J. mar. biol. Ass. India, 1985, 27 (1 & 2) : 175-182

ESTIMATES OF YIELD–PER–RECRUIT AND STOCKS OF LESSER SARDINES *SARDINELLA GIBBOSA* (BLEEKER) AND *S. DAYI* REGAN, IN THE KARWAR WATERS, WEST COAST OF INDIA

G. G. ANNIGERI*

Central Marine Fisheries Research Institute, Cochin-682 031

ABSTRACT

Consequent to the introduction of purse seiners in the Karwar waters, lesser sardine catches showed improvement forming 4-5% of total marine fish production. Along with major pelagic fish resources of oil sardine and mackerel, this group also supports fishermen of this region economically. To understand the extent of fishing stress on the lesser sardine resources *viz. S. gibbosa* and *S. dayi*, studies on yield-per-recruit (Y/R) and the maximum sustainable yield (MSY) for five years 1979 through 1983 were made. The MSY levels for both the species mentioned above will be reached at 1.0 F and 1.8 F respectively. The standing stocks and the potential average annual yields in the fishing grounds for both the species were also estimated and details are presented in this paper.

INTRODUCTION

WITH the introduction of Purse-seiners in the Karwar waters, the catches of lesser sardines in recent years are showing upward trend and form about 4-5% of the total marine fish catches. A perusal of literature indicated that practically no investigations have been carried out on the biological aspects of *Sardinella gibbosa* and *S. dayi*. To fillup this lacuna in our knowledge, investigations were initiated at Karwar on these species relating to the estimates of yield-per-recruit and their available stocks and the results thereon have been highlighted.

The author expresses his gratitude to the Director for his guidance. His thanks are due to Shri K. V. Narayana Rao, Shri T. Jacob and Shri M. Srinath. He thanks to Shri M. H. Dhulkhed for correcting the manuscript and giving valuable suggestions. He is also thankful to Shri Chennappa Gowda, for extending technical assistance during this study.

MATERIALS AND METHODS

Biweekly samples of fish were collected from centre Baithkol (Karwar) for length frequency studies. The number of fish in each size group and their CPUE was estimated by following the methods of Sekharan (1962) and Sekharan and Dhulkhed (1963). In arriving at Yield-per-recruit at various levels of fishing mortality the formula of Beverton and Holt (1957) as simplified by Ricker (1958) was followed and it is given below :

$$\frac{YW}{R} = Fe^{-M(tp'-tp)} \times W\infty \left(\frac{1}{F+M} - \frac{3e^{-K(tp'-to)}}{F+M+K} + \frac{3e^{-2K(tp'-to)}}{F+M+2K} - \frac{e^{-3K(tp'-to)}}{F+M+3K} \right)$$

Where YW/R = Yield-per-recruit in weight, F = instantaneous fishing mortality, M = instantaneous natural mortality, tp' = age at first capture and tp = age at recruitment ann W_∞ = the average weight of fish of brood when its average asymptotic length is L_∞. K = — log K, where K is the slope of the Walford line. The studies on mortaliy and growth parameters of these lesser sardines have already been made by the author (Annigeri, 1982). The mean modal length at age data were used as followed by Devaraj (1983) for estimating the growth parameters.

ESTIMATES OF YIELD PER RECRUIT

Various parameters estimating for the yield-per-recruit are given in Table 1.

* Present address : Karwar Research Centre of CMFRI, Karwar.

TABLE 1. *Growth parameters for both the species of lesser sardines*

Parameters		*Sardinella gibbosa* 1983	*Sardinella gibbosa* 1979—1983 Period	*Sardinella dayi* 1983	*Sardinella dayi* 1979—1983 Period
to (Yr)	..	—2.51	—0.16	— 1.6132	0.7413
tp (″)	..	0.50	0.50	0.75	0.75
tp′ (″)	..	0.83	0.75	0.92	0.92
L_∞ (mm)	..	144.93	144.26	152.83	150.39
W_∞ (gm)	..	24.03	24.71	32.26	31.95
K	..	0.63	0.75	0.6980	0.3000
M	..	0.8218	0.8218	0.7961	0.7961

