

Tidal Power Development Scenarios in Puget Sound, WA

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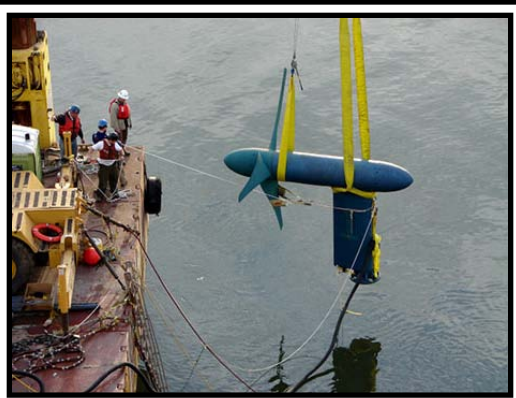
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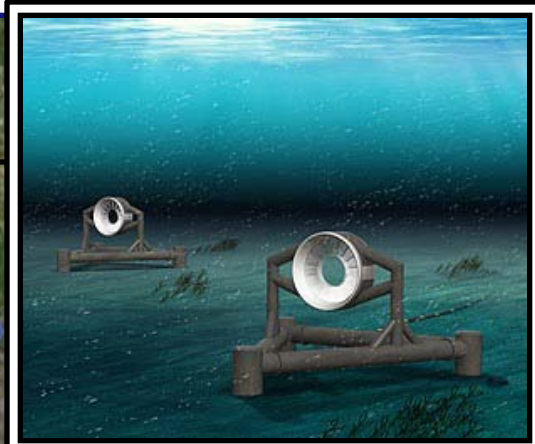
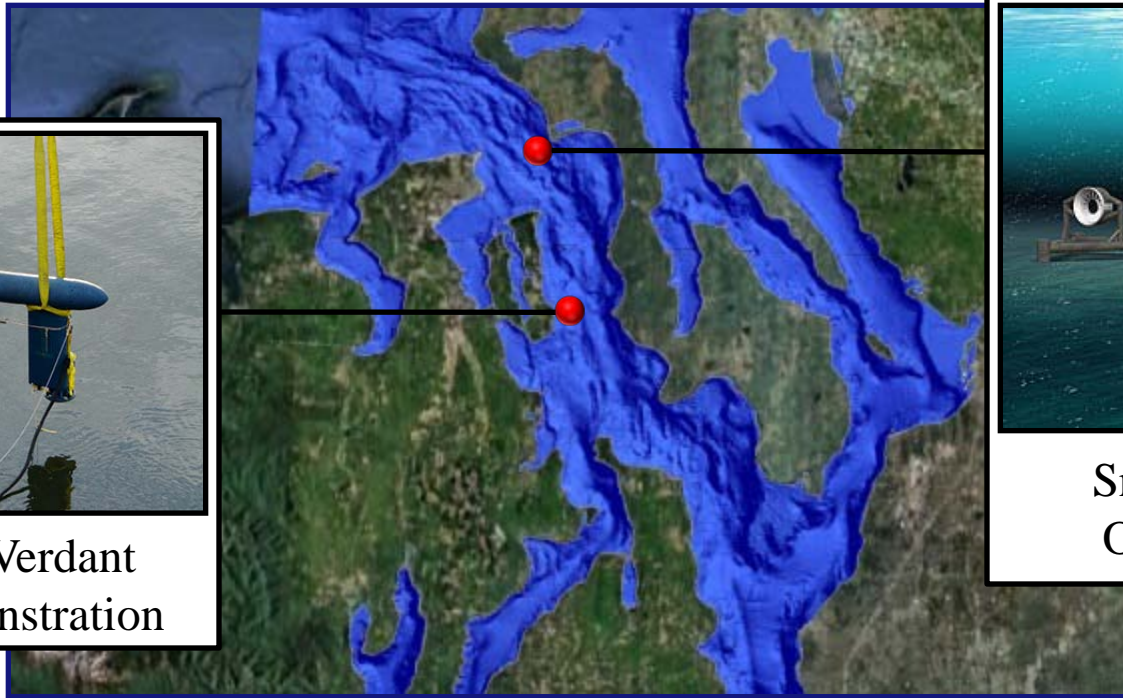
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Tidal Energy Projects in Puget Sound, WA



US Navy / Verdant
Power Demonstration



Snohomish PUD /
OpenHydro Pilot

Key Questions for Puget Sound

What is the hydrokinetic power potential?

