

Quaternary–Holocene sea-level changes, Northern England

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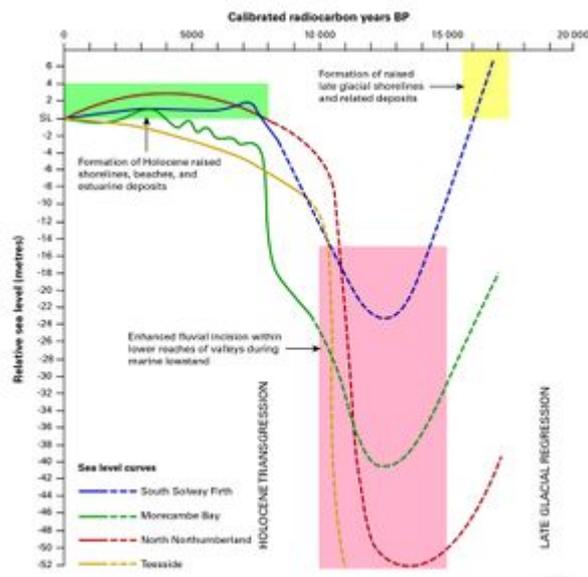
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Introduction



Representative relative sea-level curves. Solid lines are based on detailed biostratigraphical evidence; broken lines are based on predictive glacio-hydro-isostatic modelling. Pennine P916107.

At present, sea level is relatively high compared with its position during most of the Quaternary, so much evidence of past fluctuations has been either destroyed by marine erosion or submerged. Relative sea levels around northern England have been determined by both depression of the land under the ice load during glaciation and its subsequent recovery — glacio-isostatic effects, and by

changes in global sea levels — eustatic effects. The latter are mainly determined by the amount of water contained within continental ice sheets and global sea level has risen from a lowstand of about -120 m OD twenty thousand years or so ago, as those ice sheets have melted. The interaction of isostatic and eustatic effects means that former sea levels, as portrayed in relative sea level curves ([P916107](#)), vary considerably around the coast of Britain. The rate of isostatic uplift was greatest during and immediately after deglaciation and has since fallen exponentially. Some differential crustal rebound may have occurred during the Holocene in north-east England leading to the formation of flights of river terraces, the deeply dissected Durham Denes and the entrenched meander at Durham.

Two distinct sets of raised beach and estuarine deposits occur along the coasts of north-west England, where the amount of glacio-isostatic recovery was sufficiently great to bring about an early period of falling sea level. The older, Late Devensian ('late glacial') set, which occur sporadically around the Cumbrian coast, was formed during and shortly after retreat of MLD ice, whereas the younger, far more extensive set formed during the mid to late Holocene. The southern limit of Late Devensian beaches defines an important 'hinge line' in Britain stretching between Morecambe Bay and Berwick upon Tweed; net postglacial subsidence having occurred to the south; net postglacial uplift to the north (with the greatest isostatic response in the western Highlands of Scotland where the ice load was at a maximum). Raised beaches found along the North Sea coast to the south of Berwick-upon-Tweed, where eustatic sea level has been the dominant influence, are most probably all of Holocene age. Though some fragmentary raised beaches, rock platforms and marine planation surfaces in this area have been claimed as Late Devensian, the evidence is equivocal. Equally, claims that deglaciation of the Irish Sea basin was accompanied by widespread deposition of glaciomarine sediments up to 150 m OD cannot be substantiated.

The sea-level curves for northern England reveal lowstands in the early Holocene as glacioisostatic rebound outstripped global sea-level rise. Levels as low as 60 m below OD may have occurred within the northern Irish Sea basin, exposing a land bridge that linked the Isle of Man to Cumbria. Several concealed valleys in north-east England, including the Wear and Tyne, were graded to sea level at about 40 m below OD.

The subsequent postglacial transgression resulted in the formation of the set of Holocene raised beaches and associated estuarine silts, fine-grained sands and clays. Detailed investigations along the Northumberland coast reveal that sea level rose from about -5 m to +2.5 m between 9.0 and 2.5 ka BP ([P916107](#)), then fell back slightly, but is currently rising again at between 0.7 and 0.1 mm per year. In contrast, around the coast of Cumbria, sea level rose towards a distinct highstand of about +2 m OD by about 7.0 ka BP in the mid Holocene. The result was the main postglacial shoreline marked by fragmentary raised beach deposits of well-rounded shingle backed by a degraded cliff. The Cumbrian coast railway follows stretches of the raised shoreline to the north of Seascale.

Peat beds and tree stumps ('submerged forests') are intermittently exposed on the foreshores of both coasts of the district, where they provide clear evidence of lower Holocene sea level. At St Bees, one such deposit comprises compressed peat with wood fragments, nuts and seeds, interbedded with mud and tufa; a calibrated radiocarbon age of about 8.6 ka BP was obtained on a piece of wood. Another well-known submerged forest occasionally emerges on the foreshore in Hartlepool Bay. A Neolithic human skeleton has been recovered from the peat there together with flint artefacts; the bones yielded a calibrated radiocarbon age of 5.4 ka BP.

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