Flocculation and phytoplankton cell size can alter ^{234}Th-based estimates of the vertical flux of particulate organic carbon in the sea

Anya M. Waite[1,3] and Paul S. Hill[2]

1. Centre for Water Research, University of Western Australia, Crawley 6009 WA, Australia, email: waite@cwr.uwa.edu.au; FAX:+61 (8) 6488 1015

2. Oceanography Dept., Dalhousie University, Halifax, NS Canada, B3H 4J1, email: Paul.Hill@Dal.Ca

3. Corresponding author

Abstract

The deficit of ^{234}Th relative to its radioactive parent ^{238}U in the surface ocean can yield reliable estimates of vertical Particulate Organic Carbon (POC) fluxes to deeper waters, but only when coupled with an accurate ratio of POC concentration to activity of ^{234}Th on sinking matter. Assuming a simple partitioning of suspended phytoplankton mass between single cells and flocs, we calculate the ratio of the POC flux estimated from ^{234}Th deficit to the actual POC flux (*p* ratio, Smith et al., unpubl.). The *p* ratios are calculated under the assumption that particle surface area is correlated with ^{234}Th activity and particle volume is correlated with POC concentration. The value of the *p* ratio depends on the relative contributions of single cells and flocs to the vertical flux. When large single cells make up a significant fraction of the vertical flux, *p* ratios are less than one, meaning POC fluxes estimated from ^{234}Th deficits underestimate actual

POC fluxes. When large single cells are abundant but do not sink fast enough to contribute to vertical POC flux, *p* ratios are greater than one (up to 3 X overestimate). Factor analysis of the model indicates that altering the extent of flocculation in suspension and changing the density and maximum size of phytoplankton cells have the greatest effects on the *p* ratio. Failure to measure the properties of flocs when characterizing the ratio of POC to thorium on sinking matter potentially leads to large overestimation of the POC flux (over 20 X). Failure to characterize the POC to thorium ratio of large particles, by, for example, destruction of phytoplankton cells in pumps, can lead to underestimation of POC flux. Estimates of POC flux should be most reliable in highly flocculated suspensions populated by small cells and rapidly sinking flocs. These conditions are often associated with intense phytoplankton blooms.

Keywords: POC:^{234}Th, phytoplankton, diatoms, aggregation, flocculation, cell size, sinking rate, sedimentation, vertical flux, carbon