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STOCK ASSESSMENT OF THE KIDDI SHRIMP (Parapenaeopsis stylifera) OFF COCHIN, INDIA

by

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ABSTRACT

Reviewing the recent trends in production an attempt is made to assess the stock of Parapenaeopsis stylifera off Cochin using length frequency data collected during 1983-87. The trawl fishery shows an increasing trend in catch as well as CPUE, with an average annual production of 1400 tonnes for the period 1979-86. Growth parameters have been estimated for females: L_∞ = 13.5 cm and K = 1.05 per year, and for males: L_∞ = 10.8 cm and K = 1.19 per year. Stock size and exploitation level have been estimated by cohort analysis. The study shows that a further increase in fishing effort will not be advantageous.

1 INTRODUCTION

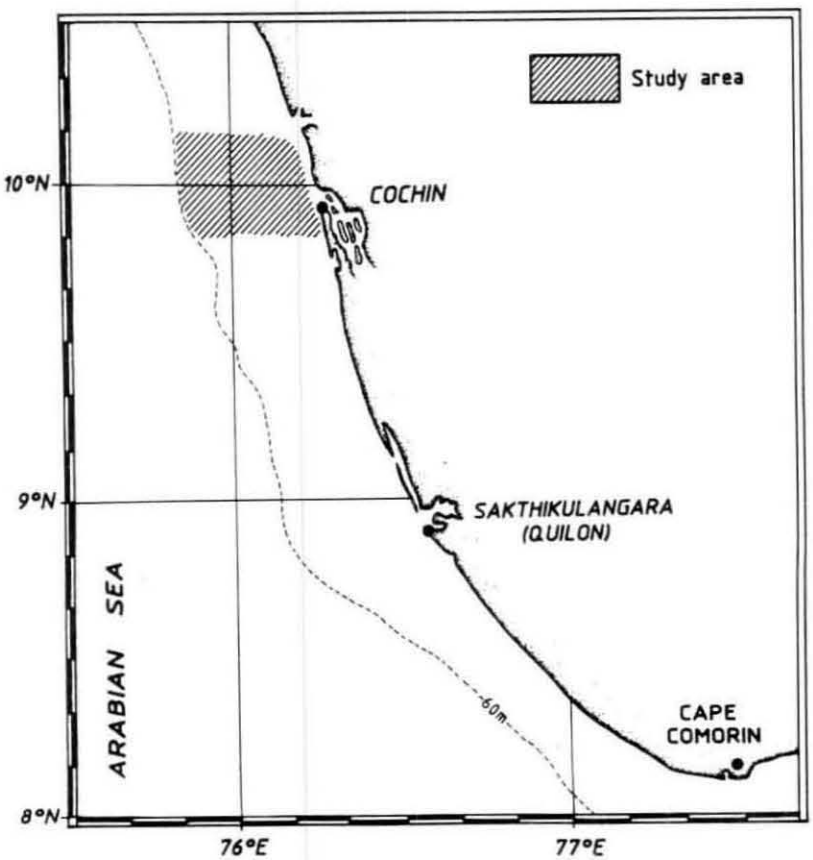
Among the maritime states of India, Kerala ranks first in the production of penaeid shrimps, which form the mainstay of the seafood export industry of the country. The increasing demand for Indian shrimp products in foreign markets like Japan, U.S.A., etc. which began some time in the late fiftees, has led to a large-scale exploitation of this resource in the coastal waters of the state by mechanised as well as non-mechanised fisheries. Though this has brought about a phenomenal increase in the production of shrimp over the past three decades, the wide annual fluctuations in the landings observed in recent years call for proper assessment of the stocks of those species on which the fishery is based, so that appropriate management measures can be taken to maintain the maximum sustainable yield levels.

The shrimp fishery off Kerala, as in other regions of India, is multispecies in character, each species having slightly different biological features and distributions in space and time. The total landings of shrimp in Kerala amount to 33,000 tonnes. The most important species constituting the fishery are Parapenaeopsis stylifera (H. Milne Edwards) (69% or 22,770 t), Metapenaeus dobsoni (Miers) (18% or 5940 t), M. monoceros (Fabricius), M. affinis (H. Milne Edwards) and Penaeus indicus (H. Milne Edwards). At present over 79% (26,300 t) of this catch is landed by trawlers. Sakthikulangara and Cochin are the two major shrimp landing centres. In the present paper, an attempt is made to assess the stock of P. stylifera off Cochin based on the landings of commercial trawlers for the period 1983-1987.

2 BIOLOGY

Parapenaeopsis stylifera (locally known as Karikkadi chemmeen) is one of the smaller shrimp species widely distributed in Indian waters. It is a coastal species, but known to occur at depths up to 90 m in the western Indian Ocean (Miquel, 1984). In Indian waters, it has been recorded up to a maximum depth of 60 m along the Kerala coast. Being commercially important, considerable work has been done on the biology of this species at various centres along the Indian coast. Notable contributions are those of Shaikmahamud and Tembe (1958, 1960, 1961) and Kagwade (1980) for the Bombay waters, Ramamurthy (1980) for the Mangalore coast and Menon (1953), George and Rao (1967) George et al. (1963, 1968), Rao (1968, 1970, 1972) and Kurup and Rao (1974) for the Kerala coast. Unlike most of the other commercially important species P. stylifera does not have an estuarine phase in its lifecycle, which is entirely completed in the sea.

