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Paper - 25

PRESENT STATUS OF OIL SARDINE FISHERY AT KARWAR

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ABSTRACT

The average annual yield of traditional gears (Rampan and Yendi) from 1967 through 1982 for 16 years is 146.4 t. Consequent to introduction of purse seiners from 1976, the average catch for the 10 year period from 1976 through 1985 for oil sardine increased to 2273 t at Karwar showing nearly 15.5 times more yield than the former period. This paper discusses whether this new development is a boon to the fishery or whether it has an adverse impact on the fishing stocks. For this purpose, the average standing crop and average annual stock of oil sardine in the fishing grounds for a year were estimated. An estimate on yield-per-recruit and the maximum sustainable yield (MSY) for varying fishing intensities and instantaneous natural mortalities was made to understand the extent of fishing stress on the resource. A closer scrutiny of all India catch data of oil sardine and mackerel from 1976 to 1980 when 35 to 400 numbers of purse seiners were introduced respectively, showed that the premechanisation period (1970-75) accounted for better annual average catch than the purse seine era (1976-1980) as the catch per day per purse seine declined. The optimum level of exploitation and the adverse effects on the stocks if they are indiscriminately exploited without proper planning are discussed in the paper.

INTRODUCTION

Oil sardine forms one of the important components of the marine fishery resources of India. For better understanding and planning future research, the extent the resource exploited, endurance of its increased exploitation in proportion to increased number of mechanised vessels are the mile stones in assessing stress on the fishery There is need to study these aspects for oil sardine fishery which is exploited by purse seiners at Karwar, on the West Coast of India. It would be highly essential to determine the magnitude of the populations, whether the rate harvested is small or large, whether any conservation measures are required if the rate of harvest is above that of the maxium sustainable yield (MSY). The exploitation rate (U) was calculated by deriving Z (instantaneous total mortality rate) by Beverton and Holt (1956) method, length converted catch curve method and age composition method. As the oil sardine is short lived species, life span appears to be 3-4 years. On the assumption that 99% fish do not survive beyond this age (t max)' the M (natural mortality) on the annual basis is 1.0172. The M for oil sardine, derived from age composition study of 1.0442 does not deviate much from the above method. Studies on yield-per-recruit for three levels, 1.5, 1.0 and 0.5 of natural mortalities (M) during the exploitation phase of the fishery indicate maximum yields of 21 gm, 28 gm and 44 gm at the fishing mortality rates of 3.7, 2.1 and 0.9 respectively. Studies on annual and standing stocks were made and they are presented in the accompanying tables below.

INVESTIGATIONS ON THE RESOURCES OF OIL SARDINE CATCH TRENDS AND EFFECT OF MECHANISATION ON TRADITIONAL GEARS

Introduction of purse seiners on commercial basis in the mid seventies has increased the marine fish catches to the tune of 63% over the average catch of 1.03 lakh tonnes (mostly by the indigenous gears) of past decade in Karnataka. In indigenous gears the catch of oil sardine at Karwar ranged from 0.06 t in 1983 to 650 t in 1968. The catch showed the main peak of 650 t in 1968, with minor peaks of lesser intensities in 1970 (153 t), 1972 (186 t), 1976 (369 t), 1978 (267 t) with lean years, in between these, ultimately stooping to very low levels from 29 t in 1979 to 0.06 t in 1983 (Fig. 1). This declining trend in production by traditional gears from 1978 to 1983 and on, is marked by the introduction of new purse seine era and catches improved considerably with increasing peaks in 1979 (2454 t), 1981 (4107 t) and 1984 (4731 t) and troughs in 1980 (2158 t), 1982 (3360 t), 1983 (1386 t) and 1985 (4498 t). From 1979 onwards till 1985 the catch of oil sardine in purse seiners at Karwar never went below 1400 t (Fig. 1). But indigenous gears (Rampan and yendi) never exceeded 650 t. It is worth to investigate, whether this increased exploitation by fishing by the purse seiners has any adverse effect on the population. It is observed that the fishery by the indigenous gears is utter failure consequent to the introduction of purse seiners in the Karwar waters. Now the fishery has been based on purse seiners. If such situation is there, what would be the quantity to be harvested?

