FLUID MECHANICS OF PADDLE-ASSISTED WALKING IN ATLANTIC CANADIAN LOBSTER

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The juvenile and adult stages of the lobster *Homarus americanus* can move about their marine benthic habitats using several locomotory mechanisms. Tail-flips are acceleratory escape maneuvers, while more routine locomotion uses the walking legs and pleopods. The pleopods are small paddle-shaped appendages arranged in a series of four pairs on the abdomen. Each pleopod consists of a cylindrical stalk and two slightly cambered oval plates that bear a fringe of fine hairs and are oriented perpendicular to flow. The plates articulate with one end of the stalk, which articulates at its other end with the ventral abdomen. Simultaneous use of the walking legs and pleopods may offer a novel locomotory strategy, where the oscillating pleopods produce additional thrust forces that assist walking. This mode of locomotion may be important when crossing obstacles or for efficient long-distance travel, such as in migrations between on- and offshore waters.

The kinematics of pleopod beating in *H. americanus* have previously been quantified [1]. In the present study, we examine the mechanism of paddle-assisted locomotion by integrating pleopod kinematics and hydrodynamics. We will quantify pleopod fluid mechanics using an experimental approach consisting of physical modeling and flow visualization. Knowledge of how lobsters navigate complex terrain and long distances using this locomotory mechanism may be applied in the design of underwater vehicles. Biomimetics research has already produced a robotic lobster equipped with a set of walking legs enabling benthic exploration [2].

We measured pleopod kinematics from digital high-speed video of a live adult female lobster in a laboratory aquarium. Fourier analysis was applied to the kinematic data to derive a mathematical expression that approximates the beat waveform, which will be used to program the motion patterns of a mechanical lobster model. Preliminary results indicate a beat frequency of 1.7 Hz for all pleopod pairs, and a Reynolds number of *ca*. 10^3. A physical model that conveniently conserves the morphology of the natural system was built from the emptied, intact exoskeleton of a lobster tail. Each pleopod is coupled to a small servo motor that is controlled *via* computer software, causing the pleopod to move in a prescribed pattern. Particle image velocimetry (PIV) will be used to visualize and quantify fluid flow generated by the mechanical model. We will describe the spatial and temporal development of pleopod-generated flow, estimate the fluid forces that they exert, and discuss the functional role of pleopods in lobster locomotion.

References

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[2] J. Ayers, “Underwater walking,” *Arthropod Struct. Dev.* **33**, 347-360, 2004.

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