Title

Diversity effects of trait-based zooplankton feeding interactions in a global ecosystem model

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Summary

Pelagic ocean ecosystems are under pressure from fisheries and global environmental change. A concurrent loss of diversity observed across ecosystems raises the question of how diversity influences ecological and biogeochemical processes of ecosystems. In terrestrial and benthic systems, controls and effects of diversity are already relatively well understood. For the global pelagic ocean, however, little is known about controls of diversity and its role in shaping ecosystem processes and biogeochemical cycles of nutrients and carbon. The oceans' vast dimensions and continuous motion restrict observations to snapshots in space and time, and thereby advocate the use of global ocean models.

Previous work demonstrates that in such models top-down processes can substantially affect phytoplankton diversity and community structure. Moreover, simulated changes in diversity could be shown to be correlated with changes in global average primary production and the export of organic matter into the deep ocean. For both aspects, the model formulations for zooplankton grazing turns out to play a deciding role for the predictions of the model. However, current models of trophic interactions are predominantly characterised by fixed interactions and prescribed trophic links. Linking trophic levels through flexible feeding interactions remains a challenge.

We propose to address this issue by making use of the tight cooperation within dynatrait of experimental approaches, field measurements and models on small scales. Models developed in such idealised communities will be adapted and applied to the global scale, which allows us to evaluate and compare effects of trait plasticity and variation on large-scale diversity under different environmental conditions imposing both temporal and geographical constraints. Specific questions within this approach are:

1. How do adaptive trophic interactions affect diversity and community structure?
2. How does zooplankton diversity affect community dynamics, diversity and ecosystem functioning?
3. How do environmental changes influence the community dynamics and the relationship between diversity and large-scale ecosystem functions?

Task 1: While trait-based models within dynatrait are being developed, existing trait-based plankton models will be identified and modified for use in a global ocean model which resolves plankton diversity. These existing models serve as test bed to prepare the modelling environment for the dynatrait models and to identify limitations of different modelling approaches such as optimality-based models or adaptive-dynamics formulations.

All plankton models used should describe links within and between trophic levels mechanistically by taking into account plankton traits. They will be calibrated against observational and experimental data, e.g., from mesocosm or feeding experiments (dynatrait and literature results) or ocean time series sites.

Task 2: The different model setups will be used to investigate global plankton diversity, biogeography and community structure. The aim is to quantify the effects of including more sophisticated plankton models with flexible interactions.

Model results will be assessed with respect to observed seasonal patterns (nutrient and biomass levels, community structure, succession of phytoplankton and zooplankton types) at ocean time series and process study sites, including the Bermuda Atlantic Time-Series Study (BATS) and the North Atlantic Bloom Experiment (NABE) sites. Global phytoplankton and zooplankton distributions, diversity, and community composition will be compared to data from databases (COPEPOD, AMT, CPR) on regional/global scales.

Task 3: The sensitivity of the model ecosystem's composition and functioning to changes in environmental conditions as, for example, expected in a future climate will be evaluated in longer-term model simulations.

We will investigate the effects of abiotic environmental changes on plankton community structure and biogeochemical fluxes. Changes in temperature and nutrient supply may affect community composition and the transfer efficiency between trophic levels, thereby influencing biogeochemical cycles. Here, we will particularly focus on large-scale ecosystem functions such as primary production and the export of organic matter/carbon to the deep ocean.