OBSERVATIONS ON THE OFFSHORE PRAWN FISHERY OF COCHIN

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INTRODUCTION

Although several accounts on the results of exploratory power fishing in the Indian coastal waters have been published (Hornell 1916, Sunder Raj 1931, Chidambaram 1953, Gopinath 1954, Jayaraman et al. 1959) no detailed account of the biological aspects of th species of prawns contributing to the fishery is available. Srivatsa (1953) has given a list of Crustaceans caught by the Japanese trawlers in Saurashtra waters. Per Sandven (1959) remarks "there is reason to believe that in the Arabian Sea outside the Malabar coast are found some of the richest prawn grounds in the world." John and Kurian (1959) observed concentrations of the penaeid prawn *Penaeopsis philippii* in deeper waters (100 to 150 fathoms) off the coast of Kerala. Menon (1955 & 1957), Panikkar & Menon (1955), George (1959 & 1961) and Menon & Raman (1961) studied the bionomics of certain species of prawns of the backwater and inshore fishery which is supported by the same species contributing to the off shore fishery of the area. Miyamoto et al. (1962) and Satyanarayana et al. (1962) reported on the development of trawling for shrimps on the West coast of India along with the influence of various types of trawls, boats and engines of different h. p. on the catches, and the prawn trawling gear of Cochin respectively. Apart from these and the reports of the Indo-Norwegian Project on their fishing results published from time to time there has not been any account of the off-shore prawn fishery of this coast.

Fishing operations in the off shore waters of Cochin by power fishing vessels commenced towards the latter half of the last decade. The fishery which started with the operation of a few boats of the Indo-Norwegian Project and the Deep Sea Fishing Station of the Government of India partly on an exploratory and partly on a commercial basis has developed to such an extent during these few years that the number of power fishing vessels stands at well over 400 at the commencement of the 1963-64 season.

A considerable portion of the catches is contributed by prawns and it is found that the prawn populations inhabiting the shallow coastal waters of the area up to 25 to 40 metres support a valuable fishery. On an average prawns constitute over 20% of the total catches. The prawn resources from these waters supporting a valuable industry has gained tremendous importance as a foreign exchange earner to the country and there is still further scope for development. It is a well established fact that in this prawn fishery as in any other growing fishery conservation of the resources is the most important single factor upon which the entire industry depends and this fact can not be overemphasised. A well planned and sound management programme is the key note to wise conservation and for such a programme a comprehensive knowledge of the biology of the various species constituting the fishery is a *sine quanon*, in order to exercise a close biological check over the existing stocks upon which the prawn fishery now depends. After a preliminary study of the shrimp industry of India, Wilkes

(1956) also pointed out the same. It is therefore imperative that research on these aspects should be pursued actively. With this view in mind the biology of these species has been under study for the past few years and the results obtained from 1957 onwards are presented here.

METHODS AND MATERIALS

The vessels operating in this area include the 6 to 9 metre pablo boats powered by 10 to 30 B. h. p. engines as well as the slightly bigger type of shrimp trawlers. They usually make single day cruises starting from the base early in the morning and returning in the evening after taking on an average 3 to 4 hauls of one hour duration. The gear used is the conventional two or four seam shrimp trawl varying from 13 to 18 metres in head rope length and with mesh sizes of 76mm, 50mm, 38mm and 25mm for wing, body, throat and cod end respectively. The trawling is mostly carried out in the areas 108, 106 and 106A (ref : map, fig. 1), in depths varying from 9 to 36 metres. Early in the season operations are mostly in the 27 to 36 metre area whereas later it is confined to lesser depths. The bottom at these trawling grounds is mostly muddy.

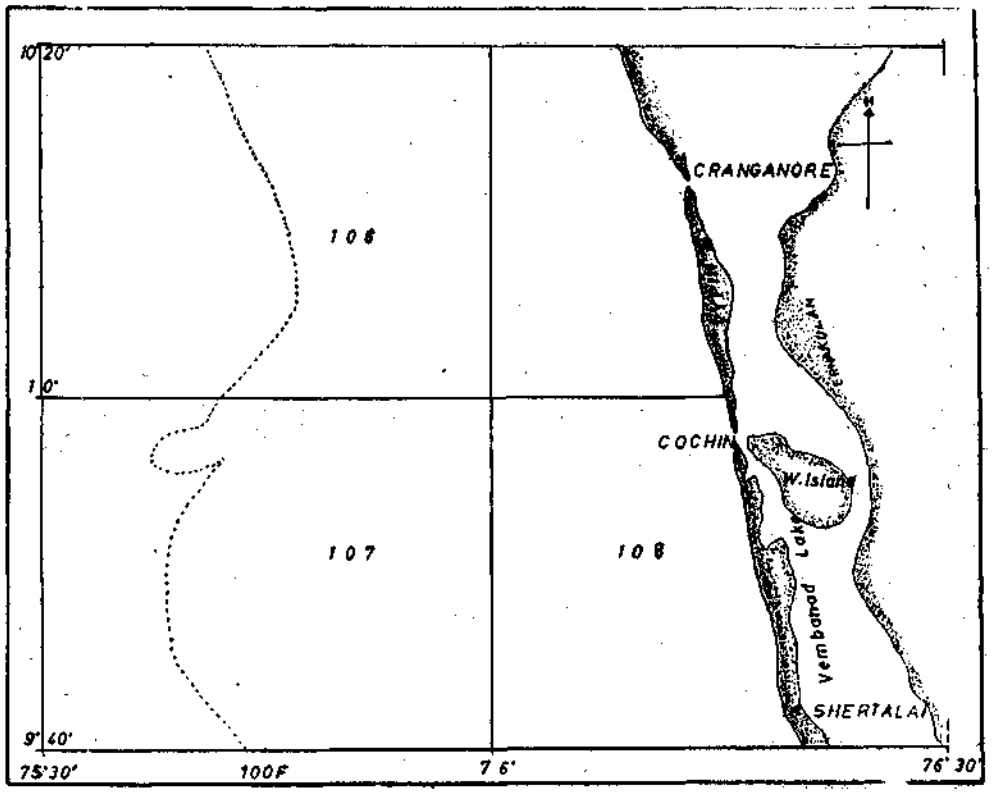


Fig. 1. Map showing the areas of trawling operations off Cochin.

Regular observations on the various aspects of the biology of the different species of prawns were made by collection and analysis of biweekly samples of catches from trawlers

operated by both the Indo-Norwegian Project and the Off-shore Fishing Station. In collecting samples vessels were selected at random since they usually operate in more or less the same area and land catches of identical composition. Each sample was sorted into the various species and the weight of each species determined. The different species were again sorted into sexes and total lengths (from tip of rostrum to tip of telson) measured. The condition of gonads was noted. In the case of females according to the development of gonads they were classified into four groups namely immature, maturing, mature and spent. The number of impregnated females was also recorded. For purposes of final interpretation the data of each month were pooled together. In order to study the distribution of the various species in different depths two vessels namely M. V. Tarpon (10·4 metres, 32 B. h. p.) of the Off-shore Fishing Station and M2 (8·8 metres, 30 B. h. p.) of the Indo-Norwegian Project were selected for detailed studies. Data for three years were analysed depthwise and percentage and catch per hour of prawns in different depths were calculated.

The length measurements were utilised for length frequency studies in an attempt to follow the population characteristics, growth and age composition of the various species in the fishery.

FISHING SEASON AND TRENDS IN PRODUCTION

In the earlier years fishing commenced by November or December and ended by May. But with the increased activities in recent years the fishing operations are suspended only during the peak of the monsoon and hence the fishing commences by September and continues through June. However, prawns begin to occu in considerable quantities in the (Fig. 2) catches only from October-November.

A regular upward trend in the percentage of prawns in the catches is seen from September onwards reaching a peak in the December-February months (Fig. 2 and Table I). After February there is a steep decline in their percentage contribution. From April again an upward trend is noticed showing the maximum percentage in June. In the case of catch per trawling hour also a similar trend is evident, showing a peak in December-February, a decline in March and subsequent rise up to June. The average monthly catch per hour and percentage of prawns for all the seasons together (Fig. 2) also show the same trend.

The total catch of prawns of these vessels shows a regular increase from 1956-57 season to 1958-59 after which there is considerable decline in the two subsequent seasons. But in 1961-62 again there is sharp rise in the total landings of prawns. In the next year 1962-63 there is again a decrease. From the years 1957 to 1963 the annual fishing effort deviated from an average of 3595 trawling hours to 2611 hours in 1960-61 and 4944 hours in 1961-62. Corresponding total prawn yields exhibit fluctuations from an average of 184 tonnes to 194 tonnes and 318

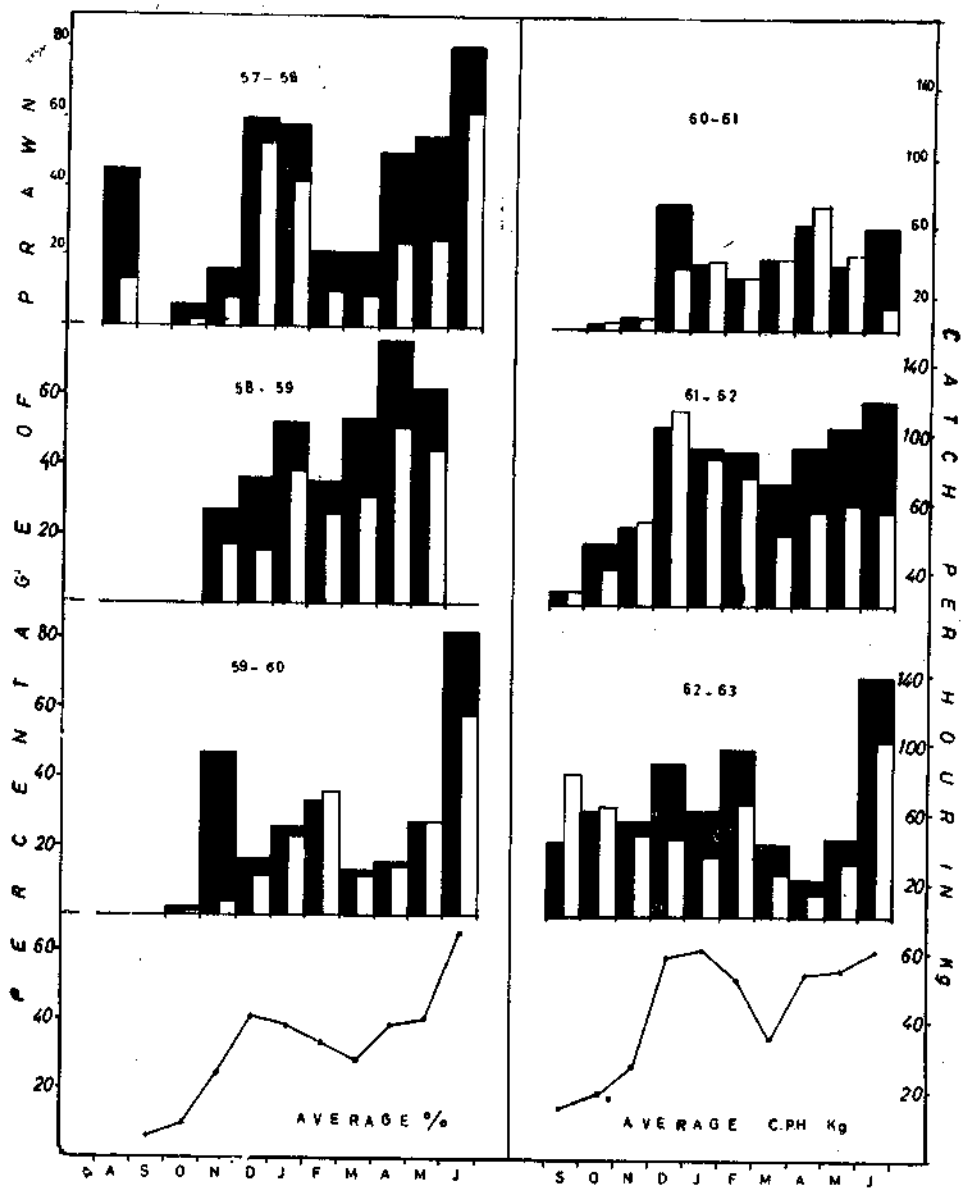


Fig. 2. Monthly percentage and catch per trawling hour of prawns for the Seasons 1957-58 to 1962-63.

tonnes in the respective seasons (Fig. 3). Since the number of vessles operated during the various seasons is not constant the total catch of prawns cannot be taken as an index of their abundance. But the catch per trawling hour as well as percentage of prawns show more or less he same trend. The annual catch per hour of trawling for the seasons 1957-58 to 1962-63 are 52·1,60·5, 41·6, 39·8, 64·4 and 43·2 kg. respectively.

