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Prawn fishery along Chennai coast in North Tamil Nadu

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ABSTRACT

The annual prawn landings along Chennai during 1992-'99 vary from 1938t in 1992-'93 to a record 4477t in 1994-'95, with an average of 3235t at 5.29 kg/hr contributing to 10.1% of trawl catches. Primary fishery occurs around January-February and the secondary during July-September, with distinctly poor abundance in peak monsoon and summer months. Migratory populations support substantial fishery. *M. dobsioni* (664t, 20.5%), *P. indicus,* (491t, 15.2%), *P. maxillipedo* (392t, 12.1%) and *M. monoceros* (305t, 9.45%) are the abundant species. The magnitude of abundance of *P. maxillipedo* is unique. Marginally deeper species of *Matapenaeopsis* and *Trachypenaeus,* share the catches in moderate abundance and the larger *P. semisulcatus* (156t, 4.8%) and *P. mondon* (59t, 1.8%) add considerable remunerative values. Revealed by species distribution, Cauvery-Pulicat axis could be apportioned as single block for effective resource management.

Peak recruitment takes place around September-October and January-February in *M.dobsoni;* around June-September and December-January in *P. indicus* and May-June and September-October in *P. maxillipedo.* The MSY is estimated at 3552t, which is marginally above the average catch of 3235t for 1992-99, suggesting the exploitation remains under optimum level during the years. However, fixation of catch and effort limits seems to have no relevance, as the rapid and steep annual variations of catches reveal the prawn productivity here is largely influenced by uncontrollable natural factors. In addition to this, uncertainties in the extent and intensity of distant fishing also casts perceptible fluctuations in catches.

Introduction

Diverging demands in affluent oversea markets for prawns have led to selective exploitations mounting increasing pressure on natural stocks over the years. The impact has been far more stressful on stocks around urban areas due to over fishing, as led by the facilities of local financial supports and extensive trade networks. Off the city of Chennai exists a vibrant prawn fishery with the annual landings crossing over 3000t. Huge capital investments have been made in fishery sector, relying on prawn catches. It is thus imperative to sustain the tempo of the industry maintaining optimum level of commercial prawn catches, motivated with pragmatic management programmes, as carefully conceived from periodical assessments on the status of fishery. Yet the necessary

supportive information on prawn resources of this region till date in literatures is scanty and accumulated mostly from the technical reports and institutional records. Important one has been the report of "All India Co-ordinated Research Project for Studies on marine prawns' (Anon, 1975), which presents some information on the resources exploited in early 1970s. The prawn fishery here has since then experienced greater transformations, but concurrent communications are rarely available.

Few earlier investigations here are specific to individual prawn species and other few only fragmentary (Subramanyam, 1965; Kathirvel *et al.* 1985; Thangaraj Subramanian, 1985, 1998, 2000; Sankaralingam, 1989; Rao *et al.*, 1993; Sukumaran *et al.*, 1993). Some documents are also available to provide information on juveline prawn resources of the adjoining nursery waters (Subramanyam and Rao, 1968; Sampson Manickam and Srinivasagam, 1972; James and Thirumulu, 1983 and Kathirvel, 1985). An early observation on rare occurrence of penaeids breeding in Adyar estuary at its serene conditions (Panikkar and Aiyar, 1939) has been a classical reference cited in global literatures. In view of paucity of such information, the paper is intended to furnish a comprehensive current picture on inshore resources of prawns off this urban, with an attempt to assess the existing status of the stocks and optimum level of exploitation.

Materials and methods

The study was based on trawl fishery landing at Kasimedu, the only landing base of the city. On each day of weekly observations about 10% of trawlers, including daily and multi-day cruisers, were selected at random to record the total catch and proportion of prawns, along with the efforts in hauling hours. Direct eye-estimations were made individually for the major commercial species, which were brought sorted out on board, but other prawns grouped as miscellaneous were assessed collectively. The random samples from miscellaneous group were later analysed for species and their weights appropriately raised to combine with the readings already recorded for the sorted out species so as to obtain the average catch of every individual species in each unit. The average weight of species for the observed units was raised to arrive at the total prawn catch, along with overall total catch and effort, for all the units on the observed day. Similarly the monthly catch and effort were estimated from the averages of observed days and further added up to get the annual estimates. The average catch per unit effort, kg/hr, was calculated for the estimated monthly and annual values. The stock position of prawns was assessed on annual values using the surplus production models, Schaefer and Fox, as described in Sparre and Vennema (1982).

The biological samples of the most abundant species, *P. indicus*, *M. dobsoni* and *P. maxillipedo*, collected on the observation days during the period, 1992-'95, were analysed for sex, length and weight of all individuals and maturity stages of females. They were then processed into size-groups to project seasonal fluctuation of sex-ratio, recruitment and spawning. The cumulative abundance of smallest size-groups of both sexes and the relative abundance of mature and spent females combined together were considered to trace the recruitment and spawning periodicity respectively.

Results

Fishing area

The main fishing grounds are situated in patches along the Chennai coast (Fig. 1). The main fishing ground is about

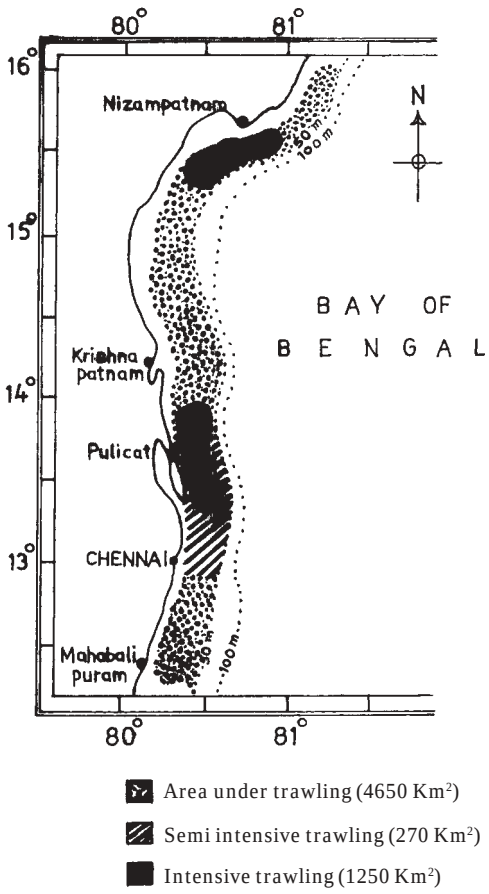

Fig.1. Fishery grounds under exploitations by trawlers from Chennai base.

