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On the chordwise and spanwise flexibilities of fish fin during free swimming

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ABSTRACT

The flexibility of fish propulsors plays critical roles in biological propulsion in nature. It is widely thought that this flexibility usually results in drag reduction and thrust enhancement during the fish swimming. In past research, fish fins are usually modeled as rigid plates undergoing pitching–plunging motion. There is a lack of studies of the flexible caudal fin in freely swimming fish. In this study, a caudal fin model with both chordwise and spanwise flexibilities is constructed based on the real fin kinematics of a bluegill sunfish performing a forward swimming in a water tunnel. Direct numerical simulations using an immersed boundary method based solver are then carried out to examine the hydrodynamic roles of the chordwise and spanwise flexibilities during the free swimming. Hydrodynamic performance and flow structures are compared with that of a rigid fin model under the same flow conditions. It is found that comparing with the rigid fin model, chordwise flexibility is responsible for the thrust production, whereas the spanwise flexibility is to enhance the hydrodynamic performance. Quantitative comparison of wake structures will also be conducted in this study. (This study is supported by NSF CBET-1313217.)