

Proceedings of the  
FIRST WORKSHOP ON SCIENTIFIC RESULTS OF  
FORV SAGAR SAMPADA

5-7 June, 1989, Cochin

*Sponsored by*

DEPARTMENT OF OCEAN DEVELOPMENT  
&  
INDIAN COUNCIL OF AGRICULTURAL RESEARCH  
NEW DELHI

*Organized by*

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE  
&  
CENTRAL INSTITUTE OF FISHERIES TECHNOLOGY  
COCHIN

OCTOBER, 1990

*Published by*

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## RESULTS OF BOTTOM TRAWLING BY FORV SAGAR SAMPADA WITH SPECIAL REFERENCE TO CATCH AND ABUNDANCE OF EDIBLE CRUSTACEANS

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### ABSTRACT

A detailed study of the crustacean components of the trawl catches taken by FORV *Sagar Sampada* between 30 and 450 m depth during cruises 1 to 50, (February, 1985 to August, 1988) has been carried out. Analysis of the catches of 378 trawl hauls spread over the entire coast line of India reveals that the existence of appreciable quantities of edible crustaceans which could be commercially exploited beyond the conventional fishing grounds, is highly localised and depth-specific. The productive areas for prawns, lobsters and crabs as revealed by the survey have been indicated, together with information on important species and their sizes. On the west coast, the coastal prawn *Parapenaeopsis styliifera* ('Karikkadi') has been encountered in varying densities in the offshore waters upto 53 m depth during the southwest monsoon period almost as a continuous belt between Quilon and Marmagoa. Commercial exploitation of this offshore stock of 'Karikkadi' during the monsoon period is worth attempting throughout the west coast. The abundance of the sand lobster *Thenus orientalis* at 40-75 m depth off Veraval to Dwaraka and Kanyakumari to Alleppey and that of the deep-sea crustaceans in the south western region offers scope for commercial fishing.

### INTRODUCTION

Lack of adequate information on the availability and extent of commercially exploitable resources beyond the conventional fishing grounds has been a major constraint for the development of deep-sea fishing in Indian waters. Deep-sea fishing being highly capital intensive, the main concern of the entrepreneurs is to catch exportable varieties of resources which would bring in sufficient foreign exchange and sustain the industry. Among the various marine living resources, crustaceans are much sought after on account of their high export value and as such any indication of their occurrence in commercial quantities outside the presently exploited zone would be encouraging to the fishing industry.

The exploratory fishery surveys conducted by the Government of India vessels in the past have demonstrated exploitable stocks of crustaceans in the shelf waters of Indian coasts, the details of which are described by George *et al.* (1963), Kagwade (1967), Rao and Dorairaj (1969), Rao (1973), Pai and Pillai (1973), Sekharan *et al.* (1973) and Muthu *et al.* (1975) to mention a few. Occurrence of deep-sea crustaceans in appreciable quantities beyond the continental shelf has also been reported by Kurian (1965), Silas (1969), Mohamed and Suseelan (1973), Suseelan (1974, 1985), Oommen (1980) and James (1987) from the southwest coast and Gulf of Mannar.

FORV *Sagar Sampada* has been conducting bottom trawling in the Indian EEZ ever since she was commissioned for fishery-oceanographic surveys along the Indian coasts. This has yielded valuable data to throw light on the fishery potential of the offshore waters hitherto unexploited or underexploited. The present paper deals with the results of a detailed analysis of the crustacean components of the catches taken by bottom trawls during cruises 1 to 50 from February, 1985 to August, 1988.

### MATERIAL AND METHODS

The catch and effort data of 378 trawl hauls taken between 30 and 450 m depth spread over the entire coast line of India covering the continental shelf and upper continental slope have been examined for the edible crustacean groups such as prawns, lobsters and crabs. Catch composition and biological aspects of important species constituting the catch in different regions of the coast were studied by analysing 112 samples taken onboard the vessel, haul-wise.

Analysis of the catch and effort data was made depthwise for each of the 1° - latitude zones of the west and east coasts demarkated by the 77°30'E longitude line. The catch data were then compiled against trawling effort for the four major regions, namely South-Western Region, North-Western Re-

gion, South-Eastern Region and North-Eastern Region demarkated by the 15°N latitude line. For depthwise analysis of data the entire depth region between 30 and 450 m was divided into the following six depth zones.

