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Planktonic contact and capture rates in turbulent environments

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The motion of plankton in turbulent environments is studied by numerical simulations, where point particles are moving in a flow described by Navier-Stokes equation. Parts of the results are supported also by observations from a controlled laboratory experiment, where approximately homogeneous and isotropic turbulence can be generated by two moving grids. We find that the contact rates of passively moving prey and predators with a spherical capture volume follow seemingly universal scaling laws in terms of the specific turbulent dissipation rate and the radius in the capture volume. For radii smaller than or comparable to the Kolmogorov-scale, also the viscosity enters the scaling laws. The models are extended to cover also non-spherical capture volumes. The average capture rate of prey is modelled by a product of the encounter rate and a capture probability, where the basic parameter for the capture is identified as the time duration of the encounter. Also the transit time of passively moving prey through the volume of interception is measured, and universal scaling laws for its probability density are estimated. Parameterizing the capture probability for given transit time, we obtain an estimate of the average capture rate of prey, indicating that small or moderate levels of turbulence are advantageous for the capture by increasing the contact rate, while strong turbulence is a disadvantage by reducing the capture probability due to the short transit times. We demonstrate how self induced cruising motions of predators can be included in the models, and obtain a parameterized expression for the average capture rate that includes also this effect.