

Numerical Modeling of Tidal Turbines: Near Wake Environmental Effects

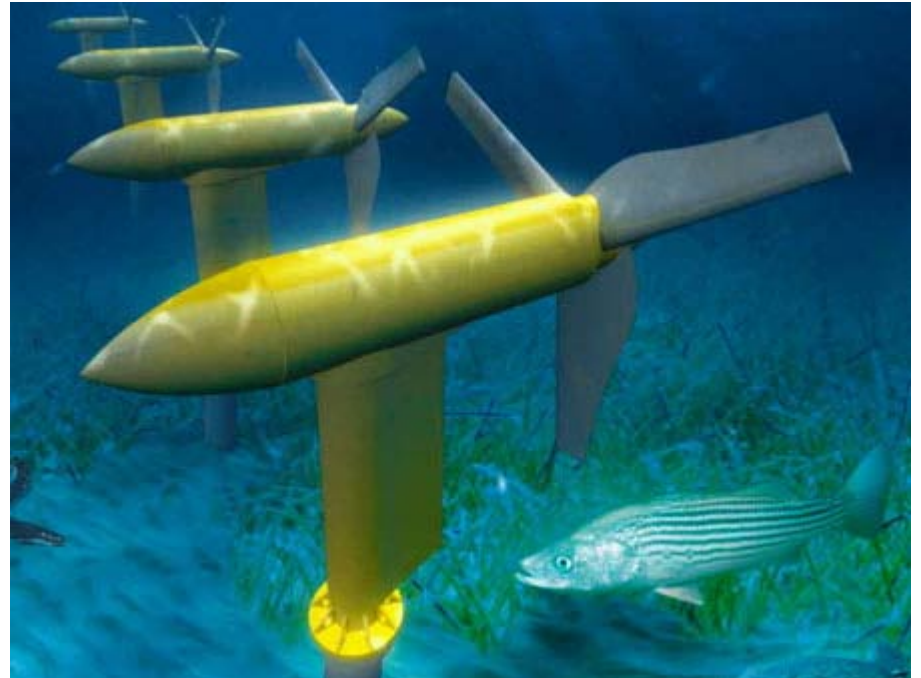
Teymour Javaherchi

Prof. Alberto Aliseda

Motivation

Understanding and minimizing the potential environmental impacts:

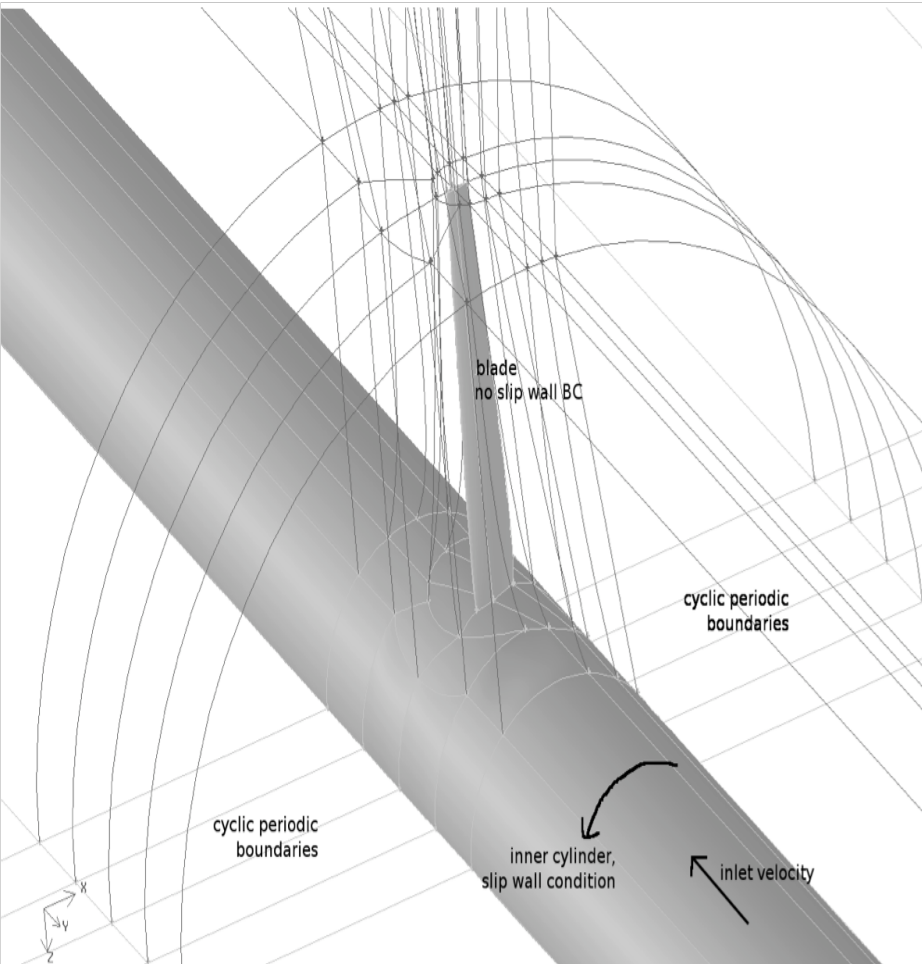
- Estuary scale changes
- Sediment transport
- Effects on marine species
- ...



