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Oil Sardine Fishery at Karwar - an Update

U. Ganga

Central Marine Fisheries Research Institute, Cochin - 682 014

Abstract

A study on the oil sardine (*Sardinella longiceps* Val.) fishery at Karwar during the period 1990-'98 was undertaken using the length frequency data collected from the purse seine landings at Karwar Fisheries Harbour. Growth parameters obtained using VBGF were L_∞ = 204(mm) and K = 1.6 (annual). Oil sardine attains a length of 163, 196 and 202 mm at the end of I, II and III year of life respectively. The fishery showed annual variations with extremely poor catches during the 1993-'95 period. The total mortality (Z) and fishing mortality (F) rates were estimated to be 6.34 and 4.91 during 1996-'98 when compared to 2.44 and 1.01 respectively in 1990-'92 period. There has been a considerable increase of 39% in the effort expended by purse seine units operated along the Karwar coast during 1996-'98 compared to that in the 1990-'92 period, and exploitation ratio(U) was 0.51 and 0.78 respectively during the two periods. Length wise estimates of F obtained using VPA indicated that it was maximum in the 80-90 mm (1990-'92) and 140-150mm (1996-'98) groups.

Introduction

The oil sardine, *Sardinella longiceps* Val. is a major pelagic fishery of Karnataka state which shows strong decadal and annual variations. The all India landings of oil sardine decreased drastically from 279,000 t in 1989 to a mere 47,000 t in 1994. Luther (1988) opined that while the fishery is showing declining trends along the west coast it has emerged as a significant fishery along the south-east where earlier it formed only a negligible portion of the landings. A study of marine fish landing trends during the period 1980-'84 and 1990-'95 had revealed remarkable changes in resource composition in catch. While in the 1980's small pelagics such as oil sardine, mackerel and anchovies made up nearly 50% of the catch, in the 1990's, the oil sardine dropped from 33% to 7% and resources such as nemipterids, cephalopods, flatfishes, ribbonfishes and carangids mostly exploited by trawler units increased in relative terms (Mohamed *et al.*, 1998). Various causes related to ocean environment dynamics (sunspot activity, rainfall, ENSO effects, sea level pressure, upwelling, currents etc.) and also possible high level of fishing pressure have been attributed to explain these fluctuations in the fishery (Nair, 1953; Antony Raja, 1972; Murty and Edelman, 1970; Madhupratap *et al.*, 1994; Srinath, 1998). Balan (1984) while reviewing the oil sardine fishery has emphasized the need to estimate population parameters at the different fishing centres in view of the spatial differences in the occurrence of size groups and maturation and growth cycles.

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Material and methods

The present study was conducted to compare the status of the oil sardine fishery at Karwar during the period 1996-'98 with that of 1990-'92 as during 1993-1995 there was only negligible quantity of oil sardine landing. Data on catch and effort by the purse seiner units was collected from the Karwar Fisheries Harbour twice a week which was pooled and raised, taking into consideration the number of fishing days in the month, to get estimates of catch, effort and catch per unit effort (CPUE). Random samples of 150-200 fish were collected monthly and their total length(mm) and weight (g) recorded. Length frequency data grouped into 10 mm intervals was used to estimate the growth parameters $L\infty$ and K using the ELEFAN module of FiSAT (FAO - ICLARM Stock Assessment Tools Ver 1.1)

The total instantaneous mortality coefficent (Z) was estimated using the Length converted catch curve method (Pauly, 1983) and the annual mean length (Beverton and Holt, 1956). The natural mortality coefficent (M) was estimated using Pauly's (1983) empirical formula,

$\ln M = -0.0152-0.279 * \ln L\infty + 0.6543 * \ln K + 0.463 * \ln T$, where $L\infty$ and K are von Bertalanffy growth parameters