Depth zone	1	:	30- 50	m
Depth zone	2	:	51-100	m
Depth zone	3	:	101-200	m
Depth zone	4	:	201-300	m
Depth zone	5	:	301-400	m
Depth zone	6	:	401-450	m

#### RESULTS AND DISCUSSION

The distribution of trawling stations occupied by *Sagar Sampada* is shown in Fig. 1. Tables 1 to 5 also furnish details of the trawling effort and catch returns of edible crustaceans in different regions of the Indian coasts.

Out of the 378 hauls, which involved a total effort of 339 hours of actual trawling, 317 hauls were attempted on the shelf region (30-200 m) and 61 hauls on the upper continental slope (201-450 m). The duration of each haul varied between 0.25 and 2.17 hours depending on bottom conditions and other factors. In general, the decapod crustaceans were less abundant in the offshore waters although in certain pockets they occurred in fairly good concentrations worth considering for commercial exploitation. The productive areas of prawns, lobsters and crabs as revealed by the present survey are indicated in Fig. 2.

#### South-Western Region

This region comprises the coasts of Kerala and Karnataka states and the Kanyakumari district of Tamilnadu. The continental shelf of this region is much narrower than that of the northern part of the west coast and is highly influenced by upwelling during the monsoon period. The upper continental slope drops suddenly in most parts except off Quilon where it forms an extensive bank upto a depth of about 375 m which is commonly referred to as the 'Quilon Bank'. Two other important submarine banks namely, the 'Chettuva Bank' (Oommen, 1974) and the 'Wadge Bank' also occur in this region and they have good trawling grounds.

A total of 169 bottom trawl operations were made in this region expending 138 hours of actual trawling. Of these, 115 hauls were taken on the shelf and 54 on the upper continental slope. In the total number of hauls, 100 hauls were negative for crus-

taceans. The maximum frequency (89 %) of negative hauls was recorded in the 51-100 m depth zone. In the positive hauls the amount of crustaceans varied from 0.1 to 1,080 kg/hr.

Out of a total quantity of about 2,900 kg of crustaceans recorded from this region, prawns accounted 1,877 kg (64.7%), lobsters 318 kg (11.0%) and brachyuran crabs 706 kg (24.3%).

#### Prawns

Prawns were recorded in varying degrees of abundance in all the depth zones except zone 6 where the sampling was extremely poor (Table 1). Littoral penaeids, whose catch varied highly with depth, were encountered in depth zones 1 and 2. *Parapenaeopsis stylifera* ('Karikkadi Chemmeen') was the only species represented in the catch from depth zone 1, and it was caught almost throughout the Kerala and Karnataka coasts north of Quilon during the southwest monsoon period (Table 2). Its catch rate worked out to 1-53 kg/hr with the highest production between 40 and 50 m depth off Quilon. In depth zone 2, the meagre catch recorded was constituted by *Penaeus canaliculatus*, *P. semisulcatus* and *Trachypenaeus* spp. The nonconventional penaeid prawns of the genus *Metapenaeopsis* (*M. coniger* and others) accounted for the major portion of the catch from the outer continental shelf coming under depth zone 3. The upper continental slope provided an entirely different picture of faunistic composition in which members of all the deep-sea penaeidean families (Solenoceridae, Aristeidae and Penaeidae) and the caridean prawns of family Pandalidae were represented commonly. In depth zone 4, the important species in the order of abundance were *Plesionika spinipes* (60.5%), *Penaeopsis jerryi* (26.3%), *Solenocera hextii* (5.6%), *Metapenaeopsis andamanensis* (3.7%) and *Heterocarpus woodmasoni* and *H. gibbosus* (2.7%). The relative abundance of the various species changed considerably in depth zone 5 where the major components in the order of importance were *H. woodmasoni* and *H. gibbosus* (44.1 %), *Plesionika spinipes* (35.3%), *P. martia* and *P. ensis* (7.9%), *P. jerryi* (5.7%), *Aristeus alcocki* (3.4%) and *M. andamanensis* (2.7%). Suseelan (1985, 1988) has dealt with in detail the systematics, biology and bathymetric distribution and abundance of the deep-sea prawns of this region based on the results of earlier exploratory surveys. The present analysis of the catches of *Sagar Sampada* has shown that commercially exploitable stocks of deep-sea prawns exist as a narrow belt extending

