Indian Journal of Fisheries 40 (1,2) : 74-84, March-June 1993

Stock assessment of the Indian squid *Loligo duvauceli* Orbigny

M M MEIYAPPAN[1], M SRINATH[2], K PRABHAKARAN NAIR[3], K SATYANARAYANA RAO[4], R SARVESAN[5], G SYDA RAO[6], K SUNILKUMAR MOHAMED[7], KUBER VIDHYASAGAR[8], K S SUNDRARAM[9], A P LIPTON[10], P NATARAJAN[11], G RADHAKRISHNAN[12], K A NARASIMHAM[13], BALAN[14], V KRIPA[15] AND T V SATHIANANDAN[16]

Central Marine Fisheries Research Institute, Cochin, Kerala 682014

ABSTRACT

The present status of the fishery, biology and stock assessment of the India squid *Loligo duvauceli* Orbigny was studied, based on the data collected at different centres on both the coasts of India for 1979-1989. The production had increased by over 280% in 3 states on the west coast, viz. Kerala, Maharashtra and Gujarat. These states accounted for about 80% of the all-India squid production (23,941 t in 1989). Trawl is the main gear, taking 86% of the total squid landings. The fishing effort and squid catch on the east coast was comparatively more in the third quarter. On the west coast the first and fourth quarters were the most productive. The natural mortality rates calculated based on different levels of M/K values (1.5, 2, 2.5 and 3) showed that they ranged from 1.35 to 2.7 for males and from 1.95 to 3.9 for females on the east coast; from 1.2 to 2.4 for males and from 1.65 to 3.3 for females on the west coast. On both the coasts the values for females were higher than for males. The maximum fishing mortality (1.2 - 4.3) under different M/K values for males was at the size of 85 mm, and for females (5.8 - 6.7) at 175 mm on the east coast. For the west coast males the maximum fishing mortality (3.3 - 4.3) was at the size of 230 mm and for females (2.3 - 3.8) at 130 mm. The standing stock of males was higher than that of females on the east coast, with a reverse order on the west coast. The MSY and mean biomass at different M/K levels were also estimated for males and females separately for each coast. The present level of exploitation was at the optimum level on both the coasts.

The Indian squid, *Loligo duvauceli* Orbigny, is an Indo-Pacific species distributed in neritic waters from Mozambique to the South China Sea, and the Philippines Sea up to Taiwan. It is the most abundant squid in the Indian waters. It occurs up to a depth of 120 m or even beyond but the concentration is within 50 or 60 m from the shore, all along the coasts, and forms fishery in trawling grounds especially on the west coast and in some non-trawling areas on the south-west coast. There has been a steady increase in production in recent years due to the rising demand in the export trade. In 1989 the landings reached the all-time high of 23 941 t.

Present address : [1]Scientist (Selection Grade), [4]Principal Scientist, [11]Scientist S-2, Madras Research Centre of CMFRI, 68/1, 4th Floor, Greams Road, Madras 600 006.

[2,14]Scientist (Selection Grade), [13]Principal Scientist, [15,16]Scientist.

[3]Scientist (Selection Grade), Vizhinjam Research Centre of CMFRI, Vizhinjam P.O., Trivandrum, Kerala 695 521.

[5]Scientist (Selection Grade), [12]Scientist, Vishakhapatnam Research Centre of CMFRI, Andhra University P.O., Vishakhapatnam 530 003.

[6]Senior Scientist, Kakinada Research Centre of CMFRI, Door No. 8-14-38, Red Cross Street, Gandhi Nagar, Kakinada 533 004.

[7]Scientist, Mangalore Research Centre of CMFRI, Post Box No. 244, Bolar, Mangalore 575 001, Dakshina Kannada, Karnataka.

[8]Senior Scientist, [9]Scientist (Selection Grade), Bombay Research Centre of CMFRI, 148, Army & Navy Building, 2nd Floor, M.G. Road, Bombay 400 023.

[10]Senior Scientist, Mandapam Regional Centre of CMFRI, Marine Fisheries P.O., Mandapam Camp 623 520.

