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GROWTH, MORTALITY RATES AND STOCK ASSESSMENT OF THE CUTTLEFISH *SEPIELLA INERMIS* (FERUSSAC AND D'ORBIGNY) IN SAURASHTRA WATERS

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ABSTRACT

Age and growth of the cuttle fish *Sepiella inermis* was estimated from the length frequency data collected from trawl net operations in Veraval during 1979-83. Natural mortality coefficient (M) is estimated to be 2.1 and the total mortality coefficient (Z) estimated as per catch curve method are given. Stock assessment has been made. The exploitation rate, total mortality, instantaneous mortality, average annual stock have been estimated by cohort analysis. The continuous decline in the annual landings and average annual stock during 1979-83 is attributed to high fishing pressure in the shallow near shore waters off Veraval. Further observation on this fishery is felt essential to formulate suitable regulatory measures with due consideration on other major fisheries of the area.

INTRODUCTION

CEPHALOPODS have of late gained attention as one of the important marine fishery resources in India owing to their growing demand in foreign trade, which has served as an additional impetus for increased landings though they form the by-catch in the shallow water shrimp fisheries. With a couple of exceptions of the studies on the stock assessment of squids and cuttle fishes at selected centres by Silas *et al.*, (1986) and on the population dynamics of the squid *Loligo duvaucelii* by Kasim (1987), most earlier studies have dealt with various aspects of the biology and fishery of different species (Hornell, 1917 : Rao, 1954, 1958, 1969, 1973 ; Jones, 1968 ; Sarvesan, 1974 ; Silas *et al.*, 1976, 1982, 1986). The present study deals with growth, mortality rates and stock assessment of the cuttle fish *Sepiella inermis* (Ferussac and d'Orbigny) from data collected during 1979-83 at Veraval in Gujarat.

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CATCH STATISTICS

Cephalopods constituted about 5% of the all fish catch of trawlers at Veraval and *Sepiella inermis* formed nearly 2% of the cephalopod landings. The estimated monthwise catch and CPUE of *S. inermis* during 1979-83 are given in Table 1. There was continuous decline in the landings of *S. inermis* from 198.1 t in 1979-80 to 0.61 t in 1982-83 (Table 1). The fishery of *S. inermis* commences in September and terminated in June due to South west monsoon and the peak period of fishing is during December to May.

AGE AND GROWTH

Age and growth of this species was studied from length frequency data collected over a

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TABLE 1. *Estimated monthwise catch (kg) and CPUE (kg/h, within brackets) of* Sepiella inermis *during* 1979-83

Season	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	Total
1979-80 ..	354	7728	—	13681	124456	10979	17664	23192	—	—	198054
	(0.032)	(0.171)	—	(0.320)	(2.307)	(0.164)	(0.370)	(0.357)	—	—	(0.550)
1980-81 ..	—	—	507	10356	3536	24	600	19506	3962	—	38491
	—	—	(0.015)	(0.198)	(0.071)	(0.0003)	(0.011)	(0.355)	(0.104)	—	(0.098)
1981-82 ..	—	—	—	1141	—	786	1008	1687	1715	—	6337
	—	—	—	(0.014)	—	(0.12)	(0.011)	(0.022)	(0.062)	—	(0.012)
1982-83 ..	—	—	66	—	—	—	—	—	119	420	605
	—	—	(0.002)	—	—	—	—	—	(0.002)	(0.193)	(0.001)
Total ..	354	7728	573	25178	127992	11789	19272	44385	5796	420	243487

period of four fishing seasons during 1979-83. The observed frequency in different length groupings (5 mm) in a sample from the catch of a day was raised to the sample day's catch and the pooled frequency of different sample days were in turn raised to the monthly catch, thus arriving at weighted frequencies (in number) for different months in a fishing season. The occurrence of a series of modes in the length frequency in each month indicates the presence of successive different broods in the fishery. These modes were plotted against respective fishing months and the progression of the modes in successive months was traced as per integrated method (Pauly, 1980) *i.e.* the simultaneous application of Petersen's method and the modal progression analysis as shown in Fig. 1. For example a mode at 45 mm in

