Challenges in Modeling the Size-Based Dynamics of Plankton Ecosystems

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Our studies reveal an apparent inconsistency between laboratory-based size-scalings for phytoplankton traits and oceanic observations of phytoplankton size distributions. Uni-modal distributions of maximum phytoplankton growth rate over cell size have been reported from laboratory experiments using single-species cultures. Our models, formulated based on size-scalings derived from laboratory results, tend to predict that medium-sized (nano-) phytoplankton dominate in the most productive regions of the ocean where chlorophyll concentrations are highest. However, oceanic observations of size-fractionated chlorophyll consistently reveal that the largest size fraction (micro-size) phytoplankton increases steadily with increasing total chlorophyll and dominates at the highest chlorophyll concentrations. Including size-selective grazing with decreasing preference for larger prey has been proposed as one possible means to reconcile laboratory-based size-scalings, which do not account for the effects of grazing, with oceanic observations, which reflect the net effect of both bottom-up and top-down processes. However, including size-selective grazing has not allowed our model to reproduce consistently the observed patterns of size-fractionated chlorophyll, primary production, and specific growth rate. Indeed, ship-board experiments reveal that micro-sized diatoms (> 20 mm) tend to have the fastest growth rates. This suggests that laboratory datasets, although valuable for providing information from controlled experiments, do not represent the full range of species and sizes present in the ocean. We will briefly introduce other challenges that have arisen in our recent studies, including modeling the $\delta^{15}N$ stable isotope ratios of size-based phytoplankton communities. Our goal is to encourage more discussions between researchers who study plankton ecosystems using experiments, observations, and modeling.

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