Hydrokinetic Energy Research

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Outline

- UAF - MHK Background
- Definition of hydrokinetic
- Types of hydrokinetic systems
- Alaska MHK resource
- Challenges to MHK
- UAF work in hydrokinetics – current projects
- Research gaps in Hydrokinetics

Marine HydroKinetics (MHK) at UAF

- Established as Alaska Hydrokinetic Energy Research Center (AHERC) within ACEP in 2010
- Research in Nenana, Ruby, Eagle, Igiugig, Yakutat
- Collaborate with UAF College Fisheries and Ocean Science (CFOS)
- Joined Pacific Marine Energy Center (PMEC) with University of Washington and Oregon State University in 2014

Hydrokinetic vs “traditional hydro”

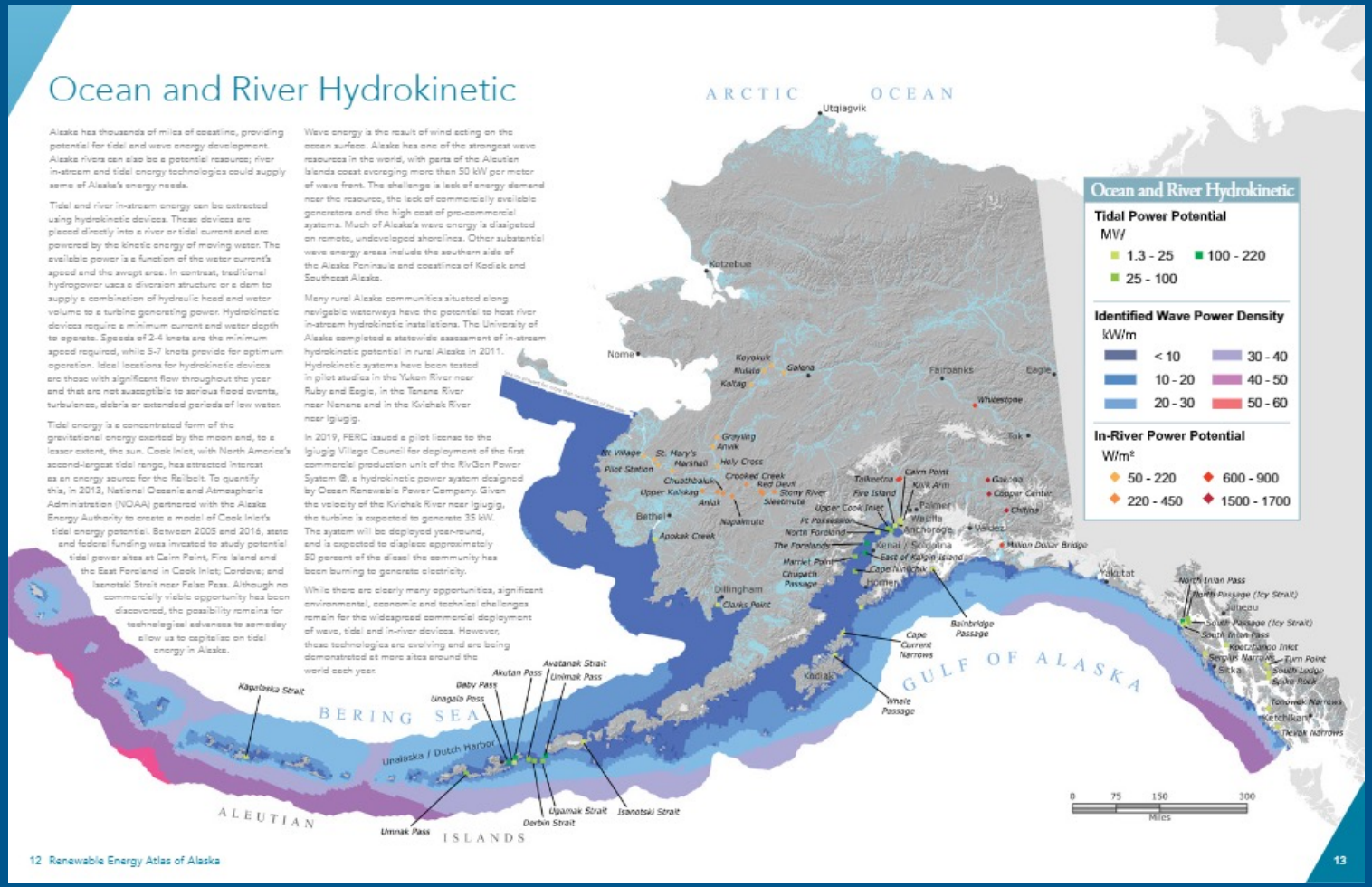
- Traditional Hydropower – Harnesses falling water
  - Dams - store water in lake
    - Grand Coulee Dam (6,800 MW)
    - Bradley Lake Hydro (120MW)
  - Diverters - “run-of-river” – no storage
    - Cordova Electric (6MW)

Hydrokinetic vs “traditional hydro”

- Hydrokinetic - Harnesses natural movement of water
  - Wave, Tidal, River
  - Device installed directly into water with no/minimal civil infrastructure
  - Floating, submerged, or bottom mounted
- DOE video - https://youtu.be/LXsuU_ZC56E

MHK Opportunities

- Alaska has:
  - 40% of US River Energy
  - 90% of US Tidal Energy
  - 60% of US Wave Energy
- Almost all communities are on rivers or coastline.



