Indian J. Fish., 62(2): 7-13, 2015

Exploitation of penaeid shrimp resources by small mechanised trawlers off Visakhapatnam, Andhra Pradesh

G. MAHESWARUDU, MIRIAM PAUL SREERAM, E. DHANWANTHARI, J. B. VARMA, C. K. SAJEEV AND S. SATYA RAO

Visakhapatnam Regional Centre of Central Marine Fisheries Research Institute, Pandurangapuram Visakhapatnam - 530 003, Andhra Pradesh, India
e-mail: maheswarudu@yahoo.com

ABSTRACT

Small trawlers (9-11 m OAL) fit for short-term cruises (2-7 days) exploit penaeid shrimps up to a depth of 70 m in the Bay of Bengal off Visakhapatnam both in the northern and southern directions. During the period 2001 to 2010, average annual fishing effort was 5,97,412 h. Penaeid shrimp catch varied from 703 t to 4,323 t with average catch per hour (cph) being 3.54 kg. The contribution of penaeid shrimps to total fish landings ranged from 6.7 to 18.32%, both fishing effort and landings of the resource showing increasing trend. Penaeid shrimp landing was supported by 24 species, dominated by *Metapenaeus monoceros* followed by *Metapenaeus dobsoni.* Mean annual species composition and cph for each species were estimated for two spells *i.e.,* 2001 to 2005 and 2006 to 2010. Catch per hour for five species declined whereas it increased for the rest 19 species. The cph for penaeid shrimps increased by 103% from spell 1 to spell 2. Expected catch for each year was estimated by Schaefer production model (CEDA; r^2=0.72) which showed that the resource was under exploitated during 2001-2005 and overexploited during 2006-2010, which indicate the necessity for restricting fishing effort at present level.

Keywords: Bay of Bengal, Catch and effort, Penaeid shrimp, Schaefer production model, Small mechanised trawlers, Total fish landings, Visakhapatnam

Introduction

The 1960's witnessed exploratory bottom trawling operations conducted by the Fishery Survey of India (FSI) in the Bay of Bengal along the north-east coast of India (off West Bengal, Odisha and Andhra Pradesh). Various aspects of the outcome of these surveys were reported by different authors (Naumov, 1961; Poliakov, 1961,1962; Borisov, 1962). These exploratory operations led to the introduction of small mechanised trawlers for exploitation of shrimps in the Bay of Bengal, in 1964 under the Indo-Norwegian project.

Visakhapatnam is one of the major fishing harbours along the east coast of India, providing berthing facilities for small trawlers, Sona boats and large trawlers. Penaeid shrimps were caught by indigenous crafts and gears until 1960 along the coast. Exploitation of penaeid shrimps got momentum after the introduction of small mechanised trawlers, under the Indo-Norwegian project. Up to 1980, fishing was carried out during day hours. Fishing during night was introduced in 1980 restricted to four months during winter season *i.e.*, October to January and was continued up to 1987. Voyage fishing began in 1987, initially for 2-3 days and gradually increased to the present trend of 6-7 days. Trawl fishery, species composition and seasonal abundance of different resources along the Visakhapatnam coast were reported by Sastry and Chandrasekhar (1986), Luther *et al.* (1988), Rao (1987,1988, 1993, 1999), Reuben *et al.* (1987) and Rajkumar *et al.* (2005).

Small trawlers (9-11 m OAL), powered by 65-83 HP engine, fit for short-term cruises (2-7 days) exploit penaeid shrimps up to a depth of 70 m in the Bay of Bengal, off Visakhapatnam. The operation is carried out both in the northern and southern directions by shrimp trawl net with cod end mesh size of 10-20 mm. These trawlers have fish hold capacity of 2-3 t with 6 member crew. The present paper reports the trend in exploitation of penaeid shrimp resource by small mechanised trawlers off the Visakhapatnam coast and their species composition during a period of ten years (2001-2010).

Materials and methods

Data on fishing effort, landings of penaeid shrimps, non-penaeid shrimps and total fish were collected from small trawlers at Visakhapatnam Fishing Harbour for the period 2001 to 2010, as per the standard procedure adopted by Fishery Resource Assessment Division of Central Marine Fisheries Research Institute (Kutty *et al.,*

1973). The observation day's catch was raised to monthly catch by a factor based on observation days and total fishing days in the month. The number of fishing days, fishing hours, depth of operation and fishing grounds were recorded by enquiry from the vessel crew.

