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Studies on the Age, Growth and Mortality Rates of Indian Oil Sardine, *Sardinella longiceps* Valenciennes, 1847 off Oman Sea, Muscat, Sultanate of Oman

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Abstract

Investigations have been carried out on the age, growth and mortality of sardine *Sardinella longiceps* based on the length frequency data. The hypothetical asymptotic length ($L\infty$) and growth coefficient (K) were estimated as 220.3 mm and 1.209 yr-1 respectively. The species grows from 155 and 200 mm at the end of 1 and 2 years of life. The life span appeared to be around 2 years of species life. The total (Z), natural (M) and fishing (F) mortalities were represented as 4.11 yr-1, 2.21 yr-1 and 1.91 yr-1 respectively. The exploitation rate (E) was 0.46. The exploitation rate suggested that the stock was below the optimum level of exploitation. As a management plan, there is a need to increase the fishing scale and protecting spawning season to maintain sustainability over time.

Keywords: The Hypothetical Asymptotic Length; Growth Coefficient; Mortalities; Exploitation Rate; Sustainability.

1. Introduction

The Indian oil sardine *Sardinella longiceps* is a commercially important small pelagic resource in the Indo-Pacific region. It is widely distributed along the coast of Omani waters. Though, this species forms a considerable proportion in the fish catches of Oman, no detailed studies on the biological characteristics of this fish have been attempted. Hence, a study was carried out to investigate the age and growth based on Length frequency distribution. Studies of age and growth based on length frequency data analysis (LFD) have been investigated by different scientists. The technique provided the evidence and an indication of age, growth and mortality based on length modes progression included for long and short lived species. Age and growth study on *S. longiceps* was initiated in Oman by Al- Barwani *et al*. (1989). He showed 2-3 age classes found in along the coast of Oman. Siddeek *et al*. (1994) investigated the age and growth of *S. longiceps* in Al-Azaiba, Oman. It was suggested that species had a maximum life span about 3.75 years.

Oman has a long coastline of 3,165 km bordered by Arabian Gulf, Oman Sea and Arabian Sea and is rich in biodiversity of species. Fisheries resources in the Sultanate of Oman are one of the significant renewable resources and support the country's economy to a greater extent. Fisheries sector of Oman supports the second national economy after oil and gas. The total fish production of the Sultanate for the year 2009 stood at 158.000 tons of which the artisanal fisheries sector contributed to about 84% of the total fish production and the rest by industrial fleet (MOFW, 2000-2009). The total value of fishery production increased in 2009 to RO 104 million, up by 9% from the previous year 2008 and about 51% of the total fish produced had been exported to other countries. The small pelagic fishes contributed to about 34% of the

artisanal production; while demersal fishes formed 32% and the large pelagics about 23% and crustaceans and mollusks 5%, sharks 3% and rest others. Of the small pelagic fisheries resources of Oman, the clupeids are the most dominant group in the landings. Although 19 species of clupeidae have been reported, only three species, such as *Sardinella longiceps*, *S. gibbosa* and *S. sindensis* are common in the catches. These clupeids are coastal water species and occur in large schools. They are mainly targeted by the beach seine which lands up to 59% of the total sardine catches of the country.

There was a dramatic decline in landings in *S. longiceps* from 58,960 in 2001 to 32,092 tons in 2005. This decrease could be the reasons of heavy fishing pressure during that period. The market price of the species was probably high and was more preferred by fishermen to increase the catch. Further, other small pelagic and sardine species might not be present during that period and eventually Indian oil sardine appeared to be highly targeted. As a result, some of age groups of this species would be reduced and probably absent in certain areas. According to that, length frequency analysis is established to investigate age groups and helps to provide information on age, growth and mortality rates which are key input parameters to stock assessment models to formulate measures for the sustainable harvest of Indian oil sardine in Oman Sea, Muscat, Sultanate of Oman.