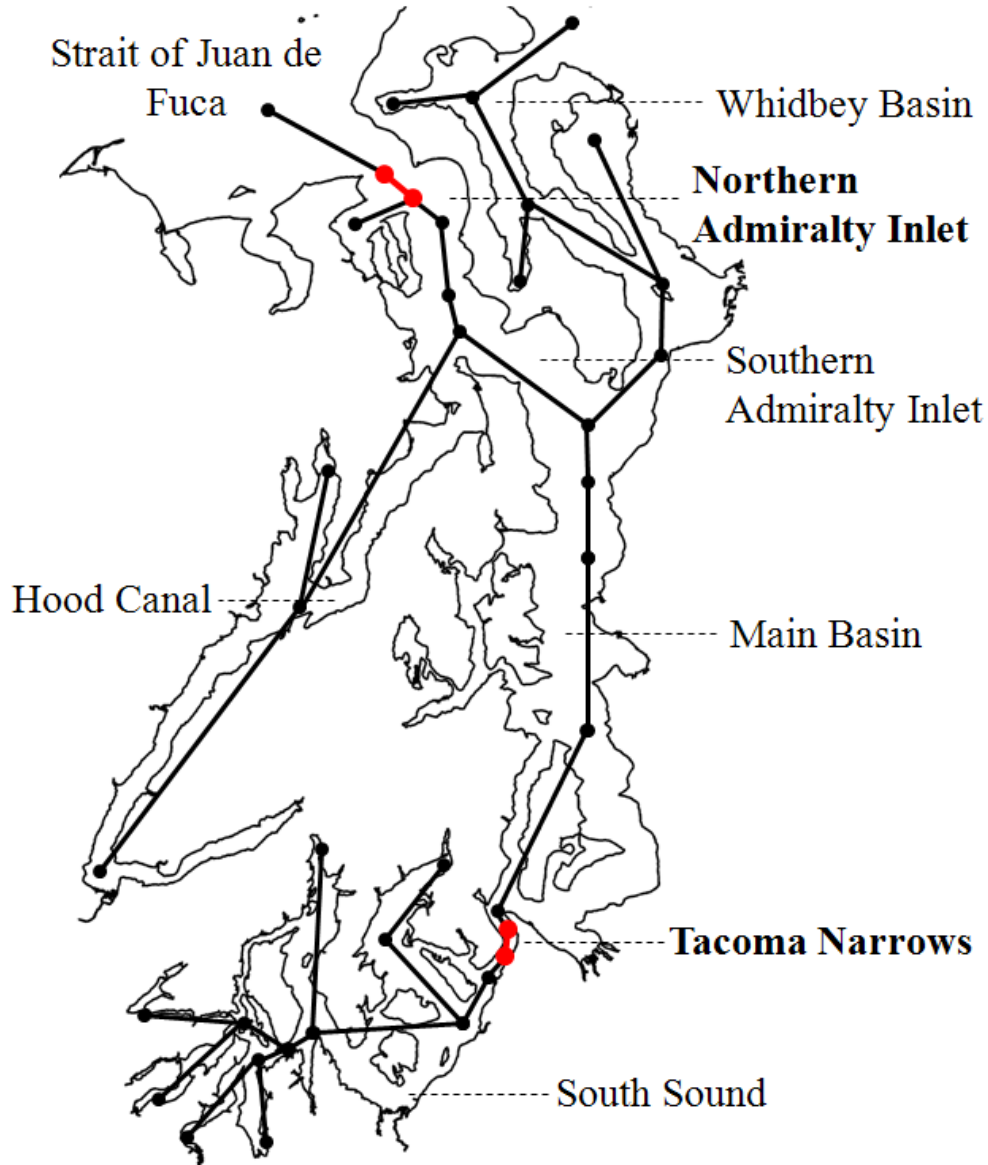
What are the effects of extracting kinetic power?

Barotropic, Far-field Environmental Effects

Category	Potential Change	Example Impacts
Tidal Range	Local contraction or expansion	Drying or inundation
Tidal Currents	Local reduction or intensification	Sediment transport Hydrokinetic resource
Mixing	Local reduction or intensification	Dissolved oxygen concentration

- Sutherland, G., Foreman, M., and Garrett C. Tidal current energy assessment for Johnstone Strait, Vancouver Island. *Proc. IMechE Part A: J. Power and Energy*. 2007, 221(2), 147-157
- Polagye, B., Malte, P., Kawase, M., and Durran, D. Effect of large-scale kinetic power extraction on time-dependent estuaries. *Proc IMechE, Part A: J. Power and Energy*. 2008, 222(5), 471-484
- Karsten, R., McMillan, M., Lickley, M., and Haynes R. Assessment of tidal current energy in the Minas Passage, Bay of Fundy. *Proc IMechE, Part A: J. Power Energy*. 2008, 222(5), 493-507

Approach: Puget Sound, WA Model



- **Goals:**
 - Determine tidal hydrokinetic potential of Puget Sound, WA
 - Preliminary understanding of far-field effects
- **Model Puget Sound as a series of rectangular channels of constant cross-section**
 - Flow dominantly 1D
 - Neglect salinity

Approach: Hydrokinetic Turbines

Power dissipation as a discontinuous decrease in total energy $\frac{u_1^2}{2g} (1 - \varepsilon \eta_d) + h_1 = \frac{u_2^2}{2g} + h_2$