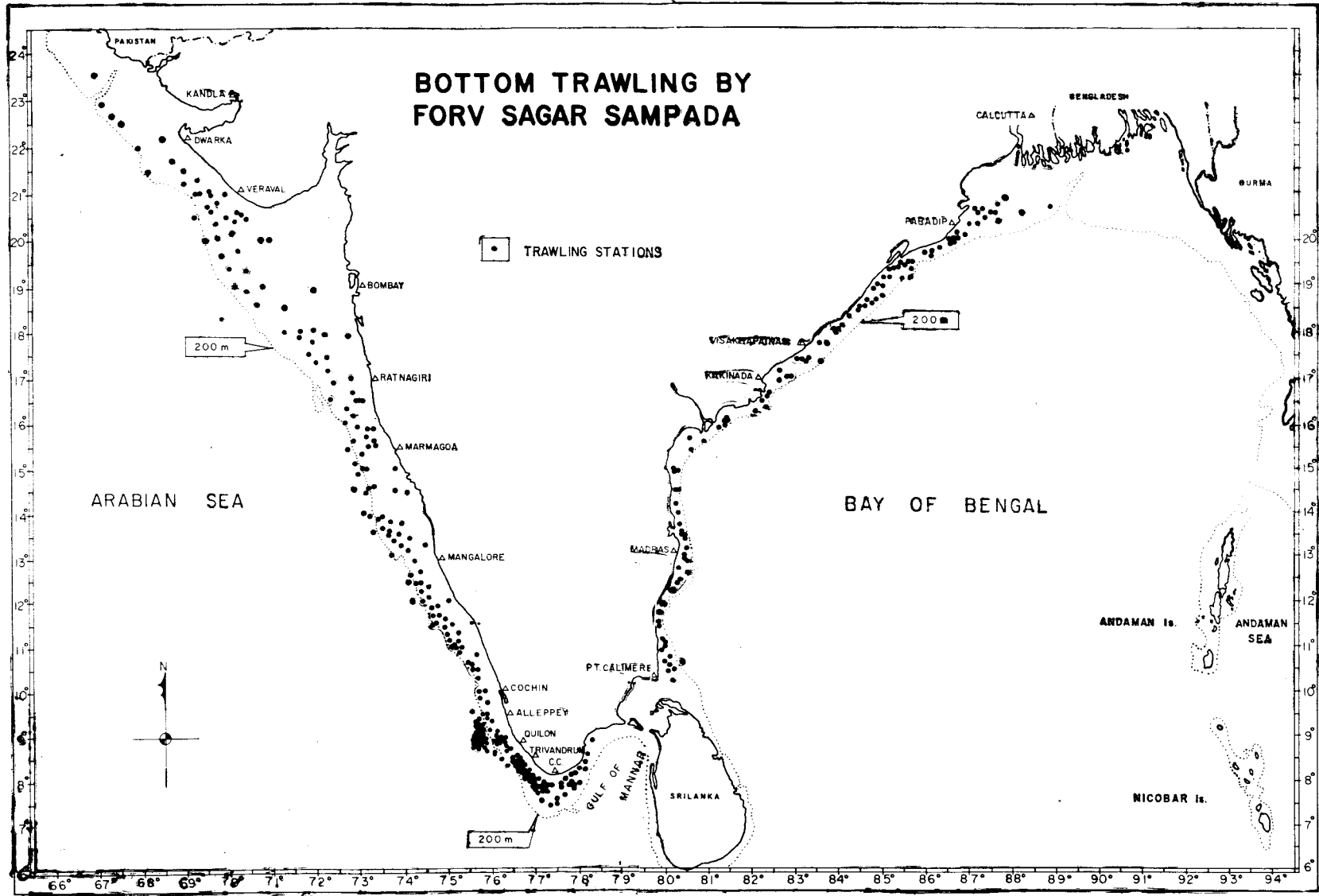


Fig. 1. Distribution of trawling stations of FORV *Sagar Sampada*.

