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Vortex arrays and ciliary tangles underlie the feeding-swimming tradeoff in starfish larvae WILLIAM GILPIN, Department of Applied Physics, Stanford University, VIVEK N. PRAKASH, MANU PRAKASH, Department of Bioengineering, Stanford University — Many marine invertebrates have larval stages covered in linear arrays of beating cilia, which propel the animal while simultaneously entraining planktonic prey. These bands are strongly conserved across taxa spanning four major superphyla, and they are responsible for the unusual morphologies of many invertebrates. However, few studies have investigated their underlying hydrodynamics. Here, we study the ciliary bands of starfish larvae, and discover a beautiful pattern of slowly-evolving vortices that surrounds the swimming animals. Closer inspection of the bands reveals unusual ciliary tangles analogous to topological defects that break-up and re-form as the animal adjusts its swimming stroke. Quantitative experiments and modeling demonstrate that these vortices create a physical tradeoff between feeding and swimming in heterogenous environments, which manifests as distinct flow patterns or "eigenstrokes" representing each behavior—potentially implicating neuronal control of cilia. This quantitative interplay between larval form and hydrodynamic function generalizes to other invertebrates, and illustrates the potential effects of active boundary conditions in other biological and synthetic systems.

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