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Gastropod resource distribution and seasonal variation in trawling grounds off Konkan Malabar region , eastern Arabian sea

Sujitha Thomas*, A.P. Dineshbabu, & Geetha Sasikumar
Central Marine Fisheries Research Institute, Research Centre Mangalore, PB. No 244,
Hoige Bazar, Mangalore, Karnataka. 575001, India
*[E-mail: sujithacmfri@yahoo.co.in]

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Gastropod resource distribution and seasonal variation was studied from 2007-2010 based on onboard collection from multiday trawlers operating in Konkan Malabar region along the eastern Arabian sea at various depth (0-50 m, 51-100 m and 101-200 m), for a total of 619 fishing days (32 months). Thirty five species belonging to 18 families and 4 orders were found in different depths. Family Muricidae dominated in all the depth zone. In 0-50 m depth Tibia sp. (45%) dominated, while *Turris* sps (19.7%) in 51-100 m and *Conus sp*. in 101-200 m. Highest diversity (Shannon Weiner H (log 2) was found in 0-50 m depth during post- monsoon season and lowest (1.36) in 101-200 m depth. Gastropod of common occurrence in all the depth zones constituted of six species viz., *Bursa* sp., *Conus* sp., *Turris* sp., *Tibia* sp., *Natica* sp., and *Murex* sp. *Bursa* sp., made major contribution to the similarity in 50 m, *Murex* sp. in 100 m and *Strombus* sp.in 200 m. *Tibia* sps made the largest contribution to the dissimilarity between 50 m and 100 m depth zone in between groups analysis, while *Strombus* sp. contributed to the difference between 100 and 200 m depth zones. When considering the season as factor, *Bursa* sp., *Murex* sp., and *Tonna* sp., makes the major contribution to similarity between premonsoon, postmonsoon and monsoon respectively. Dissimilarity between premonsoon and postmonsoon is contributed by *Turris* sps, while *Tonna* sps contributes to dissimilarity between premonsoon and monsoon season and *Tibia* sp., contributed to post monsoon and monsoon season.

[Keywords: Gastropods, Trawling grounds, Discard, Resource distribution.]

Introduction

Discarding is a common practice in fisheries world over, accounting for an estimated 8% of the annual commercial fish catches amounting to 7.3 million ton of fish returning back to the sea[1]. Bycatch and discards from trawl has been of concern in the modern fishery and its effect on the marine ecosystem is being studied world over[2,3]. Most of the marine fisheries especially in tropical waters are mixed fisheries, directed at a few commercially target species, while inadvertently capturing a wide variety of non-targeted bycatch species[4,5]. There is a general concern about changes caused in the marine benthic assemblages by the trawlers[6,7].The first step towards understanding and solving the bycatch problem is to identify and quantify bycatches[4,8]. Gastropod forms a significant non–targeted component in the fishery by trawl fishery and forms an important constituent of the benthic community. These groups affected by trawling, plays a key role in marine food web by contributing to the marine ecosystem processes and functioning which in turn determines the productivity of marine capture fisheries. Marine gastropod forms about 2% of the total fishery world over[9].

Recently considerable focus has been given to the effect of trawling on benthic community from Indian waters[10,11,12,13,14,15]. Despite gastropods forming an important component of the benthic community, little attention is given due to its low commercial value. Information on depth related gastropod zonation and seasonal patterns and assemblage levels are an important handicap in understanding the benthic diversity patterns in Arabian sea. This study focus on the gastropods caught by the trawlers at different depths of operation and it throws light on the distribution of the gastropods in the trawling grounds. Since monsoon is prevalent along the coast, seasonal trends in distribution of gastropods based on monsoon viz., Premonsoon (Feb-May), Monsoon (June-Sept) and Postmonsoon (Oct-Jan) was also studied. This study would provide baseline information of the malacological community (except bivalves and cephalopods) in the trawling ground and provides an overview of the discard from trawlers in this region.