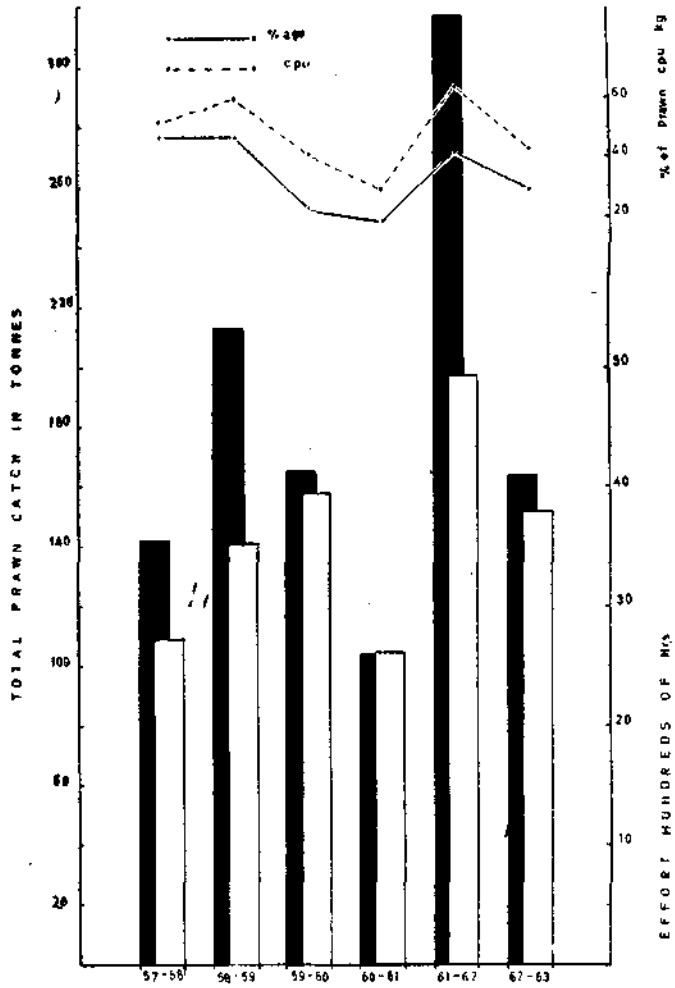


Fig. 3. Total annual landings of prawns with total effort expended along with yearly percentage and catch per hour of prawns from 1957 through 1963.

Species exploited *:

About half a dozen members of the family Penaeidae (Crustacea, Decapoda) contribute to the prawn fishery of the area. However, only three or four of these species support the major part of the fishery. The top ranking species are *Metapenaeus dobsoni* (Miers), and

*Vernacular names of the important species:

Metapenaeus dobsoni	—*Poovalan chemmeen*
Metapenaeus affinis	—*Kazhanthan* ,,
Metapenaeus monoceros	—*Choodan* ,,
Penaeus indicus	—*Naran (Vella)* ,,
Penaeus monodon	—*Kara* ,,
Parapeneopsis stylifera	—*Karikadi* ,,

TABLE I

Showing the total catches, total catches of prawns, total effort, percentage and catch per hour of prawns for the seasons 1956-57 *to* 1962-63

Months	Total catch kg.	Total prawns kg.	Total effort in hours	% of prawns	Catch per hour in kg.
January '57	134	16	15·67	11·9	1·0
February	13,525	7,198	179·25	53·2	40·0
March	34,625	14,435	295·25	41·7	49·0
April	32,011	13,593	203·50	42·4	67·0
May	56,888	36,911	219·58	65·0	169·0
June	5,887	4,356	37·43	74·0	117·0
TOTAL 1956-57	1,43,070	76,589	950·68	53·5	80·6
August '57	1,843	836	31·08	45·4	27·0
September	8,335	..	61·47	..	..
October	3,436	205	67·08	6·0	3·0
November	24,145	3,939	243·17	16·3	16·0
December	52,739	31,898	301·92	60·5	106·0
anuary '58	58,755	34,296	415·83	58·4	82·0
February	25,316	5,412	287·70	21·4	19·0
March	27,205	5,793	348·75	21·3	17·0
April	29,730	14,991	309·75	50·4	48·0
May	47,868	26,478	519·08	55·3	51·0
June	22,754	18,487	147·92	81·2	125·0
TOTAL 1957-58	3,02,126	1,42,335	2,733·75	47·1	52·1

TABLE I—*contd.*

Months	Total catch kg.	Total prawns kg.	Total effort in hour	% of prawn	Catch per hour in kg.
September '58	13,729	43	85·83	0·3	1·0
October	12,312	29	108·50	0·2	..
November	42,724	11,607	339·92	27·2	34·0
December	43,836	15,861	535·63	36·2	30·0
January '59	80,758	41,869	540·55	51·8	77·0
February	75,178	26,553	511·82	35·3	52·0
March	59,108	31,639	508·55	53·0	62·0
April	61,073	46,484	454·83	76·1	102·0
May	63,540	39,193	440·25	61·7	89·0
TOTAL 1958-59	4,52,258	2,13,278	3,525·88	47·2	60·5
September '59	3,501	3	57·00		..
October	29,696	52	107·59	1·8	1·0
November	48,678	2,306	301·17	47·4	8·0
December	63,668	10,027	430·00	15·7	23·0
January '60	89,013	22,725	491·25	25·5	46·0
February	153,192	50,113	692·68	32·7	72·0
March	106,748	14,119	608·75	13·2	23·0
April	122,535	18,944	660·42	15·5	29·0
May	76,121	20,712	387·33	27·2	54·0
June	31,259	25,636	221·50	82·0	116·0
TOTAL 1959-60	7,24,411	1,64,637	3,957·69	22·7	41·6

TABLE I—*contd.*

Months	Total catch kg.	Total prawns kg.	Total effort in hour	% of prawn	Catches per hour in kg.
September '60	3,446	...	30·16	..	..
October	56,005	727	167·84	1·3	4·0
November	43,453	1,536	207·18	3·5	7·0
December	20,054	7,309	204·75	36·4	36·0
January '61	50,052	9,612	243·25	19·2	40·0
February	53,194	7,888	264·09	14·8	30·0
March	86,586	18,129	432·67	20·9	42·0
April	120,967	37,390	511·25	30·9	73·0
May	104,458	19,824	451·25	19·0	44·0
June	4,636	1,396	98·84	30·1	14·0
TOTAL 60—61	542,851	103,811	2,611·28	19·1	39·8
September'61	20,880	776	93·32	3·7	8·0
October	39,847	7,017	303·42	17·6	23·0
November	94,731	21,462	442·00	22·7	49·0
December	146,272	76,688	675·00	52·4	114·0
January '62	95,218	43,962	510·08	46·2	86·0
February	84,668	38,279	506·25	45·2	76·0
March	70,126	25,247	600·08	36·0	42·0
April	72,987	34,031	605·50	46·6	56·0
May	94,273	49,374	827·92	52·4	60·0
June	35,890	21,519	381·25	60·0	56·0
TOTAL 61—62	754,892	318,355	4,943·82	42·2	64·4

TABLE I—*contd.*

Months	Total catch kg.	Total prawns kg.	Total effort in hour	% of prawn	Catches per hour in kg.
September '62	35,589	7,664	91·92	21·5	83·4
October	77,079	24,023	372·75	31·2	64·4
November	117,389	33,013	679·17	28·1	48·6
December	43,564	19,472	426·00	44·7	45·7
January '63	63,453	19,499	534·75	30·7	36·5
February	53,918	26,427	392·84	49·0	67·3
March	54,387	11,831	447·50	21·8	26·4
April	52,967	6,095	419·58	11·5	14·5
May	55,165	12,896	399·25	23·4	32·3
June	4,349	3,059	29·58	70·3	103·4
TOTAL 62—63	557,860	163,979	3,793·34	29·4	43·2

Metapenaeus affinis (M. Edw.) The others in descending order of importance are *Parapeneopsis tylifera* (M. Edw.) *Penaeus indicus* M. Edw., *Metapenaeus monoceros* (Fabr.), *Penaeus monodon* Fabr., *Parapeneopsis acclivirostris* Alcock and *Penaeus semisulcatus* de Haan. Of these the last three occur only in very small numbers occasionally. Only those of commerical value are treated in this report.

Species having potential commercial value include *Penaeopsis rectacutus* (Bate) and *Aristaeus* sp. recently recorded during exploratory cruises of one of the vessels in the 290-360 metre waters off Cochin.

DISTRIBUTION OF SPECIES

Seasonal :

Distribution of species during the fishing seasons 1958-59 to 1962-63 as percentage by numbers as well as by weight is shown in Figures 4 to 8. In all the years in which there is

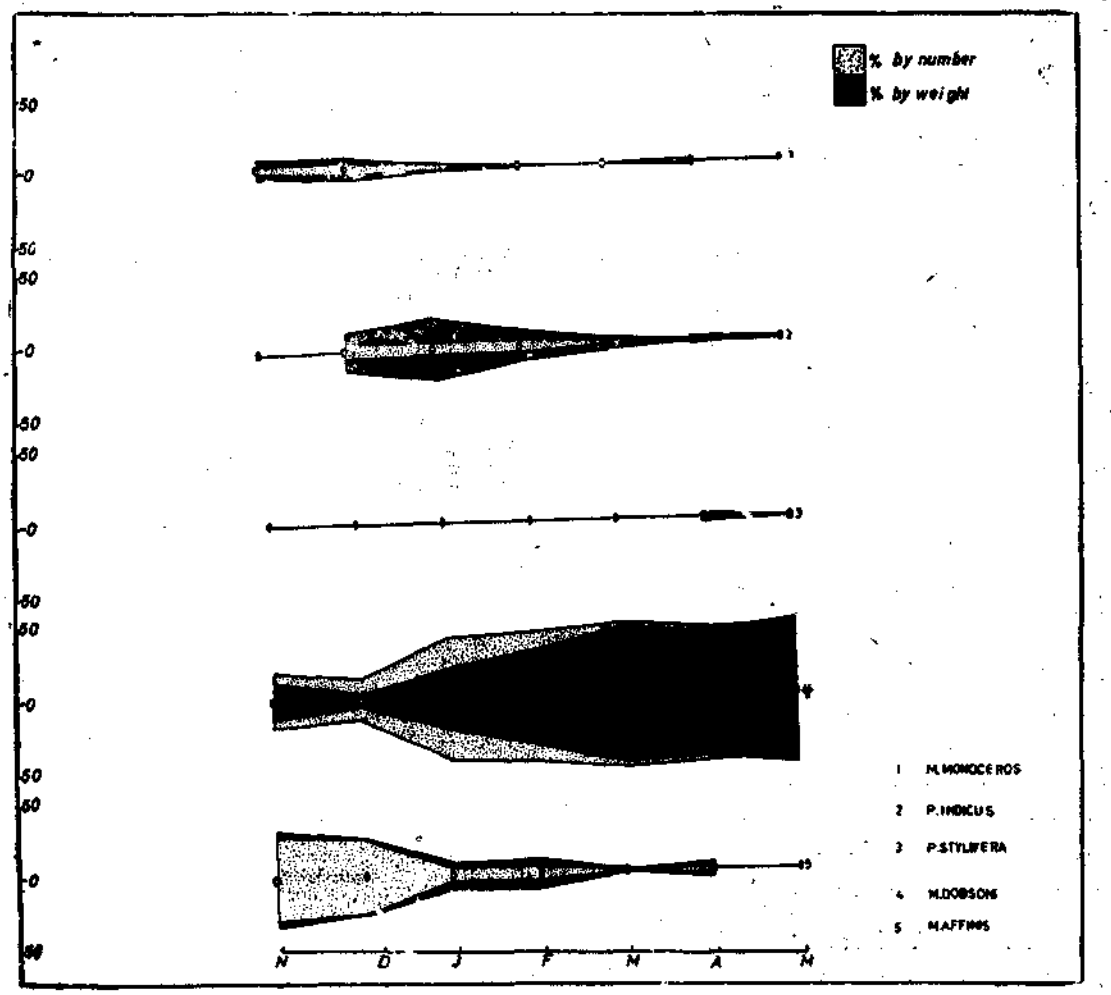


Fig. 4. Monthly distribution of prawns (Percentage by weight and number) for the season 1958 59.

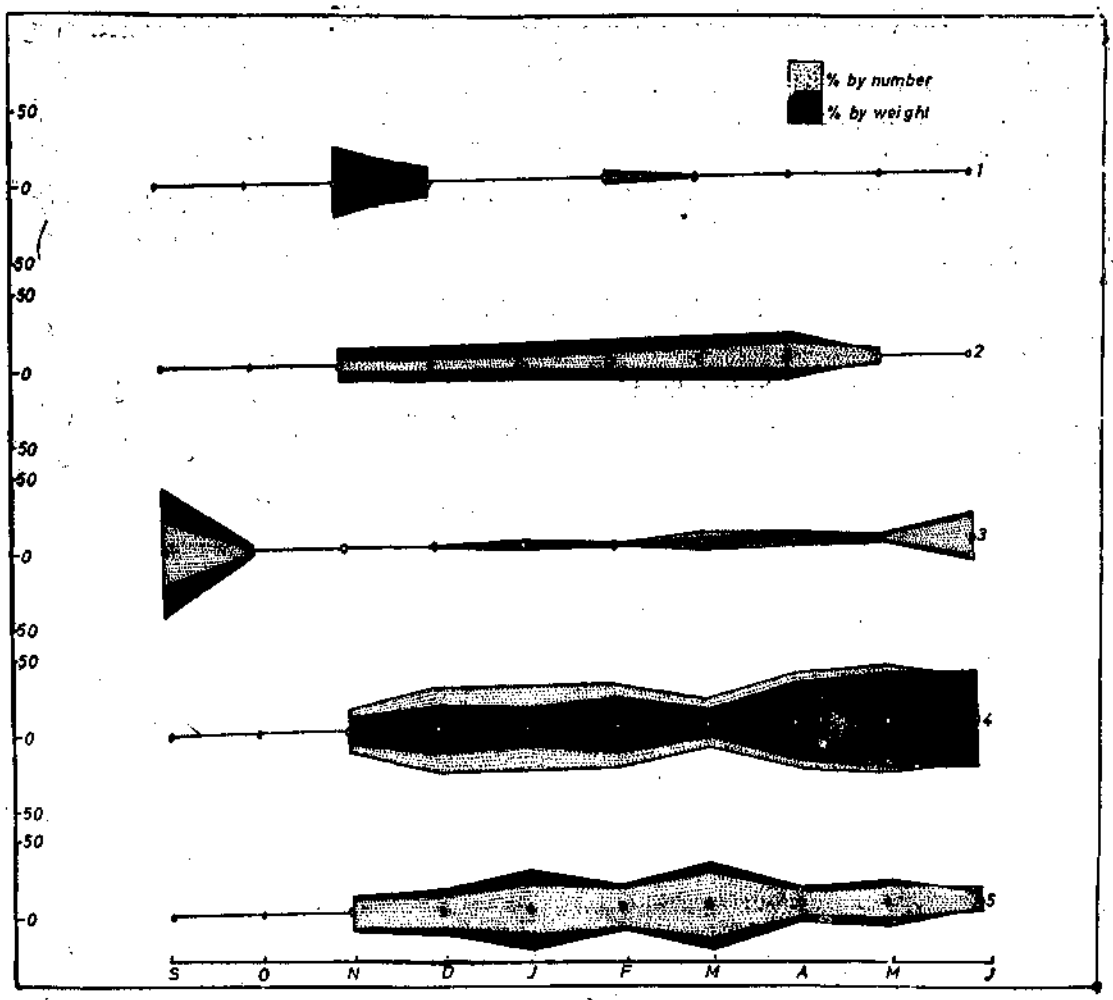


Fig. 5. Monthly distribution of species of prawns (percentage by weight and number) for the season 1959-60.

fishery in September—October the smaller species, *Parapeneopsis stylifera* dominates in the catches of these months particularly in September. Generally from October to November—December *Metapenaeus affinis* of large sizes predominates in the catches after which *M. dobsoni* takes the place. *M. monoceros* of large sizes contributes to any significant amount in the fishery only early in the season especially in November. *Penaeus indicus* does not become the dominant species in any of the months and its occurrence is found to vary considerably from season to season. In general, *M. dobsoni* and *M. affinis* are the mainstay of the fishery.

