STUDIES ON PRAWN GILL NETS OF THE KERALA COAST

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DOCTOR OF PHILOSOPHY

BY

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CERTIFICATE

This is to certify that this thesis entitled "Studies on Prawn Gill Nets of The Kerala Coast" is an authentic record of the research work carried out by Shri. V.C.George, in the Central Institute of Fisheries Technology, Cochin under my supervision in partial fulfilment of the requiremen for the Degree of Doctor of Philosophy of the Cochin University of Science and Technology, and that no part thereof has been presented before for any other degree.

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DECLARATION

I hereby declare that the thesis entitled "Studies on Prawn Gill Nets of the Kerala Coast" is an authentic record of research work carried out by me under the supervision and guidance of Dr. C.T.Samuel, Professor (Retd.), Department of Industrial Fisheries, Cochin University of Science and Technology, in partial fulfilment of the requirements of the Ph.D. Degree in the Faculty of Marine Sciences and that no part of it has previously formed the basis of the award of any degree, diploma or associateship in any University.

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INTRODUCTION

In recent years crustaceans as a food item of mankind has gained considerable importance. The mainstay of Indian fishing industry in economic terms is the penaeid prawn fishery and it forms a major component of the marine products exports from India (Anon 1985). Since substantial increase in global shrimp production could not be achieved (Gulland and Rothschild 1984) ways and means are being devised for increasing production through improved fishing techniques.

Scientific interest in fishing techniques all over the world seems to have taken place by the end of last centuary (Brandt 1984). Absence of efficient fishing techniques for exploitation of demersal fisheries along the Madras Presidency has been reported by Hornell (1938).

Trawling in Indian waters commenced by 1908 (Sheshappa 1958). Encouraging results with shrimp trawling In India (Kristjonsson 1968) paved the way for extensive application of this fishing method (Kuriyan et al. 1965, Varghese et al. 1968, Panicker et al. 1977, 1978 a,b and Rao 1988). Trawling from traditional canoes has been practiced along Indian coast (Hameed et al. 1988, Vijayan et al. 1990).

Existence of a gill net exclusively for prawn has been reported by George and Brandt (1975). Shrimp trawling being highly fuel intensive (Endal 1980), the hike in fuel prices demanded the search for alternate fishing techniques. Gill nets have been preferred and chosen as an alternate method due to lesser consumption of fuel and low capital investment. Hence it is a highly adaptable technique to developing countries (Anon 1982d,1984b). Thus a lucrative prawn gill net fishery got established in the traditional fisheries sector of India (Anon 1978, Menon 1980, George and Suseelan 1980, Kathirvel et al. 1985).

Use of apt fishing gear materials having least diameter, but without reduction in strength, lesser visibility, softness and desired elasticity and knot strength increases the efficiency of gill nets (Anon 1957, Treshchev 1963, Zaucha 1964, Tran-Van-Tri and Ha-Khao-Chu 1964, Steinberg 1964, Klust 1973). Since all these properties are not met with in a single material, selection of suitable material in a constant endeavour in each fishery, especially with the introduction of newer fishing gear materials.

The highly selective nature of gill nets by virtue of the uniform mesh size is applied in the estimation of fish population (Hamley 1975) and also for arriving at standard mesh sizes for different species (Baranov 1914).

The mesh shape and slackness of netting are dependent on the coefficient of hanging (Brandt 1984). Decrease in coefficient of hanging reduces the selective power of gill nets (Riedel 1963).

Colour serves as a camouflage, attractant or deterrant to cause variation in catch (Jester et al. 1970) and this property is used to increase the out put of gill nets by dyeing them suitably to the preferred colour (Kunjipalu et al. 1984).

Fishing height of gill nets are also dependent on the intensity of tidal current and affects its performance (Stewart and Ferro 1985, Stewart 1988).

In the present study, extensive investigations were carried out on various factors affecting the selectivity of prawn gill nets with reference to material, mesh size, coefficient of hanging &colouration. Effect of tidal current on fishing height of prawn gill net and seasonal variation of catch during the course of these investigations were also studied.

CHAPTER 1. CRUSTACEAN FISHERY RESOURCES

1. CRUSTACEAN FISHERY RESOURCES

1.1 WORLD DISTRIBUTION OF PRAWNS AND THEIR REGIONAL PRODUCTION

Of the 24,84,005 tonnes of prawns produced during 1988 (Anon 1990a) only 4.16% are contributed by the inland waters and the remaining quantity is from the sea. When considering the quantitative and qualitative distribution of the marine species, regional concentrations are noticed. The higher latitudes of North and South hemisphere comprising Atlantic Northwest, Atlantic Northeast, Pacific Northeast and Pacific Northwest in the North, Southern parts of Eastern Indian Ocean, Pacific Southeast, Pacific Southwest, Atlantic Southwest and Atlantic Southeast in the South, lands approximately 10.65% of the marine prawns. However, 84.73% is produced from the tropical and subtropical zones (Anon 1977a). Incidence of heavy tropical rains coupled with river effluents and extensive coastal lagoon systems render these tropical areas very productive zones for prawns.

Further, definite differences are noticed in the species composition of these two areas (Gulland 1971, Mistakidas 1969, Ivanov 1964). Prawn resources of the higher latitudes both in the Pacific and Atlantic are dominated by Northern prawns, Pandalids, *Pandalus borealis*, Pink Pandalid prawn of Atlantic Northwest and Northeast. The Pacific shrimp *Pandalus* sp. and

Parapandalopis spp. of the Pacific Northeast also belong to this category. Further, these Pandalids occur both in deep and shallow waters in the higher latitudes. However, they exhibit submergence towards low latitudes and tropics both in Pacific and Indian ocean, where they occur in the continental slopes with benthic penaeids.

The penaeid prawns are confined to the low latitudes and mainly occur in the shelf waters. With reference to their life history, there are three types (i) those which spent part of their life in brackish waters like *Penaeus indicus* of Indo-Pacific region (ii) certain species on the arid zones like Red sea that have no chance to enter the lagoons (iii) species which need not enter the estuary like *P. latisulacatus* of Northern Australia, *Parapenaeopsis atlantica* and *Xiphopenaeus kroyeri* of Tropical Atlantic.

1.2 ZONAL DISTRIBUTION OF PRAWNS

1.2.1 Atlantic, Northwest (Fishing area No.21)

The classification of zones followed in Fig.1.1 as well as the landing figures for each zone in Table1.1 is as given in FAO (Anon 1990a). Prawns of this region are mainly cold water Pandalid, *Pandalus borealis*. A gradual increase in landing from 1982 onwards is noticed and the figure for 1988 is 93,935 t which is 3.78% of total production of the world.

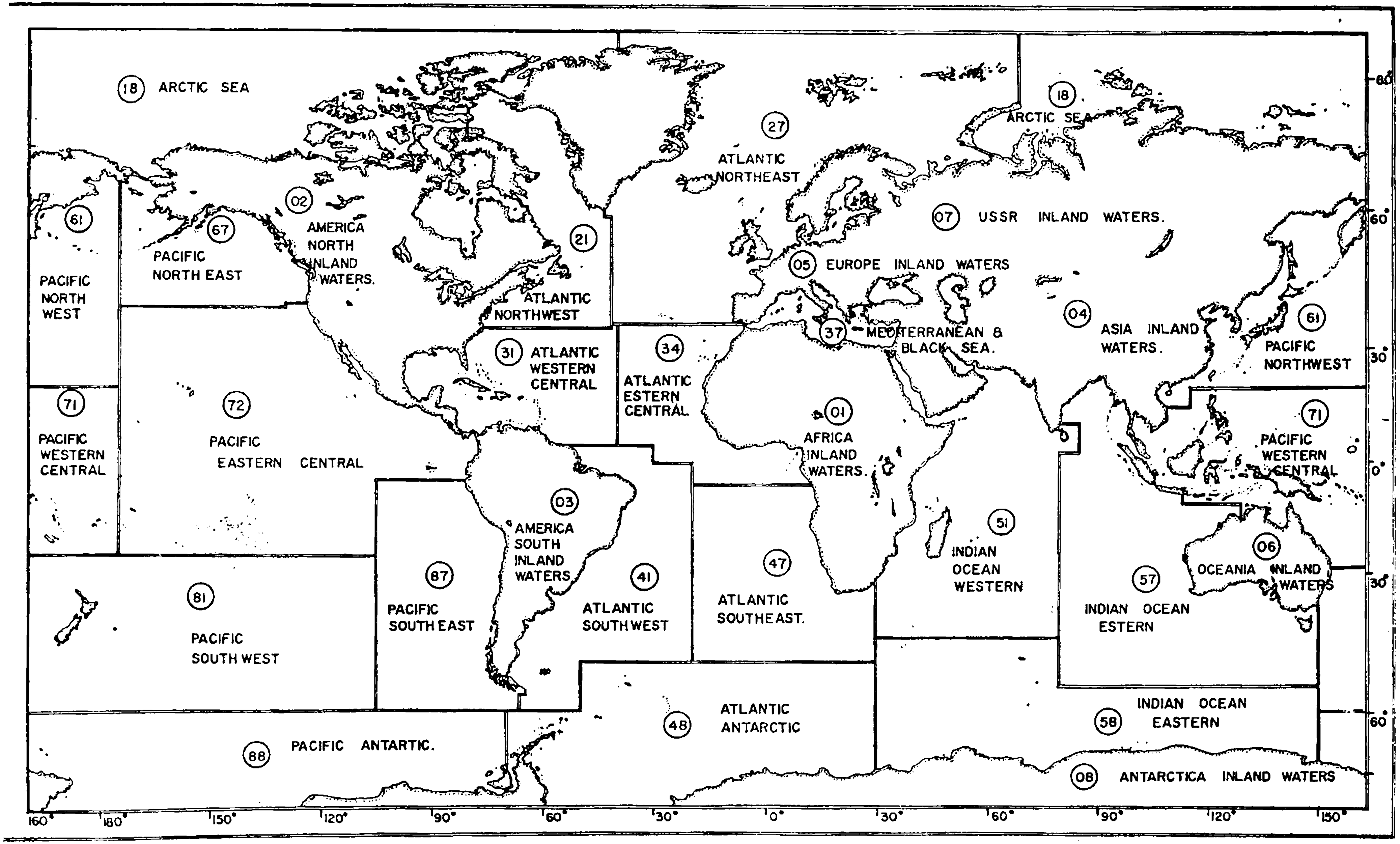


FIG. 1.1 MAJOR FISHING ZONES OF THE WORLD

Table 1.1 World catch of prawns and shrimps in major fishing areas for the years 1982 – 1988

Sl. No.	Fishing area No.	Name of Fishing area	Area km^2	Year-wise landings of prawns in tonnes 1982	1983	1984	1985	1986	1987	1988
1	21	Atlantic, Northwest	5,207,000	57,537	59,699	55,062	70,213	80,095	87,252	93,935
2	27	Atlantic, Northeast	16,877,000	124,640	165,377	187,783	196,685	150,467	144,717	134,144
3	67	Pacific, Northeast	7,503,000	20,749	9,787	9,920	15,683	29,079	35,058	36,536
4	61	Pacific, Northwest	20,476,000	370,475	418,199	458,485	587,075	672,446	745,439	806,476
5	31	Atlantic, Western Central	14,681,000	161,921	154,827	180,080	184,479	200,272	179,008	163,143
6	34	Atlantic, Eastern Central	13,979,000	41,234	39,713	42,167	40,709	37,543	45,417	44,535
7	37	Mediterranian and Black Sea	2,980,000	18,098	26,605	31,995	35,687	30,749	33,226	32,048
8	77	Pacific, Eastern Central	57,467,000	115,601	124,993	122,445	120,309	135,519	165,142	155,477
9	71	Pacific, Western Central	33,233,000	369,435	341,331	319,561	324,229	355,860	375,971	392,598
10	51	Indian Ocean, Western	30,198,000	229,456	210,610	218,010	259,702	239,977	227,189	236,830
11	57	Indian Ocean, Eastern	29,782,000	126,557	145,710	128,231	123,416	133,393	142,929	178,561
12	81	Pacific, Southwest	33,212,000	2,958	2,765	3,060	2,670	2,400	2,600	2,600
13	87	Pacific, Southeast	16,611,000	5,040	16,325	6,397	6,622	6,423	10,359	9,339
14	41	Atlantic, Southwest	17,616,000	61,199	70,112	83,374	78,914	63,817	59,588	77,254
15	47	Atlantic, Southeast	18,594,000	71	58	53	10,820	8,542	9,130	5,886
16	01	Africa-Inland waters		49	19	11	27	63	2,308	2,214
17	02	America, North Inland waters		-	-	-	21	-	71	-
18	04	Asia-Inland waters		30,602	39,656	60,846	66,436	71,969	91,707	112,427
		World landings of shrimps and prawns		1,735,622	1,825,786	1,907,480	2,120,697	2218614	2357111	2484005

1.2.2 Atlantic, Northeast (Fishing area No.27)

This area has more ecological diversities due to the influence of Gulf stream currents. The two main species are *Pandalus borealis* found from North of Spitsbergen to Northern North sea, on clay and mud bottoms at depths of 60 ~ 1000 m and brown shrimp *Crangon crangon* occurring between Central North Sea and Bay of Biscay, Irish sea and the coast of Holland and Germany. Production was fluctuating from 1982 to 1988. It rose to 1,96,685 t in 1985 from an earlier figure of 1,24,640 t in 1982. The production increased to 1,34,146 t in 1988 constituting 5.4% of the world production.

1.2.3 Pacific Northeast (Fishing area No.67)

Pandalas borealis and *P. jordani* are found along the coast of Canada, Washington, Puget Sound and Oregon. *P. borealis* dominate in the Gulf of Alaska. The present production is 36,536 t which is 1.47% of the world production.

1.2.4 Pacific Northwest (Fishing area No.61)

The main species are *Pandalus hypsinotus* along the Korean coast, *P. goniurus* in the Okhotsk sea, and *P. borealis* dominates along the west coast of Kamchatka. Production from this region has doubled compared to that of 1982, the present production being 8,06,476 t which is 32.46% of the world prawn production.

1.2.5 Atlantic, Western Central (Fishing area No.31)

The presence of river effluents in Gulf of Mexico and the lagoon system has transformed this area into one of the rich prawn grounds of the world. There are seven shallow water Penaeid shrimps, two species living in shelf waters and not entering the lagoon and one deep water shrimp. Penaeus setiferus, P. schmitti, P. aztecus aztecus, P. aztecus subtilis, P. duorarum duorarum, P. duorarum notialis and P. brasiliensis, Xiphopenaeus kroyeri, Sicyonia brevirostris and Pleoticus robustus. From 1,61,921 t in 1982, the landings increased to an all the record of 2,00,272 t in 1986, but it again reduced to 1,62,143 t in 1988 or 6.56% of the world production.

1.2.6 Atlantic Eastern Central (Fishing area No.34)

This is an area of low prawn production. Penaeus duorarum is the main species exploited from Cape Blanco to Angola and the potential ground being Niger delta and Bight of Bifra. Landings have been steady and during 1988 it was 44,535 t which is 1.79% the world prawn landings.

1.2.7 Mediterranean and Black sea (Fishing area No.37)

The rate of production is high inspite of unfertile condition and this may be due to the high rate of exploitation. Parapenaeus longirostris and deep living prawn Gamba de Profundidad (Aristomorpha foliacea and Aristeus antennatus) constitute the main species. From 18,098 t in 1982 the landings increased to 35,687 t in 1985. The landings came down to 32,048 t in 1988 contributing 1.29% of the world production.

1.2.8 Pacific, Eastern Central (Fishing area No.77)

The main species are white shrimps Penaeus vannmei, P. stylirostris, brown shrimp P. californiensis and pink shrimp P. brevirostris, sea bobs tiger Trachypenaeus byrdi, T. similis, T. faoea and sea bob titi Protrachypene precipus and Xiphopenaeus riveti. The landings have steadily increased from 1,15,601 t in 1982 to 1,55,477 t in 1988 which is 6.25% of the world prawn landings.

1.2.9 Pacific, Western Central (Fishing area No.71)

There is enormus tropical coast-line with heavy rain fall favouring a good prawn fishery. Penaeus indicus is the main species of Indonesia, Sabah, Sarawak, Singapore, Malaya and Phillipines P. merguiensis is found in Thailand and Phillipines. P. orientalis and P. japonicus are caught in yellow sea and inland seas of Japan. P. monodon and P. semisulcatus are caught in less quantity all along the region. Production of 1982 was 3,69,435 t which has shown slight decrease during 1983-86 and afterwards an upward trend was noticed. Production of 3,92,598 t in 1988 was 15.80% of the world prawn catch.

1.2.10 Indian Ocean, Western (Fishing area No.51)

This is a diverse region and contain large number of species of prawn. *Penaeus indicus* is the dominant prawn along east African coast-line and Madagascar. Further north, there are *P. semisulcatus* and *P. merguiensis*. Along the west coast of India the prawn fauna are *Metapenaeus affinis*, *Parapenaeopsis hardwickii*, *Solenocera indica*, *Penaeus indicus*, *Metapenaeus dobsoni* and *M. monoceros*. Along the Ceylon coast *Penaeus indicus*, *Penaeus merguiensis* and *P. semisulcatus* are caught. There had not been much fluctuation in catch. The yield of 2,29,456 t in 1982 increased to 2,59,702 t in 1985 and decreased to 2,36,830 t in 1988 or 9.53% of the world catch.

1.2.11 Indian Ocean, Eastern (Fishing area No.57)

The main constituent species are *Penaeus indicus*, *Metapenaeus monoceros*, *M. ensis*, *M. affinis*, *M. brevicornis*, *Penaeus semisulcatus* and *P. monodon*. Production was steady upto 1984 and then gradual increase was noted upto 1988, recording 1,78,561 t which is 7.18% of the world catch.

1.2.12 Pacific, Southwest (Fishing area No.81)

Penaeus plebejus is the major species along the coast of Australia and New Zealand, *Metapenaeus bennetae*, *Penaeus esculentus*, *P. merguiensis* and the deepwater species *Nephrops challengeri* are the other species exploited in the area.

Production from this area has shown variations. The production of 2,958 t in 1982 increased to 3,060 t in 1984 and again decreased to 2,600 t in 1988 which is 0.14% of world prawn production.

1.2.13 Pacific, Southeast (Fishing area No.87)

Heterocarpus reedi and Rhincocinetes typus are the main species exploited. Hymenopenaeus diomedeae is a deepwater species. From 5,040 t in 1982 the catch has increased to 16,325 t in the succeeding years and in 1988 the production was 9,339 t, being 0.37% of the world catch.

1.2.14 Atlantic, Southwest (Fishing area No.41)

The major shrimp resources are prevalent along the river mouth region of Brazil, Surinam, Guianas and the lagoons and estuaries of Brazil and Argentina. There are twelve species of shrimps which are exploited. The prominent species are Xiphopenaeus kroyeri, Penaeus aztecus subtilis, P. duorarum notialis, P. paulensis, Pleoticus mullerii. The production was 61,199 t in 1982. It increased to 83,374 t in 1984, the landings for 1988 was 77,254 t forming 3.11% of world prawn catch.

1.2.15 Atlantic, Southeast (Fishing area No.47)

The main species are Penaeids prawns which occur along the coast of Angola in the continental slope. The other species obtained are Parapenaeus longirostris, Aristeus varidens and

Plesiopenaeus edwardisianus. Wide fluctuations occurred in the landings from 81 t in 1982 to record landings of 10,820 t in 1985 and again decreased to 5,886 t in 1988 or 0.2% of the world prawn landings.

1.3 LEADING SHRIMP PRODUCING NATIONS OF THE WORLD, FLUCTUATION IN CATCH (1983 to 1988) AND SPECIES COMPOSITION

The first ten shrimp producing nations of the world are China, India, Indonesia, U.S.A., Thailand, Mexico, Malaysia, Phillipines, Ecuador and Greenland (Anon 1990b). The catch details of these nations for the period (1983 to 1988) along with their average catch and their share in world catch are given in Table 1.2.

1.3.1 China

During the six year period the average catch was 384.2 thousand tonnes which is 18.8% of the world landings. It can be observed that there is a steady increase in the catch from 1983. The main species are Akiami paste shrimp (Acetes japonicus) 32 to 85%, Penaeid shrimps (Penaeus spp.) 23 to 32% and Fleshy prawn (Penaeus chinensis), 8 to 43%.

1.3.2 India

About 10.4% of the world landings is contributed by India and the average catch is 213.0 thousand tonnes per year. As seen from F.A.O. Fishery Statistics for 1986 and 1988 (Anon 1988a, 1990a)

Table 1.2 Top ten shrimp producing countries of the world from 1983 to 1988 (catch in thousand tonnes)

	1983	1984	1985	1986	1987	1988	Average catch	% contribution of each nation
China	220.5	250.0	367.0	426.0	457.5	583.6	384.2	18.8
India	192.9	203.2	232.5	215.3	197.2	236.6	213.0	10.4
Indonesia	138.2	132.9	144.1	157.0	186.9	202.3	160.2	7.8
U.S.A.	119.9	145.0	152.7	183.3	165.0	250.8	152.8	7.5
Thailand	160.3	136.2	126.3	139.5	150.1	150.1	143.8	7.0
Mexico	76.9	76.1	74.6	73.2	83.9	73.2	76.3	3.7
Malaysia	76.5	70.1	69.0	73.0	72.8	72.8	72.4	3.5
Phillippines	39.8	52.2	62.4	72.1	68.0	79.6	62.4	3.1
Ecuador	44.6	39.9	36.2	52.8	78.7	80.8	55.5	2.7
Greenland	41.2	41.5	52.4	64.1	64.4	65.1	54.8	2.7

the main species are Natantian decapodes. A detailed account on the species composition is dealt with in a later session.

1.3.3 Indonesia

The average production is 160.2 thousand tonnes contributing 7.8% of the world landings. As in the case of China, there is a gradual increase in production. The main species are Natantian decapodes 33 to 37%. Banana prawn (Penaeus merguiensis) 26 - 33%, Giant tiger prawn P. monodon 13 to 19% and Metapenaeus shrimp (Metapenaeus spp.) 11 to 19%. Landings are mainly from Eastern Indian Ocean and Western Central Pacific.

1.3.4 U.S.A.

Landings show an average rate of 152.8 thousand tonnes which is 7.5% of the world landings. The main species landed from western central Atlantic are Northern brown shrimp (Penaeus aztecus) 41 to 53%, Northern white shrimp (P. setiferus) 23 to 29% and Northern pink shrimp (P. duorarum) 5 to 9%. Pacific shrimp (Pandalus sp. and Pandalopsis spp.) contribute 6 to 22% and are landed from Northeast and Eastern Central Pacific. Other species caught along West Central Atlantic are Atlantic Sea bob (Xiphopenaeus kroyeri), Rock shrimp (Sicyonia brevirostris), Royal red shrimp (Pleoticus robustus) and Penaeid shrimp (Penaeus spp.)

1.3.5 Thailand

Average production for the period is 143.8 thousand tonnes, which is 7% of the world catch. The main species exploited are Penaeid shrimp (Penaeus spp.) 56 to 64%. Sergestid shrimp (Sergestidae) 13 to 15%, Metapenaeus shrimp (Metapenaeus spp.) 8 to 11%, Banana prawn (Penaeus merguiensis) 4 to 15% and Giant tiger prawn (P. monodon) upto 9%. Bulk of the landings are from Western Central Pacific.

