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Penaeid prawn fishery and its maximum sustainable yield at Versova, Mumbai

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ABSTRACT

Penaeid prawn fishery at Versova, Mumbai was investigated for the ten-year period of 1988 to 1997. The average annual catch during the period was 3,764 t, of which the trawlers contributed 84.9% and 15.1% by the dol nets. The major species contributing to the fishery were *Parapenaeopsis stylifera* (61.2%), *Solenocera crassicornis* (12.4%), *Metapenaeus affinis* (8.9%) and *M. brevicornis* (8.5%)'in trawlers andP. *stylifera* (51.5%),*S. crassicornis* (28.3%) andP. *hardwikii* (11.0%) in dol nets. Month wise abundance, size range, mean size, maturity and sex ratio in the two gears averaged for the period are discussed. Trawling at Versova commenced in 1986-'87 and due to encouraging returns many dol net owners also shifted over to trawling. Consequently the catch of penaeid prawns also increased from 1,363.71 in 1988 to 4,740.71 in 1996, and thereafter it declined considerably. Using Schaefer's surplus yield model, maximum sustainable yield (MSY) and the related effort (F_{MSY}) were estimated. The MSY was found to be 4,368.81 with the optimum effort of 3.75 X 10^5 hours of fishing for the dol nets and trawlers together, which corresponds to operation of 158 daily trawler trips and 38 dol net boats for the sustainable penaeid prawn fishery at Versova.

Introduction

Versova is one of the major fish landing centres of Maharashtra accounting for nearly 20% of the total fish production in the metropolis of Mumbai. The fishermen traditionally practised bag net ('dol net') fishing, in which mainly Bombay duck, anchovies and non-penaeid prawns are caught (Raje and Deshmukh, 1989). However, these resources have limited demand in the local fresh fish markets, as a result these resources are sun-dried, for which large drying yards are required. Since the available open spaces in the village are dwindling due to rapid urbanisation, and also the value realisation of the dry fish is relatively poor, the fishermen of Versova have changed over to highly valued penaeid prawn fishing. The penaeid prawns have assumed great economic importance almost everywhere in the country on account of their high price and ceaseless demand in the domestic as well as export markets.

Dol net is a stationary gear, but poorly efficient in catching penaeid prawns, the

percentage of them being only 7.9-15.9% in the total fish (Srinath *et al.,* 1984) caught by the gear. Owing to this, the fishermen embarked upon trawling in 1986-'87. As the returns from trawling were encouraging, the number of trawlers increased rapidly; some fishermen even converted their dol units into trawlers, which resulted in decline in dol net operations. Therefore, the penaeid prawn fishery that was entirely supported by the dol nets about 15 years ago was now completely dominated by the trawlers. The trawling has also brought about changes in abundance, spatial distribution and the species composition of penaeid prawns at Versova. The earlier accounts of the prawn fishery at Versova given by Kunju (1967, 1968), Sukumaran (1978), Sukumaran and Rajan (1981), and Rajan *et al.* (1982) were all of dol nets. The present investigation therefore, relates to the penaeid prawn fishery after the introduction of trawlers.

Increased trawling operations at Versova, wide fluctuations in catch and inadequate returns have made it imperative to undertake stock assessment of the penaeid prawns. Therefore, an attempt is made to find out the maximum sustainable yield (MSY) of penaeid prawns and the optimum effort (F_{MSY}) i.e. the number of dol net boats and the trawlers that can be put into operation for the sustainable prawn fishery. The stock assessment of penaeid prawns along the northwest coast of India by swept area method has been reported by Ramamurthy (1994).

Materials and methods

Catch and effort data were collected weekly on separate observation days for the dol nets and trawlers by observing 10-20% of the boats from which monthly estimates were made. Effort in trawling hours was estimated by enquiry. Since each dol net boat operated three nets and took 3-4 hauls, the net-haul combination was multiplied to estimate the total hauls. As duration of each haul varied from 24 hours, depending on the tidal force, the net-haul combination was further multiplied by a factor of 3 (average duration of a haul) to arrive at the number of fishing hours for the dol net boats.

Data on species composition, sex-wise size of prawns and maturity condition of females were noted at the landing centre from the random samples. The biological data on size and maturity were pooled on monthly basis.