Because of its abundance and its economic importance in the export market, in the recent past this squid has been stuided for its biology and fishery characteristics. Noteworthy among the earlier investigations are those by Kora and Joshi (1975) on the food, Oommen (1977) on the food, feeding and fishery, Silas *et al.* (1982) on the resource, Silas *et al.* (1986 a, b) on the biology and stock assessment, Rao (1988) on the fishery and biology, Meiyappan and Srinath (1989) on the growth and mortality, and Nair *et al.* (1992) on the squids obtained in jigging operations on the south-west coast of India. Supongpan (1988) studied the mortality and yield per recruit of this species in Thailand waters.

In view of the urgent need to estimate the resource position and the maximum sustainable yield of this squid in the Indian waters for proper management of the fishery, an attempt was made to assess the stock based on the catch, effort and biological data collected at various centres on both the coasts over a number of years.

DATA BASE AND METHODOLOGY

The state-wise cephalopod catch data for the 1979-1989 and the gearwise catch data for 1985-1989 were obtained from the Fisheries Resources Assessment Division, Central Marine Fisheries Research Institute. As these data were given as cephalopods and not species-wise, the data collected at various centres like Veraval, Bombay, Mangalore, Cochin, Vizhinjam, Tuticorin, Mandapam, Rameswaram, Madras, Kakinada and Visakhapatnam on species composition have been utilized to obtain the state-wise catch of *Loligo duvauceli.* The length-frequency data of this squid caught by trawlers operating at Mangalore, Cochin, Madras and Kakinada during 1984-1988 were used. Only trawl catches were considered for the present study as this gear accounted for almost the entire landings of *Loligo duvauceli.*

The data on catch, effort, species composition and length composition collected on observation days were weighted to arrive at the day's estimates. These were pooled and weighted to obtain the monthly estimates (Alagaraja 1984). The monthly estimates were pooled to get annual estimates. The average monthly length-frequency data for 1984-1988 collected at different centres on either coast were pooled and raised to get the estimates for the respective coast.

The length was measured along mid-dorsal line from the anterior tip to the posterior tip of the mantle separately for males and females. The length-frequency was classified into 10-mm groups and the average monthly length frequency for 1984-1988 was used for the estimation of growth parameters.

The growth parametres $L\infty$ and K were estimated using ELEFAN I of Pauly and David (1981), assuming that growth in length follows von Bertalanffy growth Formula (VBGF). The males and females were treated separately as the former attains a larger size than the latter.

