SEDIMENT SIZE EFFECTS ON MEIOFAUNAL COMMUNITIES IN DISCOVERY BAY, JAMAICA

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Abstract. Meiofauna are found in both marine and freshwater benthos, from the shallowest of rivers to the deepest sea. Meiofaunal communities are not homogeneous; past studies have shown that certain taxa are restricted to certain sediment types and that the differences in community abundance and composition are primarily influenced by the sediment grain size. In Discovery Bay, Jamaica we found no difference in total abundance and size of meiofauna between two sediment types (fine and coarse sand). This lack of difference may be due to the relatively subtle differences in our grain size. However, we found that there were significantly more nematodes in the fine sediment habitat than in the coarse sediment habitat and that there were more polychaetes in coarse sediment than in fine sediment ; therefore even with small differences in grain size there was a slight change in the meiofaunal community. We found a marginally significant difference in nematode to copepod ratio between the sediment types, although this difference appears to be due to variance in copepod abundance in the fine sediment.

Key Words: coarse sediment, copepod, grain size, fine sediment, nematode, polychaete. Ting™

INTRODUCTION

Meiofauna are ubiquitous microscopic invertebrates living in sediments of nearly every aquatic habitat (Higgins and Thiel 1988). They are found in "sediments of all kinds from the softest of muds to the coarsest shell gravels (Coull 1988)." Meiofauna are defined as benthic invertebrates which are able to pass through a one mm sieve mesh opening and are thus distinguished from macrofauna, benthic invertebrates retained by one mm openings (Coull 1988). There are many factors that effect meiofaunal communities: temperature, salinity, season, latitude, water depth, tidal exposure, and sediment O2 concentration have been shown to influence abundance and distribution. However, sediment grain size is considered to be the primary factor determining abundance and species composition of meiofaunal communities. In many cases, grain size can determine the sizes and type of taxa able to inhabit the meiofaunal community (Coull 1988).

Sediment type (coarse or fine) is believed to cause shifts in the ratio of nematode to copepod abundance (N:C); past studies indicate that nematode abundance is higher in fine sediments, and copepods dominate in coarser sediments (Coull 1988; McNulty et. al. 1962). The nematodes are thinner, burrowing organisms and therefore, may be better able to adapt to fine sediments than copepods. Copepods are larger, less able to tolerate more anoxic fine grained sediments. In addition the type of fauna changes from coarse to fine sediment in response to different levels of detritus in the sediment (McNulty et. al. 1962). Coarse sediments may be closer to the source of sedimentation or associated with higher water flow, so course sediments may have less detritus content. In general, detritus feeders dominate in finer sediment, while filter and deposit feeders are most abundant in coarser sediments (McNulty et. al. 1962).

In this study we examined meiofaunal taxonomic composition and its relative abundance in coarse and fine grained sediments. We attempted to control for all factors affecting meiofaunal community structure with the exception of sediment O2 concentration and sediment grain size by choosing fine and coarse sediment sites located near to each other. While we were unable to determine relative sediment O2 concentrations, it is known that finer sediments are generally more anoxic than coarser sediments as they contain more detritus and have lower rates of gas exchange. While past studies have shown that grain size is a reliable predictor of meiofauna differences (McNulty et. al 1962; Coull 1988; Rhoads, yr. unk.), these studies have looked at extremes in grain size such as fine silt versus coarse gravel. In this study we compared meiofaunal communities of two similar habitats with less extreme variations in grain size to determine whether grain size was indeed correlated with differences in meiofaunal communities.

Our first hypothesis was that there would be an increase in abundance of meiofaunal organisms in the coarse grained sediment compared to the fine. Coarser sediments have higher O2 concentrations and larger interstitial spaces, and therefore, more organisms may inhabit them. Fine grained sediment may be more suitable habitats for burrowing nematodes which can inhabit more anoxic environments. Therefore, we predicted a higher nematode to copepod ratio in fine sediment, due to an increase nematodes and/or a decrease copepods in the fine sediment compared to the coarse sediment. Lastly, we hypothesized that because of larger interstitial spaces between coarse sediment grains there would be a greater abundance of macrofauna (organisms > 1 mm) in coarse sediments than in fine sediments.

