FINAL REPORT PROGRAM LEFE

Program LEFE/CyBER	Project Title OUTPACE	Years 2018

PI: Thierry Moutin
e-mail: thierry.moutin@mio.osupytheas.fr
Laboratory: Mediterranean Institute of Oceanography (MIO Marseille)

Participating Laboratories:
French (main)
Laboratoire d'Océanographie et du Climat (LOCEAN)
Laboratoire d'Océanographie de Villefranche (LOV)
Others (main)
Woods Hole Oceanographic Institution (WHOI, USA)
Mina and Everard Goodman, Faculty of Life Sciences (Bar Ilan University, Israel).

Contribution to
IMBER (Integrated Marine Biosphere Research project) : letter of support.

Other funding sources:
ANR OUTPACE (ANR-14-CE01-0007-01 PI: T. Moutin)
IRD (Action sud & GOPS PI: S. Bonnet)
CNES (PI: Andrea Doglioli)

Context

The oceanic biological carbon pump corresponds to the transfer of carbon from the upper surface to the ocean interior by biological processes, greatly influencing atmospheric CO_2 concentration and therefore the earth's climate. The strength of the biological carbon pump depends on nutrient availability in the upper ocean, and more particularly on nitrogen availability, which is at long term regulated by external input by N_2 fixation and internal denitrification.

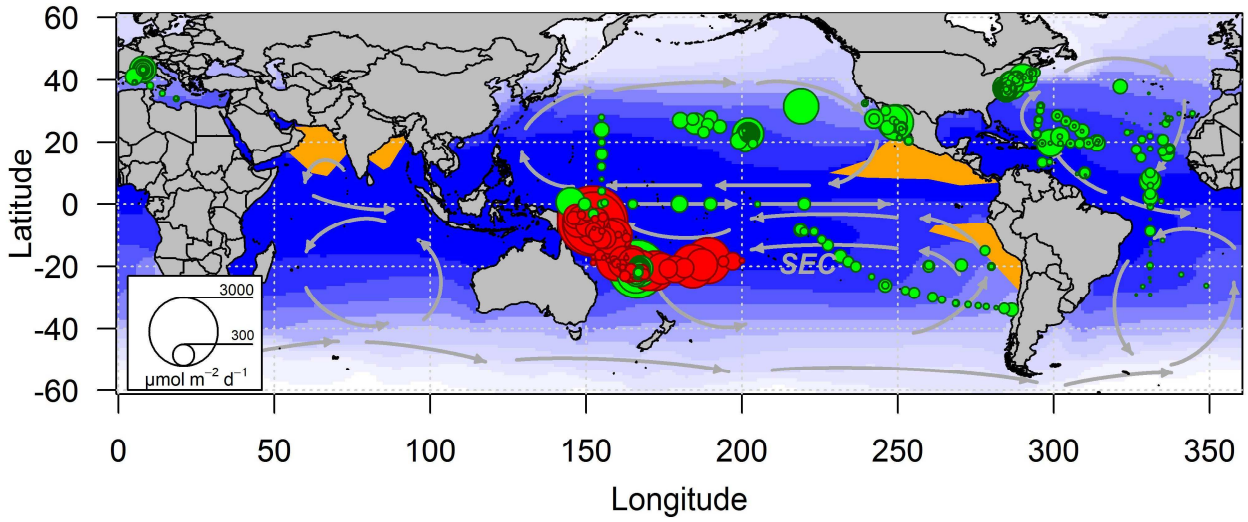
Objectives / scientific questions

The OUTPACE project is organized on three main objectives 1) To perform a zonal characterization of the biogeochemistry and biological diversity of the western tropical South Pacific (WTSP) during the austral summer 2) To study the production and fate of organic matter (including C export) of 3 contrasting oligotrophic environments with a particular emphasis on N_2 fixation, 3) To obtain a satisfactory representation of the main biogeochemical fluxes (C, N, P, Si) and the dynamics of the planktonic trophic network.