Data on species composition was collected weekly once and catch of each commercial species namely *Penaeus monodon*, *Penaeus semisulcatus*, *Marsupenaeus japonicus, Fenneropenaeus indicus*, *Fenneropenaeus meguiensis*, *Metapenaeus monoceros*, *Metapenaeus dobsoni* and *Parapenaeopsis stylifera* were recorded at the landing centre. Samples of small sized species were brought to the laboratory and analysed to arrive at species composition by weight. Species composition by weight of all four observation days of a month was pooled to derive the monthly value and the values thus obtained for the twelve months were pooled to estimate the annual figure. Catch of miscellaneous species were grouped into "others". Catch and effort data of penaeid shrimps from small trawlers for the ten year period was analysed using the Schaefer production model, Catch Effort Data Analysis (CEDA) (Kirkwood *et al.*, 2001) to estimate expected catch and status of exploitation of the resource for each year. Catch, effort and species composition was split into two spells, 2001-2005 and 2006-2010 and the results were compared.

Results and discussion

Trend of annual fishing effort, landings of penaeid shrimps, non-penaeid shrimps, total fish, catch per hour (cph) and percentage contribution of penaeid shrimps and non-penaeid shrimps to total fish landings are given in Table 1. Both penaeid shrimp catch and fishing effort showed increasing trend during the reporting period (Fig.1). Annual penaeid shrimp landings and annual fishing effort increased during the period (catch increased from 703 to 4,322 t with mean at 2,119 t and fishing effort from 2,92,569 to 10,78,796 h with mean at 5,97,412 h).

On an average, penaeid shrimps contributed 13.7% to the total fish landings. Sastry and Chandrasekhar (1986) also reported 13.8% of shrimps in the total fish landings by small trawlers during 1982-84. The cph for the resource ranged from 2.19 to 4.92 kg h^{-1} with mean at 3.55 kg h^{-1}. Sastry and Chandrasekhar (1986) reported annual cph for shrimps exploited by small mechanised trawlers, based at Visakhapatnam, as 3.0 kg and 2.7 kg for 1982-83 and 1983-84 respectively. The higher cph in the present study indicates increase in the exploitation rate.

Fishing effort per boat increased from 27. 3 to 103.7 h during the reporting period, as voyage fishing increased from 3 to 6 days, especially since 2006. Landings of non-penaeid shrimps began in 2006 and ranged from 20 to199 t, contributing <1.0 to 1.75% to total fish landings per year. Non-penaeid shrimps live in low saline waters and their emergence in the landings from 2006 is due to extension of fishing towards southern side, off Godavari Estuary.

Table 1. Catch and effort of small mechanised trawlers, based at Visakhapatnam Fishing Harbour during 2001-2010.

Year	Effort (units)	Effort (h)	Effort/trip (h)	Penaeid shrimp catch (t)	Non-penaeid shrimp catch (t)	Total fish catch (t)	Catch per hour of penaeid shrimps (kg)	Catch per hour of non-penaeid shrimps (kg)	Catch per hour of total fish (kg)	% of penaeid shrimps in total fish catch	% of non-penaeid shrimps in total fish catch
2001	10702	292569	27.3	703	0	6791	2.4	0	23.21	10.36	0.00
2002	11059	529441	47.9	1199	0	10571	2.26	0	19.97	11.34	0.00
2003	13731	712660	51.9	1802	0	17495	2.53	0	24.55	10.30	0.00
2004	10089	485546	48.1	1064	0	15857	2.19	0	32.66	6.71	0.00
2005	9713	405141	41.7	1095	0	13428	2.70	0.00	33.14	8.15	0.00
2006	9269	476818	51.4	2036	20	14724	4.27	0.04	30.88	13.93	0.13
2007	7773	429480	55.3	1938	199	11360	4.51	0.46	26.45	17.06	1.75
2008	8456	692684	81.9	3410	31	18617	4.92	0.05	26.88	18.32	0.17
2009	10402	1078796	103.7	4322	22	25119	4.00	0.02	23.28	17.21	0.09
2010	10187	870981	85.5	3622	29	20977	4.16	0.03	24.08	17.27	0.14
Mean	10138	597412	58.9	2119	30	15494	3.55	0.05	25.93	13.7	0.19
2001-2005	11059	485071	43.9	1172.8	0	12828	2.42	0	26.45	9.14	0.00
2006-2010	9217	709752	77	3066	60	18159	4.32	0.08	25.59	16.88	0.33
(+)/(-) by (%)	-16.65	46.32	75.55	161.41	0	41.56	78.65	0	-3.25	84.66	0

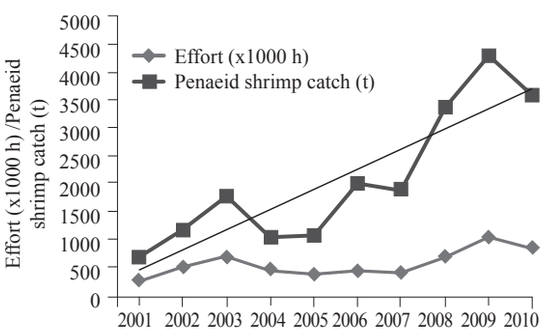

Fig. 1. Trends in effort and penaeid shrimp catch of small trawlers based at Visakhapatnam Fishing Harbour during 2001-2010