1.3.6 Mexico

Mexico produces 3.7% of the world shrimp landings and the average catch is 76.3 thousand tonnes. The main species are penaeid shrimp (Penaeus spp.) which forms 99% of the landings. Landings from Eastern Central Pacific is more compared to West Central Atlantic.

1.3.7 Malaysia

About 3.5% of the world shrimp landings is from Malaysia, the average landings being 72.4 thousand tonnes. Penaeid shrimp (Penaeus spp.) 78 to 91% and Sergestid shrimp (Sergestidae) 13 to 24% are the two main species. Exploitation is both from Western Central Pacific and Eastern Indian Ocean.

1.3.8 Philippines

With an average production of 62.4 thousand tonnes, Philippines constitute 3.1% of the world shrimp landings. Main species landed are penaeid shrimp (Penaeus spp.) 68 to 75%, Sergestid shrimp (Sergestidae) 14 to 28% and Metapenaeus shrimp (Metapenaeus spp.)

1.3.9 Ecuador

Contribute 2.7% of the world shrimp landings, the average landings of Ecuador being 55.5 thousand tonnes. White shrimp (*P. occidentalis*) is the main species.

1.3.10 Greenland

Contributes 2.7% of the world shrimp landings, the average catch being 54.8 thousand tonnes. Northern prawn *Pandalus borealis* is the main species exploited both from North west Atlantic and North East Atlantic.

1.4 CRUSTACEAN LANDINGS ALONG THE INDIAN COAST (1980 to 1989) MAJOR CONSTITUENT GROUPS AND THEIR FLUCTUATIONS

Crustacean fishery of the Indian coast are grouped as penaeid prawns, Non penaeid prawns, Lobsters, crabs and stomatopoda. The crustacean landings for the ten years period 1980 to 1989 showed a gradual increase (Table 1.3). The maximum landings of 3,15,089 tonnes was noticed during 1987 with an average landings of 251,022 tonnes. The percentage composition of different groups are also given in Table 1.3. Prawn landings during the period ranged from 1,44,790 tonnes to 2,22,990 tonnes and the average for the period being 1,85,244 tonnes or 73.79% of the crustacean landings. The share of penaeid prawns ranged between 83,539 and 1,54,483 tonnes with an average catch of 1,26,927.7 tonnes. The landings of Penaeid prawns constitute

Table 1.3 Crustacean landings of India along with their Percentage composition for the years 1980-1989

	1980		1981		1982		1983		1984	
	Landings in tonnes	Percentage	Landings in tonnes	Percentage	Landings in tonnes	Percentage	Landings in tonnes	Percentage	Landings in tonnes	Percentage
Penaeid prawn	112005	56.92	83539	43.87	110788	51.21	118151	56.47	130028	51.44
Non Penaeid prawn	58700	29.83	61431	32.26	51157	23.65	48749	23.30	61962	24.51
Total prawn	170705	86.76	144970	76.14	161945	74.86	166900	79.77	191990	79.95
Lobster	679	0.34	1481	0.77	1764	0.81	1300	0.62	3222	1.27
Crab	16896	8.58	26616	13.98	25099	11.60	19244	9.19	28745	11.37
Stomatopods	8473	4.30	17318	9.09	27519	12.72	21773	10.40	28815	11.39
Total crustacean landings	196753		190385		216327		209217		252772	

	1985		1986		1987		1988		1989	
	Landings in tonnes	Percentage	Landings in tonnes	Percentage	Landings in tonnes	Percentage	Landings in tonnes	Percentage	Landings in tonnes	Percentage
Penaeid prawn	121958	49.46	138631	49.06	154483	49.02	153073	52.59	146621	47.28
Non Penaeid prawn	67084	27.20	71985	25.47	36303	11.52	49423	17.01	76369	24.63
Total prawn	189042	76.66	210616	74.53	190786	60.54	202496	69.70	222990	71.92
Lobster	4082	1.65	3057	1.08	2562	0.81	1587	0.54	1590	0.51
Crab	22264	9.02	20780	7.35	23127	7.33	17424	5.99	16191	5.22
Stomatopods	31191	12.64	48110	17.02	98614	31.29	68981	23.74	69276	22.34
Total crustacean landings	246579		282563		315089		290488		310047	

	Total	Average for 1980-1989	Percentage
Penaeid prawn	1269277	126927.7	50.56
Non penaeid prawn	583163	58316.3	23.23
Total prawn	1852440	185244.0	73.79
Lobster	21324	2132.4	0.85
Crab	216384	21638.4	8.62
Stomatopods	420070	42007.0	16.73
Total crustacean landings	2510220	251022.0	

50.56% of the crustacean landings of India. (Alagaraja 1987, Alagaraja et al. 1987, Balan et al. 1987, Dharmaraja et al. 1987, Jacob et al. 1987, Kurup et al. 1987, Philipose et al. 1987, Scariah et al. 1987, Srinath et al. 1987 and Central Marine Fisheries Research Institute, Cochin, Pers. comm.)

1.4.1 Species composition and seasonal variations

A review of the species composition of the landings from 1978 to 1981 (Anon 1979a,1980, 1982 a,b) indicates that *Acetes indicus* constitute the major species followed by *Parapenaeopsis stylifera* in most of the years (Table1.4). The landings of *Metapenaeus dobsoni*, *Penaeus indicus* and *Metapenaeus affinis* though comes next in the rank of quantity of landings, their order of ranking moves forward and backward in the years observed. It may be stated in general that 90% of the catch is constituted by 10 species namely, *Acetes indicus*, *Parapenaeopsis stylifera*, *Metapenaeus affinis*. *Nematopalaemon tenuipes*, *Metapenaeus dobsoni*, *Solenocera crassicornis*, *Penaeus indicus*, *P. semisulcatus*, *Metapenaeus monoceros* and *Parapenaeopsis hardwickii*.

The total monthly landings of prawn generally showed a steady increasing trend from January to May with sudden decline in June. Whenever *Parapenaeopsis stylifera* dominates in the monsson period, a peak was obtained in July and that too from

Table 1.4 Species-wise break-up of prawn landings of India and their percentage for the years 1978-1981

	1978		1979		1980		1981	
	Tonnes	Percen- tage	Tonnes	Percen- tage	Tonnes	Percen- tage	Tonnes	Percen- tage
Solenocera crassicornis	3019	1.70	9635.51	5.40	6388.50	3.70	8804	5.60
Penaeus indicus	18085	10.10	7900.38	4.50	10298.20	6.00	7537	5.20
P. merguiensis	1179	0.70	741.38	0.40	495.90	0.30	1096	0.80
P. monodon	1014	0.60	416.18	0.20	2655.80	1.60	941	0.60
P. semisulcatus	6029	3.30	4568.30	2.60	1712.50	1.00	7898	5.40
P. penicillatus	-	-	-	-	932.80	0.60	-	-
Metapenaeopsis stridulens	-	-	1100.82	0.60	-	-	506	0.30
Metapenaeus dobsoni	21969	12.20	16606.72	9.40	18998.10	11.10	10059	6.90
M. affinis	20704	11.50	20261.68	11.40	7231.70	4.20	5025	3.50
M. monoceros	16447	9.10	4374.85	2.50	5607.90	3.30	7073	4.90
M. brevicornis	1124	0.60	526.17	0.30	835.70	0.50	907	0.60
M. kutchensis	-	-	-	-	1534.90	0.90	857	0.60
Parapenaeopsis stylifera	30306	16.90	29394.20	16.60	50829.00	29.80	29109	20.10
P. hardwickii	240	0.10	4320.79	2.40	2214.00	1.30	2123	1.50
P. sculptilis	-	-	1100.82	0.60	-	-	-	-
Parapenaeus longipes	-	-	1100.82	0.60	-	-	-	-
Other penaeids	-	-	11616.38	6.54	-	-	-	-
Acetes indicus	39002	21.70	41305.47	23.30	41282.40	24.20	38430	26.50
Nematopalaemon tenuipes	6078	3.40	19909.33	11.20	12653.70	7.40	19698	13.60
Exopalaemon styliferus	-		1224.37	0.70	1276.90	0.70	859	0.60
Exhippolysmata ensirostris	2533	1.40	1477.83	0.80	3091.50	1.80	2309	1.60
Other species	12127	6.70			2697.50	1.60	2458	1.70
Total	179856		177582		170737		144969	

the landings of Kerala. Generally, the catch was poor during the Southwest monsoon period (June to August) along the maritime states of Northwest and Northeast coast. It was during the last quarter that 70% of the catch was obtained in Gujarat, while in Maharashtra also substantial quantity occurred during the month of May, October and December. January and February were observed to be good season for the fishery in Karnataka, though catches were obtained during August to May. Along the Kerala coast catches were generally good during the first three quarters. An unique feature of this state was that when the fishing activities remained very weak in most of the areas of the west coast during the monsoon period the prawn production from here was the highest during July and August provided P. stylifera fishery was favourable along the Quilon area. Along the East coast peak landings were observed during June to September.

As far as productive months for penaeid prawns are concerned, October to April are productive in Gujarat, August to October in Maharashtra, August to May in Karnataka, June to April in Kerala, May to December at Tuticorin, August to March at Madras, July to May in Andhra Pradesh and September to January in Orissa.

Penaeid prawns supported the entire fishery of Goa, Karnataka, Kerala, Orissa and Andamans and 70 to 90% in Tamil Nadu, Andhra Pradesh, Gujarat and Pondicherry. The non-penaeids dominated the fishery of Maharashtra followed by Gujarat and Andhra Pradesh.

1.5 CRUSTACEAN LANDINGS FROM DIFFERENT MARITIME STATES OF INDIA FOR THE PERIOD 1980-1989 WITH REFERENCE TO PENAEID PRAWNS

The information given below on the crustacean landings of different maritime states are based on two sets of data. Data for the years 1980, 1981, 1982, 1983 and 1984 are based on Alagaraja 1987, Alagaraja et al. 1987, Balan et al. 1987, Dharmaraja et al. 1987, Jacob et al. 1987, Kurup et al. 1987, Philipose et al. 1987, Scariah et al. 1987 and Srinath et al. 1987. Data for the years 1985, 1986, 1987, 1988 and 1989 are based on the personal communication to the author on the coumputerised data of fishery landings from Central Marine Fisheries Research Institute, Cochin.

1.5.1 Gujarat

Average crustacean production during the period is 33,431 t (Table 1.5) and constitutes 13.82% of the total crustacean landings of India and ranks third. Landings show a gradual increase. Prawn landings constitute 61.83% of the crustacean landings of which penaeid prawns accounts for 39.53% and 63.93% of the total crustacean and prawn landings of the state and 12.17% and 10.41% respectively of the country. Gujarat ranks fourth in the production of penaeid prawns.

Table 1.5 Species-wise crustacean landings of India in tonnes for the years 1980-1989

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
GUJARAT										
Penaeid prawn	14481	10985	12237	9959	10848	12716	14382	16094	15812	14645
Non penaeid prawn	4109	4742	4148	8657	8539	7132	9961	6813	7926	32538
Lobsters	204	786	483	482	1604	966	612	1051	837	947
Crabs	4967	14088	7638	2779	14480	9452	4560	4433	3973	3445
Stomatopods	-	2466	5141	2199	4110	3769	3385	4233	2457	2083
Total	23761	33062	29647	24076	39551	34035	32900	32624	31005	53658
MAHARASHTRA										
Penaeid prawn	23433	21717	33914	36027	43934	51793	46341	43318	30207	37403
Non penaeid prawn	47309	52855	40809	32134	39230	55180	57387	26454	37549	41037
Lobsters	225	388	727	329	963	2504	2032	727	477	386
Crabs	297	112	474	329	790	494	360	393	211	195
Stomatopods	-	384	2397	1142	1838	2759	6150	21747	12940	18404
Total	71264	75456	78321	69961	86755	112730	112270	92639	81384	97425
GOA										
Penaeid prawn	1853	2237	3491	7744	4853	3496	4610	5795	3963	4618
Non penaeid prawn	-	-	-	-	-	-	85	-	-	-
Lobsters	18	9	24	8	6	23	4	77	8	6
Crabs	608	526	904	737	1105	1789	2872	2325	497	327
Stomatopods	1328	2170	3504	2662	4629	6554	12430	13931	14888	7838
Total	3807	4942	7923	11151	10593	11862	20001	22128	19356	12789
KARNATAKA										
Penaeid prawn	3098	4122	7698	7883	5511	4484	5016	9192	8665	8566
Non penaeid prawn	128	4	-	-	-	100	269	182	25	2
Lobsters	110	-	49	-	3	22	2	4	1	2
Crabs	2765	650	1003	533	476	596	1886	2575	762	771
Stomatopods	-	8718	9930	7701	9838	9428	15754	45159	24601	24832
Total	6101	13494	18680	16117	15838	14630	22927	57112	34054	34173
KERALA										
Penaeid prawn	52633	22268	26708	29754	35529	26685	37098	52866	67498	53317
Non penaeid prawn	1742	160	65	105	738	202	194	259	160	18
Lobsters	18	50	94	65	53	93	50	139	112	74
Crabs	326	168	347	474	469	974	1373	2560	2153	2664
Stomatopods	6960	2830	4023	6341	7091	7817	9102	11223	11550	13312
Total	61679	25476	31237	36742	43880	35771	47817	67047	81473	69385
TAMIL NADU										
Penaeid prawn	9082	13548	14086	13458	15154	11306	15640	17409	16461	16886
Non penaeid prawn	946	704	376	275	1453	165	202	810	432	52
Lobsters	90	238	312	355	566	442	324	536	132	164
Crabs	6174	9168	12668	10172	8586	6575	5875	7801	7039	5842
Stomatopods	-	317	2096	878	654	287	476	676	1003	336
Total	16292	23975	29538	25138	26413	18775	22517	27232	25067	23280

Table contd.

PONDICHERRY										
Penaeid prawn	485	336	304	273	854	754	547	508	389	442
Non penaeid prawn	42	53	16	9	63	8	55	-	10	19
Lobsters	4	5	27	32	5	12	18	16	19	9
Crabs	172	236	917	618	736	430	326	205	377	86
Stomatopods	-	-	6	7	-	-	1	97	1	8
Total	703	630	1270	939	1658	1204	947	826	796	564
ANDHRA PRADESH										
Penaeid prawn	5660	6728	9892	10571	8787	7681	11609	6765	7739	7598
Non penaeid prawn	4346	1607	4637	5851	1183	1161	2439	956	1390	1462
Lobsters	10	1	8	20	12	9	8	4	1	1
Crabs	1413	1512	955	3047	1889	1587	3220	2312	2116	2395
Stomatopods	-	288	295	612	585	399	349	406	394	1961
Total	11429	10136	15787	20101	12456	10837	17625	10443	11640	13417
ORISSA										
Penaeid prawn	1074	1328	2096	1999	2053	2598	2839	2162	1877	2451
Non penaeid prawn	30	55	222	19	21	274	216	136	145	11
Lobsters	-	3	38	3	1	2	7	-	-	1
Crabs	174	147	62	186	103	127	180	368	230	398
Stomatopods	185	145	115	199	47	173	457	1089	1145	502
Total	1463	1678	2533	2406	2225	3174	3699	3755	3397	3363
WEST BENGAL										
Penaeid prawn	152	244	299	410	2304	246	412	299	220	529
Non penaeid prawn	48	1251	884	1699	10735	2860	1103	681	1718	1183
Lobsters	-	-	-	-	-	-	-	-	-	-
Crabs	-	-	103	359	111	210	93	130	66	26
Stomatopods	-	-	12	32	23	5	6	53	2	-
Total	200	1495	1298	2500	13173	3321	1614	1163	2006	1738
LAKSHADWEEP										
Penaeid prawn	-	-	-	-	-	-	-	-	-	-
Non penaeid prawn	-	-	-	-	-	-	-	-	-	-
Lobsters	-	-	-	-	-	-	-	-	-	-
Crabs	-	-	-	-	-	-	-	-	-	-
Stomatopods	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-
ANDAMAN & NICOBAR ISLANDS										
Penaeid prawn	54	26	63	73	201	199	137	75	242	166
Non penaeid prawn	-	-	-	-	-	2	74	12	68	47
Lobsters	-	1	2	3	9	9	-	8	-	-
Crabs	-	14	28	10	30	30	35	25	-	42
Stomatopods	-	-	-	-	-	-	-	-	-	-
Total	54	41	93	86	240	240	246	120	310	255

1.5.2. Maharashtra

This state is having an average crustacean production of 87,820.5 t, ranks first among the maritime states and contributes 34.98% of the total catch. Here also a gradual increase is noticed, but maximum catches were recorded during 1985 and 1986. Prawn landings constitute 90.87% of the total crustacean production of the state, the penaeid prawn alone forms 41.91% and 46.12% of the crustacean and prawn production of the state respectively. Maharashtra ranks second in the penaeid prawn production of India and contributes 29.00% of the penaeid prawn and 42.89% of the total prawn landings of India.

1.5.3 Goa

With modest landings of 12,455 t, goa ranks seventh in the crustacean landings contributing 4.96%, Prawns form 34.32% of the crustacean landings of which penaeid prawns constitute 34.25% and 99.08% of the crustacean and prawn landings of Goa. Goa ranks seventh in penaeid prawn landings contributing 2.29% and 3.36% respectively of the prawn and penaeid prawn production of India.

1.5.4 Karnataka

Karnataka has shown a steady progress in crustacean landings during the period with an average landing of 23,311 t.

This state enjoys the fifth position in respect of crustacean landings, contributing 9.29%. The prawn forms 27.86% of the crustacean landings of Karnataka. The penaeid prawn accounts for 27.5% and 98.91% of the crustacean and prawn landings of the state. Karnataka ranks 6th in penaeid prawn production and 3.49% and 5.06% respectively of the prawn and penaeid prawn landings of India are contributed by the state.

1.5.5 Kerala

Crustacean landings of the state shows fluctuations with lowest landings during 1981 and highest during 1988, the average being 5,00,414 t. Kerala holds the second position in the crustacean landings of India. Prawn landings forms 81.52% of the total crustacean landings. Penaeid prawn contribute 80.79% of the crustacean and 99.1% of the prawn landings of the state. This state ranks first in the landings of penaeid prawn in India. Prawn and penaeid prawn landings of the state contribute respectively 21.9% and 31.86% of the total landings of India.

1.5.6 Tamil Nadu

Except for the years 1980 and 1985 Tamil Nadu has steady landings, the average catch being 23,822 t. Tamil Nadu ranks fourth in the crustacean landings of India and contributes 9.49%. Prawn landings forms 62.31% of the crustacean landings penaeid prawns contribute 60.04% of the crustacean and 96.35%

of the prawn landings of the state. Tamil Nadu holds third position in respect of penaeid prawn landings of India, contributing 7.97% and 11.27% respectively of the prawn and penaeid prawn landings.

1.5.7 Pondicherry

This state is having an average landings of 953.7 t. Certain increase in landings was noticed during the years, 1982, 1984 and 1985. The state contributes 0.38% of the crustacean landings of the country and ranks tenth in the order of landings. Prawn forms 54.65% of the crustacean landings. Penaeid prawns constitute 51.29% and 93.86% of the crustacean and prawn landings respectively of the state. In the case of penaeid prawn also the state enjoys tenth rank. The state contribute 0.28% and 0.38% respectively of prawns and penaeid prawn landed in the country.

1.5.8 Andhra Pradesh

Average crustacean landings of this state is 13,387 t with peak during 1983. The state rank sixth in the crustacean landings of India contributing 5.33%. Prawn forms 80.72% of the crustacean landings of the state. Penaeid prawns constitute 62.02% and 76.84% respectively of the crustacean and prawn landings of the state. The state ranks fifth with reference to penaeid prawns and contributes 5.80% and 6.54% respectively of prawns and penaeid prawns landed in the country.

1.5.9 Orissa

Landings of Orissa show a gradual increase with an average landings of 2,769 t. Regarding the share of crustacean yield this state ranks nineth in India and contribute 1.10% of the total landings. Prawn landings formed 78.02% of the crustacean landings of which penaeid prawns contributed 73.94% of the crustacean and 99.97% of the prawn landings of the state. The penaeid prawns of this state is 1.61% of the all India landings and holds eighth position in terms of quantity. Prawn and penaeid prawn production of the state contribute 1.16% of the landings of the country.

1.5.10 West Bengal

Crustacean landings of West Bengal is almost steady, though there has been an increase during 1983 and 1985. The average landings is 2,850.8 t and the state is eighth in the order of landings contributing 1.14% of the crustacean landings of the nation. Prawn landings formed 95.68% of the crustacean landings of which penaeid prawn landings shared 17.94% and 18.75% of the crustacean and prawn landings, respectively of the state. West Bengal contributes 1.46% and 0.40% respectively of the prawn and penaeid prawn landings of India and ranks nineth among the states in the landings of penaeid prawn.

1.5.11 Lakshadweep

There is no record of crustacean landings from this territo

1.5.12 Andaman and Nicobar Islands

The crustacean production is low and hence the share is negligible.

1.6 SIGNIFICANCE OF PRAWN FISHERY IN INDIA

The mainstay of the fishing industry in India is economic terms is the penaeid prawn fishery which forms the major component of the marine products exports from India (Table 1.6.) The average value realised by export of prawns for the 9 years period from 1980 to 1988, is Rs.325.6 crores and this constituted 84.09% of the total value of marine products exported during this period (Anon 1990b).

Silas et al. (1984) while examining the catch and effort statistics of marine prawn production from different areas of India for the period from 1966 to 1981 observed that many stocks are fully exploited. They have discussed the management measures to prevent over exploitation of prawns. Verghese (1989) has enumerated the fishery regulations in Indian territorial waters. Suggestions for improved utilization of deep sea prawn and lobster resource have been given by Suseelan (1985) and Suseelan et al. (1990 a & b). Aquaculture of shrimp has been recommended as another alternative for increasing production (Unnithan 1985 and Tharakan 1991).

Table 1.6 Share of shrimp in Marine Products Exports from India. Q = Quantity in tonnes; V = value in Rs. '000

Year		Shrimp	%	Total Marine Products Exports
1980	Q	48,251	64.73	74,542
	V	18,50,804	84.56	21,88,756
1981	Q	54,694	72.56	75,375
	V	24,90,919	86.88	28,67,128
1982	Q	54,787	72.92	75,136
	V	30,15,249	88.10	34,22,429
1983	Q	53,660	62.27	66,169
	V	31,05,586	85.40	36,23,231
1984	Q	55,251	61.45	89,912
	V	32,76,146	84.98	38,54,983
1985	Q	49,677	61.64	80,588
	V	31,47,402	83.78	37,56,683
1986	Q	52,192	58.45	89,283
	V	38,00,182	82.13	46,26,841
1987	Q	51,651	57.95	89,125
	V	40,10,334	81.91	48,95,540
1988	Q	56,076	56.47	99,306
	V	46,13,438	79.08	58,33,819
Aver-ave	Q	52,915	63.16	82,160
	V	32,56,673	84.09	38,96,601

1.7 PRAWN FISHERY RESOURCES OF KERALA

Species-wise landings of the penaeid prawns of Kerala for the years 1984, 1985, 1986, 1987 and 1988 are based on the personal communication to the author on the computerised data of prawn landings of Kerala from Central Marine Fisheries Research Institute, Cochin.

Kerala, the southwestern part of peninsular India, has a narrow stretch of land with a long surf beaten coast on the western side and a lush green mountain range on the eastern side. The coastline is 590.0 km long which is almost one tenth of the Indian coast-line.

