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AN APPRAISAL OF THE FISHERY OF *METAPENAEUS MONOCEROS* ALONG THE KAKINADA COAST*

G. SUDHAKARA RAO**

Central Marine Fisheries Research Institute, Cochin-682 014

ABSTRACT

An analysis of the data for the 12-year period 1967 to 1978, showed a gradual increase in the effort of trawlers from 1967. *Metapenaeus monoceros* forming about 12% of the prawn landings is an important component of the trawler catches. The fishery is generally better during January-May than in the other months. The landings of *M. monoceros* gradually increased from 20.3 t in 1967 to 485.6 t in 1974 and then fluctuated thereafter. Catch per hour (CPH) varied between 1.0 kg in 1967 to 0.4 kg in 1978. The CPH more or less gradually declined from 1974 to 1978. The proportion of adults, particularly one-year olds, in the catches gradually declined during the 1974-1977 period. These two factors indicate that the stock is at the threshold level of optimum exploitation. A negative correlation between the CPH of *M. monoceros* in trawler catches of an year and the rainfall of the previous year is noticed. There appears to be a positive correlation between the CPH of *M. monoceros* in trawler catches of one-year and the C/E of *M. monoceros* in estuarine catches of the previous year. Based on the estuarine fishery it is possible to predict the abundance of *M. monoceros* in the inshore waters 5-6 months in advance of the main fishing season.

INTRODUCTION

THE TRADITIONAL fishery along the Kakinada coast carried out by small plank built boats and catamarans using a variety of gear close to the shore. The exploratory surveys of the State Department of Fisheries in 1960-1962 indicated some rich prawn fishing grounds along this coast (Rao and Devara, 1962). These observations were later confirmed by Sebastian *et al.* (1964). The results of commercial ventures together with those of the exploratory and experimental surveys led to a rapid increase in the number of trawlers deployed in the area bringing in large quantities of prawns. By 1978, the number of boats operating for prawns reached a staggering 300.

Satyanarayana and Narayanappa (1973) reviewed the results of experimental trawling conducted during the period 1964-1970 off Kakinada. Muthu *et al.* (1975) documented the trawl fishery resources of Kakinada based on the data from commercial vessels for the period 1967-1970 and Narasimham *et al.* (1979) studied the demersal resources during the period 1971-1974 along with a note on the economics of different types of boats engaged in the fishery. Rao *et al.* (1980) discussed the effects of a reduction in the cod end mesh size on the prawn fishery resources of the region. CMFRI (1981) gives the trend of demersal fishery resources off Kakinada for the period 1969-1978 ; while the author (Rao, 1988) gives a detailed account

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** *Present Address*: VRC of CMFRI, Visakhapatnam-3, AP.

of the prawn fishery resources along with estimates of Maximum Sustainable Yields of different species of penaeid prawns.

Prawns form a good proportion of the catches and most of the species landed fetch a remunerative price in the export market. *Metapenaeus monoceros* (Fabricius) forming about 12% of the trawler prawn landings influences the economy of the boats operating along this coast. Hence a study of the fishery of the species is attempted based on data collected during the years 1967-1978.

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Data Collection

As the majority of the boats do not maintain any log, records of fishing grounds and catches, it was necessary to follow the procedure generally adopted for recording landings by indigenous boats. Data were collected weekly at the Kakinada Fishing Harbour on total catch and prawn catch by eye estimation from 20% of the boats operated on a given observation day. The number of fishing hours, area of operation and depth of operation of the sampled boats were recorded on enquiry from the boat crew. From the figures thus obtained on the observation days, the monthly estimates were computed depending on the number of fishing days in a month, which was recorded by enquiry from the boat crew and dealers. Random samples of prawns were collected on all the observation days to estimate the species composition and length composition. Other details regarding the analysis of data on catch and effort and length composition are given in the earlier publications of the author (Rao, 1988, MS).

Standardization of Effort

The three types of boats *viz.* 'Pablos', 'Pomfrets' and 'Sorrahs' operating off Kakinada vary in their fishing power (depending on the horse power of the engines, size of the boat and size of the net). In the present study the medium type of boat 'Pomfret' is considered as the standard boat and the trawling hour of this boat is considered as the standard unit of effort, because 'Pomfrets' form the majority of the fleet and their efficiency in catching *M. monoceros* is higher than that of the other two types of boats. As the main aim of the present study is to assess the fishery of *M. monoceros* the catch per hour of trawling of *M. monoceros* in 'Pomfrets' is taken into consideration to standardise the effort of the other types of boats depending on their catch of *M. monoceros*. This has been done on a monthly basis. The standardised effort thus obtained has been used in all the calculations of the present study.

Trends in the fishery

Monthly effort in trawler units (boat units) and the standardised effort in trawling hours are presented in Table 1. During the period from 1967 to 1978, there was a gradual increase in the number of boats as well as in the standardised effort. Effort in boat units (trawler units) dropped in 1978 although there was no decline in the standardised effort. Random variations in the effort of both boat units and standard effort were observed in different months over these years. However, the 12-year average gives a trend of the effort fluctuations in different months. Effort gradually increased from January to April and then declined gradually till July and increased sharply in August and then declined gradually to November. Monthly variations in effort observed in any particular year were mainly due to prevailing weather conditions rather than to non-availability of the species in the fishing grounds.

