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Age, growth and mortality parameters of Indian oilsardine *Sardinella longiceps* Valenciennes, 1847 from Mumbai waters, off Maharashtra, India

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ABSTRACT

Age, growth and mortality parameters of *Sardinella longiceps* Valenciennes, 1847 were studied based on the length-frequency data of 785 individuals collected on weekly basis from New Ferry Wharf, Sassoon Docks and Versova landing centres in Mumbai from September 2013 to May 2014. The data were analysed through ELEFAN employing the FiSAT program. Asymptotic length (L_∞), growth coefficient (K) and age at zero-length (t_0) were estimated at 233 mm, 1.51 y^{-1} and -0.000022, respectively. The von Bertalanffy growth formula indicated that the fish reaches 182, 221 and 230 mm at the end of 1, 2 and 3 years of life, respectively. Total (Z), natural (M) and fishing (F) mortalities were estimated at 4.82, 2.46 and 2.36 y^{-1}, respectively. The estimated M/K ratio falls within the range for the accurate estimation of natural mortality coefficient, indicating that the M and K estimates are reasonable and reliable. With exploitation rate of 0.48 and the fishing mortality being only slightly lower than the natural mortality, it can be concluded that the stock is exploited to near optimum levels in the region.

Keywords: Asymptotic length**,** ELEFAN, Growth coefficient, Modal progression analysis, Mortality parameters

Introduction

The Indian oilsardine *Sardinella longiceps* Valenciennes, 1847, is India's most commercially important pelagic fish species, which contributes to around 20% of the total marine fish production in India (Rohit *et al.,* 2018). Geographically, this species is distributed around the Gulf of Aden, the Gulf of Oman and the Indian Ocean and is usually found at depth ranges of 20 to 200 m along the coastal belt (Whitehead, 1985). The determination of age, growth and mortality parameters based on length-frequency analysis is essential for understanding population structure, size, distribution, sexual maturity, spawning behavior, recruitment pattern, harvesting level and current exploitation variability of the fishery (Morales-Nin, 1992; Love *et al.,* 2002; McRae and Diana, 2005). Several workers have reported divergent observations on L_∞, K and t_0 of *S. longiceps* from different zones of the east and west coasts of India (Hornell and Nayudu, 1924; Chidambaram, 1950; Nair, 1953; Balan, 1964; Antony Raja, 1970; Kurup *et* al., 1989; Annigeri *et al.,* 1992; Yohannan *et* al., 1998; Ganga, 2000; Rohit and Bhat, 2003; Ganga and Pillai 2006; Abdussamad *et al.,* 2010; Nair *el al.,* 2016; Nadeem *et al.*, 2017). However, there has been a scarcity of information on the different biological parameters of Indian oilsardine, especially off the Mumbai coast. Therefore, the present study was undertaken to estimate the growth parameters, asymptotic length (L_∞), growth coefficient (K), age at zero length (t_0), length at age (L_t), exploitation ratio, exploitation rate and mortality parameters of *S. longiceps* from the Mumbai coast, based on length-frequency data.

Materials and methods

Sampling

During the present study, 785 individuals were recorded via weekely sampling from landing by drift gillnet (mesh size 22-30 mm, depth of operation 8-10 m) operated near the shore of New Ferry Wharf, Sassoon Docks and Versova landing centre on the Mumbai coast, Maharashtra (Fig. 1). The size of individuals ranged from 107 to 208 mm in total length (TL) and 7.98 to 67.61 g in weight. For each fish individuals sampled, total length (to the nearest 1 mm) and total weight (to nearest 1 g) were recorded with the help of fish measuring scale and a digital weighing balance respectively.

