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Momentum balance, hydrodynamic impulse and choreography in rapidly maneuvering live fish B.P. EPPS, A.H. TECHET, MIT — It is well known that swimming fish can swim circles around underwater vehicles when it comes to maneuvering performance. A typical underwater vehicle sweeps a circular arc, about ten vehicle lengths in diameter, and this requires about 15 times the amount of time it takes for the vehicle to drive one body length. In contrast, a fish, such as the Danio aequipinnatus, can turn in a space that is approximately one third of its body length, and it requires about half the time it takes to swim one body length. High-speed Particle Imaging Velocimetry (PIV) is used to quantify the impulse imparted to the fluid during a maneuver which is compared to the change in momentum of the fish during the maneuver. In order to model the impulse of the fluid, we make the assumption that the wake may be modeled as an axisymmetric vortex ring. The evidence that this is an appropriate model comes from a recent study of rapidly maneuvering flapping foils. Our PIV results show that the fish in fact generates two such wakes, one generated by the tail and shed at the conclusion of stage one of the maneuver and the other generated by the mid-section of the body and shed at the conclusion of stage two of the maneuver. Both of these vertical impulses are required to balance the momentum change of the fish from its initial swimming trajectory to its final swimming trajectory in a classical C-shaped maneuver.

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