Distribution and fishery of the bullet tuna *Auxis rochei* (Risso, 1810) along the Indian Coast

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Abstract

Auxis rochei the smallest of all tuna species available in Indian waters is distributed along all maritime states but forms a fishery of commercial importance only in the south-west and south east regions (Karnataka, Kerala and Tamil Nadu). The fish is in great demand in southern part of the country and targeted fishery is being carried out in southern Kerala and Tamil Nadu. The average annual catch (2006-2013) is estimated at 2,637 t contributing 3.7% of the total tuna landings. The maximum catch of 4,370 was observed during 2011.Commercial exploitation is mainly by gillnets and small hook and lines with the 0-1yr old fishes comprising bulk of the commercial catch. The length weight relationship is given by the formula $W=0.0076L^{3.249}$ with no significant different between the sexes. Size at first maturity was estimated at 23.6 cm and fecundity was 12,03,258 eggs. Diet studies indicated a generalist feeding behaviour comprising of zooplankton, fishes and crustaceans as main prey items. Age and growth were estimated using length based methods. The von Bertalanffy growth parameters estimated were $L_\infty = 42.3$ cm, annual K= 0.61 and t_0 = -0.0337. Mortality estimates were M= 1.18 and Z= 5.90 and F = 4.72 with a high exploitation ratio of E = 0.80, calling for appropriate management measures to be adopted for continued exploitation at sustainable levels.

Introduction

The bullet tuna *A.rochei,* the smallest among all tuna species in the world, is an epi and meso-pelagic fish with a worldwide distribution in tropical and subtropical waters with a seasonal coastal distribution in temperate and tropical areas (Uchida, 1981; Collete, 1986). The occurrence of the species has been recorded along both the coasts of India but is harvested on a commercial scale mainly in the southwest region (Jasmine *et al.,* 2013). The average annual catch (2006-2013) was estimated at 2,637 t. Studies on the biology of *A.rochei* exploited in Indian coast are limited and include those of Silas (1969), Muthiah (1985), Gopakumar (1989), James *et al*., (1993) and Jasmine *et al*., (2013).

Material and Methods

This study extended for a period of eight years from 2006-2013. Weekly data on the catch and effort of *A.rochei* were collected from major landing centre located in Kerala and Karnataka by using the Stratified Random Sampling Technique adopted by CMFRI. Length measurements (fork length) were also taken at the landing centres and raised to the monthly/annual catches. These formed the basic data for estimating the growth and population structure of *A.rochei* using length based models. Random samples were taken from the commercial landings and transported to the laboratory for further biological studies. The length-weight relationship as suggested by Le Cren (1951) was calculated by regression analysis. Mature ova were counted and the total fecundity estimated using the formula: (Total wt. of Ovary/ Wt. of sample)* no. of ova in the sample. Size at first maturity was determined as suggested by Lockwood (1988) and King (1996).

Food contents were studied in detail to understand the food and feeding habit of *A.rochei*. Prey items were identified up to genus level and further to species level whenever possible.

Growth parameters *viz.,* asymptotic length (L$_\infty$) and growth co-efficient (K) were estimated using the ELEFAN I module of FiSAT software and the Powell–Wetherall plot (Gayanilo *et al.*, 1996). Natural mortality (M) was calculated by Pauly's empirical formula (Pauly, 1980) and total mortality (Z) from length converted catch curve (Pauly, 1983b).The length based growth performance index Ø was calculated from L$_\infty$ and K as in Pauly and Munro (1984). The probability of capture and size at first capture (Lc) were estimated as in Pauly (1984) and the age at zero length (t$_0$) from Pauly's (1979) empirical equation. Longevity was estimated from t$_{max}$ = 3/K + t$_0$ (Pauly, 1983a). Exploitation ratio was estimated from the equation, E = F/Z and exploitation rate from U = F/Z*(1-e^{-z}); where, F is the fishing mortality rate.