The annual cph of total fish landings ranged from 19.97 to 33.14 kg h^{-1}, the average being 25.93 kg h^{-1}. During 1981-1984, cph of total fish landings by small mechanised trawlers was 25.5 kg and during 1985-89 it was 23.1 kg (Rao, 1993). The cph for total fish landings was 26.45 kg and 25.59 kg during spell 1 and spell 2 respectively, slightly higher than catch rates reported during eighties.

Monthwise cph (kg) and percentage of penaeid shrimps in total landings for the period 2001-2010 is given in Fig. 2. The study revealed that immediately after the fishing ban (45-60 days), the cph and percentage of penaeid shrimps increased during June, July and August each year except in 2008 when low cph and percentage of penaeid shrimps was recorded, indicating that the fishing ban was not effective in recouping the resource. But stakeholders perception was that poor catch of the penaeid shrimps, inspite of trawl ban was due to low rainfall.

Comparison between two spells

Total number of units operated decreased from spell 1 to spell 2 by 16.65% and effort in terms of hours increased by 46.32 %. The number of fishing hours per trip increased by 75.55% from 44 to 75 h, indicating increase in fishing days from 3 to 6 days during spell 2. Increase in the landings, cph and percentage of total penaeid shrimps in total fish landings was recorded as 75.55, 78.65 and 84.66%, respectively. However, marginal decrease in cph for total fish landings was observed from spell1 to spell 2. Catch of non-penaeid shrimps was recorded during spell 2, due to extension of fishing operations to river mouth areas, up to Mahanadi in the northern side and Godavari, in the southern side.

Penaeid shrimp species composition

In total, 24 species of penaeid shrimps contributed to the landings. Monthwise mean species composition by

Table 2. Monthwise species composition by weight of penaeid shrimp landings of small mechanised trawlers at Visakhapatnam Fishing Harbour during 2001-2005.

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Effort (units)	971	1111	953	588		1006	1291	1233	1119	823	1005	959	11059
Effort (h)	45190	62626	33859	22845		34408	61545	61917	48556	31951	46674	35500	485071
Total fish catch (t)	984	1209	1090	874		752	1734	1473	1303	1046	1352	1011	12828
Penaeid shrimp catch (t)	73	109	57	20		107	196	169	137	70	143	75	1155
% of penaeid shrimps in total fish catch	7.4	9.0	5.2	2.3	0.0	14.2	11.3	11.4	10.5	6.7	10.6	7.5	9.0
cph of penaeid shrimps	1.605	1.742	1.669	0.861	0.000	3.108	3.191	2.723	2.819	2.192	3.066	2.124	2.381
Species composition by wt (t)													
Metapenaeus monoceros	11.180	15.210	9.600	3.420	0.000	21.550	41.510	27.000	11.940	8.670	19.290	8.120	177.5
M. dobsoni	6.433	1.800	0.880	0.250	0.000	28.590	35.680	34.990	26.190	13.290	8.450	1.520	158.1
M. brevicornis	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.150	0.000	0.2
M. affinis	0.219	0.360	0.270	0.110	0.000	0.860	1.170	0.650	0.480	0.370	0.490	0.340	5.3
M. lysianassa	0.000	0.000	0.000	0.000	0.000	0.120	0.000	0.000	0.000	0.040	0.020	0.000	0.2
Fenneropenaeus indicus	2.926	5.600	2.890	0.630	0.000	11.390	12.090	5.340	6.910	1.690	4.450	1.200	55.1
P. monodon	1.991	2.790	1.650	0.570	0.000	3.050	9.630	2.150	1.600	1.400	3.280	1.030	29.1
F. merguiensis	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
Marsupenaeus japonicus	0.000	0.010	0.020	0.040	0.000	0.060	0.170	0.060	0.040	0.130	0.100	0.020	0.7
P. semisulcatus	1.352	0.930	1.550	0.790	0.000	2.930	3.590	1.780	1.740	1.330	1.550	1.100	18.6
Metapenaeopsis stridulans	3.534	9.370	1.760	0.820	0.000	3.700	7.610	8.670	5.020	1.380	4.830	3.260	50.0
M. barbata	12.316	18.950	8.660	2.870	0.000	3.540	7.730	1.610	17.510	6.350	19.280	14.060	112.9
M. mogiensis	1.011	6.670	1.560	0.180	0.000	4.270	0.900	9.730	0.000	0.000	0.000	0.070	24.4
Solenocera crassicornis	7.156	14.040	3.550	3.090	0.000	6.350	15.090	15.930	8.150	6.710	12.350	11.290	103.7
S. melantho	8.413	9.470	11.510	1.850	0.000	0.680	7.840	3.270	12.350	5.610	3.430	6.480	70.9
Parapenaeopsis stylifera	0.041	0.000	0.000	0.010	0.000	6.910	18.780	26.690	12.830	10.200	39.590	1.140	116.2
P. hardwickii	0.000	0.000	0.000	0.000	0.000	0.400	1.470	0.350	0.490	2.270	2.020	0.000	7.0
P. uncta	0.000	0.150	0.150	0.000	0.000	1.720	2.980	1.990	1.840	0.720	3.330	0.990	13.9
P. maxillipedo	1.620	0.930	0.970	0.010	0.000	5.930	6.240	2.420	1.770	0.260	0.030	0.010	20.2
P. coromondelica	0.000	0.000	0.000	0.000	0.000	0.370	1.490	0.230	0.050	0.000	0.000	0.020	2.2
Trachysalambria curvirostris	8.290	16.330	5.810	1.030	0.000	3.330	8.180	18.810	13.370	4.020	9.780	11.860	100.8
Megokris granulosus	2.540	1.600	1.330	0.370	0.000	0.190	0.610	0.220	0.290	1.640	6.180	2.790	17.8
M. sedili	0.307	0.670	0.580	0.190	0.000	0.340	0.610	1.400	0.270	0.170	0.600	0.220	5.4
Parapenaeus longipes	3.207	4.200	3.800	3.420	0.000	0.690	7.440	5.290	14.060	3.800	3.870	9.900	59.7
Others	0.000	0.000	0.000	0.010	0.000	0.000	5.590	0.000	0.000	0.000	0.000	0.000	5.6
Total	73	109	57	20	0	107	196	169	137	70	143	75	1155

