J. Mar. Biol. Ass. India, **48** (1) : 51 - 55, January - June 2006

Impact of bottom trawling and its closure period on infaunal macrobenthic population along the inshore waters off Kerala (India)

Joice V. Thomas and B. Madhusoodana Kurup*

School of Industrial Fisheries, Cochin University of Science and Technology, Fine Arts Avenue, Cochin-682 016, India.
Email: madukurup@hotmail.com

Abstract

Effect of bottom trawling on the infaunal communities at depth ranging from 0-50m was studied by conducting experimental trawling operations along Cochin – Munambam area (Lat.9° 58' to 10° 10'and Long.76° 10'94 to 75° 56') in Kerala, southwest coast of India during December 2000 to November 2002. Perceptible variations were observed in the abundance (No/m^2), biomass (g/m^2) and diversity of the infaunal polychaetes while comparing the sediment samples collected before and after trawling. Polychaetes were exposed to the sediment surface due to bottom trawling and showed an increase in density in the samples collected immediately after trawling. However, their density showed a reduction with progressive trawling operations. Nevertheless, an increase in the density was discernible during the trawl ban period which indicates that ban on trawling provide great respite for their regeneration along Kerala coast.

Keywords: Impact of trawling, effect of trawl ban, Kerala

Introduction

Bottom trawling has been reported to be the most destructive type of fishing method prevalent in the world fishing sector that inflict drastic changes in the marine ecosystem by way of removal of fish and other benthic communities (De Groot, 1984; Bergman and Hup, 1992). During bottom trawling, large quantity of epifaunal and infaunal organisms are injured, removed and killed due to the passage of heavy otter boards and nets (Auster *et al.*, 1996).

Though many studies have been conducted globally in order to assess the long-term and short-term impacts of bottom trawling (Krost, 1990; Auster and Langton, 1999), no concerted attempt has been made to assess the impact along Indian waters. Thus a pioneering attempt was made in this direction with an aim to bring out the impact of bottom trawling on the infaunal populations in the inshore waters off southwest coast of India.

Materials and methods

The study was conducted along the Cochin and Munambam region (Long.76° 10'94 to 75° 56' and Lat.9° 58' to 10° 10'), Kerala, India (Fig.1). The experimental trawling was carried out with the help of a commercial trawler "Lowrence" of 45' OAL during December 2000 to November 2002 using a standard bottom trawl gear. 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 mid depth of the selected zones at 5,15,25,35 and 45 meters. The samples collected from these stations after trawling has been designated as A1, A2, A3.....A10. However, no stations could be treated as control in the study area as incessant commercial trawling operations were in vogue at all depth zones even in the shallow coastal waters demarcated for traditional fishing, in total violation of KMFRA (Kerala Marine Fisheries regulation Act) regulations.

Experimental bottom trawling was carried out at bi-monthly intervals giving uniform representation to pre monsoon, monsoon and post monsoon seasons. Trawling operations were also conducted during the fag end of trawl ban period (July) being imposed along the Kerala coast during southwest monsoon. Sediment samples from each station were collected in duplicate using a Van Veen grab of area 0.1 m^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 manoeuvered back to the station at the original position in the same depth zone where the samples had previously been collected with the help of the GPS within five minutes. The same protocol was repeated at all the ten stations within

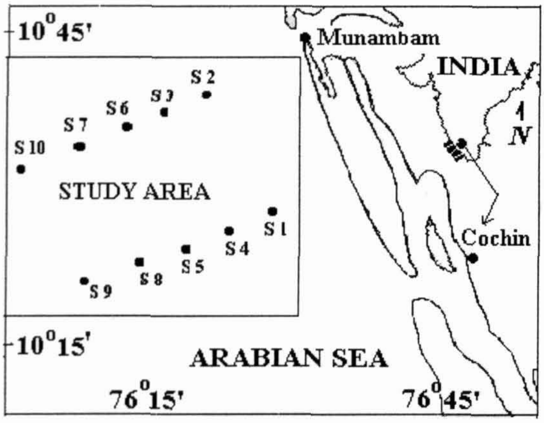

Fig. 1. Map showing study area

a span of five days in the sampling.