Power *Dissipated* by Hydrokinetic Turbines

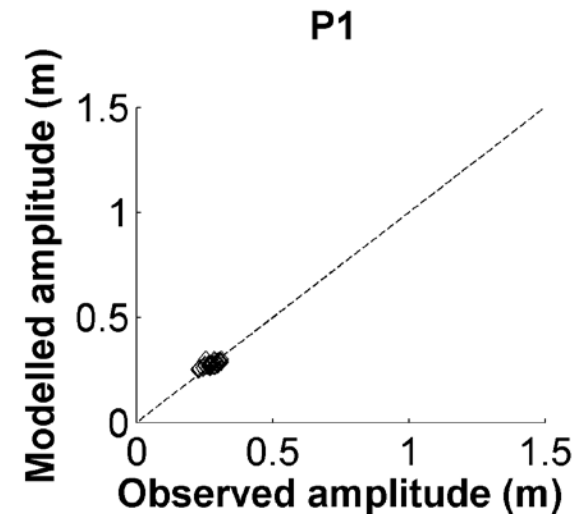
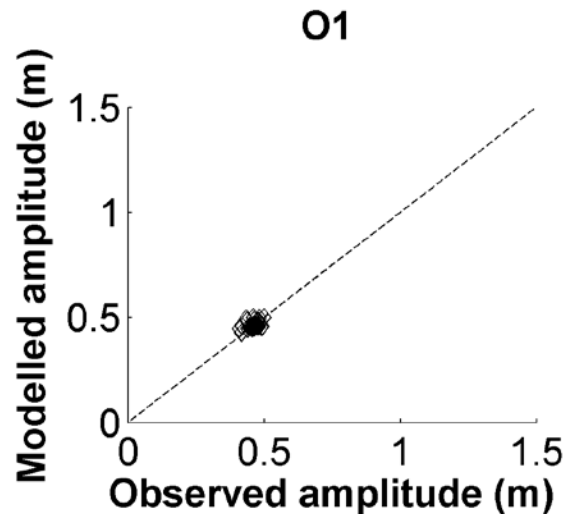
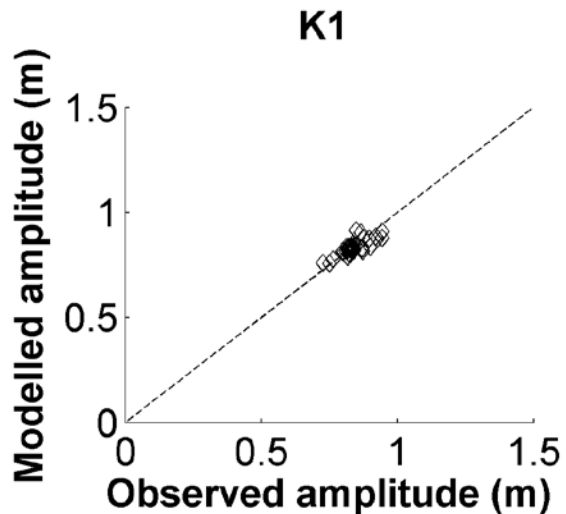
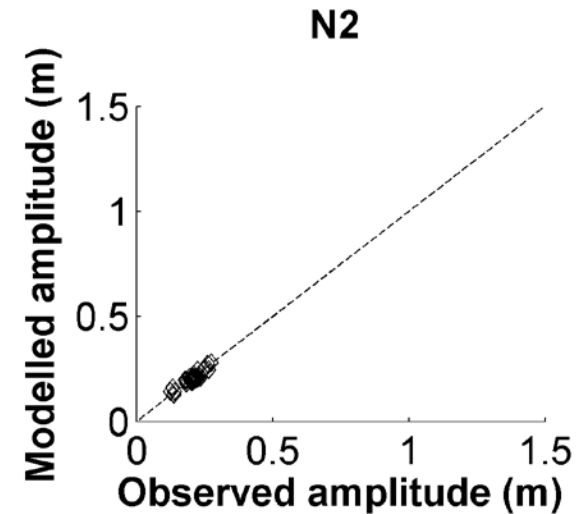
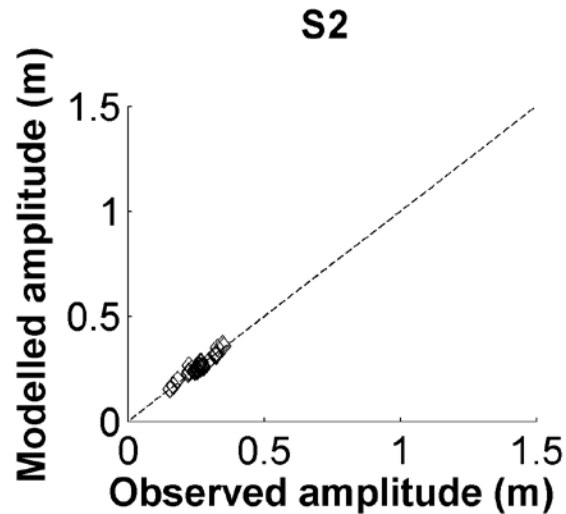
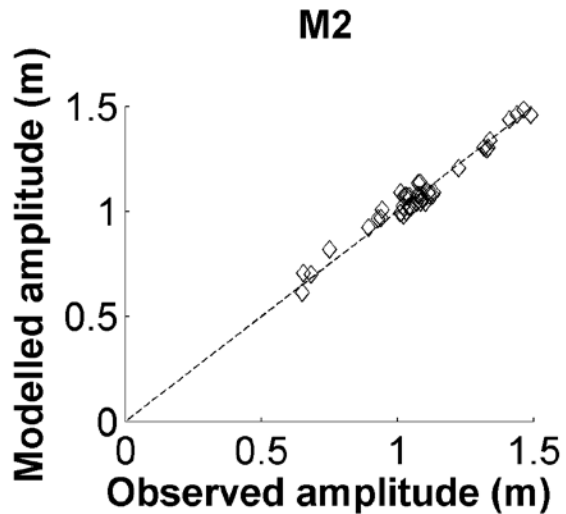
1/3 Blockage Ratio (ε)

