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MARINE CATFISH RESOURCES OF INDIA

EXPLOITATION AND PROSPECTS

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

ASSESSMENT OF THE RESOURCES OF IMPORTANT SPECIES OF CATFISHES

— K. ALAGARAJA AND M. SRINATH

DATA BASE

The centres Waltair and Mandapam, in the east coast and Cochin, Mangalore and Veraval, in the west coast, where biological data on catfishes have been collected, are considered for the assessment of resources of Tachysurus *thalassinus, T. tenuispinis, T. serratus, T. dussumieri* and *Osteogeneiosus militaris*. Length-frequency data of *T. thalassinus* collected during 1974-76 at Waltair from trawl catches, during 1972-76 at Mandapam from trawl catches, during 1981 at Cochin Fisheries Harbour from the catches of trawls, purse-seines and gill nets and during 1981 and 1982 at Veraval from trawl catches are taken up for this study. For *T. tenuispinis*, the data collected during 1974-76 at Waltair from trawl catches, during 1981 at Cochin Fisheries Harbour and during 1982-83 at Mangalore both from trawls, purse-seines and gill nets are considered. For *T. serratus*, the length-frequency data collected from the catches of trawls, purse-seines and gill nets at Cochin Fisheries Harbour during 1981 and for *T. dussumieri* and *O. militaris* those collected from the catches of trawls at Veraval during 1981 and 1982 are also considered.

ESTIMATION OF GROWTH PARAMETERS AND THE TECHNIQUES USED

i. *Estimation of 'L∞' and 'K'* : Assuming that the growth of catfish is isometric and following Von Bertalanffy's growth pattern, namely

$$L_t = L\infty\left[1 - e^{-k\,(t - to)}\right] \quad \ldots\ldots\ldots(1)$$

in the usual notation, estimates for L∞ and K are obtained using ELEFAN-I (Pauly et al, 1981). Since the estimates for each species did not show much variation between centres, sets of estimates (L∞ and K) one for each species is obtained and is presented along with the corresponding estimate for W∞ in Table 1.

TABLE - 1

Estimation of growth parameters

Parameters / Species	L∞ (mm)	K(annual)	W∞ (gm)
T. thalassinus	755	0.36	4030
T. tenuispinis	560	0.78	3230
T. serratus	1100	0.25	8000
T. dussumieri	850	0.25	6000
O. militaris	540	0.78	3200

It can be seen from the above table that estimates of 'K' decrease while the corresponding values of L∞ increase. This is quite consistent with the growth model under consideration.

ii. Estimates of 'Z' the Instantaneous Rate of Total Mortality

Age-frequency distribution was found to be very difficult to obtain from the available data. Using length-frequency data and following the method of Alagaraja (1984) estimates of 'Z' for each year at each centre for every species mentioned above have been obtained along with their error estimates. In some cases three point moving averages have been taken for this purpose. That portion of the length frequency distribution which resembled the right limb of catch curve alone was considered for estimation of 'Z'. The steps taken for this purpose as well as marking the portion considered for the estimation of 'Z' are indicated in the work sheets enclosed.

The formula used for this purpose is:

$$\log\left(N_t + \Delta_t / N_t\right) = \frac{Z}{K} \log \frac{L\infty - L_t + \Delta_t}{L\infty - L_t} \quad \ldots\ldots\ldots\ldots(2)$$

Estimates of $L\infty$ and k are available from Table 1 and L_t and $L_t + \Delta t$ are the successive mid values of the length classes whose frequencies are N_t and $N_t + \Delta t$. Since constant 'Z' for the entire size range of fishing is considered, catches in numbers at successive ages C_t and, $C_t + \Delta t$ are proportional to N_t and $N_t + \Delta t$. Hence

$$N_t + \Delta t \ / N_t = C_t + \Delta t \ / C_t \quad \ldots\ldots\ldots (3)$$

This is made use of in the above formula (2) and length frequency data are used for estimation of 'Z'. The procedure for obtaining the estimates of 'Z' is as follows. The deviations of L_t from $L\infty$ $(= L\infty - L_t)$ are to be taken. Converting them to log values (common log will do), the values log $(L\infty - L_t)$ are obtained. After tabulating these values, their successive differences log $(L\infty - L_t)$ − log $(L\infty - L_t + \Delta t)$ are calculated. In the same way, the sucessive differences of log (N_t) are to be taken and tabulated as follows :

L_t	$L\infty - L_t$	log $L\infty - L_t$	$\frac{\Delta \log (L\infty - L_t)}{A}$
1	2	3	4
C_t	log C_t	$\frac{\Delta \log C_t}{B}$	$\frac{Z/K}{B/A}$
5	6	7	8

Where Δ log $(L\infty - L_t)$ and Δ log C_t are the respective successive differences.

Thus for each row of successive differences an estimate of $\bar{z}/k$ is available. If there are 'n+1' length groups then there will be 'n' estimates of $\bar{z}/k$. If the first estimate of $\bar{z}/k$ is termed as x_1, the second as x_2 and so on with the last one as x_n then

$$\bar{z}/k = 1/n \sum_{L=1}^{n} X_i \quad \ldots\ldots\ldots (4)$$

and

$$s^2 \bar{z}/k = \frac{1}{n-1}\left[\sum_{L=1}^{n} X_L^2 - \left(\sum_{L=1}^{n} X_L\right)^2 \Big| n\right] \quad \ldots\ldots\ldots (5)$$

Hence sz/k can be obtained as the square root of the above expression. The standard error of z/k(= sz/k) is $\frac{1}{\sqrt{n}} s_{z/k}$ Multiplying $\bar{z}/k$ and $s\bar{z}/k$ by the already available estimate of 'k' the estimate of $\bar{z}$ and $s\bar{z}$ are derived. The detail procedure is given in the worksheet II. The estimates thus obtained are given in tables 2-4 below along with the sample size (n), l_c and l_r where l_c indicates the size at first capture of the fully recruited phase and l_r is the size at entry to the fishery.

TABLE 2

Values of the estimates of $\bar{z}$ and its standard error and 'n' lc and l_r for T. thalassinus

Centre	Year	Values				
		$\bar{z}$	s $\bar{z}$	n	lc (mm)	lr (mm)
1. *Waltair* (Trawls)	1974	2.34	0.41	4		
	1975	2.24	0.68	7	180	100
	1976	1.16	0.54	4		
	Combined	1.98	0.37	15	180	100
2. Mandapam (Trawls)	1972	2.32	0.62	6	170	
	1973	1.54	0.27	5	230	
	1974	1.16	0.36	7	190	
	1975	2.06	0.40	11	230	60
	1976	3.72	0.55	8	270	
	Combined	2.22	0.25	37	220	60
3. *Cochin* Fisheries Harbour (Trawl & gill net)	1981	2.06	0.52	9	360	100
4. *Veraval* (Trawls)	1981	1.71	0.88	4		
	1982	1.50	0.63	4	380	100
	Combined	1.60	0.50	8	380	100

TABLE 3

Values of estimates of $\bar{z}$, and its standard error and 'n', lc and lr for T. tenuispinis

Centre	Year	Values				
		$\bar{z}$	s $\bar{z}$	n	lc (mm)	lr (mm)
1. *Waltair* (Trawls)	1974	2.14	0.64	3	220	80
	1975	2.57	0.84	3	220	120
	1976	2.95	0.73	4	180	160
	Combined	2.59	0.40	10	200	120
2. *Cochin Fisheries Harbour* (Purse seine, trawls & gill nets)	1981	3.04	1.29	5	280	100
3. *Mangalore* (Purse seine trawl & gill nets)	1982-83	2.76	0.92	9	260	40

