Demersal Fish Assemblages of the Southwest Coast of India

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Abstract

Demersal surveys from the southwest coast of India were analyzed to determine the general pattern of distribution of demersal species assemblages in the area. Season-ality is pronounced, indicating three major periods, pre-monsoon, monsoon and post-monsoon. Each of the periods is characterized by different oceanographic circulation patterns that mainly determine the pattern of distribution of species assemblages. Spatial analysis confirmed that the Wadge Bank has the highest po-tential for producing good quality fish. Region-wise analysis of data indicated that maximum effort and highest landings are from the known grounds along the south-west coast, although certain northern areas were also found to be fairly productive.

Introduction

Marine fisheries production in India increased from 0.5 to 2.7 million t between 1950 and 1997. Landings along the Indian coast from 1970 to 1997 provide insights on the distribution and abundance of the major fish stocks. The dominant species groups of marine landings throughout India during this period were: oil sardine, penaeid prawns, croakers, Bombay duck, carangids, lesser sardines, ribbonfishes and non-penaeid prawns (Table 1). The Indian coast is subdivided into six major coastal zones, namely northwest (NWCZ), south-west (SWCZ), southeast (SECZ), northeast (NECZ), Lakshadweep Island (LAKCZ) and Andaman and Nicobar Islands (ANCZ) (Fig. 1).

Table 1. Relative abundance (%) by species group in landings along the Indian coast (1970 - 97).

Taxa	Common Name	NWCZ	SWCZ	SECZ	NECZ	LAKCZ	ANCZ	India
Setipinna spp.	Anchovies	0	0	0.1	2.2	0	0	0.1
Bregmaceros mcclellandii	Unicorn cod	0.2	0	0	0	0	0	0.1
Lobsters	—	0.2	0.02	0.1	0	0	0.02	0.1
Exocoetidae	Flying fishes	0	0.01	0.7	0	0.6	0	0.2
Sillaginidae	Mullets	0.4	0.04	0.3	0.08	0	4.4	0.2

Table 1. Relative abundance (%) by species group in landings along the Indian coast (1970 - 97) (continued).

Taxa	Common Name	NWCZ	SWCZ	SECZ	NECZ	LAKCZ	ANCZ	India
Eels	—	1	0.01	0.2	0.5	0	0	0.4
Sphyraenidae	Barracudas	0.1	0.4	0.8	0.05	0.3	3.5	0.4
Polynemidae	Threadfins	0.4	0.03	0.6	0.8	0	0.8	0.5
Lactarius lactarius	Whitefish	1	0.5	0.4	0.08	0	0	0.6
Mullidae	Goatfish	0.3	1.1	1.3	0.3	0.9	0	0.8
Synodontidae	Lizard fish	0.6	1.4	1	0.2	0	0	1
Crabs	—	0.7	0.7	2.8	0.5	0	0.5	1.2
Dasyatidae	Rays	0.9	0.5	3	1.4	0.6	0.6	1.3
Hilsa spp.	Shad	1.1	0.05	1.3	13.8	0	0.2	1.4
Thryssa spp.	Thryssa	0.9	1.1	2.4	0.8	0	4.5	1.4
Scombridae	Tunas	0.8	2.1	1	0.2	69.9	3.2	1.5
Platycephalidae	Flatfishes	1.2	2.8	0.7	0.4	0	0	1.6
Coilia spp.	Grenadier anchovies	4.4	0.01	0.4	3.2	0	0	1.7
Scombridae	Seerfishes	1.8	1.4	2.4	2.8	1.4	3	1.8
Sharks	—	2.9	0.9	2.5	2.8	4.5	2.6	2.1
Cephalopods	—	3	2.5	1.4	0.2	0.4	0.3	2.2
Other perches	—	1.1	2.1	4.2	1.1	3.8	8.6	2.3
Bramidae	Pomfrets	3.9	0.6	1.3	8.1	0	1.3	2.3
Ariidae	Catfishes	3.4	2.3	2.3	8.1	0	2.1	3
Stomatopods	—	2.4	5.7	0.4	0.6	0	0	3
Galaxiidae	Whitebaits	0.2	5.1	4.8	0.9	0	5.5	3.2
Nemipteridae	Threadfin breams	2.1	5.1	2.4	0.3	0	0	3.2
Gerridae	Silverbellies	0.2	1.6	10.4	1	0.4	6.2	3.2
Trichiuridae	Ribbonfishes	6.3	2.6	4.3	4.1	0	1.6	4.3
Non-penaeid prawns	—	12	0.07	0.7	2.6	0	0	4.3
Clupeidae	Lesser sardines	0.4	4.1	11.3	3.7	0	12.5	4.6
Carangidae	Trevally	1.9	7.9	4.8	1.7	1.4	6	4.8
Harpadon nehereus	Bombayduck	16.2	0	0.2	7.2	0	0	5.8
Sciaenidae	Croakers	10.7	2.3	5.1	15.5	0	1.1	6.4
Scombridae	Mackerel	1.6	13.7	4.7	0.8	0	3	6.8
Penaeidae	Penaeid prawns	9.3	8.7	5.9	4.5	0	1.1	8
Sardinella longiceps	Oil sardine	0.3	22	4.1	0.07	0	0	9.2

Note: NWCZ = northwest, SWCZ = southwest, SECZ = southeast, NECZ = northeast, LAKCZ = Lakshadweep Island and ANCZ = Andaman and Nicobar Islands.

The NWCZ extends from 16° N to 24° N comprising the maritime states of Gujarat and Maharashtra and the union territory of Daman and Diu. The length of the coastline is about 2 350 km and the area of the continental shelf is around 27 600 km². The annual average landings from 1970 to 1997 were 563 240 t, which contributed 33% of the mean total landing in India during the period. The NWCZ is characterized by the abundance of Bombay-duck, non-penaeid prawns and croakers, which together constituted 39% of landings in the area (Table 1). In addition to these species groups, eels, *Coilia* spp., ribbonfishes, whitefish, mullets, unicorn cod, penaeid prawns, spiny lobsters and cephalopods also contributed significantly to the landings in the NWCZ.

The SWCZ extends from 8° N to 16° N, comprising the maritime states of Goa, Karnataka and Kerala. The length of the coastline is about 990 km and the area of the continental shelf is roughly 75 400 km². The annual average landing from 1970 to 1997 was 629 780 t, which contributed 37% to the overall mean landing in India during the period. The SWCZ is characterized by the abundance of oil sardine, Indian mackerel and penaeid prawns, which together constituted 45% of the total landings in this area (Table 1). In addition to these species groups, the whitebaits, lizardfishes, threadfin breams, carangids, flatfishes and stomatopods also contributed fairly high quantities to landings in the SWCZ.

The SECZ extends from 8° N to 19° N, comprising the maritime states of Tamil Nadu and Andhra Pradesh besides the union territory of Pondicherry. The length of the coast is about 2 020 km and the area of the continental shelf is about 73 500 km². The annual average landing from 1970 to 1997 was 408 930 t, which contributed 24% to the total mean landing in India during this period. The SECZ is characterized by the abundance of lesser sardines, silverbellies and penaeid prawns, which together contributed 27% to landings in this zone (Table 1). In addition to these species groups, rays, *Thryssa* spp., flyingfishes, major perches, goatfishes and crabs contributed significantly to the landings.

The NECZ extends from 19° N to 22° N, comprising the maritime states of Orissa and West Bengal. The length of the coast is about 640 km. and the area of the continental shelf is about 40 600 km². The annual average landing from 1970 to 1997 was 83 650 t, which contributed 5% of the overall mean landings in India. The NECZ is characterized by the abundance of croakers, *Hilsa* spp. and catfishes, which together constituted 38% of the landings in this zone (Table 1). In addition to these groups, sharks, threadfins, pomfrets and seerfishes contributed a fairly high percentage to the landings.

The LAKCZ in the Arabian Sea extends from 8.5° N to 12° N and has a continental shelf area of 4 340 km². The annual average landing from 1970 to 1997 was 4 400 t, which contributed 0.3% to the overall mean landings in India. This coastal zone is characterized by the abundance of various species of tuna (70% of the landings). In addition to tunas, sharks and major perches contributed significantly to landings in this zone.

The A&N coastal zone in the Bay of Bengal extends from 7.5° N to 15° N and has a continental shelf area of 35 000 km². The annual average landing from 1970 to 1997 was 9 900 t, which contributed 0.6% to the total mean landing in India. This coastal zone is characterized by the abundance of lesser sardines, perches and silverbellies, which together contributed 28% to the overall mean landing in this zone.

Analyses of demersal species assemblages were focused within the continental shelf of the SWCZ . Specifically, the study aims to investigate the: (1) composition of species assemblages, (2) delineation of assemblage boundaries, and (3) environmental factors which explain the assemblage pattern.

Materials and Methods

Of the six coastal zones off the Indian subcontinent, the study focused on the continental shelf in the SWCZ. Trawl data were collected by a stern trawler (28.8 m LOA) using a bottom trawl with otter doors. Fish biology for the major species was done in each survey. Environmental data were collected in the zone using the facilities of a modern fisheries oceanographic research vessel.

The location of sampling stations between Cape Comorin in the south (7°N) and Ratnagiri in the north (17°N) is given in Fig 2. Each 1° square was subdivided into 36 equal squares of about 10 nm x 10 nm. Average trawl effort per 10 minute fishing squares was calculated irrespective of the number of hauls. The survey was conducted in trawlable

areas. Station gaps identified could be due to areas not suitable for trawling either because of rocky substratum or shallow depths.