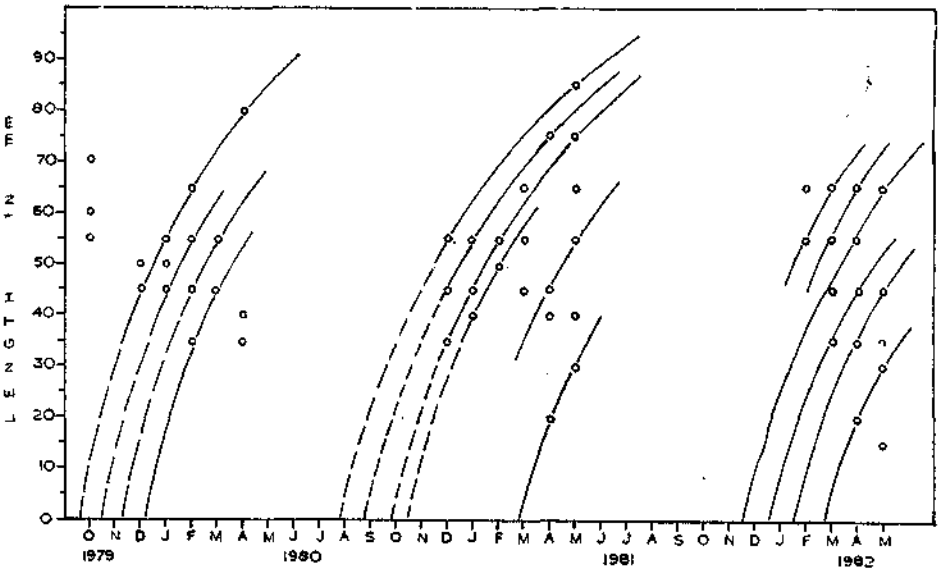

FIG. 1. Tracing of the progression of modes by scatter diagram of modal length — month for *Sepiella inermis* from Veraval.

December, 1979 is traced to the mode at 80 mm in April 1980 with a growth rate of 8.75 mm per month. Two modes one at 35 mm and another at 45 mm in December, 1980 are traced to the mode at 75 mm in May, 1981 and 75 mm in April, 1981 with a growth rate of 8 and 7.5 mm per month respectively. To correlate these modes with the time of origin, they were back traced as indicated by broken lines in Fig. 1. This treatment enables to arrange these modes chronologically in a tabular form and to obtain roughly the average length attained by the cuttle fish in consecutive months. These values were plotted against respective months and a curve was fitted through the plots

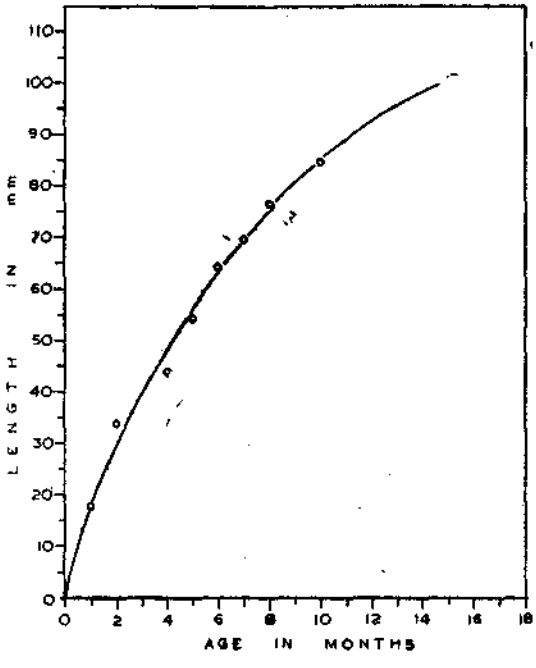

FIG. 2. Mean length at age in months based on the scatter diagram for *S. inermis* from Veraval.

as shown in Fig. 2. From this empirical growth curve, this species is assessed to attain a mantle length of 18.0, 29.0, 39.0, 48.0, 56.0, 63.0, 69.5, 75.5 and 81.0 mm in 2, 3, 4, 5, 6, 7, 8, 9 and 10 months respectively.

The growth parameters L_∞, K and t_o were estimated from these data by applying the straight line method proposed by Alagaraja (1984) which is similar to ELEFAN proposed by Pauly and David (1981). The estimated growth parameters expressed as per von Bertalanffy growth equation are $L_t = 128.8\ (1-e^{-1.3669\ (t\ +\ 0.0111)})$. The length weight relationship of this species worked out from the pooled data of male, female and indeterminate is Log W = −2.0564 + 2.0013 Log L. Based on this relationship the growth in weight (g) was also estimated. The W_∞ was estimated as 146.6 g.

