Long term observations in benthic communities of tropical seas: An interdisciplinary approach in the IAS initiative

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Abstract.

Tropical seas provide excellent natural laboratories for studies of the deep-sea benthic communities subjected to oligotrophic conditions that are altered by the hydrodynamic processes, mesoscale features and basin scale climatic changes. Since heterotrophic life in the aphotic benthic zone of the sea is based on the export of primary production that takes place in the euphotic pelagic zone, transport mechanisms that couple the primary production zone with secondary production habitats are of interest within the interdisciplinary approach. Information has been gathered in the Gulf of Mexico, a regional sea within the Intra Americas Sea (IAS), for more than a decade. Results from these observations show that the deep sea that was long regarded as a homogeneous environment, weakly influenced by processes at its surface has a large variability and is a dynamic environment pulsed mainly by processes at the surface. Inter-disciplinary registration of key events at selected sites investigating the variability in time and space are of utmost importance. Long term and large-scale investigation are important and efforts are needed to carry out a large number of experiments and measurements over longer periods of time.

Introduction.

The extreme oligotrophy that characterises the Gulf of Mexico, related to stratification of the euphotic layer has rated the basin among the most oligotrophic of the world oceans. From this standpoint the deep sea can be regarded as a homogeneous environment, weakly influenced by processes at its surface. Studies in similar impoverished tropical ocean areas have revealed significant correlation between deep-sea infaunal abundances and those factors in the water column indicating food availability (Tselepides & Eleftheriou, 1992).

The time-varying fluxes of carbon and associated biogenic elements in the ocean and the related exchanges with the sea floor are lacking in the Gulf of Mexico, however characteristics of the upper and intermediate waters restrict the organic matter supply to the deep- sea benthos. The limited export of biogenic carbon to deep may be expressed in terms of higher benthic species richness (Escobar et al., 1999). Similar high species richness recorded in tropical deep-sea environments have been attributed to trophic specialization of the benthic fauna to limited organic matter content in sediment (Pasternak et al., 1975).

At present, we have a broad appreciation of the nature of the types of benthic communities we will encounter in tropical deep-seas (Sanders, 1969; Pequegnat, 1983), and a sketchy knowledge of the linkage between the arrival of organic matter to deep. We know very little about the processes mediating their community structure. We have empirical models describing the expected species richness in the deep-sea, but we are far from understanding the mechanisms governing diversity and biomass distribution in the tropical deep-seas. We have recognised the importance of some key issues, such as the role of perturbation caused by non-predictable meteorological phenomena, such as hurricanes, winter fronts or El Niño tele-connection effect.

In formulating a work plan for the Gulf of Mexico benthic studies major objectives were adopted. The first objective was to investigate the distribution of benthic invertebrates (micro-,

meio-, macro and megafauna) in the southern Gulf of Mexico. The second objective was to improve the knowledge of the distribution of benthic infauna of and its relation to food availability. The third objective was to achieve a more quantitative understanding of processes in the upper water column that contribute to the export of biogenic carbon in the deep Gulf of Mexico. This abstract presents data on the variability in time and space of the deep-sea benthic infauna (meio- and macrofauna) of the southern Gulf of Mexico.

Methods.

The strategy adopted involved a series of cruises (R/V Justo Sierra) that were conducted in the decade of the 1990's in the southern Gulf of Mexico (Fig. 1). The sediments and benthic samples of the top 10 cm layer in different sectors and depth zones of the Gulf of Mexico have been recovered with a 0.25 US-NEL box corer deployed on replicate basis at each station.

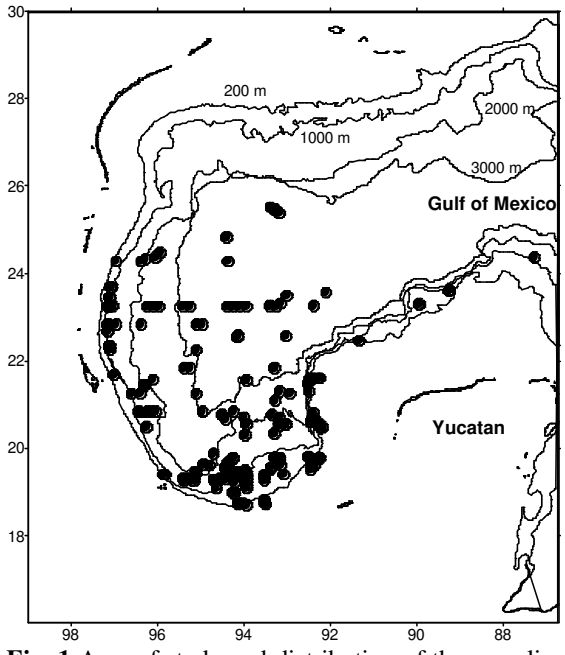

Fig. 1 Area of study and distribution of the sampling stations.

