The Utilization of Algaes' Swimming Trajectories to Determine Metabolic State and Lipid Production

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Background

Demand for Alternative Energy Sources

- Decreasing worldwide oil supplies
- Increased interest and use of biofuels

Biofuel Produced from Microalgae

- Organisms can be used because of their high oil content, fast growth rate, and nontoxic nature.

Benefits of Dunaliella

- Known for their high supply of lipids and fatty acids
- Environmental effects play a large role in their growth such as: light, temperature, and salt concentration.

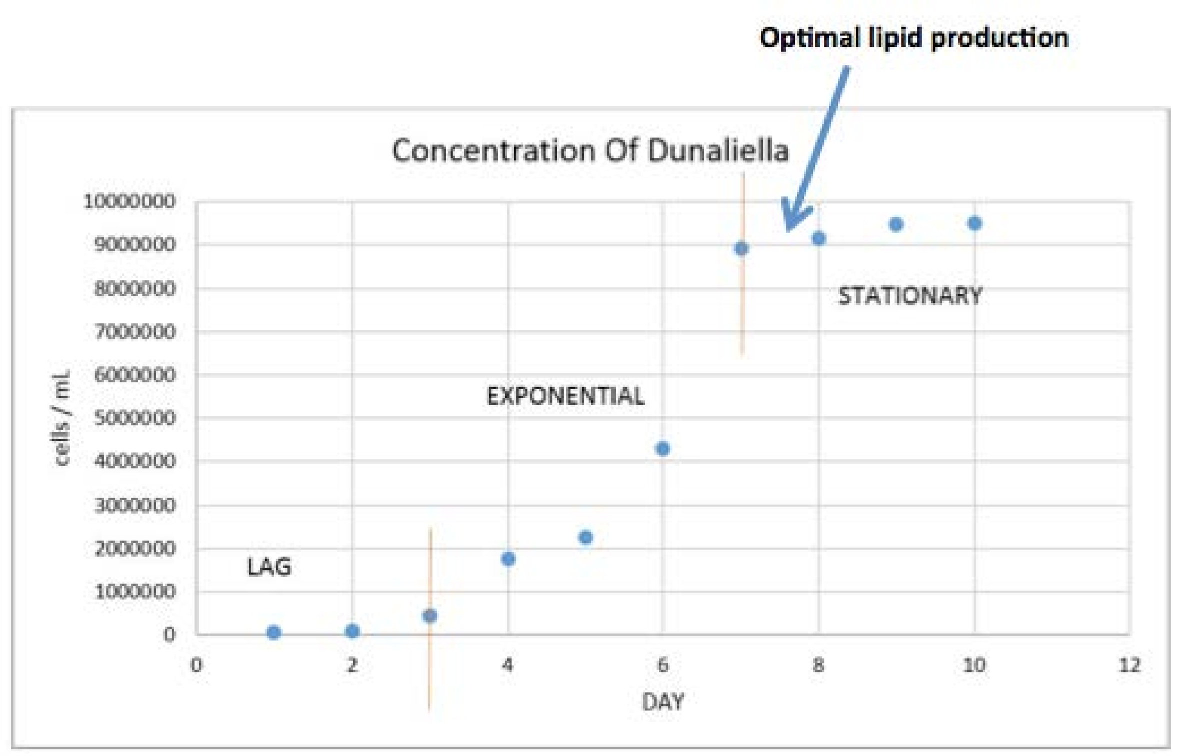


Figure 1. Concentration of Dunaliella throughout its lifecycle as a function of time (days). The optimal harvest time is at the end of the exponential period because their lipid production is at its highest.

Objective

Long-term Project Goal: To study the swimming behavior of Dunaliella throughout its life cycle to determine the relation between velocity and lipid concentration.

Methods

Overview:

- Cultures were grown using Ersheiber's growth medium
  - Grown for 5-7 days prior to use at about 22C
- A digital holographic microscope was used to record initial sample volume.
- Digital holography techniques were used to perform experiments.
- Major Experiment: 20 Days
  - Recorded sequences of 200 frames every 6 hours resulting in a total of 16,000 frames.
- Smaller Experiment: exploring effects of concentration was erformed.
- Data was processed using MATLAB and filtering.
- Analysis of reconstructed 3D particle positions was completed.

