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Quantifying Holocene sea-level change using intertidal foraminifera: Lessons from the British Isles

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Salt-marsh foraminifera have been used to reconstruct Holocene sea-level changes from coastlines around the world. In this work, we compile the results of surface foraminiferal surveys from fifteen study sites located on the east, south and west coasts of Great Britain, and the west coast of Ireland. These data, which comprise 236 samples and 84 species, are used to summarize the contemporary distributions of intertidal foraminifera around the British Isles, and to examine the environmental controls governing them.

Seasonal and sub-surface foraminiferal data suggest that foraminiferal dead assemblages provide the most appropriate dataset for studying patterns of foraminiferal distributions in the context of sea-level reconstruction. In contrast to live populations or total assemblages, the dead assemblages are less affected by seasonal fluctuations and post-depositional modifications. Sub-surface foraminiferal data also indicate that foraminifera at the study sites live primarily in epifaunal habitats. Consequently, foraminiferal samples comprising the upper centimeter of sediment are appropriate analogues for the study of past sea-level change employing fossil assemblages contained within intertidal deposits.

Surface dead assemblages from the fifteen study sites indicate a vertical zonation of foraminifera within British and Irish salt-marshes that is similar to those in other mid-latitude, cool temperate intertidal environments. Whilst the composition and vertical ranges of assemblage zones vary between sites, two general sub-divisions can be made: an agglutinated assemblage restricted to the vegetated marsh; and a high diversity calcareous assemblage that occupies the mudflats and sandflats of the intertidal zone. Three of the fifteen study sites permit further subdivision of the agglutinated assemblage into a high and middle marsh zone (Ia) dominated by *Jadammina macrescens* with differing abundances of *Trochammina inflata* and *Miliammina fusca*, and a low marsh

zone (Ib) dominated by *M. fusca*. The calcareous assemblage is commonly comprised of *Ammonia* spp., *Elphidium williamsoni* and *Haynesina germanica*, in association with a wide range of minor taxa.

The vertical zonations of the study areas suggest that the distribution of foraminifera in the intertidal zone is usually a direct function of elevation relative to the tidal frame, with the duration and frequency of intertidal exposure as the most important controlling factors. This relationship is supported by canonical correspondence analyses of the foraminiferal data and a series of environmental variables (elevation, pH, salinity, substrate and vegetation cover).

These modern foraminiferal data are used to develop predictive transfer functions capable of inferring the past elevation of a sediment sample relative to the tidal frame from its fossil foraminiferal content. The results indicate that transfer functions perform most reliably when they are based on modern data collected from a wide range of intertidal environments. The careful combination of foraminiferal estimates of paleomarsh-surface elevation with detailed lithostratigraphy and chronostratigraphy can produce high-resolution records of relative sea-level change with sufficient resolution to detect low-magnitude variability but long enough duration to reliably establish climate-ocean relationships and secular trends. Thus, the transfer function approach has the potential to link short-term instrumental and satellite records with established longer-term geologically based reconstructions of relative sea level.

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