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Stock assessment of mackerel in the Indian seas

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ABSTRACT

Analysis of mackerel landings revealed that the most important brood that contributes to the fishery is normally born some time around May. The plankton bloom that follows upwelling guarantees better larval survival, recruitment and growth. The growth parameters of the Indian mackerel, *Rastrelliger kanagurta* estimated from east and west coast of India are:

	East Coast	West Coast
L_∞ (mm)	283.5	284.50
K (annual)	1.7	1.78
C	0.0	0.20
WP	0.0	0.50

Along both the coasts they start appearing in the catches when they are about two months old. But, along the west coast they are fully recruited to the fishery at an age of 6 months and along the east coast this happens at an age of 9 months. Bulk of the catches from west coast is by large seines of small meshes where young ones are liable to be caught and peak catches are from the size group of 140-149 mm. The major gear along the east coast is gill net with larger mesh and peak catches are from size group 190-199 mm. Along the west coast the estimated annual total mortality is 3.6. With an estimated M of 2.64 the fishing mortality F is 0.96 at an exploitation rate of 0.27 and E_{max} estimated is 0.70. Along the east coast the total mortality is 7.34. With an estimated M of 2.57 the F is 4.77 at an exploitation rate of 0.65 where the E_{max} is 1. The corresponding all India values are Z = 5.14, M = 2.64, F = 2.5, E =0.49 and E_{max} = 0.7 indicating that the stock is being exploited well below the level of maximum sustainable yield. The Y/R studies made on the mackerel fishery of India using the population parameters estimated based on west coast data indicated that the present fishery is still not very efficient to take the MSY from the resource. There is ample scope for further development of the fishery. However, the present age at capture (0.5 years) is the optimum for the estimated M value.

INTRODUCTION

With the increasing efficiency of exploitation along the west and east coast of India the mackerel stocks have been under greater fishing pressure in 1990s. The average annual catch showed an unprecedented upward trend, on an average 330 crore of mackerel in numbers with a mean weight of 60 grams being caught annually since 1993 - '99. Though the annual catch

showed wide fluctuations the general trend is still that of increase contrary to the earlier estimates of mackerel stocks and MSY by Banerji (1973), George *et al.* (1977), Sekharan (1974), Noble *et al.* (1992) and Devaraj *et al.* (1994). Under the situation a revalidation of the population parameters and stock estimates of the mackerel resource in India is attempted here.

MATERIALS AND METHODS

Length frequency data collected from various fish landing centers along the west and east coast of India during the years from 1997-'99 formed the basis of the estimates. The catch data was taken from NMLRDC of CMFRI. Data collected from Karwar and Mangalore were raised to the catch from these centres. The pooled data were raised to the average annual catch from Karnataka for the period from 1990-'99. Similarly the data from Calicut and Cochin were pooled and raised to the average annual catch of Kerala for similar period. The pooled data from Kerala and Karnataka were raised to the annual average catch from the west coast. The data from Visakhapatnam and Kakinada were pooled and raised to the annual average catch of Andhra Pradesh. Data from Tuticorin and Mandapam were raised to the catch of Tamilnadu. The pooled data for Andhra Pradesh and Tamilnadu were raised to the catch from east coast.

Length-weight relation was fitted by least square method with the data collected from Calicut. Growth parameters were estimated from data collected at Calicut using ELEFAN 1 programme and were used for further studies on the fishery along west coast. Growth parameters estimated by Abdusamad and Kasim (MS) were used for studying the fishery along the east coast. Length converted catch curve method of Pauly (1984) was used to estimate the total mortality (Z) and the method developed by Pauly (1980) was used to estimate natural mortality (M) taking the average temperature as 28^0C. Exploitation ratio (U) and exploitation rate (E) were estimated using the equations:

$$E = F/ (F+M)$$

$$U = F (1-e^{-z})/Z$$

The annual total stock at the beginning of the year was estimated by:

$$Y/U$$

where Y is the annual average catch of the species.
Annual average standing stock was estimated by:

$$Y/F$$

Yield per recruit (Y/R) was estimated by the well-known method of Beverton and Holt.

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MSY was estimated by the equation

$$MSY = Y/(Y/R_p) \cdot Y/R_{max}$$

Where Y/R_p is the yield per recruit at present F and Y/R_{max} is the maximum value of Y/R.

RESULTS

Length-weight relation

The length-weight relation estimated was:

$$W = 0.0000017 \; L^{3.3403}$$

Growth parameters

Growth parameters were estimated from the length frequency data collected from Calicut. The seasonalized von Bertalannfy growth equation (Pauly and Gaschutz, 1979), $L_{(t)} = L_\infty * [1- \exp\{-K (t-t_0) + (ck/2\pi) *\sin(2\pi* (t-ts))\}]$ which gave the best fitting growth curve was used. Simultaneously the growth parameters were estimated from data collected from Kakinada (Abdusamad and Kasim, MS) also. The estimated parameters were:

	Calicut	Kakinada
L_∞ (mm)	284.9	283.5
K (annual)	1.78	1.7
C	0.2	0.0
WP	0.5	0.0

Mortality rates

Mortality rates for west and east coast, obtained using the growth parameters estimated from Calicut and Kakinada respectively, are given below:

	East Coast	West Coast
Z	7.34	5.14
M	2.57	2.64
E	0.65	0.49
E_{max}	1.00	0.71

Length at recruitment (t_r) and length at first capture (t_c)

The length frequency distribution from west coast and east coast were pooled to get the total length frequency distribution (Table 1). From this data it is seen that 84.67 % of the catch in numbers were contributed by the west coast. The minimum size at which the fish appears in the catch was 55 mm; the corresponding age in years (0.17) is taken as the t_r. The peak

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catches are made from the size group 140 – 149 mm and the corresponding age in years (0.5) is taken as the t_c.

