Ecologically motivated problems in fluid dynamics: studies in phytoplankton-turbulence interactions and the hydrodynamics of inhalant flows

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In the last few decades an interdisciplinary world of research has blossomed which examines the coupling of biological, chemical, and hydrodynamic realities in marine ecosystems. From chemotactic plume tracking of bacteria following free-falling marine snow aggregates to turbulent unmixing of motile phytoplankton, there are myriad fundamental problems in marine ecosystems requiring mechanistic understanding of various hydrodynamic phenomena. Here, we present experimental and numerical findings from two projects as illustrative examples of how we are leveraging state-of-the-art methods from experimental fluid mechanics to investigate fundamental and far-reaching problems in marine ecosystems: the dynamics of motile phytoplankton distributions in turbulent flows and the hydrodynamics of suction-driven inhalant flows. For the phytoplankton-turbulence project, we've built a 1 L oscillating grid turbulence tank, quantified the turbulence characteristics via particle image velocimetry (PIV), and directly imaged distributions of a motile dinoflagellate (*Heterosigma akashiwo)* in nearly homogeneous, isotropic turbulence via planar laser-induced fluorescence (PLIF) of the cells themselves. Preliminary spatial probability distribution functions revealed patches of cells with concentration enhancement factors comparable to those found in a direct numerical simulation (DNS) of motile cells in turbulence. For the inhalant flow project, we've employed a combination of numerical (DNS) and experimental (PIV) modeling to characterize the fundamental hydrodynamics of this ubiquitous class of flows. We've revealed nontrivial departures from the idealized inviscid flow fields, particularly at low Reynolds number, and quantified transient and pseudo-steady flow fields produced by a constant, impulsively applied suction for a variety Re and geometries. These findings have important implications for not only biological but also engineered inhalant flows and serve as the basis for investigations into more complex inhalant flows.