

Florida State University
Planning Grant: Constructual Optimization of Solar Photo-Bioreactors for Algae Growth

PI: Juan Ordonez
Students: Quinn Straub (MS), Tom Tracy (MS)

Description: This planning grant money will be used for partial support of a graduate student. We will (1) design a small (lab scale) photo-bioreactor for algae growth and (2) select the type of algae for future experimentation. The main objectives are to place us in a more competitive position in future submissions in the area of biofuels. By the end of this one year effort we expect to have a complete design of a small-scale photo-bioreactor for algae growth and to obtain additional funds that will allow us to build the photo-bioreactor.

Budget: \$15,000

Universities: FSU

External Collaborators: Federal University of Parana, Brazil

Progress Summary

Research Objectives for Current Reporting Period:

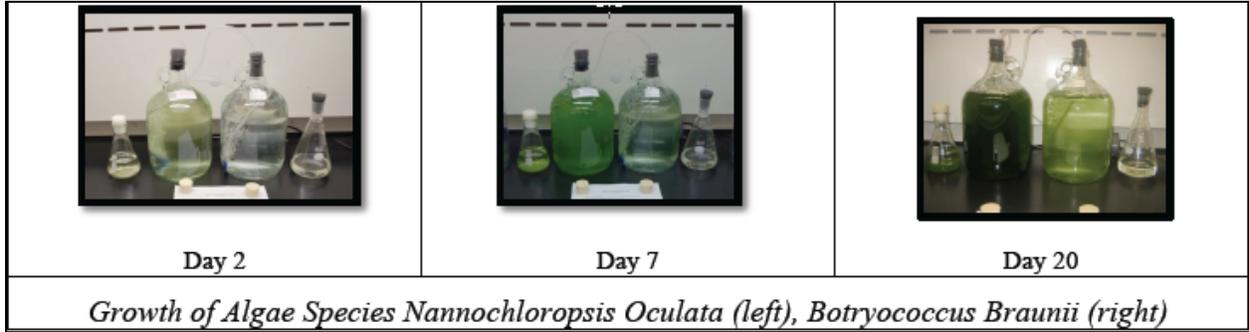
As a planning grant, the main objectives for the project are to enhance our laboratory capabilities and personnel qualifications to make us more competitive for other solicitations. Equipment has been purchased and students trained as described below. Additionally, the PI served as a member of the International Advisory Board to the Southern Conference on Computational Modeling (Brazil), presented one invited talk, had one invention disclosure, and submitted several grant proposals.

2010 Annual Report

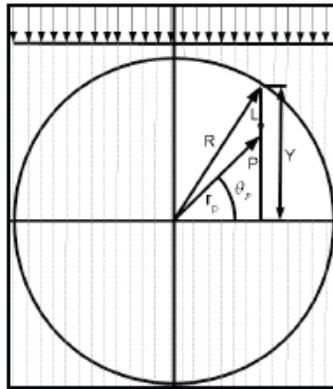
Progress Made Toward Objectives During Reporting Period:

Personnel training: Two students (T. Tracy and Q. Straub) were sent to a 2-day seminar hosted by the University of Texas at Austin. The seminar exposed the students to fundamentals of the biological interactions of micro-algae, culturing techniques, culture maintenance, as well as, proper use of lab equipment. They also toured a culture collection that is one of the best in the world (Over 3,000 species).

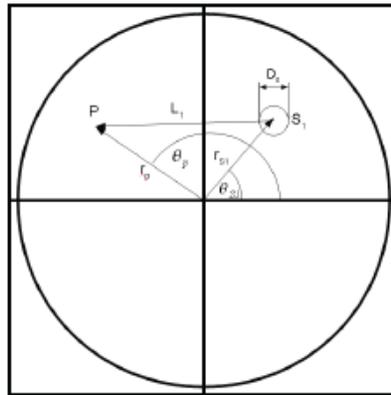
Laboratory enhancement: We acquired a Vernier photo-spectrometer, and a microscope. Simple experiments were conducted to familiarize mechanical engineering students with the use equipment typically found in a biology laboratory. The students learned how to grow *Nannochloropsis Oculata*, measure cell concentration with a Newbauer hemocytometer and a fixed volume micropipette, and measure sample's absorbance using the Vernier photo-spectrometer.