Yield per recruit at different values of t_c from 0.4 – 0.9 was estimated using the following parameters:

M   =   2.64

W_∞ =   269.07 gms

K   =   1.78

t_o =   -0.01

The result is given in Fig.1.

Stock estimates

Based on the population parameters estimated for west coast the stock estimates for the resources all along the Indian coast was made as follows:

Fig.1. The estimate yield per recruit (g) of *Rastrelliger kanagurta* at different levels of fishing mortality

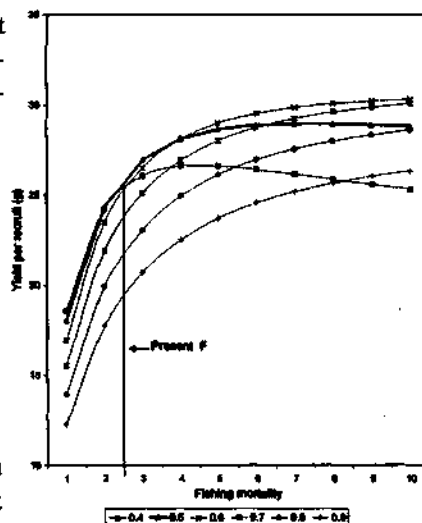|		
U	=	0.4835
Average annual catch (Y)	=	1.94 lakh tonnes
Total stock at the beginning of the year (Y/U)	=	4.00 lakh tonnes
Average annual standing stock (Y/F)	=	0.78 lakh tonnes
Maximum sustainable yield (MSY)	=	2.15 lakh tonnes

DISCUSSION

Considering the present t_c value of 0.5 years and fishing mortality of 2.5 (Fig.1.), the present fishing has not reached F_{max}, which is at 7.4. However, according to the estimates, T_c value of 0.6 will be ideal which can very well take care of any future increase in exploitation. But the T_c value seldom goes beyond 0.5 along the west coast and is often found to be around 0.4, which can be dangerous. The F_{max} at a T_c value of 0.4 is 4.6. At the present rate of increase in exploitation we may reach this value in the near future and the yield can go beyond the MSY level.

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Fixing the t_c value at 0.6 will have some practical difficulty. This will mean that the exploitation of the new recruits to the fishery will have to be avoided during the period from May to September. Along the west coast the peak season for mackerel fishery is generally during September. The availability of the resources to the important surface gears decrease subsequently due to sinking of the thermocline and moving down of the resources to deeper waters. Hence, the only alternative will be maintaining the present t_c value of 0.5 and limiting F below 3. Increasing the t_c value beyond 0.6 was not found commensurately beneficial. The present t_c value along the east coast is 0.75, which perhaps cannot be reduced due to the prevailing pattern of exploitation and the environmental conditions. Large surface gears are not operated along the east coast and large-scale movement of juveniles of mackerel to the surface waters are not observed. The Z value estimated for east coast is much higher than the west coast estimate. But the t_c value is much higher and exploitation is lighter. The Z estimates for east and west coast can be overestimates because of the behaviour of the fish. The resource appears in the exploited area suddenly and move away beyond the operational range of surface gears with changes in environment. This can cause bias in the estimation of abundance of larger size groups and consequently in the mortality rates.

Along the west coast there is a regular annual movement of mackerel resource from deeper waters to coastal surface waters (Yohannan and Abdurahiman, 1998) caused by upwelling and sinking of thermocline. The traditional surface gears were exploiting the resource intensely during upwelling. The intensity of exploitation reduces with the sinking of the thermocline after October/November. The recent extension of trawling grounds to deeper areas during summer has resulted in an increased exploitation of the resource from deeper waters. Along the east coast where the exploitation by traditional gears is comparatively poor, Sudarsan *et al.* (1988) has indicated abundance of mackerel resource in deeper waters with abundance increasing from 20-150 m depth. Perhaps due to the absence of upwelling of the intensity as that of west coast the resource is not moving to surface in abundance and only a small portion of the existing resource is presently available for exploitation along the east coast. Possibly the annual variations in the intensity and duration of upwelling and other environmental conditions along both the coast control the catachability of the resource and the reasons for the annual catch fluctuations will have to be studied against this background. The estimates of mortality and stock along the west and east coast of India made in this paper may be taken as indicator of only present state of exploitation. More reliable estimates can be made only when the true abundance throughout its area of the distribution is known. The poorly exploited deeper waters serve as the natural refuges of the resource making it strong enough to withstand high fishing mortalities.

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Table 1. Length frequency distribution of mackerel, *R. kanagurta* (Average annual numbers in millions, 1991-'99)

Mid length (mm)	West coast	East coast	Total
55	0.31	0.1	0.41
65	3.07	1.11	4.18
75	8.46	1.95	10.40
85	30.93	0.98	31.91
95	120.32	2.73	123.05
105	142.36	3.34	145.70
115	201.29	3.86	205.15
125	226.37	2.16	228.53
135	216.83	2.56	219.40
145	399.50	19.50	419.00
155	288.33	27.39	315.71
165	117.74	31.2	148.94
175	125.88	47.19	173.06
185	132.98	92.38	225.36
195	103.24	100.33	203.67
205	109.15	49.91	159.05
215	77.02	45.82	122.83
225	94.09	36.3	130.39
235	113.79	23.22	137.01
245	144.59	9.82	154.41
255	84.04	1.52	84.57
265	34.05	0.76	34.80
275	9.19	-	9.19
285	0.11	-	0.11
Total	2783.75	504.12	3287.86
%	84.67	15.33	100
In weight.	156921.22	38041.89	194963.11
%	80.49	19.51	100
Total numbers	3287862032.15		
Total wt. (tonnes)	194963.11		
Mean wt. (grams)	59.30		