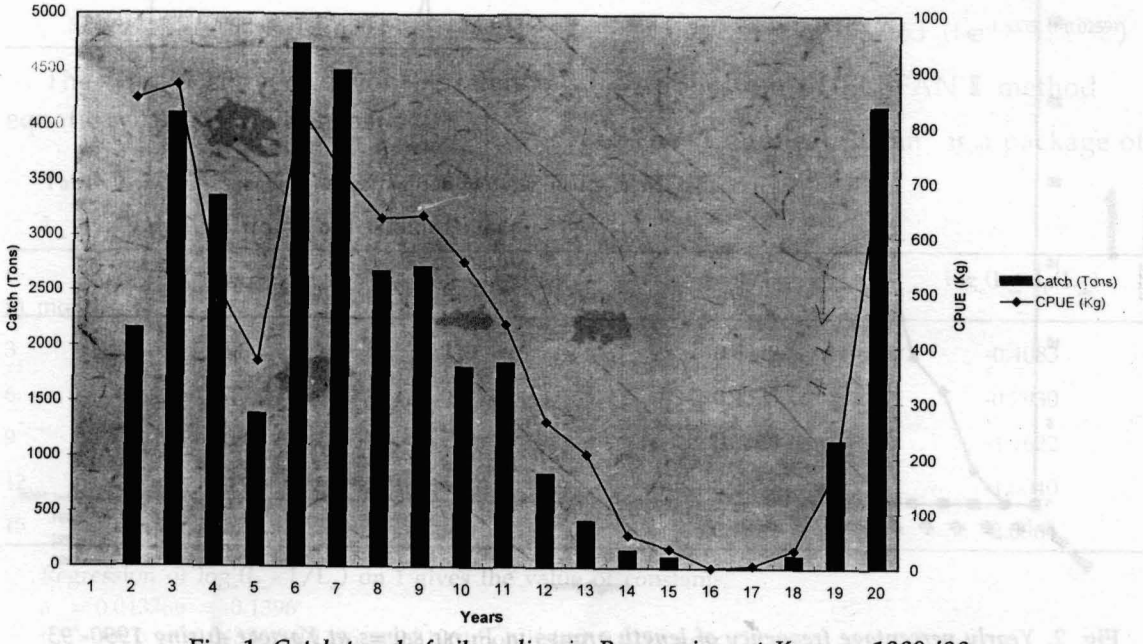

Fig. 1. *Catch trend of oil sardine in Purse seines at Karwar, 1980-'98*

and T the ambient water temperature in degrees centigrade, assumed here as 28.5°C. The fishing mortality coefficent (F) was derived from the relation Z = F + M. Length structured Virtual population analysis (VPA) of FiSAT was used to obtain population sizes and fishing mortalities per length class.

The exploitation ratio (U) was estimated from the equation $U=F/Z\ (1-e^{Z})$ and standing stock (Y/F) was estimated by taking the annual oil sardine catch (Y) during the relevant period. The relative yield per recruit (Y'/R) was obtained by Beverton and Holt equation (1964).

Biological studies

Monthly modal and mean lengths show yearly variations while the trend is that small sardines (<120mm) appear during August - October and thereafter no entry of small sized fish was recorded. Yearly percentage frequency of the length groups of oil sardine in the purse seine catches during 1990-'98 is given in Figs. 2 & 3.

The oil sardine has been observed to attain maturity at age of 1 year at a length of 150 mm with active spawners in oozing condition measuring 150-170 mm (Devaraj *et al.*, 1997). In 1993, the fishery was very poor with an estimated landing of 104 t and these were in the size range of 140-165 mm. These catches were observed in January and as peak recruitment occured in the 3rd and 4th quarters it is inferred that these were probably recruits of the previous season. In 1994 a