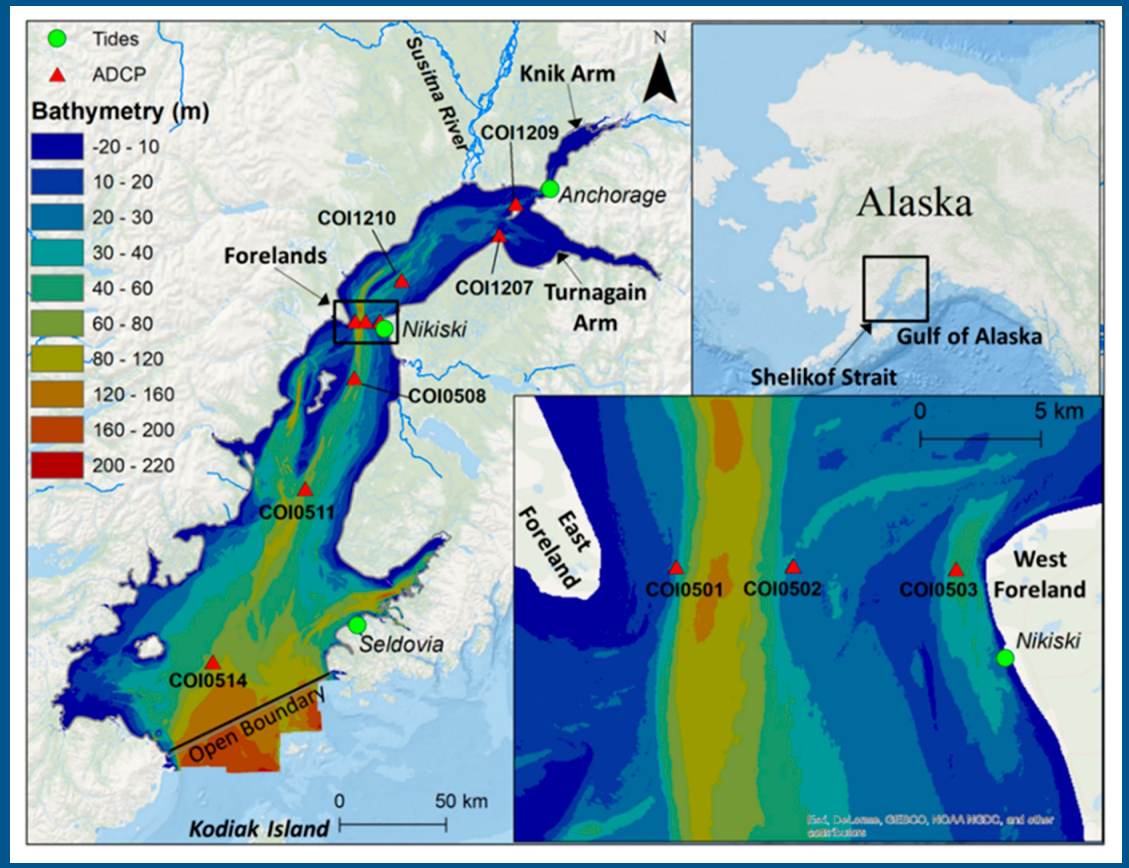
https://alaskarenewableenergy.org/library/renewable-energy-atlas/

MHK Challenges

- Cost
  - Inherently small scale
  - Competing low-cost energy sources
- Efficiency
  - low speed motions
- Reliability
  - debris, sediment, corrosion
  - Seasonality
  - extreme events – waves, floods
- Environmental
  - fish, marine mammals, sediment transport
- Integration with microgrids
  - seasonality, dispatchability, black-start

Tidal Energy

- Alaska areas of interest
  - Cook Inlet (Anchorage)
  - Kootznahoo Inlet (Angoon)
  - Aleutian Islands



- Challenges
  - Competing with low cost energy
  - Requirement for storage to serve as baseload

