

Biogeosciences Discuss., author comment AC3
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Reply on RC3

Frédéric Gazeau et al.

Author comment on "Impact of dust addition on the metabolism of Mediterranean plankton communities and carbon export under present and future conditions of pH and temperature" by Frédéric Gazeau et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-20-AC3>, 2021

We would like to thank Anonymous Referee #3 for her/his comments and suggestions on our manuscript.

In this manuscript, Gazeau and colleagues present a significant work about metabolism adaptation of Mediterranean phytoplankton to dust fertilization, under present conditions and in an acidified future ocean enriched in CO₂, with a substantial very new data set. They also provide new insights about particle export in this context, that are a precious contribution for modeling. The paper is well organized, but quite long with a lot of concepts that make it a little bit hard to follow. It does not help to clear the main ideas and conclusions easily. The paper is recommended for publication, also minor changes should be considered before this, that are listed below.

First, a table of the abbreviations would be very helpful.

This is not a problem to add such a table. However, we do not think our manuscript contains too many abbreviations to justify a table. We will rely on the editor's opinion for that matter.

L57 and 59: more recent references are needed

Although we think that those references are accurate and pertinent, we added two other references: Field et al. 1998 and Carr et al. 2006

L59: same sentence as in the abstract. Not a problem but not very elegant.

Sentence has been modified: "Atmospheric dust fluxes represent a significant source of these nutrients to surface waters in LNLC regions and as such could play a significant role in stimulating primary production".

L76: if I understand correctly the metabolic balance is not enough to draw conclusions about the biological pump, the NCP can only provide information about surface water, not about what happen at greater depth, therefore you can't really constrain the efficiency of the export from this only.

The reviewer is correct and the sentence has been modified to : "The metabolic balance (or net community production, NCP) is defined as the difference between gross primary production (GPP) of autotrophic organisms and community respiration (CR) of both autotrophic and heterotrophic organisms, revealing the capacity of surface waters to absorb atmospheric CO₂."

L80: Please add more general references. This is two very local studies.

We replaced these references by a recent review paper (Desboeufs, 2021 in press) dealing with atmospheric inputs at the scale of the whole Mediterranean Sea.

L136: it would be great to have a quick summary of the paper

We could add this sentence : "A companion paper presents the general setup of the experiments and the impacts of dust under present and future environmental conditions on nutrients and biological stocks (Gazeau et al., 2020). In this paper, we show that the effects of dust deposition on biological stocks were highly different between the three investigated stations and could not be attributed to differences in their degree of oligotrophy but rather to the initial metabolic state of the community. We further demonstrated that ocean acidification and warming did not drastically modify the composition of the autotrophic assemblage with all groups positively impacted by warming and acidification.

L158: when were the last dust events in the three areas?

As discussed further in the paper (L628 and section concerning impact at TYR), only the TYR station encountered a dust deposition prior to the cruise. For the other two sites, there was no evidence from dust forecasts (observations and models: see PEACETIME Operation Center (<http://poc.sedoo.fr/>)) that an event occurred at least three weeks

before the sampling.

L168: please do a quick summary of the experiment: why these concentrations, what is the composition of the dust? Does it reflect a pure lithogenic input, does it have an anthropogenic component?

This will be added in this paragraph: "Briefly, the fine fraction (< 20 μm) of Saharan soils collected in southern Tunisia, which is a major source of dust deposition over the northwestern Mediterranean basin, was used in the seeding experiments. The particle size distribution showed that 99% of particles had a size smaller than 0.1 μm , and that particles were mostly made of quartz (40%), calcite (30%) and clay (25%; Desboeufs et al., 2014). This collected dust underwent an artificial chemical aging process by addition of nitric and sulfuric acid (HNO_3 and H_2SO_4 , respectively) to mimic cloud processes during atmospheric transport of aerosol with anthropogenic acid gases (Guieu et al., 2010a, and references therein). To mimic a wet flux event of 10 g m^{-2} , 3.6 g of this analog dust were quickly diluted into 2 L of ultrahigh-purity water (UHP water; 18.2 $\text{M}\Omega \text{ cm}^{-1}$ resistivity), and sprayed at the surface of the tanks using an all-plastic garden sprayer (duration = 30 min). The intensity of this simulated wet deposition event (i.e. 10 g m^{-2}) represents a high but realistic scenario, as several studies reported even higher short wet deposition events in this area of the Mediterranean Sea (Bonnet and Guieu, 2006; Loÿe-Pilot and Martin, 1996; Ternon et al., 2010)."

L201: what is the percent of agreement between the replicates? Did you do some blanks?

L213: Same as above for TCHO, percentage of agreement between replicates and blanks?

This was added to the section. For TCHO, the variation coefficient between duplicate measurements was 7% on average. For TAA, the variation coefficient between duplicate measurements was 8% on average. For TCHO and TAA, instrument blanks were performed with MilliQ water. The detection limit was calculated as 3x the blank value, which is $\sim 1 \text{ nmol L}^{-1}$ for both parameters.

L215: how did you choose the different times of sampling for the different parameters and following which criteria did you chose to end the experiment?

Several aspects had to be considered when defining the sampling times for each parameter: (1) the amount of water needed, as we did not want to have a final (before the last sampling) volume in the tanks of less than 50% of the initial volume, (2) the time needed to process the samples (or perform incubations for processes), and (3) obviously the analytical costs (both human and pecuniary).