M. dobsoni.—In almost all the seasons the occurrence of this species in the catches follow a set pattern, in small percentage early in the season, gradually increasing and contributing to well over 70% of the catches towards the end of the season. However, in 1960-61 when

the minimum in the case of both percentage of prawns in the total catch as well as catch per trawling hour (Fig. 2) has been recorded the distribution of this species is found to be slightly different in that the percentage contribution decreases considerably towards the middle of the season—26·9 % by numbers and 10·6% by weight in February 1961. There is a considerable recovery in the month of April (76·8% and 65·7% respectively) after which it again goes down (Fig. 6). This probably is one of the reasons for the diminished catches noticed in the fishery in that season.

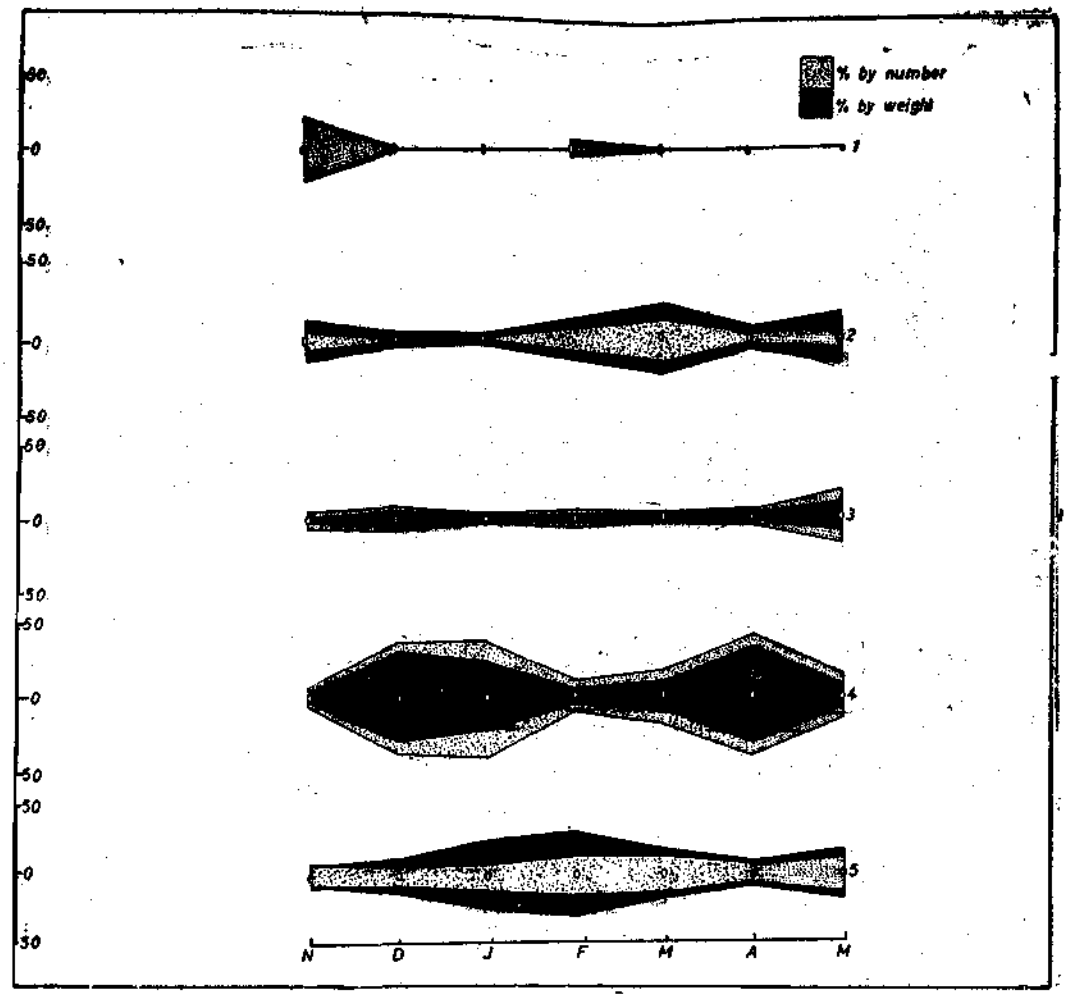


Fig. 6. Monthly distribution of species of prawn (percentage by weight and number) for the season 1960-61.

M. affinis.—This species occurs in good numbers in the first half of the season and usually predominates in the catches up to December. From January onwards there is decrease in their percentage in most of the seasons excepting 1958—59. There is a secondary

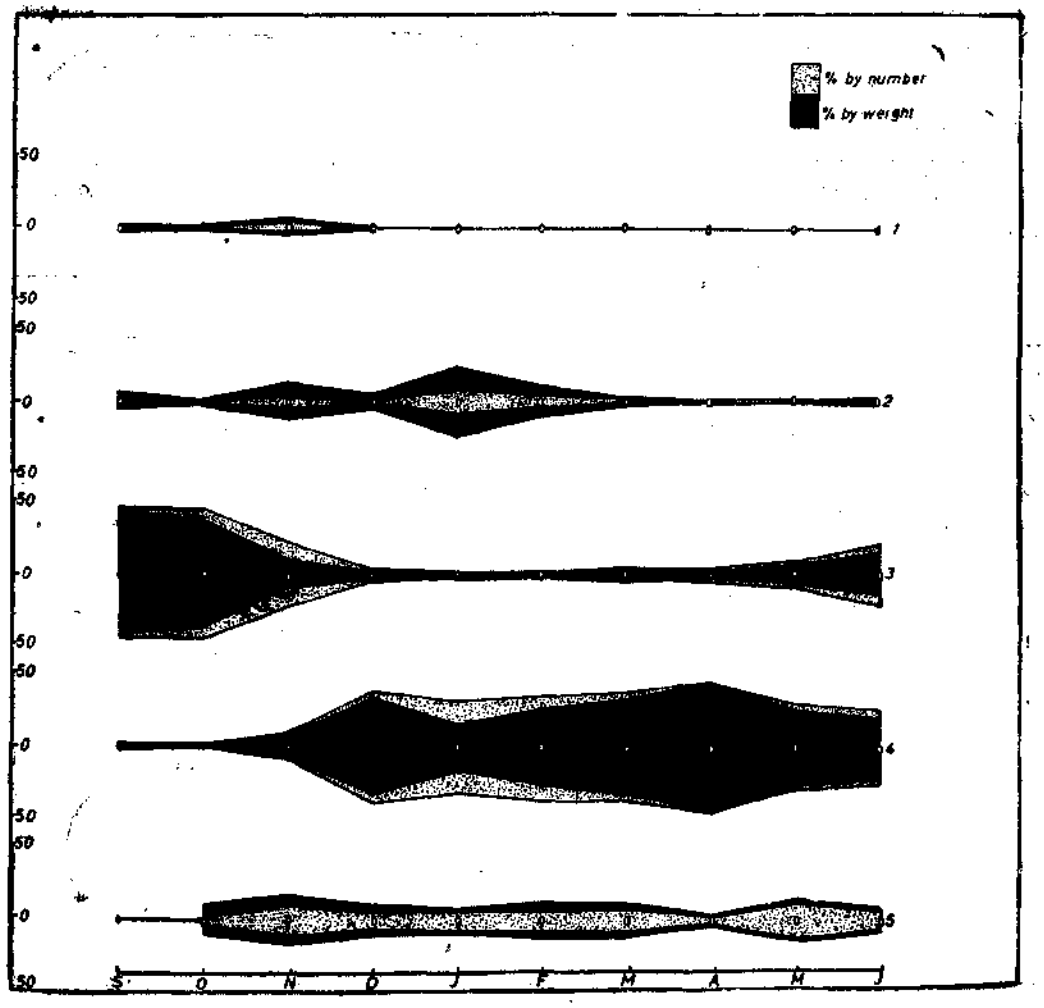


Fig. 7. Monthly distribution of species of prawns (percentage by weight and number) for the season 1961-62.

peak in its distribution either in the middle or towards the end. In any case, this secondary peak of the species is contributed by smaller sized individuals as can be noticed from the figures. The decrease in the size of the species after November—December has also been noticed in the inshore fishery of the area by George (1961).

P. indicus.—Though not contributing to the fishery to the same extent as the previous two species *P. indicus* is important from the commercial point of view due to its larger size and consumer preference. The size of the species when present in the catches is always large. However, the maximum abundance of the species in all the seasons falls in the months between January and April. The highest percentage recorded was never more than 30 by number and 48 by weight, the former in March 1961 and the latter in January 1962. Early in the season during the September — October period this species is conspicuously rare.

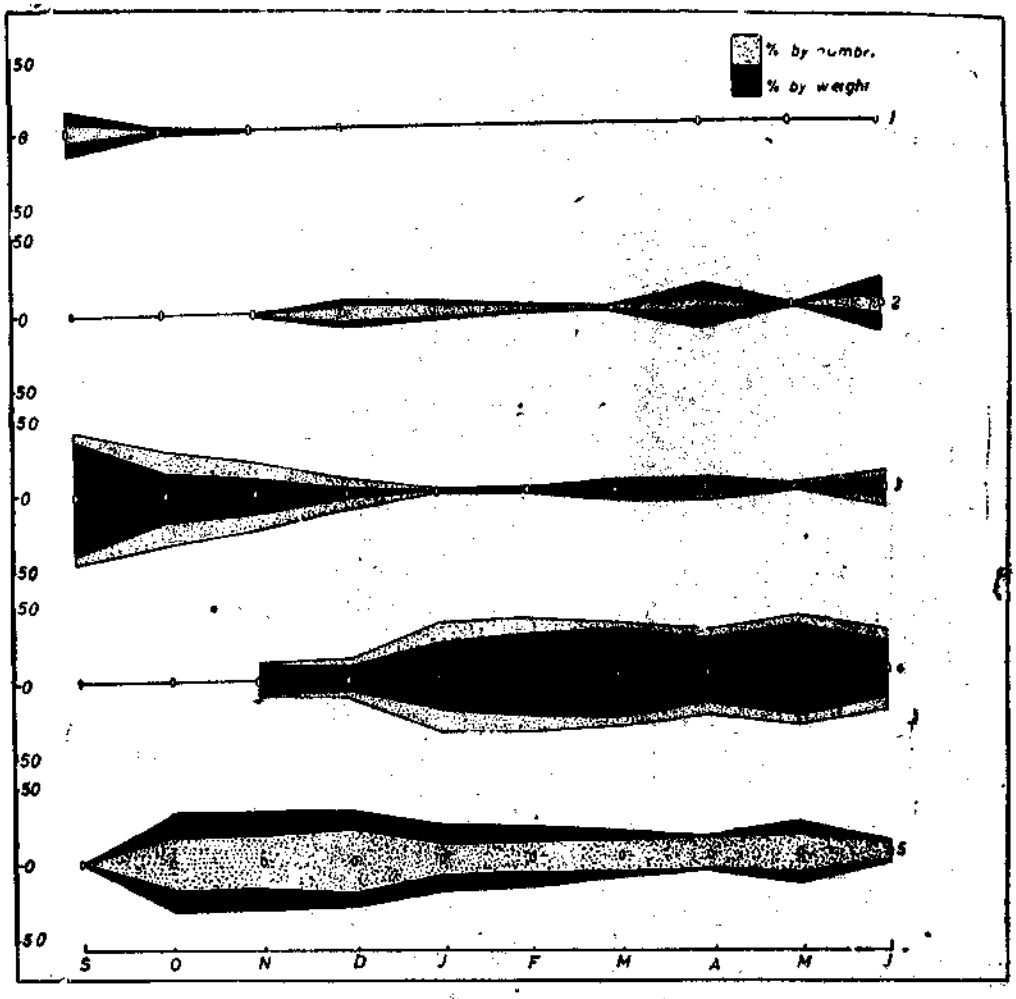


Fig. 8. Monthly distribution of species of prawns (percentage by weight and number) for the season 1952-63.

P. stylifera.—This species is present in the catches in significant quantities only in the beginning of the season when it forms the main component and in a few years (1959-60 and 1961-62) towards the close namely in the month of June. During December to May it is represented in the catches only in scanty numbers.

M. monoceros.—The fishery of this species in this area is restricted mostly to the month of November, when large sized specimens are obtained. Occasionally smaller specimens of the species are caught in small numbers in the middle of the season as well.