Table 3. Monthwise species composition by weight of penaeid shrimp landings of small mechanised trawlers at Visakhapatnam Fishing Harbour during 2006-2010.

Parameters	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Effort (units)	726	678	861	659	0	621	914	1156	1303	785	776	960	9439
Effort (h)	47173	47815	40865	26179	0	41939	67708	104842	131000	66245	67287	76676	717730
Total fish catch (t)	1520	1372	1262	975	0	877	1848	2432	2928	1744	1630	2124	18713
Penaeid shrimp catch (t)	140	146	140	57	0	244	362	314	351	310	317	269	2651
% of penaeid shrimps in total fish catch	9.2	10.7	11.1	5.9	0.0	27.8	19.6	12.9	12.0	17.8	19.5	12.6	14.2
cph of penaeid shrimps	2.963	3.064	3.425	2.189	0.00	5.816	5.344	2.996	2.681	4.681	4.716	3.504	3.693
Species composition by wt (t)													
Metapenaeus monoceros	41.716	40.200	40.759	20.389	0.00	566.625	113.916	83.376	94.953	74.265	80.236	99.141	1256
M. dobsoni	3.912	0.000	0.122	5.796	0.00	86.625	56.720	51.691	54.912	47.620	47.563	9.594	365
M. brevicornis	0.000	0.000	0.063	0.000	0.00	0.000	0.000	0.174	0.675	0.908	0.000	0.035	2
M. affinis	3.512	2.718	2.911	0.552	0.00	9.736	9.650	6.442	7.647	12.778	5.628	15.325	77
M. lysianassa	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0
F. indicus	5.545	3.460	3.931	1.140	0.00	8.886	16.545	20.827	22.217	18.878	12.566	19.065	133
P. monodon	3.636	2.810	2.925	1.281	0.00	4.136	7.594	15.177	13.675	8.541	9.764	6.403	76
F. merguiensis	0.008	0.000	0.027	0.000	0.00	0.000	0.000	0.015	0.907	0.000	0.035	0.010	1
M. japonicus	0.689	0.636	1.464	0.230	0.00	1.846	2.658	2.479	1.474	2.708	2.245	3.502	20
P. semisulcatus	1.746	1.633	2.415	1.437	0.00	2.423	4.617	3.317	7.342	3.664	13.331	4.021	46
Metapenaeopsis stridulans	1.805	9.855	8.497	0.424	0.00	7.172	11.473	5.935	9.869	1.388	27.938	2.552	87
M. barbata	20.058	7.999	8.865	3.774	0.00	16.817	7.999	7.293	18.295	28.418	14.359	12.703	147
M. mogiensis	0.148	0.362	3.143	3.960	0.00	0.765	2.834	0.047	0.000	0.000	0.632	0.000	12
Solenocera crassicornis	28.852	30.898	30.156	2.236	0.00	5.622	47.026	33.536	27.903	48.281	25.858	36.987	317
S. melantho	5.371	27.810	24.688	11.673	0.00	14.465	20.443	1.472	13.438	13.000	17.965	39.223	190
Parapenaeopsis stylifera	1.336	0.162	0.878	0.000	0.00	0.449	10.807	47.570	50.268	14.601	24.938	0.616	152
P. hardwickii	0.000	0.000	0.000	0.000	0.00	0.035	3.244	1.285	8.779	7.085	0.699	0.011	21
P. uncta	0.000	0.000	0.000	0.000	0.00	2.042	13.237	14.124	1.984	1.091	4.790	0.470	38
P. maxillipedo	0.236	0.000	0.000	0.057	0.00	4.223	8.770	5.236	1.808	0.542	0.869	0.503	22
P. coromondelica	0.000	0.000	0.000	0.000	0.00	0.171	0.278	0.006	0.004	0.000	1.727	0.000	2
T. curvirostris	14.096	12.705	4.750	1.329	0.00	14.624	17.913	6.513	10.445	25.191	11.522	11.126	130
M. granulosus	2.497	3.094	2.709	0.816	0.00	2.553	3.023	7.406	2.203	0.628	5.667	0.756	31
M. sedili	0.065	0.758	1.340	0.160	0.00	0.302	0.037	0.023	0.161	0.143	1.584	0.394	5
Parapenaeus longipes	4.538	1.398	0.327	2.051	0.00	1.247	2.257	0.121	2.217	0.380	7.407	6.207	28
Others	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0
Total	140	146	140	57	0	244	361	314	351	310	317	269	2650

