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Comment

Interactive comment on “Seasonal, daily and diel N₂ effluxes in permeable carbonate sediments” by B. D. Eyre et al.

B. D. Eyre et al.

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This paper presents a very useful new dataset detailing denitrification rates in permeable carbonate sands. Although the work is somewhat outside my field of expertise, I am satisfied both that the approach is sound and that the results are of potential (global) significance. My main suggestions for improvement of the manuscript relate to a better contextualization of the study in the introduction, some restructuring of the discussion, and a better definition of the parameters derived from the raw flux data. I wish the authors success with their revisions. Comments (Page 17XXX, Line) 438, 16-17: Insert ‘denitrification’ between ‘shelf’ and ‘may’.

Reply: Done

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439, 1-5: The opening sentence is awkwardly constructed. I suggest to include one statement about the importance of nitrogen for system production, followed by another about denitrification being responsible for the removal of nitrogen from a system.

Reply: Not changed as we feel it reads OK

There are a few multi-clause sentences throughout the manuscript. I will highlight some of these but maybe the authors can read through again from the perspective of a nonnative speaker and simplify a few things.

Reply: Comment

439, 23-24: Given the importance of advection to denitrification rates, I would suggest to expand a little here on the mechanism of this relationship. I realize this is dealt with in Eyre et al. (2008) and included at the end of Section 4.3 but an earlier elucidation would assist the non-specialist reader.

Reply: We don't feel this level of simplification is required for a technical journal such as Biogeosciences

Introduction (general): The study uses multiple flux measurements to estimate not only denitrification rates but also (aerobic) respiration rates and the efficiency of coupling between respiration, nitrification and denitrification in carbonate sands. The introduction should provide some context for these further aspects of the study.

Reply: As the focus of this manuscript is on denitrification we feel adding this type of introductory material would be distracting.

I would also find it very useful to see a simple table detailing the potential reactions and transport processes involving N species in these sediments (N₂ fixation, ammonification, nitrification, denitrification, nitrogen storage by bacteria, advective pore water flow) which could be referred back to in the discussion. The table could include an indication of which processes are expected to be active by night and by day.

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Reply: We don't feel this level of simplification is required for a technical journal such as Biogeosciences

Section 2.3 (general): This section describes some calculations used to convert flux data to rates of sedimentary redox reactions, but it is incomplete. I would like to see a more logical and comprehensive introduction here of several concepts discussed later in the manuscript. In particular, a single clear description of all 'second order' parameters derived from the data is crucial for the logical progression of the paper. Presently, Gross Primary Production (GPP) and Net Primary Production (NPP) are defined in the caption of Fig. 1, while 'remineralization ratios' (451, 2) and 'denitrification efficiency' (452, 22) are only defined in the discussion. I suggest to include a table with a system of equations showing how measured fluxes are converted into reaction rates, and how these are then combined to estimate efficiencies etc.

Reply: GPP, NPP and respiration are defined in the methods because they are referred to in the results. Denitrification efficiency and remineralisation ratios are defined in the text when discussed which we consider is appropriate. We don't believe a table is warranted.

Furthermore, I am not fully aware of the conventions in this field, but I would usually expect to see parameters such as GPP, NPP and respiration reported in terms of moles of carbon, rather than oxygen. If this was done, it would make the subsequent discussion of substrate C:N ratios easier to follow.

Reply: We have added "It was assumed that the photosynthetic quotient (PQ) and respiratory quotient (RQ) = 1" to the methods"

446, 20: Try to avoid referring forward in the manuscript if possible.

Reply: Comment

447, 3: Insert 'by' between 'measured' and 'Eyre'.

Reply: Corrected

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9, C8597–C8601, 2013

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448, 5-10: Is it possible to illustrate graphically the relationship between light availability and NPP?

Reply: This is only a minor part of the discussion and not worthy of a figure.

450, 1-17: The opening sentence of this paragraph is too long. I would suggest to deal with one potential interpretation at a time, rather than listing the full set.

Reply: Because the relationship between benthic respiration and dark N₂ efflux may be due either, or a combination of, these factors we consider it appropriate to list them at the start of this discussion

Similarly, I suggest to break paragraphs between the discussion of different processes, e.g., a paragraph break can be inserted on Line 11. This principle can be applied throughout the discussion.

Reply: If we did this we would end up with a mixture of very short and longer paragraphs. We have tried to keep the length of paragraphs similar.

450, 18 and 453, 9: The system is described first as an 'oligotrophic coral reef environment' then as a 'shallow productive environment'. I suggest to rephrase with more consistent terminology.

Reply: Coral reefs are both oligotrophic and productive, so both phase are appropriate.

451, 2/22: By N-N₂ I think the authors mean N₂-N, or nitrogen in the form of dinitrogen.

Reply: Corrected

Is that correct? In any case, I suggest to remove these definitions from the discussion and include as clearly as possible in the methods section (see above).

Reply: Denitrification efficiency and remineralisation ratios are defined in the text when discussed which we consider is appropriate.

452, 22: In this definition, 'DIN' is used in place of NH₄ + NO_x. Again, this needs to be

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Discussion Paper



more consistent and all acronyms need to be clearly defined.

Reply: DIN replaced with NH_4^+ + NO_3^-

453, 21-22: As no data are presented for nitrogen fixation, or uptake of nitrate/ ammonium by benthic microalgae, it is not possible to state that one is more likely than the other as a mechanism for explaining the low dinitrogen effluxes during daytime.

Reply: We changed the wording slightly by adding “Alternatively,” to give more equal weighting to the two possibilities.

If the authors believe benthic nitrogen fixation to be a real possibility, are there any references which can be used to support this (e.g. by indicating which benthic species may be responsible)?

Reply: We give references for N-fixation in coral reef sediments. We simply discuss that these rates may be too low due to methodological issues, not that it's a new process.

455, 20: The last sentence sounds incomplete to me. Maybe add

Reply: ‘should be investigated’ was added.

Figures: I would urge the authors to check the labeling and captions of all figures after restructuring the methods section as suggested above. E.g. Figure 1 panel 2 should report either O_2 fluxes (in mol O_2 per area per time) or, in processed form, net benthic primary production (in mol C per area per unit time).

Reply: We have added “It was assumed that the photosynthetic quotient (PQ) and respiratory quotient (RQ) = 1” to the methods” to remove ambiguity over C and O_2 fluxes.

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9, C8597–C8601, 2013

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