

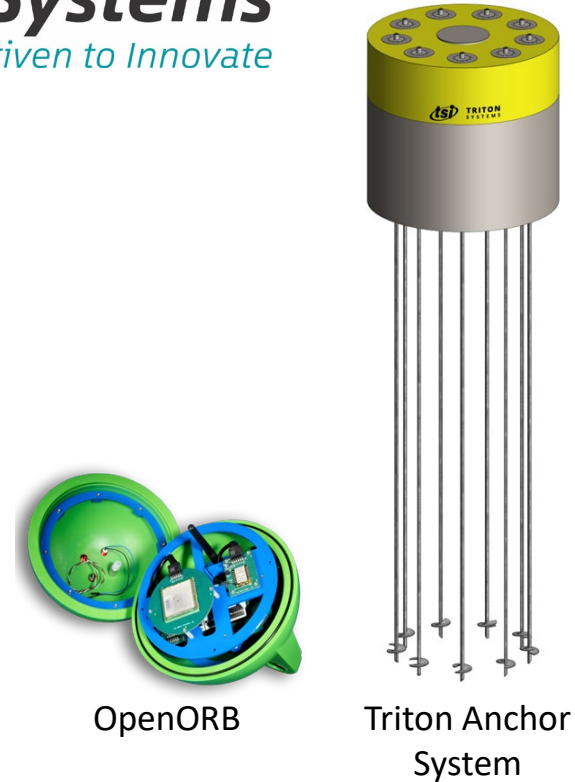


TEAMER Testing: Biofouling Analysis for Wave Energy Piston Design

Tyler Robertson
Triton Systems, Inc.
Chelmsford, MA

About Triton

- Triton Systems, Inc. is a technology incubator and systems integrator, delivering novel solutions to complex problems
- Ocean Systems Group focuses on the marine environment, including renewable energy, underwater vehicles, and anti-submarine warfare
- Successful projects:
 - OpenORB: Low-cost mooring location beacon
 - Triton Anchor: Helical anchoring system for floating offshore wind turbines



Triton Wave Energy Converter

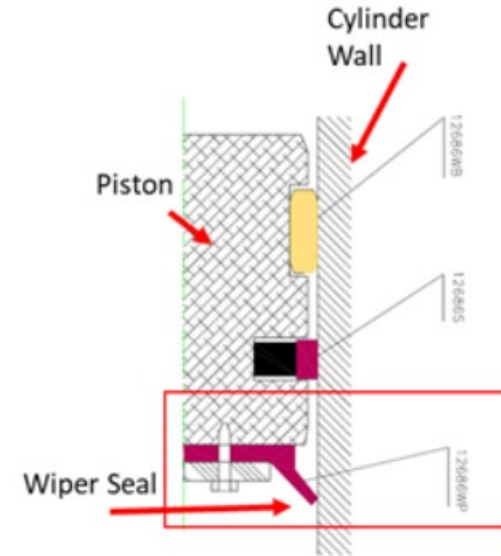
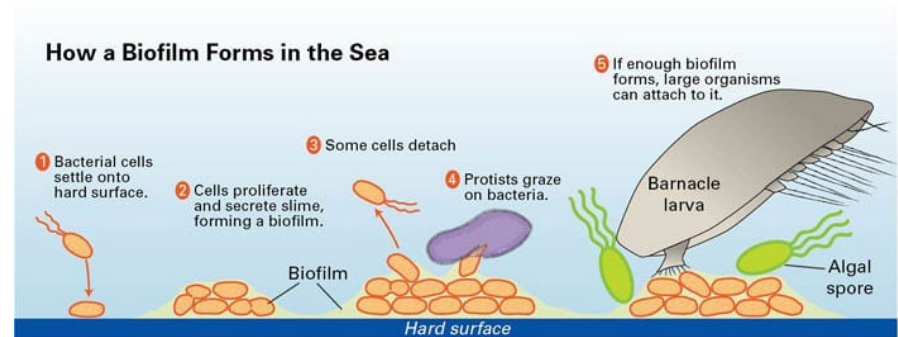
- Triton Systems, Inc. is developing small-scale wave energy harvesting technology: TSI WEC
- Supported by several DOE SBIR grants and TEAMER activities
- Targets provision of small-scale auxiliary power to ocean observing (100W) and floating LiDAR buoys (500W)
- Benefits:
 - Increased data collection, communication, and transmission
 - Extended mission duration
 - Added power redundancy
 - Complementary to other power sources



TSI WEC

The Need

- Biofouling and corrosion are the highest risks to long-term performance of wave energy converter
- Surfaces resistant to macro-biofouling are susceptible to failure due to biofilm buildup
- **Hypothesis:** prevention of biofilm can mitigate formation of macro-biofouling
- Developed a concept for novel wiper seal to remove biofilm before proliferation
- **Problem:** How to test cost effectively?



