Operation of a tidal turbine on a moored vessel in Agate Pass, WA

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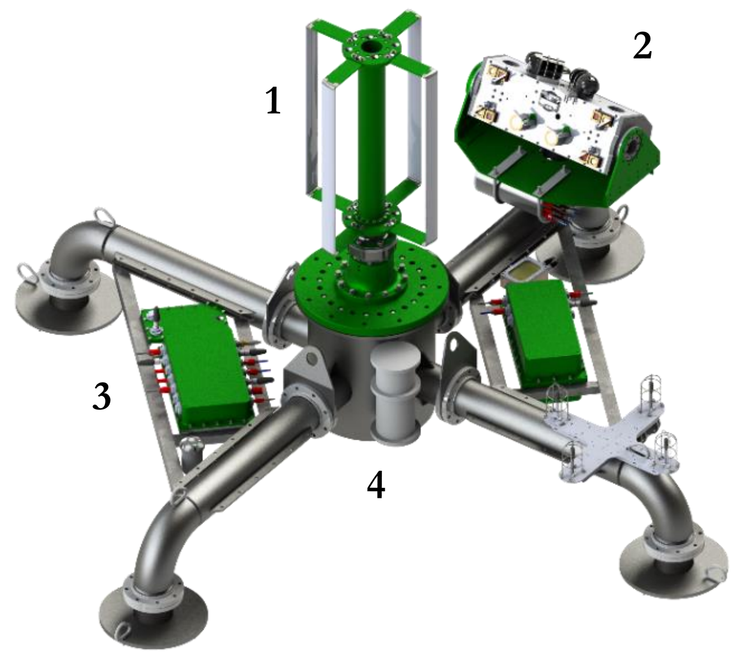
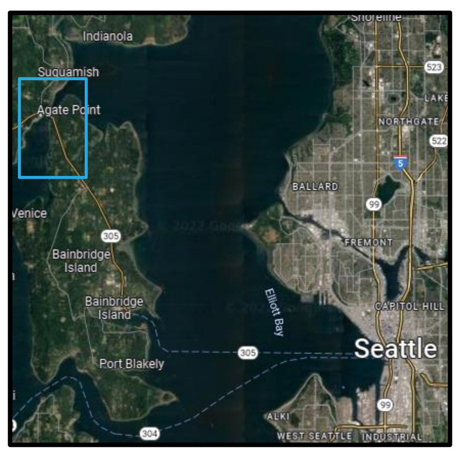
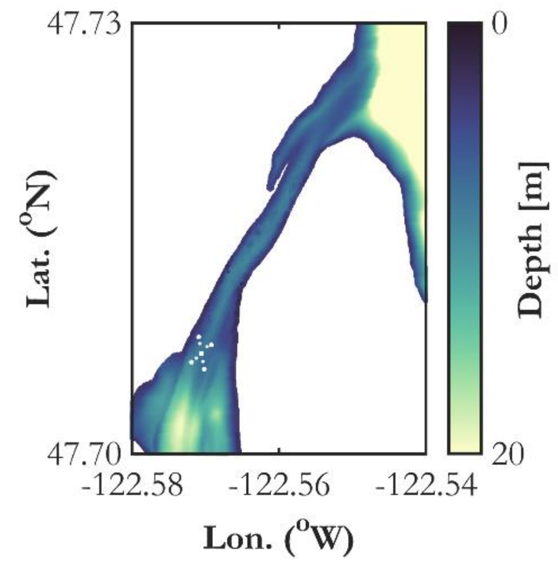
The Turbine Lander and Agate Pass Deployment

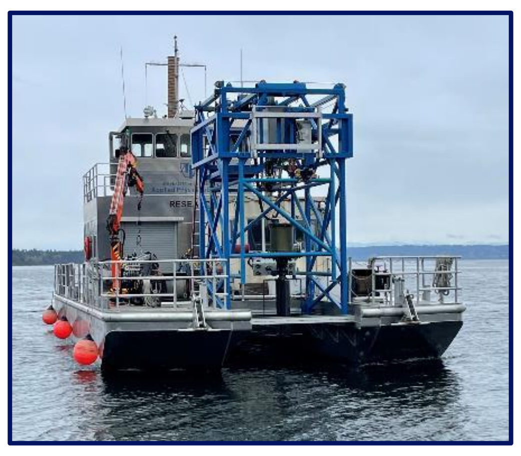


Components: [1] Rotor, [2] Adaptable Monitoring Package (LAMP), [3] Electronics, [4] Generator