P. stylifera is heterosexual, and females grow to a larger size than the males. According to Menon (1953), males attain maturity at 6.5 cm total length and females at 7.5 cm, while Rao (1968) statistically estimated the minimum size at first maturity of females at 6.32 cm. The smallest mature female observed in the commercial fishery at Cochin is about 7.0 cm. Breeding takes place throughout the year, with definite peaks, which vary from place to place and year to year. At Cochin, November to January and April form the peak spawning periods (George et al., 1968). P. stylifera is believed to spawn many times during its life time in comparatively shallow waters within 25 m depth. At a total length of 7.0 cm an average of 39,500 eggs are produced while at 12.0 cm this is 23,600 eggs (Rao, 1968). Metamorphosis is completed in the early stages up to about 7.0 cm in males and 8.0 cm in females, but thereafter it slows down. According to Rao (1970), at 7.8 cm total length they are about 4-5 months old. George et al. (1968) noticed in the trawl fishery off Cochin that the males grow from 8.1-8.5 cm to 9.6-10.0 cm and females from 8.6-9.0 cm to 10.6-11.0 cm during a period of 4 months. The species has been reported to live for more than two years, but George et al. (1968), Rao (1970) and the present authors have noticed that the average lifespan is much shorter, extending for about 12 to 15 months only.



3 DESCRIPTION OF THE FISHERY

3.1 Fishing grounds, crafts, gear and fishing seasons

The shrimp fishing grounds off Cochin lie between latitudes 9°50'N and 10°10'N covering a distance of about 35 km along the coast. From September to May trawling is confined to the inshore areas within the 35 m depth contour, but during the south-west monsoon (June-August) operations shift to deeper waters upto about 60 m (Suseelan et al., in press) (Fig. 1). The bottom of the trawling grounds is generally muddy.

Though a minor fishery exists along this coast by traditional gears such as boat-seines, bottom-set gill nets, cast-nets etc., particularly during the monsoon period, it is entirely supported by other species of penaeid prawns, while P. stylifera is exploited only by the shrimp trawlers. These are 8-13 m long and powered by 25 to 90 HP inboard engines. These vessels make single day cruises starting from base early in the morning and returning in the evening after taking 3 or 4 hauls of 1 to 1 1/2 hours duration. Usually a four seam shrimp trawl with a 12 to 28 m head rope and a codend mesh size of 2.5 cm is used. At present an average of about 200 trawlers operate from this centre every day.

Shrimp fishing is carried out almost throughout the year, but P. stylifera is mainly caught from December to September with a peak in July.

Table 1 Parapenaeopsis stylifera. catch, effort CPUE and percentage of total shrimp landings at Cochin, 1979-86

Year	Estimated landings (t)	Estimated effort (n. of boat trips)	Catch/boat trip (kg)	Percentage of total shrimp landings
1979	942	44057	21.4	28.0
1980	759	46149	16.4	21.6
1981	1249	44323	28.2	49.3
1982	1525	51098	29.8	46.9
1983	2198	43157	50.9	61.9
1984	1633	39613	41.2	64.7
1985	430	28095	15.3	27.8
1986	2471	46093	53.6	69.5

3.2 Trends in production

An organized commercial shrimp fishery by mechanised vessels began at Cochin in 1958 (Rao, 1970) following the encouraging results of the exploratory cum-commercial trawling operations of the Indo-Norwegian Project that started off the Kerala coast in 1953. According to George et al. (1963), the estimated annual production of P. stylifera during the initial stage of the fishery ranged from 104 to 318 t. The fishery registered a steadily increasing trend over the past two and a half decades relegating the once dominating species Metapenaeus dobsoni to a secondary position. The catch statistics are shown in Table 1. In terms of total landings as well as catch rates the fishery showed an upward trend from 1981 to 1983. After a decline in 1984/85 a maximum of 2471 t was reached in 1986.

In the earlier years shrimp trawlers operated only during the fair seasons, and the fishery remained totally suspended throughout the monsoon period. From about the middle of the seventies the vessels started to operate during the southwest monsoon and then the catch rates proved to be much higher than in other seasons. With the commencement of the southwest monsoon in June the population of P. stylifera moves en masse to deeper areas and remains at 30-60 m depth throughout July and August (Suseelan et al., in press). They move to the coastal waters again in September.

Table 2 Parapenaeopsis stylifera: Monthly catch and effort data, Cochin, 1983-87. Catch in tonnes, effort in number of boat trips and catch per boat trip (C/E) in kg

Year		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1983	Catch	36.0	26.0	79.0	135.7	300.7	133.8	885.1	244.0	207.7	78.1	4.0	67.6	2197.7
	Effort	3689	3455	3902	4965	5828	4199	5806	3651	1615	1131	831	4085	43157
	C/E	9.7	7.4	20.2	27.3	51.6	31.9	152.4	66.8	128.6	69.0	4.8	16.5	50.9
1984	Catch	27.3	59.6	205.0	215.0	337.2	172.9	615.0	1.1	0.2	-	-	0.1	1633.4
	Effort	3521	4561	4565	5299	5362	4726	5850	4239	34	6	20	1430	39613
	C/E	7.7	13.1	44.9	4.1	62.9	36.6	105.1	0.3	5.0	-	-	0.1	41.2
1985	Catch	16.5	8.6	105.0	73.9	57.4	91.0	73.5	3.1	No	No	-	1.3	430.3
	Effort	2322	3512	4025	4327	3594	3531	2320	378	Traw-	Traw-	234	3852	28095
	C/E	7.1	2.4	26.1	17.1	16.0	25.8	31.7	8.3	ling	ling	-	0.3	15.3
1986	Catch	14.8	11.3	20.5	47.4	326.2	336.1	1514.5	196.8	0.1	No	-	3.5	2471.2
	Effort	4555	4454	3536	4516	6669	6371	6028	3632	241	Traw-	2995	3096	46093
	C/E	3.2	2.5	5.8	10.5	48.9	52.8	251.2	54.2	0.2	ling	-	1.1	53.6
1987	Catch	9.1	19.8	48.2	176.2	160.1	689.1	-	-	-	-	-	-	-
	Effort	4863	3283	4378	5554	6900	6276	-	-	-	-	-	-	-
	C/E	1.9	6.0	11.0	31.8	23.2	109.8	-	-	-	-	-	-	-