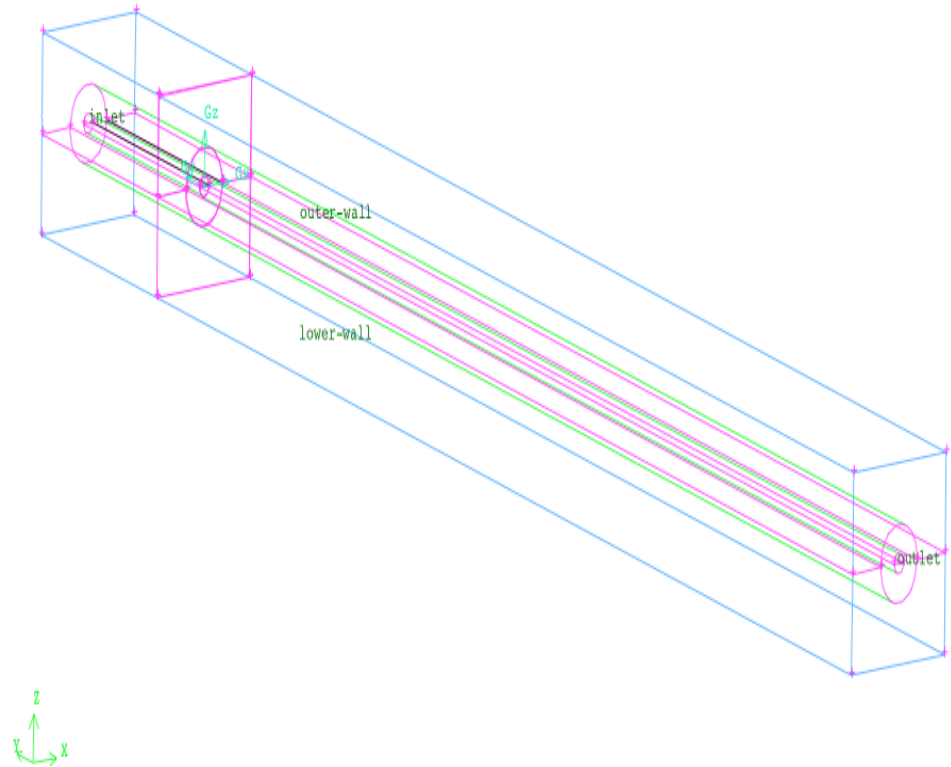
Outline

- Benchmarking numerical models:
 - Single Reference Frame (SRF)
 - Virtual Blade Model (VBM)
- Considering short range hydrodynamic impacts:
 - Turbine effect on particle settling
 - Interaction of marine species with turbine

Numerical Models

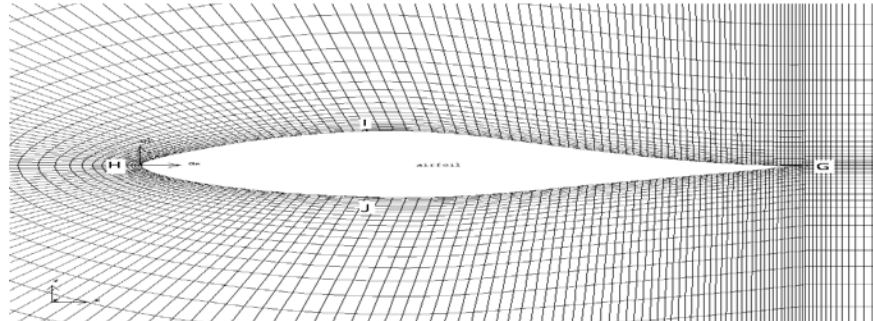
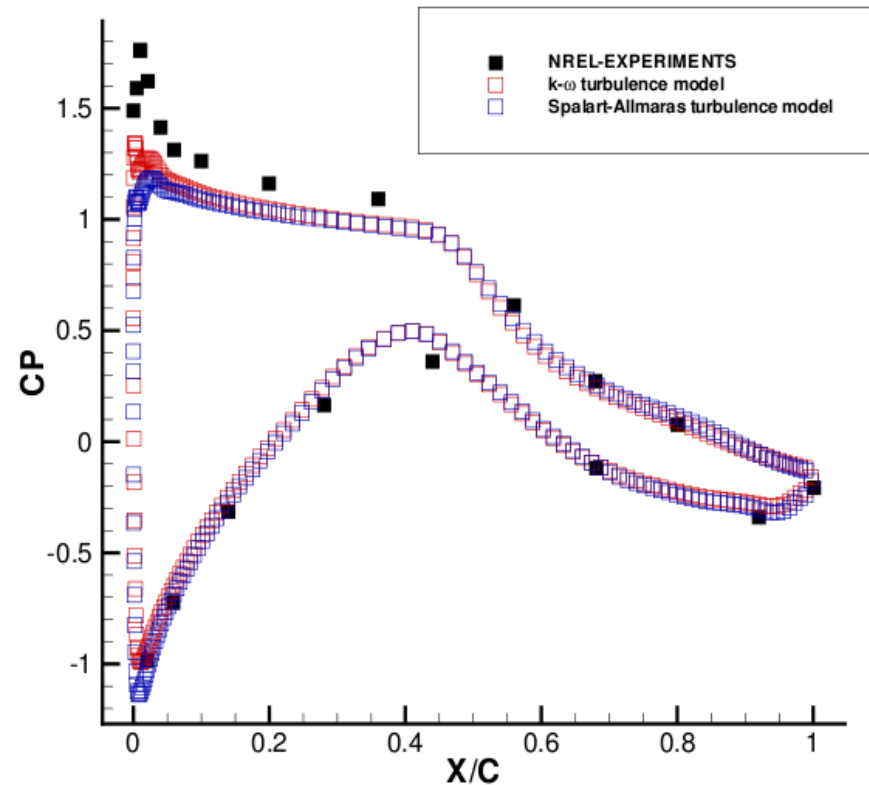
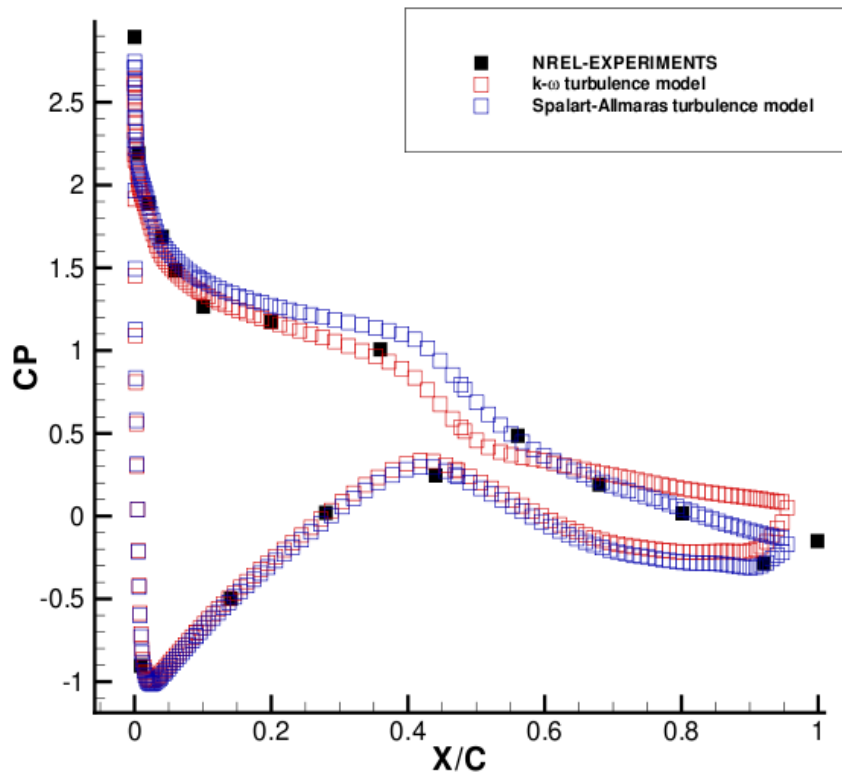


