Indian Journal of Marine Sciences
Vol. 35(3), September 2006, pp. 249-256

Variations on the infaunal polychaetes due to bottom trawling along the inshore waters of Kerala (south-west coast of India)

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Received 1 June 2005, revised 26 April 2006

Variations of the infaunal polychates populations due to bottom trawling were studied during December 2000 to November 2002 at depth ranging from 0-50 m along Cochin-Munambam area (Kerala, long.76º10' 94" to 75º 56' and lat. $9^0$58' to $10^0$10'), in the southwest coast of India. Infaunal polychaetes from the sediment samples were collected both before and after experimental trawling in order to assess the variations on their abundance (no.m^{-2}), biomass (g.m^{-2}) and diversity due to bottom trawling. Highest variations in polychaetes were recorded at station 9 in May 2002 where polychaete abundance increased to 20710 no.m^{-2} after trawling from 2787 no.m^{-2} before trawling. Biomass showed highest variations at station 3 in December 2000 where biomass increased from 7.16 g.m^{-2} recorded before trawling to 34.53 g.m^{-2} in the samples collected after trawling. Multivariate community analysis carried out based on both species abundance and biomass of polychaetes also confirm the wide variations in the similarities of the stations comparing both before and after trawling

[**Key words**: Bottom trawling, inshore waters, polychaetes, infaunal polychaetes, trawling, Kerala]

Introduction

Fishing has a great role in bringing about changes in the marine ecosystem by way of removal of the fish and benthic communities thereby causing harmful environmental effects [1,2]. Among the various fishing practices employed in the fisheries sector on a global basis, bottom trawling/dredging are the most destructive fishing methods[3]. During bottom trawling, a variety of fishes and other invertebrates are caught in the trawl net. After separating the economically important fin and shellfishes from the catch, the remaining part is thrown back to the sea as "discards" of which most of them will not survive. Besides, a significant fraction of infauna which live inside the sediments are destroyed as a result of direct contact with the gear or exposure to predators [4].

Though many studies have been conducted for assessing the long-term and short-term impacts of bottom trawling around the globe [5-7] no concerted attempt has been made in Indian waters. In the wake of large-scale commercial exploitation of prawn resources, the demand for more efficient trawl gear increased considerably in the Indian waters, which resulted in the introduction of otter trawls in early 60's. In Kerala, (south-west coast of India), bottom trawling is the major fishing activity with about 4950 bottom trawlers engaged in the daily fishing operations. Kerala, well known for its fishery resources, is now facing the problem of excessive fishing pressures due to the inordinate proliferation of the bottom trawlers[8]. This study was made on the immediate effect of bottom trawling on the infaunal communities in the inshore waters of southwest coast of India.

Materials and Methods

The region along the coastline encompassing Cochin and Munambam was selected for conducting bottom trawling experiment (Fig.1). A commercial trawler (*Lawrence* of 45 ft OAL) was used to carry out the experimental trawling. The study area was divided into five depth zones 0-10, 11-20, 21-30, 31-40 and 41-50 m, with two stations in each zone. Thus a total of 10 stations were fixed, (viz S1, S2, S3,……S10). Trawling was done more or less at the mid depth of these zones, at 5, 15, 25, 35 and 45 m. The samples collected from these stations after trawling, have been designated as A1, A2, A3, ……A10. However, no stations could be treated as control in this region as incessant commercial

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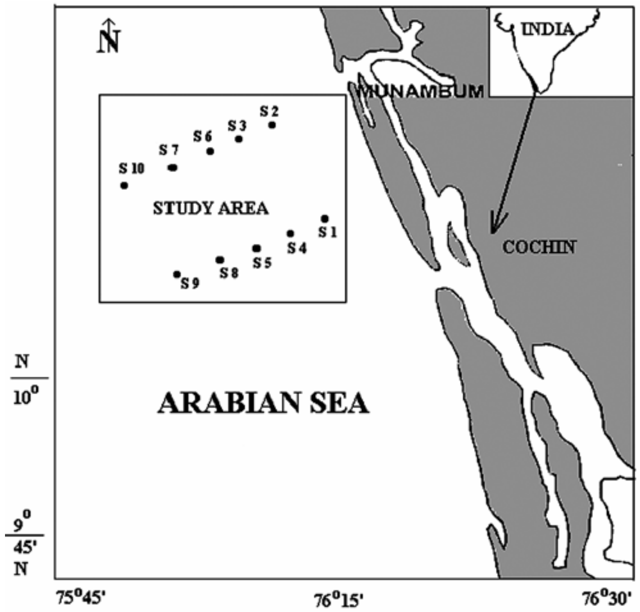

Fig. 1—Location map of the study area

trawling operations were in vogue at all the depth zones, even at the shallow coastal waters of < 5 m depth.

