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Interactive comment on "An investigation of grazing behaviors that result in winter phytoplankton biomass accumulation" *by* Mara Freilich et al.

Anonymous Referee #3

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This study analyzes the importance of considering non-linear functional responses of grazing at low phytoplankton concentrations when modelling plankton dynamics. In particular, the authors point out that including these types of responses is key to reproduce the accumulation of phytoplankton biomass observed in winter in the North Atlantic. The manuscript is well written and the results and conclusions are interesting. However, I have some comments and questions that I think should be addressed in order to be published.

General comments:

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Discussion paper

1) If I understood correctly, in the study the phytoplankton specific growth rate decays exponentially with depth due to light absorption with an attenuation coefficient Kd. This would mean that the response of phytoplankton growth to light only depends on the surface irradiance, the Kd, and depth; i.e. depends on the light level at a particular depth. However, it seems that this dependency is modeled as a linear response. If this is the case, please consider that P-I curves have a non-linear form, expressed as a saturating response, or a curve with an optimum due to photoinhibition (see examples in Tian 2006). Although the response might be close to linear in winter due to low irradiance levels, non-linear responses might be important later in the year.

2) I could not find in the model how the effect of temperature on growth and grazing rates was introduced. The potential consequences of this effect were not considered in the discussion either. According to Rose and Caron (2007), low temperatures might impact more negatively microzooplankton grazing rates than phytoplankton growth rates (although see Chen et al. 2012), which can allow phytoplankton biomass accumulation in winter. Considering this, could a combination of temperature effect and linear grazing functional response allow a phytoplankton biomass accumulation in winter? Could this combination lead to similar results as those found when applying a grazing response that is non-linear at low phytoplankton concentrations?

3) Using dilution experiments, Liu et al. (2021) showed that “Holling III function best described the functional response of microzooplankton grazing” and highlighted the importance o this type of response at low phytoplankton concentrations. I think this paper or similar ones based on experimental observations support the results of the current study and should be mentioned in the discussion.

Specific comments:

About the title: maybe replace “An investigation of” with “Investigating” or “Analyzing.” L18-24: I think at some point here, the Critical Turbulence Hypothesis (Huisman et al. 1999) could be also mentioned as it is a famous and important one.

L25: I would rather say that the Disturbance Recovery Hypothesis focuses on both phytoplankton growth and loss rates and how they are coupled or decoupled (i.e. on how their equilibrium is disrupted).

L34: What do you mean with loss at large scales? Please elaborate. Also, I think you could include a reference for this.

L36: Loss due to grazing also depends on temperature and probably on other environmental factors (see for instance Chen et al. 2012).

L40: It sounds like it is only possible to quantify this interaction through mathematical models. What about dilution experiments for example? It would be clearer if you say that it can be modeled through a mathematical relationship.

Fig. 2: What are the units of the axes? Also, I am a bit confused about what the contour colors represent. At the beginning of the figure caption, it says that colors represent grazing rates and in the next sentence, it seems that colors represent the rate of change in biomass. Additionally, in the case of Holling type III, for each phytoplankton concentration, rather than a decrease in the grazing rate with deeper mixed layer depths, there is first an increase and then a decrease (i.e. It seems that there is an optimal mixed layer depth for grazing rates at each phytoplankton biomass). Finally, I think the last sentences of the caption should be better written. Decreases and increases do not occur at a particular level but rather when moving along a particular axis (see for example "This occurs at low values of phytoplankton biomass and deep mixed layers" or "At high biomass there is also a decrease in grazing rate). At a particular combination of mixed layer depth and phytoplankton biomass can occur larger/est or lower/est grazing rates.

L 214: Reference for Kd = 0.05 m-1?

L 219-202: Maybe include a reference to Fig 3 saying between which days this peak is found. Fig. 3: There are too many lines in the gray grid. Select just a few for the x and

y axes. Why the grazing rate is not another panel? The axis labels are too small. In the units of the axis labels, erase the space before the exponent and separate mg and C. I'd add a vertical thicker line on day 1 to make it clear that the plots do not start on day 1. The thin black line from day 315 to day 5 is very difficult to see and can be confused with the thicker black line. Maybe use another color (blue?) and maybe make it dash.

L 238-239: Is it discussed whether the dp inferred by type III is more realistic? This could be supported with references.

L246: clarify which period is the end of winter by adding in parentheses which day/s of the year (or period in days of the year).

Fig. 4: Separate mg and C in the axis labels. Why for one of the curves there is a labeled dot for day 135 and in the other for 130? If there is not a clear justification, use the same day for better comparison.

L294-295: Why does light little influence on wintertime biomass accumulation? Does not an increase in light through the seasonal cycle increase phytoplankton specific growth rates and contribute to the decoupling with their grazers?

Technical corrections

L133: modify reference as "(Behrenfeld, 2010)" and maybe introduce it as "(see for example Behrenfeld, 2010)".

L136: Comma after "However".

L343: very "difficult" to quantify?

References

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