99% Dissipation Coefficient (η_d)

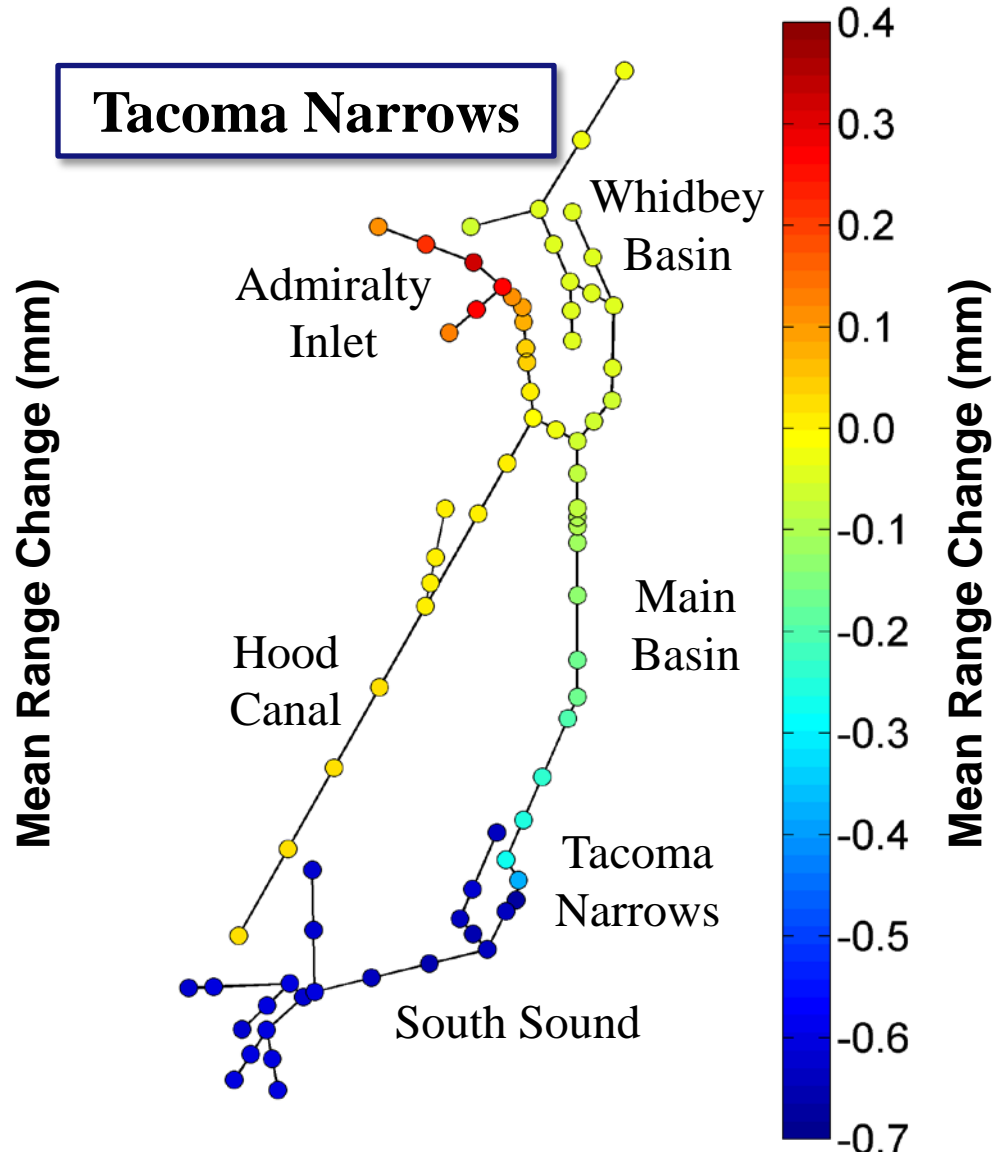
