POPULATION DYNAMICS OF THE CUTTLEFISH *SEPIA ELLIPTICA HOYLE IN SAURASHTRA WATERS*

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ABSTRACT

The cephalopod fishery in Veraval is sustained mostly by five important species which are the squid *Loligo duvaucelli*, the cuttlefishes *Sepia elliptica*, *S. pharaonis*, *S. aculeata* and *Sepiella inermis*. On an average 1582.3 t of cephalopods were landed in a year during 1979-84 which constituted 5% of total catch by trawlers in Veraval. The annual average catch composition of the cuttlefish *Sepia elliptica* was 435.3 t forming 27.5% of cephalopod landings. Age and growth, instantaneous total mortality coefficient (Z) and instantaneous natural mortality coefficient (M) were estimated for *S. elliptica*. The natural mortality coefficient is estimated to be 1.59 by regressing the Z obtained for 5 years as per the method of Alagaraja (1984) against the annual effort. The Z varied from 3.33 in 1979-80 to 5.17 in 1983-84 with an average of 3.93. Yield per recruit at constant age at first capture and varying fishing mortality coefficient for different M/K ratios are inversely proportionate. For the prevailing M/K ratio and cod end mesh size (20 mm) the F max which can produce the yield max of 33 g is 2.0. This study indicates that further increase in effort may not result in proportionate increase in production. The exploitation ratio E is higher than the E opt during the period of this study indicating that the stock is exposed to higher fishing pressure. An increase in the cod end mesh size from 20 mm to 30 mm may favour increased production in commensuration with the effort increase. This suggestion is valid only when the fishery is aimed at exploitation of *S. elliptica* subjected to modifications with reference to other commercially important fisheries like prawn fishery.

INTRODUCTION

Trawling has been developed into a viable commercial fishing industry in India mainly owing to its capacity to exploit a variety of marine fishery resources. Apart from the well known economically important resources, some of the unconventional resources have been promoted into commercially important ones due to the increasing demand in foreign trade for such resources. Presently, in addition to prawns, cephalopod is considered as one such resource, though there is no exclusive fishery for cephalopod in India and it forms only a bycatch in trawl net operations. Growing demand and better price offered in the market during nineteen seventies induced the fishermen to land more and more cephalopods in the following years. Considering the commercial and economic importance of this resource, it was felt essential to undertake a systematic study on this resource to provide required information for proper exploitation and management of this resource. Such a programme was initiated by the Central Marine Fisheries Research Institute in 1976 on all India level and this account is a part of this programme carried out at Veraval, Gujarat. This

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study deals on the cephalopod fishery and the growth, mortality rates, yield per recruit, exploitation ratio and stock of the component species *Sepia elliptica*.

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**Observations and Methods**

Since none of the trawlers maintained fishing log, the data on catch, effort and species composition were collected once in a week by sampling 5-10% of the total units operated in a year during 1981-84 ranking fourth in production and the first three in the order being Kerala, Maharashtra and Tamil Nadu (Silas *et al.*, 1986). Gearwise cephalopod production of Gujarat is 99.5% by trawl net and the rest by boat seines and hook and line. Veraval being the most important fishing port of Gujarat, as many as 666 trawlers were registered at Veraval out of 900 trawlers then operating along the coast of Junagadh District in Saurashtra (C.M.F.R.I., 1981). On an average 1582.3 t of cephalopods were landed during 1979-84 which is nearly 50% of Gujarat total cephalopod production. The catch declined from 1477 t in 1979-80 to 1127.6 t in 1981-82. This decline appears to be temporary as the catch improved considerably to 1305.2 t in 1982-83 and further to 2568.1 t in 1983-84 indicating revival in the fishery (Table 1). The effort of trawlers increased continuously except for a marginal decline in 1982-83.

Five important species have been observed to support the cephalopod fishery at Veraval. The species composition of cephalopod landings indicates that the squid *Loligo duvaucelli* constituted major portion of the catch (67.8%) followed by *Sepia elliptica* (27.5%), *Sepiella*
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Inermis (3.5%), Sepia aculeata (0.7%) and Sepiapharaonis (0.5%) (Table 1). The landings of S. elliptica fluctuated from 24.1 t in 1982-83 to 1219.4 t in 1983-84. This fluctuation may be attributed to the identical variation in the abundance of the cuttlefish as indicated by its annual catch rate. The monthly average catch rate shows that the peak period of abundance for this species is during October to January.