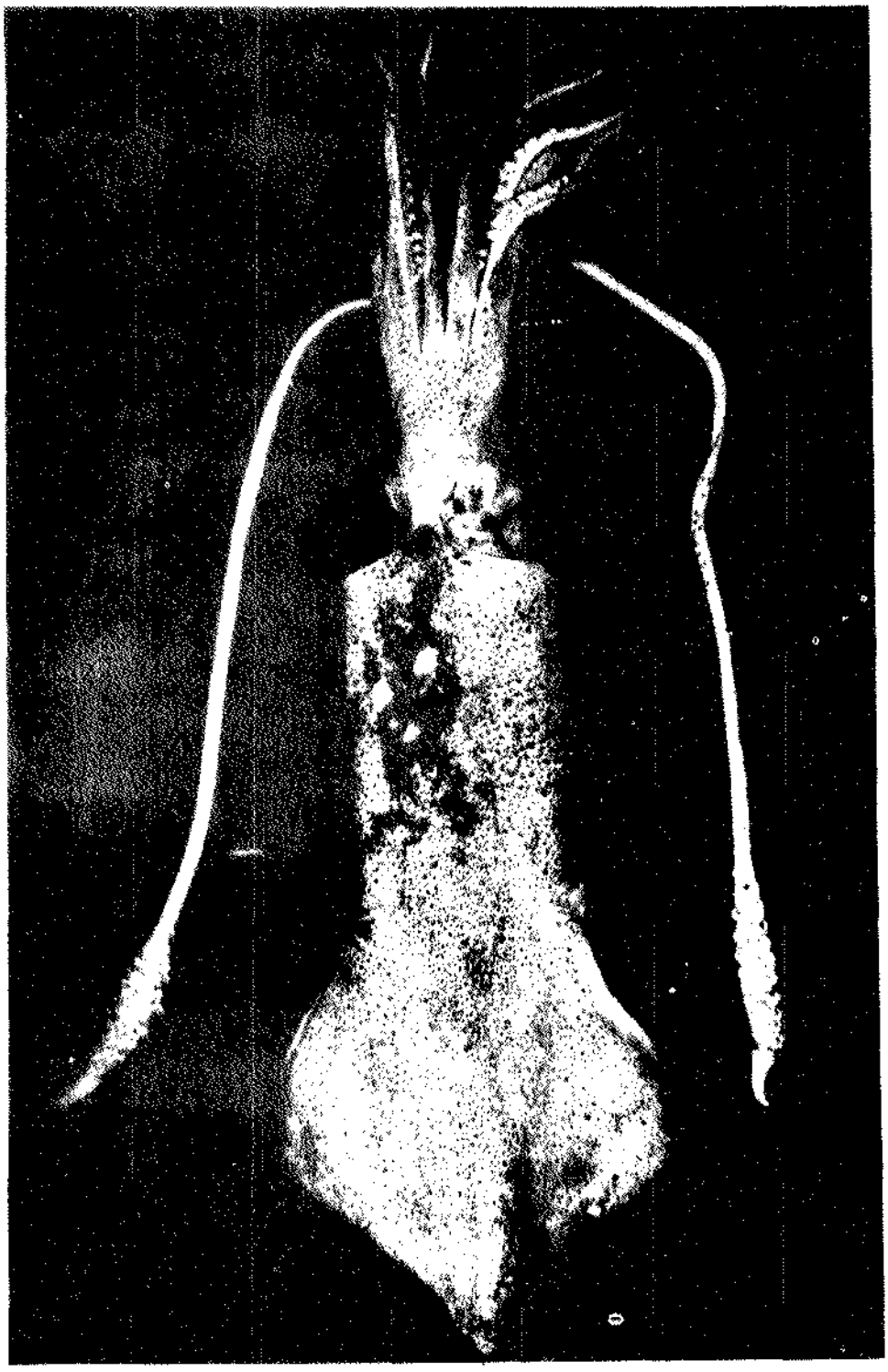
Mortality and stock estimates were made based on Jones (1984) length cohort analysis by assuming 4 different values for M/K, viz. 1.5, 2, 2.5 and 3. The yield and biomass estimates were obtained with length-converted Thompson and Bell analysis (Sparre 1985).

All the analyses were made with the help of LFSA packages of FAO (Sparre 1987).

RESULTS AND DISCUSSION

Fishery

All-India production: The annual landings



Loligo duvaucelii Orbigny

of the Indian squid showed an increasing trend from the year 1979 through 1989, except in a few years (Table 1).

State-wise production: Kerala, Gujarat and Maharashtra took the lion's share of squid production. During the 11-year period (Table 1) the average contribution by Kerala was 38% followed by the other two states accounting for 22 and 21% respectively. In 1989 when the squid catch reached the maximum, Kerala's contribution was as high as 51% (12 261 t). The landings in West Bengal, Orissa, Andhra Pradesh Pondicherry and Goa were very low throughout, while the average contribution by Tamil Nadu and Karnataka was about 6-8%

Gear-wise production: The squid was taken as by-catch in a variety of gears. Bulk of the landings (86%) was accounted for by trawl net and the rest by artisanal gears like boat seine, shore seine, hooks and line, fixed bag net (*dol*) and drift gillnet (Table 2). Trawl was operated in all the states but in West Bengal there was no squid catch by this gear; the small quantities obtained were by other gears. In Kerala, many types of traditional gears were operated and their contribution was much higher than in other states. In *dol* net which was operated in Maharashtra and Gujarat, small quantities of this squid were obtained.

Seasonal production trends: The fishing effort by trawl and the corresponding squid production on the east and west coasts, and in each of the maritime states by season (quarter of the calendar year) during 1985-89 are shown in Table 3. Among the maritime states on the east coast, the maximum effort in West Bengal was in the fourth quarter but there was no catch (also in other quarters). In Orissa and Andhra Pradesh the effort and catch were higher in the fourth quarter, while in Tamil Nadu and Pondicherry they were comparatively higher in the third quarter than in other quarters in the east coast as a whole the average values of effort and catch were higher in the third quarter than in other periods.