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 later identification. Polychaetes were identified following standard identification keys (Fauvel 1953; Day, 1967). Numerical abundance and wet weight were used as the units of faunal evaluation. Primer V5 was the statistical package used for calculating the diversity indices of macrofaunal polychaetes (Clarke and Warwick, 2001).

Results

Polychaetes emerged as the numerically dominant taxa in almost all stations and depths irrespective of seasons and this group was chosen to comprehend the impact of trawling on infauna. The other macro infaunal communities included Sipunculids, Amphipods, Nematodes, Penaeids, Gastropods and Bivalves. Polychaetes were represented by 80 genera and among these *Ancistrosyllis parva, Cossura costa, Prionospio pinnata , Sternaspis scutata, Lumbrineries latrieilli, Magelona cinta, Nepthys dibranchi* and *Glycera longipinnii* appeared as the common species which were found in abundance in sandy areas (40 m depth) when compared to silty and clayey regions (0-40m). Highest abundance and biomass was recorded during postmonsoon period followed by premonsoon and monsoon. However, a second peak was observed in July (Fig.2) during the trawl ban period during when *Ancistrosyllis parva, Cossura costa, Prionospio pinnata, Lumbrineries latrieilli, Magelona cinta* showed preponderance over these species.

The mean abundance of infaunal polychaetes recorded before and after trawling is indicated in Figure 3. Wide variations were found after trawling where the abundance was found increased in all seasons in the samples collected immediately after trawling. Figure 4 compares the variations of biomass (mean) recorded in the samples collected both before and after trawling. Dendrogram comparing abundance of polychaetes at the stations before and after trawling showed 85 % similarity in the samples collected from first five stations before trawling (Fig. 5). However, these stations showed lesser similarity (60%) immediately after trawling indicating broad difference in the polychaete abundance due to bottom trawling (Fig.5). Diversity indices based on the polychaete abundance carried out using Shannon's diversity index (H'), was in the range 1.04 - 1.56 before trawling, where the highest diversity was noticed at station 8 and the lowest at station 10. Immediately after trawling, the diversity (H') was found increased in majority of the stations, ranging between 1.00 and 1.67 and the highest value was noticed at station 7 and the lowest at station 9. 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 immediately after trawling when compared to that of variations observed before trawling (Fig.6). 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 and Sternapsis contributed much to the dissimilarity.

Discussion

The results of the present study clearly indicate that bottom trawling causes heavy disturbance and damage to

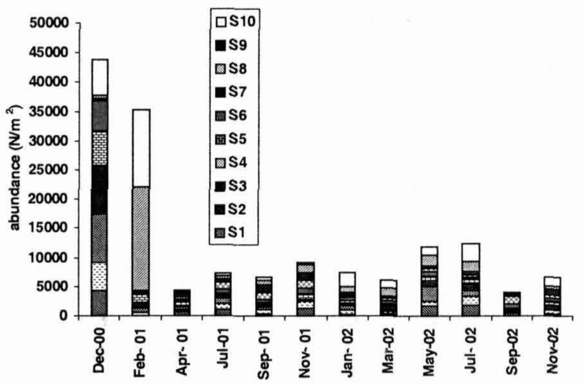

Fig.2. Mean density of polychates recorded at the study area before trawling during December 2000 to November 2002 (S1,S2,S3....S10 =stations)

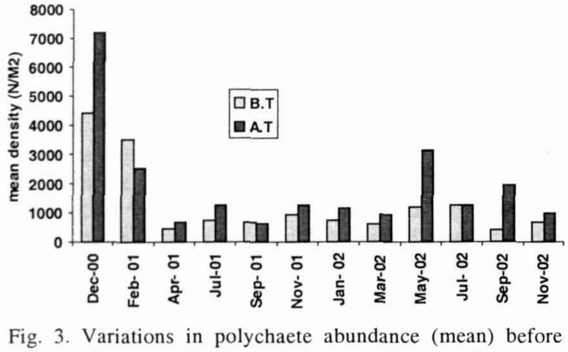

Fig. 3. Variations in polychaete abundance (mean) before and after trawling at the study area during December 2000 to November 2002 (B.T=Before trawling, A.T= After Trawling).