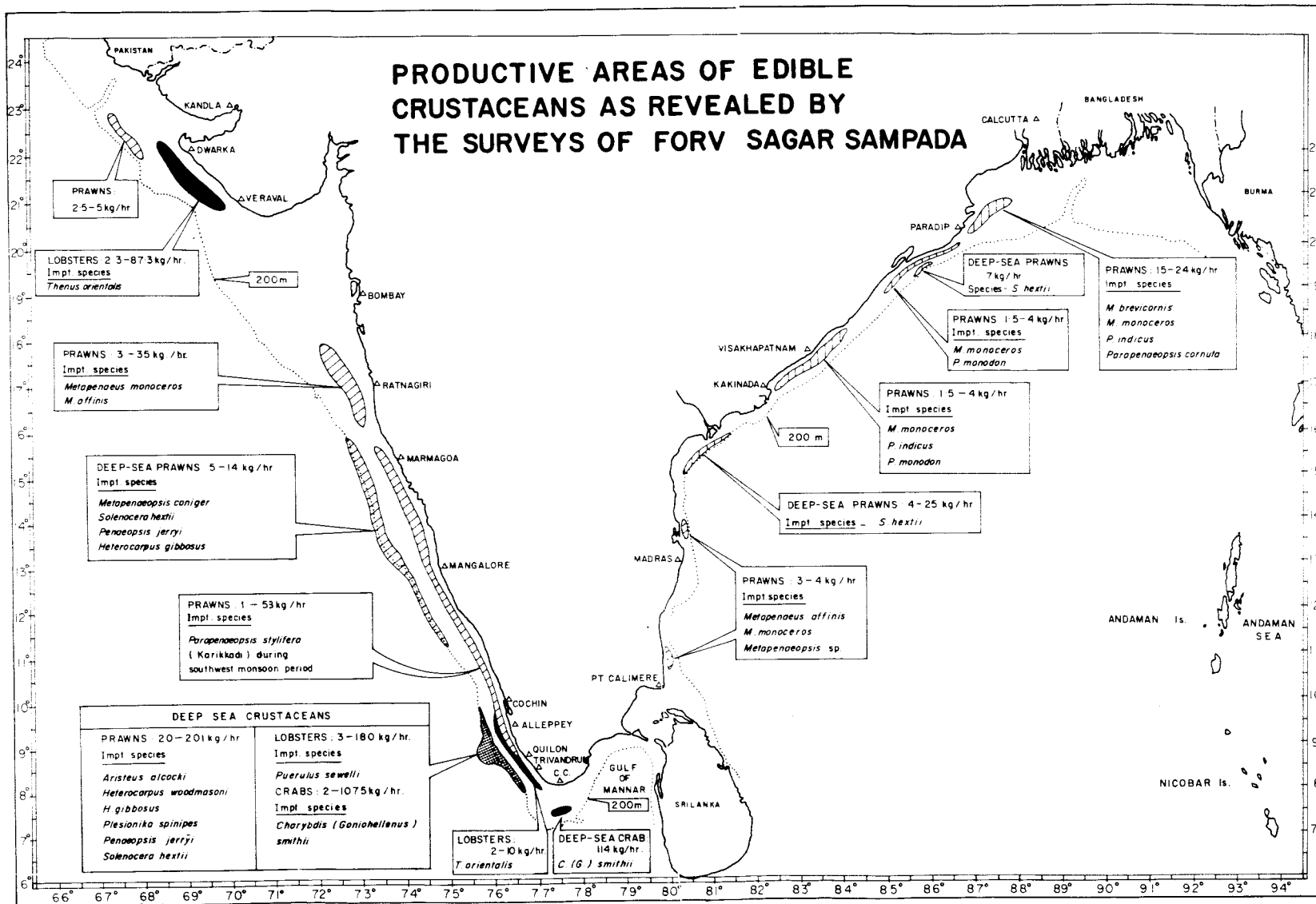


Fig. 2. Productive areas of edible crustaceans as revealed by bottom trawling of FORV Sagar Sampada.