Growth parameters

For analysis of growth parameters (L_∞, K, t_0), length-based frequency data were grouped into 10 mm length intervals and frequency raised for day as well

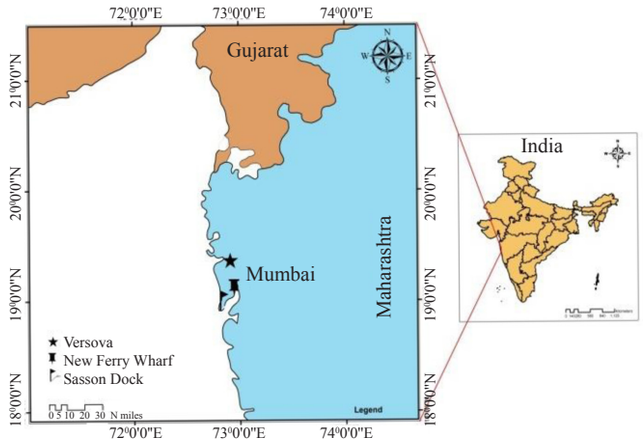

Fig. 1. Map showing the sampling areas along the Mumbai coast

as for month (Sekharan, 1962). Growth parameters were also estimated using Modal Progression Analysis, Ford-Walford, Computer assisted FiSAT programs, ELEFAN, Bhattacharya analysis method as well as Gulland and Holt plots. In the method of Bhattacharya (1967), the compound distribution was separated from the normal distribution, which represents a fish cohort. Further, the output from Bhattacharya method was refined by Gulland and Holt's plot (1959). Using the FiSAT programs, we obtained the growth co-efficient and asymptotic length from the relationship between intercept a and slope b as K = -b and L_∞ = -a/K (Gayanilo *et al.,* 1996). In addition, using VBGF equation, -ln [1-L(t)/ L∞)] = -K^*t_0 + K^*t, the value of growth co-efficient and age at zero length were estimated as a function of K = b and t_0 = -a/b (von Bertalanffy, 1934).

Mortality parameters

A number of methods have been used to estimate total mortality coefficients, including those of Beverton and Holt (1956), Jones and van Zalinge (1981) and the length converted catch curve method (Pauly, 1980). Estimates of natural mortality coefficients were based on Taylor (1960), Cushing (1968), Pauly (1980) and Alagaraja (1984). To estimate fishing mortality, natural mortality (M) was subtracted from total mortality (Z).

Exploitation rate and ratio

The exploitation rate (E) and ratio (U) were calculated using the formulae: E = F/Z and U = F/Z* (1-e^{-Z}), where the fishing and total mortality were denoted by F and Z, respectively (Beverton and Holt, 1957).

Results and discussion

In the present study, four estimates of L_∞ and K were obtained. In the scatter-diagram technique, eleven identical curves were drawn based on the progression of modes and growth was read at monthly intervals; modal lengths observed in different months are represented in Fig. 2. Asymptotic length and growth coefficient were estimated at 238.32 mm and 1.54 y^{-1}, respectively.

The calculated asymptotic length and growth coefficient value obtained from Ford-Walford plot by employing monthly mean length were similar to the results of MP analysis. After separating the Gaussian components, the means were linked with Bhattacharya method using FiSAT software and the calculated value of asymptotic length and growth coefficient were 231.35 mm and 1.56 y^{-1}, respectively (Fig. 3).

Using the Gulland and Holt's plot of the FiSAT program, L_∞ and K values were determined to be 226 mm and 1.58 y^{-1} respectively (Fig. 4). ELEFAN revealed an optimal growth line with a goodness of fit value of 0.265; values of asymptotic length and growth coefficient were 233 mm and 1.51 y^{-1}, respectively (Fig. 5).

