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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

POPULATION DYNAMICS OF THE HOODED CUTTLEFISH *Sepia prashadi* (WINCKWORTH, 1936) FROM THE OMANI COASTAL WATERS OF THE ARABIAN SEA

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Abstract: Basic population parameters of the hooded cuttlefish *Sepia prashadi*, in the Arabian Sea were described from samples collected during the demersal trawl survey of the Arabian Sea between September 2007 and August 2008. A total of 6869 *S. prashadi* with mantle lengths (ML) ranged from 3.4 to 21.2 cm were analyzed. Age and growth were studied using progression analysis model by applying Bhattacharya method. There were no significant differences in population parameters between sexes. The asymptotic ML was 24.13 cm, while the growth co-efficient K was 0.81/year and t_0= -0.14 year. Mean total, natural and fishing mortalities were 3.66, 1.54 and 2.12 per year respectively. The exploitation ratio (E =0.58) suggests that the fishing pressure on *S. prashadi* in the Omani coastal waters is slightly high. Relative yield per recruit and relative biomass per recruit analysis showed that *S. prashadi* stock in the Arabian Sea is in its optimum situation as the current E is lower than that which gives the maximum Y'/R. For the management purpose and to reduce the risk due to the sampling bias, the current exploitation rate should be reduced by about 38% to achieve $E_{0.5}$ as a target reference point and the present length at first capture should be raised to about 14 cm ML to conserve the first spawners of the stock.

Keywords: Arabian Sea, *Sepia prashadi*, Cephalopods, Age, Growth, Mortality, Exploitation rates, Management

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Özet: **Arap Denizi Umman Kıyı Şeridinden Yakalanan Başlıklı Sübye *Sepia prashadi* (WINCKWORTH, 1936)' nin Populasyon Dinamikleri**

Arap Denizi'ndeki başlıklı sübyenin *Sepia prashadi*, temel popülasyon parametreleri Eylül 2007 ve Ağustos 2008 tarihleri arasında Arap Denizi dip trol araştırmasında toplanan örneklerden tanımlanmıştır. Manto boyu 3,4 cm ile 21,2 cm arasında değişen toplam 6869 adet *S. prashadi* incelenmiştir. Yaş ve büyüme, ileri Bhattacharya analiz modeli yöntemi kullanılarak incelenmiştir. Cinsiyetler arasındaki popülasyon parametrelerinde anlamlı farklılık saptanmamıştır. Büyüme katsayısı K 0.81/yıl ve t_0= -0.14 yıl iken, asimtotik manto uzunluğu 24.13 cm bulunmuştur. Toplam, doğal ve balıkçılık nedeniyle ölümler sırasıyla yılda 3.66, 1.54 ve 2.12 olarak saptanmıştır. Sömürü oranı (E = 0.58) Umman kıyı sularında *S. prashadi* üzerinde balıkçılık baskısının az oranda yüksek olduğunu göstermektedir. Yıllık stoğa katılan birey sayısı ve yıllık ağırlık (biomass) analizleri, mevcut sömürülme oranının (E), maksimum Y'/R'oranına göre daha düşük olduğunu ve Arap denizindeki *S. prashadi* stoğunun optimum koşulda olduğunu göstermiştir. Yönetim ve örnekleme yanılmasının azaltılması amacı ile son sömürülme oranı $E_{0,5}$'e ulaşabilmek için %38 oranına düşürülürken, stoğun ilk yumurtlayacak grubunu korumak amacıyla hedef referans noktası ve ilk avlanma boyu, 14 cm manto boyuna yükseltilmelidir.

