

Disruptive Supplies of Affordable Biomass Feedstock Grown in the Open Ocean

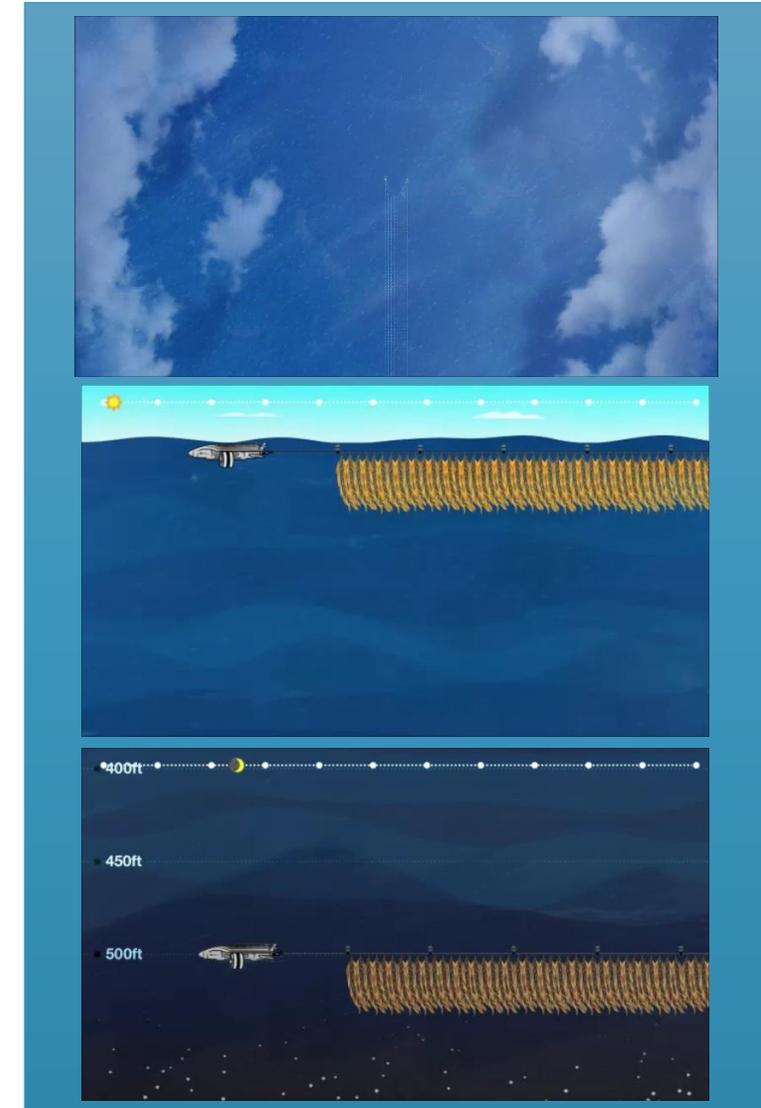
PI Brian H. Wilcox, Marine BioEnergy, Inc.

Project Vision

Abundant, affordable, carbon-neutral feedstock from kelp grown in the open-ocean by depth-cycling below thermocline every night to absorb nutrients.

Project Impact

Provide carbon-neutral feedstock that can be processed to compete with petroleum at \$60/bbl and natural gas at \$3/GJ to replace fossil fuels.



