

Studies on the Mathematical Relationships Between
Productivity and Phytoplankton Density

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The purpose of this project was to find the relationship between photosynthetic rate and phytoplankton density in Two Ocean Lake, Grand Teton National Park. Since there is only a finite rate of incoming light energy, it was proposed by the investigator that the photosynthetic rate would reach a maximum value and not exceed that value in spite of increased phytoplankton density. Figure 1 shows this hypothesis graphically.

A major objective of this project was to fit one or more mathematical functions to the data. Several functions have been suggested:

$$\mu = \frac{\mu_m P}{k+P}$$

$$\mu = \mu_m (1 - e^{-kP})$$

$$\mu = \mu_m \left[1 - \left(\frac{1}{2} - \frac{1}{\pi} \arctan(10^+k(P-k)) \right) (1-P/k) \right]$$

μ = photosynthetic rate

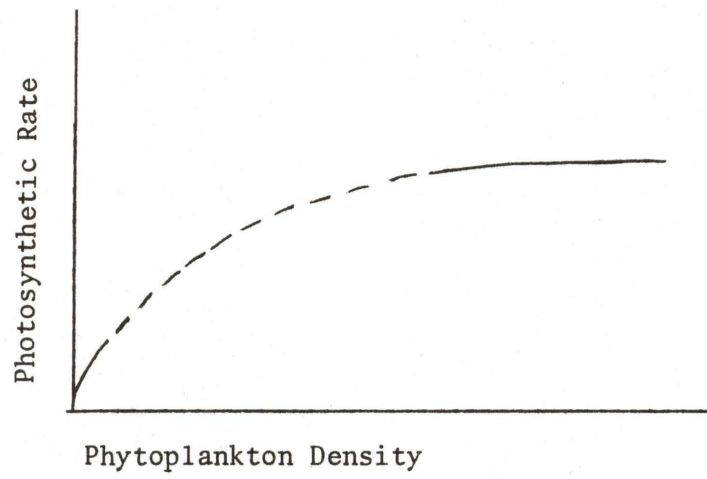
μ_m = maximum photosynthetic rate possible under the existing environmental conditions

k - a constant

P = phytoplankton density

The major portion of the summer was spent developing field procedures to artificially manipulate phytoplankton density in a productivity experiment. In the end, a somewhat acceptable technique was developed. A water sample was hydrostatically filtered through HA Millipore filters. The filtrate was used to dilute field samples. The portion concentrated in the filtering process was used to increase phytoplankton density. Each manipulated sample was incubated in situ in 300 ml. B.O.D. bottles with three light bottle replicates and three dark bottle replicates. Net productivity was calculated using the change from the initial to final readings of the light bottle oxygen levels. Respiratory rates were calculated in a similar manner using the dark bottle data. Gross productivity was taken to be the net productivity plus the respiratory rate.

Figure 1



Although the necessary statistical analysis has not yet been performed, the data suggest that the hypothesized curvilinear relationship between photosynthetic rate and phytoplankton density was found. It has not yet been determined which of the above mathematical functions give the best fit to the data.

It may be possible to gather the same type of data using a productivity vs. depth profile. In this case, the phytoplankton density would be the sum of all phytoplankton above the sample depth. Density would be in biomass/square surface area. This approach was not undertaken this summer for lack of time.

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