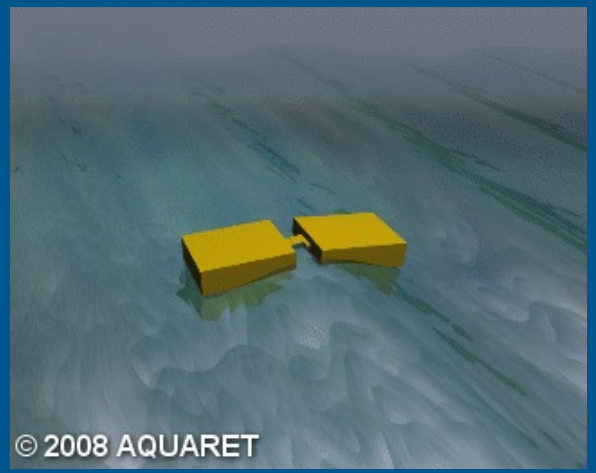
Wang T, Yang Z. A Tidal Hydrodynamic Model for Cook Inlet, Alaska, to Support Tidal Energy Resource Characterization. *Journal of Marine Science and Engineering*. 2020; 8(4):254. https://doi.org/10.3390/jmse8040254

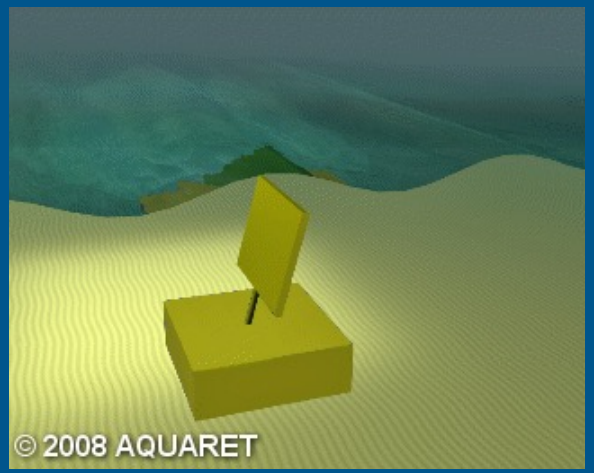
Wave Energy Converter (WEC) Challenges

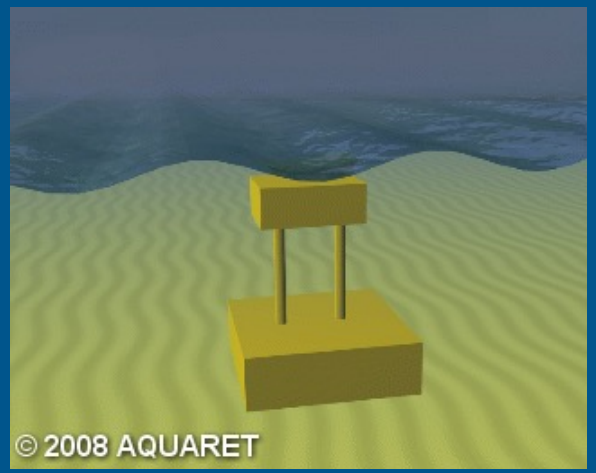
- Multiple types of motions which vary over time and space
  - pitch, heave, surge
- Challenging conditions
  - corrosion, biofouling, maintenance
- Power-Take-Off (PTO) – convert motion into electricity
  - tradeoffs between efficiency and cost/complexity

(all images from https://www.aquaret.com/index.html)