Project Team

Names, affiliations, emails, photos, and logos

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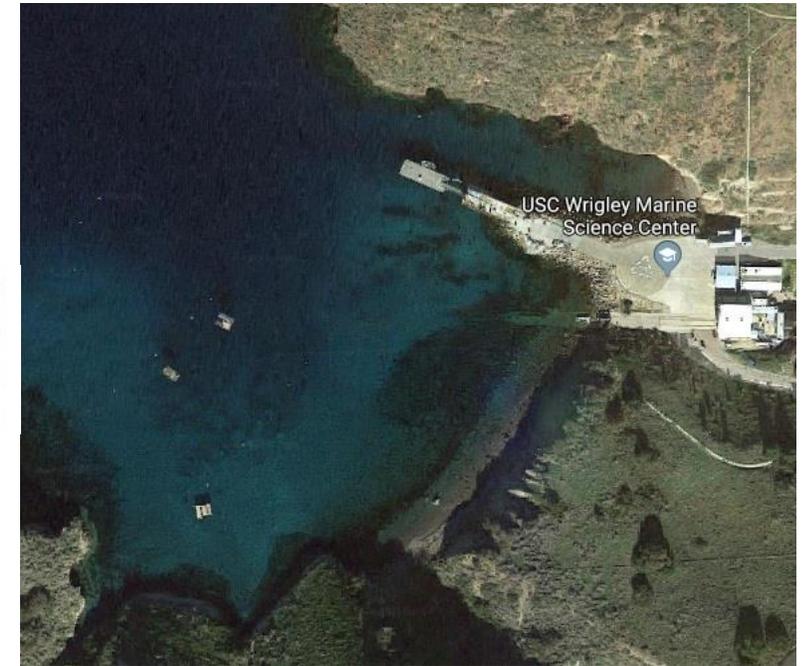
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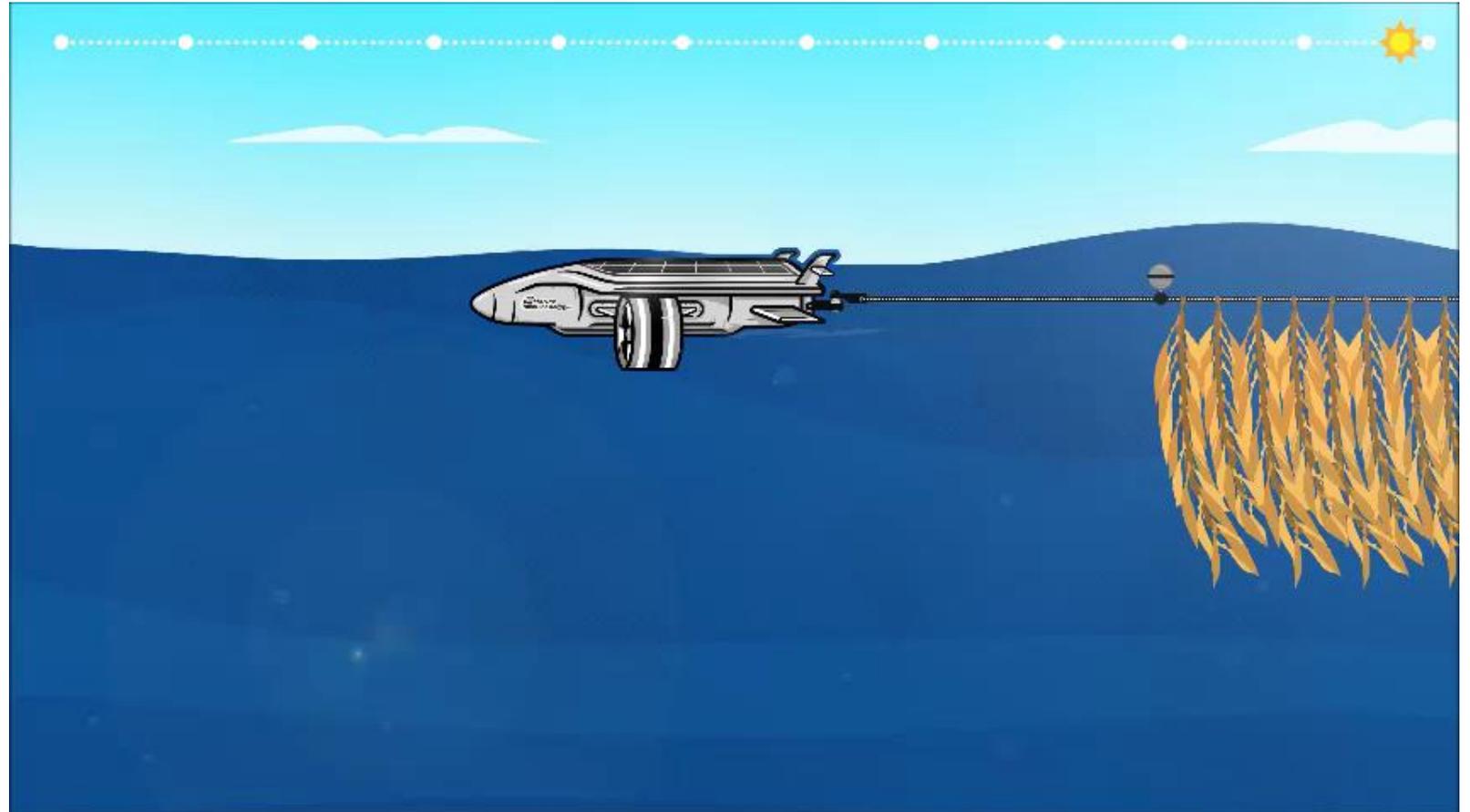
Innovation & Objectives