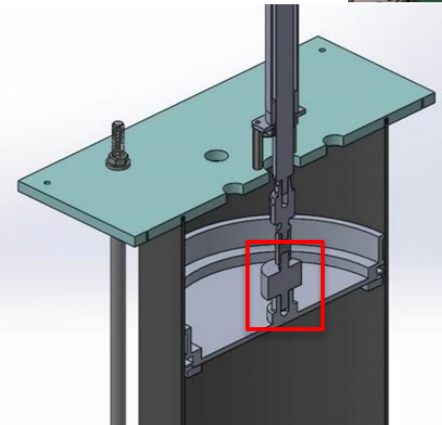
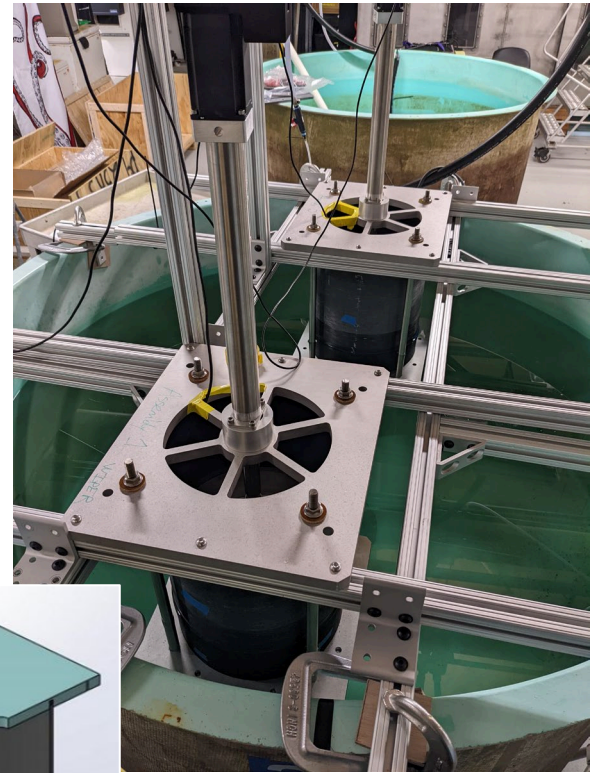
TEAMER and PNNL-Sequim

- Testing Expertise and Access for Marine Energy Research
- Pacific Northwest National Laboratory - Sequim
- Biofouling tanks in controlled environment
- Researchers/expertise



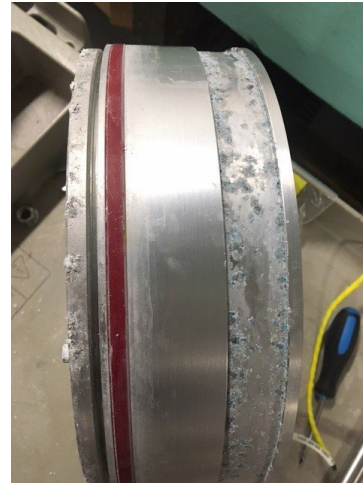
Test Articles

- Triton developed two test devices
 - One with wiper seal, one without
- Linear actuator to simulate piston motion
- Load cell to monitor piston force
- Placed in biofouling tank
 - Baseline testing (filtered)
 - Core campaign (unfiltered)



