Abstract Submitted
for the DFD08 Meeting of
The American Physical Society

Performance of skeleton-reinforced biomembranes in locomotion
QIANG ZHU, KOUROSH SHOELE, Dept of Structural Engr, UCSD — Skeleton-reinforced biomembranes are ubiquitous in nature and play critical roles in many biological functions. Representative examples include insect wings, cell membranes, and mollusk nacres. In this study we focus on the ray fins of fish and investigate the effects of anisotropic flexibility on their performance. Employing a fluid-structure interaction algorithm by coupling a boundary-element model with a nonlinear structural model, we examined the dynamics of a membrane that is geometrically and structurally similar to a caudal fin. Several locomotion modes that closely resemble caudal fin kinematics reported in the literature are applied. Our results show that the flexibility of the fin significantly increases its capacity of thrust generation, manifested as increased efficiency, reduced transverse force, and reduced sensitivity to kinematic parameters. This design also makes the fin more controllable and deployable. Despite simplifications made in this model in terms of fin geometry, internal structure, and kinematics, detailed features of the simulated flow field are consistent with observations and speculations based upon Particle Image Velocimetry (PIV) measurements of flow around live fish.

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Date submitted: 30 Jul 2008 Electronic form version 1.4