Seattle region





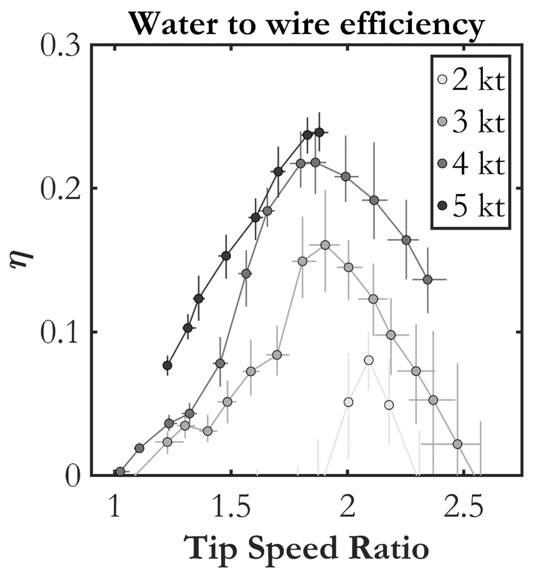
Systems as deployed

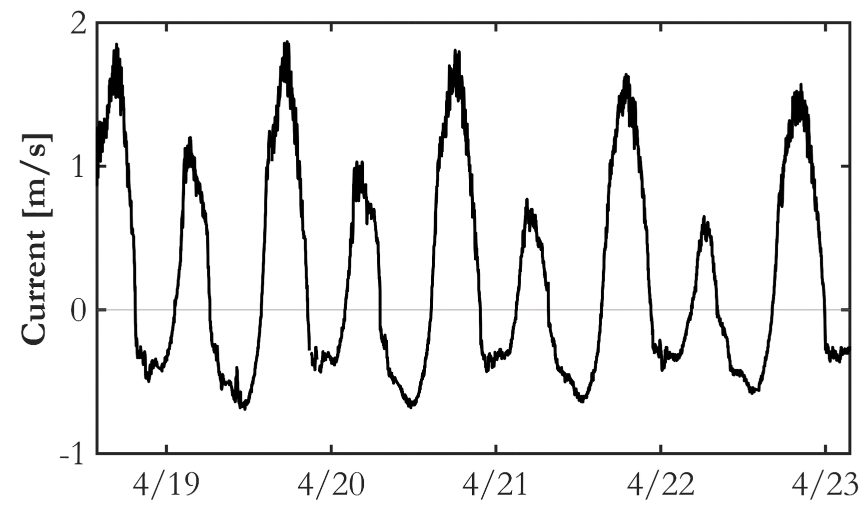
Site - Agate Pass, WA:

- Shallow (~6 m) tidal channel with peak currents exceeding 2 m/s
- Vessel deployed in a four-point moor from April 18-23, 2022
- Turbine operation driven by current measurements; constant environmental monitoring

Drone image of *R/V Russel Davis Light* moored in Agate Pass

System Performance





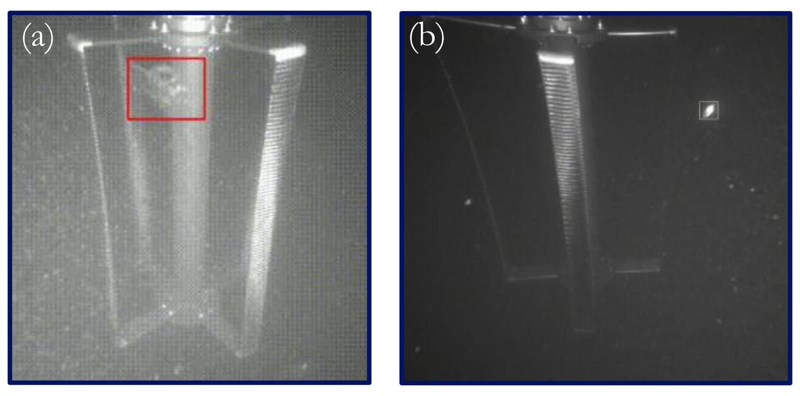
Prior Turbine Lander PTO characterization focused the system's water-to-wire efficiency while a dynamometer has been used to evaluate system losses.