TABLE 4

Values of estimates of $\bar{z}$ and its standard error and 'n', lc and lr for T. serratus, T. dussumieri and O. militaris

	Species	Centre	year	Values				
				$\bar{z}$	$s_{\bar{z}}$	n	lc (mm)	lr (mm)
i.	*T. serratus*	*Cochin Fisheries Harbour* (Purse-seine)	1981	2.83	0.58	5	310	200
ii.	*T. dussumieri*	*Veraval*	1981	2.64	0.68	6	250	180
		(Trawls & gill nets)	1982	1.98	0.74	5	260	120
		Combined		2.34	0·49	11	250	120
iii.	*O. militaris*	Veraval	1981	2.80	0.50	6	350	200
		(Trawl &gill nets)	1982	1.74	0.37	10	270	200
		Combined		2.14	0.32	16	300	200

It may be noted from the above tables that the estimates of $\bar{z}$ and $s_{\bar{z}}$ are not differing very much between years. The differences between centres are also not very high.

iii. Estimation of 'M' the instantaneous natural mortality rate :

Effort data available, did not lead to estimation of effective effort particularly when data for more than one gear was considered. In multi-species fishery operated on by multi-gears the usual approach of

$$Z = M + qf \quad \ldots\ldots (6)$$

may not be possible. Hence a different approach is taken here, following Alagaraja (1984) to estimate 'M' directly from the length frequency data. Assuming one present survival of fish after they attain a length of $L\infty - 0.5$cm, the age T at which $L\infty - 0.5$ is attained is obtained using

$$-\frac{1}{k}\log e\left(1-\frac{L\infty-0.5}{L\infty}\right) = T'-t_o = T. \quad \ldots\ldots (7)$$

and using

$$N_t / N_o = 0.01 = e^{-MT} \quad \ldots\ldots (8)$$

an estimate of 'M' is arrived at. For example in the case of *T. thalassinus* $L\infty = 755$ mm and $K = 0.36$. Hence

$$-\frac{1}{0.36}\log e\left(1-\frac{750}{755}\right) \simeq 14$$

$N_{14} / N_0 = 0.01 = e^{-14M}$

and $M = 0.33$

at one percent level of survival.

In this way 'M' for other species also have been estimated both at five and one percent levels of survival and the estimates are given below in table 5.

TABLE - 5

Estimates of 'M' instàntaneous rate of natural morality

Level of survival

Species	5%	1%
T. thalassinus	0.21	0.33
T. tenuispinis	0.50	0.76
T. dussumieri	0.15	0.22
T. serratus	0.15	0.21
O. militaris	0.50	0.77

For the present, estimates of 'M' at one percent level alone are considered since the values at five percent level appear to be low and at $L\infty - 0.5$cm length 'One percent survival' would not be far from the truth.

iv. *Construction of yield isopleths*

Considering the relatively long life span of cat fish and assuming isometric growth the yield equation

$$Y = FR\, W\infty\, e^{-M(t_c - t_r)} \sum_{n=o}^{3} \frac{Un\, e^{-nk(t_c - t_o)}}{F + M + nk} \quad \ldots\ldots (9)$$

(Gulland, 1969) has been considered here. Referring to the yield tables (Gulland 1969) for M/k = 1.0 yield isopleths have been drawn for $W\infty = 4030$ gm and $t_r = 9$mm. Eumetric fishing line BB' and the line AA' joining the maxima of yield-mesh curves are also indicated in fig. 1. Since for all the five species considered here, M/k remained more or less equal to unity, the same fig.1 can be used for these species with varying multiplying factors according to their $W\infty$ and t_r values. These multiplying factors are given below in table 6.

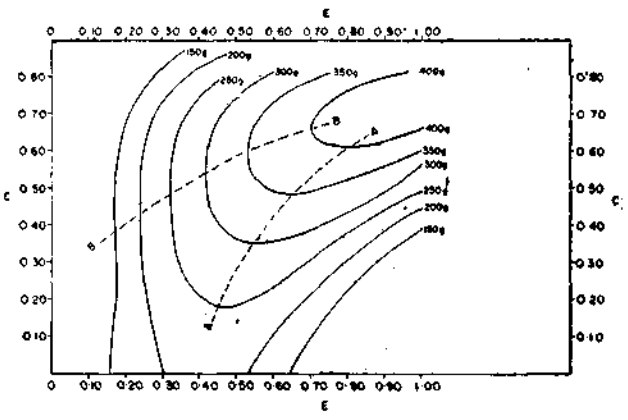

Fig. 1. Yield isopleths for the five species of cat fishes

TABLE 6

Multiplying factors to obtain actual Y/R in grams from fig. 1

Centres / Species	Waltair	Mandapam	Cochin Fisheries Harbour	Mangalore	Veraval
T. thalassinus	1.14	1.08	1.14	—	1.14
T. tenuispinis	1.01	—	0.97	0.85	—
T. serratus	—	—	2.40	—	—
T. dussumieri	—	—	—	—	1.71
O. militaris	—	—	—	—	1.24

Yield-effort curves and yield-mesh curves have also been drawn (figs.2-21) to get a clear picture of the status of fishery in each of these centres at the existing level of mesh size and effort.

From the yield isopleths (fig. 1) it can be seen the maximum sustainable yield (MSY) of about 400 gm per recruit could be obtained at the level of E=0.71 and C=0.66 where $E = F/Z$ and $C = l_c / L\infty$. The values of E and C for each species at each centre at the existing level of fishing are given in table 7.

TABLE 7

Levels of 'E' and 'C' at the existing level of fishing

Centre / Species		Waltair	Mandapam	Cochin Fisheries Harbour	Mangalore	Veraval
T. thalassinus	E	0.83	0.85	0.84	—	0.79
	C	0·24	0.30	0.48		0.50
T. tenuispinis	E	0.71		0.75	0.72	
	C	0.36		0.50	0.46	
T. serratus	E	—	—	0.93	—	—
	C	—	—	0.28	—	—
T. dussumieri	E	—	—	—	—	0.91
	C	—	—	—	—	0.30
O. militaris	E	—	—	—	—	0.64
	C	—	—	—	—	0.56

For *T. thalassinus* in all the four centres namely Waltair, Mandapam, Cochin Fisheries Harbour and Veraval the range for 'E' is 0.79 to 0.83 and for 'C' is 0.24 to 0.50. The values required for obtaining a MSY per recruit of about 400 gm are no where within the range. In other words to attain a MSY per requit of 400 gm a reduction in effort and increase in mesh size are required.

In the case of *T. tenuispinis* 'E' values are nearer to the required level for 400 gm of MSY per recruit. However, I_c values are much lower than the required level indicating that for this species also mesh size has to be increased to attain 400 gm of MSY per recruit.

So far as *T. serratus* is concerned the rate of first capture is too low. Similar is the case with *T. dussumieri*. Hence for these two species reduction in effort and increase in mesh size are required to reach 400 gm MSY per recruit.

Only in the case of *O. militaris* the level of exploitation both for effort and size at first capture is nearer to the required level for obtaining MSY per recruit of about 400 gm.

It is hence clear that the level of exploitation in general was not favourable to the fishery of all the species except *O. militaris*. In order to see the effect of fishing at the existing level of effort on these stocks yield-effort curves have been drawn. Similarly to find out the impact of mesh size used in the fishery on these stocks, yield-yield-mesh curves have been drawn (figs. 2-21).