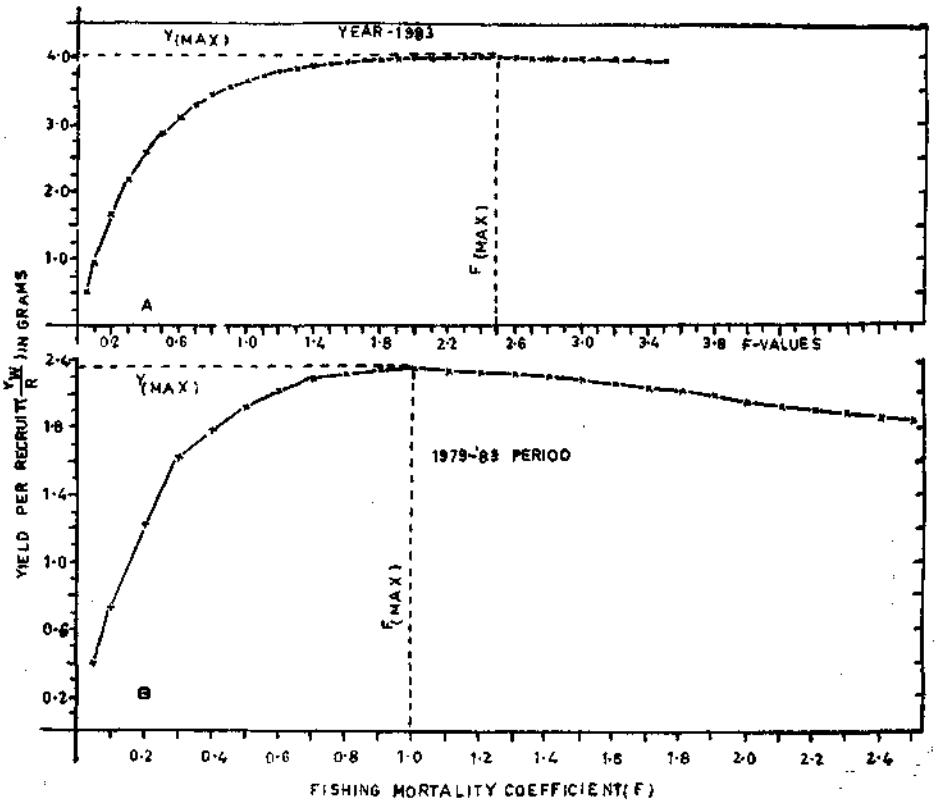

FIG. 1. Yield-per-recruit for *Sardinella gibbosa* for different values of F.

Sardinella gibbosa : Fishes are usually vulnerable to the fishing gear when they are six months old with their modal sizes of 85 to 90 mm. The brood attains 9-10 months in its exploitable phase when the modes fluctuate from 115 to 125 mm during different years. These values are given in Table 1.

The Yield-per-recruit for 1983 was worked-out for various *F* values ranging from 0.05 to 3.5. These values are plotted in Fig. 1 a. *YW/R* values plotted against *F*, show gradual increase till the maximum value (*Y*) — max is reached at *F* = 2.5 (*F*) — max and then on they show decline in their values. Similarly, the Yield-per-recruit for 1979-1983 period are plotted in Fig. 1 b, for various values of F on the abscissa with the same range as shown in Fig. 1 a. It is clear from Fig. 1 b that, the (Y) — max is reached at the fishing mortality of $F = 1.0$, (F) — max.

of different fishing mortality rates at any given age of entry.

Sardinella dayi : This species enters the fishery when it is eight to nine months old based on the data for 1979 to 1983 period. The age

