FINAL REPORT PROGRAM LEFE

Program LEFE/ CYBER	Project Title Organic matter dynamics in the NW Mediterranean Sea: Main microbial players and effects for carbon cycling (ODISEA2)	Years 2020-2022
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Context

Understanding the main drivers for dissolved organic matter (DOM) cycling in marine ecosystems will help better understand and predict carbon sequestration in the ocean.

Objectives / scientific questions (2-3 lignes)

ODISEA aimed to describe the seasonal changes in the composition of dissolved organic matter (DOM) in the NW Mediterranean Sea, its changes in bioavailability, and its main biological and environmental sources. We hypothesized that heterotrophic prokaryotes through the microbial carbon pump are the main source of recalcitrant DOM during the stratified summer period.

Main results

We performed monthly sampling (5m to 500m depth) from January 2019 to August 2021 at the MOLA observatory (open ocean, NW Mediterranean Sea, Moose site). This site is regularly visited and sampled for >10 biogeochemical and biological parameters; we added new variables to characterize DOM composition (amino acids, DOM molecular composition, optical properties, stoichiometry) and microbial activities (prokaryotic composition, viral and flagellate abundance, enzyme activities).

One of the parameters measured was DOM molecular composition using ultra-high resolution mass spectrometry via Fourier-transform ion cyclotron resonance (Bouchachi et. al. in preparation) at the Cobra laboratory (University of Rouen). This allowed the characterization of the DOM molecular composition with the molecular formula distribution (3789 molecular formulae on average).

DOM samples from surface and deep waters differed in their molecular composition, withg DOM from surface waters and the summer stratified period being more diverse and enriched in sulfur-containing compounds and double bond equivalents (Fig. 1). These results suggest that during summer stratification, when DOM accumulates in the surface mixed layer, there is a concomitant increase compounds fof different origin and reactivity, but with a relative increase in recalcitrant compounds.

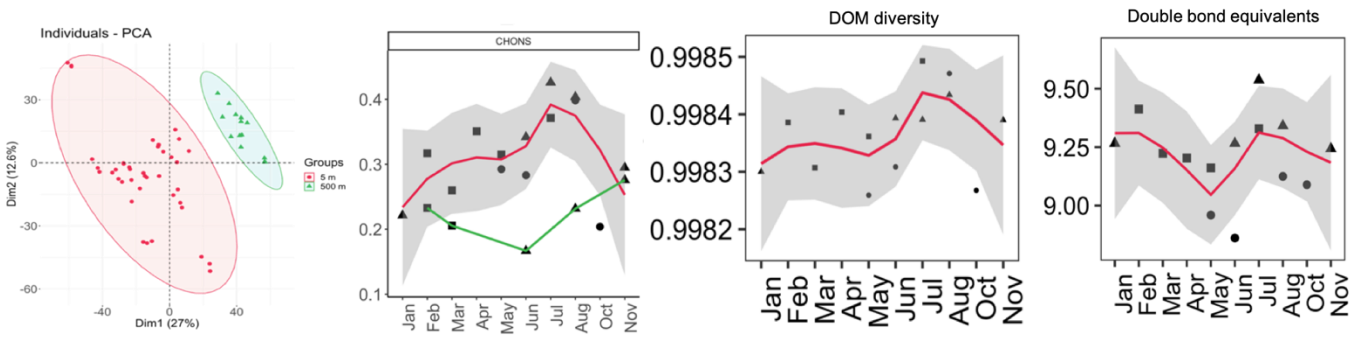

Figure 1. From left to right: Principal component analysis of MOLA samples according to the distribution and relative concentration of DOM molecular formulae after characterization by FT-ICR MS. Red=Surface; Green=Deep. Seasonal variations of DOM compounds containing carbon, hydrogen, oxygen, nitrogen and Sulphur; DOM diversity expressed as the Simpson Index, and double bond equivalents in DOM.