weight for spell 1 and spell 2 are given in Table 2 and 3 respectively. During spell 1 (2001-2005) *Metapenaeus monoceros* dominated followed by *M. dobsoni*, *Parapenaeopsis stylifera* and *Solenocera crassicornis*. Commercial species such as *M. monoceros*, *M. affinis*, *Penaeus monodon*, *Fenneropenaeus indicus*, *F. merguiensis*, *P. semisulcatus* and *Marsupenaeus japonicus* contributed 38.6%, medium size species such as *M. dobsoni* and *P. stylifera* 23.8%, and small size species like *Metapenaeopsis* spp. (16.2%), *Trachypenaeus* spp. (10.7%) *Solenocera* spp. (15.1%), *Parapenaeopsis* spp. (3.7%), and "others" together formed 37.6%.

During spell-2 catch was dominated by *M. monoceros* followed by *M. dobsoni*, *S. crassicornis* and *P. stylifera*. All seven commercial species contributed 38.7% and medium sized species 19.5%. Small sized species, *Metapenaeopsis* spp. (9.2%), *Trachypenaeus* spp. (6.3%) *Solenocera* spp. (19.2%), *Parapenaeopsis* spp. (3.1%), and others together contributed 41.8%.

It is evident from Table 4 that proportion of commercial species was more or less same between two spells, decreased for medium size species and for small size species the proportion increased during spell 2 compared to spell 1.

Catch of *Metapenaus lysianassa*, *Metapenaeopsis mogiensis*, *Megokris sedili* and *Parapenaeus longipes* decreased from spell 1 to spell 2, whereas that of the rest 20 species increased. However, the cph for the nine species *M. lysianassa*, *Metapenaeopsis barbata, M. mogiensis*, *P. stylifera*, *Parapenaeopsis maxillipedo*, *Parapenaeopsis coromandelica Trachysalambria curvirostris*, *M. sedili* and *P. longipes* decreased and for the other 15 species increased from spell 1 to spell 2 (Table, 4).

Although Muthu (1968) identified 37 species of penaeid shrimps belonging to 9 genera from the commercial landings at Visakhapatnam and Kakinada, major fishery is supported by only 10 to 12 species. Muthu *et al*. (1975) reported contribution by 12 species

