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Interactive comment on "Nutrient availability and the ultimate control of the biological carbon pump in the Western Tropical South Pacific Ocean" *by* Thierry Moutin et al.

Anonymous Referee #2

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This manuscript reports upper water column biogeochemical observations from a cruise in the western tropical South Pacific. The cruise programme had a particularly novel finding: elevated rates of nitrogen fixation throughout the Melanesian Archipelago. These results have already been reported: briefly in Bonnet et al. (2017), and in detail in a companion manuscript as part of the cruise special issue in Biogeosciences Discussions (Bonnet et al., in review). The novel contribution of the present manuscript is that an upper water column carbon budget for the region, built from observations on the cruise and longer time series datasets, appears to require an additional fixed nitrogen source other than seasonal entrainment of waters below the mixed layer. They interpret this deficit as originating from the enhanced nitrogen fixation observed

(Bonnet et al., 2017; Bonnet et al., in review). Provided all carbon system calculations are correctâĂŤwhich is not my area of expertiseâĂŤI think the manuscript is of significant interest to the scientific community. I do however have a number of comments that should be addressed.

Main comments:

Clarity of writing. The manuscript requires a large number of corrections for English, sentence structure, and correct terminology. This will much improve the readability of the paper and make it more readily understandable. There were a number of instances where I had to read a paragraph more than once to work out what message the author was trying to convey (and not always with 100% success!). Therefore I would recommend going through the paper in detail with a native English scientist in order to check sentence structure and terminology for simplicity and clarity. I have made some suggestions in the specific comments section, but these are only examples; there are more throughout the manuscript.

The role of Fe. The manuscript argues for a primary role of Fe in enabling nitrogen fixers to become established in the Melanesian Archipelago, but then invoke phosphorus availability as the primary factor controlling the activity of nitrogen fixers. Accordingly, Fe is frequently stated as 'high' (or 'Fe-replete') in Melanesian Archipelago area. Where are the Fe data? The authors do give some values from a paper in review that appear high, however, since this is central to the manuscripts conclusions, some more details are needed to describe how Fe concentrations varied though surface waters of the three regions discussed.

Surface Fe supply from shallow hydrothermal vents is also mentioned, which is very interesting, however as I understand it none of these data are yet published. Regardless, whilst this could significantly influence the overall Fe budget and capacity of the Melanesian Archipelago system for nitrogen fixation, this does not preclude periodically or seasonally low levels of Fe in surface waters of the Melanesian Archipelago.

In other words, what evidence is there that Fe is at high, steady state value in this biogeochemical province? Supplied Fe has a short lifetime in seawater because of rapid scavenging and concentrations following a point source supply diminish rapidly and require continuous inputs to lead to sustained high surface concentrations (such as under the Saharan dust plume in the tropical North Atlantic). Other Fe values reported by Moisander et al. (2011) in the vicinity of the region appear lower than the two values stated.

Sources of fixed nitrogen. Currently the authors use profiles of nitrate concentrations measured during their cruise and climatology of MLD to estimate nitrate entrainment during deeper wintertime mixing. From this they conclude that nitrate input to the surface mixed layer by this process is minimal. Indeed looking at the depth profiles of nitrate (nitracline ~70m depth) and MLD climatology (maximum mixed layer of ~75m) this would appear to be sound. However, in using climatological average mixed layer depths, the authors do not consider periodic entrainment of much deeper waters with much higher nitrate concentrations by transient storms (see, for example, general cyclone passages at: https://en.wikipedia.org/wiki/Tropical_cyclogenesis#/media/File:Global_tropical_cyclone_trac edit2.jpg). What is the role of periodic nitrate entrainment by these deep mixing events that are not characterised by average MLD climatology? It is worth noting that such storms would also entrain DIC into the mixed layer, as well as nitrate, and the net effect on carbon budgets might be low.

What is the mesoscale eddy activity in this region? These have been shown to supply significant N to other oligotrophic waters. Could eddies be supplying additional nitrate? See, for example, Falkowski et al. 1991; Oschlies and Garcon, 1998.

Additional sediment trap sample details. Some details with regards to the type of material found in the sediment traps could be valuable to support the 'mechanistic' discussion with respect to nitrogen fixation-fuelled carbon export. Were significant Trichodesmium colonies found in the sediment traps? Or diazotrophic diatoms? Or zoo-

plankton? Partly related to this, are there any details about phytoplankton community structure determined from HPLC pigment analyses, flow cyctometry, or microscopy? I appreciate that all these details could be in another article in the special issue, but I cannot see it mentioned. More generally the manuscript should be very clear/explicit as to what the new data in this manuscript are, and what is has been published/is in review elsewhere.