50 km away towards north along the barmouth of Pulicat Lake, the large nursery habitat of the major commercial penaeids. Another local fishing ground attracting round the year trawler operations is the area adjoining the Ennore estuary, receiving enormous discharge of civic wastes and silts from the close by major sewage outlet on the northern periphery of the metropolis. Small concentration of fishing activities also occurs adjoining the Muttukadu backwaters, 50 km in the South, more often during the wet season. Of late, long-cruisers, operated with chilling facilities and more holding capacity from Chennai base, beyond 150 km deep into Andhra Pradesh coast for multi-day fishing, which may extend up to a fort-night or even little more occasionally.

Fishing effort

The average annual fishing efforts estimated for 1992-'99 was 612 thousand trawling hours and showed steady upward trend largely due to gradual increase in multi-day fishing operations during the period (Table 1.) Initially the effort was 359t hours in 1992-'93 and increased to 699t hours in 1996-'97 and shot up finally to 1156t hours in 1998-'99. Seasonal fluctuation of efforts was noted to be mainly associated with the availability of prawn catches, although rough monsoon weather conditions and local fishermen issues also occasionally interrupted fishing operations.

Catch

Inclining to increasing trend, the annual prawn catches varied widely from 1938 to 4477t, with an average of 3235t during 1992-'99 (Table 1). The annual landings escalated sharply from 1938t in 1992-'93 to reach the maximum of 4477t in 1994-'95, but declined quickly to 2650t in 1996-'97 and 2575t in 1997-'98, though improved again moderately to 3527t in 1998-'99. The catch rates varied between 2.87-8.51 kg/hr, with the overall average rate of 5.29 kg/hr and showed no direct relationship against the catches during the years. Thus the annual catch rate was relatively higher at 5.4 kg/hr against the poor catch of 1938t in 1992-'93, but lower catch rate of 3.05 kg/hr against the better catch of 3527t in 1998-'99. However, the maximum rate of 8.51 kg/hr coincided with the highest catch of 4477t recorded in 1994-'95. Prawns shared 7.4-13.5%, with the average of 10.1% of the total trawl catches in annual basis during 1992-'99. The contribution of prawns was moderate at 10.4% when the catch was at the maximum in 1994-'95 and the largest contri-

TABLE 1. *Details on catch(t), effort (x1000 hrs), CPUE (kg / hr) and percentage in total catches of prawns landed by trawlers at Chennai during 1994-'99.*

Year/ Month	1992-'93	1993-'94	1994-'95	1995-'96	1996-'97	1997-'98	1998-'99	Average Catch	kg	%
April	196	194	215	142	117	77	201	163	3.1	8.4
May	119	151	202	253	110	47	183	152	2.9	9.1
June	95	207	580	352	188	107	277	258	5.5	11.3
July	135	204	427	523	383	174	289	305	6.1	8.2
August	154	237	303	611	312	93	327	291	5.8	8.7
September	122	323	543	502	311	92	377	324	6.8	10.3
October	150	272	247	319	167	100	286	220	4.9	9.3
November	197	212	205	274	101	127	278	199	3.3	9.4
December	125	285	338	240	141	248	178	222	4.4	11.1
January	251	439	775	528	365	466	305	447	8.2	12.2
February	181	341	407	463	292	633	555	410	7.6	11.5
March	213	280	235	128	163	411	271	243	4.8	10.9
Total	1938	3145	4477	4335	2650	2575	3527	3235	-	-
Effort	359	436	526	699	699	897	1156	612	-	-
Kg/hr	5.40	7.21	8.51	6.20	3.79	2.87	3.05	-	5.29	-
Percentage	7.4	9.5	10.4	13.5	10.4	8.6	10.9	-	-	10.1

bution of 13.5% against the second highest catch recorded in 1995-'96. However, the minimum contribution of 7.4% was recorded when the catch was at the lowest in 1992-'93.

Seasonal abundance

The monthly landings varied between 47t in May 1997 and 755t in January 1995, while the average monthly catches for the years fluctuated between 152t in May and 447t in January. The seasonal abundance showed two annual fishery waves, intervened by poor catches around summer and monsoon months. The post-monsoon fishery in January-February was the primary peak season, with highest landings in January and the secondary fishery season appeared during pre-monsoon months extending over June-September, with peak catches shifting between the months. The average catch per unit effort calculated for the months varied between 2.9 kg/hr in May and 8.2 kg/hr in January, with an overall average of 5.29 kg/hr. The catch-rates remained higher than 5.0 kg/hr during peak fishery seasons in June-September and January-February, the latter having recorded with distinctly higher rates.

