Biogeosciences Discuss., 4, S2057–S2062, 2007
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Biogeosciences Discussions

Interactive comment on "Phosphate availability and the ultimate control of new nitrogen input by nitrogen fixation in the tropical Pacific Ocean" *by* T. Moutin et al.

T. Moutin et al.

Received and published: 30 November 2007

We would like to thank reviewer 2 for the thorough assessment of this paper. Most of the remarks have been taken into consideration. We apologise for the fact that most remarks were related to information that was referred in the supplementary paper of Raimbault & Garcia (same issue) that was cited but not available at the time of the submission in Biogeoscience Discussion.

AR2: General Comments: In this paper the authors are trying to discuss controlling mechanisms of nitrogen fixation in the tropical Pacific by phosphate availability. The new data which are making the basis of their discussion were obtained during the BIOSOPE cruise to the ultra-oligotrophic South Eastern Pacific gyre. Those new data

were combined with the authors' previous surveys in the North Pacific Gyre and at a station in the South West Pacific for discussion of the subject posted in the title of the paper. The authors major findings from the BIOSCOPE cruise are, to my understanding, high phosphate availability and low nitrogen fixation by organisms other than Trichodesmium in the South Eastern Pacific gyre, and low phosphate availability and high nitrogen fixation (again by other than Trichodesmium) at the both ends of the transect especially in the upwelling area near Chilean coast. Among the above two new findings in this paper, I have major concerns about the N2 fixation rates. The authors measured the N2 fixation by following the 15N method of Montoya et al. But there are two important differences in the method adopted: The authors used only 0.6 liter sample water, and the measurement were done with a low precision mass spec. It is very hard to get reliable isotopic abundance data from insufficient sample gas using a low precision mass spec. This data set is the first of the in situ nitrogen fixation measurement in the very uniquely ultra-oligotrophic region, hence I strongly encourage the authors to reinforce the credibility of the data. I read this paper with difficulty because the logic leading to a rather arm-waving discussion and a conclusion is tangled and not straightforward.

Some sentences and paragraphs are not conclusive, and instead end with speculative statements. The most frustrating thing for me was that the authors do not separate the discussion on nitrogen fixation by Trichodesmium and that by other un-identified organisms. Especially, this paper is presenting the first-ever-measured in situ N2 fixation data which is very unique in the respects; showing contrasting difference from the

distribution predicted by Deutch et al. and that the fixation is not by Trichodesmium. I would suggest the authors to discuss first about the significance of the nitrogen fixation in the South East Pacific gyre, and then discuss the controlling mechanism including P availability etc.

AR2: The authors major findings from the BIOSCOPE cruise are, to my understanding, high phosphate availability and low nitrogen fixation by organisms other than Tri-

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chodesmium in the South Eastern Pacific gyre, and low phosphate availability and high nitrogen fixation (again by other than Trichodesmium) at the both ends of the transect especially in the upwelling area near Chilean coast.

RESP: We modified the abstract to take into account this remark. The N2 fixation measured in the open ocean the Chilean coast was higher than those measured inside the gyre. It is an important result because it is contrary to the recently proposed model of Deutsch et al (2007). Nevertheless, N2 fixation rates remained low compared to those measured in the SW Ocean. These results are not presented as a major finding in this paper, but are discussed in the discussion section.

AR2: I have major concerns about the N2 fixation rates. The authors measured the N2 fixation by following the 15N method of Montoya et al. But there are two important differences in the method adopted: The authors used only 0.6 liter sample water, and the measurement were done with a low precision mass spec. It is very hard to

get reliable isotopic abundance data from insufficient sample gas using a low precision mass spec. This data set is the first of the in situ nitrogen fixation measurement in the very uniquely ultra-oligotrophic region, hence I strongly encourage the authors to reinforce the credibility of the data.

