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Impact of Bottom Trawling on Sediment Texture and Organic Matter Along Inshore Waters of Kerala (South India)

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Sediment texture and organic matter were analysed before and after trawling in samples collected from 0-50 m depth zone during December 2000-November 2001, along Kerala coast (Long. 75° 56'00 to 76°10' and Lat. 9°58' to 10°10'). Up to 40 m depth the composition of sand, silt and clay were 0.19 – 15.8%, 35.33 –60.53% and 29.9 – 53.12% respectively. Beyond this, sand was dominant (sand 32.6 – 96.15, silt 1.8 – 33.8, clay 2.45- 26.48%). In samples collected before trawling, sand, silt and clay ranged from 4.76 - 87, 45.85-55.71 and 43.18 – 47.38% respectively. In the samples collected after trawling the corresponding values for sand, silt and clay were 21.25 – 35.7, 51.28 – 63.92 and 13.03 – 21.6% respectively. Organic carbon in 0-30 m depth zone ranged from 0.229 - 7.68% and it showed highest variations in July especially at depths 0-10 m and 10-20 m with respective values of 4.45 and 4.75% before trawling; while in the after trawling samples it was reduced to 2.21% and 1.90% respectively. The sand and silt fractions showed a significant increase whereas a drastic reduction in clay fraction was observed especially in 0- 40 m depth zone due to bottom trawling.

Key words : Effect of trawling, organic matter, sediment texture

Sea bottom plays an important role in the marine ecosystem as it provides shelter to the bottom dwelling organisms and augments the productivity by fertilizing the overlying seawater. Wide spread interest was shown in the ecological effects of current fishing practices and its deleterious impacts on sea floor ecology (De Groot, 1984; Messieh *et al.*, 1991; Auster *et al.*, 1996). Although there has been attempts in the past to evaluate the impact of bottom trawling to the benthic ecosystem (Auster *et al.*,1995; Bergman and Hup,1992; Graham, 1995; Bridger, 1970; Watling *et.al.*, 2001), not much efforts have been taken to delineate the impact of intensive fishing on the sea bottom sediments and its related biogeochemical cycles barring the studies of Churchill (1989), and Mayer *et al.*, (1991). Against this background, a study was conducted in order to assess the likely impacts of bottom trawling on sediments structure along coastal waters of Kochi, South India.

Materials and Methods

Bottom trawling was conducted during December 2000-November 2001on a bi-monthly basis along Cochin–Munambam area (Long. 75° 56'00 to 76°10' and Lat. 9°58' to 10°10'), Kerala, at 0-50m. The study area (Fig.1) was divided in to five depth zones viz. 10 m, 10-20 m, 20-30 m, 30-40 m, 40-50 m and two stations each from each depth were selected with the help of a GPS in a linear manner with a distance of about 5 km between stations of same contour. Mud samples were collected before and after trawling from each station. Sampling was done using a Van Veen grab of 1 m^2 Mud samples for analyzing organic matter were collected in the polyethylene bags from the top layer of the grab sample. A portion of the thoroughly mixed grab sample was also taken for analyzing the sediment pattern. Sediment texture was analyzed using Pipette analysis (Carver, 1972) and Organic carbon/

