

# A SEVERAL-CENTURY RECORD OF LOW-OXYGEN CONDITIONS ON THE LOUISIANA CONTINENTAL SHELF

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## INTRODUCTION

Hypoxia occurs in continental-shelf subsurface waters when the uptake of oxygen by respiration exceeds its resupply. Measurements of Louisiana continental-shelf waters have indicated that hypoxia (oxygen content <2mg/L) has increased since 1985 (Rabalais et al., 1999). Sediment cores taken from the Louisiana shelf have provided a record of hypoxic and low-oxygen conditions over longer time intervals of 50-100 years (Sen Gupta et al., 1996; Blackwelder et al., 1996; Osterman et al., 2005).

Our previous work established the use of the relative abundance of three low-oxygen tolerant benthic foraminifers (*Pseudonion atlanticum*, *Epistominella vitrea*, and *Buliminella morgani*) as a proxy for the present hypoxic conditions on the Louisiana shelf (Osterman, 2003; figure 1). This proxy, named the PEB index, can be used in sediment cores to document low-oxygen conditions. The analysis of the PEB index in four sediment cores provided evidence for low-oxygen events that pre-date the start of extensive use of commercial fertilizer in the Mississippi Basin (~1950). Fluctuations in the amount of these low-oxygen tolerant species between 1817 A.D. and 1910 A.D. correspond with increased discharge/flooding events in the Mississippi River drainage. In most cases, high river discharge correlates with high percentage values of the low-oxygen tolerant PEB species (Osterman et al., 2005; figure 2).

The results from the newly analyzed lower section of Louisiana shelf core PE 03-05 GC1 (60-164 cm) indicate that the percent of the low-oxygen tolerant species records significant fluctuations of bottom water oxygen in the past. At times, the PEB values in the lower core exceed the values that are found in the upper fertilizer-driven hypoxia interval (post 1900). Using a sedimentation rate extrapolated from <sup>210</sup>Pb data in the top 20 cm, low-oxygen events may extend back to ~1500 A.D.

In addition, analyses of carbon stable-isotope compositions of sedimentary organic matter have also been completed for core PE 03-05 GC1. In the upper 100 cm of the core, negative excursions in % δ<sup>13</sup>C generally correspond to increases in PEB. The very negative values of % δ<sup>13</sup>C (<-28) found in the core record most likely represent incorporation of biomass from anaerobic microbial recycling communities to the bulk sediment and support the interpretation that high PEB values represent low-oxygen bottom water conditions. Below 100 cm core depth, the correspondence of % δ<sup>13</sup>C and PEB is more variable. Sampling for carbon-isotope analyses and foraminifer census was done at different times. Thus, the offset in isotope and foraminifer records in deeper levels of the core could be caused by offsets in sampling levels.

