Title: Hydrodynamics of Inhalant-Exhalant Flows

Abstract:

Inhalant (suction) and exhalant (jet) flows are ubiquitous in organism feeding, respiration, propulsion, and transport (nutrient/oxygen/waste) processes. Building on previous work investigating viscous inhalant flows, we investigate the hydrodynamics of volume-conserving (zero-net mass flux) inhalant-exhalant flows from a fixed, single orifice using particle image velocimetry (PIV). For a laminar flow regime (phase-averaged Reynolds number = 100), we quantify the flow field at distinct phases (end exhale, end inhale, transitions, etc.) for varying ratios of inhalation to exhalation time (t_i/t_e = 1, 2, 4, 0.5, 0.25). Notable flow features include vortex ring generation at the start of the exhalant flow, instability and turbulent breakdown in the stem of fluid behind the vortex ring, exhalant puffs merging in the far field to form a coherent jet, and saddle point formation during the transition from exhalation to inhalation when the exhalant jet pinches off and inhalant flow is initiated. The relative contributions of each of these features is a function t_i/t_e and likely influences the refiltration rate, the portion of fluid previously inhaled that is subsequently reinhaled. The hydrodynamic phenomena observed here have important implications for many marine organisms.