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Fishery, population characteristics and stock assessment of cuttlefishes, *Sepia aculeata* and *Sepia pharaonis* at Kakinada along the east coast of India

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Abstract
Cuttlefishes were exploited exclusively by trawls along the coast. Growth, recruitment, mortality and exploitation rates of *Sepia aculeata* and *Sepia pharaonis* were studied. Fishery of the former was supported mainly by zero year and the latter by zero and one + age groups. Both attain sexual maturity during the first year itself and spawn during August-March with peak during November-December. Natural mortality of *S.aculeata* was 2.22, fishing mortality 2.34 and total mortality 4.56. It was 1.69, 1.97 and 3.66 respectively for *S.pharaonis*. Exploitation rate was 0.52 and E_{max} 0.72 for *S.aculeata* and it was 0.54 and 0.76 respectively for *S.pharaonis*. Their mortality and exploitation rates indicated that stock remains under-exploited and have considerable scope for improving the production. However, both stock and catch exhibited wide annual fluctuation with declining trend during the period. These necessitated immediate attention including measures to minimise juvenile exploitation for improving stock and fishery.

Key words : Cuttlefishes, Population characteristics, Stock assessment

Introduction

Cuttlefish is one of the commercially important marine fishery resources of Indian waters by virtue of its export demand. In the recent past, several studies were conducted aimed at understanding the stock and biology of commercially important species and their response to exploitation (Silas *et al.* 1985, Nair *et al.* 1993 and Rao *et. al.* 1993). These reports and review by Meiyappan *et al.* (2000) indicated that resource is optimally exploited from east coast and under-exploited from west coast. Successful exploitation and management of the resource requires sound knowledge on distribution pattern and factors controlling their abundance. However, knowledge on several crucial aspects on the biology of many species remains limited. Present study was to update such information on the commercial species of cuttlefishes along the east coast.

Materials and methods

Fishing effort, catch and species composition of cuttlefishes were monitored during 1995-'99. Size distribution, sex ratio and gonadal maturity of *Sepia aculeata* and *Sepia pharaonis* were monitored at weekly intervals. Their monthly length frequency distribution data in the catches were used to estimate growth parameters, mortality rates, exploitation rates and recruitment pattern. Growth parameters, $L\infty$ and K were estimated through surface response analysis of restructured length frequency histogram by ICLARM's FiSAT software (Gayanilo *et al.* 1995). Size at first capture (Lc_{50}) was estimated following Pauly (1984) and age at zero length (t_0) from von Bertalanffy plot (Bertalanffy 1934).

Total mortality (Z) was estimated from catch curve (Pauly, 1983) and natural mortality (M) from the empirical formula proposed by Pauly (1980). Exploitation rate (E) and ratio (U) were estimated from the equations, $E = F/Z$ and $U = F/Z \times (1- e^{-Z})$ as given by Beverton and Holt (1957) and Ricker (1975). Total stock and biomass were estimated from the formulas Y/U and Y/F respectively. Maximum sustainable yield was estimated as in Corten (1974).

Results

Fishery : Cuttlefishes were exploited exclusively by trawls. Fishery showed declining trend during the period, with wide annual fluctuation (Table 1). Catch was large, 777 tons during 1996-'97 and small, 359 tons during 1997-'98. Catch rate also registered similar fluctuation between 6.1 and 16.2 kg/unit effort during the period. Catch/hour of trawling fluctuated between 0.37 and 1.01kg. Fishery occurred round the year, with nearly 50% of the catch during August-October (Fig 1).

Table 1. Catch and catch rates of cuttlefishes in trawls at Kakinada during 1995-'99

Particulars / Period	1995-'96	1996-'97	1997-'98	1998-'99
Catch (ton)	660	777	359	378
Catch /unit effort (kg)	14.1	16.2	6.1	6.11
Catch /hour of fishing (kg)	0.69	1.01	0.37	0.38

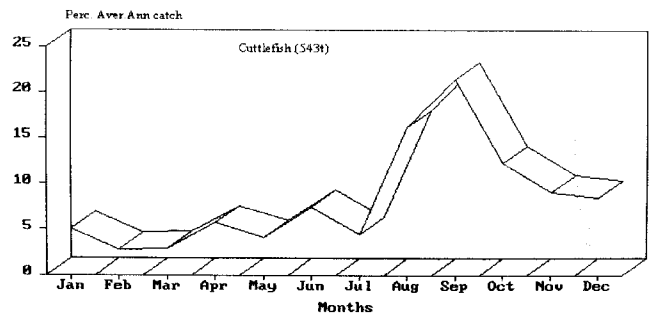

Fig 1. Seasonal pattern of cuttlefish fishery at Kakinada during 1995-'99.