METHODS

Sample Collection

Research was conducted on 7-11 March 1997 at Discovery Bay Marine Laboratory, Discovery Bay, Jamaica. To remove confounding effects of changes in salinity, tidal flow, wave action, temperature, latitude, and depth, all samples were taken within 150 m of each other along a 10 m contour line located on the eastern side of Discovery Bay. We visually estimated grain size in the field, and removed sediment samples for laboratory analysis to quantitatively determine sediment grain size differences. There were two coarse sediment sites and one fine sediment site (Fig. 1). In Discovery Bay, the current is an important factor affecting sediment grain size. In Discovery Bay, the current runs from the east bay to the west bay depositing finer sediments as it passes from east to west.

Preparation of core samplers

Prior to sampling we prepared sediment core samplers by cutting off the tips of 60 cc syringes so that the opening was a uniform 3 cm diameter. We then put four holes at the 60 cc mark to allow water to flow out when the core sampler was plunged into the sediment.

Collection of core samples

Using SCUBA equipment, we sampled at the 10 m contour on the eastern side of Discovery Bay and visually determined a fine sediment site from which we collected nine core samples. Most meiofauna are found in the top two cm of sediment (Coull 1988), and the prepared corer was inserted past the 30 cc mark to insure collection of most meiofauna. We depressed the plunger until it passed the holes at the top, creating a suction which held the core sample in the syringe. We then removed the 9 fine core samples from the sediment and expelled the sample into individually labeled ziploc bags. After finishing sampling at the fine sediment site, we swam along the contour line for approximately 75 m from the central fine site to each coarse site. Using identical sampling methods as for the fine sediment samples, we collected nine core samples at each coarse sediment site. We then marked both the fine and the coarse sediment sampling zones with buoys in case further sampling became necessary. Upon return to the boat, we placed the samples in a covered bucket in the boat to make sure the meiofauna did not overheat.

Preservation of samples

We returned to the lab and transferred the contents of each bag into 250 ml Erlenmeyer flasks. We rinsed all of the remaining sediment in the bag into the flask with filtered seawater. We let the flasks stand for two hours to let the sediment settle from the solution. To collect any meiofauna in solution, we carefully decanted the water through a 45 µm sieve. We then backwashed the sieve with a 10% formalin/Rose Bengal solution to rinse, stain and preserve all meiofauna. The backwash solution was collected in a labeled vial. We then added two tablets of Alka-Seltzer™ to four ounces of water and poured this solution onto the sediment in the flask. This Alka-Seltzer™ solution contained a high concentration of carbon dioxide (CO2) which anesthetized the meiofauna remaining in the sediment and caused them to be released into solution. We allowed the flasks to stand for 30 minutes to achieve maximal numbers of extracted meiofauna.

We then decanted this solution through a 1000 µm sieve and placed the sediment aside for sediment analysis. We passed the filtered solution through the 1000 µm sieve two more times, at which time the 1000 µm sieve was backwashed into a labeled vial. We then poured the solution through three stacked sieves of decreasing pore size: 200 µm, 64 µm, and 45 µm. We repeated this two times and backwashed each of the sieves with the formalin/Rose Bengal solution into corresponding vials.

Sample Analysis

We examined the contents of the individual vials with dissecting scopes at 225-450 x magnification and identified the macro- and meiofauna according to keys in Higgins and Thiel (1988). We defined macrofauna as anything collected from the 1000 micron sieve and meiofauna as those organisms retained by the 200, 64 and 45 micron sieves. We classified the organisms into eight taxonomic groups: nematodes, polychaetes, copepods, ostracods, isopods, gastropods, cladocerans, and others. Because of the difficulty and uncertainty in identification, we limited our identification to phyla. We chose to concentrate on the eight most common phyla due to time constraints. Some examples of other taxa found in the samples are insects, crustaceans, cnidarians, gastrothica, amphi-

pods, tardigrada, and priapulida. We examined a total of 12 core samples (6 fine sediment samples and 6 coarse sediment samples).