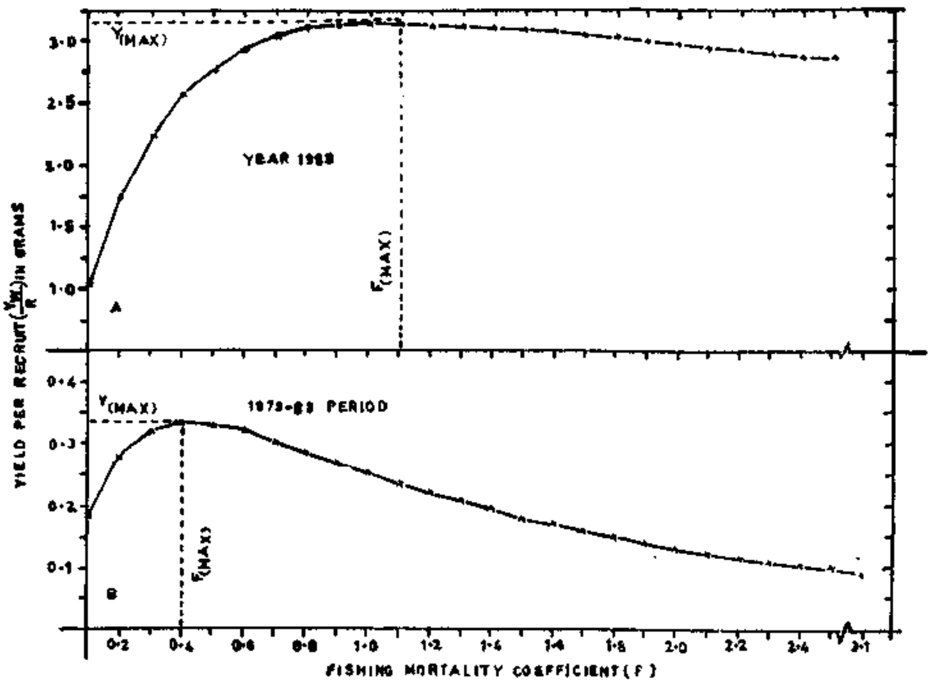

FIG. 2. Yield-per-recruit for *S. dayi* for different values of F.

In Fig. 3, eumetric yield and eumetric fishing curves (MSY) are given. In the former case keeping F constant the maximum yield is calculated for various values of tp', the age at entry. Such maximum are traced for different values of F. In the latter instance keeping tp' constant YW/R maximum is calculated for various values of F. These maximum sustainable yield (MSY) for different tp', as function of F are traced.

In Fig. 5, YW/R on the ordinate are plotted against age at entry on the abscissa. It is observed from figure that there is an optimum age of entry for each fishing mortality rate and relative increase or decrease in yield as a result

of exploitation varies from year to year. During 1983, age of exploitation was of 11 months old (0.92 year) and the pooled data for 1979-1983 period also showed the same age of exploitation as shown in Table 1.

Yield-per-recruit values were calculated and they are shown in Fig. 2 a. The values of F ranged from 0.1 to 3.0. The values (YW/R) proportionately increase with increase of F till 1.1, (F) — max when the maximum yield-per-recruit, 3.17 (Y)—max is reached. The values show decline after this maximum point.

In Fig. 2 b, yield-per-recruit for 1979-1983 period are plotted for various values of F.