2. Methodology

2.1 Sample Collection

Samples of *S. longiceps* were collected at random twice a month from artisanal catches mainly by beach seine of 47 mm stretched mesh size along the Muscat coast (Fig. 1) for a period of one year from October 2008 to September 2009. The fishes were brought to laboratory in icebox, washed and prepared prior to biological measurements. The total length (TL), standard length (SL) and body depth were measured to the nearest 1 mm. The weight of each fish was taken to the nearest 1 g. A total of 2080 fish were used for length frequency investigation.

2.2 Age and Growth

The length frequency data analysis was made to estimate the Von Bertalanffy growth model was fitted to the length at age data represented as $Lt = L\infty (1 – \exp\text{-}k (t\text{-}to))$ where Lt is the average predicted length at time t, $L\infty$ is the hypothetical asymptotic length, K the growth coefficient, t0 the hypothetical time at which fish length equals 0 and t is the age. The growth parameters such as K, $L\infty$ and t0 were estimated by LFDA5 program (Kirkwood *et al*. 2001). The length data were employed in ELEFAN technique with non-seasonal growth for age and growth purposes.

2.3 Mortality Estimates

The annual instantaneous rate of mortality (*Z*) was estimated by the average of length converted catch curve method (Pauly, 1983) and Beverton-Holt Z method employed by LFDA5 program. Natural mortality (*M*) was estimated using the equation of Pauly (1983); the general model was usually described by $\ln (M) = -0.0152-0.279 \ln (L\infty) + 0.6543 \ln (K) + 0.463 \ln (T)$ which includes water temperature and growth parameters $L\infty$ and K. The annual water temperature of Oman Sea is 28.3 ^{0}C (Al-Oufi *et al*, 2004). The fishing mortality (*F*) was calculated as $F=Z-M$ in order to estimate the exploitation rate (*E*) by the equation $E = F/Z$.

3. Results

3.1 Growth Parameters

A total of 2080 fish in the length range of 50 and 220 mm was measured during Oct-2008 - Sep-2009. The $L\infty$, K and t0 were obtained from length frequency analysis using EELFAN method of non-seasonal

growth. The estimated L∞, K and t0 values were 22.03 cm, 1.209 yr-1 and -0.010 respectively (Fig. 2). The Von Bertalanffy Growth equation can be expressed as:

Lt = 22.03{1-exp]-1.209 (t + 0.010)]}.

The fish grows to 15.5 and 20 cm at the end of 1 and 2 years respectively. The life span appeared to be around 2.5 years of species life. In fact, fishes below two years group dominant the fishery (Fig. 3).

3.2 Population Parameters

The total mortality coefficient (*Z*) of Indian oil sardine was relatively high estimated as 4.11 yr-1 based on the average of length converted catch curve method and Beverton-Holt Z. The natural mortality (*M*) was calculated as 2.21 yr-1 by using pauly's method. Then, the fishing mortality was obtained as 1.91 yr-1. The exploitation rate (*E*) was found to be 0.46.

4. Discussion

4.1 Age and Growth

The length frequency analysis (LFA) was used in the present study to estimate age and growth of *S. longiceps*. The K was obtained as 1.21 yr-1 and L∞ as 22.02 mm (TL) in the present investigation. The LFA showed that species may live for 2.5 years of life, whereas the age below two years dominant the fisheries. In fact, the LFA probably provided overestimation of age based on length frequency progression and classes. This due to the absence of size class ranged between 110-150 mm in the commercial catch except in October and January that included some sizes between 130-150 mm. Though, the size groups of a population were considerably concentrated from 160 to 200 mm, while the juvenile were only represented in April. The presented modes were not sufficient to represent a population. Therefore, the lack data set may lead to obtain overestimation of age and underestimation of growth rate. The majority of recent publications have overestimated the age of *S. longiceps* in tropical waters using LFA. First attempt of age and growth on *S. longiceps* in Omani water was investigated by Al- Barwani *et al*. (1989). He showed 2-3 years of age classes found in along the coast of Oman. The faster growth was observed in the Arabian Sea due to enchainment of plankton and nutrients of the surface water that was occurred by southwest monsoon season causing upwelling to be formed which improved feeding capabilities and enhance growth. Siddeek *et al* (1994) investigated the age and growth of *S. longiceps* in Oman. The K was lower at 0.986 yr-1 and L∞ =197.2 mm (TL). It was suggested that species had a maximum life span about 3.75 years. Similarly, Edward and Shaher (1986) showed a high growth rate of *S. longiceps* in the Gulf of Aden estimated as 0.97 yr-1 due to the occurrence of upwelling during monsoon season, while the lifespan appeared to be high within 3 years. In contrast, oil sardine managed to reach 72% of its potential average size (200 mm) in 7 months period in Indian waters (Yohannan *et al*. 1998). In fact, that was observed by the highest growth rate of K recorded as 2.1 yr-1 compared to recent reviews. The L∞ was obtained at 200 mm (TL) and he suggested the average lifespan was determined to be around 16 months where ages lower than one year group appeared in the fishery. Attempts were made to estimate growth parameters of L∞ and K from different authors along the Indian Ocean showing variability in lifespan estimations were given in Table 1 The growth parameters performed by recent publications were corresponding with the findings in the present study.