Sediment size analysis

To determine sediment grain size, we poured each sediment sample (four coarse sediment samples and three fine sediment samples) through a stack of 2 mm, 500 micron, 350 micron, 64 micron sediment sieves, with a collection container to catch the remaining grains that were smaller than 64 microns. We backwashed each of the sediment from the sieves and the collection container into a tared aluminum foil cup and dried each fraction for 6-8 hrs. Once the sediment grains were dry, we obtained the tared final weight of the dry sediment of their different size classes. We classified fine sediment as sediment with less than 30% of its total weight made up of grains larger than 350 µm, while coarse sediment had more than 30% of its total weight made up with grains larger than 350 µm.

Results

Our fine sediment sample had 19.9 ± 3.0 % sediment by weight with grain size larger than 350 µm (t-test, t=5.02, df=5, P=0.004; Fig. 2), whereas our coarse sediment sample had 39.6 ± 2.6 % sediment by weight with grain size larger than 350 µm. Qualitative observation of the two sediment types in the field suggested the top layers of the sediment differ the most in grain size.

We found nematodes to be approximately four times as abundant in fine sediment than in coarse sediment, but we found no differences in abundance of other meiofauna taxa or total meiofauna abundance between sediment types (Table 1.). We also found no significant difference in the abundance of macrofauna between sediment types (t-test, t=1.29, df=10, P=0.23). Therefore, the relative proportion of macrofauna to all animals collected (macrofauna / macrofauna + meiofauna) did not change between sediment types. In 9 fine sediment cores and 9 coarse sediment cores, there were no strong trends in differences in organism abundance for the 3 largest size classes (Fig. 3). However, the fine sediment cores had approximately three times as many organisms in the smallest (45-64 µm) size class than the coarse sediment cores (Fig. 3).

The relative abundance of nematodes was higher in fine sediment than in coarse sediment (t-test, t=6.0, df=10, P=0.0001; Fig. 4), in contrast to the higher relative abundance of polychaetes in coarse sediment than in fine sediment (t-test, t=2.58, df=10, P=0.03; Fig. 4). No other meiofauna taxa differed in relative abundance between fine and coarse sediments. The nematode to copepod ratio was approximately eleven times greater for the fine sediment than the coarse sediment, though this trend was marginally significant (t-test, t=1.53, df=10, P=0.16; Fig. 5). There was higher variance in the nematode to copepod ratio for the fine sediment (mean ± 1 S.E. = 11.0 ± 6.5) than the coarse sediment (mean ± 1 S.E. = 1.1 ± 0.4). The ratio range for the fine sediment was 1.5 to 43.0; the ratio range for the coarse sediment was 0.3 to 2.8.

Discussion

Contrary to expectations, we did not find a greater abundance of total meiofauna in coarse sediment compared to fine sediment, nor did we find a higher relative ratio of macrofauna to all benthic organisms collected in coarse sediment than in fine sediment. Benthic organism abundance for the three largest size classes (64-200 µm, 200-1000 µm, >1000 µm) was also not markedly different between sediment types. Benthic organisms inhabit the interstitial spaces between sediment grains. Coarse sediment had a higher relative percentage of sediment by weight made up of large (> 350 µm) grains than fine sediment, so it presumably also had larger interstitial spaces than fine sediment. Our data suggest that interstitial space size is not a good predictor of the abundance of benthic organisms in different size classes in this particular Discovery Bay habitat.

We did, however, find a threefold higher abundance of the smallest (45-64 µm) size class of meiofauna in the fine sediment than in the coarse sediment. The fine sediment had a higher percentage of sediment with small grains (<350 µm) than the coarse sediment, hence it also has more small interstitial spaces; however, we are uncertain as to why small meiofauna abundance and small grain size are correlated.

A possible explanation for why we found no clear relationship between sediment type and total meiofaunal or macrofaunal abundance is that by inserting corers approximately 6 cm into the sediment, we collected sediment along a large gradient of grain sizes. In the field, visual inspection of the sediment revealed that grain sizes at the surface were markedly different between the coarse and fine sediment sites. However, laboratory analysis of grain size revealed that most of the sediment grains in both sediment types were in the 64-350 µm range, which is presumably due to the fact sediment grains become progressively smaller with depth in both sediment types. It would be beneficial for future studies to look at only the top 2 cm of sediment, which is where here the differences in grain size are more extreme and where most meiofauna is reportedly found (Coull 1988), to more directly examine the relationship, if any, between the benthic organism and interstitial space size.