Single Reference Frame (SRF)



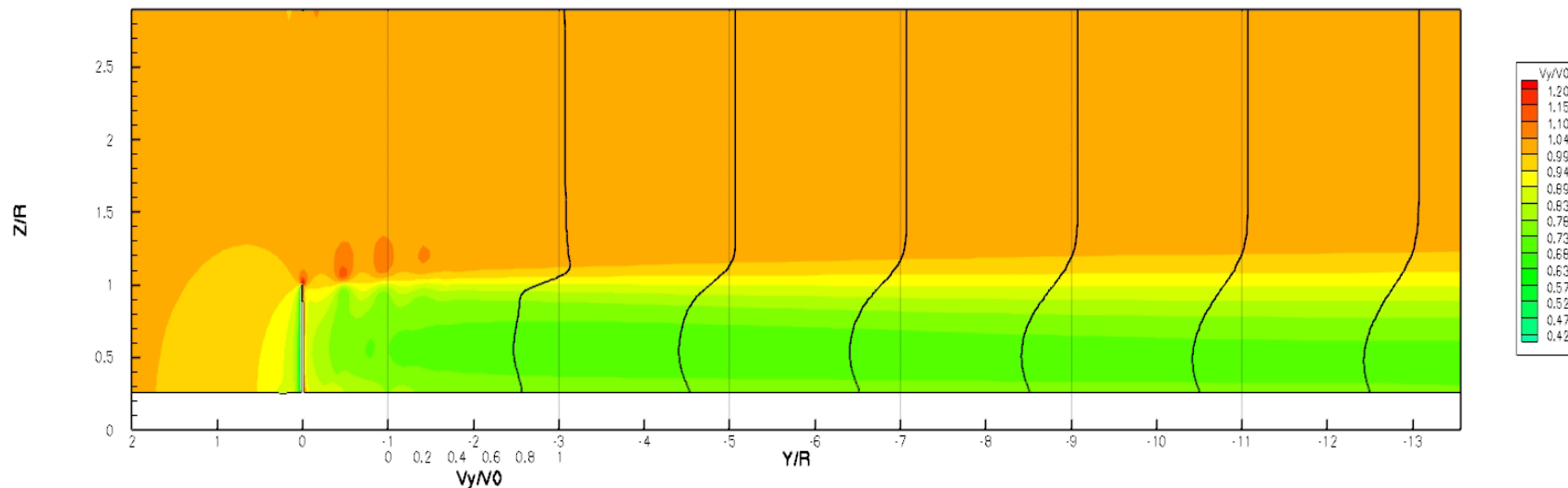
Virtual Blade Model (VBM)

Validation of SRF Methodology Against Experimental Data from AMES Wind Tunnel (NREL Phase VI turbine).