Anahtar Kelimeler: Arap denizi, *Sepia prashadi*, Cephalopods, Yaş, Büyüme, Ölüm, Sömürülme oranı, Yönetim

Introduction

Cuttlefishes are small to medium-sized cephalopods distributed on continental shelves and slopes throughout most of the world's oceans. There are over twenty hundred species of cuttlefishes currently recognized, grouped into five families from which the family Sepiidae is the most important for artisanal and industrial fisheries. The most important genus exploited is *Sepia* which contains more than hundred species (Jereb and Roper, 2005). Cuttlefish is commercially fished and consumed by humans. Its ink has many uses including homeopathic medicinal uses and used as dyes and paint. Many people keep cuttlefish as pets. People often give cuttlebones from cuttlefish to their pet birds as dietary supplements and to keep their birds' beaks in good health (Dunlop, 2003; Wood, 2009; Davis, 2010).

Cephalopod fishery (cuttlefish, squid and octopus) is economically very important for Oman, due to their high commercial values on national and international markets. Cuttlefishes constitute about 16% of the total demersals' catch in Oman coastal waters (Fishery statistics book, 2011). The cuttlefish catch in the Oman coastal waters is composed of at least four species from which *S. pharaonis* and *S. prashadi* are the major ones while the other two species are of lesser importance (*S. omani* and *S. arabica*). Hooded cuttlefish *Sepia prashadi*, is a demersal, shallow water, small-sized species ranging in depth from the coastline to 200 m. It is widely distributed in the Indian Ocean from northeastern India to the Oman Sea, Red Sea, Gulf of Suez, southern Mozambique, Madagascar, Mauritius and Andaman–Nicobar Seas.

Despite the great importance of cuttlefish in the Omani coastal waters, only three studies were carried out on those species. Meriem, *et al.* (2001) made a stock assessment study on the pharaoh cuttlefish collected during 1999 from Oman Sea, while Al-Marzouqi *et al.* (2009) carried out biological and stock assessment study on the same species collected during 2001-2002 from the Arabian Sea and recently Mehanna *et al.* (2012) assessed the fishery status of the *S. pharaonis* collected from Arabian Sea during 2007-2008 and 2011-2012. For cuttlefish stock assessment and management, studies on their fisheries status and population dynamics are urgently required. The present study is the first to estimate the basic parameters of *S. prashadi* stock in the Arabian Sea for the purpose of conservation and improving its future production.

Materials and Methods

Samples of *S. prashadi* were collected during five seasonal trawl surveys carried out in the Arabian Sea and covered the area between Ras Al-Had in the north and the Omani Yemeni border in the south between September 2007 and August 2008 (Fish resources assessment survey of the Arabian Sea coast of Oman project). The surveys were with an average duration of 47 days and carried out using RV Al Mustaqila I. RV Al Mustaqila I is of 47 m length overall, has a beam of 12.5 m, horsepower of 3602 and a displacement of 1745 ton. The trawl target distance of 2 nm at speed over the ground of 3.5 knots. The trawl net used was 35 m long headline and 38 m long ground line. The cod-end with a nominal inside mesh measurement of 40 mm. The length measurements were updated during the period from November 2011 and June 2012

Mantle length (ML) was measured to the nearest mm for each specimens and the total body weight (BW) was recorded to the nearest 0.1 g. For each sex, the length frequencies were grouped into 10 mm ML classes for modal progression analysis (MPA). FiSAT software of Gayanilo *et al*. (1997) was used to compute the population parameters of sexes combined as any regulations will proposed for both sexes. The following methods were applied:

The mantle length - weight relationship was estimated using the power equation $W= aL^{b}$ where W is the total weight, L is the mantle length.

The growth parameters (ML_{∞} and K) were estimated using Powell (1979)-Wetherall method (1986) which gave an estimate for the ML_{∞} and Z/K and ELEFAN I method (Pauly, 1987).

Bhattacharya (1967) method incorporated in the FiSAT software to discriminate the age groups and then using the Ford (1933) - Walford (1949) plot to estimate the growth parameters.

Growth performance index φ' in terms of growth in length was estimated to validate the growth parameters (Gayanilo and Pauly, 1997).

Beverton and Holt (1956) equation and Length converted catch curve method of Pauly (1983) to estimate total mortality coefficient Z.

