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Discussions

Interactive comment on "Analytical solution of nitracline with the evolution of subsurface chlorophyll maximum in stratified water columns" *by* Xiang Gong et al.

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The manuscript is an analytical study of the relationship between the vertical distributions of phytoplankton and nutrients. An earlier paper by Gong et al. (2015) investigated the impact of light intensity, vertical diffusion, and the phytoplankton sinking velocity on the depth and width of the subsurface biomass maximum. Now, Gong et al. expand upon this earlier work with a careful study of what may determine the nutricline depth. The overall setup is good and there is a logical progression in the development of the text. Although analytical studies such as this one tend to be somewhat difficult to read, in my opinion they ought to have a much more prominent place in the field than they currently have, because they can provide much deeper insights than either

(forward) numerical simulations or (inverse) parameter/state estimations. Having said all this, I think that at two points in the study, some further analysis is warranted before publication:

1) The authors admit that the assumption that the chlorophyll distribution represents the phytoplankton biomass distribution "is a significant simplification. In fact, phytoplankton increases inter-cellular pigment concentration when light level decreases (Cullen, 1982; Fennel and Boss, 2003; Cullen, 2015)." (p. 6, l. 129-131) Now, there happen to be fairly precise mathematical descriptions of this effect, e.g., Cloern et al. (1995). Thus, the authors ought to be able to investigate how and to which extent photoacclimation would impact their predictions regarding the relationship between the subsurface chlorophyll maximum and the nutricline depth.

2) An unexpected prediction is the possible existence of nitrate minima below the surface mixed layer. According to the authors, these features disappear "if the subsurface vertical diffusion is too weak or the surface mixed layer is deeper than depth zn1. The possible mechanism deserves to be explored." (p. 24/25, l. 606-608) I think I may understand the origin of these remarkable features. Consider a situation without phytoplankton sinking and with full recycling of dead phytoplankton (w=0, alpha=1). In that case, the nitrate distribution is simply the inverse of the phytoplankton distribution: if P has a maximum, then N has a minimum. When the sinking speed w increases and/or the recycling alpha decreases, a background vertical N gradient develops which makes the N minimum shallower, until it has disappeared. Essentially, the N minima are then the result of the phytoplankton eating holes in the N distributions. All this is illustrated in the attached figure. In my view, it would be very interesting, if the authors would investigate this hypothesis by varying the sinking velocity and the recycling coefficient, starting from w=0, alpha=1.

References

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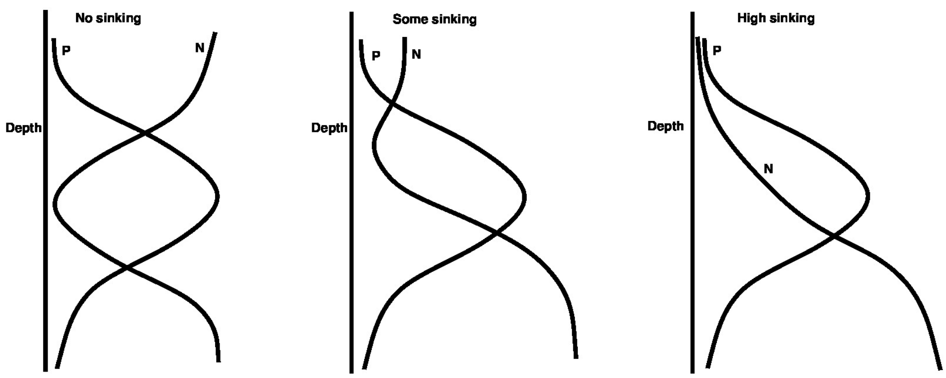

Fig. 1. The N minimum becomes shallower and eventually disappears as the sinking speed w increases.