MARINER Program First Year Highlights



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Background

In 2018, the U.S. Department of Energy through the Advanced Research Projects Agency-Energy (ARPA-E) funded 18 innovative projects as part of the Macroalgae Research Inspiring Novel Energy Resources (MARINER) program. In 2019, 6 projects have been selected for Phase 2 demonstration farms.

Sugar Kelp is the Focus of 3 Projects

• Two projects are engineering kelp farming systems to dramatically reduce CAPEX and OPEX per tonne harvested. Demonstration farms will be developed and tested in Alaska and NE US. • One project is developing tools to identify and breed superior cultivars with the goal of improving productivity 10 to 20% per generation

Proposed design for NE USA kelp farm demonstration

Robust multi-anchorage

Wave-powered nutrient upwelling hydrofoil



ARPA-E funding 18 MARINER projects

Six Category 1 demonstration farms planned, 2019 - 2022

Cat. 1: Design & Experimental Deployment of Cultivation and Harvesting Systems

• Catalina Sea Ranch-Macrosystems • Pacific Northwest National Laboratory • University of Alaska, Fairbanks • Fearless Fund • Kampachi Farms, LLC • University of Southern Mississippi • Marine Biological Laboratory • Trophic

Cat. 2: Design & Experimental Deployment of Cultivation and Harvesting System **Component Technologies** • C.A. Goudey & Associates

Cat. 3: Design & Deployment of **Computational Modeling Tools**

 Makai Ocean Engineering • Pacific Northwest National Laboratory • University of New England in Maine • University of California, Irvine



Cat. 4: Design & Deployment of Aquatic Monitoring Technology and Tools

• University of California, Santa Barbara • Woods Hole Oceanographic Institution

Cat. 5: Research & Development of Breeding and Genetic Tools

• University of Southern California • University of Wisconsin, Milwaukee • Woods Hole Oceanographic Institution

Geo-spatial Support Tools: Aquamapper & Ocean Reports • NOAA Centers for Coastal Ocean Science

Kelp Farm Techno-Economic Assessment Model

fuel use:

energy input:



Net Energy Analysis

farm work 860,000 L/yr transits 60,000 L/yr 75,000 L/yr nursery

36 million MJ/yr

dried kelp energy content: 12 MJ/kg harvested biomass energy: 525 million MJ/yr

14:1 **Net energy return:**

Advances in kelp breeding are expected to improve yield to < \$80/dry tonne

Potential for US Co-location; Wind and Kelp Farms











Active BOEM Massachusetts wind energy lease areas plus 3 others in NY/NJ total 361,000 ha. Occupying 10% of that in accordance with our 1000 ha TEA model (about 120 4-turbine cells) would yield over 100,000 km of grow-rope and kelp production of 0.42 million dmt/y.

Potential kelp farm array design in a cell between 4 wind turbines. Blue area represents exclusion area between turbines

> 3.5 M ha suitable for offshore kelp farming in Alaska, and > 1 M ha in Northeastern US





Strain Collections and Common Farm Growth Trials



Alaska farm designs; units link to larger arrays

Trials to begin with multi-line planting and harvesting – 5 lines at a time



Genetic Correlations among Traits – 150 families

			_				_		1
									0.8
DWpM									0.6
-0.46	PDW		•				•		0.4
0.12		BLen							0.2
0.12		0.41	BWMx						- 0
0.11	-0.01	0.09	0.9	BW10		•			0.2
-0.02	0.01	0.35	-0.2	-0.28	BThk				0.4
0.1	-0.08	0.35	0.11	0.04	0.28	SLen			0.6
0.15	-0.06	0.47	0.34	0.27	0.29	0.88	SDia		0.8
	 DWpM -0.46 0.12 0.12 0.11 -0.02 0.11 0.11 	 •••• <li< td=""><td> Marka Marka Marka</td><td>Image: symbol symbol</td><td>Image: book state Image: book state</td><td>Image: big state Image: big state<</td><td>Image: book state Image: book state</td><td>Image: boost state Image: boost state Image:</td><td>Image: big stress of the stress of</td></li<>	 Marka Marka Marka	Image: symbol	Image: book state Image: book state	Image: big state Image: big state<	Image: book state Image: book state	Image: boost state Image:	Image: big stress of the stress of

Abbreviations are:

- WWP, wet weight per plot (~ 1 m) DWpM, dry weight per meter PDW, percent dry weight
- BLen, blade length
- BWMx, maximum blade width BW10, width 10 cm from stipe BThk, blade thickness;
- SLen, stipe length
- SDia, stipe diameter.
- Size and color above diagonal visualize the correlation, and numerical values are given below diagonal.

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