TABLE 1. *Yearwise and monthwise standard effort in trawling hours and effort in trawler units (in parentheses) at Kakinada during the years* 1967-1978

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	All months
1967 ..	240 (60)	630 (180)	714 (204)	1308 (324)	1600 (392)	2347 (452)	2321 (484)	2453 (533)	2610 (579)	1937 (417)	2499 (519)	1524 (372)	20183 (4516)
1968 ..	3100 (675)	3330 (695)	2864 (657)	3980 (884)	4787 (1064)	3823 (840)	3338 (1046)	5461 (1238)	3762 (836)	2398 (625)	2947 (655)	2664 (592)	42454 (9807)
1969 ..	2251 (557)	1137 (303)	3810 (8.4)	2556 (957)	2524 (793)	1489 (559)	1381 (480)	3755 (780)	2218 (984)	2808 (624)	1473 (192)	2044 (570)	27716 (7663)
1970 ..	3112 (784)	2523 (666)	2717 (558)	2400 (728)	3323 (1112)	4951 (798)	3429 (678)	17076 (368)	2403 (994)	1796 (399)	3031 (330)	4500 (874)	51261 (8189)
1971 ..	1928 (588)	2353 (688)	6161 (1143)	1944 (864)	8614 (1014)	2659 (742)	3316 (896)	9302 (1380)	2387 (1221)	4136 (1380)	6018 (1280)	5472 (1216)	54290 (12412)
1972 ..	5884 (1206)	20512 (960)	9804 (1008)	6014 (1368)	6064 (1260)	4808 (1050)	5784 (1204)	5535 (1414)	3232 (1020)	3520 (780)	4337 (1815)	6333 (1270)	81827 (14355)
1973 ..	5944 (1666)	6203 (1524)	8934 (2093)	11116 (1967)	12235 (1995)	11681 (1834)	15128 (1750)	19881 (1530)	10229 (1404)	12680 (1416)	11253 (1602)	11259 (1524)	136543 (20305)
1974 ..	16820 (1953)	22487 (2429)	20113 (2268)	13456 (2210)	12344 (2130)	15358 (1692)	11546 (2061)	15692 (2054)	9294 (1476)	18415 (1720)	10862 (1730)	9055 (1488)	175442 (23211)
1975 ..	10570 (1392)	11193 (1680)	15389 (2120)	15311 (2610)	24419 (2230)	14427 (1845)	18409 (2640)	16663 (2940)	16810 (2480)	16058 (2576)	7151 (1320)	22039 (2124)	188439 (25957)
1976 ..	33681 (3141)	20479 (2817)	21420 (3340)	575 (2943)	15143 (2288)	21690 (3290)	14042 (2110)	25644 (3672)	27276 (4113)	18026 (2688)	7740 (1155)	6954 (1017)	230952 (32574)
1977 ..	27219 (3390)	38748 (5328)	56223 (6555)	45390 (7230)	44982 (7056)	29350 (4288)	15521 (2317)	33504 (4794)	33642 (4832)	10780 (1813)	17589 (3410)	39060 (6300)	392008 (57313)
1978 ..	42354 (6045)	53816 (6496)	174622 (6480)	42383 (6237)	47712 (6804)	27583 (4074)	28716 (2532)	21601 (4023)	24603 (3241)	10258 (2160)	19207 (2103)	374 (1026)	501229 (51321)

TABLE 2. *Yearwise and monthwise catch and CPH (in parentheses) of* M. monoceros *in trawler catches at Kakinada during the year 1967-1978 (both CPH and catch are in kg)*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	All months
1967 ..	—	150 (0.23)	1404 (1.97)	4128 (3.16)	2640 (1.65)	4662 (2.00)	1506 (0.65)	4221 (1.72)	1395 (0.53)	5 (0.01)	195 (0.08)	18 (0.01)	20324 (1.01)
1968 ..	—	10 (0.01)	622 (0.22)	14658 (3.68)	38849 (8.12)	9753 (2.55)	6339 (1.90)	7161 (1.31)	3044 (0.81)	230 (0.10)	709 (0.24)	1454 (0.55)	82829 (1.95)
1969 ..	1529 (0.61)	1157 (1.02)	2808 (0.74)	19174 (7.50)	9240 (3.66)	1871 (1.26)	1671 (1.21)	1921 (0.51)	4997 (2.25)	415 (0.15)	324 (0.22)	996 (0.49)	46103 (1.66)
1970 ..	436 (0.14)	2094 (0.83)	11079 (4.08)	8252 (3.44)	31152 (9.38)	1325 (0.27)	940 (0.29)	1020 (0.06)	566 (0.24)	98 (0.05)	3696 (1.22)	98 (0.02)	60756 (1.19)
1971 ..	280 (0.15)	4744 (2.02)	10179 (1.65)	8640 (4.44)	17844 (2.07)	7245 (2.72)	1104 (0.33)	20556 (2.21)	902 (0.38)	216 (0.05)	360 (0.06)	752 (0.14)	72822 (1.34)
1972 ..	765 (0.13)	7590 (0.37)	2763 (0.28)	14985 (2.49)	17352 (2.86)	41640 (3.61)	6832 (1.18)	7959 (1.44)	2664 (0.82)	5845 (1.66)	5720 (1.32)	3805 (0.60)	117920 (1.44)
1973 ..	18494 (3.11)	11394 (1.84)	57995 (6.49)	28469 (2.56)	7560 (0.62)	2086 (0.18)	1680 (0.11)	1611 (0.08)	801 (0.08)	136 (0.01)	5304 (0.47)	2898 (0.26)	138428 (1.01)
1974 ..	59668 (3.55)	122465 (5.45)	66696 (3.32)	31340 (2.33)	25840 (2.09)	9584 (0.62)	88812 (7.69)	26832 (1.71)	19386 (2.09)	15728 (0.85)	8500 (0.78)	760 (0.08)	485611 (2.77)
1975 ..	22200 (2.10)	20480 (1.83)	35070 (2.28)	78550 (5.13)	18070 (0.74)	270 (0.02)	18780 (1.02)	8410 (0.50)	2340 (0.14)	1600 (0.10)	800 (0.11)	15669 (0.71)	222239 (1.18)
1976 ..	7623 (0.23)	26307 (1.27)	—	35091 (1.99)	17032 (1.12)	30790 (1.40)	10230 (0.73)	10176 (0.40)	23409 (0.66)	5215 (0.29)	675 (0.09)	1737 (0.25)	168335 (0.73)
1977 ..	28310 (1.04)	119708 (3.09)	57870 (1.03)	143420 (3.16)	3472 (0.08)	1544 (0.05)	5299 (0.34)	2244 (0.07)	329 (0.01)	2443 (0.23)	59760 (3.40)	808 (0.20)	432207 (1.10)
1978 ..	18825 (0.44)	20021 (0.37)	53085 (0.30)	28737 (0.68)	11876 (0.25)	7840 (0.28)	10052 (0.35)	16965 (0.79)	23394 (0.95)	1065 (0.10)	1028 (0.05)	992 (0.12)	193880 (0.39)
Average	13178 (1.03)	28070 (1.83)	24964 (0.92)	34620 (2.53)	16748 (1.09)	9884 (0.85)	12770 (1.24)	9090 (0.62)	6933 (0.60)	2750 (0.32)	7256 (0.93)	2499 (0.25)	178321 (1.07)