Results

Fishery

Exploitation of *A.rochei* was mainly made by crafts deploying small hooks & lines and gillnets. Other gears that exploited *A.rochei* occasionally include the trawls, ringseines, and purseseines (fig.1).
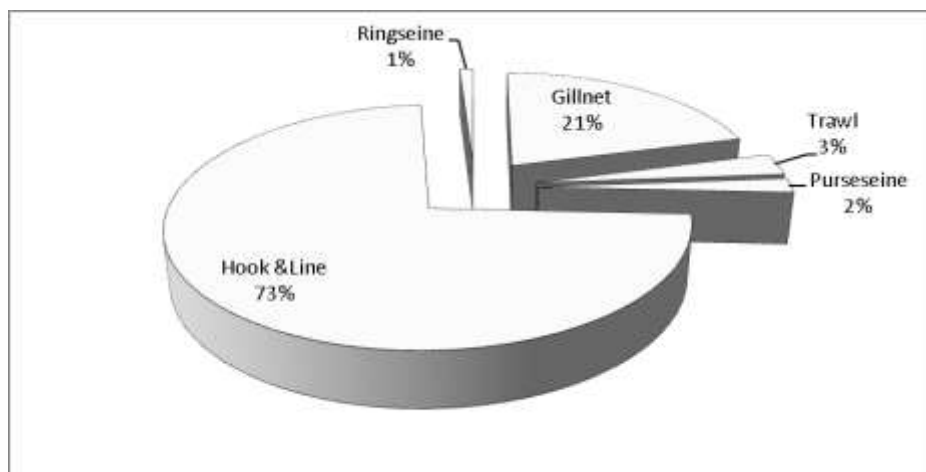

Fig.1 Contribution of different gears to total catch of *A.rochei*

The annual catch ranged between 1,121 (2008) and 3,918 t (2013) with an average catch of 2,637 t. This formed 3.7 % of the coastal tuna catch and 2.8 % of the total tuna catch of the country (fig.2).
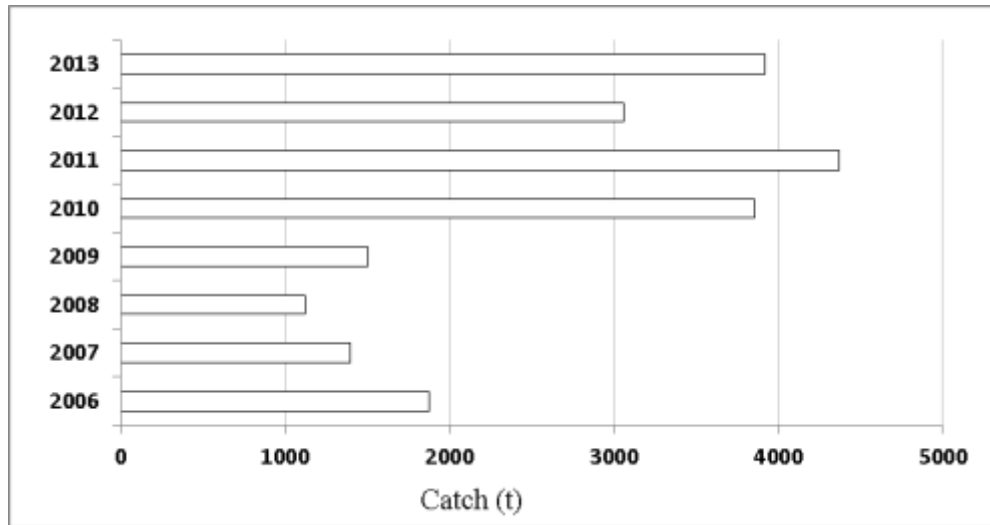

Fig. 2. Annual landings of *A.rochei*

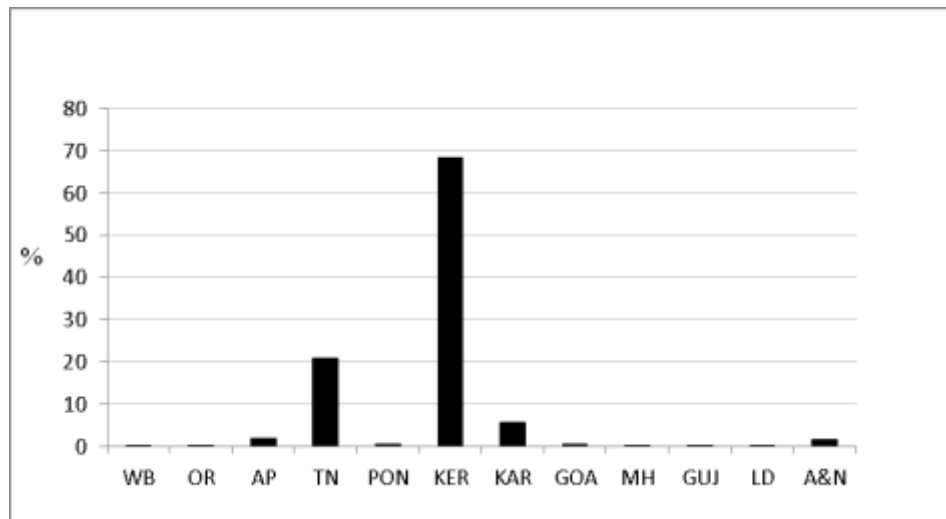Exploitation of *A.rochei on* a commercial scale was mainly at Kerala, Tamilnadu and Karnataka (fig.3).

