Biogeosciences Discuss., 10, C8116–C8125, 2014
www.biogeosciences-discuss.net/10/C8116/2014/

Biogeosciences Discussions
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Interactive comment on "Plankton community response to Saharan dust fertilization in subtropical waters off the Canary Islands" *by* G. Franchy et al.

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Received and published: 21 January 2014

This article attempts to assess the effect of Saharan dust deposition on the planktonic community of the subtropical northeast Atlantic. In this area, atmospheric dust events are frequent but their influence on marine biota is poorly known. To our knowledge, only the work by Neuer et al. (2004) presented field data to assess this question in the area. As we pointed out in the Introduction, the majority of the results are based on experiments or satellite estimations, not only in the Atlantic but also in other areas. For this reason we think this article could contribute to improve our knowledge about the actual effect of the dust deposition in the field.

In order to better describe the contents of the article and taking into account the comments of the two referees, we have considered changing the title for “Plankton community response to Saharan dust deposition in subtropical waters off the Canary Islands”.

Reply to Anonymous Referee #2

"In a general way, I am not sure that the effects of dust deposition on plankton community might be investigated at 20 meters depth, which can be too deep to see a direct effect of dust deposition on biological dynamics of the surface layer."

According to the literature, neither the time of biological response nor the depth to which this response could be found after a dust event is well established. Regarding to the vertical extent of the response, it is difficult to know until what depth is the planktonic community affected as the response in the field has been measured from satellite data in many cases. However, it seems that the effect of dust deposition is not limited to surface waters according to some results. The increase in POC concentration in the north Pacific measured robotically by Bishop et al. (2002) reached 40 meters depth. In the East Mediterranean the effect of a dust storm was measured up to 40 meters for Prochloroccocus and in the first 15 m of the mixed layer for chl a and heterotrophic bacteria (Herut et al., 2005). Therefore, the depth (20 meters) of the sampling is also suitable for the intended objective of this work as planktonic communities could be affected not only in the surface waters, but deeper in the mixed layer. The discussion of this point has been included in page 17287.

"Data of nutrient concentrations are lacking. I think that there is a need to present them in this paper. Indeed, the objective of this study is the role of fertilization on plankton community."

Data on nutrient concentration in the mixed layer were not available for the whole period, but some measurements were performed during the sampling (Benavides et al., 2013). We think that these data besides hydrographic sections presented here and the knowledge about nutrient dynamics in the area indicate that it is unlikely a substantial

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nutrient input through physical mixing during the studied period. Furthermore, high values of nitrate+nitrite and phosphate (> 0.5 μM) were measured even in May (see Benavides et al., 2013), a typically stratified period with low nutrient concentrations (<0.1 μM nitrate+nitrite, <0.05 μM phosphate) in these waters (Neuer et al., 2007). On the other hand, the release of nutrients (nitrate, phosphate and iron) from Saharan dust has been demonstrated as it is discussed in the text (e.g. Bonnet et al., 2005; Herut et al., 2005). The magnitude of the nutrient release from dust deposition and the effective increase of their concentration in the mixed layer is a complex process. It depends on a wide variety of abiotic and biotic factors (e.g. interaction with organic ligands, particle aggregation, microbial uptake) and it is not totally understood yet. In this work we cannot directly demonstrate the link between dust deposition and seawater nutrient concentration. However, as we have discussed here and in the article, there are enough evidences (atmospheric suspended matter, hydrographic data and seawater nutrient concentration) that strongly support that the intense atmospheric dust deposition during the period studied promoted the high nitrate and phosphate concentrations in the mixed layer. Nevertheless, we have modified the text from line 18 in page 17286 to line 9 in page 17287 in order to improve the discussion in this regard.

"I suggest the authors to homogenize the presentation of the data set"

Surface temperature before February 2010 was showed (fig. 2) to exclude the possibility that the winter cooling would take place before the beginning of the sampling. In the case of suspended matter (TSM) and atmospheric metal concentration (fig. 3) we wanted to show data since January to show how less intense dust events (January) could release iron concentrations as high as the intense dust event observed in March.