Materials and Methods

Study was carried out on commercial trawling vessel operating off the coast of Mangalore, Karnataka from September 2007 to April 2010. Generally fishing took place off Karnataka within an area defined by the coordinates10° 51.09 N- 75° 16.59 E and 17° 20.925 N and 72°.51.8064 E (Fig. 1) Trawler was 52''OAL wooden with 160 hp engine capacity which was engaged in multi-day trawling for a cruise period of 8 to 13 days in a trip. Trawler generally carried three types of trawl nets, with about 10 different cod end pieces to change the cod end of the trawl net according to the availability resource at space and time. Sampling involved 619 days of fishing trips for a period of 32 months. Excepting for the trawl ban period (June-July), the data collection was continuous. Multiday trawlers fished at a depth ranging from 30 to 180 m.

Data were collected by onboard observer following the direct collection method. Onboard the trawler, observer recorded all the information needed to characterise the fishing vessel, cruise no, date, depth of shooting, time of shooting, shooting longitude, shooting latitude, hauling depth, hauling time, hauling latitude, hauling longitude, net type, mesh size, total catch (kg) total discard (kg) and number of hauls/day. Along with fishing information, an unsorted portion of catch was collected as sample with token number representing the haul. One sample per haul was collected from each day of the boat trip (usually 7-13 days/trip). Samples were preserved in ice and stored in fish-hold and brought onshore. Qualitative and quantitative analysis of the samples were carried out in the laboratory. All the species were identified up to species level. Weight of samples were taken and the species present in the discarded sample were sorted out. Number of occurrence, length and weight of individual fishes and shellfishes in each group were recorded. The number was raised to number of fishes in each haul and then raised to day catch. These data were fed to MS Access files and queried for retrieving the data depth wise[10]. Spatial data collected were used as an input for the GIS study with ArcGIS 10 software[17]. Different fishery resources were mapped and for the present study only gastropod resources were taken from the total resources mapped.

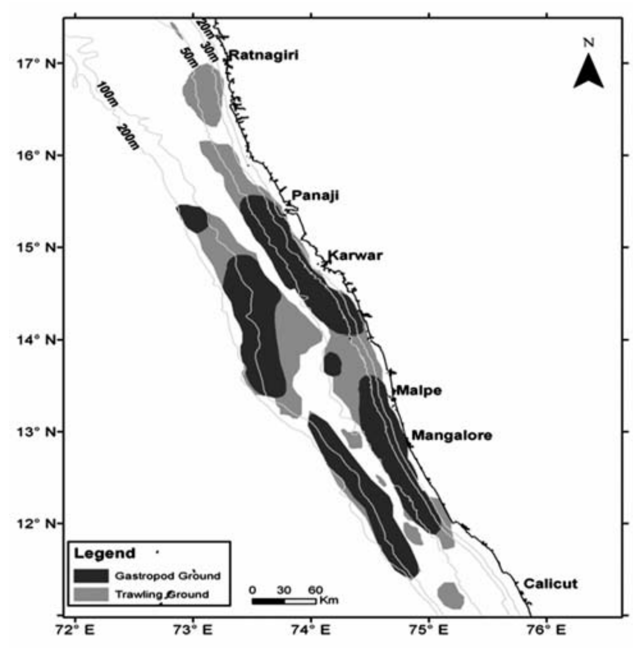

Fig. 1—Map showing the trawling grounds and areas of Gastropod occurrence off Malabar- Konkan Region.

Gastropods thus sorted from the catch were grouped into three depth zones *viz*., within 50 m (intensive trawling ground), 50-100 m (51-100 m) and 100-200 m (101-200 m) and analysed. Identification of the gastropods were done[18,19]. Observations were grouped into three seasons, pre-monsoon (February to May), monsoon (June–September) and post-monsoon (October–January)[20,21] for analysis.

Data analysis

Several summary matrices have been proposed to capture changes in fish communities in relation to fishing[22]. In this study, species diversity indices are used to examine the variation in species richness and species relative abundance and multivariate technique to explore the changes in species composition. Total gastropods collected were grouped based on the depth of operation. This study compares three depth zone in terms of gastropod species composition and diversity.

To analyse the difference of diversity between area Shannon-Weiner diversity index (H') and Pielou's evenness index (J") for evenness were calculated[23]. To compare the biodiversity between the areas, dominance plot was drawn by ranking the species in decreasing order of abundance. Similarity in species composition based on the species composition and abundance was studied by calculating the Bray-Curtis coefficient (Cluster analysis)[24]. Species contribution to the similarity of the depth and season and dissimilarity was investigated using SIMPER (Similarity Percentage Procedure) Technique. All the analyses were performed using PRIMER v6 analytical package[25].

