ATP AND CHLOROPHYLL A AS ESTIMATORS OF PHYTOPLANKTON METABOLIC ACTIVITY AND CARBON BIOMASS

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By

Bonita L. Hunter

Thesis Committee:

Edward A. Laws, Chairman
David M. Karl
Leslie R. Berger

ABSTRACT

Three marine phytoplankton, Thalassiosira fluviatilis, Dunaliella tertiolecta and Amphiprora paludosa, were grown in continuous culture at 20°C on a 12:12 light/dark illumination cycle under nutrient and/or light limitation in order to evaluate characteristic physiological changes in ATP/C, Chl a/C, and other cellular constituents.

Under ammonium and light limitation the ATP/C ratio was independent of growth rate with a mean value of 3.2 mg/g and 5.6 mg/g respectively. However, with nitrate and phosphate as the nutrients limiting growth, the ATP/C ratio is highly variable. The variability in the ATP/C ratio is dependent on a number of factors which influence the physiological growth state of the cultures. Major sources of this variation are diel variability due to the light/dark illumination cycle under all nutrient and light conditions, variation due to the type and degree of the nutrient deficiency, and variability due to species differences. The mean ATP/C ratio at a given growth rate under light, nitrate, ammonium, and phosphate limiation ranged from 0.6 mg/g to 9 mg/g, a factor of 15. Changes in the intracellular ATP concentration were neither correlated with respirate nor photosynthetic activity.

The Chl a/C ratio is significantly growth rate dependent; however, the relationship between this ratio and growth rate is species dependent, with the chlorophyte, D. tertiolecta, having a greater Chl a/C ratio than either of the diatoms. At higher growth rates, the ratio varies significantly due to the light/dark illumination. The Chl a/C ratio is not affected by differences in the source of the limiting nutrient. The mean Chl a/C ratio at a given growth rate under light and nutrient limitation

ranged from 5 to 50 mg/g, a factor of 10.

In nutrient limited systems dark respiration losses ($mgC/m^3/hr$) can be accurately estimated by multiplying the chlorophyll a concentration ($mgChl\ a/m^3$) by a factor of about 0.8. The average light saturated production rates ($mgC/m^3/hr$) can be approximated to within ± 50% by multiplying the chlorophyll a concentrations (mg/m^3) by a factor of 4 in nutrient limited systems and in upwelling areas by a factor of 6. Such estimates are not possible in light-limited systems due to the strong dependence of productivity indices on growth rates.

A comparison of the variability in ATP/C and Chl a/C ratios was made. The major disadvantages with the ATP and Chl a methods of estimating phytoplankton carbon are that both the ATP/C and Chl a/C ratios are species dependent. In addition, the ATP/C ratio is growth rate dependent under both phosphate and nitrate limitation, whereas the Chl a/C ratio is growth rate dependent under all nutrient and light limiting conditions. The advantage of the ATP method is that under ammonium and light limitation the ATP/C ratio is independent of growth rate. The advantage of the chlorophyll a method is that, at least in diatoms, there is a fairly unique relationship between Chl a/C ratios and growth rate which is independent of the type of nutrient limitation.

Based on my results, growth conditions in the oceanic system determine which method is a better estimator of phytoplankton carbon. In systems limited by ammonium or light, the ATP method would probably provide a more reasonable estimation of phytoplankton carbon, whereas in phosphate limited systems the chlorophyll a method should be used.