

A new record of Holocene sea-level change in the Thames Estuary and its implications for geophysical modelling

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Introduction

Much of our understanding of the processes related to land- and relative sea-level (RSL) movements comes from glacio-isostatic adjustment (GIA) models that are validated by RSL reconstructions from coastal sedimentary records. These GIA models play an important role in the prediction of the future rise in sea level [1]. While there have been advancements in both RSL reconstruction techniques and GIA models over the past decade, there still exists disagreement of the order of metres between the two. In other large estuaries in the UK, there has been work to reconstruct RSL using high-precision microfossil transfer functions and state-of-the-art tidal models to correct for changes over time; however, neither of these have been incorporated in the Thames [3] [4]. Additionally, the existent sea-level data from the Thames is uneven in its spatial distribution and the majority of the data is reliant on intercalated sediments, which introduce large errors in RSL reconstructions (Figure 1). Therefore, the overall aim of this study is to estimate the local impacts of sediment compaction and tidal range change on this and other RSL reconstructions in the Thames in order to provide the best possible constraints for GIA models.

Results and discussion

The stratigraphy of the collected cores is shown in Figure 2. We find three sequences of biogenic deposits occurring at 2–3, 3.5–6.5, and 7–8 ka. The $\delta^{13}\text{C}$ and C/N of all the cores indicates three primary depositional environments related to tidal datums that are represented in the cores (Figure 3). These classifications [5] are used to interpret the former position of RSL of radiocarbon-dated samples in the cores see the paleoenvironmental interpretations inferred from the core from Rainham Marsh (Figure 4).

The RSL reconstruction produced in this study is shown in Figure 5a, and the data are in good agreement with the existent database (Figure 5b). It should be noted that all points determined from intercalated peats plot well below those from basal peats, which illustrates how sediment compaction causes scatter in the data. Correction for its effect would better constrain the position of sea level over time. The palaeotidal model of [4] suggests that there were large increases in tidal amplitude during the Early Holocene. Taking into account these changes will help us to better understand the depositional environments of the Thames and better constrain Early Holocene RSL changes.

Conclusions

We find that $\delta^{13}\text{C}$ and C/N are able to provide qualitative information about the depositional environments of the Thames sediments and aid in constraining the former position of RSL. In addition, we find that sediments contained in our recently collected cores provide similar estimates of former RSL as the existent studies when the same reconstruction techniques are applied.

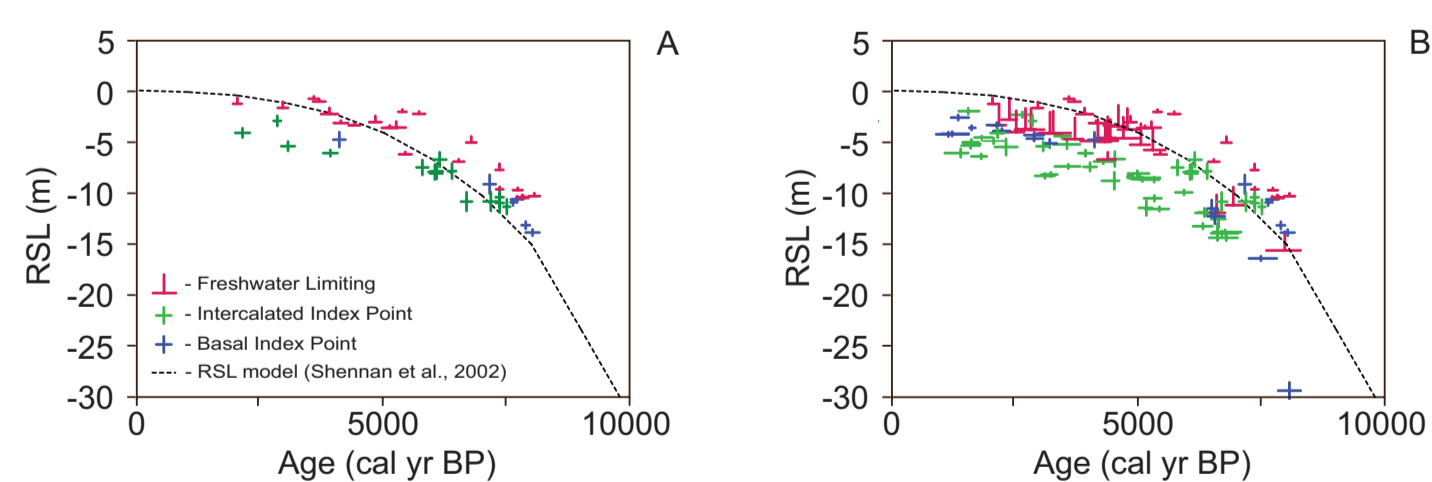


Figure 6 (a) The new RSL data produced from this study. Using this methodology, we are not able to constrain the former position of RSL in clastic sediments. By utilizing foraminiferal reconstruction techniques, we will be able to double the size of our dataset and provide higher resolution reconstructions of RSL. (b) The new Thames sea-level database with the addition of data from this study.

