Balancing the (carbon) budget: Using linear inverse models to estimate carbon flows and mass-balance 13C:15N labelling experiments in low oxygen sediments.

Introduction

Approximately 6% of the continental margin sea floor experiences persistent dysoxia within oxygen minimum zones (OMZs) (Helly & Levin, 2004). OMZs are predicted to grow as a consequence of climate change, with implications for marine biogeochemical cycles (Stramma et al., 2008). The Arabian Sea OMZ impinges upon the Indian continental margin at bathyal depths (150 – 1500 m) generating a depth-dependent oxygen gradient.

In 2008 a multi-national expedition led by Prof Hiroshi Kitazato (JAMSTEC, Japan) investigated the effects of oxygen availability, sediment geochemistry and community structure upon carbon & nitrogen cycling pathways at the Indian margin OMZ. In situ 13C-tracer experiments were conducted to quantify OM processing by sediment bacteria and fauna (Witte et al., 2011; Hunter et al., 2012a; b). However, no empirical data on OMZ.

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OMZ.

Acknowledgements

Figure 2 images collected by the submersible Shinkai 6500; courtesy of JAMSTEC. This study was funded by The Carnegie Trust, Scotland. WRH was funded under a NERC doctoral training grant. The authors wish to thank Prof. H. Kitazato, the YK08-11 science team, and the captain and crew of the RV Yokosuka. Without their unwavering dedication and enthusiasm this work would not have been possible. Mass Spectroscopy was carried out at the Royal Netherlands Institute for Sea Research, UC Davis Stable Isotope Facility and Macaulay Land Use Research Institute.

Experimental Design & Data Acquisition

Semi-enclosed mesocosms deployed fixed doses of 13C-labelled diatoms (Thalassiosira weissflogii) at the seafloor across the Indian margin OMZ (540 – 1100 m, Figs 1, 2).

The 13C label was traced into sediment OM, bacteria, foraminifera and metazoa fauna (A. Enge & P. Heinz, unpub. data; Hunter et al., 2012a; b; Witte et al., 2011).

Linear Inverse Models

Food web models were constructed following Van Oevelen et al. (2010). Food web components and flow linkages were fixed a priori. Flow magnitudes were constrained using data from the mesocosm experiments.

Final model solutions were obtained using Bayesian sampling for best fit from 25,000 iterations of each model.

Summary

1. Food-web model complexity increases concomitantly with oxygen availability.
2. Across the Indian margin OMZ labile phytodetritus was primarily processed by foraminifera and metazoan macrofauna.
3. LIM estimates community respiration to be greatest at the 800 m stations, driven by higher metazoan faunal contributions.
4. Bacterial contributions to sediment respiration increased concomitantly with the depth-dependent oxygen gradient.
5. At present, foraminiferal data are only available for station T1 540 m. Foraminifera must be integrated into all models to accurately reconstruct sediment carbon fluxes.

References