Innovation

Depth-cycling of kelp provides nutrients and sunlight – patented in major energy-importing markets worldwide. Also dives below ships and storms.

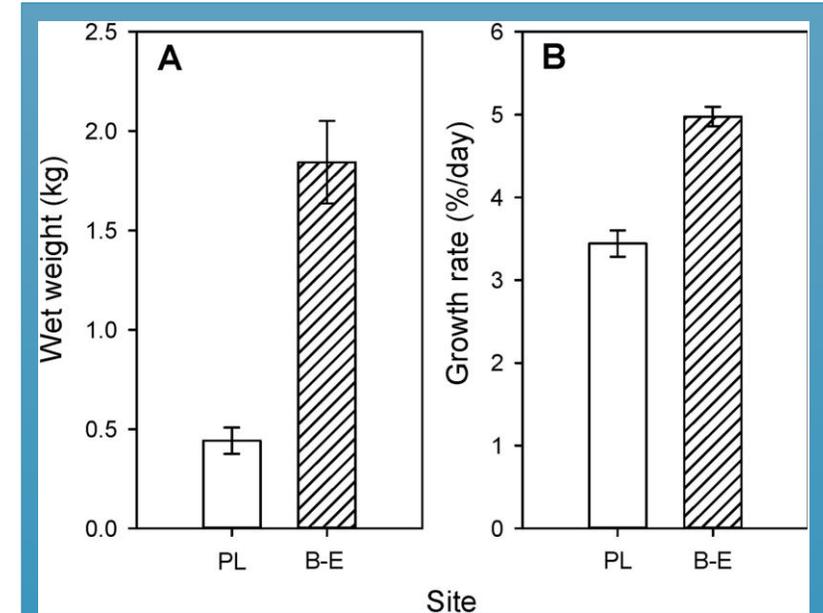
Objectives

- Demonstrate that kelp thrives in open-ocean conditions when depth-cycled.
- Develop detailed design of drone submarines and farm system.
- Rank design priorities and conduct detailed TEA to determine trade-offs.
- Perform key experiments to reduce uncertainty.