Species composition and seasonal abundance : Fishery was supported by four species. *Sepia pharaonis* is the most dominant (41.6%) in the catch. Other species in the fishery are *Sepiella inermis* (31.4%), *Sepia aculeata* (22.6%) and *Sepia brevimana* (4.4%). They were available round the year in the catch with peak abundance of *S.aculeata* and *S.pharaonis* during August-October (Table 2).

Table 2. Seasonal fluctuation in the abundance of species as indicated by catch rate (kg/hour of fishing) in trawls

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
S. pharaonis	0.19	0.28	0.05	0.12	1.76	2.52	1.27	1.08	0.84	0.40	0.15	0.11
S. aculeata	0.31	0.24	0.10	0.22	0.85	1.19	0.54	0.54	0.36	0.24	0.18	0.20
S. brevimana	0.06	0.06	0.04	0.05	0.10	0.15	0.09	0.06	0.11	0.07	0.10	0.06
S .inermis	0.68	0.04	1.32	0.84	0.52	0.91	1.03	0.67	0.72	0.63	0.36	0.30

Population characteristics of S. pharaonis

Growth : Growth parameters, $L\infty$ and K were estimated as 319.9 mm and 0.92/year respectively and 't_0' as 0.0314 years. Their growth against time can be described by von-Bertalanffy growth equation as,

$$Lt = 319.9\,[1 - e^{-0.92\,(t - 0.0314)}]$$

Length at age data obtained from the above relation shows that they grow to 58.3, 112.1, 154.7 and 188.7 mm respectively by 3, 6, 9 and 12 months. They attain 267.6, 299.1 and 311.6 mm by the end of 2nd, 3rd and 4th years respectively.

Size composition : 40-290 mm animals with 144.4 mm as mean size supported fishery in trawls (Table 3). Mainly zero and one+ year groups supported their fishery. Juveniles of 40-60 mm size entered fishery in large numbers during February-March. Their age at this stage was between 1.93 and 2.9 months. Size and age of the species at first capture was estimated as 158.5 mm and 9.1 months respectively.

Table 3. Annual size range, modes, mean size and commercial size of *S. pharaonis* in the catch

Period	Size range (cm)	Modes	Mean Size (cm)	Commercial size (cm)
1995-'96	50-290	50-60, 160-170, 180-190	133.3	160-240
1996-'97	60-260	130-140,150-160,170-180	157.7	120-210
1997-'98	40-290	70-80, 200-210	128.8	180-230
1998-'99	60-270	100-110, 160-170	142.9	120-230
1995-'99	40-290	50-60,130-140,170-180	144.4	120-240

Spawning and recruitment pattern : Recruitment pattern showing the time of origin of the stock (Fig 2), presence of animals with matured and spent gonads and small juveniles in the catch indicated that species spawn during August-March with peak, accounting 67% of the activity during November-December.

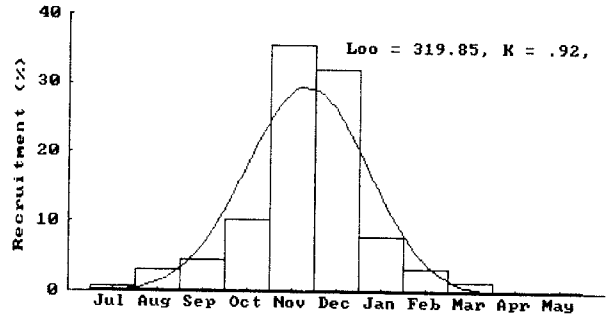

Fig 2. Recruitment pattern of *S. pharaonis* along Kakinada coast.

Mortality rates : Estimates of total mortality rate (Z) ranged between 2.19 and 4.92 during 1995-'99 with 3.66 as mean (Table 4). Natural mortality (M) was 1.69. Average fishing mortality (F) was 1.97 and it varied between 0.5 and 3.23 during the period.

Exploitation rate : Exploitation rate (E) fluctuated between 0.228 and 0.657, with 0.54 as mean for 1995-'99 (Table 4). E_{max} is large, 0.759, indicating some scope for increasing future production (Fig 3).

