


# **Seaweed 2.0 - Farming the Oceans for Fuels & Chemicals**

Marc von Keitz  
Program Director

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- ▶ **70% more food needed**
- ▶ **much higher demand for biofuels & biobased products**
- ▶ **Need to greatly increase biomass production capacity**



**Where and how  
will we grow  
our additional  
biomass?**

# Peak Farmland



# Peak Freshwater





**All eggs in  
*increased yield* basket?**

# Oceans as the next frontier

70% of world's surface, but  
only 1% of world's food supply



# Oceans as the next frontier

An aerial photograph of a vast aquaculture farm in the ocean. The farm consists of numerous rectangular floating rafts, each covered with a dense layer of green seaweed. The rafts are arranged in a grid-like pattern, extending from the shore into the open sea. The water around the rafts is a deep blue, while the seaweed on the rafts is a vibrant green. In the background, a coastline with trees and buildings is visible under a cloudy sky.

Light

Water

Space

# U.S. Exclusive Economic Zone (EEZ): Larger than total U.S. land area



# Crop for the Ocean Farm - Macroalgae



**Fast growing**

**Easy to harvest**

**Many different species**

**Mostly carbohydrate &  
some protein**

# An Existing Industry

- ▶ World production in 2012: 24 million MT
- ▶ Supplying food & hydrocolloids
- ▶ Mostly manual labor
- ▶ Dominant players today: China, Indonesia, Korea, Japan

Photo: MBARI

# Can we make it Energy-Relevant ?

## ▶ Back of the envelope calculation:

- 1 Quad ( $10^{15}$  BTU) Ethanol (~13 billion gal)
- 210 million MT of dry seaweed (~2.1 billion MT wet)\*
- 18 million acres (~28,000 square miles)\*

## ▶ Increase volume of production ~100x above current world level

## ▶ Drive down cost of production ~10x to get within range of terrestrial biomass

Photo: MBARI

# Scale-up Challenges

- ▶ **Expand into deeper, off-shore waters**
- ▶ **Accessing “free” nutrients**
- ▶ **Saltwater conversion technologies**