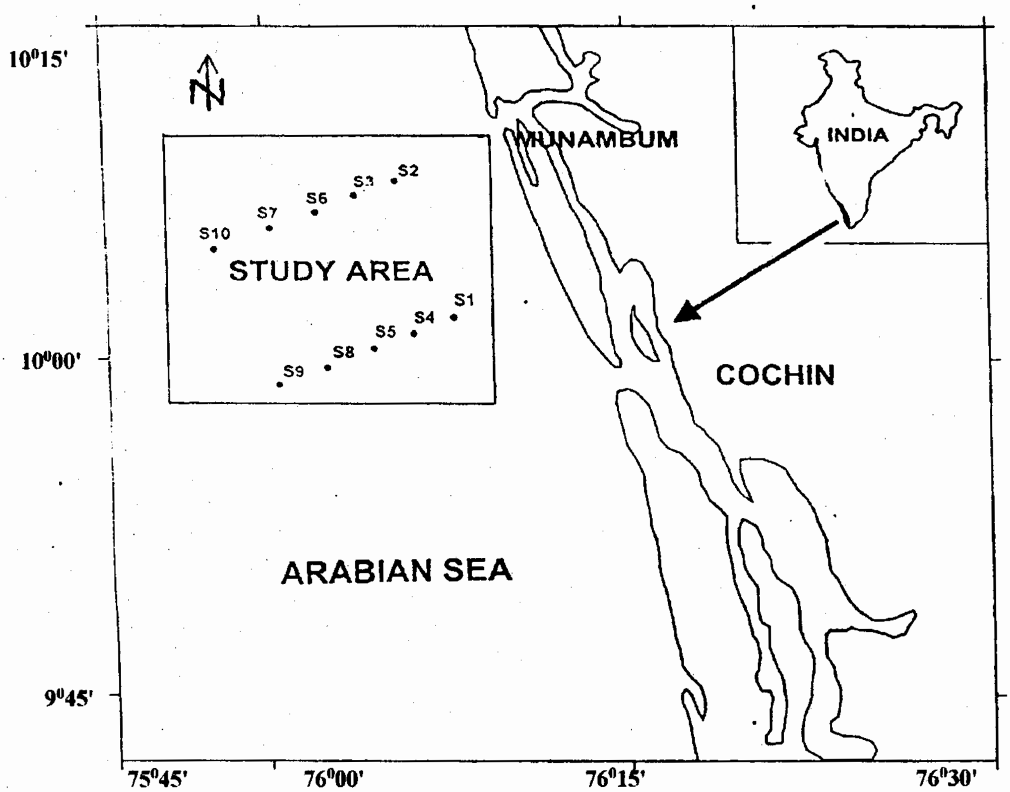

Fig. 1. Location map of the study area

matter was calculated following El Wakeel and Riley (1959).

Results and Discussion

The sediment texture of various depth zones before trawling is shown in Fig.2. The nature of the sediments up to the 30 m depth (stations 1-4) was clayey silt with, silt 49.19%, clay 41.89% and sand 8.13%. The 30-40 m depth zone (stations 4-8) was invariably appeared clayey silt with high silt (48.36%) and clay (39.25%) fractions followed by very low fraction of sand (12.43%). In contrast, unusually high fraction of sand was seen during September and November with 86.6 and 82.88% respectively. Interestingly, the 40-50 m depth zone appeared as sandy with sand content as high as 78.36%, followed by silt (11.34%) and clay (10.35%) which were found in minimal quantities.

In samples collected after trawling (Fig.3), a perceptible increase in sand and silt fractions was observed with a corresponding decrease in clay fraction. The highest variation of sediment texture was observed during

Table 1. Average values of sand, silt and clay, and organic matter before and after trawling

Depth Zones	Sand %(BT)	Sand %(AT)	Silt %(BT)	Silt %(AT)	Clay %(BT)	Clay %(AT)	Organic Matter %(BT)	Organic Matter %(AT)
0-10 m	5.27	10.02	54.82	61.91	39.8	27.08	4.37	3.56
10-20 m	7.47	11.70	49.74	53.58	42.79	34.36	5.10	3.48
20-30 m	5.66	14.31	52.04	52.4	42.17	33.28	4.81	3.89
30-40 m	36.45	40.31	34.87	38.59	28.33	21.09	4.10	3.77
40-50 m	59.82	61.52	25.91	29.74	14.03	9.32	3.73	3.39

