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Sediment characteristic of the continental shelf in the northern Gulf of Mexico

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Resumen: Los sedimentos de la plataforma en la sección norteña del Golfo de México varían en tamaño granular, de arena fina a limo. Generalmente están mezclados y predominar los granos grandes. Su contenido total de carbono varía de 0.6 a 6.1% (Media: 1.7%) y tiende a aumentar con la profundidad. El consumo de oxígeno en el lecho marino no está correlacionado con el tamaño granular y solo muestra una asociación débil (r= 0.54) con el total de carbono orgánico.

Key words: Sediment, grain size, organic carbon, benthic metabolism.

The Mississippi River is the largest river in the United States and discharges substantial amounts of nutrients, organic carbon, and sediments onto the Texas-Louisiana continental shelf in the northern Gulf of Mexico. As a basic part of an initiative to describe processes at the sediment-water interface in the northern Gulf of Mexico shelf ecosystem we measured sediment grain size and per cent total organic carbon. This paper reports sediment grain size characteristics and per cent carbon, and makes preliminary associations between these variables and carbon utilization by the benthos (calculated from sediment oxygen consumption rates) and macrofauna biomass.

We studied the area of the Texas-Louisiana shelf, west of the Mississippi River delta on cross-shelf transects of stations, generally shallower than 200m, (Fig. 1) where organic carbon has been shown to reach the sediments (Cruz-Kaegi and Rowe 1992).

Sediment samples were collected at each station using a Pamatmat multiple corer (Pamatmat 1971). The top 5 cm of sediment were removed from the core tube and frozen upright in glass specimen jars. Duplicate samples were analyzed for all stations except stations two, 2A and BL4, BL6, and BL5 when zero, one, three, and four replicates were analyzed respectively.

Sediment particle size distribution was determined by the sieving and pipetting methods of Folk (1980) and the phi notation of Krumbein (1936) was used (where phi= $-\log_2$ of the diameter in millimeters). Dry sieving was used to analyze the coarse fraction and the pebble-granule boundary ($\leq$ -2 phi) was chosen for the upper size limit. Eight phi (clay) was the lower size limit of the fine fraction and was measured using pipette analysis. The relatively high organic content of the samples required that they be pretreated repeatedly with several milliliters of 30% H_2O_2 and heated until the organics were digested. The graphic measures of Folk (1980), including median, mean, standard deviation (sorting coefficient), skewness, and Kurtosis, were used to describe the grain size distribution.

The top 1 cm of replicate sediment samples were analyzed for total organic carbon (TOC) with a LECO carbon analyzer using a method similar to that of Kolpack and Bell (1968).

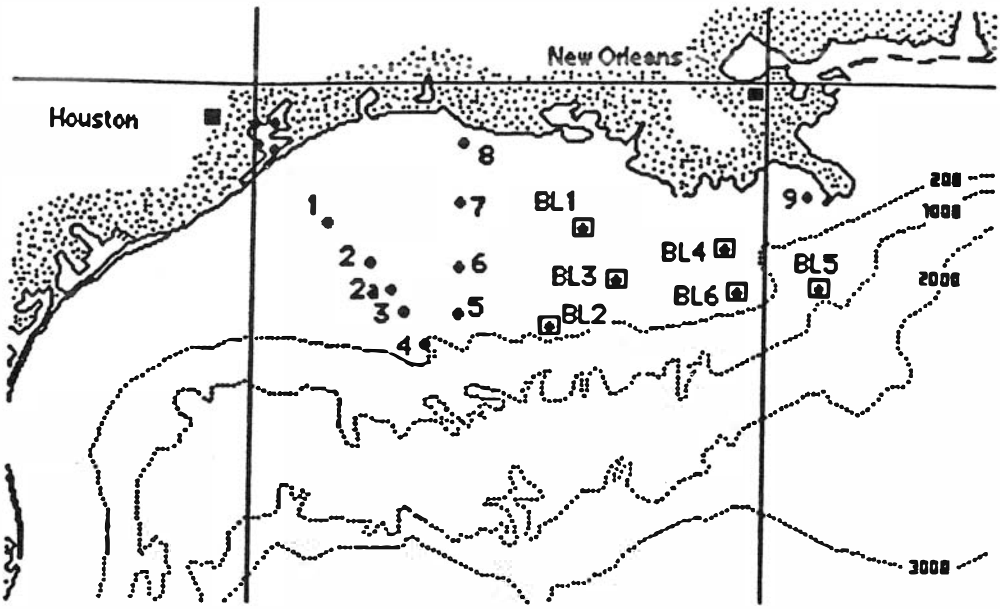

Fig. 1. Northem Gulf of Mexico sampling locations.

Four replicate samples were analyzed from each station with the exceptions of station seven (two replicates), stations one, two, and BL6 (three replicates), and BL5 (five replicates). The samples were treated with a solution of 7% hydrochloric acid to dissolve inorganic carbon, afterwhich they were washed with deionized water and ovendried at 70ºC for 24 hours. After drying the samples were ground in a mortar and well mixed. Any large particles (> 1 mm) were manually removed. Samples were weighed into crucibles containing 2.5 g of copper chip accelerant and combusted in the analyzer using oxygen. The combustion products were dried and filtered into a gravimetric absorption bulb where CO2 was recorded as a weight change in the bulb. The weight change was used in a gravimetric calculation to obtain percent TOC in the sediment.

Seabed oxygen consumption was measured by the shipboard incubation of recovered cores (generally 8-12 per station) and overlaying water at *in situ* temperatures (Pamatmat 1971, Phoel 1983).

Sediment characteristics are reported from fourteen locations on the continental shelf between the Mississippi River delta and a transect off Galveston, Texas and one location (BL5) on the continental slope (900 m depth) due south of the river plume (Fig. 1).