Experimental trawling was carried out from December 2000 to November 2002, using standard fishing equipments. The stations were sampled at bimonthly intervals giving uniform representation to premonsoon, monsoon and postmonsoon seasons. Trawling operations were also conducted during the period just prior to the lifting of ban on bottom trawling imposed along the Kerala coast during southwest monsoon (in July 2001 and 2002). Sediment samples from each station were collected in duplicate using a van Veen grab of area $0.1m^2$. The trawler was then propelled for 30 minutes and experimental trawling was carried out along the same corridor propelling back for one hour through the same corridor. The net was then hauled in after passing the station and the vessel was maneuvered back to the station at the original position in the same depth zones within 5 minutes where the samples had previously been collected, with the help of the GPS. Thereafter, the fishing vessel proceeded to the next station and the above strategy was repeated at all the ten stations from 0-50 m depth.

Mud samples were sieved through 0.5 mm aperture screen and the animals retained in it categorized as macrofauna were carefully removed and preserved in 4 % neutralized formalin for subsequent identification. Polychaetes were identified following standard identification keys[9-11]. Numerical abundance and wet weight were used as the basis of faunal evaluation in this study. The PRIMER statistical software was used to perform multivariate analysis on the community data[12]. Bray-curtis similarity index was calculated on fourth root transformed data and the resulting similarity matrics were then used to perform non-metric multidimensional scaling (MDS) with differences between the treatments (before and after trawling) tested by one way ANOSIM[13]. The SIMPER analysis was used to establish which taxa contributed most to either the similarity or dissimilarity between groupings of data[18]. Shannon Wiener diversity index was also calculated using PRIMER software [14].

Results

Polychaetes emerged as the numerically dominant taxa, in almost all seasons and depths and this group was chosen to comprehend the impact of trawling on infauna. Polychaetes showed a preference for sandy areas (> 40 m depth) and exhibited high abundance in this zone with an average of 2500 no.m^{-2} per stations, while silty and clayey regions (0 - 40 m) harbored the lowest abundance of polychaetes (average 1000 no.m^{-2}/stations). About 80 genera of polychaetes were identified among these *Ancistrosyllis parva*, *Cossura costa*, *Prionospio pinnata* , *Sternaspis scutata* , *Lumbrineries latrieilli*, *Magelona cinta*, *Nepthys dibranchi and Glycera longipinnii* were most commonly occurring species in samples collected both before and after trawling samples (Table 1). Highest abundance and biomass was recorded during postmonsoon (Oct-Jan) period followed by premonsoon (Feb-May) and monsoon (Jun-Sep).

In the samples collected after trawling, the number of polychaetes was found to be high in almost all stations (Fig.2). Highest variation in the polychaete number was observed at station 9 in May 2002 when 20710 no. m^{-2} were enumerated in the samples collected after trawling against 2787 no. m^{-2} recorded before trawling. Biomass also showed similar variations at many stations. Highest variation was observed at station 3 in December 2000 with a biomass of 34.53 g m^{-2} in the samples collected after trawling from 7.16 g. m^{-2} recorded before trawling (Fig. 3). Non-metric multi-dimensional scaling (MDS) plots based on the polychaete abundance obtained before and after trawling showed that all stations before trawling (S1, S2, S3….S10) were distant from the corresponding after trawling (A1, A2,

Table 1—Average abundance of major species obtained before and after trawling at stations 1 to 10 during the study (B.T. = Before trawling, A.T. = After trawling)