Trends in landings

Monthwise data in respect of landings and catch per hour of trawling (CPH) of *M. monoceros* for the period 1967-1978 are presented in Table 2 and 3. Details of the fishery during different years are given below :—

TABLE 3. *Monthwise percentage composition of* M. monoceros *in the trawler prawn catches at Kakinada for the year* 1967-1978

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1967 ..	—	2.0	37.7	61.6	38.8	12.1	4.4	32.1	15.8	—	3.1	—	15.4
1968 ..	—	—	39.9	47.4	55.1	25.0	10.6	17.2	9.8	3.3	3.7	7.1	24.3
1969 ..	11.8	40.3	35.9	50.0	21.6	8.8	11.1	10.2	11.4	1.6	4.1	3.2	17.2
1970 ..	1.1	8.1	67.8	39.5	40.0	4.5	4.0	3.6	0.9	0.5	21.3	0.2	15.1
1971 ..	1.1	46.8	31.6	20.8	18.9	21.5	5.0	23.6	1.0	0.5	0.5	1.3	12.1
1972 ..	0.5	5.3	15.1	33.8	42.0	47.1	11.5	8.0	4.2	9.9	10.1	11.3	13.6
1973 ..	31.5	68.2	57.9	35.7	6.9	3.6	3.3	1.4	1.7	0.2	7.1	6.4	16.8
1974 ..	57.0	63.1	23.8	25.9	23.1	26.3	48.5	40.7	29.1	17.5	10.5	1.3	33.9
1975 ..	38.9	33.4	32.3	43.3	14.8	0.2	11.6	2.2	1.9	1.6	1.4	11.3	15.1
1976 ..	6.6	22.9	—	015.	5.1	16.9	12.9	12.0	6.3	4.1	1.2	3.0	6.9
1977 ..	30.5	13.8	19.1	27.4	1.0	0.1	0.4	1.0	0.3	0.7	9.1	0.3	7.0
1978 ..	9.4	9.9	18.8	35.0	17.7	9.1	15.1	3.5	11.1	1.1	0.5	2.7	9.6

1967 : An estimated 20.3 tonnes of catch was landed for an effort of 20,183 trawling hours with an average CPH of 1.01 kg (Fig.1). The fishery was at its best during April-August with almost 84% of the annual catch landed during this period. Although the catch reached a peak in June (4.7 t), the CPH was at its maximum in April (3.16 kg). The species formed about 15.4% of the prawn catches during the year with the maximum in April (61.5%).

1968 : The fishery was very good with an estimated catch of 82.8 tonnes for an effort of 42,454 trawling hours and an average CPH of 1.95 kg. The landings gradually increased from February and reached a peak in May (38.8 t) and then declined gradually to October (0.2 t). Both percentage composition in prawn landings and CPH indicated a similar trend. The species formed about 24.3% of the prawn landings during this year.

1969 : The landings declined sharply when compared to the previous year (1968). An estimated 46.1 t of catch was landed for an effort of 27,716 trawling hours with an average CPH of 1.66 kg. The fishery exhibited peaks in April and September in respect of both landings and CPH. As in the previous years the fishery was poor in October-December. It formed about 17.2% of the prawn catches during the year with better representation during February-April (36-50%).

1970 : An estimated 60.8 tonnes of catch was landed for an effort of 51,261 trawling hours with an average CPH of 1.19 kg. The species formed about 15.1% of the prawn

landings during the year, but contributed as high as 39.5-67.8% during the March-May period (Table 3). Although there was an increase in the landings, the CPH has shown a decline when compared to the previous year. Peak landings were observed in March-April recording about 83% of the annual landings during these months. Landings were poor in the other months of the year. However, a minor peak in the landings was observed in November. The CPH of 9.38 kg observed in May was the highest in the 12-year period.

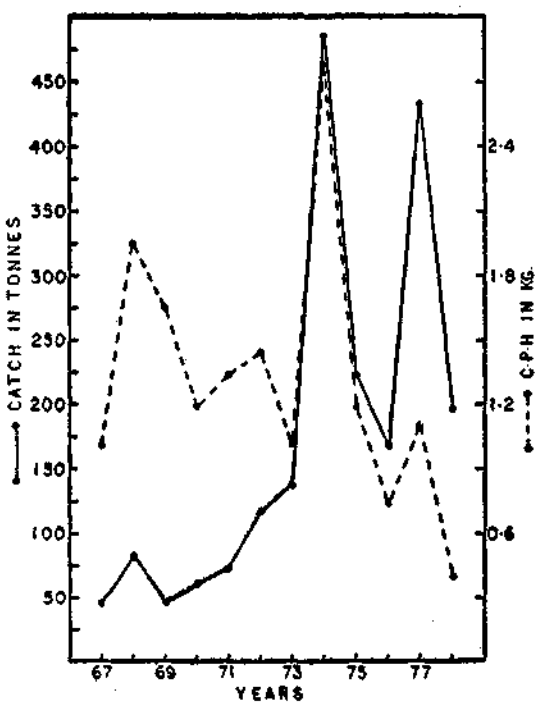

FIG. 1. Catch and catch per hour of trawling (CPH) of *M. monoceros* in the trawler catches at Kakinada.

1971 : With an estimated catch of 72.8 t, the landings increased by about 21% over those of the previous year while the increase in effort was only 6%. The average annual CPH also increased from 1.19 kg in 1970 to 1.34 kg in 1971. The percentage composition of the species in the prawn landings declined to 12.1%. Two peaks in the fishery were observed, one during April and the other in August, although the maximum catch was observed in August (20.6 t). As usual the fishery was poor during January and September-December.

