

STUDIES ON THE PRAWN FISHERIES OF THE HOOGHLY ESTUARINE SYSTEM

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This paper elaborates the results of an examination of the analyses of the prawn fisheries and the annual, seasonal and monthly fluctuations in their magnitude in different sectors of the Hooghly estuary and its associated tributaries, the Roopnarayan and the Matlah, for a period of four years. Some of the hydrological data, like temperature and salinity of the river, that govern the dynamics of fish stocks, have been correlated with the fluctuating stocks of individual prawn species to obtain a clear knowledge of the optimal requirements necessary for an efficient fisheries management.

INTRODUCTION

The Hooghly estuarine system is one of the few potentially rich inland sources for the prawn fisheries of the country. Prawns and shrimps, generally, rank either second or third in the annual fish catches of this estuarine system contributing to the tune of an 'average of 900 t a year' (Pantulu 1965).

A general account of the prawn fisheries (Chopra 1939, 1943, 1951; Panikkar and Menon 1955; Pantulu 1965) and records of studies on the size composition and fluctuations in fisheries of different species (Menon 1953, 1955; Srivatsa 1953; Chacko 1955; Shaikmahmud and Tembe 1960; George 1961; Menon and Raman 1961; Ibrahim 1962; Subrahmanyam 1964) of the country exist. However, no detailed investigation for a considerable period of time in any particular area appears to have been done. Kunju (1955), Rajyalakshmi (1961, 1964) and Rao (1967) have briefly indicated the size composition of some species of prawns in the Hooghly estuary. The present account attempts at a critical examination of the entire prawn fishery of the Hooghly estuarine system over a period of four years with particular reference to the fluctuations of the fisheries of different species in relation to some of the hydrological features of the estuary.

MATERIAL AND METHODS

The material for the study was derived from regular fortnightly samples from the commercial catches of the Hooghly estuarine system (constituted by the Hooghly main; its tributary, the Roopnarayan, and distributary, the Matlah) collected from about 30 sampling and assembly centres (Fig. 1)

situated in different representative areas of the entire estuary. The material was preserved in 5% formalin and relevant data like total weight of catch, sample weight, gear used, time and tide, etc., were recorded. For the estimation of species-wise composition of prawns and shrimps, each sample was sorted out into the component species and weighed accurately up to the decigram on a 'trip type' pan balance. The material represented catches of

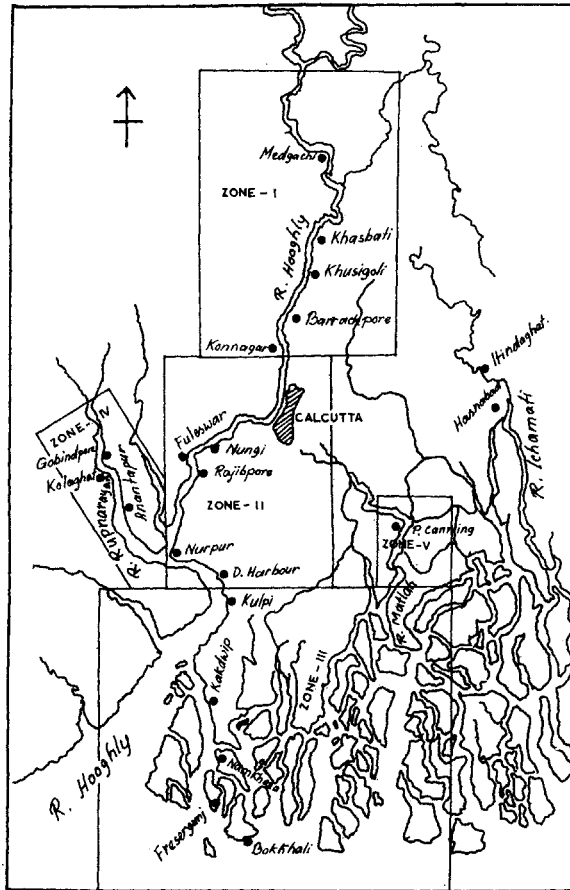


FIG. 1. Map of the Hooghly estuarine system depicting the different zones and sampling and assembly centres.

almost all the gear employed for prawns in the Hooghly-Matlah estuary, namely Bagnets (*Been* and *Thor jals*), Seine nets (*Ber* and *Chotber jals*), Trawl nets (*Buro*, *Moi* and *Kathi jals*), Lift nets (*Char*, *Chat*, *Bashali*, *Naukabashali*, *Palla* and *Dhain jals*), Cast nets (*Khapla* and *Bachari jals*), Set Barriers (*Patta*, *Charpatta* and *Kumor jals*), Traps (*Bithi* and *Duarbithi*), *Sheitki jal* and other nets. Based on varying salinity conditions, the Hooghly estuary (Fig. 1) could be divided into upper or freshwater (zone I), middle or gradient (zone

II, salinity range, from traces to 12.68‰) and lower or tidal zones (zone III, salinity range, 4.32 to 29.77‰). The salinities fluctuate in the Roopnarayan estuary (zone IV) from traces to 5.72‰ and in the Matlah (zone V) estuary from 10.72 to 30.41‰ (salinity figures of the Hooghly estuary are based on records from 1960 to 1965 of the Central Inland Fisheries Research Institute). The years when referred jointly (e.g. 1963-64) indicate the period from March of one calendar year to February of the succeeding year. Catches are given in metric units. Analysis of variance of the catches was made and *F* test (Snedecor 1956) was applied to judge the significance of the mean squares (Table IX).

PRAWN AND SHRIMP FAUNA OF THE HOOGHLY ESTUARY

The following species have been recorded to be occurring in the Hooghly estuarine system by various workers (Alcock 1906; Henderson and Mathai 1910; Kemp 1914, 1917*a, b*, 1925; Tiwari 1947):

Section: PENAEIDEA

Family: PENAEIDAE

1. *Metapenaeus brevicornis* (H. Milne Edwards)
2. *M. monoceros* (Fabricius)
3. *Parapenaeopsis sculptilis* (Heller)
4. *Penaeus indicus* H. Milne Edwards
- *5. *P. monodon* Fabricius . . . rare

Family: SERGESTIDAE

6. *Acetes indicus* H. Milne Edwards . . . shrimp

Section: CARIDEA

Family: PALAEMONIDAE

7. *Macrobrachium rosenbergii* (de Man)
8. *M. malcolmsonii* (H. Milne Edwards)
9. *M. mirabile* (Kemp)
10. *M. rude* (Heller)
11. *M. villosimanus* Tiwari
12. *M. scabriculum* (Heller)
13. *M. lamarrei* (H. Milne Edwards)
14. *M. dayanum* (Henderson)
15. *Leptocarpus fluminicola* (Kemp)
16. *Palaemon styliferus* H. Milne Edwards
17. *P. tenuipes* (Henderson)

* Not dealt in this account.

(Nomenclature of genera is based on Holthuis and Rosa 1965).

Family: **ATYIDAE**

18. *Caridina* spp. . . . shrimp

Family: **HIPPOLYTIDAE**

19. *Hippolysmata ensirostris* Kemp

The commercially important prawns, from the above list, based on the extent of landings, as well as maximum size attained by individual species and table value, are discussed elsewhere in this account.

