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# Turbulence induces metabolically costly behaviors and inhibits food capture in oyster larvae, causing net energy loss

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**Abstract:**

Planktotrophic invertebrate larvae require energy to develop, disperse and settle successfully, and it is unknown how their energetics are impacted by turbulence. Ciliated larvae gain metabolic energy from their phytoplankton food to offset the energetic costs of growth, development and ciliary activity for swimming and feeding. Turbulence may affect the energetic balance by inducing behaviors that alter the metabolic costs, and efficiency of swimming by raising the encounter rate with food particles and by inhibiting food capture. We used experiments and an empirical model to quantify the net rate of energy gain, swimming efficiency and food capture efficiency for eyed oyster larvae (*Crassostrea virginica*) in turbulence. At dissipation rates representative of coastal waters, larvae lost energy even when food concentrations were very high. Both feeding activity and turbulence-induced behaviors incurred high metabolic costs. Swimming efficiency was concave up versus dissipation rate, suggesting that ciliary activity for food handling became more costly while swimming became more efficient with turbulence intensity. Though counter-intuitive, swimming may have become more efficient in turbulence because vorticity-induced rotation caused larvae to swim more horizontally, which requires less effort than swimming vertically against the pull of gravity. Overall, however, larvae failed to offset high activity costs with food energy gains because turbulence reduced food capture efficiency more than it enhanced food encounter rates. Younger, smaller larvae may have some energetic advantages, but competent larvae would lose energy at turbulence intensities they experience frequently, suggesting that turbulence-induced starvation may account for much of oysters' high larval mortality.

Keywords: Aerobic scope, capture efficiency, ciliary swimming, clearance rate, Kolmogorov scale, swimming efficiency