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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 #1

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The manuscript deals with the mathematical description of grazing behaviors which may explain the (weak) increase in phytoplankton biomass observed in winter in the North Atlantic Ocean. The positive growth of phytoplankton during winter, light limiting conditions was previously explained by invoking a decrease in grazing pressure. More specifically, it was suggested that, due to the dilution of the water column caused be the deepening of the mixed layer, the encounter rate between phytoplankton and their grazers decreases, and this allows a weak positive growth despite light limitation. The authors highlight that this behavior can be modelled assuming a non-linear (in this case quadratic) relationship between grazing and prey biomass, a functional response known as Holling type III function. The main conclusion of the work is that assuming

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this latter functional response a simple biogeochemical model is able to simulate both the increase in biomass in winter and the subsequent spring bloom, while other widely used grazing functional responses underestimate winter phytoplankton biomass. The Holling type III model is not new and is, as also stated by the authors, already a quite popular choice within the marine modelling community. However, this paper provides a remarkably clear explanation on why this formulation should be preferred over the others, also highlighting its ecological significance. The manuscript is clearly written, model's assumptions are very well explained and the results are clear and logic. I recommend publishing this paper after minor revisions.

Specific comments: I appreciate that this paper focuses on zooplankton. However, other phytoplankton loss terms can be equally important in the formation and progression of a blooms (including relatively high winter biomass). For example, viral infection, possibly one of the main causes of mortality after grazing, could also be described by a non-linear, density dependent functional response (e.g. Mateus, 2017, FMS), and have a reduced effect on phytoplankton at low biomass concentration.

The presented model follows the classic dichotomy between autotrophic and heterotrophic organisms. However, we know that most phytoplankton exhibits mixotrophic metabolism, perhaps with the important exception of diatoms (see e.g. Flynn et al 2012 JPR, Gonçalves Leles et al., 2018 JPR and 2020 Progress in oceanography). I am wondering if mixotrophy could be involved in the increase of biomass observed under light limiting conditions.

Figure1 is a bit misleading. I think that the different functional responses (II and III) need to be run with the same parameters in order to clearly assess differences and similarities.

Minor points: Line 88: the term 1/kdH(t) is "the average light over the mixed layer.." but light is not explicitly modelled, right? Is the specific growth rate which is averaged over the ML, assuming an exponential decay. Line 110: the formulation (type III) "is

quadratic in p for low p". Why only for low p? I see that the focus here is on low winter biomass values but the formulation is quadratic for any p.

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