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Reply to comment by Boudreau on: What controls the mixed-layer depth in deep-sea sediments? The importance of POC flux

In the preceding comment, Boudreau makes two major points. (1) Smith and Rabouille (2002) did not test Boudreau's (1998) resource feedback model adequately because they used an equation for *inter-environmental* mean mixed-layer depth to predict *within-site* mixed-layer depth. (2) The resource feedback model ''demands'' a dependence between sediment mixed-layer depth and particulate organic carbon (POC) flux to the seafloor because the concentration of labile POC in surface sediments (G_o) depends directly on POC flux. We deal with these points in turn, using the same notation as in Boudreau's comment above. In particular, Boudreau (1998) will be called ''B98'' and Smith and Rabouille (2002) will be designated ''SR02.''

Let us first address point (1), that is, our test of B98's resource feedback model. Because we found the resource feedback model innovative and provocative, we sought in part to test its prediction that ''the mean mixing depth should be a worldwide constant of 9.7 cm, independent of water depth and sedimentation rate.'' However, we were confused by the ambiguous notation in B98 (*see* Boudreau's comment), and combined B98's Eqs. 5 and 6 in a way apparently not intended—that is, to compare *between-site* variations in mixed-layer depth. We are grateful to Boudreau for clarifying the use of his equations and admit that our application of Eq. 5 in SR02 might not accurately reflect the predictions of the resource feedback model.

Boudreau's second major point is that POC flux to the seafloor and G_o are directly related and that, therefore, the resource feedback model ''demands'' a dependence between POC flux and *L*. Although POC flux to the seafloor does directly influence G_o, and POC flux and G_o may covary in much of the ocean (e.g., Emerson et al. 1985), these two variables need not be positively related because many other factors also influence G_o. The steady-state concentration of labile POC at the sediment surface (G_o) depends on (1) the concentration of labile POC in sedimenting material, (2) POC flux to the seafloor, (3) the kinetics of mineralization of organic and inorganic sediment components (with mineral components typically mineralizing more slowly than reactive organic matter), and (4) the sediment mixing intensity and mixing depth (variables that, at steady state, cause dilution of the freshly depositing material). If high POC flux to the seafloor is combined with high POC reactivity and low POC concentration in depositing material, then the concentration of labile POC at the sediment surface (G_o) might be relatively low, even when POC flux to the seafloor is high. Such is the case on the JGOFS EqPac transect extending from 0° to 9–10°N along 140°W. The equatorial site on this transect has five-fold higher POC flux than at 9–10°N but also has a larger POC kinetic constant (i.e., *k* is two- to five-fold greater) and more inorganic ''ballast'' in sedimenting material (Emerson et al. 1985; Honjo et al. 1995; Hammond et al. 1996; Berelson et al. 1997; Smith et al. 1997). The dramatically higher bioturbation rates at the equatorial station further dilute POC concentrations in near-surface sediments relative to 9–10°N (Hammond et al. 1996; Berelson et al. 1997; Smith et al. 1997). The net result is that labile POC concentrations in near-surface sediments are lower at the equator than at 9–10°N (~0.42% vs. ~0.60%, respectively, *see* Emerson et al. 1985). This combination of lower G_o and higher *k* at the equatorial site, when inserted into Eq. 3 in Boudreau's comment above, suggests that the resource feedback model predicts a substantially *smaller* mixed-layer depth (*L*) at the equator than at 9–10°N along the EqPac transect. This prediction contrasts sharply with the field data tabulated by SR02, who found *L* to be fourfold *greater* at the equatorial site. We conclude that the strong positive relationship between *L* and POC flux found by SR02 for the deep sea does not necessarily fall out of B98's resource feedback model and is a fundamental advance in our understanding of processes controlling bioturbation.

One reason why POC flux, rather than labile POC concentration in surface sediments (G_o), might ultimately be a better predictor of the bioturbation regime in the deep sea (including mixed-layer depth and D_B) is that deposit feeders often are extremely particle selective in their feeding activities (e.g., Wheatcroft et al. 1990; Smith 1992; Smith et al. 1993). This could allow them to feed, grow, burrow, and mix sediments at rates largely independent of G_o; that is, selective feeding might yield a focus on freshly arrived labile POC, with the consequence that labile POC flux, rather than concentration, limits deposit-feeder activities and bioturbation (Fornes et al. 2001). Recent studies documenting a high proportion of very recently deposited material in the guts of deep-sea deposit feeders (e.g., Lauerman et al. 1997; Miller et al. 2000) are highly consistent with this line of reasoning.

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