The surveys were done in a 12-month period divided into three major predetermined seasons viz. pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January). A total of 161 fishing squares were included in this study. The station numbers assigned for each fishing square during the three monsoon periods are given in Table 2. Average catch of the total number of hauls per fishing square was calculated. Two 28.8 m - LOA stern trawlers, M/V M.F.V. Samudrika, owned by the Integrated Fisheries Project, Cochin, Ministry of Agriculture, Government of India, were used in the surveys from April 1994 to March 1996.
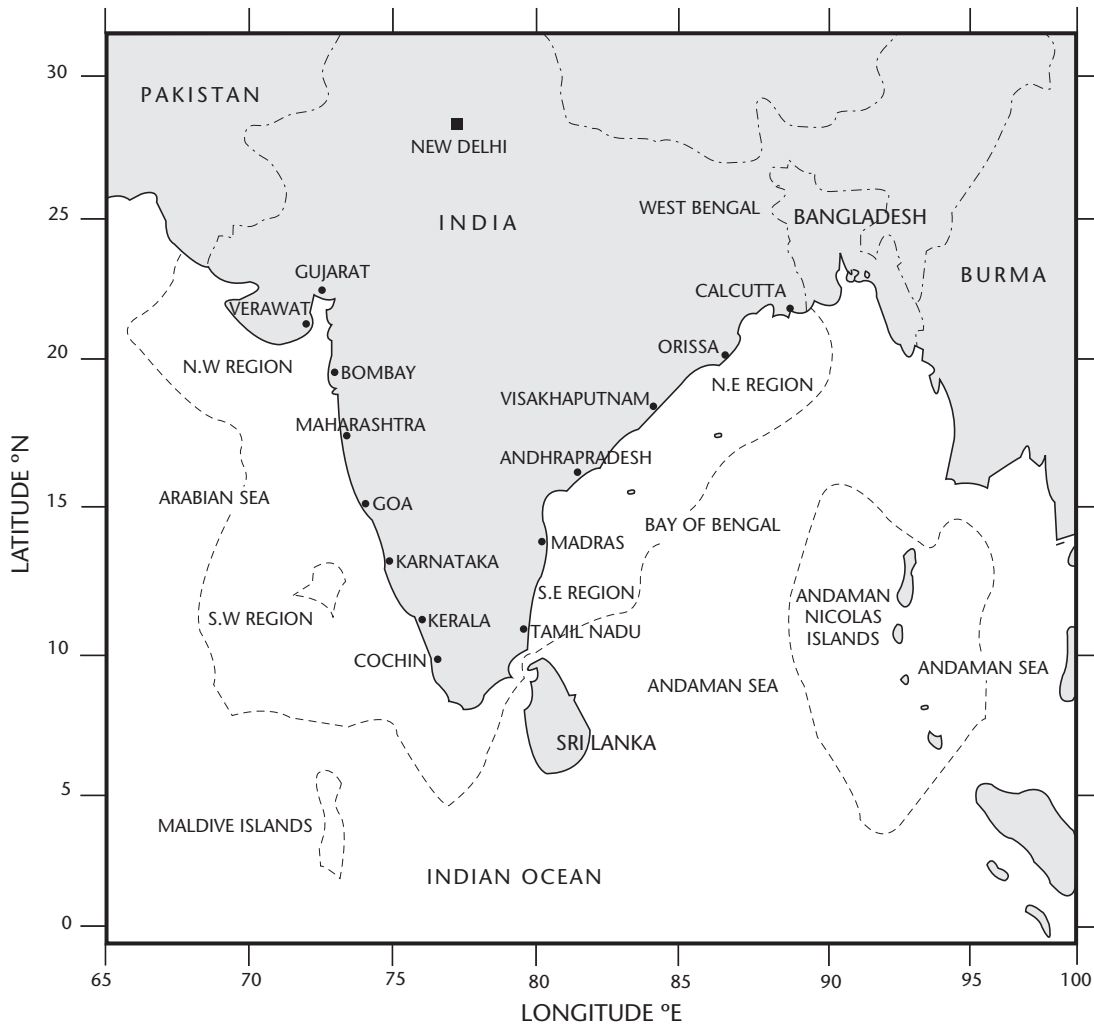
Fig. 1. Map illustrating the geographic delineation of the coastal waters of India.
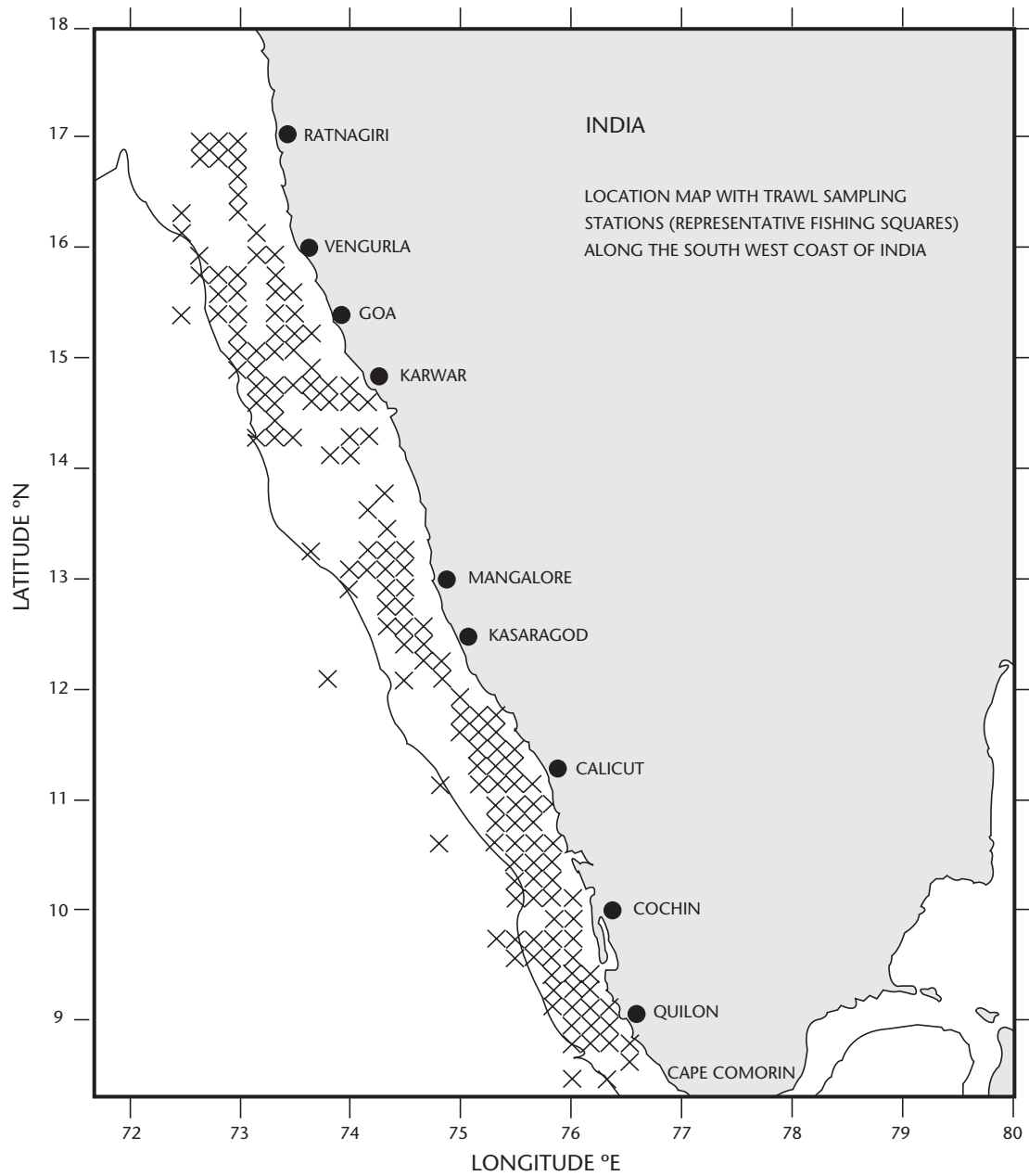
Fig. 2. Sampling squares along the Southwest coast of India (between Cape Comorin and Ratnagiri) used in this study.

Table 2. List of fishing squares and the corresponding station numbers used in the analysis.