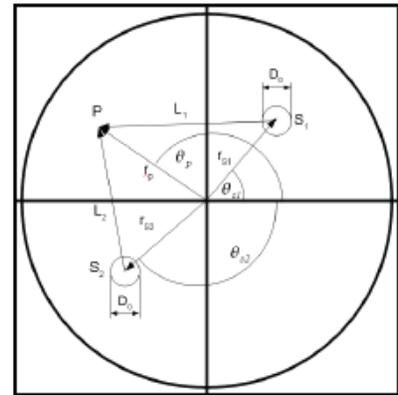
Modeling/Experimentation: In order to better understand the system at hand, research has been done to better understand the interaction of light with this type of system, whether radiated internally or from an external source. As such, a model was created and implemented to describe the behavior of light in a cylinder under two circumstances. The first circumstance occurs when light interacts with a cylinder from an external source. The second circumstance would occur when a light source is placed inside the system and allowed to radiate outward. This is better illustrated in the diagrams below:



External Light Source

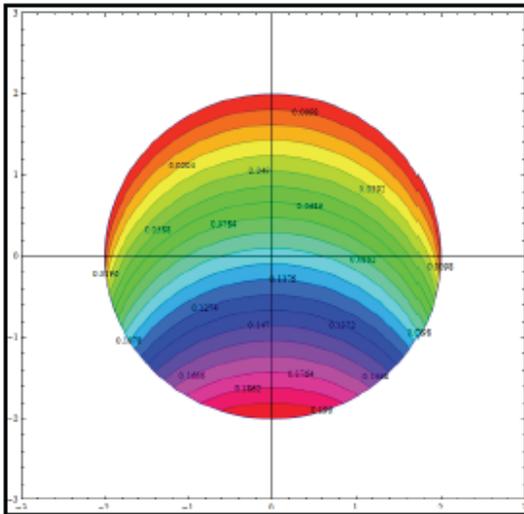


Internal Light Source

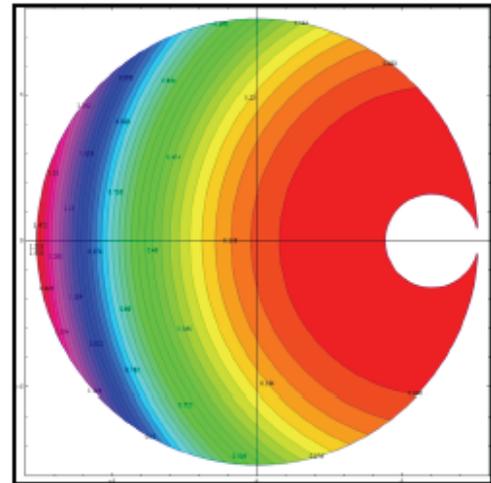


Multiple Internal Light Sources

The results of the model were then obtained and verified for accuracy experimentally. Shown in the figure below is the output of the model in the form a contour plot. It is illustrated how the intensity of light decreases as a function of the length travels through the algae medium.