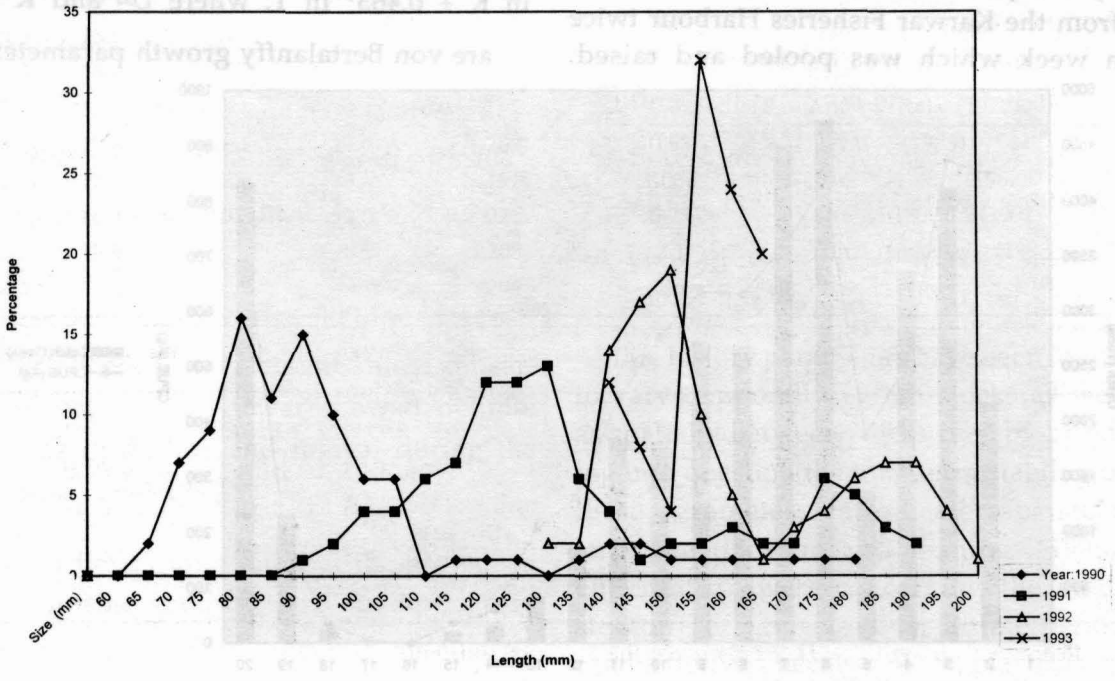

Fig. 2. *Yearly percentage frequency of length groups in Purse seines at Karwar during 1990-'93*

poor catch of 380 kg of fishes in the size range of 115-155 mm was observed in September while in 1995 there was no landings of sardines by the purse seiners. These observations indicate that spawning might not have been successful during 1993-'95 due to the absence of an adequate spawning population and that the success of the fishery seems to be largely determined by the strength of the 0 year class (<160 mm) at Karwar.

Results and discussion

Fishery

Pannikkar (1993) discussed the structural change in the Karnataka marine fisheries sector with the introduction of purse seiner units in 1976 which gradually phased out the traditional fishing gear, the giant shore seine "Rampan". Presently only 132 purse seines are operated at 25-40 m depths along the North Kanara coast (Anon, 1997). These are 30-32' OAL mini purse seiner units with 37-50 HP engine and 36-48' OAL units with 100-110 HP engines. Nylon nets of 250-400 m in length and mesh of 18-22 mm are used. The main season is during September to March after which catch rates decline and some of these units are temporarily converted into trawlers. Mechanised fishing is banned for a period of three months during June - August under the Karnataka Marine Fisheries Regulation Act of 1986.

The catch of oil sardine after the period of mechanisation of crafts (post 1976) has shown a decine from a level of 1500 tons in the late 80's to less than 500 t in the