Pre-monsoon (February - May)		Monsoon (June - September)		Post-Monsoon (October - January)	
Fishing square	Station	Fishing square	Station	Fishing square	Station
7 - 76/6E	24	7 - 77/5B	14	7 - 77/1A	38
7 - 77/4C	25	7 - 77/5D	15	7 - 77/4D	39
7 - 77/5A	26	7 - 77/5E	16	7 - 77/5A	40
7 - 77/5B	27	7 - 77/6A	17	7 - 77/5B	41
7 - 77/5C	28	7 - 77/6C	18	7 - 77/5C	42
7 - 77/5D	29	7 - 77/6D	19	7 - 77/5D	43
7 - 77/5E	30	7 - 77/6E	20	7 - 77/5E	44
7 - 77/5F	31	7 - 77/6F	21	7 - 77/5F	45
7 - 77/6B	32	7 - 78/6F	22	7 - 77/6B	46
7 - 77/6C	33	8 - 76/5C	23	7 - 77/6C	47
7 - 77/6D	34	8 - 76/6A	24	7 - 77/6D	48
7 - 77/6E	35	8 - 76/6B	25	7 - 77/6E	49
7 - 78/5F	36	8 - 76/6C	26	8 - 76/6C	50
8 - 75/6F	37	8 - 77/1A	27	8 - 76/6F	51
8 - 76/5A	38	8 - 77/1E	28	8 - 77/1B	52
8 - 77/1B	39	8 - 77/1F	29	8 - 77/1E	53
8 - 77/2B	40	8 - 77/6F	30	9 - 75/2F	54
9 - 75/4F	41	8 - 78/1A	31	9 - 75/5A	55
9 - 75/5A	42	9 - 75/3F	32	9 - 75/5F	56
9 - 75/5F	43	9 - 75/4E	33	9 - 75/6A	57
9 - 75/6F	44	9 - 75/4F	34	9 - 76/1B	58
9 - 76/3A	45	9 - 75/5E	35	9 - 76/2B	59
9 - 76/4A	46	9 - 75/5F	36	9 - 76/3A	60
9 - 76/5A	47	9 - 76/1A	37	9 - 76/3B	61
9 - 76/6A	48	9 - 76/1B	38	9 - 76/4A	62
9 - 76/6F	49	9 - 76/2A	39	9 - 76/5A	63
10 - 75/1E	1	9 - 76/2B	40	9 - 76/6A	64
10 - 75/1F	2	9 - 76/2F	41	9 - 76/6F	65
10 - 75/2F	3	9 - 76/3A	42	10 - 75/2F	1
10 - 75/6D	4	9 - 76/3F	43	10 - 75/6D	2
10 - 75/6F	5	9 - 76/4A	44	11 - 75/2C	3
10 - 76/1A	6	9 - 76/5A	45	11 - 75/2D	4
11 - 75/3C	7	9 - 76/6B	46	11 - 75/5B	5

Table 2. List of fishing squares and the corresponding station numbers used in the analysis. (continued)

Pre-monsoon (February - May)		Monsoon (June - September)		Post-Monsoon (October - January)	
Fishing square	Station	Fishing square	Station	Fishing square	Station
11 - 75/3D	8	10 - 75/1F	1	11 - 75/6A	6
11 - 75/4B	9	10 - 75/2E	2	12 - 74/1F	7
11 - 75/6A	10	10 - 75/3D	3	12 - 74/2E	8
12 - 74/2D	11	10 - 75/3E	4	12 - 74/2F	9
12 - 74/2E	12	10 - 75/3F	5	12 - 74/5E	10
12 - 74/2F	13	10 - 75/4D	6	12 - 74/6D	11
12 - 74/4E	14	10 - 75/4E	7	13 - 74/1D	12
12 - 74/6A	15	10 - 75/5D	8	13 - 74/2D	13
13 - 74/2B	16	10 - 75/6D	9	13 - 74/4C	14
13 - 74/2C	17	10 - 75/6E	10	14 - 73/2C	15
14 - 73/3C	18	11 - 75/1B	11	14 - 73/2D	16
14 - 73/4C	19	11 - 75/1C	12	14 - 73/3C	17
14 - 73/5B	20	13 - 73/3F	13	14 - 73/4A	18
15 - 72/3F	21			14 - 73/4C	19
15 - 72/4F	22			14 - 73/4E	20
15 - 72/5F	23			14 - 73/4F	21
				14 - 73/5C	22
				14 - 73/5E	23
				14 - 73/5F	24
				14 - 73/6B	25
				14 - 73/6E	26
				14 - 74/1B	27
				14 - 74/2A	28
				14 - 74/5A	29
				15 - 73/1E	30
				15 - 73/2E	31
				15 - 73/3D	32
				15 - 73/4C	33
				15 - 73/4D	34
				15 - 73/5C	35
				15 - 73/6B	36
				15 - 73/6D	37

Cluster analysis was carried out using **T**wo-**W**ay **IN**dicator Species A**N**alysis **(TWINSPAN)** for classification of stations based on the relative abundance of species. **D**etrended **C**orrespondence **A**nalysis **(DCA)** using the CANOCO program was used to verify the results of TWINSPAN. Both analyses were based on correspondence analysis, thus it is possible to directly compare their results. The data collected during the pre-monsoon, monsoon and post-monsoon seasons were analyzed separately to reduce variability due to seasonality of the catch.

Results

During the two-year period (1994 - 96) the trawler *M.F.V. Samudrika* made 22 voyages in 414 days on the southwest coast. A total of 749 hauls were made in 1 533.5 hours of trawling and 206.21 t of catch were landed at an average catch rate of 134.44 kg•hr^{-1}. In the first year of operation (1994 - 95) the vessel made 10 voyages in 191 days and hauled up to 114.56 t in 766.10 hours at an average catch rate of 188.69 kg•hr^{-1}. In the following year (1995 - 96), the vessel was at sea for 223 days on 12 voyages. The vessel spent about 767 hours fishing and landed 91.65 t at an average catch rate of 119.43 kg•hr^{-1}.

Catch Composition

Total catch landings were segregated into 22 major groups and their relative abundance calculated. Threadfin breams dominated the catch of 22.5% of the overall landings. This species group is composed of *Nemipterus mesoprion, N. japonicus* and *N. delagoae.* Of these, *N. delagoae* was caught mainly in the Wadge Bank, whereas the other two were found mixed with the bulk of the SWCZ landings. The period June to August was the peak time for this species group, though stray catches were observed from November to March from the 40 - 81 m depth zone.

Next in abundance to the threadfin breams were *Decapterus* spp. (round scads) forming 15.7% of landings, with highest abundance in the months of May and September-October. Generally three species were observed, namely, *Decapterus russelli, D. macrosoma* and *D. kurroides.* As they are usually shoaling species, more than 5 to 6 t were encountered in a single haul along the southwest coast.

Bulls eye or *Priacanthus* spp., an emerging unconventional resource, formed 7.7% of the overall landings. Commonly observed only in the months of March-April and August, these species were observed almost throughout the year during this survey. Bulls eye in demersal landings was previously quite rare. They were also abundant towards the north of Calicut in April.

Perches comprised about 12.3% of the overall landings. Serranids, lutjanids and lethrinids landings from the Wadge Bank area were grouped under three species groups; rock-cods, snappers and breams respectively.

The percentage of cephalopods was about 5.2% of the total landings, including squids and cuttlefishes. The most commonly found species in the catch were *Loligo duvauceli* (squid) and *Sepia pharaonis* and *S. aculeata* (cuttlefish). Their occurrence at a commercially valuable size was recorded during the months of August-September.

Elasmobranchs, shark, rays and skates, formed the next abundant group (6.7%). Among these, the abundance of rays was higher (4%) than sharks and skates. Though these species were caught almost throughout the year, their maximum abundance was observed in the months of August and May.

A sizeable percentage (5.2%) was contributed by the ribbonfishes, which were most abundant during the monsoon periods (i.e. June to September). Two commonly observed species in the catch were *Trichiurus lepturus* and *Lepturacanthus savala.* The percentage occurrence of Indian mackerel was about 5.1% of the overall landings during this period. Though Indian mackerel occur almost throughout the year, the most abundant months were in April-May and September-November within the 40 m-depth zone. Barracudas formed about 1.5% of the total catch and were not obtained in the months of June-July. Their most abundant period was August to November and February to May. The commonly found species of barracuda were *Sphyraena jello, S. barracuda* and *S .obtusata.* Horse mackerel was found throughout the year except in the months of June-July, constituting about 1.6% of the overall catch.

In the present study, only about 0.2% of the total catch was contributed by the catfishes, in the

months of January-February. A substantial reduction in catfish landings was conspicuous, indicating an overall decline of the resource. Better landings for this group were reported in the past from this region.

Seasonal and Spatial Distribution

In tropical waters, it is difficult to demarcate sharply any season of commercial availability of fisheries resources, as the resources are dynamic. Exploratory analyses of trawl catch data were done in this study to provide information on the distribution pattern of species assemblages in the area. The grouping of stations by monsoon period is due to the observed variation of species groups in these periods, and is based on the preliminary analysis of catch composition.

Pre-monsoon

The station-clusters based on the two techniques used in the analysis, i.e. TWINSPAN and DCA, indicated the existence of two major classifications of areas, which had sub-areas within them (Table 5 and Fig. 3, see also Appendix I).

In general sub-area A_{11} was characterized by the predominance of *Priacanthus* spp. mainly off the area between Cochin and Mangalore. This fish group formed 63% of the total landings in this period. Horse mackerel and barracudas also seemed to show affinity to the area during this season. The Indian mackerel and squids seemed to occur in all regions, thus they are classified as ubiquitous species. The sub-areas A_{12}, A_{21} and A_{22} are characterized by species of scads. The sub-areas A_{21} and A_{22} were sampled mainly at stations from the Konkan-Goa region.

Area B was dominated by species of *Lobotes*, perches, croakers, mackerel and rays. The catfishes were observed in almost all the stations. Most of the stations were in the Wadge Bank area. Relative abundance of each station-cluster is summarized in Table 6.