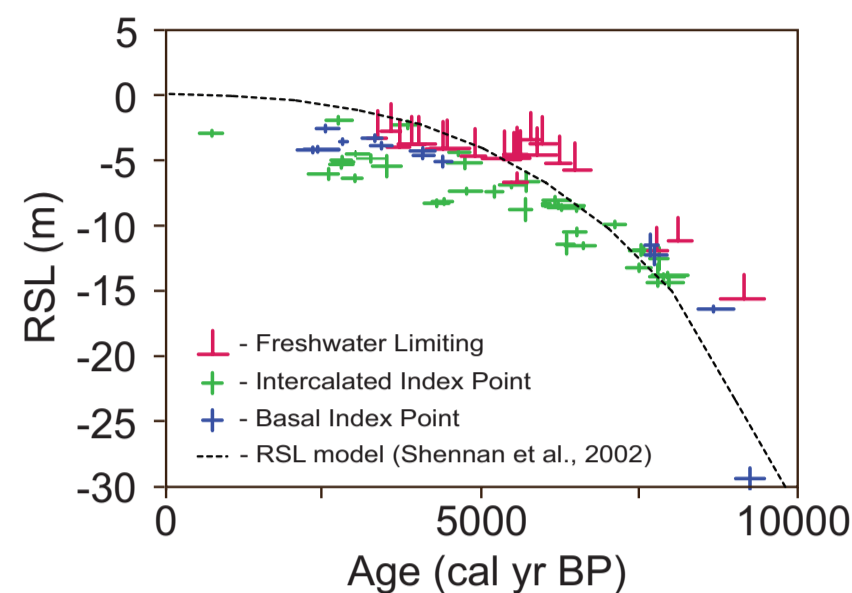


Figure 1 Existing Thames sea-level database of Shennan and Horton (2002). There are gaps in data during the Late and Early Holocene from 2 ka to present and 7–10 ka. Freshwater limiting points indicate that RSL must have been below that plotted elevation at that time.