MORTALITY RATES

The natural mortality co-efficient (M) can be estimated from the maximum life span (T max) of any species (Sekharan, 1974). T max may be taken as 3/K (Pauly, 1980). In this study it is 3/1.3669 = 2.195 yrs for *S. inermis* and the natural mortality co-efficient is 2.1. Although a number of methods are available for the estimation of total mortality co-efficient (Z) from the length frequency data, the length converted catch curve method (Pauly, 1983) was employed to estimate the Z and the estimates are given in Table 2. The fishing mortality co-efficients obtained by deducting M from Z and the exploitation rate (U) derived from the relation $U = \frac{F}{(F+M)}\ (1-e^{-(F+M)})$. are also given along with the estimates of total stock and average annual stock in Table 2. The exploitation rate (U) varied from 0.58 in 1980-81 to 0.72 in 1981-82 which indicates that this species is exposed to higher fishing pressure. The total stock (P) estimated from the annual yield (Y) and the exploitation rate declined continuously from 283.0 t in 1979-80 to 1.0 t in 1982-83. The average annual stock also declined from 40.5 t in 1979-80 to 0.2 t in 1982-83.

TABLE 2. *Estimated annual instantaneous total mortality co-efficient (Z) obtained from the catch curve method (Pauly, 1980), fishing mortality co-efficient (F), exploitation rate (U), total stock and average annual stock of* S. inermis *during 1979-83 at Veraval*

Year	Z	F	U	Total Stock (P=Y/U) (in tonnes)	Average annual stock (Y/F) (in tonnes)	Yield (Y) (in tonnes)
1979—80 ..	6.99	4.89	0.70	283.0	40.5	198.1
1980—81 ..	5.00	2.90	0.58	66.4	13.3	38.5
1981—82 ..	7.39	5.29	0.72	8.8	1.2	6.3
1982—83 ..	5.64	3.54	0.63	1.0	0.2	0.6
Mean ..	6.25	4.16	0.66	92.3	14.6	60.9

STOCK ASSESSMENT

Cohort analysis of Jones (1981) has been employed for the stock assessment of this species. In cohort analysis, the basic assumption is that within any one age group, the decline in number following an exponential curve is replaced with a 'step function' based on two assumptions *viz.* 1. the entire age group is fished at exactly middle of the age interval and 2. that only natural declines take place continuously in an exponential form. The procedures are based on age data and are adopted here with adjustments to make them applicable to the length data. Though the assumption, that the input length composition in length cohort analysis is representative of a steady state situation and that the numbers caught represent annual catches per length group, is not likely to be in practice, and a useful approximation can be obtained by determining the average length composition over a period of as many years as possible.

Cohort analysis

The basic formulation and based on this formulation the stepwise estimation of the numbers in the sea and the average numbers in the sea with the help of intermediary estimates like Zdt, F/Z, Fdt and Z from the numbers landed are dealt in detail by Sparre (1986) and Silas *et al.*, (1986). The exploitation rate, total numbers and average numbers in the sea, total mortality and instantaneous mortality rate for *Sepiella inermis* along veraval coast during 1979-80, 1980-81, 1981-82 and 1982-83 are giver in Table 3-6 and the stock estimates (in tonnes) during these 4 seasons in Table 7.

As already pointed out the annual landings of *S. inermis* declined continuously from 198.1 t in 1979-80 to 0.61 t in 1982-83 due to high fishing pressure and decline in the average annual and standing stocks. The average annual stock declined from 1284.50 t in 1979-80 to 2.70 t in 1982-83 with an average of 370.55 t and the standing stock declined from 47.50 t in 1979-80 to 0.1 t in 1982-83 with an average of 13.72 t (Table 7).

