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Biogeosciences Discussions

Interactive comment on "Contribution of picoplankton to the total particulate organic carbon (POC) concentration in the eastern South Pacific" *by* C. Grob et al.

C. Grob et al.

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Anonymous Referee #3.

All suggestions made by this referee were taken into account and included in the final version of the manuscript. Regarding the Methods section of the Supplementary Materials, a new figure and more information were added in order to better explain how mean cell sizes, cell counts, FSC and SSC signals were determined. A figure comparing the picophytoeukaryotes carbon biomasses estimated using the bio-optical approach and intracellular carbon contents has now been included in the manuscript.

Page 1476. Picophytoeukaryotes contributions to the total integrated phytoplankton carbon biomass estimated using intracellular carbon contents and attenuation coef-

ficients (bio-optical approach) are both presented in Fig. 9. Carbon biomasses for Prochlorococcus and Synechococcus were however about 1.7 and 1.5 times higher when estimated using the intracellular carbon contents (see Section 3.3). The above implies that the contribution by cyanobacteria to the total phytoplankton biomass was higher, and therefore that of picophytoeukaryotes lower, when estimated using intracellular carbon contents. This has been clarified in the text.

Anonymous Referee #1.

General comments. As suggested by this referee, the uncertainties associated with the different estimations presented in this work were included in the text.

The referee says that the main conclusion of the article by Kitchen and Zaneveld [LO 1992, 37(8):1680-1690] suggests that the simple anomalous diffraction approximation used in the present work may have severely underestimated the cp for each modelled group and as a consequence severely overestimated the contribution of detritus to cp. However, here we showed that picophytoeukaryotes' contributions to POC estimated by (1) calculating their group-specific attenuation coefficient through the anomalous diffraction approximation (bio-optical approach) and (2) using intracellular carbon content were very similar. We therefore concluded that the premise that all picophytoeukaryotic organisms have the same refractive index of 1.05 is valid for the sampled transect. Hence, this group was not severely underestimated as suggested by the referee based on Kitchen and Zaneveld (1992) results.

A paragraph has been included in the manuscript (Section 4.2) to discuss the possible errors associated with assuming a refractive index of 1.05 for Prochlorococcus and Synechococcus.

Specific comments. The uncertainties associated with the different assumptions made and the empirical relationships established in the present work have been discussed in the text. Regarding the different groups' abundances, the error associated with flow cytometry cell counts is lower or equal to 5%, which is negligible.

BGD

4, S1051–S1056, 2007

5) We did not assume that the size of Prochlorococcus and Synechococcus was the same. What we did was to calculate a volume-based conversion factor from the mean cell size and intracellular carbon content obtained for Synechococcus and then applied this conversion factor to Prochlorococcus, using mean cell sizes derived from FSC.

Section 3.3. This section has been modified to make the clarifications suggested by the reviewer.

Technical corrections. Page 1479, lines 24-25. "Our results indicate that Tchla and cp would be equally useful estimates of photosynthetic carbon biomass in the open ocean, where it is mainly constituted by picophytoplankton ($<$3 um)". This statement has been modified to specify that the relationships between picophytoplankton carbon biomass and (1) Tchla (Fig. 8a) and (2) cp (Fig. 8b) where established for the data set where no large phytoplankton cells were detected, i.e., Stations 3 to 15 + GYR. Stations MAR, HNL, 1, 2, EGY, 17 to 21, UPW and UPX in Fig. 1 where not included in these relationships. MAR station was therefore not considered when establishing the relationship because picophytoplankton was not the dominant photosynthetic biomass, i.e., larger phytoplankton cells were also present. Further research would need to be done in order to determine if Tchla and cp are good estimates for the photosynthetic biomass at this station, where Prochlorococcus presented a higher intracellular dv-chla content than in the rest of the transect.

Page 1466, line 13. A reference was added in the text for the 5% error associated with abundances determined using flow cytometry. The abundance of weakly fluorescent surface Prochlorococcus populations, on the other hand, was estimated by fitting a Gaussian curve in only 7% of the cases. We therefore consider that this estimation did not induce important errors in our final results.

Page 1469, line 8. The word "detritus" has been widely used in the literature to refer to the "unaccounted cp" (e.g., DuRand & Olson, 1996; Chung et al., 1998; Claustre et al., 1999; Claustre et al., 2000; Oubelkheir et al., 2005). For this reason, we prefer to

BGD
4, S1051–S1056, 2007

EGU

keep referring to the unaccounted group of particles as "detritus", specifying in the text that it corresponds to the quantity that was not directly measured during this study.

