



## Sea urchin spawning in benthic boundary layers: Are eggs fertilized before advecting away from females?

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**ABSTRACT:** Past work on fertilization in echinoids and other egg-broadcasting, free-spawning invertebrates suggests that these organisms might be extremely sperm limited in the field unless individuals spawn in close proximity and under nearly ideal flow conditions. However, virtually all previous experiments have used one or more techniques (surrogates for males and females, and short sampling duration) that bypassed two potentially important aspects of echinoid reproductive biology: the release of gametes in viscous fluids that cling to tests and spines, and extended longevity of eggs and undiluted sperm. We hypothesized that these attributes might interact with some flow regimes to facilitate time-integrated fertilization. Consequently, we explored fertilization processes in sea urchins induced to spawn in a benthic boundary layer in a flow-through flume, with a male 0.5 m upstream of a female. Our observations and data suggest that at free-stream flow velocities of 2.5 and 8.5 cm s<sup>-1</sup>, gametes were slowly and continually advected from the aboral surfaces of spawning animals. Eggs on the surface of the aboral mass were often fertilized before they ablated from the surface; many advected eggs were fertilized after being trapped in the vortex downstream of the female. Gamete advection and fertilization continued for several hours, with the actual time course depending on flow velocity. Fertilization levels declined only slightly with increasing flow velocity. These results suggest that fertilization in echinoderms and other free-spawners with viscous, long-lived gametes could be much less sperm-limited than currently envisioned and have additional implications for population dynamics and selection on gamete characteristics.

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