Pauly's formula (1980) and Rikhter and Efanov method (1976) to estimate natural mortality coefficient M.

The fishing mortality coefficient F was computed as F = Z – M, while the exploitation rate E was computed from the ratio F/Z (Gulland, 1971).

The relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) were estimated by using the Beverton and Holt model (1966) as modified by Pauly and Soriano (1986).

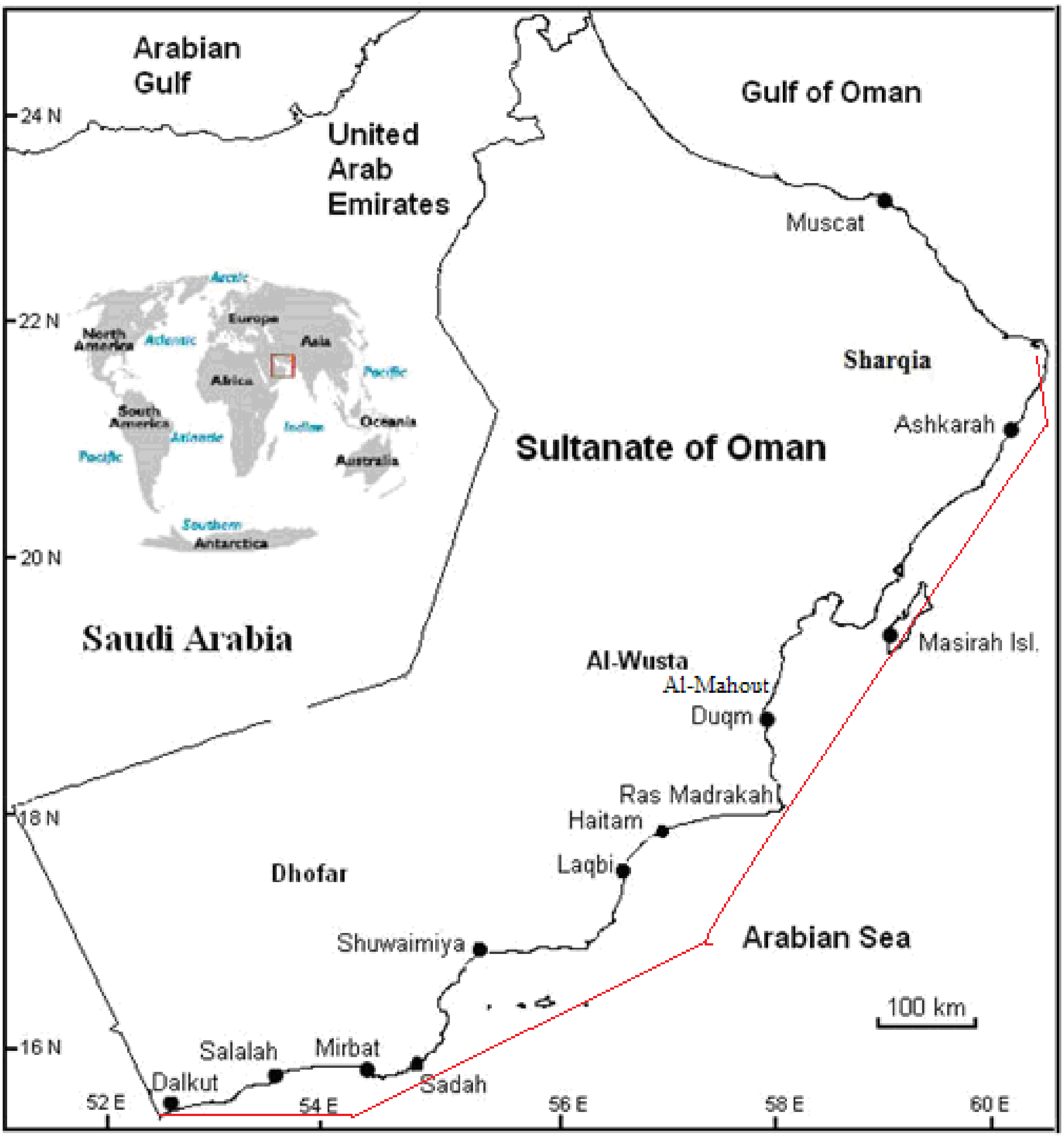

Fig. (1). Oman coast of the Arabian Sea (red line shows the surveyed area)

