Calculating the carbon content of a drop in the ocean: alternatives to chlorophyll a in phytoplankton biomass estimation.

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Abstract

Marine biogeochemical processes are closely linked to phytoplankton community assemblages: cell size in particular is a key parameter in carbon cycling, nutrient uptake and trophic transfer efficiency within marine food webs. Photosynthetic biomass is routinely assessed via quantification of chlorophyll a, a biomarker widely valued as a proxy for cellular carbon. Since all phytoplankton possess this compound, chlorophyll a analysis is synonymous with carbon estimation and ultimately biomass calculation; making it one of the most commonly measured biochemical parameters in oceanography. The conversion factors underpinning this relationship assume a constant correlation between the two. However, fluctuating environmental parameters strongly influence cellular chlorophyll levels, causing variations in chlorophyll a to carbon ratios over one or more orders of magnitude. Moreover, most chlorophyll a analyses provide a generalised overview of the carbon content of the phytoplankton community as a whole: articulation of contributions from defined size-based functional groups is rare. Conclusions drawn on the contribution of phytoplankton to community biomass based on this indicator alone may not therefore promote a true representation of trophic dynamics. Alternative mechanisms of estimating phytoplankton carbon

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content exist, but are not currently widely used. Direct measurement of cellular volume, or biovolume, removes much of the uncertainty inherent in set conversion ratios. The accuracy of this method is reliant on measurements of all cells, independent of their size, shape or phylogenetic origin. Such inclusive data is impossible to attain on a practical scale using traditional microscopy-based techniques. Analysis of phytoplanktonic DNA content offers a further alternative: the quantity of DNA within a cell is highly stable, varying only with size and independent of factors such as cell complexity and environmental forcing. Measurement of this parameter would therefore provide a steady foundation upon which to base estimations of cellular carbon content. However, widespread exploitation of this relationship has again been limited by the availability of appropriate technology. Flow cytometry permits rapid enumeration and assessment of the size and fluorescence properties of thousands of cells within minutes. The evolution of increasingly smaller and cheaper machines has increased their suitability and availability for a range of oceanographic purposes. When applied to the marine environment, this technique possesses unrivalled potential for investigation of phytoplankton communities on a level of detail far beyond that of chlorophyll a content alone. It is therefore ideally placed for use in conjunction with both biovolume and cellular DNA quantification methods in order to produce size fractionated data on photosynthetic biomass. As the significance of contributions from different trophic levels to ecosystem productivity and biogeochemical cycling becomes apparent, this work focuses on the application of new technology to existing theory in order to provide greater resolution on the roles of phytoplankton functional groups within marine food webs.

Keywords: Phytoplankton, Flow cytometry, Carbon content, Chlorophyll a, Biovolume, DNA staining