1972 : The fishery was very good with an estimated catch of 117.9 tonnes showing an increase of 62% over that of the previous year while the increase in effort was only 50%. Percentage composition increased to 13.6 from 12.1 recorded in 1971. The landings were considerable in all the months with a peak during April-June. In spite of an increase in the effort (81,827 trawling hours), the annual average CPH (1.44 kg) recorded a marginal increase over that of 1971.

1973 : An estimated 138.4 tonnes of catch was landed for an effort of 1,36,543 trawling hours with an average CPH of 1.01 kg. Although the landings showed a 17% increase from those of the previous year, the improvement was not commensurate with the increase in effort (67%). The landings were good throughout January-May with a peak in March (58.0 t). A similar trend was observed for CPH also. Percentage composition in prawn landings increased to 16.8.

1974 : The fishery reached a climax with an estimated catch of 485.6 tonnes forming about 33.9% of the prawn landings. The CPH recorded an all-time high of 2.77 kg though the effort also increased. The increase in the landings was mainly due to trawling at night which was started only during this year. The landings were good throughout the year with peaks in February (122. 5 t) and July (88.8 t). However, CPH was higher in July (7.69 kg) than in February (5.45 kg). *M. monoceros* contributed about 63.1% to the prawn landings during February.

Males formed about 37.4% of the landings by weight and the rest was contributed by

females. The seasonal trend for males and females was similar during the year.

1975 : An estimated 222.2 tonnes of catch was landed for an effort of 1,88,439 trawling hours with an average CPH of 1.18 kg. In spite of an increase in the effort the landings declined by about 54% when compared to 1974. The percentage composition also declined to 15.1 during the year. Landings exhibited peaks in April (78.6 t), July (18.8 t) and December (15.7 t). Peaks were also observed for CPH as well as percentage composition in these months. Males formed about 29.3% of the catches and the rest was comprised of females.

1976 : The landings slumped to 168.3 t in spite of an increase in the effort (2,30,952 trawling hours). CPH (0.73 kg) was the lowest during the 1967-1976 period. The landings were better in February and April-September when compared to the other months. Percentage composition in prawn catches (6.9%) recorded an all time low during this year (Table 3). Males formed about 38% of the catches by weight, a considerable increase from that of the previous year.

1977 : The fishery for this species showed considerable revival with an estimated catch of 432.2 tonnes. However, this is not commensurate with the increase in effort (3,92,008 trawling hours). Its contribution (7.0%) to the prawn landings was also low. The fishery exhibited peaks during February, April and November. Although the landings exhibited a peak in April (143. 4 t), CPH recorded a peak in November (3.4 kg). The unique feature of the fishery during this year was the peak observed in November for CPH. This was mainly due to the landing of juveniles as a consequence of cod-end mesh size reduction. Males formed about 40.5% of the catches by weight which is a considerable increase over that of the previous year.

1978 : With an estimated catch of 193.9 t for an effort of 5,01,229 trawling hours and an average CPH of 0.39 kg the fishery reached its lowest ebb during the 12-year period indicating a decline in the abundance of the species in the fishing grounds. However, a slight increase in its percentage composition in the prawn landings was seen when compared to the previous two years.

In summary, the fishery was more or less stable during the 1967-1975 period with the CPH not departing far from the mean value in spite of a gradual increase in the effort year after year (Fig. 1). The period 1976-1978 was disturbing in the sense that the CPH gradually declined till 1978. The high CPH value recorded in 1977 is deceptive and misleading since the increase was only a result of reduction in the mesh size of the cod-ends of trawl nets with consequent increase in the landings of juveniles which otherwise would have escaped through the net (Rao *et al.*, 1980). The proportion of the species in the prawn catches also registered a fall during 1976-1978 when compared to the earlier period of 1967-1975. One redeeming feature, however, is that the total landings did not show much decline when compared to the mean value.

Length composition of the catches

The monthly length-frequency distribution of males and females for the years 1974-1977 is presented by Rao and Krishnamoorthi (1990). Males of 51-165 mm in total length (TL) and females of 51-190 mm in total length were represented in the catches. Length-frequency distribution was multimodal in most of the months indicating that a number of broods contributed to the catches. Most of the modes could be traced only for 3-4 months and then they fade out. Hence analysis of length composition was done to trace the abundance of juveniles and adults in different monhts. Males and females measuring upto 100 mm and 110 mm in TL respectively were treated as juveniles and those beyond these sizes were considered as adults. Length range and percentage of adults and juveniles in the catches

during the years 1976-1977 are presented in Tables 4-7.

1974 : Males of 51-160 mm and females of 51-190 mm were represented in the catches with wide monthly variations. Among males, adults formed, on an annual basis, about 74.8% while in females adults formed about 68.6% of the catches. Adults formed the mainstay of the fishery during January-August and October whereas juveniles dominated the catches in September, November and December. The abundance of juveniles in the catches indicated four peaks for both males and females, indicating four peaks in recruitment. However, the peaks in September and November were very prominent when compared to the other peaks.

TABLE 4. *Details of length range and percentage composition of adults and juveniles in the catches in* 1974

Month	Length range in mm		Percentage composition in catches			
			Males		Females	
	Males	Females	Juveniles	Adults	Juveniles	Adults
January ..	76-160	81-190	4.4	95.6	9.2	90.8
February ..	71-155	71-185	13.3	86.7	18.1	81.9
March ..	71-160	76-185	25.2	74.8	19.3	80.7
April ..	61-155	76-190	16.7	73.3	14.3	85.7
May ..	66-155	86-190	12.8	87.2	15.0	85.0
June ..	66-155	71-195	16.0	84.0	14.8	85.2
July ..	71-155	66-185	11.5	88.5	31.3	68.7
August ..	51-155	56-180	24.5	75.5	21.6	78.4
September ..	51-155	51-170	74.5	25.5	79.3	20.7
October ..	56-155	51-175	30.1	69.9	34.7	65.3
November ..	51-115	51-110	92.1	7.9	100.0	Nil
December ..	51-115	51-115	86.8	13.2	97.0	3.0
All months ..	51-160	51-190	25.2	74.8	31.4	68.6

1975 : Males of 51-160 mm and females of 51-185 mm were represented in the catches with wide variations in different months. The annual proportion of adults declined to 60.8% in males and 56.9% in females. Adults formed the dominant component of the fishery during January-August, while the proportion of juveniles comparatively increased during September and October. Juveniles formed the mainstay of the fishery in November and December (Table 5). The proportion of juveniles in the catches indicated five peaks of abundance in February, April, June, September and November-December representing five peaks in the recruitment.