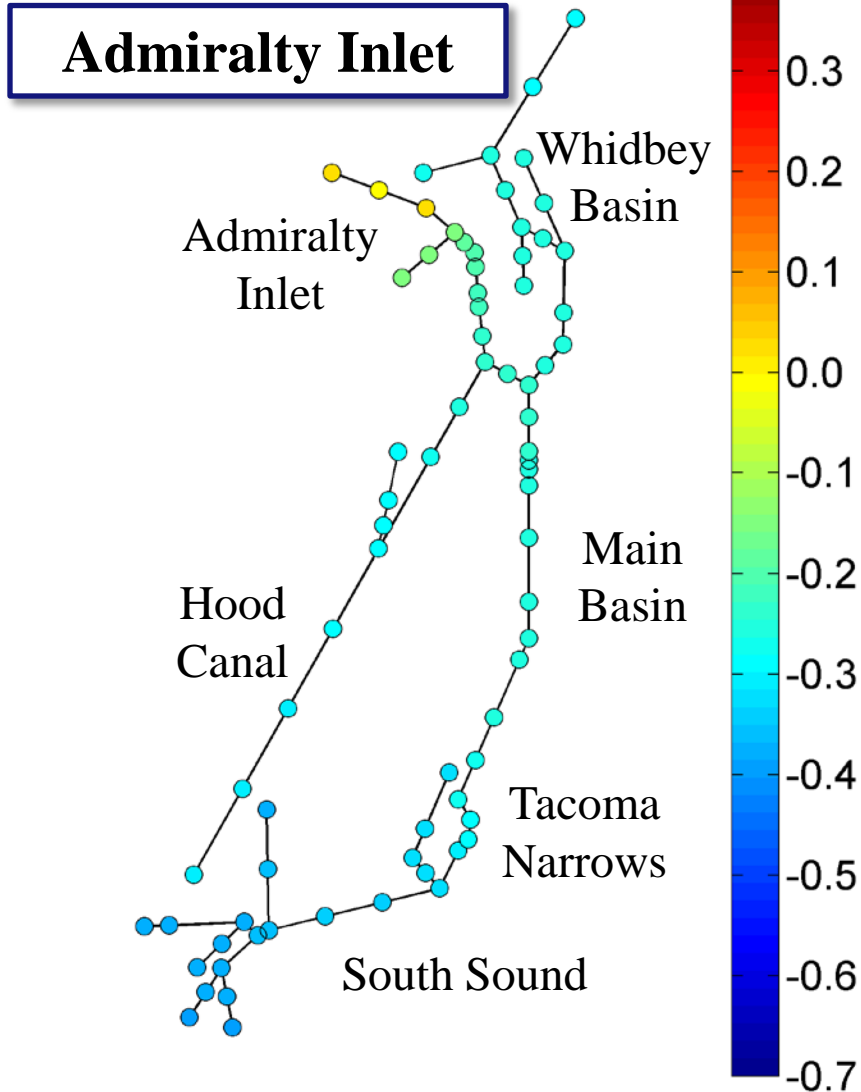