Macrofauna were sieved (125 µm to 1 mm) and fixed onboard, meiofauna were fixed onboard. Both groups were sorted and identified to the lowest taxonomic level possible in the laboratory. Biomass has been expressed, as average values, in units of gC.m² by station at each cruise. Sediment and water column factors were recorded at each sampling station. Data were analysed in a comparative format with the existing data from the northern Gulf of Mexico according to the depth zones described by Pequegnat (1983): transition zone (300 to 450 m),archibenthic (460 to 950 m), upper abyssal (975 to 2250 m), mesoabyssal (2275 to 3200 m and lower abyssal (3225 to 3850 m). Statistical analyses were carried out using a linear models nested ANOVA procedure, with terms for depth zones, the season (stratified vs mixed conditions) and year at which each cruise was carried out on replicated measures.

Results.

Meiofauna. Average biomass values ranged from 0.0004 to 0.096gC.m². The largest average values were recorded in the lower abyssal zone (0.050 gC.m², n=80). The transition and the upper abyssal zones were characterised by the lowest average biomass values (0.002 gC.m², 0.003 gC.m²; n= 20, 60 respectively). The archibenthic zone (0.005 gC.m², n= 35) showed values that were two times higher than those recorded in the transition and upper abyssal zones. The mesoabyssal zone showed the second largest biomass average values (0.036 gC.m², n=10). Seasonal differences (Fig. 2) and between years (1997 and 1999; Fig. 3) were recorded in mesoabyssal biomass average values.

Macrofauna. Average biomass values ranged from 0.002 to 0.37 gC.m². The largest average values were recorded in the lower abyssal zone (0.21 gC.m², n=106). The mesoabyssal zone was characterised by the lowest average biomass values (0.019 gC.m², n= 78). The transition (0.060 gC.m², n= 73) and the archibenthic zones (0.078 gC.m², n=150) showed similar values that were half as low as those recorded in the upper abyssal zone (0.119 gC.m², n=194). The Campeche Bay attained the largest biomass values followed by the Campeche Escarpment; the lowest values have been recorded off the Mexican Ridges.

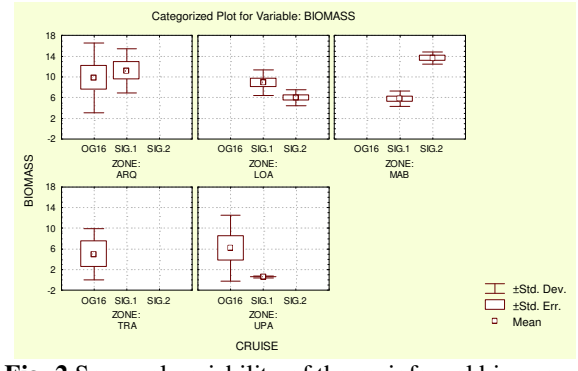

Fig. 2 Seasonal variability of the meiofaunal biomass (gC.m²) in the deep Gulf of Mexico.

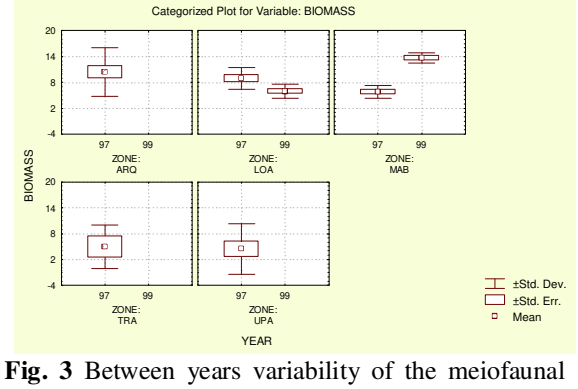

Fig. 3 Between years variability of the meiofaunal biomass (gC.m²) in the deep Gulf of Mexico.

Seasonal differences were recorded in the years 1993, 1995 and 1997: ANOVA F 3,15; p= 0.02 with highest values occurring throughout the months with mixing of the water column (Fig. 4).