1976 : Males of 51-160 mm and females of 51-190 mm were represented in the catches with wide variations in different months. The proportion of adults in the catches further declined to 42.0% and 48.1% in males and females respectively. Adults dominated the catches during January-February and May-

August while they were respresented moderately in September and December. In October and November only juveniles were observed in the catches with no representation of adults. Three peaks were observed in the abundance of juveniles in January, April and October-November with three peaks of recruitment with intense recruitment during October-November (Table 6).

July, October and December representing peaks in recruitment in these months.

In general, it may be stated that during the active fishing season of January to August adults formed the mainstay of the fishery while in the slack season of the fishery, in September-December, juveniles dominated the catches, although deviations were observed in some years as in 1977.

TABLE 5. *Details of length range and percentage composition of adults and juveniles in the catches in* 1975

Month	Length range in mm		Percentage composition in catches			
			Males		Females	
	Males	Females	Juveniles	Adults	Juveniles	Adults
January ..	86-140	91-180	15.8	84.2	39.3	60.7
February ..	81-130	91-155	30.5	69.5	50.8	49.2
March ..	96-160	96-175	0.4	99.6	2.9	97.1
April ..	81-135	81-160	13.8	86.2	21.8	78.2
May ..	101-135	111-165	Nil.	100.00	Nil.	100.0
June ..	71-160	71-185	16.0	84.0	21.7	78.3
July ..	101-140	101-175	Nil.	100.0	4.5	95.5
August ..	96-140	76-165	8.7	91.3	35.0	65.0
September ..	66-140	71-160	56.6	43.4	84.7	15.7
October ..	51-155	51-175	55.3	44.7	59.7	40.3
November ..	56- 70	56- 65	100.0	Nil.	100.0	Nil.
December ..	51- 90	51-105	100.0	Nil.	100.0	Nil.
All months ..	51-160	51-185	39.2	60.8	43.1	56.9

1977 : Males of 51-165 mm and females of 51-185 mm were observed in the catches with wide variations in different months. The proportion of adults touched an all-time low of 30.6% and 31.8% for males and females respectively. Adults formed the mainstay of fishery in January-March, June and August, moderately represented in September and November and negligible in April, May, October and December. The abundance of juveniles indicated peaks in February, May,

The abundance of juveniles in the catches indicated 3-5 peaks of recruitment in each year with time variations in their occurrence in different years. These peaks also indicate that there are 3-5 spawnings in an year. The peak represented during October-December was the major recruitment period. Rao (1975) observed peaks of abundance of juveniles in the Godavari estuarine system during October-December supporting the present conclusion. However, the intensity of recruitment varied

in different years depending on the abundance of juveniles in the estuary and the backwaters.

There was a gradual decline in the proportion of adults in the catches from 1974 to 1977. It may be inferred that with the increase in the fishing effort year after year there was a proportional decline in the composition of adults in the catches. However, total catches fluctuated only randomly during this period.

Age composition of the catches

As it was not possible to identify different age classes in the length-frequency distribution by polymodal length-frequency curves or by any such methods precisely, age classes have been derived with the help of growth parameters (Rao and Krishnamoorthi, 1990). Using these parameters the following age classes were recognised :

Age Classes	Total length in mm	
	Males	Females
0.5 year old ..	1—95	1—105
1.0 year old ..	96—145	106—165
1.5 year old ..	146—165	166—190

TABLE 6. *Details of length range and percentage composition of adults and juveniles in the catches in* 1976

Month	Length range in mm		Percentage composition in catches			
			Males		Females	
	Males	Females	Juveniles	Adults	Juveniles	Adults
January ..	81-145	81-170	48.8	51.2	46.6	50.4
February ..	96-135	91-160	8.6	91.4	29.0	71.0
March ..	No catch					
April ..	61-145	61-190	84.4	15.6	55.7	44.3
May ..	66-135	66-160	34.5	65.5	37.0	63.0
June ..	71-140	76-165	17.2	82.8	20.7	79.3
July ..	81-145	81-170	3.6	96.4	0.5	99.5
August ..	51-145	51-180	32.2	67.8	23.3	76.7
September ..	56-150	56-190	75.2	24.8	77.9	22.1
October ..	61- 90	66-100	100.0	Nil.	100.0	Nil.
November ..	66- 85	66- 75	100.0	Nil.	100.0	Nil.
December ..	51-160	51-190	68.7	31.3	68.3	31.7
All months ..	51-150	51-190	58.0	42.0	51.9	48.1

Percentage composition of these age classes in the catches during different years is given below :

Years	Males				Females			
Age classes	n	0.5	1.0	1.5	n	0.5	1.0	1.5
1974 ..	19247459	20.68	77.08	2.24	19016238	26.41	68.16	5.43
1975 ..	8783546	34.34	65.41	0.25	13291429	37.22	61.78	1.00
1976 ..	9920471	53.82	45.92	0.26	9196037	47.22	50.12	2.56
1977 ..	33742566	63.13	36.75	0.12	32696815	64.28	35.13	0.59

The values of X^2 test carried out to find the proportion of 1-year old to the rest of the age classes in the fishery for males and females are presented below :

Sex	Degree of freedom	Value of X^2	Significant or not at P 0.01 level
Males	3	8826234	Significant
Females	3	6151504	Significant

It may be observed that for both males and females the values for 1-year old were significantly different at P 0.01 level showing that the 1-year old dominated the fishery during the 1974-1977 period. However, their proportion in the catches gradually declined from 1974 to 1977 in both males and females. The possible reasons for such a phenomenon are an increase in the fishing pressure on the stocks and the reduction of cod-end mesh size of the trawls which was observed during this period rather than due to any increase in the intensity of recruitment. The stable fishery in the backwaters observed during this period supports the above assumption.