External Light Source



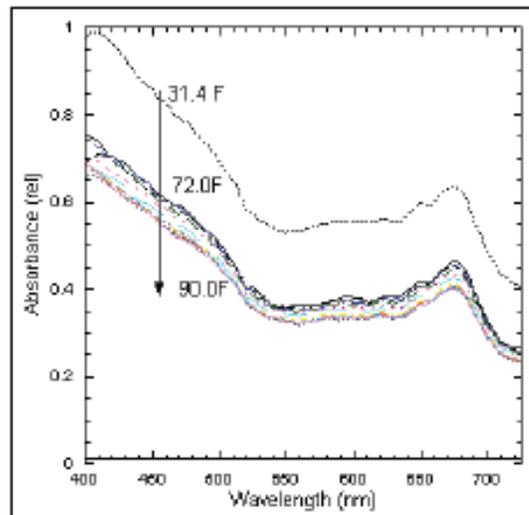
Single Internal Light Source

A comparison between the predicted results and the measured results for the above two figures are shown below in two tables. In both tables it can be see that the predicted results of the model adequately represent what is found experimentally.

External Light Source: Predicted and Measured Absorbance				
Diameter	Predicted Absorbance	Predicted Transmittance %	Measured Absorbance	Measured Transmittance %
2cm	.098	79.80	0.00	100
4cm	.196	63.68	0.21	61.72
6cm	.280	52.48	0.29	51.16
8cm	.380	41.69	0.38	41.40
10cm	.480	31.11	0.57	27.02

Internal Light Source: Predicted and Measured Absorbance				
Distance from Light Source (cm)	Predicted Absorbance	Predicted Transmittance %	Measured Absorbance	Measured Transmittance %
5.08	0.12	75.86	0.083212	82.56
5.72	0.17	67.61	0.16610	68.22
6.35	0.23	58.61	0.24621	56.73
7.62	0.39	40.18	0.33422	46.32

A test to see the variation in light absorbance with temperature was conducted. The results are illustrated in the figure below.



Absorbance Temperature Trend

Synergistic Activities:

Collaborations:

Our group international collaboration has produced results that leverage the efforts of the current planning grant; some of those results are listed below.

Service:

Served as member of the International Advisory Board to the Southern Conference on Computational Modeling (Brazil).

J.C.L Torrens, J.V.C. Vargas, E.C. Telles, A.B. Mariano, J.C. Ordonez, “ Biodiesel From Microalgae: The Effect of Fuel Properties on Pollutant Emissions,” COBEM, Gramados, Rs, Brazil, Nov. 2009.

R.L.L Ribeiro, A.B. Mariano, J.A.Souza, J.V.C. Vargas, J.C. Ordonez, “Numerical Simulation of the Biomass Concentration of Microalgae Cultivated in a Self-Sustainable Photobioreactor,” COBEM, Gramados, Rs, Brazil, Nov. 2009.

R.L.L Ribeiro, J.A.Souza, R. Pulliam , A.B. Mariano, J.C. Ordonez, J.V.C. Vargas, “The Transient Temperature Behavior in Compact Tubular Microalgae Photobioreactors,” 13th Brazilian Congress of Thermal Engineering and Sciences, Uberlandia, MG, Brazil, December, 2010

Invited Talks:

J. C. Ordonez, “An Overview of Microalgal Biodiesel,” Ubatuba, Brazil. Oct, 2009. Visit sponsored by the State of Sao Paulo. J.C. Ordonez, Thermodynamic Optimization of Energy Systems, Manila, NEECC-IIEEE, Philippines, Dec. 10, 2009. (as part of IESSES-FSU delegation to Philippines)

Invention disclosure:

“Compact Photo Bioreactor for Microalgae Cultivation,” J.V.C. Vargas, W. Balmant, A. Stall, A.B Mariano, J.C. Ordonez, Z. Hovsapien

Proposal Submissions:

Proposed work (over \$500K budget) in micro-algae related work as part of the DOE ERIC program.

Participated in the writing of FSU position paper to USAID, which includes work in micro-algae.

Met with Philippine National Academy members from Ateneo and De La Salle Universities to discuss collaboration opportunities in microalgae efforts. J.C. Ordonez (co-PI) (PI: Shih), US-Brazil Partnership in Sustainable Engineering and Aeronautical Engineering, Brazil Higher Education Consortia, \$248,534

Ordonez, Juan (PI). DOE ERIC submitted proposal for micro-algae related work. \$500,000