Depthwise :

When the fishery starts in September soon after the monsoon rains prawns are almost absent in the usual trawling areas between 10 and 30 metres. If at all any catch is obtained

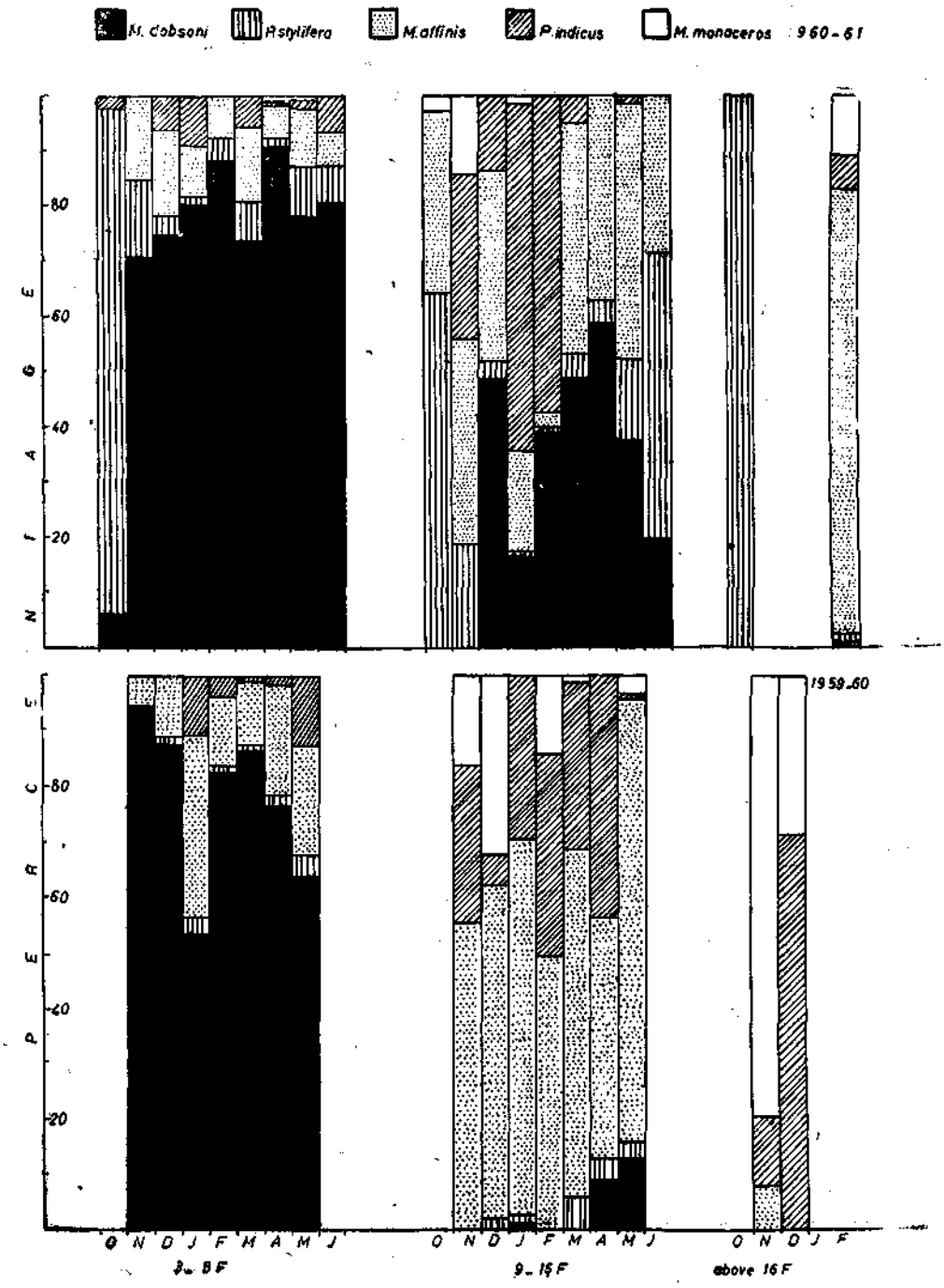


Fig. 9. Monthly depthwise distribution of different species based on the catches of the vessels M. V. Tarpon and M-2 for the seasons 1959-60 and 1960-61.

in this month it is from deeper areas beyond the 30 metre line and the catch consists mostly of *P. stylifera*. The catch per trawling hour and percentage of prawns in the catch of two vessels at various depths for the three years 1959 to 1961 are given in the Tables II to V. The percentage contributed by each species at the different depth ranges are set forth in Fig. 9 and Table VI. From October onwards the prawn beds seem to get gradually colonised in the shallow areas. It is clear from the tables that the 11 to 20 metres area is the most productive region for prawns during the main season. In certain months, in this region itself, there are concentrations at two different depths namely 12-15 metre region and 18-20 metre region. (Table VI) From the depthwise break up of the catches into species for the seasons 1959-1960 and 1960-61 (Fig. 9) it is seen that these two concentrations are brought about by different species the former by the smaller species *M. dobsoni* and the latter by the bigger ones *M. affinis* and *P. indicus* particularly by the former.

TABLE II

Showing the percentage of prawn in different depths in the catches of the vessel M-2 during the years 1959 to 1961

Month	Depth in metres								
	9	11	13	15	17	19	21	23	25 & above
January '59.	..	27·7	41·5	50·8	60·4	11·0	..	..	..
February	10·5	43·8	54·5	75·2	45·0	46·6	21·4	..	..
March	..	..	65·6	64·0	85·4	87·3	100·0	91·2	..
April	..	..	96·9	89·7	80·7	..	..	..	4·1
May	..	73·1	65·8	67·3	11·1	..	..	..	..
September	No prawns in operations 10 to 40 metres								
October	No prawns in operations 10 to 20 metres								
November	..	10·4	Nil	Nil	9·9	6·8	Nil	Nil	1·8
December	23·3	29·5	32·3	21·7	13·2	5·3	9·5	9·0	9·8
January '60	29·1	37·5	32·0	22·5	0·8	0·6	Nil	..	..
February	66·7	35·2	55·6	50·6	68·9	48·4	9·1	..	..
March	19·3	25·7	16·3	21·1	10·4	7·9	5·4	9·2	9·1
April	..	30·6	42·2	40·9	29·3	16·1	..	..	0·4
May	..	83·9	68·4	53·1	32·5	54·5	..	..	..
June	25·4	..	..	87·2	61·0	87·3	91·6	..	..
September	No prawns in operations 35 to 40 metres								
October	..	53·9	No prawns in operations 32 to 43 metres						
November	..	..	..	66·7	..	33·3	Nil	3·5	1·3
December	..	..	47·4	72·7	28·6	11·2	11·1	11·0	Nil
January '61	..	68·0	38·6	35·7	18·2	27·6	10·6	9·0	..
February	..	..	..	36·2	17·2	16·4	16·5	6·9	..
March	..	..	..	..	3·2	16·7	..	..	..
April	..	..	..	..	37·7	43·1	13·4	33·3	..
May	..	..	..	54·6	58·6	21·5	..	..	..
October	27·9	56·4	100·0	..	..	..	..	..	15·5
November	..	39·4	61·5	21·5	61·4	35·4	26·9	18·1	11·3
December	..	44·3	72·9	71·2	42·4	..	..	..	..

TABLE III

Showing catch per trawling hour of prawns in kg. for the operation of the vessel M-2 in different depths for the years 1959 to 1961

Month	Depth in metres								
	9	11	13	15	17	19	21	23	25 & above
January '59	..	23·7	76·2	88·9	104·1	12·0	..	..	..
February	3·9	78·6	98·2	138·0	84·8	54·2	9·6	..	..
March	..	..	49·6	54·2	102·1	74·5	9·1	27·2	..
April	..	..	172·5	94·3	74·6	..	..	..	3·2
May	..	121·5	72·4	111·3	3·2	..	..	..	..
September	No prawns in operations 10 to 40 metres								
October	No prawns in operations 10 to 20 metres								
November	..	18·1	Nil	Nil	11·5	8·8	Nil	Nil	1·1
December	19·8	27·4	29·5	25·4	7·9	7·1	11·5	5·9	33·1
January '60	27·3	60·6	41·3	33·8	1·5	1·2	Nil	..	..
February	90·7	62·0	99·3	100·7	187·7	20·0	2·3	..	..
March	18·2	21·5	35·7	19·3	140·6	10·0	7·5	11·9	10·0
April	..	32·9	39·7	42·2	34·4	24·0	..	..	1·0
May	..	58·2	148·8	95·7	51·9	116·3	..	..	..
June	15·4	..	..	264·7	22·7.	258·6	244·7	..	..
September	No prawns in operations 35 to 40 metres								
October	..	62·0	No prawns in operations 32 to 43 metres						
November	..	..	..	40·0	..	20·0	Nil	3·1	2·1
December	..	..	37·4	67·6	9·8	5·7	7·8	3·8	Nil
January '61	..	57·1	39·1	35·7	9·9	39·0	22·4	3·0	..
February	..	..	..	123·8	21·4	24·5	43·0	5·8	..
March	..	..	..	..	8·6	38·5	..	..	..
April	..	..	..	..	61·1	72·6	21·5	33·3	..
May	..	..	..	161·9	84·6	73·8	..	..	..
October	26·8	22·0	160·0	..	..	..	..	..	35·1
November	..	65·0	102·4	35·7	165·1	54·2	48·4	30·5	22·5
December	..	69·0	205·3	166·2	35·7	..	..	..	..

TABLE IV

Showing the percentage of prawns in different depths in the catches of the vessel M. V. Tarpon for the years 1959 to 1961

Month	Depth in metres								
	9	11	13	15	17	19	21	23	25 & above
January '59	..	..	65·3	33·0	48·6	45·4	39·4	37·9	47·2
February	47·8	32·0	32·9	33·9	38·5	17·1	15·9	21·3	Nil
March	..	..	7·3	19·3	33·6	35·2	14·7	13·5	3·9
April	65·9	35·5	58·0	61·0	42·2	69·8	27·1	..	..
May	88·4	83·7	78·2	35·2	78·9	46·3	42·7	..	..
October	..	..	Nil	..	..	Nil	..	Nil	..
November	..	..	1·5	12·6	7·2	7·1	1·3	2·4	2·6
December	..	13·5	6·5	6·7	8·7	6·5	8·7	7·0	2·7
January '60	..	13·0	17·9	12·2	16·9	18·5	5·6	..	..
February	..	..	13·6	30·8	16·4	18·9	11·3	8·1	5·7
March	..	..	..	..	6·6	8·4	8·2	4·5	3·5
April	..	4·3	10·3	4·7	12·1	6·6	8·5	3·4	10·2
May	..	..	8·9	11·0	20·2	21·0	1·5	..	..
June	..	..	65·2	..	..	..	..	..	..
September	..	..	Nil	..	..	..	..	..	Nil
October	..	..	..	..	Nil	Nil	..	..	0·8
November	..	..	..	..	..	..	..	Nil	3·3
December	Operations off Mangalore								
January '61	Do								
February	Do								
March	29·9	..	76·5	14·8	38·2	13·6	..	Nil	..
April	..	..	16·7	24·9	18·8	29·0	20·1	8·5	9·5
May	..	..	23·5	10·4	18·0	8·4	11·9	5·2	3·1
June	..	..	23·0	..	..	90·6	72·2	..	..
October	..	..	15·1	0·6	Nil	4·5	Nil	13·8	11·1
November	..	..	13·9	19·6	13·9	40·6	10·9	13·9	11·7
December	..	Nil	49·4	44·9	27·2	28·2	..	12·6	6·3

TABLE V

Showing catch per trawling hour of prawns in kg. for the operations of the vessel M. V. Tarpon for different depths in the years 1959 to 1961

Month	Depth in makers								
	9	11	13	15	17	19	21	23	25 & above
January'59	..	..	84·7	36·0	50·8	62·5	49·7	24·3	65·3
February	85·6	43·5	49·8	40·1	55·5	20·3	20·3	59·7	Nil
March	..	..	10·0	34·3	58·2	73·9	39·8	23·9	4·0
April	226·7	37·1	122·3	100·8	59·6	167·0	51·0	..	..
May	216·5	129·9	97·7	57·5	233·7	134·7	11·5	..	..
October	..	..	Nil	..	..	Nil	..	Nil	..
November	..	..	1·8	20·7	12·3	17·0	2·3	4·7	3·9
December	..	27·0	7·1	17·3	19·8	15·1	28·4	12·5	4·1
January' 60	..	34·9	38·7	31·6	40·5	39·5	9·1	..	..
February	..	..	35·4	100·1	42·7	47·4	22·1	15·6	10·1
March	..	..	..	..	21·0	25·9	20·8	9·1	7·1
April	..	7·2	29·3	10·8	31·2	15·6	14·2	8·3	20·9
May	..	16·7	27·3	43·4	42·2	3·2	..	..	..
June	..	..	66·9	..	..	..	..	..	..
September	..	..	Nil	..	..	..	..	..	Nil
October	..	..	..	..	Nil	Nil	..	..	1·6
November	..	..	..	..	..	..	..	Nil	10·3
December	Operations off Mangalore								
January' 61	Do.								
February	Do.								
March	50·0	..	23·1	27·5	111·6	28·7	..	Nil	..
April	..	..	38·4	75·5	56·5	85·7	38·8	12·0	16·0
May	..	..	40·0	23·8	53·6	19·3	37·1	16·3	5·0
June	..	..	11·5	..	..	24·0	13·0	..	..
October	..	..	21·2	0·8	Nil	6·2	Nil	13·8	39·0
November	..	..	23·1	42·6	33·3	101·5	24·0	31·0	30·5
December	..	Nil	84·1	103·0	55·1	38·3	..	19·6	12·6

TABLE VI

Showing distribution of species in different depths (percentage by weight within each depth range)

1959-60

Months	3—8 fathoms					9—15 fathoms					16 fathoms & above				
	M. dobsoni	P. stylifera	M. affinis	P. indicus	M. monoceros	M. dobsoni	P-stylifera	M. affinis	P. indicus	M. monoceros	M. dobsoni	P. stylifera	M. affinis	P. indicus	M. monoceros
November	94·8	..	5·2	..	..	..	..	55·8	27·9	16·2	..	..	8·3	12·5	79·6
December	88·4	0·3	11·0	0·3	..	..	1·9	60·4	5·7	32·1	..	..	..	71·4	28·6
January	59·2	2·4	32·8	5·6	..	1·5	1·5	67·7	29·2	..	..	..	..	..	..
February	82·8	0·8	12·8	3·5	..	..	0·2	49·6	36·1	14·1	..	..	..	..	..
March	86·9	0·2	12·4	0·3	0·2	..	5·8	62·9	30·0	1·3	..	..	..	..	..
April	77·2	1·4	20·2	1·3	..	8·9	4·2	43·5	43·5	..	..	..	..	..	..
May	64·1	3·9	19·5	12·2	0·2	13·3	2·9	79·9	0·9	2·9	..	..	..	..	..
1960-61															
October	6·1	92·1	..	1·8	..	..	64·5	33·1	..	2·4	..	100·0	..	..	..
November	71·2	14·0	14·7	..	..	..	19·0	37·0	30·2	13·8	..	..	..	..	..
December	75·2	3·4	15·3	5·7	0·3	49·4	3·1	34·4	13·1	..	..	..	..	..	..
January	80·6	1·6	9·1	8·5	0·1	16·8	0·4	18·7	62·6	1·4	..	..	..	..	..
February	88·6	4·0	7·4	..	..	39·4	0·3	3·0	57·3	..	1·4	1·1	80·5	6·3	10·7
March	74·2	7·3	13·1	5·3	0.1	48·8	4·6	41·6	5·0	..	..	..	..	..	..
April	91·3	1·6	6·3	0·4	0·2	59·1	3·8	36·8	..	0·3	..	..	..	..	..
May	78·7	9·0	10·6	1·3	0·4	37·8	14·6	46·0	0·4	0·3	..	..	..	..	..
June	81·3	6·4	6·1	6·2	..	20·1	51·7	28·1	..	..	..	..	..	..	..