Table 4. Mortalities, exploitation rates, exploitation ratios, catch, biomass and stock of exploited *S. pharaonis* population during 1995-'99 (Natural mortality (M) is 1.69)

Period	Total mortality (Z)	Fishing mortality (F)	Exploitation rate (E)	Exploitation ratio (U)	Catch (t)	Stock (t)	Biomass (t)
1995-'96	2.97	1.28	0.431	0.409	279	682	218
1996-'97	4.08	2.39	0.586	0.576	391	679	164
1997-'98	2.19	0.50	0.228	0.203	86	424	172
1998-'99	4.92	3.23	0.657	0.652	148	227	46
Average	3.66	1.97	0.538	0.524	226	431	115

Yield and stock : Their stock and biomass in the present fishing grounds continued to decline during 1995-'99 (Table 4). Stock was 682 ton during 1995-'96 and it declined to 227 ton by 1998-'99. Average stock for the period was 431 ton. Biomass during the same period declined from 218 to 46 ton with 115 ton as mean. Yield however fluctuated widely over the period between 86 and 391 ton. Maximum sustainable yield of the species from the present fishing grounds is 249 tons/year (Fig 3).

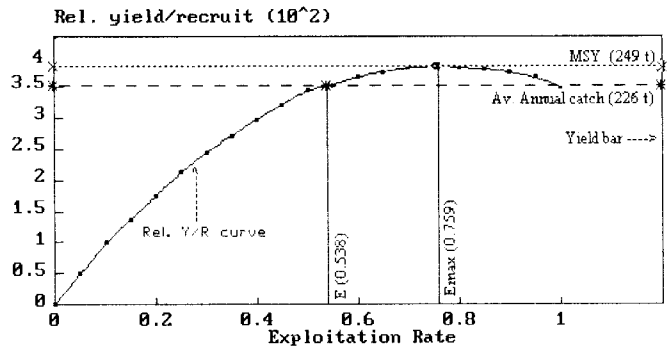

Fig 3. Relative yield/recruit of *S. pharaonis* at different levels of exploitation, super imposed with yield bar showing MSY.

Population characteristics of S. aculeata

Growth : Growth parameters, $L\infty$ and K were estimated as 225 mm and 1.2/year respectively and 't_0' as 0.059 years. Their growth against time can be described by von-Bertalanffy growth equation as;

$$Lt = 225\ [1- e^{-1.2\ (t\ -\ 0.059)}]$$

Length at age data obtained from the above relation indicated that species grow to 46.1, 92.5, 126.8 and 152.3 mm respectively by 3, 6, 9 and 12 months. They attain 203.1, 218.4 and 223.0 mm by the end of 2nd, 3rd and 4th year respectively.

Size composition : 20-210 mm animals, with 109.7 mm as mean size supported the fishery (Table 5). Mainly zero year groups supported their fishery. Juveniles of 20-40 mm size entered the fishery during February-March. Their age at this stage was between 1 and 2.1 months. Size and age of the species at first capture was estimated respectively as 105.7 mm and 6.5 months.

Table 5. Annual size range, modes, mean size and commercial size of *S.aculeata* in the catch

Period	Size range (cm)	Modes	Mean size (cm)	Commercial size (cm)
1995-'96	20-200	50-60, 110-120	81.5	110-170
1996-'97	30-170	110-120, 130-140	124.2	110-160
1997-'98	40-210	60-70, 120-130, 140-150	100.7	120-170
1998-'99	50-200	110-120, 130-140	118.5	110-160
1995-'99	20-210	50-60, 110-120, 130-140	109.7	110-160

Spawning and recruitment pattern : Recruitment pattern showing the time of origin of the stock (Fig 4) and presence of animals with matured and spent gonads and young juveniles in the catch indicated that species spawn during August-March, with peak accounting 72% of the activity during November-January.

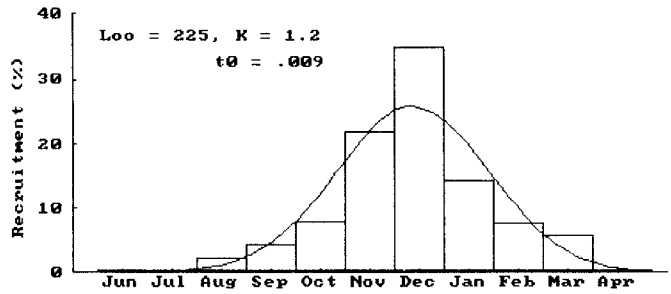

Fig 4. Recruitment pattern of *S. aculeata* along Kakinada coast.