4.2 Population Parameters

This study provides evidence of population parameters were might be used significantly to evaluate the level of exploitation of Indian oil sardine in Oman Sea (Muscat). In the present investigation suggested by length frequency distribution, the total mortality (*Z*), fishing mortality (*F*) and natural mortality (*M*) were estimated as 4.11 yr-1, 1.91 yr-1 and 2.21 yr-1 respectively. The total mortality recorded was relatively high. Similarly, Biradar and GjØossélighter (1989) showed high total mortality of 4.2 yr-1 in Indian waters.

According to the present study, the natural mortality was significantly larger than fishing mortality due to the increase of predators such as tuna, kingfishes and other large pelagic fishes or subjected to some oceanographic events like red tide and storm. Further, it was observed from recent reviews of this species, the natural mortality maintained higher as these species considered to be short-lived and fast growing species which eventually was not highly targeted by fishermen. The present study shows the stock was at lower optimum level of exploitation as E = 0.46. The exploitation observation indicated that the *S. longiceps* was not well exploited in Muscat region as a result of fishing activities, gear expansion, food availability and spawning success. The mortality parameters and exploitation rates were also derived from various previous studies of *S. longiceps* based on length frequency (Table 2). The records of population parameters obtained by literatures show some agreements with the present study.

5. Conclusion

The sardines are important resources and secondary income in Oman and they are well distributed all along the coastal area. The abundance of oil sardine in Omani waters varies seasonally and their spawning seasons seemed to extend along the year. The sardine abundance is occurred during the period of September to April and peaked during December to January when the season is cooler (Al-Jufaili, 2002). In the present investigation, the management tools were identified as spawning season and exploitation rate. The present study showed that the current exploitation of Indian oil sardine in Oman is not being well exploited (E = 0.46). The following management plans were advised to be applied to obtain sustainability over time. There is a need to increase the fishing effort scale to obtain appropriate level of exploitation. The spawning areas of oil sardine have not been yet identified in Omani water. According to that, the spawning areas should be determined to avoid the fishers from harvesting them. The spawning peak, eggs, larva and feeding habitat should be monitored and protected. These the concerned zones should be identified and managed the stock as these species highly migrated where information and data should be shared with the neighboring countries to help suggest a management plan. It was suggested to develop a selectivity gear for oil sardine targeted the marketable or legal sizes rather than the small sizes. In addition, license should be given to the gear as fishermen tend to harvest oil sardine resource. Finally, these management plans would help to improve exploitation and sustainability of Indian oil sardine in Oman in future.

