**Biogeosciences
Discussions**

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Comment

Interactive comment on "Phytoplankton competition during the spring bloom in four Plankton Functional Type Models" *by* T. Hashioka et al.

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Thank you very much for your kind comments and suggestions regarding our manuscript. Below are our responses to each of your comments.

C8096 L17: "The competitive advantages of different planktonic functional types could be presented more conceptually in the introduction." Thank you for your constructive suggestion with showing several specific examples. The addition of information about conceptual competition would significantly improve our introduction. We would like to add a section in the revised manuscript.

C8097 L1-4: "Additionally, although the authors do a fine job of noting the importance

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of sinking loss in the introduction (pages 18087 and 18088), this process is overlooked in the analyses which follow. Does sinking contribute to phytoplankton loss in these models, and how does the magnitude of this loss compare to that due to grazing?" As you mentioned, loss terms related to sinking such as phytoplankton mortality and aggregation of diatoms also contribute to the phytoplankton competition. In this study, as we didn't have enough data for the off-line calculation of all of the loss terms, it is difficult to compare the absolute values of the loss terms with the grazing terms directly. However, the effect of the loss terms might be smaller than the grazing terms at the timing of the bloom maximum in the current PFT models of MAREMIP.

Effect of mortality: First, the maximum mortality rates are one or two order smaller than the maximum grazing rates. When prey densities are high at the bloom maximum the grazing rate would be close to the maximum grazing rate. Second, there are no significant differences in parameter values of mortality between diatoms and nanophytoplankton. As a result the effect of mortality might be smaller than the effect of grazing for phytoplankton competition.

Aggregation of diatoms: The aggregation of diatoms is one of important loss processes for diatoms, and it contributes to the dominance of nanophytoplankton. PISCES, CCSM-BEC and PlankTOM5 are representing the aggregation in the model. In PISCES and CCSM-BEC, as the grazing of nanophytoplankton by microzooplankton is the only process to contribute to the dominance of diatoms. To explain the dominance of diatoms in those models, the effect of grazing should be larger than that of other loss process. In PlankTOM5, the both effects of the advantage of nutrient uptake for nanophytoplankton and the aggregation loss of diatoms are contributing to the dominance of nanophytoplankton. So in this case, it is difficult to explicitly separate the effect of each process. We would like to mention about the potential effect of aggregation of diatoms in the revised manuscript.

C8097 Section 2: "Another important comment I have concerns the reliability of estimating the relative photosynthesis ratio and inferring the contribution of different limit-

ing factors from the monthly averaged concentrations of tracers. . .How well do the authors' estimates of photosynthetic rates compare to the models' photosynthetic rates (page 18093)?" The time scale of spring bloom is shorter than one month. The absolute value of "photosynthesis rate" of each phytoplankton has temporal variability in a month because the photosynthesis rate is depending on the changes in phytoplankton concentration and in environmental condition such as nutrient, light and temperature. However, the "relative photosynthesis ratio" for understanding of phytoplankton competition is mainly determined by the relative differences in physiological properties between diatoms and nanophytoplankton. This is a difference how represent the trait of phytoplankton using each physiological process (i.e., differences in the maximum photosynthesis rate and in dependency terms) in a model, and this relationship does not change significantly in a month. For example, even if the nutrient concentration is changed in a month, nanophytoplankton always has advantage for nutrient uptake in the current PFT models in MAREMIP phase-0. And a part of the changes in absolute value could be canceled each other out (e.g., the both phytoplankton types have weak limitation in high nutrient condition, and have strong limitation in low nutrient condition.). Therefore, we think the relative ratio estimated from monthly data might be available for the analysis of the bloom from the concept of the definition.

C8097 Section 3: "Is it possible for the authors to demonstrate the evolution of these limiting factors with use of higher temporal resolution data before relying on the monthly averages? Temporal change in the importance of controlling factors is mentioned for the NEMURO model (lines 18105: 8-11), but this dynamic is not displayed in the current manuscript." In MAREMIP Phase-0, as we only have the monthly data due to the limitation of computational resources, it is difficult to calculate the higher-temporal variability. Although we successfully captured the temporally and regionally averaged general features of each PFT model in this paper, we also interested in the temporal evolution of each limiting factor to capture the switching from the growing phase to termination phase of the spring bloom. We would like to focus on this point in a next study.