Kerala occupies the foremost position in marine fish production of India accounting for almost a quarter of the total landings of the Indian coast. The state accounts for 31.86%, on an average,of the penaeid prawn landed along the Indian coast for the years 1980-1989.

The annual penaeid production is Kerala is estimated as 40,435.6 t (average of 1980-1989). The production in 1980 was 52,633 t which dipped to an all time low value of 22,268 t in 1981, slowly improving the position to 26,708; 29,754 and 35,529 t respectively during the years 1982, 1983 and 1984. However during the year 1985 there was a fall in production (26,685 t) as in 1981. Since then, the production has increased steadily as

37,098; 52,866 and 67,498 t respectively during 1986, 1987 and 1988 with a decline in 1989 having 53,317 t. Thus the highest production was during 1988 (67,498 t).

Among the crustacean landings of Kerala, prawns formed an average of 81.79% (1980 to 1989) and the fluctuation were from 75.16% (1985) to 88.15% (1980). Unlike certain states like Maharashtra, in Kerala, the penaeid prawns which has better demand in export market formed 81.10% of the crustacean landings and 99.13% of the prawn landings of the state for the period 1980-89. The main species which are of commercial importance are the Indian white prawn, *Penaeus indicus*, flower tail, *Metapenaeus dobsoni*, *M*, *affinis*, *M*. *monoceros* and *Parapenaeopsis stylifera* (George 1980) (Table 1.7) Out of this *P*. *indicus* is most important from the point of view of the size it attains and the economic importance. This is the most abundant species caught in gill nets.

The peak season is during monsoon months of June, July and August. However, depending on the successful monsoon fishery of *P*. *stylifera* at Neendakara, peak landings occur during July. Landings were also good during March and September. For traditional gear gill nets, July and August, February and March and for seines, August and September was the better season (Anon 1979a)

Table 1.7 Species-wise landings of commercially important penaeid prawns, non-penaeid prawns, lobsters, crabs and stomatopods of Kerala in tonnes for the years 1984-1988

	1984	1985	1986	1987	1988
Penaeid prawns	35529	26685	37098	52866	67498
Metapenaeus affinis	605	278	81	349	560
M. dobsoni	14388	12383	16333	23462	31847
M. monoceros	824	738	433	515	1176
M. acclivirostris	584	29	19	4	61
Parapenaeopsis stylifera	17140	10318	17558	24504	30923
P. canaliculatus	45	9	43	65	19
Penaeus indicus	1084	2423	2468	3725	2427
P. japonicus	1	-	1	2	15
P. monodon	12	3	12	12	51
P. semisulcatus	19	9	14	59	143
Trachypenaeus spp.	107	495	136	166	276
P. carinatus	-	-	-	3	-
Non penaeid prawns					
Acetus sp.	738	202	104	299	160
Lobster	53	93	50	139	112
Crab	469	974	1373	2560	2153
Stomatopods	7091	7817	9102	11223	11550
Total	43880	35771	47727	67047	81473

Neendakara is the most important centre where the maximum quantity of prawns are caught. At Neendakara P. stylifera is the most dominant species followed by M. dobsoni and P. indicus. At Cochin M. dobsoni followed by P. stylifera and P. indicus are the important species. At Calicut M. dobsoni, P. stylifera and P. indicus are the dominant species.

CHAPTER 2. PRAWN FISHING TECHNIQUES

2. PRAWN FISHING TECHNIQUES

2.0 PRAWN FISHING TECHNIQUES OF THE WORLD

Fishing techniques for harvesting prawns are diverse and varied to suit the specific requirements of each area. Thus from the age old practice of hand-picking (Gudger 1952, George et al. 1968) to trawling from sophisticated fishing vessels (Kristjonsson 1968) are employed for its exploitation. Brandt (1984) observed that scientists of different countries became interested in the development of fishing techniques during the end of the last centuary.

2.1 CLASSIFICATION OF FISHING GEAR AND TECHNIQUES

Hardy (1947) broadly classified the principles of fishing into three groups namely, luring, attacking and snaring; gill nets are included under the last category. Davis (1958) divided fishing gear into five types and included gill nets under drift nets. Klust (1959) based on the stress and strain developed on the gear while under fishing grouped them into three categories and fine gill nets like prawn gill nets are grouped under low strain fishing gear. Charernphol (1951) has classified the fishing gear of Thailand into five groups and gill nets are included under stationary nets. Sainsbury (1971) divided fishing gears into four groups and gill nets are included under static gear. A broad classification of fishing gear into active and passive categories was also proposed by Brandt (1984) and Sheshappa and Diogoenes (1985). George (1971) based on Brandt (1959a & 1962) has classified the inland fishing gear of India into nine classes with gill nets as a single type. George (1981) in his classification of the fishing gear of Karnataka state has followed Brandt (1972). Garcia and Le Reste (1981) reviewed the prawn fishing gear as artisanal and industrial. Nedelec (1982) classified the fishing gear into twenty groups based on International Standard Statistical Classification. Gill nets and entangling nets are included in one group with six subdivisions. The classification followed here is that of Brandt (1984) where the fishing techniques are grouped under 16 groups and gill nets and tangle nets are described separately.

2.2 PRAWN FISHING TECHNIQUES

2.2.1 Fishing without gear

Hand-picking of prawns are common in the estuaries and backwaters of Asian countries (Gudger 1952), so also in the paddy fields and shallow beaches of India (George et al. 1968).

2.2.2 Lines without hooks

This type of lines are operated for giant freshwater prawns in backwaters of Kerala (Job and Pantulu 1953, Kurien and Sebastian 1976 and Sebastian 1991).

2.2.3 Traps

2.2.3.1 Bush traps "Padangu"

Bush traps are operated in Kerala for prawns and fishes (Kurien and Sebastian 1976). Here coconut leaves with branches of trees are put in shallow waters. Later they are encircled with bamboo screens and the prawns collected. On the Ivory coast leaves of coconut trees are put in shallow waters to attract shrimps and the leaves are towed slowly towards the shore and the shrimps that escape are collected by scoop nets (Brandt 1984).

2.2.3.2 Net barriers

Walls of net are fixed along the shore or in tidal mud flats. Barriers are fixed during high tide and during low tide prawns and fishes that are inside the barrier are either gilled or entangled. Dar bondo of Sind (Sorley 1948), Pathi of Gulf of Kutch and South Gujarat, Moolakattu Vala of Kakinada bay and Godavari estuary, Kalamketti Vala of Adirampatanam (Ramamurthy and Muthu 1969), Char Pata Jal of West Bengal (Jones 1959), Malo Jalo or Bedha Jalo of Orissa (Mohappatra 1986) and Mal Jal of Bangala Desh (Anon 1978) are grouped under this sub class. These net barriers are also operated in Australia (Walker 1984) and Indonesia (Djajadiredga and Sachlan 1956).

2.2.3.3 Baskets

These are small split bamboo strip traps with retarding devices. This technique is extensively used in estuaries, lagoons and lakes where extensive migration of prawn with current occur. Daudi and Gaja (Job and Pantulu 1953) are baskets operated in Chilka lake of India. Similar traps are used in Benin (Lefebvre 1908), Australia (Walker 1984), Indonesia (Dajajadiredga and Schlan 1956), Malaya (Burdon and Parry 1954), Mexico and Florida (Higman 1952, De Sylva 1954, Idyll 1964), in California (Philipps 1931), in British Columbia (Butler 1963) and Alaska (Anon 1966). Use of lights to enhance the catch of these baskets has been reported from Mexico (Castello and Moller 1978), Dhomey and West Africa (Kristjonsson 1968). Massuti (1967) reported the operation of baskets attached to main line in a long line fashion off Majorca-Mediteranean. Baskets in the intertidal regions are operated in the traditional Indonesian shrimp fisheries (Unar and Naamin 1984) and these traps in Madagascar is known as Valakira (Crosneir 1965).

2.2.3.4 Drum like traps

In these traps the net body is firmly held with hoops and are having short wings. Mayer-Waarden (1931) reported extensive use of these nets in the German coastal fishery for Crangon crangon and Cheng (1984) observed them in Chinese waters as quoted by Brandt (1984) has also quoted the use of these nets in Japan for shrimps. Fyke nets called 'tesure' are operated in France for prawn (Faure 1955).

2.2.3.5 Weirs

These are wooden rafts erected in estuaries in various shapes so that the two ends form one way entrance. When water ebbs out, the stranded prawns and fishes are collected. These weirs called Thaithal, Adichil or Thattu (Kurien and Sebastian 1976) are extensively used in backwaters of India and Indonesia (Djajadiredga and Sachlan 1956). Similar weirs with catching compartments of different shapes have been reported by Le Reste and Marcille (1973) from Madagascar. Concrete poles with galvanised meshes are used in the Tapos of Mexico (Edwards 1978).

2.2.4 Aerial traps

The prawns when disturbed jump by reflex action and this habit is exploited for this type of fishing.

2.2.4.1 Boat traps

This is a scaring method extensively practised in Asia. In a typical case two canoes are tilted towards inside and connected with bamboo poles on both ends. From the bow of the canoes an iron chain is dragged along the ground which causes prawn to jump out of water. Further to attract prawns a kerosine lamp is also placed in the boat. This type of boat traps are known as Pachil, Changadom or Changala pachil (Panikkar 1937, Hornell 1938, Gopinath 1953, Job and Pantulu

1953 and Kurien and Sebastian 1976). Basket traps with scare lines are operated in Thailand (Charernphol 1951). Similar techniques with frames of netting on outer side of canoes are operated in Ryukyu Islands (Anon 1949). Use of white scare board to scare prawns into boat and use of nets to prevent further escape from boat is reported from China (Gudger 1937 and Lindblom 1943).

2.2.5 Bag nets

2.2.5.1 Scoop nets

Scoop nets with wooden frame and handle are operated from dhows in the Arabian peninsula (Selim 1968 and Thomas 1978).

2.2.5.2 Push nets

In this net, the mouth of the net is supported by a wooden frame. Push nets are operated in many parts of the world by one man wading in water. Vatta vala, Arippu vala of Kerala and Karnataka (Hornell 1938, Ramamurthy and Muthu 1969 and Kurien and Sebastian 1976), Dhobbudu or Pakkadevudu vala of Andhra Pradesh (Ramamurthy and Muthu 1969) are the Indian types. Push nets are also operated in Phillipines (Domantay 1956) and in Singapore (Kow 1955).

2.2.5.3 Scrape nets

The typical net is Yettudu Dimpudu operated in Kakinada bay and Godavary estuary (Ramamurthy and Muthu 1969, Kurien and Sebastian 1976). This net is operated in tidal areas. The mouth of the net is lowered with the rise in water level and is raised periodically to collect the catch with scoop nets. In certain cases leader net is fixed to guide more prawn to net.

2.2.5.4 Gape nets

These nets are operated in areas where there is a strong tidal current. The fish that enters more or less voluntarily are caught by filtering (Brandt 1984).

Stow nets without wings on stakes:

These nets are operated in shallow waters. Darbando of sind (Sorley 1948), Bhokshi Jal and Dol Jal of Bombay coast (Pillai 1948), Golva of Konkan, Dor or Dol of Saurashtra (Sorley 1948, Setna 1949, Gokhale 1957, Ramamurthy and Muthu 1969, Kurien and Sebastian, 1976, Ramamurthy 1985), Dol of Bombay (Kunju 1970 and George 1970, George et al. 1981) are operated along the Maharashtra, Gujarat and Sind coasta. Kurien and Sebastian (1976) and Pillai and Gopalakrishnan (1984) described small stow nets on stakes in the Rann of Kutch area. The Valu vala or Oonni vala of Kerala backwaters (Panikkar 1937, Hornell 1938, Gopinath 1953, Menon 1955, Panikkar and Menon 1956, Menon and Raman 1961) are identical to the Thokka vala and Gidasa vala of Godavari and Krishna dealts. Stow nets are also common in the Far East and West Africa (Miller 1953, Brandt 1959b, Garcia and Le Reste 1981).

Stow net without wings low anchor

Such nets are operated from anchor and hence in deeper waters. This type of fishing is called Sus fishing (Ramamoorthy and Muthu 1969). De Bondy (1968) described similar type of fishing from Senegal. Channel nets of U.S.A. (Tabb and Kenny 1969) are identical to Sus fishing. Paddy field prawn filter nets of Kerala (Panikkar 1937 and George et al. 1968) is a framed stow net.

Stow net with wings

The technique of fishing with these nets are identical to the stow nets without wings. The mouth of the nets is kept open by spreaders. These nets are operated in the Sunderbans by means of anchor. They are known as Behundi Jal, Bhim Jal, Thor Jal (Chopra 1939, Kunju 1956, Jones 1959, Pillai and Ghosh 1962, Ramamurthy and Muthu 1969, George 1971 and Kurien and Sebastian 1976). Operation of these nets in Bangla Desh has been reported by Nazer (1956) and Anon (1988b). Panch Kati Jal of Junput (Dan 1965) is identical to the Behundi Jal. Use of anchored boats, instead of anchors has also been mentioned by George (1971). The channel nets of North Carolina (Guthrie 1966) are similar to the Behundi Jal.

2.2.6 Dragged gear

All nets which are towed in water are grouped in this class. The most important industrial gear for prawn, the trawl, is included in this class.

2.2.6.1 Boat dredges

Qoofa operated from shrimp vessels in Kuwait (Brandt 1984) is a typical example of this type of fishing. The net is dragged from a moving boat.

2.2.6.2 Trawls

One boat sail trawls

Thallu madi are operated along Tuticorin area of Tamil Nadu (Bennet and Arumugam 1989). The main species exploited are *Penaeus semisulcatus* and *Metapenaeus dobsoni* (Sathiadhas 1989).

Beam trawls

The use of beam trawls for exploitation of shrimps in Humber is reported (Anon 1953). Beam trawls of the 'plumb staff' are operated in Alaska and North America (Nedelec 1975). Beam trawls were introduced into the Bombay waters by 1900 (Chidambaram 1952). Deshpande et al. (1962) had made studies on the effectiveness of beam trawls for shrimps along the Southwest coast of India. Mistakidas (1958) reported use of beam trawls by majority of boats in U.K. Beam trawl was used for *Crangon crangon* in Baltic sea (Henking 1927). A net with two sections for separating prawns and fish was described by Dutch in their beam trawls (Boddeke 1965 a,b). Electrified beam trawls are used in the shrimp fisheries in many parts of the world like North West Europe, East Asia and North America (Boonstra 1979).

Otter trawls

With the development of steam trawlers in France in 1985 and in U.K. in 1877 (Brandt 1984), otter trawls were introduced into the world fisheries especially that of N.W.Europe. In course of time this was also used for exploitation of shrimp. Kure et al. (1965) has recorded the operation of otter trawls for *Crangon crangon* in France. Prawn trawls of Australia are described by Grady (1956) and deep sea prawn trawling by Farwell (1952). Major types of Mexican shrimp trawls are described by Harvey (1951 & 1956). Marcille (1978) has also reported the use of small otter trawls in Madagascar, Mathews (1981a) and Zalinge (1984) have reported the use of trawls from Arab dhows in Kuwait and Arab peninsula.

Sheshappa (1958) recorded trawling investigations in its early stages in Indian waters. Accordingly fishing vessels like Golden Crown (1908-11) William Carrick (1921-22) and Lady Goschen (1927-30) had trawled along Bay of Bengal, Bombay, Kathiawar coast, Southwest and East coast. Japanese trawler

Taiyo Maru No.17 also conducted commercial fishing along Northwest coast in 1951 and the then Travancore Government in 1949 also conducted fishing along their coast. It was in 1955 that shrimp trawling from small mechanised boats was initiated (Kristjonsson 1968) with promising results and there was further improvements in the fishing gear rigging and operations. Kuriyan (1965) and Satyanarayana et al. (1962), have dealt in detail the various designs of shrimp trawls. Varghese et al. (1968) recommended bulged belly trawl in place of conventional trawls. Shrimp trawling in off-shore waters has been reported by George et al. (1963).

Multi rig trawling has replaced fishing with a single large trawl in many parts of the world (Sainsbury 1975). With the immediate success of trawling, the fishing technique was changed in Gulf of Mexico (Anderson 1948). Double rig trawls was employed and found successful by Texas fishermen in 1955 and later by Florida shrimpers (Knake et al. 1958). Double rig twin trawling was also tested off Texas coast, in 1971 (Harvey and Floyd 1972). Robas (1959) has elucidated the double rig trawling gear with try nets in the Gulf of Mexico. Dahlstrom (1970) reported the use of double rig trawl for Pandalus jordani. Walker (1984) has reported the use of double rig and multi rig trawls for prawns in Australia instead of beam trawls. Increased use of minimum drag trawl design and kort nozzles are also reported there. Gorman (1975) has made a statistical analysis of the Australian prawn trawl gear usage. Use of double rig trawl in U.S.A. was reported by Dumont et al. (1961) and in Surinam by Higham (1959). Double rig otter trawl system with four trawls were adopted for shrimp trawling in many countries of Central America, Arabian sea and Gulf of Guiena (Kristjonsson 1968) and in Mexico (Moya 1973). Double rig trawls with tickler chain has been found to be more effective for prawn in Texas (Guest 1958) and in Mexico (Fuss 1963a). Use of electric trawls to catch more prawns has been reported from America (Pease and Seidel 1967). Wathne 1964, Fuss 1964 and Fuss and Ogren 1966) have investigated the behaviour of shrimp in electrical field.

Namboodiri et al. (1977) has investigated the effects of impulse current in the increased exploitation of prawn along the Kerala coast. Panicker et al. (1977) studied double rig trawling in Indian waters. Rao et al. (1977) and Panicker et al. (1978) experimented with twin trawling and parallel twin body trawling, respectively. The successful establishment of double rig trawling in Vizhakapatanam for prawns has been reported by Rao (1988). He has also reported the introduction of mini trawler for double rig trawling at Vizhakapatanam. Trawling from traditional mechanised crafts are gaining importance along the Southwest coast of India (Hameed et al. 1988) and Vijayan et al. 1990). The main species caught are *Parapenaeopsis stylifera* and *Penaeus indicus*.

Pair trawls

Pair trawling is practised for penaues chinensis in Pohar sea. These nets are operated from sail ship as well as power vessels (Cheng 1984).

Midwater trawls

Use of midwater trawls with fish finder for Penaeus orientalis has been reported from yellow sea and East China sea of Japan (Hirano and Noda 1964). However, this has been discontinued later (Kristjonsson 1968).

2.2.7 Seine nets

2.2.7.1 Double stick nets

Koru vala of Karnataka (Hornell 1938 and George 1981) is of operated by two men for small prawns along Karnataka coast.

2.2.7.2 Beach seines without bag

Koru vala or Vadi vala of Kerala (Ramamurthy and Muthu 1969 and Kurien and Sebastian 1976), Kondala of Tamil Nadu (Hornell 1925), Konti vala of Andhra Pradesh (Rao et al. 1985) are beach seines with a number of cross bars in the mouth of net. These nets are operated by two men.

Shore seines are operated with towing warps with the help of a craft. Alvi vala of Andhra Pradesh and Orissa. Ramamurthy and Muthu 1969, Kurien and Sebastian 1976, Rao et al. 1985 and

Mohapatra 1986) are shore seines without bag. Devi (1985) has reported the preference of Chinna Alvi vala for prawn in Uppada area of Andhra Pradesh. The kairampani, Yendi or Pag of Karnataka coast (Hornell 1938, George 1981 and Ramamurthy, 1972). Nona vala of Alleppy in Kerala (Kurien and Sebastian 1976) Vendi of Konkan and Ind of Gujarat (Sorley 1948) are all beach seines. Beach seines are also operated in estuaries and shallow waters of Florida and Mexico (Idyll 1964, Higman 1952 and De Sylva 1954). These nets are also reported from Singapore (Kow 1955), Malaya (Burdon and Parry 1954) and Pakistan (Quershi 1955). Prawns are also occasionally caught in Rampani (Hornell 1938, Pradhan 1956 and George 1981).

2.2.7.3 Beach seines with bags

These seines are distributed all along the Indian coast. Periya valai or Karmadi of Tamil Nadu (Hornell 1925 and Ramamurthy and Muthu 1969) Pedda vala of Andhra Pradesh (Rao et al. 1985), Ber jal of Orissa (Mohapatra 1986), Kamba vala, Kara vala or Karamadi or Vizhingam (Nayar 1958) are identical. These nets do catch a substantial quantity of prawn along with fishes.

Single boat seines

Thangu vala or koru vala (Kuriyan et al. 1963, Kuriyan 1965, Kurup and Rao 1974, George 1981 and Mathai et al. 1985) is a single boat seine operated along the middle of Kerala coast where prawns are also caught during the 'Chakara' season in Southwest monsoon. At present these nets are being replaced by ring seines.

Two boat seines

Two boat seines are widely distributed in the fisheries of East and South Asia (Brandt 1984). Thuri vala of Tamil Nadu (Hornell 1925, Thyagarajan and Thomas 1962, Menon 1980 and Vivekandan 1986) and Iraga vala of Andhra Pradesh (Rao et al. 1985 and Irragali of South Orissa (Mohapatra 1984) are two boat seines. These nets can be operated along the bottom also. Very valai and Senna kuri valai of Tamil Nadu (Hornell 1925) are small meshed editions of Thuri valai for Acetes sp. Madi valai, Thathumadi (Hornell 1938, Nayar 1958, Thyagarajan and Thomas 1962 and Menon 1980) is a two boat seine operated along the Gulf of Mannar and west coast of Tamil Nadu.

Kolli nets of Malabar coast variously known as Odam vala, Paithu vala, Vattom vala and Sultan vala (Hornell 1938, Rao 1973, Ramamurthy and Muthu 1969 and Anon 1951) are also operated for prawn especially during the monsoon and post monsoon period.

2.2.8 Surrounding nets

2.2.8.1 Surrounding nets without purse line

This type of nets are operated for prawn in South Kanara coast of Karnataka in the inshore areas from two motorized traditional crafts during monsoon period when mechanised fishing is not possible. The main species caught are Metapenaeus dobsoni Penaeus indicus and Parapenaeopsis stylifera (Sukumaran 1985 and 1987).

2.2.8.2 One boat purse seines

One boat purse seines are operated in the coastal waters of Japan for Metapenaeus joyneri (Kristjonsson 1968). A mini purse seine for coastal crafts has been designed by Panicker et al. (1985). Single boat seines are operated along the Kerala and Karnataka coasts from mechanised and traditional crafts.

2.2.9 Lift nets

2.2.9.1 Lever lift nets:

These nets are common in the coastal waters of Mexico (Inglis and Chin 1966, Guest 1958 and Fuss 1963a). Similarly in Kerala also the Cheena vala or Kamba vala (Hornell 1938 and Iyer 1909) are operated in the backwaters for prawns and fish.

2.2.9.2 Blanket net:

Eda valai, Mada valai, Kambi valai of Coromandel coast of Tamil Nadu (Hornell 1925 and George 1985) is a lift net operated from four Kettumarams with lure line or kambi. In addition to fish, prawns are also captured. Marla of Ganjam coast, Orrisa (Mohapatra 1986) is a blanket net operated without lures.

2.2.10 Falling gear

2.2.10.1 Cover pots:

Domantay (1956) has reported the use of cover pots for *Penaeus monodon* in Philippines.