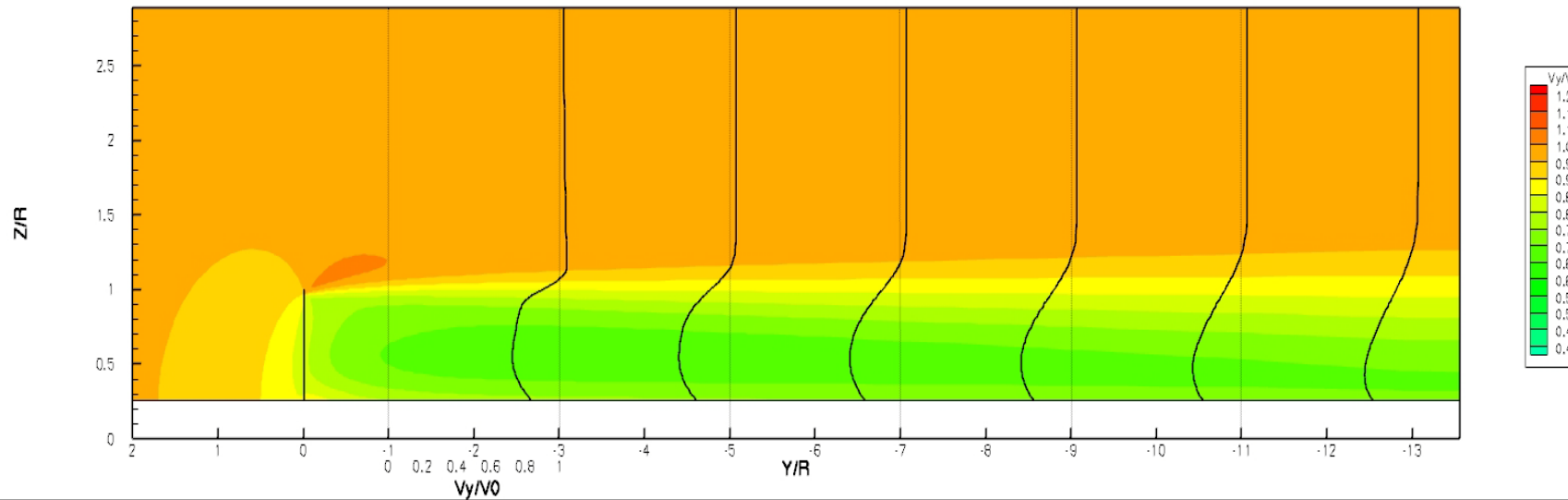
 $r/R=0.3$ $r/R=0.8$ 

Validation VBM with SRF Results

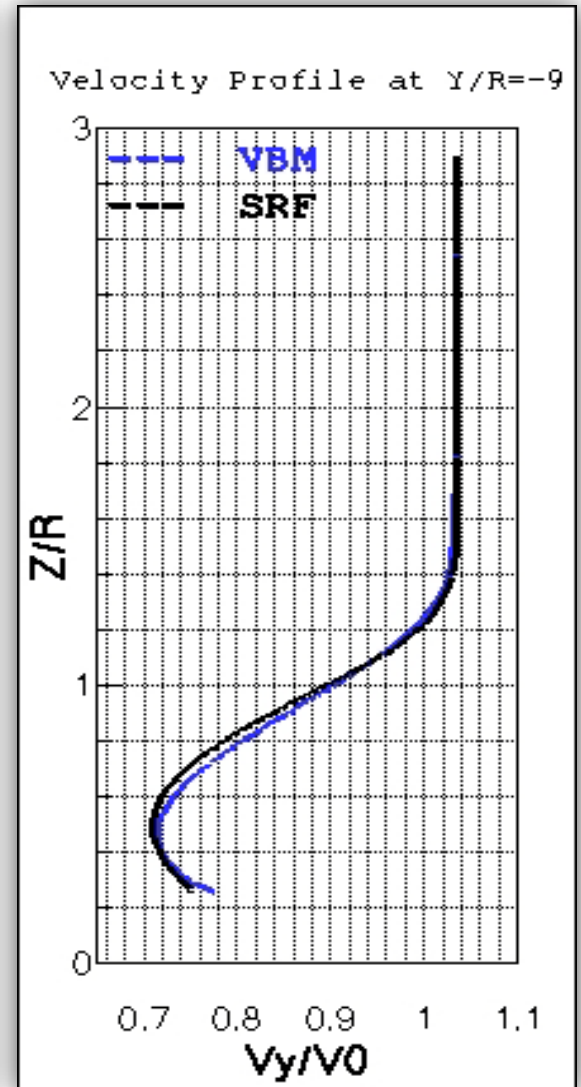
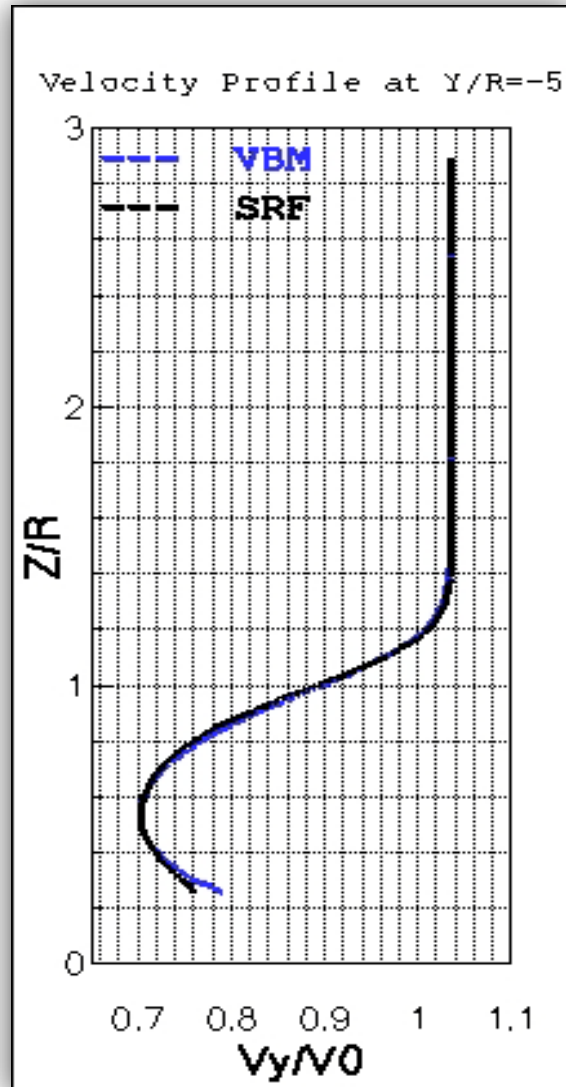
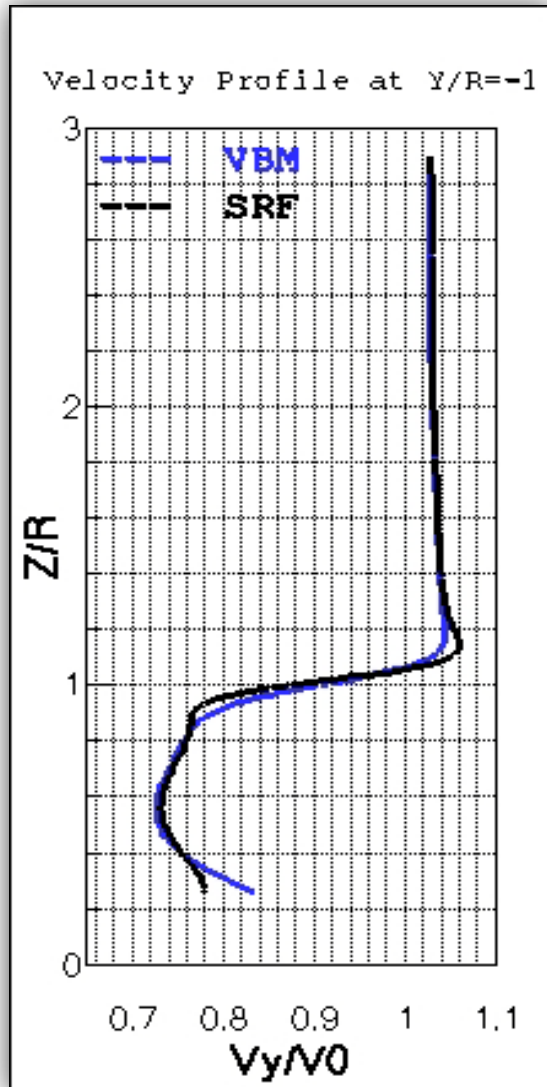
SRF / Velocity Contour / X-Cut / 1% Turbulent Intensity