TOTAL PRODUCTION OF PRAWNS AND SHRIMPS

Annual fluctuations.—Yearly prawn catches in the entire Hooghly estuary and the percentage of prawns in the total fish landings have been plotted (Fig. 2) for eight years from 1958-59 to 1965-66 (Anon 1958 to 1966). Smoothened

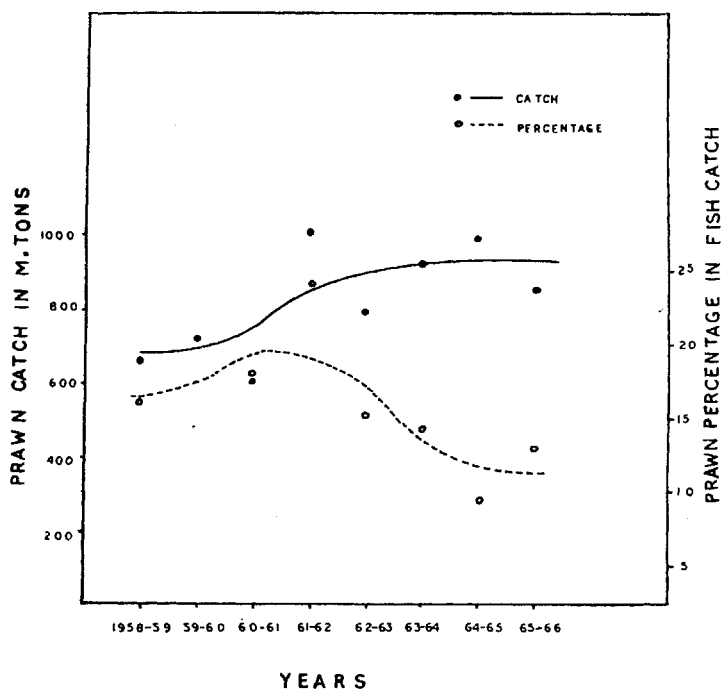


FIG. 2. Trends in the prawn catches during different years in the Hooghly estuary.

curves, based on moving averages of three, present an increasing trend in the production of prawns from 1960-61 onwards, whereas the percentage of prawns in the total landings including fish and prawns appears to be on the decline. This may probably be attributable to the availability of more fish in comparison with prawns in the estuary from 1960-61 onwards. Thus, the catches of prawns and shrimps have increased gradually from 664 t (mean of years from

1958-59 to 1960-61) to 919 t (mean of years from 1961-62 to 1965-66), whereas the percentage of prawns in the total landings decreased from 17.7 to 13.2. The average annual production of prawns and shrimps, during the entire period from 1958-59 to 1965-66 in the Hooghly estuarine system, is 823 t and the mean percentage of prawns and shrimps, 16.1.

Monthly fluctuations.—Prawn and shrimp catches in the Hooghly estuarine system plotted for different months (mean of years from 1963-64 to 1965-66) are presented in Fig. 3. It is evident from the graph that maximum landings are during the winter season, the peak being in the month of December. The total prawn production during the entire winter was 603 t which is 65.0% of the annual prawn catch in the Hooghly estuarine system, the mean monthly winter catch being 150 t. During other seasons, the catches are considerably less being 154 t or 16.6% of the annual prawn catch during the summer season and 171 t or 18.4% of the annual prawn catch during the monsoon.

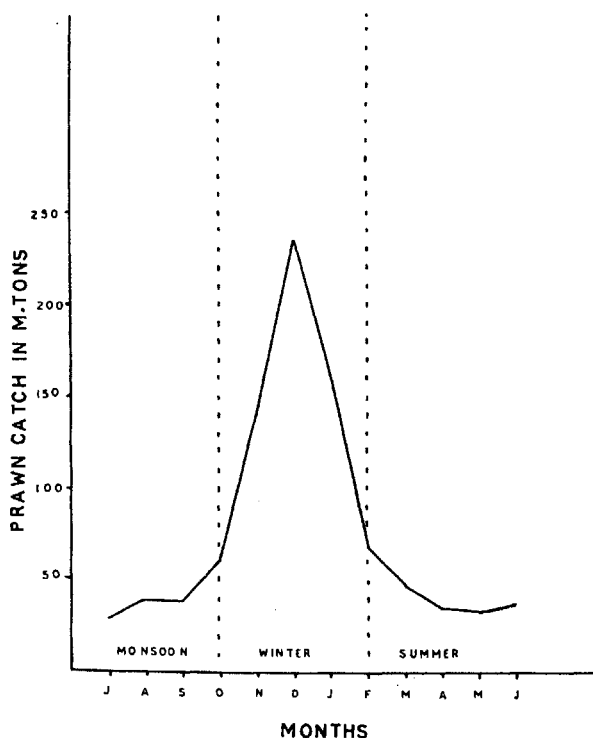


FIG. 3. Seasonal fluctuations of the prawn fisheries in the entire estuary.

Species composition during different years.—The estimated catches of different species of prawns and shrimps in the entire Hooghly estuarine system are presented in Table I. These prawn catches, during the four-year study

from 1962-63 to 1965-66, when subjected to *F* test (Table IX), indicate that the species differ among themselves with regard to landings. The mean annual catches indicate that *P. sculptilis*, *P. tenuipes*, *M. brevicornis* and *M. mirabile* are the chief species whose individual annual contribution exceeds 100 t. *P. styliferus* and *A. indicus* are of secondary importance, each contributing over 40 t annually. Of the species which are of tertiary importance contributing more than 10 t a year (items 7 to 11 of Table I), *M. villosimanus* and *P. indicus* belong to 'medium-sized' prawns based on their individual maximum sizes. From the rest of the species, *M. rosenbergii* is a 'large variety' and *M. monoceros* and *M. malcolmsonii* are 'medium-sized' prawns (Pantulu 1965) taking their individual maximum sizes into consideration as also from their table value. Thus, the most important commercial species in the Hooghly estuarine system are *P. sculptilis*, *M. brevicornis*, *A. indicus*, *P. indicus* and *M. monoceros* in penaeids and *P. tenuipes*, *M. mirabile*, *P. styliferus*, *M. villosimanus*, *M. rosenbergii* and *M. malcolmsonii* in palae-monids.

PRAWN CATCHES IN DIFFERENT ZONES

During different years.—In Table II is given the annual composition of prawns in the Hooghly, Matlah and Roopnarayan estuaries. The zones are different as regards the contribution of prawn catches (Table IX for *F* test). From the mean figures of years from 1962-63 to 1965-66, it is clear that the bulk of the total annual prawn catches, i.e. 795 t (90.45%), is from the Hooghly estuary alone, the Roopnarayan and the Matlah contributing only 63 t (7.45%) and 19 t (2.10%) respectively. The prawn composition among the three zones of the Hooghly estuary during different years shows that the maximum annual catches of an average of 600 t (68.89%) is derived from the tidal or lower zone, the freshwater (upper) zone adding 154 t (16.93%) and the gradient (middle) zone contributing 40 t (4.54%).

The percentage of prawns in the total catches landed (Table II) in the Roopnarayan, or the upper or middle zone of the Hooghly estuary, is more (by 2 to 3 times) than either in the Matlah or the lower zone of the Hooghly estuary.

Seasonal fluctuations.—Mean pooled monthly catches of prawns (for years from 1962-63 to 1965-66) are plotted for different zones of the estuary (Fig. 4). Upper and lower zones of the Hooghly present a single peak during winter (December), while the middle zone shows a major peak in the monsoon (July) (with additional minor peaks in December and March). The Roopnarayan tends to show a major peak in the summer (April) (and a minor peak during December), while in the Matlah distributary there is a peak fishery during winter (December). The monsoon peak in the middle Hooghly and the summer peak in the Roopnarayan appear to be due to the immigration of adult

TABLE I
Species-wise composition of prawns in the Hooghly-Matlah estuarine system during different years

No.	Species	1962-63			1963-64			1964-65			1965-66			Mean of all years			
		Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age	
1.	<i>P. sculptilis</i>	454.644	62.74	225.499	24.34	127.717	12.80	157.889	18.42	241.437	27.54	182.000	20.76	136.777	15.60	127.340	14.53
2.	<i>P. tenuipes</i>	15.537	2.14	85.157	9.19	342.157	34.28	285.148	33.26	96.133	11.21	136.777	15.60	127.340	14.53	47.800	5.45
3.	<i>M. brevicornis</i>	121.193	16.73	137.064	14.79	192.723	19.31	137.650	13.80	22.579	2.63	23.924	2.79	41.294	4.71	25.519	2.98
4.	<i>M. mirabile</i>	54.214	7.48	152.293	16.44	72.491	7.27	20.469	2.05	18.147	1.82	20.761	2.42	19.756	2.25	8.171	0.95
5.	<i>P. styliferus</i>	37.824	5.22	58.304	6.29	9.330	0.94	9.642	0.97	18.245	1.83	23.647	2.76	12.140	1.38	2.267	0.26
6.	<i>A. indicus</i>	7.161	0.99	113.621	12.26	14.778	1.60	5.273	0.53	34.767	3.48	2.618	0.31	6.874	0.78	7.112	0.83
7.	<i>M. rude</i>	6.748	0.93	49.211	5.31	2.850	0.29	0.133	0.01	4.851	0.49	1.640	0.19	4.734	0.54	13.217	1.54
8.	<i>M. villosimanus</i>	2.527	0.35	37.592	4.06	4.851	0.42	4.851	0.49	1.237	0.12	1.137	0.13	2.827	0.32	1.640	0.19
9.	<i>P. indicus</i>	12.691	1.75	19.368	2.09	1.237	0.12	5.582	0.60	0.162	0.02	0.411	0.05	2.268	0.26	0.411	0.05
10.	<i>M. scabriculatum</i>	0.277	0.04	6.391	0.69	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
11.	<i>H. ensirostris</i>	1.134	0.16	4.724	0.51	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
12.	<i>L. funinicola</i>	4.829	0.67	14.778	1.60	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
13.	<i>M. malcolmsonii</i>	0.408	0.06	9.823	1.06	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
14.	<i>M. lamarrei</i>	2.665	0.37	2.919	0.32	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
15.	<i>M. monoceros</i>	0.902	0.12	3.915	0.42	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
16.	<i>M. rosenbergii</i>	1.115	0.15	5.582	0.60	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
17.	<i>Caridina</i> spp.	0.709	0.10	0.162	0.02	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00
18.	<i>M. dayanum</i>	—	—	0.024	0.00	0.024	0.00	0.024	0.01	0.128	0.01	0.038	0.00	0.038	0.00	0.038	0.00