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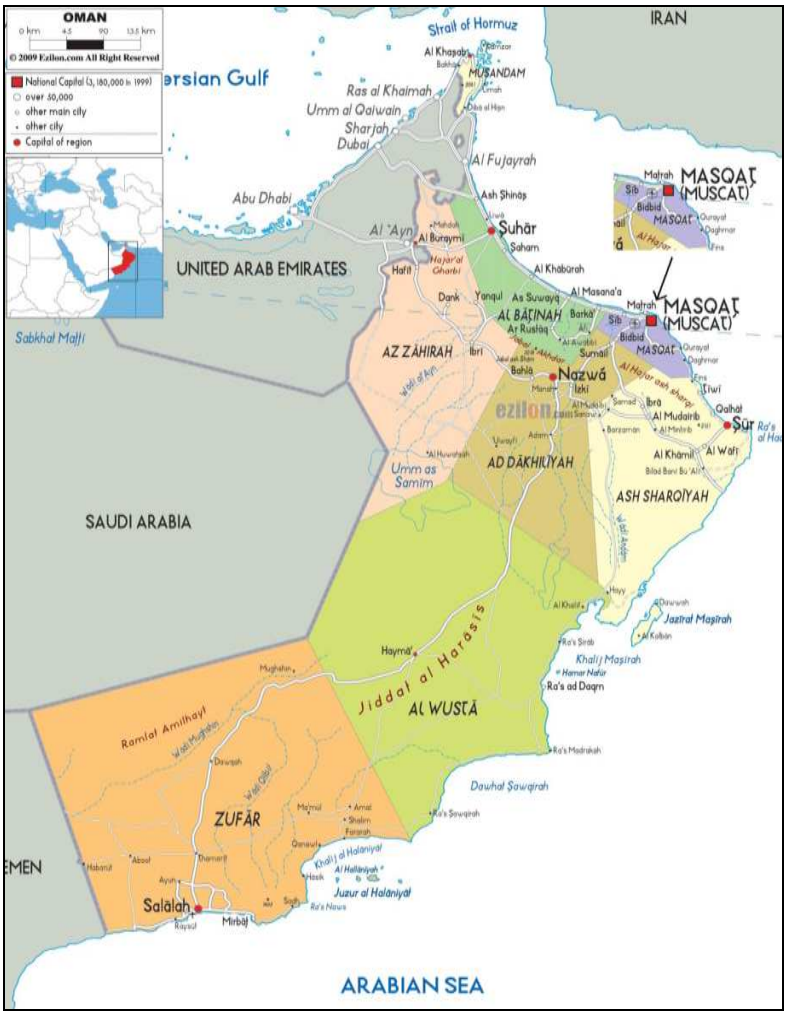

Figure 1. The Sampling sites of *Sardinella longiceps* in Muscat area (Matrah, Mina al Fahl and As Seeb). (Source: http://www.atfp.org.ae/english/countries/oman/oman.htm).