In Karnataka, Goa and Gujarat on the west coast, the maximum catch was in the

Table 1. State-wise prodcution (tonnes) of *Loligo duvauceli* during 1979-1989

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
West Bengal	0	2	0	2	7	16	3	3	11	3	15
Orissa	5	38	22	76	46	23	36	47	38	14	31
Andhra Pradesh	203	182	198	230	201	174	215	272	311	212	192
Tamil Nadu	339	262	300	576	690	657	790	695	721	749	985
Pondicherry	9	7	8	15	21	6	8	8	12	5	20
Kerala	1553	2215	1240	1846	901	2830	4324	7823	3933	7911	12261
Karnataka	57	102	222	128	816	278	199	1797	2391	1627	2043
Goa	144	175	78	138	328	340	253	1173	402	324	396
Maharashtra	1116	336	495	1348	1865	2157	3682	3506	3263	3782	4079
Gujarat	2858	1853	1465	1615	2121	1254	2427	3644	3624	1526	3919
Total (All India)	6284	5172	4028	5974	6996	7715	11937	18968	14706	16133	23941
Average (All India)	11078										

Table 2. State-wise prodcution (tonnes) of *Loligo duvauceli* by trawl net and by other gears during 1985-89 (*TN*: trawl net; *OG* other gears; *T* total)

	1985			1986			1987			1988			1989		
	TN	OG	T	TN	OG	T	TN	OG	T	TN	OG	T	TN	OG	T
West Bengal	-	3	3	-	3	3	-	11	11	-	3	3	-	15	15
Orissa	20	16	36	19	28	47	28	10	38	12	2	14	31	-	31
Andhra Pradesh	177	38	215	250	22	272	265	46	311	195	17	212	181	11	192
Tamil Nadu	260	530	790	376	319	695	566	155	721	584	165	749	534	451	985
Pondicherry	8	-	8	8	-	8	10	2	12	5	-	5	20	-	20
Kerala	2575	1749	4324	3447	4376	7823	3638	295	3933	7305	606	7911	11189	1072	12261
Karnataka	188	11	199	1407	390	1797	2375	16	2391	1622	5	1627	1385	658	2043
Goa	197	56	253	990	183	1173	383	19	402	322	2	324	333	63	396
Maharashtra	3666	16	3682	3488	18	3506	3260	3	3263	3750	12	3762	4062	17	4079
Gujarat	2375	52	2427	3540	104	3644	3615	9	3624	1525	1	1526	3895	24	3919
Total	9466	247	11937	13525	5443	18968	14140	566	14706	15320	813	16133	21630	2311	23941

Table 3. Quarter-wise trawl net fishing effort (in trawler days) and *Loligo duvauceli* catch (in tonnes) in east coast during 1985-89

	I quarter		II quarter		III quarter		IV quarter		Annual	
Year	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
1985	131936	85	127494	118	170644	152	155270	110	585347	465
1986	143398	106	133044	122	183831	269	152897	156	613170	653
1987	160420	187	126051	244	190474	291	178867	147	655812	869
1988	171446	185	146754	253	177542	219	150203	166	645945	736
1989	131304	97	134048	172	177781	269	181016	227	624149	765
Average	147700	127	133478	181	180054	240	163650	162	624882	710

Quarter-wise trawl net fishing effort (in trawler days) and *Loligo duvauceli* catch (in tonnes) in west coast during 1985-89

	I quarter		II quarter		III quarter		IV quarter		Annual	
Year	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch	Effort	Catch
1985	278396	2306	214575	1092	81535	861	284355	4742	858861	9001
1986	359312	4225	256058	1359	76670	1219	283579	6069	975619	12872
1987	436814	6213	336371	1995	113671	972	438303	4091	1325159	13271
1988	470588	3929	362046	2377	133694	2080	502831	6138	1469159	14524
1989	446142	5112	331957	3789	131204	6137	266207	5826	1175510	20864
Average	398250	4358	300201	2123	107355	2254	355055	5373	1160861	14108

first quarter, while in Maharashtra it was in the fourth quarter and in Kerala during the third quarter. On the west coast as a whole the first and fourth quarters were the best for squid production.