Species	Stn.1		Stn.2		Stn.3		Stn.4		Stn.5	
	B.T	A.T	B.T	A.T	B.T	A.T	B.T	A.T	B.T	A.T
Ancistrosyllis parva	12.5	33.3	9.2	28.3	11.7	16.7	33.3	36.7	71.7	19.2
Cirratulus dasylophius	2	13	1.7	8.3	10.0	6.7	8.3	1.7	3.3	6.7
Cossura costa	267.5	462.5	322.5	297.5	234.2	192.5	115.0	159.2	202.5	118.3
Euclymene sp.	16.7	12.5	9.2	13.3	8.3	10.8	5.0	6.7	13.3	11.7
Lumbrineries latrielli	411.0	740.8	290.0	592.5	377.5	151.7	377.5	230.0	175.0	168.3
Magelona cincta	211.7	343.3	293.3	694.2	492.5	2480.8	490.0	8.3	388.3	8.3
Nephtys dibrachii	10.8	18.3	11.7	19.2	11.7	10.0	16.7	20.0	17.5	15.0
Nereis sp.	1.7	1.7	3.3	5.0	4.2	1.7	4.2	0.0	10.8	5.0
Notomastus aberans	11.7	10.8	3.3	5.0	6.7	1.7	3.3	8.3	10.0	1.7
Prionospio sp.	21.7	18.3	10.0	28.3	24.2	23.3	20.8	17.5	20.8	34.2
Sternapsis scutata	119.2	101.7	63.3	86.7	107.5	46.7	66.7	107.5	105.8	125.0

Species	Stn.6		Stn.7		Stn.8		Stn.9		Stn.10	
	B.T	A.T	B.T	A.T	B.T	A.T	B.T	A.T	B.T	A.T
Ancistrosyllis parva	30.0	25.0	44.2	54.2	44.2	55.0	135.0	100.0	126.7	130
Cirratulus dasylophius	1.7	11.7	26.7	54.2	43.3	30.0	11.7	25.8	18.3	39.2
Cossura costa	260.8	208.3	14.2	52.5	26.7	79.2	13.3	35.8	16.7	20.8
Euclymene sp.	8.3	1.7	15.0	20.8	5.0	19.2	10.0	3.3	6.7	5
Lumbrineries latrielli	156.7	154.2	180.0	65.8	123.3	73.3	95.0	70.8	94.2	102.5
Magelona cincta	346.7	71.7	219.2	577.5	71.7	894.2	1832.3	2961.7	2085.0	3153
Nephtys dibrachii	14.2	22.5	3.3	4.2	5.0	10.0	18.3	12.5	20.0	11.7
Nereis sp.	7.5	1.7	60.0	25.0	20.0	31.7	11.7	35.0	17.5	30
Notomastus aberans	6.7	10.0	5.0	5.8	10.0	1.7	1.7	0.0	0.0	3.3
Prionospio sp.	19.2	25.8	89.2	108.3	108.3	190.8	44.2	336.7	25.0	359.2
Sternapsis scutata	109.2	104.2	18.3	23.3	14.2	21.7	13.3	20.0	10.0	15

A3….A10) stations, thus manifesting vide variations of polychaetes due to trawling (Fig. 4). MDS plots based on the polychaete biomass resembled that of abundance, with before trawling stations located at the same depth located closer in the plot. Figure 5 depicts the polychaete biomass at all stations both before (S1, S2, S3….S10) and after trawling (A1, A2, A3….A10) showing a clear cut variation in the polychaete biomass after trawling. The "Euclidean distance" between the same stations after trawling was much more than that seen before trawling. Two way ANOSIM revealed significant differences within stations ($R=0.216, P<0.001$) but significant difference could not be seen between treatments ($R=0.008, P>0.001$). Results of the community analysis using the SIMPER routine indicates that the taxa such as Lumbrineiries, Magelonidae, Ancistrosyllis, Cossura, Sternapsis contributed much to the dissimilarity between the samples collected before and after trawling.

Diversity indices based on the polychaete abundance was carried out using Shannon's diversity index (H') which varied between 1.04–1.56 in the samples collected before trawling. Highest diversity was noticed at station 8 and lowest at station 10. After trawling, the diversity (H') increased in majority of stations, which ranged between 1.00 and 1.67 with the highest and lowest at station 7 and 9 respectively. Average diversity (H') calculated for all stations before trawling was 1.25, which increased to 1.32 after trawling. Stations 1, 4, 6, 7,8 and 10 showed higher diversity after trawling when compared to that recorded before trawling (Fig. 6). However, statistically these variations were insignificant ($P > 0.01$)(Table 2).

