Wild Algae as Biofuel

Dr. Karl Kuschner
Department of Physics
College of William and Mary

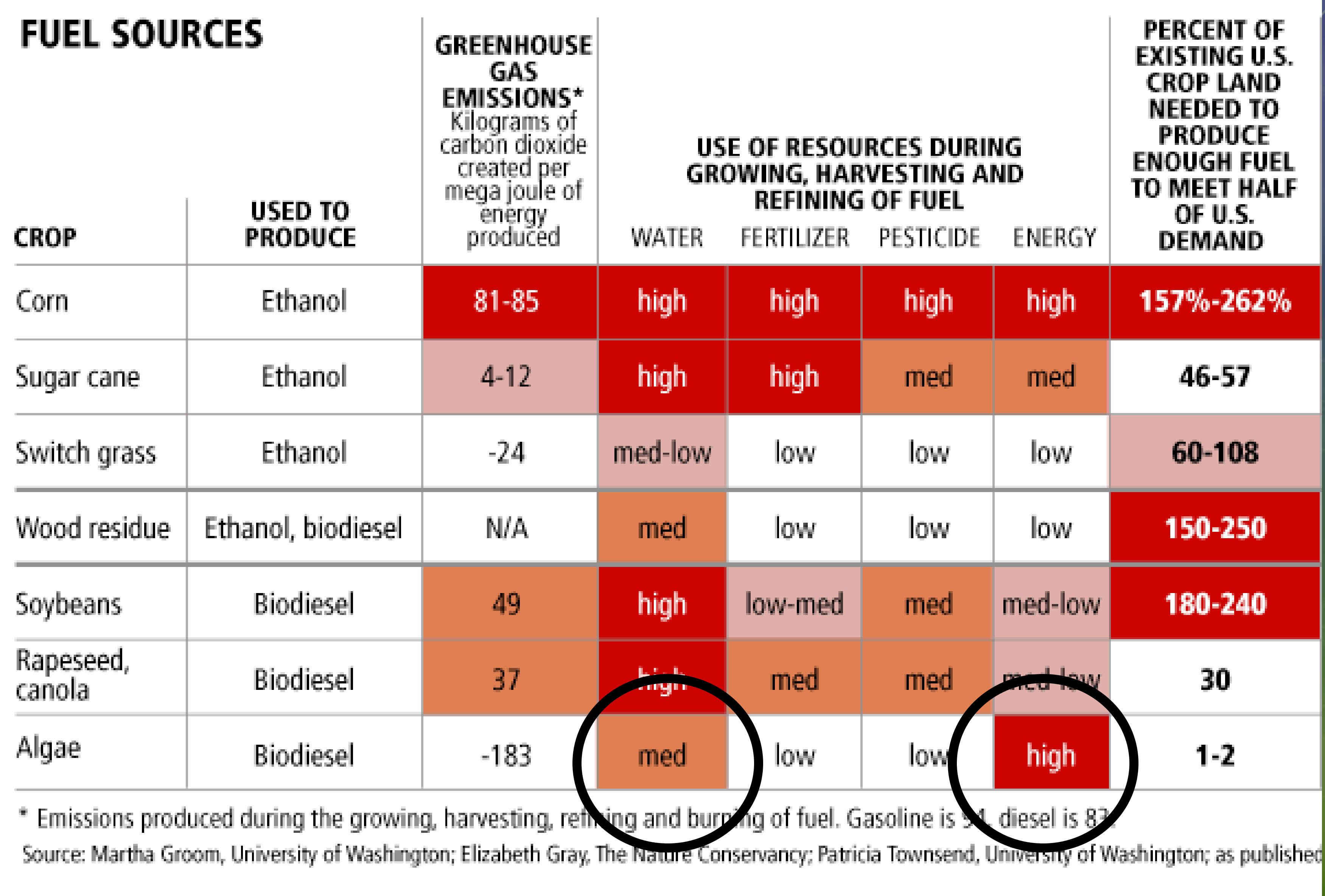
Who we are

- Chesapeake Algae Project (ChAP)
- Consortium of Industry and Universities
- Funded by
  - Statoil Hydro (Norwegian Oil Company)
  - Department of Energy
  - Universities
  - Internal Partners

Key Motivators

- Algal biofuel using microalgae (Statoil has macro algae project on west coast)
- Environmental remediation of Chesapeake Bay
  - Excess nutrient reduction
  - Build on work of Adey et al. (Smithsonian)
- Minimize energy costs

Why Algae?