Results and Discussion

Mantle length - body weight relationship

A total of 6869 specimens of the cuttlefish *S. prashadi* (2988 males, 2635 females and 1246 unsexed) were used to describe the ML-BW relationship (Fig. 2). The samples ranging in ML from a minimum of 3.4 cm for both sexes to a maximum of 19.6 cm for males and 21.2 cm for females and in BW from 5 g for both sexes to 700 g for males and to 900 g for females. The regression equations obtained from plotting BW against ML (Fig. 2) were:

Males: $W = 0.3396\ ML^{2.4644}$ ($r^2 = 0.95$)

Females: $W = 0.2505\ ML^{2.5939}$ ($r^2 = 0.946$)

Pooled data: $W = 0.3545\ ML^{2.4571}$ ($r^2 = 0.944$)

The estimated b-values were significantly different from 3 indicating negative allometric growth where $b < 3$ (CI= 2.42-2.47 for males and 2.57-2.62 for females). The same finding was observed by Imam (1994) who estimated the ML-BW relationship for *S. prashadi* sampled from Gulf of Suez as $W = 0.4993\ L^{2.456}$. The ML in his study ranged from 56 to 124 mm and the BW varied between 35 and 238 g.

Age and growth

Age was determined based on pooled length–frequency data using the Bhattacharya's (1967) method (Fig. 3). It was possible to identify two components which were considered as distinct age groups or cohorts for *S. prashadi*. The Bhattacharya method was also used to analyze the monthly length frequency data to obtain the mean length and number of individuals in each month. The ML corresponding to different months was 6.11, 11.89, 16.33 and 18.86 cm for 6, 12, 18 and 24 months old and the bulk of catch was belonged to age group of 12 months old (69%). The maximum growth rate was recorded during the first six months of life for ML and at age of 18 months for BW using length-weight relationship to convert the length by age to weight. These results are in close agreement with the findings of Emam (1994). He found that the longevity of *S. prashadi* in the Gulf of Suez was 18 months and rate of growth in length is much higher in young individuals than the old ones.

