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Swimming Plankton: Limit cycles and the effect of intrinsic vs extrinsic noise

Recent literature suggests that on fine scales the spatial distribution of plankton in the coastal oceans is profoundly affected by plankton swimming behaviour. Since the variety of swimming behaviour reported in the literature is extensive, and at times contradictory, we set out two relatively simple goals for our study. First, we wanted to identify simple flow-swimming behaviour combinations for which the resulting particle paths were qualitatively different from those due to either flow or swimming on their own. Second we wished to differentiate between two types of stochastic perturbations, namely extrinsic perturbations modelled by Brownian motion and intrinsic perturbations due to differences between individuals. We model the latter as varying the critical shear rate that triggers swimming motion, and find that while extrinsic noise "smears" limit cycles so that any one particle does not follow an exact limit cycle, intrinsic noise alters the shape of the resulting limit cycles but still allows individual particles to follow closed paths. Finally, we discuss how internal solitary wave-induced flows alter the distribution of swimming particles, and find that a combination of extrinsic noise and swimming to maintain a given light level leads to significantly enhanced number density at the rear of the wave, something that could be exploited by higher predators.