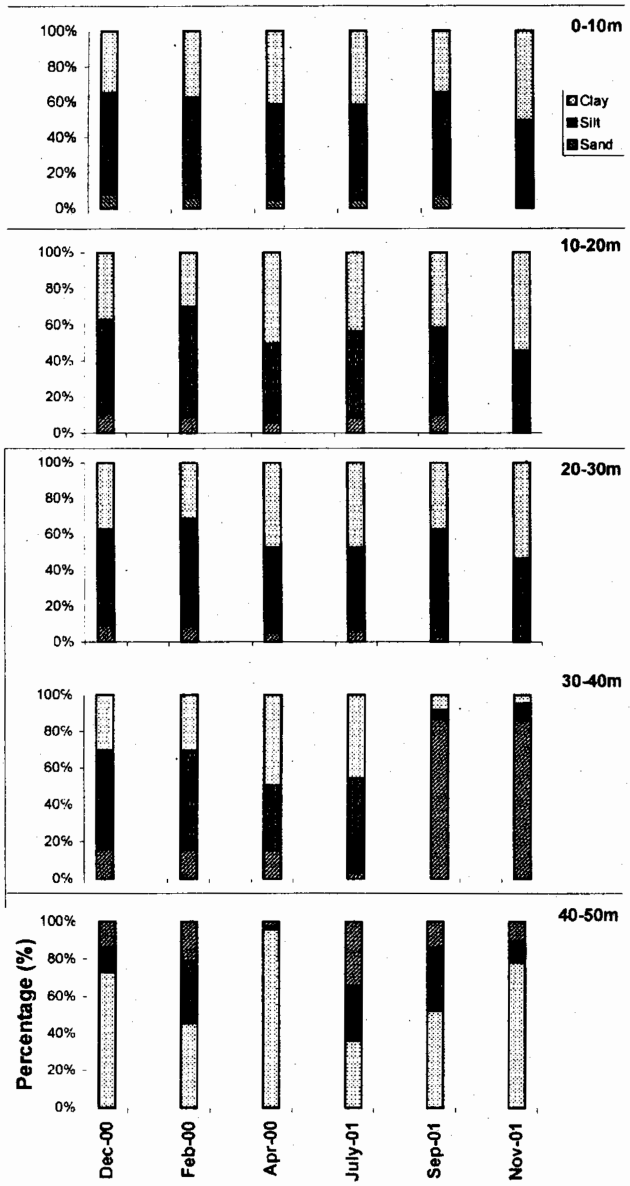

Fig. 2. Variations in sediment pattern before trawling in the study area during December 2000 to November 2001

July 2001 in 0-30 m depth zones, which coincided with the monsoon, where average sand, silt and clay fractions in the pre trawling samples were in the order of 6.78,45.85 and 47.37% (clayey silt). While in the samples collected after trawling, the values of sand, silt and clay were 26.38, 57.5 and 16.12% (sandy silt) respectively. However in 30-40 m depth zone, utmost variation in sediment texture was recorded in April where the sediment texture was altered by bottom trawling from silty clay (Mean: sand 15.21, silt 35.33 and clay 49.37%) before trawling to sandy silty clay (Mean: sand 37.58, silt 35.24 and clay, 27.09%) after trawling. Even though the textural properties of sediments in the 40-50 m depth zone remained sandy before and after trawling, a glaring increase in sand and silt fractions and a corresponding decrease in clay fraction was observed in the samples collected after trawling. At this depth, highest variation was recorded in November, where sand, silt and clay fractions were 78.36, 11.34, and 10.38% (sandy clay) before trawling whereas the percentage composition in the samples collected after trawling were 86.00, 11.62 and 2.5% (sandy) respectively.

The organic matter ranged from 0.22 to 7.76% before trawling. The organic matter values however decreased after trawling