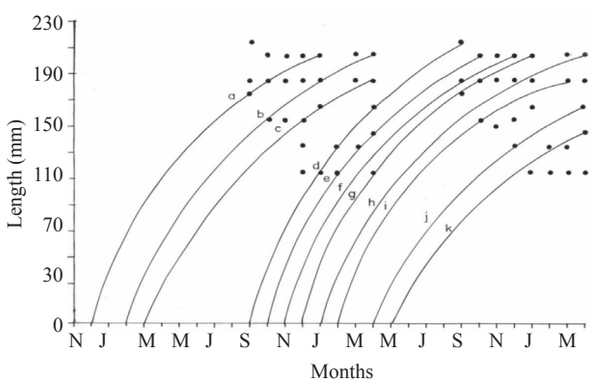

Fig. 2. Modal progression analysis of *S. longiceps* in different size groups

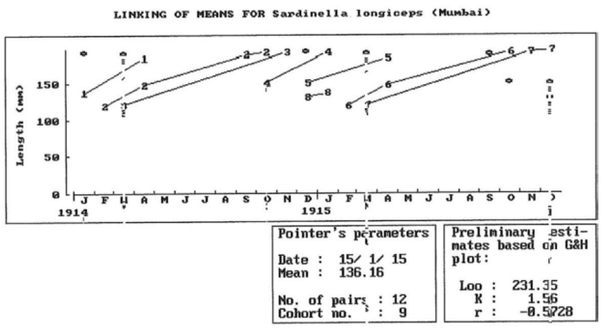

Fig. 3. Linking of means by employing modal progression analysis (Bhattacharya method)

Estimated values of asymptotic length and growth co-efficient obtained in the present study, were slightly higher as compared to previous reports (Antony Raja, 1970; Kurup *et al.,* 1989; Annigeri *et al.,* 1992; Yohannan *et al.,* 1998; Ganga, 2000; Rohit and Bhat, 2003; Ganga and Pillai, 2006) from different coastal areas (Table 1). It may be due to variation in fish size, sampling process, catch composition and fishing gear selectivity. Based on von Bertalanffy plot and monthly mean length obtained by scatter diagram technique, the t_0 was estimated as -0.000022 years. *S. longiceps* reaches a length of 182, 221 and 230 mm at the end of its 1, 2 and 3 years of life, respectively. Growth rate in the present observation during the first and second years is quite similar to the report of Yohannan *et al.* (1998) from the Malabar coast. Ganga and Pillai (2006) reported that the oilsardine growth rate fell during the third year and an annual increment of about 9 mm was attained; similar trend in growth rate was also observed in the current study.

Availability of nutrients, plankton density and feeding capabilities of different year classes probably influence the growth of oilsardine in different regions. It has been found that biological parameters vary within and between stocks as a result of changing environmental conditions, temperature, primary production and fishing pressure (Begg *et al.,* 1999).

Estimated catchable life of the species is 1.98 year. Total mortality estimated by Beverton and Holt, Jones and van Zalinge and length-converted catch curve method was 5.76, 4.51 and 4.82 y^{-1} respectively. Z calculated by the length-converted catch curve method was considered for further calculation. M was obtained as 2.10, 2.46, 3.22 and 3.23 y^{-1} using Taylor, Pauly, Cushing and Alagaraja methods, respectively. The estimate of 2.46 calculated by Pauly's empirical formula was taken for further calculations. F was 2.36 y^{-1}, which is quite higher than the values reported by Annigeri *et al.* (1992) (F=0.93) and Rohit and Bhat (2003) (F=0.93) from the west coast and Mangalore-Malpe coasts of India, but much