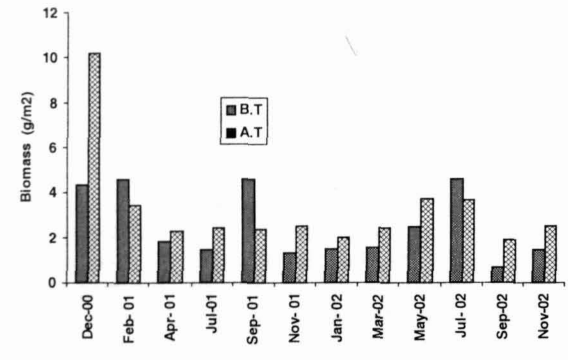

Fig.4. Variations in polychaete biomass (mean) before and after trawling at the study area during December 2000 to November 2002 (B.T=Before trawling, A.T= After Trawling).

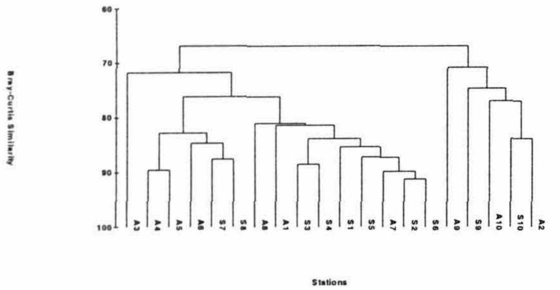

Fig.5 Similarity dendrogram of polychaete abundance before and after trawling at stations 1 to 10 (S1,S2,S3...S10 = Before trawling, A1, A2,A3...A10 = After trawling)

the infaunal macrobenthic population by way of crushing and exposing them from their natural habitat. Polychaetes were used as bioindicaters to evaluate the impact of bottom trawling since they represent the mainstay in the infaunal community throughout the year. Environmental

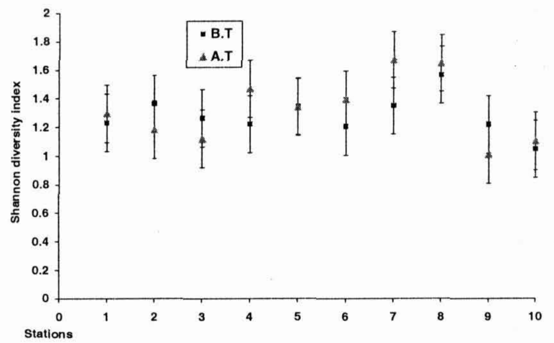

Fig.6 Shannon diversity (Mean abundance) of polychaetes before and after trawling at stations 1 to 10 during December 2000 to November 2002 (B.T=Before trawling, A.T= After Trawling)

parameters and sediment stability have major roles in the existence and abundance of the macrobenthos (Rachor, 1990). Among these, sediment grain size and water movements are the most important (Mohamed, 1955). High abundance of polychaetes observed in the sandy stations explicitly indicates that polychaetes prefer more sandy areas and fully confirms with Harkantra *et al.* (1982).

In the present study, the abundance, biomass and diversity of the polychaetes were found to be increased in the samples collected immediately after trawling. This increase may be attributed to their exposure due to the removal of top sediment layer, associated with the settlement of dispersed organisms after trawling, which is in strong conformity with that of Bergman and Hup (1992). The distribution and removal of the top layer of the sediments lifts the epifaunal communities to the water column and also lead to the exposure of animals, which live inside the sediments (Messiah *et al.*, 1991). Chicharo *et al.* (2000) also reported similar increase in abundance and diversity of polychaetes in the dredge tracks off the coast of south Portugal. Most of the polychaete communities were juveniles that manifest extreme disturbance on the sediment and this observation corroborates with Sainsbury (1988). It is inferred that these organisms do not get an opportunity to grow into adult because of the continuous trawling disturbance caused to the bottom and are therefore destined to be in the juvenile stage.