FUEL SOURCES

CROP	USED TO PRODUCE	GREENHOUSE GAS EMISSIONS* Kilograms of carbon dioxide created per mega joule of energy produced	USE OF RESOURCES DURING GROWING, HARVESTING AND REFINING OF FUEL				PERCENT OF EXISTING U.S. CROP LAND NEEDED TO PRODUCE ENOUGH FUEL TO MEET HALF OF U.S. DEMAND
			WATER	FERTILIZER	PESTICIDE	ENERGY	
Corn	Ethanol	81-85	high	high	high	high	**157%-262%**
Sugar cane	Ethanol	4-12	high	high	med	med	**46-57**
Switch grass	Ethanol	-24	med-low	low	low	low	**60-108**
Wood residue	Ethanol, biodiesel	N/A	med	low	low	low	**150-250**
Soybeans	Biodiesel	49	high	low-med	med	med-low	**180-240**
Rapeseed, canola	Biodiesel	37	high	med	med	med-low	**30**
Algae	Biodiesel	-183	med	low	low	high	**1-2**

* Emissions produced during the growing, harvesting, refining and burning of fuel. Gasoline is 94, diesel is 83.

Source: Martha Groom, University of Washington; Elizabeth Gray, The Nature Conservancy; Patricia Townsend, University of Washington; as published

Why Wild Algae?

- *In situ* growth **negates need for water supply**
  - Net cleaning effect in nutrient-rich water
  - Can scavenge or degrade pollutants
  - Does not compete for arable land
- Naturally selected for robustness
- Very **low energy cost** of production, reduced energy cost of processing
  - Filamentous algae can be harvested with **high solids**

Cons: difficult engineering, high ash, low lipid, challenge to harvest

www.xconomy.com

Our Project

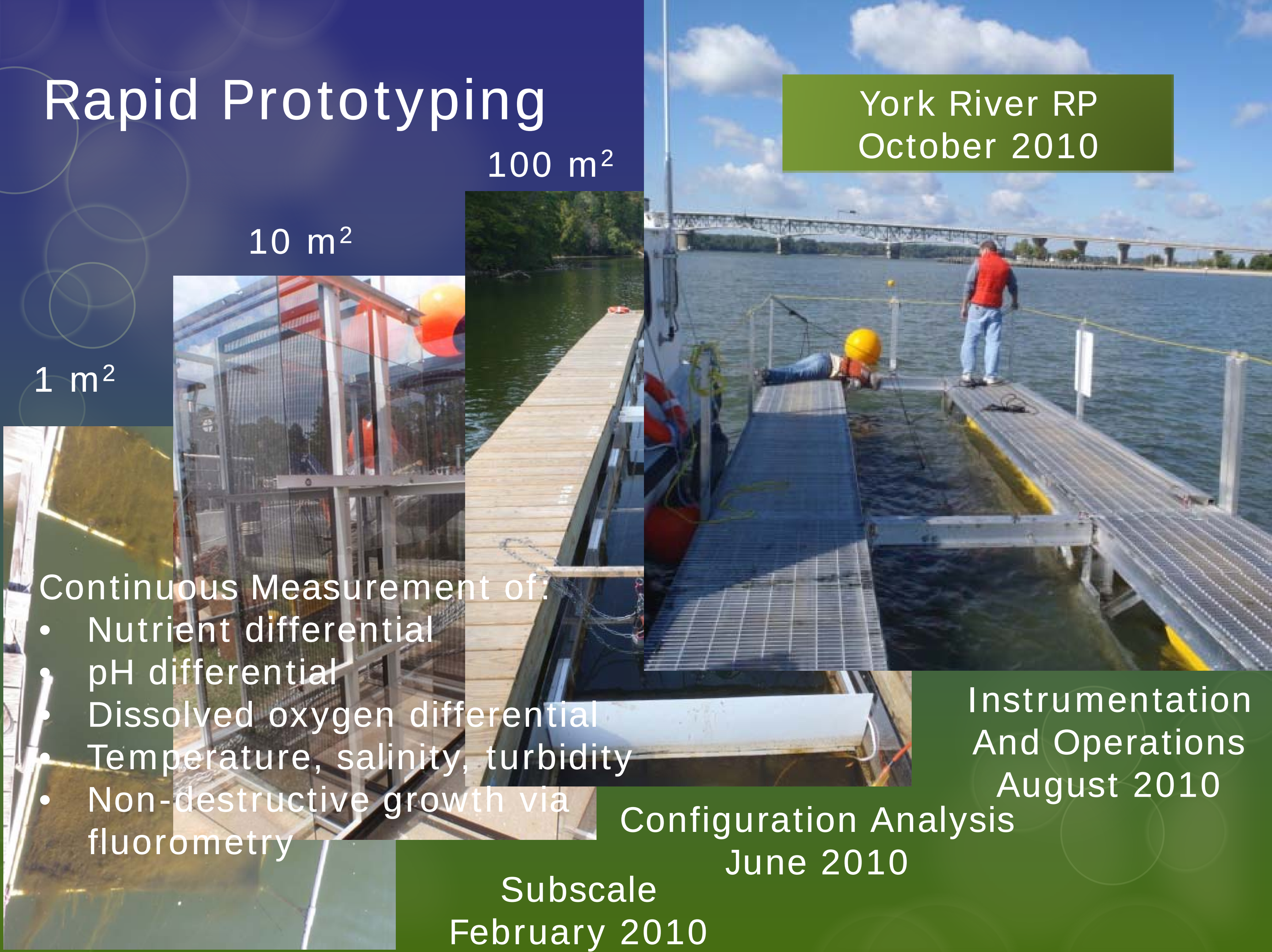
- VIMS: Algal ecology and chemistry
- W&M: Production and pre-processing
- UArk: Refining
- …many others