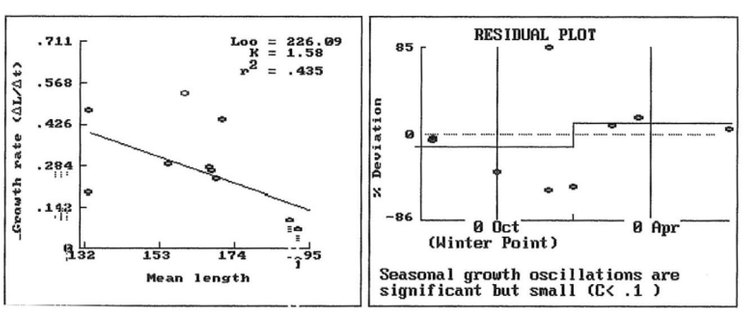

Fig. 4. Gulland and Holt plot for *S. longiceps*

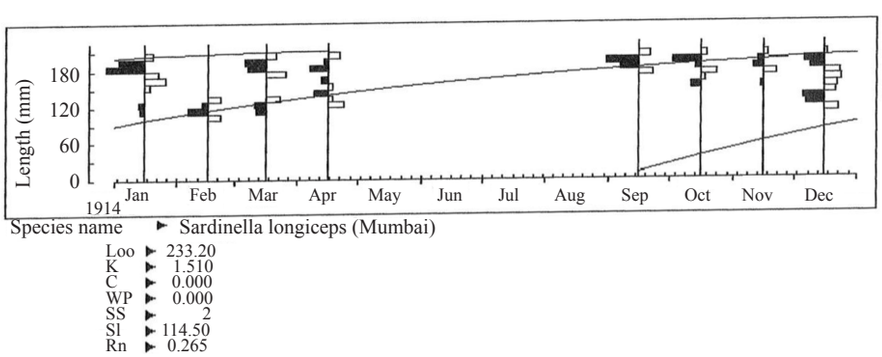

Fig. 5. Growth curves of *S. longiceps* employing ELEFAN module in FiSAT

Table 1. Comparisons of growth parameters of oilsardine with previous studies

Authors	Location	Length-at-age (mm; years)				L_∞ (mm)	K (y^{-1})	t_0 (y)
		1	2	3	4			
Hornell and Nayudu (1924)	Malabar coast	170	190	198	-	-	-	-
Chidambaram (1950)	Calicut	100	145	183	205	-	-	-
Nair (1953)	West coast	100	150	190	210	-	-	-
Sekharan (1962)	Calicut	100	150	-	-	-	-	-
Balan (1964)	Calicut	143	164	186	-	-	-	-
Antony Raja (1970)	Calicut	155	175	185	-	209.8	0.6	1.12
Kurup *et al.,* 1989	West coast	125	171	188	194	197.2	1.00	-0.08
Annigeri *et al.* (1992)	West coast	117	172	198	210	221	0.75	-
Yohannan *et al.* (1998)	Malabar coast	176	197	-	-	200	2.1	-
Ganga (2000)	Karwar	163	196	202	-	204	0.86	-
Rohit and Bhat (2003)	Mangalore-Malpe	136	191	213	222	228	0.90	-0.011
Ganga and Pillai (2006)	Visakhapatnam	168	205	214	-	216	1.5	-
Abdussamad *et al.* (2010)	Gulf of Mannar	-	-	-	-	231.6	1.55	0.09
Present study	Mumbai coast	182	221	230	-	233.1	1.51	-0.000022

lower than that reported by Ganga (2000) (F = 4.91) and Abdussamad *et al.* (2010) (F = 5.01) from Karwar and Gulf of Mannar, India. Investigation on mortality parameters is significantly essential for the management of a particular species as it provides primary insight into the level of fishing pressure on the species. In the present examination, estimated total mortality differed from previous reports from the west coast, Mangalore-Malpe and Gulf of Mannar of India (Annigeri *et al.,* 1992; Ganga, 2000 and Abdussamad *et al.,* 2010). The ratio of M and K was 1.63 which was within the limit (1.5-2.5) provided by Beverton and Holt to estimate the natural mortality coefficients accurately. Therefore, this shows that the present study's M and K estimates are reasonable and reliable. Both, estimated exploitation rate (E) and exploitation ratio (U) of oilsardine along the Mumbai coast were found to be 0.48. A similar finding has also been supported by Rohit and Bhat (2003) from the Mangalore-Malpe area. For optimal resource utilisation, it is believed that E must be equal to 0.5 in order to optimise sustainable productivity, when F and M are similar (Gulland, 1971). As the exploitation rate (E) was 0.48 and the F was only slightly below M, the stock is probably almost optimally exploited in the Mumbai region.

There has hitherto been no scientific report on the growth parameters and stock status of the Indian oilsardine along the Mumbai coast. Hence, the population parameters recorded for the species in the present investigation will find use in formulating management strategies for sustainable exploitation of the Indian oilsardine in Mumbai region.

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