We did find an effect of sediment type on the structure of the meiofaunal community. The relative percentage of nematode worms was higher in the fine sediment than the coarse sediment, whereas the relative percentage of the polychaete worms was higher in the coarse sediment than the fine sediment. Nematode and polychaete worms burrow into sediment. Meiofaunal literature cites (Riemann 1988) that nematodes are the dominant taxon in nearly all sediment types, as was found in our study, and that they easily tolerate low oxygen environments. According to Westheide (1988), most meiofaunal polychaetes inhabit the interstices of sediment. Perhaps the polychaetes prefer burrowing in sediment of larger grain size because the interstitial spaces between the grains are larger and/or the sediment has a higher oxygen content. The coarse sediment had mostly large grains on its surface, which is where the polychaetes would be expected to burrow. Future studies should also measure oxygen concentrations in the sediment to determine whether interstitial oxygen concentration influences the structure of the worm community.

Although nematode abundance was significantly higher in the fine than in the coarse sediment, copepod abundance was not significantly different between the two sediment types. The nematode to copepod ratio was eleven times higher for the fine than the coarse sediment but not statistically significant because of high variance in this ratio for the fine sediment. Variance can be attributed to locally patchy distributions of meiofauna, which may occur due to differences in food distribution, interspecific competition, reproductive activity, and/or small-scale physical differences in the environment. Meiofaunal sampling should be conducted on a larger scale to eliminate effects of local patchiness that may have masked abundance and community composition differences between sediment types in this experiment.

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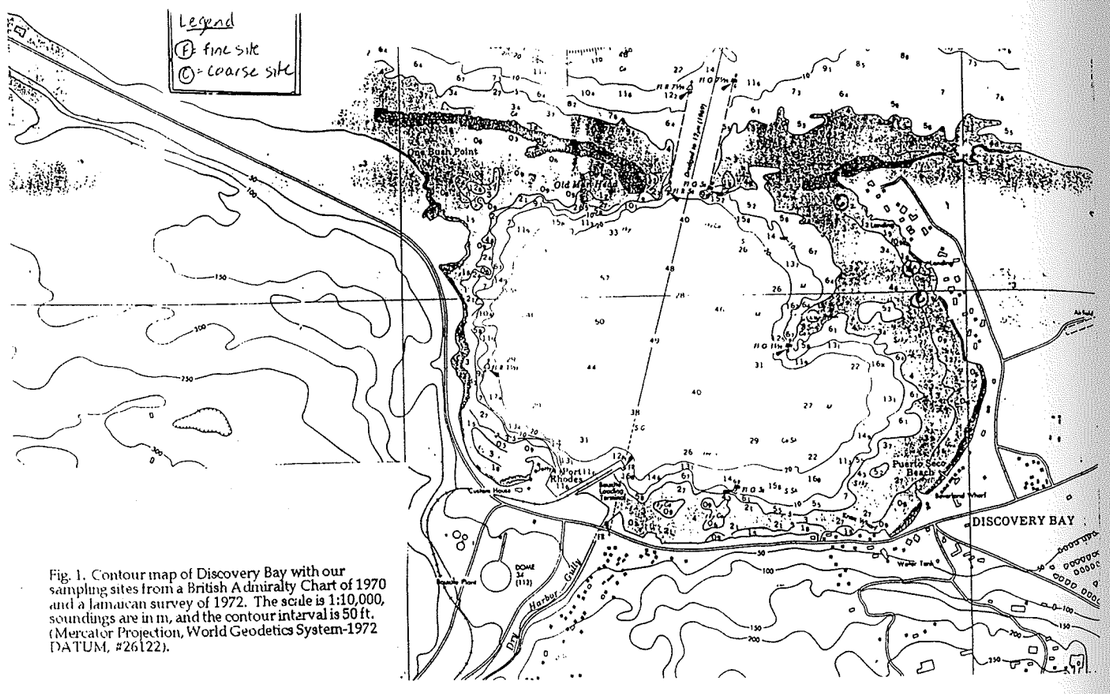

Fig. 1. Contour map of Discovery Bay with our sampling sites from a British Admiralty Chart of 1970 and a Jamaican survey of 1972. The scale is 1:10,000, soundings are in m, and the contour interval is 50 ft. (Mercator Projection, World Geodetics System-1972 DATUM, #26122).