Wave Energy Converter (WEC) Types



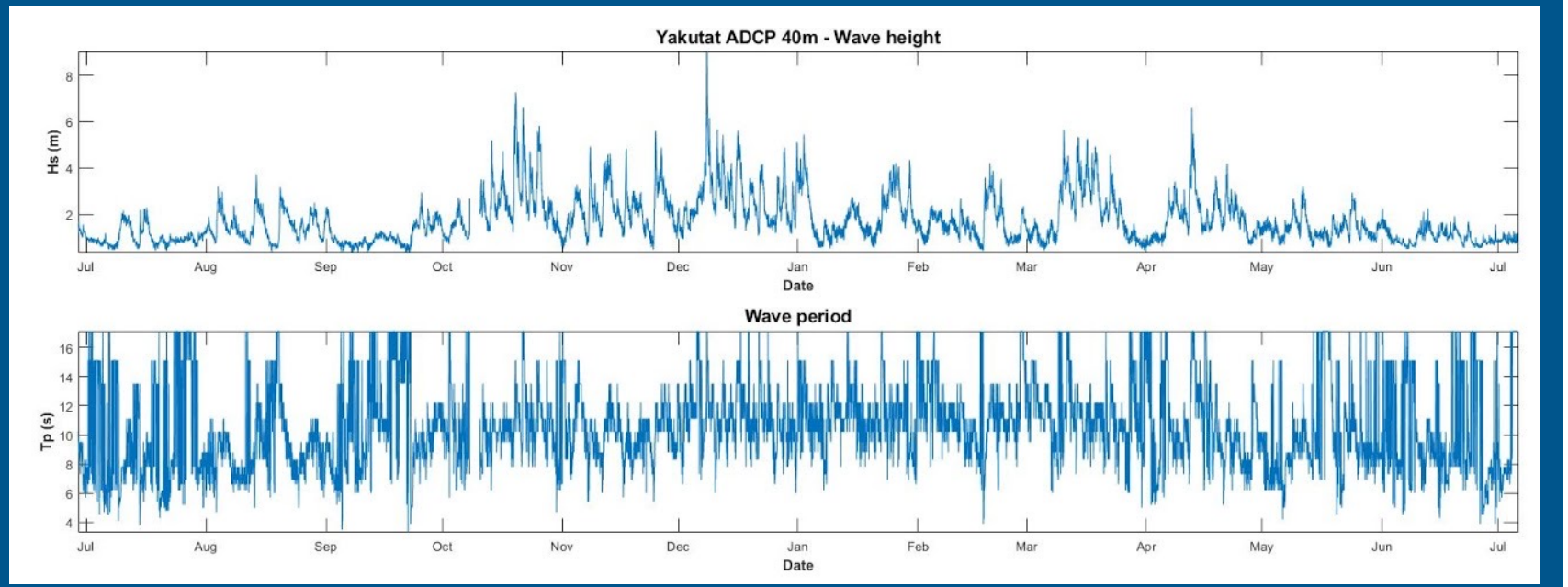


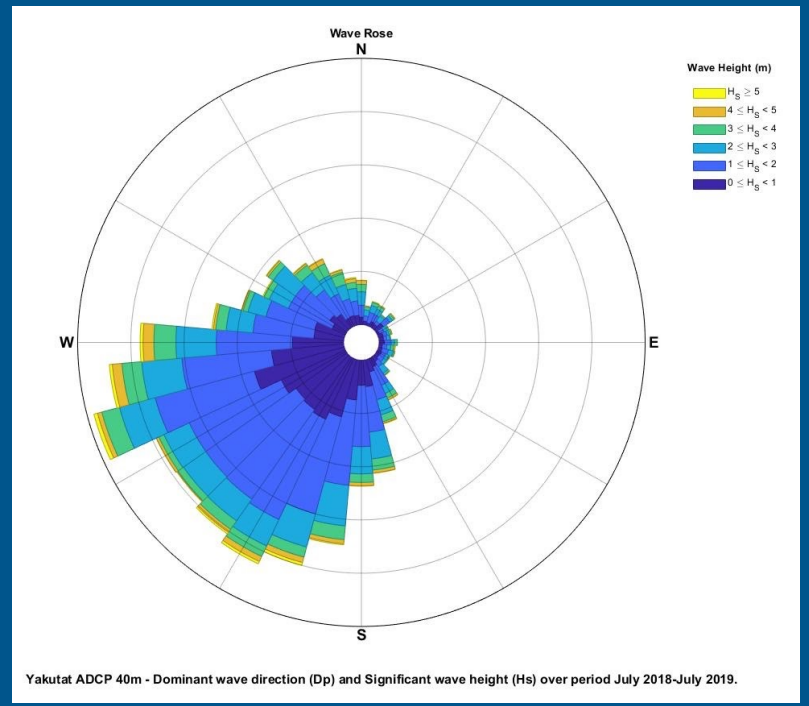


(all images from https://www.aquaret.com/index.html)

Wave energy for Yakutat, Alaska

- ACEP study of solar and wave energy resources
- Modeling of hybrid diesel-battery-solar-wave grid
- Efforts funded by ONR, Sandia, BOEM

