Bacterial activities and community structure interactions with organic matter dynamics at diel scale and during seasonal stratification in the NW Mediterranean

M.Goutx (1), N. Bourguet (1), C. Guigue (1), J. F. Ghiglione (2), M. Pujo-Pay (2), G. Mevel (3), A. Momzikoff (4), P. Raimbault (5), Lefèvre (1), V. Andersen (6)

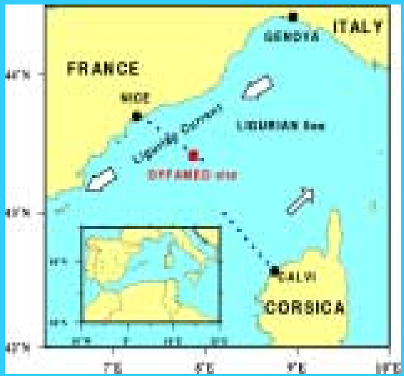
[1] CNRS -UMR 6117, Centre d'Océanologie de Marseille, Marseille, France
[2] CNRS -UMR 7621, Observatoire Océanologique, Banyuls-sur-Mer, France
[3] CNRS- UPR 9042, Station Biologique, Roscoff, France
[4] CNRS- UMR 7094, IPSL, Paris, France
[5] CNRS-UMR 6535, Centre d'Océanologie de Marseille, Marseille, France
[6] CNRS-UMR 7093, Laboratoire d'Océanologie de Villefranche, Villefrance-sur-mer, France

Introduction

Bacteria are important for determining the fate and loss of organic carbon exported to the mesopelagic layer and the deep ocean. However, the rates at which bacterial processes occur in natural environments, how they vary in response to small or larger spatio-temporal scale events and how does this impact biogeochemistry is still under question. It is thus essential for marine microbial ecologists to better understand interactions between the organic matter characteristics (quantitative as well as qualitative) and the bacterial compartment, at a microbiogeochemical scale as well as at the scale of ecosystem functioning.

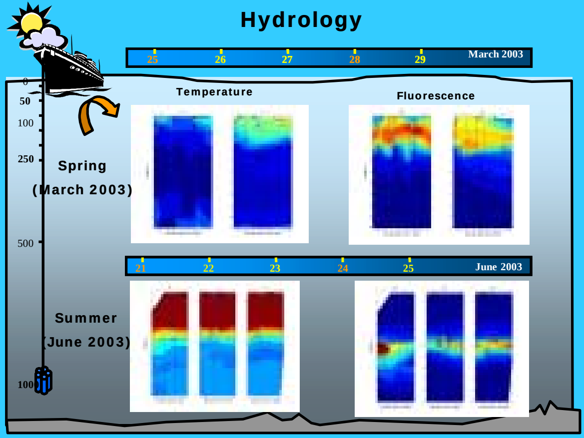
Within this context, the objectives of the PROPECHE observations (PROOF-PECHE project, Production and Exportation of Carbon : Control by HEterotroph at small temporal scale, Pis V. Andersen and M. Goutx) were to study the characteristics and dynamics of POM and DOM at daily and seasonal scale within contrasted ecosystem trophic conditions (spring and summer), and to relate variations to bacterial community activities and structure in the surface and twilight zone.

Study area



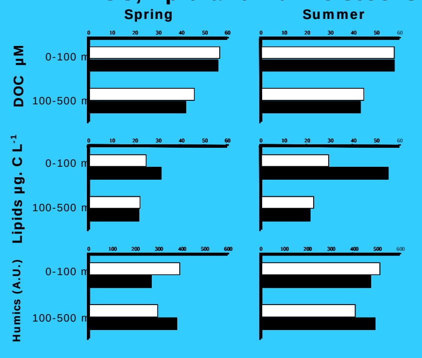
Observations were done by CTD/rosette sampling casts at a fixed station in the central zone of the Ligurian Sea (Dyfamed, NW Mediterranean), during day and night, in March and June 2003, along a 0-1000 m water column. Methodologies involved technicon analysis for nutrients, the dual labeling $^{13}C/^{15}N$ procedure for PP, Shimadzu DOC V analysis, lipid class Iatroscan analysis, HPLC separation &cdetection at 380nm of MeOH fractions of humic extracts, microscopic counts of acridine stained bacteria, ^{3}H-leucine incorporation technic for bacterial production and ^{3}H -triolein assay for lipase activity.