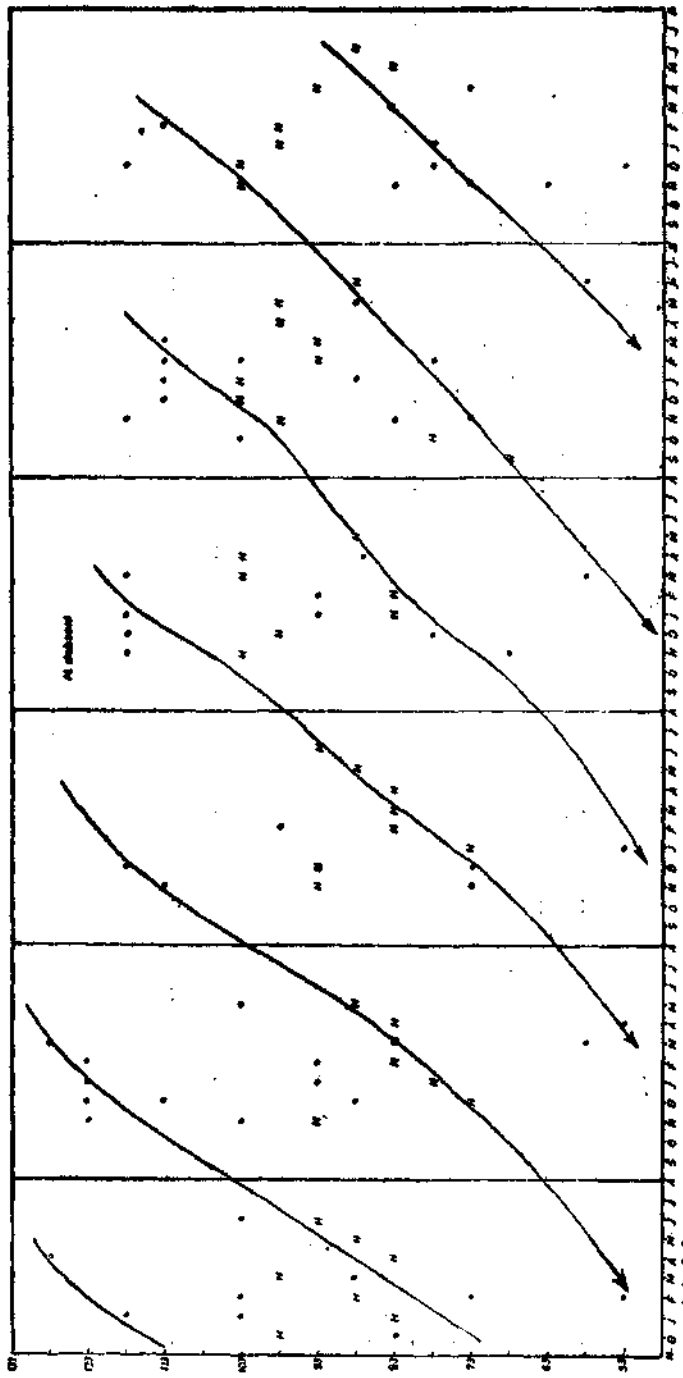


Fig. 10. Modal size distribution of *M. dobsoni*.
H—Dominant mode. ●—Lesser modes.

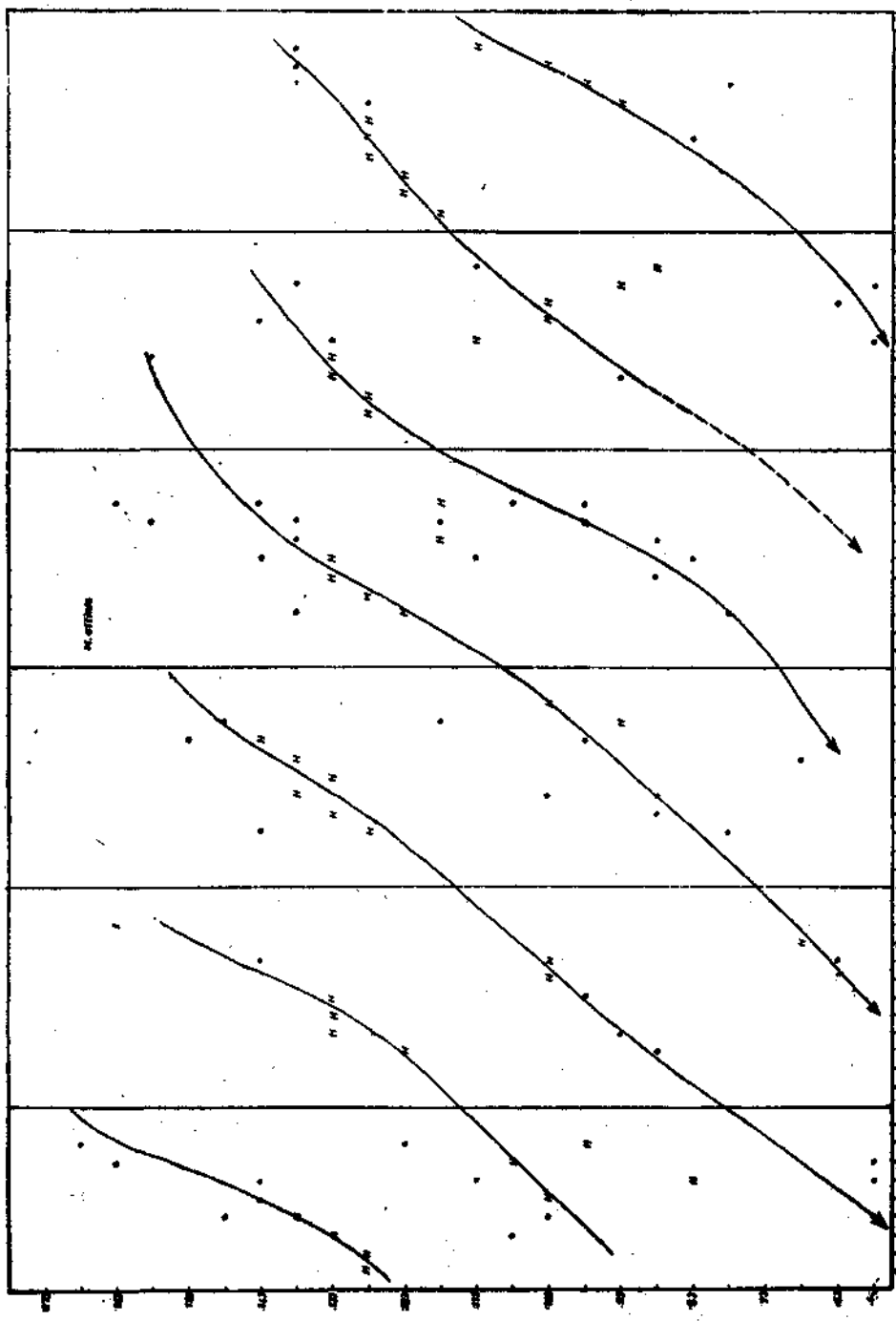


Fig. 11. Modal size distribution of *M. affinis*
H—Dominant mode, ●—Lesser modes.

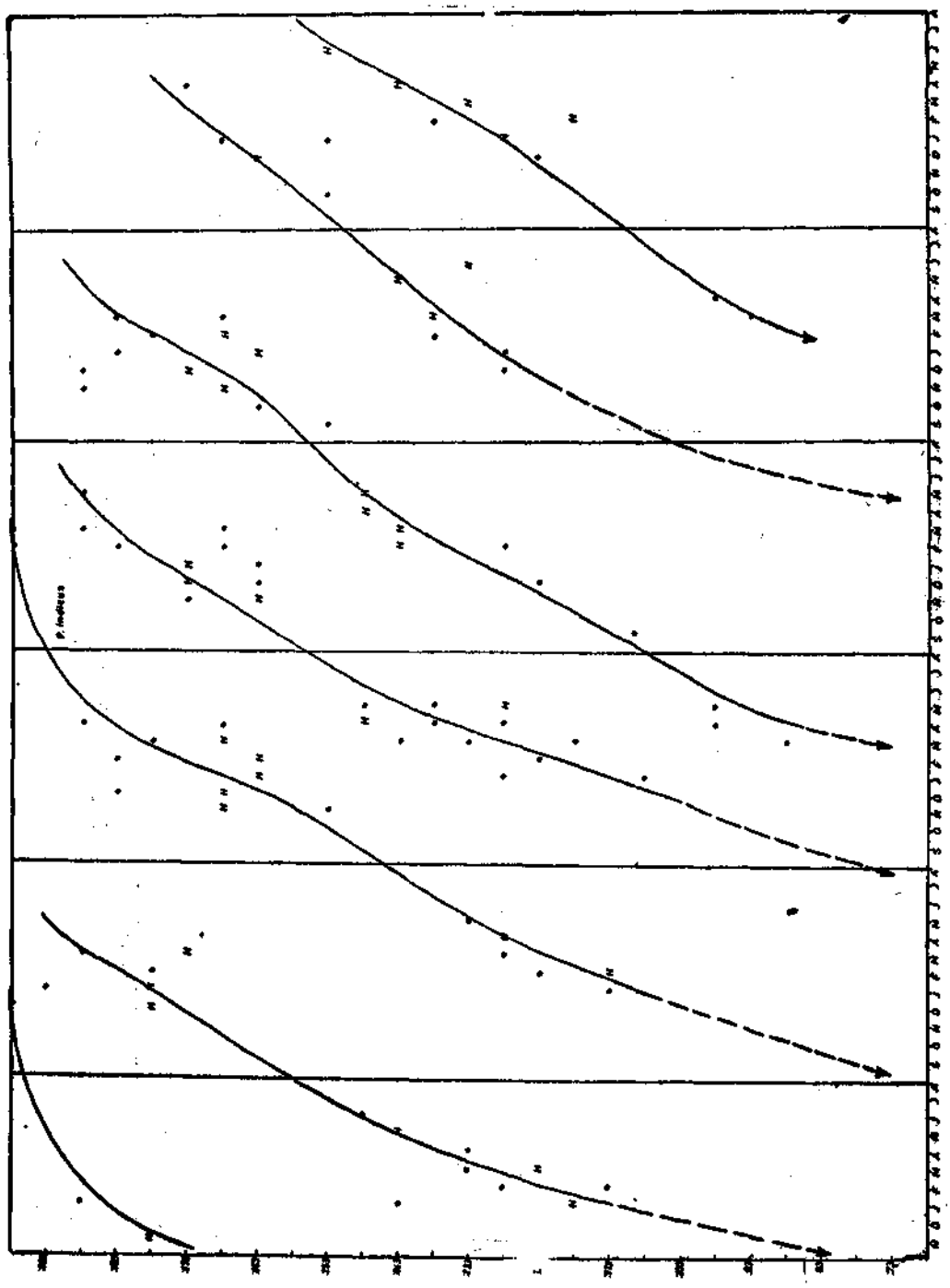


Fig. 12. Modal size distribution of *P. indicus*.
H—Dominant mode. ●—Lesser modes.