TABLE II
Zonal composition of prawns during different years

Year	Zone I (Upper Hooghly)			Zone II (Middle Hooghly)			Zone III (Lower Hooghly)			Zone IV (Roopnarayan)			Zone V (Matlah)		
	Landings (m. tons)	Percentage in total fish catch	Zonal percentage	Landings (m. tons)	Percentage in total fish catch	Zonal percentage	Landings (m. tons)	Percentage in total fish catch	Zonal percentage	Landings (m. tons)	Percentage in total fish catch	Zonal percentage	Landings (m. tons)	Percentage in total fish catch	Zonal percentage
1962-63	28.129	14.46	3.88	30.165	39.09	4.16	585.527	15.12	80.81	72.021	33.19	9.93	8.766	11.98	1.21
1963-64	231.488	37.96	24.99	70.985	41.30	7.66	542.403	10.20	58.54	60.798	36.17	6.56	20.797	17.32	2.24
1964-65	159.636	31.89	16.00	33.213	34.21	3.33	736.588	7.76	73.82	49.369	29.84	4.95	19.003	11.97	1.90
1965-66	195.691	32.06	22.83	25.870	21.88	3.01	537.879	10.17	62.74	71.605	25.38	8.35	26.329	12.24	3.07
Mean	153.736	29.09	16.93	40.058	34.12	4.54	600.599	10.81	68.98	63.448	31.15	7.45	18.724	13.35	2.10

palaemonids from fresh waters whose breeding season is mostly confined to summer and/or monsoon months.

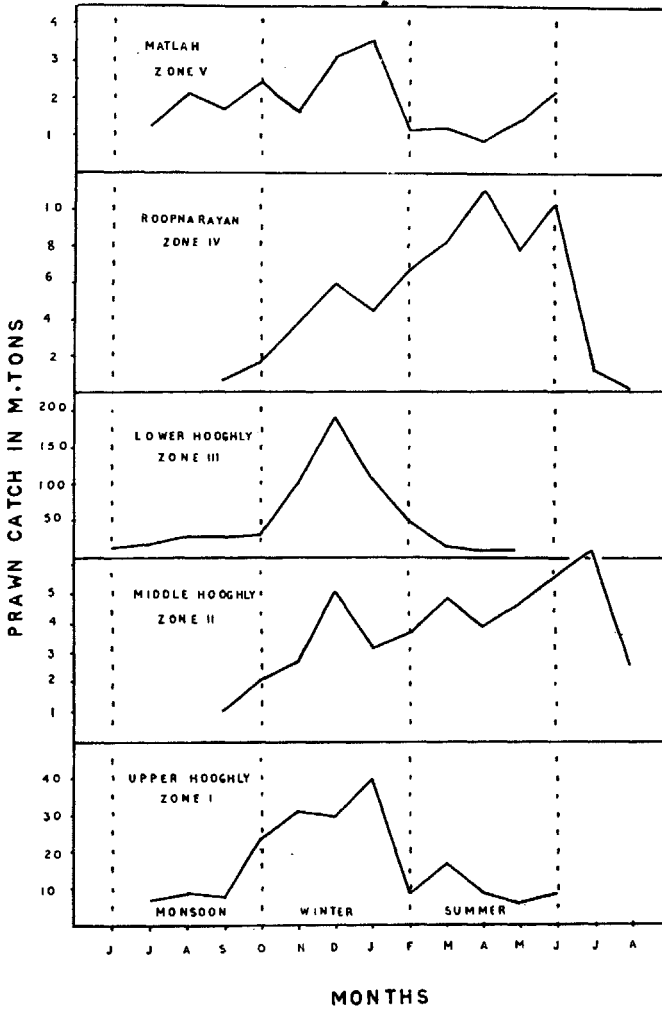


FIG. 4. Monthly fluctuations of the prawn fisheries in the different zones of the Hooghly estuary and in the associated tributaries.

Annual species composition in different zones.—Estimated total landings of different species of prawns and shrimps in different zones during the years from 1962-63 to 1965-66 are presented in Tables III to VII. The species-wise landings differ from zone to zone (*F* test for interaction in Table IX). There is no significant difference between the years within each zone as regards landings.

TABLE III
Composition of different species of prawns in the freshwater (upper) zone of the Hooghly estuary during different years

No.	Species	1962-63		1963-64		1964-65		1965-66		Mean of all years	
		Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age
1.	<i>M. mirabile</i>	12.675	45.06	109.980	47.51	102.518	64.22	105.203	53.76	82.594	53.72
2.	<i>M. rude</i>	4.312	15.33	48.705	21.04	8.819	5.13	25.107	12.83	21.578	14.04
3.	<i>M. villosimanus</i>	2.070	7.36	35.857	15.49	17.656	11.06	18.845	9.63	18.607	12.10
4.	<i>M. scabriculturn</i>	0.228	0.81	6.317	2.73	18.245	11.43	23.600	12.06	12.098	7.87
5.	<i>L. fuminitola</i>	4.570	16.25	13.473	5.82	4.965	3.11	1.937	0.99	6.236	4.06
6.	<i>M. lamarræ</i>	2.647	9.41	2.500	1.08	-	-	13.209	6.75	4.589	2.99
7.	<i>M. malcolmsoni</i>	0.408	1.45	9.306	4.02	2.411	1.51	4.892	2.50	4.254	2.77
8.	<i>M. rosenbergi</i>	1.072	3.81	5.093	2.20	1.006	0.63	1.098	0.56	2.068	1.35
9.	<i>M. brevicornis</i>	0.127	0.45	0.047	0.02	2.810	1.76	0.489	0.25	0.868	0.56
10.	<i>M. monoceros</i>	-	-	-	-	1.708	1.07	0.098	0.05	0.451	0.29
11.	<i>Caridina</i> spp.	0.003	0.01	0.162	0.07	-	-	0.411	0.21	0.144	0.09
12.	<i>M. dayanum</i>	-	-	0.024	0.01	0.128	0.08	-	-	0.038	0.02
13.	<i>P. sculptilis</i>	-	-	-	-	-	-	0.333	0.17	0.083	0.06
14.	<i>P. styliferus</i>	0.017	0.06	0.024	0.01	-	-	0.137	0.07	0.045	0.03
15.	<i>A. indicus</i>	-	-	-	-	-	-	0.254	0.13	0.063	0.04
16.	<i>P. tenuipes</i>	-	-	-	-	-	-	0.098	0.05	0.020	0.01

(i) *Hooghly estuary* :

(a) *Upper zone*: Mean catches of four years' data (Table III) show that the most important prawn is *M. mirabile* followed by other species, namely *M. rude*, *M. villosimanus* and *M. scabriculum*. Among the other species which contribute less than 10 t a year, *M. malcolmsonii* and *M. rosenbergii* are the important ones. Thus, the chief species of the upper zone belong to the genus *Macrobrachium* of palaemonids. Penaeids like *M. brevicornis* and *M. monoceros* were found to occur in very small quantities during different years.

(b) *Middle zone*: Mean estimated catches of different prawns in this zone (Table IV) indicate that the chief species of prawns belong to palaemonids, namely *M. mirabile* and *P. styliferus*, which contribute about 10 t annually. The species whose average annual production is over 1 t are penaeids like *P. sculptilis*, *A. indicus* and *M. brevicornis* and the marine palaemonid, namely *P. tenuipes*. The rest of the species do not contribute much to the prawn fishery in the gradient zone of the Hooghly estuary.