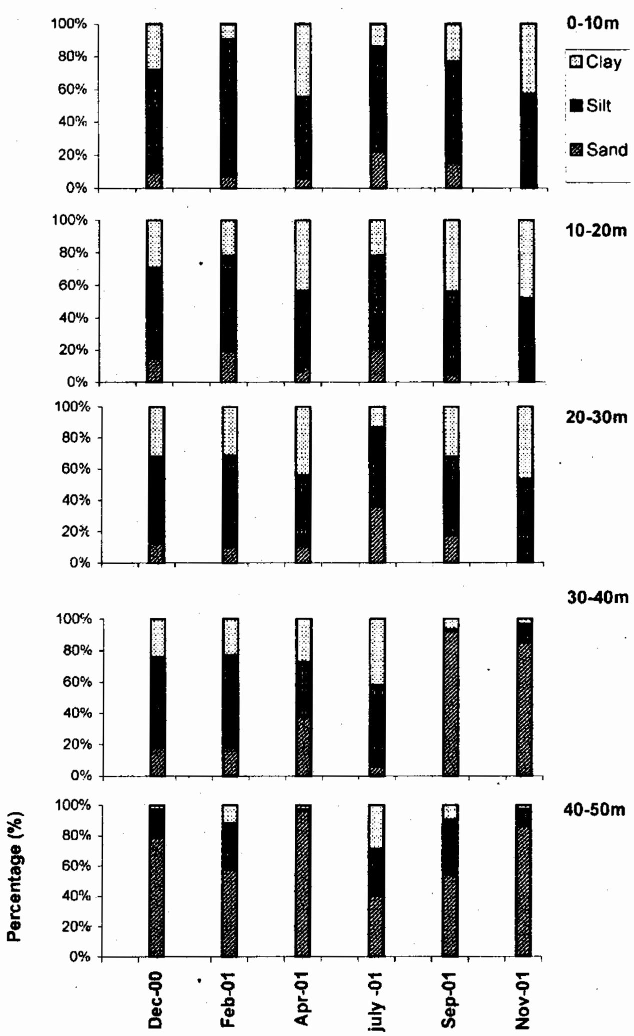

Fig. 3. Variations in sediments pattern after trawling in the study area during December 2000 to November 2001

ranging from 0.13-6.87% (Fig.4). The highest variation was recorded in July 2001 at 10-20 m depth where the organic matter content before trawling was 4.75% while in after trawling sample it reduced to 1.90%. No seasonal trend however was observed. It can be inferred from the trawling values (Table 1) that the impact of trawling on the textural properties and organic matter of sediments is

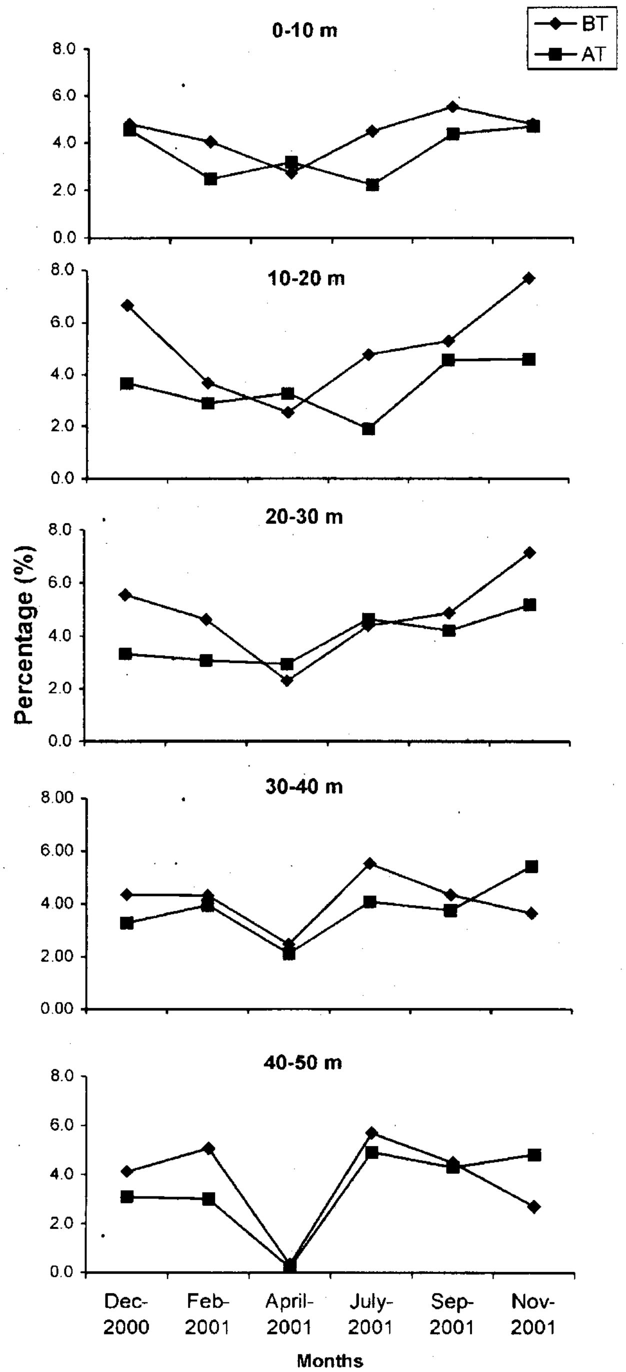

Fig. 4. Variations in organic matter before and after trawing in the study area during December 2000 to November 2001