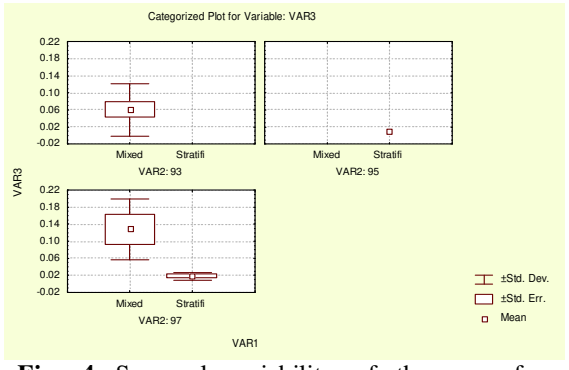

Fig. 4 Seasonal variability of the macrofaunal biomass (gC.m²) in the deep Gulf of Mexico.

The average biomass values showed significant between year differences on the upper abyssal, mesoabyssal and lower abyssal zones during the stratified condition (Fig. 5).

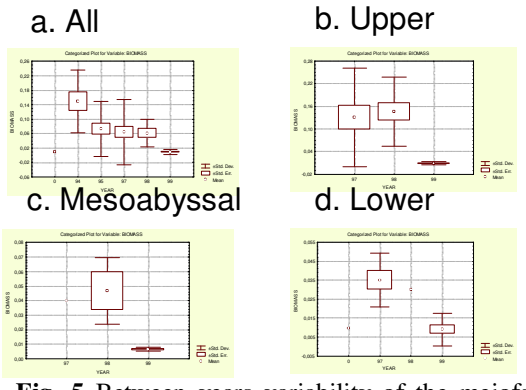

Fig. 5 Between years variability of the meiofaunal biomass (gC.m²) in the deep Gulf of Mexico.

The three abyssal zones showed similar biomass values in the years 1997 and 1998, a significant decrease in biomass values was observed for the two zones in 1999 that remained equally low in the year 2000 (Fig. 5). In general the biomass values recorded in 1994 were higher than in 1995 and then in 1997 in contrast to 1998 and 1999.

Discusion.

The variability observed in the infaunal biomass between years and in the spatial scale is in part attributed to be a response to food supply. In open ocean areas the offshore deep-sea communities rely on the export of biogenic carbon as the major mechanisms that drives a net removal of carbon to deep (Tselepides & Eleftheriou, 1992). In the Gulf of Mexico we have only a vague idea of how hydrodynamic processes contribute to the redistribution of organic matter below the thermocline on the scale of the size of the basin (Rowe & Pariente, 1992; Escobar et al., 1999). Part of this variation is attributed to the presence of the minimum oxygen layer in the transition, archibenthic and upper abyssal zones, generated by pulses of sedimentation of organic matter (Pequegnat, 1983). The minimum oxygen layer has been observed following phytoplankton blooms that may impart a seasonal signal from the euphotic zone into the deep-sea (Thiel, 1989; Lochte,

1992). Events in the scale of Niño may suggest large inputs of fresh biogenic carbon to deep that may lead to elevated oxygen consumption in the transition, arquibenthic and upper abyssal zones and have seasonal or yearly effects in the macrobenthic biomass distribution. Similar effects have been observed in Peruvian benthic assemblages (Tarazona et al., 1988).

The transport of this phytodetritus and its state of degradation will depend highly on the sinking rates which vary widely in the tropical seas ranging from a few meters per day up to over 500 $m.d^{-1}$ (Madin, 1982). The deep Gulf of Mexico attains higher temperatures than the tropical western Atlantic at similar depth, the remineralization of labile organic matter may be higher in the deep Gulf of Mexico (Pasternak et al., 1975). Degradation rates of algae in the deep sea have been suggested to be half as low as from shallow water sediments (Lochte, 1992). Traces of phytodetritus and macroalgae (*Sargassum*) have been found in different box core samples (Thiel, 1978; Tselepides & Eleftheriou, 1992). The freshness of the phytodetritus material more than the quantity of the organic matter may be of greater importance in the tropical seas to enhance a response of the benthic biomass. Our results show so far that the tropical deep sea, which was long regarded as a homogeneous environment, weakly influenced by processes at its surface has a large variability and is a dynamic environment pulsed mainly by processes at the surface. Meso-scale features may play a relevant role, additional to other environmental factors in the sediment and deep-water masses, in the distribution of the benthic biomass in the deep Gulf of Mexico. Inter-disciplinary registration of key events in the tropical seas investigating the variability in time and space are of utmost importance in the long-term.

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