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Reconstructing Holocene palaeo-environmental conditions in the Baltic: A multi-proxy comparison from the Little Belt (IODP Expedition 347, Site M0059)

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Some of the largest marine environmental impacts from ongoing global climate change are occurring in continental shelf seas and enclosed basins, including severe oxygen depletion, intensifying stratification, and increasing temperatures. In order to predict future changes in water mass conditions, it is essential to reconstruct how these conditions have changed in the past against the background of climate changes. The brackish Baltic Sea is one of the largest semi-enclosed basins worldwide, and its sediment records provide a unique opportunity to analyse palaeo-environmental and climate change in central and northern Europe. IODP Expedition 347 recovered an exceptional set of sediment cores from the Baltic Sea which allow high-resolution reconstructions in unprecedented quality.

We present a comparison of commonly-used proxies to reconstruct palaeoecosystems, -temperatures, and -salinity from IODP Site M0059 in the Little Belt over the past ~8000 years. Our aim is to reconstruct the development of the terrestrial and marine ecosystems in the research area and the related environmental conditions, and to identify potential limitations of individual proxies.

The age model for Site M0059 is based on ^{14}Cdating, biostratigraphic correlation with neighbouring terrestrial pollen records, and sediment stratigraphy. Sedimentary organic carbon content and the bulk elemental composition have been measured, and can be used to determine the depositional environment and degree of oxygen depletion (e.g., Mo, C_{org}/P_{tot}). Pollen is used as proxy for vegetation development in the hinterland of the southern Baltic Sea and as a land/air-temperature proxy. Comparison with dinoflagellate cysts, insect remains, and green algae remains from the same samples provides a direct land-sea comparison. The application of the modern analogues technique to pollen assemblages has previously yielded precise results for late Pleistocene and Holocene datasets, including specific information on seasonality, but pollen-based reconstructions for Northern Europe may be hampered by plant migration effects. Palynomorph analyses are therefore complemented with analyses of lipid palaeothermometers, such as TEX_{86} and the long chain diol index (LDI), to reconstruct variations in Baltic Sea surface temperatures (SST). In addition, the MBT/CBT proxy is used to infer past changes in mean annual air temperatures (MAAT).

Benthic foraminiferal δ^{18}O and δ^{13}C measurements (monospecific) and foraminifera and ostracod faunal assemblage analyses allow us to estimate bottom water salinity and environmental changes qualitatively and quantitatively. Low bottom water salinity (~23 in bottom waters) and varying diagenesis in the Little Belt's organic-rich sediments complicates the application of benthic foraminiferal Mg/Ca as a palaeotemperature proxy. Reliable bottom water temperatures, however, are reconstructed using clumped isotope analyses of mollusc material. In addition, diatoms and the diol index (DI) are analysed to determine variation in salinity of the Baltic Sea's surface waters over the investigated time period.

The results of this inter-proxy comparison study will be used to reconstruct gradients between different settings,

e.g. how water column stratification developed, possibly if and how changes in seasonality occurred, and to identify the circumstances under which specific proxies may be affected by secondary impacts.