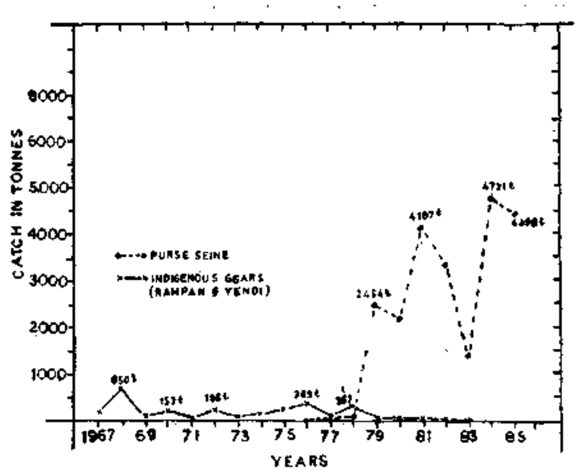

Fig. 1 Trend of oilsardine catches at Karwar during 1967-85

For this purpose, Schaefer's model (1957) was fitted to the oil sardine caught in purse seiners to the effort and relative abundance of catch to make a broad estimate on the maximum sustainable yield and effort required for this yield from 1979 through 1985. The constants 'a' and 'b' (Y=a-bf) were 1409.7 and - 0.1315 respectively, where f is effort spent and Y is the relative abundance. From this, the MSY for oil sardine fishery at Karwar is 377 t and the effort for this is 5358 unit days of operations.

ESTIMATES OF INSTANTANEOUS TOTAL MORTALITY FOR SEPARATING F (FISHING MORTALITY) AND M (NATURAL MORTALITY) FOR PURSE SEINE FISHERY

Here no need arises for describing detailed methodology for estimating total instantaneous rates of mortality. The methods are well known to most of the fishery biologists. The methods used for estimating the 'Z' were Beverton and Holt (1956), Length converted catch curve method and the Age composition method.

Sekharan and Dhulkhed (1963) found the value of Z as 1.66 for oil sardine for 1957-63 off Mangalore area. Based on the effective life span, M was 1.12. From these 'F' and 'U' (exploitation rate) were 0.26 for oil sardine. The 'Z' value obtained by Banerji (1973) on the West coast was 1.42 and M=0.67. The exploitation rate 'U' becomes 0.48 when Z of 1.66 was used. These 'M' values are used to calculate 'U' in the present account.

Table 1.

'Z' values estimated by different methods for oil sardine at Karwar from purse seiners.

Years	Beverton and Holt method	Length converted catch curve method.	Age composition method
1976	4.4322	1.7749	1.4615
1980	5.6702	5.0755	2.1340
1981	3.3148	0.1959	2.3530
1982	3.0209	3.2380	2.7665
1983	3.2545	3.9964	0.1415
1984	2.4642	1.9777	1.0006
1985	3.2973	3.0067	1.3810
Average for 1979-85	3.6363	2.7522	1.6054

'M' calculated on the basis of effective life span of oil sardine was 1.0172. The 'M' estimated from the age composition of the purse seine fishery was 1.0442. As there was no linearity between Z and effort, the 'M' calculated by the age composition method was not used for calculating F, exploitation rate (U) and yields then on. Although 'M' derived by both the methods are nearer to each other, M= 1.0172 based on the effective life span of fish is followed for calculations. Sekharan (1974) states that mean value of M around 1.00, seems as more reasonable estimate.

ESTIMATION OF STOCKS OF OIL SARDINE

Estimation of annual average stock and standing stock of purse seine fishery was made by the general formula, $U = \frac{F}{F+M}(1-e^{-(F+M)})$, Where 'U' is aunual exploitation rate, 'F' is the annual instantaneous fishing mortality rate and 'M' is the instantaneous natural mortality rate. The annual average catch of oil sardine on All India basis during 1979 through 1984, amounts to 178095.5t. The average and standing stocks for average Z values from 3 methods with M=1.0172 one given in Table 2.

a) *STOCKS ON ALL INDIA BASIS*

The annual average stock and standing stocks in the fishing grounds are 387978 t and respectively.

