JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

Friday, March 15, 2019
3:00 PM, 132 Gilman Hall

"Hydrodynamics and Control of Deformable Attenuators for Optimum Wave Energy Conversion"

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Wave energy converters that are long and relatively narrow are typically designed to operate in 'head-sea' conditions, wherein waves traveling along the body length dominate. Referred to as 'attenuators' such devices are intended for gradual energy removal from passing waves, and can potentially provide the best structural economy relative to the converted power amounts. Power conversion on such devices may be through relative oscillation between hinged elements excited by the waves (e.g. the Pelamis device, UK,~2007-2014; Yemm, 2012), internal airflows between deformable chambers arranged lengthwise (French flexible bag, UK, ~1975-1982), and internal airflows between chambers open to sea at the bottom (Kaimei, Japan, ~1975-1981).

This talk will consider an elongated deformable rectangular raft with three rows of hydraulic actuators that are designed to capture energy from the relative oscillation between points on the deformable raft and deeply submerged, moored or tension-leg supported reference bodies (or the sea floor). As with most wave energy devices, diffraction forces dominate viscous forces for the present device ($L / \lambda \geq 0.15$, L being the device length and λ being the predominant wave length). Potential theory arguments then suggest that efficient energy radiators are also efficient energy converters (e.g. Bessho, 1973; Newman, 1979; Evans, 1981; Falnes, 2002, etc.). This talk will begin with a review of the wave radiation properties of a deformable raft converting energy through two rigid-body modes (heave and pitch) and the first two out-of-plane flexible-body modes. The required actuator velocities for optimum wave energy conversion are then discussed, and by way of illustration, considered next are the dynamics of the out-of-plane modes in the time domain. The need for wave elevation prediction for optimal constrained 'impedance matching' control will also be discussed (Naito and Nakamura, 1985; Falnes, 1995; Korde and Ringwood, 2016), along with example time-series results for control/actuator forces, flexible-mode displacements, and converter power. The talk will conclude with a discussion of potential applications for elongated attenuator wave energy converters in the era of climate change and rising sea levels.