Latitudinal variation in plankton size spectra along the Atlantic Ocean

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Abstract:
Abundance-size distributions of organisms within a community reflect fundamental properties underlying population dynamics. These include characteristics such as predator to prey biomass ratios, given the relationships that exist between body mass and metabolic activity, and between body mass and the ecological regulation of population density. In this way, plankton size has an important role in structuring the rates and pathways of material transfer in the marine pelagic food web, and consequently the oceanic carbon cycle. The transfer of energy between trophic levels can be inferred from regular patterns in population size structure, where plots of abundance within size classes, also known as plankton size spectra, typically show a power-law dependence on size. Metabolic theory, based on such size relations, has provided the basis for using an allometric approach to investigate the metabolic balance of the Atlantic Ocean and to identify the main drivers of trophic status in the plankton community.

Samples were collected during three Atlantic Meridional Transect (AMT) cruises with further samples from a Marine Productivity (MarProd) cruise in the Irminger Sea. Three image analysis instruments were used to obtain plankton size spectra in the pico- to mesozooplankton size range. Data from a decadal time series at a coastal station off Plymouth, UK additionally enabled seasonal trends in plankton size spectra to be interpreted. Allometric relationships were also derived from physiological rates of individual plankton and scaled from organisms to ecosystems using community size structure data that were obtained from six earlier AMT cruises.

Contrary to common perception, the transfer efficiency between phytoplankton and mesozooplankton in the Atlantic was not related to ecosystem productivity in oceanic and coastal systems. The flow of carbon up the food web was controlled by how quickly the consumers are able to respond to a resource pulse. These findings have fundamental implications for upper ocean carbon flux and suggest that global carbon flux models should reconsider the differences in carbon transfer efficiency between productive and oligotrophic areas of the world’s ocean.

The allometric models of microbial community respiration and production provide a complementary method for understanding the metabolic balance of the upper ocean. Respiration exceeded photosynthesis in large areas of the Atlantic Ocean, suggesting that planktonic communities act as potential net sources of CO_2. Large-sized phytoplankton are suggested as the main drivers of the balance between net autotrophy and heterotrophy.