Effects of Fishing on T. thalassinus

At waltair the yield-effort curve for the existing C=0. 24 indicated that MSY per recruit could be attained at E=0.50 which is far below the present level of exploitation, where E = 0.83 and the yield at E = 0.83 is below half of that at E = 0.50. Hence effort pressure should be considerably reduced to increase the returns from this stock at the present mesh size (Fig.2). For Mandapam at C = 0.30 and the existing level of exploitation E = 0.85 the yield per recruit is just above half of the MSY that could be obtained at E = 0.55. Here also reduction in effort is suggested to increase the returns

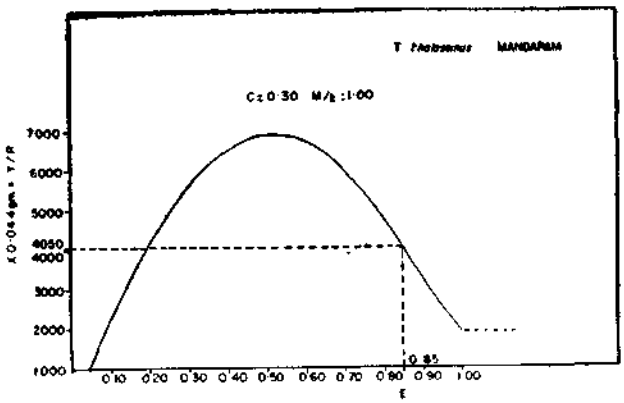

Fig. 3. Yield-effort curve for *T. thalassinus* at Mandapam

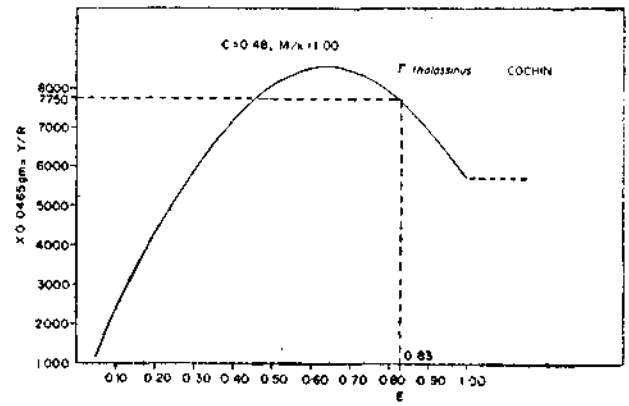

Fig. 4. Yield-effort curve for *T. Thalassinus* at Cochin

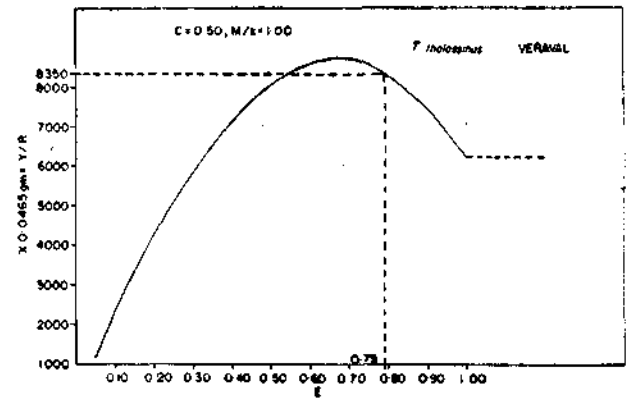

Fig. 5 Yield-effort curve for *T. thalassinus* at Veraval

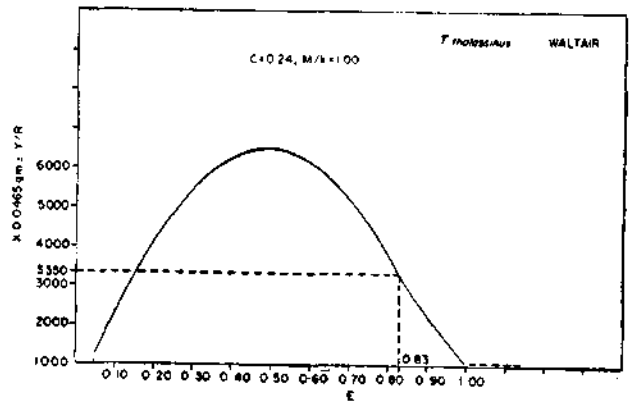

Fig. 2 Yield-effort curve for *T. thalassinus* at Waltair

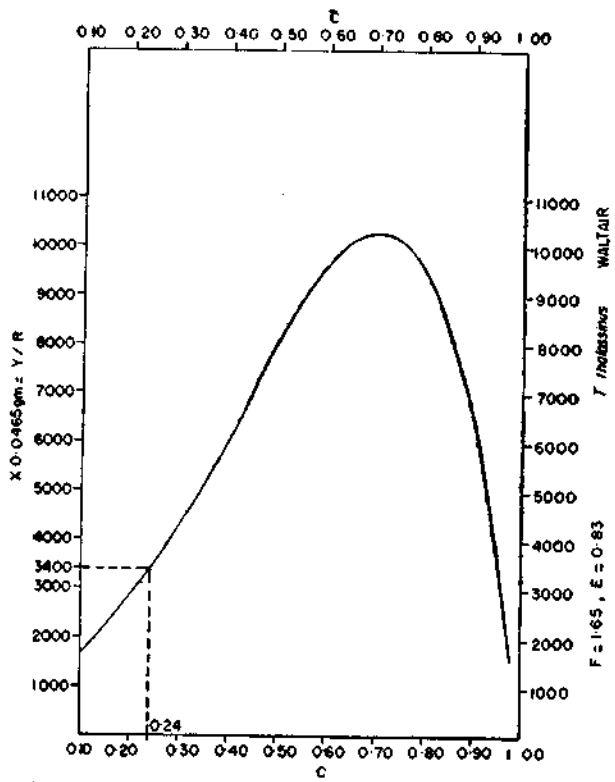

Fig. 6. Yield-mesh curve for *T. thalassinus* at Waltair

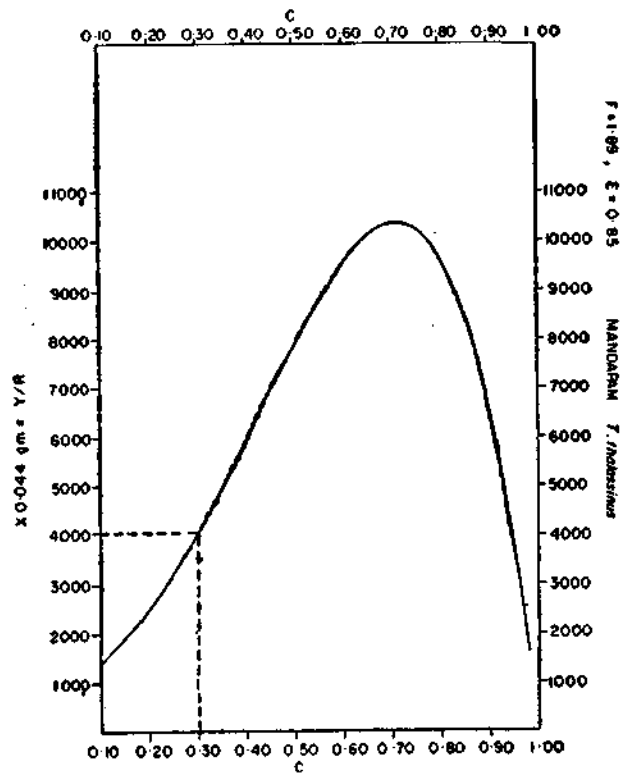

Fig. 7. Yield-mesh curve for *T. thalassinus* at Mandapam

from this species (fig.3). Though similar is the trend for *T. thalassinus* at Cochin Fisheries Harbour and Veraval the existing level of