Main results

We found a significant biological soft tissue carbon pump in the iron repleted WTSP despite no winter replenishment of surface waters by nitrate. N_2 fixation is the major process introducing the necessary N to sustain the biological soft tissue carbon pump allowing significant atmospheric C input. The WTSP appears as a hot spot of N_2 fixation (figure) and the SP Ocean deserves special attention because of its huge volume of water where the N budget is likely to be controlled by N lost in the east (denitrification) and N gain in the west (N_2 fixation). Our data suggest a prevalent role of hydrothermal sources in suppliying the necessary iron for N_2 fixation in the WTSP. The iron is coming from below rather than from above (atmospheric source) in the WTSP, known as source of iron for the whole Pacific. Changes in N_2 fixation following changes in dust (iron) supply have been suggested to play a central role in explaining past glacial/interglacial changes in CO_2 concentration and earth temperature. It was considered that N_2 fixation on a regional scale would change global nitrogen availability and the biological carbon pump on the time scale of ocean circulation. The direct link between N_2 fixation and carbon export proposed here for the WTSP, hot spot of N_2 fixation, allows for a much closer coupling between N_2 fixation and the biological carbon pump, which may in turn require us to consider changes at shorter time scales like the one associated with climate change. The low P availability may appear as the ultimate control of N input by N_2 fixation and therefore on the efficiency of the biological pump in the MA.

The specific results are detailed in more than 25 papers of a Biogeosciences special issue « Interactions between planktonic organisms and biogeochemical cycles across trophic and N_2 fixation gradients in the western tropical South Pacific Ocean: a multidisciplinary approach (OUTPACE experiment) »Editor(s): T. Moutin, S. Bonnet, K. Richards, D. G. Capone, and E. Marañón, and L. Memery :
https://www.biogeosciences.net/special_issue894.html



Integrated over the photic layer N_2 fixation rates (µmol N m^{-2} d^{-1}) mainly from the OUTPACE cruise (red dots) and from the world's oceans MAREDAT database (green dots). Grey arrows represent schematically the main surface currents. SEC: South Equatorial Current. Orange shaded areas represent the main oceanic OMZs.
Promotional paper for the OUTPACE experiment :
Bonnet, S., Caffin, M., Berthelot, H. and Moutin, T.: Hot spot of N_2 fixation in the western tropical South Pacific pleads for a spatial decoupling between N_2 fixation and denitrification, Proc. Natl. Acad. Sci., 114(14), E2800–E2801, doi:10.1073/pnas.1619514114, 2017.

Future of the project : we are now still deeply working on the large dataset obtained. Some trace metals analyses are still not done. Therefore, we need some time before to propose a future for this project.

Nombre de publications, de communications et de thèses

Most of papers (25) from the OUTPACE experiment will be included in the special issue of Biogeosciences presented below and 19 are already in discussion (*https://www.biogeosciences.net/special_issue894.html*). Other papers (5) were or will be published outside of the special issue.

8 PhD thesis used data from the OUTPACE experiment

The already (February 2018) published papers are :

Benavides, M., Berthelot, H., Duhamel, S., Raimbault, P., and Bonnet, S.: Dissolved organic matter uptake by Trichodesmium in the Southwest Pacific, Nature Scientific Reports, 7, 41315, 2017.

Bonnet, S., M. Caffin, H. Berthelot and Moutin, T. (2017) Hotspot of N_2 fixation in the western tropical South Pacific pleads for a spatial decoupling between N_2 fixation and denitrification. PNAS, doi: 10.1073/pnas.1619514114, 2017.

de Verneil, A., Rousselet, L., Doglioli, A. M., Petrenko, A. A., and Moutin, T.: The fate of a southwest Pacific bloom: gauging the impact of submesoscale vs. mesoscale circulation on biological gradients in the subtropics, Biogeosciences, 14, 3471-3486, https://doi.org/10.5194/bg-14-3471-2017, 2017.

Dolan, J. R., Gimenez, A., Cornet-Barthaux, V. and de Verneil, A. (2016), Community Structure of Tintinnid Ciliates of the Microzooplankton in the South West Pacific Ocean: Comparison of a High Primary Productivity with a Typical Oligotrophic Site. J. Eukaryot. Microbiol. doi:10.1111/jeu.12328

Moutin, T., Doglioli, A. M., de Verneil, A., and Bonnet, S.: Preface: The Oligotrophy to the UlTra-oligotrophy PACific Experiment (OUTPACE cruise, 18 February to 3 April 2015), Biogeosciences, 14, 3207-3220, https://doi.org/10.5194/bg-14-3207-2017, 2017.