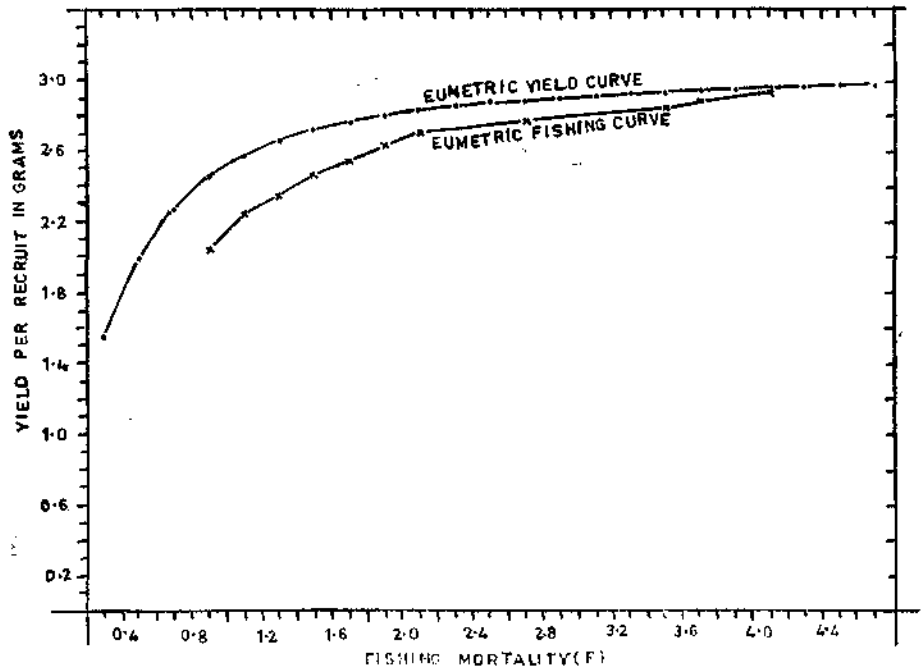

FIG. 3. Eumetric yield and fishing curves of *S. gibbosa* for 1979 to 1983.

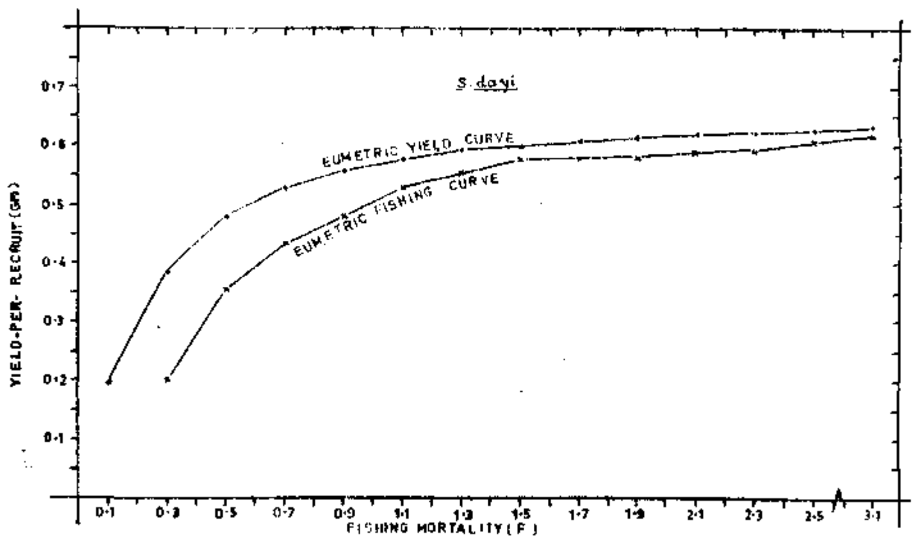

FIG. 4. Eumetric yield and fishing curves of *S. dayi* for 1979 to 1983.