Digital Inline Holography

- Setup included: Point Grey Grasshopper 3.0 CCD camera (17fps), Edmund Optics 10x microscopic objective, and HeNe (12mW 632nm) laser
- Processing Hardware: computer with an Intel Core i5-4690S CPU, Nvidia GeForce GPU, and 16GB of RAM

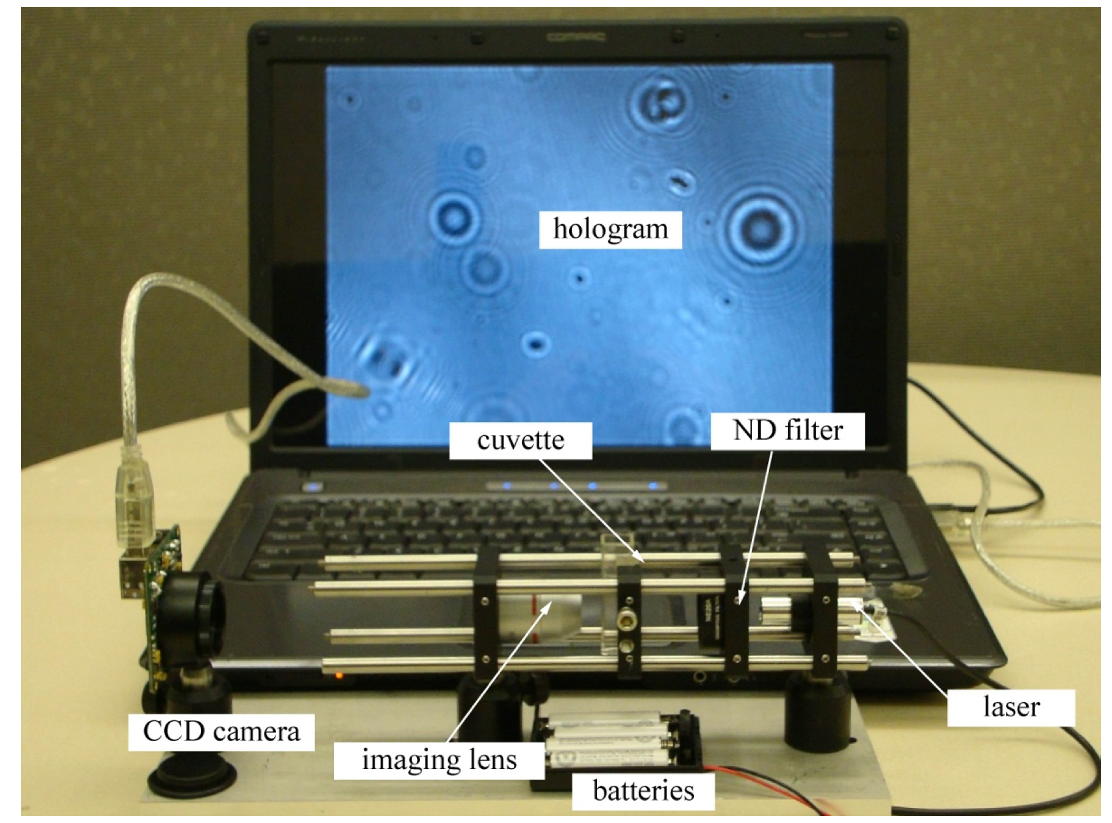


Figure 2. The digital inline holography setup is shown above.