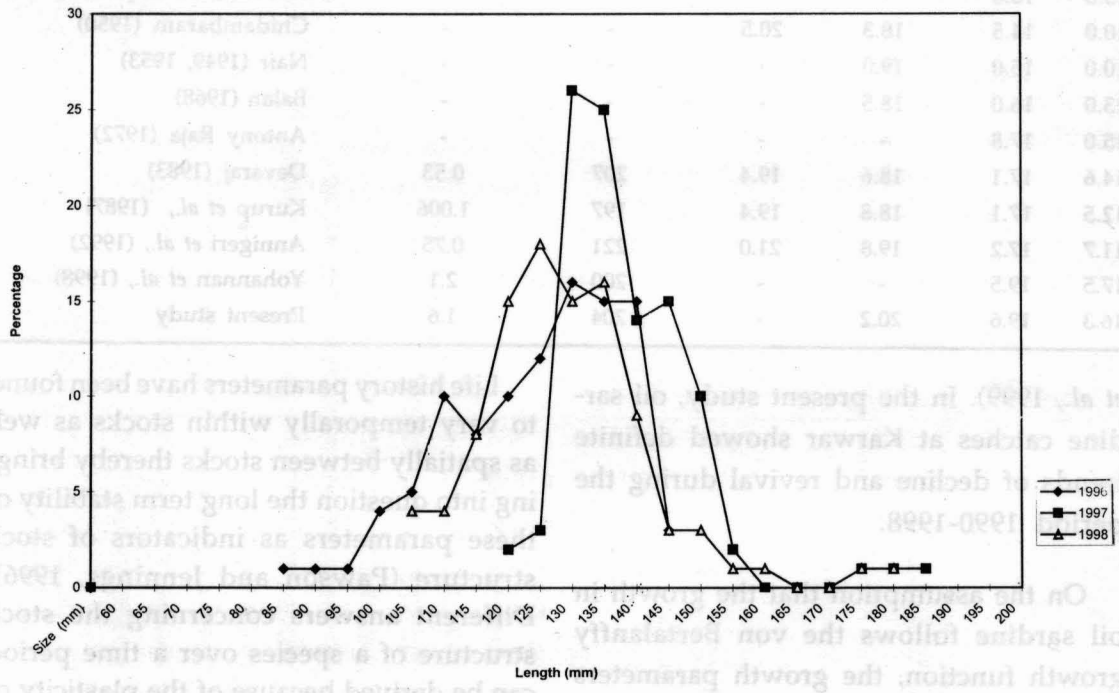

Fig. 3. *Yearly percentage frequency of length groups in Purse seines at Karwar during 1996-'98*

early nineties and the CPUE of 849 kg (1980) to 264 kg (1990). The major debacle was in 1994 and 1995 when only 0.4 tons and 6 tons were landed. Since 1996 the fishery has slowly revived and catches in 1997 and 1998 were 1161 and 4135 tons respectively (fig. 1)

Stock assessment:

Growth

Species and their stocks are dynamic interactive assemblages with spatial boundaries and associated vital life history parameters varying with time and therefore these parameters need to be examined over different time frames (Begg *et al.*, 1999). In the present study, oil sardine catches at Karwar showed definite trends of decline and revival during the period 1990-1998.

On the assumption that the growth in oil sardine follows the von Bertalanffy growth function, the growth parameters were estimated as below,

Period	1990-92	1996-98
$L\infty$ (mm)	203	204
K (annual)	1.3	1.6

Various authors have made divergent observations on age, growth rate and spawning of oil sardine at different centres, and estimates of the growth parameters derived by earlier workers are given below:

Rapid growth rate has been observed in the first year and subsequently it was relatively slow. According to Yohannan (1998), oil sardine attained 72% of the potential average size the fish can reach in a seven month period.

Length (cm) at age (Years)						Author
I	II	III	IV	L_∞ (mm)	K (annual)	
15.0	16.0	-	-	-	-	Hornell and Nayudu (1924)
10.0	14.5	18.3	20.5	-	-	Chidambaram (1950)
10.0	15.0	19.0	-	-	-	Nair (1949, 1953)
13.0	16.0	18.5	-	-	-	Balan (1968)
15.0	17.8	-	-	-	-	Antony Raja (1972)
14.6	17.1	18.6	19.4	207	0.53	Devaraj (1983)
12.5	17.1	18.8	19.4	197	1.006	Kurup *et al.*, (1987)
11.7	17.2	19.8	21.0	221	0.75	Annigeri *et al.*, (1992)
17.5	19.5	-	-	200	2.1	Yohannan *et al.*, (1998)
16.3	19.6	20.2	-	204	1.6	Present study

Life history parameters have been found to vary temporally within stocks as well as spatially between stocks thereby bringing into question the long term stability of these parameters as indicators of stock structure (Pawson and Jennings, 1996). Different answers concerning the stock structure of a species over a time period can be derived because of the plasticity of vital life history parameters to the effects

of changing environmental conditions and fishing pressure (Begg *et al.*, 1999). Earlier workers have estimated L_∞ values ranging from 197 mm to 221 mm and K values ranging from 0.53 to 1.006.

In the present study L∞ values were comparable to earlier estimates. However, the growth rate (K) was relatively high which is in close agreement with that obtained by Yohannan (1998). Kawasaki (1989) while discussing the long term variability in pelagic fish populations has described the phenomenon of 'phase variation' in sardine populations which is characte-rised by great change in growth rate as well as the extension and contraction of its distribution range. The Indian oil sardine fishery also has witnessed dramatic changes in its distribution and abundance during 1960-'90 period. Along the east coast, prior to 1961 oil sardine was not recorded in the catches, while during 1961 - '81 average landing was 215 t and during 1982-86 it was 3797 t (Luther, 1988).