DISCUSSION

Obtaining reliable estimates of growth and natural mortality co-efficient for tropical species is hampered very much due to interference of various factors such as short life span, seasonal variation in growth within a

TABLE 3. *Cohort analysis of the numbers landed in different length groups of* Sepiella inermis *at Veraval during* 1979-80

$L\infty = 128.8$ (mm) $K = 1.3669$ $M/K = 1.5$

Length* Class (mm)	Numbers landed	Numbers in the sea	F/Z	F	Z	Average numbers in the sea
20— ..	11145	18330941	0.0089	0.0183	2.0687	608971
25— ..	58403	17071191	0.0458	0.0985	2.1488	593250
30— ..	278565	15796419	0.1919	0.4869	2.5372	572184
35— ..	850193	14344676	0.4366	1.5886	3.6390	535186
40— ..	1426521	12397165	0.5949	3.0107	5.0610	473822
45— ..	2449722	9999142	0.7606	6.5149	8.5653	376016
50— ..	2503834	6778456	0.8295	9.9745	12.0248	251024
55— ..	2223458	3759935	0.8947	17.4272	19.4776	127585
60— ..	656251	1274882	0.8674	13.4131	15.4634	48926
65— ..	186742	518315	0.7934	7.8729	9.9233	23720
70— ..	104463	282940	0.7852	7.4955	9.5459	13937
75— ..	53155	149902	0.7614	6.5442	8.5945	8123
80— ..	51051	80093	0.8643	13.0629	15.1132	3908
85— ..	14720	21029	0.7000			

* Lower limit.

TABLE 4. *Cohort analysis of the numbers landed in different length groups of* Sepiella inermis *at Veraval during* 1980-81

$L\infty = 128.8$ (mm) $K = 1.3669$ $M/K = 1.5$

Length* Class (mm)	Numbers landed	Numbers in the sea	F/Z	F	Z	Average numbers in the sea
15— ..	1814	2440065	0.0113	0.0234	2.0738	77535
20— ..	11221	2279278	0.0675	0.1485	2.1989	75554
25— ..	19459	2113146	0.1148	0.2658	2.3161	73218
30— ..	70865	1943564	0.3314	1.0164	3.0668	69719
35— ..	169033	1729751	0.5659	2.6733	4.7237	63230
40— ..	258693	1431075	0.7052	4.9046	6.9549	52746
45— ..	334399	1064235	0.8094	8.7083	10.7586	38400
50— ..	149809	651103	0.7358	5.7104	7.7608	26234
55— ..	227670	447504	0.8733	14.1330	16.1833	16109
60— ..	34860	186805	0.6586	3.9552	6.0055	8814
65— ..	64939	133873	0.8488	11.5087	13.5590	5643
70— ..	13020	57365	0.6732	4.2242	6.2746	3082
75— ..	12266	38025	0.7400	5.8345	7.8849	2102
80— ..	3707	21449	0.5592	2.6013	4.6517	1425
85— ..	10374	14820	0.7000			

* Lower limit,

TABLE 5. *Cohort analysis of the numbers landed in different length groups of* Sepiella inermis *at Veraval during* 1981-82

L ∞ = 128.8 (mm) K = 1.3669 M/K = 1.5

Length* Class (mm)	Numbers landed	Numbers in the sea	F/Z	F	Z	Average numbers in the sea
10— ..	2506	633256	0.0597	0.1302	2.1805	19253
15— ..	12783	591275	0.2512	0.6877	2.7380	18589
20— ..	9904	540379	0.2135	0.5567	2.6071	17790
25— ..	23382	493999	0.4046	1.3932	3.4436	16783
30— ..	47863	436207	0.6080	3.1798	5.2302	15052
35— ..	71071	357482	0.7372	5.7510	7.8014	12358
40— ..	25031	261073	0.5477	2.4827	4.5330	10082
45— ..	68176	215370	0.8108	8.7856	10.8359	7760
50— ..	28555	131283	0.7233	5.3591	7.4095	5328
55— ..	51264	91803	0.8868	16.0665	18.1168	3191
60— ..	12497	33997	0.8090	8.6848	10.7352	1439
65— ..	17208	18550	0.9391	31.6260	33.6765	544
70— ..	158	226	0.7000			

* Lower limit.