(c) *Lower zone*: As stated earlier, the tidal or the marine zone of the Hooghly is the most important source for prawns in the Hooghly estuarine system. Average of different years, presented in Table V, suggests that penaeids like *P. sculptilis* and *M. brevicornis* and the marine palaemonid *P. tenuipes* contribute to more than 100 t each annually. The species of secondary importance whose production varies in between 10 and 30 t a year are *A. indicus*, *P. styliferus*, *P. indicus* and *H. ensirostris*. The rest of the species (items 8 to 11 of Table V) are of minor importance.

(ii) *Roopnarayan estuary*: Mean estimated catches of different species of prawns during different years, presented in Table VI, indicate that *M. mirabile* and *P. sculptilis* are the most important species of prawns contributing over 20 t each annually. *M. brevicornis*, *P. styliferus* and *A. indicus* are of secondary importance, each contributing between 3 and 6 t a year. None of the rest of the species contribute more than 1 t annually.

It is seen from the analyses of composition of prawn landings by species in the Roopnarayan and in the middle zone of Hooghly, that there seems to be a faunistic affinity between the two zones except for a higher percentage of catch of *P. tenuipes* in the latter one. This may be attributable to more or less similar salinity conditions of the river in the two zones (middle Hooghly—traces to 12.68‰ and Roopnarayan—traces to 5.72‰). A slightly higher range of salinity in the middle zone of the Hooghly may be the cause for the reported higher percentage of marine species of palaemonid like *P. tenuipes* and some penaeids in that area.

(iii) *Matlah estuary*: Species composition of different species of prawns in the Matlah estuary (Table VII), during different years, indicate that the most important of the species is *P. sculptilis*. Next are the prawns of the

TABLE IV
 Composition of different species of prawns in the gradient (middle) zone of the Hooghly estuary during different years

No.	Species	1962-63		1963-64		1964-65		1965-66		Mean of all years	
		Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age
1.	<i>M. mirabile</i>	7.635	25.31	22.751	32.05	13.896	41.84	14.246	55.07	14.632	36.52
2.	<i>P. styliferus</i>	19.004	63.00	12.515	17.63	3.384	10.19	3.120	12.06	9.506	23.73
3.	<i>P. sculptilis</i>	0.926	3.07	13.842	19.50	6.895	20.76	2.377	9.19	6.010	15.00
4.	<i>A. indicus</i>	-	-	10.137	14.28	3.145	9.47	1.418	5.48	3.675	9.17
5.	<i>M. brevicornis</i>	1.912	6.34	4.770	6.72	3.743	11.27	1.325	5.12	2.938	7.33
6.	<i>P. tenuipes</i>	0.100	0.33	3.421	4.82	0.425	1.28	2.336	9.03	1.571	3.92
7.	<i>M. villosimanus</i>	0.090	0.30	1.327	1.87	0.189	0.57	0.427	1.65	0.508	1.27
8.	<i>L. fluminicola</i>	0.259	0.86	1.136	1.60	0.070	0.21	0.044	0.17	0.377	0.94
9.	<i>M. rude</i>	0.109	0.36	0.057	0.08	0.757	2.28	0.251	0.97	0.294	0.73
10.	<i>M. monoceros</i>	0.042	0.14	0.383	0.54	0.209	0.63	0.072	0.28	0.177	0.44
11.	<i>M. lamarræi</i>	0.018	0.06	0.419	0.59	0.123	0.37	0.008	0.03	0.142	0.35
12.	<i>M. rosenbergii</i>	0.043	0.14	0.106	0.15	0.231	0.69	0.039	0.15	0.105	0.26
13.	<i>M. malcolmsoni</i>	-	-	-	-	0.103	0.31	0.186	0.72	0.072	0.18
14.	<i>P. indicus</i>	-	-	0.064	0.09	0.043	0.13	0.003	0.01	0.028	0.07
15.	<i>H. ensirostris</i>	-	-	0.050	0.07	-	-	-	-	0.013	0.03
16.	<i>M. scabriculum</i>	0.027	0.09	0.007	0.01	-	-	0.018	0.07	0.013	0.03

TABLE V
Composition of different species of prawns in the saline (lower) zone of the Hooghly estuary during different years

No.	Species	1962-63			1963-64			1964-65			1965-66			Mean of all years		
		Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age	Landings (m. tons)	Percent- age	Percent- age
1.	<i>P. sculptilis</i>	424.507	72.51	168.145	31.00	94.946	12.89	133.394	24.80	205.248	34.17					
2.	<i>P. tenuipes</i>	14.697	2.51	79.408	14.64	340.598	46.24	275.986	51.31	177.672	29.58					
3.	<i>M. brevicornis</i>	111.601	19.06	125.187	23.08	181.053	24.58	81.381	15.13	124.806	20.78					
4.	<i>A. indicus</i>	5.855	1.00	96.385	17.77	12.522	1.70	16.620	3.09	32.846	5.47					
5.	<i>P. styliferus</i>	11.476	1.96	39.324	7.25	59.074	8.02	12.748	2.37	30.656	5.10					
6.	<i>P. indicus</i>	11.184	1.91	17.574	3.24	8.471	1.15	7.046	1.31	11.069	1.84					
7.	<i>H. ensirostris</i>	0.644	0.11	4.177	0.77	34.767	4.72	2.259	0.42	10.462	1.74					
8.	<i>M. mirabile</i>	4.157	0.71	10.631	1.96	3.167	0.43	7.476	1.39	6.358	1.06					
9.	<i>M. monoceros</i>	0.059	0.01	1.410	0.26	1.768	0.24	0.807	0.15	1.011	0.17					
10.	<i>M. rude</i>	1.347	0.23	0.054	0.01	0.147	0.02	0.161	0.03	0.427	0.07					
11.	<i>M. villosimanus</i>	—	—	0.108	0.02	0.075	0.01	—	—	0.046	0.01					

TABLE VI
Composition of different species of prawns in the Roopnarayan river during different years

No.	Species	1962-63		1963-64		1964-65		1965-66		Mean of all years	
		Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age	Landings (m. tons)	Percent- age
1.	<i>M. mirabilis</i>	29.745	41.30	8.931	14.69	18.069	36.60	38.123	53.14	23.717	37.39
2.	<i>P. sculptilis</i>	25.812	35.84	33.001	54.28	16.178	32.77	8.736	12.20	20.932	33.00
3.	<i>M. brevicornis</i>	6.892	9.57	5.454	8.97	2.271	4.60	11.722	16.37	6.585	10.38
4.	<i>P. stytiferus</i>	5.718	7.94	4.122	6.78	8.087	16.36	5.442	7.60	5.842	9.20
5.	<i>A. indicus</i>	0.835	1.16	6.986	11.49	3.634	7.36	2.091	2.92	3.387	5.34
6.	<i>M. malcolmsonii</i>	-	-	0.517	0.85	0.336	0.68	2.034	2.84	0.722	1.14
7.	<i>M. villosimanus</i>	0.367	0.51	0.255	0.42	0.227	0.46	1.489	2.08	0.585	0.92
8.	<i>M. rude</i>	0.958	1.33	0.395	0.65	0.237	0.48	-	-	0.398	0.63
9.	<i>L. fluminicola</i>	0.483	0.67	0.140	0.32	0.217	0.44	0.637	0.89	0.369	0.58
10.	<i>M. monoceros</i>	0.375	0.52	0.444	0.73	0.109	0.22	0.115	0.16	0.261	0.41
11.	<i>P. indicus</i>	-	-	-	-	-	-	0.988	1.38	0.247	0.39
12.	<i>Caridina</i> spp.	0.706	0.98	-	-	-	-	-	-	0.177	0.28
13.	<i>M. rosenbergii</i>	-	-	0.383	0.63	-	-	-	-	0.096	0.15
14.	<i>P. tenuipes</i>	0.079	0.11	0.049	0.08	0.005	0.01	0.200	0.28	0.082	0.13
15.	<i>M. scabriculum</i>	0.022	0.03	0.067	0.11	-	-	0.029	0.04	0.030	0.05

genus *Palaemon* (*Leander*) and penaeids like *M. brevicornis*, *A. indicus* and *P. indicus*. Others are of minor importance.