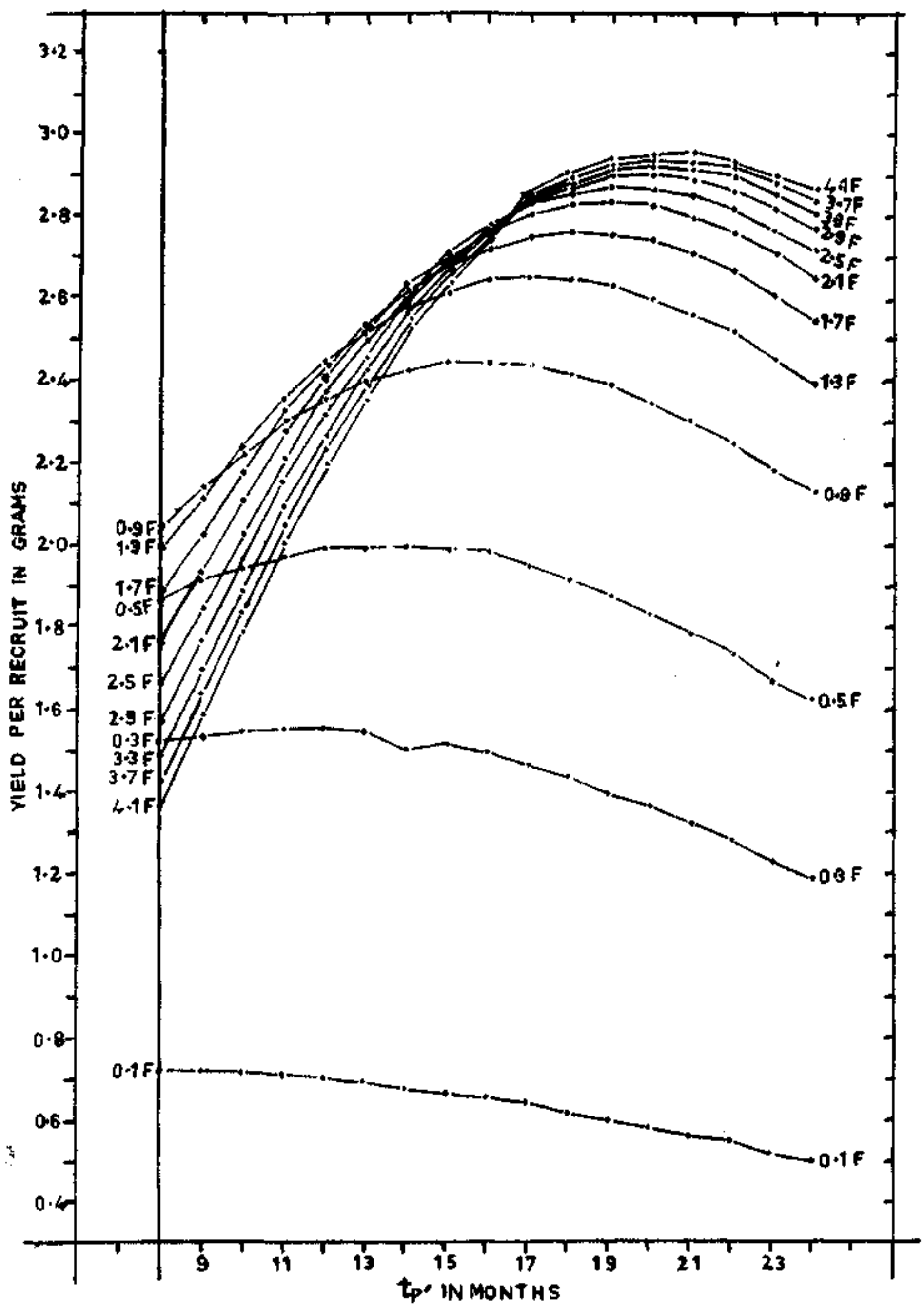

FIG. 5. The yield-per-recruit (YW/R) as a function of tp′ for various values of F for *S. gibbosa* during 1979-1983 period.

The yield-per-recruit for 0.1 is 0.18 gm. This gradually increases to the maximum of 0.33 gm, (Y) — max at 0.4 F, (F) — max. The yield is maximum at this level. Further increase of F, results in to decline in yield-per-recruit as seen from the values calculated upto 3 F.

The yield-per-recruit as a function tp' (age at entry) keeping F constant and varying F values holding tp' constant are shown in Fig. 4. In the former, it is to determine the optimum age at entry for each fishing mortality rate. In the latter instance, it is used to determine the optimum fishing rate for each age of entry. The maximum of these two cases when plotted vertically and horizontally show eumetric yield and fishing curves.

The yield-per-recruit are plotted against the different values of tp' (age at entry) in Figs . 5 and 6 for both the species of *sardinella*. These yield intensity curves are of much more important as they enable to obtain the maximum possible yield at each level of fishing intensity as shown in Fig. 6.