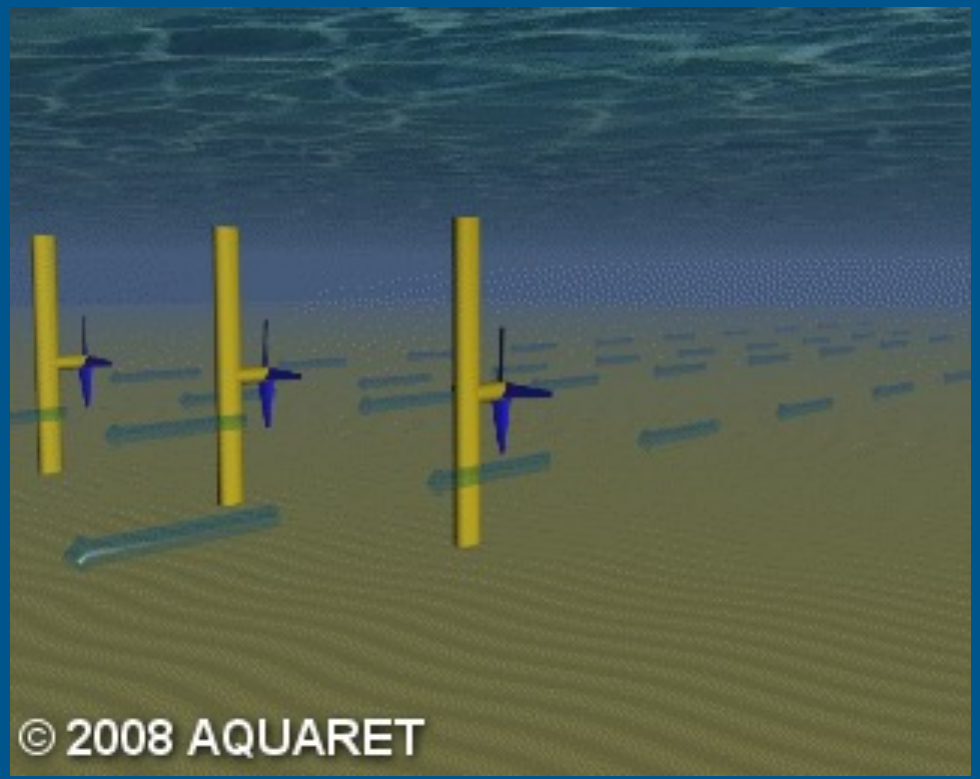


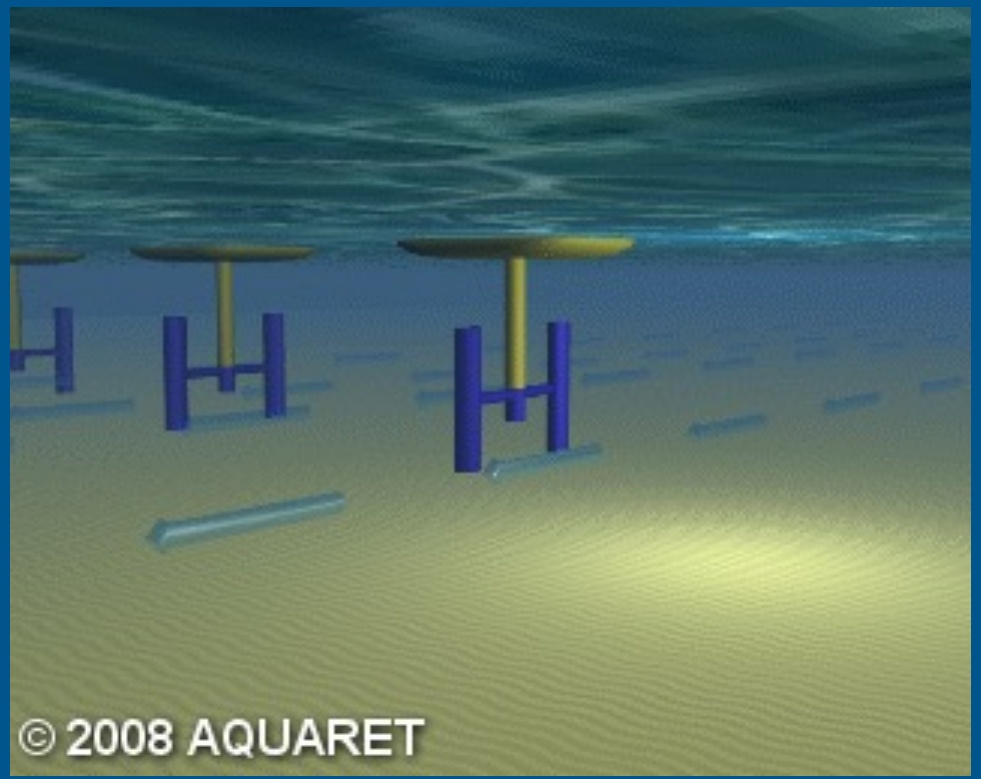


Yakutat ADCP 40m - Dominant wave direction (Dp) and Significant wave height (Hs) over period July 2018-July 2019.

Current Energy Converter (Riverine)

