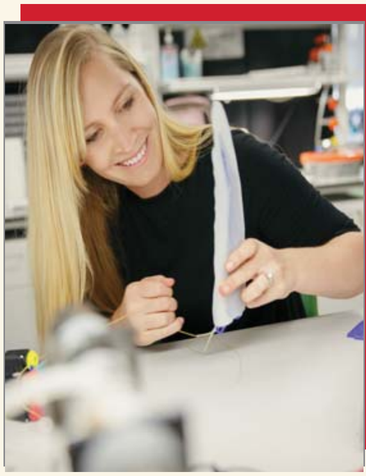
OCT 27, 2016

The hydrodynamics of sea lion locomotion



MEGAN LEFTWICH

Assistant Professor
Department of Mechanical and Aerospace Engineering
George Washington University
Washington, DC

ABSTRACT:

We are interested in fluid dynamical systems that arise in nature. There are many, highly diverse, systems that fit this description: plankton in the ocean, branches on trees and shrubs, a pumping heart, or a sneeze. In this talk, I will present a specific problem that is appropriately described as a biological-flow—the swimming California sea lion. California Sea Lions are highly maneuverable swimmers, capable of generating high thrust and agile turns. Their main propulsive surfaces, the foreflippers, feature multiple degrees of freedom, allowing their use for thrust production (through a downward, sweeping motion referred to as a “clap”), turning, stability and station holding (underwater “hovering”). To determine the two-dimensional kinematics of the California sea lion fore flipper during thrust generation, digital, high definition video is obtained using the specimen at the Smithsonian National Zoo in Washington, DC. Single camera videos are analyzed to digitize the flipper during the motions, using 10 points spanning root to tip in each frame. Digitized shapes were then fitted with an empirical function that quantitatively allows for both comparison between different claps and for extracting kinematic data. The resulting function shows a high degree of curvature (with a camber of up to 32%). Analysis of sea lion acceleration from rest shows thrust production in the range of 150-680 N and maximum flipper angular velocity (for rotation about the shoulder joint) as high as 20 rad/s. Analysis of turning maneuvers indicate extreme agility and precision of movement driven by the fore flipper surfaces. This work is being extended to three-dimensions via the addition of a second camera and a sophisticated calibration scheme to create a set of camera-intrinsic properties. Simultaneously, we have developed a robotic sea lion foreflipper to investigate the resulting fluid dynamic structures in a controlled, laboratory setting.

BIOGRAPHY:

Dr. Megan C. Leftwich is an Assistant Professor in the Department of Mechanical and Aerospace Engineering at The George Washington University. She holds a Ph.D. and M.A. in Mechanical and Aerospace Engineering from Princeton University and a B.S.E. degree from Duke University. Prior to joining GW, she was the Agnew National Security Postdoctoral Fellow at Los Alamos National Lab from 2010 to 2012. Dr. Leftwich is a member of the following: American Institute for Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineers (ASME) and the American Physical Society (APS). She is a member of Pi Tau Sigma and Tau Beta Pi Honor Societies. She has authored over sixty total refereed archival publications, conference papers and presentations. She has presented over two-dozen invited seminars and keynote addresses. Her current research includes: the fluid dynamics of rotating airfoils, high performance jetting for aquatic locomotion, unsteady activation for undulatory propulsion, and the fluid dynamics of human birth. Prof. Leftwich has a deep interest in diversity in technical fields and STEM education from the first year through the Ph.D. She is the winner of the 2016 SEAS Outstanding Young Teacher Award, and on the Advisory Board of the campus-wide George Washington University STEM Academy. In 2015 she won a STEM Academy Teaching Innovation Grant to create MOOC videos for a non-MOOC class. Over 50% of her lab comes from under represented groups in STEM, and she is a member of the GWU SEAS taskforce on Women in STEM. Professor Leftwich received an ONR Summer Research Faculty Fellowship in both 2015 and 2016. In 2014, she received the Young Researcher Award, 4th International Conference on Experimental Fluid Mechanics in Beijing, China. Her work on unsteady propulsion has been profiled in over 20 popular media venues including: Wired, the Smithsonian Magazine and the New York Times.