Reviewer – Toby Westberry

We thank Toby Westberry to his toughtful review.

General Comments:

In this paper, Huot and co-authors present a dataset of phytoplankton photosynthetic parameters collected in the Arctic Ocean (Beaufort Sea), and explore predictive re- lationships which describe their observed variability. The case is well-stated that the Arctic Ocean is undergoing rapid climate change, and remote assessment and mon- itoring of these changes relies on proper characterization of in situ variability. To this end, Arctic ecosystems have been underrepresented in field datasets used to develop ocean color based primary production models. The data presented here and the resultant functional relationships derived from them seek to bridge this need. The paper is well written and the authors nicely compare their dataset with historical data collected in the region and point out similarities and differences.

I have only two points of "general" concern. First, there has historically been some uncertainty as to what exactly the 14C method measures. Most recently, Halsey et al. (2010; 2011) have presented some intriguing results showing that what the 14C method measures is dependent upon incubation duration and growth rate of the phy- toplankton. In particular, typical short-term incubations (~1-3 hours) show something far from net primary production and much closer to gross primary production. One conclusion from that work is that we should avoid short-term 14C incubations entirely. Barring that, we must consider that the dataset employed in the present paper will have some significant error (>40%) which cannot be resolved without knowledge of corre- sponding growth rate of the natural phytoplankton assemblage. Some recognition and discussion of this needs to be presented.

To our knowledge there is not a perfect method to measure primary production, long term incubation suffer from bottle effects. These can be particularly important in the mixed layer where incubation at a constant depth is not representative of the irradiance received by the phytoplankton population of the mixed layer. Short incubations reduce these artifacts but are straddling the gross and net primary production measurements depending on the timescale of the measurement. The Hasley papers pointed out by the reviewer makes this point very clearly through experimental determination of gross and net photosynthesis.

Of course our intention with this paper was not to address these questions. Nevertheless, we agree with the reviewer that an attempt to contextualize our measurement can be useful for future users. We have added the following paragraph to our paper :

Short-term incubations allowed us to obtain a large number of samples in a relatively short time. The construction of PvsE curves at many depths allows easy modeling of primary production for any irradiance at any depth. As with the longer-term incubations, short-term incubation, however, suffer from their limitations (Cullen, 2001; Marra, 2002). In the case of short-term incubations, the most limiting problem lies in the interpretation of the measurements, in particular whether the gross or net primary production was measured. To know where the measurement fall between these two extremes, the growth

rates must be known (Dring and Jewson, 1982; Halsey et al., 2010; Halsey et al., 2011); we did not have such measurement during the cruise. Previous measurements performed in the Arctic, however, suggest that given the right model, calculation made with PvsE curves of the daily-integrated primary production obtained from 2 to 4 h incubation provide equivalent results to deck incubations for 24 hours (Harrison et al., 1985). The same authors note that temperate waters do not show the same results.

Cullen, J. J. (2001). Primary production methods. In J. H. Steele (Ed.), *Encyclopedia of ocean sciences* (pp. 2277-2284). Academic

Dring, M. J., & Jewson, D. H. (1982). What does ^{14}C uptake by phytoplankton really measure? A theoretical modelling approach. *Proceedings of the Royal Society of London. Series B. Biological Sciences*, *214*(1196), 351-368.

Halsey, K. H., Milligan, A. J., & Behrenfeld, M. J. (2011). Linking time-dependent carbon-fixation efficiencies in dunaliella tertiolecta (chlorophyceae) to underlying metabolic pathways. . *Journal of Phycology*, *47*(1), 66-76. doi:10.1111/j.1529-8817.2010.00945.

Halsey, K. H., Milligan, A. J., & Behrenfeld, M. J. (2010). Physiological optimization underlies growth rate-independent chlorophyll-specific gross and net primary production. *Photosynthesis Research*, *103*(2), 125-37. doi:10.1007/s11120-009-9526-z

Harrison, W. G., Platt, T., & Lewis, M. R. (1985). The utility of light-saturation models for estimating marine primary productivity in the field: A comparison with conventional "simulated" in situ methods. *Can. J. Fish. Aquat. Sci.*, *42*, 864-872