Current Energy Converter Types

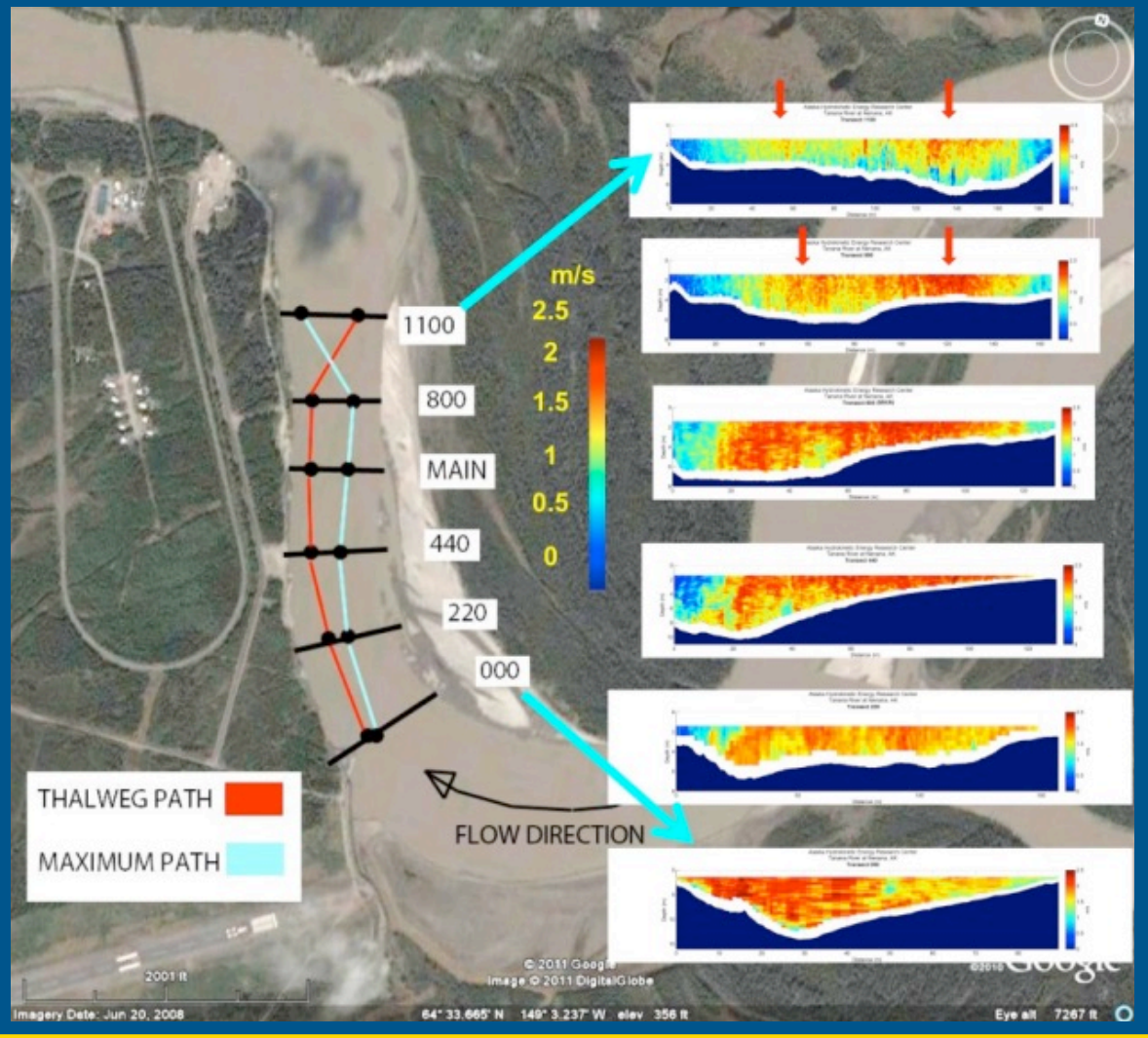




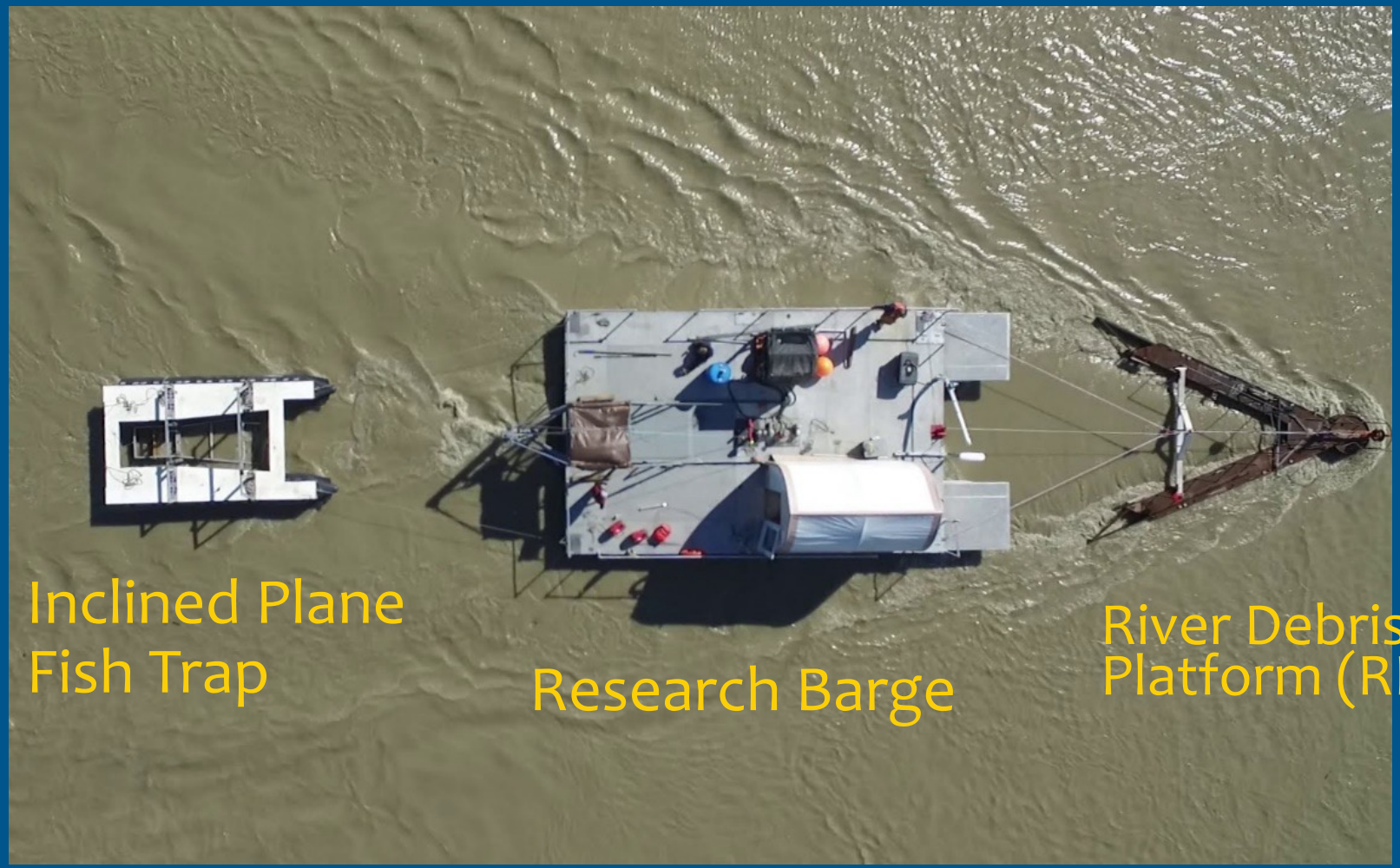
ACEP video on ORPC in Igiugig at https://youtu.be/lANhN3xTwR0