Species composition

The perennial abundance of commercially valuable species was the significant feature of prawn fishery of the area. More than 47 species of prawns recorded in trawl catches during the years could be broadly categorised by weight into generic level as: *Penaeus* spp. forming about 22% of prawns; *Metapenaues* spp., 35%; *Parapenaeopsis* spp., 18% and other genera, largely *Metapenaeopsis* and *Trachypenaeus*, comprising the rest. However, the dominant individual species (Table 2) supporting the fishery in the order of abundance were *Metapenaeus dobsoni, Penaeus indicus, Parapenaeopsis maxillipedo, M.*

TABLE 2. *Annual catch (t), overall averge cpue (kg/hr) and percentage in total prawns for important species landed at Chennai during 1992-'99.*

Species/ Year	1992-'93	1993-'94	1994-'95	1995-'96	1996-'97	1997-'98	1998-'99	Average Catch	kg/hr	%
M. dobsoni	421	699	806	827	547	556	788	664	1.09	20.5
P. indicus	315	493	714	591	360	379	586	491	0.80	15.2
P.maxillipedo	224	344	652	493	309	352	371	392	0.64	12.1
M. monoceros	146	287	460	400	227	315	303	305	0.50	9.4
M. stridulans	96	261	136	319	256	205	254	218	0.36	6.7
P. semisulcatus	91	181	176	205	122	127	189	156	0.26	4.8
M. mogiensis	88	122	146	108	131	77	132	115	0.18	3.5
T. sedilii	58	131	171	188	72	43	73	105	0.17	3.2
M.moyebe	37	82	212	199	40	22	99	93	0.15	2.8
P.longipes	48	93	130	142	47	44	54	80	0.13	2.4
T.curvirostris	45	100	126	143	19	49	14	71	0.12	2.2
P. stylifera	40	34	83	89	68	43	117	68	0.11	2.1
P.uncta	28	74	106	97	65	35	66	67	0.11	2.0
T.asper	38	43	67	54	80	67	97	64	0.11	2.0
P.monodon	39	58	73	67	50	45	83	59	0.09	1.7
T.pescado-reensis	38	62	57	37	43	63	69	53	0.09	1.6
S.crassico-rnicus	52	7	53	22	77	42	85	48	0.07	1.5
M.affinis	60	41	10	84	60	13	27	42	0.07	1.3
Total prawns	1938	3145	4477	4335	2650	2575	3527	3235	-	-
Kg/hr (Total prawns)	5.40	7.21	8.51	6.20	3.79	2.87	3.05	-	5.29	10.1

monoceros, *Metapenaeopsis stridulans* and *Penaeus semisulcatus*. Among the other minor species, *Metapenaeopsis mogiensis* and *Trachypenaeus sedilli* supported about 3% of prawns and species like *Metapenaeus moyebi*, *Parapenaeus longipes*, *Trachypenaeus curvirostris*, *Penaeus mondon and Parapenaeopsis stylifera* contributed around 2% each. Most other spices, including the larger *Penaeus japonicus* and *P. canaliculatus* and *P. merguiensis*, appeared stray and some others like *Metapenaeus affinis* and *M. lyssinassa* occasionally in small patches. Multiplicity of species was more vivid in catches during pre-monsson and post-monsson months, around August-September and January-December respectively.

M. dobsoni : It was the most abundant species consistently supporting the fishery with the average annual landings of 664t at the rate of 1.09 kg/hr supporting 20.5% of prawns. The annual catches showed a sharp increase in the initial years from 421t in 1992-'93 to the maximum of 827t in 1995-'96, while the catch rate improved from 1.17 kg/hr in 1992-'93 to the maximum of 1.60 kg/hr in 1993-'94. After slight drop in 1995-'96, steep decline followed to remain low around 547-556t during 1996-'98, although climbed substantially again to 788t in 1998-'99. The species supported consist-

ently around 20% annual catches of prawns, with the average contribution of 20.5 and maximum of 22.3% n 1998-'99. As for the seasonal abundance (Table 3), the monthly catches varied between 8-159t for the entire period, while the overall average monthly landings fluctuated between 24.8t in May and 104.6t in January. The fishery showed two major seasons each extending over 2-3 months within July-October and December-February with marginal annual shifting. The average monthly catch rates varied from 0.47 kg/hr in May to 1.92 kg/hr in January.

P. indicus : The annual landings of this most remunerative species varied between 315-714t averaging 491t during the years (Table 3). The catches increased sharply from 315t in 1992-'93 to reach the maximum of 714t in 1994-'95 and then declined similarly to 360t in 1996-'97, although climbed again slightly to 379t in 1997-'98 and 586t in 1998-'99. The catch rates also revealed similar pattern varying between 0.42-1.36 kg/hr with an average of 0.80 kg/hr. The catch rate was moderate at 0.88 kg/hr in 1992-'93 and reached the maximum of 1.36 kg/hr in 1994-'95, but decreased steadily down to 0.42 kg/hr in 1997-'98, although improved marginally to 0.51 kg/hr in 1998-'99. The species contributed 13.5-16.6% with the annual average of 15.2% of prawn catches. The fishery showed two peak seasons extending from June-September and December-February, with slight annual variations. The peak season, August-September, in 1993-'94, had advanced to June-July in 1994-'95 and another spell from December-January in 1995-'96 shifted to January-February in 1996-'97.

P. maxillipedo : The marine species ranked third in abundance and its annual catches ranged between 224-652t, with the average of 392t at 0.64 kg/hr forming 12.1% of prawns (Table 3). The fishery showed a sharp increase initially for few years improving from 2242t in 1992-'93 to 344t in 1993-'94 and then to the maximum of 621t in 1994-'95. After a drop subsequently to 309t in 1996-'97, the catches showed moderate improvement to reach 392t in 1998-'99. The share of the species to total prawns was between 10.5% in 1998-'99 and 14.6% in 1994-'95. Two annual fishery waves each extending over 2-3 months were noted within June-September and December-March, with minor annual variations. The average monthly landings fluctuated between 12.1t in May and 59.6t in August (Table 3). It formed the dominant proportion of 20.5% of prawns in August, the peak month of its abundance.

