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Interactive comment on "Tidal and seasonal forcing of dissolved nutrient fluxes in reef communities" *by* Renee K. Gruber et al.

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MS No.: bg-2018-413, Anonymous Referee #3

Referee comments are included below denoted as "Ref3".

Author response to each referee comment is given below the comment denoted as "Authors". Please note that page/line numbers correspond to the revised version of the manuscript rather than the original version. Please also note that this version of the manuscript contains corrections from Referees #1 and 2.

Ref3: The study reports results from measurements of dissolved nitrogen and phosphorus fluxes in a tide-dominated reef. The fluxes were estimated using a one-dimensional control volume method, i.e. nutrient concentrations were measured on

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the reef platform at two points along the flow path of the tidal currents, and from the concentrations changes occurring between the two points, fluxes were estimated. The measurements suggest a release of nitrate, while fluxes of NH4+ and DIP varied between net uptake and release. The results are interesting and produce new insights into the functioning of tide- dominated reefs.

Authors: We thank the referee for their supportive comments and review of this manuscript (ms).

Ref3: A few points need clarification and revision: This is a subtropical environment with healthy seagrass and coral cover. Nutrients in the water column are low and it is surprising that the reef platform with seagrass and healthy coral releases nitrate during low tide. Assuming that during the low water phase photosynthesis of vascular and unicellular plants reaches a maximum, one would expect nutrient uptake of the benthic community resulting in a net uptake.

Authors: Actually, it is common for in situ reef studies communities to measure a release of nitrate. There are many references cited in the Discussion that have also found nitrate release on reefs (p10 L12-16). This is thought to be due to processes such as grazing of benthic filter-feeders and other reef organisms on phytoplankton and detrital remineralisation. To our knowledge, no one has yet conclusively showed why nitrate release occurs, so this is very much an open question! We would guess that this release is not coming from the seagrass community; based on nutrient concentrations at the end of ebb tide (when advection was negligible) shown in Figure 3, nitrate is quite low in the seagrass community. It is important to note that the control volume (CoVo) method provides estimates of benthic fluxes over the length of the transect (thus a function of all ecological communities along the transect), rather than separate fluxes for seagrass and coral communities. This point has been clarified on p5 L22-23.

Ref3: Tidal current vector fields previously published by the authors for this study site (Lowe et al. 2015) revealed that the tidal water in and outflow is not symmetrical, resulting in a residual current entering the reef at its southeastern edge and leaving at its northeastern edge. These residual currents include flows parallel to the reef, which may cause that the two sampling stations measure some waters that took different pathways over the reef platform. It is conceivable that the residual currents transport water with different nutrient concentrations to the two measuring stations and that the observed difference in nitrate concentration between the two stations is a function of the pathways of the residual currents.

Authors: We are confident that ‘current pathways’ are not the cause of the observed nitrate release. The CoVo approach is only used when the direction of flow aligns with the sampling transect (during ebb tide), and not when flow vectors are moving perpendicular to the transect (this is described on p5 L6-8). Nitrate concentrations become most elevated at the end of ebb tide, when flow is very slow $\sim$2 cm/s. During this period, the “local” flux term will dominate our estimates of Jnet, meaning that local processes (nutrient release in the vicinity of the station) are causing these changes rather than advection of water parcels.

Ref3: The reef lagoon appears to be lined by mangrove forest and the seagrass community accumulates organic-rich sediments. The mixed zone between seagrass and coral has pockets of sediment and a porous structure. Could release of fluid from the sediments and the porous structure of the mixed zone explain the nutrient increase during decreasing water level as the path of the residual currents is along the mixed zone? This should be clarified.

Authors: There may be porewater advection occurring on Tallon reef, which we discuss on p10 L16-18. However, we doubt this is the cause of increases in nitrate, as porewater tends to have very low nitrate concentrations (near detection limit). The cause of net nitrate release is most likely the processes discussed in Section 4.2.

Ref3: The tidal range exceeding 8 m is unusual. This is not a typical scenario, which needs to be considered and pointed out when generalizing the results.