more pronounced at the 0-40 m depth zone where the nature of the sediment is muddy. The immediate effect of bottom trawling is to suspend fine sediments in to the water column; Black & Parry, 1999). The sand and silt fractions being denser than the clay fraction settle at a quicker rate, while the finest fraction may remain in suspension for some time and the reworking of the substratum may have left the seabed in an altered condition (Currie & Parry, 1996; Schwinghamer *et al.*, 1998). The increased sand, silt fraction and decreased clay fraction in the after trawling samples may be attributed to resuspension (Caddy, 1973; Langton & Robinson, 1990). Rasheed and Balchand (2000) while studying dredging impacts in Cochin harbour, reported the presence of higher amount of sand in dredged areas. Similar results were observed by Watling *et al.* (2001). Increased silt concentration may have an adverse impact on pelagic and benthic productivity since it can cause an increase in the extinction coefficient and thereby affecting photosynthetic activity (Triantafyllou *et al.*, 2000). In sandy areas however, turbidity is less due to minimal amount of clay. Bottom trawling may lead to modification in microbial activity along with sediment texture (Mayer *et al.*, 1991).

The nematodes and harpacticoids are generally known to dominate and sub dominant (Shirayama, 1993; Kim *et al.*, 1998) in the sediments with fine grain size and relative abundance in harpacticoids increases where the sediment becomes coarser (Shirayama & Kim, 1998). The increased sand fraction after trawling may cause a change in the natural community structure of nematodes and harpacticoids. Churchill (1989) documented that coarse sand was penetrated to a depth of 1 cm by otter boards. Interestingly meiobenthos show abundance in upper 1cm of sandy sediments (Kim *et al.*, 2000). Hence the disturbance caused by the otter boards may result in reduction of meiobenthic abundance.

Organic carbon present in surface layers of sediments may get abraded due to the churning action of the trawl gear. Mayer *et al.*, (1991) documented mixing of surface organic matter to sediment depth and return of solutes to the surface. Bottom trawling may be causing reduced organic matter content in the samples (Watling *et al.*, 2001). Deposit feeders obtain nutrition from sedimentary organic matter (Lopez & Levinton, 1987; Levinton, 1989). The reduced organic matter levels after trawling may adversely affect the survival of such deposit feeders.

One of the factors governing the abundance and distribution of benthic fauna are sediment characteristics like grain size and silt (Duineveld *et al.*, 1991). Bottom trawling causes visible changes to sea bottom and such physical disturbance may lead to the destruction of spawning beds (Messiah *et al.*, 1991), changes in the community of benthos by removal of epifauna and infauna (Watling *et al.*, 2001) which may affect benthic ecosystem productivity (Ball *et al.*, 2000). The disturbance of sediment structure caused by the dragging of trawl net could indirectly affect the benthic communities, causing reduction in habitat complexity, benthic diversity and production (Brylinsky *et al.*, 1994; Kaiser & Spencer, 1996). Collie (2001) during his studies on impact of fishing gear on sea floor in New England found that the ecological consequences of fishing gear disturbance as reduction in habitat complexity and bio diversity, as the juvenile stages of commercially important fishes depend on these habitats for protection from predators and for food and prey that live on the epifaunal species. Benthic production in the undisturbed natural habitat is probably the key-limiting factor regulating demersal fish production, as it is the food and energy source for most demersal fish (Smith *et al.*, 2000).

Dragging of trawl gear through the bottom can be responsible for disturbing and relayering the sediment causing a change in grain size, affecting the chemical composition and altering the nutrient cycling (Mayer *et al.*, 1991). Alterations may also occur to the sediment porosity and chemical exchange processes (McConnaughey *et al.*, 2000). High levels of turbidity and sedimentation, due to trawling in muddy areas have been reported to prevent settlement of benthic larvae (Galtsoff, 1964; Stevens, 1987), thus affecting recolonization after disturbance.

Disturbance due to bottom trawling may alter the habitat structure and composition, which appears to be an important criterion for some fish species (Sainsbury, 1987; Gibson & Robb, 1992). Studies have demonstrated the relationship between flat fish species and sediment particle composition of the seabed, which may be more important than the occurrence of associated epibenthic structures or fauna that occur in that habitat (Rogers, 1992). Hence a specific particle size composition may be essential for flat fish. In contrast, there is good evidence to suggest that structural complexity can have important implications for the survival of round fishes (Thrush *et al.*, 1995). Thus bottom trawling may result in a shift in the abundance of certain fish groups.

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