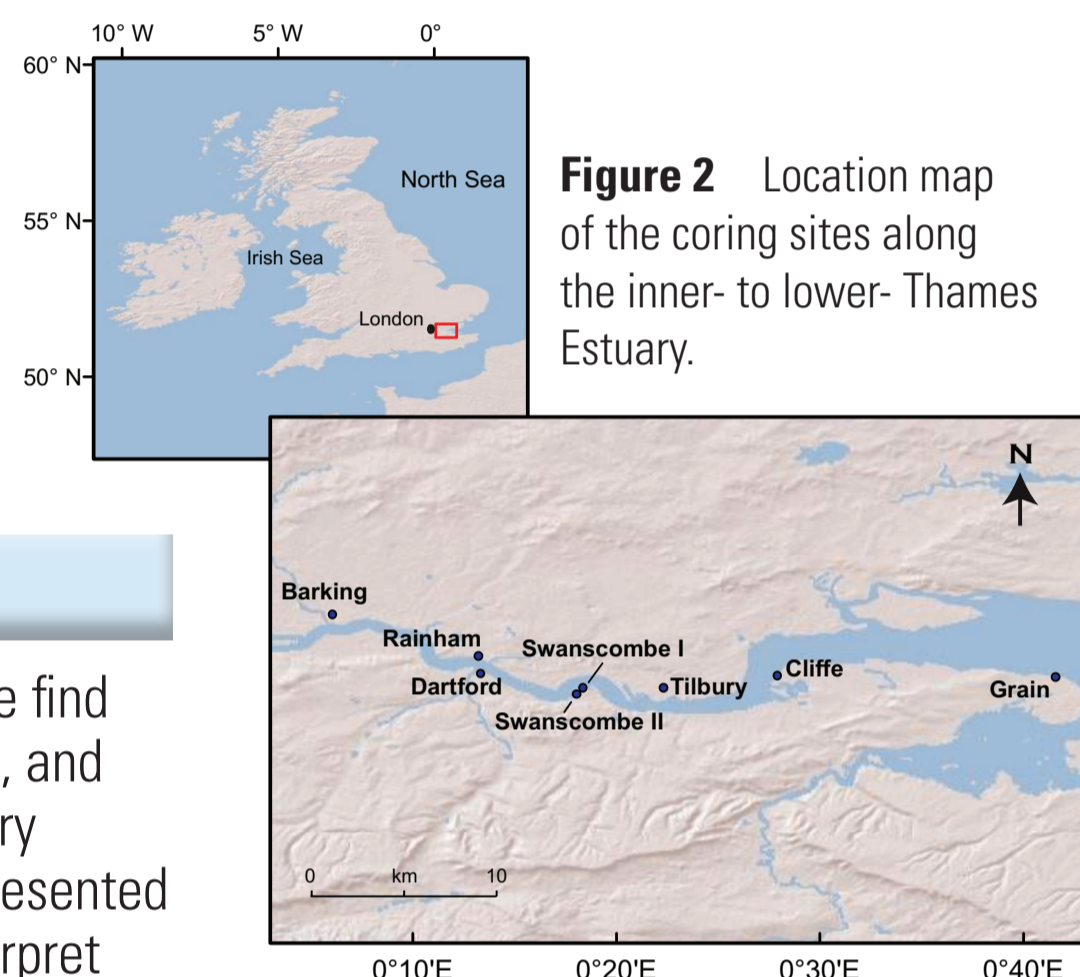


Figure 2 Location map of the coring sites along the inner- to lower- Thames Estuary.

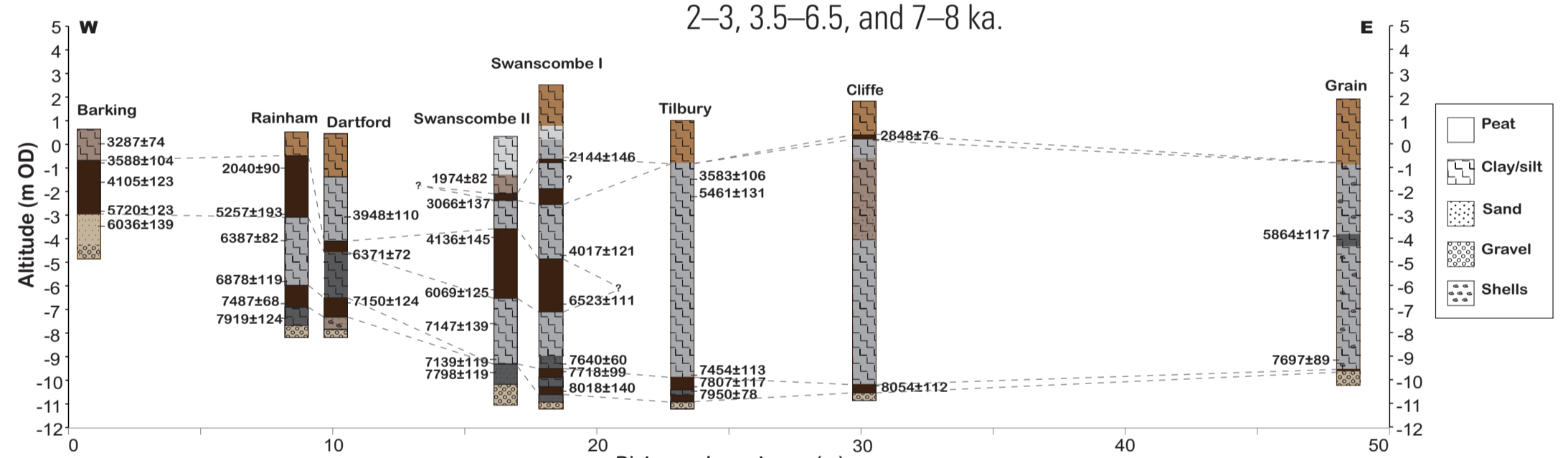


Figure 3 (below) Stratigraphy of the cores retrieved from the inner- to lower- Thames Estuary and selected radiocarbon dates from the sequences. Deposited above the Holocene basement (Thames Valley Gravel), there are two to three biogenic and minerogenic sequences apparent in the stratigraphy of these cores that appear to have been deposited between 2–3, 3.5–6.5, and 7–8 ka.