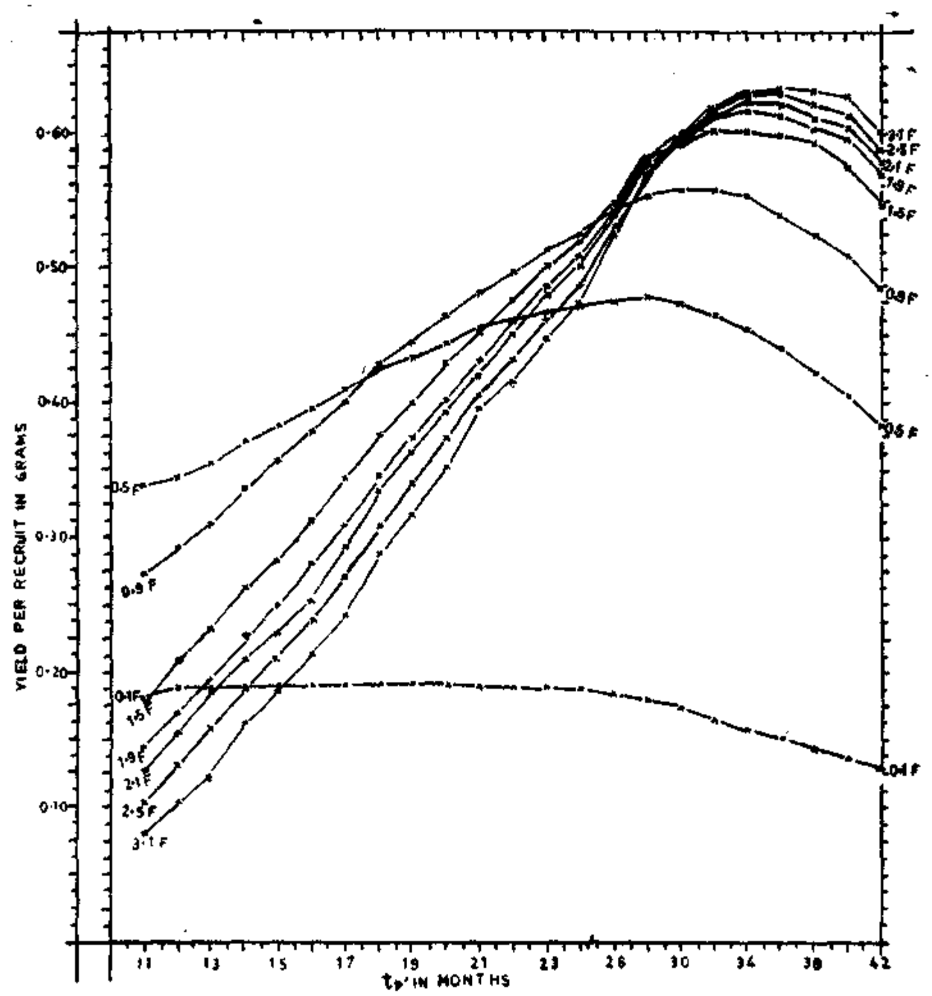

FIG. 6. Yield-per-recruit (YW/R) as a function of tp' for various values of F for *S. dayi* during 1979-1983 period.

TABLE 2. *Total annual and average standing stocks of* S. gibbosa (in tonnes)

Years	All India				Karnataka			Karwar		
	Exploitation rate (U)	Total annual stock (Y/U)	Average standing stock (Y/F)	Total catch	Total annual stock (Y/U)	Average standing stock (Y/F)	Total catch in Karnataka	Total annual stock (Y/U)	Average standing stock (Y/F)	Total catch in Karwar
1979	0.067	458907	341631	30747	31912	23756	2138	8768	6527	588
1980	0.056	250734	93607	14041	15462	5773	866	2895	894	134
1981	0.134	89916	44625	12049	7736	3836	1036	839	416	112
1982	0.271	77945	55587	21123	4426	3156	1199	1645	1173	446
Mean	0.1224	159231	87399	19490	10701	5873	1310	2614	1435	320

TABLE 3. *Total annual and average standing stocks of* S. dayi (*In tonnes*)

Years	All India				Karnataka			Karwar		
	Exploitation rate (U)	Total annual stock (Y/U)	Average standing stock (Y/F)	Total catch	Total annual stock (Y/U)	Average standing stock (Y/F)	Total catch in Karnataka	Total annual stock (Y/U)	Average standing stock (Y/F)	Total catch in Karwar
1979	0.23	81627	48139	18774	5676	3348	1306	1560	920	359
1980	0.62	47278	17243	29312	2916	1063	1808	452	165	280
1981	0.36	122035	62761	43932	10491	5395	3777	1139	586	410
1982	0.71	24072	7367	17091	1367	418	970	156	508	361
Mean	0.54	50514	21311	27278	3639	1535	1965	653	275	352

Estimates of Stocks of Lesser Sardines

From the total instantaneous mortality rates (Z), the exploitation rate (U) were calculated by using the formula (Ricker, 1958) :

$$U = \frac{F}{(F+M)} (1\text{-}e^{-(F+M)})$$

Where F = fishing mortality and M = Natural mortality

In Tables 2 and 3 are given the total annual stock and average standing stock of *S. gibbosa* and *S. dayi* respectively on both coasts of Karnataka and Karwar area.

