Quanta vs. watts

Tyler (1973) has soundly advised marine biologists of the potentially huge errors that may be incurred by measuring light available for photosynthesis in the sea by photometric techniques. He has proposed two alternatives: one is to measure light quanta available by means of a device equally sensitive to quanta at all wavelengths; the other involves measuring power available by means of a photocell equally sensitive to power at all wavelengths. This second approach is more commonly used and frequently the instrumentation involved consists of a photovoltaic or photoconductive cell whose response curve is altered by means of filters (Květ and Šetlík 1966) to provide equal energy response.

Unfortunately the application of measurements of power available is not nearly as straightforward as would first appear. We encountered problems in attempting to obtain instrumentation to monitor continuously the light available for photosynthesis in a brown seaweed (Phaeophyta). Our problem is as follows:

1. Studies of the quantum efficiency of photosynthesis with respect to wavelength in brown algae indicate that the number of quanta required to reduce one molecule of CO_2 is about 14 regardless of wavelength between 400 and 700 nm (Yocum and Blinks 1954). This is despite the fact that there is considerably more energy in a quantum of blue light than there is in a quantum of red light, since $E = nhc/\lambda$, where E = energy, n = numbers of quanta, h = Planck's constant, c = speed of light, and λ = wavelength.

2. If an irradiance detector having equal energy response is used in the sea, changes in current output may be a result either of shifts in light spectrum (and hence of energy/quantum) or of numbers of light quanta. However, in brown algal systems the important parameter is numbers of quanta only, so that there is a potential error in measuring power available. For example, in a photomorphogenetic experimental design requiring equal quantities of red or blue light, equal power levels will contain twice as many quanta of red light than of blue; the error may thus be as great as 100%. Depth-dependent shifts in light quality in the sea will also produce significant, though smaller, errors. Thus for brown algae it is strongly advised that total quanta be measured rather than power available.

In plant groups other than phaeophytes neither quantum or energy measurements are entirely satisfactory. In green and red algae the quantum efficiency of photosynthesis varies across the photosynthetic spectrum. For greatest accuracy a quantum scan across the relevant spectrum is required. At present this is not feasible for continuous, in situ operation.

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