PRESENTATION OF THE INTERDISCIPLINARY OPERATION MELISSA (FRENCH NATIONAL PROGRAMME PROOF)

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Abstract

The Mediterranean interdisciplinary MELISSA project (MEditerranée LImitationS SAisonnières) is part of the French national PROOF programme. Its objective is to better understand the causal relationship between a given chemical forcing (availability of nutrients) and assimilation processes, phytoplankton dynamics, trophic functioning and carbon fluxes. The temporal variability of these parameters is studied at the DYFAMED time-series station (Ligurian Sea). The project is scheduled on 12 monthly campaigns (2004), 3 seasonal campaigns (2005) and a fertilising experiment in 2006 or 2007.

Keywords: nutrient availability; assimilation processes; trophic status; carbon flux.

Planktonic growth depends among others on the availability of several chemical species. As the surface layer of the western Mediterranean is subjected to seasonal succession of nutrient inputs, the main objective of the MELISSA project (MEditerranée LImitationS SAisonnières) is to better understand causal relationships between chemical constraints and the functioning of the trophic chain. Climatic changes partly determine the evolutions of such constraints, which have consequences on carbon fluxes. In this way, this project will provide data for the study of retroaction of chemical limitation of the biological production on the fate of CO_2, and, thus, on climatic evolutions.

The MELISSA project integrates time-series data acquired at the DYFAMED site (central Ligurian Sea) since 1991. The seasonal evolution of N/P ratios clearly indicates a succession of the limiting factor between N and P. This seasonal pattern is linked to the temporal variability of nutrient inputs in the western Mediterranean Sea. Certain phenomena are not well identified, and the characterisation of seasonal features is not easy (e.g., the rapid and early P to N limitation at the end of the stratification period).

MELISSA proposes multidisciplinary approaches: nutrient inputs and their availability in the euphotic zone, concomitant evolutions of the trophic system (impact of a given limitation on planktonic dynamics), and consequences on carbon fluxes. These data will be simultaneously taken into account, which will permit to better understand the involved processes, from the input of nutrient to the exported fluxes. Reciprocally, measurements of microbial respiration will provide data on the retroaction of seasonal limitations on pCO_2 variations.

Experimental and field data (processes of stimulation of the biological production, of trophic transfers, of recycling, etc.) will provide informations for the conception and development of process models.

Environmental evolutions, in particular anthropogenic perturbations, influence the C:N:P:Si ratios and the abundance of dissolved iron. Results acquired after three years in the present project (including *in vitro* and *in situ* fertilising experiments), completed by the DYFAMED time-series, will feed predictive models.

The characterisation of seasonal situations implies the understanding of the impact of events (e.g., significant atmospheric events) and assimilation processes. The different fields on which studies will focus are:

- *Atmospheric inputs*

Atmospheric fluxes of N, P, Si and Fe will be characterised and quantified, and their temporal variability (event/season) will be assessed. Solubilisation kinetics will be studied, since the physico-chemical form under which nutrients are introduced into the surface layer determines their assimilation by biota.

- *Stocks and fluxes of biogenic elements*

The seasonal succession of nutrient concentrations will be measured in surface waters together with matter fluxes. Ultra-sensitive analytical methods will be used for the stratification period. Vertical profiles will be measured in the water column at the DYFAMED site to assess the distribution of dissolved mineral and organic stoks of N, P, Si, Fe and C.

- *Production*

Primary production (particulate + dissolved) monthly data from the Service d'Observation DYFAMED will be used, as well as specific measurements during monthly campaigns in 2004. New and regenerated production will be measured. Bacterial activity will be measured in the surface water column (0-200 m). The temporal variability of exported carbon fluxes will be studied through monthly data from the Service d'Observation DYFAMED, and through specific measurements during the 2004 campaigns.

- *Biomass*

Seasonal variations of phytoplanktonic biomass (total + specific) will be monthly measured, and also during the 2004 campaigns. Seasonal variations of picoplankton abundance will be studied by flux cytometry, and the genetic diversity of populations will be studied in the water column.

- *DOM-TEP*

The biogeochemical significance of dissolved organic matter (DOM) will be addressed by chemically characterising its high molecular weight (HWM) fraction. The role of different factors that could contribute to seasonal and interannual variations in the production and sinks of this material such as variations in sources (algal and bacterial) in the availability of inorganic nutrients, and the ability of different bacterial species to hydrolyse specific dissolved biomolecules at different depths will be investigated. Transparent Exopolymeric Particles (TEP), which may be a significant source of carbon, and may be a favourable support for bacterial development, will be particularly studied.

- *Assimilation processes*

Although the observed P-limitation in several oceanic zones is due to the biological fixation of N_2, the quantification of this process has not yet been carried out in the Mediterranean. This process will be studied here by ^{15}N measurements. Genetics studies (characterisation of the genus *nifH*) will be complementary. The study of the N_2 fixation process will be carried out in relation with the quantification of other nutrient fluxes, in particular P and Fe.

The relation between nutrient limitation and microbial population diversity will be assessed. This will be studied through experiments based upon the concept of competitive assimilation of phosphate, in case of P-limitation.

The efficiency of bacterial growth will be estimated in the surface layer (0-200 m) by measuring the microbial production and respiration. Heterotrophic metabolism will be studied in relation with particulate organic carbon and dissolved organic carbon fluxes.

- *Fertilising experiments*

On the basis of nutrient atmospheric fluxes measured at the Cap Ferrat sampling station, fertilising experiments will be carried out at the DYFAMED site: LET GO apparatuses (4.5 L) will be spiked and incubated *in situ* with nutrient concentrations calculated from wet atmospheric events. The role of mineral dust (Fe, Si, P) will be also examined through *in vitro* experiments.

- *Modelling*

The processes involved in the successive chemical limitations will be modelled. The data acquired in this project will allow to follow the evolutions of the stoichiometric ratios in the exported material. On the basis of stoichiometric variations, the vertical export of carbon out of the euphotic zone will be constrained by values of i) primary production, ii) heterotrophic respiration, iii) net carbon fixation, iv) chemical composition of the dissolved and particulate exported material (C:N or C:P).

The impact of external inputs of nutrients on P:Si:N:C ratios will be modelled to forecast the trends of a system driven by climate change and anthropogenic activities (e.g., what are the consequences of the evolution of molar ratios on the planktonic populations at the decenal scale?). Neural network models will be used in order to model stochastic processes of the ecosystem.

Continuous atmospheric sampling (Cap Ferrat coastal site, SE France) and monthly campaigns are planned in 2004; 3 seasonal campaigns are planned in 2005; a *in situ* fertilisation (simulation of a natural nutrient-rich atmospheric event) is planned in 2006 or 2007. The MELISSA project gathers 44 persons and 9 French laboratories.