The Enhanced Benthic Foraminifera Oxygen Index as renewed proxy for marine oxygenation

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Changes in biodiversity are often triggered by fluctuations in the oceanic chemistry affected by changing climate conditions and anthropogenic influence. These changes are reflected in expanding hypoxic conditions on the seafloor from the deep ocean to shelf environments. Spreading of these so-called oxygen minimum zones (OMZs) gained much interest due to their effect of trapping greenhouse gases, the reduction of livable habitat and biodiversity loss. This makes changes in dissolved oxygen (DO) a driving factor of changing biodiversity and highlights the importance to trace and predict expanding OMZs.

A frequently used tool to reconstruct DO values is the Benthic Foraminifers Oxygen Index (BFOI). We realized shortcomings using the original BFOI calculation compared to quantitative analyses on fossil datasets. Therefore, we revised and enhanced this method by using all available data, including oxic, suboxic, and dysoxic indicators. The new formulas of the Enhanced Benthic Foraminifera Oxygen Index (EBFOI) thus consider calcareous and agglutinated foraminifers as well as infaunal and epifaunal taxa for calculating the livable habitat of benthic foraminifers, including bottom water oxygenation and pore water oxygenation.

Another improvement was the introduction of a transfer function to directly convert the EBFOI into DO values in ml/l for the first time (DO[ml/l]=5.28475*e0.00616*x–3.78475).

Our new approach significantly improves the definition and reconstruction of marine oxygen levels and eutrophication and highlights the importance of faunal analyses to reconstruct environmental parameters.

All formulas are calibrated on modern samples, showing an accuracy increase of up to ~38% near OMZs compared to the BFOI. The EBFOI was subsequently also applied on several Cenozoic as well as late Mesozoic fossil datasets. So far, the EBFOI is still limited by needing modern equivalents to group foraminiferal taxa into oxic, suboxic and dysoxic categories. Nevertheless, new projects are already proposed to allow using the EBFOI further into deep time. Thus, our new formulas provide a major improvement in reconstructing oxygen levels and the reliability of benthic foraminifers as an oxygen proxy in general and will continue to improve in the future. This allows a much more detailed reconstruction of marine habitats regarding ecology and (paleo-)environments, a better understanding of past changes as well as tracking and predicting future expanding OMZs.