2.2.10.2 Cast nets:

Cast nets are widely used in many countries of the world in the artisanal sector. Cast nets are used in Mexico, South America (Inglis and Chin 1966 and Lender 1957) in North Carolina (Broad 1951), Indonesia (Djajadiredga and Sachlan 1956), Brazil (Villegas and Dragovich 1984). In India, cast nets are operated from boats or beach, the former being larger in size.

2.2.11 Gill nets

Single layered drift nets are either exclusively used for prawn or for prawn and other fishes.

These prawn gill nets are used in China (Cheng 1984), in the traditional fishing sector of Indonesia (Unar and Naamin 1984) and in Pakistan (Quershi 1955). Single walled drift nets are used for catching crustaceans and they are set vertically or even slopping as in Mauritanian coasts, in the latter case for increased entangling (Brandt 1984). Loop vala of Kerala (George and Brandt 1975), Ara valai of Tamil Nadu (Menon 1980) are gill nets of multifilament nylon operated as off bottom gill nets. Vivekānanda et al. (1980) has reported that Ara valai landed

11.9% of the prawn catch of Tamil Nadu. Kathirvel et al. (1985) has stated that Penaeus indicus in bulk and P. monodon are caught in Ara valai during January to June. Vaisali vala (George 1990) is identical to the loop vala but made of nylon monofilament. Kilia vala of Andhra Pradesh (Menon 1980, Rao et al. 1985 and Ramamurthy and Muthu 1969) are same as loop vala. Kiluni vala or silkiwala of Orissa (Mohapatra 1986) is identical to kilia vala. Jagawala of Orissa (Mohapatra 1986) is a bottom drift gill net operated for prawn and croakers. Ral valai or Tamil Nadu (Menon 1980) is operated for prawns and lobsters. Behendi jalo of Orissa (Mohapatra 1986) is a surface drift net for prawn and small fish. Vala valai of Tamil Nadu (Hornell 1925) and Kafla vala of Andhra Pradesh (Anon 1978) are gill nets for prawn and fishes. George (1981) has mentioned the use of drift gill nets for prawn while reviewing the trawl bycatch. Luther (1982) described the prawn gill net, Kocchu vala operated at Vizhinjam. Srivatsa (1954) while dealing the fishing gear of Saurashtra has reported of gill nets operated for prawns. Devi (1985) while describing prawn fishing technique of Andhra Pradesh has grouped nylon prawn gill nets into four types as Madras, Jookavala, Big silk net and kilevala based on mesh size. George and Suseelan (1980) has reported that gill nets are constituting 3.9% of the catch of prawn in India, and Tamil Nadu and Maharashtra produces the maximum quantity of prawn by gill nets.

Sankoli et al. (1991) has described the operation of Tiyani a bottom gill net for prawn in the Konkan region during monsoon. Mathai et al. (1990) has investigated the selectivity of gill nets in Zuari estuary.

Horizontal combination gill nets with monofilament webbing for fishes in the upper part and multifilament webbing in the lower part for prawns are operated along Tamil Nadu (Menon 1980) and Andhra Pradesh (Anon 1978). Further modification of combination nets with vertical and horizontal panels for fishes like mackerel and prawns are operated in Tanjore district (Menon 1980).

2.2.12 Entangling nets

Single layered bottom set entangling nets are used along the Kerala and Karnataka coast. Kanda bala (Hornell 1938), Kandha bala (George 1981), Kanatha bala or Kantha bala (Rai 1962 and Sebastian and Kurien 1976) belong to this category. Nandakumar (1988) and Sukumaran (1987) reported the operation of these nets during monsoon for prawn along the Mangalore coast. Entangling nets are also used in Philippines (Domantay 1956). Joel and Ebenezer (1985) reported the extensive use of trammel net known as Disco nets in Kanayakumari district of Tamil Nadu which is said to be replacing the Ral valai used hitherto for prawns. Kathirvel (1985) reported bumper catch of *Penaeus indicus* with these trammel nets - Mani valai off Madras, while Sathiadhas

(1989) reported the operation of these nets from mechanised boats during June to September, off Tuticorin. These nets are so effective and are used along the east coast of India and Bangla desh (Anon 1988b). Soodhom as quoted by Nedelec (1987) has also reported use of Trammel nets for tiger prawns in Malaysia. Engvall (1991) described the origin of trammel net fishing in the world and suggested the utility of trammel nets for prawn in the traditional trawling grounds of 20 - 50 m depth, as an alternative for trawling.

Brandt (1984) and Kristjonsson (1968) have reported an entangling net for Penaeus japonicus in Japanese waters. Here the lower end of the net is turned into pockets into which prawns get entangled while jumping. Recently a new type of this net Genshiki Ami with the pockets having arch shaped openings at the bottom allowing the shrimp to enter the pocket of the net as it sweeps the bottom has been introduced (Brandt 1984 and Kristjonsson 1968). The operation of these nets from Mikawa bay in Japan has been reported (Anon 1977b).

Combined entangling and gill nets with lower trammel nets are used in the Mediterranean and Japan (Brandt 1960) and in Japan (Brandt 1984, Breme 1987 and Fahfouhi and Assabir 1987). Bishi and Shahensha of Ratnagiri (Sankoli et al. 1991) is a combination net of the above type operated for Penaeus merguiensis in Ratnagiri during monsoon.

2.3 IMPORTANCE AND RELEVANCE OF THE PRESENT STUDY

Gulbrandsen (1988) has emphasised that developing countries attach increasing emphasis on small scale fishing to provide employment and income to fishing community and that traditional craft fishing must not be under estimated. Willman and Garcia (1985) while reviewing the shrimp fishery of Surinam have stated that penaeid shrimps are traditionally exploited in many tropical countries by artisanal fishermen and it was by the fifties, industrial fishing expanded. Further, artisanal shrimp fisheries require small investment in craft and operate the gear which are energy saving, use little imported inputs, supply cheap and highly nutritious food and they provide food and income to a large number of the poor fishing families. Nair (1989) while reviewing the course of mechanisation in Kerala has stated that mechanisation of craft and gear picked up early due to high returns from shrimp trawling. During the sixties, cotton webbing gave way to nylon and later to polyethylene etc. Late seventies witnessed introduction of purse seining. By eighties, motorisation of traditional crafts started accompanied by change in fishing gear, like introduction of ring seine. Later mini trawls, gill nets etc. were extensively used. This sudden and quick change in exploitation of resources and fishing techniques warrants immediate steps to rationalise exploitation. In the coastal waters of developing countries, there seems to exist a considerable amount of demersal fishery resources which are not yet surveyed and exploited (Anon 1979b).

These resources can be exploited by gill net fishing as this method is relatively easy, with low initial cost and the catching rate can be improved by future improvements (Anon 1979b).

In view of the extended fishery under the exclusive economic zone, gill nets are becoming more important because of its low cost and low consumption of energy. However this gear may not be economical in traditional fishing unless the target species are high priced fishes and crustaceans (Brandt 1984). Hubert (1983) has also mentioned the advantage of passive capture technique over active ones in saving fuel and has grouped these techniques into two, entanglement and entrapment. Until recently, trawling was considered as the most important industrial fishing method for prawns and many agencies have competed to improve the performance of these trawls. Increasing cost of fuel has given second thoughts to the prospects of trawling (Brandt 1984). Perhaps this may not be so acute in shrimp trawling. However, there is marked reduction in the landings of prawn from trawlers, as at Cochin, where the prawn catch per trawler trip of 110.0 kg in 1975-1979 was reduced to 70.0 kg during 1980-84 (Jacob et al. 1987). Further, prawn catch per hour of trawling in Kerala has come down from 15.81 kg in 1971 to 5.71 kg in 1982 (Kalawar et al. 1985).

The trawling may be at a disadvantage with increasing fuel prices (Anon 1979c). Endal (1980) based on his investigations in

Norwegian waters indicated that purse seining is the most energy efficient method of fishing followed by long lining, gill netting and fish trawling, while shrimp trawling is the most energy intensive. Sheshappa and Digoenes (1985) in their investigation on vessel profitability for off shore fishing along the west coast of India with reference to active and passive fishing technique have noticed that the energy yield (kg of fish per kg of fuel) for long lining is almost three times more than that of trawling, further better income is also with the long line crew than that of trawler. Panikkar et al. (1991) while studying economics of fishing techniques with reference to fuel efficiency have observed that oil expenditure is minimum for gill net operation. Brandt (1984) has advocated gill netting as a fishing method with low energy consumption calculated on the relationship of fuel/fish (both in kg) and this fact will have a growing influence on the fishery with gill nets in near future. The conference on "Appropriate technology for alternative energy sources in fisheries" focussed attention on the development and use of passive gears and suggested that efforts should be made to improve methods of fish capture which were relatively fuel efficient per unit production (Anon 1982c). George et al. (1981) has estimated that the bycatch from trawlers of India for 1979 as 3,15,902 t or 79.18% of the trawl catch. Engvall (1990) has also reported the bycatch from shrimp trawling in the tropics and has stated that along the Northeastcoast of India 1,00,000 t of bycatch are discarded. He has even advocated the banning of trawling in the inshore waters.

Gill netting in the coastal waters is a practical method for development of coastal fisheries as it is simple with relatively small outlay but with high performance (Anon 1984b)

Owing to large scale migration during monsoon season Penaeus indicus can be advantageously harvested along the south west and southeast coast of India during the above period (Suseelan and Rajan 1991). Further, gill net catches are more profitable, as it is supported by larger species belonging to Penaeid group which carries high unit value. Prawn gill nets along Kerala coast have been recorded by George and Brandt (1975) and this is identical to Ara valai of Tamil Nadu (Menon 1980). In Tamil Nadu the most significant gear development in the traditional fisheries has been the introduction of bottom drift prawn gill net which by far is the most widely used type of gill net and this is due to the lucrative price of prawn (Anon 1978). George and Suseelan (1980) have reported that gill nets are being increasingly used in several areas for catching the large sized prawns which are in great demand from the industry. They have also stated that gill nets of different mesh sizes are used and during 1978 about 3.9% of the prawn catch was contributed by gill nets. Thus in the changing pattern of prawn fishing in the country, gill nets are becoming more important. With the allocation of the coastal waters for traditional fishing along the Indian coast by various maritime states (Varghese 1989) and with the ban on trawling in these waters especially during monsoon as in Kerala, alternate fishing techniques have been suggested. Nair (1989) has recommended trammel nets, gill nets and boat seines (Thangu vala) which are less harmful in the inshore areas to avoid under exploitation of the resources. Vivekanandan et al. (1986) reported that gill nets land about 11.9% of prawn catch of Tamil Nadu. Based on the landings of 1985-89, Suseelan and Rajan (1991) have observed that gill nets contribute 4% of the landings of traditional sector of India. Gill nets landed 1,200 t or 11.2% and 1,000 t or 34.1% of the prawn catch of Kerala and Andhra Pradesh respectively. At Pentakota, gill nets landed Metapenaeus affinis 46%, Penaeus indicus 27% and P. monodon 3%. At Mandapam, P. semisulcatus contributed to the bulk of the catch (Anon 1990c)

According to Jacob et al. (1985), there are 3,78,819 drift gill nets in India of which 23,307 are in Kerala. Considering the subsequent addition of gill nets, it is safe to estimate that there are about 12,000 gill nets for prawns in Kerala.

As no in-depth studies have been conducted on this fishing gear except that of Mathai et al. (1990) on the gill nets of

Zuari estuary and in view of its importance it was considered apt to undertake further investigations on this fishing gear which form the material for this study.

CHAPTER 3. MATERIAL AND METHODS

3. MATERIAL AND METHODS

3.1 FISHING GROUND

Fishing experiments were centred around three adjacent stations namely, Saudi, Lat. 09°57'N, Long. 76°14.4'E; Beach road, Lat. 09°57.4'N, Long. 76°14.2'E and Fort Cochin. Lat. 09.57.6'N, Long. 76.14.1'E. (Figure 3.1). The bottom of the fishing ground was generally muddy and the depth ranged from 8.0 to 20.0 metres.

3.1.2 Depth of the fishing ground

The depth of the ground was measured with a sounding lead (5.0 kg) to which 12.0 mm dia rope marked at 0.5 m interval was attached. Depth was taken in the beginning and end of each operation and average was taken as the depth of operation.

3.2 PERIOD OF INVESTIGATIONS

The various investigations which included studies on (1) selectivity of material, (2) selectivity of mesh size, (3) coefficient of hanging, (4) colouration, (5) fishing height of the net and (6) hydrography studies, were conducted during the period from 1985 to December 1987.

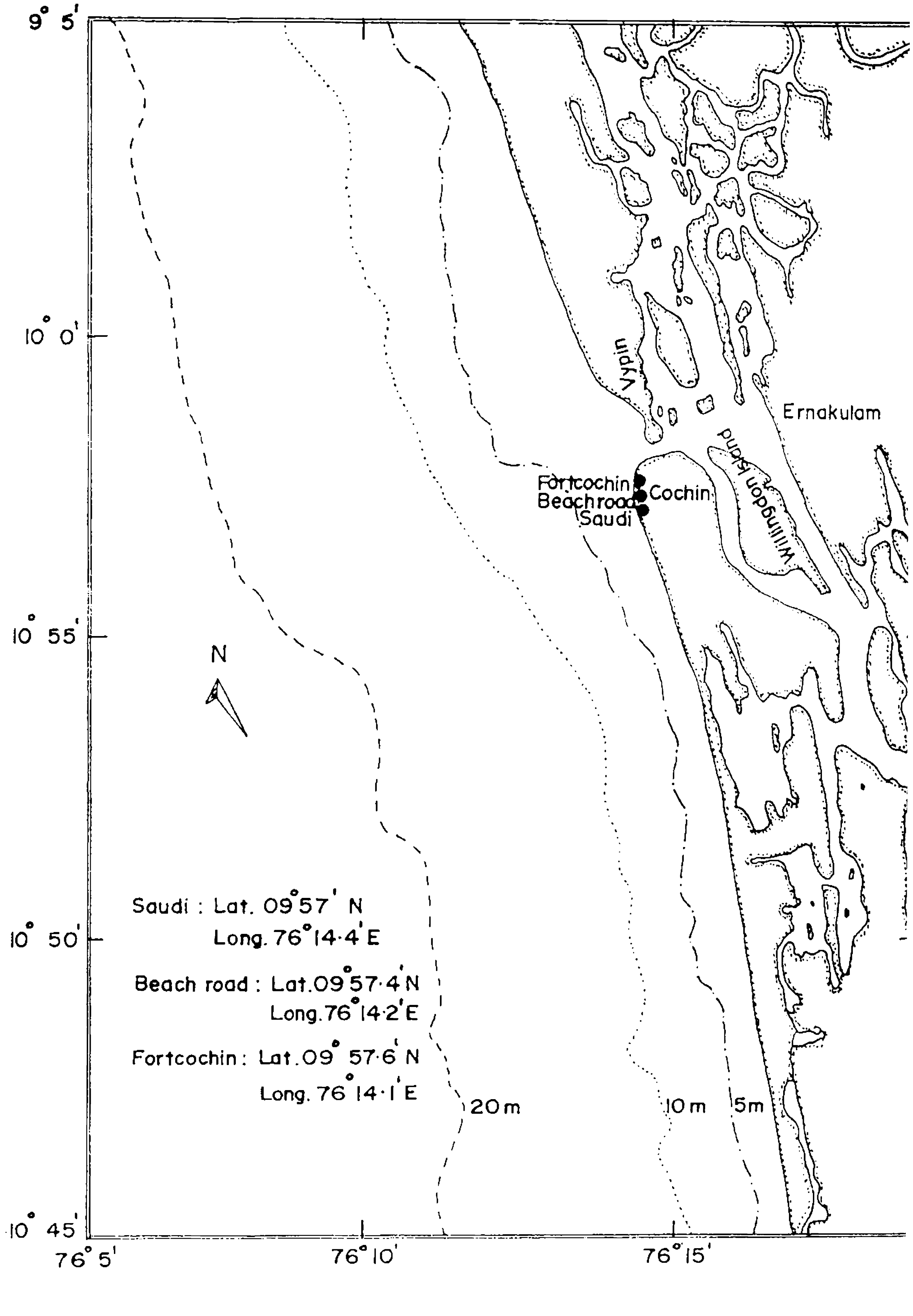


Fig. 3.1. Fishing Ground

3.3 CRAFT

A plank built canoe of 8.90 m LOA manned by a crew of 4 was used for the experimental fishing. The craft was propelled manually most of the time and sail was used occassionaly while fishing in deeper waters.

3.4 FISHING GEAR

Gear for this study consisted of 44 units of nets. Each unit has a 30.8 m long head rope and foot rope and a fishing height of 6.6 m. The net was hung with a hanging coefficient of 0.5 for routine observations and with 0.4, 0.5 and 0.6 for studies on the effect of hanging coefficients on catch. The details of each net used for different investigations are furnished in Table 3.1 a,b,c. Design of a gill net unit fabricated of nylon multifilament twine of 210Dx1x2 with 34 mm stretched mesh (net no.2 of Table 3.1a) is given in Fig. 3.2 along with accessories and rigging. Salient features of the gear used for each investigation, are given below.

3.4.1 Selectivity of materials

For this study nets of nylon, multifilament twine, polyethylene twisted monofilament and polyethylene monofilament yarn were used. Three sets of nets, each set consisting of nine nets (net nos. 1 to 27 of Table 3.1a), were used. The

Table 3.1a Design of the experimental nets

Particulars of netting

	Main netting									Selvedge
Material type and size	Nylon multifilament twine (210Dx1x2)/polyethyele twisted monofilament (0.45 mm dia)/polyethylene monofilament yarn (0.268 mm dia)									PA multifilament 210Dx4x3
Mesh size stretched mm	32.0	34.0	38.0	42.0	46.0	50.0	52.0	54.0	56.0	50.0
No. of meshes										
Length	1925	1815	1625	1470	1340	1232	1185	1142	1100	-
Depth	238	224	200	182	165	152	146	141	136	1.5
Coefficient of hanging	0.5									
Fishing height m	6.6									

Particulars of lines and ropes

	Material	Size (dia) mm	Length m
Head rope	Polyethylene	4.0	30.8
Foot rope	Polyethylene	4.0	30.8

Particulars of accessories

	Numbers	Material	Shape	Size mm	Buoyance g	Weight in air (total) g
Floats	35	Polyvinyl chloride	Cylindrical	65x18	65/No.	-
Sinkers	6	Stone	Irregular	-	-	900.00

Serial Nos. 1 to 9 Nets of Nylon multifilament twines of increasing mesh size.
10 to 18 Nets of Polyethylene twisted monofilament of increasing mesh size
19 to 27 Nets of polyethylene monofilament yarn of increasing mesh size

Table 3.1b. Design of the experimental nets

Particulars of netting

	Main netting								Selvedge
Serial No. of set	35	28	29	30	31	32	33	34	
Material	Nylon (PA) multifilament twine								
Size	210Dx1x2								210Dx4x3
Colour	White	Violet	Indigo	Blue	Green	Yellow	Orange	Red	
Streched mesh size, mm	42								50.0
No. of meshes Length	1470								
Depth	182								1.5
Coefficient of hanging	0.5								
Fishing height m	6.6								

Particulars of line and rope

	Material	Size dia mm	Length m
Head rope / Foot rope	Polyethylene	4.0	30.8

Particulars of accessories

	Number	Material	Shape	Size mm	Buoyancy	Weight in air (total) g
Floats	35	Polyvinyl chloride	Cylindrical	65x18	65/No.	..
Sinkers	6	Stone	Irregular	..	..	900

Table 3.1c Design of the experimental nets

Particulars of netting

	Main netting									Selvedge
Serial No. of net	36	37	38	39	40	41	42	43	44	
Material	Nylon (PA) multifilament twine									
Size	210Dx1x2									210Dx4x3
Stretched mesh size, mm	38.0	38.0	38.0	42.0	42.0	42.0	46.0	46.0	46.0	50.0
No. of meshes										
Length	1350	1625	2025	1223	1470	1835	1118	1340	1675	-
Depth	218	200	190	197	182	172	179	165	157	1.5
Coefficient of hanging	0.6	0.5	0.4	0.6	0.5	0.4	0.6	0.5	0.4	
Fishing height m	6.6									

Particulars of lines and ropes

	Material	Size (dia) mm	Length m
Head rope	Polyethylene	4.0	30.8
Food rope	Polyethylene	4.0	30.8

Particulars of accessories

	Number	Material	Shape	Size	Buoyancy	Weight in air g (total)
Floats	35	Polyvinyl chloride	Cylindrical	65x18	65/No.	-
Sinkers	6	Stone	Irregular	-	-	900

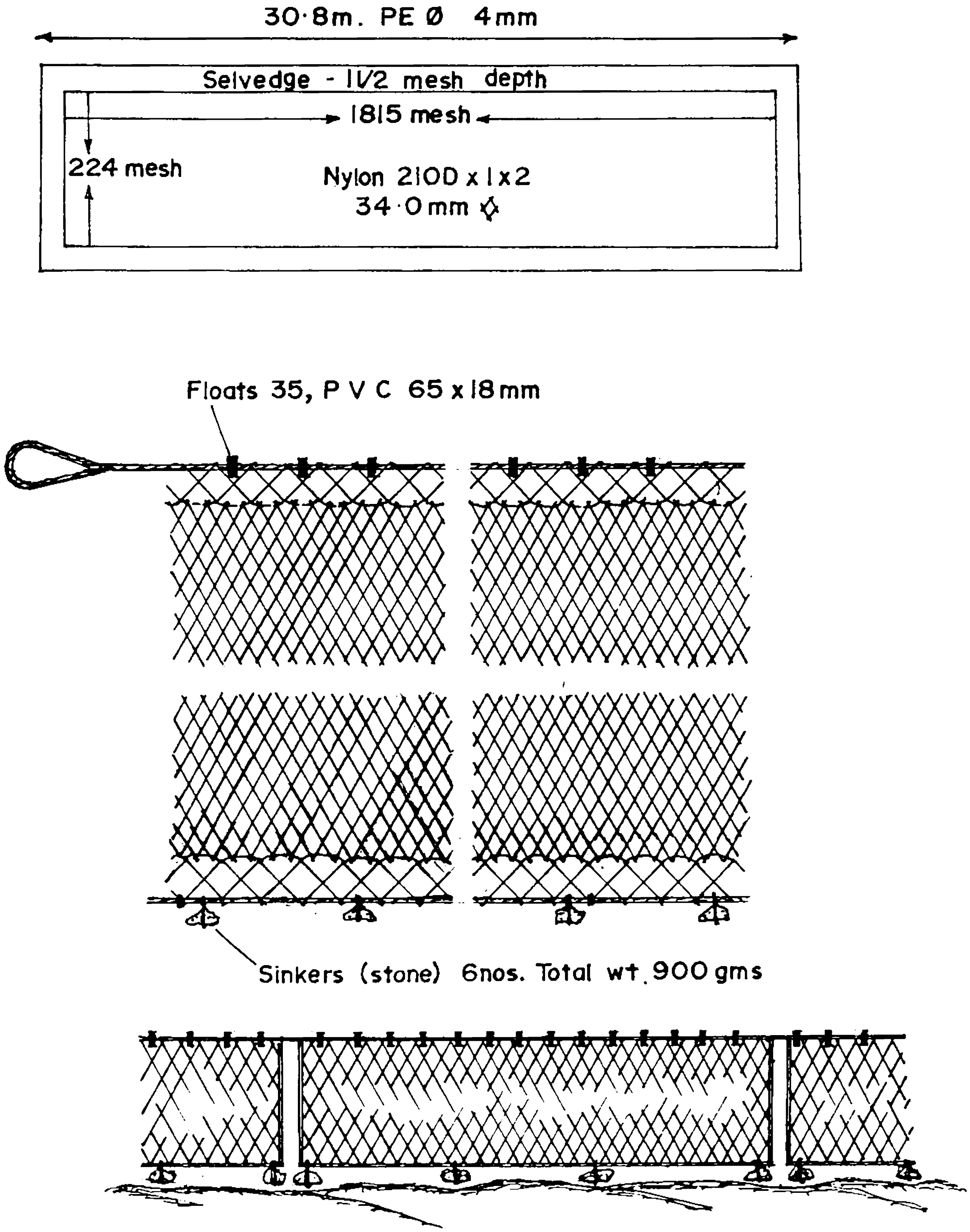


Fig. 3. 2. Design details of the experimental gill net.

first set of nine nets (net nos. 1 to 9 of Table 3.1a), had nylon multifilament of 210Dx1x2 and 0.370 mm dia as the main netting material, while the second set of nine nets (net nos. 10 to 18 of Table 3.1a) were of polyethylene twisted monofilament of 1x3 construction and twine diameter of 0.45 mm and the third set of nine nets (net nos. 19 to 27 of Table 3.1a) were fabricated with polyethylene monofilament yarn of 0.268 mm dia. The nine nets of each set had mesh size, 32.0, 34.0, 38.0, 42.0, 46.0, 50.0, 52.0, 54.0 and 56.0 mm. Experiments on physical tests of twines and netting are dealt in detail in section 4.1.

