# Rotating algal biofilm reactor generates biomass in dairy wastewater

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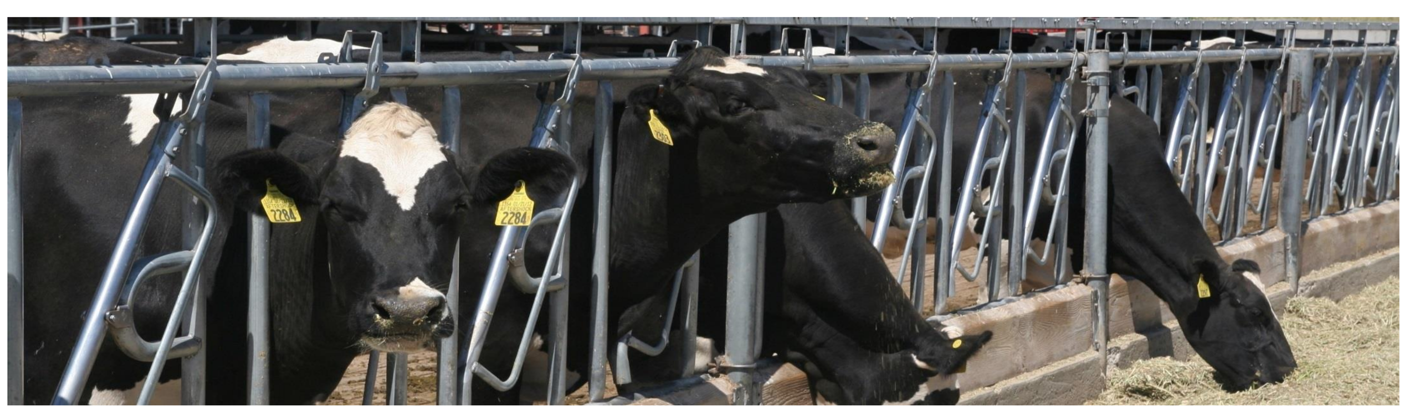
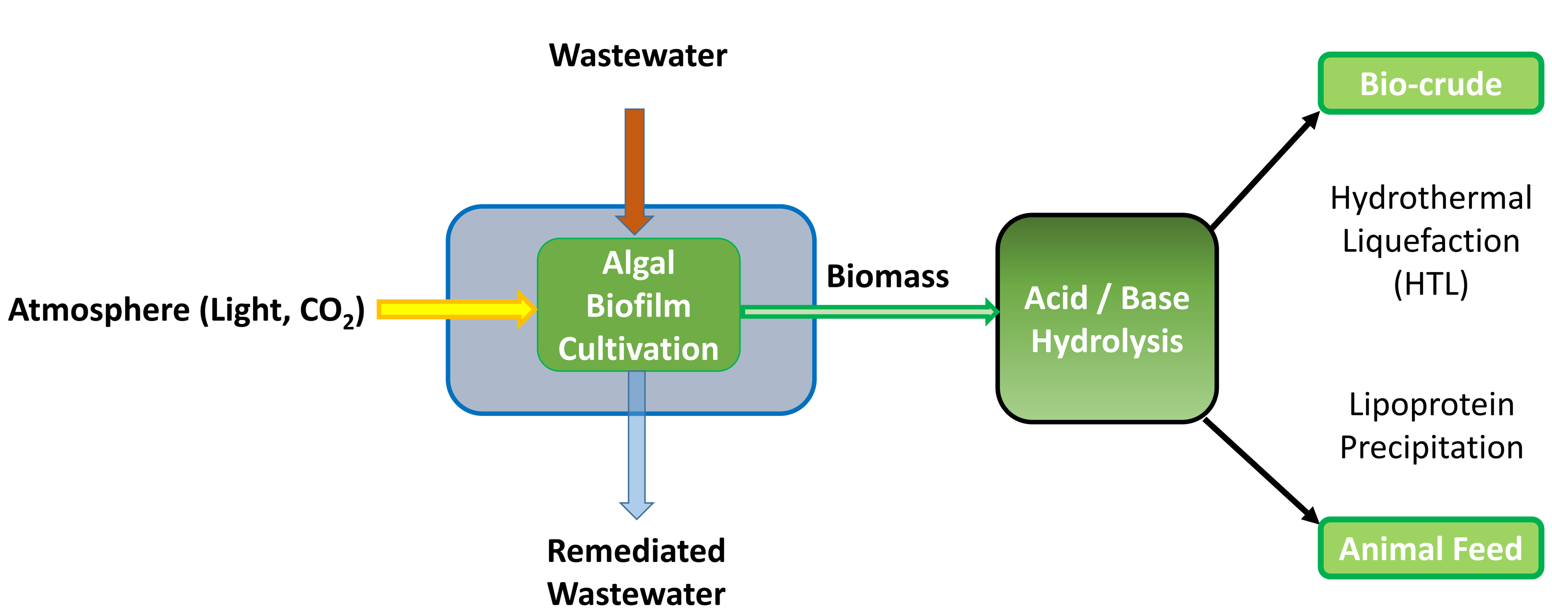
## Abstract

