"Simulation of Tidal Energy Generation by Nesting CFD in the Regional Ocean Modeling System"

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This project uses Computational-Fluid-Dynamics (CFD) to study Marine-Hydro-Kinetic (MHK) turbine arrays at a geo-physical scale, where turbulent wakes of MHK turbines can interact with estuary-scale flow dynamics. Secondary flows generated by bathymetric features can impact the survivability and efficiency of MHK turbines; and likewise, MHK turbine arrays can alter the aquatic environment. Mesoscale CFD simulations are performed via solutions of the Reynolds-Averaged Navier-Stokes (RANS) equations to capture the combined flow features generated by bathymetry and tidal turbine wakes.

An outcome of this project is a computer-aided-engineering (CAE) tool, focused on the use of CFD to study estuarine flows and marine hydrokinetic power plants at contrasting scales (software available at github.com/nnmrec/topo-Cascadia). Estuary scale flow features are simulated with the Regional Ocean Modeling System (ROMS) code, and a nested domain is built using the STAR-CCM+ code to model the meso-scale features using boundary conditions provided by the parent ROMS. The estuary-scale (Regional Ocean Modeling System) in combination of nested CFD (STAR-CCM+) models can perform resource characterization, forecasts of tidal farm energy generation, and simulate the turbulent wakes of turbines and interaction with environment.

This CAE tool allows construction of different scenarios; in this example result, a hypothetical 11 MegaWatt tidal power plant composed of 10 turbines is deployed in Admiralty Inlet (following specifications of the U.S. Department of Energy Reference-Model-1 Tidal Turbine). The model aims to (1) quantify uncertainty in the numerical model introduced by testing different resolutions and sources of bathymetric maps, and (2) to compare the flow field in proximity to tidal farms at pre-installation and post-installation conditions.

This study aims to inform design of efficient, robust, and environmentally friendly large-scale arrays of tidal turbines.

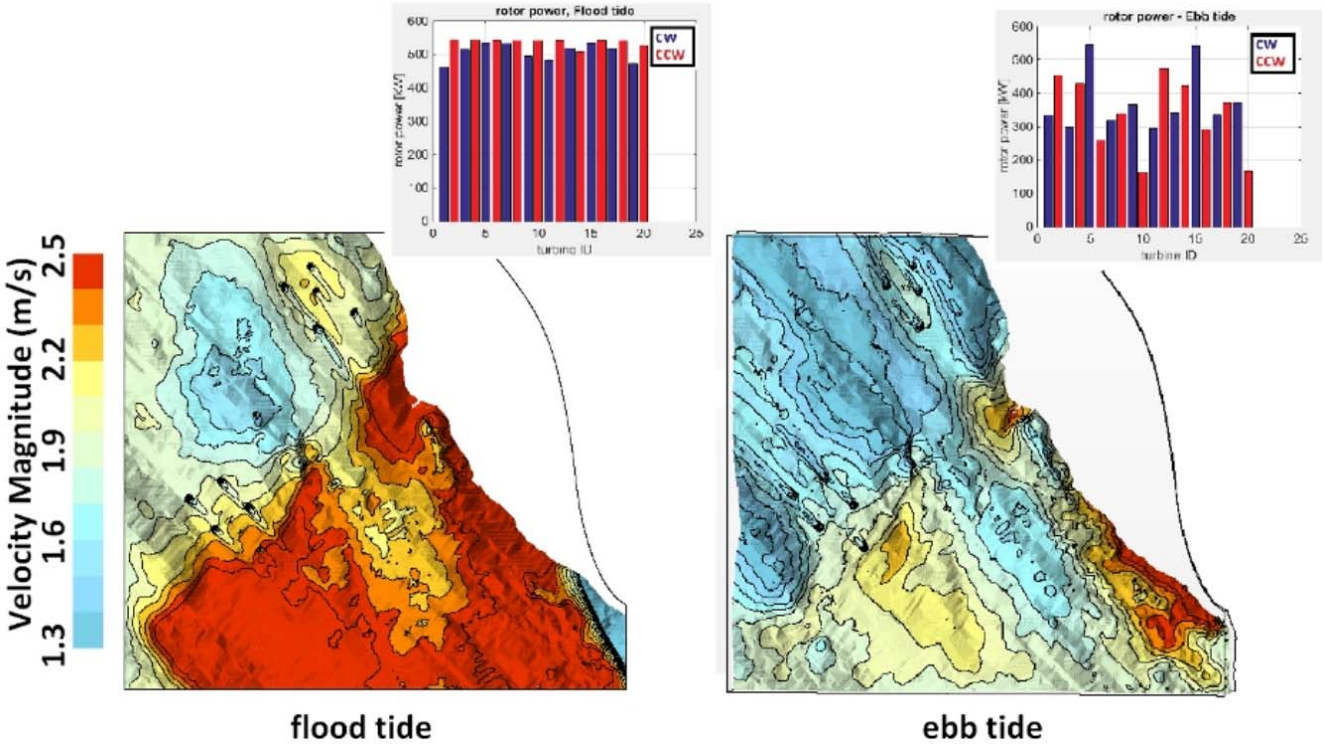

Fig 1. Velocity field shown at turbine hub-height elevation from the seabed. On the flood tide, all turbines can generate rated power, but the ebb tide produces significantly less power and suggests that turbine locations can be further optimized.