Mortality rates : Estimates of total mortality (Z) ranged between 3.2 and 6.94 with 4.5 as mean (Table 6). Natural mortality (M) was 2.22. Average fishing mortality (F) was 2.34 and it varied between 0.67 and 4.72 during the period.

Table 6. Mortalities, exploitation rates, exploitation ratios, catch, biomass and stock of exploited *S. aculeata* population during 1995-'99 (Natural mortality (M) is 2.22)

Period	Total mortality (Z)	Fishing mortality (F)	Exploitation rate (E)	Exploitation ratio (U)	Catch (t)	Stock (t)	Biomass (t)
1995-'96	3.43	1.21	0.353	0.341	150	440	124
1996-'97	6.94	4.72	0.680	0.679	195	287	41
1997-'98	3.51	1.29	0.368	0.356	82	230	64
1998-'99	3.20	0.98	0.306	0.301	64	213	65
Average	4.56	2.34	0.520	0.514	123	239	53

Exploitation rate : Exploitation rate (E) fluctuated between 0.209 and 0.68, with 0.52 as mean during 1995-'99 (Table 6). E_{max} is large 0.723, when compared to present levels of exploitation indicating scope for increasing future production (Fig 5).

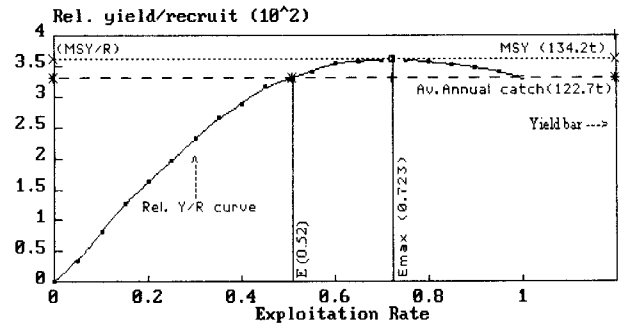

Fig 5. Relative yield/recruit of *S .aculeata* at different levels of exploitation, super imposed with yield bar showing MSY.

Yield and stock :Their stock and biomass in the present fishing grounds showed a declining trend during 1995-'99 (Table 6). Stock was 440 ton during 1995-96 and it declined to 213 ton by 1998-'99. Average stock for the period was 239 ton. Biomass during the same period fluctuated between 41 and 124 ton with 53 ton as mean. Yield fluctuated between 64 and 195 ton with a clear declining trend. Maximum sustainable yield from the present fishing grounds of the coast is 134 ton/year (Fig 5).

Discussion

Catch and catch rate of cuttlefishes shown declining trend with wide annual fluctuation during 1995-'99. Stock of major species also shown such fluctuation with declining trend. However, present level of exploitation of the species is low compared to Emax. This suggested operation of some fishery independent factors in the fishing ground unfavourable for the stock. These have to be traced out through constant and close monitoring of the fishery, fishery environment, behaviour of the stock and their response to fishing.

Fishery of *S.pharaonis* was supported mainly by zero and 1+ year groups and *S.aculeata* by zero year groups with large proportions of juveniles. Silas *et al.* (1985) reported that along the east coast former attain sexual maturity at 121-138 mm size and latter at 100-118 mm size. Present growth estimate shows that their ages at these sizes will be respectively 7-8 and 6-7 months. Though they attain sexual maturity at an early age and have prolonged spawning season, vulnerability of young ones to fishing and precedence of peak fishing season to spawning season, may limit chances of large proportion of the population for spawning before being caught. So the present level of exploitation though low may have some adverse effect on the recruitment and stock as evident from continuous and sharp decline in the catch and stock of *S.pharaonis*.

These species spawns in shallow inshore waters and young ones feed on small shrimps and fishes in the shelf area, they are vulnerable to trawls from their early juvenile stage onwards. Trawls being aimed primarily for resources like shrimps, mesh size of the gear is expected to be very small. So mesh size regulation to conserve this resource alone is not a practically viable proposal. The only alternative is regulating effort to reduce fishing pressure in coastal waters especially during peak period of juvenile abundance. Fishing pressure on the stock can also be reduced by diverting large trawlers to deeper waters, for exploitation of other under-exploited resources. Such measures will improve catch and also the stock by way of enhanced survival and recruitment.

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