Maximum sustainable yield (MSY) and the optimum effort $F_{(MSY)}$ were calculated by employing Schaefer's surplus yield model (1954), in which effort in hours of fishing and catch per hour (CPH) were regressed. Since trawl is an efficient gear for catching the penaeid prawns, and dol net is a stationary gear, in which they are caught as only by-catch, the dol net effort was standardised in relation to trawl effort by using the following expression:

$$\text{Standard effort of dol net in trawler units} = \frac{\text{CPH for dol net}}{\text{CPH for trawl}} \times \text{effort for dol net.}$$

The trawler effort and the standardised dol net effort and the catches from the respective gears were pooled together to get the catch per unit effort (CPUE) for the estimation of MSY and $F_{(Msy)}$ for the total penaeid prawns.

Fishing operations

The operation of dol nets at Versova has been described by Raje and Deshmukh (1989). However, since the advent of trawling the number of dol netters have been considerably reduced from 175 in 1984-'85 to mere 45 in 1997. For dol net fishing, a group of 3-4 boats set their nets at 18-30 m depth in north western direction off Versova, about 12-25 km from the shore.

Each dol netter generally operates 3 nets and after taking 3-4 hauls the catch of the entire group is brought ashore every day by one of the boats in the group. This practice not only saves the fuel but also offers more fishing time for the boats.

The dol net fishing commences in late September or early October and lasts till early June. The fishing is totally suspended during June-September on account of inclement weather conditions in monsoon.

Although trawling in Maharashtra started in early 1960, the Versova fishermen took to it only in 1986-'87. The trawling began with 8 trawlers, but their number increased rapidly to 170 in 1997. Initially each trawler made daily trips, leaving the Versova creek early morning and returning late afternoon, the time spent in actual fishing being 6-8 hours. This practice soon changed and from 1991-'92 onwards they undertook overnight fishing, returning on alternate days only. Later on, some trawlers returned only after 2-3 days of fishing, and by 1997 majority undertook such voyage fishing trips. At the same time a few small dol net boats were converted into trawlers but they were without any mechanical winch, the net being hauled manually, hence they are called hand trawlers. These hand trawlers operated in very shallow waters of 5-10 m depth and always undertook daily fishing. The regular trawlers generally operated in 15-40 m depth, parallel to the coastline from Vasai in the north to Murud-Janjeera in the south.

The fishing season for the trawlers commences after heavy monsoon, in late August and lasts till late May or early June. A few of them also go for fishing in monsoon during fair weather periods.

Trends in prawn landings

The average annual landing of penaeid prawns at Versova during the ten-year period was 3,7641 of which 3194.81 (84.9%) was contributed by the trawlers and 569.2

TABLE 1. *Estimated catch (in tonnes), effort, catch per hour (in kg) and percentage of penaeid prawns at Versova landed by the trawlers during 1988-'97*

Year	No. of trawlers	Trawling hours	Penaeid prawn catch	Total fish catch	% penaeid prawns	Catch/hour
1988	10454	91459	1363.7	5313.2	25.7	14.91
1989	16810	147366	2792.8	8551.3	32.7	18.95
1990	17948	152897	2678.7	8843.7	30.3	17.52
1991	15855	163791	3996.5	11617.2	34.4	24.40
1992	16204	237163	4104.7	9600.9	42.8	17.31
1993	16816	270738	2669.3	8408.8	31.7	9.86
1994	17113	287268	3868.4	12773.3	30.3	13.47
1995	14014	256866	3034.5	11196.2	27.1	11.81
1996	14640	275105	4740.6	12192.4	38.9	17.23
1997	21533	306349	2698.9	10321.1	26.1	8.81
Average	16139	199000	3194.8	9881.8	32.3	16.05

t (15.1%) by the dol nets.