"The Fig. 3 is interesting, showing the different dust inputs during the sampling period. However, this study only presents the impact of one of these (the greatest input observed in March). I think it is a pity that the authors did not investigate/present the effects of the different inputs on the plankton community. However, the other inputs are not very clear to me. I am not sure that the TSM peaks are significant."

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The high frequency and less intensity of the other events identified make it difficult to study the potential effect upon the planktonic community. The signal of these smaller events would be less clear and could be easily masked by biological uptake and trophic interactions. Thus, we decided to focus on the highest event because its potential influence upon planktonic community would be higher and, actually, a clearer signal was observed.

"Did the authors analyze the heterotroph prokaryotic community (included into the flow cytometry data set)? I think that it can be useful to integrate this compartment to the present work (there are different papers on the bacterial responses to dust input in the surface waters)."

Yes, we did. Heterotrophic prokaryotes were discriminated from its DNA content (LDNA or HDNA) from flow cytometry analysis. However, we considered the total heterotrophic prokaryote cells to evaluate possible differences in the response to dust deposition.

"Also, I suggest to report the metal data concentration on the TSM concentration since it appears from the Fig. 3 a huge heterogeneity in the metal content (and so, type?) of dust."

We do not understand this comment as metal concentration has been measured from total suspended matter (TSM).

"The Fig. 5 is not clear, too much lines are present on the plots. I also suggest to present the sum of picophytoplankton biomass (APE+Syn+Pro)."

Taking into account the differences in the temporal evolution of cyanobacteria and APE we consider that it is better to present these data as we did. Furthermore, it is consistent with other figures in which these three groups were considered separately.

"P 17280, lines 13-17. I am sceptical on the reason why fluorescence and Chl.a concentration were not correlated during the May-June sampling period. I don't think so that the reason was the fluorometer (it should be a great problem in this case!), but

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much more a problem of environmental forcing on chl. a fluorescence, such as light. Indeed, greater light in surface, lower the chl a fluorescence as a photophysiological response of algae. Also in May-June, diatom biomass was different from the previous period and was very low, so, maybe, with different cell size and photophysiological properties."

The fluorometer was not the cause that we proposed to explain the low correlation between chl a and fluorescence during May and June. We argued that the few data included (only four samplings) and the narrow range obtained (all concentrations measured in those months were very low) resulted in the non-significant relationship observed. We do not think that light could be affecting this relationship since light intensity is rather stable at this latitude. Neither the change in autotrophic community seems to be a reason because a lower diatom biomass was also measured during February and March without observing a less significant relationship between chl a and fluorescence.

"P 17278, line 28: I suggest adding “from the deeper layer” after “. . .of nutrients in the mixed layer”."

Done. We have added “from deeper waters” before “. . .in the mixed layer”.

"P 17283: lines 8-10: I am wondering about the following affirmation: “the absence of intense mixing”. It appears to me that the mixing might be high in the first 30 meters layer (from the plot 2a). I think that the low biomass value might be due to this feature, or to the low nutrient concentrations?"

Of course vertical mixing should be high in the mixed layer, but it has to be intense and deep enough to erode the thermocline and allow a substantial nutrient input. Thus, the absence of deep mixing because of the high stratification would prevent the input of new nutrients into the mixed layer. However, we have changed this phrase in the text, as this question is discussed later in the Discussion section.

"P 17284: lines 8: I suggest ratio instead of “relationship”."

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Done. We changed “relationship” by “ratio”.

"The plots on the figs 6 and 7 do not convince me. I suggest to present the temporal evolution of the parameters from 2/3 weeks before to 2/3 weeks after the dust event. Indeed, we can hypothesize that some components react quickly and other do react slowly."

The temporal evolution of the different parameters is showed in figures 4 and 5, in which dust deposition events are also indicated.