**Population Dynamics**

Review of literature reveals that earlier studies on cephalopods were mostly on various aspects of taxonomy, biology and fisheries of different species by Hornell (1917), Rao (1954, 1958, 1969, 1973), Jones (1971), Sarvesan (1974) and Silas *et al.* (1976, 1986) and the most recent being the C.M.F.R.I. Bulletin (1986) on the bionomics, fisheries and resources of cephalopods with a brief account on the stock assessment of *L. duvaucelli* (Kasim, 1985) and *Sepia* inermis (Kasim, 1988) has been carried out and such studies on other component species are lacking. An attempt is being made here-under to present an account on these aspects on the cuttlefish *Sepia elliptica*.

**Age and growth**: The estimated length frequency of *S. elliptica* obtained during 1979-82 was used to study the age and growth of this species by integrated method of Pauly (1980) wherein the series of modes available in different months were plotted as a scatter diagram against respective fishing months and the progress of the modes was traced in subsequent months by free hand curves as shown in Fig. 1. The time of origin of some recent being the C.M.F.R.I. Bulletin (1986) on the bionomics, fisheries and resources of cephalopods with a brief account on the stock assessment of *L. duvaucelli*, *S. aculeata* and *S. pharaonis*. Detailed study on the age and growth, mortality rates, yield per recruit, exploitation rate and stock assessment of *L. duvaucelli* (Kasim, 1985) and *Sepiella* inermis (Kasim, 1988) has been carried out and such studies on other component species are lacking. An attempt is being made here-under to present an account on these aspects on the cuttlefish *Sepia elliptica*.

**Fig. 1.** Tracing of the progression of modes by scatter diagram of modal length—month for *S. elliptica* from Veraval.
and average sizes attained by this species in subsequent months were obtained as per George and Banerji (1968). These average sizes were plotted against respective months and a curve was fitted through the plots (Fig. 2). This curve may be taken as the empirical growth curve of this species and it can be read from this curve that this species attains 60.9, 95.9, 120.3, 137.8 and 148.4 mm in 0.5, 1.0, 1.5, 2.0 and 2.5 years respectively. These data were used to estimate the vital growth parameters to $L_{\infty}$, $K$ and $t_a$ by Bagenal (1955) method. The growth in length of this species may be written as per von Bertalanffy growth equation

$$L_t = L_{\infty} \left(1-e^{-\frac{t}{t_a}}\right)$$

The length-weight relationship of this species is described as per the equation

$$\log W = 3.1491 + 2.6464 \log L.$$  

**Gear selection**: The size at first capture ($L^*$) and recruitment ($L_t$) due to selective property of trawl net were estimated from the left side of the length converted catch curve as per Pauly (1984) and the average length at first capture and recruitment are 52.1 and 45.5 mm respectively. The corresponding age at first capture and recruitment are 0.4375 and 0.3669 year respectively.

**Mortality rates**: The total mortality coefficient $Z$ is estimated by the method of Alagaraja (1984) and the estimates are 3.33, 3.43, 4.19, 3.55 and 5.17 during 1979-80, 1980-81, 1981-82, 1982-83 and 1983-84 respectively. The average annual total mortality coefficient is 3.93. The annual effort in trawling hours were regressed against annual $Z$ to obtain the natural mortality coefficient $M$. The $M$ is estimated to be 1.59 i.e. the intercept ($a$) of the regression and the slope $b$, provides the catchability coefficient ‘$q$’. The $q$ is estimated to be $4.6362^\times$. This regression analysis indicates that the stock of *S. elliptica* is affected by trawling. The catchability coefficient $q$ is used for the conversion of the fishing mortality $F$ into trawling hours.

**Yield per recruit**: The yield per recruit estimated by Beverton and Holt (1957) modal simplified by Ricker (1958) for $M/K$ ratios 1.5, 1.96 and 2.5 keeping the age at first capture at prevailing level of 0.4375 yr and at varying $F$ are shown in Fig. 3 for this species. The yield per recruit increases with the increase in $F$ to a certain level and then it tends to decline on higher $F$ in all the $M/K$ ratios. Lower the $M/K$ ratio and higher the yield per recruit. The optimum age of exploitation and potential yield per recruit estimated as per Krishnankutty and Qasim (1968) are 0.9991 yr and 45 g respectively for this species.