Trawler landings: The estimated annual landings of penaeid prawns from trawlers during the years 1988-'97 are presented in Table 1. In the period, the catch increased from 1363.7 t in 1988 to 4740.6 t in 1996 with the annual average of 3194.81. The penaeid prawns contributed on an average 32.3% to the total fish landed by the trawlers, with the lowest of 25.7% in 1988 and the highest of 42.7% in 1992. Although, due to rising number of trawlers the annual effort in boat-trips increased from 10,454 in 1988 to 17,948 in 1990, it declined in subsequent years as some of the fishermen gave up daily fishing and undertook overnight fishing. The number of boat trips however, increased to 21,533 in 1997 on account of introduction of hand trawling and also due to overall increase in the number of trawlers. The actual fishing hours showed an increasing trend from 91,459 in 1988 to 306,349 in 1997. Correspondingly, the annual catch rate

TABLE 2. *Monthwise catch in tonnes and C.P.U.E. in hrslkg (in parenthesis) of penaeid prawns landed at Versova by trawlers during 1988-'97*

Years/ Months	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Total
January	133.79	81.80	335.47	343.72	302.91	160.63	500.76	254.07	514.04	386.80	3013.97
	(19.44)	(9.59)	(33.05)	(20.36)	(12.33)	(5.39)	(13.47)	(7.96)	(18.03)	(12.03)	(13.30)
February	53.95	16821	67.07	181.55	16534	182.77	531.90	123.76	27622	263.30	2014.67
	(7.64)	(16.09)	(4.79)	(12.98)	(8.14)	(6.84)	(17.43)	(4.64)	(8.65)	(8.32)	(9.44)
March	56.33	327.84	71.13	165.04	12928	163.77	34106	26.74	26622	16850	1716.80
	(8.19)	(17.96)	(4.74)	(11.60)	(6.05)	(6.91)	(11.60)	(1.22)	(8.01)	(7.95)	(8.36)
April	60.77	181.11	334.11	147.06	170.01	160.65	405.61	43629	195.73	175.76	2267.09
	(8.03)	(10.94)	(17.74)	(10.09)	(6.39)	(5.58)	(13.09)	(10.74)	(6.54)	(5.70)	(9.24)
May	49.90	182.08	217.45	19526	155.85	198.63	175.77	75.32	206.19	311.00	1767.45
	(4.99)	(8.86)	(11.61)	(11.17)	(4.92)	(6.95)	(4.55)	(3.84)	(5.95)	(9.61)	(7.00)
June	35.63	37.45	43.15	31.42	46.86	27.35	14.84	30.66	38.31	149.42	455.09
	(7.81)	(4.93)	(8.26)	(11.75)	(6.47)	(5.27)	(1.95)	(11.68)	(5.91)	(15.57)	(7.74)
July	0.00	0.00	0	1.46	3.85	2.98	0	0	0	0	829
	0.00	0.00	0.00	(13.52)	(3.22)	(11.07)	0.00	0.00	0.00	0.00	(5.28)
August	45.09	38.64	23.56	62.44	61.22	103.43	68.93	825	0.00	80.76	492.31
	(10.54)	(24.64)	(7.03)	(24.31)	(9.35)	(11.34)	(12.18)	(8.43)	0.00	(16.31)	(12.62)
September	95.51	90.92	116.87	465.04	27323	369.03	39.83	207.08	1537.11	252.31	3446.93
	(26.71)	(20.14)	(10.25)	(40.44)	(12.79)	(26.53)	(2.96)	(14.09)	(59.06)	(10.60)	(23.90)
October	400.03	731.12	667.05	853.01	717.69	38325	51951	447.49	46191	393.72	5575.07
	(27.14)	(37.80)	(34.48)	(43.24)	(24.80)	(18.32)	(18.50)	(14.85)	(17.91)	(9.60)	(22.47)
November	122.15	664.56	535.16	1130.65	1069.79	168.49	661.11	607.86	736.04	344.17	6039.98
	(10.10)	(34.61)	(28.18)	(55.56)	(51.99)	(7.42)	(19.71)	(18.12)	(26.50)	(8.89)	(24.40)
December	310.56	289.11	267.65	41951	1008.16	748.36	.60750	81698	508.80	173.16	5150.58
	(22.48)	(13.90)	(14.99)	(14.15)	(37.75)	(26.82)	(18.95)	(23.98)	(16.54)	(4.32)	(18.81)
Total	1363.70	2792.84	2678.68	3996.54	4104.78	2669.33	3868.41	3034.48	4740.57	2698.89	3194821
	(14.91)	(18.95)	(17.52)	(24.40)	(17.31)	(9.86)	(13.4V)	(11.81)	(17.23)	(8.81)	(14.60)

showed declining trend from 24.40 kg/hr in 1991 to 8.81 kg/hr in 1997. The average catch rate during the 10-year period was 14.60 kg/hr.

