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Plankton settling and survival

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The balance between size-related metabolic activities and sinking is known to affect size composition of planktonic communities both on ecological and evolutionary timescales. One important driver toward the evolutionary reduction of plankton size is the fact that larger cells with negative buoyancy sink below the mixed layer. In this work, we address the role of turbulence and of its temporal fluctuations in the adaptive evolution of cell size. As pointed out by Magalef (1978), the adaptive success of planktonic cells must depend on their capability of matching mixing intensity in the water column. Turbulence in the mixed layer affects nutrient availability and light exposure, as well as the settling speed of negatively buoyant particles, therefore shaping the repartition of cells along the vertical gradients of nutrients and light. We incorporate the dependence of sinking rate on size in a model for adaptive evolution of cell size and show how different turbulent regimes (associated with different settling velocities) can have opposite effects on the adaptive value of organisms of a given size. We show that the outcome of phytoplankton competition on ecological timescales and of evolutionary dynamics on longer timescales depends on both the turbulent state of the mixed layer, affecting the dependence of the sinking rate on the cell size, and on the characteristic frequency of changes in turbulence properties. In general, larger-sized plankton is favoured for higher turbulence and for fast changes in the turbulent state. This opens a question on whether one can recognise regional-level processes, whereby the properties of small-scale turbulence (modulated by wind, for instance) cause an inversion of the evolutionary trend towards smaller sizes, and on the time scale of evolutionarily relevant variations in turbulence.