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A turbulence-induced switch in phytoplankton swimming behavior FRANCESCO CARRARA, MIT, ANUPAM SENGUPTA, ROMAN STOCKER, ETH — Phytoplankton, unicellular photosynthetic organisms that form the basis of life in aquatic environments, are frequently exposed to turbulence, which has long been known to affect phytoplankton fitness and species succession. Yet, mechanisms by which phytoplankton may adapt to turbulence have remained unknown. Here we present a striking behavioral response of a motile species – the red-tide-producing raphidophyte Heterosigma akashiwo – to hydrodynamic cues mimicking those experienced in ocean turbulence. In the absence of turbulence, H. akashiwo exhibits preferential upwards swimming ('negative gravitaxis'), observable as a strong accumulation of cells at the top of an experimental container. When cells were exposed to overturning in an automated chamber – representing a minimum experimental model of rotation by Kolmogorov-scale turbulent eddies – the population robustly split in two nearly equi-abundant subpopulations, one swimming upward and one swimming downward. Microscopic observations at the single-cell level showed that the behavioral switch was accompanied by a rapid morphological change. A mechanistic model that takes into account cell shape confirms that modulation of morphology can alter the hydrodynamic stress distribution over the cell body, which, in turn, triggers the observed switch in phytoplankton migration direction. This active response to fluid flow, whereby microscale morphological changes influence ocean-scale migration dynamics, could be part of a bet-hedging strategy to maximize the chances of at least a fraction of the population evading high-turbulence microzones.

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