Month-wise prawn landings from the trawlers during the ten-year period are presented in Table 2. It is seen that the maximum monthly catch of 1537.11 was recorded in September 1996 with a catch rate of 59.06 kg/hr while the minimum (1.461) was noticed in July 1991, but the lowest catch rate was observed in March 1995 (1.22 kg/hr). It was observed that almost every year the catch exhibited a single peak in October-December period, which accounted for 52.5% of the average annual prawn landings. The corresponding catch rate during the peak period was 21.79 kg/hr, which was almost double of that seen during the rest of the year (10.95 kg/hr).

Dol net: The estimated catch and effort for the dol nets during 10-year period is presented in Table 3. It is seen that the estimated number of boat-trips of dol netters showed a declining trend from 18,166 in 1988 to 6,478 in 1996. This decline was mainly due to shifting over from dol net fishing to trawling by the fishermen of Versova. An increase in boat-trips in 1991 and 1992 may be attributed to temporary discontinuation of carrier boat practice followed by these fishermen. The effort in fishing hours however, showed a clear declining trend from 1990 to 1997. During the 10-year period the average annual catch of penaeid prawns was 569.2 t, which fluctuated widely from 1370.5 t in 1991 to 194.11 in 1995. Similarly, the average percentage contribution of the prawns to total fish landed by the dol nets was 7.8%, which varied from 16.2% in 1992 to 3.9% in 1988. The catch rates also varied from 2.98 kg/hr in 1991 to 0.757 kg/hr in 1994. Although effort showed a declining trend, the corresponding increase in CPH was not observed. This could be due to the fact that increasing number of trawlers was simultaneously operating in the same fishing grounds.

TABLE3. *Estimated catch (in tonnes), effort, C.P.U.E. (kg/hr) and percentage of penaeid prawns in dol nets at Versova during 1988-'97*

Year	No.of dol nets	Fishing hours	Penaeid prawn catch	Total fish catch	% penaeid prawns	Catch/hour
1988	18166	432189	332.3	8445.5	3.9	0.77
1989	16658	401220	569.8	14238.6	4.0	1.42
1990	14992	665715	851.1	9657.5	8.8	1.28
1991	19859	459951	1370.5	10788.4	12.7	2.98
1992	16403	458583	1253.6	7727.8	16.2	2.73
1993	14228	435183	369.8	6598.9	5.6	0.85
1994	12123	369255	279.5	4889.9	5.7	0.76
1995	7113	217323	194.1	3095.5	6.3	0.89
1996	6478	206910	263.6	3666.1	7.2	1.27
1997	7805	226980	208	4051.7	5.1	0.92
Average	13383	387331	569.2	7316.0	7.8	1.47

Month-wise estimated catch and catch rates for the period in dol nets are given in Table 4. It is seen that in dol nets too, the penaeid prawns showed the peak landings during October to December which accounted for nearly two third of the annual landings. The maximum monthly catch of 882.9 t was noticed in October 1992 and minimum of 0.23 t in September 1991. Similarly, the highest and the lowest catch rates were observed in September 1996(33.19 kg/hr) and March 1997(0.11 kg/hr) respectively.

Species composition

Kunju (1967) recorded 19 species of penaeid prawns from Maharashtra, to which Kagwade (1975) added one and Aravindakshan and Karbhari (1985) added two species. Out of these 22 species only

TABLE 4. *Monthwise catch in tonnes and CPH in kg (in parenthesis) of penaeid prawns landed at Versova by dol nets during 1988-'97*