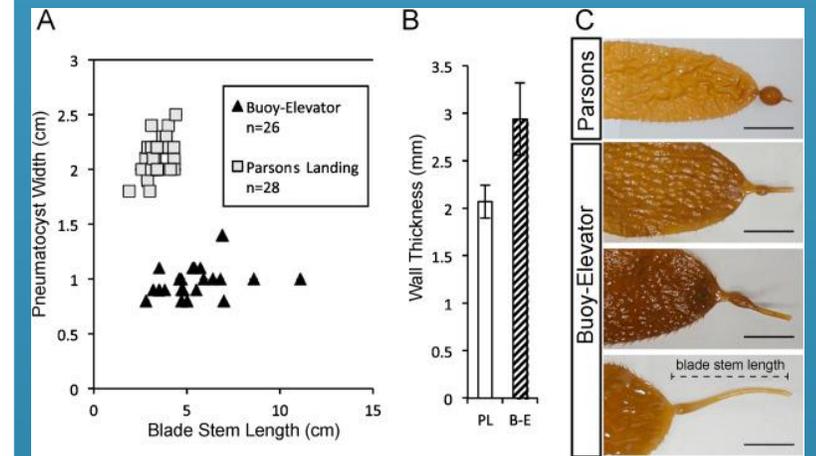


Technology Progress

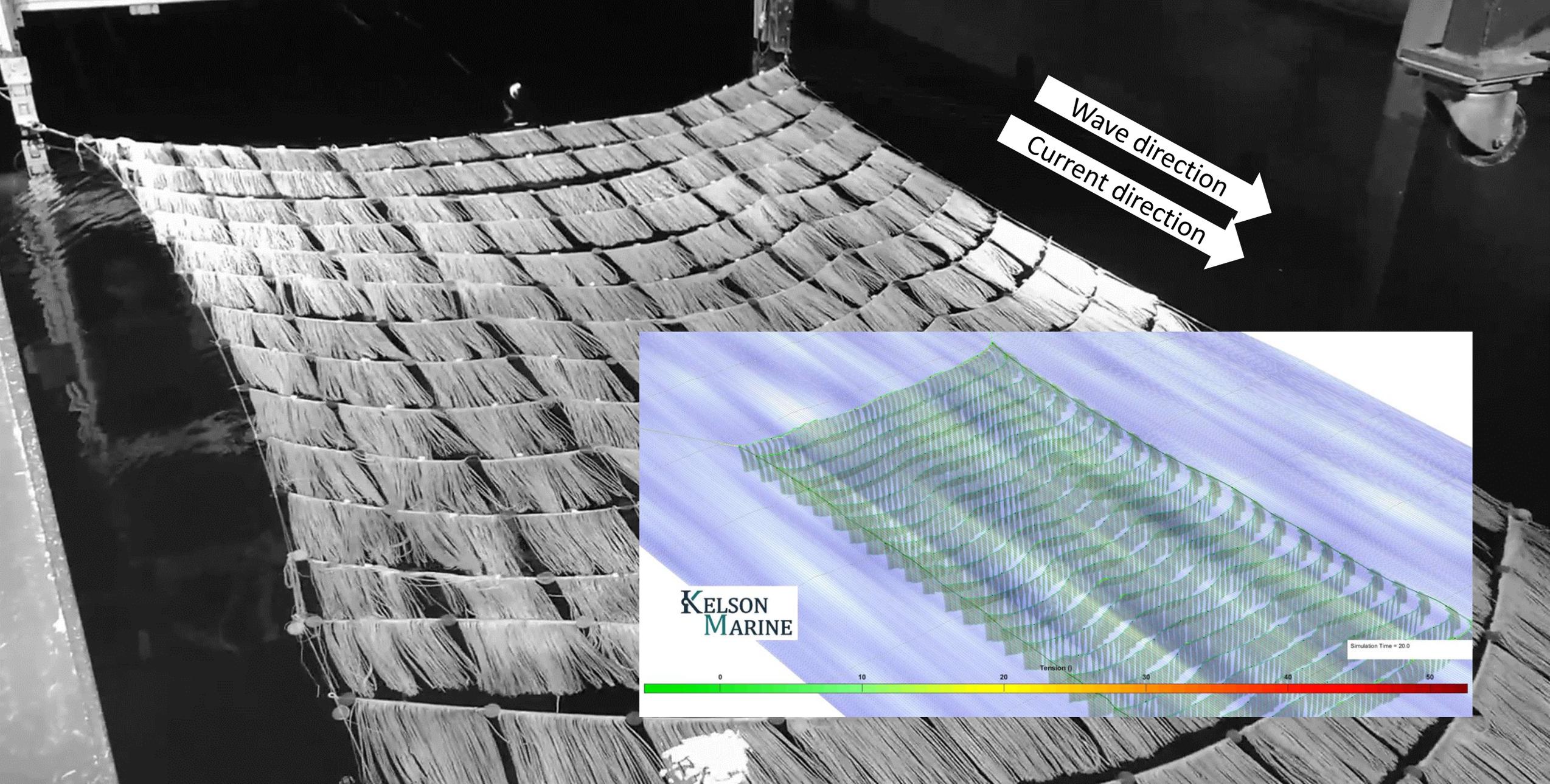
- Published peer-reviewed article on depth-cycling (Renewable and Sustainable Energy Reviews, May 2021 <https://doi.org/10.1016/j.rser.2021.110747>)
- Conducted tow-tank tests at USNA Annapolis
- Now developing detailed design for farm buoyancy control and drone submarines.
- Developing propeller design tool for efficient thrusting at low-speed.
- Next step is to test sub-assemblies and then deploy “first farm” system



