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Discussions

Interactive comment on "Biogeochemical fluxes and fate of diazotroph derived nitrogen in the food web after a phosphate enrichment: Modeling of the VAHINE mesocosms experiment" *by* A. Gimenez et al.

Anonymous Referee #3

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The study of Gimenez et al. aims to model the change in biogeochemical fluxes and the fate of diazotroph-derived nitrogen (DDN) throughout the planktonic food web of the South West Pacific Ocean during a phosphate-enrichment experiment. The model results are compared with and help understand direct observations of the diazotroph role from the VAHINE project where phosphate-enrichment experiments have been carried out in 3 mesocosms near New Caledonia. The model is a 1D vertical box model which accounts for the growth of 2 main types of nitrogen fixers present in this area (Trichodesmium and UCYN-C). The model has one of the most realistic model representation of nitrogen fixation including prognostic equations for enzyme nitrogenase,

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cell quota and a distinction between different temporal diazotrophs ability to protect nitrogenase against O2 damage. Gimenez study presents four main results: (1) diazotrophs (mostly under the form of UCYN) responded with a 10-day delay to the PO4 enrichment, which suggests that traditional short-term nutrient-addition experiments are not long enough to inform on nitrogen fixing dependant community; (2) phosphate addition resulted in a increase in nitrogen fixation which then increased primary production and bacterial production; (3) DDN is mainly found in the dissolved pool (NH4+ and DON) before benefiting the whole planktonic community. After 25 days, 43 %, 33 %, and 15 % are found in non-diazotroph organisms, UCYN-C and DON, respectively; and, finally (4) there is a strong impact of UCYN increase on export production probably via the aggregation of small particles due to TED production, effect on the rest of the food web

This work is the first modelling study that look at the fate of diazotroph-derived nitrogen throught the food web, which is an important aspect of the nitrogen cycle as nitrogen fixation is often recognised as an important source of nitrogen to the ocean, but is rarely quantified and looked through in details. This modelling work is then novel and key for the ocean biogeochemical community. In particular, it focuses on the South West Pacific Ocean, which is one of the highest nitrogen fixing area of the global ocean, and has direct observations to compare the model results with. I thus strongly recommend publication of this work. I have however some reservations related to the 10-day delay model result and how concise the manuscript is currently written.

General comments:

*10-day delay: This is an important result suggesting that there is a 10-day lag between the phosphate enrichment and the increase in diazotrophs. First, it is often confused in the text the response between nitrogen fixation and diazotroph concentration, which needs to be corrected. It is not diazotrophs but nitrogen fixation that responds with a delay. Figure 5 shows that Trichosdesmium and UCYNC increase concentration right after the phosphate addition (when looking at model results). In addition if the authors base their results on nitrogen fixation rate, there is the issue that the model does not match the observations for nitrogen fixation: observed nitrogen fixation rises 5 days after the enrichment (day 10, based on Figure 5), whereas modelled nitrogen fixation rises 10 days after. To conclude that there is a 10-day delay is quite an uncertain result, which needs to be clearly mentioned and discussed. Finally, the text does not describe accurately the results in the model and data: "Since we observed the increase in PP and BP only after 10 days in both experimental and simulation results" (line 537). This is not what Figure 4 shows and should be amend accordingly as well as tone down the conclusion "we may conclude that 10 days are necessary for the newly fixed N by diazotrophs to sustain the observed high production rates, and to see an effective change in the planktonic populations".

*UCYN as the dominant nitrogen fixers: It is not clear from the presented model results (mainly figure 5) that UCYN-C is the dominant nitrogen fixers. I agree that the increase is stronger for UCYN than Trichodesmium, but there isn't enough presented evidence that UCYN explains most of the nitrogen fixation increase (especially considering that Trichodesmium have a larger volume than UCYN). Can you provide more evidence to validate this important point?

*Length of the manuscript: While the structure of the manuscript is good (logical, well-organised), the sections are overall too long with too many not necessary relevant details. This makes the manuscript difficult to follow. I would encourage the authors to shorten the paper as much as possible while staying precise and concise.

Specific comments:

- The 1D model has 14 levels of 1 m each, so represents only the first 14 m of the water column. This seems quite shallow as most places the mixed layer is 50-200 m deep. Can you justify this choice?

- There are too many acronyms making the reading quite difficult. Can you use the full name at the start of a new section at least on the key messages?

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- How do you know that phosphate is not used directly by other organisms and that the increase in PP, Chla is due to DDN?

- Part 4.1: Mismatch between the description of model results and observations

- Figure 6: Units overlapping

- Why if the population growth rate start only at day 5 but UCYN-C are growing earlier?

- Why not include DDA in the model since it looks like they play a big part in the first part of the experiment?

- Can you justify the location of the study in the abstract?

- Line 34: Tone down the "only few" as there are quite a few models now that incorporate state variables for nitrogen fixers. Add some more references.

- Line 43: also DDA were modelled in Monteiro et al. (2010, 2011)

- Line 100: Can you say which boundary conditions were implemented for Eco3M?

- Section 3.1 is a good description of the results, but it needs to be specified more clearly if they are model or data results.

- Line 370: Can you define more what the difference is between specific growth and population growth as important later on to describe the model results?

- Line 378: Define fgrowthTRItrich and fgrowthTri

- Figure 7: Is that the correct initial condition in the sense that there are more TRI than UCYNC? Why TRI never come back even after the PO4 enrichment. Do observations show higher TRI concentration than UCYN?

- Line 423: It is not obvious from the observations (Figure 4a, black diamonds) that there is a decrease in nitrogen fixation. Can you please explain/amend?

- Line 439: "the DIP enrichment resulted in an increase in the abundances of all planktonic groups except PHYL and COP". This is not what the observations show for PHYL.

- Looking at Figure 4, the system looks like it is loosing DIP during the standard model run, a trend not present in the observations. Have you thought about this feature and do you think it might impact your model results (for ex, in relation to TRI, PHYL and COP)?

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