M. monoceros : The average annual landings of this medium size and commerically valuable species were 305t at 0.50 kg/hr forming 9.4% of the total prawns (Table 3). The catches showed sharp increase during the initial years from 146t in 1992-'93 to 460t in 1994--'95 and 400t in 1995-'96 and then declined to 227t in 1996-'97, though picked up again to reach about 300t in 1997-'99. The seasonal fishery waves occurred around August-September and January-February, with minor annual variations. The average monthly landings fluctuated between 9.3t in May, 43.1t in January and the contribution varied between 6.1-11.7%, with higher representation during August-September.

P. semisulcatus : The species added higher commercial values, although the annual landings averaged moderately at 156t forming 4.6% of the total prawns (Table 3). The catches showed a sharp initial increase from 91t in 1992-'93 to the highest of 205t in 1995-'96 and dropped to remain around 122-127t during 1996-'98, though increased considerably again to 189t in 1998-'99. The monthly catches during the years varied between 1.0t in May 1993-'94 and 41t in January 1998-

TABLE 3. *Annual and monthly catch details for important species of prawns landed by trawlers at Chennai during 1992-'99*

Species	Year	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb	March	Total	cpue (kg/hr)	% in prawns
P.indicus																
	1992-'93	16	26	18	27	46	19	19	18	25	44	39	18	315	0.88	16.3
	1993-'94	15	6	41	34	59	59	26	12	57	101	44	39	493	1.13	15.7
	1994-'95	27	26	88	89	63	58	66	33	41	75	103	45	714	1.36	16.0
	1995-'96	51	38	56	68	77	77	38	27	61	51	28	19	591	0.85	13.6
	1996-'97	6	8	23	45	52	50	25	12	25	47	44	23	360	0.52	13.5
	1997-'98	13	6	19	28	26	12	16	19	40	69	114	17	379	0.42	14.7
	1998-'99	17	15	55	47	70	50	32	19	106	95	49	31	586	0.51	16.6
	Av.	20.7	17.9	42.9	48.3	56.1	46.4	31.7	20.0	50.7	68.9	60.1	27.4	491	0.80	15.2
P.semisulcatus																
	1992-'93	3	4	3	8	10	7	8	5	6	20	10	7	91	0.25	4.7
	1993-'94	4	1	10	12	11	29	16	7	29	34	17	11	181	0.41	5.8
	1994-'95	5	10	23	14	20	18	27	12	14	8	16	9	176	0.34	3.9
	1995-'96	21	15	28	13	30	27	19	9	15	19	4	5	205	0.29	4.7
	1996-'97	3	4	8	8	21	9	8	6	17	18	12	8	122	0.18	4.6
	1997-'98	3	4	8	8	21	9	8	6	17	18	12	8	122	0.18	4.6
	1997-'98	5	2	5	14	8	3	6	6	12	22	38	6	127	0.14	4.9
	1998-'99	4	5	8	25	27	17	11	7	26	41	14	4	189	0.16	5.4
	Av.	6.4	5.9	12.1	13.4	18.1	15.7	13.6	7.4	17.0	23.1	15.9	7.1	156	0.26	4.8
M.dobsoni																
	1992-'93	29	28	11	41	51	32	23	21	35	68	53	29	421	1.17	21.7
	1993-'94	18	8	31	54	99	83	32	16	86	147	68	57	699	1.60	22.2
	1994-'95	38	41	49	107	56	88	82	41	44	83	109	68	806	1.55	18.0
	1995-'96	68	52	77	93	120	84	55	37	77	93	43	28	827	1.18	20.6
	1996-'97	9	11	34	66	77	56	45	20	45	74	76	34	547	0.78	20.6
	1997-'98	19	9	28	42	50	29	20	23	44	108	158	26	556	0.62	22.3
	1998-'99	21	25	64	57	96	71	36	44	116	159	57	42	788	0.68	22.3
	Av.	28.9	24.8	42.0	65.7	78.4	63.3	41.8	28.9	63.9	104.6	80.6	40.6	664	1.09	20.5

TABLE 3. *(Contd.)*

M. monoceros															
	1992-'93	4	7	3	14	28	8	7	10	12	27	15	11	146	0.41	7.5
	1993-'94	8	5	12	20	37	39	17	10	26	64	27	22	287	0.66	9.1
	1994-'95	17	16	70	51	36	51	44	18	34	38	17	15	400	0.57	9.2
	1995-'96	38	21	35	42	60	66	16	18	33	39	17	15	400	0.57	9.2
	1996-'97	4	5	19	30	31	37	7	11	20	15	35	13	227	0.33	8.6
	1997-'98	8	4	11	26	16	14	9	13	17	55	895	47	315	0.35	12.2
	1998-'99	8	7	11	26	30	36	21	12	27	64	35	26	303	0.26	8.6
	Av.	12.4	9.3	23.0	29.9	34.0	35.8	17	13.1	24.1	43.1	39.9	23.4	305	0.50	9.4
P.maxillipedo																
	1992-'93	10	9	9	13	41	21	12	7	17	34	29	22	224	0.62	11.6
	1993-'94	9	3	32	39	73	63	17	8	23	35	24	17	344	0.79	10.9
	1994-'95	21	19	76	84	121	46	60	24	68	56	54	23	652	1.24	14.7
	1995-'96	27	32	46	51	76	69	32	20	65	46	17	12	493	0.71	11.4
	1996-'97	6	6	4	36	55	31	12	17	37	55	35	15	309	0.44	11.7
	1997-'98	5	5	9	32	21	10	11	10	40	74	95	40	352	0.39	13.7
	1998-'99	15	10	36	31	30	46	18	11	41	70	35	38	371	0.32	10.5
	Av.	13.3	12.1	30.3	40.6	59.6	40.9	23.1	13.8	41.6	52.9	41.3	22.4	392	0.64	12.1
M.stridulans																
	1992-'93	6	5	3	12	9	17	2	2	13	15	8	3	96	0.27	5.0
	1993-'94	4	7	19	23	14	38	12	6	25	65	28	20	261	0.60	8.3
	1994-'95	14	9	6	13	7	12	13	4	18	21	12	7	136	0.26	3.0
	1995-'96	34	17	25	34	48	33	26	19	39	30	8	6	319	0.46	7.4
	1996-'97	4	6	28	25	30	34	13	10	24	37	27	18	256	0.37	9.7
	1997-'98	9	1	10	23	20	17	9	8	12	36	29	31	205	0.23	8.0
	1998-'99	10	8	26	22	18	29	16	12	22	51	19	21	254	0.22	7.2
	Av.	11.6	7.6	16.7	21.7	20.8	25.7	13.0	8.7	21.8	36.4	18.7	15.1	218	0.36	6.7

'99 and the average monthly landings varied between 5.9-23.1t showing relatively better fishery in August-September and December-February with minor shifts between years.