Conventional suspended algal cultures are often light limited in turbid waters. The rotating algal biofilm reactor overcomes this problem by exposing an algal biofilm to nutrients, water, and sunlight in each revolution. Attached cultivation also yields a more concentrated biomass product at harvest compared to suspended cultivation. A pilot-scale rotating algal biofilm reactor was operated in dairy wastewater in a passively heated greenhouse under natural light conditions. The reactor's polystyrene foam discs were rotated at five rpm and areal algal productivities as high as 41 g $m^{-2}$ $d^{-1}$ have been attained. The effects of disc spacing and cardinal orientation on light exposure were also measured. This project aims to produce algal biomass for bioproducts, correlate biomass productivity with environmental parameters, and demonstrate the long term operation of the RABR at pilot scale.



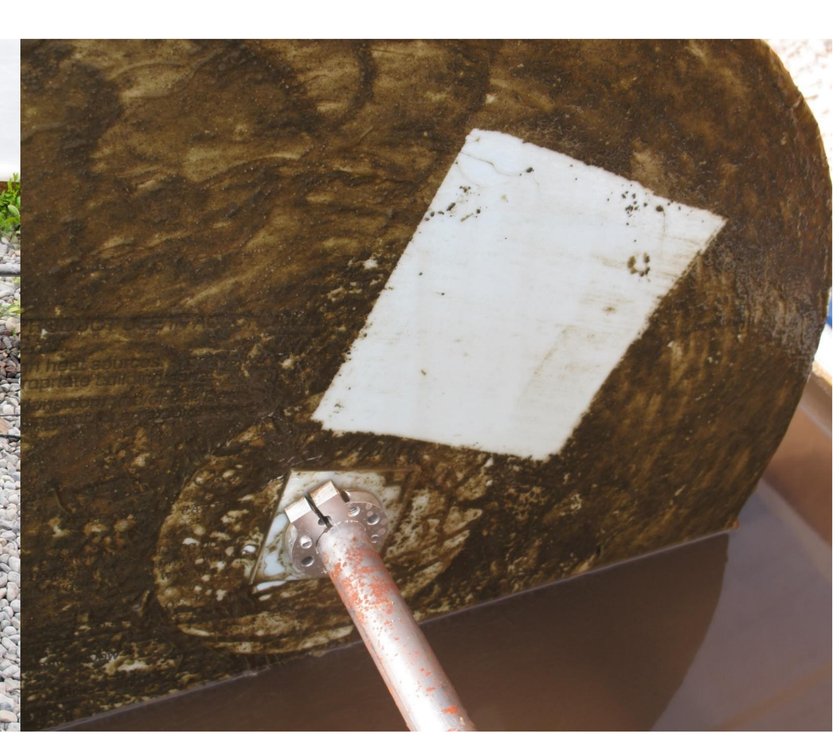
## Background




Attached algae cultivation is being examined as a means to simultaneously generate biomass and remediate wastewater. A proposed algal biorefinery would convert the biomass into energy-rich bio-crude and protein-rich animal feed. The remediated wastewater would be land applied for irrigation.