VBM / Velocity Contour / X-Cut / 1% Turbulent Intensity



Validation VBM with SRF Results



Application of Numerical Models to Quantify the Potential Environmental Effects

- Apply VBM to model particle settling in the tidal turbine wake.
- Apply SRF model to look at possible effect on the interaction of marine species with turbine blades and blade tip vortices.

Particle Settling with VBM

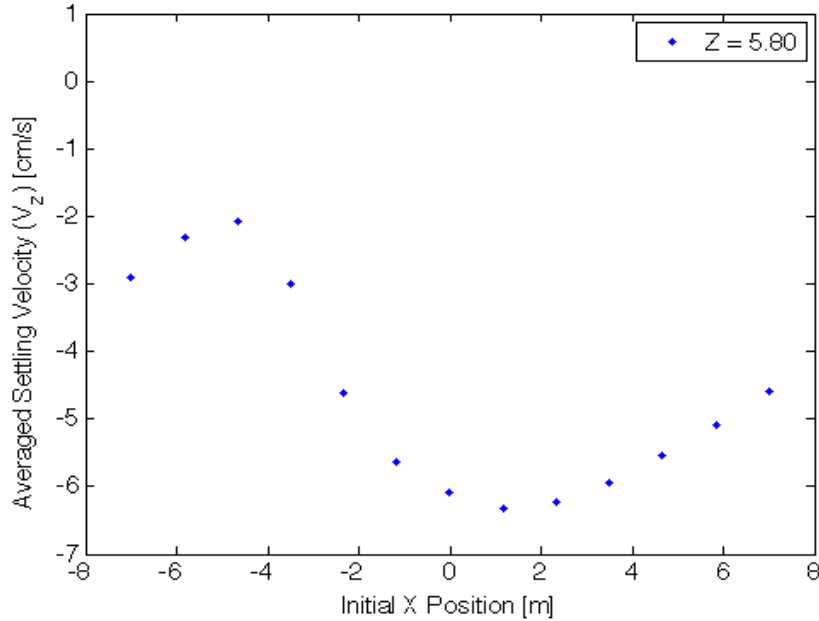
- Spherical particles with different diameters.