Authors: We agree with this comment and have added a new paragraph to the Discussion to help readers understand how our results can perhaps be generalised to other reefs that are tide-dominated but not necessarily macrotidal. See p12 L19-28.

Minor comments.

Ref3: P1L9 a “forcing” is not a “regime”, please rephrase.

Authors: We have rephrased this statement.

Ref3: P1L25 “Reef waters have carbon concentrations that are orders of magnitude greater than nitrogen (N) and phosphorus (P)”. If a ratio close to Redfield is applicable here, C concentrations order(s) magnitudes higher than those of the nutrients can be expected. Benthic communities would not be nutrient limited. If carbon is way higher, please rephrase.

Authors: I'm not sure I understand this comment. P1 L25 is referring to the fact that benthic organisms tend to be N and/or P limited rather than C-limited. The Redfield ratio is a C:N:P ratio that is often used to infer phytoplankton nutrient limitation, and I'm not sure how this is related to the line in our ms?

Ref3: P2L10 “labile dissolved inorganic species”. “Labile” here seems the wrong word as some of these inorganic species can be very stable in the marine environment.

Authors: “Labile” is a term commonly used to refer to NOx, NH4, and PO4, as these nutrient species can be readily utilised by organisms. In contrast, DON and DOP are often called “refractory” meaning less-readily utilised by organisms.

Ref3: P2L16 “turbulent transport” should be added to the list of the controls of nutrient transfer

Authors: This sentence is referring to the relationship derived from fluid dynamics that controls benthic nutrient uptake and is not a ‘list of controls of nutrient transfer’. Later in the ms (Eqns 3 and 4), these relationships are defined mathematically, and do not include turbulence.

P4L8 “reef benthos, which represent the net uptake or release of nutrients”. Please add information on nutrient uptake/release of water column organisms

Authors: This statement has been rephrased (p4 L7-8) for clarity.

Ref3: P4L32 “All nutrient concentrations presented are the mean of duplicate samples” why didn’t you take triplicate samples, which would have allowed calculation of standard deviation, opening up other options for statistical analysis?

Authors: Triplicate samples weren’t part of this study design, as we weren’t attempting to determine statistically whether one nutrient measurement was significantly different to another nutrient measurement. Error estimates, however, are central to this study as described on p7 L14-18.

Ref3: P5L8 How large is the error introduced by using depth-averaged current velocity instead

Authors: Instead of. . .? Depth-averaged current velocity is fairly ubiquitous in studies of shallow water environments.

Ref3: P11L8 If the coral zone is 20% more productive than the seagrass zone (Gruber et al., 2017), one would expect an increasing N consumption during decreasing water level as light intensity at the reef surface increases, with higher N demands in the coral zone. The results suggest the opposite, how is this explained?

Authors: As mentioned above, the CoVo approach gives flux estimates over the full transect (incorporating seagrass and coral communities). This release of nitrate is most likely coming from the reef community, for reasons that are discussed above (phytoplankton grazing and remineralisation) and in detail in Section 4.3 of the Discussion.

Ref3: P11L20 “In a simplified wave-driven reef, offshore (oceanic) water moves from reef crest to back reef roughly unidirectionally. Thus, benthic communities are subjected to the physico-chemical water properties present in offshore waters modified by the communities 'upstream' of them." This should be explained in more detail, as water transported into the reef also has to leave the reef, irrespective of the transport process. This release may traverse the communities that contacted this water before as in the tidal dominated reef.

Authors: On wave-driven reefs, water tends to cross the reef flat and then travel alongshore and eventually exit the reef through channels. This is a well-established transport process (see Monismith, S. (2007): Hydrodynamics of coral reefs, Annu Rev Fluid Mech, 39, 37-55 for more details and references therein). We have added some text (p12 L5) to clarify this.

Please also note the supplement to this comment:
https://www.biogeosciences-discuss.net/bg-2018-413/bg-2018-413-AC3-supplement.pdf

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