Landings by commercial fishing vessels is an indicator of the stock abundance of oil sardine and the estimated oil sardine landings along the south west coast was 1,42,000 t in 1991 compared to 39000 t in 1996. Wada and Kashiwai (1989) observed growth inversely related to stock abundance in the Japanese sardine, *Sardinops melanostictus* while Kawasaki (1989) found high growth rates during periods of weak year classes and *vice versa* in the far eastern sardine, *Sardinops sagax.* In the present study high growth rate was observed during the 1996-98 period which was a period of low abundance of oil sardine along the south west coast. While studying growth pattern of oil sardine Antony Raja (1972) observed the fastest growth rate in 1963 coinciding with the

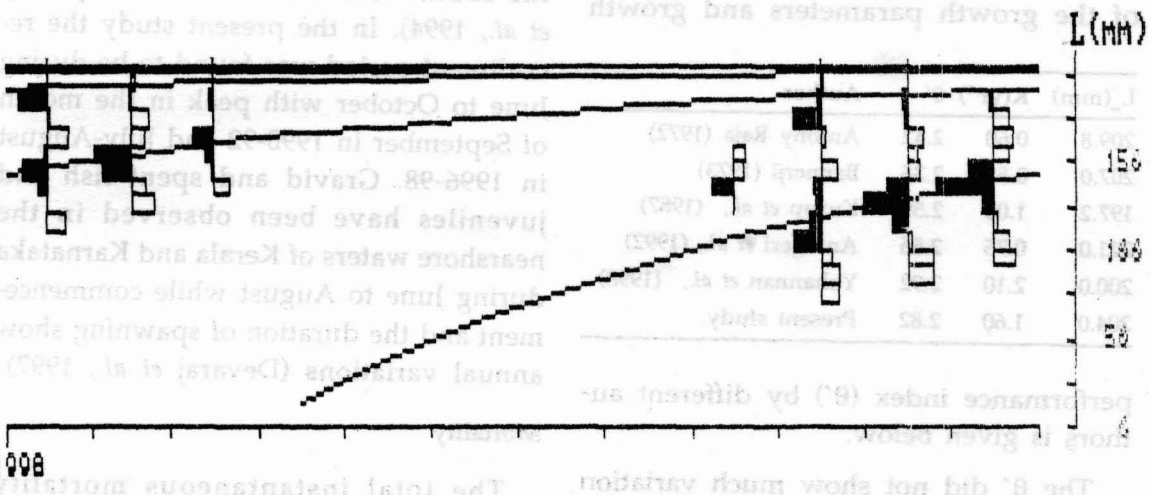

Fig. 4. *Growth curve of Oil sardine (*S. longiceps*) at Karwar during 1996-'98 using Elefan 1 method*

failure of the fishery at Calicut and slowest growth rate during the year 1961 and 1964 when the fishery was exceptionally good. This may be occurring due to less competition for food among the fewer individuals of a species resulting in higher food gain. Wada and Kashiwai (1989) have observed that good individual growth results in good recruitment and therefore sardine populations will select grounds of high forage density and as food gain decreases with increasing stock abundance they will spread to outer regions of lower food density at the cost of individual growth. According to Yohannan (1998), annual variations in the population density, food availability and other environmental conditions influence the growth parameters of different year classes.

Sparre and Venema (1998) opined that comparing different estimates of K and $L\infty$ should not be on the basis of one individual parameter but on the basis of the resulting growth curve. A comparison of the growth parameters and growth performance index (θ') by different authors is given below.

L_∞(mm)	K(yr^{-1})	θ'	Author
209.8	0.60	2.42	Antony Raja (1972)
207.0	0.53	2.36	Bannerji (1973)
197.2	1.01	2.59	Kurup *et al.*, (1987)
221.0	0.75	2.56	Annigeri *et al.*, (1992)
200.0	2.10	2.92	Yohannan *et al.*, (1998)
204.0	1.60	2.82	Present study.

The θ' did not show much variation and ranged between 2.3-2.9

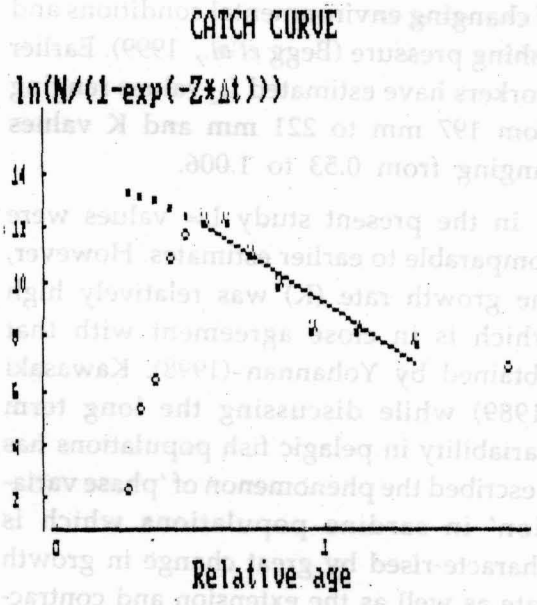

Fig. 5. *Length Converted Catch Curve of Oil sardine* (S. longiceps) *at Karwar during 1996-'98.*