Monsoon

During this season there were two major groupings observed evident in the result of TWINSPAN and DCA (Table 7 and Fig. 4). Area B is characterized by the absence of sharks, rays, ribbonfish, croakers, pomfrets, perches etc., which are dominant in A. Squids and cuttlefish were observed in both but relatively higher in area B. Threadfin breams and *Priacanthus* spp. were not reported in A during this period. Area A stations were in the Wadge and Quilon banks while area B mainly consists of stations in the Alleppey and Cochin regions. The relative abundance of each species taxa by station-cluster is presented in Table 8.

Table 5. Stations-clusters generated from TWINSPAN (February-May).

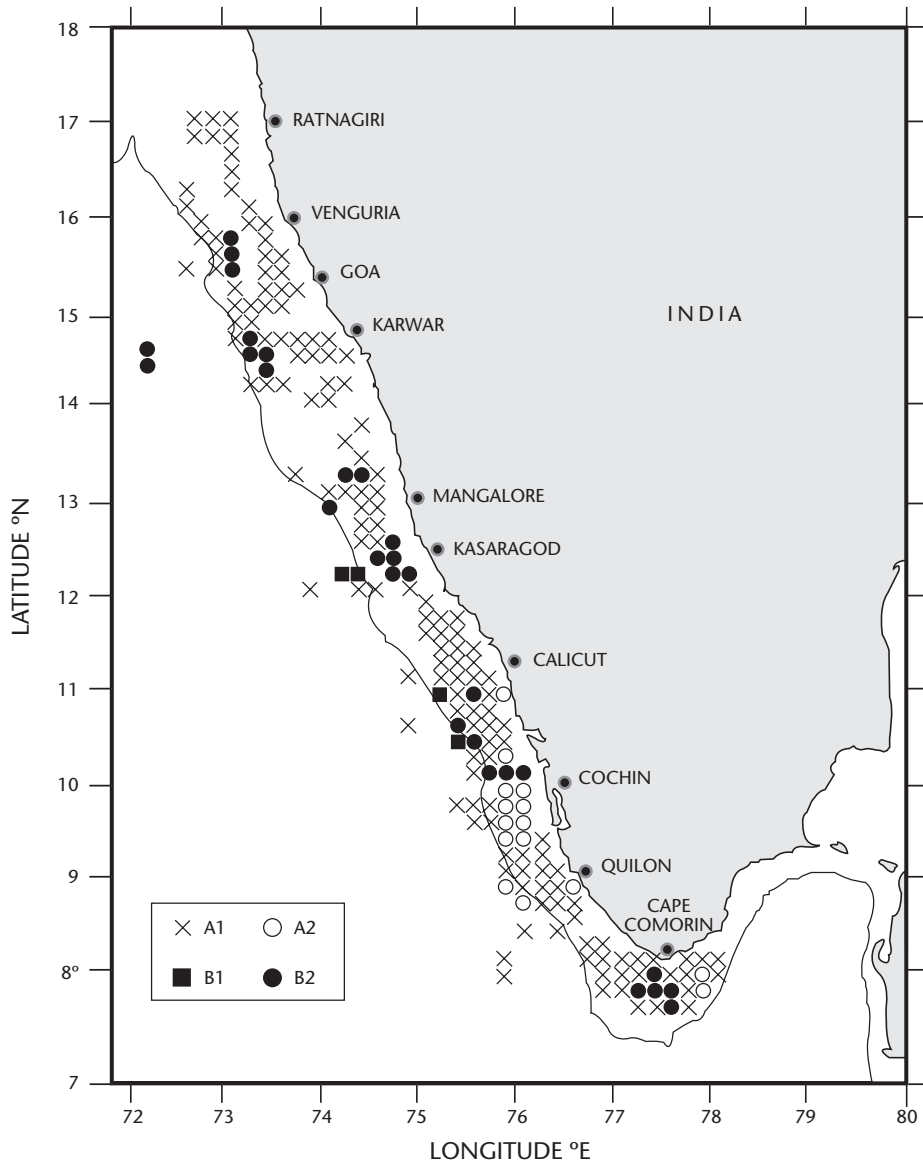| Group	Sub-group	Region	Stations
A	A_{11} and A_{12}	Cochin - Mangalore	23, 22, 18, 11, 16, 17, 8, 6, 7, 9, 19, 13, 14, 2, 10, 20, 21, 15, 4, 12, 1
	A_{21} and A_{22}	Konkan - Goa - Allppey	43, 46, 47, 31, 36, 45, 41, 38, 42, 49, 44, 37, 3, 5, 48
B	B_{11} and B_{12}	Wadge bank - Quilon	24, 39, 30, 33, 35, 40, 29, 34
	B_{21} and B_{22}	Wadge bank - Quilon	26, 27, 48, 25, 32

Fig. 3. Spatial distribution of sampling square based on the classification analysis using TWINSPAN during the pre-monsoon season.

Table 6. Relative abundance (%) of the species groups by station-cluster during the pre-monsoon period.

Species/Taxa	Station-Groups							
	A				B			
	A_{11}	A_{12}	A_{21}	A_{22}	B_{11}	B_{12}	B_{21}	B_{22}
Barracuda (Sphyraenidae)	6.46	0.56	0.49	0.00	0.00	0.24	0.00	0.00
Caranx spp.	0.00	0.00	0.05	0.00	0.55	0.32	0.00	0.00
Catfish (Ariidae)	12.11	0.01	0.24	0.16	2.50	2.06	0.01	0.00
Chirocentrus spp.	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Horse mackerel (Carangidae)	0.00	0.73	0.22	0.28	0.00	0.00	0.00	0.00
Indian mackerel *(Rastrelliger kanagurta)*	0.00	1.44	10.17	14.24	5.55	3.74	0.04	0.00
Lizard fishes (Synodontiade)	0.00	0.00	2.59	0.00	0.00	0.00	0.00	0.00
Lobotes spp.	0.00	0.01	1.30	0.00	50.65	53.81	0.37	0.00
Lobster	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00
Perch	0.00	0.00	0.00	0.00	0.00	1.14	75.08	77.88
Pomfrets (Bramidae)	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Priacanthus spp.	62.81	19.89	2.31	0.00	0.00	0.00	0.00	0.00
Rays (Dasyatidae)	0.00	0.22	3.62	3.29	19.75	19.12	8.10	0.00
Ribbonfishes (Trichiuridae)	9.86	0.08	0.21	0.00	0.00	0.00	0.00	0.00
Scads (Carangidae)	0.00	75.93	77.81	80.97	0.00	0.00	0.00	0.00
Croakers (Sciaenidae)	0.00	0.01	0.26	0.00	14.56	15.13	15.01	22.12
Seerfishes (Scombridae)	8.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sharks	0.00	0.00	0.00	0.25	5.55	3.70	1.39	0.00
Silverbellies (Gerridae)	0.00	0.02	0.41	0.00	0.00	0.00	0.00	0.00
Soles (Soleidae)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Squids	0.00	0.76	0.26	0.00	0.89	0.74	0.01	0.00
Threadfin breams (Nemipteridae)	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00

Table 7. Stations-clusters generated from TWINSPAN (June-September).

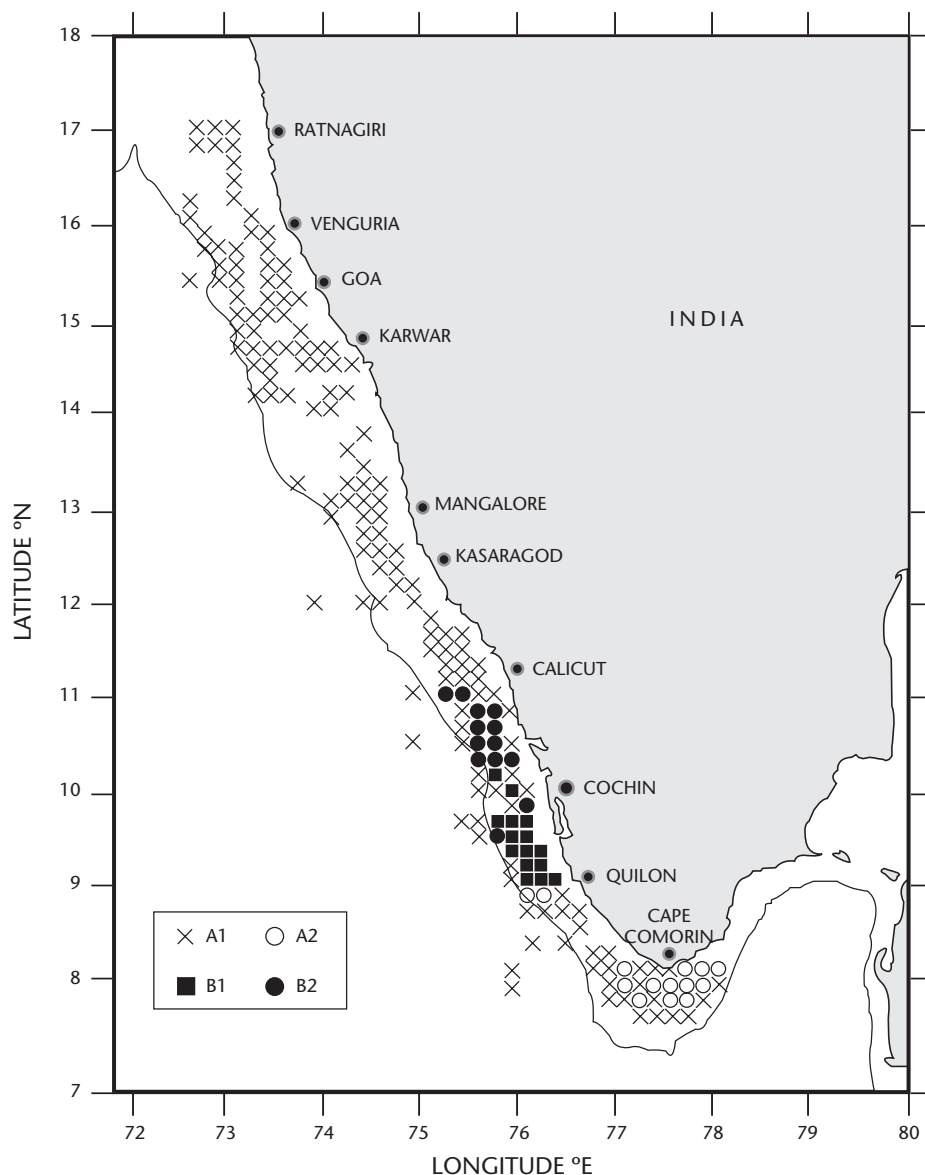| Groups	Sub-group	Region	Stations
A		Wadge bank - Quilon	24, 27, 28, 29, 30, 31, 14, 15, 16, 17, 18, 19, 20, 21, 22
B	B_1, B_{21} and B_{22}	Aleppey - Cochin	25, 32, 34, 35, 36, 37, 38, 39, 40, 42, 43, 44, 45, 1, 2, 4, 5, 6, 7, 9, 11, 12, 23, 26, 33, 41, 46, 3, 10, 8, 13