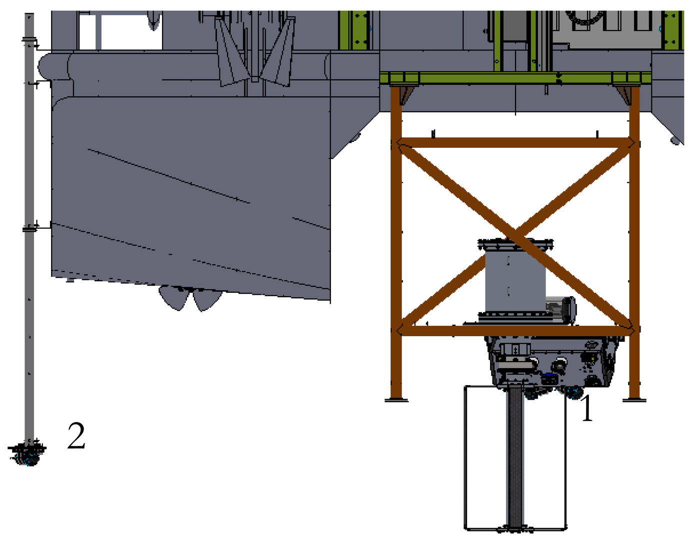
The system's performance in Agate Pass was consistent with prior tests performed under propulsion.

Deployment outside of the site constriction strongly affected ebb currents relative to predictions, limiting operation more than expected (only ~40 hours of turbine operation)

Collision Monitoring

An AMP[1] was used for environmental monitoring focusing on collision. Key instruments labeled in the drawing below were [1] stereo optical cameras (20 fps) and [2] Blueview imaging sonars (10 fps)





AMP configuration at Agate Pass

Plant debris, krill, jellyfish (a), and small fishes (b), were detected.

No collisions were observed (in data that has been reviewed) between the rotor and small fishes. Jellyfish and plant debris collisions were observed (a).

Ongoing work focuses on detection, classification, and tracking of targets for use in ongoing collision studies.

[1]Polagye, B.; Joslin, J.; Murphy, P.; Cotter, E.; Scott, M.; Gibbs, P.; Bassett, C.; Stewart, A. Adaptable Monitoring Package Development and Deployment: Lessons Learned for Integrated Instrumentation at Marine Energy Sites. *J. Mar. Sci. Eng.* **2020**, *8*, 553.

