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Technical Notes

IMMEDIATE EFFECT OF TRAWLING ON SEA BOTTOM & ITS LIVING COMMUNITIES ALONG KERALA COAST

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Introduction

Otter trawling, the most widely used towed bottom fishing gear, is known to have a wide range of impact on benthos. Seabed disturbance by mobile bottom fishing gear has emerged as a major concern related to the conservation of essential fish habitat (DeAlteris *et al.,* 1999). Several studies have been conducted on the impact of trawling on sea bottom and its living communities (Walting and Norse 1999,Churchill, 1989, Gibbs *et al*., 1980), however no concerted attempt has so far been made to assess its real impact on the sea bottom ecology along Indian coast. Trawl fishing with more than 5000 units, is the most widespread method of capturing marine fishes and invertebrates in Kerala, the southernmost state of India with a coastline of 590 Km (Raveendran, 2001). Menon (1996) reported that incessant trawling operations in a climatically limited coastal habitat slowly resulted in disproportionate destruction of non – target groups too along with juveniles /sub adults of homogeneous species of commercially important fishes and shell fishes and a wide spectrum of benthic organisms. Benthos representing the secondary level of the benthic productivity forms the major food resource of demersal fishery resources represented by prawns, bottom dwelling fishes and other marine invertebrates thereby serving as an inevitable link in the benthic food chain (Mohammed, 1955). Benthic animals also have a role in releasing nutrients back into the water column and aid in the stability of sediments. The distribution of macrofaunal species on the sea bottom is closely related to salinity, water movement, sediment grain size and organic content of the sediment (Duineveld *et al*., 1991). Availability of benthos at a region can be an indicator of demersal fishery potential since they form an important food reserve for crabs and fishes (Varshney *et al*., 1988). This paper deals with the results of the experimental bottom trawling conducted along the Cochin coast with a view to bring out the extent to which trawling operations are responsible in altering the physico-chemical parameters of the soil, water and the living communities of the sea bottom.

Materials and methods

Experimental trawling was conducted along Cochin –Munambam area (Long. 75º 56’00 to 76º10’ 94” and lat. 9º58’ to $10^0$10’) in the south west coast of India (Fig: 1) at depth ranging from 0-50m during December 2000- November 2002. Bottom trawling operations were carried out at predetermined depth zones such as 0-10, 10-20,20-30,30-40 and 40-50m using a 39 m statutory trawl net of 35mm cod end with the help of a commercial trawler of 30-40ft OAL. Trawling was conducted for one hour during daytime starting from 8 am to 6 pm in all stations. The physical and chemical parameters of water observed were temperature, salinity, dissolved oxygen turbidity, pH, nitrite nitrogen and inorganic phosphate, both before and after trawling operations conducted at selected depth zones. Bottom water was collected from sites using horizontal water sampler (Hydro Bios, West Germany). Salinity was determined following Knudsen’s method, dissolved oxygen was determined using standard Winkler’s method, and pH was measured using pH meter, temperature by a mercuric thermometer and turbidity by Nephaloturbidity meter. Nitrite and phosphate concentrations were estimated following standard procedures (Grasshoff, 1983). Pipette analysis (Carver, 1971) was performed to understand the texture of sediment while the sediment organic matter was analysed using El Wakeel and Riley (1959). Macro and meiofauna were sorted and analysed using Holme and McIntyre (1975). ANOVA was performed to establish the level of significance of the data followed by t test, both before and after trawling.

Results & Discussion

The physico-chemical parameters like temperature, salinity, pH and dissolved oxygen play vital roles in the high production of pelagic fishes and other living organisms (Suresh *et al*., 1978). Lower temperature was recorded during July and August at Cochin harbour (Ramamirtham and Jayaraman, 1963). Ramesh Babu *et al.* (1980) also pointed out the lowering of salinity (< 34 ‰) in the coastal waters of Kerala under the influence of summer monsoon.

A slight decrease of pH values was registered in monsoon months. Rivonker *et al.* (1990) also pointed out trifle variation in pH during their study conducted along the west coast of India. Jayaraman *et al*. (1959) registered the distribution of dissolved oxygen at surface and sub surface layers upto 50 meters and were of the opinion that there exists more or less uniform oxygen content in the coastal waters of Kerala. In general, inshore waters were well aerated during major part of the year except during the southwest monsoon season.

Turbidity showed inverse relationship to oxygen throughout the stations. High turbidity values were noticed during monsoon, which could be the result of increased river and land run off and the churning action of the sea. Highly turbid waters were noticed at the near shore waters, which may be due to the rise of clayey soil by the action of currents and waves as well as the river flow into the sea.