Taking Z and M values for present study of Sekharan (1974) and Banerji (1973), the stocks for 1979-1984 (with All India average catch of 178,095.5 t, may be estimated as below:

From the table 3, it is observed that when natural mortality rates 1.0172, 1.12 and 0.67 are used with 'Z' values of the present account, the pooled averages of annual stock and standing stock approach to 392,213 t and 160,688 t respectively showing 4235 t more average stock and 7122 t less standing stock than the averages of Table 2, when M= 1.0172, alone was used. This is because of differences in the rates of exploitation under different situations stated above.

When 'Z' values of Sekharan (1974) and Banerji (1973) as shown in Table 3, for 3 levels of instantaneous natural mortality rates are taken, the resultant pooled annual average and standing stocks for Z= 1.66 are 537,506 t and 262,254 t and for Z=1.42, they are 794,785 t and 424,419 t respectively.

Table 2.

Average annual and standing stocks (in tonnes) of oil sardine (All India) when M=1.0172 during 1979-1984 period.

Method of estimate	Z	F	Annual average stock (YIU)	Annual average standing stock (YIF)	Remarks
Beverton and Holt (1956)	3 6363	2.6191	253,951	67,999	Stock
Length converted catch curve method	2.7522	1.7350	301,754	102,649	estimates were made
Age composition	1.6054	0.5882	608,250	302,781	for a Single
Average of above methods			387,978	158,810	M value

Table 3.

Annual average and standing stocks of oil sardine (All India) using three, M=1.0172, M=1.12 (Sekharan, 1974) and M=0.67 (Banerji, 1973) values.

Z	F	M	Annual average stock (tonnes)	Annual standing stock (tonnes)	Remarks
	2.6191	1.0172	253,951	67,999	
3.6363	2.5163	1.12	264,315	70,777	
	2 9663	0.67	224,245	60,040	Mechanised
	1.7350	1.0172	301,754	102,649	period by
2.7522	1.6322	1.12	506,385	109,114	purse seiners
	2.0822	0.67	251'441	85,532	
	0.5882	1.0172	608,250	302,781	
1.6054	0.4854	1.12	737,150	366,905	
	0.9354	0.67	342,425	190,395	
Average (Mechanised period)			392,213	150,688	
1.66	0.6428	1.0172	567, 907	277,062	
(Z after	0 54	1.12	675.804	329,806	
Sekharan 1974)	0.99	0.67	368,728	179,894	
Average			537,506	262,254	Non mechanised
1.42	0 4028	1.0172	827,966	442,144	period
(Z after Banerji,	0.30	1.12	1111,707	593,652	by the traditional
1973)	0.75	0.67	444,683	237,461	gears.
Average			794,785	424,419	
Average (Non-mechanised period			666,146	343.337	

From the present study, it is noticed that in the total mortality range of 1.6054 to 3.6353 the annual average stock and annual average standing stock are 391 t, 213 t and 150,688 t in the fishing grounds; but when 'Z' values were low (1.66 and 1.42), the pooled annual average stock and annual average standing stock are 666,146 t and 343, 337 t respectively in the fishing grounds.

It may be mentioned here that Sekharan (1974) estimated U as 0.26 taking M=1.12 and F=0.54 and the annual average and standing stocks estimated by him were 810,000 t and 390,000 t respectively when the annual average catch of oilsardine on the West Coast during 1960-1971 was 210,000 t He calculated U of 0.48 for Z=1.66 taking Banerji's value of M =0.67 and from this annual average stock in the fishing grounds of 440,000 t and the standing stock of 210,000 t. In the present study, the annual stock and standing stock show lower values than the ones estimated by the above authors and the exploitation rates were higher in the fishing grounds by the purse seiners. The higher annual average and standing stocks during the premechanised period may probably be due to better recruitment to the fishery than the mechanised period.

b) *STOCKS OF OIL SARDINE AT KARWAR WATERS (EXPLOITED BY THE PURSE SEINERS)*

From the Table 1, the average 'Z' values for the three methods are 3.6363, 2,7522 and 1.6054. From these Z, average F values, 2.6191, 1,7350, 0 5882 were found by deducting M =1.0172 from Z. Then the corresponding 'U' values 0.7013, 0.5902 and 0.2928 were obtained. The annual average stock and standing stock during different years are shown in Table 4 for the purse seine fishery at Karwar.