More specific comments

ADCP data. These data are mentioned with regards to the zooplankton migration, with implications for sub-mixed layer carbon export. Can we see plots of the data? How were the reported zooplankton respiratory carbon losses to the sub-mixed layer calculated?

DOP and alkaline phosphatase activity. Figure 5 shows significant phosphate available as DOP, even in DIP-depleted Melanesian Archipelago waters. Could the P demand of nitrogen fixers be sustained by DOP access? Was alkaline phosphatase activity measured? Recent findings show that Fe/Zn is required for some dominant forms of alkaline phosphatase and so Fe/Zn availability could also control P access, in addition to N access via nitrogen fixation (Mahaffey et al., 2014; Browning et al., 2017i; Landolfi et al., 2015).

Relative influence of iron and nitrogen in the WGY region. Biologically accessible nitrogen is inferred to be the limiting resource to the overall phytoplankton community in the WGY (western gyre region) (with Fe being the limiting nutrient for diazotrophs). What is the evidence that nitrogen and iron are not directly co-liming to the overall phytoplankton community in this region (Saito et al., 2014; Browning et al., 2017iiâĂŤ both studies through the edge of gyre boundaries)? In the study of Moisander et al. (2011), which was in proximity to the OUTPACE cruise region, a bottle enrichment experiment displayed Fe was serially limiting (following nitrogen) to the overall phytoplankton community, supporting this possibility.

Co-limitation. Co-limitation is not mentioned once in the manuscript but it seems central to the discussion. For instance, iron and phosphorus could co-limit nitrogen fixation (Mills et al., 2004), but iron could also co-limit phosphorus acquisition by the microbial community from the DOP pool, and iron and nitrogen could co-limit the overall phytoplankton community. These interactions and potential for feedbacks are pertinent when hypothesising a role of 'ultimate' limiting nutrients and potential for future change (both topics of this manuscript). To quote Moore et al. (2013; referenced in the manuscript): "Establishing the identity of a single ultimate limiting nutrient may thus be less relevant than understanding the controls on, and feedbacks pertaining to, any given process". Personally I would avoid conclusions/discussion that heavily refer to 'ultimate' limiting nutrients (e.g. Moore et al., 2013; Tyrrell, 1999) as this is more relevant to larger spatial-temporal scales than this dataset can be used for.

Figures. Figures are generally clear but some details to captions need to be added. For example, check that all vertical/horizontal lines in Figs 3–6 are defined in the figure caption (even if defined in the text). Figure 1 (map) is good for detail but not very good for placing the cruise in its wider geographic position. Could an inset map or similar with continents for geographic context be included in addition to the current map? See Bonnet et al. (in review in this special issue Fig 1).

Tables. Currently commas rather than decimal points are used in tables. This could be confusing for some readers. Please change.

Spelling/sentence structure/grammar: see first main point, below are some examples: Pg 2 Line 3: 'deep Sea' → 'deep sea'

Pg 5 Line 41: allowing to draw first-order winter to summer seasonal variations → 'allowing us to draw first-order winter to summer seasonal variations'

Pg 6 Line 10: 'and 2, 3, and 3' → 'and 2, 3, and 4'?

Pg 8 line 23: 'Rapidly, seawater was collected in triplicates from the Niskin bottles in 2.3

L polycarbonates bottles at 6 depths (75 %, 54 %, 19 %, 10 %, 1 %, and 0.1 % surface irradiance levels), like for PP measurements' → 'As for PP measurements, seawater was rapidly collected in triplicate from the Niskin bottles in 2.3 L polycarbonates bottles at 6 depths (75 %, 54 %, 19 %, 10 %, 1 %, and 0.1 % surface irradiance levels).'

Pg 11, line 12: 'Otherwise, very low and improbable P contents were found in the swimmers' → Please be more specific with regards to 'very low' and 'improbable'

Pg. 11 line 37: 'large precipitation' → do you mean rainfall?

Pg 12 line 41: 'Else we need…' → 'Otherwise we need..'

Pg 18 Line 17: 'from an iron limitation in the east' → 'from probable iron limitation in the east'; currently no iron data is given to rule out other potential controls.

Pg. 18 Line 28: 'Furthermore, both diazotrophy and denitrification are known to undergo drastic alterations due to climate change.' → References needed to back up this statement?

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