RESP: During the BIOSOPE cruise, uptake rates for 3 forms of nitrogen were performed simultaneously: nitrate, ammonium and diazote. For practical reasons, we chose to work with smaller volumes of water samples but defined a corresponding detection limit. All the procedures are detailed in Raimbault and Garcia, this issue. The dual isotopic enrichment analysis were performed on an Integra-CN mass spectrometer calibrated with glycine references following every batch of 10-15 samples, with a very low detection limit of 3 μg N (0.2 μmoles N, corresponding to that given by the manufacturer). The following relationship was obtained with a PN range between 0 and 150 μg: [Measured PN] = 0.9757[Theoretical PN]+2.7 with r2=0.9955.

The accuracy of our analytical system was regularly verified using reference materials

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from the International Atomic Energy Agency (AIEA, Analytical Quality Control Services), see table 1 in response to reviewer 1.

The mean delta^{15}N does not vary between 0.2 and 10 μmoles N (figures 1 and 2 in response to reviewer 1). The low background of the system enables us to analyse samples containing low nitrogen concentrations (0.2 μmole = 2.8 μg N), values often observed in surface oligotrophic waters.

Finally, the ^{15}N isotope enrichment of a sample is reported in terms of atom % excess ^{15}N or delta^{15}N over time, for the atom% ^{15}N or delta^{15}N in a sample that is not enriched, taken from the same phytoplankton population **and containing the same PN**. Therefore, the value of time zero enrichment is necessary and determined along with the samples (same volume as incubated sample) being filtered immediately after isotope addition. For N_2 experiments, the time zero value, established from 8 samples, was 0.3676 $\pm$ 0.007%.

Due to the natural variation of delta^{15}N (-5 to 158240;), we considered results to be significant when ^{15}N excess enrichments were higher than 0.014 % (twice the standard deviation obtained from time zero samples), equivalent to delta^{15}N = 378240;. Finally, according to the experimental conditions, the detection limit for nitrogen fixation, calculated from significant enrichment (0.014% in excess) and lowest particulate nitrogen (0.2 μmole N) is estimated to be 0.12 nmol.l^{-1}.d^{-1} (for an initial $^{15}N_2$ enrichment R_{N2} $\approx$ 24%).

AR2: Some sentences and paragraphs are not conclusive, and instead end with speculative statements. The most frustrating thing for me was that the authors do not separate the discussion on nitrogen fixation by Trichodesmium and that by other unidentified organisms.

RESP: We have added some additional information on nitrogen fixation by other unidentified organisms in the discussion and have rewritten some sentences in the discussion.

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AR2: This paper is presenting the first-ever-measured in situ N2 fixation data which is very unique in the respects; showing contrasting difference from the distribution predicted by Deutch et al. and that the fixation is not by Trichodesmium. I would suggest the authors to discuss first about the significance of the nitrogen fixation in the South East Pacific gyre, and then discuss the controlling mechanism including P availability etc.

RESP: The complete description of N_2 fixation data from BIOSOPE cruise and its global significance is the scope of Raimbault and Garcia paper in the same special issue (Biogesociences discussion 4, S1419-S1425, 2005). This was cited but not available when this paper was first presented. We showed .the contrasting difference from the distribution predicted by Deutch et al. in order to discuss about the controlling factors of N_2 fixation in the tropical Pacific Ocean. The absence of Trichodesmium spp has been specified in the abstract.

AR2: Specific Comments:

p2422, section 4.1.4 The term "Availability" used here is different from that defined form turnover-time. It is no more than the DIP/DIN ratio.

RESP: Yes, as DIP/DIN ratio, P* is a convenient estimate of the relative availability of P vs N. We added Relative in the title of the paragraph.

AR2: Care should be taken, however, that the trend suggested by Deutch et al (2007) may not directly be reflected in a snap shot observation.

RESP: We added this remark.

AR2: Technical Corrections:

Fig 1. Better to put number of degree on the latitude scale.

RESP: Done

AR2: Fig.2. NO3 concentration could be n-mole, instead of micro-mole.

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Interactive Comment

RESP: The nitrate concentrations are expressed in μM. We have added the isoconcentration 0.05 μM for a clearer understanding of the figure.

AR2: Fig.3. Description of summer and winter symbols are better moved into legends, since it appears in N-Gyre as well.

RESP: Done

Interactive comment on Biogeosciences Discuss., 4, 2407, 2007.