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Assessment of the fishery and stock of striped bonito, *Sarda orientalis* (Temminck and Schlegel, 1844) along Kerala coast with a general description of its fishery from Indian coast

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ABSTRACT

The striped bonito, *Sarda orientalis* is found to form a seasonal fishery all along the coasts of its occurrence except in Kerala where it is fished almost throughout the year. During the period 2006-2010, of the all India annual average catch of 849 t, Kerala contributed the maximum of 65.6% followed by Andaman and Nicobar (23.4%) with the rest being accounted for by Gujarat (6.6%), Tamil Nadu (2.3%), Andhra Pradesh (1.4%), Maharashtra (0.6%) and Karnataka (0.2%). From West Bengal and Odisha, no landing of the species has been reported. Size ranged from 16 to 68 cm. Mature fishes dominated in June and July. Size at first maturity was 42 cm FL. They are carnivorous fishes with crustaceans and cephalopods constituting the chief food items. Length-weight relationship was $W = 0.00869\ L^{3.1}$ ($n = 134$, $r^2 = 0.96$). The von Bertalanffy growth equation was: $Lt = 74.75\ [1 - e^{-0.68\ (t + 0)}]$. The prediction analysis based on Kerala landing show that the current exploitation is well below the MSY level indicating scope for increasing the effort to exploit the resource.

Keywords: Age and growth, Biology, Fishery, Mortality, Striped bonito, *Sarda orientalis*, Thompson and Bell, VPA

Introduction

The striped bonito *Sarda orientalis* (Temminck and Schlegel, 1844) has a wide distribution in the Indo- Pacific region from east coast of Africa to the west coast of America (Jones, 1960). It grows to a length of over half a metre and does not form a regular fishery of any appreciable magnitude anywhere. Jones (1960) reported on the occurrence of juveniles of *S. orientalis* between Trivandrum and Cape Comorin. Silas (1963) reported that the species is distributed along the west coast of India. The first report of its occurrence along the Chennai coast of India was by Gnanamuthu (1966). He was of the opinion that the species was likely to constitute a sporadic fishery along the east coast of India also during June to September, which is the season for its fishery along the west coast. Rao (1962) gave a brief description of the ovaries of *S. orientalis* based on his observation at Vizhinjam, along the south-west coast of India. Silas (1962) reported on the taxonomy and biology of *S. orientalis*. Silas (1963) gave an account on the biological data of *S. orientalis* based on the data available from the west coast of India. Siraimeetan (1985) described the occurrence of the juveniles along Tuticorin and Siraimeetan *et al*. (1999) from the Coromandal coast. With extension of the fishing ground and change in the fishing pattern, there seems to be some changes in the landing of this species also. Currently this species forms a fishery almost throughout the year in Kerala besides a seasonal fishery all along the coast including Andaman and Nicobar islands, though it is yet to be recorded from Odisha, West Bengal and Lakshadweep as is evident from the present study. As there is little information on the fishery and population characteristics, the present paper deals the fishery, biology and stock assessment of the resource based on the data collected for the period 2006-2010.

Materials and methods

Catch and effort data on *Sarda orientalis* along the west and east coasts of India for the period 2006–2010 was obtained from Fishery Resource Assessment Division of the Central Marine Fisheries Research Institute (CMFRI), Kochi. This was further fortified with the data collected from specified centres all along the coast. The length frequency and other biological details were collected from the landings by major gears operated along each region. The length frequency data was raised to the annual average catch for the respective region. The food was analyzed qualitatively. Maturity stages were studied following the standard classification of the stages of maturity (Rao, 1967). Fecundity was estimated by gravimetric method and the

relative fecundity was derived by dividing the absolute fecundity with body weight. The size at first maturity was estimated following the method of King (1996). The length- weight relationship was calculated as in Le Cren (1951). Considering the erratic nature of the fishery and the magnitude being quite inconsequential in all the states other than Kerala, stock estimation was attempted based on the fishery of Kerala. Growth parameters like asymptotic length (L_∞) and growth co-efficient (K) were estimated using the ELEFAN I module of FiSAT software and the Powell -Wetherall plot (Wetherall *et al*., 1987). The length based growth performance index Ø was calculated from L_∞ and K as in Pauly and Munro (1984). Longevity was estimated from $t_{max} = 3/K + t_0$ (Pauly, 1983a).

