Integrated Strategy for Optimizing Microalgae Biomass Productivity by Matching Strain to Location & Season

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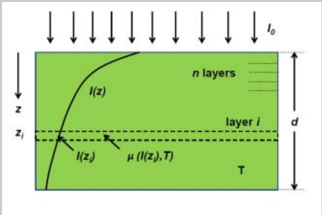
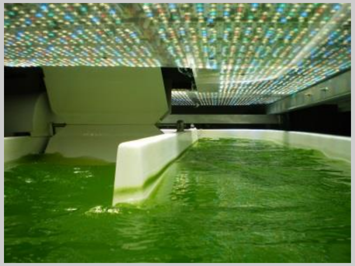
Strain Characterization	Biomass Growth Modeling	Climate-Simulated Culturing	Outdoor Raceway Cultivation



$I(z) = I_o \cdot e^{-k_a B z}$

$\mu = \mu_{max} \cdot f(I,T)$

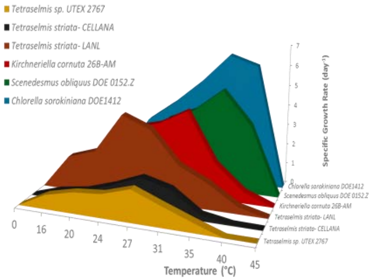
$B(t + \Delta t) = B(t) \cdot e^{\mu \cdot \Delta t}$



Challenge:
- Identify strains that exhibit high biomass productivity in outdoor ponds

Solution:
- Characterize strains: specific growth rate μ = f (temp, light, salinity, pH)
- Predict seasonal and annual biomass productivities in outdoor ponds
- Generate strain-specific biomass productivity maps, find best location
- Quantify biomass productivity in indoor climate-simulation ponds
- Conduct outdoor validation studies

Impacts:
- Optimize annual biomass productivity by matching strain to location
- Minimize capital and labor cost through climate-simulated culturing
- Use data for techno-economic analyses to reduce biofuels costs



Maximum specific growth rate as a function of temperature for six different microalgae strains. Temperature tolerance and optimum temperature differ markedly among strains.

Climate Simulated Culturing Capabilities

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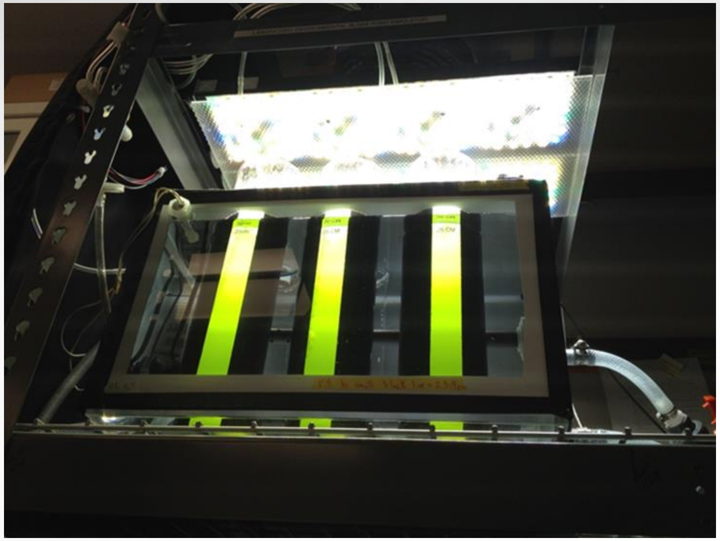
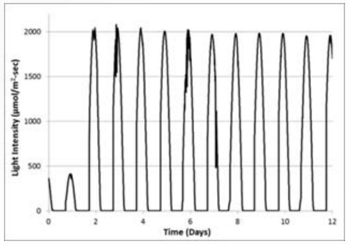
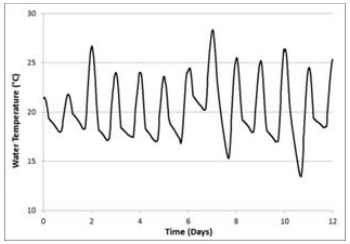
LED-Lighted Climate-Simulation Raceway Ponds

