

## ***Interactive comment on “Is dark carbon fixation relevant for oceanic primary production estimates?” by Federico Baltar and Gerhard J. Herndl***

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### **Reviewer #1**

1. Reviewer General comments The manuscript mentioned above by Baltar & Herndl estimates the importance of dark carbon fixation (e.g. chemoautotrophic production plus anaplerotic reactions) in carbon budgets in the ocean. Authors use a novel approach to interpret routinely measured data, such as dark bottle incubations used for primary production estimations, to calculate dark carbon fixation rates. Interestingly the two datasets studied show a) that dark carbon fixation estimates are equal to 2.5 - 22% of the phototrophic carbon fixation, b) there is a seasonal effect on the ratio of dark

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and light carbon fixation, especially for one site and, c) nitrification accounts for only a minor proportion (2-9%) of the total dark carbon fixation. These results are of relevance because they clearly show that dark carbon fixation in the euphotic layer can substantially increase the PP estimates. This estimated dark carbon fixation corresponds to a production of 1.2 to 11 Pg C y<sup>-1</sup> which scales well with the carbon respiration fluxes reported for ocean sediments and the dark ocean. Thus dark carbon fixation rates should be considered in future carbon budget studies of the ocean. Furthermore, the fact that nitrification plays a minor role in carbon cycling in the euphotic ocean suggests that the major sources of dark carbon fixation are unknown and deserve further study. In general, I find the manuscript well prepared and related work is well credited. To my knowledge, the methodology used is sound and I find no reason to doubt the interpretations of the data. I therefore recommend publication of the manuscript with minor corrections.

Comment: We honestly appreciate the positive comments and the support of the reviewer.

2. Reviewer Specific comment The results indicate that nitrification explains less than 10% of the total dark production. The Authors thus state that other chemoautotrophic processes (different from nitrification) and heterotrophic processes (anaplerotic reactions) should account for the remaining 90%. Assuming anaplerotic reactions account for 30% of this dark carbon fixation (line 72), then more than half of the activity remains un-assigned to a specific process. I ask the Authors to briefly discuss or present a specific hypothesis as to which other autotrophic processes may be involved, or suggest methods that can be used to unravel the sources of this unknown dark carbon fixation activity.

Comment and action: That 30% the reviewer mentions (former line 72), refers to the total carbon incorporated into biomass (including the heterotrophic incorporation of carbon typically measured via the <sup>3</sup>H leucine incorporation), but not 30% of the dark fixation specifically. In other words, that 30% refers to the comparison between the

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amount of carbon fixed via DIC fixation (measured by dark  $^{14}\text{C}$  incubations) relative to the amount of carbon incorporated into biomass (measured by  $^3\text{H}$ -leucine incorporation). In any case, we agree with the reviewer it is a good idea to include some more information on it, so we have included new text suggesting potential sources of dark carbon fixation (p.5, l.165-166); it reads: "This could include aerobic anoxygenic photosynthetic bacteria (AAnPB), and oxidizers of nitrite, carbon monoxide, sulfur, etc (Hügler and Sievert, 2011)."

3. Reviewer Technical corrections Abstract: Choose one term throughout the text for consistency: "dark carbon fixation", "dark DIC fixation" or "dark  $\text{CO}_2$  fixation".

Action: Done.

4. Reviewer Line 59: text states "citation on light sensitivity" please include reference.

Action: Done.

5. Reviewer Line 114: please state actual maximum value instead of ">2.5".

Action: Done.

6. Reviewer line 122: replace "sigma-t" with "density ( $\sigma_t$ )" ; after "[...] same period" add "Fig. 2)."

Action: Done.

7. Reviewer Line 123: change "(Fig 2)" to "(Fig 2C)".

Action: Done.

8. Reviewer Line 123-125: When explaining the seasonality observed at Bats for the dark to light carbon fixation ratio the Authors mention a deepening of the deep chlorophyll maximum but do not explicitly describe how this affects the calculated ratio. I ask the Authors to rephrase these sentences so that the readers can clearly understand the connexion that is currently implied in the text.

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Action: We have explained this now in the text (p.4, l.132-135); it reads: "Thus, this relative decrease in chlorophyll-a (and PP) relative to the dark DIC fixation might explain the increase in the dark to light DIC fixation ratio in recent years, while also suggesting that autotrophic DIC fixation seems more sensitive to a deepening of the mixed layer than dark DIC fixation."

9. Reviewer Line 136-149: include a reference to Table 1 to guide the reader through the calculations.

Action: Done.

10. Reviewer Line 138: change "[. . .] by (Yool et al., 2007)" for "[. . .] by Yool et al. (2007)".

Action: Done.

11. Reviewer Line 139-140: state the  $\text{NH}_4^+$  values taken from Segura-Noguera MM et al 2014 and Lipschultz 2001 to estimate nitrification either in the text or in table 1.

Action: Done.

12. Reviewer Line 141: Dore & Karl are written twice. Correct reference.

Action: Done.

13. Reviewer Line 156: "during over the diel cycle" please correct wording.

Action: Done.

14. Reviewer Line 158-159: add a reference to Table 1.

Action: Done.

15. Reviewer Line 163: add citation for the concept that nitrification is reduced in light.

Action: Done.

16. Reviewer Figure 1: keep the same range for the ratio for both plots, from 0 to 3, so

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that the colour scheme is the same.

Comment: Done.

17. Reviewer Figure 2: remove names from plots (upper right corner) or write correctly (not Temp but Temperature).

Action: Done.

18. Reviewer Table 1: last column “% of dark DIC fixation from other chemolithoautotrophic and anaplerotic processes to total PP” is not explained or referred to in the text for either site. Please erase from table. Change “chemolithoautotrophy” for “chemoautotrophy”.

Action: Done.

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