Recruitment

Planktivorous fishes like oil sardine prefer productive regions in the sea and time their appearance and spawning to coincide with productive conditions during the south west monsoon (Madhupratap *et al.*, 1994). In the present study the recruitment period was found to be during June to October with peak in the month of September in 1990-92 and July-August in 1996-98. Gravid and spent fish and juveniles have been observed in the nearshore waters of Kerala and Karnataka during June to August while commencement and the duration of spawning show annual variations (Devaraj *et al.*, 1997).

Mortality

The total instantaneous mortality rate(Z) is found to vary seasonally and

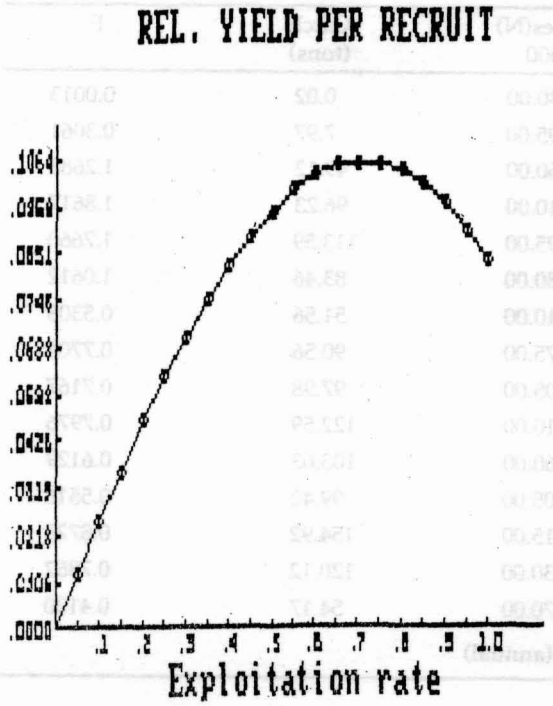

Fig. 6. *Relative yield per recruit of Oil sardine* (Sardinella longiceps) *during 1996-'98.* E_{max} = 0.71, $E_{0.1}$= 0.6604 *and* $E_{0.5}$ = 0.3630

annually depending on the fishing mortality (F) and natural mortality(M) according to the equation Z = F + M. In the present study Z, F and M was estimated using the length converted catch curve method and the Beverton and Holt method as below:

Annigeri(1971) estimated Z for the oil sardine fishery at Karwar in terms of the standard fishing unit, namely, the shore seine. The estimates were Z = 1.57 - 3.7, F = 0.12 - 2.25, (average 1.215) and M = 1.45. On the basis that $Z^* t_{max} = 6$ for *Sardinella* species, Devaraj (1983) assumed that the t_{max} for exploited populations of oil sardine in the Indian seas is four years and arrived at a Z value of 1.5 and concluded that in a virgin stock Z = M = 1.5. In the present study during the 1990-92 period, Z, M and F was estimated as 2.7, 1.43 and 1.47 respectively which agrees with the observations by earlier workers. During the 1996-98 period there has been a considerable increase in Z to 6.34 and F to 4.91. This increase in fishing mortality is obviously because of the change in fishing pattern that has occurred. Since 1980, traditional non-mechanised fishing by shore seine units have been replaced by the highly effective purse seines for pelagic shoaling fishes. Also from 1990-94 period to 1995-98 period there has been an increase of 39% in the fishing effort by purse seiners operated along the Karwar coast.

The Length-weight relationship for the oil sardine stock along the west coast of India as described by Annigeri *et al.*, (1992) by the function $W = 0.00000347194 * L^{3.163582}$ (g,mm) was used for cohort analysis to determine catch, stock size and fishing mortality (F) for the various length classes during the period (Tables 1 & 2).