Biology

Size range: The male squids attained larger sizes than the females. There were also differences in the maximum size of squids

recorded at different centres. While the smallest size was 20 mm for both the sexes, the maximum sizes differed. In general the squids were smaller on the east coast than on the west coast as observed earlier by Silas *et al.* (1986 a). The maximum size of male squid on the east coast was 260 mm (Visakhapatnam), whereas on the west coast it was 371 mm at Vizhinjam and 330 mm in Bombay. The maximum size of females on the east coast was 210 mm (Visakhapatnam) and the west coast 235 mm (Vizhinjam). In general, the fishery was supported by squids within the size range of 100-200 mm.

Sex-ratio: On most of the occasions there was numerical difference in sex. The expected 1:1 ratio was rarely observed. Since males attain larger sizes than females, there were only males above certain lengths. Rao (1988) observed that off Mangalore the proportion of females beyond 150 mm was 5%; above 180 mm it was negligible and beyond 230 mm all were males. Among the squids obtained in jigging operations in the south-west coast of India, males were slightly more in number in the ratio 53:47 below 100 mm size; females outnumbered males in the ratio 42:58 among those between 100 mm and 200 mm which accounted for the bulk of the catch; above 200 mm the ratio was 94:6, while above 240 all were males.

Food and feeding: Crustaceans and fish were the most important food of this squid. Cephalopods also formed part of the food. The crustacean food included prawns, crabs, stomatopods, euphausids, mysids and ostracods. Oommen (1977) found that crustaceans were the dominant food during April-May and fish during October-March. Sardines, anchovies, mackerel, threadfin bream and white fish were the dominant fish diet. Cephalopods formed the food throughout the year. Kore and Joshi (1975) found a decrease in feeding intensity in squids during the spawning season.

Maturity: The male squids on the east coast attain maturity from a size of 50 mm onwards, the size at first maturity (the size at which 50% of the individuals are mature) being 67 mm at Visakhapatnam and 85 mm at Madras (Silas *et al.* 1986a). On the west coast they become mature at slightly larger size, of 90 mm onwards. The size at first maturity was 108 mm at Vizhinjam and 122 mm at Cochin. At Mangalore the respective sizes were 70 and 124 mm (Rao 1988).

On the east coast, the mature females were observed from a size of 70 mm, with 50% maturity at 108 mm at Visakhapatnam and 96 mm at Madras. On the west coast the minimum size of mature females was 90 mm, with 50% maturity at 110 mm at Vizhinjam, 128 mm at Cochin and 107 mm at Bombay. At Mangalore, Rao (1988) observed mature female squids at 70 mm and above, with 50% maturity at 108 mm.

Nair *et al.* (1992) based on pooled samples of squids collected in squid jugging on the south-west coast of India indicated that the sizes at first maturity of males (134 mm) and females (130 mm) were higher than the sizes mentioned above.

The size at first maturity for both the sexes was smaller on the east coast than on the west coast. Generally the males attain first maturity at slightly smaller size than the females, except what was observed at Mangalore and in the case of squid jigging experiments.

Spawning: Silas *et al.* (1986a) observed that squids with mature gonads occur almost

throughout the year all along the coast, indicating that spawning is continuous. This is further supported by the presence of juveniles on both the coasts during most part of the year. However, peak periods of spawning were noticed in several months at different centres as inferred by the presence of fully mature squids, and also spawning or spent individuals in very small numbers. Rao (1988) observed that off Mangalore, December to May can be generally considered as the major spawning season, and that the female squids appear to spawn only once. However, it is not conclusively proved that there is post-spawning mortality in *Loligo duvauceli* as observed by Fields (1965) in *Loligo peali*. In fact, there is wide gap in our knowledge in this regard, and all aspects associated with spawning have to be studied in detail.

Fecundity: The very limited study at Mangalore on fecundity of this squid (Rao, 1988) indicated that the number of ripe eggs produced by the individuals ranged from 1 500 to 13 156. The relative fecundity showed peak between 110 and 140 mm, indicating that the squids may spawn when they are in this length range. The size at first maturity observed in this case was 108 mm.