PL= Parson's Landing= Control Kelp adjacent to native bed
BE= Buoy-Elevator= Depth-Cycled Kelp as tested

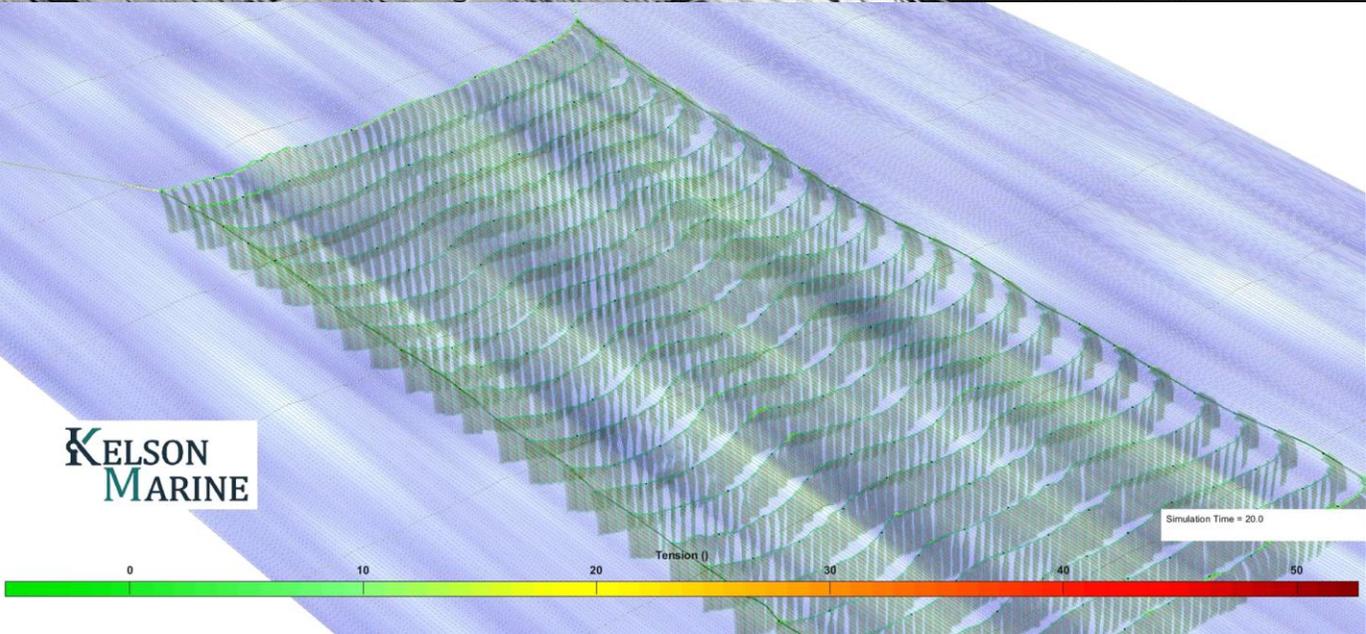


Wave and Tow Tank Testing to Inform and Validate