- Garrett, C. and Cummins, P. The efficiency of a turbine in a tidal channel. J. Fluid Mech. 2007, 588, 243-251.

Calibration: Constituent Amplitude

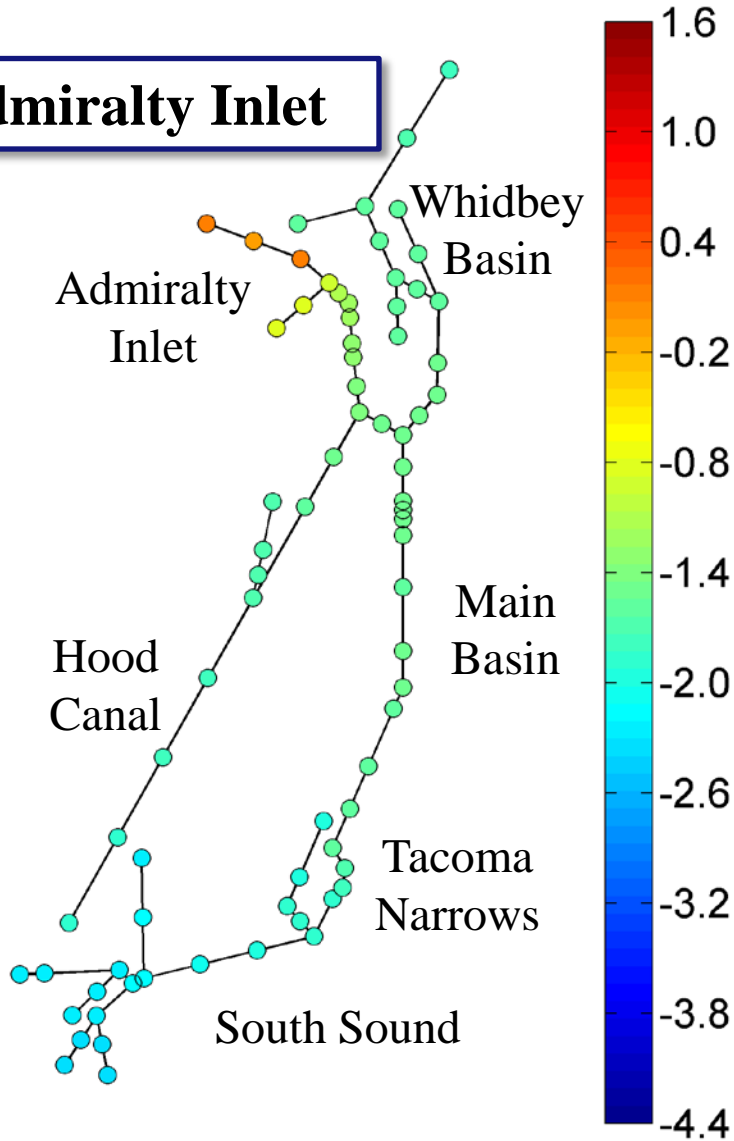


Results: Pilot – 0.5 MW Average Electric

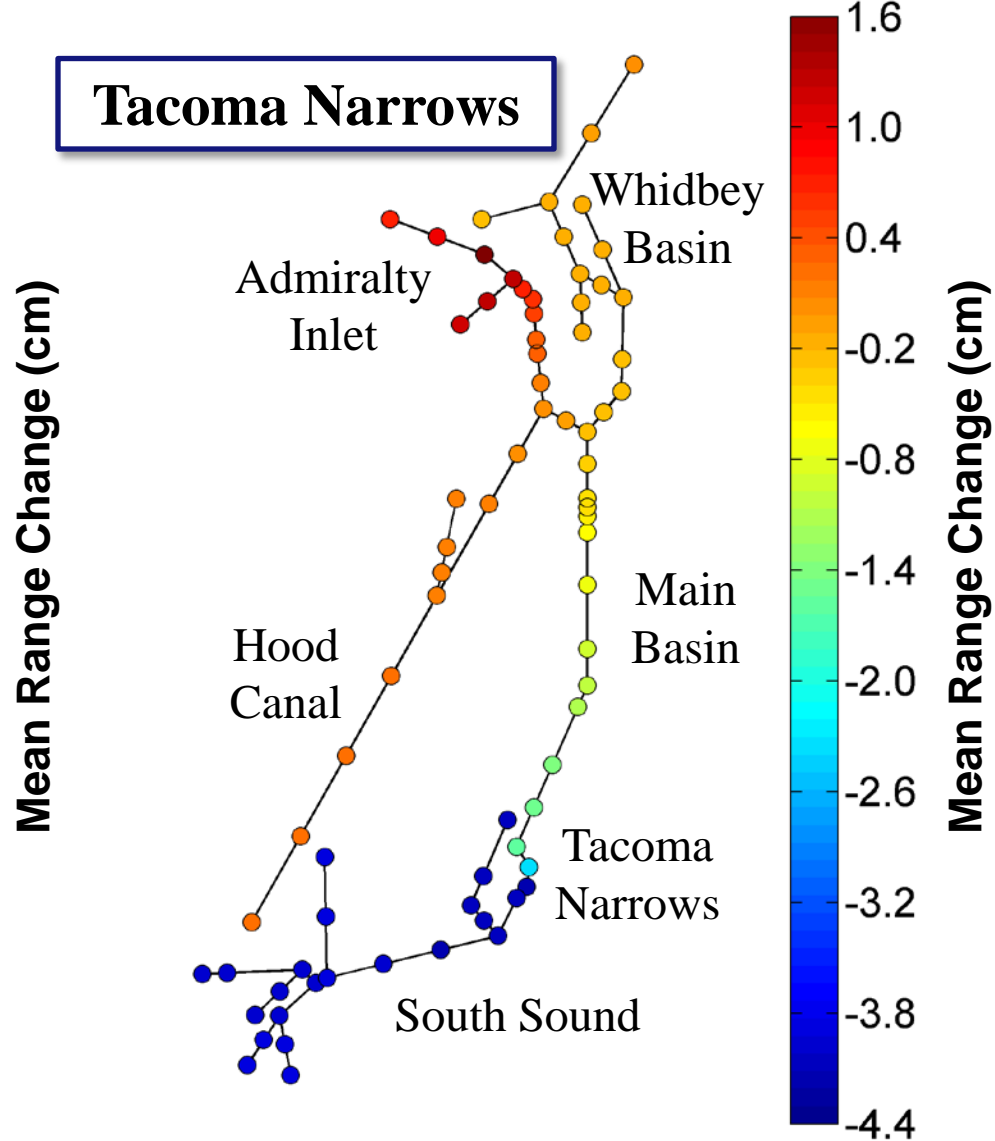


Results: Commercial – 100 MW Rated

Admiralty Inlet

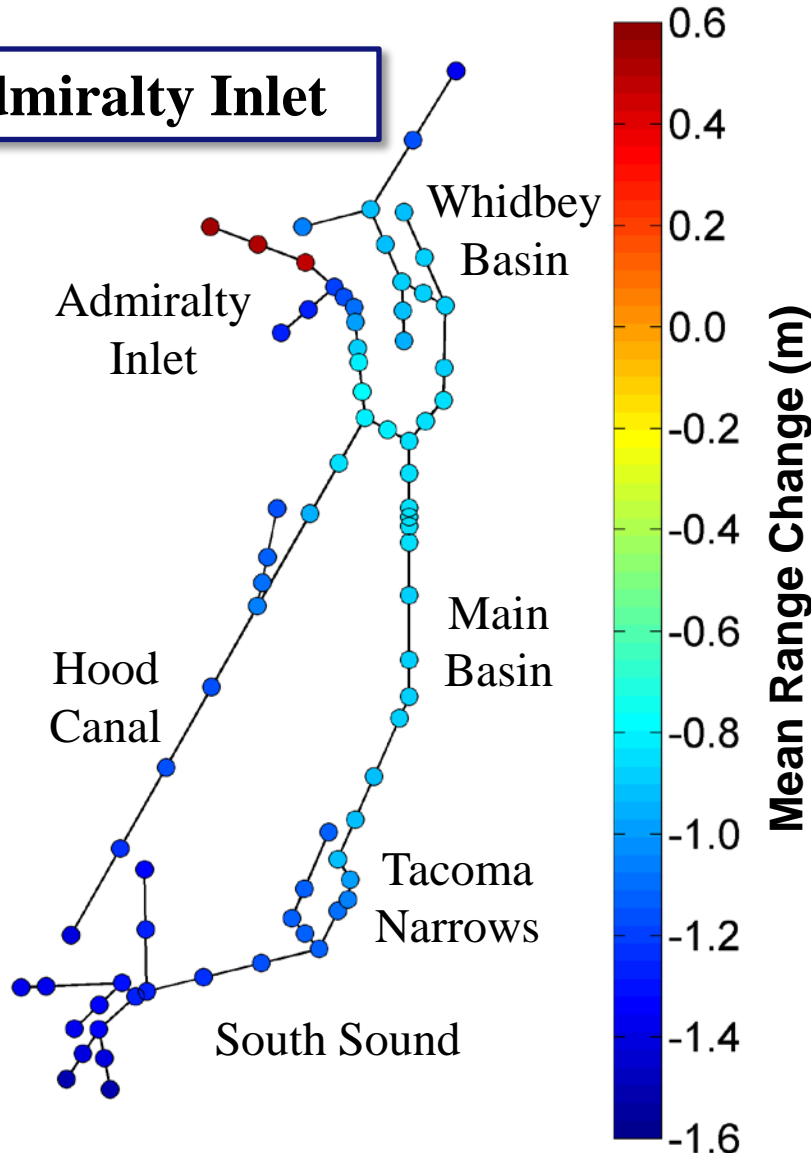


Tacoma Narrows



Results: Resource Limit – 3 GW Rated

Admiralty Inlet



- **Resource Limit:** the point at which additional turbines would produce less total power.
- **Superseding Limits**
 - *Environmental:* far-field and near-field impacts
 - *Technical:* available space to deploy turbines
 - *Economic:* diminishing returns

Conclusions

- **Hydrokinetic tidal energy in Puget Sound represents a regionally important renewable energy resource.**
- **Far-field environmental effects depend on the scale of and site chosen for hydrokinetic development.**
- **These effects are predicted to be negligible at *pilot scale*, but may be important at *commercial scale*.**
- **For pilot scale installations, near-field environmental risks likely to be of greatest concern.**