TABLE 1. Details of trawling operations, catch and catch/ hour of edible crustaceans by depth zones in the South - Western Region

Particulars	Continental shelf		Upper continental slope				Total		
	Depth zones								
	1	2	3	4	5	6			
Total No. of hauls	19	71	25	15	38	1	169		
Total No. of trawling hrs	16.50	61.35	22.10	11.14	27.20	0.25	138.54		
No. of negative hauls	13	63	17	4	2	1	100		
No. of positive hauls	6	8	8	11	36	-	69		
<i>Catch and catch/hour in kg</i>									
Prawns	-	C	57.5	2.9	10.2	297.0	1,509.8	-	1,877.4
		C/hr	3.5	-	0.5	26.7	55.5	-	13.6
Lobsters	-	C	-	29.2	-	151.0	137.7	-	317.9
		C/hr	-	0.5	-	13.6	5.1	-	2.3
Crabs	-	C	-	0.2	34.0	152.4	519.0	-	705.6
		C/hr	-	-	1.5	13.7	19.1	-	5.1
Total crustaceans		C	57.5	32.3	44.2	600.4	2,166.5	-	2,900.9
		C/hr	3.5	0.5	2.0	53.9	79.7	-	209.9

C = Catch, C/hr = Catch per hour.

from Cannanore to Marmagoa between 160 and 285 m depth (5-14 kg/hr), and in the Quilon Bank between 250 and 400 m depth (20-201 kg/hr). The important species occurring are *M. coniger*, *S. hextii*, *P. jerryi* and *H. gibbosus* in the former ground and *H. woodmasoni*, *H. gibbosus*, *P. spinipes*, *P. jerryi*, *A. alcocki* and *S. hextii* in the latter.

An interesting finding that has emerged from this survey is that *S. hextii* which enjoys a distribution throughout the west coast is represented by two different populations, each one being formed by a type distinctly different from the other in colour, size and other morphological features. One of these, is originally described by Wood-Mason (1891) from the Bay of Bengal and the other recorded by others from the Arabian Sea. Attaining about 155 mm in total length, this form has robust body which is more fleshy and appealing to the industry. It occurs mainly in the southern part of the southwest coast with maximum density in the Quilon Bank. The other form, which is being described as a new variety of the species in a separate communication, is a smaller one not exceeding 85 mm in total length. It has a thin and more reddish body, and is found to inhabit slightly

shallower areas (160-285m) along with *M. coniger*. This variety of *S. hextii* is the most common along the coasts of Karnataka and Goa.

The size range of *P. stylifera* recorded during the monsoon period was 65-114 mm, but the bulk of the catch was constituted by the size groups 71-95 mm. Among females, which numbered about half of the population, mature specimens were extremely rare. The dominant sizes of the other important species of prawns were 61-70 mm for *M. coniger*, 81-105 mm for *P. spinipes*, 71-100 mm for *P. jerryi*, 101-120 mm for *H. woodmasoni*, 91-125 mm for *H. gibbosus*, 110-135 mm for *S. hextii* (Quilon Bank) and 136-170 mm for *A. alcocki*.

#### Lobsters

In the bottom trawls, lobsters were caught only in depth zones 2, 4 and 5. The sand lobster *Thenus orientalis* occurred at the rate of 2-10 kg/hr in depth zone 2 off Kanyakumari and Alleppey, with an average catch rate of 0.5 kg/hr. The deep-sea spiny lobster *Puerulus sewelli* was trawled in appreciable quantities (3-180 kg/hr) from depth zones 4 and 5 mainly between Kanyakumari and Alleppey.

The highest catch per haul was recorded in depth zone 4 (201-300 m) off Trivandrum. The size of this lobster ranged from 71 to 200 mm in total length, with the dominant size group 136-175 mm. Among females, which formed more than half of the catch by number, over 67% were in ovigerous state particularly during January-February period. The lobster was found to feed predominantly on deep-sea prawns, bivalves and fishes.

#### Crabs

The swarming crab *Charybdis (Goniohellenus smithii)* formed an important constituent of the catch in the offshore waters. It was recorded in depth zones 2 to 5 at catch rates varying from 2 to 1,075 kg/hr. The greatest concentration was observed in depth zones 4 and 5 between Trivandrum and Alleppey. The size of the crab ranged from 42 to 72 mm in carapace width. In most of the hauls females predominated, and among females majority were in ovigerous condition.