Photo: Erik K Veland

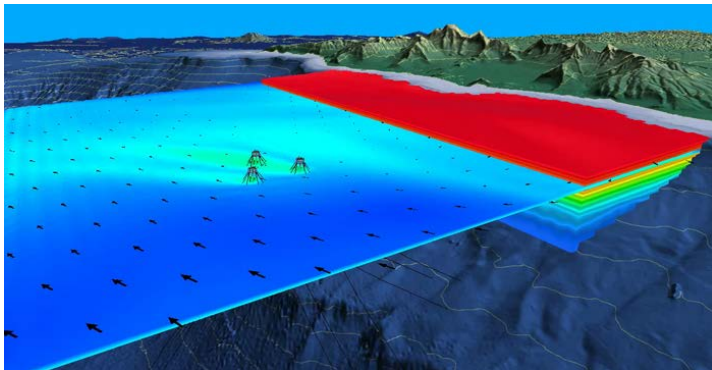
# Leveraging new tools to leap forward



**Satellite Imaging  
& Remote Sensing**



**Robotics  
& Automation**



**Computational  
Modeling**



**Advanced Breeding  
& Genetics**

# One idea: Seaweed “Ranching”

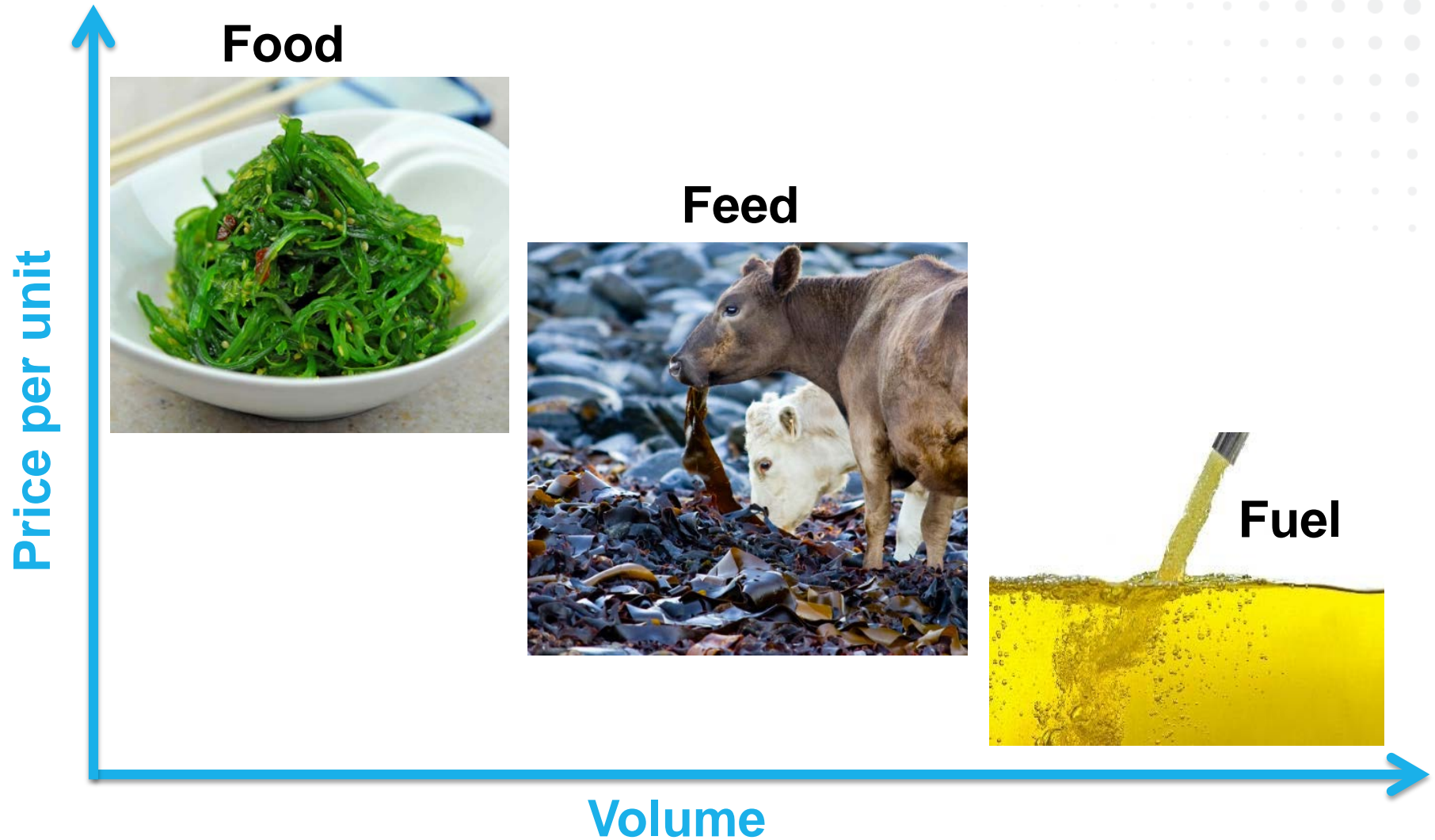
Harvesting floating seaweed before it hits the beaches



Photo: Romel Hall



# Stepping Stones to Commercialization





CHANGING WHAT'S POSSIBLE

# Innovative Approaches to Ocean Cultivation of Macroalgae for Production of Fuels & Chemicals

ARPA-E Workshop  
February 11 & 12, 2016  
Capitol Hilton, Washington, DC



CHANGING WHAT'S POSSIBLE

A photograph of an underwater kelp forest. The water is a clear, deep blue. Tall, brown kelp stalks with long, green, blade-like leaves rise from the bottom. In the center of the frame, a scuba diver is visible, swimming horizontally. The diver is wearing a dark wetsuit and has a tank on their back. The overall scene is serene and natural.

# Thank you !

[marc.vonkeitz@hq.doe.gov](mailto:marc.vonkeitz@hq.doe.gov)