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▶ To cite this version:

Sophie Bonnet, Mathieu Caffin, Hugo Berthelot, Thierry Moutin. Hot spot of N 2 fixation in the western tropical South Pacific pleads for a spatial decoupling between N 2 fixation and denitrification. Proceedings of the National Academy of Sciences of the United States of America , National Academy of Sciences, 2017, 114 (14), pp.E2800 - E2801. 10.1073/pnas.1619514114 . hal-01621724

HAL Id: hal-01621724

https://hal-amu.archives-ouvertes.fr/hal-01621724

Submitted on 21 Mar 2019

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LETTER

Hot spot of N_2 fixation in the western tropical South Pacific pleads for a spatial decoupling between N_2 fixation and denitrification

Sophie Bonnet[a,b,1], Mathieu Caffin[b], Hugo Berthelot[b], and Thierry Moutin[b]

Nitrogen (N) is the building block of life. Quantifying the sources and sinks of N to the ocean is essential for predicting its productivity and potential carbon sequestration. In his paper, Gruber (1) seeks for "elusive marine nitrogen fixation" following results from Knapp et al. (2), who measured unexpectedly low N input through N_2 fixation in the eastern tropical South Pacific (ETSP), seriously bringing into question the proposed close spatial coupling between N input (through N_2 fixation) and loss (through denitrification) (3). Here, we compile data from recently published and unpublished studies revealing a hot spot of N_2 fixation in the western tropical South Pacific (WTSP) arguing for a spatial decoupling between N sources and sinks in the South Pacific.

Based on four cruises performed between 2012 and 2015 during austral winter and summer conditions, with a total of more than 600 $^{15}N_2$ incubations-based measurements, and particularly a 4,000-km zonal transect at ~20°S in 2015 (OUTPACE cruise: dx.doi.org/10.17600/15000900), we report N_2 fixation rates of 570 μmol N·m^{-2}·d^{-1} on average over the WTSP (Fig. 1). They are far higher than model predictions for the area (~150–200 μmol N·m^{-2}·d^{-1}) (1) and in the upper range (100–1,000 μmol N·m^{-2}·d^{-1}) of rates gathered in the global N_2 fixation Marine Ecosytem Data (MAREDAT) database (4).

The close spatial coupling between N sources and sinks in the Pacific was hypothesized because denitrification in the oxygen minimum zones (OMZs) creates excess phosphorus (P) surface waters (nitrate-poor but phosphate-rich), that is, potential ideal niches for N_2 fixation. Downstream of the OMZs, surface waters were supposed to gradually lose this excess P through N_2 fixation, restoring the system to a "Redfieldian" balance (3). However, predicted and actual measurements of N_2 fixation in the South Pacific are not in agreement (1): unexpected low N_2 fixation rates are measured in the ETSP (2) and in the South Pacific Gyre (2, 5), and we report here high N_2 fixation rates in the WTSP (Fig. 1). Such a hot spot of N_2 fixation in the WTSP is likely due to the alleviation of iron limitation, a major component of the nitrogenase enzyme that catalyzes N_2 fixation (6), when waters originating from the east reach the WTSP through the South Equatorial Current (SEC) (Fig. 1). Surface iron concentrations are indeed higher in the WTSP [average, 0.57 nM (7)] than in the central and ETSP [~0.10–0.30 nM (8)], where it limits N_2 fixation (9). The WTSP appears to provide optimal environmental conditions for diazotrophs to bloom extensively, but this region deserves special attention to better identify the reasons for such an ecological success.

Such a hot spot in the WTSP sheds light on the elusive marine nitrogen fixation in the Pacific (1) and indicates that this region may play an obvious role in replenishing the Pacific Ocean in N, which could partly counterbalance the N losses in the ETSP.

Acknowledgments

This research is a contribution of the OUTPACE project (dx.doi.org/10.17600/15000900) managed by the MIO funded by the Agence Nationale de la Recherche (Grant ANR-14-CE01-0007-01), the Les enveloppes fluides de l'Environnement (LEFE)-CyBER program [CNRS-Institut National des Sciences de l'Univers (INSU)], the IRD, the Grand Observatoire du Pacifique Sud (GOPS) program (IRD), and the Centre National d'Etudes Spatiales (CNES) (BC T23, ZBC 4500048836), MoorSPICE (DOI: 10.7284/903044), PANDORA (dx.doi.org/10.17600/12010050), and BIFURCATION (dx.doi.org/10.17600/12100100) projects managed by Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) and SCRIPPS Institution of Oceanography, part of the Climate and Ocean: Variability, Predictability and Change (CLIVAR)/Southwest Pacific Ocean Circulation and Climate Experiment (SPICE) International Program, and funded by NSF Grant OCE1029487, Agence Nationale de la Recherche Grant ANR-09-BLAN-0233-01, and INSU/LEFE projects Solwara and SPICEMoor.

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Author contributions: S.B. and T.M. designed research; S.B., M.C., and H.B. performed research; S.B. and M.C. contributed new reagents/analytic tools; S.B. and M.C. analyzed data; H.B. and T.M. added suggestions on the paper; and S.B. wrote the paper.

The authors declare no conflict of interest.

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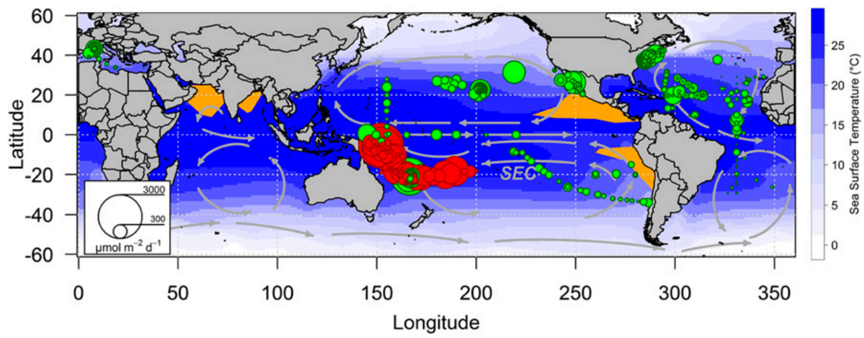

Fig. 1. N_2 **fixation in the world's oceans quantified using** $^{15}N_2$ **incubation-based measurements. Green dots: integrated** N_2 **fixation rates (in micromoles of nitrogen per square meter per day) from the MAREDAT database (4) and Knapp et al. (2). Red dots:** N_2 **fixation rates quantified at 57 stations (WTSP) including data from Bonnet et al. (2015), DOI 10.1002/2015GB005117, using either the** $^{15}N_2$ **bubble addition method or the enriched seawater method (10). To ensure accurate rate calculations, the** $^{15}N/^{14}N$ **ratio of the** N_2 **pool in the incubation bottles was systematically measured. Discrete rate measurements were depth integrated over the photic layer using trapezoidal integration. Gray arrows: main surface currents. SEC: South Equatorial Current. Orange shaded areas: main OMZs.**

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