Numerical Model-based Design



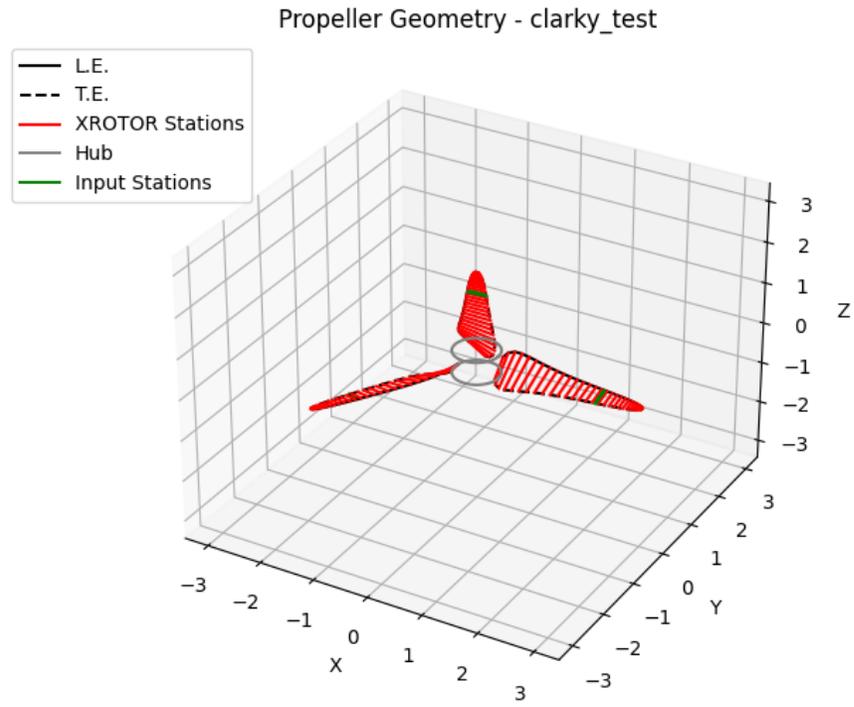
Wave direction

Current direction



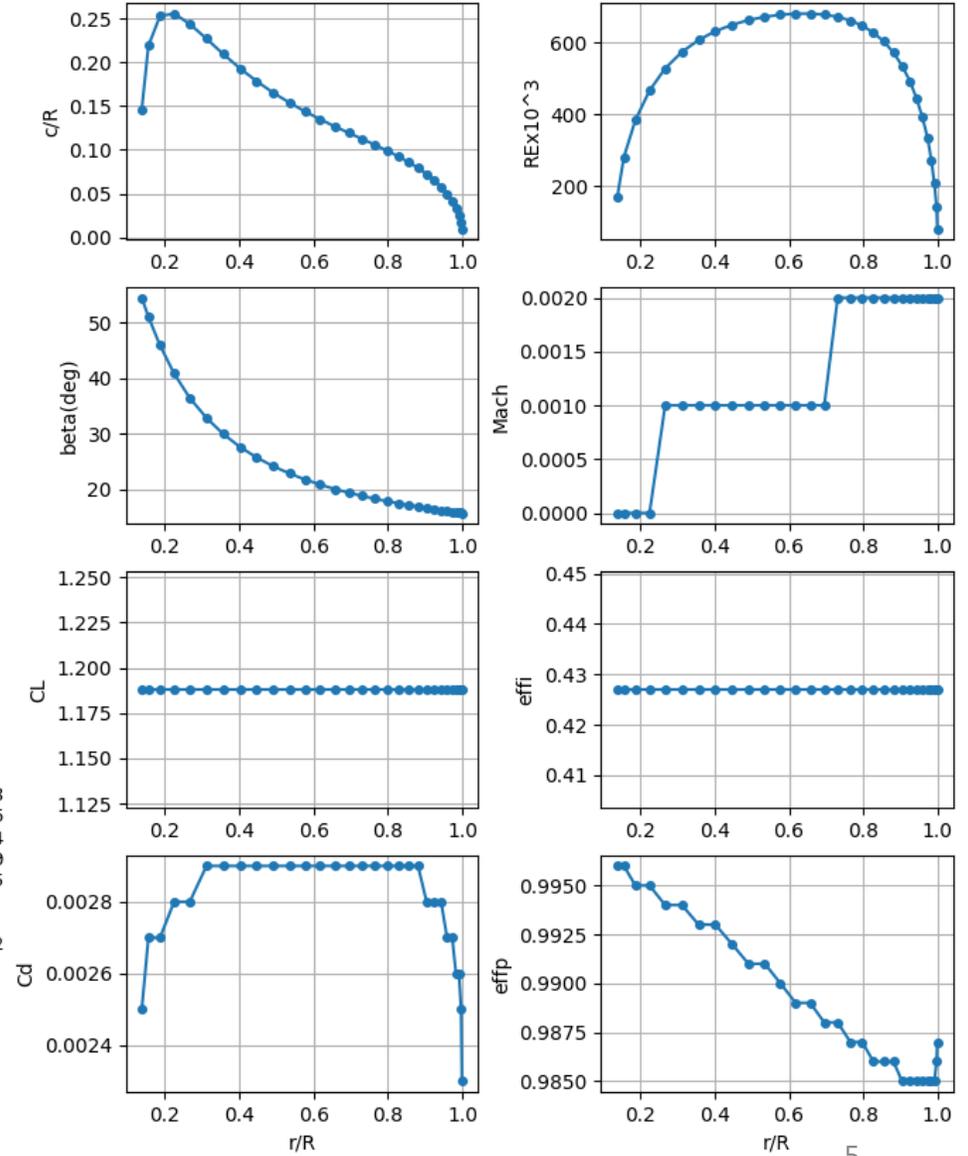
Design Tool for Efficient Low-Speed Propellers