Fig.3. Contribution of different maritime states to total *A.rochei* landings.

Seasonal abundance

The bullet tuna was landed throughout the year with major peak during June and the second peak in November when 13.8 and 13.6% of the catch was landed (fig.4).
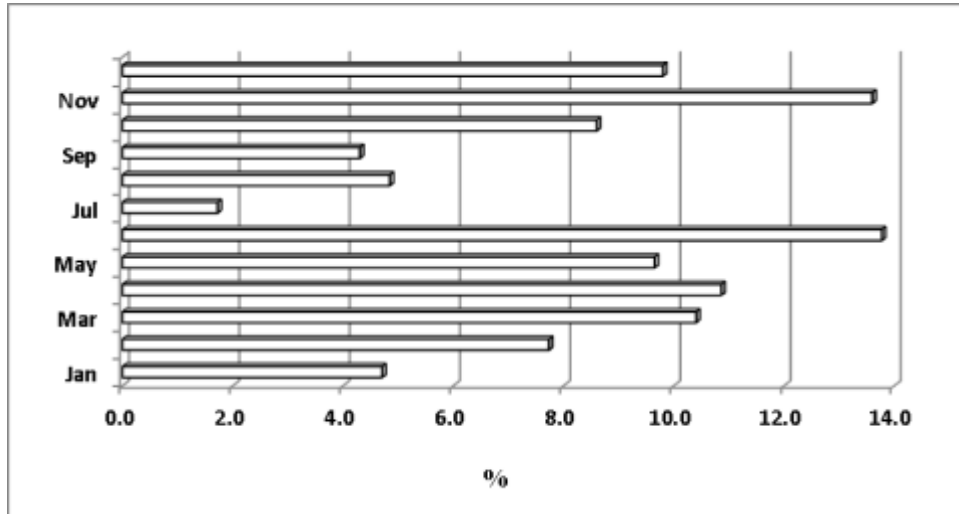

Fig.4.Seasonal abundance of *A.rochei* landings

Length composition

The length range varied from a minimum of 14 cm to a maximum of 40 cm (fig.5). Fishes in the length rage of 22-26 cm dominated the catch and contributed 82% of the catch. Major mode was at 24 cm and the annual mean length was estimated at 25.3 cm.
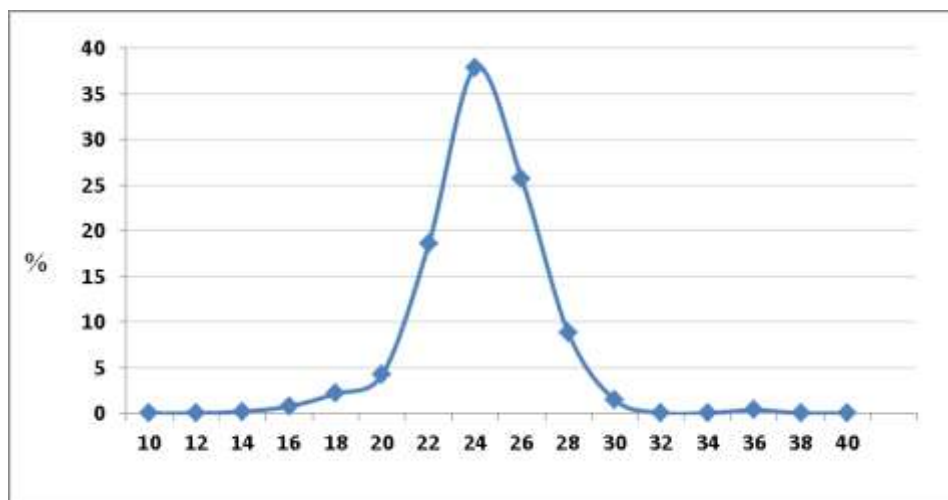