General Remarks

Studies on yield-per-recruit and stocks of fish population in Indian waters are limited. Some of them include the ghol fishery of north west coast (Venkata Subba Rao, 1971), mackerel and oil sardine fisheries (Banerji, 1973), silverbelly fishery of Palk Bay (Venkataraman *et al.*, 1981), population dynamics of Indian mackerel (Yohanan, 1983) and seer fishes of India (Devaraj, 1977). The present account deals with YW/R and stocks of lesser sardines *viz.*, *S. gibbosa* and *S. dayi*. This study shows comparison between both the species of *Sardinella*, in respect of yield-per-recruit and stocks. The yields were also calculated for a single year 1983 to note the extent of variation from the five year period 1979-1983. The maximum yields (Y) max for *S. gibbosa* and *S. dayi* were reached at 1.0 F, (F) max and 0.4 F, (F) max respectively for 1979-1983 period. Similarly, the yield maxima for 1983 of both the species were at the fishing mortalities of 2.5 F, (F) max and 1.1 F, (F) max. These values are falling on the higher side of the five yearly smoothened values of 1.0 and 0.4 F, deviating from the five yearly averages. The yields were calculated in three different ways. First is to determine the maximum yield (Y) max and (F) max for various values of F (Figs. 1, 2). Second and third is to find out eumetric yield and eumetric fishing by changing the age at entry (tp') keeping F constant and holding tp' constant and changing the F values to obtain optimum levels of both types of yields (Figs. 3 to 6). The stocks on all India, Karnataka and Karwar areas were estimated and the average standing crop on these coasts for *S. gibbosa* showed more encouraging feature than for *S. dayi* (Tables 2 and 3).

References

Annigeri, G. G. 1982. On the fishery and biology of *Sardinella dayi* (Regan) at Karwar, India. *J. mar. biol. Ass. India*, **24** (1 & 2) : 133-140.

Banerji, S. K. 1973. An assessment of the exploited pelagic fisheries of the Indian seas. *Proc. Symp. living Res. seas around India, Spl. Publin, CMFRI*, 114-136 pp.

Beverton, R. J. H. and S. J. Holt 1957. On the dynamics of exploited fish populations. *U.K. Min. Agric. Fish. Fish Invest. London, Ser.* **2** : 19-533.

Devaraj, M. 1977. The biology and fishery for the seerfishes of India. *Ph. D. Thesis, Madurai Kamaraj University, Madurai.*

——— 1983. *Fish population dynamics course manual, CIFE Bulletin*, **3** (10) 83 : 1-93.

Ricker, W. E. 1958. Hand book of computations for biological statistics of fish populations. *Bull. Fish. Res. Bd. Can.*, **119** : 300 pp.

Sekharan, K. V. 1962. On oil sardine fishery of Calicut area during 1955-56 to 1958-59. *Indian J. Fish.*, **9** (2) : 679-700.

Sekharan, K. V. and M. H. Dhulkhed 1963. On the oil sardine fishery of the Mangalore Zone during the years 1957-1963. *Ibid.*, **10A** (2) : 601-626.

Venkata Subba Rao, K. 1971. Estimates of mortality and yield-per. recruit of 'ghol' *Pseudosciaena diacanthus* (Lecépède). *Ibid.*, **15** (1 & 2) : 88-98.

Venkataraman, G., M. Badruddeen and R. Thiagarajan 1981. Population dynamics of silver belly *Leignathus jonesi* in Palk Bay. *Ibid.*, **28** : 65-86.

Yohannan, T. M. 1983. Population dynamics of Indian mackerel based on data from Mangalore during 1967-75. *Ibid.*, **29** (1 & 2) : 50-62.