Years/ Months	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Total
January	40.05	70.00	187.26	160.82	35.31	35.85	39.62	12.59	37.87	20.44	639.81
	(0.86)	(2.52)	(4.18)	(2.82)	(0.71)	(0.72)	(0.87)	(0.49)	(0.95)	(0.77)	(1.55)
February	15.10	60.05	37.81	63.05	37.70	42.05	45.23	15.34	28.25	17.33	361.89
	(0.41)	(1.27)	(1.00)	(1.17)	(0.76)	(0.74)	(0.76)	(0.33)	(1.00)	(0.67)	(0.82)
March	2.53	108.80	19.19	40.21	28.35	24.24	24.93	7.17	15.21	2.36	272.97
	(0.17)	(2.20)	(0.06)	(0.88)	(0.53)	(0.35)	(0.43)	(0.38)	(0.85)	(0.11)	(0.40)
April	14.18	82.84	30.72	52.32	34.20	27.83	31.39	16.49	17.45	10.14	317.54
	(0.20)	(0.99)	(0.69)	(0.65)	(0.46)	(0.42)	(0.49)	(0.50)	(0.52)	(0.37)	(0.55)
May	23.57	34.69	0.90	32.93	30.16	45.90	32.29	11.33	17.50	10.69	239.96
	(0.30)	(0.49)	(0.01)	(0.40)	(0.46)	(0.74)	(0.49)	(0.38)	(0.47)	(0.29)	(0.40)
June	2.72	9.80	0.00	4.74	4.22	1.88	4.79	1.79	6.88	5.49	42.29
	(0.21)	(0.81)	0.00	(1.59)	(0.41)	(0.15)	(0.45)	(0.30)	(0.90)	(0.52)	(0.49)
July	0.00	0.00	N	0.00	0.00	F	I	S	H	I	N G
August	0.00	0.00	N	0.00	0.00	F	I	S	H	I	N G
September	0.00	0.00	16.04	0.00	1.89	0.23	0.00	12.97	17.92	0.00	49.05
			(1.92)	0.00	(2.48)	(0.41)	0.00	(5.06)	(33.19)	0.00	(3.84)
October	96.11	41.12	178.08	246.51	882.86	18.61	19.55	63.29	77.41	50.80	1674.34
	(1.63)	(1.30)	(6.08)	(5.42)	(19.13)	(1.52)	(1.03)	(3.51)	(7.64)	(1.96)	(5.64)
November	96.73	146.79	238.62	439.68	118.20	86.68	69.41	15.78	22.98	59.74	1294.60
	(1.51)	(4.45)	(5.18)	(9.50)	(2.35)	1.74)	(3.34)	(0.92)	(1.68)	(2.12)	(3.51)
December	41.28	15.76	142.51	330.26	80.69	86.55	12.35	37.35	22.16	31.02	799.93
	(0.90)	(0.34)	(2.41)	(7.20)	(1.38)	(1.53)	(0.46)	(1.85)	(1.22)	(1.34)	(1.99)
Total	33236	56984	851.11	1370.51	1253.51	369.81	279.55	194.09	263.62	20802	5692.39
	(0.77)	(1.42)	(1.28)	(2.98)	(2.73)	(0.85)	(0.76)	(0.89)	(1.27)	(0.92)	(1.47)

ten species, namely *Penaeus merguiensis, P. penicillatus, Metapenaeus affinis, M monoceros, M.brevicornis, Parapenaeopsis stylifera, P. hardwickii, P. sculptilis, Solenocera crassicornis and Metapenaeopsis stridulans* occurred in commercial quantities. Other species such as *Penaeus monodon, Metapenaeus kutchensis, Parapenaeopsis cornutus, Parapenaeus longipes, Trachypenaeus curvirostris* and *Atypopenaeus compressipes* were landed as stray specimens and therefore, grouped as 'other penaeids'.

The trawl fishery was mainly supported by *P. stylifera, S. crassicornis, M. affinis, M. brevicornis, Metapenaeopsis stridulans, P. hardwickii, Penaeus* spp., *P. sculptilis,* and M. *monoceros* and their percentages in pooled annual catch during the 10-year period were 61.2%, 12.4%, 8.9%, 8.5%, 4.1%, 2.8%, 0.6%, 0.6%, and 0.5% respectively. The 'other penaeid'constituted only 0.4% in trawl catches. Similarly, the dol net fishery was largely supported by *P. stylifera* (51.5%), S. *crassicornis* (28.3%), *P. hardwickii* (11.0%), *M. affinis* (5.2%), *M. brevicornis* (1.3%), P. *sculptilis* (1.3), and *M. stridulans* (1.1%). The 'other penaeids' including *Penaeus* spp. contributed 0.5% to the total penaeid prawn catch of the dol nets.