Result

Out of 619 days of cruise spanning 32 months 65 boat trips with 7-10 days of operation , gastropods occurred at depths of 0-200 m. Trawling carried out during the study estimated a discard of 105 t in which 1 t (0.91%) was gastropods. In the trawling grounds the gastropods were observed within the coordinates 11.4°N to 15.572°N latitude and 72.85° E to 75.114°E longitude (Fig.1).

Thirty five species belonging to 18 families and 4 orders were recorded from 0-50 m, 51-100 m and 101-200 m depths in the discards. Among these species belonging to family Muricidae (17%) dominated the catch in all the depth zones. Other families which dominated the catch were Bursidae, Casidae and Naticidae (8%) (Fig. 2). In the intense fishing zone (0-50 m), *Tibia* species (45%) dominated the catch while in 51-100 m, *Turris sp.* dominated the catch and in 101-200 m *Tonna* sps (14 %) dominated the catch (Fig. 3). *Bursa* sp., *Conus* sp., *Turris* sp., *Tibia* sp., *Natica* sp., and *Murex* sp., recorded occurrence in the entire trawling ground irrespective of the depth.

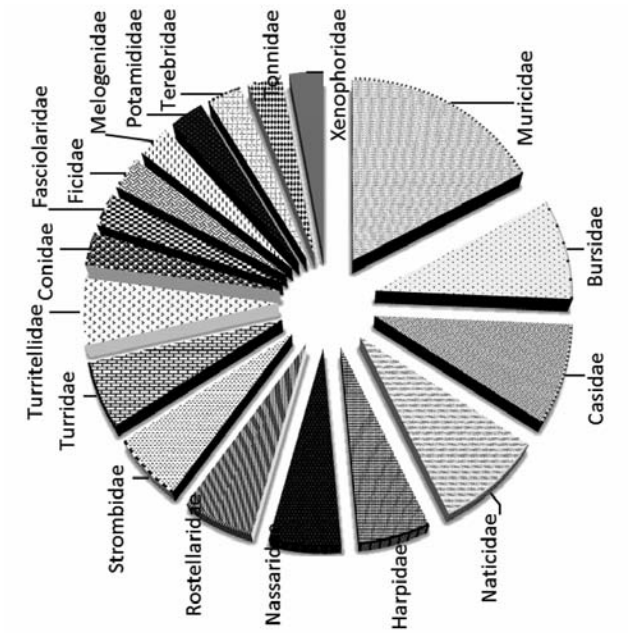

Fig. 2—Major families contributing to the gastropod species in trawling grounds off Karnataka

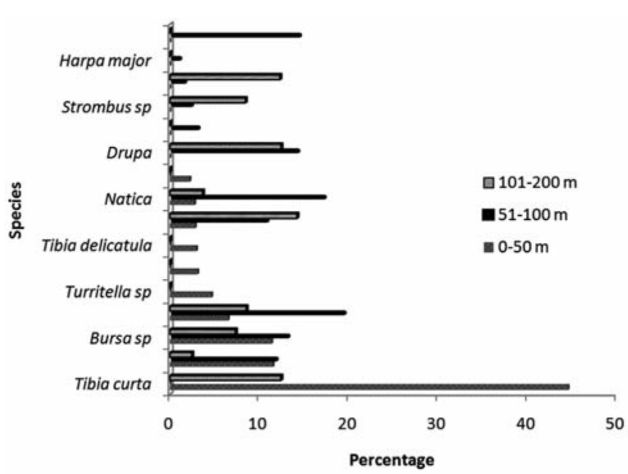

Fig. 3—Species of Gastropods contributing in different depth zones.

Spatial variations in species diversity were recorded from different depths. Shannon Weiner Diversity indices (H'(log 2) ranged from 1.36 to 4.15. Highest diversity indices was observed in 50 m depth (3.42-4.15) followed by 100 m depth (3.06-3.48). In 200 m depth the diversity indices ranged from 1.36 to 3.06. Highest diversity was observed during post monsoon season at 50 m depth (4.15). The species richness (Margalef d) ranged from 0.58 to 3.98. Highest was observed during postmonsoon season at 50 m depth. Evenness index (J') ranged from 0.84 to 0.96 in all the depths. Higher values indicate that many species had even distribution in the population in all the depth. (Fig. 4).