Hydrology

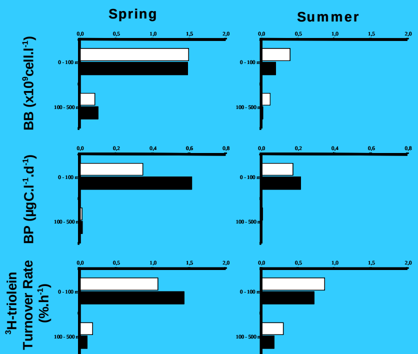


In spring, nitrates and phosphates started to be limited in relation to the phytoplankton bloom (PP=64-28 mg m^{-3} 12h^{-1}), the biomass was concentrated in the surface layer ($Chla_{max}$= 2.8 µg.l^{-1}). Nutrients regeneration was active and led to NH_4 accumulation down to 50 m. In summer, stratification started to establish. The surface layer was depleted in nitrates and phosphates. The primary production (PP=8-2 mg m^{-3} 12h^{-1}, $Chla_{max}$ = 1.6 µg.l^{-1}) and related nutrients fluxes were low and concentrated in a subsurface maximum. The system was net autotroph in spring and net heterotroph in summer.

DOC, lipid and humic stocks



Bacterial biomass & activities



In summer, we observed an excess DOC (7µM) and Labile/semi-labile (glycerides) and refractory lipids (humic acids) accumulated at the surface. Day/night variations of the lipid stocks (and their quality, data not shown) reflected biological activity (i.e. zooplankton grazing) at night. Daily and seasonal humic accumulations reflected the effect of biotic (production of humic precursors such as glycerides)and abiotic (UV effects) interactions. BB and BA decreased with depth and between spring and summer.

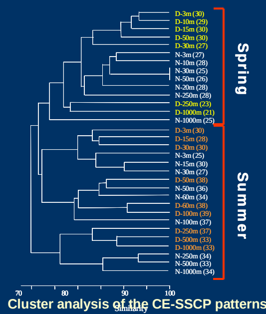
Lipid dynamic through microbial process

Measurements of *in situ* bacterial lipase activity (Bourguet et al. 2003, *Appl. Environ. Microbiol. 69, p7395*) and bacterial production were used to assess organic matter dynamic through bacterial processes in the surface layer (0-100 m).

		Input of monomers (mg C . m^{-2} d^{-1})		Assimilation of monomers (mg C . m^{-2} d^{-1})		Input/Assimilation of monomers	
		0-100 m	100-500 m	0-100 m	100 -500 m	0-100 m	100 -500 m
Spring	Day	741.1	76.6	36.6	2.8	20	27
	Night	723.3	26.1	64.7	3.7	11	7
Summer	Day	540.7	121.1	23.2	1.0	23	124
	Night	676.6	75.5	28.8	0.7	23	115

Major changes in the lipid dynamic through microbial process occurred between day and night at spring, and were depth-related in summer. They were related to changes in the BCS (see below). Uncouplings between bacterial hydrolysis (responsible for monomers inputs), and assimilation, probably were the cause of the lipid accumulation and excess DOC at the surface in summer.

Bacterial community structure (BCS)



In spring, there were clear differences between day and night BCS, especially for the upper layer : Days samples from 3 to 50m clustered together with a different profile for the 30m sample (bottom of the Chl *a* peak). Samples from 250m and 1000m depth clustered differently with low similitude value (around 78%). Night samples from 3 to 250m clustered together with distinguishable profiles at 20m (DCM) and 250m. The BCS at 1000m at night showed the lowest percentage of similarity with the others samples of this cruise (around 73%).

In Summer, three different layers could be distinguished, in accordance to the qualitative distribution of the ribotypes. Samples from day and night followed the same depth-dependant distribution, but were grouped separately in the upper and deep waters. The influence of the DCM level looked to be restricted at 50m during the day and extended to 50 and 60 m depth during the night.

Cluster analysis of the CE-SSCP patterns 5 (*Ghiglione et al., 2005*)

Conclusion

Spring mixing and summer stratification had major effects on OM bacterial cycling and the structure of the bacterial community in the water column. In spring, due the high PP and strong grazing of zooplankton during the night, there were only slight uncouplings between hydrolysis and assimilation at surface and depth, an uncoupling which decreased at night. In summer, such uncoupling increased, in the 100-500 m zone in particular, leading to an excess DOC accumulation. Both lipid and humic matter accumulated in the water column. The limited trophic conditions due to the high stratification/low nutrients, weak DCM, and low carbon resources, prevailing at surface, intermediate and deep waters, respectively, were likely responsible for the change in the structure of the community and for a selection of the most competitive species in each layer.