Nutrients are essential to life in the sea and among them nitrogen and phosphorus are the most important elements (Tyrrell, 1999; Naqvi and Jayakumar, 2000). The distribution of nitrite-nitrogen and phosphate phosphorus observed in the present study strongly agrees to that in the previous studies conducted in the Kerala waters (Damodaran, 1973; De Sousa *et al.*, 1996). Distinct seasonal variations were noticed with high nitrite and phosphate concentrations in the monsoon period while postmonsoon and premonsoon periods showed comparatively lower values. Subramanyan (1958) recorded high nitrite and phosphate during southwest monsoon in Kerala coast. The depletion of nutrients in the closing stages of postmonsoon period can be attributed to the planktonic productivity as reported by Sankaranarayanan and Qasim (1969). Damodaran (1973) recorded the surface phosphate phosphorus in the range 0.03 - 3.37 μ ML^{-1} and between 0.03 and 5.39 μ ML^{-1} at the bottom. In the present study, the surface and bottom phosphate concentrations ranged between 0.02 - 3.44 and 0.04 - 5.83 μ ML^{-1} respectively which strongly corroborate to his findings. Nitrite-nitrogen recorded in bottom waters showed lesser values than that of phosphate phosphorus recorded at the study area, ranging from 0.01 - 3.9 μ ML^{-1} in the samples collected before trawling which also agrees to the earlier findings of Rivonker *et al*. (1990) and Lakshmanan *et al.* (1987). Rittenberg *et a*l. (1955) opined that in marine condition, the major source of nutrients is the run - off from terrestrial environs. High phosphate and nitrite concentrations observed in the near shore waters in the present study also agree to this.

The results of the natural sediment structure computed from the study area before trawling were corroborated to the earlier reports (Bhosle *et al.*, 1978; Hashimi *et al.*, 1978). In the present study, the distribution of sediments were in the silty clay/ clayey silt range up to the 30 m depth and silty/ clayey sand between 30-40 m however, it turned into sandy above 40 metres depth. Seasonal variations of organic matter reported in the present study also agree with the previous studies (Nair and Balchand, 1992). The high organic matter observed during the postmonsoon and monsoon months are due to the heavy river runoff and surface productivity as reported by Subrahmanyan and Sarma (1965).

Towed gears in contact with the seabed will disturb it physically and cause resuspension of fine particles and relocation of stones and boulders (Gislason, 1995). Of the five major physico– chemical parameters studied, both dissolved oxygen and turbidity showed wide variations in the trawled grounds when compared to the samples collected before trawling. Salinity, temperature and pH did not exhibit any noticeable changes due to bottom trawling while dissolved oxygen concentration was found reduced after trawling. During bottom trawling trawl net scrape the sea bottom leading to the rise of sediments of few centimeters to the water column (De Groot, 1984; Redant, 1987). Trawling pressure is more in the months of August and September in the inshore waters (<100 meters). Besides the low dissolved oxygen concentration during monsoon, intense trawling operations during this period may create a persistent hypoxic condition in water, which may destroy the eggs, larvae and juveniles of fish and other living organisms as discussed by Morgan *et al*. (1983) and Newcombe and MacDonald (1991). Oxygen level decreased significantly after dredging / trawling probably because of mixing of reduced products such as methane and hydrogen sulphide and/ or because the resuspended particulate material like bacteria attached to sediments exerting an increase in oxygen demand in the water column (Riemann and Hoffmann, 1991). Dredging and trawling causes high oxygen demand that has the potential to form a barrier which may hamper the movement of migratory fishes (Eliott *et al.*, 1988).

Trawling on muddy grounds generate heavy sediment clouds in the water column (Ganz, 1980; Main and Sangster, 1981). High turbidity values recorded immediately after trawling in the present study also agree to this. Churchill *et al*., (1994) also discussed the adverse effect on shellfish and other benthic organisms due to the rise of turbidity plumes during trawling. In the present study average four - fold increase of turbidity was noticed after trawling. Turbidity of bottom water nutrients at bottom waters was reported to be increasing during dredging in Cochin harbour (Thressiamma *et al.,* 1998). They also reported a two – three fold increase in the phosphate phosphorus and nitrite concentrations immediately after the dredging at the Cochin port. In the present study almost all stations showed steep increase in turbidity after trawling. The incessant bottom trawling during the monsoon season, and the upwelling periods in southwest coast of India by all means poses a threat to the growth of marine animals.