Dendrogram showed distinct clusters of high similarity in the polychaete population collected before trawling at the same depth zone. However, while comparing the stations after trawling, no such similarity could be observed, thus clearly manifesting the variations seen in polychaete abundance. These results are strong indication of disturbance caused to the benthic ecosystem due to bottom trawling. The availability of benthic population have a direct relationship with demersal fishery potential since they form an important food resource for crabs and fishes (Varshney *et al.*, 1988). The exposure of polychaetes after trawling operations may lead to the alteration of these important links in the food chain thus eventually leading to disruption of trophic relationship. Bottom trawling causes shift in benthic communities by removing the epifaunal and infaunal organisms thus subjecting the exposed organisms to heavy and easy predation and dispersion of light infaunal organisms along with the sediment clouds formed during trawling (Ramsay *et al.*, 1998). The high abundance of polychaetes observed immediately after trawling in the present study also indicates that more and more infaunal species succumb to easy predation by fishes, other marine invertebrates and scavengers due to their exposure to the sediment surface (Ball *et al.*, 2000; Kutti, 2002). Penetration of otter boards into the sediment was attributed as the major reason for the decrease or increase of the infaunal communities (Lindboom and De Groot, 1998; Bergman and Santbrink, 2000) an observation, which showed strong agreement with the present findings. A reduction in the polychaetes abundance was observed during the second year when compared to first year. It can therefore be inferred that the reduction might be due to the destruction and removal of these fragile organisms due to predation while these are getting exposed during trawling and this type of progressive reduction may destabilize the fishing pattern of the coastal waters.

In the present study, highest abundance of infaunal communities was recorded during postmonsoon period followed by premonsoon and monsoon showing a very strong agreement with the earlier findings (Harkantra and Parulekar, 1994). The abundance of polychaetes during postmonsoon session may be due to the reproduction and recruitment as reported by Sunil Kumar (1993). However, a second peak was observed during June-July, which synchronize with the trawl ban period imposed along Kerala coast. Among polychaetes, fast growing and continuous breeding species such as *Lumbrineries*, *Cossura*, *Magelona*, *Heteromastus* and *Diopatra* were predominated as major species during this period. It would thus appear that the polychaetes might have got an opportunity for their recoupment and regeneration, as the sea bottom is totally free from any sort of perturbations from bottom trawling operations during these months. The results of this present study show that the closure period for bottom trawlers are very much useful in the partial recovery of macrofauna which plays an important role in the benthic food chain, thus providing great respite for their recoupment and regeneration. On the contrary, heavy plummets of infaunal communities observed during September-May may be due to heavy trawl fishing impacts due the spectacular increase in the trawl fishing pressure observed in the study area. (Kurup *et al.*, 2004).

Based on the present study, it can be concluded that bottom trawling causes abrupt variations in the abundance, biomass and diversity of infaunal communities immediately after trawling. It is also postulated that regulated bottom trawl fishing would give great respite to the sea bottom improving the sustainability of demersal fish stock by mounting the benthic productivity. It also points to the fact that the ban on trawling during monsoon months helps to conserve the benthic ecosystems by way of providing serene environment for the recovery of infaunal communities besides saving the young ones and juveniles of fin and shellfishes. Based on the results of the present study it can be concluded that the production and sustainability of demersal fishery off Kerala can be improved only by imposing strong regulation on the bottom trawl fishing effort and casting the closure period of bottom trawling from the present 45 days to 65 days.

Acknowledgements

The authors express their gratitude to the Director, School of Industrial Fisheries, Cochin University of Science and Technology for providing the necessary facilities. Thanks are also due to crew of fishing vessel "Lawrence" for the valuable help rendered during the experimental trawling operations. The financial assistance from Department of Ocean Development, New Delhi, is gratefully acknowledged

References

Auster, P.J. and R. W. Langton. 1999. The effects of fishing on fish habitat. *In:* Benaka, L. R (Ed.) *Fish habitats: essential fish habitat and rehabilitation.* Published by American Fisheries Society, Bethesda, M. D. 22: 150-187

————, R.J. Malatesta, R.W. Langton, L Watling, P.C. Valentine, C.L.S. Donaldson, E. W. Langton, A.N. Shepard, and I.G. Babb. 1996. The impacts of mobile fishing gear on seafloor habitats in the Gulf of Maine (Northwest Atlantic): Implications for conservation of fish populations. Reviews in *Fish. Sci.*, 4: 185-202.

Ball, B.J., G. Fox, and B.W. Munday. 2000. Long and short- term consequences of a *Nephrops* trawl fishery on the benthos and environment of the Irish Sea. *ICES J. Mar. Sci.*, 57: 1315-1320.

Bergman, M.J.N. and M. Hup. 1992. Direct effects of beam trawling on macrofauna in sandy sediment in the southern North Sea. *ibid,* 49(1): 5-11.

