Anonymous Referee #3

Moutin et al.'s study investigates the regulation of the ocean C, N and P fluxes in the western tropical South Pacific Ocean, a key oligotrophic oceanic region for nitrogen fixation. They combine a large new dataset collected during the OUTPACE campaign (February-April 2015) with climatologies of upper water properties. The OUTPACE cruise followed a 4000 km longitudinal transect going from the Melanesian Archipelago (MA) to Papeete (French Polynesia). Comparing seasonal trends of C, N, and P mass balances for 3 main areas of the WTSP, they find that (1) the MA is a net sink of atmospheric CO2, mainly caused by the soft-tissue biological pump; (2) the MA biological pump results from both high rate of N2 fixation fuelling export production and mesozooplankton diel vertical migration; and (3) MA N2 fixation is essentially controlled by phosphate availability.

I think the tackled questions and presented results of this study are really interesting and important and deserve publication. There are lots of uncertainties on the role of nitrogen fixers in fuelling ocean production and export in oligotrophic area especially of the Pacific Ocean due to lack of observations. This region is particular important as covering a large area and presenting high rates of N2 fixation. I thus strongly recommend this work for publication. I have however the following main comments that need to be taken into consideration.

We thank Referee #3 for remarking on the new large dataset obtained and his conclusion that the tackled questions and presented results are interesting, important and deserve publication. We really appreciate the detailed expression of our main conclusions, showing that the diel vertical migrations of zooplankton are only a part of one of the three main conclusions.
In the following paragraphs, the original review comments from Referee #3 are in bold and our responses are interspersed in normal characters.

Main comments

Paper presentation - At the moment the results and the argument for the role of nitrogen fixation and mesozooplankton vertical migration for the atmospheric CO2 sink of the Melanesian Archipelago region are a bit convoluted. While it is nice to follow the steps of thought of the authors on how they come about to find these links, this is done a step too far: for instance, the second half of section 4.3 more or less repeats what is said in section 4.2. I recommend the authors to reorganise the results and discussion to be a lot more concise. This will help following the argument and strengthening the case of the paper.

Following all the comments from the other Referees regarding zooplankton vertical migrations (which, as previously mentioned, was not the primary focus of this paper), and also the recommendation by Referee #3 regarding repetition in the Discussion, we have considerably shortened this part, deleting all sentences in the Abstract and Conclusion concerning this topic, and limiting the Discussion to what we consider to be our main focus. The diel vertical migrations of zooplankton-micronecton during OUTPACE will be the focus of a new paper by C. Menkes and collaborators in the near future. With these changes, we hope to focus the reader's attention on what we consider to be the main message in this paper, the biogeochemical budgets.

To help make a stronger case for the paper, I wonder also if it would be possible to add a diagram that visualises the main processes occurring in the region (N2 fixation, vertical migration of zooplankton, CO2 uptake . . .).

We agree with Referee #3, but the diagram below has already been published in the OUTPACE preface paper (Moutin et al., 2017: https://www.biogeosciences.net/14/3207/2017/). Therefore, we proposed to add (see Moutin et al., 2017; their figure 1) after: The “soft tissue” pump in the new version of the ms. Please note that the vertical migrations of zooplankton were not specifically shown.

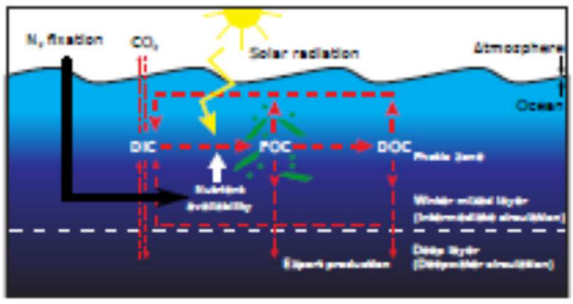

Figure 1. Major C fluxes for a biological pump budget and the main role of N_2 fixation. Biological pump is the C transfer into the ocean interior by biological processes. DIC is dissolved inorganic C, POC is particulate organic C, and DOC is dissolved inorganic C. See Moutin et al. (2012) for a detailed description.

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.

Effect of zooplankton vertical migration - The current manuscript presents the vertical migration of mesozooplankton as an explanation for the missing sink in the upper C budget at WMA. It would be nice to quantify this process either based on other technique or by simply doing a mass balance (which the authors are shying away). MA net sink of atmospheric CO2 - It would be good to quantify the net sink in pCO2 and compare it with other estimates and with other regions.

We now only suggest, in a section of the Discussion and among 2 other hypotheses, a probable role of diel vertical migrations of zooplankton in the transfer of carbon.

Minor comments

P2, L3: Confusing sentence. In my mind mineral refers to carbonate and silicate which is at odd in association with the soft-tissue pump which refers to organic carbon.

We have replaced 'mineral' by 'dissolved inorganic', to avoid confusion.

P3, L35: Can you give slightly more information of the climatology of de Boyer- Montegut et al. (2004)? Mainly the type of collected data and coverage.

The 2° resolution global climatology of the mixed layer depth (MLD) of de Boyer Montegut et al (2004) is constructed from nearly 5 million individual temperature profiles from the following databases: NODC WOD09 from 1941 to 2008, WOCE 3.0 from 1990 to 2002 and ARGO PFL from 1995 to sept. 2008. Profiles with any spurious data in the mixed layer have been removed (about 8% of the total profiles). For each selected profile, a MLD was estimated following the chosen criterion. In our study the MLD_DT02 data were used where the MLD is defined as the depth where the temperatures on the profiles differed from a fixed threshold of 0.2°C compared to the temperature at 10m. The MLD defined on individual profiles were gathered into monthly boxes of 2° latitude by 2° longitude.

For our study, pixels corresponding to each station of the different groups were extracted from the global climatology. Even if the number of existing profiles in the South Pacific Ocean is low, the MLD in the selected pixels were estimated from at least 5 and up to 80 profiles, depending on the pixel and month.

P6, L39: Say in the Figure 2 caption, what the red lines refer to.

We have added: “The vertical red lines indicate the period of the OUTPACE cruise:18 Feb. to 3 Apr. 2015.” in the new version of the ms.

P9, L27: Need to specify that shallow nitracline indicates oligotrophic waters.

We have added: “with shallower nitracline depths » at the end of the sentence.

P12, L35: Can you add the sum of the MA regions so that we can see that the MA area is a net sink of atmospheric CO2?

We have rewritten this and added the mean atmospheric CO_2 input for the MA.

P12, L40: Little bit misleading as the Table 6 and main text do not use the same unit. Can you add in the text the numbers in mol m-2 d-1 as well?

We have modified the ms to use the same unit.

P18, L40: Can you stipulate here if the source of P changes with climate change, how this might affect N2 fixation, zooplankton migration and CO2 sink?

We did not think that the sources of P would change with climate change, but more precisely that the main expected alteration following climate change would strengthen the P limitation. This was developed in Moutin et al., (2008). In other words, the P-limited areas such as the MA, the Sargasso Sea or the Mediterranean Sea, might be extended.

Moutin, T., Karl, D. M., Duhamel, S., Rimmelin, P., Raimbault, P., Van Mooy, B. A. S., and Claustre, H.: Phosphate availability and the ultimate control of new nitrogen input by nitrogen fixation in the tropical Pacific Ocean, Biogeosciences, 5, 95-109, 2008.