3.4.2 Selectivity of mesh

The gear included nine nylon multifilament nets (210Dx1x2) of mesh size 32.0, 34.0, 38.0, 42.0, 46.0, 50.0, 52.0, 54.0 and 56.0 mm stretched mesh (net nos. 1 to 9 of Table 3.1a).

3.4.3 Coefficient of hanging

Three sets of nylon multifilament nets (210dx1x2) with mesh size 38.0, 42.0 and 46.0 were used in this study and each set consisting of three nets was hung with coefficient of hanging 0.4, 0.5 and 0.6 (net nos. 36 to 44 of Table 3.1c)

3.4.4 Colouration

Eight nylon multifilament nets (210x1x2) of uniform mesh size of 42.0 m dyed with violet, blue, green, indigo, yellow, orange and red along with white (control net) was used for this investigation (net nos. 28 to 35 of Table 3.1b)

3.4.5 Fishing height

Nylon multifilament (210Dx1x2) net with a mesh size of 32 mm (net no.1 of Table 3.1a) was used for this experiment.

3.5 PHYSICAL TESTS OF YARN AND NETTING

The tests carried out included diameter, linear density, breaking load and stiffness of the yarn as well as the weight and strength of the netting. The diameter was taken with a travelling microscope and weight with an electronic balance SARTORIUS 2004 MP. All the load tests were taken with a Universal Testing Machine (UTM) ZWICK 1484. The details of the tests are given in 4.1.

3.6 FISHING OPERATIONS

The fishing operations were conducted from early morning till afternoon. On reaching the fishing ground the depth was noted using the sounding lead. The net was paid out from the canoe and on completion a rope (polyethylene 10 mm dia) of 30.0 m long was attached to the boat end of the net and later to the boat. The net was allowed to drift for 45 minutes, except under conditions of unfavourable weather when the net was hauled up before completing the scheduled period. Information collected included duration of soaking and details on total catch of fish and prawn from each net along with the length of prawn.

The weight of fishes was taken as wet weight of each group on the shore.

Length of prawn was measured using the measuring board and the length referred in the test is the total length (from the tip of telson to the tip of rostrum). The weight of individual prawn was determined with an electronic balance (SARTORIUS 2004 MP).

3.7 HYDROGRAPHY

Data on these aspects were taken at 12.00 am of the day of sampling. The procedure adopted is given below:

3.7.1 Turbidity

A Secchi disc made of a flat circular iron disc 30.0 cm in diameter, the upper surface of which is divided into four equal parts and painted alternatively with black and white paint was used for this purpose. The lower side is provided with sinkers and upper side is provided with a rope marked at intervals of 25.0 cm. While measurements are taken, the portion less than 25.0 cm length was measured with a metre scale. Extinction coefficient was computed from secchi disc reading using the relationship 1.7/D where D is the depth in metres at which secchi disc just disappears from sight (Poole and Atkins 1929). Turbidity was noted during each day of operation and the average value worked out for the month.

3.7.2 Cloudiness of the sky

Cloudiness was recorded at 12.00 am on each day of fishing following the method of Anon 1950, and the average for the month was worked out.

3.7.3 Temperature

An ordinary chemical thermometer with an accuracy of 0.1°C was used to measure the temperature of air and surface water. The water sample was drawn from the fishing ground by taking a sample in a plastic bucket. Temperature was recorded once on each day of operation and average value for the month was computed.

3.7.4 Dissolved oxygen

Dissolved oxygen of surface water was estimated once in a fortnight by Winkler method (Strickland and Parson 1968). The average value for each month was calculated from the measurements.

3.7.5 Rainfall

Data on rainfall were gathered from the Indian Daily Weather Report published by Director General of Metereology (Weather Forecasting) Metereological Office, Pune-5.

3.8 DESCRIPTION OF A TYPICAL GEAR

Each unit of gear is a rectangular net 30.8 m in length and 6.6 m in depth (fishing height). The material used for the main netting was different depending on the type of investigation. However nylon multifilament (210Dx1x2) was taken as the standard. The main body of the netting was strengthened on four sides by a row of selvedge of nylon multifilament (210Dx4x3) of 50.0 mm mesh size. The main netting was hung to the selvedge on equal length basis by nylon twine (210Dx1x3). The head rope and foot rope were of polyethylene rope 4.0 mm dia and 30.8 m long. These ropes were passed through the selvedge meshes and fixed at regular intervals. The design details of a 34 mm mesh nylon multi-filament net is given in Fig. 3.2.

Cylindrical polyvinyl chloride floats of 65.0x18.0 mm size with central bore of 10 mm was used as floats. Granite stone chips were used as sinkers and attached to the foot rope by thin coir ropes.

CHAPTER 4. RESULTS AND DISCUSSIONS

4. RESULTS AND DISCUSSIONS

4.1 SELECTIVITY OF MATERIALS

In a highly selective gear like gill nets, materials used for fabrication plays a dominant role. Due to complexity of fishing operation, no material can be considered as ideal either for a particular fishery or gear, but a compromise can be made as to what is best among available materials.

Earlier attempts were mainly focussed on the comparative merits of synthetic nets over nets of natural fibres in terms of out put. Superiority of nylon (polyamide) gill nets over cotton/linen is reported by Lawler (1950), Molin (1950, 1956), Giesel (1953), Anon (1954), Shabtay (1956) and Pycha (1962) to mention a few. The commercial application of polyamide (PA) for the construction of gill nets was reported by Firth (1950).

A more in depth treatment of the subject, can be seen in the work of Young (1950), Brandt and Liepolt (1955), Saetersdal (1959) and Muncy (1960). Distinguishing features of spun, monofilament and multifilament nylon gill nets are also reported by Molin (1955, 1956), Brandt and Leipolt (1955), Rahm (1955) and Carrothers (1959). A more detailed study of this aspect is given by Pristas and Trent (1977). Catch efficiency of nets of different groups of synthetic fibres received the attention of many workers (Carrothers 1962, Honda and Osada 1964, Zaucha 1964 and Anon (1959 a,b).

4.1.1 Materials in use for gill nets

Klust (1959a and 1960) mentions polyamide and polyester fibre as suitable for gill net fabrication. Klust (1959b) classified German fishing gear into different groups based on the strain on the netting and suggested the use of polyamide for fine gill nets with low strain and polyamide, polyester (PES), polyethylene (PE) and polypropylene (PP) for gears with medium strain, to which group drift nets belong. Steinberg (1964) experimented with polyethylene gill nets along with nylon and Pajot (1980) used PE for large meshed heavy gill nets. Carter and West (1964) advocated the use of polypropylene for gill nets.

4.1.2 Status of synthetic materials in India

The first comparative fishing experiment with cotton and nylon nets in a systematic manner was done by George and Mathai (1972) in Gobindsagar reservoir. Comparative fishing experiments in marine waters with polyethylene tape twisted twine for large mesh gill nets and nylon monofilament for small meshed fine gill nets were undertaken by Radhalakshmy and Nayar (1985). Khan et al. (1975) have compared the performance of nylon mono and multifilament gill nets. Use of continuous multifilament twine and monofilament for lower and upper parts of gill nets is reported by Ratcliff et al. (1978). Pillai et al.

(1989) and Mohan Rajan et al. (1991) have reported the results of fishing experiments with polyethylene yarn, polyethylene twisted monofilament and polypropylene twine gill nets in comparison with nylon twine gill nets.

4.1.3 Choice of material for gill nets

Choice of material for a gear depends on availability, properties and economics. These properties directly or indirectly, independently or interdependently influence the choice of material. The relation between diameter of twine to mesh bar (d/a) is referred to as unit of resistance (Anon 1959a). The high breaking strength of the material allows the use of finer continuous filament twines to gill the fish effectively. Baranov (1948) has worked out separate constants for the relation d/a, for soft bodied and hard bodied fishes. The elasticity of nylon is cited as beneficial in allowing fish to force through the mesh and get caught, accounting for larger size (Young 1950, Atton 1955) or wide range of fish sizes with a given mesh size (Saetersdal 1959). Steinberg (1964) opines that catch efficiency depends not only on the construction but also on the properties of netting yarn, especially visibility, softness, diameter and breaking strength. The fact that monofilament is invisible under water and that the knots of polyethylene is less visible than continuous filament led to experiments with mono and multifilament nets by many workers (Larkins 1964, Washington 1973, Collins 1979, Hylen and Jakobson 1979 and Satyanarayanappa et al. 1990). An interesting development in netting yarn is the experience with multimono gill nets (Anon 1984c).

4.1.4 Material and methods

Nylon multifilament twines of size 210Dx1x2, polyethylene twisted monofilament and single yarn formed the samples. As the nettings of these materials were available the finest under each category was chosen for the investigations.

The physical properties of the netting yarn were determined as per Indian Standard 5815 Parts I to IV (Anon 1970 a,b; 1971 a,b). The quantity of material required for a given size of netting was determined and strength of netting of varying mesh sizes was recorded.

4.1.4.1 Netting yarn

Diameter

The sample was kept under standard tension (Tex/2) and the diameter was measured using a travelling microscope.

Linear density

A known length of the sample was cut off from the material kept under standard tension and mass determined with an electronic balance SARTORIUS 2004 MP. The mass in grams for 1000 m length of material expressed as Rtex and length of material for unit mass (kg) in metre were calculated.

Breaking load and elongation

The material was strained in between the grips of Universal Testing Machine (UTM) ZWICK 1484 and the test speed adjusted so as to break the specimen within 20 seconds. The breaking load and elongation was recorded and the load elongation curve was drawn autographically (Fig. 4.1).

Wet knot breaking load

To determine this the sample was kept for 24 hours in water and an over hand knot was tied and tested in the same way as above.

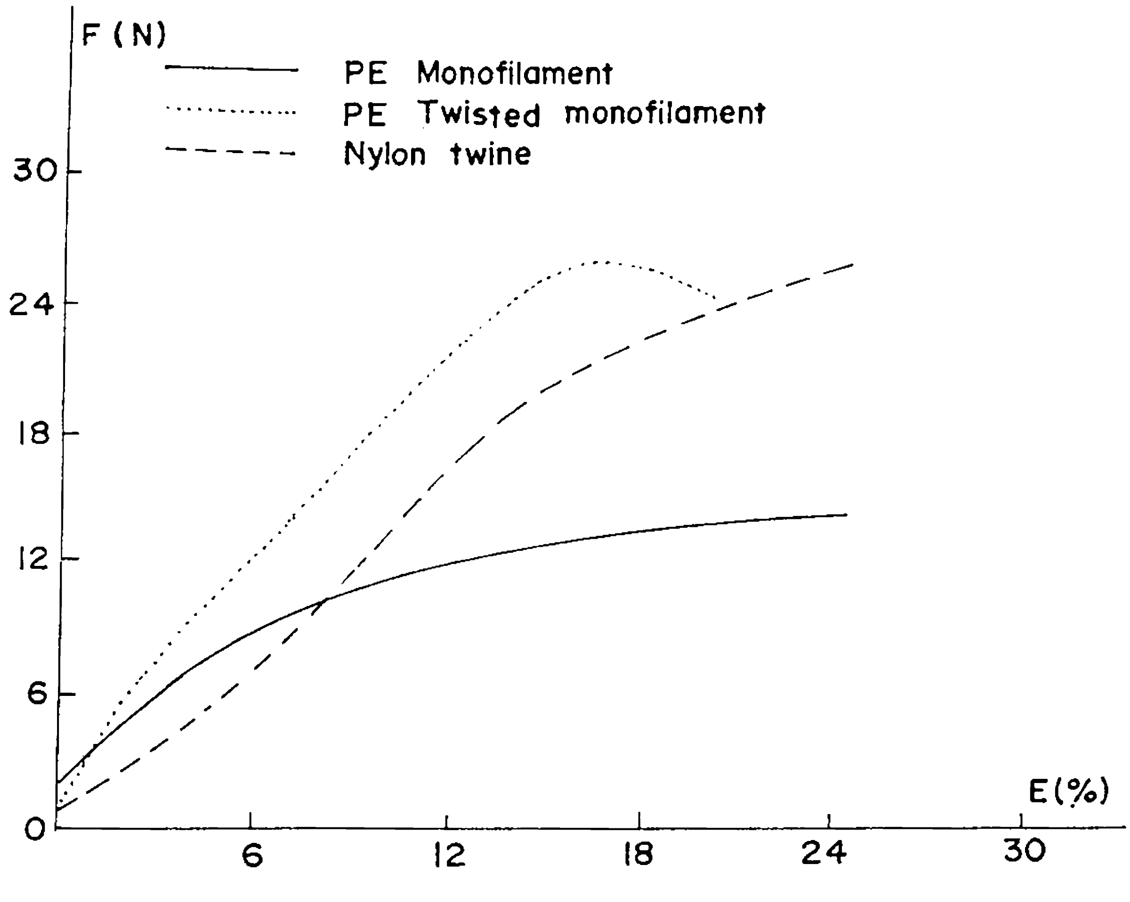
Stiffness

Stiffness of textile yarn is the ratio of load to elongation (Harris 1954, Grover and Hamby 1960). The ratio of breaking load to elongation at 30% of the breaking load was recorded, using the UTM ZWICK 1484 which is taken as a measure of stiffness.

4.1.4.2 Netting

Weight of netting

The dimension of netting in number of meshes in length and depth and mesh size as the length of a stretched mesh measured from inside of one knot to outside of the opposite one were noted and the quantity of webbing was computed.



Load (F) elongation (E) curve of netting yarns.

Fig. 4.1. Load elongation curve.

Strength of netting

Strips of netting of 2 to 5 meshes width and 5 meshes in depth were mounted on pins between the grips of UTM ZWICK 1484 and strained under a test speed of 300 mm/min following Brandt and Carrothers (1964).

4.1.4.3 Fishing tests

For comparative fishing tests, three sets of nets (Net nos. 1 to 27 of Table 3.1a) each set made of nylon multi-filament 210Dx1x2 of 0.370 mm dia, polyethylene twisted mono-filament of 0.45 mm dia and polyethylene monofilament yarn of 0.268 mm dia respectively were used. Each set consisted of 9 units with mesh size of 32.0, 34.0, 38.0, 42.0, 46.0, 50.0, 52.0, 54.0 and 56.0 mm. The fishing tests were conducted during the months of May and June 1986. During this period 40 fishing operations were made at the rate of 20 operations per month. The species-wise catch of each net and the length and weight of prawns and group-wise weight of fishes were also recorded.

4.1.5 Results and Discussion

4.1.5.1 Netting yarn

Physical properties of the netting yarns are presented in Table 4.1 Polyethylene monofilament yarn was the finest with good transparency and had almost equal Rtex to that of nylon twine. Nylon twine and polyethylene twisted monofilament

Table 4.1 Physical properties of netting yarn

Material	Diameter mm	R tex	Runnage m/kg	Breaking load N Dry	Breaking load N Wet knot	Elongation	Ratio of load to elongation at 30% of wet breaking load N/tex	Tenacity N/tex	Tenacity g/Denier
Nylon twine 210D x 1 x 2	0.370	56.6	17670	26.26	19.43	26.32	1.547	0.460	5.26
Polyethylene monofilament yarn	0.268	59.0	16950	14.57	12.50	35.11	2.800	0.246	2.80
Polyethylene twisted monofilament	0.450	102.0	9800	23.6	20.38	17.11	3.111	0.231	2.62

had almost equal wet knot breaking load. One of the criterion for substitution of material in fishing gear is equal wet knot breaking load (Brandt 1964).

The load elongation curve was characteristics of each material. Polyethylene showed lower elongation at low loads as distinct from nylon. Here the curve was concave to the stress axis initially, followed by upward curvature. Meredith (1959) and Klust (1973) have also mentioned two distinct patterns of load elongation curve among the netting yarns analysed.

As a corollary to the pattern of load elongation curve, the ratio of load to elongation expressed as N/tex for 30% of the maximum wet breaking load i.e. load experienced during actual fishing operation was higher in polyethylene than nylon. Consequently nylon possessing more elongation at low load is expected to behave as a more flexible material than polyethylene during fishing operations.

4.1.5.2 Weight of netting

The method followed is a modification of the relation worked out by Machii and Nose (1987). While these authors expressed the weight for a standard dimension of netting from a single mesh, in terms of diameter, the calculation followed here is based on the Rtex of the sample. Accordingly the weight of netting of 1000 x 100 meshes will be equal to

$$W = R_t \left(L + 0.032 \frac{Rt}{\rho}\right)$$

Where W = the weight in grammes of 1000 x 100 mesh

Rt = R tex of the material

L = 2 x stretched mesh size

ρ = density of the fibre

Applicability of this relation was ascertained by actual recordings as given in Table 4.2.

As seen from the table the maximum difference observed was 10%.

4.1.5.3 Strength of netting

Strength of netting of different materials and mesh size are presented in Table 4.3 strength of netting was found to bear a linear relationship with the number of meshes in width represented by

$$Y = a + bX$$

where Y is strength of netting in N, a and b constants and X is the number of meshes in width.

The correlation coefficient (r) was very high in the relation as can be seen from the Table 4.4.

The influence of mesh size on mesh strength was ascertained by analysis of variance (ANOVA). Between mesh variation was not significant at 5% level ($F = 2.13$, df 3, 9). Strength of

Table 4.2 Weight of netting of 1000 x 100 meshes in different materials

Nylon 210Dx1x2			Polyethylene monofilament			Polyethylene twisted monofilament		
Mesh size mm	Weight of netting in g		Mesh size mm	Weight of netting in g		Mesh size mm	Weight of netting in g	
	Observed	Calculated		Observed	Calculated		Observed	Calculated
34.0	400.0	397.0	-	-	-	-	-	-
38.0	444.0	443.0	38.0	525.0	462.0	38.0	843.0	808.0
42.0	515.0	490.0	42.0	570.0	510.0	42.0	820.0	890.0
50.0	630.0	580.0	46.0	620.0	560.0	52.0	1090.0	1094.0
52.0	575.0	600.0	52.0	700.0	630.0	54.0	1148.0	1135.0
54.0	640.0	625.0	54.0	740.0	650.0	56.0	1190.0	1175.0

Table 4.3 Strength of netting in N

Material	Nylon 210Dx1x2				Polyethylene monofilament				Polyethylene twisted monofilament			
Meshes width	2	3	4	5	2	3	4	5	2	3	4	5
Mesh size mm												
32.0	43.75	66.36	85.01	107.10	41.44	54.84	77.80	116.86				
42.0	45.64	64.82	82.10	106.60	32.83	50.80	87.38	113.68	59.28	101.85	116.88	155.86
46.0	40.72	72.00	98.85	119.49	45.23	57.76	74.83	105.96	54.43	94.51	117.71	148.84
52.0	41.97	66.41	86.06	102.40	33.15	55.56	82.80	112.03	55.53	77.23	126.76	163.01

Table 4.4 Strength of netting(material nylon 210Dx1x2)

Mesh size mm	a	b	r
32.0	1.71	21.07	0.9996
42.0	4.01	20.12	0.9839
46.0	-9.32	26.31	0.9834
52.0	6.82	18.99	0.9896

Table 4.5 Strength of netting (different materials)

Material	a	b	r
Nylon 210Dx1x2	0.44	21.83	0.9992
Polyethylene monofilament	-15.04	24.70	0.9991
Polyethylene twisted monofilament	-8.72	32.77	0.9995

mesh is therefore independent of mesh size and is in conformity with the observations of Kondo (1960).

The above assumption were translated to the other two materials also and a generalised equation for strength of netting independent of mesh size for each material was worked out as in Table 4.5 . Mesh strength bear a linear relationship with number of meshes in width in all the three cases with high correlation coefficient.

4.1.5.4 Economics

The ratio of quantity of netting to a given dimension of netting was 1.0, 1.14 and 1.83 respectively for nylon multi-filament, polyethylene monofilament yarn and polyethyelene twisted monofilament with minimum mesh size considered and the coast per unit quantity of netting is 1:1:0.625. The cost ratio for equal dimension of netting would be then 1:1.14:1.4. Making of netting with polyethylene yarn is difficult by hand or machine. The raw material cost of polyethylene is less but when made into webbing it is comparable to nylon for unit weight.

4.1.5.5 Fishing tests

The catch of P. indicus and fish by 27 experimental nets made of three different materials in nine different mesh sizes were analysed using ANOVA. There is significant difference ($P < 0.01$) between quantity of P. indicus caught by nets of different materials ($F=30.47$, df 2,16). The mean catch of P. indicus by nets of three different materials was operated with the help of least significant difference. Nylon net catches significantly higher ($P < 0.05$) quantity of P. indicus compared to other materials.

Between materials variation in fish catch was not significant at 5% level ($F = 1.69$, df 2,16) all the three materials are equally good in the capture of fish.

The difference in performance of materials with regard to prawn and fish catch is due to the variation in the mechanism of capture of the two organisms. Prawns are caught both by gilling and entangling. The soft and pliable nylon twine is more amenable to entangling than stiffer polyethylene (Tran-Van-Tri and Ha-Khao-Chu 1964).

Fishes are caught by gilling alone in the present studies. The attributes for a good gill net material are softness, pliability and invisibility under water. Nylon is the softest of all materials (Klust, 1973). Under water observations of Steinberg (1964) point to the invisibility/lesser visibility of monofilament/polyethylene twisted monofilaments compared to nylon multifilament twines. As such a soft and flexible nylon and lesser visible polyethylene exhibit equal catch efficiency for fish. The view of Tran-Van-Tri and Ha-Khao-Chu

(1964) that monofilament nets possess the disadvantage of bulkiness and a tendency to blow around is endorsed by the present investigations.

4.2 SELECTIVITY OF MESH

The property of any fishing gear or method which cause the probability of capture to vary with the characteristics of species, generally size, is called selectivity. Selectivity of fishing gear is an integral part of fisheries management and research as it facilitates judicious exploitation. In order to have an optimum yield of a particular species and size group, it is highly necessary to determine the selective character of the gear.