TABLE 7. *Details of length range and percentage composition of adults and juveniles in the catches in 1977*

Month	Length range in mm		Percentage composition in catches			
			Males		Females	
	Males	Females	Juveniles	Adults	Juveniles	Adults
January ..	81-165	85-180	10.1	89.9	21.6	78.4
February ..	81-145	71-165	37.3	62.7	43.0	57.0
March ..	71-160	81-180	8.3	91.7	20.8	79.2
April ..	56-145	61-170	90.5	9.5	84.2	15.8
May ..	76-100	76-100	100.0	Nil.	100.0	Nil.
June ..	66-160	71-185	20.6	79.4	21.7	78.3
July ..	61-100	71-110	100.0	Nil.	100.0	Nil.
August ..	81-135	76-145	30.0	70.0	56.1	43.9
September ..	61-150	51-185	55.0	45.0	60.5	39.5
October ..	51-195	51- 95	100.0	Nil.	100.0	Nil.
November ..	61-145	1-170	55.7	44.3	66.7	33.3
December ..	51-105	51-105	97.0	3.0	100.0	Nil.
All months ..	51-165	51-185	69.4	30.6	68.2	31.8

Relationship of the fishery to rainfall

Annual rainfall and the total catch of *M. monoceros* by trawlers did not indicate any

relationship (Fig. 2). But a significant inverse relationship was observed between CPH of one year and the rainfall of the previous year (Fig. 3). Regression analysis of these parameters by least squares gives the values of regression constants '*a*' and '*b*' as 6.1806 and —0.0431. The calculated straight line fitted to the data shows a good fit ($r = 0.76$). Possibly the higher rainfall leads to lower salinity in the estuary which may limit the survival and growth of the postlarvae and juveniles in the estuary. This will be reflected in the marine catches of the succeeding year. It may be mentioned here that the major abundance of *M. monoceros* in the estuary is during October-December and the main season in the sea is during February-May. Hence it can be said that there is a time lag of 5-6 months. Similarly, major rainfall season is during June-November and its influence is felt in the estuary immediately, but in the sea after a time lag of 5-6 months.

Relationship of the inshore fishery to the estuarine fishery

Like most of the commercial penaeid prawns supporting fisheries in the sea, *M. monoceros* spends its early part of the life cycle in the estuaries (Panikkar and Menon, 1956; Menon and Raman, 1961; George, 1962 Subramanyam 1965; Mohamed and Rao, 1971; Rao, 1975). Kutkuhn. (1966) classified the penaeid species according to their dependence on estuaries for successful completion of their life-cycles. He placed *M. monoceros* as one of the species highly dependent on estuaries as nursery grounds.

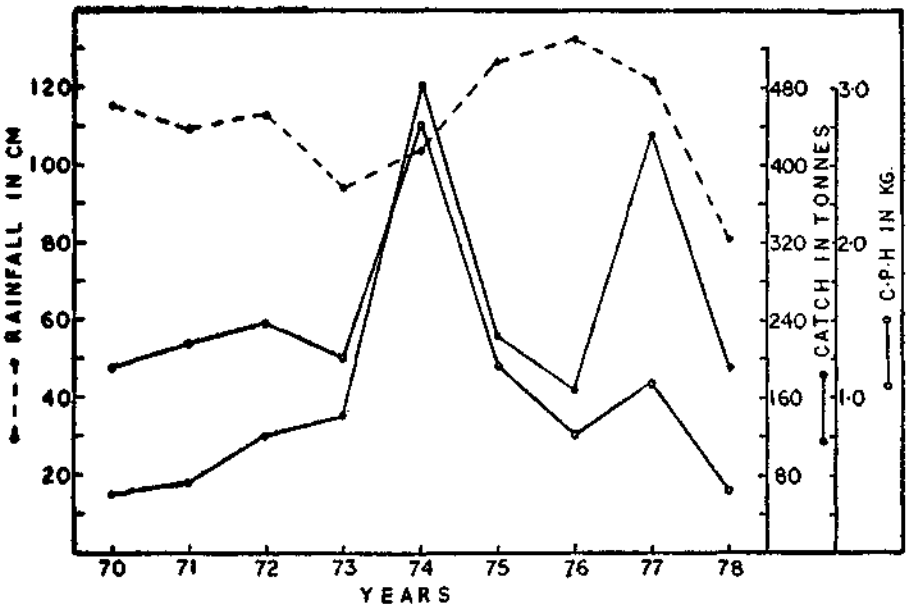

FIG. 2. Trend of catch and CPH of *M. monoceros* in trawler landings and rainfall at Kakinada.

For *M. monoceros* occurring off Kakinada, the Godavari Estuary forms the main nursery ground where the species supports a commercial fishery (Subrahmanyam, 1965). Stakenets and dragnets account for over 90% of the *M. monoceros* landings in the Godavari Estuary

and adjacent backwaters (Rao, 1975). Data on the estuarine landings of *M. monoceros* were collected at B. V. Palem for the years 1970-1977. Effort was standardised taking stakenet as a standard unit of effort. Annual landings at this centre varied from 141 t (1977) to 367 t (1973) with similar variations in the catch per unit of effort (C/E) also. These annual values were compared with the annual trawler catches of *M. monoceros* in the inshore waters (Fig. 4). When catches from the two localities are compared for the same year no direct relationship is evident. Direct relationship between the C/E of estuarine and the inshore catches (CPH) of the same year was also not observed. Since the major period of recruitment from the estuary is during October-December its effect in the inshore waters would be generally felt only in the succeeding calendar year. Hence, the index of inshore abundance (CPH) of one year has been compared with the previous year's estuarine abundance (C/E). It was observed that one year's CPH in inshore waters plotted against the previous year's C/E in estuarine waters showed positive linear relationship (Fig. 5). Regression of these parameters by least squares gives the values of regression coefficients '*a*' and '*b*' as 0.1308 and 0.1017 respectively. The calculated line fits well with the observed data with a high degree of correlation ($r = 0.91$).

