

Incorporating Respiration into the Ocean Carbon Budget: Lifting the Lid off Pandora's Box

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One of JGOFS primary aims has been to quantify the oceanic carbon budget. The organic budget is a major component of this. The organic budget for the euphotic zone comprises some six terms, of which three dominate: planktonic photosynthesis, export to the mesopelagic zone and euphotic zone respiration. JGOFS studies have concentrated on former two. For reasons that are not entirely clear, the quantification of respiration was not seen as a priority matter. This is unfortunate as our consequential poor understanding of respiration prevents us closing the organic budget. We thus lost a valuable constraint.

The last 5 years has seen a considerable growth in the assessment of respiration in relation to organic production – curiously by the scientific community mainly outside the JGOFS community. These studies have brought to light major apparent problems when the respiration term is introduced into the budget. Put bluntly, we have difficulties balancing the books. This could reflect the rudimentary understanding of respiration in the oceans, however there are strong suggestions that some of aspects of our present budget may need revision.

The first area of concern is associated with the balance between P and R in the euphotic zone of the central parts of the oceans. Common sense and the physics and chemistry tell us that these areas must have a substantially isolated organic budget. As the euphotic zone exports organic material to the mesopelagic and bathypelagic zones, the euphotic zone organic budget must be slightly positive. Geochemical measurements of upper water column net production, based on calculation of air-sea gas (O₂ and CO₂) exchange are consistent with this. However, analysis of observations of P and R suggest otherwise – they imply deficits. I shall point to two possible solutions to this dilemma – both imply that we are currently underestimating organic production.

The second problem is associated with the second measured major term – the export of organic production from the surface. This is an important and extensively studied feature of the oceans. The prevailing view is that the euphotic zone exports some 10 to perhaps as much as 25% of primary production, thus some 75 to 90% must respired in the euphotic zone. Thus, the implied ratio of respiration in the epipelagic (150 m depth horizon) to that in the mesopelagic (150-1000 m) zone must be 3:1 to 10:1 or more. Present assessments of the relative distribution of direct measurements of metabolism in these two zones imply much lower ratios – in some cases approaching unity. In this case it is less clear where the discrepancy may lie. Although there have been past concerns over the accuracy of sediment traps, especially for the upper parts of the ocean, complementary studies based on ²³⁴Th-thorium and ¹³C give support to the sediment trap values. Whatever the eventual explanation, the disparity reveals the importance in obtaining a more accurate assessment of the level of mesopelagic metabolism.

In conclusion, respiration is a valuable and underused constraint of the oceanic carbon budget and, as it can in many instances be easily measured, it should feature more prominently in future programmes.