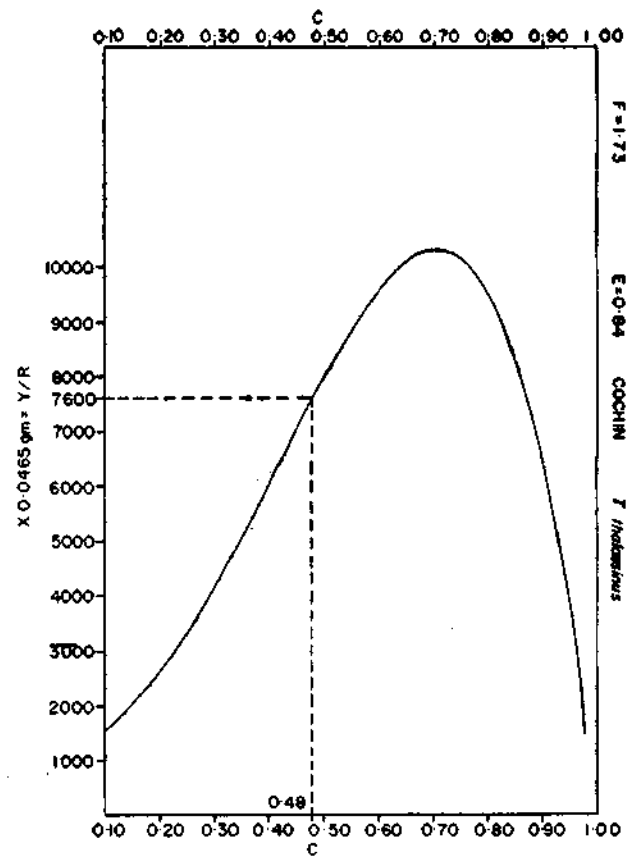

Fig. 8. Yield-mesh curve for *T. thalassinus* at Cochin

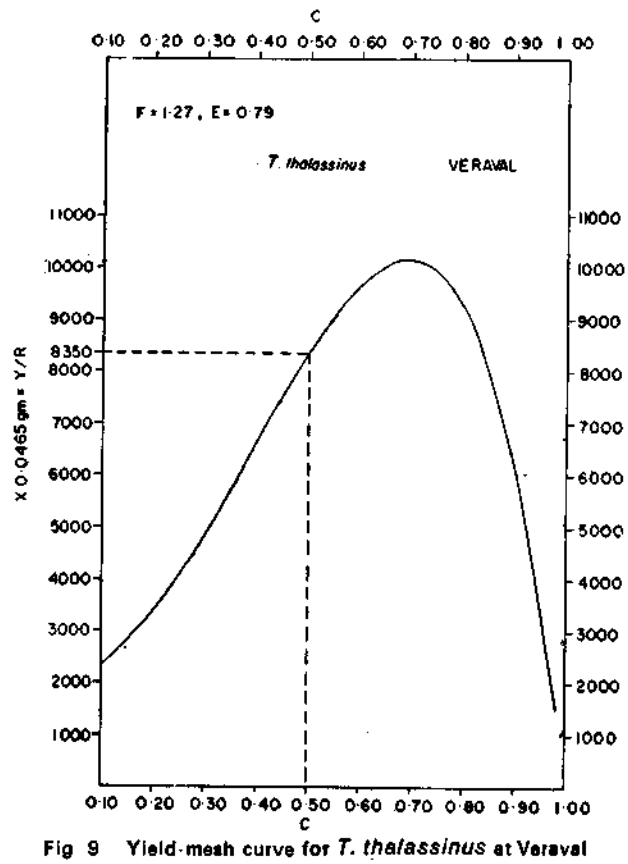

Fig 9 Yield-mesh curve for *T. thalassinus* at Veraval

exploitation is not far away from the required level to obtain MSY and relatively less reduction of effort will improve the landings at these centres (fig. 4 and 5). Yield-mesh curve for this fishery at Waltair (fig. 6) indicates that the existing mesh size (C = 0.24) is far below the required one (C = 0.70) and this mesh has to be increased considerably to gain in returns from the fishery. Similar trend is seen at Mandapam (fig. 7). Regarding Cochin Fisheries Harbour (fig. 8) and Veraval (fig. 9), relatively less increase in mesh size will improve the landings.

Effects of Fishing on T. tenuispinis

The existing levels of effort at Waltair (fig.10) Cochin Fisheries Harbour (fig. 11) and Mangalore (fig.12) are not far above the required level for obtaining MSY. This is quite in contrast to the fishery of *T. thalassinus* where considerable reduction in effort is recommended to achieve MSY. This is due to higher levels of 'C' for *T. tenuispinis*. Yield-mesh curves indicate