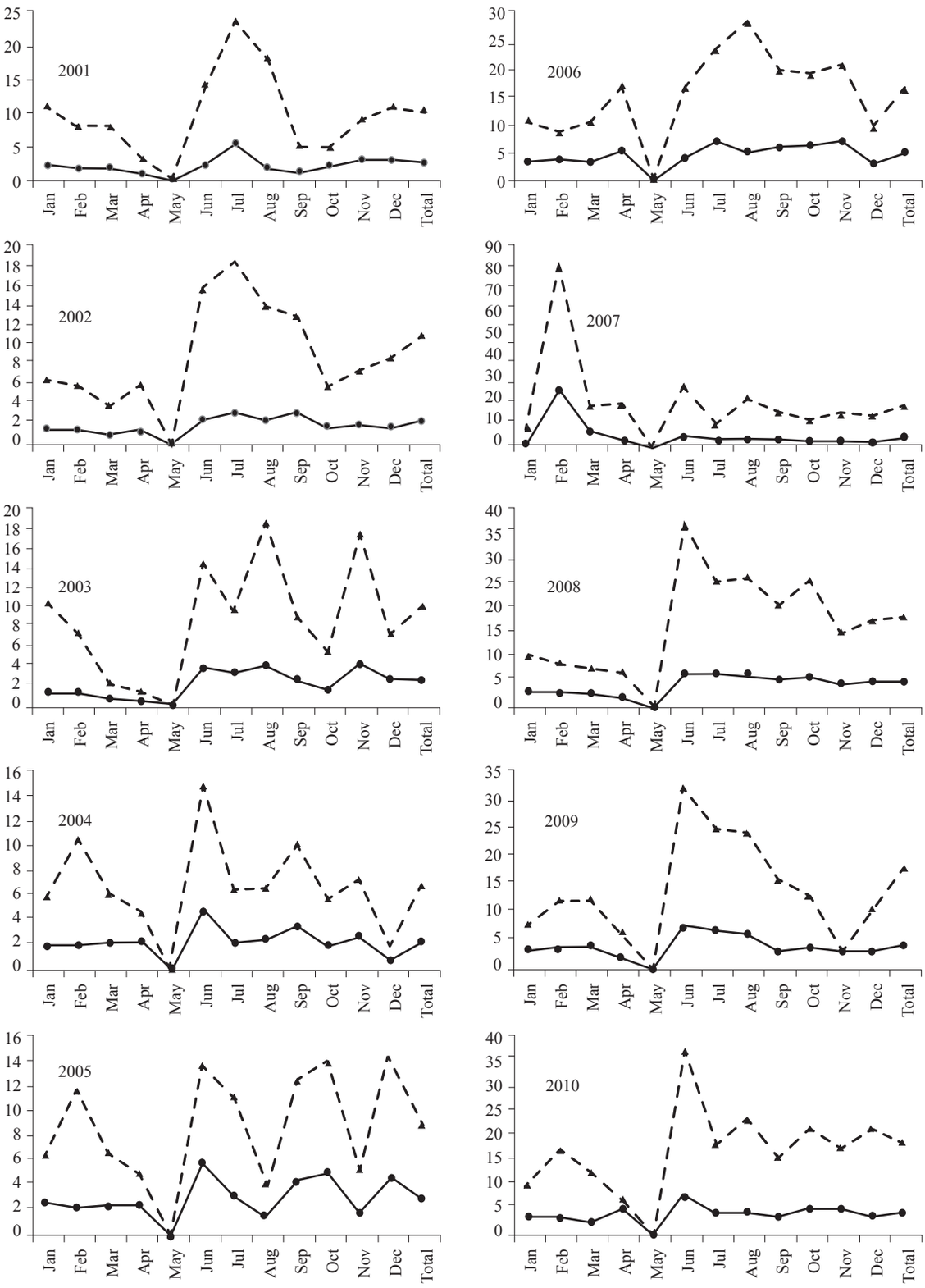

Fig. 2. Monthwise cph (kg) and % of penaeid shrimps in total fish landings by small mechanised trawlers based at Visakhapatnam Fishing Harbour during 2001-2010.

Table 4. Specieswise comparison of mean annual catch, composition and catch per hour between two spells

