2008 Award Winner

Simulated Fish

Application Note V3V-009

Biological flows have generated a lot of interest recently in the field of fluid mechanics. The flight techniques of birds and insects have tremendous potential in the development of flying machines such as micro air vehicles (MAVs), and the flow patterns around fish and other acquatic animals have revealed interesting phenomena which has been used in the development of underwater vehicles, and in the study of the ways in which fish travel and feed. Even the development of fishing lures has benefited from the study of such flows. With the objective of mimicking smaller fish, a potential source of food, these lures are most effective when the generated flow is most similar to the actual animal they are designed to imitate. Since predatory fish use a variety of senses in hunting, it is not enough to rely on the coloring of the lure. In fact, often the sense of sight is of less importance to these creatures than the senses of hearing and touch, which is manifested in the detection of pressure fluctuations. From the standpoint of the fishing lure, it becomes important that the device leave a convincing wake.

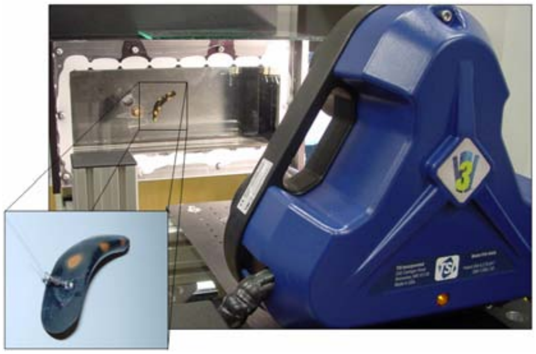

Fig. 1: The simulated fish in the water channel showing the location of the V3V camera. *(Inset: close view of the model).*

In this application, the wake downstream of a simulated fish developed by Lazy Ike is investigated. The model was placed in a water channel with a freestream velocity of 0.1 m/s, to mimic the typical velocity seen by these types of lures. The experimental setup can be seen in Fig. 1. The water tunnel had a square cross-section with side length of 100 mm. The model itself is contoured and had dimensions of approximately 60 mm in length, 25 mm in height, and 18 mm in width. The orientation of the simulated fish can be seen in Fig. 2.

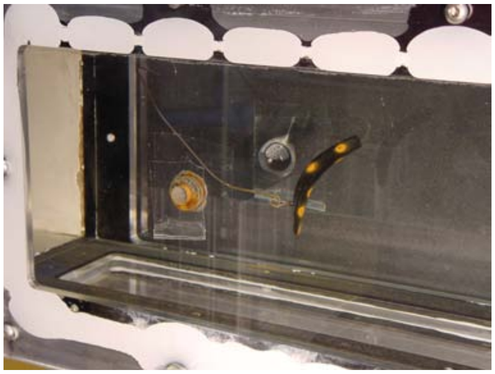

Fig. 2: Orientation of the simulated fish during testing. Flow is from left to right.

The TSI V3V (Volumetric 3-Component Velocimetry) system was used to analyze the resulting flow structure. The flow was illuminated by a model YAG200-NWL 200 mJ dual-head pulsed Nd:YAG laser operating at 7.25 Hz and 532 nm wavelength. Light cone optics were used at the exit of the laser to shape the beam into an illuminating cone. The laser cone was formed with two -25mm cylindrical lenses mounted at 90° to each other. These cylindrical lenses diverged the beam in the horizontal and vertical directions to illuminate a volume approximately 120 mm × 100 mm × 100 mm. The model V3V-8000 3D camera probe consists of three apertures and a total of 12 million pixels. The camera was aligned and calibrated with the CCD a distance of approximately 750 mm from the back plane of the measurement volume. The data capture was synchronized with the model 610035 synchronizer. The images were streamed to the model HYPER2 HyperStreaming® computer, and subsequently analyzed. The freestream velocity was 10.0 cm/s and was seeded with 12 micron silver-coated hollow glass spheres. Two image captures were taken with a Δt of 1500 µs, and volumetric velocity fields were obtained through unique particle identification, triplet matching, and particle tracking algorithms in TSI's INSIGHT™ V3V software.