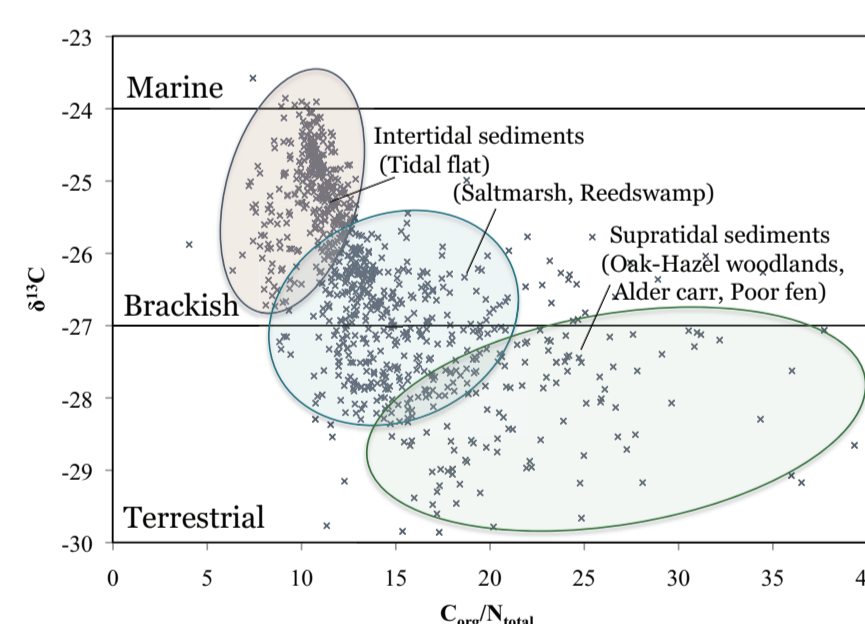


Figure 4 (left) $\delta^{13}\text{C}$ and C/N values for all of the cores collected from the Thames. Sediments are grouped on the basis of their $\delta^{13}\text{C}$ and C/N into inter- and supratidal environments [5].

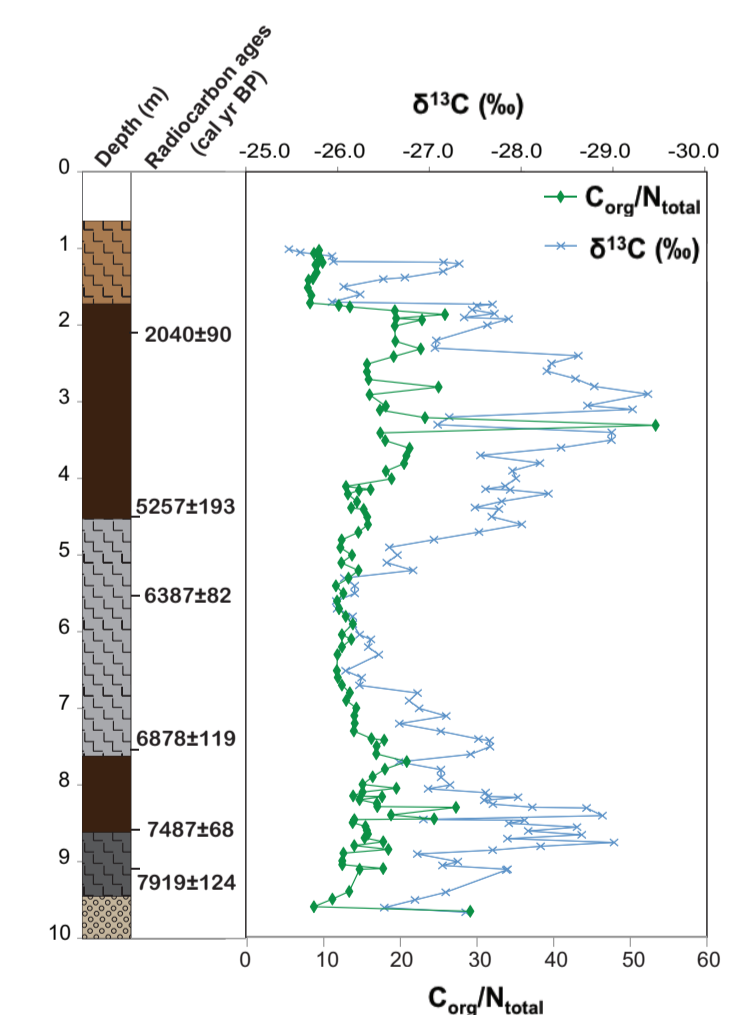


Figure 5 (above) The downcore variation in $\delta^{13}\text{C}$ and C/N in the core collected from Rainham marsh. The lithology follows the key of Figure 2. Biogenic sediments exhibit a more negative $\delta^{13}\text{C}$ and higher C/N ratio than those of minerogenic sediments reflecting its more terrestrial character. From these values, we interpret changes in paleoenvironment. From 7.5–8 ka we find organic-rich clays with $\delta^{13}\text{C}$ and C/N values representative of a salt marsh environment. Following 7.5 ka, there is a transition briefly to a supratidal wetland environment into an intertidal reed swamp. From ~7 ka onwards, tidal flat conditions persist, culminating in freshwater wetland conditions from ~5 ka to 2 ka. Above the peat sequence, a tan clay layer exists that is indicative of a reclamation surface.

Future work

- Complete additional fieldwork to establish modern analogues for the foraminifera and stable carbon isotopes found in the cores
- Complete foraminiferal identifications to provide higher-precision constraints on the former position of RSL
- Apply corrections for sediment compaction and changes in tidal range to these reconstructions

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