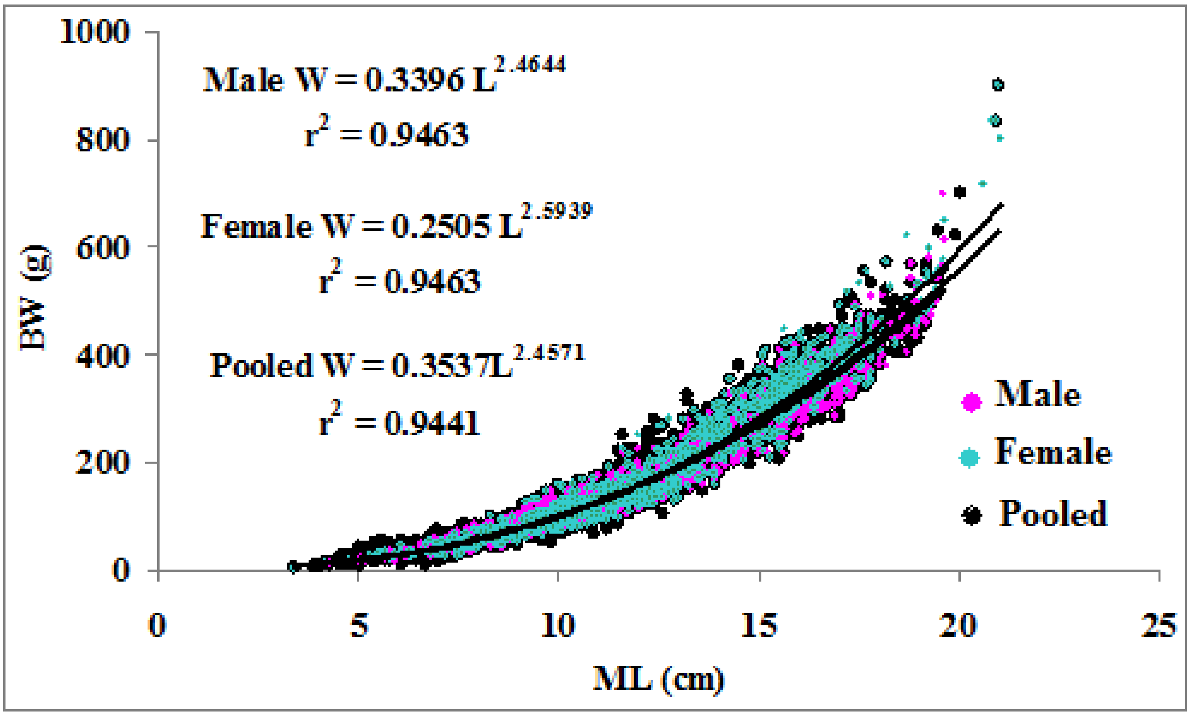

Figure 2. Length-weight relationship of *Sepia prashadi* from Arabian Sea, Oman

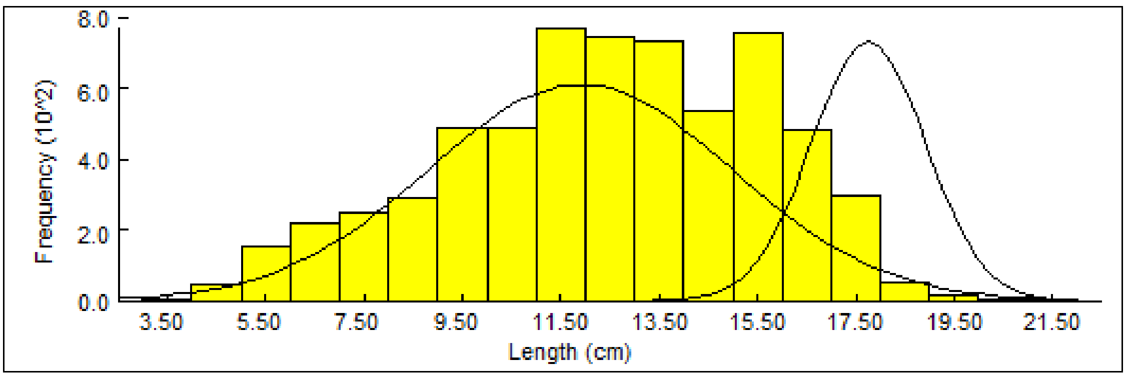

Figure 3. Bhattacharya plot of *Sepia prashadi* (pooled data) from Arabian Sea, Oman

Growth parameters

First estimates of the asymptotic length (L_∞) and the ratio between the coefficients of total mortality and growth (Z/K) obtained from Powell-Wetherall plot were 23.8 cm and 5.75. Subsequently the estimates of L_∞ was used in ELEFAN I and the parameters obtained by this method are L_∞ = 24.3 cm and K = 0.86 per year (Fig. 4). Although the growth parameter L_∞ could be estimated using ELEFAN I program directly, the Powell-Wetherall method was used to facilitate the identification of K-value compatible with the value of L_∞ which is more reliable than when this parameter is estimated together with L_∞ (Pauly, 1986). The mean lengths obtained from Bhattacharya method were applied to the Ford (1933)-Walford (1949) plot to estimate L_∞, K and t_o. The values obtained were L_∞ = 24.1 cm, K = 0.81 per year and t_o = -0.14 year. Results of the ELEFAN I program compare well with those of the Bhattacharya analysis.