Fig.5. Length range of exploited *A.rochei*

Maturity, fecundity, spawning and recruitment:

The size at first maturity when 50% of the sampled *A.rochei* were found to be mature was estimated at 23.6 cm (fig.6).
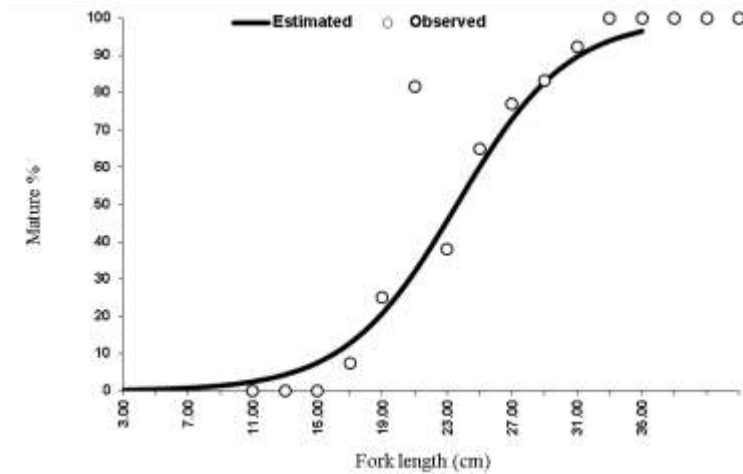

Fig.6. Size at first maturity estimated for *A..rochei*

Spawning was observed throughout the year with peaks in July and January (fig.7). Recruitment too was in two peaks in July and August when more than 60% recruits entered the fishery (fig.8). The fecundity was estimated at 12,03,258 eggs.
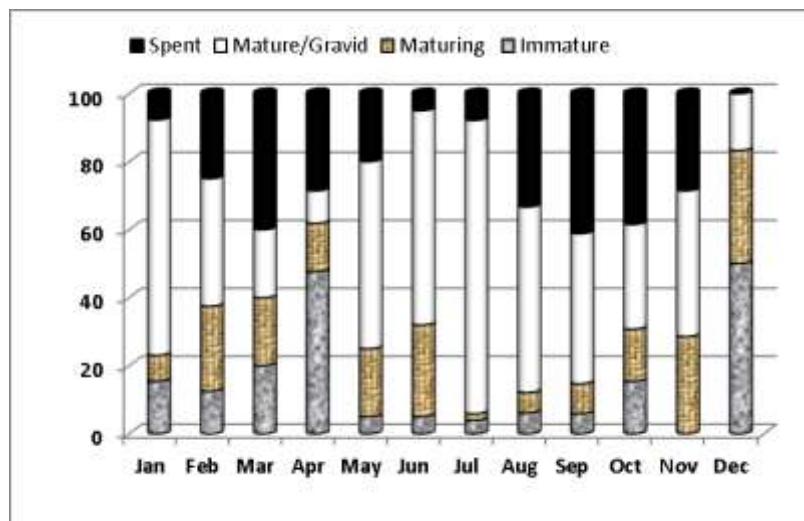

Fig.7. Seasonal gonad maturity stages observed in *A.rochei*

Food and feeding:

Feeding intensity was generally low for the species with none of the sampled fish having gorged or full stomach condition. Stomachs in empty condition contributed 60.3%. Feeding habit indicated *A.rochei* to be a nonselective generalist feeder foraging mainly on small crustaceans, fishes and molluscs. The larval and juvenile stages of the crustacean and fishes contributed considerably to the diet. Crustaceans component mainly included *Acetus* spp, followed by other penaeid prawns and crabs. Fishes were represented by anchovies, sardines and mackerel. Gastropods represented the molluscan component in the diet.

Growth

The fish followed an isometric growth pattern and the length-weight relationship of *A.rochei* estimated using the method suggested by Le Cren (1951) was $W = 0.0076\ L^{3.243}$ where 'W' is the weight of fish in grams 'L' is fork length in cm.

The different growth parameters in the von Bertalanffy growth equation $L_t = L_\infty\ [1-e^{-\ k\ (t-t_0)}]$ was $L_t = 42.3\ [1-e^{\ -0.61(t-0.0337)}]$.