Discussion

The results of the study revealed that bottom trawling inflicted irreversible and irreparable damages to the infaunal macrobenthos due to exposure from

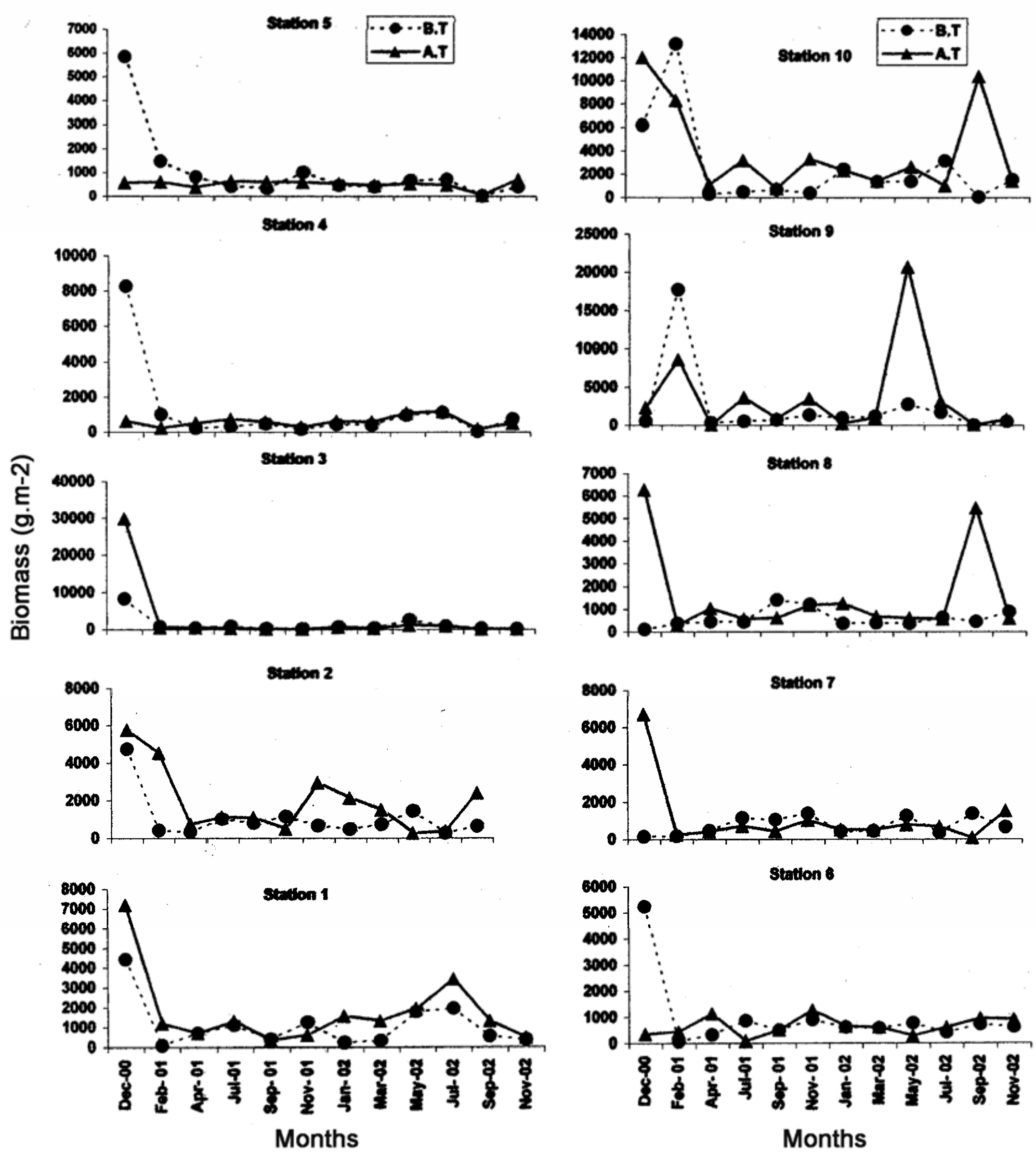

Fig. 2—Variations in the polychaete abundance at the study area before and after trawling during December 2000 to November 2002 (B.T.=Before trawling, A.T.=After trawling)

their tubicolous habitation. Polychaetes were adjudged to evaluate the effect of bottom trawling since it represents the mainstay in the infaunal community around the year. Dominance of polychaetes in the infaunal macrofauna has been invariably reported along the shelf waters of India[15,16]. Environmental parameters and sediment stability have major roles in the availability and abundance of the macrobenthos[17], among this, sediment grain size and water movements are the most important[18]. High abundance of polychaetes in the sandy stations observed in this study also corroborate to the earlier findings[19]. The distribution and abundance of these species may be due to their continuous breeding habits[20].

