

Biogeosciences Discuss., referee comment RC1
<https://doi.org/10.5194/bg-2022-11-RC1>, 2022
© Author(s) 2022. This work is distributed under
the Creative Commons Attribution 4.0 License.

Comment on bg-2022-11

Anonymous Referee #1

Referee comment on "Pronounced seasonal and spatial variability in determinants of phytoplankton biomass dynamics along a near-offshore gradient in the southern North Sea" by Viviana Otero et al., Biogeosciences Discuss.,
<https://doi.org/10.5194/bg-2022-11-RC1>, 2022

Otero et al. analyzed the dynamics of a simple NPZD model to untangle the co-limitation in time and space of nutrients, light, temperature, and grazing on phytoplankton growth. They used observations of the southern North Sea to validate and constrain their modelling simulations. While I started reading their work with interest, unfortunately, I consider their modelling approach falls short to convince me for the reasons outlined below. I would have appreciated a thorough presentation of the model assumptions, their limitations, how they impact the author's interpretations and how much their analysis advances our understanding of the co-limitation of planktonic communities in coastal ecosystems.

Major points of concern:

The modelling approach has well-known limitations that go beyond what the authors briefly discussed. This aspect in addition to the lack of mathematical formalism and an adequate presentation of the equations and the processes that compose each state variable and what is the rationale to include them is particularly worrisome. Specifically, why their model application includes: A) a single phytoplankton group where their growth is determined by simple Monod kinetics, B) fixed Chl:C:N:P ratios, C) a single zooplankton grazer where their growth is also described by a Monod-like function, D) fixed sinusoidal surface irradiance which is used in a simple Lambert-Beer exponential decay function only applied at 3m depth to determine what they call PAR. The latter is used across their three areas spanning from near-shore to off-shore without any justification. Also, their model does not account even in the simplest terms for vertical mixing or any other type of transport. These are some of the issues I spot in the very superficial description of the model in the appendix. These are openly discussed issues in the marine ecosystem modelling community for the last three decades, see a (non-extensive) selection of the references presenting and discussing all of these various issues (Fasham et al., 1990; Anderson, 1993, 2005, 2010; Flynn, 2003, 2008; Gentleman et al., 2003; Mitra and Flynn, 2006; Hall, 2009; Anderson et al., 2010; Smith et al., 2011, 2014; Bonachela et

al., 2016; Flynn and Mitra, 2016). I found these omissions, without justification, a lamentable modelling practice. This is worrisome given that the authors aim to describe the temporal and spatial variability of co-limitation of nutrients, light, temperature, and grazing on phytoplankton growth in a highly dynamic coastal ecosystem, and the variability of all of those factors play a role in the structure of planktonic communities (Cloern et al., 2014; Emeis et al., 2015).

The model to data comparison (or validation) needs to be better presented. If the authors want to provide a stronger case for better model performance. A simple plot of model prediction against observations will go a long way in that endeavour. Also, a comparison with other coastal or regional seas models needs to be discussed, and the literature for the North Sea is quite rich in that respect, e.g. ERSEM, MIRO, HAMSOM, BLOOM-Delf3D and MAECS.

In addition to the issues stated above, it is not clear how co-limitation is untangled in the simple NPZD model, in what they call "relative contribution". Particularly, how this method compares with other more established approaches, for example, based on Leblig's law (Klausmeier et al., 2004), dynamic energy budget (Bruggeman and Kooijman, 2007), or acclimation (Wirtz and Kerimoglu, 2016), and how much their observations advance our understanding of resource co-limitation in planktonic communities? These aspects remain unanswered and present a more interesting research venue than just predicting Chla and overinflating the implications of a model with still many reservations.

References

Anderson, T. R. (1993). A spectrally averaged model of light penetration and photosynthesis. *Limnol. Oceanogr.* 38, 1403–1419.

Anderson, T. R. (2005). Plankton functional type modelling: running before we can walk? *J. Plankton Res.* 27. doi:10.1093/plankt/fbi076.

Anderson, T. R. (2010). Progress in marine ecosystem modelling and the "unreasonable effectiveness of mathematics". *J. Mar. Syst.* 81, 4–11. doi:10.1016/j.jmarsys.2009.12.015.