TABLE 6. *Cohort analysis of the numbers landed in different length groups of* Sepiella inermis *at Veravel during* 1982-83

L ∞ = 128.8 (mm) K = 1.3669 M/K = 1.5

Length* Class (mm)	Numbers landed	Numbers in the sea	F/Z	F	Z	Average Numbers in the sea
25— ..	109	39163	0.0376	0.0801	2.1304	1361
30— ..	182	36262	0.0629	0.1377	2.1880	1322
35— ..	2537	33370	0.5007	2.0559	4.1063	1234
40— ..	2774	28302	0.5534	2.5409	4.5913	1092
45— ..	7418	23290	0.8119	8.8503	10.9007	838
50— ..	4400	14153	0.7979	8.0955	10.1458	544
55— ..	4896	8639	0.8889	16.4039	18.4543	299
60— ..	1072	3131	0.7952	7.9618	10.0121	135
65— ..	1248	1783	0.7000			

* Lower limit.

TABLE 7. *Stock estimates of* Sepiella inermis *off Veraval during* 1979-83

Year	Annual landing (t)	Average annual stock (t)	Standing stock (t)
1979-80 ..	198.1	1284.5	47.5
1980-81 ..	38.5	162.1	6.1
1981-82 ..	6.3	32.9	1.2
1982-83	0.6	2.7	0.1
Mean ..	60.9	370.55	13.72

year etc., as in the case of mackerel (Yohannan, 1982). The maximum size observed in the fishery is 112 mm in the east coast and 124 mm in the west coast (Silas *et al.*, 1982). Generally in nature, the oldest fishes of the stock grow to reach about 95 percent of their asymptotic length (Taylor, 1962 ; Beverton, 1963). When the oldest cuttle fish measuring 124 mm in the west coast is considered as 95 percent of $L\infty$, then the $L\infty$ may be 130.5 mm. In the present study the $L\infty$ is 128.8 mm which is farily close to the above estimate.

Silas *et al.* (1986) have obtained from the study of modal progression that this species grows to a size of 33 mm, 57 mm and 73 mm at the end of 0.5, 1.0 and 1.5 years on Waltair coast and along Madras coast it attains a size of 35 mm, 61 mm and 82mm in 0.5, 1.0 and 1.5 years respectively. In Mandapam area, Unnithan (1982) has observed this species to grow to a size of 51 mm and 80 mm at the end of 1st and 2nd year respectively. This species is reported to grow 35 mm, 61 mm, 81 mm and 101 mm at the end of 0.5, 1.0, 1.5 and 2.0 years respectively in Cochin waters. In the present study this species estimated to grow 64.7 mm, 96.5 mm, 112.5 mm and 120.6 mm in 0.5, 1.0, 1.5 and 2.0 years respectively in Veraval waters. Application of Bagenal (1955) method to the growth data of this species from Cochin waters yield an estimate of 221.6 mm of $L\infty$ and K 0.2908. The K is small due to slow growth rate, this species may have a life span of 10 years according to the relation 3/K (Pauly, 1980). Present study reveals that this species has a faster growth rate and shorter life span than that of the estimates obtained by Silas *et al.* (1986) and Unnithan (1982). Shorter the life span and higher the M value (Pauly, 1985). The life span of *S. inermis* is 2.195 and the M is 2.1 as already pointedout.

The populations of *S. inermis* are distributed in shallow inshore waters upto about 40 m depth and therefore, this species being exposed to heavy fishing pressure by the trawlers, though the aim of the trawl net operation is not aimed at this species but for prawns. This may be one of the reasons for the continuous decline in the annual landing and consistant reduction in the stock size. Reduction in the effort of trawlers is not at all possible and on the other hand increase in the effort is imminent at Veraval due to the expansion work under taken in the fisheries harbour. Therefore, further observation is highly essential to formulate suitable regulatory measures with due consideration on other major fisheries of the area. The information presented in this study will be useful hopefully for evolving better regulatory measures as this is the first report on the stock assessment of this species in India.

REFERENCES

ALAGARAJA, K. 1984. Simple methods for estimation of parameters for assessing exploited stocks, *Indian J. Fish.*, 31 : 177-208.

BAGENAL, 1955. The growth rate of the long rough dab *Hippoglossoides platessoides* (Fabr.). *J. Mar. Biol. Ass. U.K.*, 34 : 297 -311.

BEVERTON, R. J. H. 1963. Maturation, growth and mortality of clupeoid and engraulid stocks in relation to fishing. *Rapp. Cons. Perm. Int. Explor. Mer.*, **154** : 44-67.