In the present study, the number and biomass of the polychaetes increased in the samples collected immediately after trawling and this may be attributed to their exposure due to the removal of top sediment layer associated with the settlement of dispersed organisms after trawling. The infaunal polychaetes especially Lumbrineiries, Magelonidae, Ancistrosyllis,

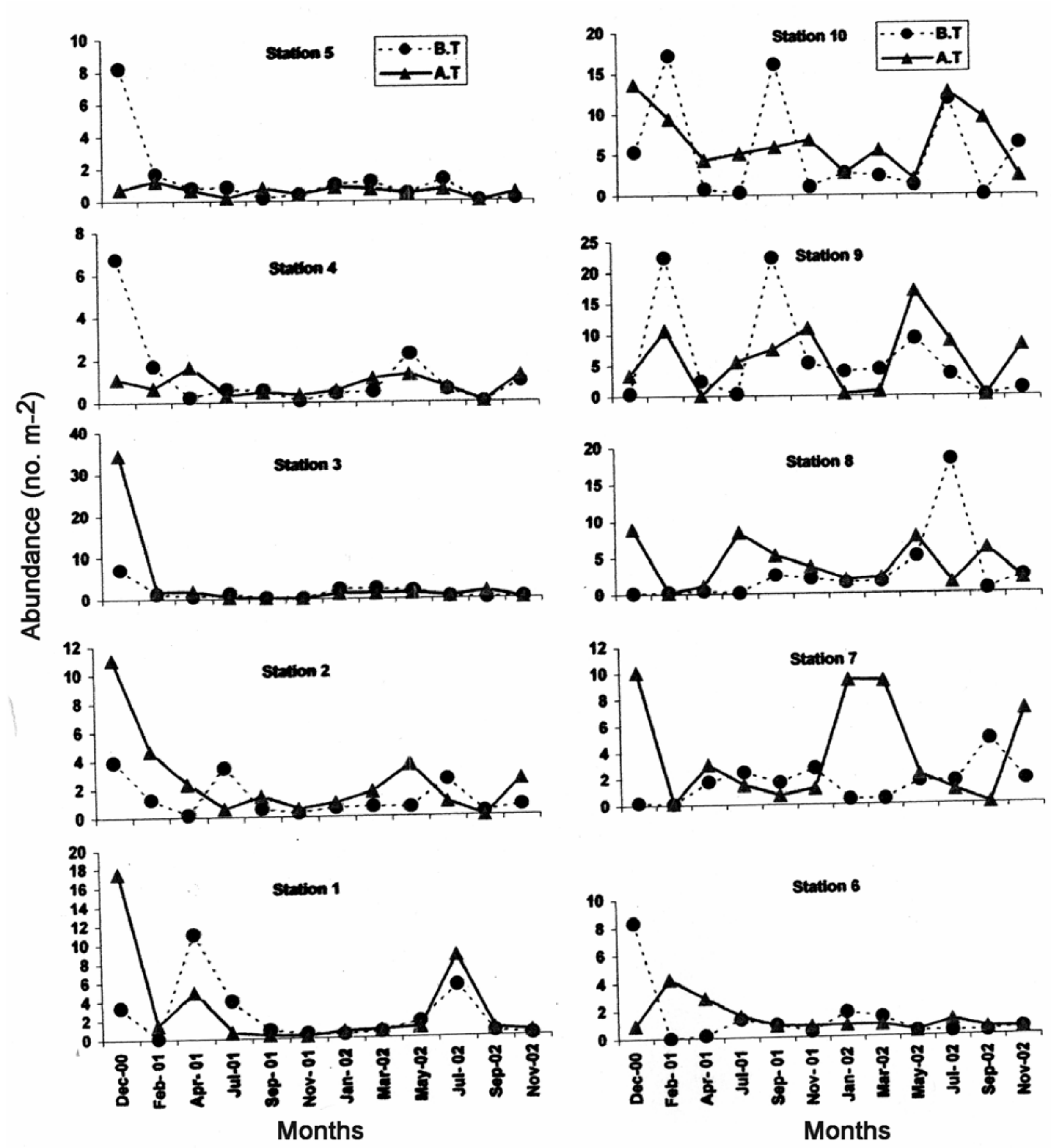

Fig. 3—Variations in the polychaete biomass at the study area before and after trawling during December 2000 to November 2002 (B.T.= Before trawling, A.T. = After trawling)