The diversity indices also showed variations with seasons. Shannon Weiner diversity indices (H'(log 2) ranged from 1.36 to 4.15. Highest was recorded in post-monsoon season at 50 m depth and lowest of 1.36 during the same period at 200 m depth. Species richness (d) also followed the same pattern. The evenness index (J') ranged from 0.84 to 0.97, indicating that many species had even distribution in the population during all seasons.

Diversity was high at 50 m depth and low in 200 m depth. Similarity in species composition and abundance in three depth range studied by Bray Curtis Coefficient (Cluster Analysis) resolved the depth and season to three clusters in the range 4.0 to 47.3. Dendrogram showed that the species composition showed maximum similarity of 33.87 with post monsoon 50 m and pre-monsoon 100 m, monsoon species composition in depths of 100 m and 200 m

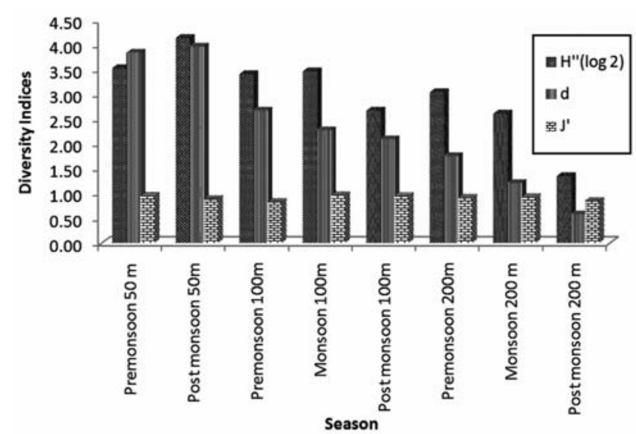

Fig. 4—Gastropod species diversity by season and depth in trawling grounds

showed maximum similarity at 47.3 and pre-monsoon 50 m and post-monsoon 100 m showed similarity at 32.01. All the other seasons were linked to this. The faunal similarity between depth and season is given in fig. 5.

Application of the SIMPER technique to the former revealed that *Bursa* sp., made major contribution to the similarity in 50 m depth, *Murex* sp in 100 m depth zone and *Strombus* sp.in 200 m depth zone. Results for between groups analysis showed that *Tibia* sps made the largest contribution to the dissimilarity between 50 m and 100 m depth zone, while *Strombus* sp. made the largest contribution to the difference between 100 and 200 m depth zones. (Table 1). When considering the season as factor, *Bursa* sp., *Murex* sp., and *Tonna* sp., made the major contribution to similarity between pre-monsoon, post-monsoon and monsoon respectively. Dissimilarity between pre-monsoon and post-monsoon is contributed by *Turris* sps, while *Tonna* sps contributes to dissimilarity between pre-monsoon and monsoon season and Tibia sp., contributed to post monsoon and monsoon season. (Table 2). Multi-dimensional (MDS) scaling on the similarity matrix into an ordination plot showed the dissimilarity between season and depth (fig. 6).

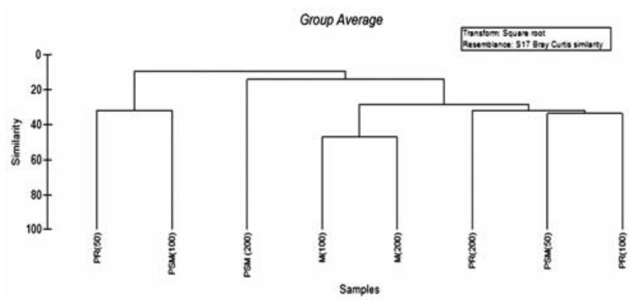

Fig. 5—Cluster graph showing gastropod faunal similarity between depth and season PR-premonsoon; PSM-post monsoon; M-monsoon

Table 1— SIMPER analysis of dissimilarity between different depths Groups 50 & 100
Average dissimilarity = 77.71