Table 2 gives the monthly catch and effort data for the period 1983-87. The fishery started every year in December, except during 1983, and lasted till September/October. The maximum production of P. stylifera is recorded between March and July. After attaining its peak in July the fishing effort dwindles to what practically amounts to a closed season between September and October. Only in 1983 the fishery continued throughout the year.

3.3 Size distribution, recruitment and sex ratios

The size range of the species in the fishery was 3.5-11.5 cm total length for females and 3.5-10.0 cm for males, the bulk of the landings being supported by the size groups 6.0-10.0 cm in females and 6.0-9.0 cm in males. The monthly size frequency distribution has a multimodal pattern in most of the months indicating mixing of several broods in the fishery. The frequency polygons of all the months invariably have a prominent mode between 6.5 cm and 9.5 cm in females and 6.5 cm and 8.0 cm in males. Active recruitment of younger shrimps into the fishery is observed between February and July. The distribution of sex ratios in the fishery (Table 3) indicates that the two sexes were more or less equally represented throughout the most productive period March to July. From August to January, the females were more numerous than males.

4 MATERIAL AND METHODS

Catch, effort and length frequency data collected from commercial shrimp trawlers operating from Cochin Fisheries Harbour during 1983 to 1987 form the main data base of this study. Monthly estimates of catch and effort were made based on 16-18 days observations of the landings each month. To study length frequency and other biological aspects, an unbiased random sample consisting on an average of about 250 specimens of each sex was taken once a week when landing data were also recorded.

Table 3 Parapenaeopsis stylifera: monthly sex ratios at Cochin, 1984-86 (in %)

Month	1984		1985		1986	
	Male	Female	Male	Female	Male	Female
Jan.	46.0	54.0	56.5	43.5	32.0	68.0
Feb.	49.0	51.0	59.4	40.6	55.2	44.8
Mar.	46.5	53.5	41.4	58.6	52.5	47.5
Apr.	58.1	41.9	50.4	49.6	44.2	55.9
May	48.8	51.2	48.8	51.2	47.2	52.8
June	47.6	52.4	46.9	53.1	46.5	53.5
July	54.8	45.2	51.2	48.8	44.3	55.7
Aug.	48.6	51.4	28.5	71.5	38.9	61.1
Sept.	-	-	-	-	32.4	67.6
Oct.	-	-	-	-	-	-
Nov.	-	-	-	-	-	-
Dec.	36.2	63.8	38.2	61.8	38.6	61.4
Annual	51.9	48.1	53.1	46.9	44.8	55.2

The samples were analysed in fresh condition in the laboratory. After sex-wise sorting out, the total length from the tip of the rostrum to the tip of the telson was measured to the nearest millimeter keeping the abdomen fully stretched. The total weight by sex in the sample was also recorded for the purpose of sex-wise estimation of the catch. For length frequency analysis, they were sex-wise grouped into 0.5 cm class intervals and raised to the total estimated landings. In the present study the average catch per month (Tables 4 and 5) for the entire period of data was used and the estimates of growth and mortality parameters made separately for males and females because of the differential growth rates between the sexes.

The estimation of parameters were made by microcomputer, using the Length Based Fish Stock Assessment (LFSA) package (Sparre, 1987). For each month and each sex the length frequency samples were resolved into normally distributed cohort components using the Bhattacharya method. The results of the Bhattacharya analysis were then used as input to the modal progression analysis and the Gulland and Holt plot, from which the growth parameters L_∞ (asymptotic length) and K (curvature parameter) were estimated.

The average total number of shrimp landed per year by length group, the estimated growth parameters and the natural mortality (calculated by Pauly's formula) were used as input for the Jones' length converted cohort analysis. The combined estimates of F (from cohort analysis) and M (Pauly's formula) were compared to the value of Z estimated from the length converted catch curve analysis, which was also used to estimate the "resultant" selection ogives, data for a "clean" mesh size assessment were not available.

The current state of the stock and the potentials were assessed using the length converted Thompson and Bell analysis. Males and females were combined in a mixed fishery analysis (Sparre, 1985 and Murty, this volume). Inputs for this analysis were the fishing mortalities and the average recruitment estimated by length converted cohort analysis. The catches were predicted under different assumptions of future fishing patterns (i.e. different arrays of fishing mortalities by length group). For each fishing pattern a range of alternative levels of fishing effort were considered, whereby catch in weight (yield) and stock biomass as a function of effort were calculated. A fishing pattern was modeled by the logistic curve, using the parameters:

Table 4 Average monthly number landed of P. stylifera females at Cochin Fisheries Harbour for the period 1983-87 (in thousands)

total length	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OKT	NOV	DEC	Total
3.5-													
4.0-						166							166
4.5-		2	87	121	129	2488	167						2993
5.0-	49	19	256	112	930	3676	3067	1					8110
5.5-	240	120	600	1923	1720	4859	5633	4	234				15333
6.0-	404	104	1153	2407	5098	5252	11046	118	1053	298	7	7	26947
6.5-	355	137	1890	3635	6502	6723	16093	778	671	355	8	103	37250
7.0-	405	238	1944	4415	9358	6630	25276	1415	1596	827	25	195	52323
7.5-	478	486	1783	3058	7962	7652	22125	2463	1754	1173	42	328	49304
8.0-	431	454	2643	2303	7137	6455	26019	2766	1777	443	11	390	50827
8.5-	206	537	2162	1504	5245	6854	13814	2643	1578	440	11	623	35614
9.0-	313	380	1841	1496	2494	5038	13265	1431	1209	172	16	391	28046
9.5-	260	517	1711	1331	2023	4045	5691	1356	559	123	12	138	17767
10.0-	118	403	1047	760	792	1716	2437	337	118	7	18	204	7957
10.5-	154	107	653	643	562	1582	1563	183		21	7	176	5650
11.0-	67	29	827	221	69	356	525	78			4	9	2184
11.5-	48	26	252	87		168							580
12.0-		4	102	9									114
Total	3527	3561	18949	24026	50020	63659	146723	13571	10549	3858	159	2564	341165

Table 5 Average monthly number landed of P. stylifera males at Cochin Fisheries Harbour for the period 1983-87 (in thousands)

total length (cm)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
3.5						225							225
4.0				51		345							397
4.5		2		51	41	1275	226						1595
5.0	12	15	145	351	161	1624	967						3275
5.5	135	92	815	2728	1734	2110	1529	12	117			5	9276
6.0	454	267	2802	6559	8777	3919	8518	67	353	244	9	13	31982
6.5	674	346	3670	8186	14460	7035	21850	507	962	750	45	100	58583
7.0	111	609	4836	6120	15748	12656	34319	3469	2173	1134	72	646	82493
7.5	370	854	4976	3238	5362	11642	34783	4228	2521	618	12	956	69559
8.0	527	801	2158	1284	766	8591	27437	3686	1104	239	12	418	47022
8.5	98	280	944	596	244	2469	10359	1568	285	44	3	139	17028
9.0	46	170	148	279	67	626	1797	270		151		75	3628
9.5	17	28	6	59		115		75					299
Total	3043	3463	20498	29502	47361	52632	141785	13881	7514	3181	152	2350	325362

Table 6 Estimation of growth parameters for P. stylifera females by the Gulland & Holt plot. L_∞ = 13.5; K = 1.05

t1 (1985)	t2 (1985)	dt	L(t1)	L(t2)	$\bar{L}$	dL/dt
Feb. 15	Apr. 15	0.16	6.05	7.01	6.53	5.93
Apr. 15	May. 15	0.08	7.01	7.60	7.31	7.16
May. 15	Jun. 15	0.09	7.60	8.41	8.00	9.50
Jun. 15	Jul. 15	0.08	8.41	8.77	8.59	4.47
Jul. 15	Sep. 15	0.17	8.77	9.32	9.05	3.22
Sep. 15	Oct. 15	0.08	9.32	9.44	9.38	1.46
Oct. 15	Dec. 15	0.17	9.44	10.44	9.94	6.00

L50%: The length at which 50% of the shrimps are available to the fishery

L75%: The length at which 75% of the shrimps are available to the fishery

Fmax: Fishing mortality of shrimps under maximum exploitation (i.e. the level of the right hand side of the selection ogive)

The parameters L50% and L75% were estimated from the length converted catch curve using the method described in Sparre (1985) and Fmax was taken from cohort analysis. These predictions of yield and biomass are made assuming that recruitment and all other parameters of the system remain constant. The predictions do not deal with any particular year, but give the average long term picture.

5 RESULTS

5.1 Length-weight relationship

The relationship between total length and weight of P. stylifera was determined from a sample of 35 males and 29 females taken from the commercial catches, and is expressed in the exponential form

$$W = aL^b,$$

where W is the weight in grams, L the total length in cm and a and b are parameters. The equations found for the two sexes are as follows:

Female: $W = 0.000557\ L^{4.13}$ $(r = 0.99)$

Male : $W = 0.000652\ L^{4.09}$ $(r = 0.99)$

5.2 Estimation of growth parameters

It was assumed that the growth of the shrimp follows the von Bertalanffy Growth Formula (VBGF)

$$L_t = L_\infty\ (1-e^{-K(t-t_o)})$$

The mean lengths for cohorts estimated by the Bhattacharya method for females and males are given in Tables 6 and 7. Applying a Gulland and Holt plot L_∞ and K have been estimated and the values obtained for the different sexes are shown below. The method does not produce an estimate of t_o.

Sex	L_∞(cm)	K (annual)
Female	13.5	1.05
Male	10.8	1.19

Table 7 Estimation of growth parameters for P. stylifera males by the Gulland and Holt plot. L_∞ = 10.8; K = 1.19

t1 (1985)	t2 (1985)	dt	L(t1)	L(t2)	$\bar{L}$	dL/dt
May. 15	Jun. 15	0.09	6.90	7.37	7.13	5.53
Jun. 15	Jul. 15	0.08	7.37	7.57	7.47	2.37
Jul. 15	Aug. 15	0.09	7.57	7.90	7.73	3.92
Aug. 15	Dec. 15	0.33	7.90	8.97	8.43	3.20

5.3 Estimation of mortality parameters and stock size

The instantaneous rate of natural mortality (M) was calculated using Pauly's (1983) equation given the mean temperature of the trawling ground as 27°C. Computational details of the estimation of the fishing mortality (F) by Jones' length cohort analysis are presented in Tables 8 and 9 and the results in Fig. 2. The terminal exploitation rate (F/Z) was chosen so that the exploitation rate for the last 5 length groups became approximately equal. The approach is based on the assumption that the last 5 length groups are all under full exploitation, have the same mortality rates and therefore also the same exploitation rate. The value chosen was obtained by a few iterative trials.