## The Rotating Algal Biofilm Reactor (RABR)

Pilot-scale rotating algal biofilm reactor (RABR)



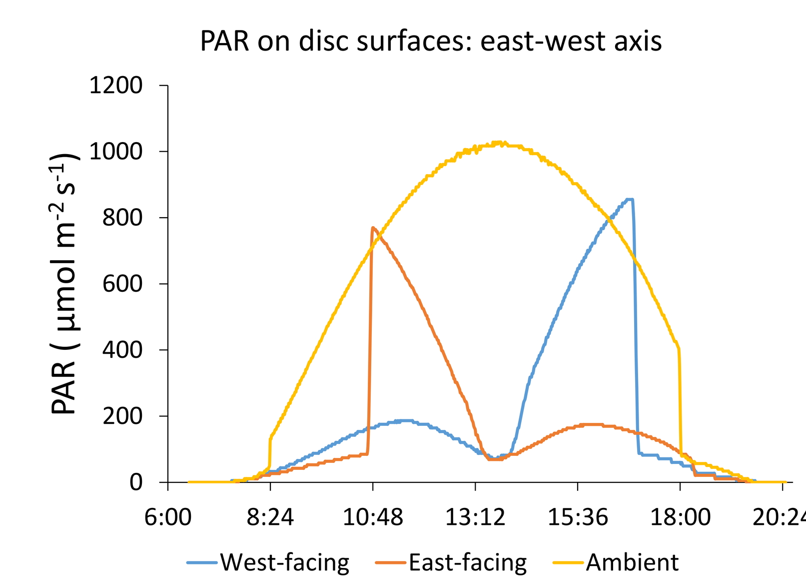
Biofilm growth on disc (6" x 6" area harvested)

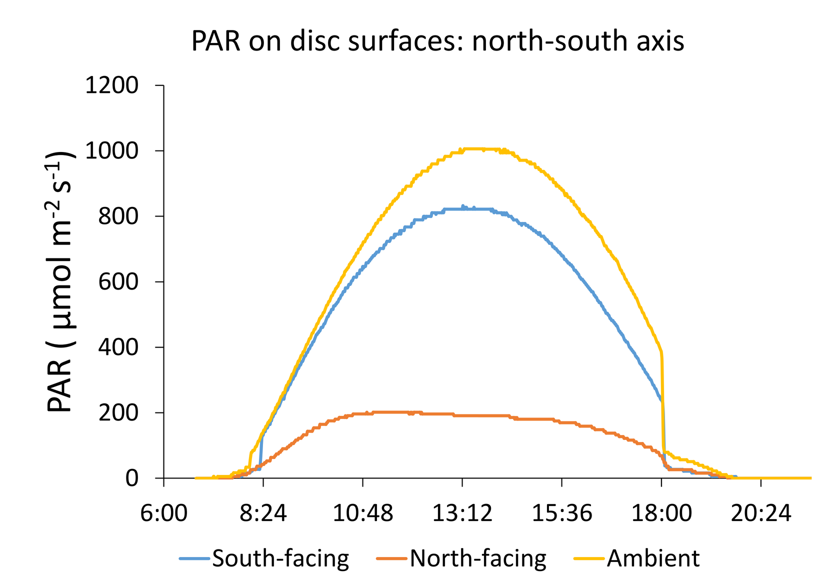
The rotating algal biofilm reactor (RABR) is composed of a series of rotating polystyrene discs (left panel). A pilot-scale reactor was constructed at the Utah State University Caine Dairy Center and operated under continuous flow conditions in dairy wastewater. The reactor was inoculated with an algal polyculture from the Logan, UT Lagoons wastewater facility and has since supported the growth of an algal biofilm. Algal biomass is harvested directly from the disc surfaces by manual scraping. The reactor is housed inside a greenhouse with passive heating and lighting.