Species	Catch (t)			cph (kg)			Species composition (%)		
	2001-2005	2006-2010	Inrease/ decrease (%)	2001-2005	2006-2010	Inrease/ decrease by %	2001-2005	2006-2010	Inrease/ decrease (%)
M. monoceros	177.5	1255.6	607.4	0.366	1.749	378.1	15.4	28.3	83.9
M. dobsoni	158.1	364.6	130.6	0.326	0.508	55.9	13.7	13.8	0.5
M. brevicornis	0.2	1.9	1101.8	0.000	0.003	712.2	0.0	0.1	439.2
M . affinis	5.3	76.9	1344.2	0.011	0.107	876.0	0.5	2.9	530.1
M. lysianassa	0.2	0.0	-93.7	0.000	0.000	-95.8	0.0	0.0	-97.3
F. indicus	55.1	133.1	141.5	0.114	0.185	63.2	4.8	5.0	5.2
P. monodon	29.1	75.9	160.7	0.060	0.106	76.2	2.5	2.9	13.6
F. merguiensis	0.0	1.0	100.0	0.000	0.001	100.0	0.0	0.0	0.0
M. Japonicus	0.7	19.9	2925.2	0.001	0.028	1944.6	0.1	0.8	1236.4
P. semisulcatus	18.6	45.9	146.5	0.038	0.064	66.6	1.6	1.7	7.4
M. stridulans	49.9	86.9	74.0	0.103	0.121	17.6	4.3	3.3	-24.2
M. barbata	112.9	146.6	29.8	0.233	0.204	-12.2	9.8	5.5	-43.4
M. mogiensis	24.4	11.9	-51.3	0.050	0.017	-67.1	2.1	0.4	-78.8
S. crassicornis	103.7	317.4	206.1	0.214	0.442	106.8	9.0	12.0	33.4
S. melantho	70.9	189.5	167.3	0.146	0.264	80.6	6.1	7.2	16.5
P. stylifera	116.2	151.6	30.5	0.240	0.211	-11.8	10.1	5.7	-43.1
P. hardwickii	7.0	21.1	202.2	0.014	0.029	104.2	0.6	0.8	31.6
P. uncta	13.9	37.7	172.0	0.029	0.053	83.8	1.2	1.4	18.6
P. maxillipedo	20.2	22.2	10.2	0.042	0.031	-25.5	1.7	0.8	-52.0
P. coromondalica	2.1	2.2	1.7	0.004	0.003	-31.3	0.2	0.1	-55.9
T. curvirostris	100.8	130.2	29.2	0.208	0.181	-12.7	8.7	4.9	-43.7
M. granulosus	17.7	31.4	76.7	0.037	0.044	19.4	1.5	1.2	-23.1
M. sedili	5.4	5.0	-7.5	0.011	0.007	-37.5	0.5	0.2	-59.6
P. longipes	59.7	28.2	-52.8	0.123	0.039	-68.1	5.2	1.1	-79.4
Others	5.6	0.0	-100.0	0.012	0.000	-100.0	0.5	0.0	-100.0
Total	1155	2650	129.4	2.381	3.692	55.0	100.0	100.0	

of shrimps to the fishery from the Bay of Bengal, off Kakinda. But Narasimham *et al.* (1979) and Rao (1988) reported 10 penaeid species in commercial fishery from the same ground. Maheswarudu *et al.* (2014) during 1991-2002, observed that the penaeid shrimp landings along the Andhra coast was supported by 19 genera/ species. During seventies and eighties, high value commercial species were stored in ice and brought to the landing centre, and small species (low value) were mixed and dried on the deck. Subsequently due to increase in the value of small sized species, these were also stored in ice and landed, resulting in their appearance in the fishery.

Exploitation

Observed total penaeid shrimp landings, total fish landings and fishing effort for all the ten years (2001 to 2010) was used to estimate expected total penaeid shrimp landings (t) and total fish landings (t) for each year (Fig. 3 and 4) by Schaefer production model (CEDA). The r^2 values for fishing effort and penaeid shrimp landings

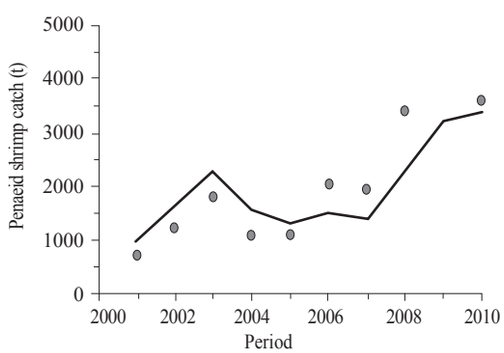

Fig. 3. Expected (thin line) and observed (O) penaeid shrimp catch (t) landed by small mechanised trawlers based at Visakhapatnam Fishing Harbour during 2001-2010.

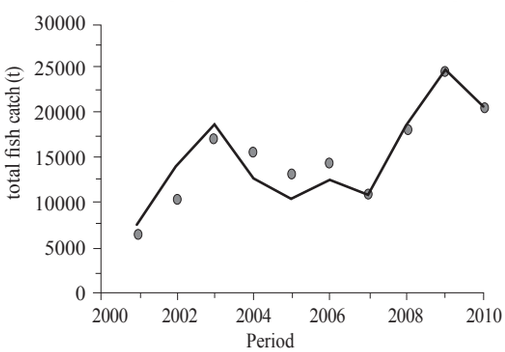

Fig. 4. Expected (thin line) and observed (O) total fish catch (t) landed by small mechanised trawlers based at Visakhapatnam Fishing Harbour during 2001-2010.

and fishing effort and total fish landings were 0.72 and 0.82, respectively. It is evident from Fig. 3. that penaeid shrimps were underexploited during the first five year period (2001-2005) and during subsequent five years it was overexploited. Total marine fish resource was found to be underexploited during initial three years (2001-2003), overexploited during subsequent three years (2004-2006) and during the last four years (2007-2010) exploitation was at optimum level. Considering exploitation of both penaeid shrimp resources and total fish resources, it is advisable that the small mechanised trawlers continue the present fishing effort to sustain the resources.