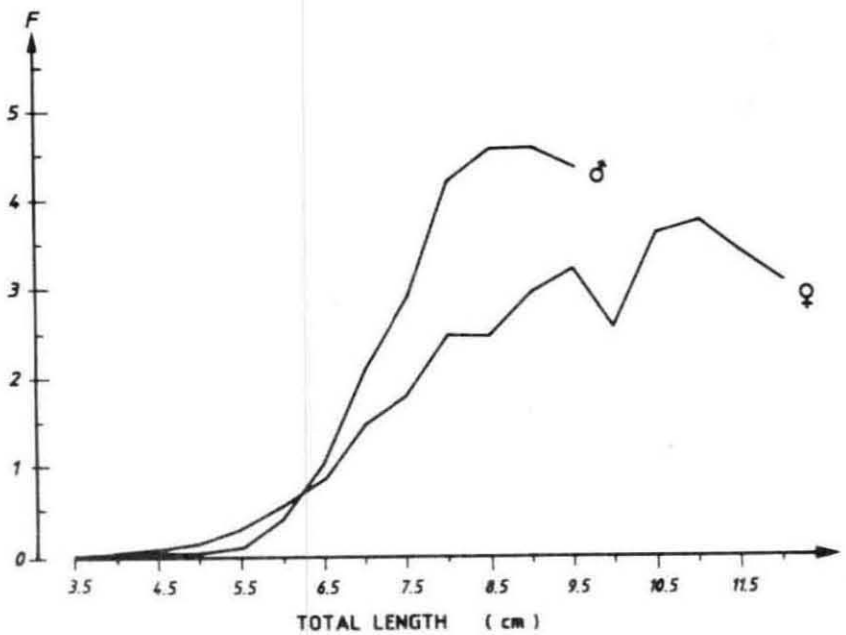


Fig. 2 Fishing mortality rates (F) of P. stylifera by sex and length groups, based on length cohort analysis

The mean value of F is calculated in order to compare the result of the cohort analysis with the result of the length converted catch curve analysis. Therefore the starting point of the range used must be the same for both methods. The total instantaneous mortality (Z) was directly estimated by analysis of the length converted catch curve as shown in Figs. 3 and 4. The mean values of the mortality parameters estimated by the above methods are as follows:

Sex	M	F	M + F	Z
Females	2.3	2.1	4.4	4.4
Male	2.6	2.8	5.4	5.2

Using the results of Jones' length cohort analysis (Tables 8 and 9) in the (length converted) Thompson and Bell model, gives estimates of the current size of stock biomass and potential yield (Table 10). Figs. 5 and 6 give the values of yield and biomass at different levels of fishing effort, compared to the actual level (XX = 1.0). It is seen that at the current level of effort the yield is about 1100 tonnes per annum for females; 1000 t for males and 2100 t for both sexes combined. The exploitation rate E = F/Z is 0.48 for females and 0.52 for males.