Gill nets are highly size selective and though the awareness underlined the practice in earlier times, a scientific approach was brought in later by Baranov (1914). Holt (1963) proposed an algebraic method of estimating complete selectivity curves from comparisons of catches by nets of different mesh sizes which stimulated the current interest in describing gill net selectivity. According to Regier and Robson (1966), there is no sampling gear that exhibit equal selectivity towards fish of all sizes and the knowledge of how selectivity depends on the characteristics of the gear may be used to design the gear to yield a sample of known characteristic over a specified range. The most important factors which affect gill net selectivity are mesh size, net construction and material, the size, shape and behaviour of fish species and mode of capture (Hamley 1975).

Knowledge of selectivity is needed in managing a commercial gill net fishery, as the proper mesh size aids in obtaining the maximum yield (McCombie 1961).

Though a great deal of work has been carried out stressing the importance of selectivity of gill nets for fishes (Hodgson 1927 and 1933, Havinga and Deedler 1949, Baranov 1948, Holt 1963, Olsen 1959, Nomura 1961, Joseph and Sebastian 1964, Regier and Robson 1966, Sulochanan et al. 1968, 1975, Sreekrishna et al. 1972, Hamley 1975, Panicker et al. 1978, Mathai et al. 1991 and Salvanes 1991), comparatively less effort is spent on gill net for prawns. Masuda and Matuda (1976) attempted to study the mesh selectivity of Japanese prawns (P. japonicus). The present study is to determine the selectivity characteristics of prawn gill nets and the optimum mesh size suitable for harvesting prawns of the coastal waters of Kerala.

4.2.1 Material and Methods

One set consisting of nine experimental nets of mesh sizes 32.0, 34.0, 38.0, 42.0, 46.0, 50.0, 52.0, 54.0 and 56.0 mm mesh size and made of nylon multifilament 210Dx1x2 (Net no.s 1 to 9 of Table 3.1a) was used for this study.

Fishing was conducted for 15 to 18 days per month. But the number of operations per day and also during the individual months could not be kept constant due to operational difficulties. These investigations were made during the months of December

1985 to December 1986 and 359 fishing observations were made. During each observation species-wise data on length and weight of prawns and the total weight of fishes of each group were recorded.

4.2.2 Results and Discussion

The percentage frequency distribution of the number of *Penaeus indicus* caught in different nets was calculated and presented in Table 4.6. As seen from the table, there is shifting of the model length in 34.0, 38.0, 42.0, 46.0 and 50.0 mm nets; the length group being 10-11, 11-12, 12-13, 13-14 and 14-15 cm, respectively. The selectivity curves for these nets are presented in Fig.4.2a,b,c. The maximum percentage value and the percentage of the area to the left and right of this and the nature of skewness are presented in Table 4.7. As seen from the length frequency distribution 32.0, 42.0, 46.0, 50.0, 52.0 and 56.0 mm meshed nets are negatively skewed, while that of 34.0, 38.0 and 54.0 mm nets are positively skewed.

These selectivity curves reflect as to how the prawns are caught. The skew on the left side or right side are indicative that the prawns are caught by entangling. Brandt (1984) has reported that crustaceans are caught by entangling. The present observations follows the pattern of selectivity curve of cods in trammel nets (Salvanes 1991) where larger species are caught

Table 4.6 Percentage frequency distribution of the number of P. *indicus* caught in gill nets of mesh size 32.0, 34.0, 38.0, 42.0, 46.0, 52.0, 54.0 and 56.0 mm nets

Mesh size mm	32.0	34.0	38.0	42.0	46.0	50.0	52.0	54.0	56.0
Length in cm									
8 - 9	3.06	1.28	0.19	0.70	-	-	-	-	-
9 - 10	29.25	6.89	1.72	0.47	-	-	-	-	-
10 - 11	44.57	44.63	24.86	5.39	2.82	-	-	-	2.65
11 - 12	19.50	32.65	42.64	26.46	14.87	2.00	2.22	-	2.65
12 - 13	3.62	11.22	22.75	44.73	31.03	11.20	7.22	1.32	3.54
13 - 14	-	1.53	6.89	17.56	34.10	26.80	20.56	11.84	7.08
14 - 15	-	-	0.76	3.99	15.39	49.20	56.11	41.45	18.58
15 - 16	-	-	0.19	0.70	1.79	10.40	11.11	36.18	37.17
16 - 17	-	-	-	-	-	0.40	2.78	6.58	11.50
17 - 18	-	-	-	-	-	-	-	1.97	15.04
18 - 19	-	-	-	-	-	-	-	0.66	1.79

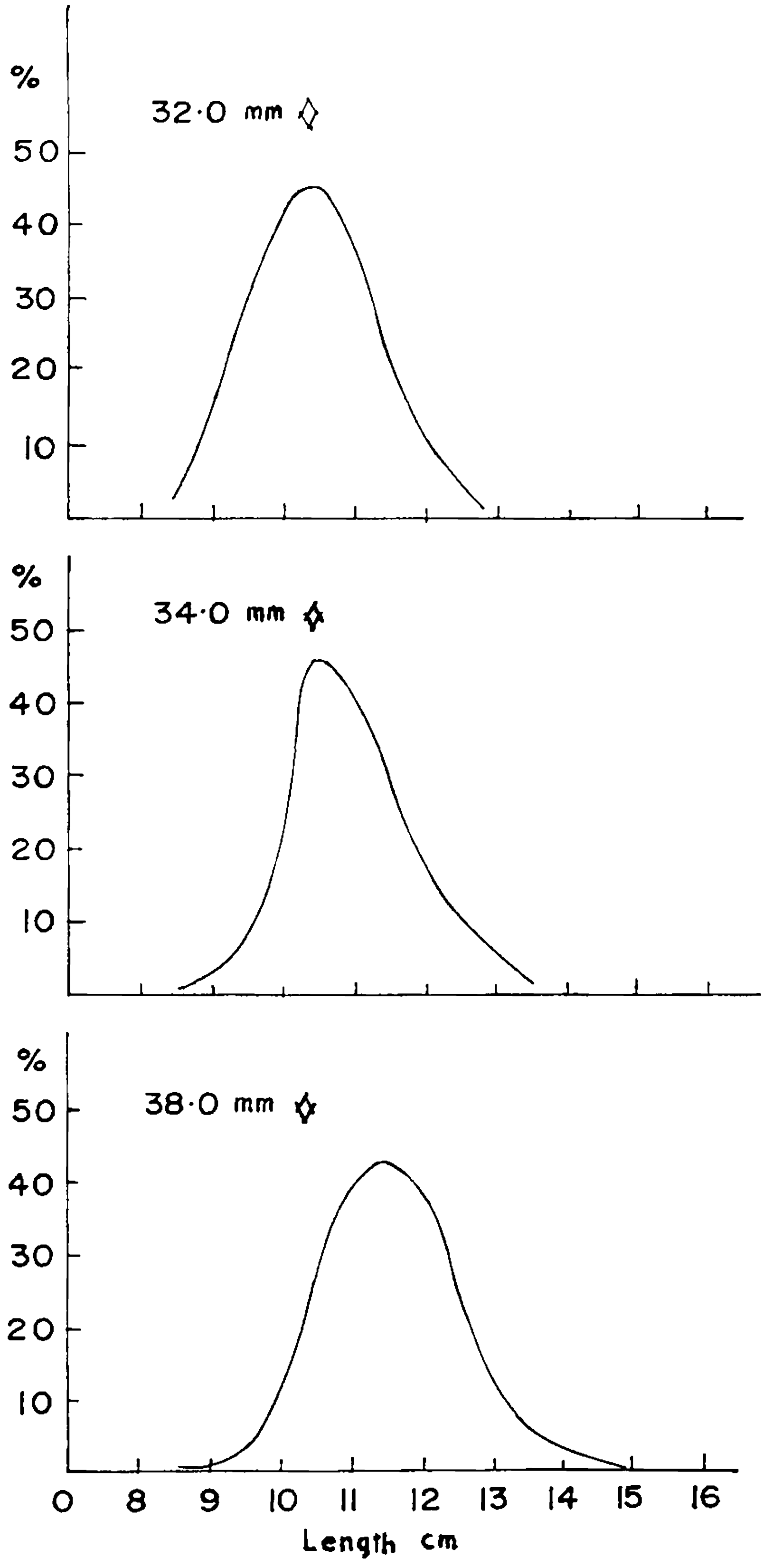


Fig. 4. 2a. Selectivity curves

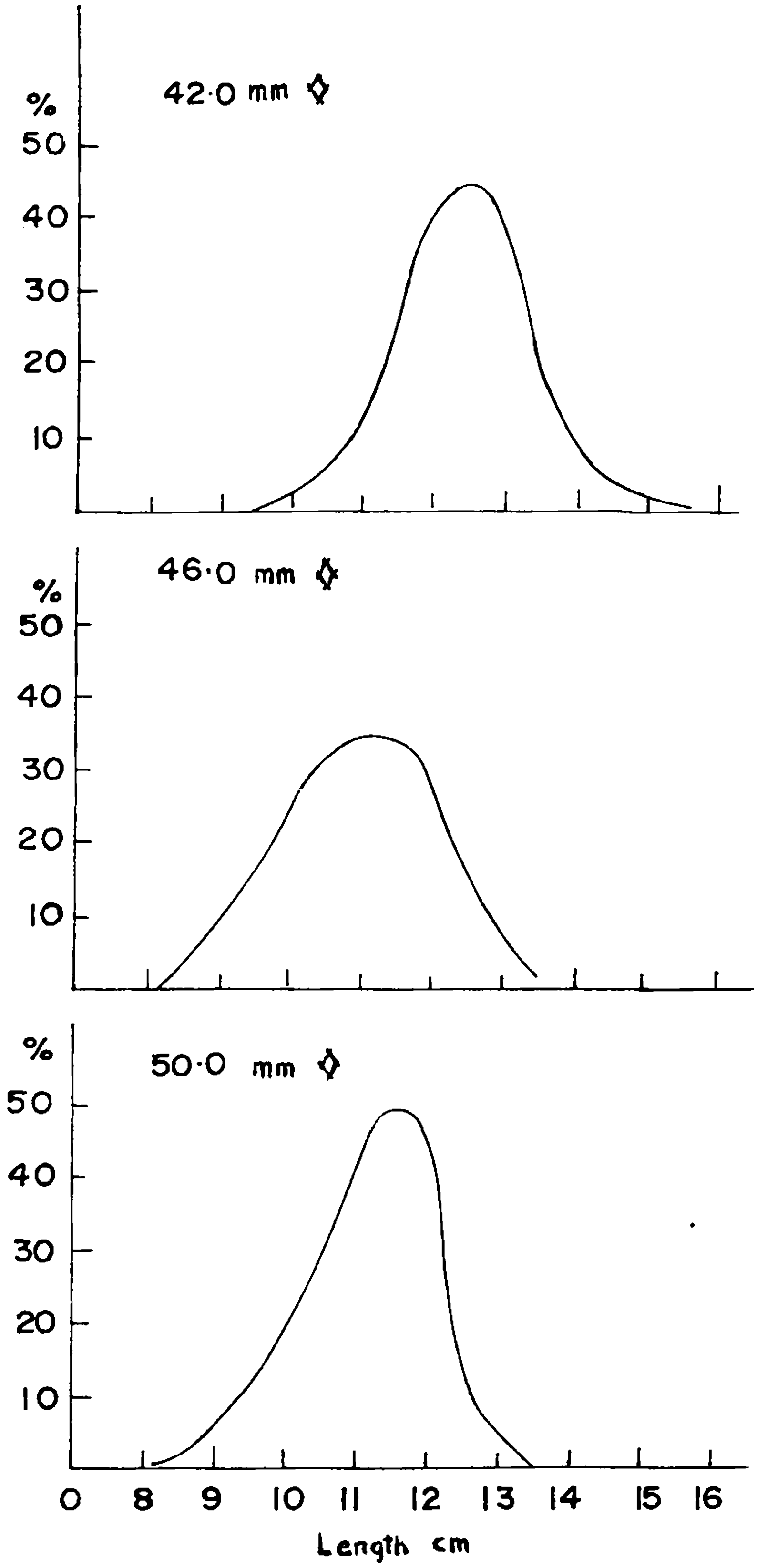


Fig. 4.2b. Selectivity curves

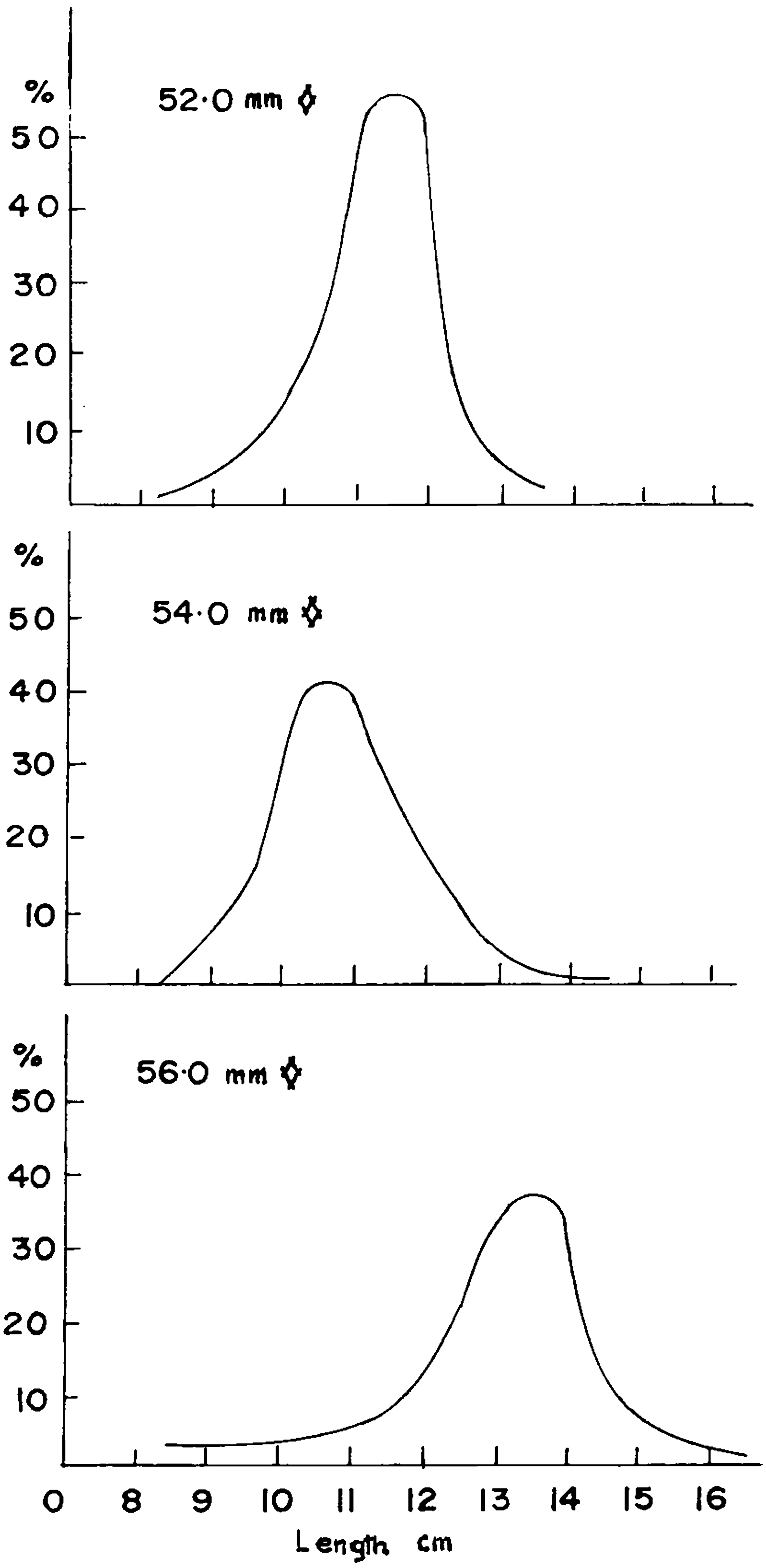


Fig. 4·2c. Selectivity curves.

Table 4.7 Nature of skewness of the selectivity curves

Net mesh size mm	Maximum	Left	Right	Type of skewness
32.0	44.57	32.31	23.12	-
34.0	46.43	8.17	45.40	+
38.0	42.64	26.77	37.47	+
42.0	44.73	33.02	22.25	-
46.0	34.10	55.72	17.18	-
50.0	49.20	40.00	10.80	-
52.0	56.11	40.00	13.89	-
54.0	41.45	13.16	45.39	+
56.0	37.17	34.50	28.33	-

by entangling and hence selectivity curve has a positive skew. The negative skew observed in many cases shows that the small prawns are not able to pass through the meshes as could have happend in the case of smooth bodied fish like cods either in gill net or trammel net (Salvanes 1991) but are entangled by the spiny protuberances and exoskeleton.

But the shifting of the model length with respect to mesh size of 34.0, 38.0, 42.0, 46.0 and 50.0 mm is indicative that P. indicus are caught by gilling also. Mathai et al. (1990) has also noticed the same phenomena in the case of P. merguiensis. Thus in the case of P. indicus it is reasonable to conclude that they are caught both by gilling and entangling.

The data on the landings of P. indicus caught by the different meshed gill nets were analysed by ANOVA. Between mesh size variation was significant at 1% level (F=148.08, df 8, 80). The least significant difference between net was 0.0304 at 5% and it was observed that 38.0, 42.0 and 46.0 mm nets caught more P. indicus compared to others and there is no significant difference between these three nets. The coefficient of proportionality in the relation between mesh size in mm and model length of prawns caught in mm was calculated. The value ranged between 0.32 to 0.35 in the different mesh sizes with an average of 0.34. The appropriate mesh size in mm (a) for the desired length group of prawns in mm (l) can therefore be fixed as $a = 0.34\ l$.

4.3 COEFFICIENT OF HANGING

The particular shape which individual meshes assume in a gill net is determined by the process of hanging the netting to the mounting rope, the length of which is less than the stretched length of the netting. Coefficient of hanging is the ratio between the length of mounting rope to which the netting is hung and the fully extended length of the netting, expressed here as a decimal fraction. A given coefficient of hanging result in a particular shape and opening of mesh in the horizontal and vertical direction which in turn determines the length and depth of the mounted netting. In gill net design every effort is made to match the shape of the mesh to the shape of cross section of the body of target species at the point of gilling. With increase in the coefficient of hanging, the slackness of netting as well as the resultant vertical depth decreases.

One of the various aspects of gill net design and construction that affect its ability to fish is the coefficient of hanging (Hamley 1957). Work of Riedel (1963) on Tilapia gill nets has shown that decrease in hanging coefficient reduces the selectivity of gill nets and observed that it is responsible in the first place for the degree of selectivity of the whole of gill net. Decreasing mesh size and coefficient of hanging reduced the selective power. Miyazaki (1964) and

Thomas (1964) have also stressed the importance of hanging ratio in gill nets. They have also specified the range of hanging ratio for gilling as well as for gilling and entangling. Mohr (1965) suggested that hanging ratio has got importance in captures by entangling and little on catch by wedging or gilling. Giedz (1971) has also worked out the relation of hanging ratio to the selectivity of gill nets. Importance of slackness of netting in gill net efficiency effected by hanging ratio of nets has been reported by Brandt (1984).

4.3.1 Material and Methods

The experimental work consisted of comparative fishing with three sets of nets (Net No.36, 37, 38, 39, 40, 41, 42, 43 and 44. Table 3.1c of 38.0, 42.0 and 46.0 mm mesh size and each set having three units with 0.4, 0.5 and 0.6 as coefficients of hanging. Data on the total number of prawns and fishes and their total lengths was recorded. The individual weight of prawns was also recorded once in a fortnight. The total weight of all fishes were also recorded in the field. These investigations were made during May 1987 to December 1987 and 193 observations were taken.

4.3.2 Results and Discussion

Figure 4.3 on the number of *Penaeus indicus* caught in the ß mesh sizes with the three hanging ratios indicates that

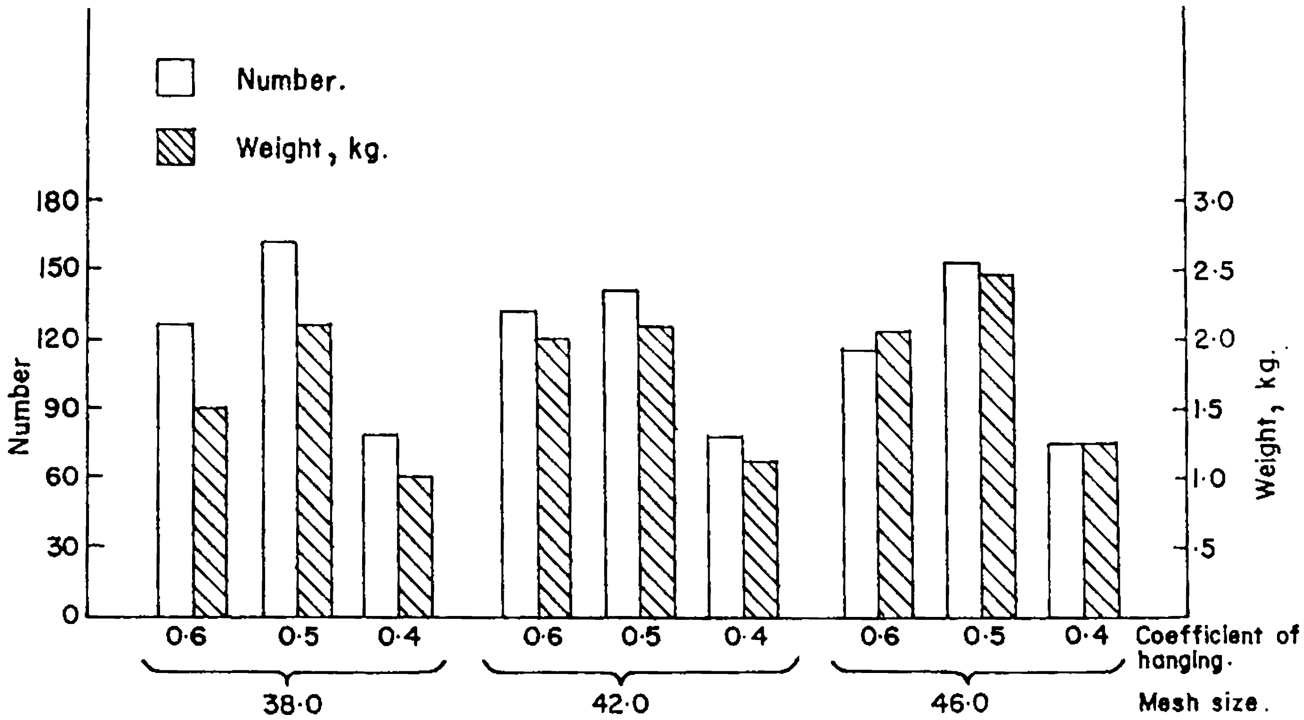


Fig. 4·3· Relationship between number and weight of Penaeus indicus caught by gill nets differing in mesh sizes and coefficient of hanging.

there is a gradual decrease in the number-weight ratio as the mesh size increases, irrespective of hanging ratio.