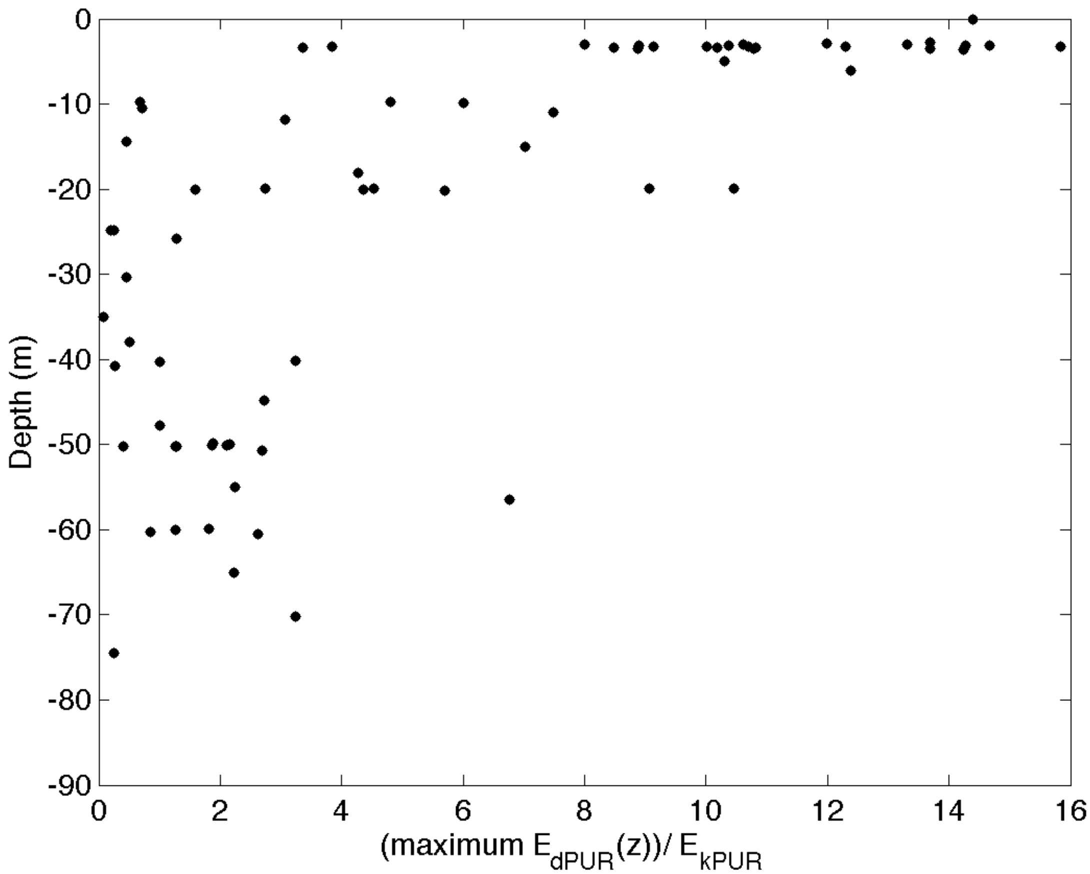
Marra, J. (2002). Approaches to the measurement of plankton production. In P. J. Le B. Williams, D. N. Thomas, & C. S. Reynolds (Eds.), *Phytoplankton productivity: Carbon assimilation in marine and freswater ecology* (pp. 78-108). Wiley-Blackwell

Second, and perhaps more philosophically, what is the purpose of predicting Pmax_chl at depth? Cells below the depth of the mixed layer are generally light limited, right? That is, Pmax_chl is likely only realized by the phytoplankton inhabiting the surface mixed layer, right? And when mixed layers are deep, even that statement may not be true, particularly at extremely high latitudes where incident irradiance is generally low. If true, some further justification is needed for the primary goal of the paper. Perhaps I'm wrong here, but this could be addressed by evaluating the in-water irradiances relative to the estimated Ek's.

There are many reasons to study and describe photosynthetic parameters that go beyond the estimates of primary production : studies of photoacclimations or photoadaptations in arctic water could make good use of a comparison with our dataset. As such, we feel that it is justified to describe and publish these parameters whatever the level of saturation of the photosynthetic apparatus is at any depth.

This said, the question of the reviewer piqued our curiosity and we made a quick comparison in the figure below. The x-axis represents the maximum PUR irradiance that

would have been measured at the sampling location for a given sample for the whole cruise divided by the E_{kPUR} for that sample. The maximum irradiance was computed using the maximum irradiance measured on the deck during rosette casts multiplied by the percent irradiance at the sampling depth. There is a clear decreasing relationship with depth, but many deep samples have values that are around 2 or greater indicating that the irradiance is greater than E_{kPUR} and that the primary production from these samples cannot simply be computed using a linear relationship.



Specific Comments:

The point for distinguishing whether a water sample is “dominate” by microplankton or not is 0.65 thorughout the paper. Why are values shown in Figure 6 truncated at 0.3?

The colorscale used was incorrect, it was representing a value that was directly proportional to the Microplankton fraction but not the microplankton fraction. We have made a new figure. The figure is very similar to the previous one since the two colorscale are linearly related. Thank you for pointing this out.

There are no reference to Figures 8B&C anywhere in the text.

This was corrected by adding appropriate reference in the paragraph discussion Figure 8.

Technical Corrections:The paper is generally well-written and I did not find any technical problems. References:

Halsey, K.H., Milligan, A., Behrenfeld, M.J. Physiological optimization underlies growth rate-independent chlorophyll-specific gross and net primary production. Photosynth. Res. doi: 10.1007/s11120-009-9526-z, 2010.

Halsey, K.H., Milligan, A.J., Behrenfeld, M.J. Linking Time-dependent Carbon-fixation Efficiencies in Dunaliella Tertiolecta (Chlorophyceae) to Underlying Metabolic Path- ways.J. Phycol.. 47, 66-76, 2011

Interactive comment on Biogeosciences Discuss., 10, 1551, 2013.