Diameter	Density [kg/m ³]
100 μm – 1 mm – 5mm	1200

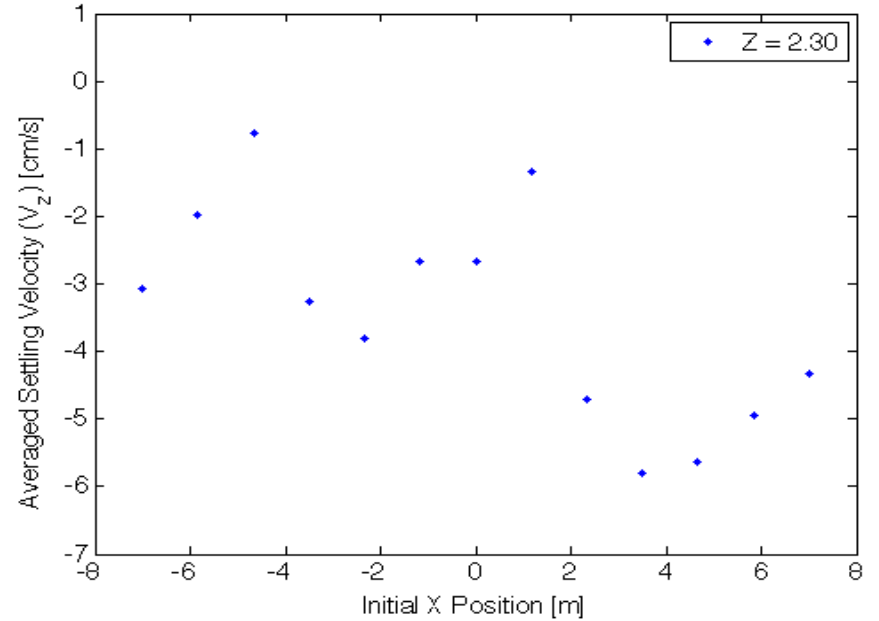
- Uniformly distributed particles injected at the inlet and just below the turbine.
- Comparing particle motion along the channel with and without a turbine.

Settling Velocity - 1mm Particles Injected at the Inlet

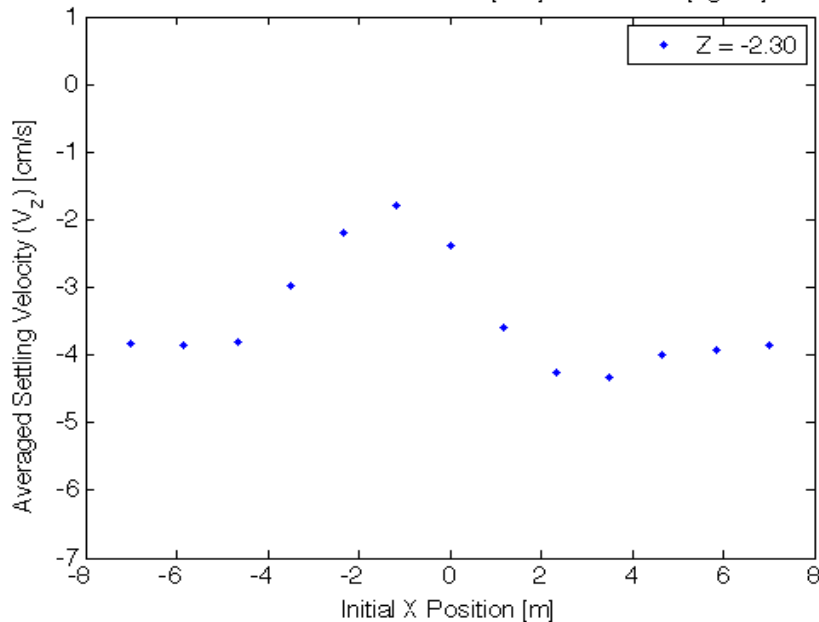
channel with turbine effect - d=1 [mm] - rho=1200 [kg/m³]



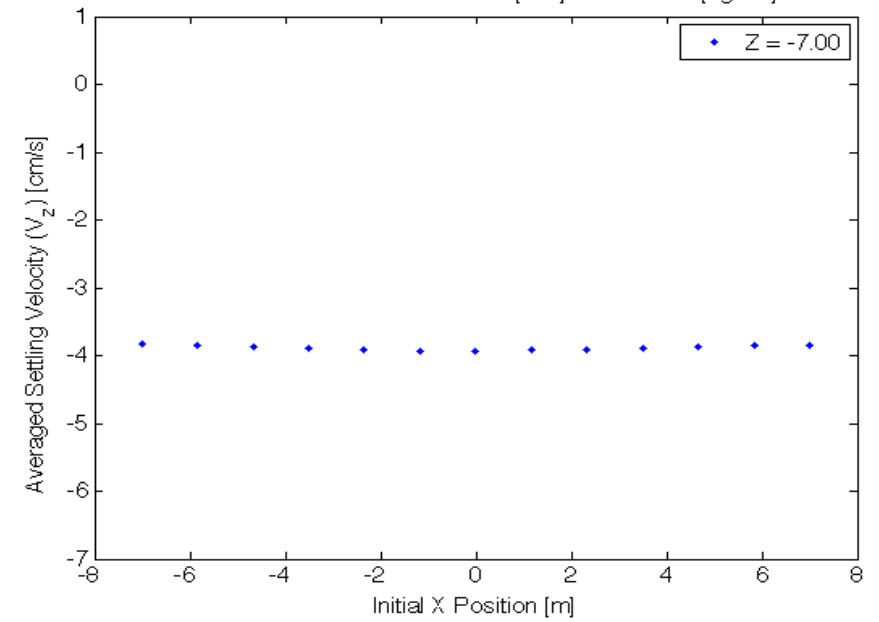
channel with turbine effect - d=1 [mm] - rho=1200 [kg/m³]



