Reply to Horizons Article ‘Plankton functional type modelling: running before we can walk’ Anderson (2005): 
I. Abrupt changes in marine ecosystems?

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The ongoing debate in climate projections is not about what will be the most likely climate at the end of the century but about what is the most dangerous climate that may be lying in front of us.

In a recent Horizons paper, Anderson (Anderson, 2005) argues that the development of global biogeochemistry models must build slowly from the strong foundations that NPZD models have provided us and that the emergence of models based on many plankton functional types (PFTs) (Le Quéré et al., 2005) is premature.

NPZD models may give us the most likely response of marine CO₂ to climate, but nothing else. The problem with NPZD models is that their representation of biological fluxes is entirely dependent on physical processes. These models do not include many of the ecological processes that are known to be sensitive to, for instance, changes in temperature or pH, such as bacterial remineralization (Rivkin and Legendre, 2001), zooplankton grazing rates (Buitenhuis et al., 2006), the aggregation role of mucus secreted by some phytoplankton (Engel et al., 2004), the ballasting of organic particles by plankton shells (Klaus and Archer, 2002) and pH sensitivity of calcifying phytoplankton (Riebesell et al., 2000) and zooplankton (Orr et al., 2005).

Anderson further argues that we do not understand ecology well enough yet for major development of PFT-based models, although he acknowledges that physiological information about the responses of individual PFTs to their environment is available. One of the great values of large-scale modelling is that it enables us to examine the consequences of physiological differences between PFTs for large-scale phenomena such as spatial distributions and seasonal successions. We will not understand ecology until we have built models that include the necessary processes.

Anderson claims that parameters are under-determined. Laboratory studies provide independent constraints on the values of many parameters (Veldhuis and de Baar, 2005 and references therein). The degree of precision varies, and constraints are best considered as a range. However, the range is narrowed down if information on individual PFTs is gathered rather than information on the generic ‘phytoplankton’ or ‘zooplankton’, which forms the basis of NPZD models. In this respect, PFT-based models perform better-informed tuning than do NPZD models, which rely solely on the reproduction of biogeochemical fields as a test of their performance.

Anderson finally argues that PFT-based models do not do any better than NPZD models. Whereas they may not do better than NPZD models for the moment, they also are no worse; they reproduce good geographical and seasonal patterns in chlorophyll a and in CO₂ and O₂ fluxes, which have challenged NPZD models throughout their development (Le Quéré et al., 2005). Anderson is correct that adding complexity (and realism) to models does not necessarily improve their predictive power—especially if the information needed to construct and/or evaluate the more complex models does not exist. However, the situation is much better now compared with just a decade ago: the SeaWiFS satellite has provided us with nearly nine continuous years of surface chlorophyll data and associated parameters such as blooms of certain PFTs and
reconstruction of phytoplankton dominance by emerging bio-optical methods (Alvain et al., 2005); in situ pigment data provide global and seasonal coverage of ecosystem composition (Uitz et al., in press); and much of the existing laboratory and field experiments have already been synthesized, for instance during the European IRONAGES project, which has built freely accessible databases for five PFTs (Veldhuis and de Baar, 2005). Finally, our understanding of plankton physiology has also advanced with theoretical models for understanding the factors that control the ratios of cell carbon to nutrients and chlorophyll (Geider et al., 1997), and so on.

PFT-based models have the potential to help us understand and quantify the interactions between marine ecosystems and climate. Most importantly, they may help us foresee if there are sensitive areas in ecosystem ecology or potential dangerous climate regimes that we should carefully avoid or closely monitor, a task that NPZD models will never be able to undertake. I argue that models are far behind theoretical understanding, that information is urgently needed and that the rate of model development and data acquisition in this field should rather be accelerated.

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REFERENCES