The asymptotic weight was 1,429 g. The growth performance index was 3.0 and longevity 4.9 years. The length attained by the fish at the end of 1st, 2nd, 3rd and 4th years were 18.6 cm, 29.3 cm, 35.2 cm and 38.4 cm respectively. Fishery was sustained mainly by the 1+ yr old fishes (22 to 26 cm).

Mortality, exploitation and VPA

The natural mortality rate (M), fishing mortality rate (F) and total mortality rate (Z) computed were 1.18, 4.72 and 5.9 respectively (fig.9). The exploitation rate was 0.8 and exploitation ratio was 0.792. E_{max} is 0.421 which is much lower than the present exploitation, indicating that the stock is already under high fishing pressure.

Discussion:

The bullet tunas have a distribution along all the maritime states of India but forms a significant part of the tuna catch only along the south west coast (Kerala, Karnataka). A similar observation on the doistribution pattern of *A.rochei* along the Indian coast has been made by earlier Indian workers (Muthiah, 1985; Gopakumar *et.al*., 1989; James and Pillai, 1993; James *et.al*., 1993; Gopakumar *et.al*.,1994; Pillai *et.al*., 2002; Pillai *et al*., 2003 and Pillai and Gopakumar, 2003 and Gopakumar and Ajithakumar, 2005). This tuna species is highly preferred by locals in southern Kerala and fetches a good price in the local domestic market. Therefore, targeted fishing is carried out in this region to exploit the available stock and the landings made at other regions too are transported and marketed in southern Kerala. Fishing for *A.rochei* therefore in this region is more market driven under demand from locals. The fishery is mainly sustained by 1+year old fishes and weighing 0.5 to 0.7 kg.

A.rochei attained maturity at a fork length of 23.6 cm when the fish is around 2 years old. The present length at first maturity is comparable (23 cm) to the earlier studies made by Muthiah (1985) for fishes exploited along Mangalore (Karnataka). However, the size at first maturity estimated is much smaller than the size estimated by Rodriguez-Roda, 1983 for *A.rochei* captured in Spanish waters. Macias *et al*., (2005) too have suggested that *A.rochei* attain maturity when the fish has a fork length of 35 cm. The age at maturity has been estimated at 2 years which is comparable with the age estimated in the present study. The present as well as earlier studies (studies Megalophonou *et al*., 2000 (Niiya, Y, 2001; Macías *et al*., 2005) has shown that fecundity of *A.rochei* is very high and it is a multiple spawner with asynchronous oocyte development.

Muthiah (1985) estimated the fecundity of *A. rochei* to range from 52,570 (25.2 cm size) to 1,62,777 (33.7 cm size). Earlier Silas (1969) estimated the fecundity to vary from 31,000 to 1,03,000 ova wiith an average of 52,000 ova per spawning. According to Macías *et al*., (2005) bullet tuna has an indeterminate fecundity. This fecundity pattern depends on estimates of batch fecundity and spawning frequency to determinate potential annual fecundity (Hunter and Macewitz, 1985; Hunter *et al*., 1992). The estimates of relative batch fecundity for this species obtained by Niiya (2001) in the Pacific Ocean were around 52 oocytes per gram body mass. Macias, *et al*. (2005) estimated the average fecundity of *A. rochei* as 2, 33,941 oocytes by spawning batch and the relative fecundity was 242 oocytes per gram of body mass. These results disagree with those obtained in earlier by Niiya, (2001). The present study also indicated higher relative fecundity (12,03,258 / kg body weight).

 A.rochei mainly fed on small fishes, molluscs and crustaceans. Mostarda, *et al*., (2007) have reported that the bullet tuna is an epipelagic off-shore predator feeding on whatever abundant resources is available in the environment, with a preference for planktonic crustaceans, small cephalopods and fish larvae.

Studies on the growth of *A.rochei* in Indian waters is limited. The present study indicated rapid growth with a maximum life span of 5 years. Studies conducted elsewhere showed comparable values for L_∞ (fork length ranging between 41 and 44 cm). The differences observed in the total growth may be due to ecological changes in the fish environment. However de la Serna *et al*., (2005) estimated high L_∞ and k values of 73.2 cm and 0.447 respectively along West Mediterranean coast and Kaharaman *et al*., (2011) estimated a values of 57.3 0.18 in Turkish waters.

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