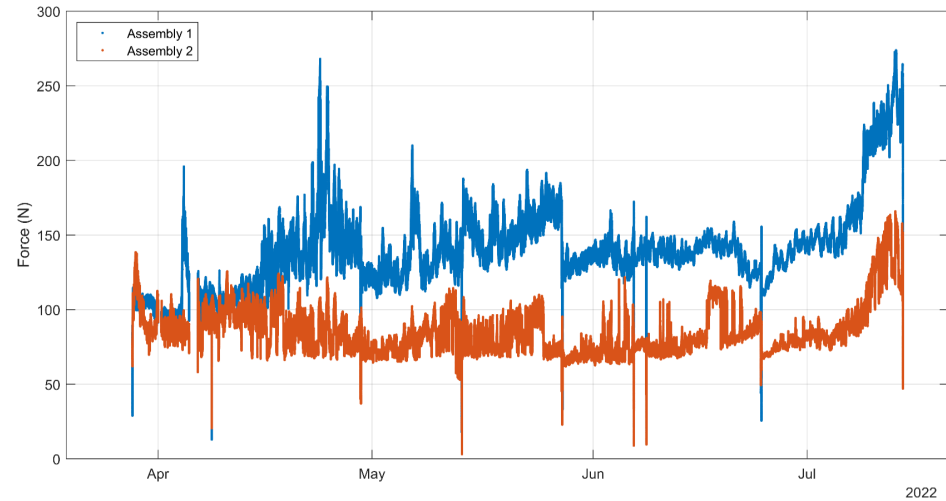
Early Failure

- Over initial two weeks of test, load cell force increased steadily until pistons jammed
- PNNL conducted thorough investigation
- Identified wearbands as problem source
 - Composite wearbands had an undisclosed bronze powder additive



Results: Seal Performance

- The wiper seal assembly showed higher forces throughout test
- Qualitative observations suggested less biofouling over stroke with wiper; difficult to confirm with data
- Largest takeaway was identification of fundamental seal issues

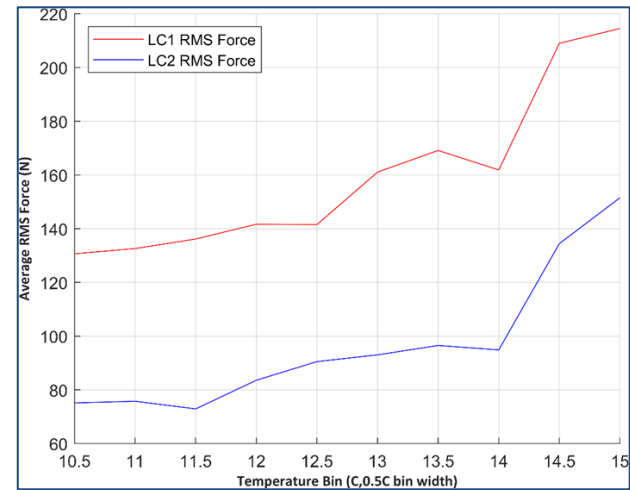


Piston load cell force over time;
Wiper (blue) vs Control (orange)

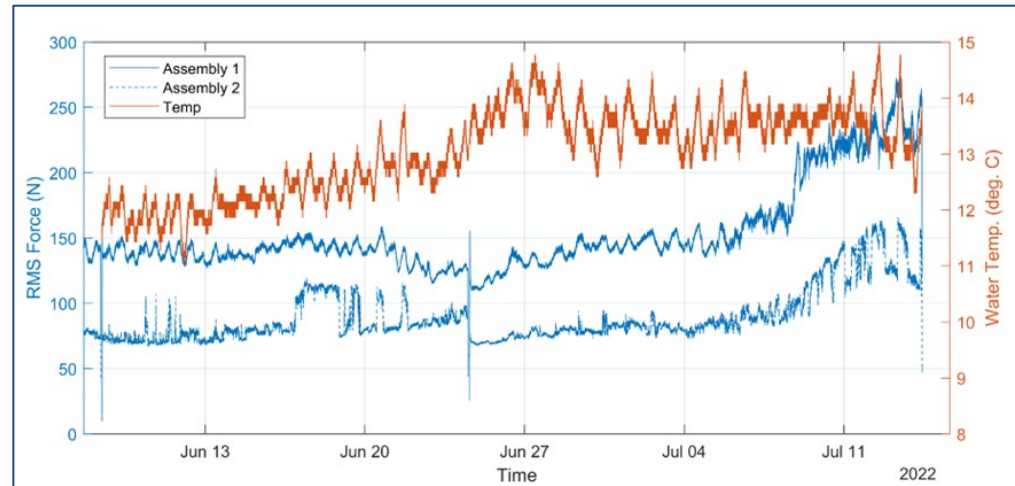
Results: Temperature

- PNNL researchers noticed that load cell forces fluctuated daily
- Correlated to local Sequim bay water temperature
- Identified need for alternative seal design and material considerations for piston