Tanana River Test Site – Overview

- Located in Nenana, AK (55 highway miles SW of Fairbanks)
- Open water May thru October
- Velocity 1.3 to 3.0 m/s
- Depth ~ 6m (20 ft)
- Fully Permitted
- http://acep.uaf.edu/facilities/tanana-river-hydrokinetic-test-site.aspx



Tanana River Test Site - Equipment

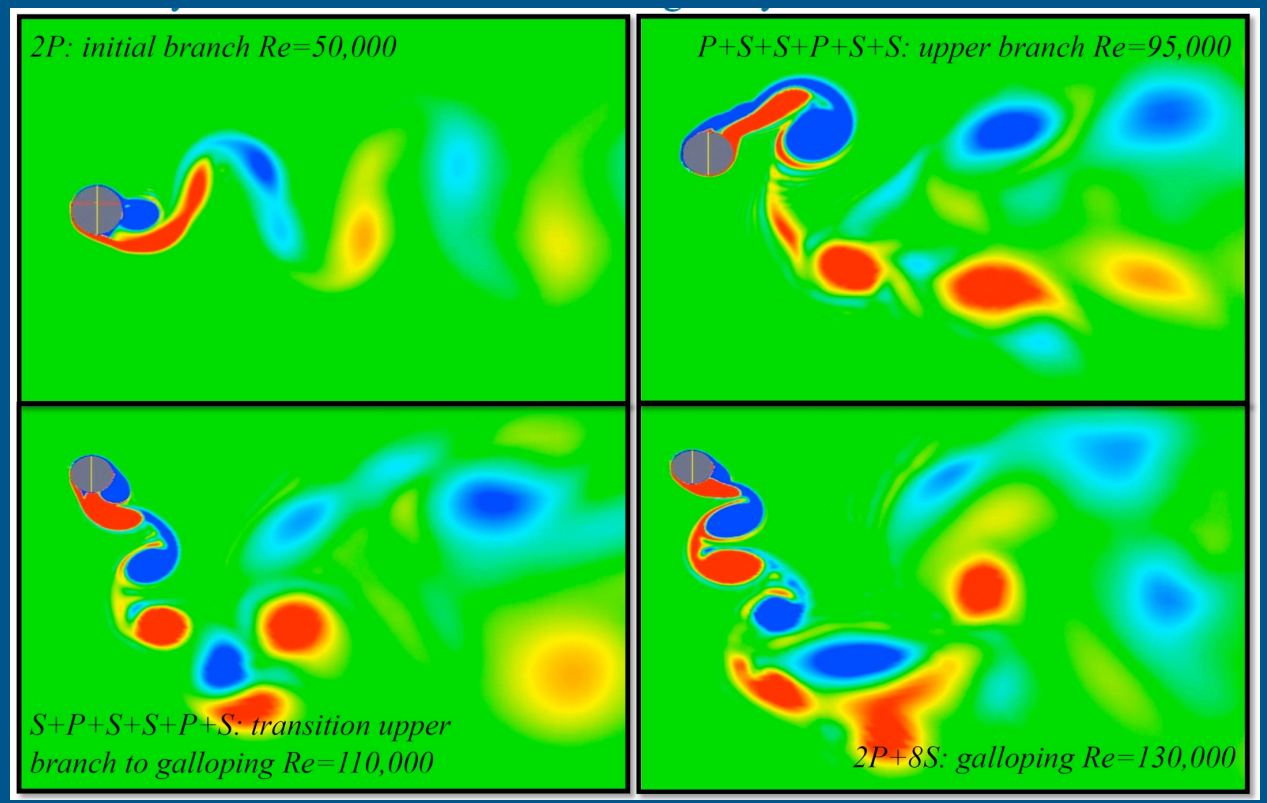


UAF Research

- Publications available at:
  - https://acep.uaf.edu/programs/alaska-hydrokinetic-energy-research-center/publications.aspx
- Resource assessments
  - wave, river
- Fish Characterizations
  - smolt interactions with turbines
- Debris
  - characterization, detection, diversion, forces
- MHK System Testing & Development
  - Ruby, Eagle, Igiugig, TRTS