Month-wise percentage composition of the prawns pooled for the period is shown in Fig. 1 for the trawlers and dol nets separately and described for the important species in the foregoing accounts.

Biological considerations

Biological data on the sex-wise size range and mean size, maturity distribution of females and sex-ratio for the four most

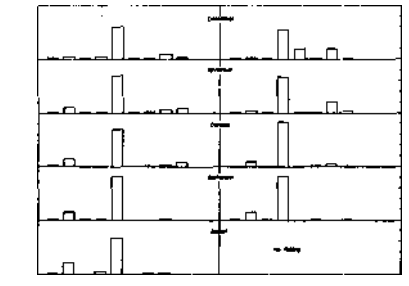

Fig. 1.Month-wise species composition of penaeid prawns in trawl and dol net.

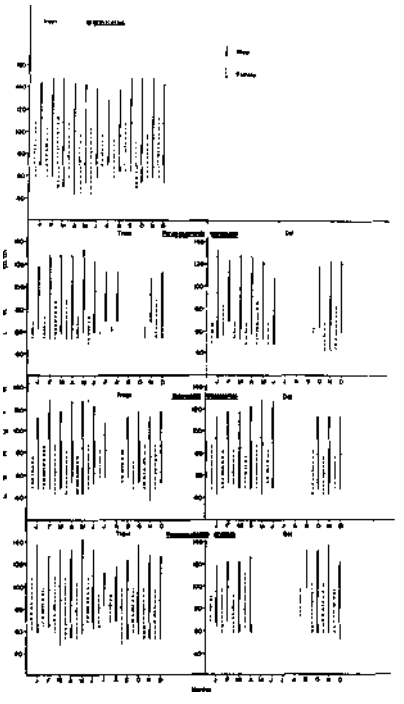

Fig.2 Sex-wise size range and mean size of important penaeid prawns in trawl and dol net

important species *viz. P. stylifera, crassicornis, P. hardwikii and M. brevicornis* were pooled and averaged month-wise for the 10-year period and presented in Figs. 2 and 3 respectively.

***P.* stylifera:** With the average annual landings of 1955.21 in trawl and 293.11 in dol nets, it was the most dominant species in both the gears. It constituted 61.2% in the former and 51.5% in the latter gear. Month-wise percentage composition (Fig. 1) shows that the species dominated the penaeid prawn catch in trawl in almost all the months except in April. The percentage was maximum in September (81.6%) and minimum in April (31.8%). The percentage in trawl remained as high as 70% throughout the post-monsoon period of September-December. In dol nets too, the highest percentage of the species was

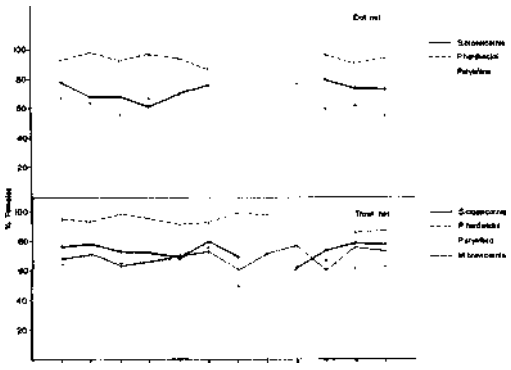

Fig.3 Sex-ratio of important penaeid prawn in trawl and dol net.

observed in September and October (83.9%), which declined to 55.4% in December and further to the lowest of 3.9% in April. Kunju (1967) and Rajan *et al.* (1982) also reported that the species constituted as high as 79% and 86.5% respectively in September-November period in dol nets at Versova.

The size of the species in trawl (Fig. 2) ranged from 48 mm to 108 mm for the males and 53 mm to 143 mm for the females, but generally sizes between 83 mm to 113 mm formed the mainstay of the fishery. Similarly, in dol nets the size ranges were 58 mm to 113 mm and 53 mm 138 mm for the males and females respectively, and the size range 83-108 mm formed the mainstay of the fishery. Mature and ripe females occurred in almost all the months but their percentage was higher in May (59.3%) and June (58.2%) in trawl and April-May (39.5%) in dol indicating peak breeding in pre-monsoon period. The females dominated the sex ratio in trawl as well as in dol in all the months except in July (Fig. 3).