Length-weight relationship: The study of the length-weight relationship of *Loligo duvauceli* of the Madras and Cochin coasts by Silas *et al.* (1986 a) and of the squids collected in squid jigging on the south-west coast of India by Nair *et al.* (1992) showed that the rate of increase in weight in relation to the rate of increase in length differed in males and females. According to Rao (1988) there was good correlation between the length and weight at different stages of maturity and that in general the weight increase in females appeared to be more than in males. In the present case the length-weight relationship in the form $W = a\ L^b$ was studied and the results are:

East Coast Males a = 0.000683
b = 2.3769
Females a = 0.00037
b = 2.5201

West Coast (Meiyappan and Srinath, 1989)
Males a = 0.00182949
b = 2.143
Females a = 0.00095313
b = 2.298

Age and growth: Silas *et al.* (1986a) and Meiyappan and Srinath (1989) observed differential growth rates in males and females of *Loligo duvauceli*. The results of the present study based on length-frequency data collected at Madras and Kakinada on the east coast, and Cochin and Mangalore on the west coast indicated the sizes (mm) attained at ages (months) as follows:

Centre	Sex	Age in months				
		6	12	18	24	30
Madras & Kakinada	Male	80	131	163	184	197
	Female	98	149	176	190	197
Cochin & Mangalore	Males	119	198	252	287	311
	Female	98	155	187	206	217

The above results showed that on the east coast the females grow faster than the males up to the end of the second year, but the two sexes grow to the same size by $2^1/_2$ years. By contrast, the growth of males on the west coast was faster than that of females throughout.

Stock assessment

Growth parameters: The estimates of growth

parameters $L\infty$ and K for males and females are given below:

East Coast	Males	: $L\infty$	= 220 mm
		K	= 0.9/year
	Females	: $L\infty$	= 205 mm
		K	= 1.3/year
West Coast	Males	: $L\infty$	= 360 mm
		K	= 0.8/year
	Females	: $L\infty$	= 232 mm
		K	= 1.1/year

Mortality rates and stock sizes: The total mortality (Z), fishing mortality (F) and stock sizes were estimated by Jones' (1984) length cohort analysis with the terminal exploitation rate (F/Z) chosen as 0.5 on the assumption that the stock is under reasonably good exploitation. The results of the analysis are as follows:

	M/K = 1.5		M/K = 2		M/K = 2.5		M/K = 3	
	M	F	M	F	M	F	M	F
			East Coast					
Catch (t)	587	497						
Natural mortality 'M'	1.35	1.95	1.8	2.6	2.25	3.25	2.7	3.9
Standing stock (t)	256	155	361	185	605	229	1,236	296
Mean 'F' (L > 30)	1.46	1.50	1.11	1.21	0.71	0.93	0.35	0.69
			West Coast					
Catch (t)	7,407	8,822						
Natural mortality 'M'	1.2	1.65	1.6	2.2	2.0	2.75	2.4	3.3
Standing stock (t)	2,470	3,612	2,776	4,304	3,166	5,263	3,670	6,641
Mean 'F' (L > 20)	1.66	1.05	1.43	0.82	1.22	0.63	1.02	0.46

M, Male; F, female.

On both the coasts the 'M' values for females were higher. But the average fishing mortality (L> 20) of males was higher than of females on the west coast. The maximum fishing mortality (ranging from 1.2 to 4.3) under different M/K values was observed in males of the size 85 mm, and from 5.8 to 6.7 in females of the size 175 mm on the east coast. In the west coast sector the same ranged from 3.3 to 4.3 in males of the size 230 mm, and from 2.3 to 3.8 in females of the size 130 mm. The standing stock estimates are higher for males than for females on the east coast, whereas it was the opposite in the west coast sector as seen from the pattern of the actual catches.

Maximum sustainable yield (MSY) and mean biomass: The results of the length-based Thompson and Bell long-term forecast analysis are summarized below:

M/K	MSY (t)		'F' - Factor at MSY		Biomass at MSY level of	
	Male	Female	Male	Female	Male	Female
			East Coast			
1.5	584	500	0.91	0.76	275	189
2.0	613	500	1.59	1.29	226	154
2.5	777	541	3.11	2.17	242	144
3.0	1 323	635	8.02	4.02	350	148
			West Coast			
1.5	8 448	8 751	0.46	0.84	5 707	4 071
2.0	7 664	8 881	0.64	1.44	4 335	3 339
2.5	7 355	9 704	0.91	3.02	3 314	2 850
3.0	7 455	11 444	1 34	5.02	2 874	3 166

The exploitation of male squid was at almost optimum level at M/K = 1.5. At the next level of M/K = 2 the MSY can be obtained with an increased effort of 60% but the increased yield will be 5% only; at M/K = 2.5 and 3 the effort has to be increased by about 200 and 700% respectively. In the case of females at M/K = 1.5 level the exploitation has already gone beyond the MSY. But in the other 3 ranges of M/K the MSY can be achieved by increasing the effort by 30, 100 and 300% respectively.