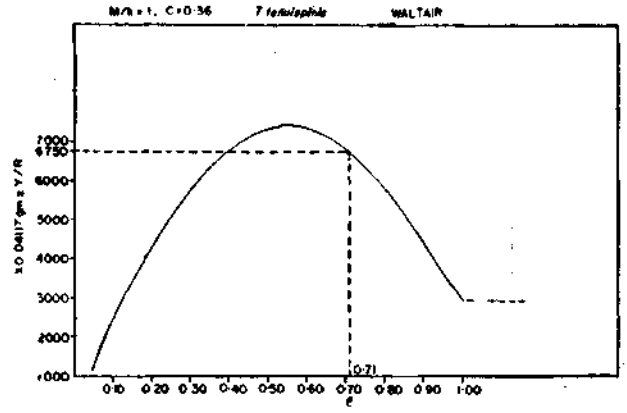

Fig. 10 Yield-effort curve for *T.tenuispinis* at Waltair

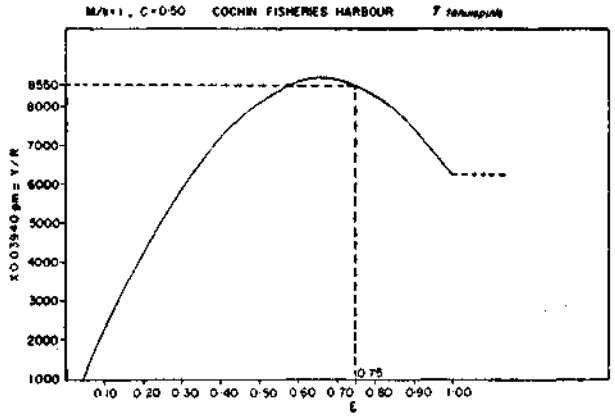

Fig. 11 Yield-effort curve for *T. tenuispinis* at Cochin Fisheries Harbour

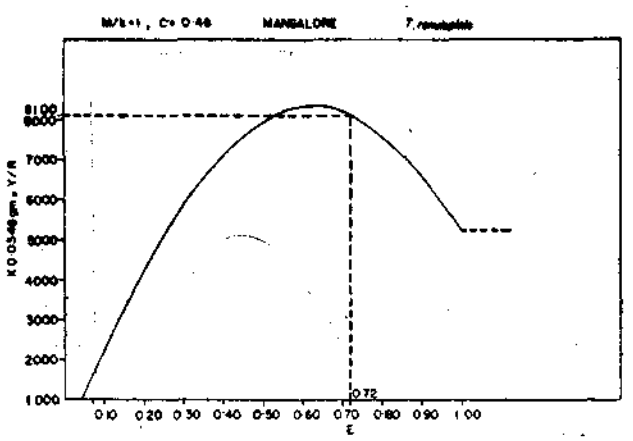

Fig. 12. Yield-effort curve for *T. tenuispinis* at Mangalore

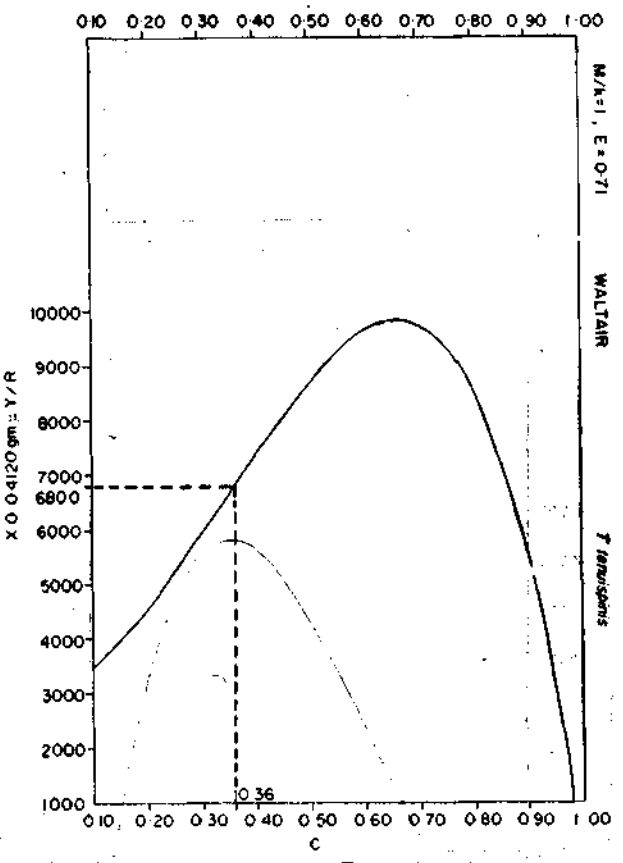

Fig. 13. Yield-mesh curve for *T. tenuispinis* at Waltair

that size at first capture at the present levels of exploitation have to be increased so as to attain MSY at Waltair (fig.13), Cochin Fisheries Harbour (fig. 14) and Mangalore (fig. 15).

Effects of Fishing on T. serratus, T. dussumieri *and* O. militaris

The fishery of *T. serratus* as observed at Cochin Fisheries Harbour is facing high fishing