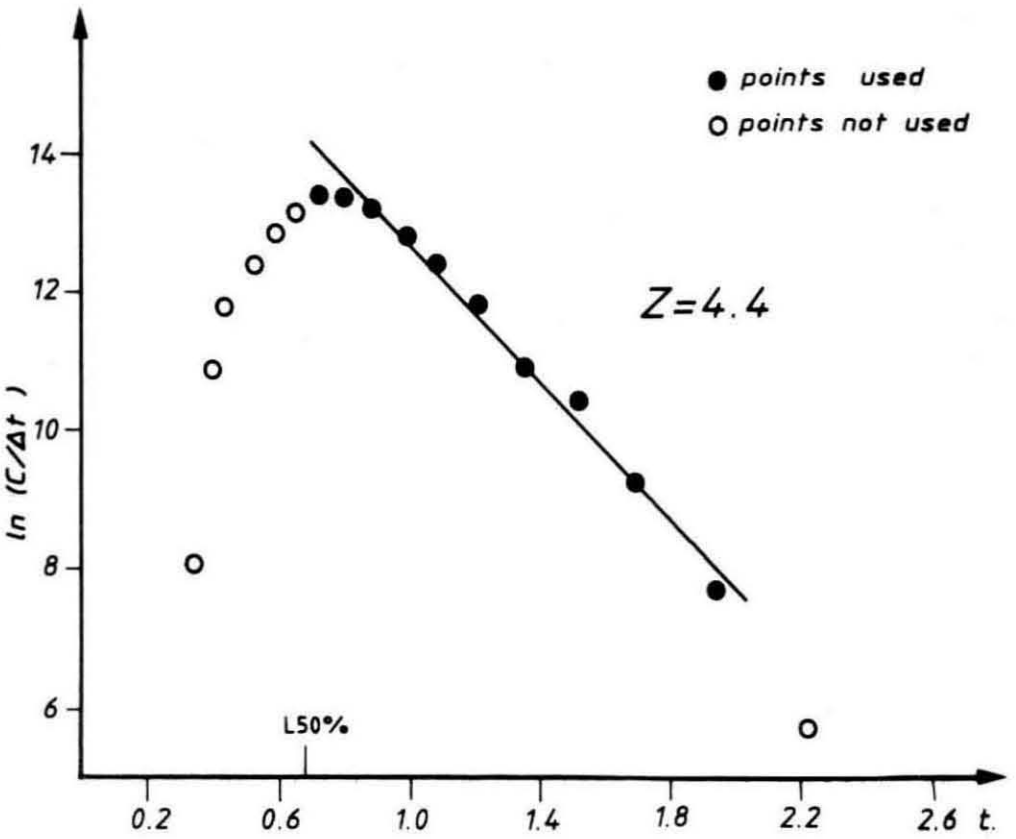


Fig. 3 Length converted catch curve for P. stylifera, females

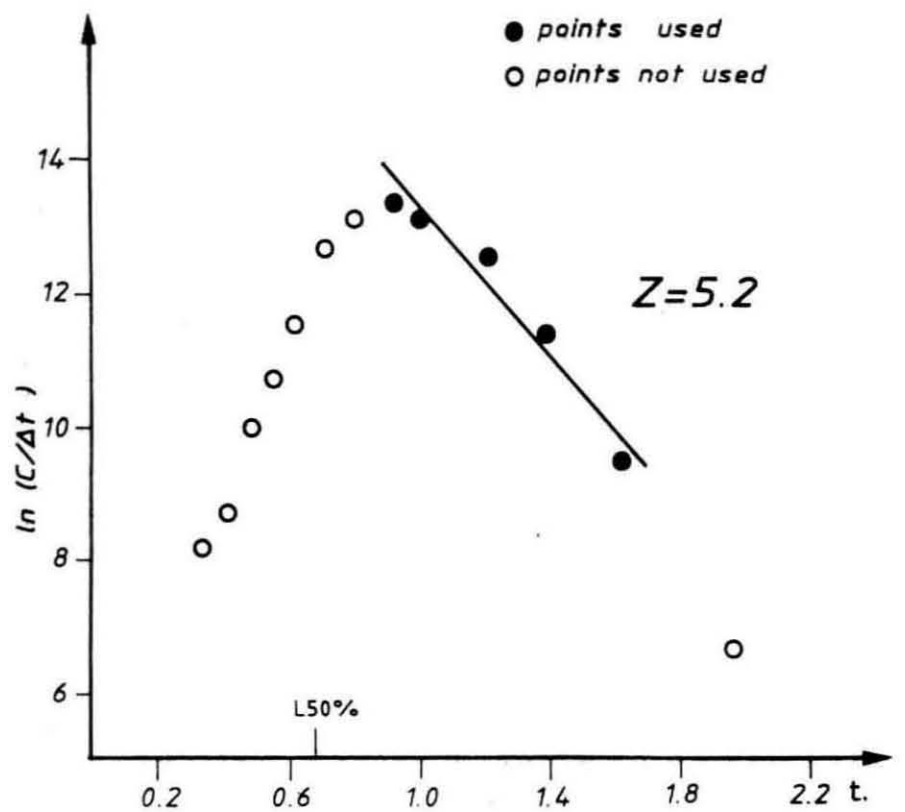


Fig. 4 Length converted catch curve for P. stylifera, males

Table 8 Length cohort analysis of P.stylifera, females

length	C	N	F/Z	F	Z
3.5- 4.0	0	1514935	0.00	0.00	2.30
4.0- 4.5	166	1353936	0.00	0.00	2.30
4.5- 5.0	2993	1202560	0.02	0.05	2.35
5.0- 5.5	8109	1058227	0.06	0.14	2.44
5.5- 6.0	15333	909040	0.11	0.29	2.59
6.0- 6.5	26947	783595	0.20	0.57	2.87
6.5- 7.0	37250	648701	0.28	0.91	3.21
7.0- 7.5	52323	517152	0.40	1.53	3.83
7.5- 8.0	49303	386052	0.44	1.81	4.11
8.0- 8.5	50827	274236	0.52	2.51	4.81
8.5- 9.0	35614	176775	0.52	2.52	4.82
9.0- 9.5	28045	108610	0.57	3.03	5.33
9.5-10.0	17766	59260	0.58	3.24	5.54
10.0-10.5	7956	28882	0.53	2.60	4.90
10.5-11.0	5649	13885	0.61	3.66	5.96
11.0-11.5	2183	4686	0.62	3.75	6.05
11.5-12.0	579	1164	0.60	3.44	5.74
12.0-plus	114	196	0.58	3.18	5.48
	Total	9051901			

Mean F (L≥7) = 2.1, Terminal exploitation rate: 0.58
L_∞ = 13.5 cm, K = 1.05/year, M = 2.3/year
q^∞ = 0.00557, b = 4.13 in $W = qL^b$

Table 9 Length cohort analysis of P. stylifera, males

length groups	C	N	F/Z	F	Z
3.5- 4.0	224	2087139	0.00	0.00	2.60
4.0- 4.5	396	1787214	0.00	0.00	2.60
4.5- 5.0	1595	1512178	0.01	0.02	2.62
5.0- 5.5	3275	1260773	0.01	0.04	2.64
5.5- 6.0	9276	1032399	0.04	0.12	2.72
6.0- 6.5	31982	823099	0.16	0.48	3.08
6.5- 7.0	58583	618893	0.30	1.10	3.70
7.0- 7.5	82492	421229	0.45	2.15	4.14
7.5- 8.0	69558	238783	0.53	2.98	5.58
8.0- 8.5	47022	108633	0.62	4.24	6.84
8.5- 9.0	17028	32752	0.64	4.62	7.22
9.0- 9.5	3627	6143	0.64	4.62	7.22
9.5-plus	299	475	0.63	4.43	7.03
	Total	9929716			

Mean F (L≥7) = 2.8, Terminal exploitation rate: 0.63
L_∞ = 10.8 cm, K = 1.19/year, M = 2.6/year
q^∞ = 0.00806, b = 4.09 in $W = qL^b$

Table 10 Length converted Thompson and Bell analysis of yield and mean biomass for P. stylifera (females and males) in tonnes

xx 1)	females		males	
	yield	biomass	yield	biomass
0.0	0	1728	0	1356
0.2	600	1258	492	1074
0.4	868	994	725	919
0.6	997	828	852	820
0.8	1062	716	928	752
1.0	1095	635	977	702
1.2	1110	573	1011	663
1.4	1115	525	1034	632
1.6	1115	487	1052	606
1.8	1110	455	1065	585
2.0	1104	429	1075	566
2.2	1096	406	1082	549
2.4	1088	387	1088	535
2.6	1079	370	1093	522
2.8	1070	355	1097	510
3.0	1061	342	1099	500

1) xx is the "F-factor", where xx=1 corresponds to the present level of fishing. MSY and Biomass at MSY ar underlined.