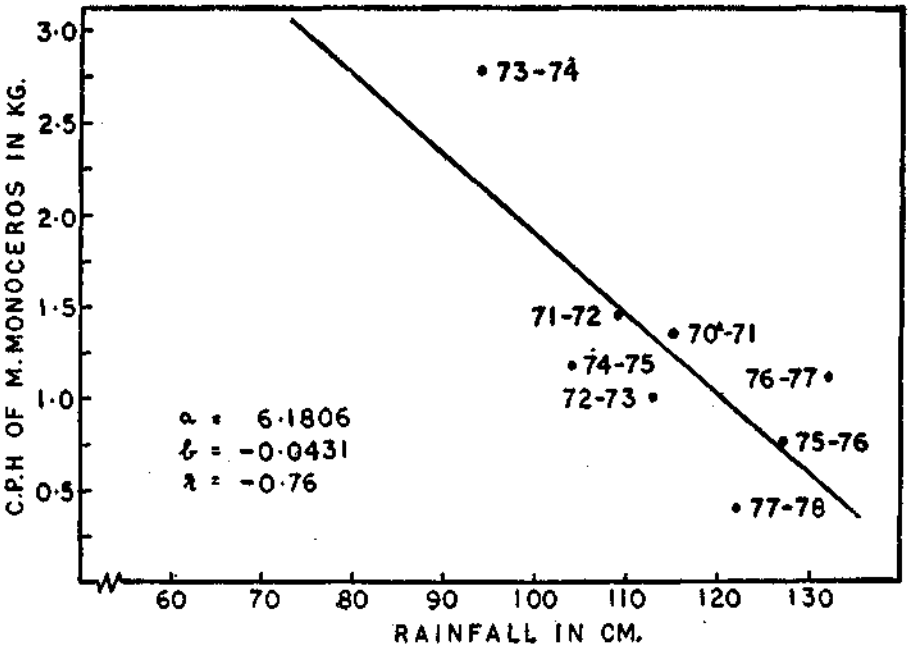

FIG. 3. Relationship between CPH of *M. monoceros* in trawler catches in one year and rainfall of the previous year at Kakinada.

From the above analysis it would appear that the inshore fishery of *M. monoceros* is influenced by the abundance of the species in the estuary after a time lag of 5 to 6 months.

DISCUSSION

Rounsefell (1975) is of the opinion that the signs that could indicate possible depletion in productivity are (1) a decrease in the average size or age ; (2) species composition changes ;

(3) over population of prey species (4) shrinkage of the area inhabited, (5) shifts in fishing areas and (6) a fall in the catch per unit of effort. How many of these conditions are satisfied for, the observed decline in the fishery for *M. monoceros* is examined in the account that follows.

It was observed that proportion of adults in the catches decreased gradually from 1974 to 1977 in both the sexes indicating a reduction in the average size also during this period. Furthermore, the 1-year old also, gradually decreased in the fishery during these years. During the 1967-1975 period the percentage composition of *M. monoceros* in the prawn landings varied between 12.1% in 1971 to 33.9% in 1974, while a decline to 6.9% in 1976 followed by an increase to 9.6% in 1978 was registered. The present investigations are inadequate to conclude whether or not population changes in the prey species occurred during this period. But shrinkage in the area of distribution of the species was not observed. However, there was a gradual shifting of fishing areas from 1967 to 1978 (Rao, 1988). Nevertheless, the catch per hour of trawling continued to decline gradually during the 1974-1978 period except for a deceptive increase in 1977. The foregoing analysis shows that all the five factors for which information is available indicate that the stock of *M. monoceros* off Kakinada is threatened with overfishing. However, of the five phases diagnosed by Kesteven (1971) in the history of a fishery *viz.* 'nascent' fishery, 'developing' fishery, 'stabilised' fishery, 'declining' fishery and 'extinguished' fishery, the inshore prawn fishery for *M. monoceros* has passed the first three phases and it is at the threshold of the fourth phase *viz.*, 'declining fishery' as could be seen in the variations of catch, CPH and the biological parameters. Because of high fecundity of the species typical of penaeid prawns (Neal, 1974), it is unlikely that the fishery for *M. monoceros* would pass through the fifth phase. Nevertheless, it is difficult to

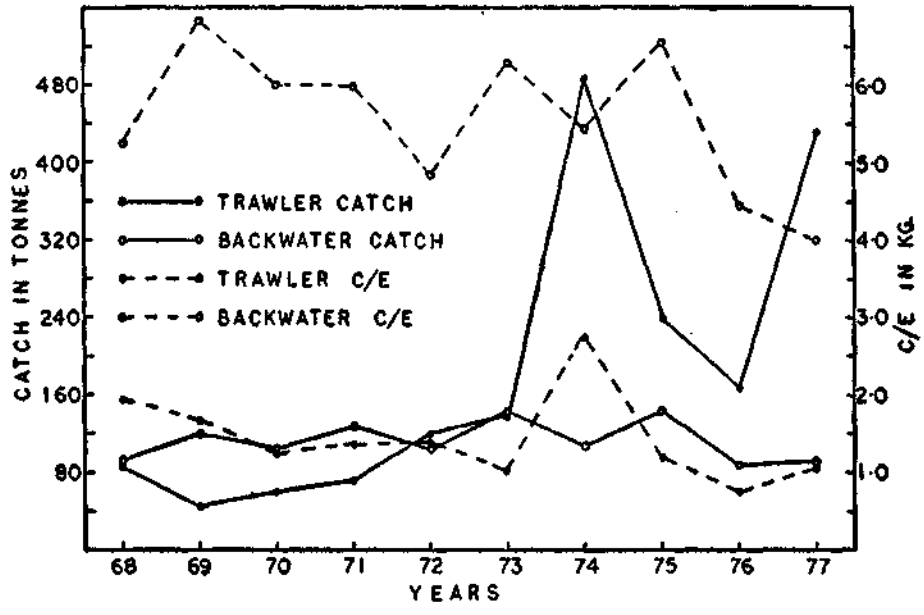

FIG. 4. Relationship between trawler catches and backwater catches of *M. monoceros* at Kakinada.

quantify the criteria laid down by Kesteven (1971) and Rounsefell (1975). The four types of stock assessments made (Rao, MS) , also indicate that the fishery is just at the level of optimum exploitation and if the increasing trend in effort is maintained the optimum level will be crossed in the very near future. Hence, efforts should be made, even now, to stabilize the fishery at the present level of exploitation.