M. stridulans : This small prawn is caught mainly from the deeper margins in recent years and its annual landings varied between 95t in 1992-'93 and 219t in 1995-'96, with the average of 218t during 1992-'99 (Table 3). The catches fluctuated between 96 and 319t during 1992-'96, but remained closely at 200-250t during 1996-'99. The average catch rate for the years varied from 0.22 kg/hr in 1998-'99 to 0.60 kg/hr in 1993-'94, with the average of 0.36 kg/hr and supported 3.0-9.7%, with the average of 6.7% of prawns. The monthly catches of the species were at the minimum of 2.0t in October-November, 1992-'93 and the maximum of 65.0t in January, 1993-'94 and the average monthly landings for the years fluctuated between 7.6t in April and 36.4t in January. Relatively increased catches were noted during July-September and December-February and distinctly in poor abundance during the mid-monsoon and summer months.

Minor species : Several other species occurring in minor catch, are given in Table 2 and 4 for the proportionate and seasonal abundance. *P. monodon,* the largest in size fetching attractive price, had the annual landings between 39t in 1992-'93 and 73t in 1994-'95, with the average of 59t. The highest monthly catch recorded was 12.2t in August 1995 and the average monthly landings for the years varied from 3.0t in May to 7.1t in February, with the peak abundance in January-February. *M. moyebi* showed varying annual catches between 22t in 1997-'98 and 212t in 1994-'95, the average being 93t. The maximum monthly catch was 34.8t landed in Marh 1995 the average being 93t. The maximum monthly catch was 34.8t landed in March 1995 and the average monthly landings fluctuated from 4.9t in February to 10.3t in October, with higher abundance in September-October and March-May. *P. stylifera* had the annual landings varying between 34t in 1993-'94 and 117t in 1998-'99, with the average of 68t. The heaviest catch for an individual month was 32.8t in October 1994 an the average monthly landings were between 1.3t in June and 11.3t in October, the abundance being relatively more around January-February, June and October.

T. sedilli showed the annual catches varying from 43t in 1997-'98 to 188t in 1995-'96, with an average of 105t. The maximum monthly catch was 37.5t in October 1995 and the average monthly landings fluctuated between 4.5t in April and 15.3t in January showing higher abundance during January-February and June-October. *T. curvirostris* recorded the annual landings between 14t in 1998-'99 and 143t in 1995-'96, with an average of 71t. The highest catch for a month was 34.7t landed in September 1994 and the average monthly catches varied from 1.1t in May to 11.5t in September, with better landings in September-October and January-February. *T. asper* had the annual catches fluctuating between 38t in 1992-'93 and 87t in 1998-'99 with an average of 64t and highest of 27t in December 1994. The average monthly landings varied from 1.7t in June to 10t in December, with higher abundance extending over August-February with slight drop in September and January. *T. pescadoreensis* had the annual catches varying from 37t in 1995-'96 to 69t in 1998-'99. The maximum catch was 38.2t recorded in Ocotber 1994 and the average monthly landings varied between 1.5-7.7t, with peak in August-October.

M. mogiensis, the most abundant among minor species, had the annual catches between 88t in 1992-'93 and 146t

in 1994-'95, with the average of 115t. The maximum monthly landings were 39.0t in September 1994 and the average monthly catches fluctuated from 6.1t in November to 13.2t in January, with the peak around December-January. *P. longipes,* a deeper form recorded landings between 44t in 1997-'98 and 142t in 1995-'96, with an average of 80t. The highest catch for any month was 35.1t in June 1994 and the average monthly landings ranged between 1.7t in May and 9.3t in June, with primary season in June-July and a mild spell in October-November. *S. crassicornis* appeared inconsistently and varied annually between 7t in 1993-'94 and 85t in 1998-'99, with the average of 48t. The heaviest landings were 17.9t in February 1998 and average monthly catches were recorded between 2t in May and 8.7t in January, with peak catches in January-February.

Stock assessment

Using the catch per unit effort and their logarithmic transformations against effort as input, the surplus production models, such as, Schaefer and Fox, were followed to obtain the maximum sustainable yield (MSY) and optimum level of fishing (fmsy) for prawns. The estimated values (Fig. 2) were :

Model	MSY (t)	f_{msy} ('000 hrs)
Schaefer	3696.2	808.8
Fox	3407.7	834.0
Average (of both)	3552.0	821.4

Although the annual catches had largely exceeded the optimum level during 1994-'96, the average catches of 3235t for all the years remained within the limit with considerable margins.