Fig. 4. Spatial distribution of sampling square based on the classification analysis using TWINSPAN during the monsoon season.

Table 8. Relative abundance (%) of the species assemblages formed during the monsoon period.

Species/Taxa	Station-Groups			
	A		B	
	A	B_1	B_{21}	B_{22}
Barracuda (Sphyraenidae)	1.5	1.31	0.00	0.00
Caranx spp.	5.47	0.00	0.00	0.00
Catfishes (Ariidae)	0.04	0.02	0.00	0.00
Cuttlefishes	0.63	0.58	0.94	0.23
Horse mackerel (Scombridae)	0.00	0.08	0.00	0.00
Lizardfishes (Synodontidae)	0.04	0.00	1.41	1.21
Lobotes spp.	25.7	0.00	0.00	0.00
Miscellaneous	3.76	0.30	0.46	0.18
Perch	12.31	0.00	0.00	0.00
Pomfrets (Bramidae)	0.14	0.00	0.00	0.00
Priacanthus spp.	0.98	18.63	8.59	7.55
Rays (Dasyatidae)	20.44	0.00	0.00	0.00
Ribbonfishes (Trichiuridae)	1.55	0.00	0.00	0.00
Sardines (Clupeidae)	0.00	0.13	0.00	0.00
Scads (Carangidae)	0.10	1.91	32.46	14.41
Croakers (Sciaenidae)	19.40	0.07	0.10	0.00
Scomberoides spp.	0.01	0.00	0.00	0.00
Sharks	1.14	0.00	0.00	0.00
Silverbellies (Gerridae)	0.36	0.00	0.00	0.00
Soles (Soleidae)	0.02	0.00	0.00	0.00
Squids	6.42	12.35	0.00	0.00
Threadfin breams (Nemipteridae)	0.00	64.61	56.05	76.42

Post-monsoon

During this season DCA station-clusters indicated two major groupings with some embedded clusters revealed by TWINSPAN (Table 9 and Fig. 5). There seems to be a more or less homogeneous mixture of species during this period. Sub-area A_1 is characterized by the abundance of *Caranx* spp. followed by seerfish, pomfrets, horsemackerel and *Priacanthus* spp. This station-group is mainly found in the Konkan region (northern part of SW coast). Ribbonfishes and Indian mackerel dominate the sub-area A_2 with stations found in Quilon Bank to North Kanara region (Table 10). The sub-area B_1, which is in the Konkan region is characterized by the dominance of threadfin breams, scads and *Priacanthus* spp. Most of the stations in this sub-area are deep-water stations with depths ranging from 100 - 180 m. Sub-area B_2 is exclusively found in the Wadge Bank area characterized by the abundance of perches and seerfishes.

Table 9. Station-clusters generated from TWINSPAN (October-January).

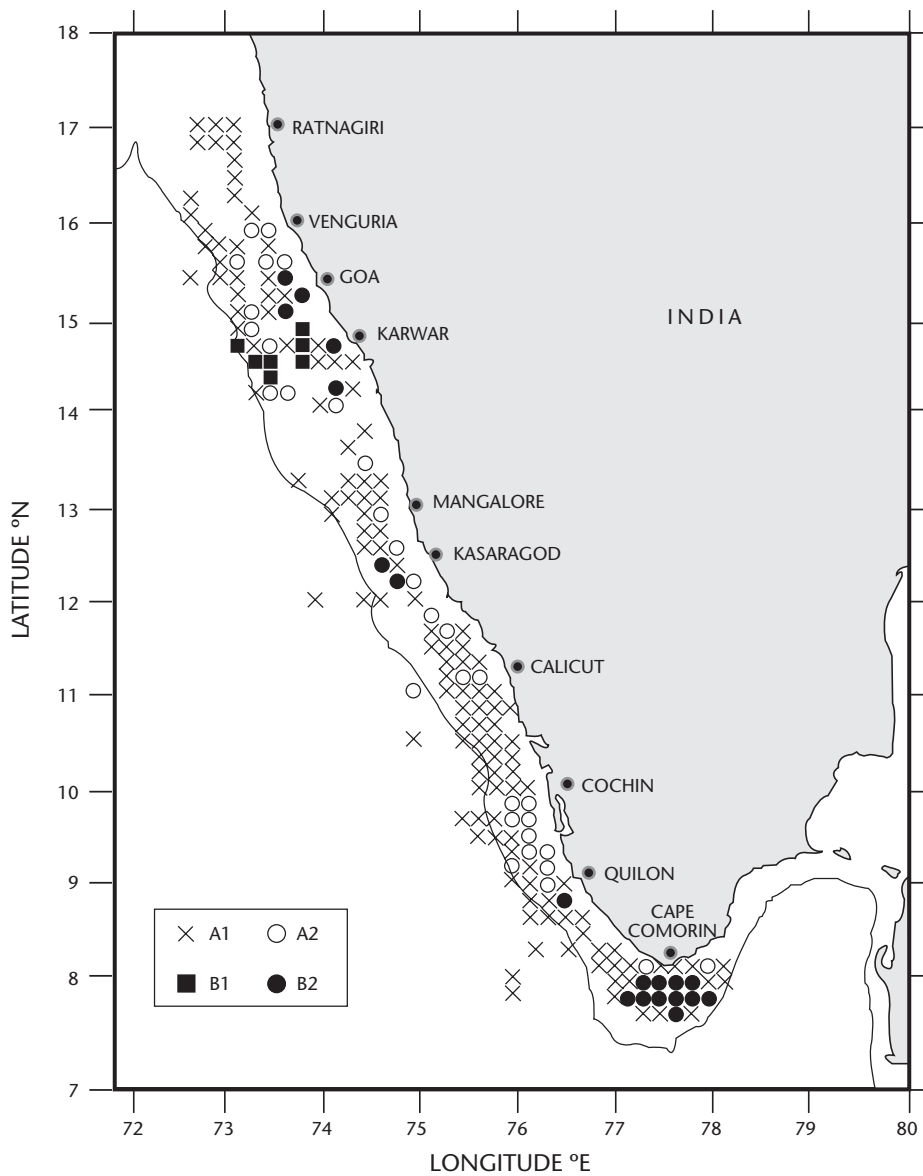| Groups	Sub-group	Region	Stations
A	A_1	Goa	8, 13, 20, 28, 29, 30, 31, 32
	A_2	Cochin - Malabar	51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 14, 15, 16, 22, 24, 25, 27, 33, 34, 35, 36, 38
B	B_1	Konkan	17, 18, 19, 21, 23, 26, 37
	B_2	Wadge bank - Quilon	39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50

Fig. 5. Spatial distribution of sampling square based on the classification analysis using TWINSPAN during the post-monsoon season.

Table 10. Relative abundance (%) of the species assemblages formed during the post-monsoon period.