——— and J.W. van Santbrink. 2000. Mortality in megafaunal benthic populations caused by trawl fisheries on the Dutch continental shelf in the North Sea in 1994. *ibid*, 57: 1321-1331

Chicharo, L.M., M.A. Chicharo, F. Alves, and J. Regala. 2000. Ecological analysis of dredge impact on the south of Portugal. Ecodredge Project (FAIR PL – 4465) Interim report. 39pp.

Clarke, K.R. and R.M. Warwick. 2001. Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. Primer-E: Plymouth. 91pp.

Day, J.H. 1967. A Monograph on the Polychaeta of Southern Africa. Trustees of British Museum (Natural History) London. 374 pp.

De Groot, S.J. 1984. The impact of bottom trawling on benthic fauna of the North Sea. *Ocean Management*, 9: 177-190.

Fauvel, P. 1953. The fauna of India including Pakistan, Ceylon, Burma and Malaya. Indian Press, Ltd, Allahabad. 507pp.

Harkantra, S.N. and A.H. Parulekar. 1994. Soft sediment dwelling macro-invertebrates of Rajapur Bay, central west coast of India. *Indian J. mar. Sci.*, 23: 31-34.

———, C.L. Rodrigues, and A.H. Parulekar. 1982. Macrobenthos of the shelf off north eastern bay of Bengal. *ibid*, 11: 115-121.

Krost, P. 1990. The impact of otter trawl fishery on nutrient release from the sediment and macrofauna of Keiler Bucht (Western Baltic). Berichte aus dem Institut fur Meereskunde an der Christian- Albrechts-Universitat, *In*: Kiel. Nr..Kruskal, J.B. and M. Wish (Eds.) *Multidimensional scaling*. Published by Sage Publications, Beverly Hills, California. 200: 157pp.

Kurup, B. M., C. Sreedevi and Joice V. Thomas. 2004. Immediate effect of trawling on sea bottom and its living communities along the Kerala coast. *In*: Pandian T. J. (Ed.) *Proceedings of Ocean Life food and Medicine Expo. International conference and exposition on marine living resources of India for food and medicine*. p.142-163.

Kutti, T. 2002. Analyses of the immediate effects of experimental otter trawling on the benthic assemblage of Bear Island (Fishery Protection Zone) Barents Sea. Thesis submitted to the University of Bergen. 63pp.

Lindeboom, H.J. and de Groot, S.J.1998. (eds). The effects of different types of fisheries on the North Sea and Irish Sea benthic Ecosystems.NIOZ Report 1998-1.RIVO-DLO Report C003 98. Netherlands Institute of Sea Research, Den Burg, Texel, The Netherlands. 404 pp.

Messieh, S.N., T.W. Rowell, D.L. Peer and P.J Cranford. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. *Cont. Shelf Res.*, 11: 1237-1263.

Mohammed, S.Z. 1955. Observations on the benthic macrofauna of the soft sediment on western side of the Arabian Sea Gulf (ROPME se area) with respect to 1991 gulf war oil spill. *Indian J. mar. Sci.*, 24: 147-152.

Rachor, E. 1990. Changes in sublittoral zoobenthos in the German Bight with regard to eutrophication. *Netherlands J. Sea Res.*, 25(1/2): 209-214.

Ramsay, K., M.J. Kaiser and R.N. Hughes. 1998. The responses of benthic scavengers to fishing disturbance by towed gears in different habitats. *J. Expe. Mar. Biol. Ecol.*, *224*: 73-89.

Sainsbury, K.J. 1988. The ecological basis of multi-species fisheries and management of a demersal fishery in tropical Australia. *In:* Gulland J.A. (Ed.) *Fish Population Dynamics* John Wiley, London. p.349-382.

Sunil Kumar, R. 1993. Studies on the benthic fauna of the mangrove swamps of Cochin area. *PhD. Thesis* submitted to the Cochin University of Science and Technology, Cochin, Kerala. 137pp.

Varshney, P.K., K. Govindan, U.D. Gaikwad and B.N. Desai. 1988. Macrobenthos off Versova (Bombay), west coast of India, in relation to environmental conditions. *Indian J. mar. Sci.*, 17: 222-227.

Accepted: 12 June 2006