Getting a kick from water waves

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Wave-driven propulsion occurs when a floating body, driven into oscillations at the fluid interface, is propelled by the waves generated by its own motion. Longuet-Higgins [1] first demonstrated this using a wave-making raft (see Fig. 1), proposing that the raft's forward thrust originates from the backward-radiation of wave momentum. More recently, wave-driven propulsion has been observed in the case of the waves generated by a honeybee trapped on the surface of water [2], in the case of *SurferBot*, a centimeter-scale interfacial robot that was inspired by the stricken honeybee [3], and at much larger scales, in the case of the waves generated by jumping up and down on a canoe, also known as *gunwale bobbing* [4], which are all illustrated in Fig. 1.

We propose a new theory for wave-driven propulsion based on coupling the equations of motion of a floating raft to a quasi-potential flow model of the fluid. Using this model, we derive expressions for the drift speed and propulsive thrust of the raft which in turn are shown to be consistent with global momentum conservation. We explore the efficacy of our model in describing the motion of *SurferBot*, demonstrating close agreement with the experimentally determined drift speed and oscillatory dynamics. The efficiency of wave-driven propulsion is then computed as a function of driving oscillation frequency and the forcing location, revealing optimal values for both of these parameters which await confirmation in experiments.

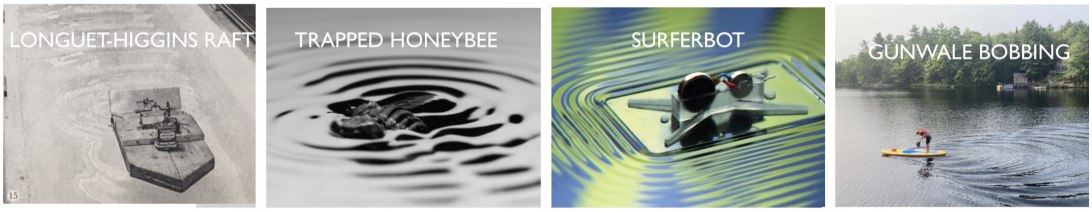

Figure 1. Examples of wave-driven propulsion, given by Refs. [1,2,3,4]

Références

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