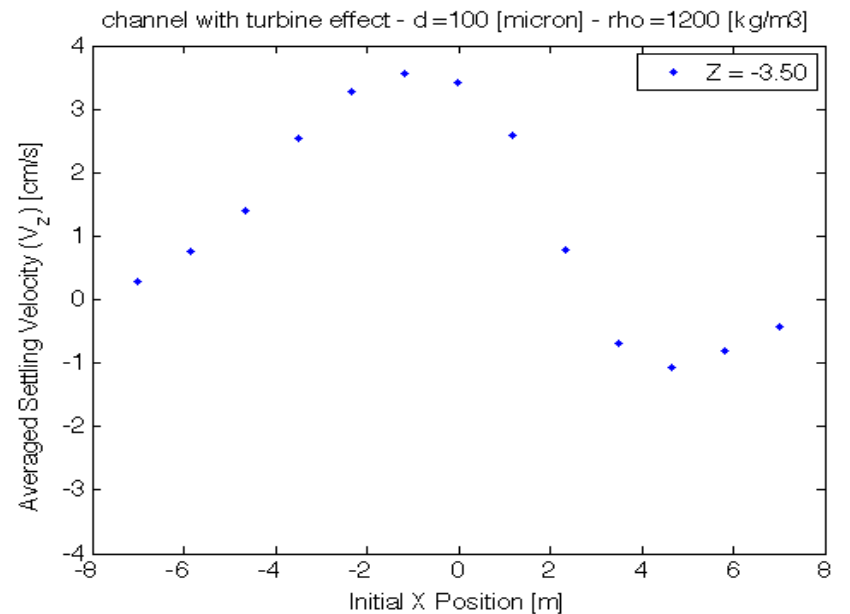
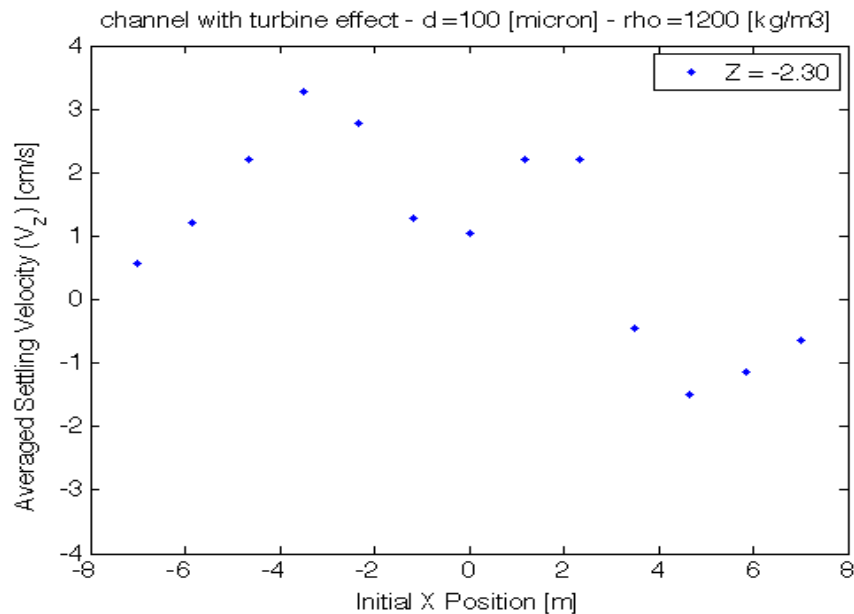
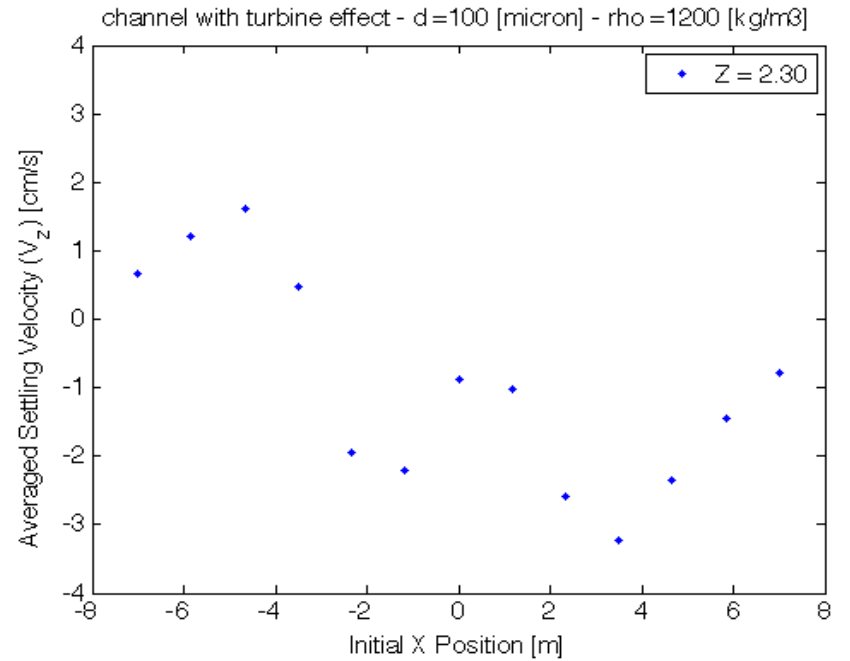
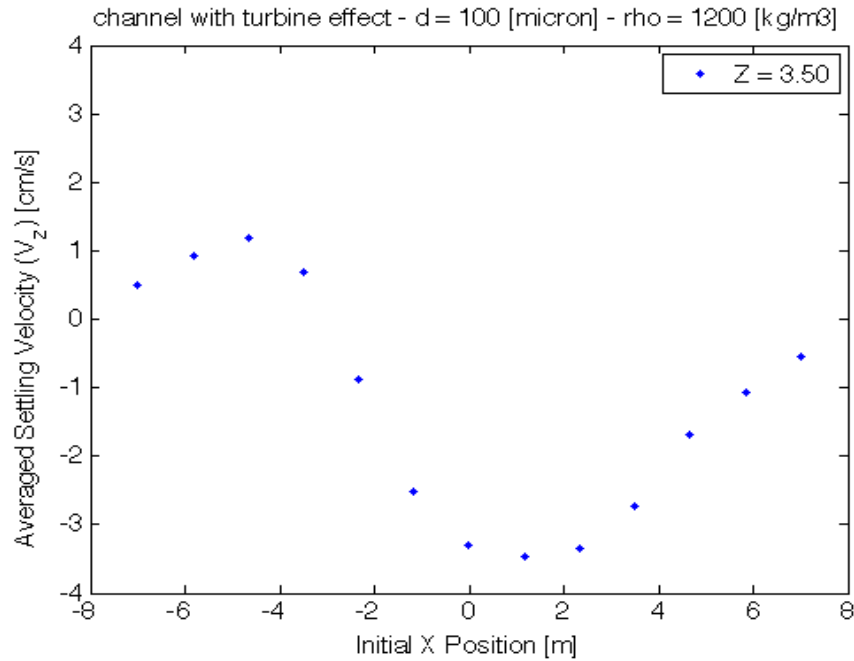
channel with turbine effect - d=1 [mm] - rho=1200 [kg/m³]