Nitrite-nitrogen and phosphate phosphorus recorded in the samples collected after trawling was conspicuously high when compared with that of samples collected before trawling. German researchers noted significant remobilization of nutrients from pore water as a result of disturbance to surface sediment layers (ICES, 1989). During dragging along the bottom, the churning action of otter boards and heavy trawl net raise the sediments into the water column along with nutrients and minerals (de Groot, 1984). Gislason (1995) stated that the bottom trawling cause physical disturbance and resuspension of sediments as well as increase the exchange of nutrients and pollutants between the sediment and the water column. The high concentration of nutrients observed in the present study, immediately after trawling also points to the same fact. The nitrite has showed average of two – three fold increase in the after trawling samples; whereas phosphate recorded average four fold increase in values as observed by Reimann and Hoffmann (1991).The more perceptible variations in the phosphate concentrations recorded after trawling than that of nitrites also strengthens the view that the phosphate content is more at the sea bottom than nitrite especially in the coastal waters (Qasim 1977).

Rasheed (1997) noticed an increase of nutrients in the surface waters due to the dredging activities in the Cochin port. The results of the present study also highlights the heavy transport of the nutrients into the water column due to bottom trawling. Bottom trawling directly affect physical properties of sea floor by increasing turbulence and by altering grain size distribution, sediment porosity and chemical exchange process (McConnaughey *et al.*, 2000). Various observations have revealed that turbulence in the wake of trawl doors and big nets often generate large and highly turbid clouds of suspended sediments (Main and Sangster, 1981; Wardle, 1983 ; Churchill, 1989). Bottom trawling causes abnormally high nutrients levels in the ocean by stirring up the sediments and this could increase noxious phytoplankton production notorious for the mass fish kills and shift the balance of plankton populations which would in turn could shift the balance of the fish and other marine life that feed on them as reported by Collie (2000); Gordon *et al*. (1998) and Rogers *et al*., (1998). Morrison *et al*. (1998) noticed the high algal production at the coastal upwelling zone due to the heavy nutrient concentration. Messiah *et al*. (1991) opined the possible effect of a sudden release of nutrients or contaminants from sediments due to trawling. Heavy nutrients observed in the bottom waters in the present study reveals the significant disturbance occurring at the sea bottom due to trawling.

Though the nutrients may increase the productivity of water column the possible rise of lethal gases such as ammonia, methane and hydrogen sulphide will adversely affect the living organisms in water (Churchill *et al*., 1988). Abnormal bloom formation due to the presence of nutrients and minerals at the surface would deplete dissolved oxygen (De' Sousa and Singbal, 1986).

Bottom trawling causes severe damage to the upper sediment layers. Sediments are dispersed off into the subsurface water column due to the scrapping of heavy otter boards and nets (Messiah *et al*., 1991). In the present observation, sand and silt fractions were found to be increasing in the trawled grounds after trawling. This may be due to the quicker settlement of the heavier sand and silt particles when compared to the lighter clay particles. The latter on the other hand, showed drastic decline at the trawled grounds. It can be surmised that clay fractions being lighter, gets removed from the sediment due to the dispersion along with the current created in the wake of passage of nets. The predominance in silt proportion after trawling at the stations 1 – 6, where sand proportion was minimal, clearly depict the loss of clay content during trawling. Moreover, wide changes occurred in the percentage distribution of sediments at stations 4, 5 and 6 where the pattern of sediment changed from silty clay to clayey silt after trawling, manifesting a severe loss of clay fraction during trawling. The increased sand, silt concentrations and subsequent decrease in clay content in the samples collected after trawling are attributed to resuspension as opined by Shelton and Rolfe (1972); Caddy (1973) and Langton and Robinson (1990). Rapid resettling of the heavier particles also has a major role in the coarsening of sediments, with the finer fraction remaining suspended for some time. The incessant perturbations on the substratum may leave the seabed in an altered condition (Eleftheriou and Robertson, 1992; Black and Parry, 1994) with permanent sediment clouds in the water column as noticed by Schwinghamer *et al*. (1996) and Currie and Parry (1996).

Many studies conducted in the west and east coasts of India especially along the shelf waters reported the dominance of polychaetes in the infaunal macrofauna (Damodaran 1973; Harkantra *et al.*, 1982). Parulekar and Ansari (1981) also reported that polychaetes were the most important group (70%) in the macrobenthic assemblage in the Andaman Sea. In the present observations, high abundance of polychaete were noticed at the sandy stations, which also corroborate to the findings of Harkantra (1982) and Sunil Kumar (1995). Bottom layers of sand with a mixture of silt or clay form ideal substrates for polychaete and bivalves (Parulekar and Wagh, 1975). In the present study, highest abundance and biomass was recorded during post monsoon period followed by premonsoon and monsoon. Harkantra and Parulekar (1994) reported the replenishment of benthic fauna with high species diversity after southwest monsoon. The present findings show very strong agreement with the above view. However, a second peak was observed in July, during the trawl ban period along the Kerala coast imposed by the Govt. of Kerala. It appears that the polychaetes get an opportunity for their recoupement and regeneration as the sea bottom is totally free from any sort of disturbance due to the imposition of ban for bottom trawlers.