Period	Catch curve			Beverton and Holt method			Average		
	Z	F	M	Z	F	M	Z	F	M
1990-92	2.44	1.01	1.43	2.95	1.52	1.43	2.90	1.47	1.43
1996-98	6.36	4.93	1.43	6.32	4.89	1.43	6.34	4.91	1.43

Table 1. *Stock size, catch and fishing mortality(F) of Sardinella longiceps during 1990-92 along Karwar Coast.*

Mean length(mm)	Population *1000	Catches(N) *1000	Catch (tons)	F
55.00	2774217.50	180.00	0.02	0.0013
65.00	2575255.50	41895.00	7.97	0.3061
75.00	2337624.50	164550.00	49.12	1.2683
85.00	1987539.63	217210.00	96.23	1.8617
95.00	1603491.38	180495.00	113.59	1.7660
105.00	1276839.50	96680.00	83.46	1.0612
115.00	1049880.38	44810.00	51.56	0.5308
125.00	884346.81	60475.00	90.56	0.7704
135.00	711622.38	51305.00	97.98	0.7167
145.00	557950.06	51210.00	122.59	0.7976
155.00	414925.28	34860.00	103.03	0.6129
165.00	298725.59	27605.00	99.42	0.5516
175.00	199549.56	35715.00	154.92	0.8723
185.00	105287.83	23230.00	120.12	0.7862
195.00	39806.83	8870.00	54.17	0.4100
Input parameters:	L = 203 mm	K = 1.3(annual)		

Table 2 *Stock size, catch and fishing mortality(F) of Sardinella longiceps during 1996-98 along Karwar Coast.*

Mean length (mm)	Population(N) *1000	Catch (n) *1000	Catch (tons)	F
55.00	6330978.50	0.00	0.00	0.0000
65.00	5962256.50	10.80	0.00	0.0000
75.00	5590791.50	240.40	0.07	0.0009
85.00	5216145.50	939.60	0.42	0.0036
95.00	4837618.00	58698.80	36.94	0.2216
105.00	4400206.50	220735.10	190.56	0.8526
115.00	3809232.75	532270.38	612.47	2.2563
125.00	2939626.25	777552.70	1164.39	4.1277
135.00	1892699.00	724214.81	1383.13	5.7352
145.00	987917.25	447885.51	1072.14	6.2420
155.00	437436.03	153247.20	452.93	3.7422
165.00	225631.95	53390.00	195.88	1.9384
175.00	131118.88	25399.60	110.18	1.1647
185.00	74534.49	20149.10	104.19	1.2118
195.00	30609.07	10803.20	65.98	0.7800
Input parameters	L = 204 mm	K = 1.6 (annual)		

Fishing mortality(F) was estimated for the various length groups during the two periods and was found to be maximum for the 80-90 mm group during 1990-92 and 140-150 mm during the 1996-98 period. Exploitation ratio (U) calculated for the two periods were 0.51 and 0.78 respectively which is a reflection of increasing fishing effort in recent years. The relative yield per recruit was found to be maximum when the exploitation rate was 0.53 and 0.71 during 1990-92 and 1996-98 respectively.

Period	Z	F	M	Exploitation ratio (U)	Av. Catch (Y) t	Av. Standing stock Y/F(t)
1990-'92	2.90	1.47	1.43	0.51	478	325.2
1990-'98	6.34	4.91	1.43	0.78	1803	367.2

Estimates of mortality coefficents, exploitation ratio(U) and annual stock of *S. longiceps* along Karwar coast are as follows:

As of present there is no unanimity over the factors determining the fluctuations in abundance of sardine stock while the consensus among most of the researchers is that there is a significant interplay of environmental factors that indirectly influence stock. Introduction of new fishing technologies and diversification of fishing operations as witnessed in the rapid growth and popularization of purse seiner and ring seiner fleets, and motorization of traditional fishing crafts have led to increased exploitation of sardine resources in the coastal fishing grounds. It has been observed that after a certain level of fishing effort the catch of small pelagics like oil sardine do not seem to bear any significant relationship with efford and therefore the appropriate manipulation of fishing effort becomes a function of fisheries economics (Devaraj *et al.*, 1997). At present there are no particular management measures in the tropical multi-species, multi-gear fishery of India and therefore it is all the more imperative to make periodical assessments of the health of the exploited stock using standard reference points.

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