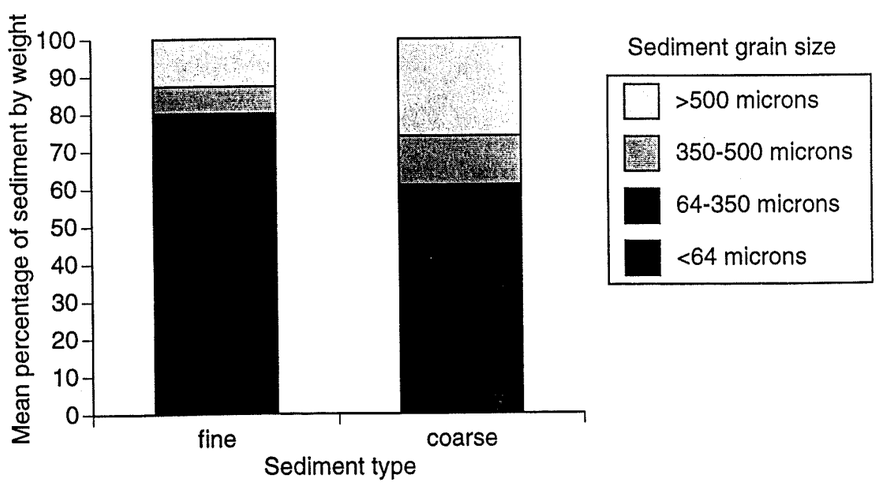

FIG. 2. Distribution of sediment weight by grain size in fine (N=3) and coarse (N=4) sediments collected at a depth of 10 m in Discovery Bay, Jamaica.

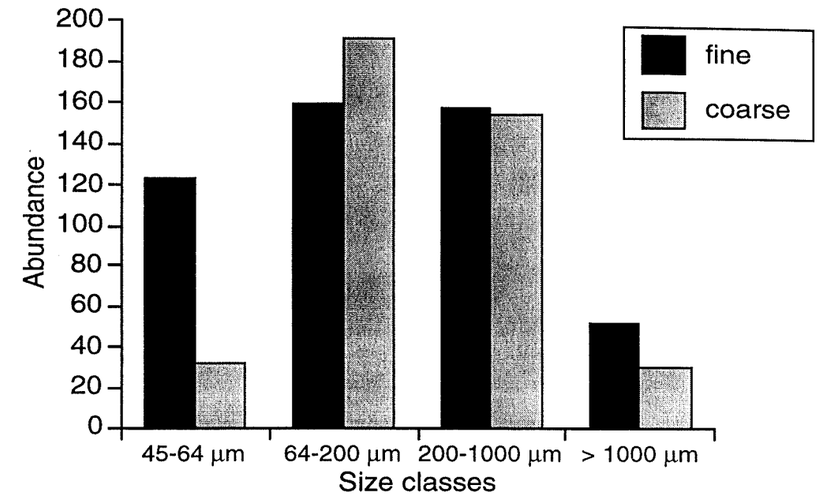

FIG. 3. The frequency distribution of meiofauna and macrofauna belonging to different size classes collected in 9 fine and 9 coarse sediment cores from a depth of 10 m in Discovery Bay, Jamaica.