During the study, the number and biomass of the polychaetes were found increased in the samples collected immediately after trawling. This increase in abundance may be attributed to their exposure due to the removal of top sediment layer associated with the settlement of dispersed organisms after trawling. Polychaetes showed high abundance after beam trawling in an experiment conducted by Bergman and Hup (1992). Most of the polychaetes observed throughout this study were small in size and this was due to the fact that communities become dominated by juvenile stages where extensive and repeated fishing disturbance are prevalent (Sainsbury 1988; Eleftheriou and Robertson,1992). These organisms do not get the opportunity to grow into larger size because of the continuous trawling disturbance at the bottom.

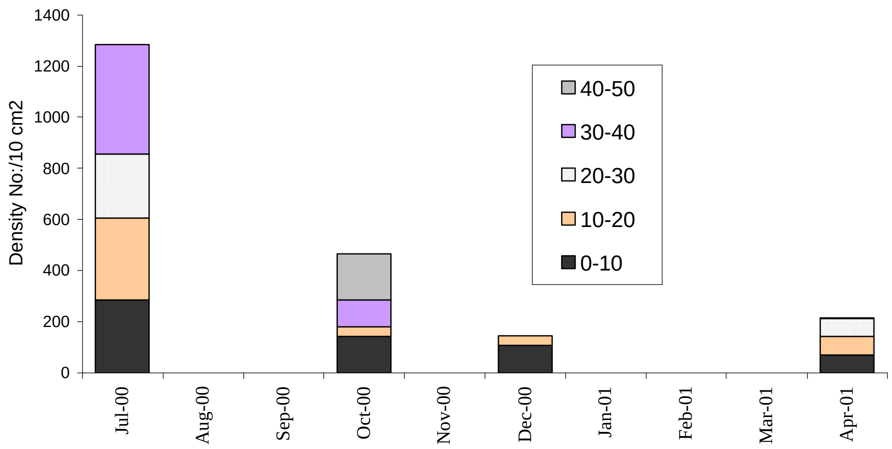

Fig. Pattern of variations in polychaetes in different depth zones along Cochin- Munumbam area during Dec-2000 April 2001

Nematodes have been found to be among the most dominant groups in the composition of meiofauna in various studies of meiofaunal distribution (Heip *et al* 1990; Bell and Sherman 1980; Harkantra and Parulekar, 1989). Particulate organic matter serves as food source for many meiobenthic organisms (Coull, 1973). More nematodes were found in the inshore regions characterised by silty nature of sediment which can be corroborated to the studies of Harkantra and Parulekar, 1989 and Desai and Krishnankutty, 1967. The premonsoon and monsoon months harbored more nematodes, while post monsoon seasons manifest a decline in abundance, during the successive years of study. Thus it can be inferred that there is destruction of meiofauna throughout the post monsoon season, which can be attributed to the lift of monsoon ban on trawling during this season. On the other hand, studies on the meiofauna of this region indicate that postmonsoon is the phase of proliferation of these organisms (Damodaran, 1973; SunithaRao and RamaSarma, 1990).

During bottom trawling, the trawl net and otter boards penetrate the top few centimeters of the sediment layer (Caddy 1973), exposing the fauna immediately below it leading to an increase in the after trawling samples. Thus there is a progressive reduction in the nematode abundance during each sweep of the trawl gear, and several studies have come out with the conclusion that the mobile fishing gear can cause reduction in abundance of some fragile infaunal species (Bergman and Hup, 1992). Most of the nematodes are found at depths 0-10 cm, (Damodaran, 1973) and thus are well within the reach of the trawl gear. Thus bottom trawling perturbs the benthic environment by displacing the nematodes from its natural niche and altering the habitat characteristics. Though their reproductive abilities are high, their recolonisation is gradual but steady process.

In summary, bottom trawling had a strong and immediate impact on the marine milieu. Variations in the major physico-chemical parameters due to human intervention in the form of bottom trawling activities are highly deleterious so as to inflict irreparable perturbations in the marine ecosystem. Considering the results obtained in the study, it is clear that bottom trawling alter seafloor habitat, reduce habitat complexity, and may lead to increased predation on infaunal species which affect stability of the ecosystem as a whole.