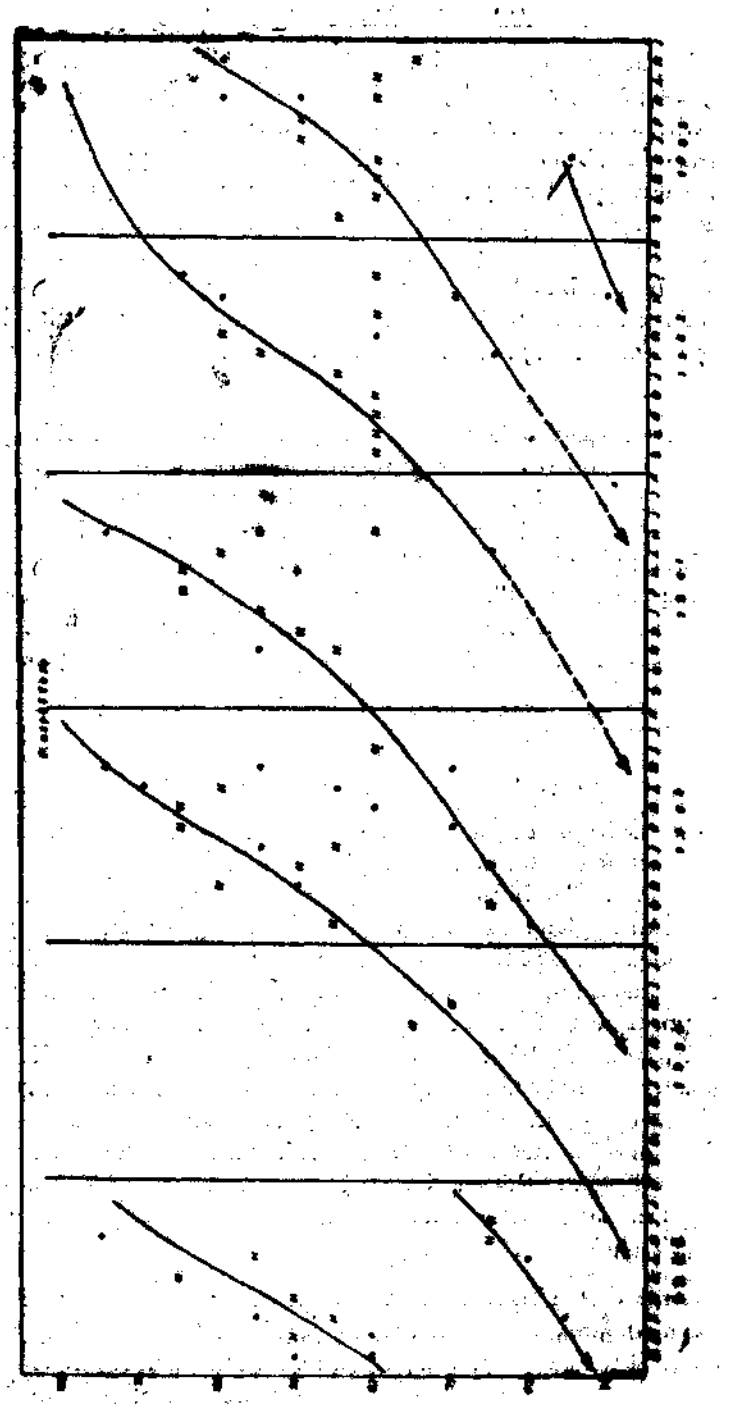


Fig. 156. Modal size distribution of *P. stylifera*.
H—Dominant mode. L—Lesser modes.

POPULATION CHARACTERISTICS

Monthly size frequency modal distribution for each species in the fishery for the season 1958-59 through 1962-63 are given in Figs. 10-13. Plotted serially for all the years under observation and fitted with smooth curves the size distribution modes can be seen, in the case of all the species, to trace each brood from its recruitment to its disappearance from the fishery. Each curve is more or less typically sigmoid describing the population growth in size. From the curves the inter-relationships of successive broods seem to be sufficiently clear. However, slight variations in the fitted lines do pose a question regarding their causes. Perhaps part of this variation could be attributed to sampling error, disproportionate availability and differential growth of sexes, most probably the latter. It may also probably be due to the continuous spawning activity throughout the year by most of the species as observed by Goerge (1962).

In the case of all the species the O-year class is recruited into the fishery in very small numbers. The first and second year classes support the fishery in consecutive years and then disappear. The O-year class contribution to the fishery being very little in each year the fishery is sustained by two year classes the first year class from the previous years brood and the second year class from the brood previous to that. Thus a brood which comes into the fishery can be easily traced to its disappearance. The second year classes generally enter the fishery in the earlier half of the season and the first year class makes their appearance in the latter half (Figs. 10-13). In the case of *P. indicus* the third year class also seem to be represented in certain years (1958-59 and 1960-61 seasons) as indicated by the lesser modes fitting into the curves (Fig. 12) at 193 and 198 mm during the middle of the season.

GROWTH AND AGE COMPOSITION

M. dobsoni.—In the beginning of the season two modes are seen in the length frequency distribution (Fig. 14), at 66-70 mm and 101-105 mm in males and 76-80 mm and 116-120 mm in the case of females. The bigger mode is found to disappear from the picture within the next one or two months. The mode at the smaller size group shows a gradual shifting through the months to 86-90 mm and 101-105 mm respectively in May-June thereby showing a growth of 20 mm in males and 25 mm in females during the span of 6 to 7 months. The same trend in the appearance of the modes and the growth of the species is seen in all the seasons. Menon and Raman (1961) has recorded the dominant mode in the fishery of this species in the backwaters of Cochin as 46-50 mm in May—June months. It is probably this group after being brought out into the sea during the monsoon months that appears at 66-70 mm and 76-80 mm in the two sexes at the beginning of the off-shore fishery in the post-monsoon period. Of course this can be confirmed only by conducting extensive tagging operations. Differential rate of growth in sexes is clearly seen in the case of this species (Fig. 14) as observed by Menon (1955) and George (1961).

M. affinis.—In the earlier months of the season this species is represented by large sized specimens with the dominant mode at 121-125 mm in males and 136-140 mm in females. By the end of the season (May-June) these modes shift to 141-145 and 161-165 mm respectively. A growth of 20 mm among males and 25 mm among females is noticed during the season. Towards the middle of the season the number of the large sized specimens becomes less and the smaller sizes get recruited into the fishery. In February these smaller specimens show a

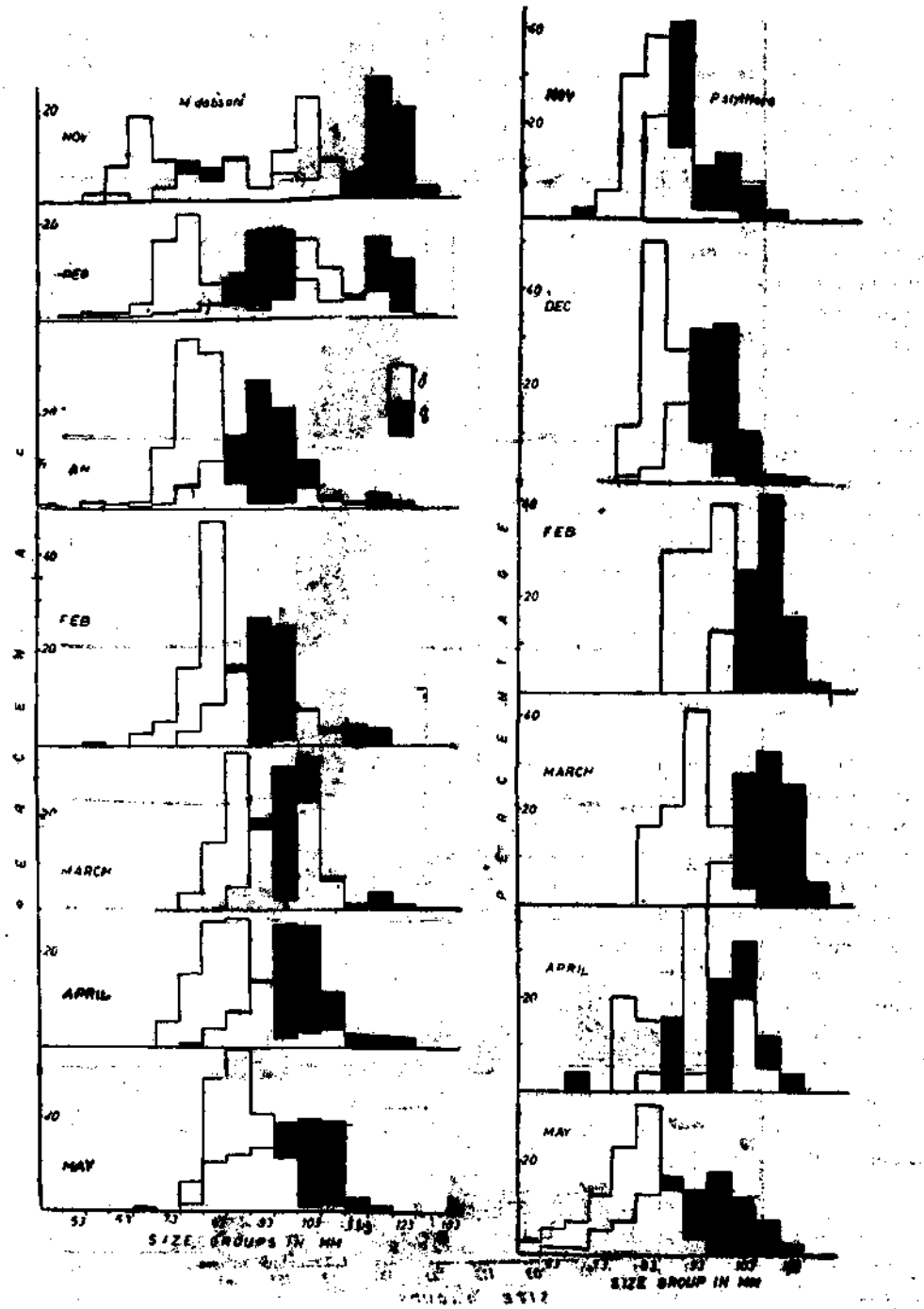
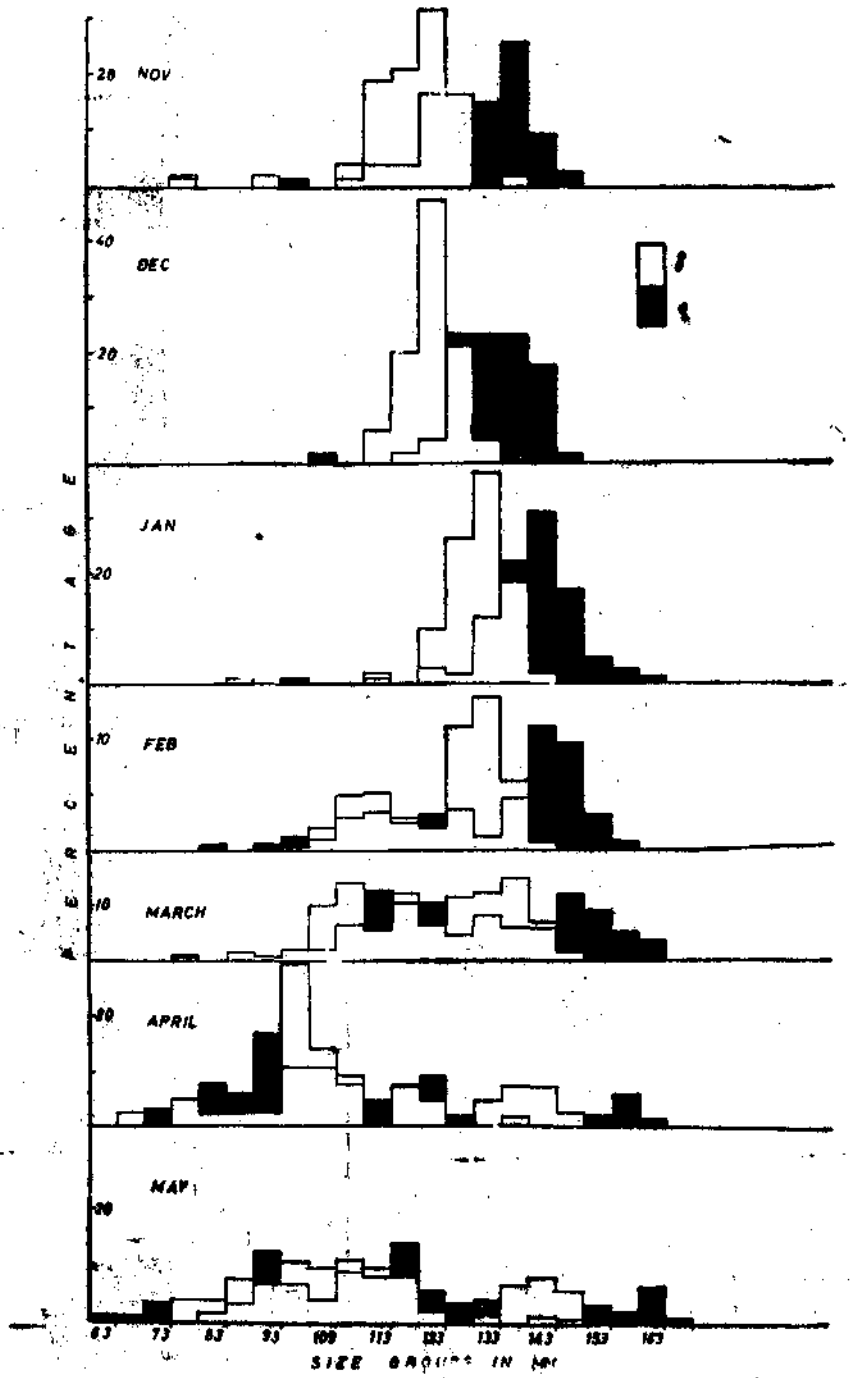


Fig. 14. Length frequency distribution of *M. dobsoni* and *P. stylifera* for the season 1960-61



15. Length frequency distribution of *M. affinis* for the season 1960-61.

mode at 111-115mm. which is seen shifting gradually towards the right (Fig. 15) in the subsequent months. This pattern of size distribution and growth during the season appears to be the same in all the seasons of observation. Differential rate of growth in the two sexes are noticed in this species also, females growing faster.