Species/Taxa	Station-Groups			
	A		B	
	A_1	A_2	B_1	B_2
Barracuda (Sphyraenidae)	0.00	4.14	1.31	1.53
Caranx spp.	61.80	1.61	0.00	0.07
Catfishes (Ariidae)	0.00	0.45	0.00	0.00
Chirocentrus spp.	3.34	2.44	0.00	0.00
Cuttlefishes	0.00	0.70	1.79	0.11
Eels	0.00	0.13	0.00	0.00
Horse mackerel (Scombridae)	4.10	6.45	0.07	0.00
Indian mackerel (*Rastrelliger kanagurta)*	0.00	22.18	0.00	0.00
Lizardfishes (Synodontidae)	0.00	0.13	0.13	0.00
Lobotes spp.	0.00	0.00	0.22	0.00
Miscellaneous	0.00	1.27	0.00	0.02
Perch	0.00	2.30	0.17	63.52
Pomfrets (Bramidae)	7.84	3.16	0.07	0.00
Priacanthus spp.	4.15	0.56	12.35	2.14
Rays (Dasyatidae)	0.00	5.12	0.00	6.49
Ribbonfishes (Trichiuridae)	0.00	36.81	0.53	0.00
Sardines (Clupeidae)	0.00	0.79	0.00	0.19
Scads (Carangidae)	0.00	0.00	12.17	0.00
Croakers (Sciaenidae)	0.00	0.00	0.00	21.98
Seerfishes (Scombridae)	16.63	0.64	0.07	0.00
Sharks	2.14	5.07	0.00	1.53
Silverbellies (Gerridae)	0.00	0.73	0.00	0.00
Squids	0.00	5.33	0.18	2.42
Threadfin breams (Nemipteridae)	0.00	0.00	70.96	0.00

Discussion

The southwest coast of the Indian continent is mainly characterized by three major monsoon periods. The months of February to May are classified as the "pre-monsoon period" which is commonly known as the winter to summer season. Months of June to September are the "monsoon period" or the southwest monsoon season, and the months of October to January are the "post monsoon period" or the northeast monsoon season. Each of the periods is characterized by different oceanographic circulation patterns that mainly determine the pattern of distribution of species assemblages on the southwest coast of India.

During the southwest monsoon (May-October) there is a southerly flow observed along the west coast spread over the entire shelf region. At the time of the change from the southwest monsoon to the winter season, a northerly current is established off the shelf. Adjacent to and on the seaward side of the northerly flow, a southerly current is present, but is limited to the southerly regions. From winter to summer (February-April) the northerly current vanishes and the circulation breaks up into eddies. The southerly current persists in summer though it is limited to a narrow belt. Once again during the southwest monsoon period this narrow southerly stream spreads over the entire shelf. In general along the west coast, the current during the winter season appears to be stronger than the southwest monsoon current. During the northeast monsoon period (October-January) the surface current reverses its direction and turns northerly.

The stronger current during the winter season ("pre-monsoon") is associated with the relatively gradual increase in catch rate as compared to the other monsoon periods. The presence of a large concentration of threadfin breams, round scads, bullseyes and cephalopods in the landings in the west coasts and the relatively fast increasing catch rate were observed during the southwest monsoon season ("monsoon") associated with the weaker current system. The reversal of current during the northeast monsoon season ("post-monsoon) was observed to be evident in the relatively more productive multi-species population of the Wadge Bank.

The spatial analysis confirmed that the Wadge Bank is potentially the best ground for quality fish such as perches. The area has been intensively fished by various agencies.

In the Alleppey-Cochin area, the resources were mainly threadfin breams and round scads within the 41 - 80 m depth range, while mackerel was reported from 0 - 40 m area. June-July and August showed better landings for threadfin bream, while *Decapterus* spp. (round scads) were more abundant in the month of May and September-October. There is increasing interest in the fishing industry for squids and cuttlefish due to greater export demand. This group, which formed less than 1% of the total landings earlier, is now found to represent over 6.6%. The region between latitude 8ºN and 11º N and within 80 m depth, in September–October periods yielded progressive catches of cephalopods.

Towards the northern latitudes along the Karnataka, Konkan, Goa, Maharashtra and Sourashtra coasts high potential for demersal resources were reported earlier (Bapat et al. 1972; Joseph 1980). Exploratory survey results of Fishery Survey of India confirmed the above findings. Moderate landings of pomfret, seerfish, ribbonfish and golden anchovy recorded in the area were distinct from the landings of southwest coast. Under-size threadfin breams and bullseye reported from Karnataka and Goa region indicate the need to explore the migration pattern of these varieties towards higher latitudes.

On the whole an analysis of region-wise data indicated that the maximum effort and highest landings are from the known grounds along the southwest coast although certain northern areas were also found to be fairly productive. It is observed that there is an inverse relationship between the fishing effort and catches; wherever there was a high catch rate, the intensity of fishing was found to be less. An increased effort in the commercially known fishing grounds produced only lesser yields, as evidenced in Quilon ground and Wadge Bank area.

During the past two decades several attempts have been made to assess the potential of the EEZ based on the commercial fisheries landings, and the estimates were found to vary widely. The generally accepted estimate for the demersal finfish resources of the EEZ beyond 50 m is around 1.7 million t as against the current yield of 0.5 million t.

So there is further scope for enhancing the production from this area. According to recent estimates marine production in India has already reached its full potential yield, and 90% of this is landed from the area less than 50 m depth. This is the same area that the research surveys were conducted in.

Studies on the effect and influence of oceanographic parameters on the distribution and abundance of fish groups along the SW coast of India are comparatively limited, but the works of (Longhurst and Wooster 1990; Madhupratap et al. 1994; Murthy 1965; Murthy 1992; Murthy 1993; Murthy 1995; Murthy and Edlman 1970; Pillai 1982; Pillai 1991; Pillai 1996; Pillai et al. 1998a) are worth mentioning in this context. Studies made by (Murthy et al. 1990) on board FORV *Sagar Sampada* revealed a tremendous contrast among three regions viz. Gulf of Mannar, Wadge Bank and Quilon (07º to 09º N Lat. and 75º 28' to 78º 43' E Long.) in respect of oceanographic conditions. During the peak of the SW monsoon season (July-August) both seawater temperature and salinity of Quilon Bank waters were comparatively low, whereas Wadge Bank waters were moderate in water temperature but high in salinity. The Gulf of Mannar waters were found to be moderate in respect of salinity but warmer with thermal inversions in the middle region of the water column. The bottom water temperature, rather than salinity appeared to be the reason for the species variations in the trawl catches in the region. Nemipterids were not present in the Gulf of Mannar where the bottom temperatures were comparatively high. Barracudas were absent in both the Wadge Bank and Quilon Bank where the bottom waters were comparatively cooler. Nemipterids constituted a good monsoon fishery off Cochin where the process of upwelling resulted in comparatively cooler bottom waters with lower dissolved oxygen concentrations. Probably the concentration of nemipterids on the Quilon Bank and Wadge Bank areas are due to the extended effect of upwelling southwards down to Wadge Bank because of favourable southerly currents.

(Suseelan et al. 1990), based on observations carried out onboard FORV *Sagar Sampada* observed a noteworthy feature along the southwest coast of India with regard to the occurrence of the coastal prawn *Parapenaeopsis stylifera* (Karikkadi prawn), in varying densities in the offshore waters up to 53 m depth during the southwest monsoon period (June and July) almost as a continuous belt between Quilon and Goa. This species is basically

a coastal species inhabiting areas within the 30 m depth contour. Experimental shrimp trawling off Cochin established that during June-July *P. stylifera* migrates in large numbers to the offshore areas up to about 60 m depth as a result of upwelling. Nemipterids exhibit a shoreward (deep water to shallow water) as well as alongshore (southerly along the west coast) migration following the movement of cold, high saline, oxygen deficient upwelling waters during the SW monsoon season (Pillai et al. 1998b). The *Priacanthus* spp. (bulls eye) also take advantage of the shoreward movement of the upwelling water and reach comparatively shallower areas of the shelf during the Southwest monsoon season.

Summary and Conclusion

The southwest coast of the Indian continent is mainly characterized by three major monsoon periods (i.e. winter to summer, southwest monsoon and northeast monsoon). Each of the periods are characterized by different oceanographic circulation patterns that mainly determine the pattern of distribution of species assemblages on the southwest coast of India.

Spatial analysis confirmed that the Wadge Bank was potentially the best ground for quality fish such as perch. In the shallower region of the area (30 - 50 m) balistids have become predominant. In the Alleppey-Cochin area, threadfin breams and round scads dominated the depths within 41 - 80 m while mackerel was reported from 0 - 40 m. Towards the northern latitudes along Karnataka, Konkan, Goa, Maharashtra and Sourashtra coasts high potential for demersal resources were observed.

Region-wise analysis of data indicated that maximum effort and highest landings are from the known grounds along the southwest although certain northern areas were also found to be fairly productive. Increased effort in the commercially known fishing grounds produced only lesser yields as evidenced in the Quilon ground and Wadge Bank area.

Acknowledgements

References

Bapat, S.V., N. Radhakrishnan and K.N. Rasachandra Kartha. 1972. A survey of the trawl fish resources off Karwar, India, p. 354 - 383. *In IPFC*, Proceedings of the 13th Session, 14 - 25 October 1968, Brisbane, Queensland, Australia. Section III - Symposium on Demersal Fisheries. IPFC Proceedings 13 (3), 664 p.

Joseph, K.M. 1980. Comparative Study of the demersal fishery resources of the Indian waters as assessed by the 17.5 m trawlers. Bulletin of the Exploratory Fisheries Project No. 10, Bombay, India.

Longhurst, A.R. and W.S. Wooster. 1990. Abundance of oil sardine *(Sardinella longiceps)* and upwelling on the southwest coast of India. Canadian Journal of Fisheries and Aquatic Sciences 47 : 2 407 - 2 419.

Madhupratap, M., S.R. Shetye, K.N.V. Nair and P.S. Nair. 1994. Oil Sardine and Indian mackerel: their fishery problems and coastal oceanography. Current Science 66(5) : 340 - 348.