#### North-Western Region

This region includes the coasts of Goa, Maharashtra and Gujarat where the continental shelf is the widest with a maximum extent of about 350 km from the shore. The trawling operations in this region were mostly confined to the shelf waters particularly in depth zone 2. A total of 73 hauls were taken involving about 70 hours of trawling. Of this, 54 hauls did not yield any catch of crustaceans. In most of the positive hauls the amount of crustaceans recorded was very poor.

In the total crustacean catch of 147 kg realised from this region, prawns accounted 56 kg, lobsters 91 kg and crabs 0.4 kg (Table 3).

#### Prawns

Prawns were recorded from depth zones 1-4, with the highest yield in depth zone 2, where the average catch rate worked out to 1.1 kg/hr. Off Marmagoa, *P. styliifera* was caught in moderate numbers from the offshore waters (53 m depth) dur-

TABLE 2. Occurrence and catch details of 'Karikkadi' (*P. styliifera*) in the offshore waters during the monsoon period

Position (latitude)	Depth (m)	Coast	Month	Duration of haul (hours)	Catch (catch/hr)
9° 00' N	40	SW : Off Quilon	July, '87	0.75	40.0 kg (53.3 kg)
9° 05' N	49	SW : Off Quilon	June, '87	1.00	12.0 kg (12.0 kg)
12° 00' N	35	SW : Off Mangalore	June, '87	0.50	2.0 kg (4.0 kg)
12° 30' N	42	SW : Off Mangalore	July, '87	0.75	2.0 kg (3.0 kg)
13° 16' N	35	SW : Off Mangalore	June, '87	0.50	1.0 kg (2.0 kg)
14° 28' N	30	SW : Between Karwar and Marmagoa	July, '87	0.50	0.5 kg (1.0 kg)
15° 30' N	53	NW : North of Marmagoa	July, '87	0.75	0.5 kg (0.8 kg)



ing the southwest monsoon period (Table 2, Fig. 2). In still deeper areas fairly good catches of other littoral penaeids, such as *Metapenaeus monoceros* and *M. affinis*, were obtained off Ratnagiri (3-35 kg/hr) and Kandla (2.5-5 kg/hr). Rao (1973) recorded maximum catch rates for prawns between 41 and 65 m depth along the Bombay-Saurashtra coasts.

The size range of *P. styliifera* caught during the monsoon season was 60-89 mm for males and 60-109 mm for females. The major size constituting the population was 75-79 mm for both sexes. *M. affinis* and *M. monoceros* were represented by the size ranges 106-145 mm for the former and 105-180 mm for the latter.

#### Lobsters

The sand lobster *T. orientalis* and the spiny lobster *Panulirus polyphagus* were caught in depth zones 1 and 2, the former species in fairly good quantities (2-85 kg/hr) between 40 and 75 m depth off Veraval to Dwaraka. The size range of this species was 76-198 mm in total length, with the dominant size group of 101-115 mm.

#### Crabs

The catch of brachyuran crabs was negligible throughout the region.

The bottom trawling surveys conducted by M. T. Muraena between 55 and 360 m depth along this coast (Bapat *et al.*, 1982) have indicated average catch rates of 0.35 kg/hr in 55-90 m depth range, 0.03 kg/hr in 91-125 m depth range and 0.34 kg/hr in 126-360 m depth range for crustaceans comprising of prawns, lobsters and crabs. The total crustacean catch realised by this vessel for 247 hauls amounted to only 113 kg with minimum catch (4 kg) from 91-125 m depth range.

#### South-Eastern Region

This region extends from Kanyakumari to north of Nellur in Andhra Pradesh and includes the Gulf of Mannar, Palk Bay and the Coromandal coast. Off Kanyakumari, the 'Wadge Bank' continues eastwards. The shelf area is relatively less extensive and the continental slope plunges suddenly along the Coromandal coast.