Biological information

M. dobsoni : Size distribution showed sexual disparity. Females were larger in size and the overall size range for them

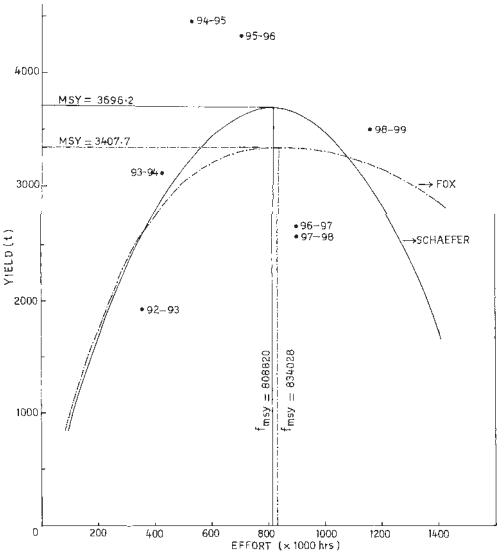

Fig.2. Stock estimates by Schaefer and Fox models for prawns along Chennai coast

was 51-120mm, with the dominant size groups supporting the fishery at 71-100mm and the same for male was 51-110mm, with 66-85mm. The average monthly size-frequency for 1992-'95 revealed more abundance of fresh recruits around September-October and January-February. The overall sex-ratio was 58.5 : 41.5 in favour of females, with the ratio exceeding 60% in most of the months. Females were dominant among larger length groups measuring over 85mm. The smallest female possessing mature ovary in the samples, indicating minimum size at maturity, measured 61.5mm, but most of them attained maturity at 66-75mm size range. The seasonal frequency of maturity stages (Fig. 3) showed continuous breeding activities with two main seasons during June-August and January-March and peak in June and January.

P. indicus : The overall size in commercial catches ranged 121-195mm, with bulk of the individuals belonging to 151-180mm among males and 121-200mm, with 151-185 mm forming the bulk among females. Peak recruitment peri-

ods were during June-September and December-January (Fig. 3). The average sex-ratio was 44:55.5 in favour of females and no significant deviation from 1:1 was noted. The smallest size-group of females possessing mature ovary was 126-130mm, though large number of such females exceeded 140mm length. Though the species breeds continously, higher intensity of spawning activities was noted in two sharp spells around June and January.

P. maxillipedo: The population of this exclusively marine species in trawl catches was supported by size ranging 41-105mm for males, with bulk of them belonging to 61-90mm and females were relatively larger in size ranging 41-115mm, with majority measuring 61-95mm. Males exceeding 95mm and females over 105mm size formed not more than 2.0% of the population landed. Fresh recruits measuring around 56-60mm size showed two peak recruitment seasons in May-June and September-October, with additional moderate spell in February-March (Fig. 3). Females outnumbered with the average ratio varying between 56.3-58.0% for 1992-95. The smallest gravid female measured 58.5mm size, but bulk of the females attained maturity around 66-75mm size. Spawning periodicity showed two strong annual spells around October and February.

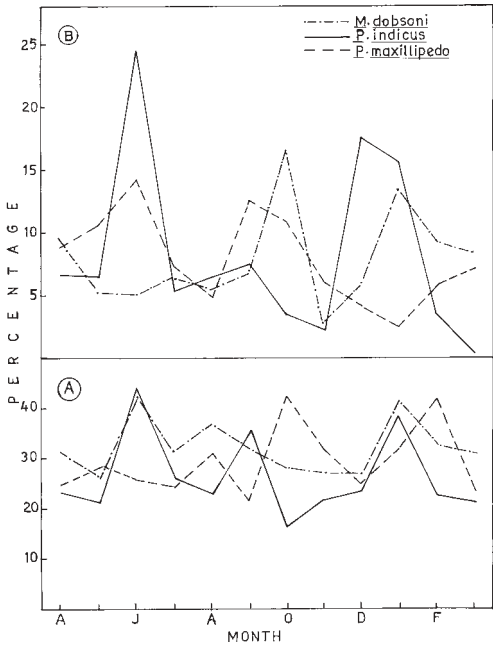

Fig.3. Seasonal abundance of spawners (A) and fresh recruits (B) of *P. indicus, M. dobsoni and P. maxillipedo* at Chennai

Discussion

The foregoing content convince the existence of a vibrant prawn fishery off Chennai. Data over the past few years disclose rapid transformations of fishery during 1990s, that the annual landings of just 167t in 1972 (Anon, 1975) and 183t in 1980 (Anon, 1982) have shot up to exceed 3000t in 1990s, with the record of 4477t in 1994-'95. Such an explosive increase in catches could be accomplished by advancements in crafts and gears, enabling expansion of fishing operations towards deeper and distant areas to have incorporated additional resources giving new complexion to the catches. Similar changes in fishing operations and catches have occurred during the period with the introduction of the larger 'sona boats' adjacent to Andhra Pradesh coast (Rao, 1999).

Large abundance of prawn fishery along the coast, despite the estuarine habitats of the two minor rivers present in the city serving merely as sewage bowls, with exception of few occasions of intermittent monsoon floods, is fairly evident of the possible influx of migratory population from outside areas. Considering mark-recovery experiments establishing migratory habits among penaeids up to 700km (Anon, 1983; Ruello, 1975), the populations far from Cauvery and Krishna-Godavary delta regions are likely to visit here. A few massive school movements of penaeids reported along the proximity of the city

TABLE 4. *Average monthly landings (t) of prawn species in minor catches at Chennai during 1992-'99*

Species/Month	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
P.mondon	3.3	3.0	4.5	5.4	5.5	3.8	5.7	3.9	5.9	6.3	7.1	4.9	59
M.moyebi	8.3	8.2	7.7	6.7	6.1	10.2	10.3	6.8	7.3	7.7	4.9	8.8	93
P.stylifera	4.3	7.0	1.3	8.3	4.7	4.5	11.3	5.3	4.5	6.9	6.6	3.2	68
T.sedilii	4.5	6.7	11.0	8.3	9.1	10.3	9.9	6.3	4.8	15.3	11.4	7.7	105
T.curvirostris	3.1	1.1	7.7	4.9	5.7	11.5	8.3	3.8	5.2	8.7	4.9	9.9	75
T.asper	5.3	3.8	1.7	4.4	7.0	4.7	6.8	6.1	10.0	4.4	6.4	3.1	64
T.pescado-reensis	2.2	1.5	2.2	3.6	5.9	6.1	7.7	4.2	3.1	2.8	5.5	3.5	48
M.mogiensis	6.9	6.4	9.7	9.2	9.0	15.7	8.3	6.1	12.4	13.2	10.1	8.1	115
P.longipes	6.2	1.7	5.3	8.3	9.9	8.8	8.6	6.8	5.9	8.4	4.7	3.5	78
S.crassico-rnicus	2.6	2.0	4.0	4.3	3.0	2.3	2.5	4.9	2.5	8.7	7.3	5.0	49
Total prawns	163	152	259	305	291	324	220	199	222	447	410	243	3235