Table 2—Results of one-way anova on shannon's diversity on polychaete abundance (mean) before and after trawling

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.00857	1	0.0086	0.2442	0.62718	4.41386
Within Groups	0.63178	18	0.0351			
Total	0.64035	19				

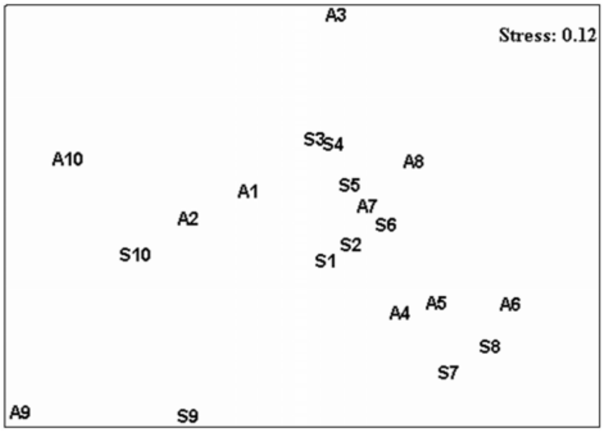

Fig. 4—MDS ordination plot of comparison of polychaete abundance at stations sampled before and after trawling during December 2000 to November 2002. (S1, S2, S3…S10 = Stations before trawling; A1, A2, A3…A10 = Stations after trawling)

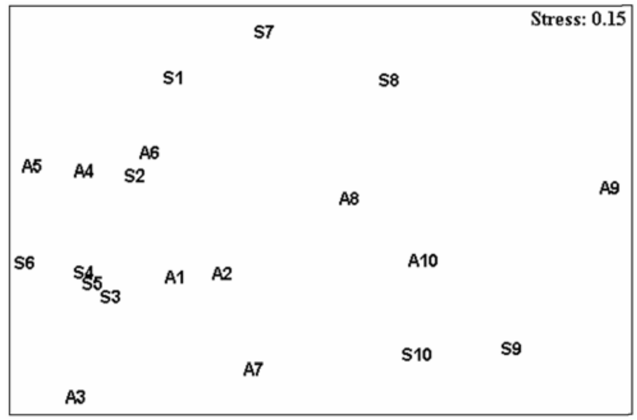

Fig. 5—MDS ordination plot of comparison of polychaete biomass at stations sampled before and after trawling during December 2000 to November 2002 (S1, S2, S3…S10 = Stations before trawling; A1, A2, A3…A10 = Stations after trawling)

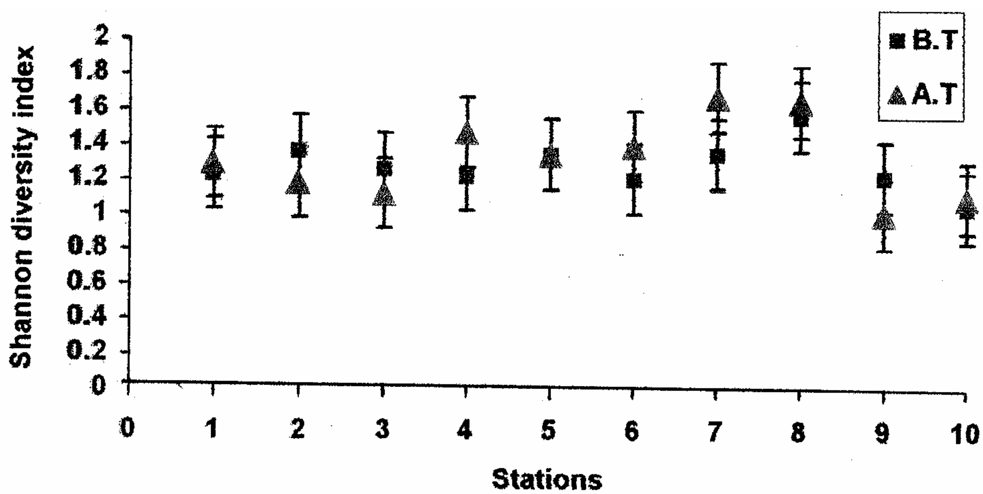

Fig. 6—Shannon diversity (Mean abundance) of polychaetes before and after trawling at stations 1 to 10 during December 2000 to November 2002 (B.T= Before trawling, A.T= After Trawling)