Natural mortality (M) was calculated by Pauly's empirical formula (Pauly, 1980) and total mortality (Z) from length converted catch curve (Pauly, 1983b). Length structured virtual population analysis (VPA) was used to obtain fishing mortalities per length class and to understand the impact of fishing on the stock as well as the MSY by the Thompson and Bell method (Sparre and Venema, 1992). Exploitation ratio was estimated from the equation, E = F/Z where, F is the fishing mortality and Z is the total mortality.

Results

Fishery

S. orientalis is exploited mostly by gillnet and also by hooks and line. The annual catch of *S. orientalis* during the period 2006-2010 showed a progressive increase from 550 t in 2006 to 1551 t in 2009 and thereafter it plummeted to 257 t in 2010 (Fig. 1). Of the annual average catch of 849 t (Fig. 2), Kerala contributed the maximum of 65.6% followed by Andaman and Nicobar islands (23.4%) with the rest being accounted for by Gujarat (6.6%), Tamil Nadu (2.3%), Andhra Pradesh (1.4%), Maharashtra (0.6%) and Karnataka (0.2%). Landing of this resource has not yet been reported from West Bengal and Odisha.

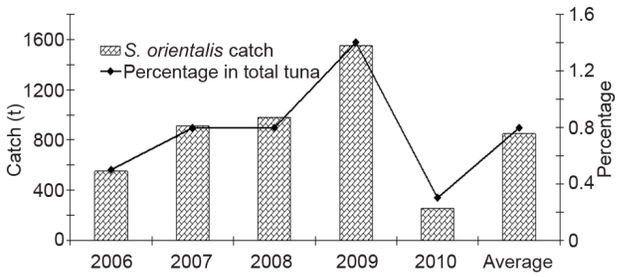

Fig. 1. Annual average all India catch of *Sarda orientalis* and its percentage contribution to the total tuna catch

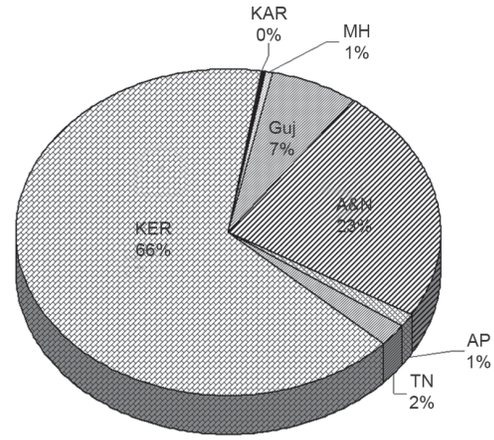

Fig. 2. State-wise contribution to *S. orientalis* landings in India during the period 2006-2010
KAR - Karnataka; MH - Maharashtra; GUJ - Gujarat; A&N - Andaman and Nicobar; AP - Andhra Pradesh; TN - Tamil Nadu; KER - Kerala

Seasonal abundance

The species formed seasonal fishery in all the coastal states of India except in Kerala. The season was between July and November in Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra. In Gujarat, it occurred during January to May and August to December. In Kerala, however, it was found to occur in all the months although peak period of abundance was from July to September (Fig. 3).