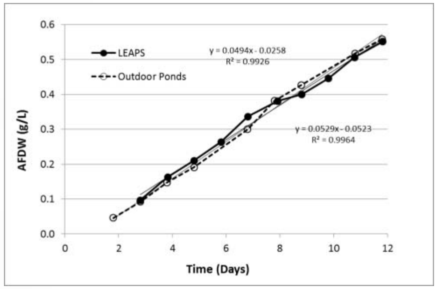
Laboratory Environmental Algal Pond Simulator (LEAPS)



- Both climate-simulation culture systems are operated using light and temperature scripts generated by the PNNL Biomass Assessment Tool (BAT) for a specific location and season.
- Both systems have been validated by comparing biomass productivities in the climate-simulation cultures to those in measured in outdoor ponds.





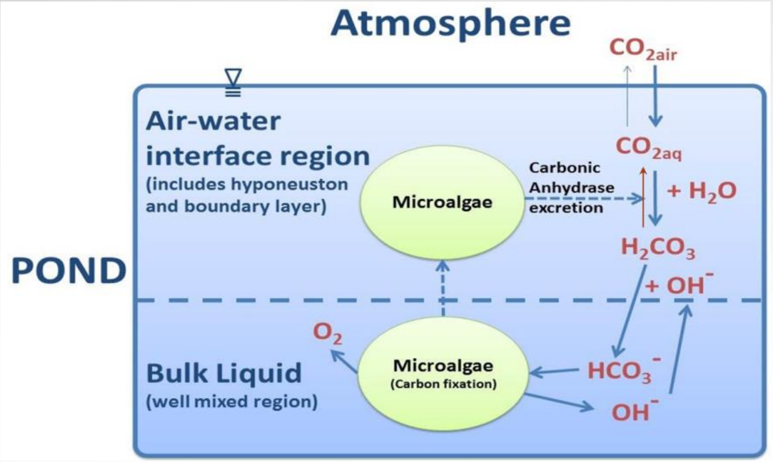


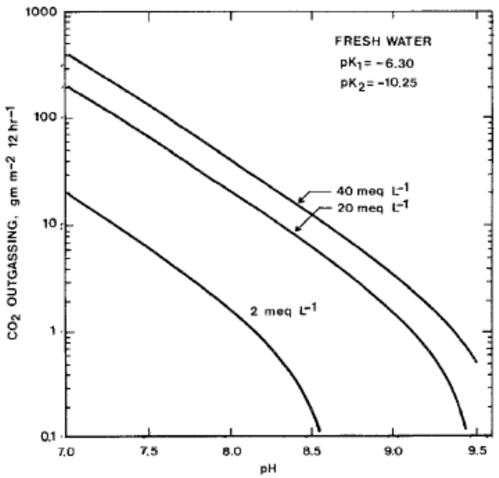
Increasing CO_2 Mass Transfer and CO_2 Utilization Efficiency

The mass transfer rate of CO_2 from the gas phase into the culture, and thus the CO_2 utilization efficiency, can be increased by physical, chemical, and biological processes:

- **Physical: Increased mixing (turbulence) results in a smaller boundary layer.**
  - **Challenge**: Very energy intensive.
- **Chemical: High pH increases chemical-enhanced CO_2 mass-transfer. CO_2 outgassing declines dramatically with increasing pH.**
  - **Challenge:** Requires strains with high productivity at high pH (9.5 or greater).
- **Biological: Addition of carbonic anhydrase increases CO_2 mass transfer.**
  - **Challenge:** Expensive unless excreted by cells.

These methods to increase CO_2 mass transfer are being evaluated in our BETO Incubator Project and this knowledge can be applied to increase carbon capture efficiencies.





Weissman, Goebel, and Benemann, 1987.