C8097 Section 4: "The authors should provide more information regarding model initial conditions, model spin-up, and atmospheric forcing (lines 18090: 16-18)." We would like to add more information about experimental setting.

C8097 Section 4: "Was the time of blooms (and the controlling factors examined) constant through time, or did this shift slightly from year to year?" Inter-annual variability of timing and magnitude of spring bloom associated with the changes in physical environment exist. However, in MAREMIP Phase-0, as we only have monthly data for recent 12 years (1996-2007), it was difficult to discuss the statistically significant signals of the inter-annual variability. So we used a climatological mean for our analysis to focus on more general mechanisms of phytoplankton competition. In the next phase of MAREMIP, which targeted the long term simulation (1985-2100), we could look at the inter-annual variability.

C8098 Section 1: "By exploring a wider range of environmental conditions (and so including the subtropical ocean ecosystems) may allow more complete comparison between top-down and bottom-up processes in the ocean." As you mentioned, our approach is applicable not only to the spring bloom in high latitudes oceans but also to any other regions or seasons. Regional and seasonal comparison would be useful for further comprehensive understanding of phytoplankton competition. We would like to tackle those attractive themes in the next paper, as it might be too large to include in this paper.

C8098 Section 1: "Is it possible to attribute changes in model output to differences in PFT structure without also examining changes in the larger biogeochemical properties? Testing the response of the PFT models to a standard range of environment conditions may be more enlightening than the current approach in which the relive importance of PFT, biogeochemical, and circulation models is challenging." The differences in the reproduced biogeochemical and physical properties in the models affect to the difference in estimations of photosynthesis rate as bottom-up control. At the sea surface, as differences in temperature and light intensity are small between models,

the differences in nutrient concentrations are important. Actually reproduced nutrient fields in MAREMIP Phase-0 are different between models (Vogt et al., in preparation). As a result the peak timing and magnitude of the bloom are different between models. However, if we focus on the "phytoplankton completion" at the bloom maximum, the role of nutrient limitation is similar between models as we showed in Figure 5 (relative ratio of limitation terms). Namely, nanophytoplankton has advantage in nutrient uptake in all of the models. The differences between models or regions are smaller than the difference in the maximum photosynthesis rate and light dependency. So, we conclude the differences in the treatment of physiological processes are more important for phytoplankton completion than the difference in biogeochemical fields. The replacement of nutrient fields to the observational data is useful way for the separation of biogeochemical effects and ecosystem structure as you suggested, although some key nutrients fields such as iron and ammonium are not exist in the observational global grid data like WOA. We have been trying to do suck kind of an analysis for the next paper. Thank you for your constructive comments.

C8098 Section 3: "I would recommend attempting to use real observations from focused time series (perhaps similar to the approach of Saba et al. 2011) rather than relying on statistical models." Thank you for your suggestion. As the differences in satellite estimations for the percentage of diatoms are significantly large, we would like to add more explanation about reliability of each method. In Hirata et al. (2011), they obtained the relationship between chl and percentage of diatoms as a simple regression equation using an observational data set of HPLC. We would like to show the raw plots of HPLC data in Fig 3e. On the other hand, in a result estimated from Alvain et al. (2008), we assumed a simplified relationship for a conversion from the dominance frequency of diatoms in a month to the percentage of diatoms (Equation 2). We would like to describe uncertainties in this simplified estimation of Equation 2.

C8098 Section 4: "Finally, I was somewhat disappointed by the lack of critical discussion in the manuscript. ...What is the way forward? What is necessary to resolve the

differences among the models? What types of data should observationalists be focusing on? Does sinking play an important role that needs to be addressed?...." Thank you for your suggestion. We would like to add a section for future direction of PFT modeling such as introductions of more physiological processes for nutrient uptake, relationships of trade-off, explicit treatment of stoichiometry, improvement of grazing equations, etc...

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