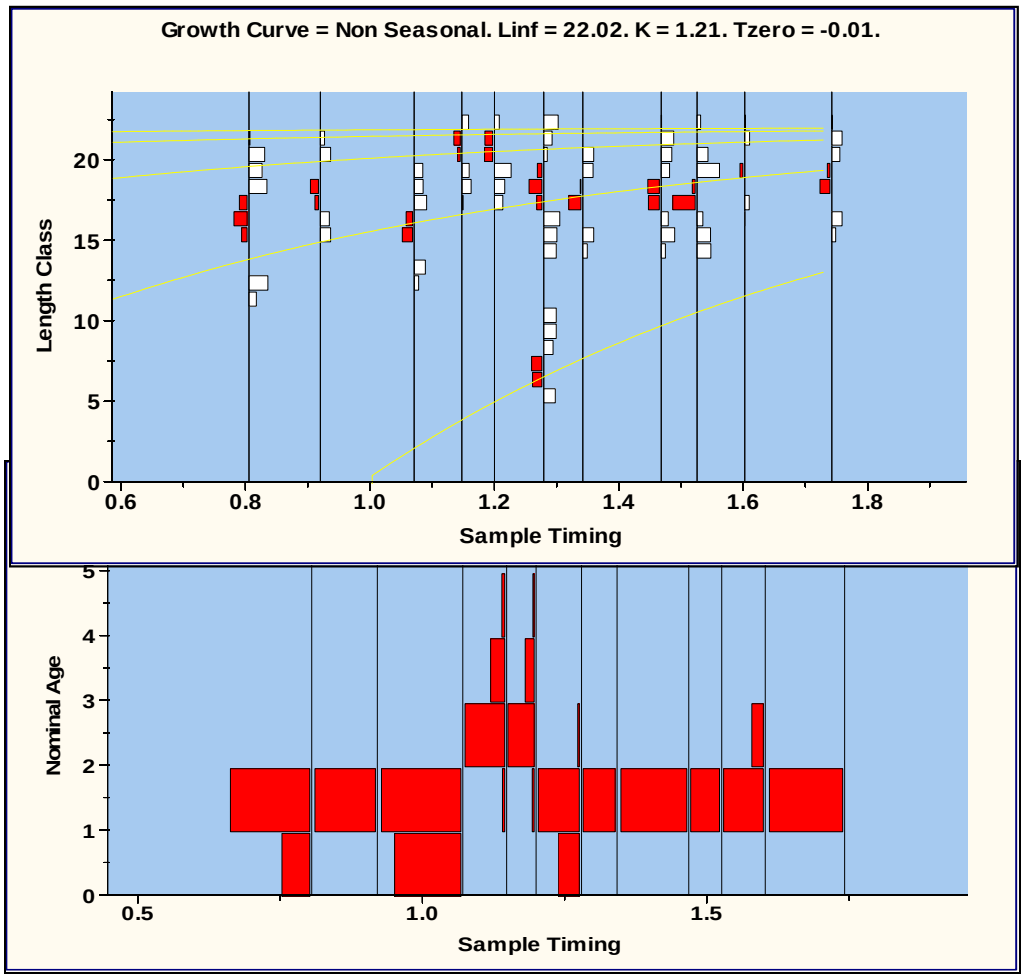

Figure 3. Age composition of *S. longiceps* in commercial catch.

L∞ (mm)	K (yr-1)	Area	Author
19.7	0.986	Oman (Muscat)	Siddeek *et al*. (1994)
23.8	0.97	Gulf of Aden	Edward and Shaher (1986)
21.0	1.10	Philippines	Ingles and Pauly (1984)
20.66	0.4	India	Banerji (1973)
20.9	0.5	India	Antony Raja (1972)
21.0	1.4	India	Biradar and GjØossélighter (1989)
22.1	0.75	India	Annigeri *et al*. (1992)
19.7	1.006	India	Kurup *et al.* (1987)
21.0	0.8	East Java, Indonesia	Pet *et al*. (1996)
20.0	2.1	India	Yohannan *et al*. (1999)
26.0	0.86	Philippines	Aripin and Showers (2000)
20.4	1.6	Karwar, India	Ganga (2000)
22.8	0.90	India	Rohit and Bhat (2003)
21.6	1.5	India	Ganga and Pillai (2006)
22.02	1.21	Oman (Muscat)	Present study

Table 1. Summary of growth parameters estimated based on length frequency analysis of *S .longiceps*.

Table 2. The Estimates of mortality coefficients and exploitation rate (E) of *S. longiceps* based on length frequency along the Indian Ocean from previous studies compared with present study.

Z (yr-1)	M (yr-1)	F (yr-1)	E	Area	Author
1.30	0.95	0.35	-	Gulf of Aden	Edward and Shaher (1986)
7.37	2.10	-	0.72	Philippines	Ingles and Pauly (1984)
4.2	2.0	2.2	0.52	India	Biradar and GjØossélighter (1989)
2.2	1.30	0.9	0.41	India	Annigeri *etal*. (1992)
3.1	1.3	1.8	0.6	East Java, Indonesia	Pet *etal*. (1996)
3.65	1.68	1.97	0.54	Philippines	Aripin and Showers (2000)
6.34	1.43	4.91	0.78	Karwar, India	Ganga (2000)
2.74	1.51	0.93	0.34	India	Rohit and Bhat (2003)
4.11	2.21	1.91	0.46	Oman (Muscat)	Present study