Thus, in both the lower zone of the Hooghly and in the Matlah estuary, there is the dominance of (Tables V and VII) penaeids and *Palaemon* genus. This may be due to similar salinity conditions prevalent in both the zones (lower Hooghly—4.32 to 29.77‰ and Matlah—10.72 to 30.41‰).

M. mirabile appears to be consistently dominant, during different years, in both the upper and middle zones of the Hooghly and in the Roopnarayan river, whereas *P. sculptilis*, *P. tenuipes* and *M. brevicornis* consistently dominate in the lower zone of the Hooghly and in the Matlah estuary.

MONTHLY FLUCTUATIONS OF DIFFERENT PRAWN SPECIES IN RELATION TO HYDROLOGICAL CONDITIONS

Estimated mean monthly catches, during the years from 1962-63 to 1965-66, are plotted for individual species as well as the hydrological conditions (average of years 1960 to 1965) (Figs. 5 to 8) like surface water temperature and salinity (in parts per thousand) of the river for each zone separately.

(i) Hooghly estuary :

(a) *Upper zone*: The monthly trend in 10 species of prawns in the fresh-water zone, where the salinity is traces throughout the year, is shown in Fig. 5. *M. mirabile*, *M. villosimanus*, *M. scabriculum*, *L. fluminicola*, *M. malcolmsonii* and *M. brevicornis* (items 1, 3 to 6 and 9 of Fig. 5) conform to a particular pattern showing their peak fishery during the winter season (December to February) when the temperature of the river is low, reaching a minimum of about 21.0 °C. Of the above species, except *M. brevicornis* whose distribution is seasonal occurring in winter and summer, all others are caught throughout the year. However, *M. malcolmsonii* tends to show a peak during the monsoon also. *M. rude*, *M. scabriculum*, *M. lamarrei*, *M. rosenbergii* and *M. monoceros* (items 2, 4, 7 and 8 of Fig. 5) can be categorized yet as another group whose peaks of fishery are during the monsoon season during which time the temperature remains, more or less, steady at 30.0 °C. Out of these species, only *M. rude* and *M. scabriculum* appear to be available throughout the year while *M. rosenbergii*, *M. lamarrei* and *M. monoceros* are seasonal.

Though *Metapenaeus* spp. are known to be marine in habitat, it is of interest to note that the young of the species occur in this zone albeit in small quantities during certain seasons.

(b) *Middle zone*: Fig. 6 indicates that only *M. mirabile*, *P. styliferus* and *M. brevicornis* (items 1, 2 and 5) occur, more or less, throughout the year and thus appear to be tolerant to the entire range of salinities (0.1 to 12.68‰) prevalent in this zone. However, the extent of their fishery during August to

TABLE VII
Composition of different species of prawns in the Malabar estuary during different years

No.	Species	1962-63		1963-64		1964-65		1965-66		Mean of all years	
		Landings (m. tons)	Percent-age	Landings (m. tons)	Percent-age	Landings (m. tons)	Percent-age	Landings (m. tons)	Percent-age	Landings (m. tons)	Percent-age
1.	<i>P. sculptilis</i>	3.399	38.78	10.511	50.54	9.698	51.03	13.049	49.56	9.164	48.94
2.	<i>P. tenuipes</i>	0.661	7.55	2.279	10.96	1.129	5.94	6.548	24.87	2.654	14.17
3.	<i>P. styliferus</i>	1.836	18.36	2.319	11.15	1.946	10.24	1.132	4.30	1.752	9.36
4.	<i>M. brevicornis</i>	0.661	7.54	1.606	7.72	2.846	14.97	1.216	4.62	1.582	8.45
5.	<i>A. indicus</i>	0.471	5.37	0.133	0.64	1.168	6.14	3.541	13.45	1.328	7.09
6.	<i>P. indicus</i>	1.507	17.19	1.730	8.32	1.128	5.93	0.134	0.51	1.125	6.01
7.	<i>M. monoceros</i>	0.426	4.86	1.678	8.07	1.057	5.56	0.548	2.08	0.927	4.95
8.	<i>H. ensirostris</i>	0.007	0.08	0.497	2.39	-	-	0.008	0.03	0.128	0.68
9.	<i>L. fluminicola</i>	-	-	0.029	0.14	0.021	0.11	-	-	0.013	0.06
10.	<i>M. mirabile</i>	0.002	0.02	-	-	0.006	0.03	0.153	0.52	0.039	0.21
11.	<i>M. villosimanus</i>	-	-	0.015	0.07	-	-	-	-	0.004	0.02
12.	<i>M. rude</i>	0.022	0.25	-	-	-	-	-	-	0.006	0.03
13.	<i>M. lamarrei</i>	-	-	-	-	0.010	0.05	-	-	0.002	0.01

November is at its minimum when the salinity conditions are in traces. *M. mirabile* and *P. styliferus* show peaks of fishery during winter season (December) when the temperatures are at the minimum of 22.0 °C and salinity shows an upward trend from 5 to 10‰. *M. mirabile* shows an additional peak, as

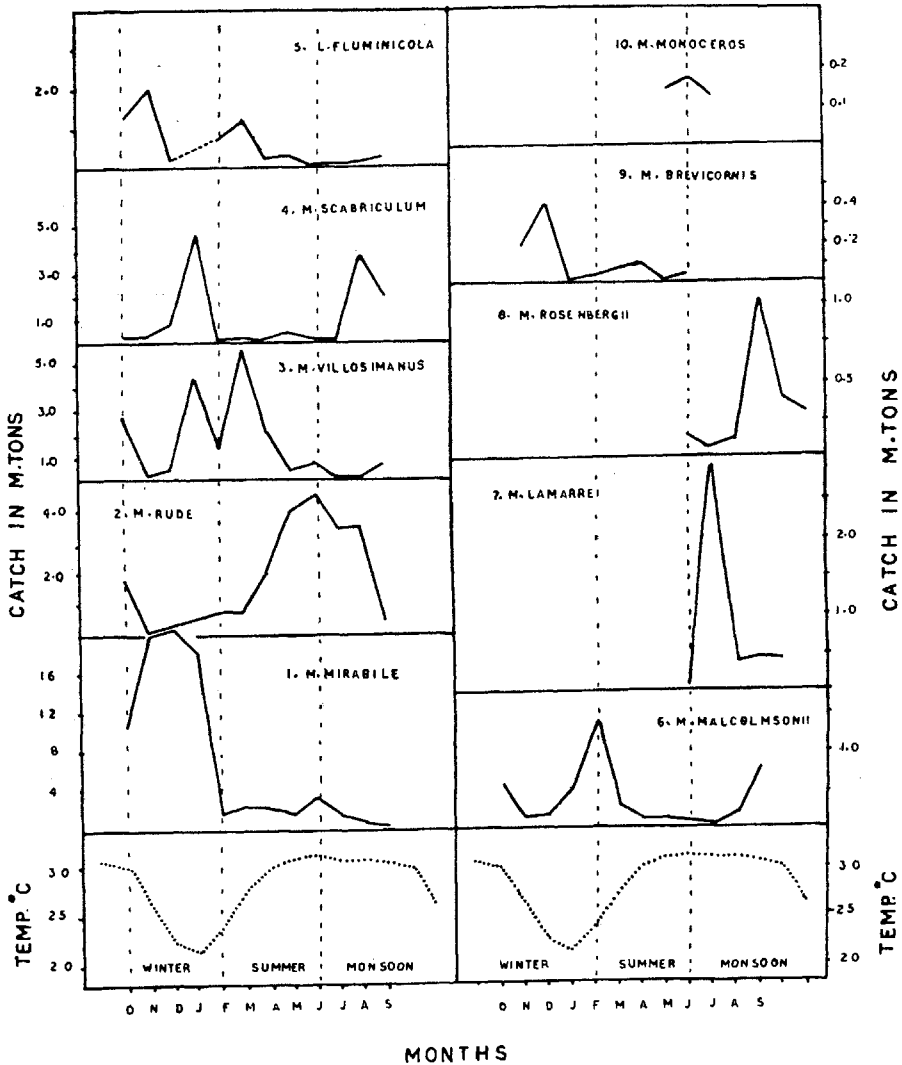


FIG. 5. Monthly fluctuations of different species in relation to temperature in the upper Hooghly.

also *M. brevicornis* during monsoon (June) when the temperatures are, more or less, steady at 30.0 °C and salinity shows a downward trend of similar range.