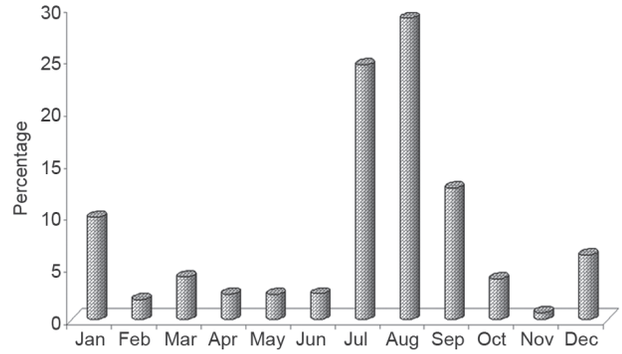

Fig. 3. Month-wise abundance of *S. orientalis* along Kerala coast

Biology

Size

The length of *S. orientalis* in the landings in Kerala ranged between 16 and 68 cm FL. Fishes of 48 to 58 cm FL were dominant (Fig. 4). Comparatively smaller length groups were recorded during June to December. However, in Gujarat, the length group below 32 cm was not observed and the size group varied from 32 to 58 cm with 44 to 50 cm forming the dominant group whereas in Karnataka, it ranged from 26 to 46 cm with 38 to 42 cm as the major group. The size varied from 32 to 64 cm in Tamil Nadu with 54 to 58 cm as the dominant group.

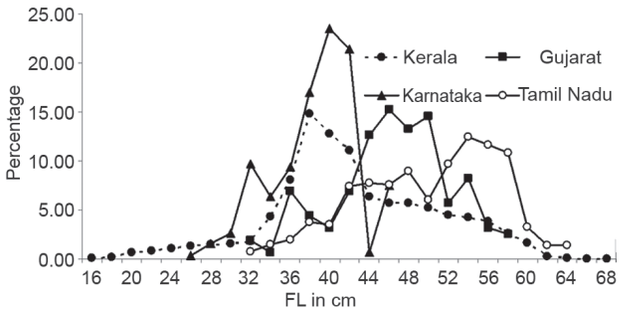

Fig. 4. Size frequency distribution of *S. orientalis* in different states in India

Food and feeding

Even though stomach in different fullness of state were observed, 60% of the stomachs were empty. Qualitative analysis showed that the food comprised mainly of fishes, crustaceans (crabs and prawns) and cephalopods (squids). Out of the stomachs with food, 75% were with fish, 20% with crustaceans and the rest with cephalopods. Among fishes, *Selar* sp., *Decapterus* sp., *Auxis* sp., *Sardinella* sp., *Stolephorus* sp., and *Platycephalus* sp. were noticed.

Maturity and fecundity

Immature and maturing fishes were observed in all the months except from May to July. Mature fishes occurred in most of the months and were dominant in June and July. Spent fishes were also observed in almost all the months (Fig. 5). The size at maturity was 42 cm (Fig. 6). The average relative fecundity was 4, 04,048 eggs per kg body weight. Relative fecundity varied from 293,793 to 696,512 for fishes between 39 and 52 cm FL.

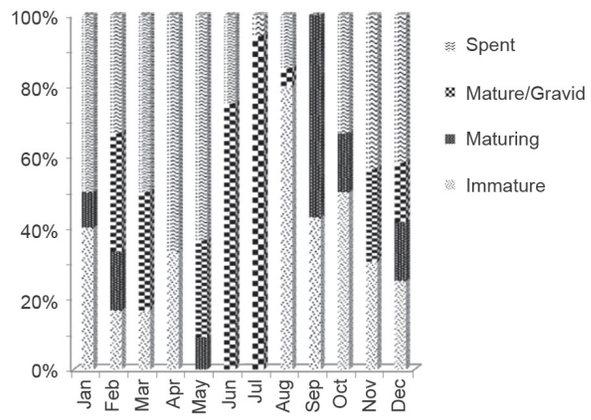

Fig. 5. Monthly occurrence of different maturity stages in Kerala

Length-weight relationship

The length-weight relationship derived was : $W = 0.00869\ L^{3.1}$ ($n = 134$, $r^2 = 0.96$), where W is in g and L is fork length in cm.