### RABR methods and specifications:

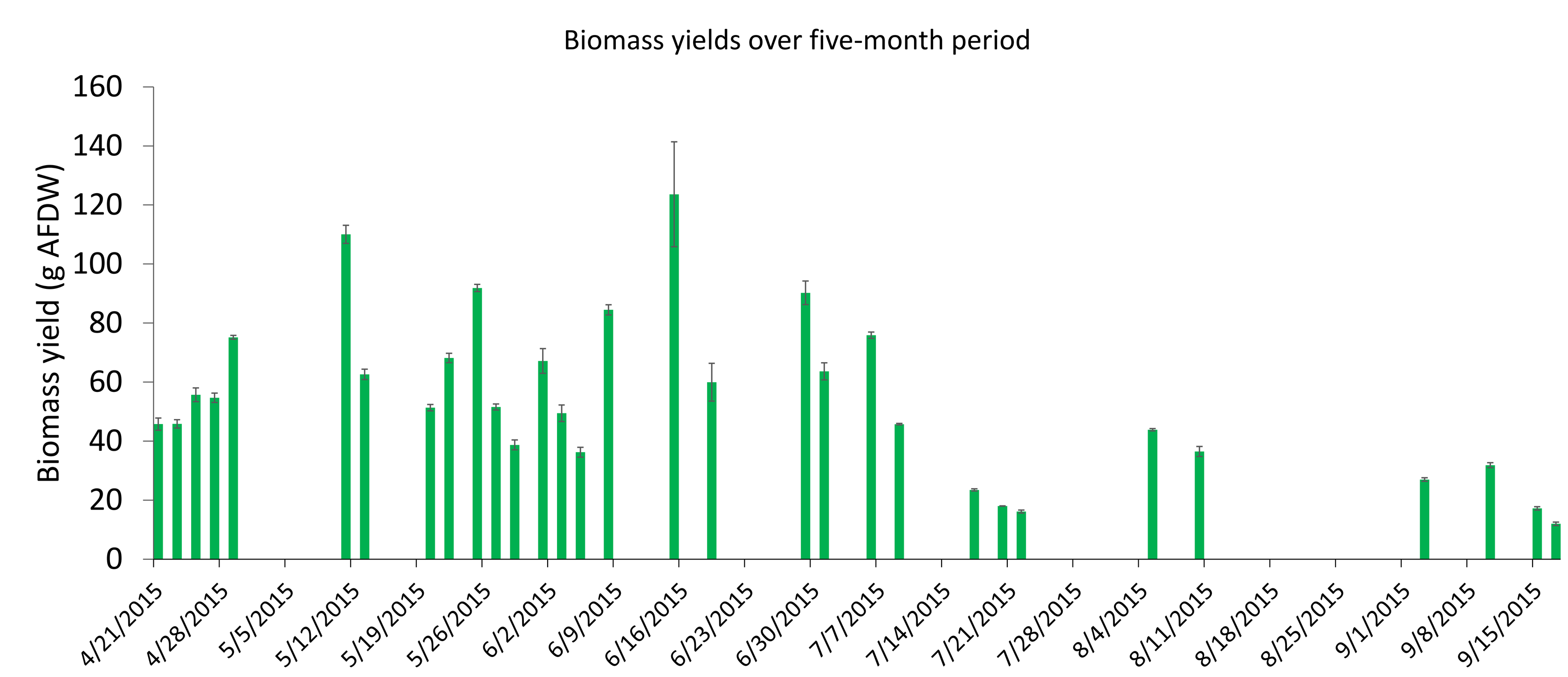
- Continuous flow dairy wastewater reservoir with a hydraulic retention time of 7 days
- Polystyrene discs (2' diameter) rotated at 5 rpm
- Total harvestable surface area of 4.7 $m^2$
- Biomass solids content ranging from 7-9 % at harvest
- Biomass ash content ranging from 25-35 % at harvest
- Air temperature, reactor water temperature, and photosynthetically active radiation (PAR) monitored by datalogger