The length frequency distribution of P. indicus in each of the nine nets are given in Table 4.8 and Figure 4.4. As can be seen from the figure, in almost all cases the frequency distribution is skewed to the right which is indicative of the fact that the capture is more by entangling.

The catch of P. indicus landed by these nets of three different mesh size and three different hanging ratios, was analysed using ANOVA. The catch by number was converted to logarithmic values for analysis.

Between coefficient of hanging variation was significant at 5% level by weight and number with F values 50.87 (df = 2) and 134.40 (df = 2) respectively. The least significant difference and the mean values are presented in Table 4.9. The number and weight of P. indicus caught in nets with 0.5 as coefficient of hanging are significantly higher followed by nets with 0.6 and 0.4 as hanging coefficients.

Between mesh variation was not significant at 5% level when catch is analysed either by weight (F = 5.57, df = 3) or ber (F = 1.20, df = 2) indicating that the three mesh experimented are equally effective in the capture of licus.

Table 4.8 Length frequency distribution of <u>Penaeus indicus</u> caught in nets of 38.0, 42.0 and 46.0 mm mesh size with 0.4, 0.5 and 0.6 as coefficients of hanging

Size group total length mm	Mesh size in mm and coefficient of hanging								
	38.0			42.0			46.0		
	0.6	0.5	0.4	0.6	0.5	0.4	0.6	0.5	0.4
8 - 9	1	0	0	0	0	0	0	0	2
9 - 10	1	0	0	0	0	0	0	0	1
10 - 11	3	2	2	1	0	0	0	3	1
11 - 12	30	43	16	16	21	13	0	13	5
12 - 13	55	59	35	45	48	23	27	23	10
13 - 14	22	33	12	32	39	26	35	58	19
14 - 15	6	15	9	21	16	7	18	21	14
15 - 16	5	8	3	16	10	28	28	24	15
16 - 17	0	3	1	2	5	2	8	7	5
17 - 18	0	0	0	0	3	1	1	3	2

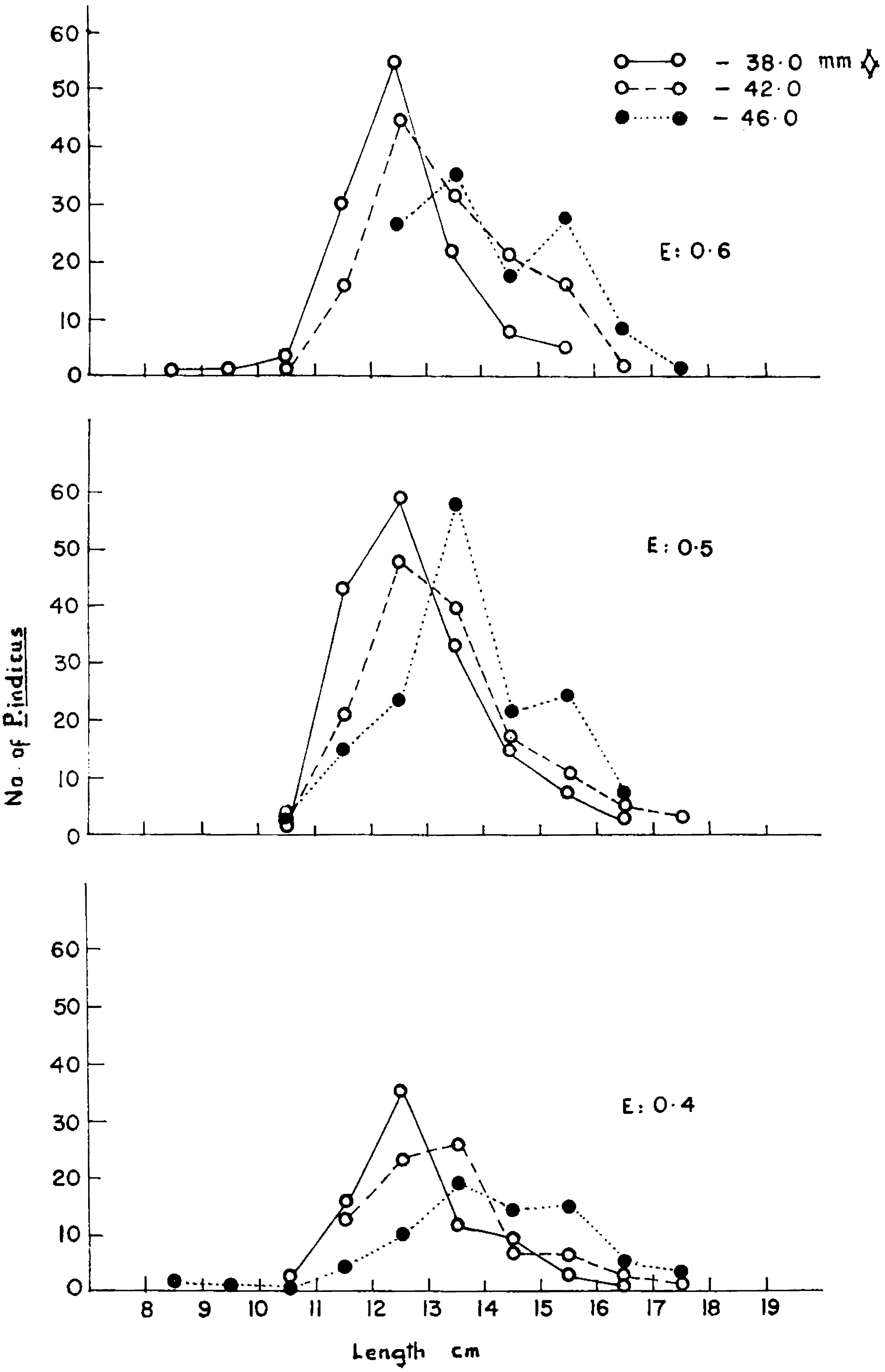


Fig. 4·4· Length frequency distribution of *Penaeus indicus* in nets with different hanging coefficient(E).

Table 4.9 Results of ANOVA of catch of *Penaeus indicus* in experimental gill nets with 0.4, 0.5 and 0.6 as coefficients of hanging

	Coefficient of hanging	Catch in kg	Catch in number converted to logarithmic values
Least significant difference		0.3068	0.1603
Mean value	0.6	1.8560	2.0988
	0.5	2.2270	2.1792
	0.4	1.1320	1.8845

Dependence of mesh size and coefficient of hanging on the catch of P. indicus was analysed using chi-square test. The calculated value of chi-square is 2.264 (df = 4) which is not significant at 5% level leading to the conclusion that mesh size and coefficient of hanging are independent.

The positive skew of length frequency distribution at different coefficients of hanging for different mesh sizes is indicative of the fact that capture is more by entangling rather than gilling. This is characteristic of crustaceans to which prawns belong (Brandt 1984). Thus there is no necessity of decreasing the coefficient of hanging from 0.5 in order to facilitate more gilling and entangling. Higher catch of P. indicus both by number and weight in nets with hanging coefficient 0.5 compared to nets with 0.6 and 0.4 as coefficients of hanging also supports this view and is in conformity with the observation of Mohr (1965). The broader frequency curve for hanging coefficient of 0.4 in all the three mesh sizes (Fig. 4.4) is in agreement with the observation of Riedel (1963), but the steeper curve for small mesh size deviates from this concept. Relation of number and weight of P. indicus presented in Figure 4.3 for different mesh sizes and coefficients of hanging supports this statement.

4.4 COLOURATION

Gill nets being passive gear, every effort has been made to make the gear more effective. While softness is considered as a desirable property for gill net material, better results are obtained with comparatively stiffer but transparent material (Steinberg 1964). The transparency amounts to invisibility which can also be achieved through colouration that matches with the surrounding medium. Earlier emphasis on softness rather than visibility is due to the fact that the natural fibres had only definite colours of their own. The idea of colouration started mainly with the advent of synthetics. One of the synthetic material Platil, had the dual advantage of transparency being monofilament and matching hue with the surroundings due to its green colour. Brandt (1984) has stated that dyeing of gill nets will render it invisible as far as possible and harmonize closely with the surroundings. The colour like other visual stimuli is of greater importance in determining the visual response of fish to stationary gear like gill nets. Dickson (1988) and Wardle et al. (1991) have reported that invisibility of gill net material occur at certain threshold light intensities depending on the material and its colour. Drift nets are successful and mechanically selective when the fish blunders into the meshes(Cui et al. 1991). For this reason fishermen choose materials with colour which, they considered, are less likely to be seen by fish. All the information relating to the performance of coloured gill nets refer to fish capture as gill nets for prawns is a later development.

It seems reasonable to assume that fishes are able to discern some colours and they will respond differently to gill nets of different colours. Mohr (1964) found decreasing efficiency sequence of green, red, brown, black, blue, white and yellow colours for European perch. Jester et al. (1970) observed that colour served as a camouflage, attractant or deterrent to cause variation in the catch rate of gill nets. Blaxter et al. (1964) concluded that visibility was the primary factor determining the efficiency of gear in clear water. Yoshimuta and Mitsugui (1963), Steinberg (1964) and Nambiar (1973) had also recorded similar observations. Yoshio et al. (1957) studied the influence of colour on fish nets by transfer of fishes among black, white, red, yellow and blue coloured underwater net models and found less stopping effect for black, red and yellow colour, while white and blue had more stopping influence.

Threshold value of light intensity for visual reaction of mackerel to coloured nets was determined by Cul et al. (1991). Koyama et al. (1964) investigated dependance of maximum visible distance of nets in turbid waters. Konda et al. (1958 a & b) worked out the behaviour of fishes in the neighbourhood of coloured nets and also passage of fishes through coloured nets. Jester (1973), Koike (1968) and Nambiar et al. (1970 a & b) indicated that colour influence was species specific.

Andreev (1962) found that nets dyed with light colour performed well. Nomura (1959 and 1961) reported better catch with darker nets during day time and during night time this difference was not observed. Tweddle and Bodington (1988) based on their experiments in African lakes found that white nets were 1.79 times more effective than black nets which is not in conformity with that of Nomura (1959) and Baranov (1969). Brandt and LeiPolt (1955) showed the relative effect of coloured nets over colourless ones. Koike (1968) reported the preference of sea bass, black progy and rock trout to coloured nets. Nambiar et al. (1970 a,b) found preference of blue and black nets in their investigations on avoidence response of fish to colour nets. Kunjipalu et al. (1984) found that yellow and white nets were best suited for pomfret and hilsa. George et al. (1975) found yellow colour better for the endemic species of Gobind Sagar reservoir. They observed species specificity with different colours. Narayanappa et al. (1977) stated preference of yellow nets followed by grey and green in Hirakud reservoir. Mohan Rajan and Mathai (1988) reported exclusive use of yellow and white nets along Saurashtra coast.

4.4.1 Material and Methods

Experimental gear consisted of eight nets (Net No. 28, 29, 30, 31, 32, 33, 34 and 35 of Table 3.1b with 42.0 mm mesh size. The colour of these nets were violet, indigo, blue, green, yellow, orange, red and white control net.

Netting of the experimental nets along with separate twine for repair of nets were dyed with dyes of M/s. Sandoz India, Bombay and the procedure followed was that of Kunjipalu et al. (1988). After dyeing the net was hung on ropes.

Colour units of the dyed repair twine was measured according to the Lovibond system where the colour is expressed in Lovibond units (Anon 1964).

Fishing was conducted in a statistically arranged manner. The investigations were conducted from July 1987 to December 1987 and 120 numbers of observations were made.

4.4.2 Results and Discussion

The colour number for each of the eight twines is given in Table 4.10 and the hydrographic data in Table 4.11 The catch details from the experimental nets as well as the length frequency distribution of *Penaeus indicus* obtained in the experimental nets are given in Tables 4.12 and 4.13 respectively.

From the hydrographic data (Table 4.11) the sky was cloudy

Table 4.10 Colour of each twine in Lovibond colour units

Colour	Lovibond units
White (control)	0.5Y + 0.3R + 0.7B
Violet	33.0R + 8.9B
Indigo	14.0B + 8.1R
Blue	22.0B + 20.0Y + 5.0R
Green	40.0Y + 19.0B + 3.0R
Yellow	60.0Y + 12.0R
Orange	50.0Y + 12.0R
Red	34.0R

Table 4.11 Hydrographic data

Month and year	Depth of ground, m	Cloudiness	Turbidity in m and Extinction coefficient	Rain fall mm	Temperature °C		Dissol-ved oxygen ml/1
					Air	Surface water	
July, 1987	8.75	4/8	1.25(1.36)	192.0	28.3	26.5	6.2
August, 1987	8.50	4/8	0.75(2.26)	449.0	26.0	25.0	6.8
September, 1987	8.00	2/8	1.25(1.36)	87.0	28.5	27.8	5.7
October, 1987	8.50	2/8	2.75(0.61)	299.0	29.5	30.0	7.1
November, 1987	14.00	2/8	6.00(0.28)	267.0	29.1	30.0	6.8
December, 1987	10.25	0/8	7.00(0.24)	31.0	30.1	31.2	5.3

Figures in parenthesis in column 4 are extinction coefficients
Rainfall, Based on Indian Meteorological Data furnished by Director General of Meteorology (Weather Forecasting), Meteorological Office, Pune-5

Table 4.12 Species-wise catch composition from control and colour nets

Colour of net	*P. indicus*	*P. monodon*	*M. affinis*	*M. dobsoni*	Shark	Oil sardine	Lesser sardine	*Thrissocles* spp.	*Raconda russeliana*	Sciaenids	*Anadontostoma chacunda*	*Lactarius lactarius*	*Gerres filamentosus*	*Rastrelliger kanagurta*	*Sillago sihama*	*Lieognathus* spp.	*Chirocentrus dorab*	*Lepturus* spp.	*Polynemus* spp.	*Selar crumenophalmus*	*Megalaspis cordyla*	*Mugil* spp.	Gar fish	Pomfret	*Sphyraena* spp.	Others	Total (Prawns)	Total (fishes)	Grand total
White (Control)	75	-	2	16	9	69	-	14	2	100	18	20	-	2	4	90	-	2	3	2	4	2	-	-	-	21	93	362	455
Violet	96	-	4	14	2	98	-	96	-	110	26	52	-	4	-	78	-	-	6	2	6	4	-	-	-	54	114	538	652
Indigo	95	-	4	32	8	148	2	52	4	142	38	50	2	2	2	102	4	-	-	4	-	6	-	-	-	66	131	632	763
Blue	126	-	4	22	8	116	-	42	-	120	26	54	-	2	2	72	4	-	2	6	8	2	2	-	-	54	152	520	672
Green	197	2	8	28	8	236	4	112	6	180	50	118	-	10	6	112	4	-	-	-	2	4	-	-	-	120	235	972	1207
Yellow	96	2	-	18	16	158	-	50	4	204	42	42	-	14	6	66	4	-	2	2	4	6	-	-	-	66	116	686	802
Orange	120	-	6	22	22	184	2	42	4	190	28	46	-	6	8	64	8	2	-	2	6	2	4	-	-	74	148	694	842
Red	130	2	10	12	30	254	-	34	-	202	14	48	2	14	2	74	4	-	8	4	-	-	-	-	-	40	154	730	884

Catch given here is in numbers

Table 4.13 Length frequency distribution of *P. indicus* in control and coloured nets

Size group in mm	Colour of nets							
	White (Control)	Violet	Indigo	Blue	Green	Yellow	Orange	Red
8-9	2	2	-	-	-	-	-	-
9-10	-	-	-	-	1	-	-	-
10-11	1	8	5	7	12	4	1	9
11-12	9	23	20	27	44	24	23	19
12-13	31	29	45	55	86	41	57	57
13-14	20	18	14	20	33	13	12	27
14-15	6	10	7	15	15	11	12	10
15-16	6	6	4	2	15	3	15	8
16-17	-	-	-	-	6	-	-	-

during July and August due to the monsoon clouds and became progressively clear towards the end of the year. The maximum rain fall was during August followed by October and November. The highest turbidity (0.75m) was noted during August which gradually reduced during July and September and thereafter became progressively less towards December.

Maximum catch of P. indicus was obtained during the month of July followed by August and September and the catch was negligible during October, November and December (Table 4.14)

The catch of P. indicus by the different coloured nets (Table 4.12) was tested using Chi-square test. The calculated value of Chi-square is 83.863 (df = 7) which is significant at 0.1% level indicating that the number of P. indicus in the different coloured nets were different. A closer examination of the data showed that green coloured nets caught significantly higher number of prawns compared to others. The length frequency distribution of P. indicus (Table 4.13) is identical in all the coloured nets and control net.

The weight of P. indicus landed by the coloured nets during the peak months of July, August and September was also analysed by ANOVA technique. There is significant difference ($P < 0.05$) between coloured nets in the output with green coloured nets landing higher catch than the others ($F = 3.30$, d = 7, 14).

Table 4.14 Catch of *P. indicus* in control and coloured nets from July 1987 to December 1987

Month	No. of *P. indicus*
July 1987	588
August 1987	236
September 1987	92
October 1987	17
November 1987	0
December 1987	2

This was followed by orange, red and blue. Between month variation in catch was highly significant at 5% level (F = 89.21 df: 2, 14) emphasising maximum output during the month of July. The coefficient of correlation between extinction coefficient and the number of P. indicus caught in different coloured nets showed significance only in green coloured nets. This indicates that as the extinction coefficient increases green coloured nets caught significantly more number of P. indicus. In other words, the camouflaging effect of green colour for P. indicus is increasingly manifest as turbidity increases.

4.5 FISHING HEIGHT

The physical configuration of net in water is effected by tidal current. Fishing height or head line height is influenced by current which in turn affects the efficiency of gill nets. Fridman (1969) formulated an approximate iterative method for calculating the head line height of gill net set across the water flow. Matuda and Sannomiya (1977 a & b) estimated the moving speed and shape of bottom drift net set across a flow using numerical analysis. This numerical solution was obtained by using a conjugate gradient method (specially Fletcher Reeves Method) on FACOM 230/75 computer. A perturbation method was used by Matuda and Sannomiya (1978) to obtain approximate analytical solution to the motion and shape of the net. But their studies failed to determine the fishing height of the net. Matuda (1988) analytically derived an approximate formula for determining the fishing height of bottom set gill net, set across a uniform flow with head line free, using differential equation to describe the forces of the net. Stewart and Ferro (1985) measured the fishing height and drag of a series of short gill nets set parallel to uniform flow in a flume tank. They subjected the measurements to multiple linear regression to arrive at an expression for netting drag and fishing height. Stewart (1988) measured the effect of fishing height of gill nets at sea using manometer. This study revealed that the analytical solution are in good agreement with the field observation.

4.5.1 Material and Methods

In order to ascertain the fishing height at different tidal velocities, a gill net of mesh size 32.0 mm (Net No.1 of Table 3.1a) was used.

An electronic current meter (Sivadas 1981) with a range of 0 - 4.0 knots and sensitivity of 0.1 knot was used to measure the speed of the flow.

A bamboo pole painted in black and white colours alternatively with a cleft at its lower end was employed to measure fishing height.

The net with complete rigging was released from the craft. One end of the net was secured to the boat by 30.0 m of 10 mm dia polyethylene rope. As the net attained a steady speed with the current, the velocity of the current was measured with the current meter. Two professional fishermen were employed to measure the fishing height of net while under drift. One of them dived to engage the foot rope into the cleft at the lower end of the pole on which a sudden jerk is given. Acting on this signal the position of the head rope on the upper side of the pole was noted by the other diver. The distance between this upper mark and the lower end of the pole which corresponds to the fishing height was measured by a measuring tape. This was repeated till two consecutive constant readings were obtained. These observations were made during November 1987 during day time.

The measurements were taken at the mid-length of the gill net.

The following equations were used by Stewart and Ferro (1985) for theoretical prediction of total net drag and fishing height assumed by the gear under drift, respectively.

1. $D_t = L\ (0.04HV^{1.82} + 1.38V^{1.2}\ HoSo^{0.53}B^{0.55}T^{0.45})$

2. $(1/AFH)-1 = 2.04V^{1.34}So^{0.51}B^{-0.79}T^{0.42}$

D_t	=	Total drag in kg
L	=	Set length of net in metres
H	=	Net height under the action of current in metres (For drag calculation, measured net height are used)
V	=	Water speed in knots
Ho	=	Fishing height of the net in metres
So	=	Twine solidity
B	=	Net buoyancy in kg
T	=	Dummy variable
		1 for twisted multifilament nylon net
AFH	=	Adjusted fractional height
		$\frac{\text{Net height under current}}{\text{Set height of the net}}$

The prediction and measurement was made under three current speeds (V = 1.1, 0.7 and 0.5 knots) as measured by the current meter.

The value for B and So was worked out to be 0.325 kg and 0.053 respectively.

4.5.2 Results and Discussion

The predicted and observed values of net height at three speeds and the percentage of difference from the measured values as well as the predicted net drag at each speed are given in Table 4.15.

The formula for adjusted fractional height is evolved from multiple linear regression on data derived from measurement on nets with fishing heights of 1.08 to 2.55 m under uniform current condition of a flume tank.

Net drag was calculated using the measured fishing height. Difference in netting drag using predicted fishing height is about 3% only. The rope frame drag forms only 10% of the total drag (Stewart and Ferro 1985). The difference between predicted fishing height and observed fishing height ranged from 0.6 to 4.3%. But the fishing height (Ho) changes depending on the speed of the tidal current.

It is not advisable to operate the net when the current speed exceeds 1.0 knot as the fishing height of the net decreases by more than 50% of the net height (Ho).

Table 4.15 The predicted and observed values of fishing height at different velocities along with the predicted drag

Current speed kn	Predicted net height m	Measured net height m	% difference with reference to measured height	Predicted drag using measured net height kg
1.1	2.92	2.90	+ 0.6	39.80
0.7	3.91	3.80	+ 2.9	23.25
0.5	4.59	4.40	+ 4.3	15.40

4.6 SEASONAL VARIATION AND HYDROGRAPHY

The data on operation of experimental set of nine nets (net nos. 1 to 9 of Table 3.1a) were further analysed for assessing the catch composition and other details.

4.6.1 Results and Discussion

The monthly catch per unit effort (CPUE) in respect of nine nets for 13 months for the major species are given in Table 4.16. The number of *Penaeus indicus* caught in the individual nets for 13 months are furnished in Table 4.17. Hydrographic data for the above period are presented in Table 4.18. The coefficient of correlation between catch and hydrographic parameters are given in Table 4.19.

As observed in Table 4.16 the maximum CPUE (prawns and fishes combined) is obtained during November (1435.78 g), thereafter the CPUE has shown a declining trend with least out put during July (327.93 g). The catch consisted of prawns (5 species) and fishes grouped into 23. The ratio of prawns to fishes in the catch was of the order of 1:15 by weight whereas in Zuari estuary it was 1:17 (Mathai et al. 1990).