1979). But Hildebrand and Gunter (1953) and Gunter and Hildebrand (1954) showed for *P. setiferus* in the Texas waters that there was a good positive correlation between catch of one year and rainfall of the previous two years. Some years later, Gunter and Edwards (1969) confirmed these results using longer time series (1927-1964) of the same species and from the same region. Menon and

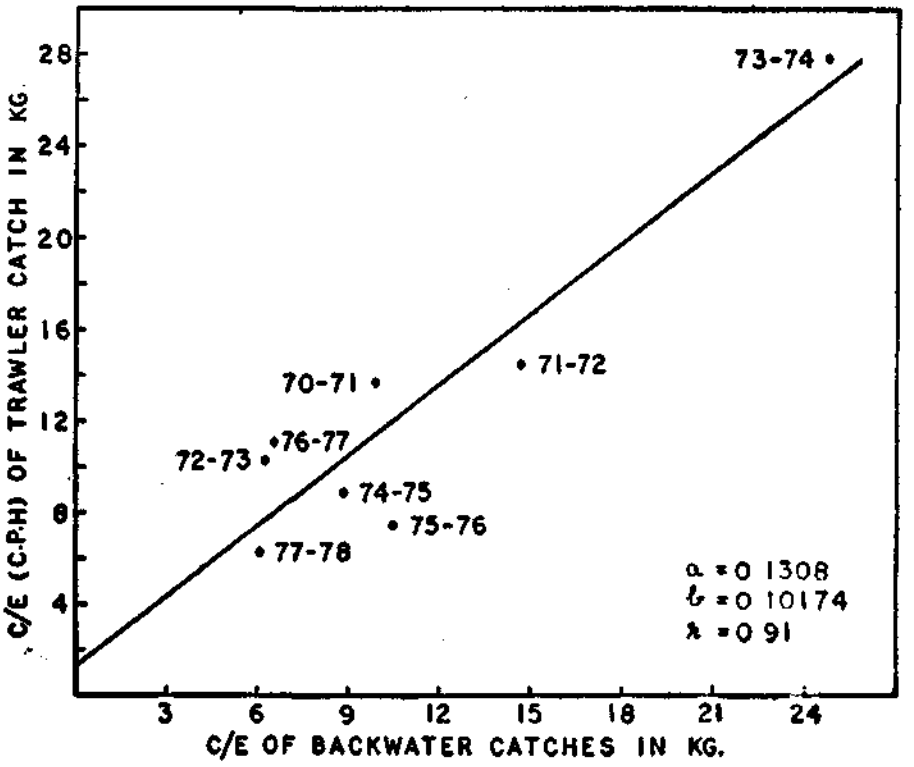

FIG. 5. Relationship between CPH of trawler catches of one year and C/E of backwater catches of the previous year of *M. monoceros* at Kakinada.

The abundance (in terms of CPH) of *M. monoceros* in the sea was negatively correlated to the rainfall of the previous year. Similar negative correlations between rainfall and catch were observed for *M. dobsoni* in the Mangalore Estuary (Ramamurthy, 1972), for *P. aztecus* in the Louisiana waters (Barrett and Gillespie, 1973, 1975); and for *P. duorarum* in Senegal (Le Raste, Raman (1961) also observed a positive correlation between rainfall and the catches of penaeid prawns in the Cochin Backwater. Similar positive correlation was observed for *M. dobsoni* off Mangalore (Ramamurthy *et al.*, 1978) for *P. d. notalis* in Senegal (Lhomme and Garcia, 1964) and for *P. merguiensis* in the Gulf of Carpentaria, Australia (Staples *et al.*, 1984).

Baxter (1963) indicated the possibility of using abundance of postlarval prawns as an index of predicting fishing prospects along the Texas coast. Yokel *et al.* (1969) showed with *P. duorarum* in Florida that if seasonal variations in size at migration (implying different time lags) were taken into account there was a good correlation between indices of numerical abundance of migrating juveniles and those of young recruits on the fishing grounds. Berry and Baxter (1969) on *P. aztecus* of Texas have shown that there was good correlation between the catches of juveniles in the bait shrimp fishery and the catch of adults in the sea. Caillouet and Baxter (1973) gave equations of the relationship obtained for Texas and Louisiana. Thus in Texas there was an excellent correlation ($r = 0.85$) for *P. aztecus* if the annual catch at sea was related with the juvenile abundance in Galveston Bay and a medicore one ($r = 0.28$) if this catch was related with the annual estuarine catch. The correlation was fair ($r = 0.58$) with the same kind of data for *P. setiferus*. In Louisiana the correlation between the annual estuarine and marine catch is excellent for *P. aztecus* ($r = 0.73$) and *P. setiferus* ($r = 0.86$), which has been confirmed by Barrett and Gillespie (1975). Sutter and Christmas (1983) observed good correlation ($r = 0.97$) between postlarval abundance in estuaries and commercial catches in the sea for *P. aztecus* off the Mississipi Coast, U.S.A. George (1963) tried to correlate the postlarval index of one year with the inshore catch of two years later in *M. dobsoni* with no success. Subramanyam and Rao (1968) showed that, for two successive years, postlarval abundance and catches varied in the same direction in the Pulicat Lake. However, these studies were made over periods which were too short to assess the quantitative value of the relationship. But Ramamurthy *et al.* (1978) did not observe any clear relationship between juvenile fishery in the estuary and in the inshore fishery for *M. dobsoni* along the Mangalore Coast. The present study on *M. monoceros* clearly indicates that the inshore catches of one calendar year are influenced by the abundance of the estuarine catches of the previous calendar year. This helps in predicting the magnitude of the inshore fishery five or six months in advance so that effort of the fleet is properly deployed to harvest he resource economically.

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