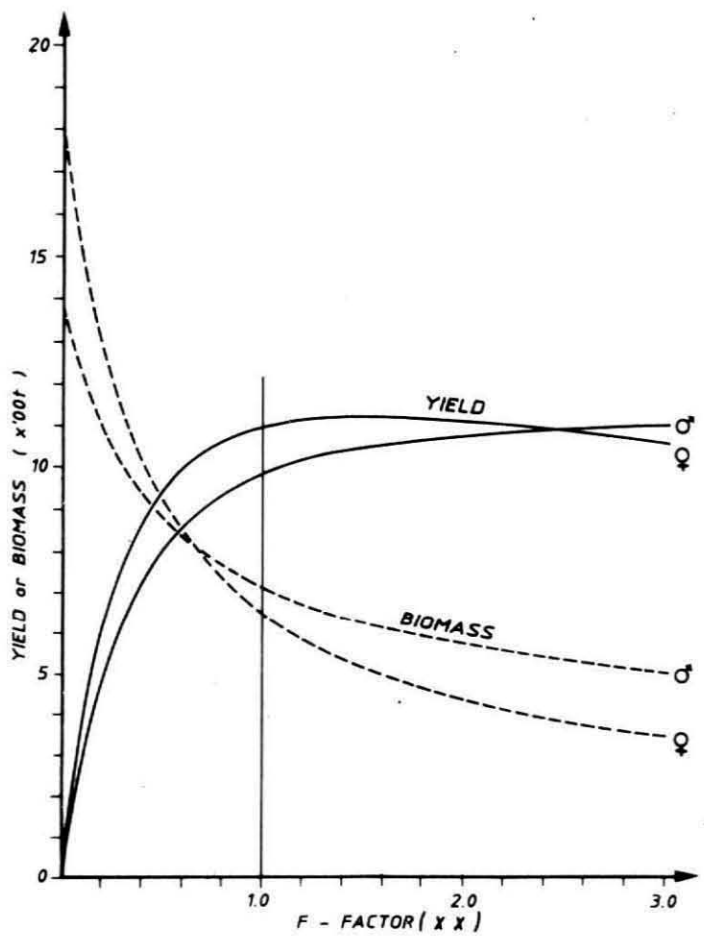


Fig. 5 Yield and biomass curves of different levels of effort in relation to current level (XX = 1.0, see vertical line), separately for females and males of P. stylifera

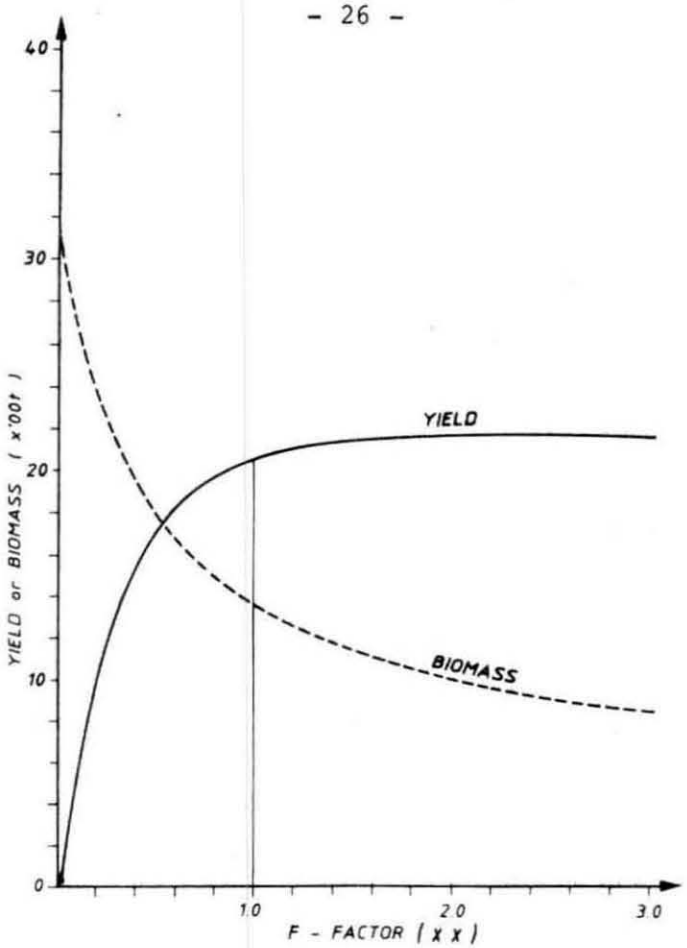


Fig. 6 Yield and biomass curves at defferent levels of effort (see Fig. 5), for P. stylifera, females and males combined

The maximum sustainable yield for females is maximal 1100 t for an F-factor (XX) of 1.4, and also 1100 t for males for an F-factor of 3.0. Combining the data of both sexes results in a maximum sustainable yield of 2200 t for a mean F-factor of 2.1.