Among the rest of the species (items 3, 4 and 6 to 10 of Fig. 6) which occur seasonally, *P. sculptilis*, *A. indicus* and *P. tenuipes* do not occur at all during

August to November when the salinities are traces, *P. sculptilis* and *P. tenuipes* showing peak fishery in the summer season (March/April) and *A. indicus* at the advent of monsoon (June). The rest, viz. *M. villosimanus*, *L. fluminicola*, *M. rude* and *M. monoceros*, attain the peak fishery during monsoon (July to

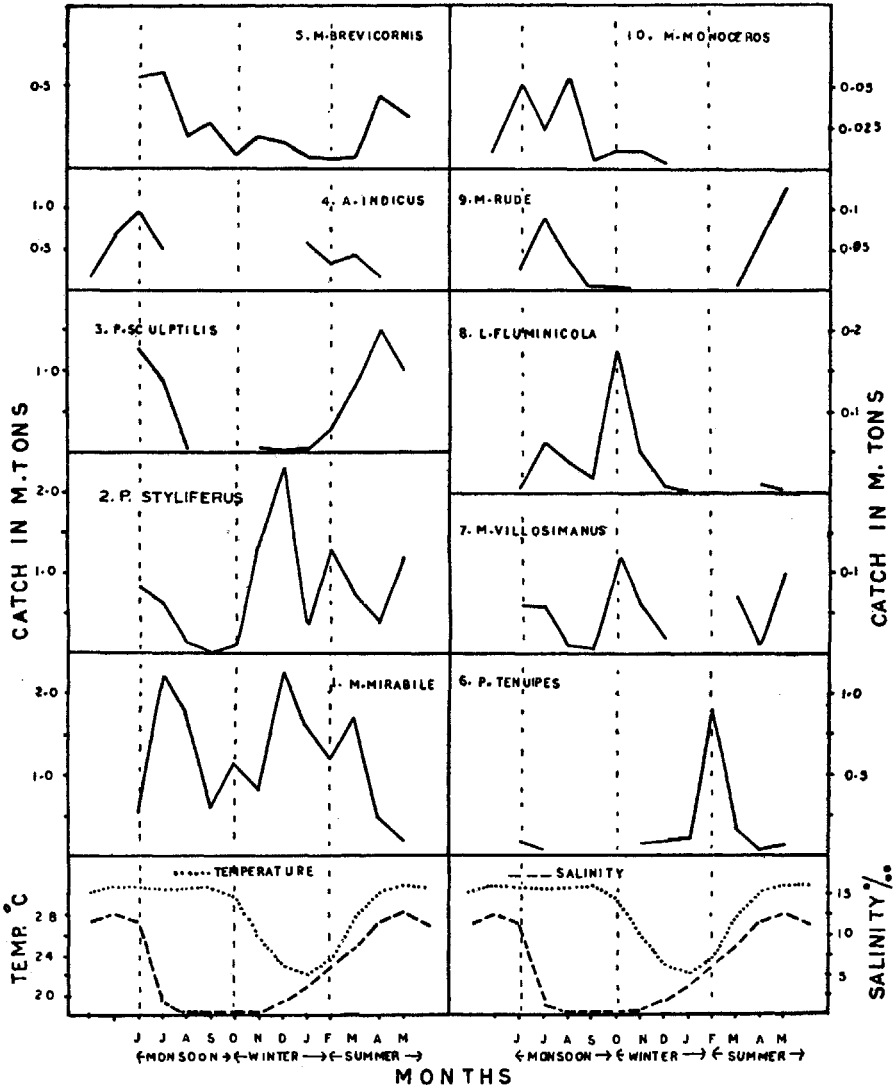


FIG. 6. Monthly fluctuations of different prawn species in the middle Hooghly.

September) when salinities are traces, although some of them occur during summer when the salinities start increasing.

(c) Lower zone: *P. sculptilis*, *P. tenuipes*, *M. brevicornis*, *A. indicus*, *H. ensirostris* and *M. mirabile* (items 1 to 4 and 7 and 8 of Fig. 7) conform

to a single similar pattern showing the maximum of fishery during the winter season (December/January) when the salinities of the river show an upward trend from 10 to 25.0‰ and the temperatures reach a minimum of 22.0 °C

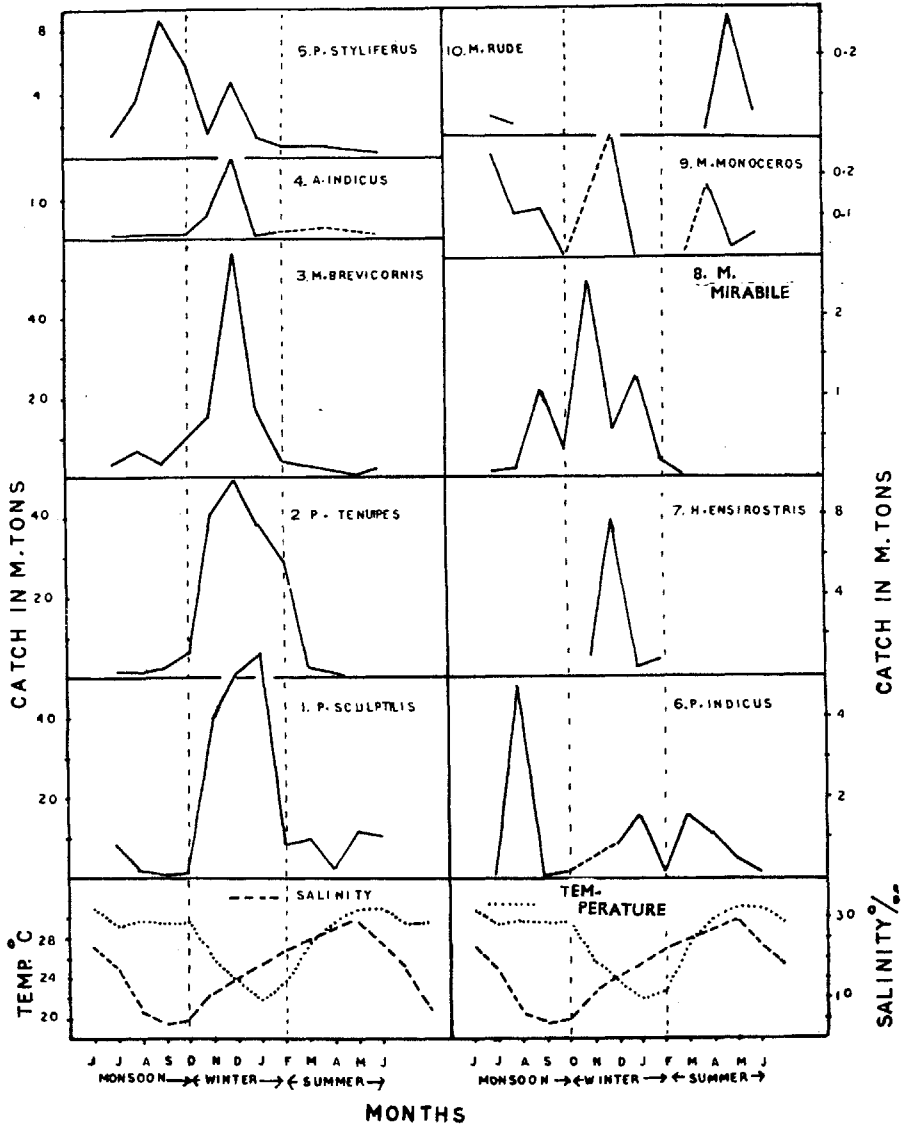


Fig. 7. Monthly fluctuations of different species in the lower Hooghly.

(of this list, *H. ensirostris* and *M. mirabile* are seasonal, the former occurring in winter and the latter in both monsoon and winter). *P. styliferus* and *P. indicus* show peaks during the monsoon (August/September) when the salinities

are low at 10·0‰. Fluctuations of *M. monoceros* are unsteady and *M. rude* exhibits a single seasonal peak during June.