"P 17285, Lines 6-10: The statement reported here is not clear to me."

Winter surface cooling promotes the late winter bloom in these waters through the erosion of the seasonal thermocline that allows the input of new nutrients in the mixed layer. In order to discard the possibility of the bloom occurrence before we started to sampling, we showed that surface temperatures were higher before February 2010. These data indicate that the winter surface cooling, and consequently the characteristic winter bloom, did not take place before the beginning of the sampling. We have rewritten this first paragraph of the Discussion to better explain this question.

"P 17286: - Evolution of nutrient concentrations is strongly lacking in the ms. – Great part of the discussion on nutrient dynamics is speculative (e.g., nitrogen, silicate)."

This question has been answered above in the point about nutrients.

"Fig. 9: I suggest presenting cell concentration data, instead of biomass concentration."

Data on diatom composition was showed in terms of biomass because the changes observed were significant in terms of biomass, not abundance.

"P 17287: discussion on the discrepancy between PP and biomass responses. I am not convinced by this part of the discussion. The authors did not provide any strong hypothesis on this feature. Hypotheses regarding biomass losses, such as grazing or

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sinking must be discussed."

Agreed. In the text we just illustrated how the unequal response of primary production and chl a is a common result. We have included a paragraph about this point proposed in page 17287, line 27.

"P 17288: The relation between dust input and increase of the presence of Chaetoceros sp. is rather speculative. Thus, it is almost clear that in correspondence to this period, a deepening of mixing layer occurred (Fig. 2a), that might induce changes in the phytoplankton community at 20 meters depth, with an increase in diatoms and a lowering of picophytoplankton."

The reviewer is right. Although the appearance of Chaetoceros sp. matched the increase in diatom biomass after the dust event on March 18, other two maxima were also observed and related to the presence of Chaetoceros sp. that cannot be clearly linked to an effect of dust deposition. This part of the Discussion has been modified in page 17288, lines 24-28.

"The references are not really updated. Some recent papers dealt with the effect of dust deposition on the surface layer ecosystem of the Med. Sea."

Agreed. We have included some recent works dealing with the Saharan dust effect in the Mediterranean Sea (Pulido-Villena et al., 2010; Giovagnetti et al., 2013; Ridame et al., 2014).

""“In summary, our results showed that the Canary Islands waters were continuously affected by the Saharan dust deposition during the period studied.” This affirmation does not really fit with the data presented."

Although the Saharan dust deposition event on March was the highest, less intense events were frequent during the whole period studied (see fig. 3). Thus all these events would be affecting these waters in this period. Nevertheless, we have change the phrase by “. . .the Canary Islands waters would be potentially affected by the Saharan

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dust deposition during the whole period studied".

""Dust fertilization was evident by the high atmospheric iron, and nitrate and phosphate concentrations found in the mixed layer. " These data are not presented in the ms."

Metal concentration was measured from total suspended matter (TSM), while nitrate and phosphate concentration in the mixed layer was measured elsewhere and referenced in this work to sustain our discussion. We have rewritten this phrase to avoid misunderstandings.

""Finally, the response of the planktonic community consisted, on one hand, in the enhancement of primary producers, mostly diatoms, and mesozooplanktonic organisms, as it has been observed before." This response appears to me a seasonally driven response, since diatom biomass increased for a long time (until the end of May)."

This question has been answered above in the point about nutrients.

""On the other hand, picophytoplankton seemed to be negatively affected, but if this effect was directly caused by dust or indirectly by grazing losses remains unknown. This unequal effect upon autotrophs, favoring diatoms instead the small autotrophs, could also enhanced the biological pump due to a higher carbon export flux resulted from diatom sedimentation." This assumption is too speculative respect to the data presented in the ms."

Data presented here showed a significant increase of diatoms and decrease of small phytoplankton cells after the dust event on March 18. From this data we just hypothesized that it could be a significant consequence of dust deposition that it has been taken into account because of its potential influence in the carbon export process.

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