Accounting for grazing dynamics in nitrogen–phytoplankton–zooplankton (NPZ) models

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ABSTRACT: Nitrogen-phytoplankton-zooplankton (NPZ)-type models are widely used to explore the dynamics of marine planktonic ecosystems. Within these models, grazing by zooplankton on phytoplankton that are subjected to varying degrees of nitrogen limitation is described using N-based grazing kinetics together with fixed N assimilation efficiency. There is no empirical evidence for zooplankton displaying such behavior; on the contrary, there is evidence for a decline in zooplankton growth rates on consumption of N-impoverished prey, with decreased assimilation efficiencies coupled with decreased ingestion rates of nutrient-limited (i.e., poor quality, low N:C) prey. Unwittingly, then, traditional NPZ models make unjustified assumptions concerning changes in predator-prey interactions on consumption of low-quality prey. We explore the effects of this flawed description, also asking why NPZ models can still give reasonable descriptions of field data. Our conclusion is that one flaw may be countered by another, namely, by an inadequate description of nongrazing phytoplankton losses. In nature, these nongrazing losses are enhanced within nutrient-depleted phytoplankton populations. In models, a decline in grazing losses on nutrient-deprived phytoplankton is, de facto, compensated for by enhanced nongrazing losses. While the fit of the revised model to the data is not dissimilar to that of the original model (with its inappropriate descriptions of grazing and nongrazing phytoplankton mortality), the fate of primary production is very different. With the biologically more acceptable description, more material flows through the detrital compartment, with important implications for trophic dynamics. Care must be taken not to oversimplify descriptions of biology in models, as these may directly or indirectly mask the simulation of other important ecological processes.