P. indicus.—In the case of this species also large sized specimens are represented in the catches early in the season when the 2nd year class dominates with the dominant mode at 161—165mm. for males and 171—175mm. for females (Fig. 16). These modes shift to 166—170mm. and 181—185mm. respectively by February and then disappear. Simultaneously another mode representing the smaller size groups appear in February indicating the recruitment from the next brood (1st year class) into the fishery (Fig. 16). The mode is at 126—130mm. for males and 141—145mm. for females. A gradual shifting of these modes are noticed in the subsequent months reaching 146—150mm. in the case of males and 156—160mm. in the case of females in May thus showing a growth of 20mm. in males and 15mm. in the case of females during the period of four months. The trend of appearance of two stocks during the season and the recruitment of the smaller size groups and their growth is strikingly similar in all the seasons covered in the present report. The two sexes show differential rate of growth.

P. stylifera.—As seen in Fig. 14, in November the dominant mode of this species is 81—85mm. in males and 86—90mm. in females. These modes are noticed to shift gradually to 96—100mm. and 106—110mm respectively by the middle of the season in February-March. The growth in the intervening period of 4 months works out to 15mm. for males and 20mm. for females, which compares quite well with the other species mentioned above. From the figure it can be seen that smaller groups of probably the next brood come to the fishery in April-May. The pattern of the recruitment of the age classes into the fishery is quite similar in all the seasons. The rate of growth in the two sexes are different, the females showing fast growth.

M. monoceros.—The fishery for this species is mostly restricted to the months of November-December, especially November. In some years very small quantities occur in the catches in the months of February or April. In every season the catches in November-December consist of large sized specimens with modes varying from 125—130mm. to 141—145mm. in the case of males and 131—135mm. to 146—150mm. in the case of females. The catches in February or in April-May when present is represented by smaller sized specimens with mode at 76—80mm. to 101—105mm. evidently of subsequent brood. So the pattern of second year classes appearing in the fishery early in the season and the first year class being recruited after the middle of the season is seen in the case of this species also, although growth could not be traced due to lack of catches in some of the intervening months.

SEX RATIO

Most of the species generally exhibit preponderance of females in the catches during most of the months with the exception of *P. indicus*. In the case of *M. dobsoni* data for the six years show a higher percentage of females in several months. In most of the seasons towards the end a reversal of sex dominance is noticed, males being more than females in May-June months. In the inshore fishery of the species in this area Menon (1957) observes the dominance of females in larger sizes (the second year classes) and that of males in the smaller sizes (the first year classes). The present observation is quite in agreement with this in that in the earlier

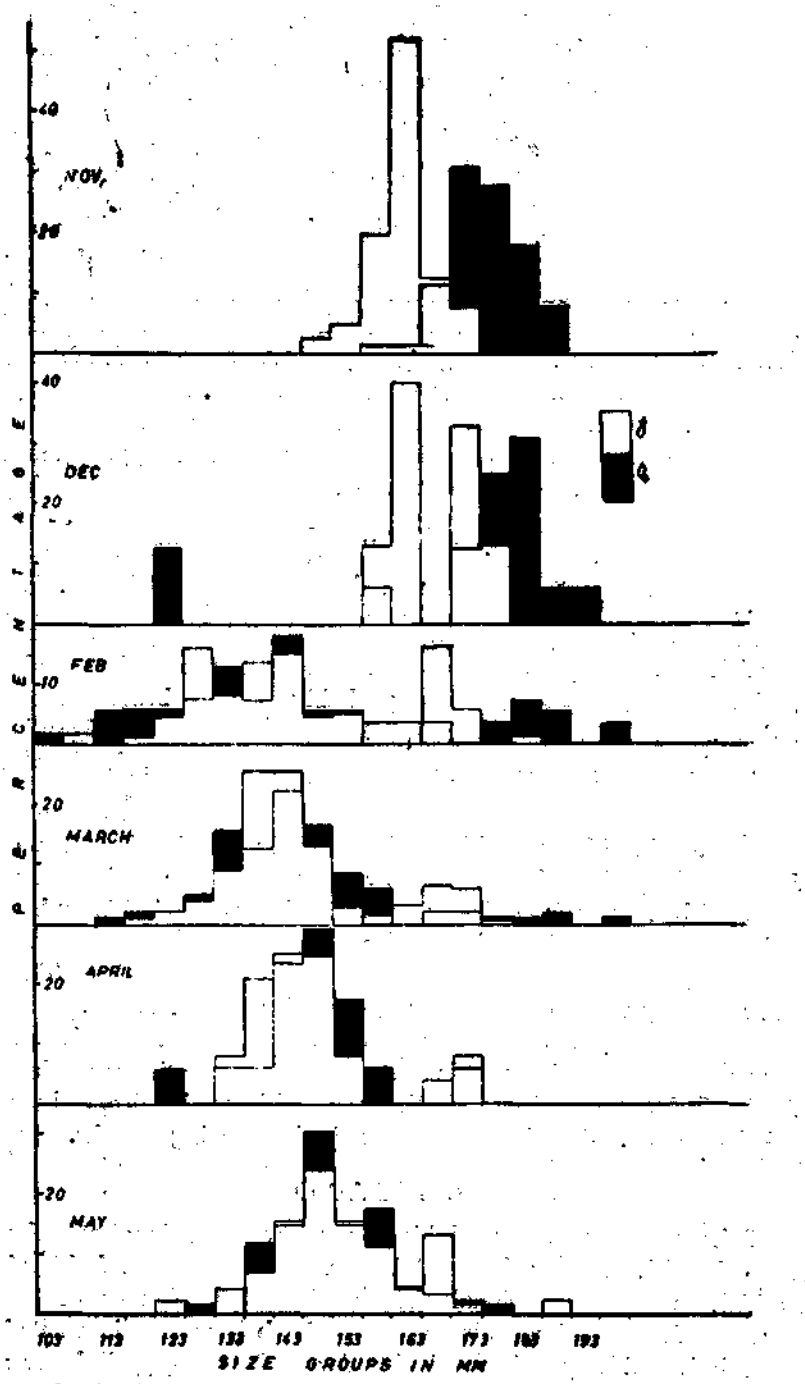


Fig. 16. Length-frequency distribution of *P. indicus* for the season 1960-61.

months when the second year classes dominate in the fishery it is the females which are in excess and in the end of the season when the first year classes are recruited more into the fishery it is the males which dominate, As suggested by Menon (op. cit.) these difference in the sex ratio may be linked with the breeding movements of the species.

Although not so pronounced as in *M. dobsoni*, *M. affinis* also shows more of the female in the catches over half the total number of months of observation. But the occurrence of this phenomenon in the case of this species is so erratic that no definite conclusion can be arrived at.

In *P. stylifera* Menon (op. cit.) recorded females far in excess of males only in very large sized specimens over 100mm. whereas in the smaller groups (less then 100mm. size) his observation is dominance of males. In the off-shore catches of the present study, however, females are found to predominate the catches in most of the months, both when the larger, sizes as well as the smaller sizes are recruited into the fishery. Out of 39 months in which data are available only 9 months show slightly higher percentage of males than that of females. In all the other months female percentage is higher.

P. indicus exhibit a slightly different pattern in the nature of sex ratio in the catches. In 21 out of 29 months of observation through the seasons males are in excess of females. Menon (op. cit.) observes in the inshore fishery of this species in this area a higher percentage of females in the sizes above 150mm. and in smaller specimens more of males. But in these off-shore catches even when the very large sized specimens of the species are caught in the early months of the season males are predominant. Female percentages are found to be higher than males only in a few months towards the latter half and close of the seasons when only smaller sizes are recruited into the fishery. This may probably be due to large percentage of females of the larger size group moving to still deeper or other areas for spawning activities and never returning.

In the case of *M. monoceros* in most of the months in which the species is available a higher percentage of females is noticed.

MATURITY STUDIES AND BREEDING SEASONS

M. dobsoni.—In the case of males in all the seasons the entire catch is contributed by mature specimens, the percentage of mature males being never less than 87 (Table VII). Mature and maturing females occur in varying numbers throughout the season so that it is difficult to pin point a breeding period for this species among the months of their occurrence. However, the presence of spent specimens, whenever they are noticed in the catches, early in the season and also a slightly higher percentage of maturing and mature individuals of females in the earlier months may be taken as an indication of a peak in the breeding season at that time namely November—February months. By the indirect evidence of recruitment of post-larvae into the backwaters of Cochin, George (1962) has observed the species to breed throughout the year with peak breeding in November and June—August. Although Menon (1951 and 1955) has not mentioned year round breeding for the species the peak seasons suggested therein is in agreement with the present observation.

TABLE VII

Showing the maturity conditions of both sexes of *M. dobsoni* during the seasons 1959-60 to 1962-63

Month	1959-60							1960-61						
	Male			Female				Male			Female			
	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent
November	Nil	100·0	12·5	35·0	50·0	15·0	Nil	21·7	78·3	56·8	44·6	43·2	12·2	Nil
December	Nil	100·0	23·7	32·6	60·0	7·4	Nil	5·2	94·8	53·7	5·1	75·7	17·6	1·6
January	10·0	90·0	30·3	43·1	50·0	6·9	Nil	3·5	96·5	39·9	16·3	70·5	12·3	0·9
February	7·2	92·8	48·8	37·5	57·8	4·7	Nil	Nil	100·0	33·6	0·7	63·6	35·7	Nil
March	9·5	90·5	49·8	53·9	42·6	3·5	Nil	Nil	100·0	7·4	Nil	77·7	22·3	Nil
April	9·5	90·5	42·2	60·1	37·8	2·1	Nil	Nil	100·0	29·7	Nil	74·2	19·7	Nil
May	Nil	100·0	11·4	45·9	49·6	4·5	Nil	0·6	99·4	50·0	1·5	42·4	56·1	Nil
June	Nil	100·0	30·9	53·7	41·5	4·8	Nil	..	..	..	..	..	..	..
	1961-62							1962-63						
November	0·7	99·3	22·5	5·1	66·7	23·9	4·3	8·7	91·3	76·9	28·9	67·8	3·3	Nil
December	0·3	99·7	29·5	43·1	39·7	17·2	Nil	2·4	97·6	42·7	44·0	39·2	16·8	Nil
January	0·6	99·5	47·9	61·9	30·2	7·9	Nil	4·8	95·2	46·6	32·0	59·9	8·1	Nil
February	1·5	98·5	24·7	36·0	61·8	2·2	Nil	6·9	93·1	21·0	36·8	50·8	12·4	Nil
March	1·2	98·8	37·2	53·5	44·4	2·1	Nil	12·9	87·1	27·9	52·9	40·0	7·1	Nil
April	Nil	100·0	29·4	53·7	43·1	3·2	Nil	12·2	87·8	20·5	63·1	32·9	4·0	Nil
May	1·7	98·3	27·1	53·3	38·9	7·8	Nil	4·4	95·6	19·4	61·1	35·6	3·3	Nil
	0·8	99·2	20·8	50·8	42·7	6·5	Nil	Nil	100·0	25·5	32·9	64·6	2·5	Nil

M. affinis.—In this species the maximum percentage of mature males are observed in the early months of the season and a regular decrease in their numbers is noticed as the season advances. This is the case with maturing, mature and impregnated females also (Table VIII). From these it may be concluded that the active breeding season is from November to February.

P. indicus.—From the occurrence of mature males and maturing, mature and impregnated females in the months in which data are available (Table IX) it may be inferred that this species is breeding throughout the season with two peaks, one in December-January and the other later in the season during May-June which is in agreement with the observations of Panikkar and Menon (1955). Subrahmanian (1963), however, deduced by gonad index studies the breeding activity of the species to be pronounced in March and May to September. This difference may be brought about by the differences in ecological factors and other life conditions, his study being on the catches from the east coast.

P. stylifera.—The percentage figures of maturing and mature females show the maximum in December during 1959-60 season with a regular decrease in their number in the subsequent months (Table X). This agrees with the observations of Menon (1953) and George (1961).

But from the data for the following seasons it is difficult to delineate any particular peak period of breeding for the species.

M. monoceros.—Samples of the species were available only during a few months every eason and hence no definite conclusion regarding breeding period could be arrived at, with the present data. During the monsoon cruises of the research vessel "Varuna" recently George and George (1964) located a possible spawning ground for this species in the sand shelves at the 50—60 metre depths off Cochin by collecting a good quantity of potential breeders from the area.