Another way of looking at changes in DOM composition, which allows to distinguish phytoplankton from heterotrophic prokaryotic DOM sources, is to characterize DOM by its d-l amino acid concentration (Von Jackowski et. al. in preparation). In the MOLA time series, the concentration of d-aa was higher in summer (Fig. 2). The temporal dynamics of d-aa were significantly related to temperature and negatively related to dissolved inorganic nitrogen, confirming the higher presence of DOM of prokaryotic origin in the stratified and nutrient-limited period.

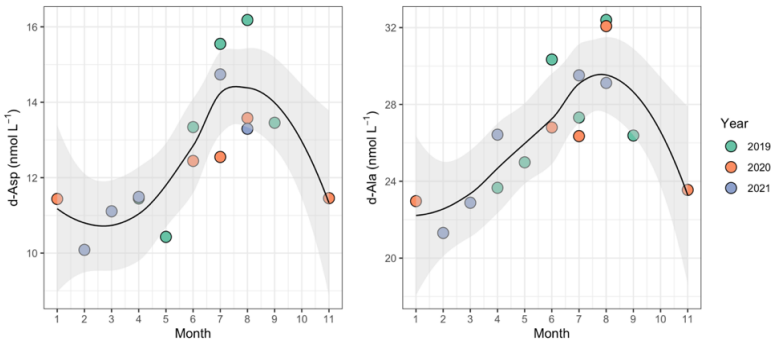

Figure 2. Concentrations of d-Aspartate and d-Alanine withe months in surface waters of the NW Mediterranean Station MOLA. Master 2 Julien Terroire

These results were also in line with our experimental approach: Using model bacterial strains and natural plankton communities from the Mediterranean Sea; we demonstrated a significant effect of P limitation on the quantity and quality of the DOM release, with a predominance of humic-like DOM when communities grow under P limitation (Bouchachi et. al. 2022). When this experimental design was repeated over the year using in situ MOLA DOM and prokaryotic communities, we observed maximum FDOM release rates in spring, when DOM is likely to be enriched in labile substrates but inorganic nutrients are beginning to become limiting. The change in prokaryotic composition may also influence DOM release rates (Masters 1 Cecile Carpaneto-Bastos and Franck Li).Taken together, our results show an important role of nutrient limitation, a condition that is expected to increase due to global warming, on carbon cycling and sequestration by the microbial carbon pump.

Future of the project *:*

All samples taken during the timeseries sampling and experiments have been analyzed, and the different data collected are being processed. Two publications have already been derived from the ODISEA project and other works are planned to be submitted. A new PhD student will be recruited in 2023 and he/she will work on the linkage between all DOM and microbial compartments in MOLA using the data collected during the ODISEA Project. ODISEA is in direct link with the funded ANR JCJC « Micropump » and ANR PRCI "APERO"

Nombre de publications, de communications et de thèses

(citer au maximum 5 publications en lien direct avec le projet)

PhD Thesis: (1) Nawal Bouchachi, PhD Sorbonne Université. 2019-2023. Role of the microbial carbon pump on carbon cycling in the Mediterranean Sea

Master 2 (1): Julien Terroire. Université de Poitiers. Linkage between amino acid composition and microbial diversity across temporal scales in the NorthWestern Mediterranean Sea. July 2022

Master 1 (4):

Publications:

- N, Bouchachi, I, Obernosterer, C, Carpaneto Bastos, F, Li, L, Scenna, B, Marie, O, Crispi, P, Catala, E, Ortega-Retuerta. Effects of phosphorus limitation on the bioavailability of DOM released by marine heterotrophic prokaryotes. Submitted to Microbial Ecology
- Bouchachi, N., Obernosterer, I., Marie, B., Crispi, O. and Ortega-Retuerta, E. (2022), Phosphorus limitation determines the quality of dissolved organic matter released by marine heterotrophic prokaryotes. Limnol. Oceanogr. Lett. doi.org/10.1002/lol2.10287
- Nawal Bouchachi, Barbara Marie, Olivier Crispi, Hélène Lavanant, Isabelle Schmitt-Afonso, Clément Castilla, Maxime Sueur, Carlos Afonso, Ingrid Obernosterer, Eva Ortega-Retuerta. Vertical and temporal dynamics of DOM molecular composition in the NW Mediterranean Sea. In prep

Data availability

Data will be made fully available in the scientific publications.