Water Horse - Galloping Current Energy System

- Bluff body vortex shedding changes with Reynold, $Re = \frac{\rho v L}{\mu}$
- Shedding frequency per Strouhal, $St = \frac{fL}{v} \cong 0.2$



M. M. Bernitsas, "The VIVACE Converter," 2011.

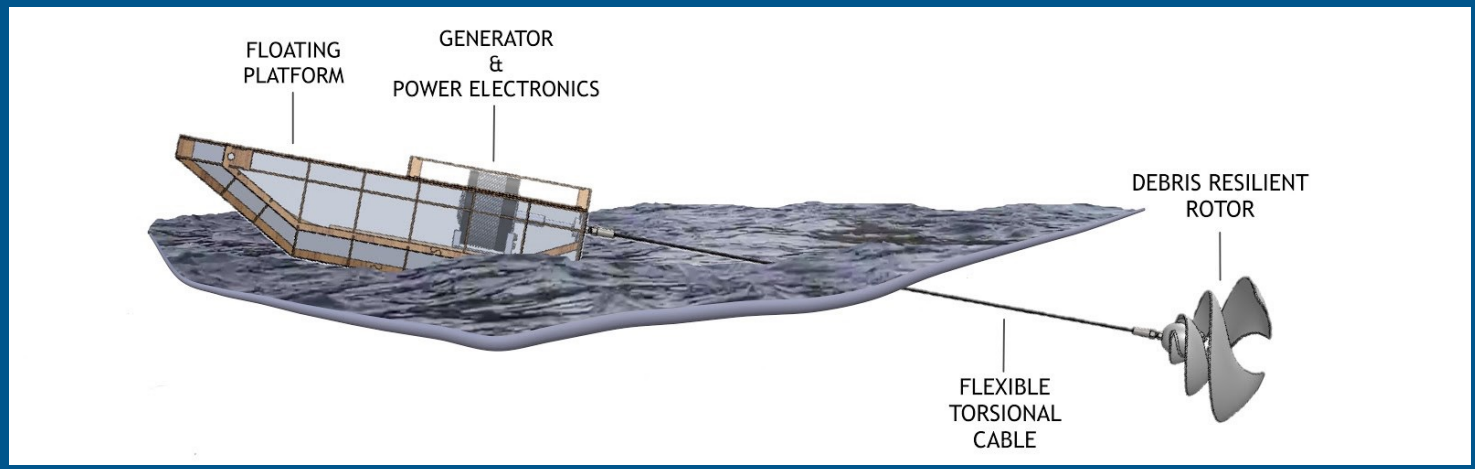
Water Horse Prototype

- WPTO Funding
- Renerge, Inc IP
- Tested at TRTS July 2020

ARPA-E SHARKS

- 3-year award starting 2021
- Programmatic focus on LCOE
  - Material Efficiency
  - Conversion Efficiency
  - Operating Expenditures
- Collaboration with private sector startups
  - BladeRunner Energy, Inc.
  - C-Motive Technologies, Inc.

ARPA-E SHARKS



- Tethered turbine with single point mooring.
  - All structural loads are in tension. Highly material efficient.
  - Decouples generator and rotor sizing. Can scale rotor to match resource.
- Electrostatic generator.
  - High efficiency at direct-drive speeds.
- Shore-based deployment/retrieval system
  - Drastic reduction in OpEx.
  - Improved capacity factor.

MHK Research Gaps

- Compare to Wind/Solar
  - Industry has not coalesced around a single architecture – everyone is still trying to solve multiple problems at the same time
  - Range of unique challenges – submerged generators, debris, marine construction
  - More predictable (tidal, river), improves grid integration and storage efficacy

MHK Research Gaps

- Gaps are recognized and being addressed by:
  - Private Sector Technology Developers
  - Test Sites – TRTS in AK, PACWAVE off Oregon, WETS in Hawaii
  - Public Funding
    - Department of Energy
      - Water Power Technology Office (WPTO) – National Labs
      - Advanced Research Projects Agency – Energy (ARPA-E)
    - Bureau of Ocean Energy Management (BOEM)
    - Office of Indian Energy
    - State of AK
      - EETF and REF (previously)

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Links to Post in Chat

- DOE Video – MHK - https://youtu.be/LXsuU_ZC56E
- ACEP Video – Igiugig ORPC - https://youtu.be/lANhN3xTwR0
- ACEP Publications - https://acep.uaf.edu/programs/alaska-hydrokinetic-energy-research-center/publications.aspx
- Ocean Energy Europe - https://www.oceanenergy-europe.eu/