## Results and Discussion

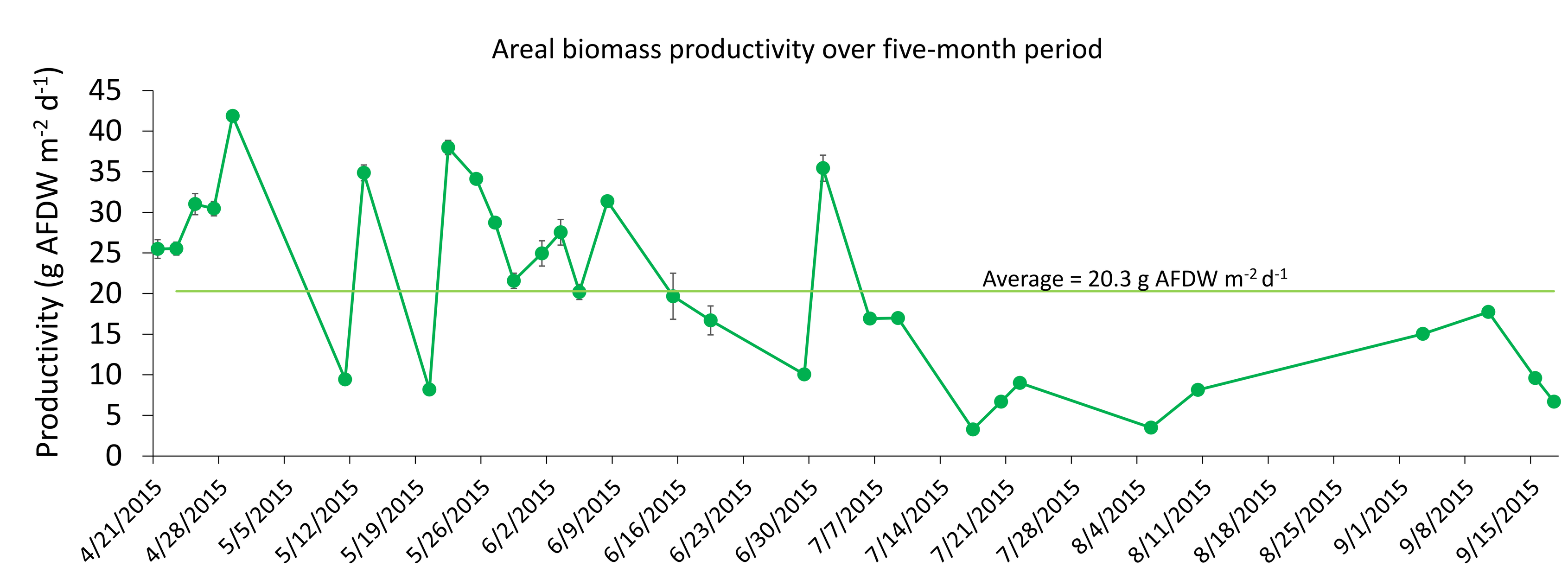



To determine the effect of cardinal orientation on disc illumination under natural light conditions, PAR sensors were embedded in discs on an east-west axis (left panel) and north-south axis (right panel). *The pilot-scale reactor was constructed on an east-west axis for balanced PAR exposure*. (PAR = photosynthetically active radiation.)




*The reactor operated for a five-month period under continuous flow with no algal culture crashes.* Biomass yields were measured on an ash-free dry weight (AFDW) basis. Error bars denote one standard deviation of triplicate measurements.




*Productivity was highly variable during the five-month operational period with an average of 20.3 g AFDW $m^{-2}$ $d^{-1}$*. Areal productivity values were measured on an ash-free dry weight (AFDW) basis per footprint area. Error bars denote one standard deviation of triplicate measurements.

## Conclusions

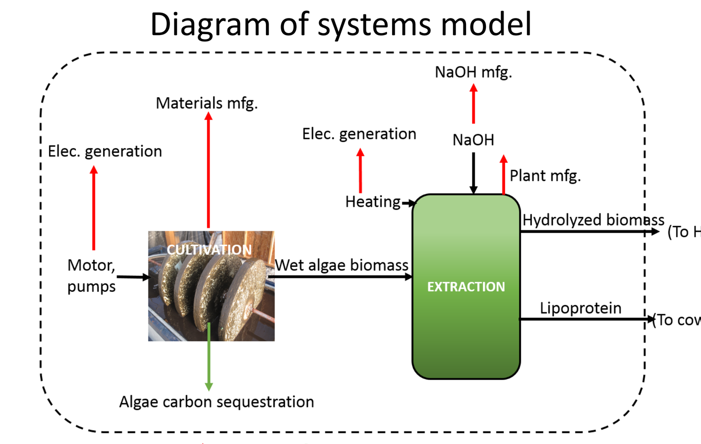
- Biomass was produced with an average productivity of 20.3 g AFDW $m^{-2}$ $d^{-1}$ .
- Algal productivity was variable but with no complete crashes of the algal polyculture.
- The pilot-scale RABR was demonstrated for a five-month period under natural lighting and passive heating.

## Future Work

- Correlation of algal productivity with environmental parameters
- Hydrothermal liquefaction (HTL) of algal biomass to bio-crude
- Life-cycle and techno-economic analysis of attached growth system

Greenhouse for winter operation

Diagram of systems model




## Acknowledgements

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