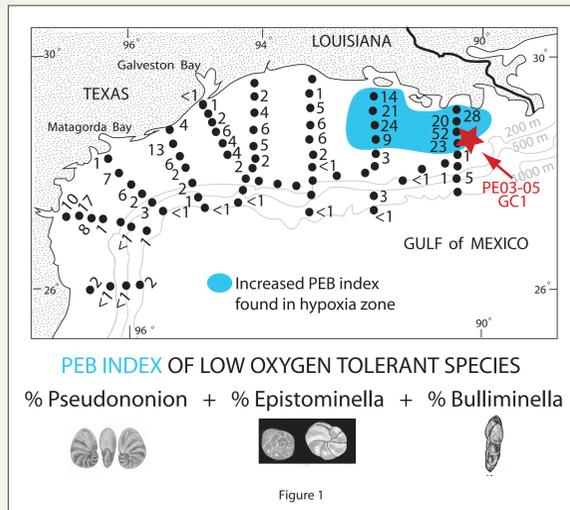


Figure 1

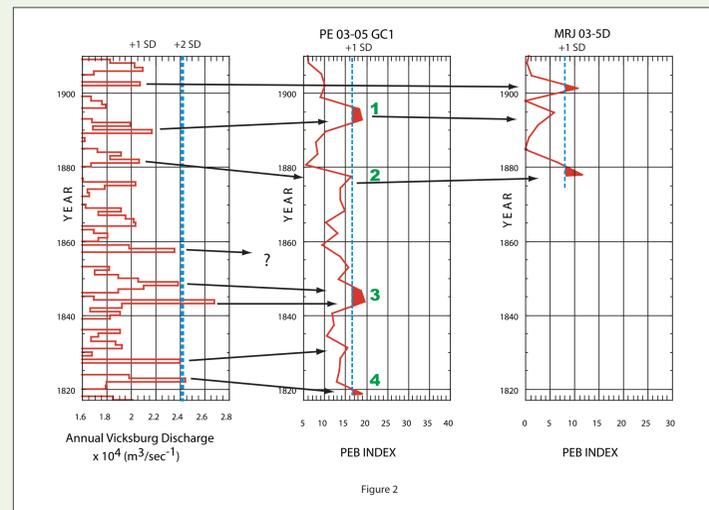


Figure 2

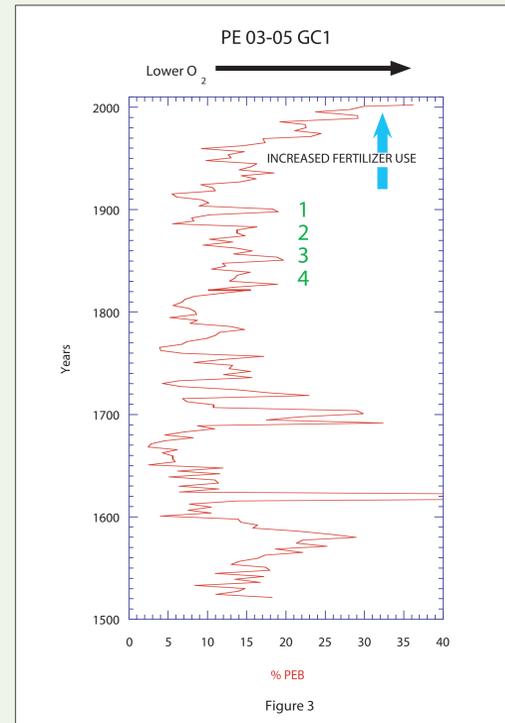


Figure 3

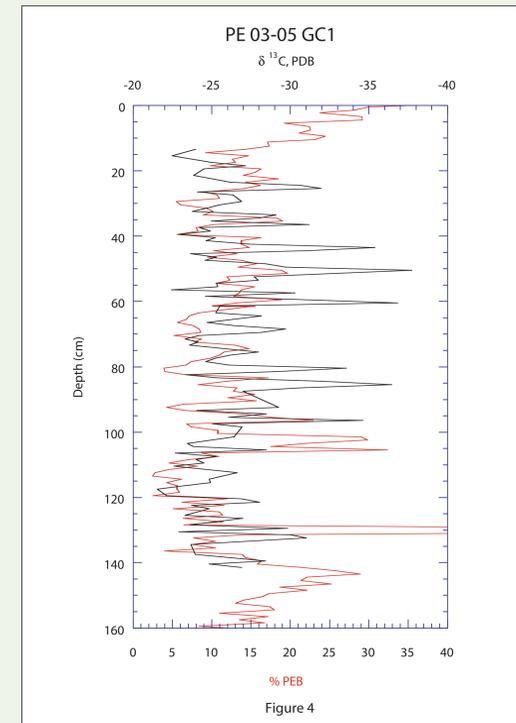


Figure 4

## MULTI - CENTURY RECORD FROM CORE PE 03-05 GC1

Figure 3 shows variation in PEB index in core PE 03-05 GC1 extending back to the 1500's. Chronology is based on <sup>210</sup>Pb dating in the top part of the core. The increase in PEB from 1950 to the present matches previous studies (Blackwelder, et al., 1996; Sen Gupta, et al., 1996) suggesting that increased occurrence of low-oxygen bottom water conditions on the Louisiana shelf corresponds to increased use of commercial fertilizer in the Mississippi drainage basin. The PEB record from PE 03-05 GC1 however shows that low-oxygen events have occurred on the Louisiana Shelf for the last several hundred years. PEB values in the older portion of the record indicate that several low-oxygen events in the 1500's to early 1700's were as severe as events occurring in the last 50 years.

Figure 4 shows the record of bulk sediment δ<sup>13</sup>C along with the PEB index in core PE 03-05 GC1. The data are plotted in the depth domain. PEB index and δ<sup>13</sup>C generally correspond in the upper 100cm of the record. The very negative δ<sup>13</sup>C (<-28) most likely represent incorporation of biomass from anaerobic microbial recycling communities to the bulk sediment, which is consistent with the interpretation that high PEB values represent low oxygen bottom water conditions. Correspondence of carbon isotope data and PEB index is more variable below 100 cm depth. Sampling for carbon isotope and foraminifer analyses was done at different times. Thus the offset in isotope and foraminifer records in deeper levels of the core could be caused by offsets in sampling levels.

## CONCLUSIONS

Abundance fluctuations in low-oxygen tolerant benthic foraminifers (PEB index), supported in part by bulk sediment δ<sup>13</sup>C data indicate low oxygen bottom water events have developed periodically on the Louisiana shelf for the last few centuries. The PEB index suggests low-oxygen conditions near the Mississippi Delta in the late 1500's to early 1700's were as severe as conditions associated with hypoxia events of the last 50 years. Our results indicate that the development of low-oxygen bottom waters on the Louisiana shelf is a complex natural process that has been altered by human activities.

## REFERENCES CITED

Blackwelder, P., Hood, T., Alvarez-Zarikian, C., Nelson, T.A., and McKee, B., 1996, Benthic Foraminifera from the NECOP study area impacted by the MR plume and seasonal hypoxia: Quaternary International, v. 31, p. 19-36.

Osterman, L.E., 2003, Benthic foraminifers from the continental shelf and slope of the Gulf of Mexico: An indicator of shelf hypoxia: Estuarine, Coastal and Shelf Science, v. 58, p. 17-35.

Osterman, L.E., Poore, R.Z., Swarzenski, P.W., and Turner, R.E., 2005, Reconstructing a 180 yr record of natural and anthropogenic induced low oxygen conditions from Louisiana continental shelf sediments: Geology (in press).

Rabalais, N.N., Turner, R.E., Justic, Dortch, Q., and Wiseman, W.J., Jr., 1999, Characterization of Hypoxia, Topic 1 report for the integrated assessment on Hypoxia in the Gulf of Mexico: NOAA Coastal Ocean Program Decision Analysis Series No. 15. NOAA Coastal Ocean Program, Silver Spring MD. 167 p.

Sen Gupta, B.K., Turner, R.E., and Rabalais, N.N., 1996, Seasonal oxygen depletion in continental-shelf waters of Louisiana: Historical record of benthic foraminifers: Geology, v. 24, p. 227-230.