Murthy, A.V.S. 1965. Studies on the surface mixed layer and its associated thermocline off the West Coast of India and the inferences thereby for working out a production strategy of the pelagic fisheries of the region. Indian Journal of Fisheries 12(1) : 118 - 134.

Murthy, A.V.S. 1992. A critical study on the bed effects of upwelled waters on fisheries as exemplified by the situation of the Kerala-Karnataka region of the West Coast of Indian. Journal of the Marine Biological Association of India 34 (1&2) : 264 - 252.

Murthy, A.V.S. 1993. The impact on sardine fishery, of the counter surface currents in the north Indian Ocean including the Bay of Bengal and the Arabian Sea - A need for international co-operative study. Journal of Aquatic and Biology 8(1&2) : 24 - 29.

Murthy, A.V.S. 1995. Advances in Indian fishery oceanographic investigation of practical utility and their futurology. Journal of Aquatic and Biology 10 (1&2) : 75 - 80.

Murthy, A.V.S. and M.S. Edlman. 1970. On the relation between the intensity of the southwest monsoon and the oil sardine fishery of India. India Journal of Fisheries XIII (i) : 142 - 149.

Murthy, A.V.S., N.G.K. Pillai, M. Zafarkhan, K.U. Sanilkumar and V.A. Shankar. 1990. Variation in fish catches from the continental shelf between Quilon and Gulf of Mannar and its relation to oceanographic conditions during the SW monsoon period, p. 291 - 294. *In* Proceedings I workshop of FORV Sagar Sampada.

Pillai, V.N. 1982. Physical characteristics of the coastal waters off the southwest coast of India with an attempt to study the possible relationship with sardine, mackerel and anchovy fisheries. Cochin University of Science and Technology, India. Ph.D.Dissertation.

Pillai, V.N. 1991. Salinity and thermal characteristics of the coastal waters off the southwest coast of India and their relation to major pelagic fisheries of the region. Journal of the Marine Biological Association of India 33(1&2) : 115 - 133.

Pillai, V.N. 1996. Oceanographic aspects of Lakshadweep waters in relation to Skipjack tuna fisheries. Proceedings workshop on status of scientific database of Lakshadweep islands. Cochin (LAMPSHOP), GSI.

Pillai, V.N., M. Devaraj and E. Vivekanandan. 1998a. Fisheries environment in the APFIC region with particular reference to the northern Indian Ocean. Proceedings of APFIC Conference, Bangkok, 1997.

Pillai, V.N., V.V. Singh P. Krishnakumar and A. Nandakumar. 1998b. Presence of upwelled water in the shelf region along the northeast coast of India towards the end of the southwest monsoon season and its possible effect on the migration of Bull's eye *(Priacanthus* spp.*)* into shallower areas of the continental shelf. Proceedings IV Asian Fisheries Society, Indian Fisheries Forum, Cochin.

Suseelan, C., G. Nandakumar and K.N. Rajan. 1990. Results of bottom trawling by FORV sagar Sampada with special reference to catch and abundance of edible crustaceans, p. 337 - 346. *In* Proceedings I workshop of FORV Sagar Sampada.

Clusters	A_{11}	A_{12}	A_{21}	A_{22}	B_{11}	B_{12}	B_{21}	B_{22}
	Fishing Squares by Station-Group							
Resource	**2 2** **2 3**	**11221 111111 1** **2890149123567160478**	**444334** **367165**	**344443 4** **812947358**	**2 3** **4 9**	**333423** **035094**	**222** **678**	**2 3** **5 2**
Wolfherring	– –	– – – – – – – – – – – – – – – – – – –	– 1 – – – –	– – – – – – – – –	– –	– – – – – –	– – –	– –
Lizardfishes	– –	– – – – – – – – – – – – – – – – – – –	– 1 – 2 2 2	– – – – – – – – –	– –	– – – – – –	– – –	– –
Lobsters	– –	– – – – – – – – – – – – – – – – – – –	– – – – – –	– – – – – 2 – – –	– –	– – – – – –	– – –	– –
Silverbellies	– –	– – – – – – – – – – – – – – – – 1 – –	1 1 1 – – –	– – – – – – – – –	– –	– – – – – –	– – –	– –
Scads	– –	1 1 1 2 1 3 1 3 4 5 3 3 3 1 1 1 1 1 1	5 4 5 5 4 5	5 5 5 5 5 4 1 1 4	– –	– – – – – –	– – –	– –
Ribbonfish	2 2	1 1 1 1 2 – – – – – – – – – 1 – – – –	– – 1 – – –	– – – – – – – – –	– –	– – – – – –	– – –	– –
Seerfish	2 2	– – – – – – – – – – – – – – – – – – –	– – – – – –	– – – – – – – – –	– –	– – – – – –	– – –	– –
Horse Mackerel	– –	1 1 1 2 1 1 1 1 1 1 1 2 2 1 2 1 1 1 2	1 1 1 – – –	– – – – – – – – 2	– –	– – – – – –	– – –	– –
Pomfrets	– –	– – – – – – – 1 1 1 2 – – 2 2 2 1 – –	– – – – – –	– – – – – – – – –	– –	– – – – – –	– – –	– –
Priacathids	4 4	– 5 5 4 5 4 2 3 2 2 2 3 3 3 2 – 2 2 3 3	1 2 1 – – –	– – – – – – – – –	– –	– – – – – –	– – –	– –
Threadfin breams	– –	– – – – – 1 1 – – – – – – – – – – – –	– – – – – –	– – – – – – – – –	– –	– – – – – –	– – –	– –
Barracuda	2 2	– – – – – 1 1 1 1 1 1 1 1 1 1 1 1 2 2	– 1 1 1 1 –	– – – – – – – – –	– –	– – – – 1 1	– – –	– –
Indian mackerel	– –	2 1 1 1 1 2 2 2 2 1 2 2 2 2 2 3 1 2 2	1 1 2 1 1 –	– 2 – 2 2 3 2 1 2	2 2	1 1 1 1 1 1	– – 1	– –
Squids	– –	1 1 2 1 1 1 1 2 1 1 1 2 2 1 1 1 2 1 2	– 1 1 – – 1	– – – – – – – – –	1 1	1 1 1 1 1 1	– – –	– –
Cuttlefish	1 2	1 – – – – – – – – – – – – – – – – – –	1 1 1 1 1 1	– – – – 1 – – – –	1 1	1 1 1 1 1 1	– – –	– –
Rays	– –	– – – – – – – – – – – – 1 1 – 5 3 5	– 2 1 1 1 2	– – – – 2 – 3 2 2	2 2	2 2 2 2 2 2	2 2 2	– –
Sharks	– –	– – – – – – – – – – – – – – – – – – –	– – – – – –	– – – – 1 – – – –	2 2	1 1 1 1 1 1	2 1 1	– –
Perches	– –	– – – – – – – – – – – – – – – – – – –	– – – – – –	– – – – – – – – –	– –	– – – – 1 –	4 4 4	4 5
Croakers	– –	– – – – – 1 – – – – – – – – – – – – –	– – – 1 1 –	– – – – – – – – –	2 2	2 2 2 2 2 2	2 2 2	3 2

b. TWINSPAN classification of fishing squares during monsoon.

Clusters	Fishing Squares			
	A	**B₁**	**B₂₁**	**B₂₂**
Resource	**2 3 3 1 1 2 2 2 2 1 1 2 1 1 2** **4 0 1 6 9 1 2 0 9 4 5 8 7 8 7**	**4 4 3 4 4 3 4 2 3 3 3 3 3** **2 1 4 5 5 2 3 8 0 5 4 7 2 6 9**	**1 1** **9 4 5 1 6 7 2**	**1 1 2 2 3 4 4** **8 0 3 3 6 3 6 3 1**
Croakers	5 2 2 2 2 2 2 2 2 2 2 3 2 2	– – – 1 1 1 – – – – – – – – –	– 1 – – – – –	– – – – – – – – –
Sharks	– 2 2 – 1 1 1 1 1 – – 2 – – –	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Caranx spp	– – – 2 2 2 2 1 2 2 2 2 2 – 2	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Lobotes spp	– – – 3 3 2 2 2 2 3 3 3 3 2 3 2	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Rays	– 3 3 2 2 2 2 2 2 2 2 2 2 2 2	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Ribbonfishes	– – – 1 – 1 2 1 1 – – – – 1 1	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Soles	– – – – – 1 – – – – – – – – –	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Pomfrets	– – – 1 – 1 – 1 – – – – – – –	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Seerfishes	– – – – – – – 1 – – – – – – –	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Silverbellies	– – – – 1 1 – 1 – – – – – – –	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Perches	– 3 3 – 2 3 2 2 2 – – – – – –	– – – – – – – – – – – – – – –	– – – – – – –	– – – – – – – – –
Miscellaneous	– – – 2 2 2 2 1 1 – – – – – –	– – – 2 – – – 1 – 1 – 1 1 – –	– – – – 1 2 –	– – – – – – – – –
Catfishes	– – – – – – – – – – – – – 1 1	– – – – – 2 – – – – – – – – –	– – – – – – –	– – – – – – – – –
Barracuda	– – – – 2 – – 2 2 – – – – – –	– – 2 2 2 3 2 1 1 2 1 2 – – 1	– – – – – – –	– – – – – – – – –
Squids	– – 2 1 1 1 1 1 1 1 2 1 2 2 2	1 4 4 4 4 2 3 4 3 1 2 2 2 2 2	– – – – – – –	– – – – – – – – –
Cuttlefish	– – – – 1 1 – 1 – 1 1 – 1 – 1	1 – 2 – 2 1 – – – 1 1 1 – – –	1 1 1 – 1 1 –	– – – – – – – – –
Horse mackerel	– – – – – – – – – – – – – – –	– – – – – – – 1 1 – 1 – – – –	– – – – – – –	– – – – – – – – –
Priacanthus	– – – – 1 1 1 1 1 – – – 2 2 2	5 3 2 2 1 – 2 2 2 2 2 3 3 2 3	1 2 2 2 2 2 2	2 – – – – – –2 3
Sardines	– – – – – – – – – – – – – – –	– – – – – – – – – – – – – 2 –	– – – – – – –	– – – – – – – – –
Scads	– – – – – – – – – – – – – – 2	– – – – – – – 1 1 2 – 2 – – –	5 3 3 3 2 2 2	2 – – – – – 2 – –
Threadfin breams	– – – – – – – – – – – – – – –	– – – – 2 3 3 2 3 4 4 3 4 4 4	2 3 3 4 4 4 4	5 5 5 5 5 5 5 5 4
Lizardfishes	– – – – – – – – – – – – – 1 – –	– – – – – – – – – – – – – – –	1 1 – 1 1 – 1	1 – – – – – – – –

c. TWINSPAN classification of fishing squares during post-monsoon.