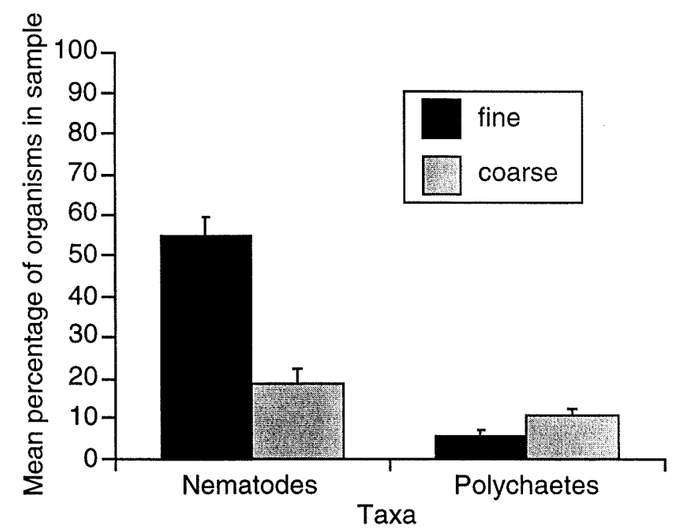

FIG. 4. Mean percentage (± 1 S.E.) of nematodes and polychaetes found in fine sediment samples and coarse sediment samples (N=12) from a depth of 10 m in Discovery Bay, Jamaica.

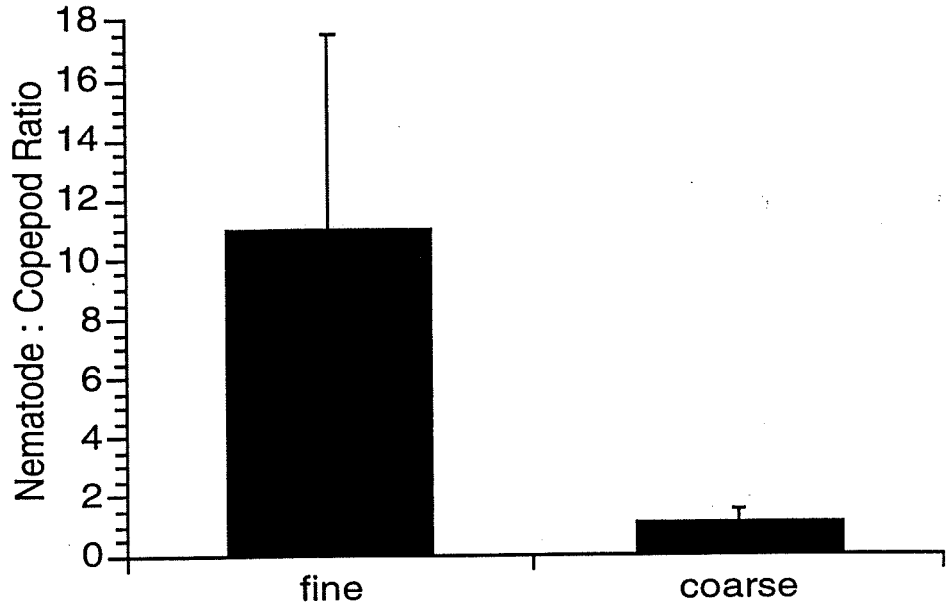

FIG. 5. Mean (± 1 S.E.) of nematode to copepod ratio found in fine sediment and coarse sediment samples from a depth of 10 m in Discovery Bay, Jamaica (t-test, t=1.53, df=10, P=0.16).

TABLE 1. Mean abundances of meiofauna in fine and course sediments (N=12) collected from a depth of 10 m Discovery Bay, Jamaica.

Meiofauna type	Fine Sediment Mean ± 1. S.E.	Coarse Sediment Mean ± 1 S.E.	t	df	P
Nematode	59.2 ± 7.3	16.2 ± 6.7	4.34	10	0.0015
Copepod	13.8 ± 3.9	21.8 ± 8.9	0.82	10	0.43
Ostracod	8.8 ± 2.6	15.8 ± 6.4	1.02	10	0.33
Gastropod	8.8 ± 1.4	8.7 ± 2.9	0.05	10	0.96
Polychaete	6.3 ± 2.2	8.8 ± 2.2	0.80	10	0.44
Isopod	2.7 ± 1.1	0.7 ± 1.1	1.24	10	0.25
Cladoceran	1.0 ± 0.4	3.2 ± 1.4	1.55	10	0.15
Other	6.5 ± 3.4	5.3 ± 1.5	0.31	10	0.76
TOTAL	107.2 ± 8.3	80.5 ± 21.1	1.19	10	0.27