



Fig. S1. (A) Amplitude-envelope function of cyclic swimming event (Fig. 4), measured in world coordinate. (B) Effective lateral excursions of the tail in different computational fluid dynamic (CFD) approaches by input amplitude envelope function measured in world coordinate. In our horizontal free-swimming model, side-slip and yaw reduce the effective lateral excursions of the tail in an earth frame of reference, allowing slip results in a large reduction of propulsion. (C) CFD speed curves produced by amplitude-envelope functions measured respectively in fish head and world coordinate using our horizontal free-swimming model.