On the west coast in the case of males

at the first 3 M/K levels the yield had gone beyond MSY and in the fourth level of M/K = 3, about 30% increase in effort is needed to obtain the MSY. For females, at the first level the yield had already exceeded the MSY but at the other 3 levels much larger increases in effort is required to reach the MSY.

Loligo duvauceli accounts for 42% of the cephalopod landings in the country. Bulk of the production (86%) is obtained from the operation of shrimp trawls in the coastal zone up to 50 m depth, most of the catch coming from the 20 - 30 m depth zone. The catches come down drastically beyond 50 m depth contour.

The size of the squids caught in trawls normally ranged from 20 to 260 mm in males, and from 20 to 180 mm in females. Squids beyond this range have been observed only in very few numbers. This may suggest that larger squids prefer the water column towards surface where the trawl is not operated, or they migrate away from the fishing ground.

A shoal of spawning squids of this species, mostly made up of males in the size range 140 - 330 m, was observed off Alleppey during a post-monsoon period. The squids were caught in cast nets and scoop nets very close to the shore (Meiyappan and Srinath 1989). Similar phenomenon was observed later in monsoon period also. Therefore, trawl landings may be indicative of most part of the population but not the entire one, as there are chances that larger individuals are left out.

The Indian squid spawns throughout the year but information on its spawning behaviour, spawning grounds and juveniles is wanting. Spent individuals of either sexes were rarely come across in the fishery. This may be an indirect evidence of post-spawning mortality, a phenomenon observed in some cases like the Japanese flying squid and the opalescent squid (Roper *et al.* 1984), or migration out of fishing grounds after spawing.

The study of the growth of this species has posed problems as in the case of other squids. While Silas *et al.* (1986a) and Supongpan (1988) assumed that growth in length follows the classical von Bertalanffy Growth Formula, Meiyappan and Srinath (1989) gave a modified growth formula for weight and length which is nothing but a generalized VBGF. Lange (1981) fitted exponential growth in weight in *Loligo pealii*, while Lange and Sissenwine (1983) assumed asymptotic growth in squids. They are also of the opinion that some cohorts may follow linear growth depending upon the availability of food. In the present study we have fitted VBGF to arrive at the growth parameters.

Another aspect which needs attention is the estimation of natural mortality. Meiyappan and Srinath (1989) estimated the natural mortality using catch curve method based on the data collected on a shoal of spawning squids. As reliable estimates of 'M' could not be obtained with available methods, a range of M/K values was assumed for the estimation of mortality rates and stock sizes. The use of a range of M/K values covers a wider range of 'M' values. In other words, this amounts to giving 'confidence limits' to 'M' and a range of management options within this belt (Ref. J. Gulland's communication to the Editor of FISHBYTE, Vol.6, No.1, April 1988). The study of Silas *et al.* (1986 b) on the stock of this squid was also on the basis of an assumed value for M/K.

The estimates of MSY and F-factor analysis for the full range of M/K values indicated that the present level of exploitation is almost at the MSY level,

and any increase in effort may increase the catch only marginally.

RECOMMENDATIONS

Any recommendation to increase the effort to obtain the MSY for this resource by a gear like trawl net which is targetted towards a group of multi-species assemblage will not hold good without studying the gear in its totality. As pointed out by Murty (1989), when making assessments of a single species which is one of the components of a mixed fishery, the management measures taken for that component may conflict with those for the others. Attempts should be made, therefore, to make mixed fishery assessments with due consideration to all the individual components occurring in the fishery, if the management measures are to be meaningful. However, the present study is important as far as it gives a clear picture of the present exploitation of the squid and a gross estimate of its stock.

ACKNOWLEDGEMENTS

We thank Dr P S B R James formerly Director, CMFRI, for suggesting this topic and for the constant interest shown throughout the course of the study.

REFERENCES

Algaraja K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian Journal of Fisheries* 31: 177-208.

Caddy J F. 1983. The Cephalopods: Factors relevant to their population dynamics and to the assessment and management of stocks. Caddy J F. (ed.) Advances in Assessment of World Cephalopod Resources. *FAO Fisheries Technical Paper.* (231): 416-452.