Anderson, T. R., Gentleman, W. C., and Sinha, B. (2010). Influence of grazing formulations on the emergent properties of a complex ecosystem model in a global ocean general circulation model. *Prog. Oceanogr.* 87, 201–213. doi:10.1016/j.pocean.2010.06.003.

Bonachela, J. A., Klausmeier, C. A., Edwards, K. F., Litchman, E., and Levin, S. A. (2016). The role of phytoplankton diversity in the emergent oceanic stoichiometry. *J. Plankton Res.* 38, 1021–1035. doi:10.1093/plankt/fbv087.

Bruggeman, J., and Kooijman, S. A. L. M. (2007). A biodiversity-inspired approach to aquatic ecosystem modeling. *Limnol. Oceanogr.* 52, 1533–1544. doi:10.4319/lo.2007.52.4.1533.

Cloern, J. E., Foster, S. Q., and Kleckner, A. E. (2014). Phytoplankton primary production in the world's estuarine-coastal ecosystems. *Biogeosciences* 11, 2477–2501. doi:10.5194/bg-11-2477-2014.

Emeis, K. C., van Beusekom, J., Callies, U., Ebinghaus, R., Kannen, A., Kraus, G., et al. (2015). The North Sea - A shelf sea in the Anthropocene. *J. Mar. Syst.* 141, 18–33. doi:10.1016/j.jmarsys.2014.03.012.

Fasham, M. J. R., Ducklow, H. W., and Mckelvie, S. M. (1990). A nitrogen-based model of plankton dynamics in the oceanic mixed layer. *J. Mar. Res.* 48, 591–639.

Flynn, K. J. (2003). Modelling multi-nutrient interactions in phytoplankton; balancing simplicity and realism. *Prog. Oceanogr.* 56, 249–279. doi:10.1016/S0079-6611(03)00006-5.

Flynn, K. J. (2008). The importance of the form of the quota curve and control of non-limiting nutrient transport in phytoplankton models. *J. Plankton Res.* 30, 423–438. doi:10.1093/plankt/fbn007.

Flynn, K. J., and Mitra, A. (2016). Why Plankton Modelers Should Reconsider Using Rectangular Hyperbolic (Michaelis-Menten, Monod) Descriptions of Predator-Prey Interactions. *Front. Mar. Sci.* 3. doi:10.3389/fmars.2016.00165.

Gentleman, W., Leising, A., Frost, B., Strom, S., and Murray, J. (2003). Functional responses for zooplankton feeding on multiple resources: a review of assumptions and biological dynamics. *Deep Sea Res. Part II Top. Stud. Oceanogr.* 50, 2847–2875. doi:10.1016/j.dsr2.2003.07.001.

Hall, S. R. (2009). Stoichiometrically explicit food webs: Feedbacks between resource supply, elemental constraints, and species diversity. *Annu. Rev. Ecol. Evol. Syst.* 40,

503–528. doi:10.1146/annurev.ecolsys.39.110707.173518.

Klausmeier, C., Litchman, E., Daufresne, T., and Levin, S. (2004). Optimal nitrogen-to-phosphorus stoichiometry of phytoplankton. *Nature* 429, 171–174. doi:1.1029/2001GL014649.

Mitra, A., and Flynn, K. J. (2006). Accounting for variation in prey selectivity by zooplankton. *Ecol. Modell.* 199, 82–92. doi:10.1016/j.ecolmodel.2006.06.013.

Smith, S. L., Merico, A., Wirtz, K. W., and Pahlow, M. (2014). Leaving misleading legacies behind in plankton ecosystem modelling. *J. Plankton Res.* 36, 613–620. doi:10.1093/plankt/fbu011.

Smith, S. L., Pahlow, M., Merico, A., and Wirtz, K. W. (2011). Optimality-based modeling of planktonic organisms. *Limnol. Oceanogr.* 56, 2080–2094. doi:10.4319/lo.2011.56.6.2080.

Wirtz, K. W., and Kerimoglu, O. (2016). Autotrophic stoichiometry emerging from optimality and variable co-limitation. *Front. Ecol. Evol.* 4. doi:10.3389/fevo.2016.00131.