Average RMS force by temperature bin



RMS-filtered load cell force and tank water temperature

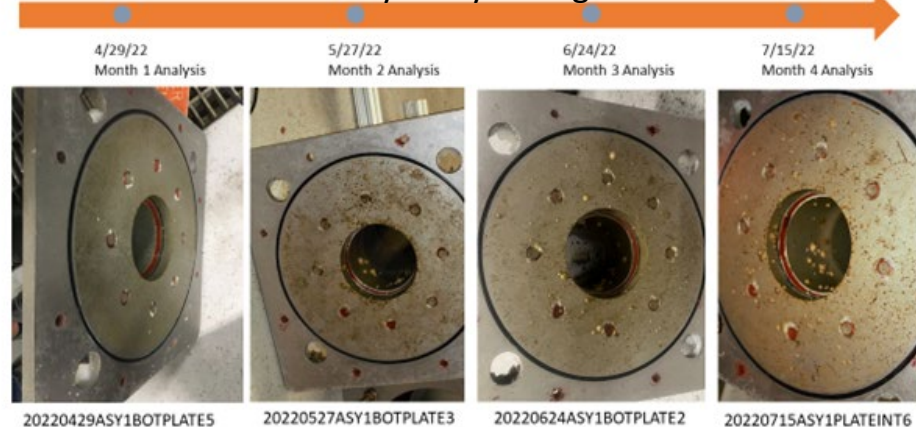


Results: Biofouling and Corrosion

- Identified areas for improvement related to material selection and dissimilar metals
- Highlighted areas which would require further biofouling mitigation

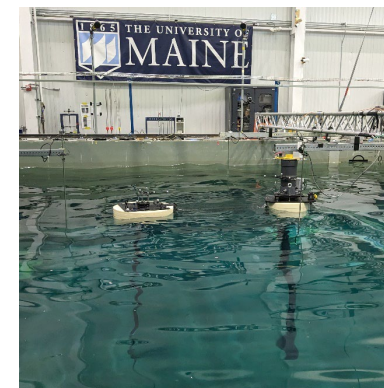
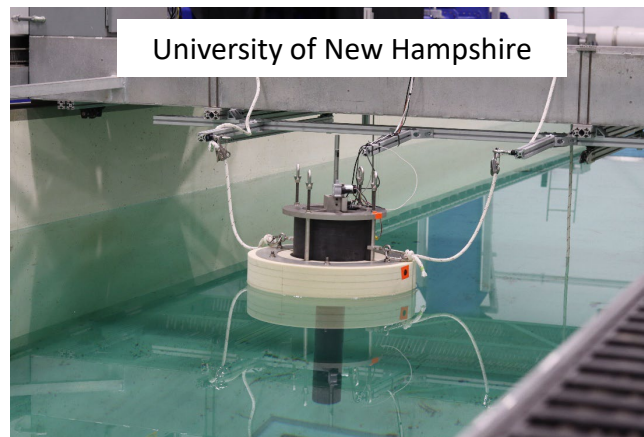


Monthly analysis of growth



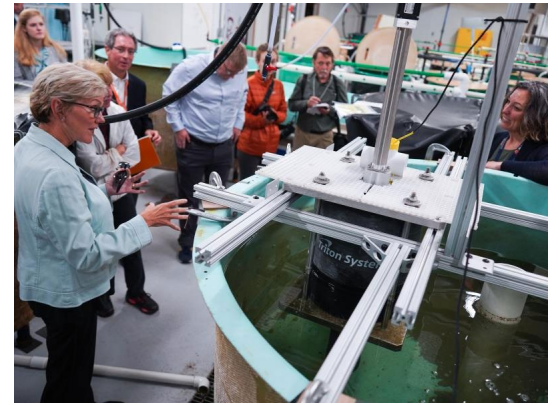
Impact

- TEAMER enabled:
 - Wave tank test campaigns
 - Open water deployments
 - Continuous improvement of concept
- Other Efforts:
 - WEC-Sim for Triton Wave Energy Converter (Sandia)
 - Open Water Tether Analysis (PNNL)



Acknowledgements

- **Testing Expertise and Access for Marine Research (TEAMER)**
 - *Biofouling Analysis for Wave Energy Piston Design*, PNNL
- **Pacific Northwest National Laboratory**
 - Nichole Sather
 - Robert J. Cavagnaro, Ph.D.
 - Linnea Weicht
- **U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Water Power Technologies Office**
 - *Wave Energy Harvesting to Power Ocean Buoys*, DOE Phase II, DE-SC0020830
 - *Wave Energy Harvesting to Power LiDAR Buoys*, DOE Phase II, DE-SC0021944
- “Teaming Up for Marine Energy”, WPTO Press Release, April 13, 2023



Secretary of Energy Jennifer Granholm learning about experiment from Nichole Sather