S. crassicornis: With average annual catch of 396.21 in trawl and 161.11 in dol nets, the species contributed 12.4% and 28.3% to the total penaeid prawn landings in the two gears respectively. The species showed its abundance with better catches during March-May in trawl and February-June in dol nets.

The size of males and females ranged from 43 mm to 88 mm and 43 mm to 128 mm in trawl and 43 mm to 83 mm and 43-118 mm in dol nets respectively, but the sizes between 78 mm to 108 mm formed the mainstay of the fishery. The mature and ripe females occurred in greater percentage during July (57.6%) and December-January (61.3%) in trawl and in October (52.4%) and December-January (53.2%) in dol nets. The sex ratio showed disproportionate distribution in favour of females in all the months in both trawl (1:3) as well as dol nets (1:2.5).

P. hardwickii: Although with 90.4 t of average annual catch the species formed only 2.83% in trawl, it contributed 11% to the penaeid prawn catch of the dol nets. The catch of the species was better during March-May in trawl and in December-May in dol nets.

The pooled monthly size distribution (Fig. 2) showed that it ranged from 43-88

mm for the males and 48 mm to 133 mm for the females in trawl while the same was 48 mm to 88 mm and 53 mm to 133mm in dol nets for the two sexes respectively. Females in ripe and mature condition were maximal in January (65.7%) in trawl and January-February (70.1%) in dol nets indicating its peak breeding period. The sex ratio was highly disproportionate with very poor representation of males in both trawl (1:13.7) as well as dol (1:15.4).

*M. **brevicornis:*** The species occurred in good quantities almost throughout the year in trawl with average annual catch of 272.8 t contributing 8.5% to the penaeid landings. In dol nets however, the annual catch was only 6.31 with poor contribution of only 1.1%. In trawl, the catches were better during December-May but in dol nets they were mostly seen only during January.

In trawl, the size of *M. brevicornis* ranged from 43 mm to 108 mm for the males and 43 mm to 148 mm for the females, but the sizes between 83 mm to 123 mm formed the mainstay of the fishery. The mature and ripe females were more in December (40.4%), February (36.7%) and July (33.7%). The sex ratio showed dominance of females in all the months.

Among the remaining species of prawns, *M. affinis* occurred *in* good quantities during September-November and in April in trawlers but in dol nets it was found in limited quantity with better landings during October-November only. *M. monoceros* was caught only in trawls with notable catch during January-February; its contribution being 0.5%. The catch of *Metapenaeopsis stridulans* constituted 4.1% in trawl and 1.1% in dol nets. Although *M. stridulans* occurred during September-April in trawl, the catches were better during November-December. In dol nets the species occurred during October-December only, with peak in November. *Parapenaeopsis sculptilis* was found in both the gears almost throughout the year but the catches were better during January-February. The catch *ofPenaeus* spp., was mostly constituted by *P. merguensis* in both the gears. In trawl the 'other penaeids' were mainly *T. curvirostris* during December-February and *P. longipes* in March-May while in dol nets the catch was contributed by *Atypopenaeus compressipes.*

MSY and the related effort

The surplus yield model fitted to the trawler data (Table 1) using trawling hours as effort and the CPH (in kg/h) for the 10 year period is shown in Fig.4. It is seen that the coefficient of regression, 'b' is -0.0000374 and the constant, a =23.615 with fairly good correlation coefficient (r = -0.59). From these values the MSY was found to be 3,726.71 and the effort required to fish this catch (F_{MSY}) was 3,15,624 trawling hours.

In contrast to the trawl data, when the same model was employed for the dol nets using the actual fishing hours and the CPH, the required assumption of the model *i.e.* decline in CPH with increasing effort, was not met with. The parameters of the regression analysis were a=0.6987, b= +0.00000178 and r = +0.31, as a result estimations of MSY and the optimum effort (F_{MSY}) were not possible.