**Discussion**

Population dynamics of short lived species with emphasis on squids and cuttlefish have been dealt in detail by Pauly (1985), Silas *et al.* (1986) and Kasim (1985). Estimation of
growth and natural mortality coefficient for tropical species is affected to a great extent by interference of different factors such as short life span, more than one breeding season and variation in growth within a year (Sparre, 1985; Pauly, 1980). The largest sizes recorded for males and females of *S. elliptica* caught in trawl net in Cochin area by Silas *et al.* (1986) are 129 mm and 119 mm respectively. The maximum size observed in the fishery during 1979-84 in Veraval is 149 mm. The study of the progression of modal sizes of males and females of this species by Silas *et al.* (1986) showed a growth of 75 mm in six months and 117 mm in one year and this is little lower than the growth observed in this study. Naturally the oldest individuals in a stock grow to reach nearly 95 per cent of their asymptotic length (Taylor, 1962; Beverton, 1963). Considering the oldest cuttlefish observed in the fishery, i.e., 149 mm the $L_\infty$ may be 157 mm. Present estimate of $L_\infty$ is 174 mm which is marginally higher than the estimate from $L_{\text{max}}$.

In nature, there are necessarily minimal and maximal natural mortality rates which vary according to the stage of life of the individual specimen. Maximum rates occur at the larval and juvenile stages and in latter life, particularly after spawning. However, in general the natural mortality rate remains constant when the longevity of the species in natural conditions remains relatively constant (Caddy, 1983). Further, shorter is the longevity and higher the natural mortality rate especially so among tropical species (Pauly, 1985). The longevity of *S. elliptica* is determined as 4.0 years from the relation $T_{\text{max}} = 3/K$ (Pauly, 1980) and the $M$ is 1.59. The natural mortality rate of *S. elliptica* is barely higher than the squid *Loligo duvaucelii* (Kasim, 1985) and lower than the cuttlefish *Sepiella inermis* (Kasim, 1988) from Veraval.

The average effort expended during the period of this study was 504282 trawling hrs which generated a fishing mortality rate of 2.4 and yield per recruit of 30.5 g for the prevailing age at first capture 0.4375 yr with 20 mm cod end mesh size. Whereas for the above-said conditions the effort should have been only 430459 hrs with $F = 2.0$ and yield 33 g. The annual effort expended in all the three years during 1981-84 were higher than the effort which can produce the highest yield. The exploitation rate $U$ calculated from the relation $U = F/Z (1-e^{-F})$ and the exploitation ratio $E = F/Z$ also indicate that the stock of *S. elliptica* was under higher fishing pressure during the period of this study as the $E$ was higher than the $E_{\text{opt}}$, i.e. $E_{\text{opt}} = 0.50$ (Pauly, 1980). The annual average stock of *S. elliptica* is estimated to be 725.5 t from the relation $P = Y/U$ where $P$ is the stock, $Y$ is the annual catch and $U$ the exploitation rate.

It can be seen from the yield isopleth diagram (Fig. 4) that further increase in effort keeping the age at first capture at present level...
may not be desirable as the yield per recruit is not commensurate with the increase in effort. However, if the age at first capture is increased from the present level by enlarging the cod end mesh size there is scope for increase in effort and yield. Further increase in effort is inevitable as the expansion of the fisheries.

end mesh size is maintained even at 30 mm the age at first capture increases to 0.7592 yr, the yield increases to 38 g and the effort to 860919 hrs. Similar studies on other component species, the squid *Loligo duvaucelii* (Kasim, 1985) and *Sepiella inermis* (Kasim, 1988) from Veraval indicate that an increase in the

harbour at Veraval would have already been completed which would have increased the berthing facilities of fishing vessels and handling of the landings. To regulate the fishery of *S. elliptica* at the optimum age of exploitation, the mesh size should be 36 mm and the effort can also be increased manyfold which will result in enhanced production. When the cod

age at first capture by way of increasing the cod end mesh size to be favourable for higher yield and increased effort input. However, considering the trawl fishery, increasing the cod end mesh size may not be possible practically as main aim of the gear is to exploit the prawn resource and the cephalopod are only

Fig. 4. Isopleth diagram for yield per recruit in gram of *S. elliptica* population from Veraval waters. The line A—A indicate the cunetric fishing curve and the line B—B the maximum sustainable yield curve. The potential yield per recruit of 45 g is also shown.
by-catch. Therefore, if the prawn resource also exhibits similar condition explained in this study, then the above observations may hold good and implementation of mesh size regulation may be considered for better management of these resources.

References