Results

Holograms and Velocity Profiles

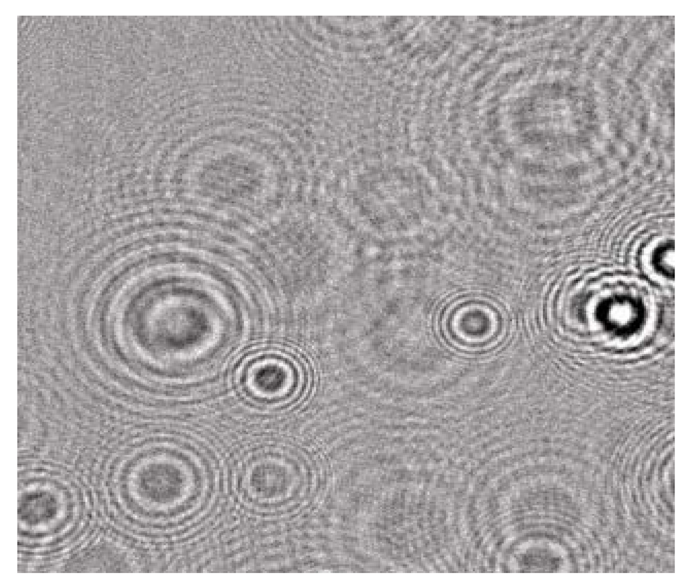
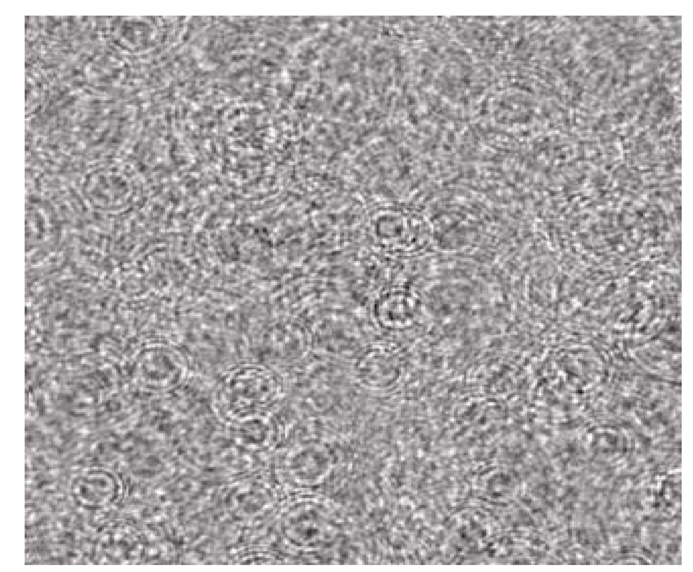
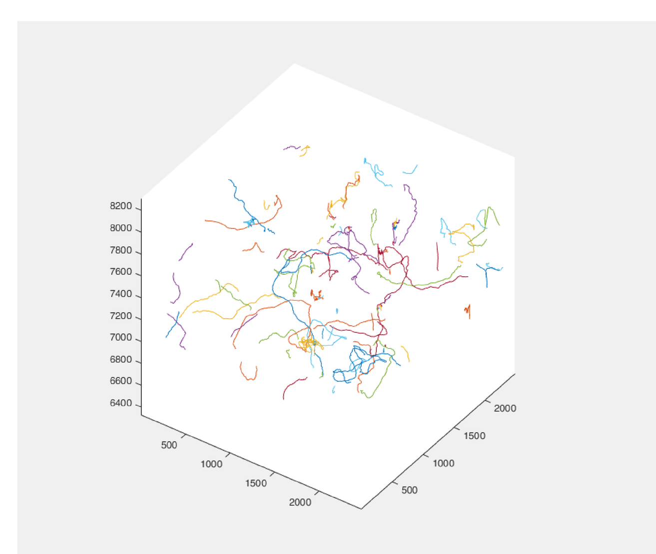
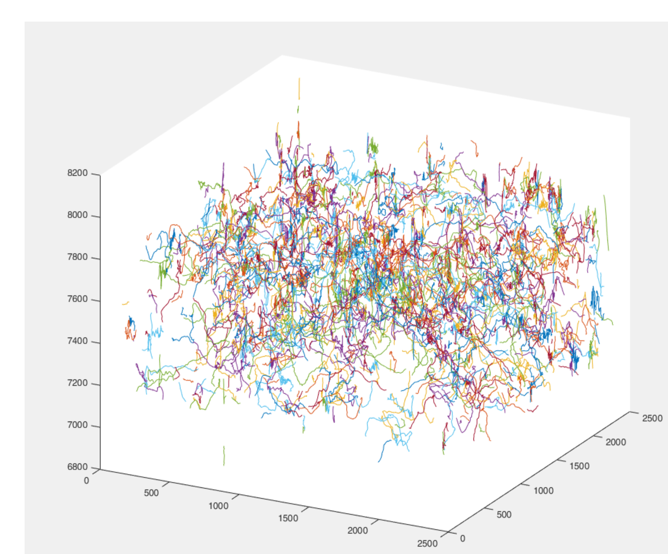
	Lag Phase	Exponential Phase
Hologram		
Velocity Vector Field		

Table 1. Freeze frames of the holograms and velocity fields are shown from samples in both the lag and exponential phase. The amount of microalgae increased immensely between phases which was expected.

