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# Introducing mixotrophy into a biogeochemical model describing an eutrophied coastal ecosystem: The Southern North Sea

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Most biogeochemical/ecological models divide planktonic protists between phototrophs (phytoplankton) and heterotrophs (zooplankton). However, a large number of planktonic protists are able to combine several mechanisms of carbon and nutrient acquisition. Not representing these multiple mechanisms in biogeochemical/ecological models describing eutrophied coastal ecosystems can potentially lead to different conclusions regarding ecosystem functioning, especially regarding the success of harmful algae, which are often reported as mixotrophic. This modelling study investigates, for the first time, the implications for trophic dynamics of including 3 contrasting forms of mixotrophy, namely osmotrophy (using alkaline phosphatase activity, APA), non-constitutive mixotrophy (acquired phototrophy by microzooplankton) and also constitutive mixotrophy. The application is in the Southern North Sea, an ecosystem that faced, between 1985 and 2005, a significant increase in the nutrient supply N:P ratio (from 31 to 81 mole N:P). The comparison with a traditional model shows that, when the winter N:P ratio in the Southern North Sea is above 22 molN molP-1 (as occurred from mid-1990s), APA allows a 3 to 32% increase of annual gross primary production (GPP). In result of the higher GPP, the annual sedimentation increases as well as the bacterial production. By contrast, APA does not affect the export of matter to higher trophic levels because the increased GPP is mainly due to Phaeocystis colonies, which are not grazed by copepods. The effect of non-constitutive mixotrophy depends on light and affects the ecosystem functioning in terms of annual GPP, transfer to higher trophic levels, sedimentation, and nutrient remineralisation. Constitutive mixotrophy in nanoflagellates appears to have little influence on this ecosystem functioning. An important conclusion from this work is that different forms of mixotrophy have different impacts on system dynamics and it is thus important to describe such differences in an appropriate fashion.