Acknowledgements

The authors express their gratitude to the Director, Central Marine Fisheries Research Institute, Kochi, Kerala, India.

References

Borisow, N. I. 1962. *Report to the Government of India on experimental and exploratory fishing in the Bay of Bengal*. Report No.7466, FAO. of the United Nations, Rome, p. I-29.

Kirkwood, G. P., Aukland, R. and Zara, S. J. 2001. *Catch Effort Data analysis (CEDA), Version 3.0*. MARG Ltd., London, UK.

Kutty, M. K., Kesavan, A. K. and Qasim, S. Z. 1973. An evaluation of the sampling design adopted by Central Marine Fisheries Research Institute for estimating marine fish production of India. *Indian J. Fish.,* 20(1): 16-34.

Luther, G., Rao, T. A., Rueben, S., Sastry, Y. A., Somaraju, M. V. and Radhakrishna, K. 1988. Marine Fish Calendar. 20. Visakhapatnam. *Mar. Fish. Infor. Serv., T& E. Ser.,* 80: 1-21.

Maheswarudu, G., Rao, G., Sudhakara, Rajamani M., Thangaraj Subramanian, V., Nair, K. R., Manmadhan, Saleela, K. N., Dhanwanthari, E., Sreeram, Miriam Paul and Unnithan, K. Asokakumaran 2014. Penaeid prawn resources along the east coast of India during 1991-2011. *Mar. Fish. Infor. Serv., T& E. Ser.,* 219: 8-14.

Muthu, M. S. 1968. On some new records of penaeid prawns from the east coast of India. *Indian J. Fish.*, 15 (1&2): 145-154.

Muthu, M. S., Narasimham, K. A., Sudhakara Rao, G., Appanna Sastry, Y. and Ramalingam, P. 1975. On the commercial trawl fisheries off Kakinada during 1967-70. *Indian J. Fish.,* 22: 171-186.

Narasimham, K. A., Sudhakara Rao, G., Appanna Sastry, Y. and Venugopalam, W. 1979. Evaluation of demersal fisheries resources off Kakinada with a note on the economics of commercial trawling. *Indian J. Fish.,* 26: 90-100.

Naumov, K. V. 1961. *A survey of the fisheries resources of the Bay of Bengal. Report No. 1393*. FAO of the U. N., Rome, p. I - 60.

Poliakov, M. P. 1961. *Interim Report to the Govt. of India on experimental and exploratory trawling in the Bay of Bengal in 1960 - 61*. FAO (Mimeo), p. 1-23.

Poliakov, M. P. *1962. Report to the Government of India on exploratory trawling in the Bay of Bengal*. FAO EPTA Report No. 1573.

Reuben, S., Rao, G. Sudhakara, Luther, G., Rao, T., Appa, Radhakrishna, K., Sastry, Y. Appanna and Radhakrishna, G. 1987. An assessment of the bottom-trawl fishery resources of the northeast coast of India. *CMFRI: Bulletin National Symposium on Research and Development in Marine Fisheries Sessions I & II*., 44 (Part -1). p. 59-77.

Rajkumar, U., Maheswarudu, G., Nasser, A. K. V., Rao, K. N., Kingsly, H. J., Varma, J. B. and Rao, M. P. 2004. Trawl fisheries off Visakhapatnam. In: Boopendranath, M. R., Mathew, P. T., Gupta, S. S., Pravin, P. and Jeeva, J. E. (Eds.), *Sustainable fisheries development: Focus on Andhra Pradesh*, Society of Fisheries Technologists (India), Cochin, p. 35-49.

Rao, G. Sudhakara. 1987. A preliminary study on the prawn fishery of big trawlers along the north-east coast of India. *Indian J. Fish*., 34: 312-328.

Rao, G. Sudhakara. 1988. Exploitation of prawn fishery resources by trawlers off Kakinada with a note on the stock assessment of commercially important species. *Indian J. Fish.,* 35: 140-155.

Rao, G. Sudhakara. 1988. Prawn fishery by the “big trawlers” along the north-east coast, *Mar. Fish. Infor. Serv. T& E. Ser.,* 87: 15-30.

Rao, G. Sudhakara. 1993. An appraisal of the marine fishery resources of Visakhapatnam coast. *Fishing Chimes,* 13: 81-87.

Rao, G. Sudhakara. 1999. Prawn fishery by the Sona boats at Visakhapatnam. *Indian J. Fish*., 46: 13-23.

Sastry, Y. A. and Chandrasekhar, M. 1986. The small commercial trawl fisheries off Visakhapatnam during 1982-83 and 1983-84. *J. Mar. Biol. Ass. India,* 28: 74-83.

Date of Receipt : 10.09.2014
Date of Acceptance : 19.12.2014