Results (Continued)

- Effects of Temperature on velocity were not isotropic
  - Warmer temperatures can affect nutrient abundance available to the algae.
- Higher initial concentration leads to faster growth rate.
  - That final concentration ends lower than that of samples with a lower concentration

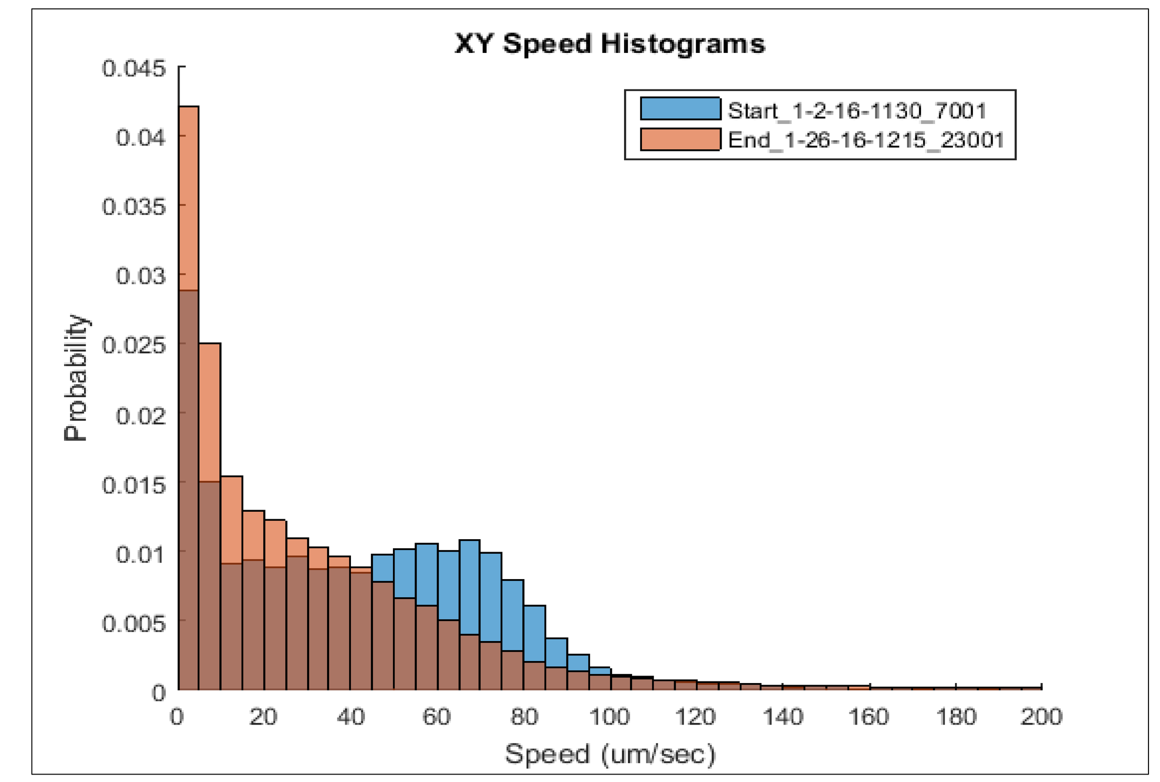


Figure 3. The histogram shows the distribution of speeds for two concentrations. Velocities vary between phases for different concentrations.

Discussion

- Future studies could include the discovery of a dimensionless parameter to correlate with lifecycle or lipid production.

Conclusions & Significance

- The concentration drastically increases as the life cycle of Dunaliella goes on.
- During the Lag phase, the algae behaves as an almost stagnant being traveling with flow.
- As the lipid production increases, the velocities decrease at the end of the exponential phase.
- It is crucial to harvest the microorganisms for fuel at that time so maximum harvest can be reached and identified.

References

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