Timeline

  - Preliminary Research: Oct 2009
  - Primary Funding: May 2010
  - Project Completion: May 2011

Goal: design criteria for pilot-scale production system

Rapid Prototyping



1 m^2

10 m^2

100 m^2

York River RP
October 2010

Continuous Measurement of:

- Nutrient differential
- pH differential
- Dissolved oxygen differential
- Temperature, salinity, turbidity
- Non-destructive growth via fluorometry

Subscale
February 2010

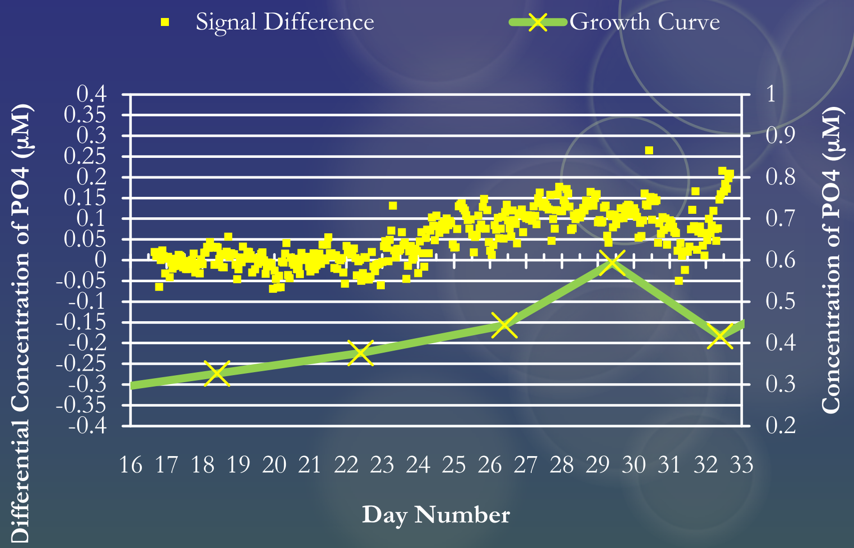
Configuration Analysis
June 2010

Instrumentation
And Operations
August 2010

Preliminary results

(Nov. 2010)

- Measurable nutrient uptake



- Clear chemical differential

- Moderate growth x large packing factor

~ 8 m^2 of substrate per m^2 of water surface

Current activities

- Improve instrumentation
- Repeat previous experiment in high growth season
- Develop harvester technology
- Develop design package for pilot-scale device
- Economic analysis
- Collaborators – perfect refining processes