Benthic bacterial abundance and distribution in different areas of the Mediterranean Sea : relationships with organic matter

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It is well-known that benthic bacterial distribution is closely related to the sediment properties (such as grain size and organic content (DALE, 1974; DE FLAUN and MAYER, 1983). This paper summarizes data on the spatial distribution of benthic bacterial populations in different areas of the Mediterranean Sea in relation to the sediment organic matter content in order to point out factors relating to the bacterial distribution.

Surface sediment samples were collected from 8 Stations facing the river Entella, (July 1989), 5 Stations at the Portofino Promontory (July 1990), 1 Station in Posidonia bed sediment (from Dec. 90 to Dec. 91), 15 Stations at the mouth of the river Arno (November 1989), all-these from the Ligurian Sea and 22 Stations in Ionian and Aegean Seas (September 1989) using an Usnel 0.1 m^2 box-corer.

Sediment Organic Matter (TOM) was determined by the difference between the dry weight of the sediments (24 h, 60 °C) and the residue left after combustion (4 h, 550 °C).

Sediment Bacteria. Total bacterial number (TBN) in each sediment replicate (n=3, 1 cm^3) was analysed as described in MONTAGNA (1982). Bacterial Biomass (BBM) was calculated converting biovolume into carbon content, assuming 308 fgC x μm^3.

The entire data set did not show a significant correlation between TOM and BBM. Among the environmental conditions that can affect the benthic bacterial distribution and activity, two factors appeared to be significant in explaining the lack of correlation:

1) geographic and biogeochemical differences between the considered environments which determine the different foodsupply for benthic organisms.

2) large differences in hydrodynamic conditions (measured by using currentmeters placed at the water/sediment interface) in non food-limiting environments, as in coastal areas. Analysing the relationships between TOM and TBN or BBM in each area different patterns were found.

Entella Mouth was characterized by large amounts of organic matter (from 32.2 to 82.6 mg g^{-1} sed. d. w.) with an increasing gradient from shallower to deeper stations. This trend is related to the hydrodynamic conditions which are responsible for higher degree of resuspension in the shallower stations. Significative TOM vs TBN and TOM vs BBM correlations were found ($p<0.01$).

Arno Mouth. In sediments facing the river Arno (from 15 to 58 m depth) organic matter failed to correlate with bacterial density or biomass. This area was characterized by large amounts of sediment organic matter (from 52.1 to 80.9 mg g^{-1} sed. d. w.), mostly composed of refractory material because of the influence of riverine waters. Sediment texture appears to be largely homogeneous and a gradient of hydrodynamic stress between stations is lacking. This area is highly polluted because of the large heavy metal input from the river, and a negative relationship between Cadmium concentrations (FABIANO *et al.*, in prep.) and bacterial biomass was found.

Ionian and Aegean Seas. Analysis of sediment organic matter in the deep-sea generally shows very low concentrations (from 5.6 to 15.1 mg g^{-1} sed. d. w.). TOM significantly correlates with depth but not with benthic bacteria. The Eastern Mediterranean deep-sea can be considered a food limitating environment because of the low concentrations and mostly refractory composition of TOM. The factor controlling bacterial distribution was the amount of labile compounds (i.e. carbohydrate, lipid and protein). A significant relationship between bacterial number and carbohydrate content (unpubl. data) was found ($p<0.05$).

Posidonia Bed Sediments. In the studied sheltered bay (very low hydrodynamism), three main inputs of organic matter can be distinguished: algal bloom and decay, Posidonia leaf-fall and terrestrial input of organic matter brought to the sea by rains. Bacterial density and biomass show strong seasonal fluctuations but were not related to the amounts of sediment organic matter. Since food supply was never a limiting factor (TOM was annually on average 32 mg g^{-1} sed. d. w.) bacterial abundance depended on temperature (n=22, $p<0.01$) and on phosphate concentrations in interstitial waters (n=22, $p<0.001$).

To conclude, an analysis of the bacterial distribution along an hypothetical profile from 0 to 2400 m depth is shown in Fig. 1. The general trend seems to follow a bimodal curve with maximum bacterial densities in shallow water with little water movement (Posidonia bed sediments) and in deeper low energy environments rich in organic matter (muds from 60 to 135 m) confirming the results of NOVITSKY and MacSWEEN (1989) which observed higher TBN in protected sandy sediments than those which were exposed. Table I shows the environmental conditions characterizing the areas considered. The reported values were defined from very low (--) to very high (++++).

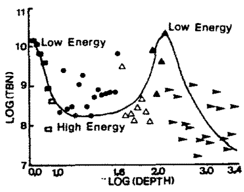

Fig.1

SEDIMENT TYPE	FOOD SUPPLY	ENVIRON. ENERGY	BACTERIAL BIOMASS
Posidonia	+ + +	–	+ + + +
Sandy Sediment	+	+ + +	–
Sandy Mud Sediment	+ +	+ +	+
Mud Sediment	+ + +	–	+ + +
Deep Sea Sediment	–	– –	+

Tab. I

REFERENCES

DALE N.G., 1974.- Bacteria in intertidal sediments: Factors related to their distribution. *Limnol. Oceanogr.*, 19 (3) : 509-517.

DE FLAUN M.F. & MAYER L.M., 1983.- Relationships between bacteria and grain surface in intertidal sediments. *Limnol. Oceanogr.*, 28 : 873-881.

MONTAGNA P.A., 1982.- Sampling design and enumeration statistics for bacteria extracted from marine sediments. *Appl. Env. Microbiol.*, 43 : 1366-72.

NOVITSKY J.A. and McSWEEN M.C., 1989.- Microbiology of an high energy beach sediment : evidence for an active and growing community. *Mar. Ecol. Prog. Ser.*, 52 : 71-75.