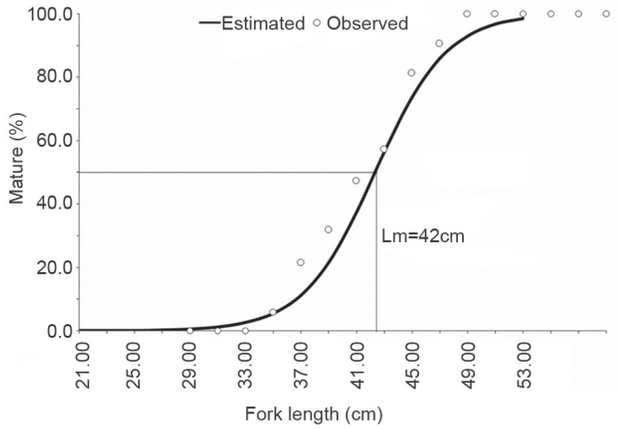

Fig. 6. Size at first maturity of *S. orientalis*

The findings on food and feeding, maturity, fecundity and length-weight relationship are based on the data collected mainly from Kerala, Gujarat and Tamil Nadu.

Age and growth

The L_∞ estimated from Powell-Wetherall plot was 70 cm. L_∞ and K estimated using the ELEFAN I programme were 74.75 cm and 0.68 year^{-1}, respectively. The t_o is assumed as zero. The growth parameters obtained by ELEFAN were used for further analysis. The von Bertalanffy growth equation was: $Lt = 74.75\ [1 - e^{-0.68\ (t + 0)}]$. Accordingly, the species attained a size of 40 cm by the end of 1st year and 50 cm by the end of 2nd year (Fig. 7).

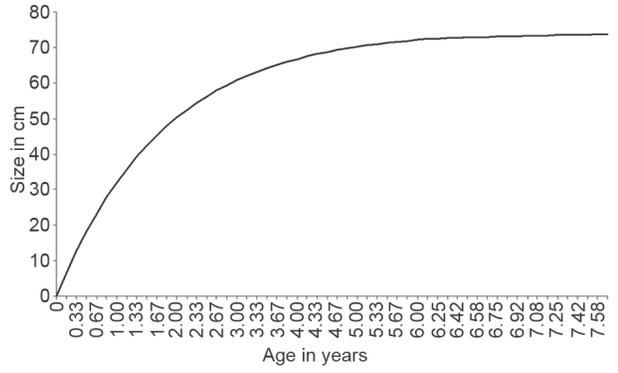

Fig. 7. von Bertalanffy growth curve of *S. orientalis*

The asymptotic weight was 5587 g. The growth performance index was 3.58. Longevity was estimated to be 4.4 years.

Mortality

The total mortality Z was found to be 3.18 by the length converted catch curve and the natural mortality M was 1.09. Thus the fishing mortality F was 2.09. The M/K value was 1.6. From the VPA analysis also, it was seen that fishing mortality in the smaller size groups was very low whereas

from 46 cm onwards it was higher averaging 2.37. A total of 2 million bonitos were recruited to the fishery in Kerala at a recruitment length of 16 cm. Exploitation ratio was found to be 0.66.

Thomson and Bell prediction analysis

The exploitation of *S. orientalis* along the Kerala coast had not reached the MSY. Both MSY and MSE were achieved at an F-factor of 1.6 taking present fishing level as 1.0 (Fig. 8). The spawning stock biomass at the present level and at MSY and MSE level was 30 % and 22 % of the virgin spawning stock biomass respectively.