Table 1 lists the sediment characteristics referred to below. Mean grain size ranged from 2.2 phi (fine sand) to 6.1 phi (fine silt) (using the conversion chart of Inman 1952). Ten of the 15 samples were either coarse or medium silt (4-6 phi), however no pattern was evident. The sorting coefficient indicated that 11 of the samples were poorly sorted, three samples were moderately sorted and one (BL2) was very poorly sorted (using the sorting scale of Folk and Ward 1957). With the exception of the sample from station BL2, the samples were skewed toward coarse grain size distributions since negative values of skewness indicate that the grain size distribution is skewed toward larger diameters (Inman 1952). The sample from BL2 (which was very poorly sorted) had a skewness close to zero which represents a near normal distribution. No analysis has been performed using kurtosis and it is listed for information only.

Mean percent TOC was 1.695 (standard deviation = 1.416) with station BL2 having almost four times as much organic carbon (6.104%) as the mean. Percent TOC generally increased with depth (Fig. 2, R= 0.66).

TABLE 1

Sediment characteristics of the East Texas and Louisiana Shelf

Station	Depth (m)	Median/Mean Grain Size (phi)	Sorting Coefficient	Skewness	Kurtosis	Total Organic Carbon (%)
1	19	5.28/4.85	1.972	-5.814	1.145	0.581
2	46	No Data	No Data	No Data	No Data	1.283
2A	58	5.484/5.147	1.653	-4.192	0.719	1.748
3	85	3.427/3.937	1.995	-2.151	0.915	2.939
4	173	6.292/6.076	0.804	-5.831	1.483	3.233
5	86	6.077/5.758	1.106	-5.258	0.74	2.129
6	42	5.049/4.636	2.18	-3.218	0.729	0.924
7	17	3.559/3.992	2.099	-1.911	0.712	0.356
8	10	4.335/4.670	1.619	-2.997	0.732	0.789
9	26	6.312/6.093	0.796	-5.901	2.098	1.39
BL1	100	5.582/5.324	1.446	-4.485	0.763	1.006
BL2	54	1.189/2.168	3.346	0.363	1.13	6.104
BL3	30	6.192/5.912	0.97	-5.548	0.892	1.08
BL4	35	4.551/4.384	2.16	-2.836	0.755	0.825
BL5	978	6.295/5.937	1.016	-5.784	2.083	1.324
BL6	98	5.821/5.004	2.068	-4.267	0.754	1.409

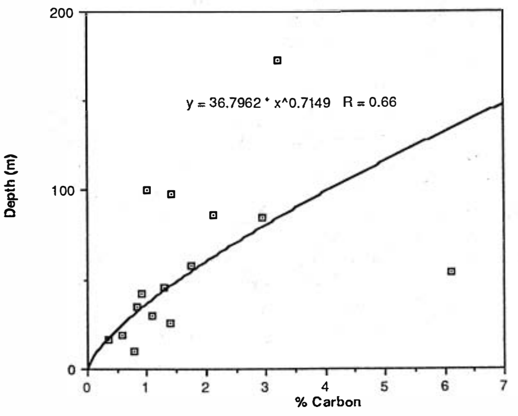

Fig. 2. Comparison of depth and sediment % total organic carbon.

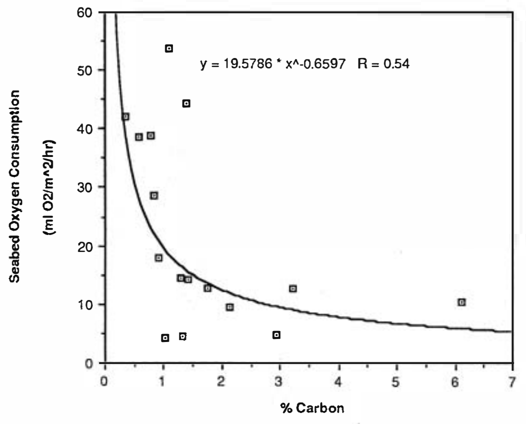

Fig. 3. Comparison of SOC and sediment % total organic carbon.

We related grain size characteristics and sediment percent TOC with seabed oxygen consumption (SOC), a measure of benthic community metabolism. Seabed oxygen consumption, showed no correlation with grain size but had a weak correlation (R=0.54) with percent TOC (Fig. 3). For the same locations Rowe et al. (1992) showed that SOC declined with depth and Cruz-Kaegi and Rowe (1992) reported a cross-shelf decrease in benthic macrofauna biomass with depth.

Organic carbon is known to influence benthic biomass and benthic community metabolism. Cross-shelf decreases in benthic biomass account for the concomitant decreases in SOC, however both variables decrease while sediment TOC increases. Meiofauna and bacteria biomass measurements have not yet been completed for these locations but the addition of this biomass could indicate an increase in total benthic biomass across the shelf. This would produce the contradiction of increasing TOC and biomass and decreasing SOC (although some of the decrease in SOC might be explained by lower temperatures in the deeper, offshore waters).

The high nutrient input of the Mississippi River supports high rates of primary production in the surface waters and this primary production is the main source of carbon to the sediments. Dortch *et al.* (1992) have measured high respiration rates in the water column which indicate that organic carbon reaching the sediments may already have served as a food source. The quality of sediment organic carbon (*e.g.* labile or refractory) has been shown to influence benthic metabolism (Hargrave 1978). The more distant the sediment is from its souce and the deeper the sediments are, the more likely it is that the sediment TOC is refractory and less capable of supporting benthic biomass and metabolism. Since the sediment TOC we measured increases with depth and distance from its source, but does not support concomitant rates of benthic metabolism, we suggest that it is more refractory and not readily available to support a large benthic community. The benthic samples from our study are being identified and enumerated and will be reported elsewhere.

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