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Biogeosciences Discussions

Interactive comment on "Sedimentary phosphorus and iron cycling in and below the oxygen minimum zone of the northern Arabian Sea" *by* P. Kraal et al.

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We thank anonymous referee #1 for their kind words regarding this manuscript. Below are our responses to the specific comments made by the referee (starting with a short overview of the referee's comment between parentheses):

1 (14C ages and sedimentation rate). Based on earlier comments, the 14C ages and the linear sedimentation rate for Station 4 have been included in the BGD manuscript (see Figure 2 and its caption).

2 (Seasonal variations in bottom water oxygenation). There are seasonal, monsoon-driven changes in productivity that may impact the extent of the OMZ and bottom water characteristics, as was shown by Brand and Griffiths (Deep Sea Research II, vol. 56,

p. 283-295). Such changes may indeed impact sedimentary Fe and P cycling as the burial mechanisms and efficiency of these elements is strongly dependent on bottom water redox conditions. However, in a comprehensive study of pre- and post-summer monsoon sediment cores from the Arabian Sea, Law et al. (Deep Sea Research II, vol. 56, p. 305-323) found no significant seasonality in sediment geochemistry at a variety of stations across the Arabian Sea OMZ except for one station, located at the upper boundary of the OMZ. Overall, changes in depositional conditions at the depths that we investigated, well away from the upper boundary of the OMZ, are thus likely to be limited. The relationship between changes in surface water productivity and bottom water conditions is complex due to the lag between organic matter production and deposition at the sediment-water interface, which is likely to smooth out seasonal variability.

3 (Differences between Station 1B and 2). It is unlikely that the different sediment characteristics at Station 1B and 2 are a matter of oxygen thresholds: Station 1B is located closest to the core of the OMZ and had the lowest bottom water oxygen concentrations at the time of sampling (Table 1). Nevertheless, a surface layer with fresh Fe (oxyhydr)oxides indicative of relatively well-oxygenated bottom water conditions was present. This differs from Station 2 where higher bottom water oxygen concentrations were measured and the sediment geochemistry indicates more reducing conditions (lower concentrations of Fe (oxyhydr)oxides, Fe sulfide minerals at shallow depth in the sediment). We suggest that spatial variability and past changes in bottom water oxygenation are responsible for these unexpected results. As mentioned in the manuscript (p. 3847, L25 – p3848, L7), sediments with abundant Fe (oxyhydr)oxides have been found in the Arabian Sea OMZ before and likely reflect transient, local variations in bottom water oxygenation.

4 (Carbon to phosphorus ratios as redox proxy). The work of Ingall and colleagues in the early 90s (e.g. Ingall et al., GCA 57, p. 303) first demonstrated that there is a relationship between the P burial efficiency relative to organic carbon and bottom

water oxygenation. Since then, phosphorus to organic carbon ratios have been used to reconstruct bottom water oxygenation in a variety of settings and for a variety of sediment ages, from ancient to modern. With regard to the Arabian Sea, the work by Schenau et al. (GCA 69, p. 919) is especially relevant, since it shows how P abundance and Corg/P ratios reflect changes in productivity and the extent of the Arabian Sea OMZ over a 120-kyr time period. As our study mostly focuses on modern P and Fe cycling, we added a short remark on the potential of using P abundance and Corg/P ratios for reconstruction of bottom water conditions (p. 3849, line 17-19).

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9, C559–C561, 2012

Interactive Comment