Page 1477, line 9-10. See the explanation provided below regarding the discrepancies between Table 1 and Fig. 8.

Fig. 7a and 7c. This figure has been modified in order to represent the group-specific attenuation coefficients as cumulative curves for easier visualization. The possible errors associated with these estimates are discussed in the text. We decided not to include error bars in the figure because it would make it very difficult to visualize the results. At the same time, we believe that it is important to include the results for the entire transect to observe the variability in the group-specific contributions to cp, and therefore POC, across the eastern South Pacific. Important information regarding this variability would be lost if only the long stations (MAR, HNL, GYR, EGY and UPW) were included.

Fig. 8. This figure has been modified as suggested by this referee to make Prochlorococcus and picophytoeukaryotes more distinguishable. The reviewer also suggests that there is a flat relationship between Tchla and Synechococcus carbon biomass up to log (Tchla) = -1.2 and then a vertical relationship between both variables. However, when applying statistical analyses to (1) Tchla lower or equal to -1.2 v/s the corresponding Synechococcus biomass and (2) Tchla larger than -1.2 v/s the corresponding Synechococcus biomass, the results indicate that the former are not significantly correlated ($p >> 0.05$) and the latter show a significant negative correlation ($r = -0.29$; $p < 0.05$). When considering the entire data set, we found a significant negative correlation between Tchla and Synechococcus carbon biomass ($r = -0.55$; $p < 0.001$), that we assumed to be the general tendency for these two variables.

Fig. 8 includes only the data from samples where no large phytoplankton was detected, i.e., stations 3 to 15 + GYR, from the surface up to the depth of 1.5Ze or 0.1% of surface light. Table 1, on the other hand, shows the correlation coefficients found between the

BGD
4, S1051–S1056, 2007

EGU

different water-column integrated picoplankton abundances (0 to 1.5Ze) and between these and the Tchla concentration integrated over the same depth range, including all profiles sampled during the BIOSOPE cruise. The discrepancy between fig. 8 and table 1 can therefore easily be explained by the fact that the former includes only part of the data used to calculate the correlation coefficients presented in the latter. Furthermore, whereas fig. 8 includes all depths sampled for each of the profiles included (Stations 3 to 15 + GYR), the correlation coefficients in table 1 were calculated for the water-columned integrated data, including the entire transect.

The negative correlation observed between Synechococcus carbon biomass and Tchla concentrations (Fig. 10a) when considering Stations 3 to 15 + GYR is not surprising, since in this region Synechococcus' abundance (and therefore their biomass) decreases with depth (Fig. 4d), whereas Tchla concentrations increase with depth (Fig. 4f). When considering the entire transect, on the other hand, water-columned integrated Synechococcus abundance and Tchla concentrations both tend to decrease towards the centre of the gyre and increase towards meso- and eutrophic conditions, which would explain the positive correlation found between these two variables (Table 1).

In the case of picophytoeukaryotes, between Stations 3 and 15 (including GYR) this group's abundance clearly follows the same vertical pattern as Tchla (see Figs. 4d & g), so their positive correlation is not surprising. The lack of correlation between water-column integrated picophytoeukaryotes carbon biomass and Tchla concentrations when considering the whole transect can be explained by (1) the fact that under meso- and eutrophic conditions large phytoplankton cells contribute significantly to Tchla and (2) the important Prochlorococcus abundance subsurface maximum that contributes significantly to integrated Tchla at the centre of the gyre.

Regarding Table 1, it has now been specified in the text and in the table's legend that the correlation coefficients presented there were calculated using the entire data set. We believe that plotting these results as suggested by the reviewer would not

BGD
4, S1051–S1056, 2007

EGU

necessarily improve their visualization.

Supplementary Materials. Page 1. Across the eastern South Pacific, usually 2 to 3 different picophytoeukaryotes populations could be identified, i.e., 3 peaks were visible in the FSC distirbution. However, the second and third peaks were always much smaller than the first one, the latter corresponding to the dominant picophytoeukaryotes population. Because of the presence of a largely dominant picophytoeukaryotic group in all samples, average FSC signals obtained by using weighted or arithmetical are not significantly different.

Interactive comment on Biogeosciences Discuss., 4, 1461, 2007.