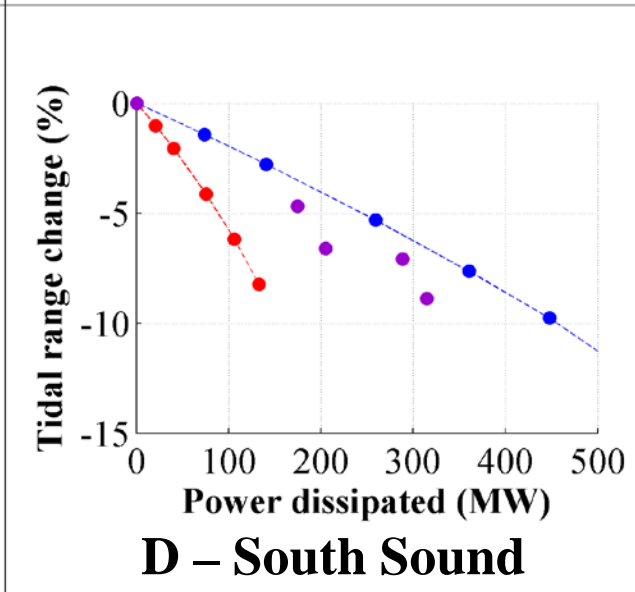
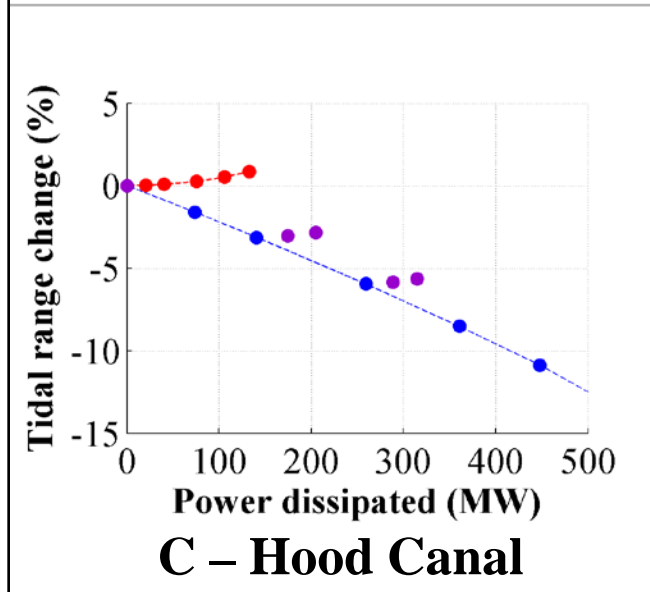
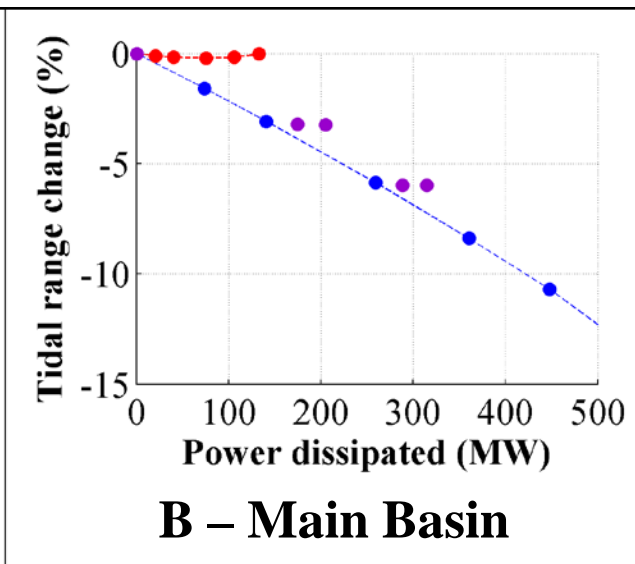
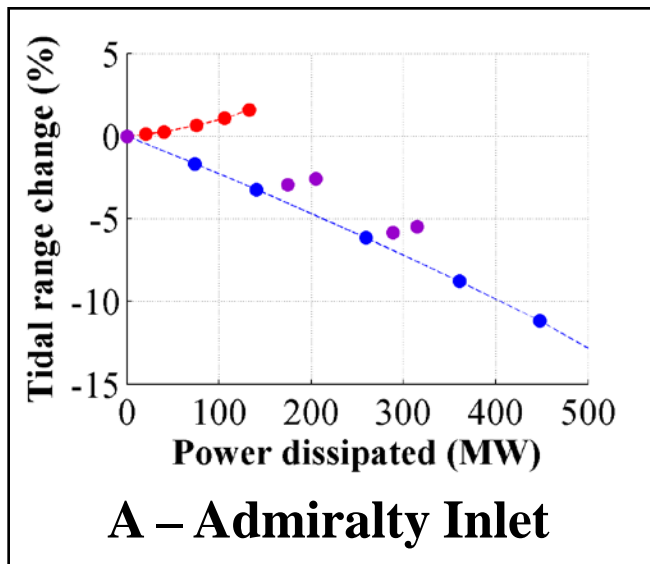
Acknowledgements

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- **US Department of Energy** 

Publication

- Polagye, B., Kawase, M., and Malte, P. In-stream tidal energy potential of Puget Sound, Washington, Proc. Inst. MechE, Part A: J. Power and Energy, 2009, 223(5), 571-587.

Results: Site Variability



- Admiralty Inlet
- Tacoma Narrows
- Both Sites