(Kathirvel *et al.*, 1985; Sankaralingam, 1989) could have been apparently during their long inward journey. The main attraction for the migratory population to throng here could be for feeding on enormous civic sewage and silts being dumped into the coastal grounds. Additional possibility is that the population, to keep away from thinning effect of heavy monsoon river floods along the neighbouring Cauvery and Krishna-Godavary delta regions, would move to take shelter under relatively stable and moderate hydrological conditions prevailing here then for lack of much local river flows. The two seasonal fishery waves are timed with the pre-monsoon in July-September and post-monsoon in December-February, each of which appears to be under different mode of influence. The former fishery spell coincides with upwelling when the stressful hydrological conditions with depleted oxygen contents, sedimentation and lower temperature at the bottom, creep shoreward. As the consequence, the populations of shallow water species scattered into deeper grounds retract, while the marginally deeper forms like *P. longipes* and species of *Metapenaeopsis* and *Trachypenaeus* shift shoreward into the fishing limits to increase the catches. On the other-hand, higher productivity of post-monsoon fishery wave is supported by enlargement of nursery habitats on inundation of monsoon floods, with complements of visiting population converging to feed on monsoon silts. Influence of rainfall and freshwater drainage on penaeid productions was also reported from Texas and Louisiana waters (Gunter and Edwards, 1969).

The striking features of prawn fishery of the area is the multiplicity of species, considerably contributed by expansion of fishing to deeper grounds and distant fishing, besides the visiting populations. The more remunerative, *P. indicus*, *M. dobsoni*, *M. monoceros* and *P. semisulcatus* are the dominant species and the similar species domination has been reported in the adjoining nursery habtiats of local Ennore estuary (James and Thirumulu, 1983) and the neighbouring Pulicat Lake (Sampson Manickam and Srinivasagam, 1972; Rao and Gopalakrishnayya, 1974). Fishing beyond the conventional shrimp-trawl grounds in later years has unfolded the existence

of fishery resources, like *P.maxillipedo* and the species of *Metapenaeopsis*, *Trachypenaeus* and *P. longipes* in abundance. Similar occurrence has been reported along other regions on either coast (Suseelan *et al.*, 1982; Thangaraj Subramanian, 1999). It is significant to record that the fishery magnitude of *P. maxillipedo* here with an annual catch of 392t has no parallel occurrence from any waters. The general pattern of species compositions off Cuddalore along Cauvery base in the south (Thangaraj Subramanian, 1999) agrees closely with the fishery here, while different combination of species contributes the fishery off Mandapam in further south (Maheswarudu *et. al.*, 1996) and off Kakkinada in the north (Rao, 1988). The extend of species distribution indicates Cauvery-Pulicat axis as the core area of fishery for the key species of *P. indicus*, *M. dobsoni* and *P. maxillipedo*. Whereas, the fishery distribution of *P. semisulcatus* extends decreasingly northward into the area from Mandapam region, the prime area of its fishery abundance (Nandakumar, 1980) and *M.monoceros* overlaps here dispersely from its main area off Kakkinada (Rao, 1988). It is thus appropriate to apportion the prawn resources along Pulicat-Cauvery axis as single block for effective resource management. Rao *et al.* (1993) suggested own regulatory measures necessary for each individual block area of fishery.

The biological activities and the abundance of both *P. indicus* and *M.dobsoni* are closely associated with monsoon along this region. The major spawnig spells in premonsoon months, June-September, are so timed to prefer the higher fertilizing effects of upwelling conditions promoting bloom of larval feed, to be followed by enlargement of juvenile habitats by inundating monsoon floods lasting next few months. Similar spawning seasons have been noted earlier among the penaeids along this region (Subramanyam, 1965; Thomas, 1974). Unlike the other two species, *P. maxillipedo* has an additional spawning spell during peak monsoon in October, which could indicate an intermediary option for this marine species between marine and estuarine conditions moderated by persistent rainwater floods at inshore grounds.

The MSY is estimated as 3552t annually which is slightly higher than the average catch of 3235t for the years suggesting that the exploitation has been under the optimum level. However, the validity of fixing MSY as the permissible limit of exploitation of prawn resources is often doubted for the unpredicted fluctuation of populations quite independent of fishing efforts. Gracia (1989) explains to this effect, 'the shrimps exploit being essentially one year class, the annual yield is largely a function of the level of recruitment, which is influenced by the environmental conditions'. The steep escalation of catches quickly from the minimum 1938t in 1992-'93 to the record 4477t in 1994-'95, without concurrent changes in effort, could fairly suggest the possible influence of uncontrollable natural factors on prawn productions. However, the recent development of long distance fishing outside the local grounds to share substantial landings of prawns has also been a major cause for catch fluctuations. Uncertainty in the extent and intensity of fishing activities looms over these distant grounds due to territorial rivalry and clashes among fishing activities affecting the local catch variations. It needs an effective control over this fishermen problem, apart from the conventional approaches to sustain the desired tempo of catches.

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References

Anon 1975. Report of the All-India Co-ordinated Research Project for 'Studies on marine prawn resources and biology'. *Tech. Rep. CMFRI (ICAR),* 1975, 134 pp.

Anon 1982. Synopsis of marine prawn fishery of India, 1980. *Mar. Fish. Infor. Serv. T&E. Ser.,* **35 :** 1-14.