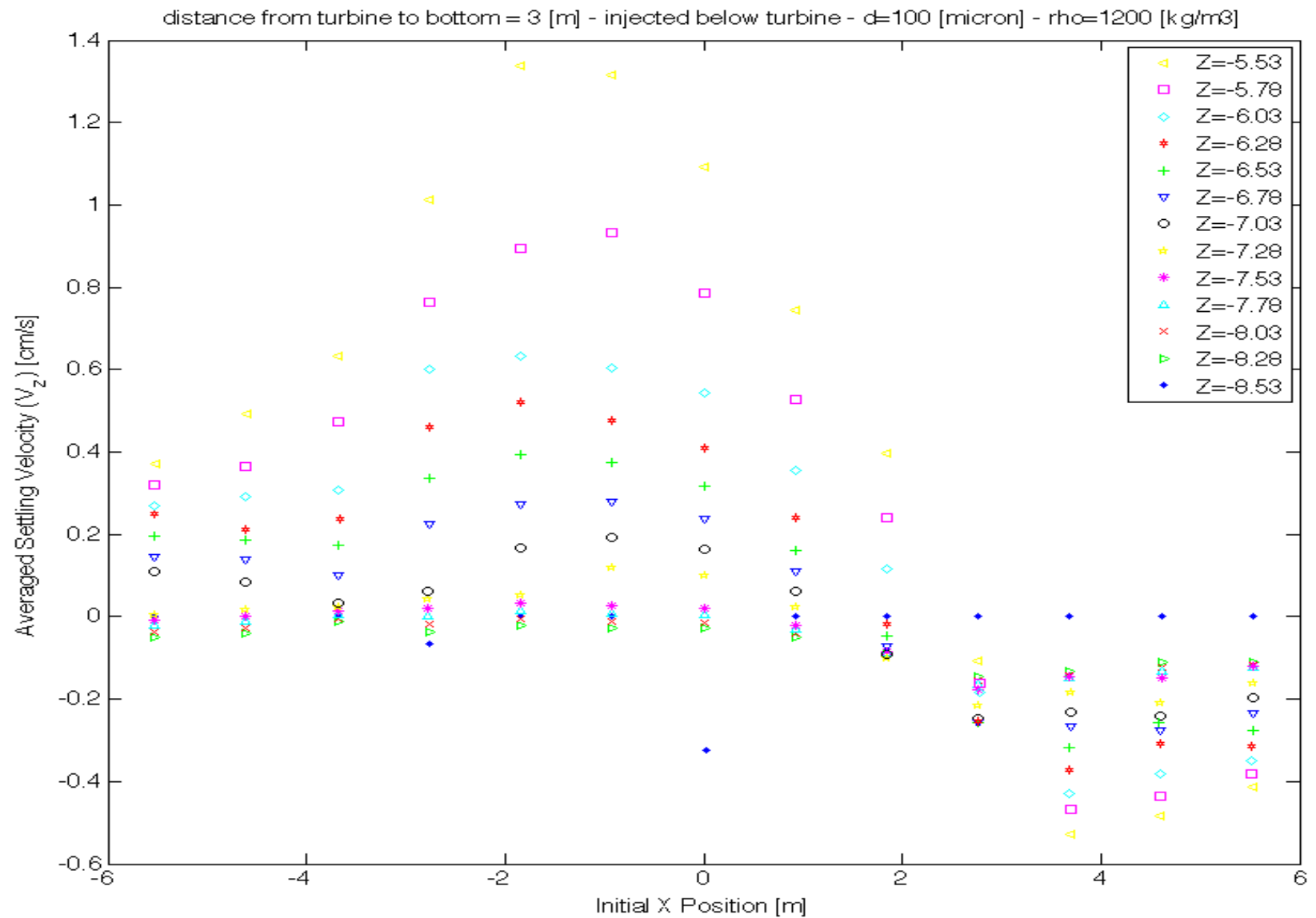
channel with turbine effect - d=1 [mm] - rho=1200 [kg/m³]



Settling Velocity – 100µm Particles Injected at the Inlet



Particles Injected within 3m Gap Between Turbine and Seabed



Summary

- A methodology for numerical simulation of tidal turbines has been developed and benchmarked with literature (NREL)
- Settling velocity of approximately 69% of 1mm particles injected at the inlet is enhanced along the channel. However, the average settling velocity is 1% lower than in the perturbed case.
- Settling velocity of 47% of 100 μ m particles injected at the inlet is enhanced along the channel. The average settling velocity of the whole cloud is enhanced by 33%.
- For the case of 100 μ m particles suspended beneath the turbine, settling velocity is hindered for 57% of the particles. The overall average settling velocity along the channel is decreased by 150%. The velocity changes sign and particles move up in the water column.