From the above table annual average stock and the annual average standing stock from 1979 through 1985 are 7063 t and 2873 t at Karwar area which are 55.5 and 52.5 times lower than those estimated for the whole West coast of India (i. e. 392213 t and 150688 t) respectively.

STUDIES ON THE YIELD-PER-RECRUIT(Y/R) OF OIL SARDINES OCCURRING IN PURSE SEINERS FOR DIFFERENT INTENSITIES OF INSTANTANEOUS NATURAL AND FISHING MORTALITIES

Yield-per-recruits for 3 levels of instantaneous natural mortality rates at 1.5, 1.0 were

TABLE 4

Annual average and standing stocks (in tonnes) at Karwar (purse seiners)

Years	Annual catch in tonnes	Annual average stock (Y/U)	Annual average standing (Y/F)	Remarks
1979	2454	6885	3160	These stocks are the pooled averages from the three methods calculated separately as stated above sumped summed up and averaged.
1980	2158	3344	1309	
1981	4107	6550	2431	
1982	3368	5365	1704	
1983	1386	1889	0542	
1984	4731	156883	97725	
1985	4498	12239	5533	
Average	3242	7063	2873	

estimated by the well known formula of Beverton and Holt (1957) which was simplified by Ricker (1958) as below:

$$Y/R = F e^{-M(tp1-tp)} W\infty \left\{ \frac{1}{(F+M)} - \sum_{n=0}^{3} \frac{Un\, e^{-nK(tp1-t_0)}}{(F+M+nK)} \right\}$$

where F= Fishing mortality, M= Natural mortality, tp1= age at capture, tp= age at recruitment, t_0= Arbitrary origin of age when fish has zero length, and Un= summation variable.

a). *YIELD AS FUNCTION OF 'F' KEEPING tp1 AS CONSTANT*

Fig. 2A, shows yield per-recruit calculated for M= 0.5. It is observed from the figure that when the fishery is exploited during November-December, when the fish are 8 to 9 months old, the maximum yield of 44-45 gm is obtained at

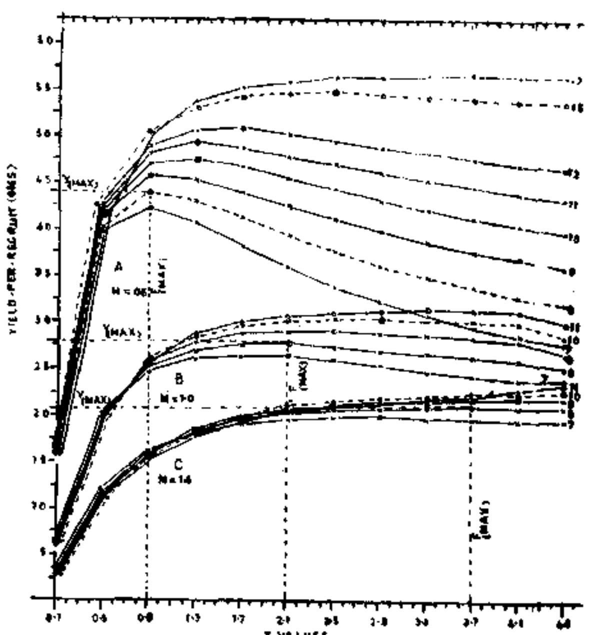

Fig. 2

F= 0.9, these values are Y (Max). At higher natural mortality rate when M = 1.0 (Fig. 2 B) the fishery at the same age and time show the maximum yield of 28-29 gm (Y Max) when F values are 2.1 and 2.6 (F Max). Y (Max) and F (Max) when M= 1.5, for 8 and 9 month fish in November - December period, are 21 gm at 3.7 F and 22 gm with 4.1 F respectively. Increase of natural mortality and F above 1.0 M and 2.5 F may result into less yield when compared to lower M and F values than these as stated above (fig. 2A-C).