Bottom trawling was conducted in the Gulf of Mannar and Coromandal coast only. A total of 58 hauls involving about 53 hours of trawling effort were made. Except for a single haul attempted in depth zone 6, the survey was almost entirely confined to the shelf waters. Most of the hauls (54) were taken within 100 m depth. In general the crustacean component was extremely poor in this region, the

TABLE 3. Details of trawling operations, catch and catch/hour of edible crustaceans by depth zones in the North-Western Region

Particulars	Continental shelf		Upper continental slope				Total
	Depth zones						
	1	2	3	4	5	6	
Total No. of hauls	14	44	12	2	-	1	73
Total No. of trawling hrs	13.6	41.75	11.15	2.25	-	1.0	69.75
No. of negative hauls	11	32	9	1	-	1	54
No. of positive hauls	3	12	3	1	-	-	19
<i>Catch and catch/hour in kg</i>							
Prawns	C	0.6	46.7	8.5	0.2	-	56.0
	C/hr	-	1.1	0.8	0.1	-	0.8
Lobsters	C	81.2	9.8	-	-	-	91.0
	C/hr	6.0	0.2	-	-	-	1.3
Crabs	C	-	0.4	-	-	-	0.4
	C/hr	-	-	-	-	-	-
Total crustaceans	C	81.8	56.9	8.5	0.2	-	147.4
	C/hr	6.0	1.4	0.8	0.1	-	2.1

total catch recorded being 154 kg formed by prawns (37 kg) and crabs (117 kg) (Table 4). Moderate catches of prawns (3-4 kg/hr) predominantly constituted by *M. affinis*, *M. monoceros* and *Metapenaeopsis* spp. were observed in two pockets; one north of Pt. Calimere and the other off Pulicat Lake, between 30 and 50 m depth. A good haul of 25 kg of the deep-sea prawn *S. hextii* was also recorded for an hour of trawling between 170 and 180 m depth north off Nellur. The deep-sea crab *C. (G.) smithii* showed dense concentration (114 kg/hr) in the Wadge Bank area off Kanyakumari.

#### North-Eastern Region

This region includes most part of the Andhra coast and the coasts of Orissa and West Bengal. The narrow continental shelf extends upto about Paradip in the north and beyond that the shelf is much wider. The continental slope, however, takes a steep course throughout.

Bottom trawling was conducted in depth zones 1 to 4. Out of the total number of 78 hauls taken in this region, expending over 78 hours of actual trawling, 75 hauls were tried on the shelf and 3 on the upper continental slope. The survey was mainly restricted to depth zones 1 and 2. An important

feature noticed in this region is that though the catches of crustaceans in individual hauls were relatively poor, fairly good percentage of positive hauls were recorded as in the South-Western Region.

The total crustacean catch from this region amounted to 222 kg (2.84 kg/hr) formed by crabs (145 kg), prawns (74 kg) and lobsters (3 kg) in the order of their abundance (Table 5).

#### Prawns

This group occurred in all the depth zones covered during the survey in varying quantities ranging from 0.1 kg to 24 kg per hour of trawling. Depth zone 1 registered maximum catch and catch rates. Moderate catches of littoral penaeids (15-24 kg/hr) chiefly constituted by *Metapenaeus lysianassa* and *M. monoceros* were recorded at 30-35 m depth off Paradip. Though in lesser quantities (1.5-4 kg/hr), prawns were also encountered more frequently off Chilka Lake and Visakhapatnam between 30 and 60 m depth. The deep-sea prawn *S. hextii* occurred in fair abundance on the shelf edge off Chilka Lake.

The major size groups of important species of prawns recorded from this region were 70-89 mm for *M. lysianassa*, 116-139 mm for *M. monoceros* and 55-69 mm for *S. hextii*.

