.118	325.074	7.852	818.729	1.022	106.612	3.049	3.539	0.8616
40-42 ..	2.785	338.107	4.234	513.993	0.499	60.558	5.583	6.073	0.9194
42-44 ..	0.901	127.304	1.204	169.036	0.144	20.181	6.308	6.798	0.9279
44-46 ..	0.155	25.035	0.227	36.571	0.032	5.094	4.914	5.404	0.9094
46-48 ..	0.043	7.871	0.056	10.321	0.008	1.504	5.232	5.722	0.9144
48-50 ..	0.008	1.725	0.009	1.944	0.001	0.286	6.024	6.514	0.9248
50-52 ..	0.0002	0.044	0.0003	0.084	0.00009	0.019	2.285	2.774	0.8235
52-54 ..	0.00007	0.019	0.0001	0.037	..	..	0.000	0.000	0.5000
Total ..	11.15427	1083.349	233.8524	7744.797	24.25309	925.488			

TABLE 5. *Exploitation rate, total mortality, instantaneous mortality rate, number in the sea, average number and weight in the sea with respect* to A. thazard

M/K=1.0, F/Z=0.80

Length class (cm)	Numbers landed (lakhs)	Weight landed (mt)	Numbers in sea (lakhs)	Weight in sea (mt)	Average numbers in sea (lakhs)	Average weight in sea (mt)	*F*	*Z*	*F/Z*
12-14 ..	0.011	0.413	23.036	84.772	1.843	6.784	0.006	0.496	0.0122
14-16	0.019	0.106	22.122	125.871	1.842	10.482	0.010	0.500	0.0203
16-18 ..	0.058	0.483	21.200	176.600	1.841	15.332	0.032	0.521	0.0605
18-20 ..	0.122	1.423	20.242	236.624	1.832	21.417	0.066	0.556	0.1195
20-22 ..	0.057	0.899	19.223	304.683	1.822	28.889	0.039	0.521	0.0598
22-24 ..	0.022	0.457	18.273	381.914	1.818	37.999	0.012	0.502	0.0240
24-26 ..	0.223	5.992	17.361	467.003	1.806	48.589	0.123	0.613	0.2012
26-28 ..	0.450	15.349	16.253	554.243	1.769	60.333	0.255	0.744	0.3420
28-30 ..	0.254	10.744	14.937	632.138	1.727	73.085	0.147	0.637	0.2308
30-32 ..	0.388	20.092	13.837	717.311	1.689	87.548	0.230	0.719	0.3192
32-34 ..	0.386	24.181	12.623	791.573	1.638	102.699	0.236	0.725	0.3248
34-36 ..	0.956	71.756	11.435	857.807	1.542	115.673	0.621	1.110	0.5589
36-38 ..	1.197	106.275	9.724	863.472	1.378	122.403	0.868	1.358	0.6393
38-40	3.118	325.074	7.852	818.717	1.022	106.611	3.049	3.539	0.8616
40-42	2.785	338.107	4.233	513.980	0.499	60.558	5.584	6.073	0.9194
42-44	0.907	127.304	1.204	169.022	0.144	20.178	6.300	6.799	0.9280
44-36	0.155	25.035	0.227	36.557	0.032	5.091	4.917	5.407	0.9094
46-48	0.043	7.871	0.056	10.307	0.008	1.501	5.245	5.739	0.9146
48-50	0.008	1.725	0.009	1.930	0.001	0.282	6.111	6.601	0.9258
50-52	0.0002	0.044	0.0003	0.071	0.00007	0.015	2.939	3.429	0.8571
52-54	0.00007	0.019	0.00009	0.024	..	..	0.000	0.000	0.8000
Total ..	11.15927	1083.349	233.84739	7744.619	24.25307	925.469			

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