b). *EUMETRIC YIELD AND FISHING CURVES*

Figs. 3A, B and C show eumetric yield and fishing curves for 3 levels (0.5 M, 1.0 M and 1.5 M) of instantaneous natural mortality rates. In Figures, eumetric yield curves (broken lines) are obtained by plotting the maxima of Y/R (gm) from each of all tp1 values against the corresponding 'F' values. In these eumetric yield curves (Figs. 3 A, B & C) high values of Y/R

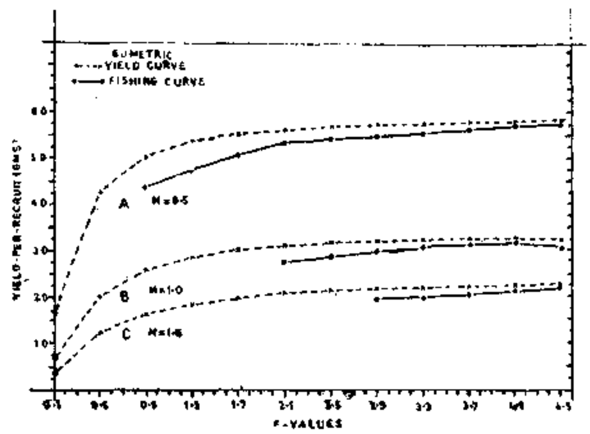

Fig. 3

(Maxima) show fall to low yield values as 'M' increases from 0.5 to 1.5. The eumetric fishing curves which lie below the yield (mesh) curves show also same tendency for instantaneous natural mortality ranging from 0.5 to 1.5. In these curves, as the fishing intensity increases yield curves approach to asymptote and indicate no clear cut maxima.

c.) *EUMETRIC FISHING AS A FUNCTION OF AGE AT ENTRY FOR EACH LEVEL OF F, KEEPING F AS CONSTANT*

In Figures 4 A, B and C there are shown yield mesh curves for each of a number of different values of F, for each value of natural mortality for 0.5, 1.0 and 1.5, separately. It is found that as F increased, the mesh required to give the maximum yield and the quantity of that

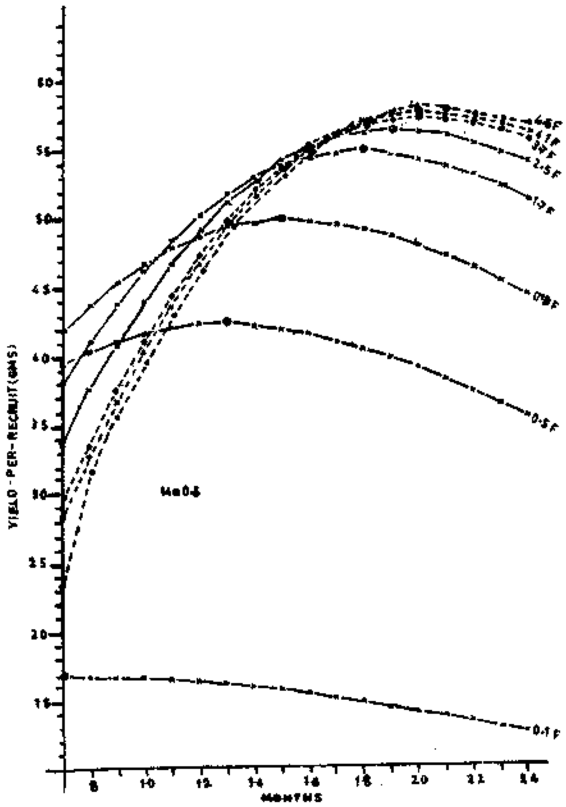

Fig. 4

yield also increases. This is still clear by the description given below.