(ii) *Roopnarayan estuary*: As stated earlier, this zone shows an affinity to the middle zone of the Hooghly estuary in the availability of different prawns, although individual species show variations in the timings of peaks in fishery. *M. mirabile*, *M. brevicornis* and *P. styliiferus* (items 1, 3 and 4 of Fig. 8) are the only species which occur throughout the year in this zone

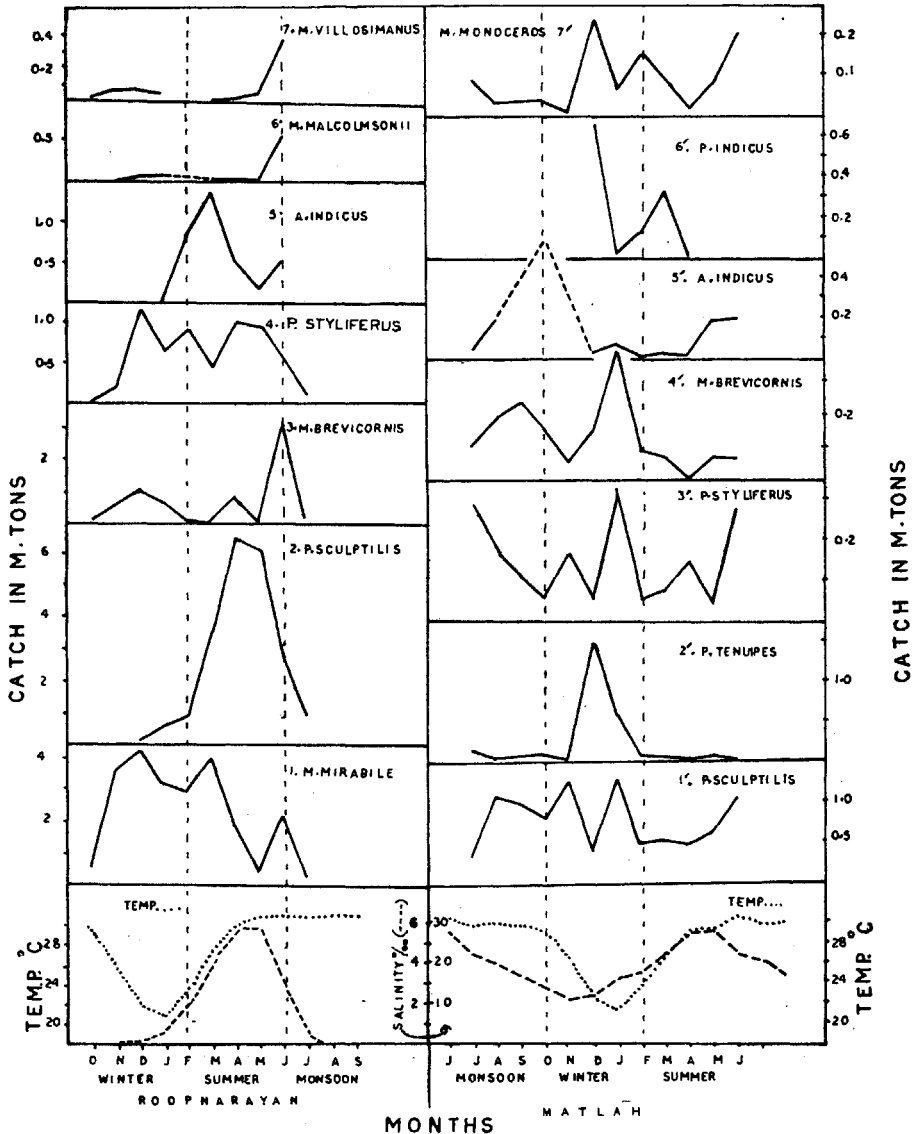


FIG. 3. Seasonal fluctuations of different species in the Matlah and the Roopnarayan tributaries.

where salinity ranges from traces to $5.78^{\circ}/_{\infty}$. *M. mirabile* shows maximum fishery in winter and summer, *M. brevicornis* in monsoon and *P. styliiferus* in monsoon and winter.

Of the seasonal species, *P. sculptilis* and *A. indicus* (items 2 and 5) show peaks in summer when the salinity reaches its maximum limits of $5.72^{\circ}/_{\infty}$ and do not occur at all when the waters are fresh. *M. malcolmsonii* and *M. villosimanus* (items 6 and 7) have limited fishery and show their peaks in monsoon when the waters are least saline.

(iii) *Matlah estuary*: Fishery of seven species of prawns in relation to hydrological conditions during different months are shown in Fig. 8. Except *P. indicus*, all the species dealt with occur throughout the year and thus are tolerant to 10.72 to $30.41^{\circ}/_{\infty}$ salinity range prevalent in this zone. The peak fishery for *P. tenuipes* occurs in winter (December). Other species present an erratic trend of fluctuations in fishery. *P. sculptilis* has the least amount of fishery during the summer. *P. styliiferus*, *M. brevicornis* and *M. monoceros* show their peaks of fishery during winter and summer/monsoon months. *A. indicus* is dominant in monsoon/winter (December). Fishery of *P. indicus* is maximum in winter and limited in summer.

As seen from the fishery of individual species, the Matlah and the lower zone of the Hooghly estuary appear to have an affinity which may be due to more or less similar hydrological conditions.

PERCENTAGE ZONAL DISTRIBUTION AND EXTREME LIMITS OF SALINITY FOR DIFFERENT SPECIES

From the tests made with the help of *F*-statistic, we find that (i) the differences between the species, (ii) the differences between the zones and (iii) the interaction (zone \times species) are all highly significant (Table IX). This means that the species differ in their contribution by way of landings, that zones differ with regard to total landings of prawns and the pattern of contribution of different species of prawns varies from zone to zone. The variation between years (within zones) is not significant.

From the total quantity of landings of each species (Table III), the percentage of catch in each zone has been computed for all the species and the figures are presented in Table VIII. The extreme limits of salinities for different species of prawns are based on their monthly distributions in relation to salinities in the respective zones (Figs. 5 to 8).

Among palaemonids, only *M. dayanum* and *Caridina* spp. are completely freshwater forms and occur in zones I and IV. Species belonging to *Macrobrachium* and *L. fluminicola* predominate the freshwater zone of the Hooghly estuary to the extent of 64 to 99%. Of these, only *M. mirabile* not only occurs in considerable quantities in all the zones, but also predominates the prawn fisheries in zones I, II and IV. The maximum salinity tolerance up

TABLE VIII
 Percentage of proportion of occurrence and salinity limits of different species of prawns in the Hooghly-Matlah estuarine system for the pooled data from 1962-63 to 1965-66

Sl. No.	Species	HOOGHLY					Extreme limits of salinity
		ZONE I UPPER	ZONE II MIDDLE	ZONE III LOWER	ROOPNARAYAN ZONE IV	MATLAH ZONE V	
		%	%	%	%	%	‰
(a)	Salinity range in zones (‰)	0-0	0-10-12-68	4-32-29-77	0-0 - 5-72	10-72-27-83	
(b)	Temperature range in zones (°C)	21-48-31-22	22-18-30-94	21-89-31-00	20-62-30-69	21-09-30-41	
1.	<i>M. dayanum</i>	100	-	-	-	-	Freshwater
2.	<i>Caridina</i> spp.	44-92	-	-	55-08	-	Freshwater
3.	<i>M. malcolmsonii</i>	82-27	1-43	-	14-30	-	0-0-9-00
4.	<i>M. rosenbergii</i>	91-16	4-62	-	4-22	-	0-0-16-00
5.	<i>M. lamarrei</i>	97-00	3-00	-	-	-	0-0-13-00
6.	<i>M. rude</i>	95-05	1-29	1-88	1-76	0-02	0-0-30-00
7.	<i>M. mirabile</i>	64-85	11-50	4-99	18-64	0-02	0-0-22-00
8.	<i>M. villosinanus</i>	94-22	2-57	0-23	2-96	0-02	0-0-15-00
9.	<i>L. fluminicola</i>	89-14	5-39	-	5-28	0-19	0-0-13-00
10.	<i>M. scabriculum</i>	99-65	0-11	-	0-24	-	0-0-4-0
11.	<i>P. sculpitidis</i>	-	2-49	85-01	8-61	3-80	2-0-30-0
12.	<i>P. styliferus</i>	0-09	19-89	64-13	12-23	3-66	0-1-30-0
13.	<i>P. tenuipes</i>	-	0-86	97-62	0-05	1-46	2-0-30-0
14.	<i>M. brevicornis</i>	0-63	2-15	91-25	4-81	1-16	0-1-30-0
15.	<i>M. monoceros</i>	15-97	6-25	35-76	9-23	32-79	0-1-30-0
16.	<i>A. indicus</i>	-	8-90	79-53	8-20	3-22	2-30-0
17.	<i>P. indicus</i>	-	0-22	88-78	1-98	9-02	2-30-0
18.	<i>H. ensirostris</i>	-	0-11	98-68	-	1-21	2-30-0

to 30.0‰ is shown by *M. rude* and *M. mirabile*. Species like *M. rosenbergii*, *M. lamarrei*, *M. villosimanus*, *M. malcolmsonii* and *L. fluminicola* have their extreme limits of salinities of 9 to 16‰, while *M. scabriculum* tolerates only up to 4‰.