5.4 The L50% analysis

Table 11 gives the input for the L50% analysis, which is required in addition to the natural mortality and the recruitment figures. Tables 12a, b and c give the estimated yields for females, males, females + males combined respectively. In each case 25 alternative combinations of L50% and effort were considered, namely 50% reduction, 25% reduction, no change, a 25% increase and 50% increase of each variable. The ratio L75%/L50% was assumed to remain constant.

Each entry in Tables 12a-c represents the result of a complete length converted Thompson and Bell analysis.

Table 11 Results of selection analysis based on the length converted catch curve analysis

	length (cm)		
	$L_{50\%}$	$L_{75\%}$	F_{max}
Female	6.8	7.3	3
Male	6.9	7.2	3

Table 12 L50% analysis for P. stylifera, Cochin. Total yield (tonnes) as a function of relative L50% and effort

A. Females

Relative L50%/Eff.	0.50	0.75	1.00	1.25	1.50
0.50	770	742	683	621	567
0.75	893	928	913	882	849
1.00	955	1059	1100 *)	1113	1113
1.25	861	1004	1085	1135	1167 **)
1.50	598	731	821	885	934

B. Males

Relative L50%/Eff.	0.50	0.75	1.00	1.25	1.50
0.50	750	779	761	728	693
0.75	823	919	956	967	965
1.00	730	865	946 *)	997	1031 **)
1.25	430	540	618	678	724
1.50	113	158	198	232	264

C. Males and females

Relative L50%/Eff.	0.50	0.75	1.00	1.25	1.50
0.50	1521	1521	1443	1349	1260
0.75	1716	1847	1869	1849	1813
1.00	1685	1924	2046 *)	2110	2144 **)
1.25	1291	1543	1704	1813	1891
1.50	711	889	1018	1118	1198

*) current values
**) maximum values in table

6 DISCUSSION

Among the various species of shrimps contributing to the commercial fishery of India, P. stylifera is the most widely distributed and heavily exploited one particularly on the West coast. The catch and effort data pertaining to this species at Cochin Fisheries Harbour indicate a progressive trend in production as compared to the declining fishery of Sakthikulangara (Rajan and Suseelan, in press). It is not known whether the fisheries of these two neighbouring areas are of the same stock or not. A systematic study is needed to throw light on this aspect.

Attempts made to estimate the growth and mortality parameters of the species at different centres yielded varying results. The value of asymptotic length estimated for female shrimps in the present study compares well with the estimates of the earlier workers (Kurup and Rao, 1974; Ramamurthy, 1980; Alagaraja et al., 1986). In the case of males, however, the value shows some deviation from the known estimates. Kurup and Rao (1974) recorded an asymptotic length of 12.6 cm for males in the Ambalapuzha fishery, while the values of Ramamurthy (1980) from Mangalore and Alagaraja et al. (1986) from Cochin were 11.4 cm and 13.0 cm respectively. The present estimate of 10.8 cm appears to be more realistic when considering the largest size of 10.0 cm encountered in the fishery.

In an earlier study of the same fishery, Alagaraja et al. (1986) obtained slightly higher exploitaition rates for both sexes. They also observed a difference in fishing pressure for males and females. The fishing mortality estimates and exploitation rates arrived at during the present analysis reveal that males are subjected to a higher fishing pressure than females. This may, however, be connected to the estimation of the growth parameters.

In 1986 2471 tonnes of P stylifera were landed at Cochin by trawlers. The length converted cohort analysis indicates that the average annual yield is about 2100 tonnes at the existing level of fishing. This is very close to the MSY level (of 2200 tonnes, derived from the length converted Thompson & Bell analysis) which was already surpassed in 1986. A further increase in fishing input is bound to bring down the mean biomass (Fig. 6) and eventually the catch-per-unit of effort, which is likely to make the fishing operations uneconomical. The present level of fishing therefore appears to be close to the optimum for this fishery.

The L50% analysis (Table 12) shows that a change in L50% is unlikely to produce a higher yield. For the five different levels of effort considered the optimum level of L50% turned out to be the current level. The implications of these findings as far as mesh size regulation is concerned have to be based on speculations, as no direct observations on gear selectivity are available.

The selection ogive estimated by the catch curve analysis is the resultant curve, i.e. the product of the gear selectivity and the ogive for the recruitment to the fishing grounds. The selectivity of the gear is the combined effect of a number of factors of which mesh size is only one. Other factors are, for example, trawling speed, haul duration, by-catches and rigging of gear. Thus, it is possible that there is no direct relationship between L50% of the selection ogive from catch curve analysis and SF * M = (gear selection factor) * (mesh size).

In the present context "selection factor" means (50% retention length)/(mesh size) obtained from a gear selection experiment (e.g. a covered cod-end experiment). It should be noted that SF * M (= 50% retention length) is expected to be smaller than or equal to L50% and that Lr (= the length at which 50% of the shrimps has recruited to the fishery) is smaller than or equal to L50%.

If Lr is larger than SF * M then (approximatively) Lr = L50% and relatively small changes of the mesh size will have no impact. If SF * M is larger than Lr there may be an impact of a mesh size change. If SF * M is larger than L50% this would indicate that the selectivity of the commercial gear is determined also by other factors than mesh size and consequently, the effect of a mesh size change may be less than expected.

If SF * M equals L50% we are in the situation where the selection ogive is determined by the mesh size only. If this is the case for the Cochin trawlers we are in a position to conclude from the analysis above, that no gain from a mesh size change is to be expected.

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