From the Figure 4A, it would be seen that when M= 0 5, low yields are obtained for lower F values. As F increases, yields also increase. Maximum yields are obtainable when F values are increased from 1.7 to 4.5, at the ages from

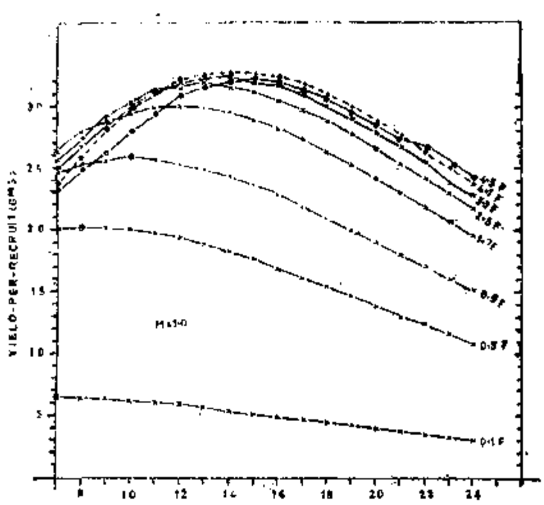

Fig. 5

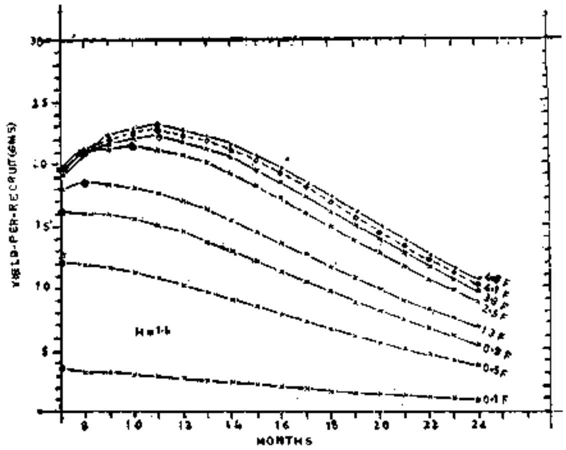

Fig. 6

18 months to 21 months (i. e. 1.5 year to 1.75 year). For M= 1.0 also, increasing F value from 1.7 to 4.5, gives maximum yield for ages 12 months to 15 months (i. e. 1 year to 1.25 year olds) and for M= 1.5, by increasing F values upto 4.5 show low yields for higher ages and higher yields for the lower ages (Figs. 4 A, B and C). One important feature noticed here is that as M increases higher ages tend to produce low yields and the quantity produced is also low.