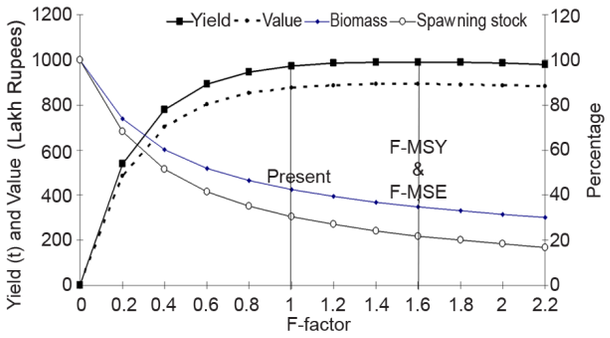

Fig. 8. Thompson and Bell prediction analysis

Discussion

Published information on *S. orientalis* is limited to the recording of its occurrence, brief notes on its biology and season of occurrence (Silas, 1963, Gnanamuthu, 1966; Siraimeetan, 1985; Siraimeetan *et al*., 1999). This is mainly due to its landing in limited areas coupled with its fluctuating fishery. The highly erratic landings along the Indian coast observed during the study period exemplify this. The main season of fishery was found to be the same as reported earlier by Silas (1962) and Gnanamuthu (1966). However, one of the notable changes is the shift from a seasonal fishery to a continuous fishery in Kerala. But here, the fishery is limited to the southern sector especially Vizhinjam area. According to the fishermen, the resource is available mostly in the vicinity of a sea mount situated off Vizhinjam. Motorization and consequent extension of fishing ground must have also enabled improvement in magnitude over space and time.

Occurrence of smaller size groups of 16-20 cm were observed during June and July. Jones (1960) and Silas (1962) recorded juveniles of size 80 mm and above from Cape Comorin, Vizhinjam and Calicut area during the months of October and November. Siraimeetan (1985) reported the occurrence of 9.8 to 19.9 cm juveniles from Tuticorin in the month of July during 1976-78 and later Siraimeetan *et al*. (1999) reported size groups of 100-220 mm during July and August from Coromandal coast. The fact that these juveniles were caught very near the coast with shore seine, sardine gillnet *etc.,* indicates their migration towards the coastal region. Food and feeding studies showed the carnivorous feeding habit which conforms to the observations of Jones (1960) that the adults feed on young and small sized fishes, crustaceans and squids. In the case of juveniles, Siraimeetan *et al.* (1999) also found that they feed mainly on *Anchoviella commersonii* constituting the most important food item followed by *Sardinella* spp.

Maturity studies clearly shows that the spawning is continuous with a peak in June and July. Rao (1962) opines that the species spawns in the local waters off Vizhinjam from April to September and possibly in other months also with a peak in July-August. Silas (1962) has also reported the availability of fishes with ripe ovaries or partially spent ovaries from the same area during the months of August-September. The occurrence of early juveniles during October-November as reported by Jones (1960) and Silas (1962) from the same area lend further credence to the peak spawning months. At the same time, the present study which shows the occurrence of spent groups and availability of juveniles in majority of the months especially in Kerala where there is a continuous fishery, point to its continuous spawning. Further, as opined by Rao (1962), the capture of females with ripe and running ovaries along the south-west coast (Trivandrum to Cape Comorin) indicates that the sea off this coast is one of the spawning grounds of this species. According to Silas (1962), fecundity varied from 0.24 to 0.64 million for fishes between 386 and 605 mm whereas Rao (1962) recorded fecundity ranging from 0.91 to 1.15 million. Both these observations very well agree with the present study.

Age and growth studies indicate that the species has longevity of more than four years. Accordingly they were found to mature around one year as L_m is 42 cm. In tune with the relatively shorter life span, the species is found to be highly fecund with an average relative fecundity of 4.04 lakhs ova.

Studies on population dynamics is mainly based on the data from Kerala as the data from other regions are too fragmental to subject them for analysis. Accordingly this applies to the stocks exploited in Kerala. However, this will give an indication of the status of the stock in other areas too. According to Beverton and Holt (1959), the value of M/K ratio generally ranges from 1-2.5. The value of 1.6 from the present study very well conforms to this. As there is no aimed fishery for this and it is fished along with other pelagic resources, the data on the catch may not give a true picture of the abundance. Notwithstanding this fact, the present study shows that the current exploitation is well below the MSY level, and hence there is scope for

increasing the effort to exploit the resource. This is further corroborated by the fact that the fishery showed gradual increase in the landing from 362 t in 2006 to 972 t in 2009. But the high fluctuation noticed in the fishery especially along the Indian coast necessitates study of fishery independent factors also along with the study on the fishery and biology for a better understanding of the resource position.

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