MOVEMENT

Early in the season when fishing operations commence all the trawlers have to go out for fishing to greater depths, 36 metres and more because of the absence of prawns in the usual trawling grounds, between 10 and 30 metres. This is probably because of the effect of upwelling as suggested by Banse (1959). According to him upwelling occurs all along the Malabar coast during the five months June to October when the cold, badly aerated water covers the shelf. Ramamirtham and Jayaraman (1960) have also observed the phenomenon of upwelling in these waters during the monsoon period. They remark that "except for a thin layer of 10 metres at the top the entire shelf is pervaded by cold (below 22°C), highly saline and poorly oxygenated water". According to them upwelling appears to practically disappear by the end of October. By November when normal conditions are restored prawns begin to occur in shallower areas. The question arises as to where the prawns are moving to during the upwelling period. According to Banse (op. cit.) during this time "either the fishes (and prawns) are pressed against the shore or are migrating to deep waters. Mid water life does not seem to be maintained for a long period even if it occurs". As regards *M. dobsoni* the former seems to be true since it supports a very lucrative fishery during the monsoon months in the mud bank formations in the inshore regions near Cochin. Menon (1955 & 1958) reports

TABLE VIII

Showing the maturity conditions of both sexes of *M. affinis* during the seasons 1959-60 to 1962-63

Month	1959-60 Male		1959-60 Female					1960-61 Male		1960-61 Female				
	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent
November	43·3	56·7	13·9	72·2	22·2	5·6	Nil	48·9	51·1	27·8	88·9	11·1	Nil	Nil
December	19·1	80·9	20·8	81·7	15·0	3·3	Nil	30·8	69·2	50·6	45·0	29·2	25·8	Nil
January	15·3	84·7	37·3	84·2	13·0	2·8	Nil	10·9	89·1	5·9	19·6	49·0	31·4	Nil
February	20·5	79·5	32·3	70·1	27·6	2·3	Nil	30·9	69·1	39·3	8·5	60·2	30·3	1·0
March	25·8	74·2	23·9	84·1	13·5	2·4	Nil	46·9	53·1	37·1	2·0	58·3	39·7	Nil
April	53·8	46·2	30·3	84·9	12·1	3·0	Nil	79·1	20·9	19·7	12·2	54·5	33·3	Nil
May	77·6	22·4	13·3	84·7	15·3	Nil	Nil	75·2	24·8	15·5	30·2	60·3	9·5	Nil
	1961-62							1962-63						
October	31·3	68·7	86·2	13·9	10·3	75·8	Nil	46·1	53·9	36·4	42·2	50·7	7·1	Nil
November	20·3	79·7	74·2	2·5	55·8	41·7	Nil	40·8	59·2	46·2	26·9	64·1	9·0	Nil
December	19·0	81·0	26·7	15·1	35·8	49·1	Nil	16·0	84·0	21·2	46·3	46·9	6·8	Nil
January	18·3	81·7	59·4	17·7	76·0	6·3	Nil	21·2	78·8	19·4	16·1	74·2	9·7	Nil
February	60·2	39·8	20·6	19·7	63·0	12·3	Nil	26·7	73·3	24·3	37·5	52·8	9·7	Nil
March	71·3	28·7	29·0	39·3	51·7	9·0	Nil	81·7	18·3	6·6	81·3	17·5	1·2	Nil
April	83·3	16·7	8·1	59·5	32·4	8·1	Nil	95·1	4·9	7·8	82·2	15·0	2·8	Nil
May	98·9	1·1	1·4	88·6	8·2	3·2	Nil	96·3	3·7	15·9	54·2	42·6	3·2	Nil
June	98·7	1·3	Nil	100·0	Nil	Nil	Nil	90·3	9·7	5·3	85·7	14·3	Nil	Nil

TABLE IX

Showing the maturity conditions of both sexes of *P. indicus* during the seasons 1959-60 to 1962-63

Month	1959-60							1960-61						
	Male		Female					Male		Female				
	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent
November	7·1	92·9	Nil	75·0	25·0	Nil	Nil	Nil	100·0	3·3	80·3	16·4	3·3	Nil
December	2·6	97·4	Nil	Nil	96·3	Nil	3·7	Nil	100·0	12·5	24·9	56·3	18·8	Nil
January	29·4	70·6	Nil	86·4	13·6	Nil	Nil	Nil	100·0	..	..	..	..	..
February	17·6	82·4	Nil	88·3	11·7	Nil	Nil	36·4	63·6	Nil	23·5	45·5	25·5	5·5
March	16·3	83·7	Nil	85·7	14·3	Nil	Nil	26·9	73·1	Nil	Nil	64·1	32·0	3·9
April	38·8	61·2	Nil	84·7	13·5	1·8	Nil	16·7	83·3	Nil	Nil	52·9	47·1	Nil
May	90·0	10·0	Nil	94·7	5·3	Nil	Nil	13·0	87·0	Nil	68·2	20·3	10·1	1·4
	1961-62							1962-63						
November	Nil	100·0	2·8	5·6	75·0	19·4	Nil	..	..	..	..	..	..	..
December	4·8	95·2	Nil	33·4	33·3	33·3	Nil	2·6	97·4	Nil	22·2	61·1	16·7	Nil
January	2·8	97·2	Nil	31·1	35·9	33·0	Nil	58·0	42·0	Nil	100·0	Nil	Nil	Nil
February	13·4	86·6	Nil	48·4	45·5	6·1	Nil	93·3	6·7	Nil	100·0	Nil	Nil	Nil
March	50·0	50·0	Nil	22·2	61·1	16·7	Nil	..	..	..	..	..	..	..
April	..	..	..	..	..	..	..	28·2	71·8	Nil	20·9	69·4	9·7	Nil
May	..	..	..	..	..	..	..	..	..	..	..	..	..	..
June	..	..	..	..	..	..	..	10·7	89·3	Nil	55·4	44·6	Nil	Nil

TABLE X

Showing the maturity conditions of both sexes of *P. stylifera* during the seasons 1959-60 to 1962-63

Month	1959-60							1960-61						
	Male			Female				Male			Female			
	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent	Immature	Mature	Impregnated	Immature	Maturing	Mature	Spent
November	..	..	..	..	..	..	..	Nil	100·0	100·0	67·4	23·3	9·3	Nil
December	16·7	83·3	100·0	Nil	66·7	33·3	Nil	Nil	100·0	99·2	21·4	59·5	19·1	Nil
January	Nil	100·0	100·0	63·4	23·3	13·3	Nil	Nil	100·0	100·0	8·3	66·7	25·0	Nil
February	Nil	100·0	100·0	60·0	30·0	10·0	Nil	Nil	100·0	100·0	Nil	64·5	35·5	Nil
March	Nil	100·0	100·0	62·2	30·5	7·3	Nil	Nil	100·0	100·0	2·3	74·4	23·3	Nil
April	Nil	100·0	97·2	72·2	27·8	Nil	Nil	Nil	100·0	88·0	76·0	16·0	8·0	Nil
May	Nil	100·0	100·0	75·0	25·0	Nil	Nil	15·0	85·0	96·6	17·4	66·7	15·9	Nil
June	11·8	88·2	93·3	79·5	20·5	Nil	Nil	..	..	..	..	..	..	..

Month	1961-62							1962-63						
September	1·5	98·5	100·0	75·4	24·6	Nil	Nil	1·3	98·7	100·0	59·9	40·1	Nil	Nil
October	5·1	94·9	95·4	70·1	22·0	7·9	Nil	1·2	98·8	94·7	59·1	35·9	5·0	Nil
November	Nil	100·0	96·9	42·1	41·9	16·0	Nil	2·9	97·1	92·9	44·3	54·4	1·3	Nil
December	Nil	100·0	94·8	63·0	28·4	8·6	Nil	1·2	98·8	90·4	55·1	32·1	12·8	Nil
January	Nil	100·0	91·7	47·5	58·3	4·2	Nil	Nil	100·0	91·7	41·7	50·0	8·3	Nil
February	Nil	100·0	97·1	65·7	31·4	2·9	Nil	Nil	100·0	100·0	30·8	53·8	15·4	Nil
March	2·1	97·9	90·2	47·5	49·2	3·3	Nil	Nil	100·0	92·1	35·5	51·3	13·2	Nil
April	4·0	96·0	87·5	70·8	29·2	Nil	Nil	2·3	97·7	92·4	59·7	33·6	6·7	Nil
May	14·4	85·6	81·0	76·0	21·5	2·5	Nil	7·7	92·3	94·4	23·7	55·6	16·7	Nil
June	11·8	89·2	81·0	76·0	21·5	2·5	Nil	Nil	100·0	85·5	76·4	19·7	3·9	Nil

from this coast the occurrence of shoals mostly contributed by this species so close to the shore as to make it possible for the fishermen to use the cast net for catching them. In the case of the other species the fact that they are caught from comparatively deeper areas soon after the monsoon and as the season advances they are fished in larger numbers from the shallower regions may be taken as an indirect evidence of their movement to deeper waters during the monsoon period. Alsc, the larger sizes of the second year classes of the different species at this part of the season tend to show that these are not the stock moving out from the estuaries and backwaters. The stock which comes cut from the nursery grounds (backwaters and estuaries) appear in the fishery later in the season by February-March. Since they are not recruited into the off-shore fishery immediately after their return from the backwaters it is quite possible that they are confined to the very shallow inshore areas during this interval. Further elucidation of the migratory movements of these prawns can only be done by carrying out intensive mark recovery experiments.

DISCUSSION

With the increased mechanised prawn fishing activities off this coast and the ever increasing exploitation of prawns from these waters doubts have been raised in some quarters regarding depletionary tendencies in total production and necessity for conservatory steps to be taken to ensure sustained production. One of the points raised is that there is a disturbing tendency of a continuous decrease in the catch during the last five years. Taking the combined operational results of the Government of India vessels and the vessels of the Indo-Norwegian Project operating off Cochin it is true that the 1962-63 season was less productive when compared to 1961-62 season which was exceptionally productive. Since the catch per unit of effort does not show any continuous steep decline in the six years' data given a slight decrease in the catch per unit of effort may be due to natural fluctuations rather than due to excessive fishing mortality. The fact that in previous year, *viz.*, 1960-61, lesser catch per unit of effort was recorded when the fishing intensity was not as much as in the late years as is evidenced by the minimum of total effort expended in that season also strengthen this view.

There has also been doubts that the size of the prawns caught by the trawlers is showing a gradual decrease. The data presented early in this report clearly indicate that this is only an apparent effect caused by the distribution pattern of the various species contributing to a multispecies fishery and it need not be taken as due to indiscriminate fishing. As presented in the chapter on 'Growth and Age composition', in each species the bigger second year classes come into the fishery in the early part of the season and it is the smaller first year classes which are recruited into the fishery in the latter half. This is true for all the species concerned with the cumulative effect that the apparent size reduction as the season advances is the general pattern. Added to this the fluctuation in abundance of the various species also contribute to this phenomenon of reduction in size because it is the species which grow to larger sizes that dominate the catches in the earlier part of the fishery and smaller species which gain predominance during the latter part. In either case no deviation from the normal pattern of species and size distribution is noticeable through the seasons.

Another factor which is relevant to the context is that the proportion of active breeders is very low in the commercial catches as shown by detailed analysis of maturity conditions of the prawns (ref. Tables VII to X). The percentage of mature specimens is always low and

that of spent specimens still less. This means that the prawn breeding grounds are not at all encroached upon by the present fishing effort. Since the spawning areas and nursery grounds are not situated within the limits of the present area of exploitation the question of protection of breeders and fry for conservation of stocks does not arise at this stage.

The slight decrease noticed in the total catch and the catch rate in 1962-63 can only be due to natural fluctuations in the fishery. In this connection a similar instance may be pointed out from the Gulf of Mexico shrimp fishery. Kutkuhn (1960) attempting an analysis of the fishable biomass and yield trends of the Senibel—Tortugas area in 1956 to 1959 noticed a steadily declining trend in annual yield over these years despite a static expenditure of effort which according to him is a matter of some concern. But Eldred *et al.* (1961) examining the same data from 1951 through 1959 expresses the opinion that it "does show fluctuation in abundance of the yield from year to year, but, does not suggest to us an actual yearly decline of the population". According to them this is only due to deviation in annual yield from the average size crop brought about by weather conditions and yearly sea temperature fluctuations. As suggested by Lindner and Anderson (1956) and Racek (1959) fluctuations in abundance may also be caused by any one or more of a combination of factors such as temporary geographic barriers preventing the shoals from reaching the fishing grounds in the conventional season, unfavourable currents, scarcity of food, predation including cannibalism and unfavourable meteorological conditions. The important role of food in the distribution of shrimp has been pointed out by Mistakidis (1957) and Williams (1958). The influence of temperature, rainfall and salinity on abundance of prawns has been studied by various authors Gunter (1950) and Gunter and Hildebrand (1954) have shown a relationship between shrimp abudance and rainfall in the Texas coast. Lindner and Anderson (op. cit.) stressed the combined influence of salinity and temperature on the distribution of commercial shrimps in the Gulf of Mexico. In the words of Eldred *et al* "temperature variations provide yet another ecological factor that can account for absolute and relative abundance of the three common commercial shrimps."

Racek (1959) studying the off-shore prawn fishery of the east coast of Australia which is quite similar to that of the South west Coast of India recommended the abolition of a legal minimum for prawns which was imposed earlier in fear of depletion in the fishery. Gunter (1956) reviewing the shrimp fishery management programme of the Gulf of Mexico recommends catching as much shrimp as fast as possible from the open sea. Taking all these views into consideration and in the light of the evaluation of the data presented earlier in this report it is more or less clear that at present there is no alarming tendency towards depletion of stock due to overfishing. However, limiting the fishing intensity in the areas exploited now may sooner or later result in diminishing returns. But there is ample evidence as shown by the results of some of the recent exploratory cruises and also the data collected during the biological studies in the past few years that the off-shore prawn stocks are capable of yielding a much higher catch than at present, provided the methods employed as well as exploratory initiative are improved. With the increased exploitation close scientific study of the operations and particularly of the catches will have to be continued in order to ensure that maximum production is attained without detrimental effects.

SUMMARY

Various aspects of the off-shore prawn fishery of Cochin based on the catches of the vessels of the Deep Sea Fishing Station and the Indo-Norwegian Project through the seasons 1956-57 to 1962-63 have been studied.

The total catch of prawns along with percentage and catch per trawling hour of prawn for the various seasons are presented and the trends in production discussed.

The catch composition, distribution of species in time as well as depth and population characteristics of the different species are described. Among the four major species composing the catches fluctuations in abundance exhibit the pattern of the larger species dominating the early part of the season and the smaller ones coming into significance in the latter part. The depth-wise distribution of the species indicates that 11 to 20 metre area is the most productive region with two concentrations in certain months *viz.* 12 to 15 metre and 18 to 20 metre regions, the former contributed by the species *M. dobsoni* and the latter by *M. affinis* and *P. indicus*. Length frequency studies of the different species through the seasons reveal that in the case of all the species it is the large sizes of the second year classes which enter the fishery early in the season and the smaller first year classes coming later in the season. The year classes entering the fishery show a certain amount of growth—15 to 25mm in the course of 4 to 6 months. Differential growth among the sexes is noticed in all the species, female showing faster rate of growth.

In most of the species females show a higher percentage of occurrence in the catches in most of the months. In *P. indicus* males are predominant in several months.

Maturity studies of the gonads show prolonged breeding season for all the species with peak breeding activity generally in the earlier months of the season.

Seasonal movements of the prawns and suspected depletionary tendency in production are discussed. No alarming tendency of depletion caused by over exploitation is noticeable so far. However, the need for close watch and research on biology side by side with the increasing exploitation is stressed.

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