	Group 50	Group 100			
Species	Av.Abund	Av.Abund	Av.Diss	Contrib%	Cum.%
Tibia curta	35.4	6	7.85	10.11	10.11
Turris sp	15.1	22.85	6.16	7.93	18.04
Bursa sp	20.88	21.3	5.92	7.62	25.66
Natica	9.85	22.62	5.59	7.19	32.86
Drupa	0.87	20.68	5.3	6.82	39.67
Tibia sp	19.47	1.56	5.27	6.78	46.45
Murex sp	7.05	20.87	4.98	6.42	52.87
Conus	10.17	17.8	4.76	6.13	59
Murex trapa	19.18	0.67	3.47	4.47	63.47
Turritella sp	13.03	0	3.17	4.08	67.55
Ficus gracillis	3.04	8.73	2.66	3.42	70.97
Tonna dolium	3.08	4.92	2.31	2.97	73.94
Telescopium	0	9.35	2.03	2.62	76.55
Thias tissoti	6.13	0	1.93	2.49	79.04
Bursa suensonis	9.94	0	1.78	2.29	81.33
Fusinus nicobaricus	3.04	1.22	1.57	2.02	83.35
Phalium sp	8.43	0	1.51	1.94	85.3
Strombus sp	0	7.2	1.32	1.69	86.99
Strombus listeri	0	2.99	1.07	1.38	88.37
Natica lamarckii	5.94	0	1.06	1.37	89.74
Rapana bulbosa	5.94	0	1.06	1.37	91.11

Groups 50 & 200
Average dissimilarity = 86.07

	Group 50	Group 200			
Species	Av.Abund	Av.Abund	Av.Diss	Contrib%	Cum.%
Tibia curta	35.4	10.11	9.69	11.26	11.26
Strombus listeri	0	13.97	9.41	10.94	22.19
Bursa sp	20.88	7.76	6.28	7.29	29.48
Tonna dolium	3.08	12.85	6.23	7.24	36.73
Tibia sp	19.47	5.44	4.92	5.71	42.44

Contd

Table 1— SIMPER analysis of dissimilarity between different depths Groups 100 & 200 —*Contd*

Average dissimilarity = 78.04

Turris sp	15.1	8.38	4.71	5.47	47.92
Ficus gracillis	3.04	12.82	4.52	5.25	53.17
Drupa	0.87	10.44	4.5	5.22	58.39
Murex trapa	19.18	4.48	4.46	5.19	63.58
Tibia delicatula	0	10.02	3.5	4.07	67.65
Turritella sp	13.03	0	3.2	3.71	71.36
Natica	9.85	5.49	3.1	3.6	74.96
Conus	10.17	3.25	2.94	3.42	78.38
Murex sp	7.05	3.94	2.77	3.22	81.6
Bursa suensonis	9.94	0	1.9	2.21	83.81
Thias tissoti	6.13	0	1.88	2.18	85.99
Phalium sp	8.43	0	1.61	1.87	87.86
Xenophora solaris	2.37	0	1.16	1.35	89.21
Natica lamarckii	5.94	0	1.13	1.32	90.52

Groups 100 & 200

Average dissimilarity = 78.04

	Group 100	Group 200			
Species	Av.Abund	Av.Abund	Av.Diss	Contrib%	Cum.%
Strombus listeri	2.99	13.97	7.92	10.14	10.14
Drupa	20.68	10.44	6.98	8.95	19.09
	Group 100	Group 200			
Turris sp	22.85	8.38	6.67	8.55	27.64
Bursa sp	21.3	7.76	6.65	8.52	36.16
Tonna dolium	4.92	12.85	6.5	8.32	44.48
Natica	22.62	5.49	6.44	8.25	52.73
Murex sp	20.87	3.94	5.82	7.46	60.19
Tibia curta	6	10.11	4.9	6.28	66.47
Ficus gracillis	8.73	12.82	4.73	6.06	72.53
Conus	17.8	3.25	4.52	5.8	78.33
Tibia delicatula	0	10.02	3.56	4.56	82.89
Tibia sp	1.56	5.44	3.22	4.13	87.02
Telescopium	9.35	0	2.22	2.84	89.86
Murex trapa	0.67	4.48	1.65	2.11	91.97