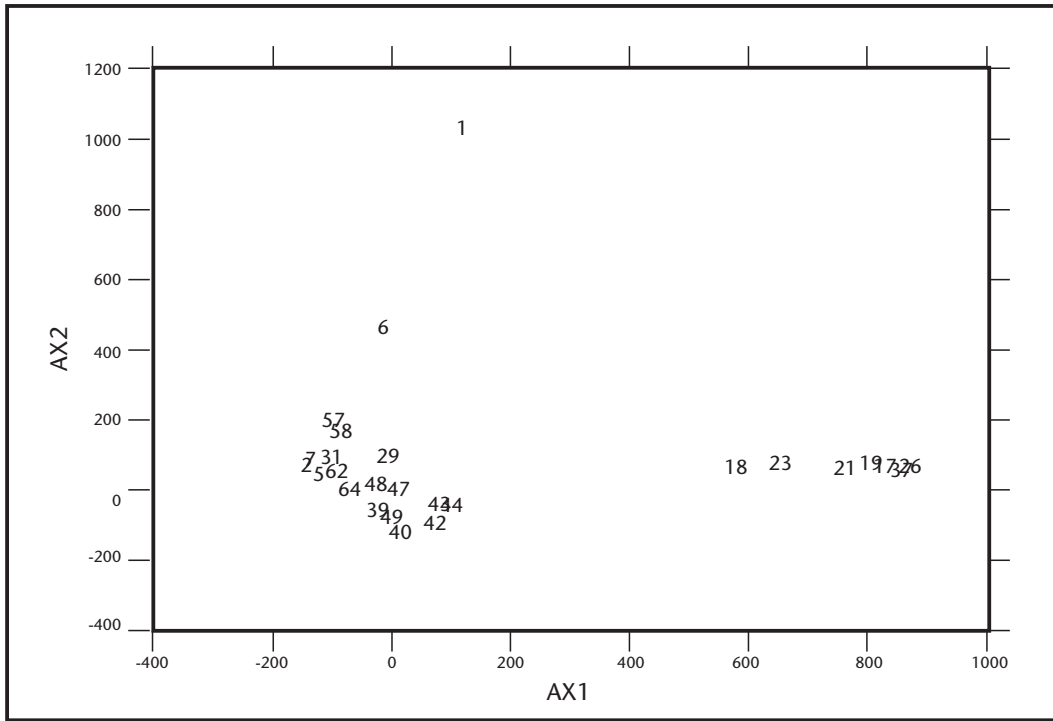| Clusters	Fishing Squares			
	A	B₁	B₂₁	B₂₂
Resource	2 333122 98201308	66　　　1255　126333556562556656 2311311 1223456226727346859710575863494545301	2311212 67793811	3444445444445 92346940157806
Caranx spp.	25534244	– 2 – – – – – – – – 2122 – – – – – – – – 221112 – 1– 111111	– – – – – – – –	– – 1 – – – – – – – – – –
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183
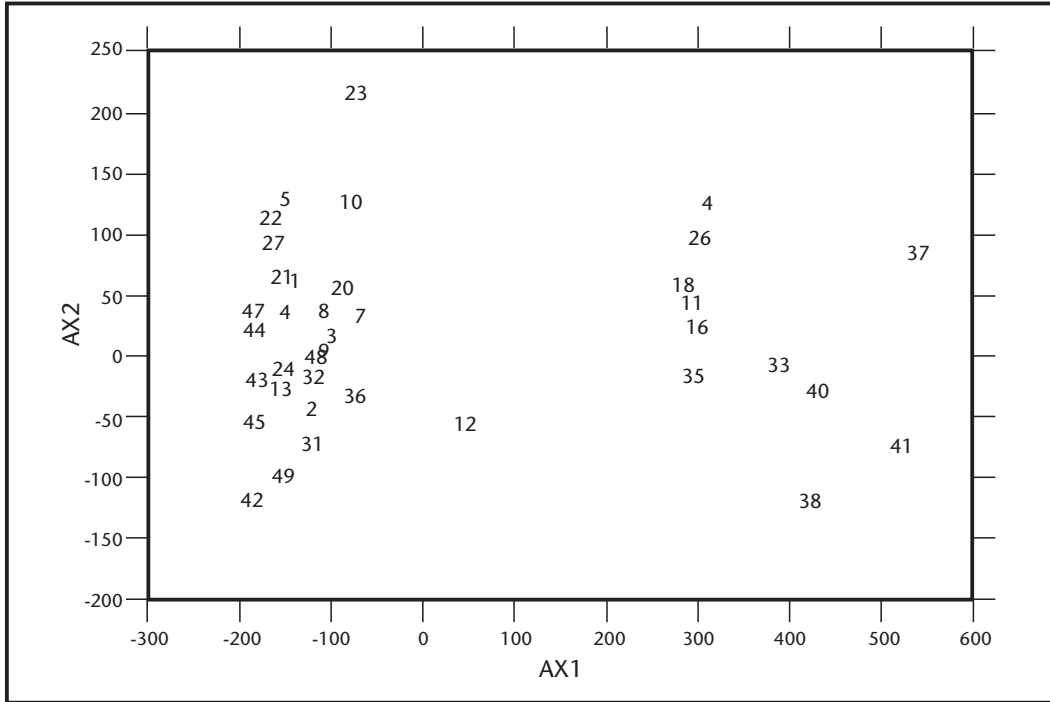
d. Premonsoon ordination of stations (DCA results).
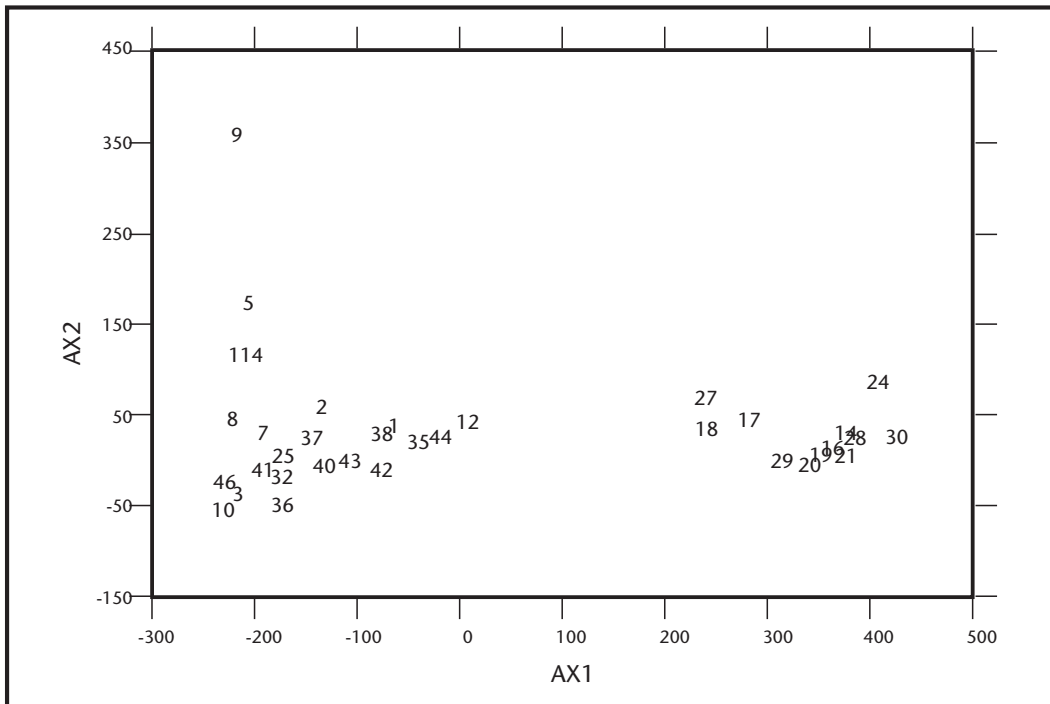
e. Monsoon ordination of the stations (DCA results).

f. Postmonsoon ordination of the stations (DCA results).