Idealized Headland Simulation for Tidal Hydrokinetic Turbine Siting Metrics

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Outline

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Where should turbines go and why?

Placement depends on:

- Economics
- Survivability

Numerical Model: Idealization of Admiralty Inlet

- Regional Ocean Modeling System (ROMS)
- 3D, terrain-following vertical coordinates, hydrostatic
- 100 meter horizontal and 4 meter vertical resolution
- 7 km wide, 105 km long, 155 meters deep
- West, east boundaries: M_2 tidal forcing; north, south are closed, no-slip

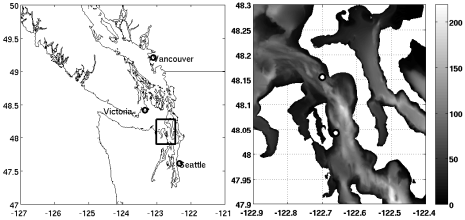


Figure: Puget Sound; Admiralty Inlet

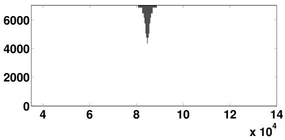


Figure: Idealized headland domain, *x*-*y*

Flow Field

Figure: Depth-averaged vorticity in color with velocity arrows

Outline

Mean Kinetic Power Density

$$K_M(x, y, z) = \frac{1}{T} \int_0^T \frac{1}{2} \rho s^3 dt, \;\; s \equiv \text{speed}$$

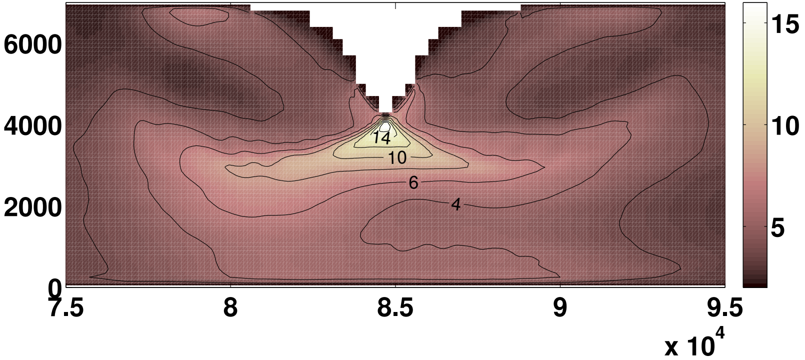
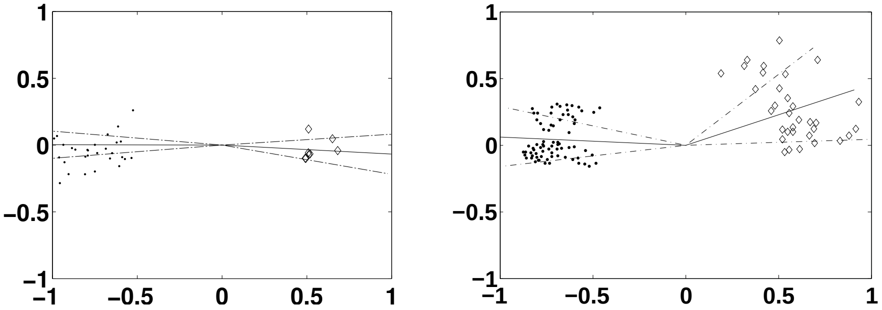


Figure: Mean normalized depth-averaged kinetic power density, x-y

Asymmetry of Tidal Flow

- Expect east-west tides for channel flow
- Headland causes asymmetry



Bidirectionality

$$a(x,y) = |\theta(x,y)_{ebb} - \theta(x,y)_{flood} - 180^\circ|.$$

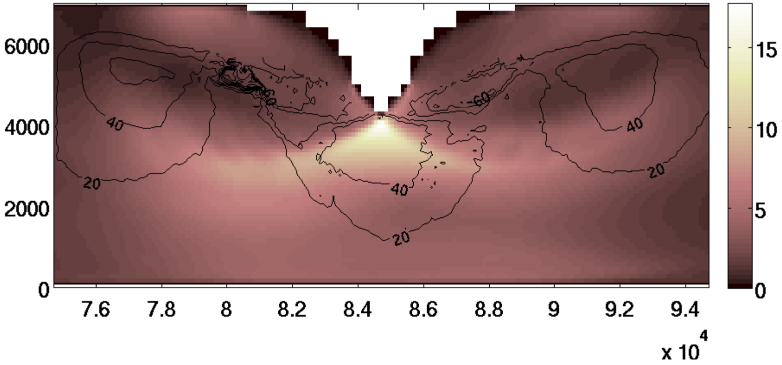


Figure: Contours of asymmetry parameter overlaid on shades of mean kinetic power density

Directional Deviation

Standard Deviation of Direction

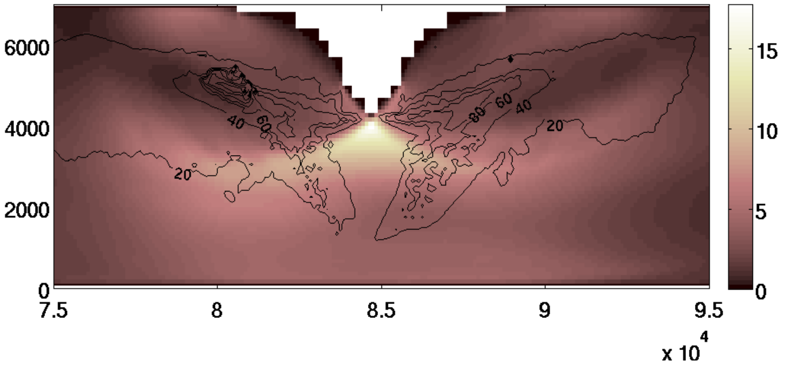


Figure: Contours of directional deviation overlaid on shades of mean kinetic power density

Outline

Summary

- Areas of high mean kinetic power density are necessary for economically viable tidal development
- Extractability of the resource must be taken into account along with power resource
- Bidirectionality and directional deviation of the tidal flow are two metrics that may be important for turbine siting, depending on turbine design
- Presence of a headland significantly affects the mean kinetic power density and tidal asymmetry of a channel flow

More Metrics

Many more metrics to consider:

- Percentage of time a turbine would spend producing power
- Percentage of time spent idle
- Timing of power production throughout day
- Bias of power toward ebb or flood tide

Idealized Sills Model and Realistic Model

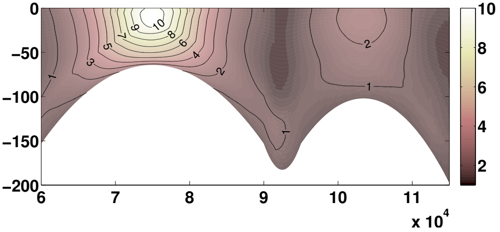


Figure: Mean kinetic power density, *x*-*z*, for idealized double-silled channel

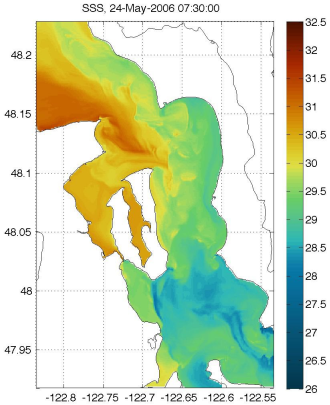


Figure: Surface salinity in Admiralty Inlet numerical model