Figure 3 shows an instantaneous volumetric velocity field. The trailing edge of the model was located at (x,y,z) = (0,0,0). The flow is from left to right and into the page. The vertical slice shows the streamwise velocity, where blue represents slower velocity and red indicates higher velocity; the downstream wake region is clearly seen. Red scalar isosurfaces represent vorticity magnitude at a fixed value of ω = 2.5 1/s.

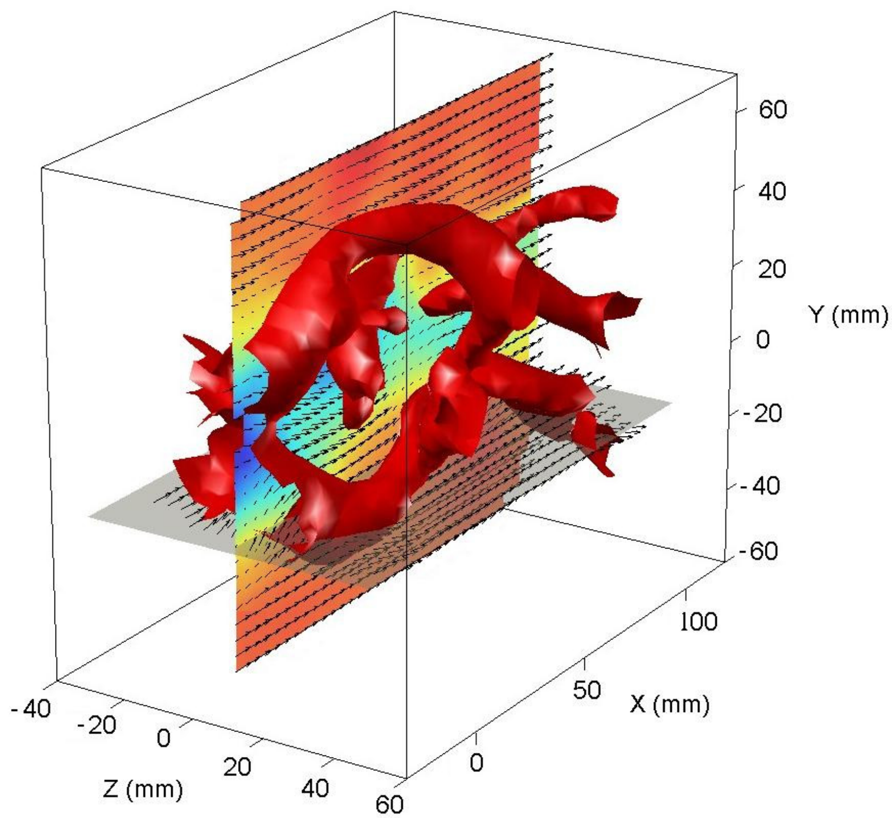

Fig. 3: Volumetric 3-component velocity field of the flow downstream of the lure. The red isosurface represents vorticity magnitude, and the vertical slice represents the streamwise velocity.

During the experiments, the model was seen to "dance" from side to side in a fairly regular pattern. This dancing is explained by the complex vortical structures shed into the wake as seen from the data. The primary features include a twisting leading edge vortex, as well as vorticity oriented along the streamwise (x) direction shed from the trailing fin.

TSI Incorporated – 500 Cardigan Road, Shoreview, MN 55126 U.S.A

USA	**Tel:** +1 800 874 2811	**E-mail:** info@tsi.com	**Website:** www.tsi.com
UK	**Tel:** +44 149 4 459200	**E-mail:** tsiuk@tsi.com	**Website:** www.tsiinc.co.uk
France	**Tel:** +33 491 95 21 90	**E-mail:** tsifrance@tsi.com	**Website:** www.tsiinc.fr
Germany	**Tel:** +49 241 523030	**E-mail:** tsigmbh@tsi.com	**Website**: www.tsiinc.de
India	**Tel:** +91 80 41132470	**E-mail:** tsi-india@tsi.com	
China	**Tel:** +86 10 8260 1595	**E-mail:** tsibeijing@tsi.com	

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