Cossura and Sternapsis were showed a perceptible increase after trawling due to their abundance on the top layer of 5-20 cm deep from the sediment surface. Many studies reported that bottom trawling caused damages to the infaunal communities. Polychaetes showed high abundance after beam trawling in the southern North Sea[21,22]. Studies conducted in the stable sediments reported that otter boards and net penetrated into the sediments reduced the number of species and individuals drastically while dragging[4]. Most of the polychaetes observed throughout this study were of smaller in size and this is a clear indication of extreme disturbance imparted on the sediment. These organisms do not get an opportunity to grow into larger size due to the continuous disturbance caused to the sea bottom by way of regular trawling operations.

In the present study, highest abundance and biomass were recorded during post monsoon period followed by premonsoon and monsoon, which are corroborating with the earlier findings[23]. However, a second peak was observed in July can be attributed to the ban imposed to the bottom trawling along Kerala coast. It would thus appear that the ban provided great respite to the polychaetes for their recoupment and regeneration on sea bottom and this fully justifying the fishing holidays for bottom trawlers. Heavy reduction of polychaetes observed during monsoon months after July may be due to high trawling pressure exerted immediately after the lifting of the ban period.

The results of the present study further revealed that bottom trawling brought about perceptible variations in the diversity of polychaetes with ostensible increase after trawling, though it is not statistically different and therefore firmly complement with that of the study conducted in a previously un-fished sheltered area[24]. Multivariate analysis based on the abundance and biomass of the polychaetes obtained during the study also confirm the variations, which took place in the polychaete community due to trawling. The wide distance between before and after trawling stations, in the MDS comparison indicated variations in the abundance and biomass of the polychaetes due to bottom trawling. Increase in the diversity of the polychaete abundance also manifests the amount of disturbance inflicted on these fragile organisms during bottom trawling. The variations in the benthic populations due to bottom trawling with significant increase in the total number of individuals, biomass and species abundance of polychaetes reported earlier equivocally confirmed that there is an increase in the polychaete species immediately after bottom trawling[25-27]. In the present study, the variations in the abundance and biomass noticed after trawling when compared to before trawling in many of the stations signify the fact that the relative abundance and biomass of the infaunal communities could be altered as an immediate effect of bottom trawling. ANOSIM results showed that trawling did not have immediate significant effect on the structure of the benthic assemblages, however, the wide variations noticed in the diversity at many stations indicated that there were remarkable changes on the benthic populations due to bottom trawling.

The availability of benthos at a region can be considered as an indicator of demersal fishery potential since they form an important food resource for crabs and fishes[28]. High quantity of scavenging polychaetes were observed in the diet of fish obtained from the intensely trawled areas[29]. Demersal fishing activities provide food for scavengers in the form of damaged animals which are left in the trawled / dredged track[30]. This means that the bottom trawling had augmented the removal of benthic population indirectly by improving the feeding condition of certain fishes by enhancing the abundance of small opportunistic benthic species such as polychaetes in the heavily trawled areas and presumably lead to the dietary changes of fish in the benthic ecosystem as postulated by early workers[31,32]. Intensive trawling might lead to changes in the benthic habitat resulting in the shift of fish communities[33]. The results revealed the short-term changes in macrobenthic community structure associated with bottom disturbance from bottom trawling. The ostensible variations observed in the infaunal population in the trawled areas demonstrate that incessant and prolonged bottom trawling activities in the inshore waters lead to the loss of biomass of infaunal organisms in the trawled grounds including changes in the habitat structure and biogeochemical exchanges between the sediment and water column affecting the suitability of the seabed as habitat for both adult and younger life stages of marine organisms. Considering the results obtained in the study, it is clear that bottom trawling alters seafloor habitat, reduces habitat complexity, may lead to increased predation on infaunal species and affect the total ecosystem productivity.

Acknowledgement

The financial assistance from Department of Ocean Development, New Delhi, is gratefully acknowledged.

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