Regarding the duration of the experiments, we have added this in the revised version of the companion paper. From Gazeau et al. (2020, BGD): "The experiment at stations TYR and ION lasted 72 h (3 days) whereas the last experiment at station FAST was extended

to four days. This relatively short duration of the experiments was constrained by the time available between stations and the time needed to properly clean the tanks between the experiments, following the protocol described by Bressac and Guieu (2013). As a larger time window was possible at the end of the cruise, the experiment at FAST was extended to four days."

L225: Does the measures of the two filters agree? Did you do several measures on the same filter? What does the blank represent compared to the samples?

For TEP, the variation coefficients averaged 28%. All TEP values have been blank corrected. Blanks were always <1% of sample values. This was added to the section.

L239: "compared to" instead of "then" I think

Modified to, following R#4 suggestion: "Bottles were incubated for 8 h in two extra 300 L tanks maintained under similar light and temperature regimes as in the experimental tanks"

L254: did you do some blanks and replicates? What is the standard deviation associated to the measurement?

Yes, we performed triplicate measurements in the light and one in the dark. From the submitted version: "From each tank, four polystyrene bottles (70 mL; three light and one dark bottles) were filled with sampled seawater and amended with 40 μCi of $\text{NaH}^{14}\text{CO}_3$."

Standard deviations are shown in Fig. 4.

L282: same as the precedent comment

Due to the amount of volume necessary (2 L), no replicated sampling could be done. Corrections were made from blank measurements that were performed on pre-filtered seawater from the tanks.

L301: according to your first definition it's an addition not a difference

We disagree. As mentioned in the text : NCP and CR were estimated by regressing O₂

values against time, and **CR was expressed as negative values.**

Therefore, $NCP = GPP + CR$, and $GPP = NCP - CR$

L343: Have you measured Na to check if the salt was correctly removed and does not contribute significantly to the weight?

To remove the salt, the JGOFs protocol was followed (Knap et al., 1996). That protocol has been used routinely by the Service National de la Cellule Pièges for more than 30 years. The protocol has been established to remove all Na from seawater.

L345 to 356: please quantify the blanks, agreement between replicates and the standard deviation

The blanks were 1.1 % of the average concentration of the sample (thus negligible), replicates agreement was on average 0.3 - 2.3 % (and no standard deviation as we analyse only 2 aliquots over the 3 when the 2 first measurements agree (<5% difference) and that was the case for all the samples analysed in this study.

L356 to 358: please provide the references those ratios come from

Klaas and Archer, 2002

Klaas, C., & Archer, D. E. (2002). Association of sinking organic matter with various types of mineral ballast in the deep sea: Implications for the rain ratio. Global Biogeochemical Cycles, 16(4), 63-1.

L598: it would help to have a graph of comparison in the supplementary

We do not think that having a plot containing 3 points would be very useful.

L631: it would be better to do a citation, it is well-known that dust events provide Al

We believe that giving the in situ evidence that a large dust deposition occurred a few days before the TYR station was occupied is more pertinent. The citation is now: Bressac et al., in rev. 2021 (Bressac, M., Wagener, T., Leblond, N., Tovar-Sánchez, A., Ridame,

C., Albani, S., Guasco, S., Dufour, A., Jacquet, S., Dulac, F., Desboeufs, K., and Guieu, C.: Subsurface iron accumulation and rapid aluminium removal in the Mediterranean following African dust deposition, *Biogeosciences Discuss.* [preprint], <https://doi.org/10.5194/bg-2021-87>, in review, 2021.)

L808: maybe add a quick summary

Agreed. "Gazeau et al. (2020) have already discussed temperature/pH mediated changes in nutrient uptake rates and autotrophic community composition in these experiments. Briefly, they showed that warming and acidification did not have any detectable impact on the release of nutrients from atmospheric particles. Furthermore, these external drivers did not drastically modify the composition of the autotrophic assemblage with all groups benefiting from warmer and acidified conditions. Here, we showed that the difference in the response of plankton community metabolism to dust addition under present and future conditions of temperature and pH was highly dependent on the sampling station (Fig. 9)."

L784: you can cite studies on the ballast effect, of P. Lam for example

We added a sentence to refer to some key papers about ballast effect.

L894: you could highlight better how useful your work can be for modeling

We added a short paragraph at the end of the conclusion about the possible link with models.(see reply to RC1).

L1282: Please add the dates of the cruise in the caption, the latitude and longitude on the map, the color bar for the bathymetry you represent. Enlarge the numbers of the station, as your study is part of a larger work it will help to compare with other publications.

We actually have changed the figure to be consistent with the one shown in the companion paper. Latitude and longitude are now displayed. The dates of the cruise have been added to the caption.

The other figures are tiny and hard to read, except figures 5 and 8. Please enlarge the titles of the axis, especially the time. When you have several panel (in figure 4 or 6 for example), it would be better with letters for the different panels.

Unfortunately, we cannot increase label sizes as otherwise labels from the different panels would overlap. However, we strongly believe that the fact that figures were tiny in the submitted version of the manuscript is linked to the portrait setup of the pages, this will be modified in the revised version.

If not included in the points and if possible include the error bars on figures 2,3,5,7,8.

We cannot provide error bars for parameters for which only two measurements were done. This is the case for DOC and AA (Fig. 2) and for TEP (Fig. 3). No replicated analyses were done for POC (Fig. 3), 13C-POC (Fig. 5) and for export (Fig. 8). We have added error bars to Fig. 7, thanks for detecting the oversight. Please note that for parameters which were analysed in duplicates, the correspondence between these duplicates has been added in the Material and Methods following the reviewers' advice.