Table 2—SIMPER analysis of dissimilarity between different seasons

Groups Premonsoon & Postmonsoon

Average dissimilarity = 83.53

	Group Premonsoon	Group Postmonsoon			
Species	Av.Abund	Av.Abund	Av.Diss	Contrib%	Cum.%
Turris sp	28.34	9.6	7.92	9.48	9.48
Bursa sp	24.57	13.38	7.53	9.01	18.49
Natica	24.13	7.18	6.32	7.56	26.05
Tibia curta	4.25	22.45	5.87	7.03	33.08
Strombus listeri	5.37	6.24	5.79	6.94	40.02
Ficus gracillis	14.61	2.36	5.04	6.03	46.05
Drupa	17.35	0	4.34	5.19	51.25
Murex sp	16.84	6.95	4.32	5.17	56.41
Conus	14.9	6.31	4.14	4.96	61.37
Tibia delicatula	10.02	0	4.07	4.88	66.25
Tibia sp	0	14.55	3.97	4.76	71.01
Murex trapa	5.15	12.78	3.61	4.33	75.33
Turritella sp	0.58	8.11	2.21	2.64	77.98

Contd

Table 2—SIMPER analysis of dissimilarity between different seasons

Groups Premonsoon & Postmonsoon

Average dissimilarity = 83.53

	Group Premonsoon	Group Postmonsoon			
Species	Av.Abund	Av.Abund	Av.Diss	Contrib%	Cum.%
Tonna dolium	0	4.11	2.15	2.58	80.55
Telescopium	8.06	0	1.63	1.95	82.5
Strombus sp	7.2	0	1.45	1.74	84.24
Thias tissoti	0.58	3.51	1.41	1.69	85.93
Bursa spinosa	3.63	0	1.38	1.65	87.58
Fusinus nicobaricus	0.33	2.91	1.31	1.56	89.15
Bursa suensonis	0	6.62	1.15	1.38	90.53

Groups Premonsoon & monsoon
Average dissimilarity = 75.53

	Group Premonsoon	Group monsoon			
Species	Av.Abund	Av.Abund	Av.Diss	Contrib%	Cum.%
Tonna dolium	0	23.58	9.14	12.1	12.1
Drupa	17.35	21.52	8.26	10.93	23.03
Turris sp	28.34	5.05	6.77	8.97	31.99
Tibia curta	4.25	19.52	6.21	8.22	40.21
Bursa sp	24.57	7.55	5.9	7.81	48.02
Natica	24.13	5.05	5.58	7.39	55.4
Murex sp	16.84	8.59	5.11	6.76	62.17
Conus	14.9	9.92	5.09	6.74	68.9
Ficus gracillis	14.61	9.9	4.58	6.06	74.96
Tibia delicatula	10.02	0	3.36	4.45	79.41
Tibia sp	0	8.15	3.09	4.09	83.5
Strombus listeri	5.37	8.04	2.68	3.55	87.05
Telescopium	8.06	1.94	2.08	2.75	89.8
Murex trapa	5.15	0	1.63	2.16	91.97

Groups Postmonsoon & monsoon

Average dissimilarity = 80.18

	Group Postmonsoon	Group monsoon			
Species	Av.Abund	Av.Abund	Av.Diss	Contrib%	Cum.%
Tibia curta	22.45	19.52	11.09	13.83	13.83
Drupa	0	21.52	10.38	12.95	26.78
Tonna dolium	4.11	23.58	9.75	12.16	38.94
Tibia sp	14.55	8.15	5.27	6.57	45.52
Bursa sp	13.38	7.55	5.21	6.5	52.02
Conus	6.31	9.92	4.82	6.01	58.03
Strombus listeri	6.24	8.04	4.49	5.59	63.63
Murex sp	6.95	8.59	4.31	5.38	69
Ficus gracillis	2.36	9.9	4.27	5.32	74.33
Turris sp	9.6	5.05	3.71	4.63	78.96
Natica	7.18	5.05	3.07	3.83	82.79
Murex trapa	12.78	0	2.33	2.9	85.69
Turritella sp	8.11	0	1.48	1.84	87.53
Xenophora solaris	1.58	2.6	1.31	1.63	89.16
Bursa suensonis	6.62	0	1.21	1.5	90.67