TABLE IX
Results of analyses of variance for prawn landings

Sl. No.	Source of variation		D.F.	S.S.	M.S.	F test
(i) Zone I (Freshwater zone of Hooghly)						
1.	Species	17	26223.76	1542.57	10.35*
2.	Years	3	1311.49	437.16	2.93
3.	Error	51	7599.45	149.01	
4.	Total	71	35135.00		
(ii) Zone II (Middle zone of Hooghly)						
1.	Species	17	1113.02	65.47	8.46*
2.	Years	3	72.23	24.07	3.11
3.	Error	51	394.52	7.74	
4.	Total	71	1579.77		
(iii) Zone III (Lower zone of Hooghly)						
1.	Species	17	286083.32	16828.43	5.69*
2.	Years	3	1448.15	482.72	0.16
3.	Error	51	150880.21	2958.40	
4.	Total	71	438411.68		
(iv) Zone IV (Roopnarayan river)						
1.	Species	17	3466.41	203.91	11.59*
2.	Years	3	19.09	6.36	0.36
3.	Error	51	897.18	17.59	
4.	Total	71	4382.68		
(v) Zone V (Matlah estuary)						
1.	Species	17	325.04	19.12	12.92*
2.	Years	3	8.62	2.87	1.94
3.	Error	51	75.28	1.48	
4.	Total	71	408.94		
(vi) For combination of all zones (Generalized)						
1.	Species	17	71274.37	4192.61	6.69*
2.	Zones	4	52598.59	13149.65	20.98*
3.	Interaction (Species × Zones)	68	245937.22	3616.72	5.77*
4.	Within zones (between years)	15	2859.54	190.64	0.30
5.	Error	255	159846.94	626.85	
6.	Total	359	532516.66		

* Highly significant at 1% level. Rest—Insignificant.

Penaeids and *P. tenuipes* (items 11 to 18 of Table VIII), except *M. monoceros* and *P. styliferus*, occur to the extent of 80 to 99% in the lower zone

of the Hooghly estuary. Species of *Metapenaeus* and *P. styliiferus* occur in fresh waters in minute quantities as 0-year age groups, although their fishery mostly exists in zones III and V. Rest of the species, namely *P. sculptilis*, *P. tenuipes*, *A. indicus*, *P. indicus* and *H. ensirostris*, do not occur in fresh waters (their minimum salinity tolerance limit being 2‰) and dominate in zones III and V mainly.

DISCUSSION

The assessment of the optimum conditions of salinity and temperature and their relation with the distribution and abundance of population of any Indian prawn does not appear to have been investigated so far. The magnitude of the catches of individual species of prawns and shrimps and the temperature and salinity profiles of the Hooghly estuary for each month in different zones are plotted in Figs. 5 to 8. In the Hooghly estuary, as stated earlier, the water conditions particularly salinity varies from zone to zone. It has been shown, elsewhere in this account, that the pattern of contribution of different species varies significantly from zone to zone (*vide* analysis of variance, Table IX). It may be probable that the water conditions like salinity and temperature act as controlling factors in limiting the extent of their fishery as has been observed in the case of pandalid prawns (Schmitt 1921; Mistakidis 1957; Allen 1959; Butler 1964). Taking each zone into consideration, it is seen that while the peaks of fishery in certain species (Figs. 5 to 8) coincide with rise in salinity and/or temperature, in others a reverse condition is apparent (this aspect has been dealt in detail in an earlier chapter). Thus, each species is distributed within the limits of hydrological conditions of the estuary it can tolerate. These extreme conditions (given in Table 8 for each species) may not be encountered by all the stages in the life-history, from egg to adult, of a species since they may enter into estuarine and brackish water areas as juveniles and by the time they become mature they migrate back to the sea as in penaeids (Pantulu 1965) or go to estuarine water for breeding purposes as in the case of freshwater palaemonids (Bhimachar 1965). Thus, while the maximum fishery of a species is supported by a specific zone, the other zones may contribute very little only due to the breeding and juvenile migrations. Therefore, the optimum hydrological conditions for any species are to be assessed from the zone or zones where substantial or dominant fishery of the species exists. For all *Macrobrachium* spp. and *Leptocarpus fluminicola*, about 64 to 100% of fishery for each species is supported by zone I alone where the salinity is nil or traces (fresh water) and temperatures, 21.48 to 31.22 °C. *Caridina* spp. are, more or less, equally dominant in zones I and II to the extent of 45 to 55%. In zone II, they contribute to the catches only during the monsoon season when the salinity becomes traces or nil. Thus, their optimum conditions are—temperatures, 20.62 to 31.22 °C and fresh

water. *Parapenaeopsis* spp., *Metapenaeus* spp., *Penaeus indicus*, *Palaemon styliferus* and *P. tenuipes* support fishery to the extent of 64 to 99% of each of their catches in zone III alone, and the water conditions—temperatures, 21.89 to 31.0 °C and salinities, 4.32 to 29.77‰—existing in this zone will be the optimum conditions for these prawns. It can be seen from Fig. 7 that the fishery for most of the species, dealt in zone III, is in winter season. However, some species like *Penaeus indicus* and *Palaemon styliferus* contribute in the monsoon months also. During the monsoon and winter months, the range in the salinity is practically the same as given above.

Relative abundance: A study of catches in the Hooghly estuary (Table I) clearly indicates that *P. sculptilis*, *P. tenuipes* and *M. brevicornis* form the bulk of the prawn catches, each of them contributing over 100 t annually. Most of these catches are from the winter fishery existing in the lower Hooghly. *M. mirabile* is the only freshwater species contributing over 100 t a year, the fishery being constituted by both the upper and middle Hooghly and the Roopnarayan river. Catches of *M. mirabile* in the saline zone of the Hooghly and in the Matlah are negligible. Among prawns of secondary importance contributing 40 t a year are *P. styliferus* and *A. indicus*. The catches of these prawns are mostly contributed from the lower Hooghly during the winter and monsoon months. The importance of big and medium-sized prawns, like *M. rosenbergii*, *M. malcolmsonii*, *M. villosimanus* and *P. indicus*, as table prawns and hence their commercial value have been discussed elsewhere. Analyses of abundance of prawns in different zones indicate that a maximum of nearly 600 t a year are from the lower zone of the Hooghly estuary. Among other zones, only the upper Hooghly is of some importance in providing another 150 t annually.

CONCLUSION

1. The average annual production of prawns in the Hooghly estuarine system is 823 t. There seems to be an increase in the prawn catches from 1961 onwards.

2. During the winter season alone, about 65% of the total prawn output is landed, while the rest is, more or less, equally shared by summer and monsoon catches.

3. Commercially, the most important species of the estuary are *P. sculptilis*, *M. brevicornis*, *A. indicus*, *P. indicus* and *M. monoceros* in penaeids and *P. tenuipes*, *M. mirabile*, *P. styliferus*, *M. villosimanus*, *M. rosenbergii* and *M. malcolmsonii* in palaemonids, taking the quantity of landings and individual maximum sizes into consideration.

4. The main Hooghly alone contributes 90.5% (of which that of tidal or lower zone is 69%) of the total landings, while the Roopnarayan and the Matlah contribute 7.5% and 2% respectively. The fishing seasons in the different zones of the estuary are described in detail.

5. *Macrobrachium* spp. are predominant in the upper Hooghly. In the Roopnarayan and middle Hooghly *M. mirabile*, *P. styliferus*, *P. sculptilis* and *M. brevicornis* are the dominant ones. In the lower Hooghly and the Matlah *P. sculptilis*, *M. brevicornis*, *P. tenuipes*, *A. indicus* and *P. styliferus* are the most important ones.

6. Fisheries of different species in relation to salinity and temperature of the river are studied in detail. Percentage of zonal distribution, extreme and optimum hydrological conditions required for each species are also discussed.

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