——— AND S. J. HOLT 1957. On the dynamics of exploited fish populations. *Fishery Invest., Lond., Series* **2, 19** : 533 pp.

HORNELL, J. 1917. The edible molluscs of Madras Presidency. *Madras Fish. Bull.*, **11** : 1-51.

JONES, S. 1968. The molluscan fishery resources of India. *Proc. Symp. Molluscs, Mar. Biol. Ass. India*, **3** : 906-918.

JONES, R. 1981. The use of length composition data in fish stock assessments (with notes on VPA and COHORT analysis). *FAO Fish. Circ.*, **734** : 55 p.

KASIM, H. M. 1987. Population dynamics of the squid *Loligo duvaucelii* d'Orbingny (Cephalopoda) in Saurashtra waters. *J. mar. biol. Ass. India*, **27** (1 & 2) : 103-112.

PAULY, D. 1980. A selection of simple method for the assessment of tropical fish stocks. *FAO Fish. Circ.*, **729** : 54 p.

——— 1983. Length converted catch curves : A powerful tool for fisheries research in the tropics (Part II). *Fishbyte*, **2** (1) : 17-19.

——— 1985. Population dynamics of short lived species with emphasis on squids. *Scientific Council Studies No. 9. Special session on Squids, September*, 1984. *North West Atlantic Fisheries Organisation*, pp. 1-177.

——— AND N. DAVID 1981. ELEFAN, I. a BASIC program for the objective extraction of growth parameters from length frequency data. *Meeres. forsch.*, **28** (4) : 205-211.

RAO, K. VIRABHADRA 1954. Biology and fishery of the Palk Bay squid *Sepioteuthis artipinnis* Gould. *Indian J. Fish.*, **1** : 37-66.

——— 1958. Molluscan Fisheries. In : S. Jones (Ed.) *Fisheries of the west coast of India*, pp. 55-59.

——— 1969. Molluscs nave many uses. *Indian Farming*, **19** (9) : 41-46.

——— 1973. Distribution pattern of the major exploited fishery resources of India. *Proc. Symp. Living Resources of the seas around India. Spl. Publ. CMFRI*, pp. 18-101.

SARVESAN, R. 1974. V. Cephalopods. In : *The commercial Molluscs of India. Bull. Centr. Mar. Fish. Res. Inst.*, **25** : 63-83.

SEKHARAN, K. V. 1974. Estimates of stocks of oilsardine and mackerel in the present fishing grounds off the west coast of India. *Indian J. Fish.*, **21** (1) : 177-182.

SILAS, E. G., S. K. DHARMARAJA AND K. RENGARAJAN 1976. Exploited marine fishery resources of India — A synoptic survey with comments on potential resources. *Bull. Cent. Mar. Fish. Res. Inst.*, **27** : 1-25.

———, K. SATYANARAYANA RAO, R. SARVESAN K. PRABHAKARAN NAIR AND M. M. MEIYAPPAN 1982. The exploited squid and cuttlefish resources of India A review. *Mar. Fish. Infor. Serv. T & E Ser.*, **34** : 17 pp.

———, R. SARVESAN, K. PRABHAKARAN NAIR, Y. APPANNA SASTRI, P. V. SREENIVASAN, M. M. MEIYAPPAN, KUBER VIDYASAGAR, K. SATYANARAYANA RAO AND B. NARAYANA RAO 1986. Some aspects of the biology of cuttlefishes. In : E. G. Silas (Ed.) *Cephalopod Bionomics, Fisheries and Resources of the Exclusive Economic Zone of India. Bull. Centr. Mar. Fish. Res. Inst.*, **37** : 49-70.

SPARRE, P. 1986. Introduction to tropical fish stock assessment. *FAO/DANIDA Project training in Fish stock assessment. GCP/INT/392/DEN.*

TAYLOR, C. C. 1962. Growth equation with metabolic parameters. *J. Cons. CIEM*, **27** : 270-286.

UNNITHAN, K. A. 1982. Observation on the biology of cuttlefish *Sepiella inermis* at Mandapam. *Indian J. Fish.*, **29** (1 & 2) : 101-111.

YOHANNAN, T. M. 1982. Population dynamics of Indian Mackerel based on data from Mangalore during 1967-75. *Ibid.*, **29** (1 & 2) : 50-62.