Exception to Triantafyllou's Strouhal number rule of flapping
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Center, Newport, RI — Triantafyllou and Triantafyllou (Sci. Amer. 1995) have
shown that fish caudal fins have a preferred Strouhal number of 0.25-0.35 for effi-
cient swimming. Strouhal number is defined as fA/U, where f is flapping frequency,
A is the peak-to-peak flapping amplitude at the tip of the caudal fin, and U is
stream velocity. Although this preference was attributed to efficient swimming,
they did not measure the efficiency of fish swimming. Later Biorobotic experiments
by Bandyopadhyay et al. (JFE 2000) have suggested that while Strouhal number
is the dominant factor, another yet unidentified factor is also involved in efficiency.
Rohr and Fish (JEB 2004) have shown that in captive cetaceans the most common
range of Strouhal number is 0.20-0.30—slightly lower than that given by Triantafyl-
lou and Triantafyllou. We have carried out the measurements of efficiency and forces
produced by a single penguin-like fin. We show that for a single fin, in the range of
maximum efficiency of 0.55-0.60, the Strouhal number is 0.28-0.55. Here Strouhal
number is defined with amplitude A equal to the arc length traversed by the point
on the fin which divides the swept area in two. In addition to Strouhal number,
the pitch amplitude also determines the regime of high efficiency, with the peak of
efficiency seen at lower Strouhal numbers for low pitch amplitudes and at higher
Strouhal numbers at higher pitch amplitudes.

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