Fields W G. 1965. the structure, development, food relations, reproduction and life history of the squid, *Loligo opalescens* Berry. *Calif. Dept. Fish and Game, Fish. Bull.* (131): 108 p.

Jones R. 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). *FAO Fisheries Technical Paper* (256): 118.

Kore B A and Joshi M C. 1975. Food of the squid *Loligo duvauceli* Orbigny. *Proceedings of the Indian Academy of Science* 81 B (i): 20-28.

Lange A M T. 1981. Yield-per-recruit analyses for squid *Loligo pealei* and *Illex illecebrosus* form the Northwest Atlantic. *Journal of Shellfish Reserach* 1 (2): 197-207.

Lange A M T and Sissenwine M P. 1983. Squid resources of the Northwest Atlantic. Caddy, J. F. (Ed.), Advances in Assessment of World Cephalopod Resources. *FAO Fisheries Technical Paper* (231): 21-54.

Meiyappan M M and Srinath M. 1989. Growth and mortality of the Indian squid (*Loligo duvauceli*) off Cochin, India. Venema S C and Van Zalinge N P. (Eds) Contributions to Tropical fish Stock Assessment in India. FI: GCP/INT/392/DEN/ 1: 1-14.

Murty V S. 1989. Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada. Venema, S C and Van Zalinge N P (Eds). Contributions to Tropical Fish Stock Assessment in India FI: GCP/INT/392/DEN/1: 69-86.

Nair K, Prabhahran, Meiyappan M M, Kuriakose P S, Srvesan R, Lipton A P, Mohamed Sunilkumar, Asokan P K, Mathew Joseph and Nagaraja D. 1992. Biology of squids. *Bulletin, Fisheries Survey of India* 23: 27-42.

Ommen V P. 1977. Studies on the food, feeding and fishery of certain cephalopods from the west coast of India. *Bulletin of Marine Science, University of Cochin* 8: 73-152.

Pauly D and David N. 1981. ELEFAN, a BASIC program for the objective extraction of growth parameters from length frequency data. *Meeres forsch* 28 (4): 205-11.

Rao G S. 1988. Biology of inshore squid *Loligo duvauceli* Orbigny, with a note on its fishery off Mangalore. *Indian Journal of Fisheries* 35 (3): 121-30.

Roper C F E, Sweeney M J and Nauen C E. 1984. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. *FAO Fisheries Synopsis* (125) 3: 277.

Silas E G, Satyanarayana Rao K, Sarvesan R, Prabhakaran Nair K and Meiyappan M M. 1982. The exploited squid and cuttlefish resources of India. A review. *Marine Fisheries Information Service T and E Ser.* 34: 1-16.

Silas E G, Satyanarayana Rao K, Sarvesan R, Prapharanakn Nair, Vidyasagar Kuber, Meiyappan

M M, Appanna Sastri Y and Narayana Rao B. 1986 a. Some aspects of the biology of squids. In: Silas E G. (Ed.) Cephalopod Bionomics, Fisheries and Resources of the Exclusive Economic Zone of India. *Bulletin, Central Marine Fisheries Research Insititute* 37: 38-48.

Silas E G, Sarvesan R, Meiyappan M M, Prabhakaran Nair, Srinath M, and Satyanarayan Rao K. 1986 b. Stock assessment: Squids and cuttlefishes at selected centres. Silas E.G. (Ed.), Cephalopod Bionomics, Fisheries and Resources of the Exclusive Economcl Zone of India. *Bulletin, Central Marine Fisherie Research Institute* 37: 71-79.

Sparre P. 1985. Introduction to tropical fish stock assessment. Rome, FAO, Denmark - Funds - in - Trust, FI: GCP/INT/392/DEN. manual 1: 338 p.

Sparre P. 1987. Computer Programme for fish stock assessment. Length-based fish stock assessment (LFSA) for Apple II Computers. *FAO Fisheries Technical Paper.*(101) Supply. 2: 217 p.

Supongpan M. 1988. Assessment of Indian squid (*Loligo duvauceli*) and mitre squid (*L. chinensis*) in the Gulf of Thailand. *FAO Fisheries Report.* (389): 25-41.