- A largely open-source tool that will permit relatively rapid design and evaluation of propeller geometries.
- Leveraging code bases released through MIT, our design team has built a tool that will generate minimum-induced loss geometry based on our kelp-farm specific inputs.
- Expect propeller design will permit the maximum farm area per the minimum towing drone expected cost.



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Free Tip Vortex Wake Formulation Solution:  Designed blade
                                             Wake adv. ratio:  0.14908
no. blades : 3                            radius(m) : 3.0000    adv. ratio:  0.06366
thrust(N) : 0.530E+04                       power(W) : 0.251E+04  torque(N-m) : 0.240E+04
Efficiency : 0.4222                          speed(m/s) : 0.200    rpm : 10.000
Eff induced: 0.4270                          Eff ideal : 0.4739    Tcoef : 9.3725
Tnacel(N) : -4.9243                          hub rad.(m) : 0.4000  disp. rad. : 0.4000
Tvisc(N) : -3.2448                          Pvisc(W) : 26.9
rho(kg/m3) :1000.00000                       Vsound(m/s) : 1500.000  mu(kg/m-s) : 0.1150E-02
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Helicopter: Sigma: 0.10373  CTh/s: 0.18309  FOM: 0.64630
              Ct: 0.14722  Cp: 0.06974  J: 0.20000
              Tc: 9.37245  Pc: 22.19861  adv: 0.06366
    
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Future Vision, Building the Industry

As Marine BioEnergy deploys more farms and harvests more feedstock:

- The genetics teams will see demand increase for a variety of robust, sterile hybrids, and additional species.
- The nursery suppliers will increase in number and size.
- Near-shore boats will be needed for new farm deployment and crop management.
- Liquid fuel processors will address higher demand bio-fuel markets, such as marine, truck and jet.
- Digesters will produce biogas to replace natural gas in the pipelines to back-up the grid on days of low wind and low sun.

Commercial Opportunities/T2M

Customers:

CR&R, Inc. has signed a letter of intent and plans to digest the kelp into biogas to replace diesel fuel in its fleet of trash trucks. Biogas is pumped into the pipeline and will be available for all “natural gas” customers including grid operators. In bench-scale tests, the kelp performed 5% better in the digester when compared to their regular feedstock of lawn/garden waste.

Primary Ocean plans to process the kelp into a bio-stimulant for the agricultural market.

In addition to US-based farms, Marine BioEnergy will license farms overseas to grow feedstock for fuel, feed and food.