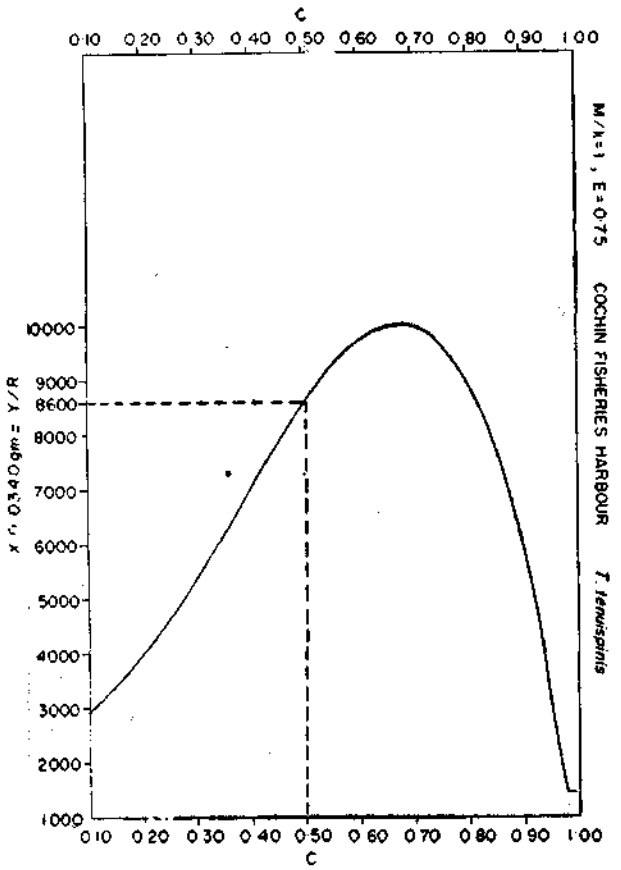

Fig. 14. Yield-mesh curve for *T. tenuispinis* at Cochin Fisheries Harbour

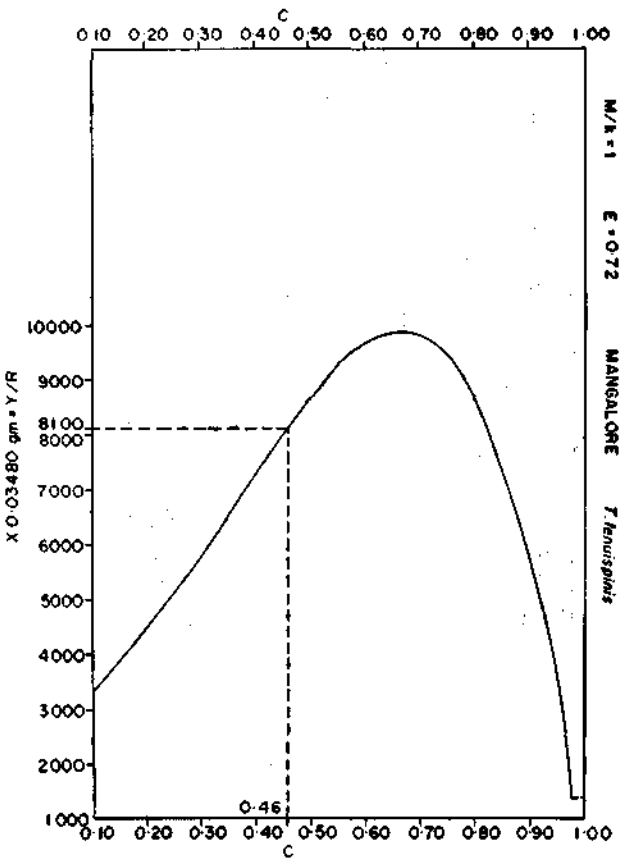

Fig. 15. Yield-mesh curve for *T. tenuispinis* at Mangalore

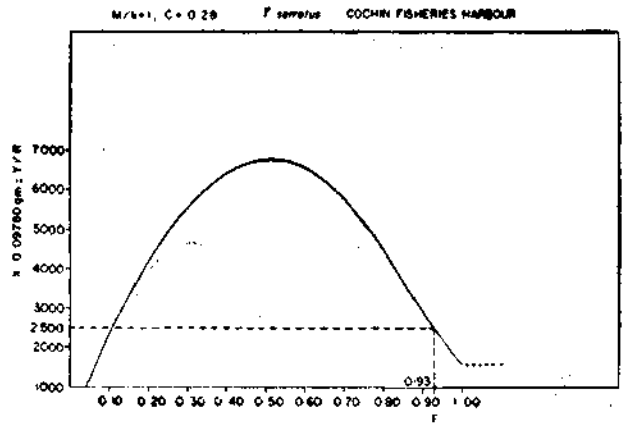

Fig. 16. Yield-effort curve for *T. serratus* at Cochin Fisheries Harbour

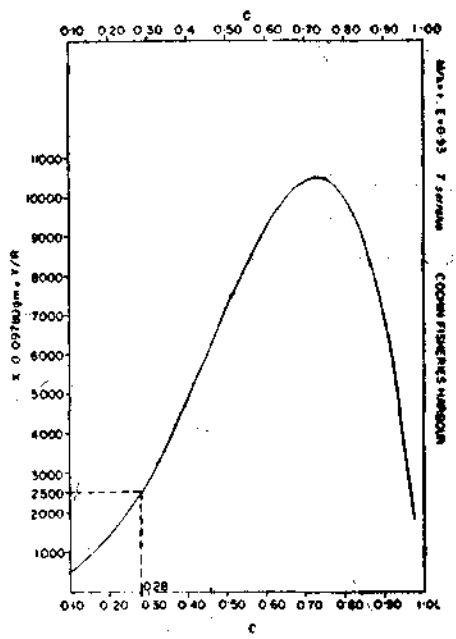

Fig. 17. Yield-mesh curve for *T. serratus* at Cochin Fisheries Harbour

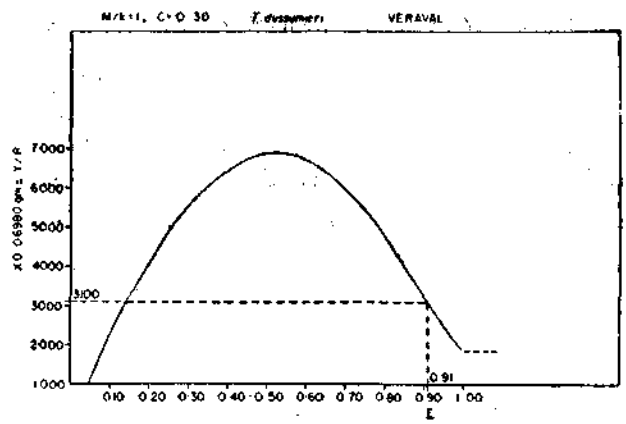

Fig. 18. Yield-effort curve for *T. dussumieri* at Veraval

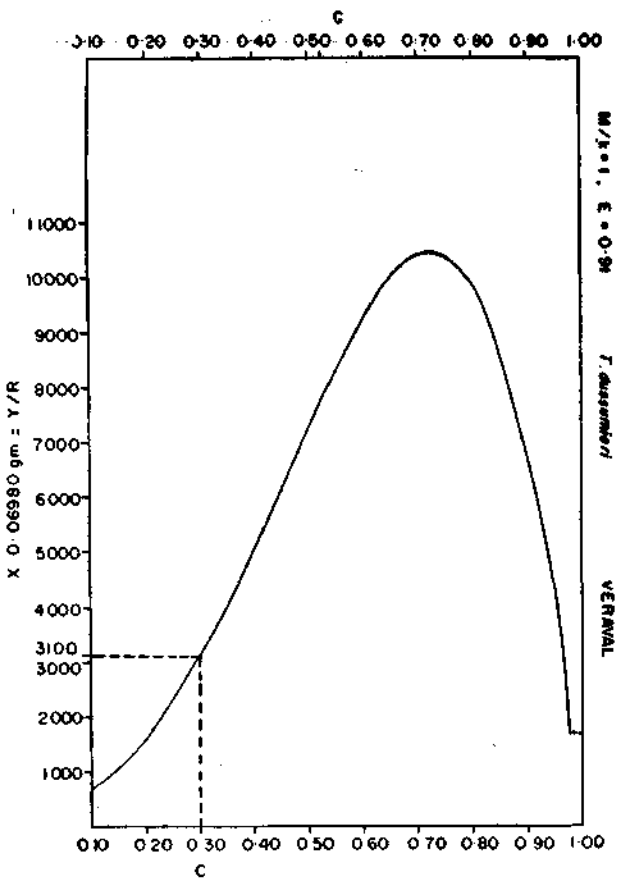

Fig. 19. Yield-mesh curve for *T. dussumieri* at Veraval

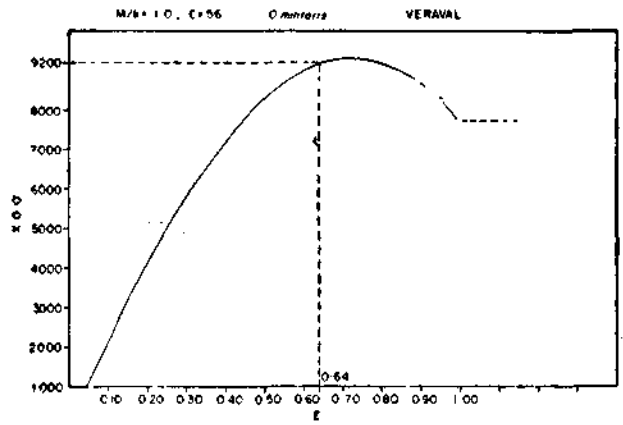

Fig. 20. Yield-effort curve for *O. militaris* at Veraval

pressure (fig. 16) and at this level the yield per recruit is only just above one third of MSY that could be obtained had the effort been reduced considerably. Yield-mesh curve also

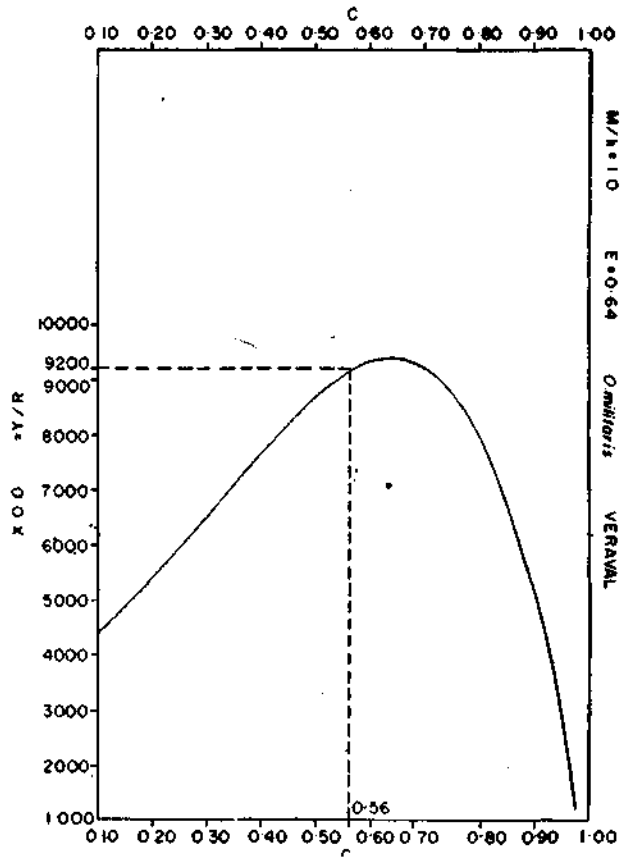

Fig. 21. Yield-mesh curve for *O. militaris* at Veraval

indicates (fig. 17) that at this level of fishing pressure the size at first capture should be increased two and half times so as to get MSY without effecting the stocks.

The fishery of *T. dussumieri* at Veraval is very similar to that of *T. serratus* as seen above. The yield-effort curve (fig.18) and yield-mesh curve (fig.19) indicate the same trends as in those of *T. serratus*. Hence heavy reduction of fishing pressure at the present level of 'C' or steep increase in the level of 'C' for the existing fishing pressure along will lead to MSY.

However, in the case of *O. militaris* the present level of exploitation at Veraval appears to be ideal both in terms of effort (fig.20) and the size at first capture (fig.21).

CONCLUSIONS

The stocks of the four species of catfish considered here other than O. militaris were under heavy fishing pressure. It is hence indicated that in order to get MSY from these stocks either the fishing pressure is to be reduced at the existing level of 'C' (the index of the size at first capture) or the present level of 'C' is to be increased considerably at the existing level of fishing pressure.