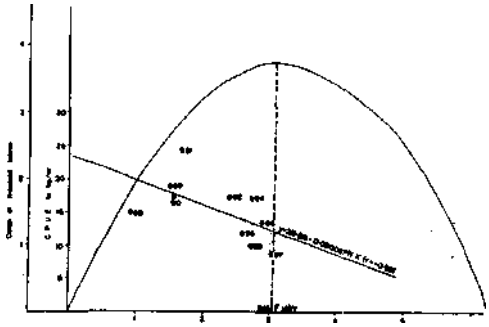

Fig.4. Relation between effort, catch and catch per unit effort of trawlers.

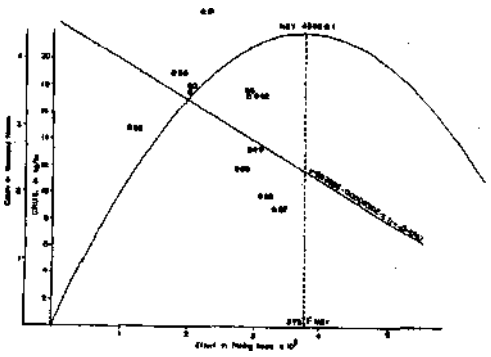

Fig.5. Relation between combined effort, catch and catch per unit effort of trawlers and dol nets

Estimation of MSY and the optimum effort (F_{MSY}) for the two gears by simply combining the catch and effort together was not appropriate. This is so because trawl is a mobile gear catching the penaeid prawns very efficiently, whereas dol net is a stationary gear, and actually not targeted for the penaeid prawns but Bombay duck and non-penaeid prawns. On account of this problem the dol net effort was standardised in relation to trawl effort and pooled with the trawl effort to get the combined estimates of MSY and the related effort (F_{MSY}). Table 5 shows the pooled effort and the CPH for the two gears and Fig. 5 exhibits the parabolic curve of the Schaefer's model. The parameters of the regression analysis were, a = 23.2826, b= -0.000031 and r -0.474. The MSY and the optimum effort (F_{Msy}) were 4368.8 t and 3,75,284 hours respectively. Subtracting the MSY for trawlers from the combined MSY gave the MSY for dol nets and similar procedure when followed for the effort gave the optimum standard effort for the dol nets, which were 642.11 and 59,660 hours respectively. Conversion of the standard effort gave the actual fishing effort of 2,76,529 hrs for the dol nets.

TABLE 5. *Estimated standard effort (in tonnes) for dol nets pooled effort (in hours) and catch (in tonnes) for the two gears and C.P. U.E. in (kglhr) at Versova during 1988-'97*

Year	Standard effort of dol nets in trawler units in hours	Pooled effort for dol and trawl	Pooled catch for dol and trawl	C.P.U.E.
1988	22281	113750	1696.0	14.91
1989	30063	177429	3362.6	18.95
1990	48563	201460	3529.8	17.52
1991	56174	219965	5367.0	24.40
1992	72439	309602	5358.3	17.31
1993	37520	308258	3039.1	9.86
1994	20758	308026	4147.9	13.47
1995	16428	273294	3228.6	11.81
1996	15297	290402	5004.2	17.23
1997	23600	329949	2906.9	8.81
Average	34313	253214	3764.0	14.86

From the F_{MSY} of 315, 624 for the trawlers, the actual number of boats required to fish the MSY of 3726.7 t of penaeid prawns was calculated. Considering 60 days of closed season during monsoon (as imposed by the Government of Maharashtra), 30 days for the repairs and maintenance and 8-10 days of closure on account of bad weather and holidays for the crew etc., the number of fishing days in a year works out to 250 for each boat. If a single day trawler undertakes 8 hours of actual fishing, then the annual fishing hours are 2000 and the total number of trawler works out to 158. However, if they undertake three day of fishing, as practised recently, then their number should be restricted to 53 only. Similarly, for the dol nets with average three hours of a haul and 10 hauls per boat would work out 9,218 boat trips per year and with 240 days of fishing the number of dol net boats would be only 38.

Thus, sustainable fishing activity at Versova with MSY of 4368.8 t can be achieved with 158 single day trawlers and 38 dol net boats. This implies that the number of trawlers should be reduced by 11% and the dol nets by 18% of those operated in 1997.

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