The growth performance index Ø' values were estimated as 2.71 for ELEFAN I parameters and 2.67 for Ford-Walford parameters. The two values were within a very narrow range indicating that all estimates from the two methods pointed towards similarity in the growth pattern. The growth parameters of non-linear least square method were used for subsequent calculations of stock assessment.

Mortality estimates

Beverton and Holt equation gave an estimate of Z = 3.62, this value is closed to the value of Z obtained using length – converted catch curve analysis (Z= 3.71) (Fig. 5). The natural mortality coefficient calculated from Pauly's formula using mean annual water temperature of 26^0C was 1.6 per year. Rikhter and Efanov method gave an estimate of M = 1.49 per year. The mean values of Z and M gave a value of fishing mortality F = 2.12 and exploitation rate E = 0.58. Relatively high values of fishing mortality and exploitation rate reflect the high level of exploitation. The higher level of exploitation may be due to the increasing of fishing effort targeting the cuttlefish fishery during the recent years, where the number of fishing boats operating in the Arabian Sea increased by 36% in 2011 compared with the number in 2007 (Annual fishery statistics book, 2011).

Length at recruitment and at first capture

The mid-point of the smallest length group in the catch of hooded cuttlefish during the survey period was taken as length at recruitment (L_r), while the length corresponding to the first value in the descending limb of the length converted catch curve was taken as the length at first capture (L_c). The estimated L_r and L_c were 3.5 and 11.5 cm ML, respectively. It was observed that a considerable part of the catch was under-sized and not reaches its sexual maturation (61%).

Relative yield per recruit Y'/R and reference points

The plot of Y'/R against E (Fig. 6) gives an optimum level of exploitation rate at E = 0.74. The present level of E (0.58) was lower than that which gives the maximum Y'/R by about 28% but the raise of the current exploitation rate to this level will be associated with a negligible increase in Y'/R (8.8%). Both of $E_{0.1}$ (the level of exploitation at which the marginal increase in yield per recruit reaches 1/10 of the marginal increase computed at a very low value of E) and $E_{0.5}$ (the exploitation level which will result in a reduction of the unexploited biomass by 50%) were estimated. The obtained values of $E_{0.1}$ and $E_{0.5}$ were 0.6 and 0.36, respectively. It is obvious that the current E is higher than the exploitation rate ($E_{0.5}$) which maintain 50% of the stock biomass. For management purposes, the exploitation rate of *S. Prashadi* should be reduced from 0.58 to 0.36 (38%) to maintain a sufficient spawning biomass since the maximum Y'/R is not the target point but the maximum constant yield (the maximum constant catch that is estimated to be sustainable, with an acceptable level of risk, at all probable future levels of biomass) is the target reference point for fisheries management (Caddy and Mahon, 1995). Besides, it is always safe to be on the left of the maximum Y'/R than to use its current value.

