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The Flow Field on Hydrofoils with Leading Edge Protuberances[1]

DERRICK CUSTODIO, Worcester Polytechnic Institute, CHARLES HENOCH, Naval Undersea Warfare Center, Newport, RI, HAMID JOHARI, California State University, Northridge, OFFICE OF NAVAL RESEARCH COLLABORATION — The agility of the humpback whale has been attributed to the use of its pectoral flippers, on which protuberances are present along the leading edge. The forces and moments on hydrofoils with leading edge protuberances were measured in a water tunnel and were compared to a baseline NACA 63(4)-021 hydrofoil revealing significant performance differences. Three protuberance amplitudes and two spanwise wavelengths, closely resembling the morphology found in nature, were examined. Qualitative flow visualization techniques were used to examine flow patterns surrounding the hydrofoils, and Particle Image Velocimetry (PIV) was used to quantify these patterns. Flow visualizations have revealed counter-rotating vortices stemming from the shoulders of the protuberances. These streamwise vortices are a result of the spanwise pressure gradient brought about by the varying leading edge curvature. PIV was used to quantify the strength of these vortices as a function of angle of attack and leading edge geometry. At low angles of attack, these vortices are symmetric with respect to the protuberances; however, the symmetry is lost at high angles of attack. The loss of symmetry can be correlated with the separation point location on the hydrofoil.

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