Suggestion to increase mesh size so as to increase 'C' may not be appreciated as the trawl fishery is mainly aimed at shrimp fishing and shrimp fishery may not be profitably exploited at the increased level of mesh size. However, effort pressure may be brought down so as to attain MSY from these stocks.

Instead of studying catfish fishery from trawl landings in isolation, it would be better to study this fishery along with other stocks particularly the shrimps to arrive at final conclusion on the suitable levels of mesh size and effort pressure. As indicated above so far as *O. militaris* is concerned present level of exploitation at Veraval appears to be ideal.

Annual catch estimates (Y in tonnes) for Waltair are based on the years 1978-80, for Mandapam on 1972-'76, for Cochin on 1981, Mangalore on 1982-'83, and for Veraval on 1981 and 1982. But for Mandapam, at other centres the estimates on average annual stock and average standing stock are comparable as these are based on the recent years.

For *T. thalassinus* Waltair region appears to be better when compared to other areas. However, for *T. tenuispinis* Managalore region indicates the maximum average annual stock. Regarding other species though region-wise comparision is not possible, from the present data base it can be said that the Veraval region hosts *T. dussumieri* and *O. militaris* more in abundance than *T. thalassinus*. Similarly Cochin region appears to be more favourable to *T. tenuispinis* than to *T. thalassinus* and *T. serratus* (Table 8).

TABLE 8

Estimates of annual catch (Y in tonnes), average standing stock (Y/F in tonnes) and average annual stock (Y/U in tonnes)

Species	Centre	F	$\left(\frac{F}{Z}\ \frac{U}{(1-e^{-Z})}\right)$	Y	Y/F	Y/U
					(tonnes)	
I. *T. thalassinus*						
1.	Waltair	1.65	0.72	151	92	210
2.	Mandapam	1.89	0.76	40	21	53
3.	Cochin	1.73	0.73	116	67	159
4.	Veraval	1.27	0.63	99	78	157
II. *T. tenuispinus*						
1.	Waltair	1.83	0.65	158	86	243
2.	Cochin	2.28	0.71	209	92	294
3.	Mangalore	2.00	0.68	1008	504	1482
III. *T. serratus*	Cochin	2.62	0.87	165	63	190
IV. *T. dussumieri*	Veraval	2.12	0.82	438	207	534
V. *O. militaris*	Veraval	1.37	0.57	275	200	482

WORK SHEET I-A

A. *T. thalassinus* (Catch in numbers)

i. Mandapam

Mid point (mm)	1972	M. A.*	1973	M. A.*	1974	M. A.	1975	M. A.*	1976	M. A.*
70	6673		1721		448		4396		5982	
90	17629	16505	4816	4220	776	1568	11305	10918	16597	16892
110	25214	22383	6125	6886	3479	3875	16513	16818	28089	25272
130	24305	24760	10018	11036	7371	7563	22937	23071	31120	32906
150	24761	25223	16965	15914	11839	10817	29763	28794	39502	38138
170	26604	26961	20758	20130	13242	12961	33683	34237	43792	44069
190	29519	26756	22666	22658	13801	13624	39264	37720	48914	47183
210	21446	24056	24550	24206	13830	13283	40213	39277	48842	50346
230	18496	18995	25403	24299	12217	12805	38354	39811	53282	52947
250	14344	13738	22944	22781	12367	10704	40866	38448	56715	56369
270	8385	9560	19997	19640	7637	8709	36123	34866	59110	56870
290	5662	5802	15978	15660	6123	6389	27608	26917	54784	51077
310	3069	6434	11004	12198	5406	6315	17021	21257	39336	39308
330	10272	...	9611	9689	7415	5367	19141	17265	23805	25061
350	15931	...	8452	10175	3280	5580	15634	15987	12041	13510
370	19574	...	12463	...	6046		13187	12652	4686	6764
390	17968		12285		1911		9136	8636	3566	3395
410	9689		3388		1139		3586	5191	1933	1928
430	1719		732		501		2852	2279	284	943
450	460		90		1606		398	1417	612	345
470	789		0		31		1001	—	140	
490	108		146		—		—	—	...	

ii. Waltair (Catch in numbers)

Mid point	1974	1975	M.A.*	1976	M. A*
100	—			7936	
140	—	4928		18681	14341
180	21805	35333	16213	16407	17998
220	13071	8379	15726	18907	17410
260	7790	3465	4865	16917	15813
300	3684	2750	2841	11617	10588
340	2693	2308	2527	3229	5218
380	527	2523	1964	808	
420	—	1060	1321		
460		381	489		
500	—	25			

iii. *Veraval* (Catch in numbers)

Mid point	1981	1982
380	23765	43358
420	21144	36595
460	14038	18939
500	9394	5359
540	1226	4293

Note:-

1. M. A. * indicates three point moving average.
2. Bracketed portion alone is considered for the estimation of 'Z'.

T. thalassinus (Catch in numbers) contd.

iv Cochin 1981

Mid point	Trawl	Gill net	Total	M. A.*
110	994	—	994	
130	35790	—	35790	13633
150	4114	—	4114	13821
170	1517	42	1559	2822
190	2511	281	2792	4639
210	9189	377	9566	8157
230	12034	78	12112	12392
250	15121	377	15498	26716
270	51949	588	52537	34844
290	35159	1340	36499	39608
310	26297	3492	29789	35536
330	35735	4586	40321	30233
350	15592	4997	20589	30331
370	22282	7801	30083	22204
390	6017	9923	15940	20915
410	9052	7670	16722	13315
430	3034	4248	7282	8779
450	—	2334	2334	3736
470	—	1593	1593	1890
490	—	1744	1744	1620
510	—	1522	1522	1460
530	—	1115	1115	1190
550	—	935	935	1235
570	—	1655	1655	1418
590	—	1664	1664	1620
610	—	1542	1542	1526
630	—	1374	1374	1398
650	—	1277	1277	955
670	—	213	213	564
690	—	201	201	149
710	—	33	33	81
730	—	10	10	

Note: 1. M. A.* indicate three point moving average.
2. Bracketed portion alone is considered for estimation of 'Z'

WORK SHEET I - B

B. *T. tenuispinis* (Catch in numbers)

I. Waltair

Mid point (mm)	1974	M. A*	1975	M. A*	1976
100	4295	...			
140	26646	10961	2152	8734	11402
180	1943	21916	13858	12150	8534
220	37160	19322	10193	9366	6809
260	18865	27692	12399	6665	3370
300	27053	20617	5505	2682	1279
340	15933	15298	3091		310
380	2909	6349	450		
420	204				

ii. Cochin 1981

Mid point	Purse seine	Trawl	Gill net	Total	M. A*
110	—	2238	—	2238	
130	—	21958	—	21958	11092
150	—	9080	—	9080	13366
170	—	9061	—	9061	11349
190	—	15906	—	15906	22387
210	—	42192	40	42233	27822
230	295	25367	141	25803	31430
250	1182	26730	876	28688	42630
270	5908	75795	1381	83086	58451
290	103304	72828	3262	86394	73683
310	8272	72426	7644	88342	70809
330	2954	67174	18327	88455	66327
350	591	59380	29515	89486	49061
370	295	20630	23559	24484	28389
390	—	5157	8830	13987	9942
410	—	4038	1080	5118	—
430	—	—	74	74	—
450	—	—	128	128	—
470	—	—	—	—	—
490	—	—	—	—	—
510	—	—	—	—	—
530	—	—	—	—	—
550	—	—	160	160	—

Note: 1. M. A. * indicates three point moving average.
2. Bracketed portion alone is considered for the estimation of 'Z'..