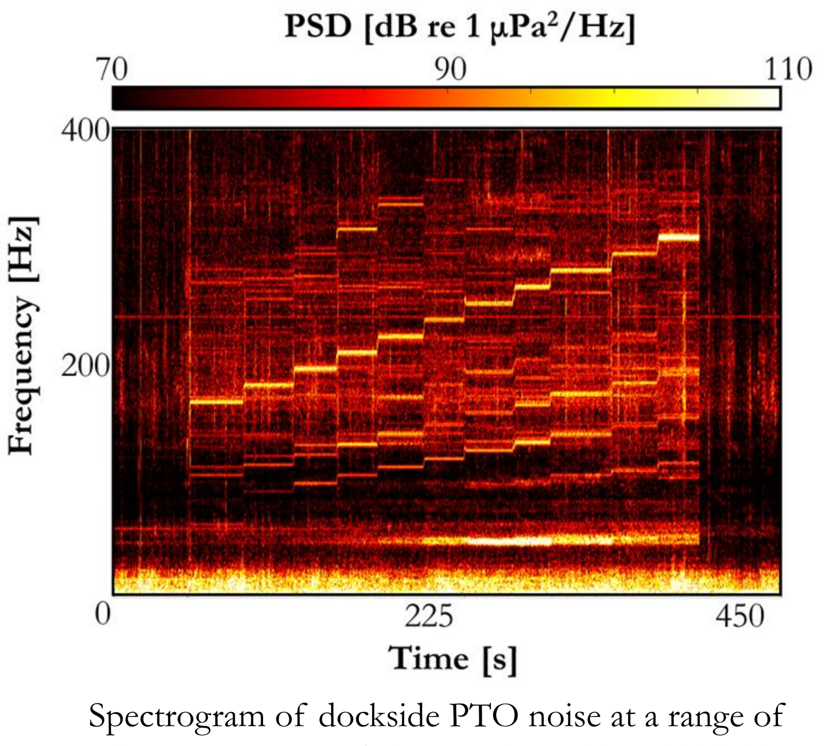
Radiated Noise Measurements

Three DAISYs (passive acoustic drifters) were deployed to identify and localize noise generated by the Turbine Lander PTO.

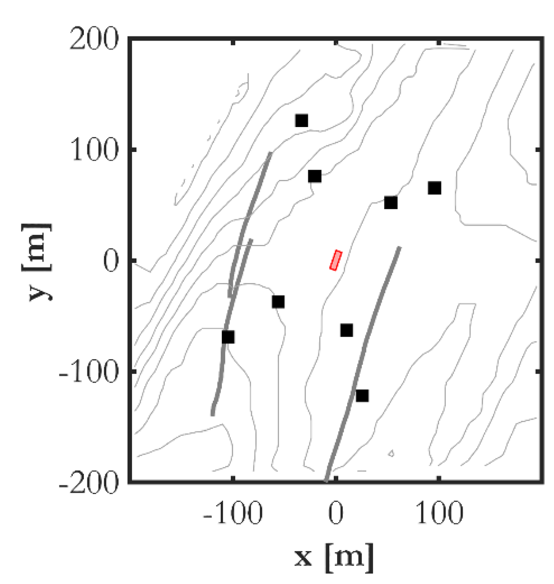
Noise from the PTO motoring was measured dockside to provide context to measurements at Agate Pass.

Analysis of acoustic data is ongoing. Noise from the PTO is difficult to distinguish from ambient conditions at modest ranges (< 100 m). Localization has been successfully demonstrated.

Recovering a DAISY



Spectrogram of dockside PTO noise at a range of <2 m as rotor speed changes from 60 to 100 RPM



Examples of three co-temporal DAISY tracks during sampling at Agate Pass (red - vessel; black - anchors; gray – DAISYs)

Moored Testing Considerations

Do the benefits of moored vessel testing outweigh the costs of testing under propulsion?

Benefits of moored testing:

Tests under propulsion could further bias results in environmental monitoring studies. Thus projects with strong environmental components may benefit from moored operations.

Permitting is less of a hurdle when turbine system components do not touch the seabed.

Costs of moored testing:

Location: A moored vessel approach is not as flexible as one might imagine. Bathymetry, bottom type, and traffic patterns limit ones ability to deploy in optimal locations.

Moorings: As sites get more energetic the costs of mooring systems overcome loads increases. Deploying/recovering the anchors and supporting systems required four days, a second vessel, and four staff members, significantly increasing costs..

Personnel: To manage systems staff were present on board 24-hours a day. This includes a vessel operator in case of an emergency.

Vessel Time: Vessel time is expensive. Mooring a vessel 24-hours per day when strong tides only occur a fraction of that time is wasteful.

Behavior: Bad behavior of members of the boating public poses a threat to moored systems.

The costs of moored testing strongly favor testing under propulsion except when environmental monitoring is a priority. In environments with fixed infrastructure (e.g., UNH Living Bridge), the costs and benefits for "moored" operations are more favorable. Ignoring the significant fixed costs for deployment/recovery, the cost of each day of moored operations could cover the costs of more than two 12-hour days of operations under propulsion in a similar environment. Thus, operating under propulsion achieves greater than four times the net system up-time and requires considerably less planning and oversight.

Acknowledgements

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