TABLE 4. Details of trawling operations, catch and catch/hour of edible crustaceans by depth zones in the South-Eastern Region

Particulars	Continental shelf		Upper continental slope				Total	
	Depth zones							
	1	2	3	4	5	6		
Total No. of hauls	24	30	3	-	-	1	58	
Total No. of trawling hrs	17.97	26.29	3.33	-	-	1.00	52.61	
No. of negative hauls	19	27	2	-	-	1	49	
No. of positive hauls	5	3	1	-	-	-	9	
<i>Catch and catch / hour in kg</i>								
Prawns	-	C	10.25	1.70	25.00	-	-	36.95
	-	C/hr	0.57	0.07	7.51	-	-	0.71
Lobsters	-	C	-	-	-	-	-	-
	-	C/hr	-	-	-	-	-	-
Crabs	-	C	3.50	114.00	-	-	-	117.50
	-	C/hr	0.20	4.34	-	-	-	2.23
Total crustaceans	-	C	13.75	115.70	25.00	-	-	154.45
	-	C/hr	0.77	4.40	7.51	-	-	2.94

TABLE 5. Details of trawling operations, catch and catch/hour of edible crustaceans by depth zones in the North - Eastern Region

Particulars	Continental shelf		Upper continental slope				Total		
	Depth zones								
	1	2	3	4	5	6			
Total No. of hauls	33	32	10	3	-	-	78		
Total No. of trawling hours	31.67	32.21	9.25	4.00	-	-	78.13		
No. of negative hauls	17	21	6	1	-	-	45		
No. of positive hauls	16	11	4	2	-	-	33		
<i>Catch and catch/hour in kg</i>									
Prawns	-	C	51.95	9.05	8.35	4.30	-	-	73.65
		C/hr	1.59	0.28	0.90	1.07	-	-	0.94
Lobsters	-	C	2.00	1.25	-	-	-	-	3.25
		C/hr	0.06	0.04	-	-	-	-	0.04
Crabs	-	C	2.00	46.00	12.00	85.0	-	-	145.00
		C/hr	0.06	1.42	1.29	21.25	-	-	1.85
Total crustaceans		C	55.95	56.30	20.35	89.30	-	-	221.90
		C/hr	1.71	1.74	1.19	22.32	-	-	2.84

### Lobsters

Stray catches of the sand lobster *T. orientalis* were recorded occasionally in depth zone 2.

### Crabs

Brachyuran crabs formed a significant portion of the catch in several hauls and were represented in all the depth zones 1-4. The highest production was observed in the upper continental slope (201-250 m) off Visakhapatnam where small spider crabs yielded catch rates upto 85 kg/hr.

### GENERAL CONSIDERATION AND RECOMMENDATIONS

The overall performance of bottom trawling conducted by FORV *Sagar Sampada* indicates that the existence of appreciable quantities of edible crustaceans which could be commercially exploited beyond the conventional fishing grounds is highly localised and depth-specific in most part of the Indian coasts. Among the potential stocks, the abundance of deep-sea crustaceans on the shelf edge and upper continental slope of the south-western region is encouraging for commercialised fishing. The sand lobster *T. orientalis* has assumed considerable importance in recent years as an export commodity. It

contributes significantly to the lobster landings of Maharashtra and Gujarat states. The survey indicates good potential for this species between Veraval and Dwaraka in Gujarat where it could be tapped better at 40-75 m depth. The availability of a moderate population of the species between Kanyakumari and Alleppey also offers scope for commercial exploitation of the sand lobster along this coast.

A noteworthy feature observed on the west coast is the occurrence of *P. stylifera* in varying densities in the offshore waters upto 53 m depth during the southwest monsoon period (June and July) almost as a continuous belt between Quilon and Marmagoa. This species is basically a coastal species inhabiting areas within the 30 m depth contour. On the Kerala coast it is caught in enormous quantities during the southwest monsoon period by shrimp trawlers at centres like Cochin and Sakthikulangara (Quilon). Suseelan *et al.* (1988, 1989) have recently established by conducting experimental shrimp trawling off Cochin that during the southwest monsoon period *P. stylifera* migrates in large numbers to the offshore areas upto about 60 m depth as a result of upwelling, and is being caught by shrimp trawlers which venture into the high-seas during that period.

The present finding suggests that the offshore migration of 'Karikkadi' during the monsoon period may be taking place throughout the west coast and therefore commercial trawling to exploit this offshore stock is worth attempting throughout the coast.

#### ACKNOWLEDGEMENTS

The authors are grateful to Dr. P.S.B.R. James, Director and to Dr. (Mrs.) P.V. Kagwade, Head of the Crustacean Fisheries Division, CMFR Institute for their keen interest and encouragement in this study.

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