T. tenuispinis (Catch in numbers)

Mangalore 1982—83

Mid point (mm)	Purse-seine	Trawl	Gill net	Total	M. A*
50	—	18482	—	18482	
70	—	255058	—	255058	124448
90	—	99805	—	99805	122897
110	13827	—	—	13827	40260
130	1887	5262	—	7149	70139
150	—	189440	—	189440	426926
170	—	1084189	—	1084189	784129
190	—	1078758	—	1078768	1259842
210	—	1616579	—	1616579	1111906
230	37	630345	—	640382	1001129
250	37	746389	—	746426	850307
270	9853	1153764	497	1164114	927855
290	29632	841002	2391	873025	787685
310	45392	271878	8645	325915	543195
330	273013	127460	30173	430646	415453
350	275856	179044	34897	489797	409271
370	189728	76763	40880	307371	319951
390	118360	10992	33333	162685	246431
410	155292	57946	56000	269238	173910
430	42477	10992	36339	29808	148035
450	—	—	12183	12183	95698
470	—	—	5672	5672	6335
490	—	—	1150	1150	—

Note: 1. M. A* indicates three point moving average.
2. Bracketed portion alone is considered for the estimation of 'Z'.

WORK SHEET I — C

T. serratus (Catches in numbers)

Cochin Fisheries Harbour

Mid point (mm)	Purse seine	Trawl	Gill net 1981
210	—	3427	—
230	20	—	10
250	82	—	44
270	61	—	41
290	204	3427	35
310	204	3427	159
330	163	—	41
350	122	3427	297
370	61	—	570
390	41	—	421
410	41	—	197
430	41	—	64
450	—	—	112
470	—	—	285
490	—	—	1350
510	—	3427	1150
530	—	—	1790
550	—	—	1762
570	—	—	1309
590	—	—	1243
610	—	—	2019
630	—	—	3216
650	—	—	4226
670	—	—	4139
690	—	—	3541
710	—	—	2132
730	—	—	1681
750	—	—	2674
770	—	—	2468
790	—	—	3194
810	—	—	3252
830	—	—	2728
850	—	—	3116
870	—	—	2667
890	—	—	1709
910	—	—	1665
930	—	—	829
950	—	—	774
970	—	—	230
990	—	—	26

Note:- 1. The repetition of the frequency 3427 in trawl catches does not appear to be representative of the landings.

2. Regarding gill net catches also, the characteristics of gill net landings do not conform to the data available here.

3. Hence considering purse seine data alone and taking three point moving average **

l_t (mm)	M. A.** (Nos)
250	54
270	116
290	156
310	190
330	163
350	115
370	75
390	48
410	41
430	—

** (M. A.) the bracketed portion shown below is taken for the estimation of 'Z'.

WORK SHEET I-D

T. dussumieri (Catch in numbers)

Veraval:

Mid point (mm)	Trawl	1981 gill net	M.A 1 (trawl only)	1982 Trawl	Gillnet	Mid point (mm)	M. A 2 (Trawl only)
130	—	—	—	273	—		
150	—	—	—	—	—	140	
170	—	—	—	273	—	180	14174
190	3273	—	—	289	—	220	32559
210	7102	—	9837	13727	—	260	48520
230	19137	—	12165	28657	—	300	40387
250	10257	—	13413	16516	—	340	22690
270	10844	—	10053	38913	—	380	7216
290	9097	112	9519	13952	—	420	1876
310	8658	—	7486	34392	—	460	1837
330	4743	—	5035	16811	—		
350	1705	575	2269	578	—		
370	359	463	1185	969	—		
390	1490	1842	1414	1369	—		
410	2392	535		611	926		
430	1894	911		1310	1184		
450	868	1560		1027	1028		
470	1455	1242		344	1075		
490	85	1620		1226	3216		
510	601	2050		995	3849		
530	247	2384		1258	4464		
550	—	1831		3259	4914		
570	—	610		958	3537		
590	—	2077		1769	6096		
610	—	2538		2058	3589		
630	—	3808		395	3802		
650	—	3592		647	5107		
670	—	2448		711	3105		
690	—	4227		857	3390		
710	—	2727		857	3579		
730	—	1447		459	3090		
750	—	620		84	1526		
770	—	—		—	18		
790	—	68		—	—		
810	—	211		—	—		

Note: 1. Data for gill nets do not appear to be the representative of gill net landings. Hence catch in numbers of three point moving average for trawls alone are considered for estimating 'Z'.

2. In this case successive classes have been merged forming a single wider class and for such wider classes three point moving average is taken.

3. Bracketed portion alone is considered for the estimation of 'Z'.

WORK SHEET 1-E

O. militaris (Catch in numbers)

Veraval

Mid point (mm)	1981 Trawl	Gill net	Total	M. A*	1982 Trawl	Gill net	Total	M.A.*
190	—	—	—	—	—	—	—	—
210	1543	53	1596	—	5226	895	6121	—
230	13806	311	14117	18619	10429	958	11387	16090
250	38825	1318	40143	33980	29580	1181	39761	26154
270	46361	1319	47680	48571	32516	3799	36315	37600
290	56074	1816	57890	52365	41640	4085	48725	35973
310	49976	1549	51525	52157	23908	1970	25878	32127
330	44824	2233	47057	44979	22051	2727	24778	24414
350	35036	1319	36355	45682	16958	2929	22587	24226
370	52860	773	53633	35950	23125	2190	25315	21406
390	17532	357	17889	26749	13699	2617	16316	17648
410	8583	143	8726	10577	9461	1751	11312	11536
430	5022	94	5116	5445	6900	3079	6970	6776
450	2461	31	2492	2842	1884	153	2037	3263
470	917	—	917	1228	—	773	773	979
490	276	—	276	—	126	—	126	—

Note:
1. M. A.* indicates three point moving averages.
2. Bracketed portion alone is considered for the estimation of 'Z'.

CHAPTER NINE

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WORK SHEET II

Estimation of 'Z' for A. thalassinus *at Mandapam from the bracketed portions of work sheet I. A for the year 1972.*

$l\infty = 755$ mm and $k = 0.36$.

l_t	$l\infty - l_t$	$\log (l\infty - l_t)$	Their difference (A)	C_t	$\log C_t$	Their difference (B)	B/A x_i
170	585	2.7672		26961	4.4307		
			0.0152			0.0033	0.22
190	565	2.7520		26756	4.4274		
			0.0156			0.0462	2.96
210	545	2.7364		24054	4.3812		
			0.0162			0.1026	6.33
230	525	2.7202		18985	4.2786		
			0.0169			0.1407	8.32
250	505	2.7033		13738	4.1379		
			0.0176			0.1574	8.94
270	485	2.6857		9560	3.9805		
			0.0182			0.2169	11.92
290	465	2.6675		5802	3.7636		

$\bar{x} = 6.45$ $\quad n = 6.$

$$s^2_x = \frac{1}{n-1}\left[\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2 \Big/ n\right]$$

$$= \frac{1}{5}\left[340.11 - (38.69)^2/6\right]$$

$$= \frac{1}{5}\left[340.11 - 249.49\right]$$

$$= 18.12$$

Hence $s_x = \sqrt{18.12} = 4.26$ and $s_{\bar{x}} = 4.26/\sqrt{6} = 1.74$

Now $\bar{x} = \bar{z} / k$. Hence $\bar{z} = k\bar{x} = 0.36 \times 6.45 = 2.32$

$s_{\bar{x}} = s_{\bar{z}}/k$. Hence $s_{\bar{z}} = k\, s_{\bar{x}} = 0.36 \times 1.74 = 0.62$

Thus $\bar{z} = 2.32$ and $s_{\bar{z}} = 0.62$