

## ***Interactive comment on “Microphytobenthos and benthic macroalgae determine sediment organic matter composition in shallow photic sediments” by A. K. Hardison et al.***

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Response to Anonymous Referee #2 by A.K. Hardison et al. Interactive comment on “Microphytobenthos and benthic macroalgae determine sediment organic matter composition in shallow photic sediments”

We thank the anonymous referee for his/her positive and thoughtful comments on the manuscript. Below we address the reviewer’s general and specific comments:

“Firstly I am curious as to how sediment TOC and TN increase in the dark (Fig. 2), in the absence of any new carbon production (i.e. primary production). Could this be due to bacteria utilizing water column DOC? Some discussion on the potential of water col-

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umn DOM driving benthic carbon metabolism might be useful. For example Maher and Eyre (2010, 2011) suggest water column DOC may contribute to benthic bacterial production, and also suggest a diel cycle of benthic DOC production/consumption. Was there any analysis on the diel differences in the ‘Light’ treatments (MPB and macroalgae)?”

Response: This reviewer brings up an excellent point. Like Reviewer 2, we were intrigued by the increase in TOC and TN in the long-term dark treatment. A companion stable isotope study (Hardison et al., 2011) shows evidence that that TN and TOC in the Dark treatments had incorporated  $^{15}\text{N}$  and  $^{13}\text{C}$  from added  $^{15}\text{NH}_4^+$  and  $\text{H}^{13}\text{CO}_3^-$ . Fluxes of nutrients ( $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{PO}_4^{3-}$ ), DIC, dissolved oxygen, and  $\text{N}_2$  were measured in another companion study (Anderson, unpublished). Results from the Dark treatment showed strong uptake of  $\text{NH}_4^+$  with almost equal release of  $\text{NO}_3^-$ . Together, these data provide evidence of nitrification in the Dark treatment. Carbon fixed during nitrification in the Dark treatment (calculated from the sum of  $\text{NO}_3^-$  efflux and denitrification in porewater, corrected for loss to the atmosphere, and assuming 1 mole of carbon fixed per 10 moles of  $\text{NH}_4^+$  oxidized) resulted in total carbon uptake in the Dark that was comparable to the total carbon uptake based on the slope of the excess  $\text{TO}^{13}\text{C}$  enrichment over time. Thus, we believe the increased TOC and TN to be driven to a large extent by nitrification in the Dark treatment. This increase could also be driven by water column DOM, as the reviewer suggested, however, we unfortunately do not have DOC and DON flux data to support this. We will include discussion in the revised manuscript of both mechanisms to explain the TOC and TN increases in the Dark treatment. In our companion flux study, we analyzed diel differences in all treatments (Anderson, unpublished). Generally, the data showed the sediments to be net autotrophic during the day in the Light and Macro treatments and net heterotrophic at night, as would be expected from previous studies (e.g., Eyre and Ferguson, 2002; McGlathery et al., 2001). Macroalgae increased benthic GPP and respiration relative to the Light treatment with microphytobenthos alone. We will incorporate some discussion of this in the revised manuscript and intend to include the data in a separate paper

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in the future.

“Secondly, what are the implications for benthic-pelagic coupling of nutrient/carbon cycling with the reported changes in SOM composition associated with a shift from MPB to macroalgae. While I understand that this was not the focus of this study, the benthic and pelagic systems are tightly coupled in these shallow productive systems, so I think some discussion on the implications and potential feedback mechanisms is warranted.”

Response: We agree with Reviewer 2 that benthic-pelagic coupling is particularly important in shallow systems. Much of the carbon and nutrient cycling will occur at the sediment-water interface due to high primary production, high organic matter loads (from both allochthonous and autochthonous sources), and an active sediment bacterial community. Benthic plants alter this coupling in a number of ways. For example, both microphytobenthos and benthic macroalgae have been shown to take up nutrients diffusing from the sediments to the water column, thereby reducing the flux to the overlying water (McGlathery et al., 2001; Sundback et al., 2000). These communities are also sources of inorganic and organic carbon and nutrients at the sediment-water interface. For example, as discussed in response to Reviewer 1, macroalgae can be a source of DOM to the surrounding water while alive and during senescence (Tyler et al., 2001; Tyler et al., 2003; Maher and Eyre, 2010). Similarly, microphytobenthos are a known source of DOM in the form of extracellular polymeric substances (Underwood & Patterson, 2003), which can be utilized by sediment bacteria (Middelburg et al., 2000; Cook et al., 2007; Hardison et al., 2011). The shift from a community dominated by microphytobenthos to macroalgae will change the role of the sediments in nutrient cycling, which we discuss at length in our companion isotope tracer paper (Hardison et al., 2011). Numerous studies suggest that tight coupling between microphytobenthos and sediment bacteria serves as a mechanism for retaining carbon and nitrogen in the sediments (Hardison et al., 2011; Evrard et al., 2008). If microphytobenthic production is decreased due to the presence of benthic macroalgae, this will in turn decrease this retention, allowing a greater flux of carbon and nitrogen from the sediments to the over-

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lying water. Although macroalgae are capable of taking up large amounts of carbon and nitrogen, retention of carbon and nitrogen within the sediments would likely be a more stable sink than retention as ephemeral macroalgal biomass. Once macroalgae die, nutrients are re-released to the water column, which can support phytoplankton, including harmful algal blooms, and bacterial metabolism (McGlathery et al. 2001; Tyler et al., 2003). Thus, shunting of carbon and nitrogen through macroalgae rather than microphytobenthos will likely create a positive feedback to eutrophication, whereas the sediment microbial community may actually play a key role in buffering the effects of increased nutrient loading. We will include a discussion of these implications in the revised manuscript.

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