GENERAL CONSIDERATIONS

This paper deals with some vital aspects of population dynamics on oil sardine fishery resources of Karwar on the West coast of India. At present the fishery is exploited by the purse seiners. As a result of this the artisanal fishery by the indigenous gears has been almost obliterated. As this paper relates to purse seine fishery of this area, attempt was made to understand whether catches are sustainable or not. Data fitted to Schaefer's model indicate that the average annual sustainable yield (MSY) for oil sardine fishery by purse seiners at Karwar is 3775 t and effort for this is 5358 unit days of operations for an year. As seen from the Table 4, the average annual harvest of 3242 by the purse seiners, is less than the MSY level and it is well within the limit at Karwar. Therefore, another 500 t may easily be harvested without any adverse effect on the sardine fishery here. This species is migratory and shows wide seasonal fluctuations. It is assumed that immigration into the fishing grounds and emigration of the population from these grounds are constant. For the same set of data, it is observed that there is bound to be difference in the 'Z' estimates from one method to the other. Here three methods viz., Beverton and Holt (1956), Length converted catch curve method and Age composition method were followed for estimating 'Z' values (Table 1). The average 'Z' value for the first method was higher than that of the second and that of second was higher than the third. In such situations annual average stock and standing stock (for same source of data) are lower for higher Z values and vice versa. It is not correct to say that one method is underestimate and the other is overestimate. To solve this difficulty, the oil sardine stocks are calculated by each method, pooled and averaged for all three methods for annual average and standing stocks. They are estimated at 987978 t and 157810 t on All India basis (Table 2). These are for a single value of M= 1.072. When 3 M values of different authors on oil sardine are chosen for above 'Z' values (Table 3), the pooled average annual and standing stocks on All India basis in the fishing grounds are 3922(3 and 150688 t respectively. This difference in the first and second set of values is because of difference in natural mortality rates obtained under different fishery situations in them. In the third set of Z values of different authors (Sekharan, 1974 and Banerji, 1973) the annual average and standing stocks when pooled are 666146 t and 343337 t respectively (Table 3). The average annual and standing stocks present in the fishing grounds are 7063 t and 2873 t respectively (Table 4). The average annual catch during 1979-1985 is 3242 t and this is more than the standing stock at Karwar. The reactions of fish population to fishing and natural mortalities are remarkable and also for changes in its environment. Such losses from population are compensated by accessions to it, and restore balance under such changing conditions, as fish populations have self regulating mechanism and this resiliency of population is generally observed in any sustained fishery. Studies on yield-per-recruit of oil sardine at 3 levels of natural mortality rates show that fishery in the exploitation phase, with M= 0.5, the Y (Max) and F (Max) being 44-45 gm and 0.9 F respectively. As 'M' values increase to 1.0 and 1.5 in the exploitation phase, Y (Max) and F (Max) are 28-29 gm and 2.1 to 2.6 F and 21-22 gm and 3.7 F-4.4 F respectively, showing the reduction of yield as natural mortality increases. This trend is also noticed in eumetric yield and fishing curves (Figs 3A, B and C). By keeping F constant and changing tp 1 (age at entry) the mesh required to give the maximum yield for 0.5 M, 1.0 M and 1.5 M was calculated. For 0.5 M, increase of F from 1.7 to 4.5 at ages 1.5 year to 1.75 year showed better yield. For M= 1.0, same increase of F gave maximum yield for ages 1 year to 1.25 year fish. Finally for M= 1.5, the same increase of F again showed low yields for the higher ages and high yields for lower ages (Figs. 4 A, B and C).

Now, the idea centres round whether mechanisation has become boon to the fishing industry or not. Purse seines in 1970 were 4 in numbers. This number increased to 35 in 1976, on the West Coast. During 1980, there was unexpected sudden rise to 400 number. In the subsequent years after 1980, more numbers were added every year. It would be of interest to note that the average catch of oil sardine from 1960 to 1975 which is described as non-mechanised period was 190026 t and the period 1976 to 1984 which is characterised by the mechanised one with more than 400 purse seines operating showed the annual average catch of 172, 894 t which is far below the average catch obtained by the traditional gears alone. This has indicated that, mechanisation has not brought any success by increasing more fleet strength in the fishing grounds. In fact, this has made the average catch to decline. Such situation reflects on the standing stock present in the area. According to Sekharan (1974) and Banerji (1973), annual average standing stocks of oil sardine are 390,000 t and 210,000 t respectively, when the fishery was exploited exclusively by the traditional gears during 1960-1971 and recruitment to the fishery was better as judged from the average catch during this period. They also observed lesser exploitation rate. In the present study during 1979-84, the fishery exploited by the purse seiners shows higher rate of exploitation (U) and annual average standing stock approaches to 157810 tonnes. Therefore, introduction of more number of purse seiners beyond the present MSY level (i. e. 2.1 F when M = 1.8), would definitely imbalance the standing stock and then consequently the rate of natural increase, resulting into depletion of the stocks. According to Banerji (1973), the average F of 0.75 would give the maximum yield-per-recruit (Y/R) when M = 0.67 for oil sardine on the West coast of India. This may be compared to above fig 0.9 F when M = 0.5. The catches of purse seiners diminishing at present when compared to those in 1976 or soon after when their number was limited to very few. The optimum catch for the present rate of fishing (2.1 F when M = 1.0), is 331400 t, which shows higher value when compared the optimum sustainable yield, of 213,000 t for oil sardine on the West Coast of India (Banerji, 1973). Therefore, great care should be excercised in regulating the number so as to prevent the harmful effect on the oil sardine resources of the country which should be conserved and renewed by its judicious exploitation.

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