Among the five species of prawns (*Penaeus indicus*, *P. monodon*, *Metapenaeus affinis*, *M. dobsoni* and *Parapenaeopsis stylifera*) caught, the proportion of *P. stylifera* was negligible and hence not considered. Further among the remaining four

Table 4.16 CPUE in g/1000^2 for different species

Month (No. of observations)	*P. indicus*	*P. monodon*	*M. affinis*	*M. dobsoni*	Shark	Oil sardine	Lesser sardine	*Thrissocles* spp.	*Pellona* spp.	*Raconda russeliana*	Sciaenids	*Anodontostoma chacunda*	*Lactarius lactarius*	*Gerres filamentosus*	*Rastrelliger kanagurta*
Dec. 85 (74)	3.05	0.00	0.08	2.81	628.00	3.36	30.49	68.59	5.67	2.17	24.96	0.96	1.04	0.36	5.49
Jan. 86 (49)	0.26	0.00	0.00	4.63	558.31	317.49	3.24	70.55	11.70	1.07	18.07	0.00	0.00	0.00	4.14
Feb. 86 (22)	14.99	0.00	0.46	0.84	321.74	1.88	1.04	41.91	13.01	0.37	20.87	1.96	1.04	0.00	20.79
Mar. 86 (26)	22.86	0.00	0.00	0.00	235.45	3.99	4.37	28.38	2.14	0.00	28.17	11.00	1.47	0.00	17.59
Apr. 86 (14)	44.99	0.00	0.00	0.00	109.31	0.00	0.00	23.42	0.46	0.00	59.34	30.68	8.23	0.00	18.15
May 86 (15)	83.13	2.06	0.72	2.35	153.16	12.47	0.76	27.35	4.70	1.13	40.84	10.02	2.55	0.00	40.69
June 86 (30)	89.59	2.21	0.00	1.88	108.40	0.00	0.76	12.97	0.00	0.00	54.29	0.47	55.73	0.00	1.69
July 86 (52)	228.29	3.51	0.40	0.41	7.35	0.39	0.00	1.05	0.00	0.65	30.27	0.40	11.40	0.00	0.00
Aug. 86 (10)	60.17	0.00	0.00	0.00	0.00	4.15	0.00	15.03	0.00	0.81	15.30	17.16	26.94	0.00	101.66
Sep. 86 (8)	5.73	0.00	0.00	0.20	71.74	2.59	0.00	7.65	0.00	3.14	15.03	0.88	84.72	0.00	63.54
Oct. 86 (14)	6.26	0.00	0.00	0.00	368.95	5.93	25.92	29.75	2.49	0.00	59.34	44.46	23.65	0.00	192.44
Nov. 86 (23)	1.18	0.00	0.00	0.00	831.78	7.22	0.00	72.14	4.25	0.00	13.30	31.13	9.03	0.00	17.68
Dec. 86 (22)	4.13	0.74	0.00	1.46	756.54	0.00	15.97	93.17	8.57	0.00	14.90	10.08	9.81	0.00	11.55
$\bar{X}$	43.43	0.66	0.13	1.12	319.29	27.65	6.35	37.84	4.08	0.72	30.36	12.25	18.12	0.02	38.11

Table 4.16 contd.

Table 4.16 contd.

Month (No. of observations)		*Sillago sihama*	*Leiognathus* spp.	*Chirocentrus dorab*	*Lepturus* spp.	*Polynemus* spp.	*Selar crumenopthalamus*	*Megalaspis cordyla*	*Mugil* spp.	Gar fish	Pomfret	*Sphyraena* spp.	Others	Total (prawns)	Total (fish)	Grand total
Dec. (74)	85	0.00	0.10	215.68	0.00	7.23	0.00	46.71	16.28	4.72	0.00	0.00	1.69	5.94	1063.45	1069.39
Jan. (49)	86	0.00	0.00	87.00	0.00	1.56	3.34	0.83	3.90	0.89	1.11	0.00	1.11	4.89	1084.31	1089.20
Feb. (22)	86	0.00	0.00	34.78	0.00	10.93	160.25	0.00	27.82	0.00	0.00	0.00	3.22	16.29	661.61	677.90
Mar. (26)	86	0.00	0.00	42.04	0.00	4.20	69.37	0.00	17.65	0.00	4.20	0.44	3.78	22.86	474.24	497.10
Apr. (14)	86	0.97	0.00	0.00	0.00	6.24	29.28	0.00	30.06	0.00	0.00	0.00	0.78	44.99	316.92	361.91
May (15)	86	0.91	0.00	7.29	0.00	1.45	32.82	0.00	15.31	2.91	0.00	0.00	1.82	88.26	356.18	444.44
June (30)	86	3.64	0.25	18.21	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.38	0.54	93.68	258.05	351.73
July (52)	86	0.26	29.65	8.43	0.00	1.05	1.57	0.00	2.57	0.00	0.00	0.00	0.31	232.61	95.32	327.93
Aug. (10)	86	1.36	2.24	10.93	0.00	7.65	0.00	41.15	3.82	0.00	0.00	2.35	13.66	60.17	274.21	334.38
Sep. (8)	86	0.00	0.00	40.99	0.00	0.00	0.00	0.00	0.00	0.00	6.83	0.00	53.29	5.93	350.40	356.33
Oct. (14)	86	0.97	22.68	39.04	239.29	7.02	0.00	0.00	0.00	0.00	11.71	9.33	50.36	6.26	1133.33	1139.59
Nov. (23)	86	0.00	11.47	261.41	37.73	0.47	0.00	7.15	82.34	19.01	0.00	2.59	25.90	1.18	1434.60	1435.78
Dec. (22)	86	0.62	2.86	109.31	0.00	0.99	0.00	0.00	98.26	1.98	2.48	0.00	72.29	6.33	1219.38	1225.71
$\bar{X}$		0.67	6.87	67.31	21.31	3.81	22.82	7.37	22.92	2.27	2.03	1.16	17.60	45.34	670.92	716.26

Table 4.17 Number of *P. indicus* caught in the experimental nets during December 1985 to December 1986

Month and year		Mesh size in mm									Total
		32.0	34.0	38.0	42.0	46.0	50.0	52.0	54.0	56.0	
December	1985	20	14	8	6	0	0	0	0	0	48
January	1986	1	0	0	1	0	1	0	0	0	3
February	1986	24	15	20	14	0	2	1	1	0	77
March	1986	55	60	39	13	0	0	0	0	0	167
April	1986	48	45	38	21	0	1	0	0	0	153
May	1986	63	59	73	41	27	7	3	3	6	282
June	1986	33	43	61	46	46	29	27	38	27	350
July	1986	101	136	267	279	296	193	142	104	76	1594
August	1986	6	8	9	12	14	7	8	6	4	74
September	1986	0	1	2	1	2	0	0	0	0	6
October	1986	2	4	2	3	3	0	0	0	0	14
November	1986	0	4	2	0	0	0	0	0	0	6
December	1986	5	4	4	1	2	0	0	0	0	16
Total		358	393	525	438	390	240	181	152	113	2790

Table 4.18 Hydrographic data for the period December 1985 to December 1986

Month and Year	Depth of ground m	Clou- diness	Turbidity in m and Extinction co effi- cient	Rainfall mm	Temperature °C		Dissolved oxygen ml/1
					Air	Surface water	
December 1985	11.0	4/8	2.00(0.85)	143.00	29.1	28.1	7.4
January 1986	15.0	4/8	1.50(1.13)	000.00	29.0	28.8	6.0
February 1986	9.0	2/8	3.75(0.45)	86.00	29.6	29.2	3.8
March 1986	9.0	2/8	5.00(0.34)	106.00	31.0	30.0	4.5
April 1986	8.5	4/8	2.60(0.65)	51.00	30.5	30.0	3.8
May 1986	9.0	7/8	1.80(0.94)	287.00	29.0	30.0	3.0
June 1986	8.5	7/8	2.00(0.85)	609.00	29.0	28.0	3.2
July 1986	8.5	3/8	1.00(1.70)	291.00	28.5	26.5	5.2
August 1986	8.0	3/8	1.00(1.70)	391.00	28.8	27.8	5.4
September 1986	7.5	6/8	0.75(2.26)	273.00	26.5	27.0	7.5
October 1986	8.0	2/8	1.50(1.13)	128.00	29.0	28.2	6.8
November 1986	17.0	2/8	5.00(0.34)	164.00	29.0	28.0	8.0
December 1986	10.0	3/8	2.60(0.68)	11.00	30.0	29.0	5.0

Figures in parenthesis in column 4 are extinction coefficients. Rainfall is based on Indian Meteorological Data furnished by Director General of Meteorology (Weather Forecasting), Meteorological Office, Pune-5

Table 4.19 Correlation coefficients between hydrographic parameters and catch

	Dissolved oxygen	Surface water temperature	Air temperature	Rain fall	Turbidity
Penaeus indicus	-0.3895	-0.3735	0.1265	0.5093	0.3346
Total prawn	-0.3950	-0.3692	0.1242	0.5089	0.3318
Total fish	0.5805*	0.0876	0.1419	-0.5853*	-0.4350
Total of prawn and fish	0.5754*	0.0380	0.1363	-0.5627*	-0.4255

* $P < 0.05$

species, *P. indicus* formed more than 95% of the catch. The season for *P. indicus* commenced from February with peak in July. Variation in size was observed with change of season. The occurrence of prawn in the smaller meshed nets during February - August coincides with the availability of smaller size groups in the population. But in the subsequent months, the catch appeared in the large meshed nets also indicating the occurrence of larger prawns.

The fish catch was more during January to February and October to December and the peak was in November. The catch was comparatively less during the period from March to September. This showed that post-monsoon period yielded better output when compared to pre-monsoon and monsoon months. But in the case of prawn a reverse trend was noticed.

The main species that contributed more than 50% of the catch were shark, *Chirocentrus* spp. *Rastrelliger kanagurta*, *Thrissocles* spp. and Sciaenids with an average catch rate of 319.29, 67.31, 38.11, 37.84 and 30.36 g/1000 m^2 respectively. Cloudiness of sky was less during February, March, October and November and high during May, June and September under the influence of monsoon. The turbidity was high during September, July and August and least during November, March and February 1986.

Rainfall was high during the months May to September and was maximum in June followed by August. Moderate to high rainfall occurred during the remaining months except in January when there was no rain fall.

The lowest air temperature was noticed during September (26.5°C) followed by July and August and the highest in March, April and December 1986. Surface water temperature was high during March, April and May and low in July and September.

Highest dissolved oxygen was found to occur during December 1986, September 1986, December 1985 and October 1986. Lowest value of 3.0 ml/l and 3.2 ml/l occurred during May and June 1986.

From the coefficient of correlation between catch and environmental parameters (Table 4.19) is observed that total fish catch was positively correlated with dissolved oxygen and negatively correlated with rainfall at 5% level indicating that as dissolved oxygen increases fish catch also increases and as rainfall increases the fish catch decreases. The grand total catch (prawn and fish) showed positive correlation with dissolved oxygen and negative correlation with rainfall indicating that grand total catch increases with increase in dissolved oxygen but decreases with increase in rainfall.

CHAPTER 5. SUMMARY AND RECOMMENDATIONS

5. SUMMARY AND RECOMMENDATIONS

A detailed study on the prawn gill nets was undertaken during the period of December 1985 to December 1987 with the objective of improving prawn gill nets for the efficient exploitation of the prawn resources. The results of the investigations are incorporated in this thesis entitled "Studies on Prawn Gill Nets of the Kerala Coast". This thesis is structured into five chapters.

5.1 CRUSTACEAN FISHERY RESOURCES

This chapter begins with a brief introduction enumerating the importance of prawn fishery in India and a review of its global distribution. The tropical and sub-tropical areas are the regions where prawns are mainly distributed. The distribution also shows regional specificity, the Pandalids dominating higher latitudes and Penaeids in the tropics. This is followed by a detailed description of the important species of the major fishing zones. The contribution of the first ten prawn producing countries along with their share in the world prawn catch is also included.

Prawn landings of the Indian Coast from 1980 to 1989 with major constituent groups are presented. The abundance and seasonal variation are also incorporated.

The contribution from different maritime states for the ten year period (1980-1989) with particular reference to penaeid prawns is discussed in detail.

The importance of prawn fishery in the Indian fisheries along with measures to augment the prawn production is also highlighted.

The chapter ends with a brief discription of prawn fishery resources, species composition, variation in catch and seasonal abundance of the major species at Neendakara, Cochin and Calicut.

5.2 PRAWN FISHING TECHNIQUES

Different systems of classification of fishing techniques are discussed and that of Brandt (1984) is adopted in the present case. The fishing techniques for prawns are grouped into twelve classes. The different techniques prevalent in India with special emphasis to practices in Kerala are discussed under appropriate classes.

The relevance of prawn gill net fishing is discussed in the context of fuel intensive nature of trawling, dwindling share of shrimps in trawl catches and increasing fuel costs. Apart from this, gill netting as a less capital intensive fishing method is also beneficial to developing countries. The advantage of this method gains prominence in view of the fact that gill netting enables the fishermen to limit the harvest to the marketable size of the desired species due to size selective nature of the gear. The growing use of this fishing technique along the Indian Coast in recent years is an indication of its acceptance for capture of prawns.

5.3 MATERIAL AND METHODS

Fishing investigations were conducted from grounds off Cochin from a plank built canoe, the dimensional details of which are given separately.

The fishing ground, test procedure for assessing physical properties of material, experimental gear and the fishing experiments conducted for determining selectivity of materials, selectivity of mesh size, coefficient of hanging, colouration and fishing height are detailed in this chapter. Procedure adopted for collection of environmental data are also included.

5.4 RESULTS AND DISCUSSIONS

Results and discussions are presented in chapter 4 following the same sequence as given in chapter 3, based on results of statistical analysis.

5.4.1 Selectivity of materials

The physical properties of netting yarns and netting provide basic information for the selection of material. A 0.268 mm dia polyethylene monofilament yarn and polyamide multifilament twine (210D x 1 x 2) possesses equal R tex. The smallest size of twisted polyethylene monofilament (0.45 mm dia) possesses equal wet knot strength compared to that of nylon, making it an appropriate substitute for the latter as suggested by Brandt (1964). The load elongation curves exhibit differential pattern characteristic of each material. Nylon twine with greater elongation for low load will function as a more flexible material during fishing operations.

The modification of the procedure of Machii and Nose (1987) incorporating R tex in place of diameter is advantageous in that these values are more dependable; diameter given for netting yarns are usually nominal values. The strength of netting was found to bear a linear relation with the number of meshes and independent of mesh size. These two properties, weight and strength of netting conjointly help in quantity estimation and comparable quality evaluation of netting. The cost-quantity ratio recommends nylon as the more economical material.

Nylon 210D x 1 x 2 is the best material for prawn gill nets. This could be explained in terms of the mechanism of capture and properties of the material. Prawns are caught by gilling and entangling. The material satisfying the minimum requirement is nylon (Klust 1973). Nylon is soft and flexible as evident from the pattern of load elongation curve.

5.4.2 Slectivity of mesh

The aim of the investigation was to find out optimum mesh size for *P. indicus*. The most suitable mesh size was observed to be 38.0, 42.0 46.0 mm among the nine mesh sizes investigated for the capture of *P. indicus*.

The coefficient of proportionality (k) for P. indicus for the length (l) and mesh size (a) was determined as 0.34 (Baranov 1948).

The shifting of modal size of P. indicus from 10-11, 11-12, 12-13, 13-14 and 14-15 cm with mesh size of 34.0, 38.0, 42.0, 46.0 and 50.0 mm respectively indicates that P. indicus is caught by gilling as well. In this case prawns are bent like 'U' posture accomodating the portion between cephalothorax and abdominal segment within the mesh lumen (Photograph 10).

The skew either negative or positive of the mesh selectivity curves is indicative of entanglement. Right handed skew has been cited as entanglement of larger size groups (Salvanes 1991).

5.4.3 Coefficient of hanging

On determining mesh size and dimension of material, further perfection can be brought about by altering the coefficient of hanging. There is no necessity of decreasing or increasing the coefficient of hanging from 0.5, as higher catch of P. indicus both by number and weight was obtained in this net compared to other nets, with 0.4 and 0.6 coefficients of hanging. Therefore, for better capture of P. indicus, net with 0.5 coefficient of hanging is the best suited.

5.4.4 Colouration

The performance of coloured nets was better during the month of July followed by August and September.

Green coloured nets caught significantly higher catch of prawns both by number and weight, followed by orange, red and blue. There is significant correlation between extinction coefficient and green coloured net indicating the camouflaging effect of green colour.

5.4.5 Fishing height

The calculated fishing height was found to vary from 0.6 to 4.3% of the observed values. At a current speed over 1.0 knot the fishing height was reduced by 50%. The drag of the netting was found as 90% of the total drag of the net itself.

5.4.6 Seasonal variation and hydrography

The maximum CPUE was obtained during the month of November and the least during July. The ratio of prawn to fish was 1:15 by weight.

Among prawns P. indicus was the most abundant species and the best season extended from February to August with peak during July. The catch in small meshed net was maximum during February - August and in large meshed nets from May to August.

Fish was abundant during the postmonsoon period. Abundance of fish was positively correlated to dissolved oxygen and negatively correlated to rainfall.

5.5 RECOMMENDATIONS

Gill netting is comparatively simple and requires lesser fuel and is practised mainly for harvesting fishes. But this method is gaining popularity in recent years for catching prawns. The present study was undertaken to improve the existing gear for efficient exploitation of prawns at reduced fuel costs. The main aspects included in the study and the recommendations based on the findings are given below.

5.5.1 Nylon 210D x 1 x 2 of 0.37 mm dia having a wet knot breaking load of 19.43 N and greater elongation at low loads with its softness and flexibility was found to be the most suitable material for prawn gill net.

5.5.2 Mesh sizes 38.0, 42.0 and 46.0 mm was found to be the optimum mesh size for the capture of *Penaeus indicus* of commercial size.

5.5.3 Proportionality coefficient k between mesh size and length of *P. indicus* has been found to be 0.34.

5.5.4 The most suitable coefficient of hanging for *P. indicus* is 0.5 as maximum quantity of the same by weight and by number was caught in nets with 0.5 as coefficient of hanging, compared to 0.4 and 0.6 as coefficient of hanging.

5.5.5 Green coloured net caught significantly higher catch of prawns by number and weight followed by orange, red and blue. Hence green colour is preferred.

5.5.6 This net can function well upto 1.0 knot current velocity and any further increase in velocity will adversely affect the fishing height. It is seldom that in very few places along the coast of Kerala that the current speed exceeds 1.0 kn.

5.5.7 For prawn capture with gill nets, the season is from February to August with peak during July. The small meshed nets caught better during February to August and large meshed nets from May to August. Abundance of fish was positively correlated to dissolved oxygen and negatively correlated to rainfall. Fish was abundant during the post-monsoon season.

These recommended parameters of the prawn gill net were put to field trials on several occasions and the results were found to be in agreement with the earlier observations.

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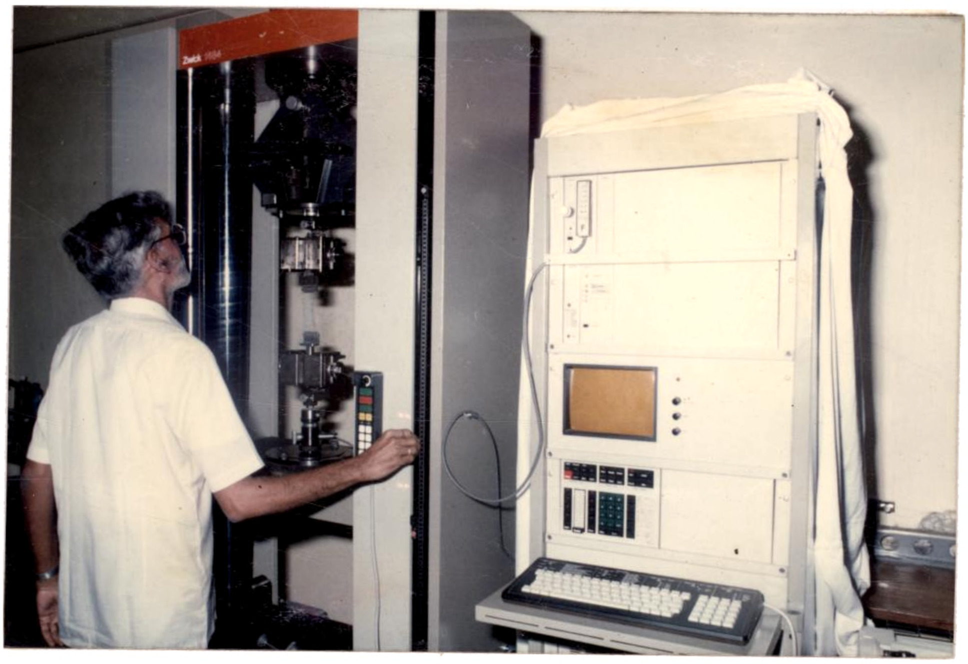
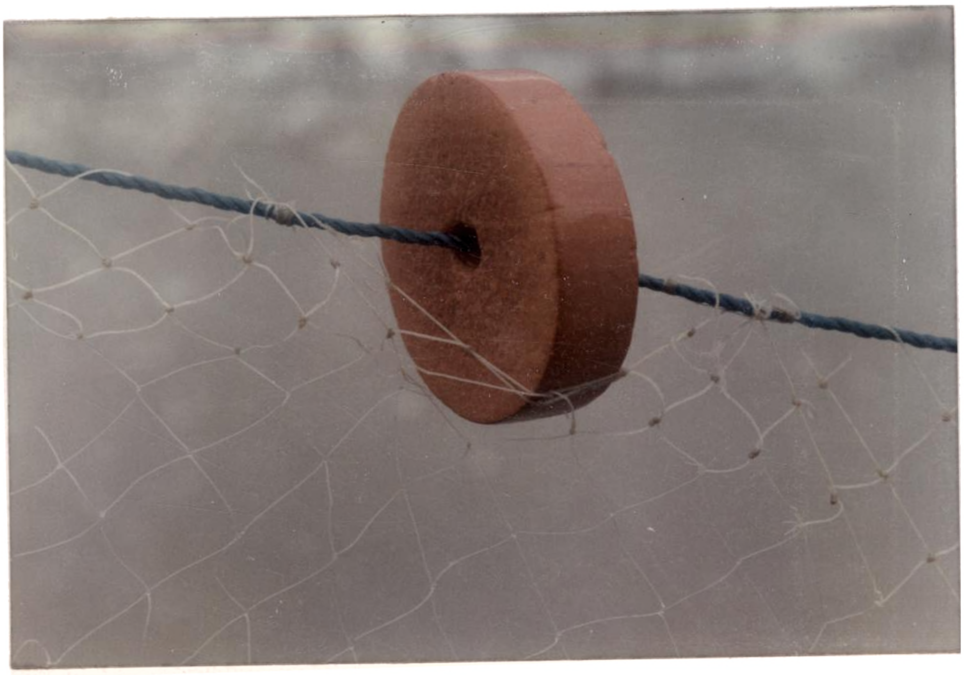
Photograph No. 1.

NYLON TWINE DYED WITH DIFFERENT COLOURS



Photograph No.2.

STRENGTH OF NETTING BEING TESTED WITH UTM-
ZWICK 1484



Photograph No.3.

RIGGING OF FLOAT

Photograph No.4.

SECCHI DISC IN OPERATION

Photograph No.5.

COUNTRY CRAFTS PREPARING FOR FISHING

Photograph No.6.

THE EXPERIMENTAL GEAR MADE READY FOR OPERATION

Photograph No.7.

THE GEAR UNDER OPERATION

Photograph No.8.

HAULING UP OF GEAR

Photograph No.9. *

THE GEAR WITH FISH AND PRAWN CATCH

Photograph No.10.

PENAEUS INDICUS ENMESHED IN THE NET

Photograph No.11.

PRAWN CATCH FROM THE EXPERIMENTAL GEAR

Photograph No. 12.

MEASURING FISH LENGTH