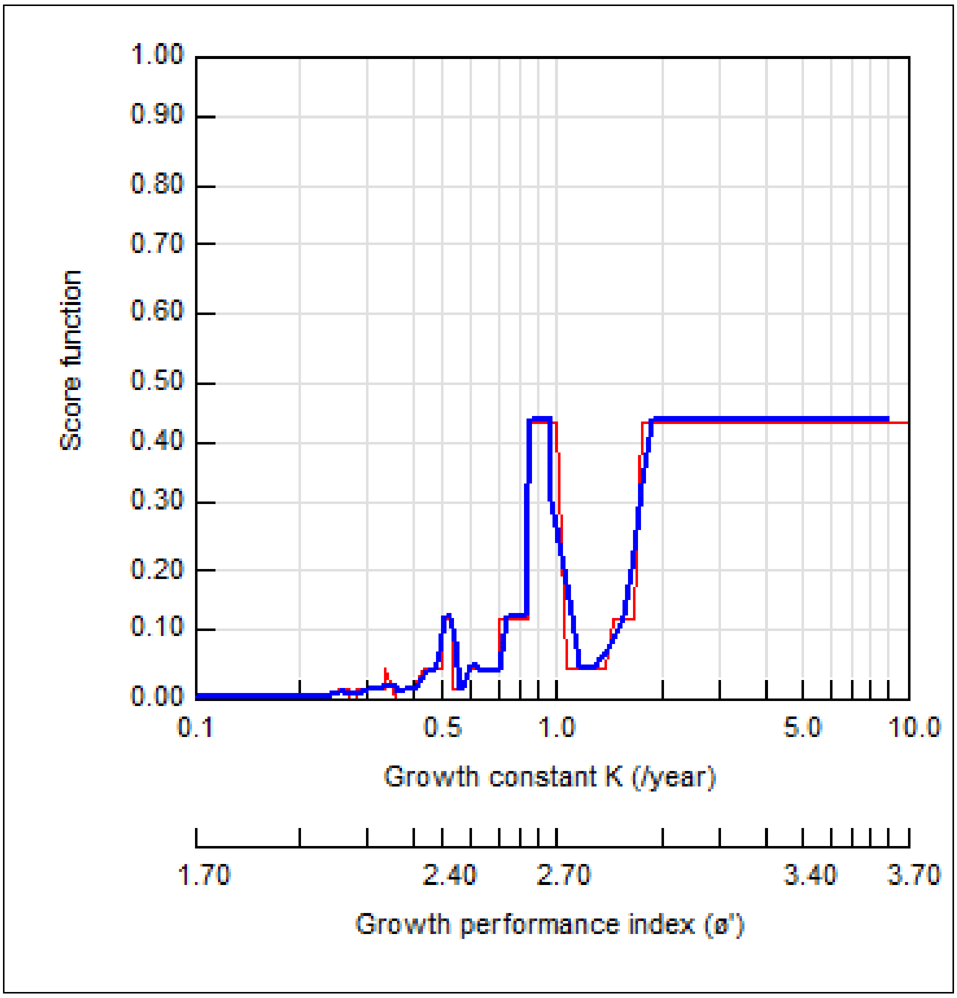

Figure 4. K-scan using ELEFAN I for *Sepia prashadi* in the Arabian Sea, Oman

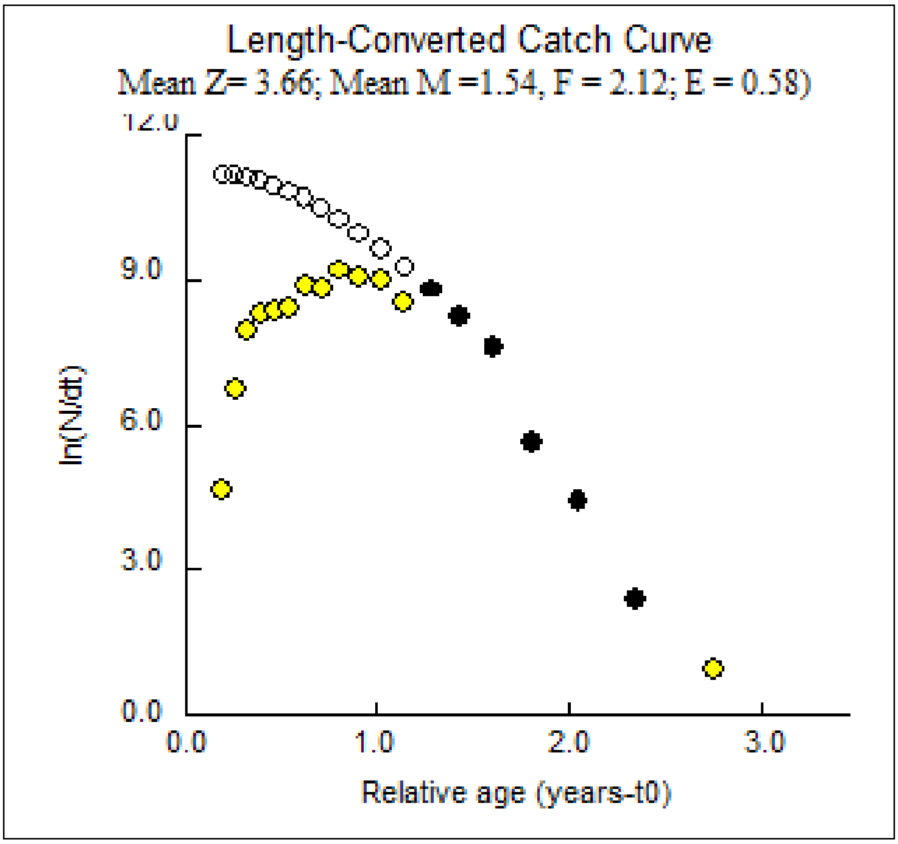

Figure 5. Length converted catch curve of *Sepia prashadi* from Arabian Sea, Oman

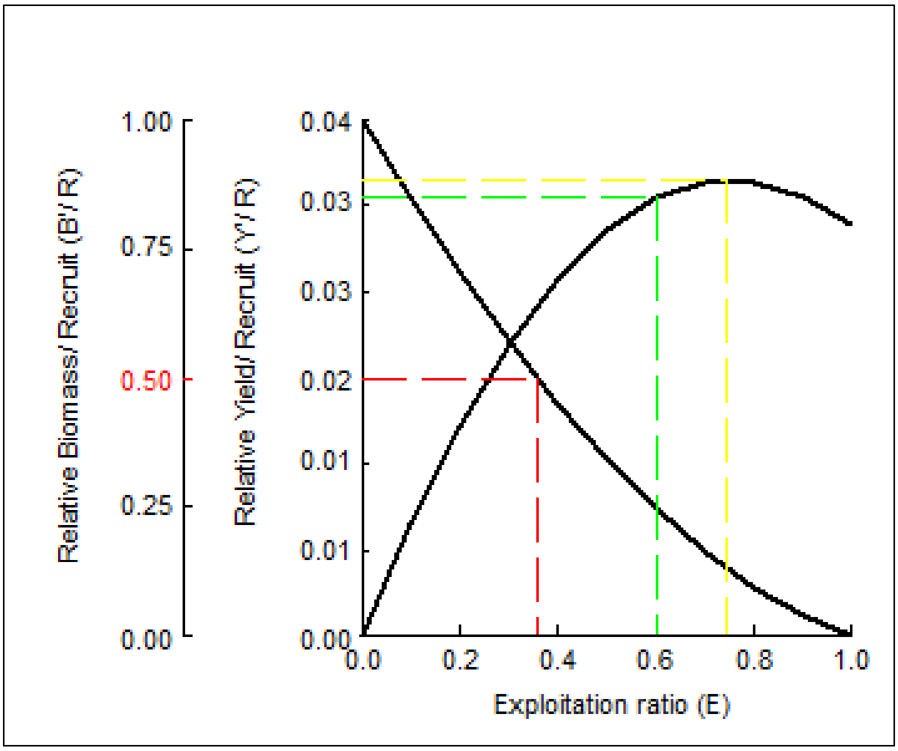

Figure 6. Relative yield per recruit analysis of *Sepia prashadi* from Arabian Sea, Oman

Conclusion

It could be concluded that there is a scope to increase the annual yield of *S. prashadi* stock in the Arabian Sea. This can be achieved by increasing the length at first capture through the increase of nets mesh size. This will conserve the young individuals and give them the chance to grow up to a marketable size and reproduce at least once before catching. The results of stock assessment show that though there is scope to increase the effort by 20-30% to get MSY from the fishing grounds, the increase in yield will be marginal (5-9%). Also, separate catch statistics for this species and other Oman fish species is strongly recommended.

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