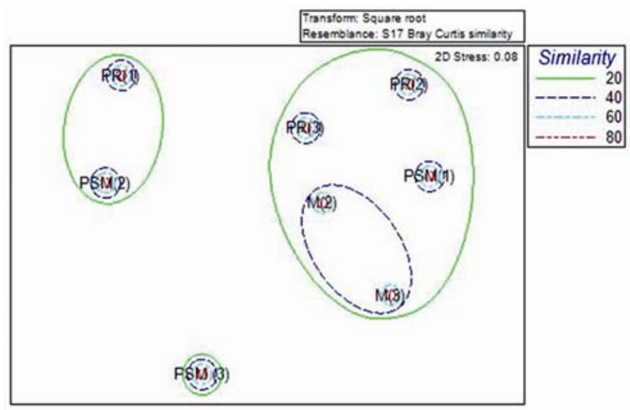

Fig. 6—Multidimensional scaling ordination based on Bray- Curtis similarity for three seasons and depth . PR1: pre monsoon depth 0-50 m; PSM 2 – post monsoon depth 51-100 m; M 3- monsoon depth 101-200 m.

Discussion

The results of the studies shows that maximum species diversity in gastropod was observed from 0-50 m depth and species zonation was evident at different depths. This pattern could be more explained by incomplete recolonization or poor food supply downslope or in deeper waters when compared to the intensively trawled productive inner shelf waters[26]. Since the intensity of trawling is more in 0-50 m depth, it could be one of the reasons for high values in diversity index. Disturbance from trawling could be linked with the non equilibrium state hypothesis which predicts high diversity in maximum disturbed area[27]. Towards the coast (0-50 m) Tibia sps dominated, which may be due to the reason that the substratum suitable for this species is more in 0-50 m depth. Gastropod of common occurrence in all the depth zones constituted of six species viz., *Bursa* sp., *Conus* sp., *Turris* sp., *Tibia* sp., *Natica* sp., and *Murex* sp. Seasonal pattern of variation may be probably associated with some spatial variations in fishing zones or may be due to the recruitment variability of the species. Decrease in species diversity in the depth zones may be due to variation in the substratum in the depth zones also. Similar observations were done[28] in invertebrate discard, where they observed that variation was due to rocky bottom. Although other minor fauna and bivalves were not included in the present study, the gastropods form the mega fauna in the fishing grounds which are indicators and throw light on the fishing effects as they are more vulnerable to fishing than smaller species as they take longer time to recover. Removal of mega fauna reduced the complexity and species diversity of the benthic community[29]. In the study area beyond 50 m, trawl nets are the main cause of discarding of non-commercial gastropods as other gears such as purseseine and gill net operations are restricted upto 50 m. Trawls could have more direct physical impact on bottom invertebrates in addition to their capture and discarding[30]. Gastropods which are caught are usually discarded onboard. This would have some impact on the gastropod population as the discarding usually occurs while the fishing vessel is moving, which would result in the relocation of the species on a substratum different from which it was originally caught. About 60% of the gastropod caught are damaged. Implications in terms of potential recolonisation are particularly important for the gastropods as they have poor mobility[31].

The gastropod forms a major component of the benthic community and these resources are discarded in the trawling ground itself. The effect of trawling on the benthic community has been demonstrated by experimental trawling where trawling is done in small areas. These experiments have shown that trawling alters the benthic community[32,33]. But long term effect of the commercial trawl is not studied much. Studies on the trawling grounds of Kerala showed that about 65 gastropods are discarded[14]. Result obtained in the present study shows that considerable quantity of gastropods are trawled and discarded in different depth. This illustrates the negative impact of discards and in particular in the gastropods that constitute a major component in the benthic community. The study shows that about 35 species of gastropods are discarded by commercial trawlers in the fishing grounds, which would have implications in terms of conservation, management and sustainable use of marine resources. Studies also shows that discard rates observed were associated with greater fishing effort on highly complex substratum at low depth that are rich in terms of biodiversity. This study helped in identifying the gastropod resources which are usually discarded by the trawlers onboard and this would form a baseline for future studies on its habitat preferences in terms of depth, salinity and sea bottom temperature. The present study also gives a visual projection of the distribution of gastropod which could be used for integrating fish assemblages and their interactions.

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