Anon 1983. New light on the migration of the Indian white prawn, *Penaeus indicus. Mar. Fish. Infor. Serv. T&E Ser.,* **45**: 1-9.

Garcia, S. 1989. The management of coastal penaeid shrimp fisheries. In : *Marine Invertebrate Fisheries - The Assessment and Management.* J. F Caddy, (Ed.), J. Wiley and sons, New York, 281-306.

Gunter, G. and M. Edwards 1969. The relation of rainfall and freshwater drainage to the production of the penaeid shrimp (*Penaeus fluviallis* and *Penaeus azetecus*) in Texas and Louisiana waters. *FAO Fish. Rep.,* **57** : 875-922.

James, D. B. and P. Thirumulu 1983. Good seasons for prawns predicted off Madras. *Mar. Fish. Infor. Serv. T&E Ser.,* **53** : 23-25.

Kathirvel, M., V. Selvaraj, A. Ramakrishnan, S. Shahul Hameed, P. Poovannan and M. Bose 1985. An unusual bumper catch of white prawn, *Penaeus ndicus* from Kovalam Bay near Madras. *Mar. Fish. Infor. Serv. T & E Ser.,* **65** : 15-17.

Kathirvel, M. 1985. Occurrence of maturing females of Kuruma prawns, *Penaeus japoniucs* in the mariculture farm at Muttukkadu. *Mar. Fish. Infor. Serv. T & E Ser.,* **65** : 12-14.

Maheswarudu, G., P. E. Jameson Manickam, P. Vedavysa Rao and M. Arputharaj 1996. Observations on the exploitation of penaeid prawn resources in the Palk Bay off Mandapam during 1986-'93. *Indian. J. Fish.,* **43** : 205-213.

Nandakumar, G. 1980. Observations on the prawn fishery of Mandapam area. *Indian. J. Fish.,* **27** : 27-260.

Panikkar, N. K. and R. G. Aiyar 1939. Observations on breeding in brackishwater animals of Madras. *Proc. Indian Acad. Sci.,* **9** : 343-363.

Rao, K. J. and C. H. Gopalakrishnayya 1974. Penaeid prawn catches from Pulicat Lake in relation to ingress of post-larvae and lake hydrography. *Indian J. Fish.,* **21** : 445-453.

Rao Sudharakara, G. 1988. Exploitation of prawn resources by trawlers off Kakkinada with a note on the stock assessment of commercially important species. *Indian J. Fish.,* **35** : 399-405.

Rao Sudhakara, G. V. Thangaraj Subramanian, M. Rajamani, P. E. Sampson Manickam and G. Maheswarudu 1993. Population dynamics of *Penaeus* spp. in the east coast. *Indian J. Fish.,* **40** : 1-19.

Rao Sudhakara, G. 1999. Prawn fishery by the sona boats at Visakapatnam. *Indian J. Fish.,* **46** (1) : 13-23.

Ruellos, N.V. 1975. Geographical distribution, growth and breeding migration of the Eastern Australian king prawn *Penaeus plebejus* Hess. *Aust. J. Mar. Freshwat. Res.,* **26** : 343-354.

Sampson Manickam, P.E. and S. Srinivasagam 1972. Prawn fishery of Pulicat Lake. *Proc. Semi. Mar. Mech. Fish.,* Madras : 57-59.

Sankaralingam, S. 1989. Instance of heavy catches of *Metapenaeus dobsoni* along the Madras coast. *Mar. Fish. Infor. Serv. T&E Ser.,* **95**:8.

Sparre, V. and S.C. Venema 1992. *Introduction to tropical fish stock assessment. FAO Fish. Tech Paper,* **306**(1), 376 pp.

Subramanyam, C.B. 1965. On the reproductive cycle of *Penaeus indicus* (M.Edw.). *J. Mar. Biol. Ass. India*, **7** (2) : 284-290.

Subramanyam, M. and K. J. Rao 1968. Observations on the post-larvae prawns (Penaeidae) in the Pulicat Lake with notes on their utilization in capture and culture fisheries. *Proc. Indo-Pacif. Fish. Counc.*, **13** (2) 113-123.

Sukumaran, K.K., K. Alagaraja, C. Suseelan, K. N. Rajan, V. Thangaraj Subramanian, V. S. Kakati, G. Nandakumar, N.S. Kurup, P. T. Sarada and T. V. Sathianandan 1993. Stock assessment of the penaeid prawn *Metapenaeus dobsoni* (Miers) along the Indian coast. *Indian J. Fish.*, **40** : 35-49.

Suseelan, C., M.M. Thomas, N.S. Kurup and K. N. Gopalakrishnan 1982. A potential new resource of prawns from Neendakara area in Kerala coast. *Mar. Fish. Infor. Serv. T & E Ser.*, **35** : 15-17.

Thangaraj Subramanian, V. 1985. *Reproduction, culture and fishery of Metapenaeus dobsoni Miers (Crusacea : Penaeidae).* Ph.d. Thesis, Univ. Madras : 246 pp.

Thangaraj Subramanian, V. 1998. A small concentration of *P. japonicus* Bate off the north Tamil Nadu. *Mar. Fish. Infor. Serv., T & E Ser.*, **154**: 11-14.

Thangaraj Subramanian, V. 1999. Prawn fishery of Cuddalore, North Tamil Nadu coast, with special reference to long-term changes. *Mar. Fish. Infor. Serv. T & E Ser.*, **166**:1-11.

Thangaraj Subramanian, V. 2000. Fishery biology of penaeid prawn, *Parapenaeopsis maxillipedo* Alcock along Chennai (Madras) coast. *Indian J. Fish.*, **43** (3) : 175-183.

Thomas, M.M. 1974. Reproduction, fecundity and sex-ratio of the Green tiger prawn *Penaeus semisulcatus* De Haan. *Indian. J. Fish.*, **21** : 152-163.